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GNSS-Lab tool
Software User Manual

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Document Change Log

Iss./Rev	Date	Section / Page	Change Description
1.0	08/09/2009	All	First version of the document
1.1	29/10/2009	All	Included RIDS comments from ESA and new screenshots from gLAB v1.2.
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1.3	08/07/2010	Section 4 - 6	Revision and update with new gLAB v1.4
1.4	31/07/2010	Section 4.1 Section 6.4	Description of Auxiliary files. Inclusion of preferences and about snapshot Removed limitation of combination measurements and to save current configuration to a file.
1.5	31/08/2010	Section 2.1.1 Section 4.2.5 Section 4.2.3	Maximum number of filter iterations added. Satellite elevation and azimuth addition in the Model message. Update according to the new DCB management

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1 INTRODUCTION

The GNSS-Lab Tool suite (gLAB) is an interactive multipurpose package to process and analyse GNSS data. The first release of this software package allowed processing only GPS data. A later release expanded gLAB to SBAS and differential processing (DGNSS). The current update includes multiple GNSS constellations and frequencies.

This software package is targeting the following groups of users:

- Education professionals aiming to teach GNSS from both a theoretical and practical points of view.
- Standalone students and professionals with basic knowledge on GNSS as a self-learning tool.
- Professionals with more in deep knowledge on GNSS who want an easy and user-friendly tool with precise positioning capability.

From an operative point view, this tool is conceived as a full software package to support a practical GNSS courses, where the fundamentals introduced in the theory are experimented through guided exercises. See for instance the gAGE-ESA GNSS book or the gAGE Tutorials in https://gage.upc.edu). In this way, the tool is conceived for being used:

- as part of a GNSS course with practical exercises integrated following a manual, or
- experimenting around with contextual help with hyperlinks for more information, or
- to process RINEX data and obtain a standalone or differential positioning

The gLAB tool is distributed within a learning material package containing the following components:

- **Software:** A binary that is able to read RINEX data, process it and show the results in the form of text files and graphics. The processing options will be fully parametrizable through a Graphical User Interface (GUI) that facilitates the understanding of the tool and its different options. The software is able to work in Windows, Linux and Mac Operating Systems.
- **Tutorials:** The gAGE-ESA GNSS book [RD-15] and the gAGE Tutorials [RD-16] containing the GNSS fundamentals and several practical exercises covering from the basics of data processing, such as reading standard RINEX format to more complex processes, as positioning a rover and analysing the results.
- **Data:** The data sets files used in the exercises.

1.1 DOCUMENT SCOPE AND PURPOSES

This document contains the information related to the use of the gLAB software package, and its purpose is to provide an overall overview to the end user of the software. In particular, how to install it and use it, with different options that the software has.

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1.2 DOCUMENT OVERVIEW AND STRUCTURE

This document is split in sections, which describe:

- A generic description on the different software modules included in the package (Section 2).
- A detailed description of the installation procedure (Section 3).
- How to use the Graphic User Interface (GUI) component (Section 4).
- How to use the Data Processing Core (DPC) component (Section 5).
- How to use the Data Analysis Tool (DAT) component (Section 6).

IMPORTANT NOTE: All parameters, options and output messages are copied from the command line help of the processing and plotting tools. Therefore, the command line help always has preference over this manual (and may sometimes be more complete), except for the command line usage examples and the plot examples, which are not in the command line help. The command line help can also be accessed through the GUI in the menu: Help->User manuals.

1.2.1 Applicable documents

The following documents refer to the applicable documents for the project.

AD-01 RINEX-2.10 format: http://igscb.jpl.nasa.gov/igscb/data/format/rinex211.txt

AD-02 RINEX-3.00 format: ftp://epncb.oma.be/pub/data/format/rinex300.pdf

AD-03 RINEX-3.04 format: ftp://ftp.igs.org/pub/data/format/rinex304.pdf

AD-04 RINEX-B format: ftp://ftp.igs.org/pub/data/format/geo_sbas.txt

AD-05 EMS format: http://www.egnos-pro.esa.int/ems/EMS_UID_2_0.pdf

AD-06 IONEX format: http://igscb.jpl.nasa.gov/igscb/data/format/ionex1.pdf

AD-07 SP3 format: http://igscb.jpl.nasa.gov/igscb/data/format/sp3.txt

AD-08 RINEX clock format: http://igscb.jpl.nasa.gov/igscb/data/format/rinex_clock.txt

AD-09 ANTEX format: ftp://igscb.jpl.nasa.gov/igscb/station/general/antex13.txt

AD-10 RTCA-MOPS, December 2006.

AD-11 PEGASUS Interface Control Document. PEG-ICD-02: https://www.icao.int/Meetings/AMC/MA/2004/GNSS/icd.pdf

AD-12 EGM96 grid values:

http://earth-info.nga.mil/GandG/wgs84/gravitymod/egm96/egm96.html

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1.2.2 Reference Documents

RD-1 Python Programming Language, http://www.python.org

RD-2 Guide to Applying the ESA Software Engineering Standards to small Software Projects Doc.-No. ESA BSSC (96)2 Issue 1, 199.

RD-3 Gnuplot: http://www.gnuplot.info

RD-4 Architecture Design Document for gLAB, gAGE/UPC 2009.

RD-5 ANTEX file: http://igscb.jpl.nasa.gov/igscb/station/general/igs05.atx

RD-6 SP3 files: http://igscb.jpl.nasa.gov/igscb/product

RD-7 GIPSY OASIS-II, Mathematical description, 1986

RD-8 A. E. Niell, Global mapping functions for the atmosphere delay at radio wavelengths, Journal of Geophysical Research, Vol. 101, No. B2, p. 3227-3246, 1996.

RD-9 RTCA, 2001. Minimum Operational Performance Standards For Global Positioning Sysmte/Wide Area Augmentation System Airborne Equipment. RTCA/DO-229C. Prepared by SC-159. November 28, 2001. Supersedes DO-229B. Available at http://www.rtca.org/doclist.asp . pp. 338-340 of 586 in PDF.

RD-10 D. McCarthy and G. Petit, IERS Conventions, International Earth Rotation and Reference Systems Service (IERS), 2003

RD-11 S. Malsys, M. Larezos, S. Gottschalk, S. Mobbs, B. Winn, W. Feess, M. Menn, E. Swift, E. Merrigan and W. Mathon, The GPS accuracy improvement initiative, ION GNSS 1997, Kansas City, USA, pp. 375-384, 1997.

RD-12 GPSConstellationStatus.txt file, available at:
http://gge.unb.ca/Resources/GPSConstellationStatus.txt

Or a similar file provided by CODE:

ftp.aiub.unibe.ch/BSWUSER52/GEN/SATELLIT.I14

RD-13 ICD-GPS-200, Navstar GPS Space Segment / Navigation User Interfaces, 1993.

RD-14 Global Positioning System Standard Positioning Service Signal Specification. U.S. Department of Defense, DOD 4650.5/SPSSP V3, 3rd Edition, August 1, 1998.

RD-15 J. Sanz Subirana, J.M. Juan Zornoza and M. Hernández-Pajares, “GNSS Data Processing” Vol. 1: Fundamentals and Algorithms and Vol. 2: Laboratory exercises. ESA Communications. Noordwijk, the Netherlands. ISSN 1013-7076, ISBN 978-92-9221-886-7 (two volumes plus CD).

RD-16 J. Sanz Subirana, J.M. Juan Zornoza and A. Rovira-García, GNSS Data Processing Theory Lectures and GNSS Data Processing Laboratory Tutorials. Ed. J. sanz Subirana. Publisher Reasearch Group of Astronomy and Gepmatics (gAGE/UPC). ISBN 978-84-932230-7-6, 31 July 2019.

RD-17 International Association of Marine Aids to Navigation and Lighthouse Authorities:

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http://www.iala-aism.org/product/performance-and-monitoring-of-dgnss-services-in-the-frequency-band-283-5-325khz-1112/

RD-18 full list of colormaps: https://matplotlib.org/users/colormaps.html.

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1.2.3 Acronyms

AD	Applicable Document
AWGN	Additive White Gaussian Noise
CRC	Cyclic Redundancy Check
DAT	Data Analysis Tool
DOP	Dilution of Precision
DoY	Day of Year
DPC	Data Processing Core
EGNOS	European Geostationary Navigation Overlay Service
EMS	EGNOS Message Server
ESA	European Space Agency
FIR	Flight Information Region
FTP	File Transfer Protocol
gAGE	Research Group of Astronomy and Geomatics
gLAB	GNSS-Lab tool
GDOP	Geometric Dilution of Precision
GEO	Geosynchronous Equatorial Orbit
GLONASS	GLObal NAvigation Satellite System
GNSS	Global Navigation Satellite System
GUI	Graphic User interface
GPS	Global Positioning System
HDOP	Horizontal Dilution of Precision
HE	Horizontal Error
HPE	Horizontal Positioning Error
HMI	Hazardous Misleading Information
HPL	Horizontal Protection Level
HWIR	Horizontal Worst Integrity Ratio
ICD	Interface Control Document
IGF	Iono Geometry Free
IGS	International GNSS Service
IGP	Ionospheric Grid Point
IALA	International Association of marine aids to navigation and Lighthouse Authorities
IMO	International Maritime Organization
IOD	Issue of Data
IODE	Issue of Data Ephemeris
IODF	Issue of Data Fast Correction
IODI	Issue of Data Ionospheric
IODP	Issue of Data PRN mask
IODS	Service Issue of Data
IONEX	IONosphere map Exchange format
IPP	Ionospheric Pierce Point
LTC	Long Term Corrections
MI	Misleading Information
MT	Message Type

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MOPS	Minimum Operational Performance Standards
NPA	Non Precision Approach
OS	Operative System
PA	Precision Approach
PDOP	Position Dilution of Precision
PL	Protection Level
PEGASUS	Prototype EGNOS and GBAS Analysis System Using SAPPHIRE
PPP	Precise Point Positioning
PRC	Pseudo Range Correction
PRN	PseudoRandom Noise
RD	Reference Document
RINEX-B	Receiver Independent EXchange format Binary
RRC	Range Rate correction
RSS	Root Sum Square
SAPPHIRE	Satellite and Aircraft Data Base for System Integrity Research
SBAS	Satellite Based Augmentation System
SIS	Signal In Space
SNR	Signal to Noise Ratio
SOW	Statement Of Work
S/W	Software
TBC	To Be Confirmed
TBD	To Be Determined
TBW	To Be Written
TGD	Total Group Delay
TOW	Time of Week
UD	User Domain
UDRE	User Differential Range Error
UDREI	User Differential Range Error Indicator
UIVE	User Ionospheric Vertical Error
UPC	Technical University of Catalonia
URA	User Range Accuracy
URL	Uniform Resource Locator
VDOP	Vertical Dilution of Precision
VE	Vertical Error
VPE	Vertical Positioning Error
VPL	Vertical Protection Level
VWIR	Vertical Worst Integrity Ratio
WIR	Worst Integrity Ratio

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2 gLAB SOFTWARE TOOL

The gLAB software tool is able to run under Linux and Windows operating systems (OS). It is programmed in C99, Python and Qt languages and contains three main software modules:

- Data Processing Core (DPC) [gLAB.exe in Windows, gLAB_linux for Linux, gLAB_mac for Mac]
- Graphic User Interface (GUI) and [gLAB_GUI.exe in Windows, gLAB_GUI in Linux and Mac]
- Data Analysis Tool (DAT) [graph.exe in Windows, graph.py in Linux, graph in Mac].

The DPC implements all the data processing algorithms and can be executed either, in command line or with the GUI. The GUI consists in different graphic panels for a user friendly managing of the SW and the tool configuration. They provide all the options to configure the model and navigation. The Data Analysis Tool provides a user friendly environment for the data analysis and results visualizing.

The tool contains a precise modelling of the GNSS observables (code and phase) at the centimetre level, allowing both standalone positioning and PPP. A previous release expanded gLAB with SBAS and differential processing (DGNSS). The current update includes multiple GNSS constellations and frequencies.

2.1 SOFTWARE PACKAGE FEATURES

- Graphic User Interface (GUI) to ease the utilisation of the tool with most of the capabilities of the DPC. The GUI allows a high customisation interface to process a wide range of options.
- Tooltips in the GUI, which allow understanding and using the different options.
- Supports all constellations (GPS, Galileo, GLONASS, GEO, BeiDou, QZSS and IRNSS with precise orbits and broadcast orbits).
- SBAS one frequency and SBAS DFMC processing.
- DGNSS processing (with GPS only)
- Capable to read:
    - Station measurements from Observation RINEX standard version 2.11, 3.00, 3.01, 3.02, 3.02, 3.03, 3.04 and 3.05.
    - Broadcast message from Navigation RINEX standard version 2.11, 3.00, 3.01, 3.02, 3.02, 3.03, 3.04 and 3.05.
    - Satellite clocks from Clocks RINEX standard.
    - Satellite orbits and clocks from SP3 standard version a,b,c and d.
    - Ionospheric maps from IONEX standard.

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  - Constellation status (with information between Satellite Vehicle Number (SVN) and PRN) of the satellite.
  - Antenna Phase Center information from ANTEX standard.
  - Differential Code Biases from precise .DCB files.
  - GPS Receiver type information from GPS Receiver File Types.
- The DPC is able to work both with command-line parameters and a configuration file.
- Automatically detects RINEX version.
- Fully capable to read all constellations from RINEX files.
- Able to process both pseudorange and carrier phase.
- Detection of cycle-slips in carrier phase measurements for GPS with four different methods:
  - Geometric-free carrier phase combination.
  - Melbourne-Wübbena combination.
  - Code-Phase difference (for single-frequency receivers)
  - Triple/quadruple frequency IGF (Iono Geometry Free) combinations, computed with two methods: By adding two dual iono free combinations or with a specific formula.
- Time handling routines (The internal time format of the software is Modified Julian Day and seconds of day).
- Prealignment of carrier phase to pseudorange measurements. This is done to avoid large differences between both kinds of measurements, and allow a more direct comparison. The alignment is done keeping the integer part of the carrier phase.
- Pseudorange jump checking. Some receivers have an inconsistent set of pseudorange and carrier phase measurements when they adjust their own clock (doing one or more leap milliseconds). Their pseudorange measurements are consistent with this change in clock, but carrier phases do not show it. This creates an inconsistency and a general cycle-slip for all satellites if not handled properly. gLAB detects and corrects this problem.
- Decimation capabilities. gLAB can decimate the input RINEX to increase computation speed if a high sampling rate is not needed. The decimation comes after the cycle-slip detection to take full profit of the input data rate.
- Individually select/deselect each satellite for processing.
- Set an elevation mask to ignore low satellites for processing.
- Automatic or manual selection of frequencies to be used in the processing. Automatic selection can be fine-tuned using an preference list.
- Pseudorange smoothing option.
- Orbit interpolation of SP3 data.
- Broadcast message support (orbit estimation, clock correction, TGD correction).

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- Orbit/Clock comparison mode (it can compare the orbit and clocks from 2 different sources, i.e. broadcast, SP3 and clocks files).
- Sun approximate positioning (for satellite orientation).
- Models implemented (all of them can be enabled or disabled):
    - Satellite clock error correction.
    - Transmission time computation.
    - Earth rotation in flight time of the signal.
    - Satellite phase center correction.
    - Receiver phase center correction.
    - Receiver Antenna Reference Point (ARP) correction.
    - Relativistic correction.
    - Ionospheric correction: Klobuchar, BeiDou, SBAS or IONEX.
    - Tropospheric correction [one simple model and the more refined Niell mapping model]
    - Differential Code Bias (DCB) correction.
    - Wind up effect.
    - Solid tides correction.
    - Gravitational delay correction [an effect of general relativity due to the gravity field gradient between receiver and transmitter].
- Full measurement configurability in a per satellite basis, i.e. each satellite may have a different configuration in the filter and cycle-slip detection (e.g. for receivers that for some satellites tracks GPS L2C and for other L2P).
- Assign different weights to each measurement and satellite. Weight modes can be: fixed, elevation dependent, SNR dependent, SNR and elevation dependent.
- Orientation estimation of both the satellites and the receiver (and thence the azimuth/elevation of the receiver-satellite pair).
- Standalone processing using broadcast and C/A code (fully configurable to be able to used also carrier phase if required).
- Precise Point Positioning (PPP) with precise orbit and clocks, precise models and Pc/Lc measurements (ionospheric-free combinations). It is also fully configurable.
- Able to create different plots to visualise the data processed.
- Detection and warning of convergence problems.
- Able to read a reference position file (in columnar text file format, in SP3 format or RTKlib output file format) for comparing gLAB position with the reference position.
- Able to read a user defined error file (a columnar text file) in order to add error to measurements.

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- Able to read a sigma multipath file (a columnar text file) in order to make a user defined sigma multipath in function of elevation or SNR (for SBAS mode).
- Provides a built in Date format and coordinate system converters.

2.2 IDENTIFIED LIMITATIONS

Multi-constellation processing and SBAS DFMC is only available in command line.

2.3 MINIMUM HARDWARE REQUIREMENTS

gLAB requires the following computer minimum hardware requirements in order to be properly executed:

- 2GB of RAM memory.
- CPU with at least 1GHz.
- 1GB of hard disk free space.
- Screen resolution of at least 1024x768 is recommended, but the program window can be resized at will.

2.4 MINIMUM SOFTWARE REQUIREMENTS

The program runs under Windows (7, 8, 10 and 11) and Linux (Ubuntu 16.04 and above) Operating systems (in 64-bit systems only). It also works in Mac, from version 10.11 (El Capitan) and onwards. Also, for Linux, it can also run in ARMv7 and ARM64.

2.4.1 Windows

No specific software is required to execute the program in Windows.

2.4.2 Linux

For Linux users on 64 bits, all software is precompiled.

In ARMv7 and ARM64, the GUI is precompiled, but the core needs to be compiled. Also the plotting tool requires python to run.

To compile the core, the programs need to be compiled can be installed with this command:

```
sudo apt-get install gcc make
```


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In order to use the plotting tool with Python 3, the following packages must be installed:

```
sudo apt-get install python3-matplotlib python3-tk python3-numpy
```

Furthermore, to create SBAS or WIR plots, the following packages need to be installed (optional):

```
sudo apt-get install python3-mpltoolkits.basemap python-mpltoolkits.basemap-data
```

2.4.3 Mac

No specific software is required to execute the program in Mac, as all binaries are precompiled.

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3 INSTALLATION PROCEDURE

The gLAB software package can be downloaded from the following URL:

http://gage.upc.edu/gLAB/

In this web page it is possible to download the last version of gLAB in Windows, Linux and Mac.

3.1 WINDOWS

The installation of the Windows version is initiated by executing the installation program. During the installation process you have several configurable options, such as the installation directory (by default, C:\Program Files\gLAB), and the possibility to create shortcuts.

The installation will create a gLAB group in the start menu with the following elements:

- *gLAB on the Web*, will forward to the webpage of gLAB.
- *Uninstall gLAB*, to completely remove gLAB from the computer.
- *gLAB_GUI*, the Graphic User Interface of gLAB.
- *Command line in directory*, which will open a new command line window in the directory gLAB was installed.

Executing the gLAB_GUI option will run the GUI program.

3.2 LINUX

gLAB has been successfully tested under Ubuntu, but should work in other Linux distributions.

The Linux version of gLAB has to be decompressed to a directory, using the following command:

tar –xvzf glab_vx.x.tgz

This will create a directory called ‘gLAB’ with all the program structure. Next, it is necessary to compile the DPC.

To compile the core, the programs need to be compiled can be installed with this command:

- sudo apt-get install gcc make

To compile the core:

cd gLAB

make

This will create the binary for the DPC of gLAB (gLAB_linux).

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In order to be able to launch the python programs (GUI and DAT), it is necessary to have the following packets installed in the system (other versions may also work):

- Python v2.5.4
- Python matplotlib v0.98.5.4
- Python Tkinter v5.4.0
- Python Basemap v1.0.7
- Python Numpy v1.3.0

In Ubuntu, this can easily be done by using the following command:

sudo apt-get install python3-matplotlib python3-tk python3-numpy

Optionally, to create SBAS or WIR plots, the following packages need to be installed (optional):

sudo apt-get install python3-mpltoolkits.basemap python-mpltoolkits.basemap-data

3.3 MAC

gLAB has been successfully tested under OS X 10.11 and OS X 10.12. It should work for future OS X versions.

To install, simply doble click on the ".dmg" file, and drag the "gLAB_GUI" icon to the "Applications" folder.

To open gLAB, open Mac launcher and click on "gLAB_GUI".

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3.4 DIRECTORY STRUCTURE

gLAB

gLAB/LICENSES

gLAB/source

gLAB/test

gLAB/win

The *gLAB* directory contains all the binaries, python programs and other files.

The gLAB/LICENSES directory contains the licenses of the gLAB (Apache, GPL and LGPL).

The *gLAB/source* directory contains the source code of the different gLAB components (DPC, GUI and plotting tool).

The *gLAB/win* (only available in the windows distribution) directory contains all the required data for the GUI and DAT binaries. This directory can be fully generated by the “Manual binary generation” procedure set above.

The *gLAB/test* directory contains a set of test files to be used with the gLAB program.

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4 *gLAB* GRAPHIC USER INTERFACE (GUI)

4.1 THE BASICS

The GUI is an interface between the other two components, the DPC and the DAT. It will allow the user changing different parameters, and execute the other two programs with the proper arguments. The initial screen of the GUI can be seen in Figure 4-1.

Figure 4-1: Initial screen of the gLAB Graphic User Interface

The menu in the top-bar can be found with different drop-down sub-menus. The following sections will provide in-deep information on the different options of the GUI. Most of the information here can also be found with the inline tooltips.

- **Mode**: Selects the different functions of the gLAB:
  - Positioning: The interface with the DPC, allows selecting all the different processing options to be performed.
  - Analysis: The interface with the plotting, and allows selecting all the different plotting options.
  - Converter: The interface to convert SBAS and RTCM formats to RINEX, EMS and Pegasus formats, see AD-11.
  - Compare Orbits & Clocks: Mode to compare the orbit and clocks from 2 different sources, i.e. broadcast, SP3 and clocks files.
  - Show Orbits & Clocks: Mode to calculate satellite coordinates, velocities and clocks.

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- Add User Error to RINEX: Read a RINEX Observation file, a user defined error file and create a RINEX observation file with the user defined error.

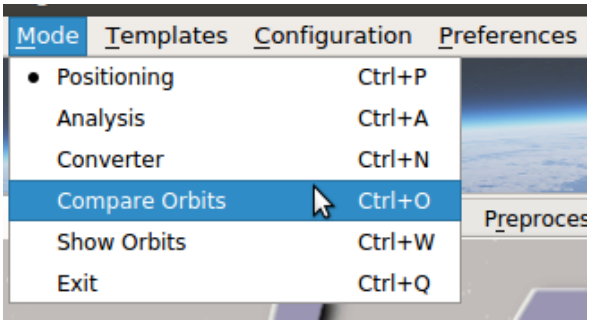

Figure 4-2: Mode drop-down menu

- **Templates:** Configure all the options of the program for a specific processing
  - SPP: to perform a Standard Positioning Service (SPS) processing.
  - PPP: to perform a regular Precise Point Positioning (PPP) processing for the computation of precise coordinates.
  - SBAS 1F: to perform a regular SBAS 1F processing.
  - SBAS DFMC: to perform a regular SBAS DFMC processing.
  - DGNSS: to perform a regular differential (DGNSS) processing.

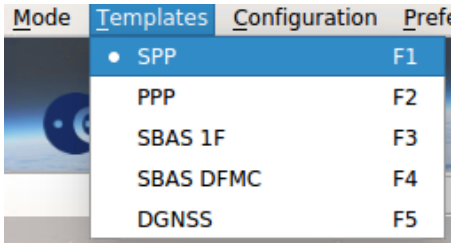

Figure 4-3: Templates drop-down menu

- **Configuration**: Allows saving, loading and opening the configuration last read or saved. By default, it generates the minimum set of instructions to change the defaults of the DPC, but all options can be saved if desired. In addition, the command line instruction generated by the GUI to be executed by the DPC can be displayed. There are also options to set the number of threads and to print in the legacy version 5 format.

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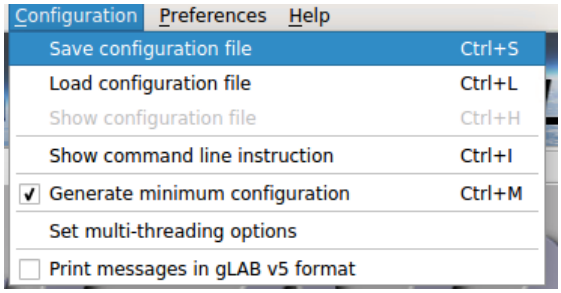

Figure 4-4: Configuration drop-down menu

- **Preferences**: Allows to select/deselect explanatory tooltips (selected by default), and to show the header of the GUI (selected by default).

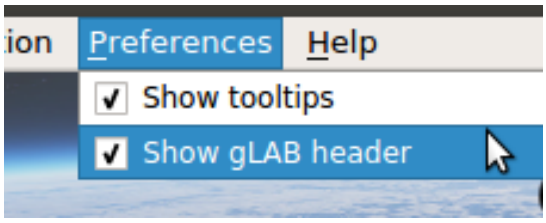

Figure 4-5: Preferences drop-down menu

- **Help:** This section contains useful information about gLAB such as the FAQ, manuals, the release notes, credits, a date and coordinate converter and the possibility to check for new updates. It also includes links to ftp sites to download data and the gLAB website, among others.

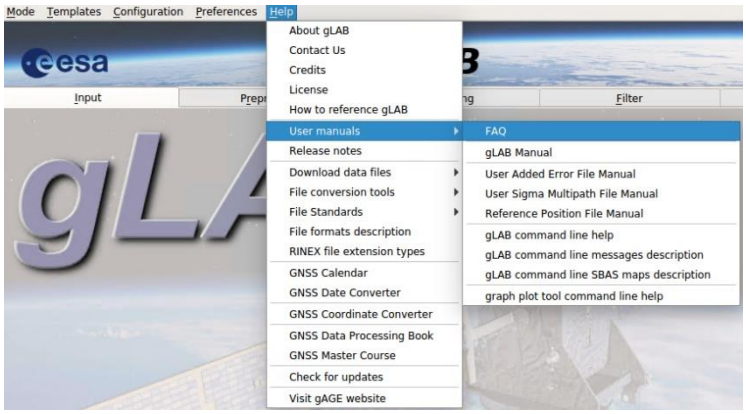

Figure 4-6: Help drop-down menu

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4.2 POSITIONING MODE

The positioning mode is split into 5 different sections, which correspond to 5 different modules inside the DPC (see the Architecture Design Document for gLAB RD-4). The different modules of the DPC are:

- **INPUT module:** It can be understand as a "driver" between the input data and the rest of the program. This module implements all the input reading capabilities and stores it in structures defined in the DATAHANDLING module.
- **PREPROCESS module:** This module process the data before the MODEL. It checks for cycle-slips, pseudorange-carrier phase inconsistencies, pseudorange smoothing and decimates the data (if required).
- **MODELLING module:** This module has all the functions to fully model the receiver measurements. As said, it implements several kind of models, which can be activated or deactivated.
- **FILTER module:** This module implements an Extended Kalman Filter (EKF) fully configurable, and obtains the estimations of the required parameters.
- **OUTPUT module:** This module is in charge of printing all messages as well as writing the necessary output files (SP3 file, Stanford-ESA file, …).

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4.2.1 Input

This section provides all the configuration options to select the input files for gLAB.

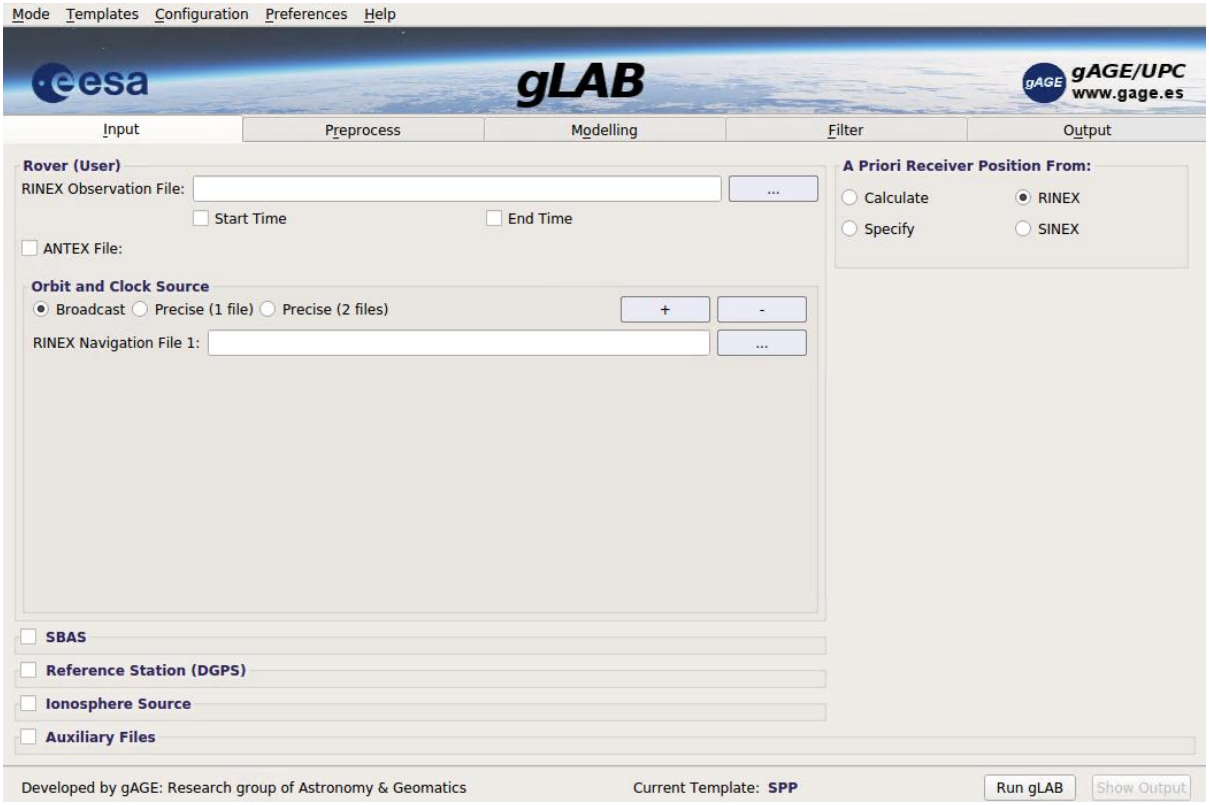

Figure 4-7: Screenshot of the INPUT section.

- **Input files:** Section to include all the files required for the proper functioning of the program.
    - **RINEX Observation File:** Selects the input RINEX observation file. This file contains the GNSS measurements for a given station. It supports RINEX formats 2.11, 3.00, 3.01, 3.02, 3.02, 3.03 and 3.04.
    - **ANTEX File:** Selects the input ANTEX file[1]. This file contains information on the antenna phase centre of the GNSS satellites and ground stations.

[1] The last ANTEX files can be found in: [RD-5]. The gLAB suite includes two different ANTEX files: igs05.atx and igs_pre1400.atx. The first file is directly downloaded from [RD-5], and should be used for data sets after GPS week 1400 (5th of November of 2006). The second one should be used before this date. This is because there was a change in the way that Satellite Phase Centers were obtained. Thence using Precise files for navigation with the incorrect set of ANTEX file will be translated in higher than expected errors.

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- **Orbit and Clock Source:** Origin of the orbit and clock products. The option selected here must be consistent with the *Navigation Mode* in the **Templates**: Broadcast => SPP, Precise (1 file) or Precise (2 files) => PPP
  - **Broadcast:** Selects as orbit and clock product source the navigation message sent by the satellites in one or more RINEX navigation files.
  - **Precise (1 file):** Selects as orbit and clock products source an SP3 file. This file contains the orbits and clocks of the satellite at specific times. The orbit and clock interpolation degrees in the Modelling section affects the computation of orbit and clocks in this mode[2].
  - **Precise (2 files):** Selects as orbit and clock products source an SP3 file (for orbits) and a CLK file (for clocks). These files contain the orbits and clocks of the satellite at specific times. The use of a CLK file provides a higher rate of the clocks, and thence a higher rate processing step. The orbit and clock interpolation degrees in the Modelling section affects the computation of orbit and clocks in this mode.
    - Orbits SP3 File: Source of orbit data.
    - Clocks Rinex File: Source of clock data.
- **SBAS:** Selects the input SBAS 1F or SBAS DFMC messages file. Supported formats are RINEX-B 2.11 or EMS. SBAS message file may have data for multiple GEOs.
- **Reference Station (DGPS):** Selects the input reference station file. Supported formats are:
  - RINEX observation file: A RINEX observation file from a fixed station with known coordinates.
  - RTCM Auto: In this mode gLAB will autodetect if RTCM file is version 2.x or 3.x.
  - RTCM 2.x: RTCM version 2. In this mode, the initial date and hour of the data has to be provided, as this information is not in the binary file.
  - RTCM v3.x: RTCM version 3. In this mode, the initial date of the data has to be provided, as this information is not in the binary file.

  NOTE: gLAB supports a change of reference station during DGNSS processing. In RTCM v2.x, the corrections are sent by the reference station, so its coordinates are not used. In RTCM v3.x, the reference station coordinates get updated every time message is read. In RINEX observation file, the user can or either add a new RINEX observation header with the new coordinates, or add an event epoch with the APPROX POSITION XYZ record.
- **Ionosphere Source:** Origin of the ionosphere data when correcting it (see the Modelling section (4.2.3) for more information).

[2] SP3 files can be found at the IGS site: [RD-6].

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- **Broadcast (same as navigation):** For Klobuchar ionospheric model, use the same broadcast file as for the orbits and clocks for the Klobuchar parameters.
- **Broadcast (specify):** For Klobuchar ionospheric model, specify a different broadcast file to use for the Klobuchar parameters. This option is also useful when using SP3 and correcting ionosphere.
- **IONEX:** Specify a file to obtain the IONEX correction.
- **SBAS:** Specify a file to obtain the SBAS ionosphere correction.

- **A priori Receiver Position:** Initial receiver position. This is used to linearize the filter and to obtain the values for the models. The OUTPUT message type gives the position obtained by the filter differenced with this a priori position. If this position is accurate enough, the difference can be used as a direct measure of the error.
  - **Calculate:** Do not provide a priori position, gLAB will calculate it, and adjust it as necessary (useful for moving receivers, or when the approximate receiver position is unknown) with three different initial options:
    - **Earth's surface:** gLAB will automatically calculate the a priori receiver position, starting from Earth's surface (6378137,0,0).
    - **RINEX:** gLAB will automatically calculate the a priori receiver position, but starting from the RINEX observation header record APPROX POSITION XYZ. If these coordinates are (0,0,0), then the Earth's surface (6378137,0,0) will be used as initial coordinates.
    - **User defined:** gLAB will automatically calculate the a priori receiver position, but starting from the user coordinates. These coordinates cannot be (0,0,0).

    If a reference position file is given, the differential fields of the OUTPUT message will be the difference between the gLAB solution and the position given in the reference file. If no reference file is given or there is no value in the reference file (for a given epoch), the differentials fields will be zero.
  - **RINEX:** Use the RINEX observation header record APPROX POSITION XYZ as the receiver a priori position. This is used to linearize the filter and to obtain the values for the models. Besides, some fields of the OUTPUT message are given as difference to this a priori position.
  - **Specify:** Specify the receiver a priori position by providing the coordinates (for fixed receivers) or a reference position file (for moving receivers). This is used to linearize the filter and to obtain the values for the models.

    Besides, the differential fields of the OUTPUT message are given as difference to this a priori position.
    - **User defined:** Specify the receiver a priori position by providing the coordinates Set the input coordinate format to cartesian (XYZ) or geodetic (longitude, latitude, height).
    - **Reference file:** Specify the receiver a priori position by providing a reference position file (for moving receivers).

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And set the interpolation degree for computing the reference position from the data read in the file. The position will be interpolated with Lagrange interpolation (like in SP3 files). This is useful for computing a reference position in an epoch that is not provided in the file (but is between two epochs available in the file).

- **SINEX:** Match the RINEX observation header record MARKER NAME with the marker position present in the SINEX file. This is used to linearize the filter and to obtain the values for the models. Besides, some fields of the OUTPUT message are given as difference to this a priori position.
- **Baseline (DGNSS mode only):** If reference station data is from a RINEX observation file, coordinates will be read from the header record APPROX POSITION XYZ, otherwise they will be read from the RTCM file.

  The rover coordinates will be computed (using the reference station coordinates as initial position), and the differential fields of the OUTPUT message will be compared with the reference station coordinates.
- **User Baseline (DGNSS mode only):** Same as “Baseline” mode, but reference station coordinates are provided by user (in XYZ or geodetic).
- **RINEX Rover (DGNSS mode only):** If reference station data is from a RINEX observation file, coordinates will be read from the header record APPROX POSITION XYZ, otherwise they will be read from the RTCM file.

  The rover coordinates will be computed (using the rover RINEX observation header record APPROX POSITION XYZ as initial position), and the differential fields of the OUTPUT message will be compared with the rover RINEX observation coordinates.
- **User RINEX Rover (DGNSS mode only):** Same as “RINEX Rover” mode, but reference station coordinates are provided by user (in XYZ or geodetic).
- **Specify Rover (DGNSS mode only):** If reference station data is from a RINEX observation file, coordinates will be read from the header record APPROX POSITION XYZ, otherwise they will be read from the DGNSS file.

  The rover coordinates will be computed (using the user provided coordinates as initial position), and the differential fields of the OUTPUT message will be compared with the user provided coordinates.
- **User Ref & Rover (DGNSS mode only):** Same as “Specify Rover”, but reference station coordinates are provided by user (in XYZ or geodetic).

In the Help menu, section “User manuals”, there is a description on how to generate a reference position file.

- **Auxiliary files:** User can provide different auxiliary files: to get information about the receiver and to correct the Differential Code Biases (DCB) which are the delays due to electronic, antennas and cables of receiver and transmitter devices which directly affect the measurements with a bias. This effect can be corrected using the information extracted from: The RINEX Navigation file or Precise .DCB files.
  - **P1 – C1 Correction:**

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- **DCB File:** Specify a file with the P1-C1 Differential Code Bias DCB corrections. This file is generated by the International GNSS Service (IGS) and gives an accurate monthly estimation of the (P1-C1) bias for all Satellites.

  Because the code generation depends on the Receiver Type, this receiver-related information has to be given (see next field).

- **GPS Receiver Type from File:** Specify a GPS Receiver Type file, where gLAB will search for the receiver name read from the RINEX observation header record REC # / TYPE / VERS.

  - Receiver Type File: Specify a receiver type file. This file details naming conventions for IGS equipment, in-site logs, RINEX headers, and SINEX files.

    These naming conventions include manufacturer's name, model and code of: Receivers, Antennas, Radomes, and Antenna+Radome. Additional and historical equipment names also appear.

- **GPS Receiver Manual Selection:** Manually select a GPS Receiver Type.

  - GPS Receiver Type: Specify a receiver type.

  NOTE: If user selects receiver type 2, P1-C1 file will not be necessary (but it is recommended). This is to account for receivers that state in the header that P1 measurement is available, but all the P1 measurements have a value of 0. When receiver type 2 is set by the user, gLAB will ignore P1 measurement instead of trying to use this measurement in the cycle-slip detectors.

Because codes are generated differently depending the Receiver Type, C1-P1 biases need to be removed as follows:

Type 0 : C1-P1 classification unknown.

Type 1 : Cross correlated receiver, reporting:

C1

P2 = C1 + (Y2 - Y1)

Needs Corrections to obtain P1 and a consistent P2: P1=C1+b and P2=P2+b

Type 2 : C1 reported in place of P1:

Needs Corrections to obtain P1: P1=C1+b

Type 3 : L1,L2,P1,P2 reported as consistent set:

No bias removal needed.

- **P1 – P2 Correction:**

  - **DCB Source:** Select the P1-P2 Differential Code Bias (DCB) corrections source.

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        - **Broadcast (same as navigation):** Use the same RINEX navigation file for the DCB computations than the orbit and clock product source.
        - **Broadcast (specify):** Specify a RINEX Navigation file where the (P2-P1) bias are given as the Total Group Delay (TGD) located in the 3rd field of the 7th row of the broadcast ephemerides. This estimation is generated by the Control Segment that monitorises all satellites.
        - **Precise .DCB file:** Specify a Precise .DCB file where the International GNSS Service (IGS) gives an accurate estimation of the (P1-P2) bias. This file contains a monthly estimation of the (P1-P2) Differential Code Bias (DCB) for all Satellites.
        - **IONEX (same as ionosphere):** Use the same IONEX file for the DCB computations than the IONEX correction source.
        - **IONEX (specify):** Specify a IONEX file where the (P2-P1) bias are given in the PRN / BIAS / RMS header
    - **User Added Error File:** Columnar text file which indicates the user defined error that gLAB must add to measurements. In the Help menu, section “User manuals”, there is a description on how to generate this file.
        - **User Added Error File:** Text file for adding error to satelite raw measurements on certain epochs. Using an adder error file is equivalent to modifying the measurement values in the RINEX observation file.
        - **Insert User Added Error after preprocessing:** If unchecked, added error values will be added to measurements just after reading the observation file, affecting all steps of measurements processing.

          If checked, added error values will be added to measurements after the preprocessing, therefore, the preprocessing steps (code jumps detection, cycle-slip detection and smoothing) will not be affected by the added error values.
    - **User defined SBAS sigma multipath file:** Columnar text file for a user defined SBAS sigma multipath in function of the satellite’s elevation or SNR. In the Help menu, section “User manuals”, there is a description on how to generate this file.
        - **Sigma Multipath File:** Text file for setting a a user defined model for sigma multipath model for a SBAS receiver, which can be elevation or SNR dependent. This model consists of a set of elevation or SNR samples with its corresponding sigma values. With this set, gLAB will linearly interpolate the sigma value from the closest samples to the current value.

- **RUN gLAB button:** Execute the DPC program with all the configured parameters of the *Calculus* tab. This button can be used in all Input, Preprocess, Modelling, Filter and Output sections.
- **Show Output button:** This button opens a text editor with the output of the last execution of gLAB.

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4.2.2 Preprocess

This section provides all the configuration options to preprocess the input data. In particular, it allows changing the decimation rate, the elevation mask, the cycle-slip detection, and selecting individual satellites for the processing. Figure 4-8 shows a screenshot of the PREPROCESS section.

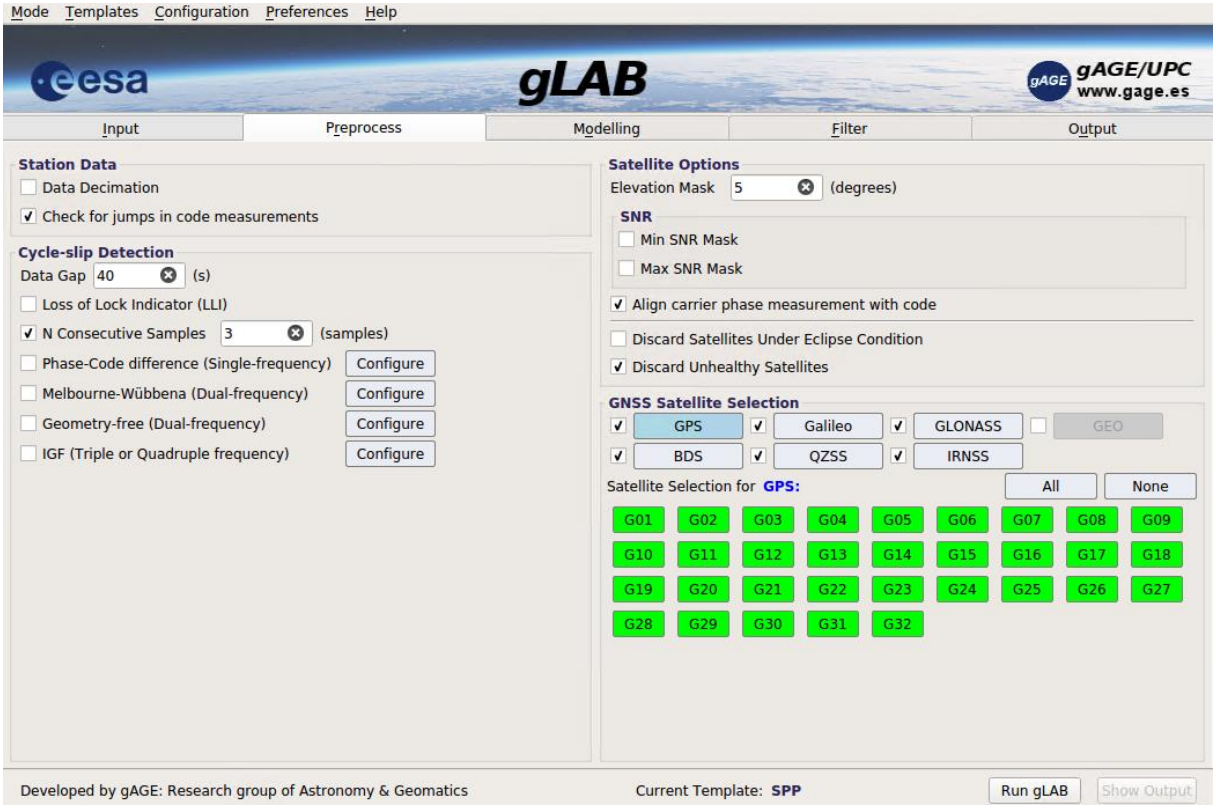

Figure 4-8: Preprocess section screenshot.

- **Station Data.**
  - **Data Decimation [s]:** Mark this option to decimate the input data at the specified rate [in seconds] (rate can be decimal, up to 0.0001 seconds resolution). If this option is unchecked, every time an epoch is found in the input RINEX observation file, all the processing takes place. If this option is checked, the data is decimated and not even modelled. Even in decimated data, all the epochs are used for cycle-slip detection, and arc length computations, but the process is stopped just before the modelling. This option is meant to be used to reduce computation time.

    NOTE: If decimation is higher than one second the decimation value will be truncated to avoid problems with decimals.
  - **Check for jumps in code measurements:** Some receivers do not output a set of physically consistent measurements. When they adjust their clock, a "jump" should appear both in pseudorange and carrier-phase measurements, but it

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only appears in pseudorange. This creates a massive cycle-slip for all satellites in this epoch if it is not corrected.

If this option is enabled, gLAB will detect and correct this behaviour, providing a set of consistent observables.

- **Satellite options.**
  - **Elevation Mask [Degrees]:** The elevation mask parameter is used to discard all the satellites below the specified elevation. Low elevation satellites should be discarded for geodetic processing as they may contain increased errors due to low signal-to-noise ratio and multipath.
  - **Minimum and maximum SNR Mask [dBHz]:** This parameter allows to discard satellites below or above a SNR (Signal to Noise Ratio) threshold, which is included in the RINEX observation file. The SNR can be provided in two ways, as a measurement (with names S1, S2, etc. in RINEX v2 and S1X, S2X, etc. in RINEX v3) or as a discrete value with the measurement (in the last character of the measurement).

    NOTES:

    - In command line, the user can set a different SNR threshold to each satellite by providing the parameter **'-pre:snrsel'** as many times as necessary.
    - If SNR is available in both ways (as a measurement and as a discrete value). gLAB will prefer the SNR as a measurement, as it is more precise.
    - When a measurement is under the SNR threshold, the sample will be omitted (as if no measurement had been read in the file). Therefore, any measurement discarded due to low SNR will not enter into the smoother and will count as a data gap.

    The advanced mode in minimum and maximum SNR allows to select in a per constellation, frequency and measurement basis in a separate window:

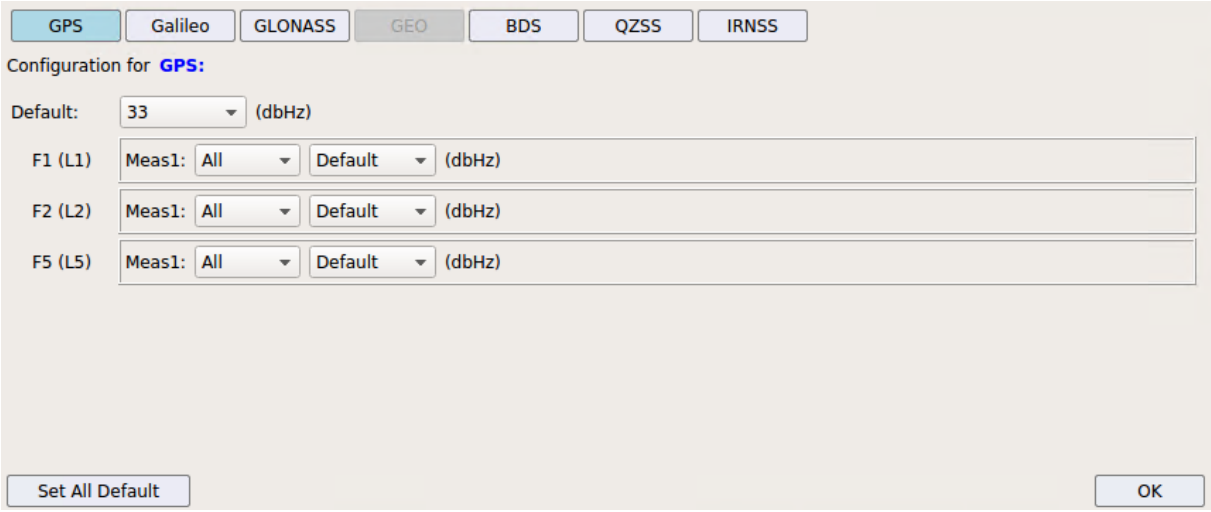

Figure 4-9 SNR thresholds window.

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- **Align carrier phase measurement with code:** In the first sample of each arc, for each couple of code and carrier phase measurements, compute the difference between them. During the same arc, add this constant difference to the carrier phase measurement. Therefore, the carrier phase measurement is at the same scale (aligned), and the scale of the ambiguities are reduced.
- **Discard satellites under eclipse condition:** This option allows to activate the discard of satellites if they are under eclipse conditions:
  - They do not have direct visibility of the Sun or
  - They have been in the former condition at some time of the last 30 minutes.

- **Discard unhealthy satellites (Broadcast only):** This parameter allows to discard satellites if the health flag of the broadcast navigation message is set to **unhealthy** or **marginal** (as both are non healthy states).
- **Discard Marginal Satellites:** This parameter allows to discard satellites if the health flag of the broadcast navigation message is set to marginal (this state only applies to Galileo satellites).
- **Cycle-slip Detection:** This section provides all the configuration options for cycle-slip detection. This is only used for carrier phase measurements. Each cycle-slip detection method can be enabled/disabled individually.
  - **Data Gap:** This parameter sets the maximum period of time (in seconds) allowed between two consecutive data samples. Therefore, a larger period of time between data samples will automatically declare a cycle-slip.

    NOTES:
    - Samples discarded due to SNR mask will also count for the data gap.
    - If all cycle-slip detectors are disabled (LLI, Phase-Code, Melbourne-Wübbena, Geometry-free and IGF), then Data Gap will be automatically disabled.
  - **Loss of Lock Indicator (LLI):** The LLI parameter is included in the carrier phase measurements of the RINEX observation file (in the penultimate character). When it is odd (i.e. 1, 3, 5 or 7), indicates that the measurement may contain cycle-slip.

    NOTE: LLI detector will only trigger if all measurements for the cycle-slip detectors enabled are available.
  - **N Consecutive Samples:** When there is a data gap between samples smaller than the maximum allowed, wait until there are N consecutive sample to use again data from this satellite. It is not a cycle-slip detector by itself, but it is useful for discarding measurements of satellites which are constantly appearing and disappearing (they usually have measurements with a lot of error) or as a blind measurement filter.

    This problem occurs only on high data rate files (sampling interval of 15 seconds or less). Thus gLAB will automatically disable this option if sampling interval is

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greater than 15 seconds (the sampling interval is computed automatically by gLAB).

The minimum value for N consecutive is 2 samples (wait until the second consecutive sample). Smaller values will disable this option.

- **Phase-Code difference (Single frequency):** This cycle-slip detector for single-frequency receivers uses the difference between pseudorange and carrier phase. This difference contains basically noise coming from the code, sudden jumps coming from cycle-slips, and a ionospheric divergence with time, due to the different effects that the ionosphere causes in carrier phase and pseudorange measurements. This detector computes the mean and standard deviation of code and phase along the epochs, proving a sliding window to limit the divergence. The expected mean value is compared against the obtained one, and if it is larger than a specific threshold, a cycle-slip is declared.

  The threshold is obtained as:

  Th = **k-factor**·stdDev

  The sigma is inflated with an **initial stdDev** during the first iteration and after every cycle-slip to avoid noisier or unrealistic sigma estimates.

  N-sample is the number of epochs needed before the detection function is active. Being **k, initial stdDev, window size** and the **N-sample** configurable parameters.

  Notice that **N-sample** will be overridden by **n**, where:

  n = maximum(N-sample of Phase-Code [if enabled], N-sample of Melbourne-Wübbena [if enabled], N-sample of Geometry-free [if enabled], N-sample of Iono Geometry-free [if enabled]).

  Phase-Code Options:

  - **Consistency Check:** This a code to detect large variations in code and carrier phase measurements from epoch to epoch (both measurements should vary in a similar way). It is computed with the following method:

    $$DeltaCode = Code - Code_{Previous\ Epoch}$$
    $$DeltaPhase = Phase - Phase_{Previous\ Epoch}$$
    $$DeltaCodePhase = abs(DeltaCode - DeltaPhase)$$

    If option is checked, and DeltaCodePhase is greater than a threshold, the satellite is skipped in this epoch.
  - **Initial stdDev:** Initial standard deviation (in metres) to initialize the cycle-slip detector.
  - **Window:** Maximum time allowed (in seconds) between the first and last sample used to compute the mean and the standard deviation. This limit is to avoid the ionosphere divergence.
  - **K-factor:** Factor (adimensional) to multiply the computed standard deviation in order to get the cycle-slip detector threshold.

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- **N-sample:** Minimum number of samples to consider that the cycle-slip detector is active. It must be equal or greater than 2. Until N-samples+1 are available, the satellite will be discarded.

  NOTE: If more than one cycle-slip detector is enabled, then N-sample will have the following value:

  N-sample = maximum(*N-sample of Phase-Code difference [if enabled]*, *N-sample of Melbourne-Wübbena [if enabled]*, *N-sample of Geometry-free [if enabled]*, *N-sample of Iono Geometry-free [if enabled]*)

- **Automatic measurements selection:** gLAB will automatically select the frequencies and measurements to use. gLAB will select the frequencies and measurements according to the frequency and measurement priority table, which can be set in the menu *Set GNSS Frequencies and Measurements Order* available at the FILTER tab.

  The number of iterations of this cycle-slip detector will be as much as necessary to cover all carrier phase measurements used in the filter.

  NOTES:
  In case that gLAB cannot create iterations of this cycle-slip detector (due to missing frequencies or measurements in the RINEX observation files or the user has disabled too many frequencies or measurements) an INFO message will be printed with the frequencies not processed by the cycle-slip detector.
  In automatic mode, the frequencies and measurements are selected in a per satellite basis, even though in the GUI the frequencies and measurements order can only be selected in a per constellation basis.

- **Manual measurements selection:** Manually select the frequencies and measurements to use in each iteration of the cycle-slip detector (up to three different iterations). Each iteration corresponds to a single frequency combination. There are three ways of selecting the frequencies and measurements:
  - **Automatic mode**: Frequencies and measurements are selected by gLAB (the default). In this mode frequencies are set to "Auto" and measurement selection is disabled. Note that when a frequency is manually select, it will automatically switch to semi-automatic mode.
  - **Semi-automatic mode**: The user selects only the frequencies of each iteration, but the measurements are selected by gLAB. To use this mode, select the frequencies and leave the measurements to "Auto". Note that if any measurement is selected, it will switch automatically to manual mode.
  - **Manual mode**: Select both the frequencies and measurements.

  NOTES:

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- If the iterations selected do not cover all carrier phase measurements used in the filter, gLAB will add as much iterations as necessary. It is possible to disable this behaviour with the command line switch '**-pre:cs:sf:noautofill'** (for single frequency detector only) or with '**-pre:cs:noautofill'** (for all cycle-slip detectors).
- In the GUI, each iteration applies to all satellites of a constellation with a maximum of 3 iterations. In command line, it is possible to provide different number of iterations (with different frequency and measurement combination) in a per satellite basis.

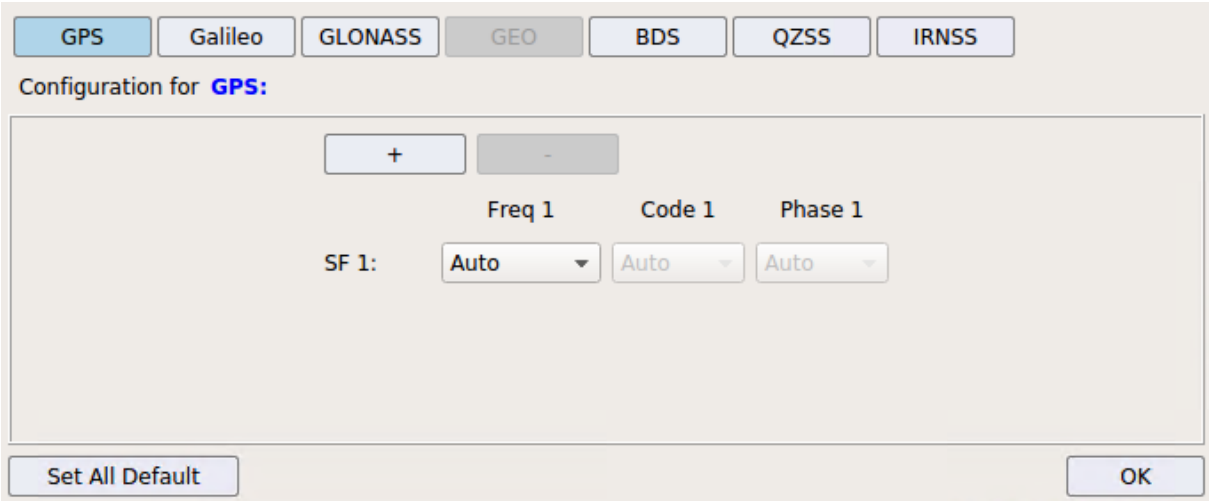

Figure 4-10 Single Frequency cycle-slip detector manual measurement selection.

- **Melbourne-Wübbena combination (Dual frequency):** This cycle-slip detector for dual-frequency receivers uses the Melbourne-Wübbena combination (geometry-free ionosphere-free). This combination uses pseudorange measurements, and thence, can be very affected by high noise and multipath effects. This combination is basically a constant with noise and jumps due to the cycle-slips. In this sense, the mean, the standard deviation and a mobile mean over the sliding **window** (last seconds) is computed. A cycle-slip is declared when all these three conditions are fulfilled:

  1. The mean is compared with the measured value, and it must be larger than a specified threshold. The threshold depends on the standard deviation from the last cycle-slip, and is computed as: Th = **k-factor** · stdDev

  2. The mobile mean over the **window** is compared with the measured value, and it must be larger than the wave length of the Melbourne-Wübbena combination (~0.8 m).

  3. The standard deviation must be equal or larger than the **minimum stdDev** (configurable parameter) set as default to the wave length of the Melbourne-Wübbena combination (~0.8 m).

  N-sample is the number of epochs needed before the detection function is active.

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Notice that **N-sample** will be overridden by **n**, where:

n = maximum (N-sample of Phase-Code [if enabled], N-sample of Melbourne-Wübbena [if enabled], N-sample of Geometry-free [if enabled]], N-sample of Iono Geometry-free [if enabled])

NOTE: When a cycle-slip is detected, the sample will be set as an outlier and ignored. If in the next sample a cycle-slip is also detected, a cycle-slip will be declared. Otherwise, the arc will be maintained.

Melbourne-Wübbena Options:

- **Do not declare outliers:** After filling the cycle-slip sample buffer, the first time the cycle-slip detector triggers, instead of declaring a cycle-slip, an outlier is declared. When an outlier is declared, the sample is skipped and waits for the next epoch. If in the next epoch the cycle-slip detector triggers again, a cycle-slip is declared. Otherwise, the arc continues (but the sample declared as outlier is skipped).

  This technique is useful for trying to make arcs longer, as sometimes only a single bad sample (an outlier) is given in a continuous arc.

  Enable this option to disable gLAB behaviour to declare outliers (therefore any time the cycle-slip triggers a cycle-slip will be declared).

  NOTE: An outlier sample does not count as a data gap.

- **Minimum stdDev:** Minimum standard deviation (in metres) to compute one of the thresholds for the Melbourne-Wübbena cycle-slip detector.
- **Window:** Maximum time allowed (in seconds) between the first and last sample used to compute the mean and the standard deviation. This limit is to avoid the ionosphere divergence.
- **K-factor:** Factor (adimensional) to multiply the computed standard deviation in order to get the cycle-slip detector threshold.
- **N-sample:** Minimum number of samples to consider that the cycle-slip detector is active. It must be equal or greater than 2. Until N-samples+1 are available, the satellite will be discarded.

  NOTE: If more than one cycle-slip detector is enabled, then N-sample will have the following value:

  N-sample = maximum(*N-sample of Phase-Code difference [if enabled]*, *N-sample of Melbourne-Wübbena [if enabled]*, *N-sample of Geometry-free [if enabled]*, *N-sample of Iono Geometry-free [if enabled]*)

- **Automatic measurements selection:** gLAB will automatically select the frequencies and measurements to use. gLAB will select the frequencies and measurements according to the frequency and measurement priority table, which can be set in the menu *Set GNSS*

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Frequencies and Measurements Order available at the FILTER tab.

The number of iterations of this cycle-slip detector will be as much as necessary to cover all carrier phase measurements used in the filter.

NOTES:
In case that gLAB cannot create iterations of this cycle-slip detector (due to missing frequencies or measurements in the RINEX observation files or the user has disabled too many frequencies or measurements) an INFO message will be printed with the frequencies not processed by the cycle-slip detector.
In automatic mode, the frequencies and measurements are selected in a per satellite basis, even though in the GUI the frequencies and measurements order can only be selected in a per constellation basis.

- **Manual measurements selection:** Manually select the frequencies and measurements to use in each iteration of the cycle-slip detector (up to three different iterations). Each iteration corresponds to a single frequency combination. There are three ways of selecting the frequencies and measurements:
  - **Automatic mode**: Frequencies and measurements are selected by gLAB (the default). In this mode frequencies are set to "Auto" and measurement selection is disabled. Note that when a frequency is manually select, it will automatically switch to semi-automatic mode.
  - **Semi-automatic mode**: The user selects only the frequencies of each iteration, but the measurements are selected by gLAB. To use this mode, select the frequencies and leave the measurements to "Auto". Note that if any measurement is selected, it will switch automatically to manual mode.
  - **Manual mode**: Select both the frequencies and measurements.

NOTES:
- If the iterations selected do not cover all carrier phase measurements used in the filter, gLAB will add as much iterations as necessary. It is possible to disable this behaviour with the command line switch '**-pre:cs:mw:noautofill'** (for MW detector only) or with '**-pre:cs:noautofill'** (for all cycle-slip detectors).
- In the GUI, each iteration applies to all satellites of a constellation with a maximum of 3 iterations. In command line, it is possible to provide different number of iterations (with different frequency and measurement combination) in a per satellite basis.

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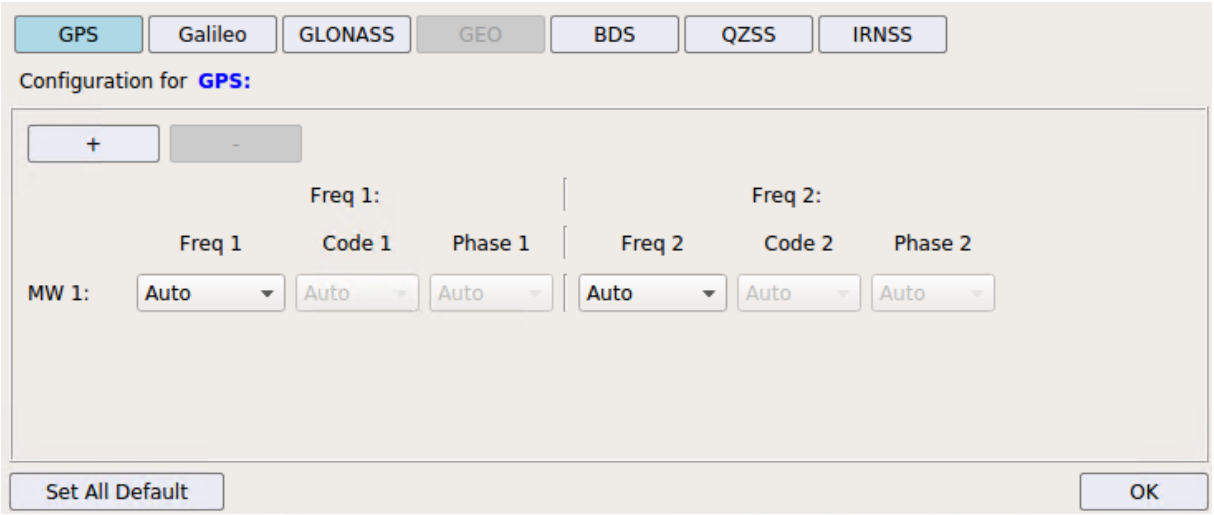

Figure 4-11 Melbourne-Wübbena cycle-slip detector manual measurement selection.

- **Geometry-free carrier phase combination (Dual frequency):** This cycle-slip detector for dual-frequency receivers uses only carrier phase measurements. The detection is based on fitting a second-degree polynomial with the geometry-free combination within a sliding window of **N-sample**. Note that this combination may be affected by ionosphere. A cycle-slip is declared when any of the two following statements (OR) is fulfilled:

  1. If the expected value is larger than the measured one by more than a specific threshold (Th) **AND** also larger than 2 times the residual (res) of the Least Square (LS) used to fit the second-degree polynomial. The threshold is obtained as:

  Th = **maximum threshold** / (1 + exp(-Data Gap / **Time constant**))

  Therefore, the conditions to fulfil a cycle-slip are:

  | LIt - LIEstimated | > Th

  | LIt - LIEstimated | > 2*res

  2. The jump between two consecutive geometry-free combinations (LI) is larger than the **maximum jump threshold** (MaxJumpTh). That is,

  | LIt - LIt-1 | > MaxJumpTh

  N-sample is the number of epochs used to fit the second-dregree polynomial. Notice that **N-sample** will be overridden by **n**, where:

  n = maximum(N-sample of Phase-Code [if enabled], N-sample of Melbourne-Wübbena [if enabled], N-sample of Geometry-free [if enabled]], N-sample of Iono Geometry-free [if enabled])

  NOTE: When a cycle-slip is detected, the sample will be set as an outlier and ignored. If in the next sample a cycle-slip is also detected, a cycle-slip will be declared. Otherwise, the arc will be maintained.

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Geometry-free Options:

- **Do not declare outliers:** After filling the cycle-slip sample buffer, the first time the cycle-slip detector triggers, instead of declaring a cycle-slip, an outlier is declared. When an outlier is declared, the sample is skipped and waits for the next epoch. If in the next epoch the cycle-slip detector triggers again, a cycle-slip is declared. Otherwise, the arc continues (but the sample declared as outlier is skipped).

  This technique is useful for trying to make arcs longer, as sometimes only a single bad sample (an outlier) is given in a continuous arc.

  Enable this option to disable gLAB behaviour to declare outliers (therefore any time the cycle-slip triggers a cycle-slip will be declared).

  NOTE: An outlier sample does not count as a data gap.

- **Maximum Jump Threshold:** Set the maximum difference (in meters) between two consecutive geometry-free combinations (LI). If this value is surpassed, a cycle-slip will be declared.
- **Maximum Threshold:** Set the upper bound value (in metres) of the threshold computed in the formula:

  Th = ***maximum threshold*** / (1 + exp(-*Data Gap* / *Time constant*))

- **Time Constant:** Set the time constant (in seconds) of the threshold computed in the formula:

  Th = *maximum threshold* / (1 + exp(-*Data Gap* / ***Time constant***))

- **N-sample:** Minimum number of samples to consider that the cycle-slip detector is active. It must be equal or greater than 2. Until N-samples+1 are available, the satellite will be discarded.

  NOTE: If more than one cycle-slip detector is enabled, then N-sample will have the following value:

  N-sample = maximum(*N-sample of Phase-Code difference [if enabled]*, *N-sample of Melbourne-Wübbena [if enabled]*, *N-sample of Geometry-free [if enabled]*, *N-sample of Iono Geometry-free [if enabled]*)

- **Automatic measurements selection:** gLAB will automatically select the frequencies and measurements to use. gLAB will select the frequencies and measurements according to the frequency and measurement priority table, which can be set in the menu *Set GNSS Frequencies and Measurements Order* available at the FILTER tab.

  The number of iterations of this cycle-slip detector will be as much as necessary to cover all carrier phase measurements used in the filter.

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NOTES:
In case that gLAB cannot create iterations of this cycle-slip detector (due to missing frequencies or measurements in the RINEX observation files or the user has disabled too many frequencies or measurements) an INFO message will be printed with the frequencies not processed by the cycle-slip detector.
In automatic mode, the frequencies and measurements are selected in a per satellite basis, even though in the GUI the frequencies and measurements order can only be selected in a per constellation basis.

- **Manual measurements selection:** Manually select the frequencies and measurements to use in each iteration of the cycle-slip detector (up to three different iterations). Each iteration corresponds to a single frequency combination. There are three ways of selecting the frequencies and measurements:
  - **Automatic mode**: Frequencies and measurements are selected by gLAB (the default). In this mode frequencies are set to "Auto" and measurement selection is disabled. Note that when a frequency is manually select, it will automatically switch to semi-automatic mode.
  - **Semi-automatic mode**: The user selects only the frequencies of each iteration, but the measurements are selected by gLAB. To use this mode, select the frequencies and leave the measurements to "Auto". Note that if any measurement is selected, it will switch automatically to manual mode.
  - **Manual mode**: Select both the frequencies and measurements.

NOTES:
  - If the iterations selected do not cover all carrier phase measurements used in the filter, gLAB will add as much iterations as necessary. It is possible to disable this behaviour with the command line switch '**-pre:cs:li:noautofill'** (for MW detector only) or with '**-pre:cs:noautofill'** (for all cycle-slip detectors).
  - In the GUI, each iteration applies to all satellites of a constellation with a maximum of 3 iterations. In command line, it is possible to provide different number of iterations (with different frequency and measurement combination) in a per satellite basis.

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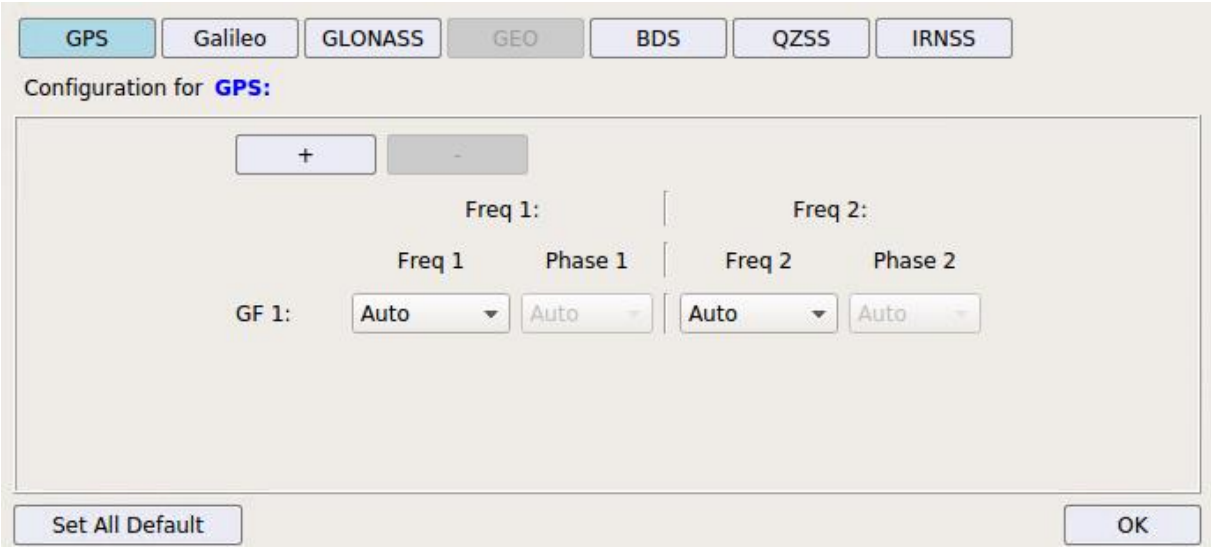

Figure 4-12 Geometry-Free cycle-slip detector manual measurement selection.

- **Iono Geometry-Free carrier phase combination (Triple or Quadruple frequency):** This cycle-slip detector for triple or quadruple frequency receivers uses only carrier phase measurements. The detection is based on fitting a second-degree polynomial with the iono geometry-free combination within a sliding window of ***N-sample***.
  The iono geometry-free can be calculated with two methods: using two linearly independent iono-free combinations (see tooltip *Two Iono Geometry-Free* below) or with a minimum noise combination (see tooltip *Minimum Noise* below).

  A cycle-slip is declared when any of the two following statements (OR) is fulfilled:

  1. If the expected value is larger than the measured one by more than a specific threshold (Th) **AND** also larger than 2 times the residual (res) of the Least Square (LS) used to fit the second-degree polynomial. The threshold is obtained as:

  Th = **maximum threshold** / (1 + exp(-Data Gap / **Time constant**))

  Therefore, the conditions to fulfil a cycle-slip are:

  | LIt - LIEstimated | > Th

  | LIt - LIEstimated | > 2*res

  2. The jump between two consecutive geometry-free combinations (LI) is larger than the **maximum jump threshold** (MaxJumpTh). That is,

  | LIt - LIt-1 | > MaxJumpTh

  N-sample is the number of epochs used to fit the second-dregree polynomial. Notice that **N-sample** will be overriden by **n**, where:

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n = maximum(N-sample of Phase-Code [if enabled], N-sample of Melbourne-Wübbena [if enabled], N-sample of Geometry-free [if enabled]], N-sample of Iono Geometry-free [if enabled])

NOTE: When a cycle-slip is detected, the sample will be set as an outlier and ignored. If in the next sample a cycle-slip is also detected, a cycle-slip will be declared. Otherwise, the arc will be maintained.

Iono Geometry-free Options:

- **Do not declare outliers:** After filling the cycle-slip sample buffer, the first time the cycle-slip detector triggers, instead of declaring a cycle-slip, an outlier is declared. When an outlier is declared, the sample is skipped and waits for the next epoch. If in the next epoch the cycle-slip detector triggers again, a cycle-slip is declared. Otherwise, the arc continues (but the sample declared as outlier is skipped).

  This technique is useful for trying to make arcs longer, as sometimes only a single bad sample (an outlier) is given in a continuous arc.

  Enable this option to disable gLAB behaviour to declare outliers (therefore any time the cycle-slip triggers a cycle-slip will be declared).

  NOTE: An outlier sample does not count as a data gap.

- **Minimum Noise:** Construct a iono geometry-free combination with three frequencies using the following combination:

  $$IGF = \alpha \cdot L1 + \beta \cdot L2 + \gamma \cdot L3$$

  α, β and γ are computed by gLAB (and printed in IGFCSDATA message) with the following formulas:

  $$\alpha + \beta + \gamma = 0$$
  $$\alpha \cdot \lambda 1^2 + \beta \cdot \lambda 2^2 + \gamma \cdot \lambda 3^2 = 0$$
  $$\alpha > 0$$
  $$\alpha^2 + \beta^2 + \gamma^2 = 1$$

  L1, L2 and L3 are the carrier phases of three different frequencies, while λ1, λ2 and λ3 are the wavelength of the respective carrier phases.

  Combining this formulas, the following equations result to compute α, β and γ:

  $$\alpha = (\lambda 3^2 - \lambda 2^2) / N$$
  $$\beta = (\lambda 1^2 - \lambda 3^2) / N$$
  $$\gamma = (\lambda 2^2 - \lambda 1^2) / N$$

  With:

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$$N = (\lambda 3^2 - \lambda 2^2)^2 + (\lambda 1^2 - \lambda 3^2)^2 + (\lambda 2^2 - \lambda 1^2)^2$$

This combination provides the iono geometry-free combination with minimum noise, but has the side effect that some frequencies will have a small weight in the combination (due to any of the factor α, β or γ being much smaller than other of the factors), potentially hiding a single cycle cycle-slip in the combination.

This combination has been extracted from *The System: Three's the Challenge* (Oliver Montenbruck et al), available at https://www.gpsworld.com/threes-challenge/

- **Two Iono Geometry-Free:** Two linearly independent Geometry-free combinations are computed and then subtracted to each other. The remaining contents are the ambiguities and wind-up. These dual geometry-free combination can be computed using three or four different frequencies (by default three frequencies are used).
- **Maximum Jump Threshold:** Set the maximum difference (in meters) between two consecutive iono geometry-free combinations (IGF). If this value is surpassed, a cycle-slip will be declared.
- **Maximum Threshold:** Set the upper bound value (in metres) of the threshold computed in the formula:

  Th = ***maximum threshold*** / (1 + exp(-*Data Gap* / *Time constant*))

- **Time Constant:** Set the time constant (in seconds) of the threshold computed in the formula:

  Th = *maximum threshold* / (1 + exp(-*Data Gap* / ***Time constant***))

- **N-sample:** Minimum number of samples to consider that the cycle-slip detector is active. It must be equal or greater than 2. Until N-samples+1 are available, the satellite will be discarded.

  NOTE: If more than one cycle-slip detector is enabled, then N-sample will have the following value:

  N-sample = maximum(*N-sample of Phase-Code difference [if enabled]*, *N-sample of Melbourne-Wübbena [if enabled]*, *N-sample of Geometry-free [if enabled]*, *N-sample of Iono Geometry-free [if enabled]*)

- **Automatic measurements selection:** gLAB will automatically select the frequencies and measurements to use. gLAB will select the frequencies and measurements according to the frequency and measurement priority table, which can be set in the menu *Set GNSS Frequencies and Measurements Order* available at the FILTER tab.

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The number of iterations of this cycle-slip detector will be as much as necessary to cover all carrier phase measurements used in the filter.

NOTES:
In case that gLAB cannot create iterations of this cycle-slip detector (due to missing frequencies or measurements in the RINEX observation files or the user has disabled too many frequencies or measurements) an INFO message will be printed with the frequencies not processed by the cycle-slip detector.
In automatic mode, the frequencies and measurements are selected in a per satellite basis, even though in the GUI the frequencies and measurements order can only be selected in a per constellation basis.

- **Manual measurements selection:** Manually select the frequencies and measurements to use in each iteration of the cycle-slip detector (up to three different iterations). Each iteration corresponds to a single frequency combination. There are three ways of selecting the frequencies and measurements:
  - **Automatic mode**: Frequencies and measurements are selected by gLAB (the default). In this mode frequencies are set to "Auto" and measurement selection is disabled. Note that when a frequency is manually select, it will automatically switch to semi-automatic mode.
  - **Semi-automatic mode**: The user selects only the frequencies of each iteration, but the measurements are selected by gLAB. To use this mode, select the frequencies and leave the measurements to "Auto". Note that if any measurement is selected, it will switch automatically to manual mode.
  - **Manual mode**: Select both the frequencies and measurements.

NOTES:
  - If the iterations selected do not cover all carrier phase measurements used in the filter, gLAB will add as much iterations as necessary. It is possible to disable this behaviour with the command line switch '**-pre:cs:li:noautofill'** (for MW detector only) or with '**-pre:cs:noautofill'** (for all cycle-slip detectors).
  - In the GUI, each iteration applies to all satellites of a constellation with a maximum of 3 iterations. In command line, it is possible to provide different number of iterations (with different frequency and measurement combination) in a per satellite basis.

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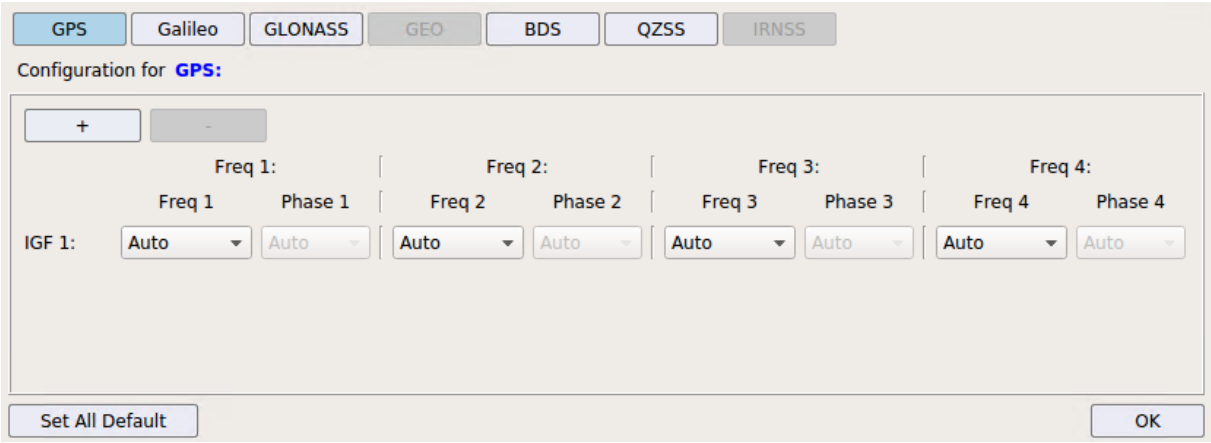

Figure 4-13 Iono Geometry-Free (with two iono-free combinations) cycle-slip detector manual measurement selection.

- **GNSS Satellite Selection:** The buttons allow to individually select/deselect each satellite of each constellation for processing (or disable a constellation). A deselected satellite shall not be taken into account when processing. Green color marks selected satellites and red deselected satellites.

4.2.3 Modelling

This section provides the configuration options to set/unset each individual model that is used by gLAB. Figure 4-14 shows a screenshot of the MODEL section.

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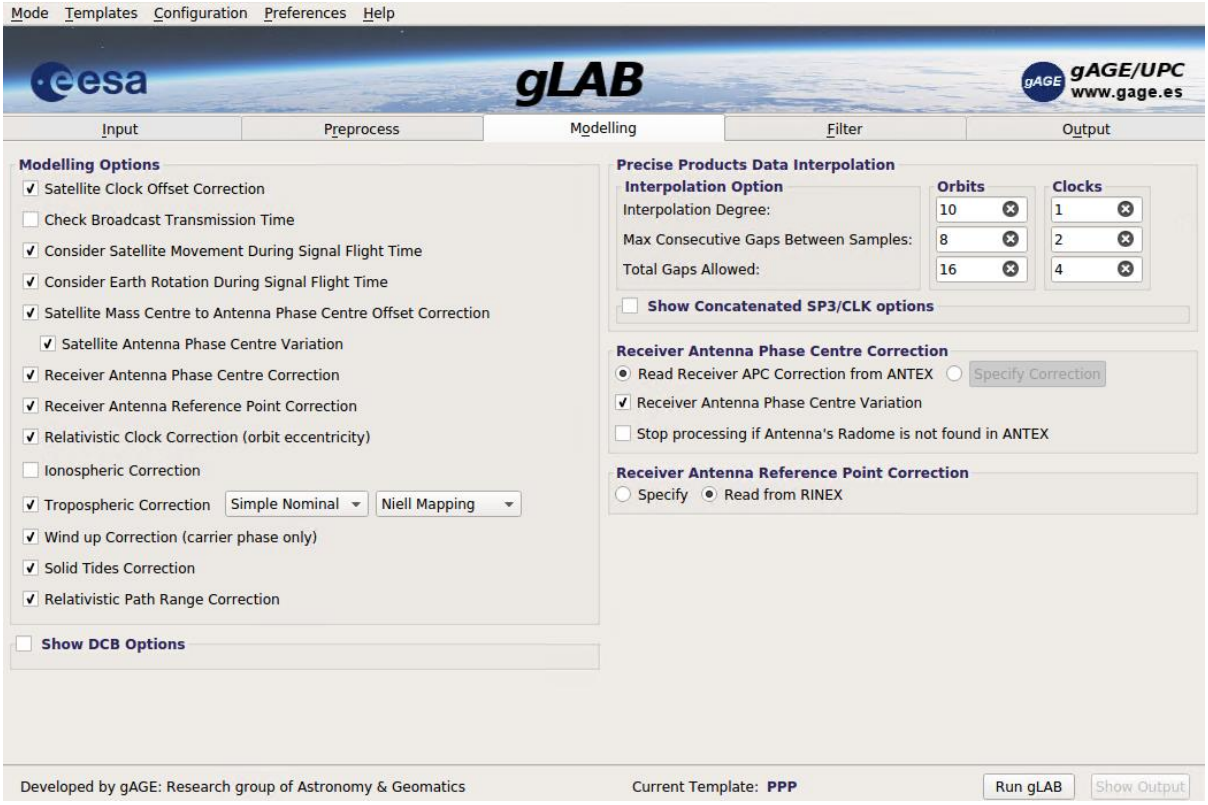

Figure 4-14: Modelling section screenshot

- **Modelling Options:** The following options allow to enable/disable the different models included in the processing.
    - **Satellite clock offset correction:** The satellite clock errors correspond to the clock synchronism errors of the satellite clocks in relation to the GNSS time scale. These errors depend heavily on the type of oscillator of the satellite and are quite unpredictable. They can only be obtained by some kind of estimation. The typical source for estimations of these errors are the navigation messages, or some kind of external estimation, such as SP3 files. The effect of these clock errors can reach up hundreds of kilometres.
    - **Check Broadcast Transmission Time:** Each RINEX navigation message has a transmission time field in it, which refers to the first time that the satellite sends the current navigation message, but receivers set it to the first time they receive the message. Therefore, receivers on different locations will set different transmission times in their RINEX navigation files, as satellite visibility will be different. gLAB uses this time to check whether it can use or not use a navigation message, as if current epoch is previous to the transmission time, this means that the package was not available yet.

      In SBAS and DGNSS this check is disabled, as in these modes corrections sent to the user are referred to a navigation message (with the IOD (Issue of Data)), therefore these navigation message had to be already sent by the satellite in order to compute the corrections.

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- **Consider satellite movement during signal flight time:** Due to the distance between satellites and receivers (between 20000 and 26000 Km for GPS), the signal travel time is not despicable (about 70 ms for GPS). Thence the receiver is obtaining the measurement after it has been emitted by the satellite. This fact should be taken into consideration, as the position of the satellite must be computed in the transmission time, not in the reception time. This effect can impact on the measurements up to hundreds of metres.
- **Consider Earth rotation during signal flight time:** Besides the satellite movement during signal flight time, the Earth also moves [rotates]. If this effect is not taken into consideration, an error of about 30 m in the east direction would be seen.
- **Satellite mass center to antenna phase center correction:** Each data source of satellite orbits (in general the navigation message or an SP3 file) provides these orbits in its specific reference. In particular, the SP3 files provide the positions of the satellite referred to its mass center (which is different than the antenna phase centers). In order to properly correct the GNSS measurements with the satellite position, a correction between these two centers must be done. Usually these corrections can be obtained from an ANTEX file. This error can be up to 1-2 m. The positions computed from the navigation message do not require any additional corrections, as they are referred to the antenna phase center.
    - Satellite Antenna Phase Centre Variation: Satellite Mass Centre to Antenna Phase Centre Offset Correction has an additional term which is dependent on the satellite elevation. This additional term is also provided in the ANTEX file, on the next line after the Antenna Phase Centre Offset Correction. This correction can be up to 1-5 cm.
- **Receiver antenna phase center correction:** Normally the positions of the stations are given in relation to the base of the station. The difference between this point and the antenna phase center should be taken into account. This effect depends on the frequency, and can reach up to some decimetres.
- **Receiver antenna reference point correction:** Additionally to the Antenna Phase Center, the position of a station can be given in relation to a specific point (such as a geodetically positioned point in the ground). This correction allows to give a specific correction to the position in North/East/Up components. In most receivers, this correction is zero, but when it is not zero, its typical value is between 1-5 metres, especially in the Up component.
- **Relativistic clock correction:** The rate of advance of two identical clocks, one placed in the satellite and the other on the terrestrial surface, will differ due to the difference of the gravitational potential (general relativity) and to the relative speed between them (special relativity). The special relativity difference can be broken into (Hofmann-Wellenhof):
    - A constant component that only depends on the nominal value of the semi-major axis of the satellite orbit, which is adjusted modifying the clock oscillating frequency of the satellite.

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- A periodical component due to the orbit eccentricity (that must be adjusted by the user receiver) equal to:

  $rel = 2*(\mathbf{r}\cdot\mathbf{v})/c$

This effect can reach up to 13 m.

- **Ionospheric correction:** The ionosphere is the zone of the terrestrial atmosphere that extends itself from about 60 km until more than 2000 km high. Due to the interaction with free electrons, electromagnetic signals that go through it suffer a delay/advancement in relation to the propagation in a vacuum. This effect is a dispersive effect (frequency dependent), and can be removed in multi-frequency receivers (with a specific combination of measurements). The ionosphere is hard to model, and the Klobuchar model (the one defined in the GPS/SPS-SS [RD-14] and available in the navigation message) can only reduce its impact between a 50% and a 60%. The ionosphere effect can reach up to 50 m in turbulent ionospheric environments. In the current update, the ionospheric correction of SBAS and IONEX are implemented. The ionosphere models supported by gLAB are:

  - **Klobuchar (GPS):** Defined in the GPS ICD, it uses eight parameters broadcast in the GPS navigation message (in RINEX v2, in the header records ION ALPHA and ION BETA; in RINEX v3, in the header record IONOSPHERIC CORR -with the preambles GPSA and GPSB-. It can only reduce its impact between a 50% and a 60%.
  - **NeQuick (Galileo):** Defined in the Galileo ICD, it uses three parameters broadcast in the Galileo navigation message (in RINEX v3, in the header record IONOSPHERIC CORR -with the preamble GAL-. It can only reduce its impact between a 50% and a 70%.
  - **Klobuchar (BeiDou-2):** Defined in the BeiDou-2 ICD, it uses eight parameters broadcast in the BeiDou navigation message (in RINEX v3, in the header record IONOSPHERIC CORR -with the preambles BDSA and BDSB-. It can only reduce its impact between a 50% and a 60%.
  - **IONEX:** IONEX (IONosphere map EXchange) files provide a global ionosphere delay estimation in a grid forma (in one or multiple layers) during one day. Optionally, it can also provide a sigma of the estimation in the same format. They are computed in postprocess by several agencies or universities, and are several times more accurate than Klobuchar.
  - **SBAS:** SBAS ionosphere model are computed and broadcast in real time through the SBAS GEOs (messages type 18 and 26) in the area defined by the provider (e.g. Europe for EGNOS provider). Its accuracy is about to 1 metre.

- **Tropospheric correction:** Troposphere is the atmospheric layer placed between Earth's surface and an altitude of about 60 kilometres. The effect of the troposphere on the GNSS signals appears as an extra delay in the measurement of the signal travelling from the satellite to receiver. This delay depends on the temperature, pressure, humidity as well as the transmitter and receiver antennas location. Because at the frequency which the GPS signal is

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emitted the troposphere behaves like a non dispersive media, its effect independent of the frequency. The tropospheric delay can be modelled in an approximate way (about 90%-95%) using the following expression:

$$T = d_{dry} \cdot m_{dry}(elev) + d_{wet} \cdot m_{wet}(elev)$$

where d_{dry} corresponds to the vertical delay due to the dry component of the troposphere and d_{wet} corresponds to the vertical delay associated with the wet component (due to the water vapor of the atmosphere). These two different nominals can ve computed as

- Using a simple nominal described in GIPSY-OASIS [RD-7]:

  $$d_{dry} = 2.3 \exp(-0.116 \cdot 10^{-3} \cdot H)$$

  $$d_{wet} = 0.1$$

  where H is the height over the ellipsoid.

- Computing a nominal from the receiver's height and estimates of five meteorological parameters: pressure, temperature, water vapour pressure, temperature lapse rate and water vapour lapse rate. It is adopted by SBAS systems (AD-10).

Finally mdry(elev) and mwet(elev) are the slant factors in order to project the vertical delay in the direction of the satellite observation for the dry and wet components. Two models can be chosen to compute these m(elev):

- A simple mapping model (used in SBAS [RD-9]). This mapping only depends on satellite elevation and it is common for wet and dry components.
- The more refined Niell mapping model [RD-8]. This mapping considers different obliquity factors for the wet and dry components.

The main part of the troposphere which has not been properly modelled (about 10%) corresponds mainly to the wet component. The total effect of troposphere can range up to 10 m.

- **Wind up correction (Carrier phase only):** The wind up only appears in carrier phase measurements and is due to the rotation of the Line-of-sight vector in relation to the antenna. The wind-up has an accumulative effect, and for fixed antennas can reach up to half the wave length of the measurement.
- **Solid tides correction:** The attraction of Sun and Moon and the inelasticity of the Earth's mantle cause variations to the positions of ground receivers. This effect can reach up to some decimetres (the model used is described in [RD-10], and is implemented up to degree 3).
- **Relativistic path range correction:** As introduced in the *Relativistic clock correction* section, the difference of the gravitational potential (general relativity) affects the measurement. This is a small effect that has elevation dependence, and has a total effect of about 4 cm.

- **GPS DCB Options:**

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- **GPS DCB: C1 - P1:** Differential Code Biases (DCB) are the delays due to electronic, antennas and cables of receiver and transmitter devices which directly affect the measurements with a bias.

  When satellite orbits and clocks are estimated, a reference measurement or combination must be selected. For GPS, broadcast orbits use the iono-free (IF) combination of measurements P1 and P2 (C1P and C2P in RINEX3 notation). As these signals are military encrypted, civil receivers report these measurements as C1W and C2W, as the tracking does not unencrypt the military signals. In precise orbits and clocks, the IF based on C1W and C2W is used by most providers (e.g IGS).

  The reference measurement or combination, by definition, always has all satellite DCB=0. Therefore, when a user utilizes any measurement (or combination) which is different from the reference combination, a bias appears in the clock estimate, which is what the DCB corrects.

  The DCB correction can be provided in two ways:

  1. Directly correcting the DCB for one specific measurement (note that DCB are always referred to a single measurement) to the reference measurement or combination (they are usually named DCB or TGD -Total Group Delay-)
  2. Providing a correction that converts (i.e. adjust the bias) a measurement to another measurement which has a DCB that corrects the remaining bias (therefore multiple corrections will have to be applied to fully remove the bias). These are refered as Inter Signal Correction (ISC).

  In the case of GPS C1-P1, it is called DCB for historical reasons (as at that time the term "ISC" did not exist), but it is indeed an ISC, now provided in the CNAV message (ISC L1 C/A - L1 P(Y)). Before the CNAV broadcast navigation message, this ISC was only provided by CODE GPS P1-C1 files (containing the C1-P1 DCB but with the sign changed, therefore they are known as P1-C1 DCB files).
  The GPS C1-P1 DCB (or ISC) converts the signal C1 to P1. This DCB is also a special case, as GPS receivers used C1 to track P1 and P2, therefore depending on the receiver type, it is also necessary to apply this DCB to get consistent P1 and P2 measurements:

  - **Type 0** : GPS C1-P1 classification unknown, no correction applied.
  - **Type 1** : Cross correlated receiver, reporting:
    - C1
    - P2 = C1 + (Y_2 - Y_1)

    Needs Corrections to obtain P1 and a consistent P2: P1=C1+b and P2=P2+b
  - **Type 2** : C1 reported in place of P1:

    Needs Corrections to obtain P1: P1=C1+b

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Mark this option to correct GPS C1 - P1 bias. Because the GPS code generation depends on the GPS Receiver Type, this GPS receiver-related information has to be given together with the corrections. gLAB works in two different modes:

- **Flexible**: gLAB will use whichever GPS C1 or P1 measurement is available in the receiver. If ISC L1 C/A - L1 P(Y) from CNAV is set and available, it will apply the ISC correction to C1 if it is used. Moreover, if a GPS Receiver type is provided, it will apply the ISC according to the receiver type. If ISC is not available, C1-P1 DCB will not be corrected. If both code measurements are available, P1 will be used as default. Used when receiver provides C1 but P1 is missing.
- **Strict:** gLAB stops if the receiver cannot be matched with the GPS Receiver Type File or both files are not provided (in the Input Section):
  - **GPS P1-C1 DCB File**: Containing the GPS P1-C1 DCB corrections.
  - **GPS Receiver Type File:** To identify how codes are generated in the receiver, and how to remove these GPS P1-C1 biases.

NOTE: If option GPS DCB C1-P1 is set to strict and ISC L1 C/A - L1 P(Y) is enabled, DCB C1-P1 (from DCB file) will be used.

- **GPS DCB: P1 - P2:** Differential Code Biases (DCB) are the delays due to electronic, antennas and cables of receiver and transmitter devices which directly affect the measurements with a bias.

When satellite orbits and clocks are estimated, a reference measurement or combination must be selected. For GPS, broadcast orbits use the iono-free (IF) combination of measurements P1 and P2 (C1P and C2P in RINEX3 notation). As these signals are military encrypted, civil receivers report these measurements as C1W and C2W, as the tracking does not unencrypt the military signals. In precise orbits and clocks, the IF based on C1W and C2W is used by most providers (e.g IGS).

The reference measurement or combination, by definition, always has all satellite DCB=0. Therefore, when a user utilizes any measurement (or combination) which is different from the reference combination, a bias appears in the clock estimate, which is what the DCB corrects.

The DCB correction can be provided in two ways:

1. Directly correcting the DCB for one specific measurement (note that DCB are always referred to a single measurement) to the reference measurement or combination (they are usually named DCB or TGD -Total Group Delay-)
2. Providing a correction that converts (i.e. adjust the bias) a measurement to another measurement which has a DCB that corrects the remaining bias (therefore multiple corrections will have to be applied to fully remove the bias). These are refered as Inter Signal Correction (ISC).

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In the case of GPS P1-P2, it corrects the bias between the single measurement P1 or P2 to the reference IF combination of P1 and P2. This DCB (or TGD) is provided in the following files:

- A RINEX Navigation file, where the GPS (P2-P1) bias are given as the Total Group Delay (TGD) located in the 3rd field of the 7th row of the broadcast ephemerides (LNAV and CNAV navigation messages). This estimation is generated by the Control Segment that monitorises all satellites.
- A Precise .DCB file, where the International GNSS Service (IGS) gives an accurate estimation of the (P1-P2) bias. This file contains a monthly estimation of the (P1-P2) Differential Code Bias (DCB) for all Satellites.
- A IONEX file, where a daily estimation of the (P2-P1) bias are given in the PRN / BIAS / RMS header lines.

The GPS P1-P2 DCB is cancelled in the ionospheric-free combination. This effect can reach up to the meter level.

About TGDs & DCBs:

The relation between the DCBs of the precise files or IONEX DCBs and the TGDs broadcast in the GPS navigation message is:

$$TGD_{GPS\ Broadcast\ Message} = -\alpha_1 / (\alpha_2 - \alpha_1) \cdot DCB_{File}$$

$$TGD_{GPS\ Broadcast\ Message} = -\alpha_1 / (\alpha_2 - \alpha_1) \cdot IONEX_{DCB}$$

Where:

$$\alpha_i = 40.3 / f_i^2$$

- **GPS ISC: L1 C/A - L1 P(Y):** Differential Code Biases (DCB) are the delays due to electronic, antennas and cables of receiver and transmitter devices which directly affect the measurements with a bias.

  When satellite orbits and clocks are estimated, a reference measurement or combination must be selected. For GPS, broadcast orbits use the iono-free (IF) combination of measurements P1 and P2 (C1P and C2P in RINEX3 notation). As these signals are military encrypted, civil receivers report these measurements as C1W and C2W, as the tracking does not unencrypt the military signals. In precise orbits and clocks, the IF based on C1W and C2W is used by most providers (e.g IGS).

  The reference measurement or combination, by definition, always has all satellite DCB=0. Therefore, when a user utilizes any measurement (or combination) which is different from the reference combination, a bias appears in the clock estimate, which is what the DCB corrects.

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The DCB correction can be provided in two ways:

1. Directly correcting the DCB for one specific measurement (note that DCB are always referred to a single measurement) to the reference measurement or combination (they are usually named DCB or TGD -Total Group Delay-)
2. Providing a correction that converts (i.e. adjust the bias) a measurement to another measurement which has a DCB that corrects the remaining bias (therefore multiple corrections will have to be applied to fully remove the bias). These are refered as Inter Signal Correction (ISC).

ISC L1 C/A - L1 P(Y) is located in the 1st field of the 8th row of the broadcast ephemerides CNAV navigation message and converts the bias from C1 to P1. As this ISC is the same as DCB: C1-P1, it can also be applied to get consistent measurements according to the GPS receiver type (see *DCB: C1 - P1* tooltip for details).

NOTE: If option GPS DCB C1-P1 is set to strict and ISC L1 C/A - L1 P(Y) is enabled, DCB C1-P1 (from DCB file) will be used.

- **GPS ISC: L2C (M or L) - L1 P(Y):** Differential Code Biases (DCB) are the delays due to electronic, antennas and cables of receiver and transmitter devices which directly affect the measurements with a bias.

  When satellite orbits and clocks are estimated, a reference measurement or combination must be selected. For GPS, broadcast orbits use the iono-free (IF) combination of measurements P1 and P2 (C1P and C2P in RINEX3 notation). As these signals are military encrypted, civil receivers report these measurements as C1W and C2W, as the tracking does not unencrypt the military signals. In precise orbits and clocks, the IF based on C1W and C2W is used by most providers (e.g IGS).

  The reference measurement or combination, by definition, always has all satellite DCB=0. Therefore, when a user utilizes any measurement (or combination) which is different from the reference combination, a bias appears in the clock estimate, which is what the DCB corrects.

  The DCB correction can be provided in two ways:

  1. Directly correcting the DCB for one specific measurement (note that DCB are always referred to a single measurement) to the reference measurement or combination (they are usually named DCB or TGD -Total Group Delay-)
  2. Providing a correction that converts (i.e. adjust the bias) a measurement to another measurement which has a DCB that corrects the remaining bias (therefore multiple corrections will have to be applied to fully remove the bias). These are refered as Inter Signal Correction (ISC).

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ISC L2C (M or L) - L1 P(Y) is located in the 2nd field of the 8th row of the broadcast ephemerides CNAV navigation message and converts the bias from C2S, C2L or C2X to C1P.

NOTE: C2X measurement is not specified in GPS ICD. gLAB will apply to C2X the same criteria as C2S or C2L as they all have the same reference signal according to RINEX standard.

- **GPS ISC: L5I5 - L1 P(Y):** Differential Code Biases (DCB) are the delays due to electronic, antennas and cables of receiver and transmitter devices which directly affect the measurements with a bias.

  When satellite orbits and clocks are estimated, a reference measurement or combination must be selected. For GPS, broadcast orbits use the iono-free (IF) combination of measurements P1 and P2 (C1P and C2P in RINEX3 notation). As these signals are military encrypted, civil receivers report these measurements as C1W and C2W, as the tracking does not unencrypt the military signals. In precise orbits and clocks, the IF based on C1W and C2W is used by most providers (e.g IGS).

  The reference measurement or combination, by definition, always has all satellite DCB=0. Therefore, when a user utilizes any measurement (or combination) which is different from the reference combination, a bias appears in the clock estimate, which is what the DCB corrects.

  The DCB correction can be provided in two ways:

  1. Directly correcting the DCB for one specific measurement (note that DCB are always referred to a single measurement) to the reference measurement or combination (they are usually named DCB or TGD -Total Group Delay-)
  2. Providing a correction that converts (i.e. adjust the bias) a measurement to another measurement which has a DCB that corrects the remaining bias (therefore multiple corrections will have to be applied to fully remove the bias). These are refered as Inter Signal Correction (ISC).

  ISC L5I5 - L1 P(Y) is located in the 3rd field of the 8th row of the broadcast ephemerides CNAV navigation message and converts the bias from C5I to C1P.

  NOTE: C5X is not specified in the ICD, but gLAB will apply to C5X the same criteria as C5X has the same reference signal as C5I according to RINEX standard.

- **GPS ISC: L5Q5 - L1 P(Y):** Differential Code Biases (DCB) are the delays due to electronic, antennas and cables of receiver and transmitter devices which directly affect the measurements with a bias.

  When satellite orbits and clocks are estimated, a reference measurement or combination must be selected. For GPS, broadcast orbits use the iono-free (IF) combination of measurements P1 and P2 (C1P and C2P in RINEX3 notation).

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As these signals are military encrypted, civil receivers report these measurements as C1W and C2W, as the tracking does not unencrypt the military signals. In precise orbits and clocks, the IF based on C1W and C2W is used by most providers (e.g IGS).

The reference measurement or combination, by definition, always has all satellite DCB=0. Therefore, when a user utilizes any measurement (or combination) which is different from the reference combination, a bias appears in the clock estimate, which is what the DCB corrects.

The DCB correction can be provided in two ways:

1. Directly correcting the DCB for one specific measurement (note that DCB are always referred to a single measurement) to the reference measurement or combination (they are usually named DCB or TGD -Total Group Delay-)
2. Providing a correction that converts (i.e. adjust the bias) a measurement to another measurement which has a DCB that corrects the remaining bias (therefore multiple corrections will have to be applied to fully remove the bias). These are refered as Inter Signal Correction (ISC).

ISC L5Q5 - L1 P(Y) is located in the 4th field of the 8th row of the broadcast ephemerides CNAV navigation message and converts the bias from C5Q to C1P.

- **GPS DCB for Double Frequency:** Differential Code Biases (DCB) are the delays due to electronic, antennas and cables of receiver and transmitter devices which directly affect the measurements with a bias.

  When satellite orbits and clocks are estimated, a reference measurement or combination must be selected. For GPS, broadcast orbits use the iono-free (IF) combination of measurements P1 and P2 (C1P and C2P in RINEX3 notation). As these signals are military encrypted, civil receivers report these measurements as C1W and C2W, as the tracking does not unencrypt the military signals. In precise orbits and clocks, the IF based on C1W and C2W is used by most providers (e.g IGS).

  The reference measurement or combination, by definition, always has all satellite DCB=0. Therefore, when a user utilizes any measurement (or combination) which is different from the reference combination, a bias appears in the clock estimate, which is what the DCB corrects.

  The DCB correction can be provided in two ways:

- Directly correcting the DCB for one specific measurement (note that DCB are always referred to a single measurement) to the reference measurement or combination (they are usually named DCB or TGD -Total Group Delay-)
- Providing a correction that converts (i.e. adjust the bias) a measurement to another measurement which has a DCB that corrects the remaining bias

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(therefore multiple corrections will have to be applied to fully remove the bias). These are refered as Inter Signal Correction (ISC).

- Prior to the introduction of new frequencies and signals in GPS, GLONASS and the introduction of new constellations, when working with dual frequency combinations, the DCBs could be applied correct the measurement either to each single frequency signal (that is, before computing the dual frequency combination) or after computing the dual frequency combination (with the adequate conversion factor).

  With the introduction of new signals and frequencies, most of the dual frequency combinations do not match with the reference iono-free combination used to compute the orbits and clocks. In order to compute the adequate DCB correction, the ICD provides specific formulas which require some of the terms to be applied after computing the dual frequency combination. As gLAB used to apply the DCB terms before the iono-free computation, and print each DCB term applied in a single frequency measurement in the MODEL message, it was decided to print the computed DCB from the ICD formula in a different term, named "Double Frequency DCB" in order to have a clear separation. In GPS, the formulas for the DCBs are the following:

  - L1 C/A (C1C) and L2C (C2S or C2L):
    $DCB_{L1\ C/A\ (C1C)\ -\ L2C} = c \cdot (ISC_{L2C} - \gamma_{12} \cdot ISC_{L1\ C/A}) / (1- \gamma_{12}) - c \cdot T_{GD}$
  - L1 C/A (C1C) and L5I5 (C5I):
    $DCB_{L1C/A\ -\ L5I5} = c \cdot (ISC_{L5I5} - \gamma_{15} \cdot ISC_{L1C/A}) / (1- \gamma_{15}) - c \cdot T_{GD}$
  - L1 C/A (C1C) and L5Q5 (C5Q):
    $DCB_{L1C/A\ -\ L5Q5} = c \cdot (ISC_{L5Q5} - \gamma_{15} \cdot ISC_{L1C/A}) / (1- \gamma_{15}) - c \cdot T_{GD}$
  - $L1C_P$ (C1L) and L2C (C2S or C2L):
    $DCB_{L1CP\ -\ L2C} = c \cdot (ISC_{L2C} - \gamma_{12} \cdot ISC_{L1CP}) / (1- \gamma_{12}) - c \cdot T_{GD}$
  - $L1C_D$ (C1S) and L2C (C2S or C2L):
    $DCB_{L1CD\ -\ L2C} = c \cdot (ISC_{L2C} - \gamma_{12} \cdot ISC_{L1CD}) / (1- \gamma_{12}) - c \cdot T_{GD}$
  - $L1C_P$ (C1L) and L5Q5 (C5Q):
    $DCB_{L1CP\ -\ L5Q5} = c \cdot (ISC_{L5Q5} - \gamma_{15} \cdot ISC_{L1CP}) / (1- \gamma_{15}) - c \cdot T_{GD}$
  - $L1C_D$ (C1S) and L5Q5 (C5Q):
    $DCB_{L1CD\ -\ L5Q5} = c \cdot (ISC_{L5Q5} - \gamma_{15} \cdot ISC_{L1CD}) / (1- \gamma_{15}) - c \cdot T_{GD}$
  - $L1C_P$ (C1L) and L5I5 (C5I):
    $DCB_{L1CP\ -\ L5I5} = c \cdot (ISC_{L5I5} - \gamma_{15} \cdot ISC_{L1CP}) / (1- \gamma_{15}) - c \cdot T_{GD}$
  - $L1C_D$ (C1S) and L5Q5 (C5I):
    $DCB_{L1CD\ -\ L5I5} = c \cdot (ISC_{L5I5} - \gamma_{15} \cdot ISC_{L1CD}) / (1- \gamma_{15}) - c \cdot T_{GD}$

  In SBAS DFMC, the ISC are already incorporated in the SBAS DFMC corrections, therefore the following formula is used:

  - L1 C/A (C1C) and L5Q5 (C5Q):
    $DCB_{SBAS\ DFMC\ L1C/A\ -\ L5Q5} = - c \cdot T_{GD}$

  Where:

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- **ISC_i**: Inter-signal correction for the channel indicated by the subscript
- **T_{GD}**: DCB correction explained in tooltip *GPS DCB: P1-P2*
- **c**: Speed of light
- **γ_{12}** = $(f_{L1}/f_{L2})^2 = (77/60)^2$
- **γ_{15}** = $(f_{L1}/f_{L5})^2 = (154/115)^2$

NOTES:

- C1X is not specified in the ICD, but gLAB will apply to C1X the same criteria as C1S or C1L as they all have the same reference signal according to RINEX standard.
- C2X is not specified in the ICD, but gLAB will apply to C2X the same criteria as C2S or C2L as they all have the same reference signal according to RINEX standard.
- C5X is not specified in the ICD, but gLAB will apply to C5X the same criteria as C5X has the same reference signal as C5I according to RINEX standard.

- **Galileo DCB Options:**
  - **Galileo DCB: E1 (F1) - E5a (F5):** Differential Code Biases (DCB) are the delays due to electronic, antennas and cables of receiver and transmitter devices which directly affect the measurements with a bias.

    When satellite orbits and clocks are estimated, a reference measurement or combination must be selected. For Galileo, broadcast orbits use two different iono-free (IF) combinations:

    - **I/NAV navigation message**: Uses E1 and E5b (F7) iono-free combination. The exact measurements attributes used to compute the IF are not specified.
    - **F/NAV navigation message**: Uses E1 and E5a (F5) iono-free combination. The exact measurements attributes used to compute the IF are not specified.

    In precise orbits and clocks, the IF based on E1-E5a (F5) is used by most providers (e.g MGEX), but the exact measurements attributes used to compute the IF are not specified.

    The reference measurement or combination, by definition, always has all satellite DCB=0. Therefore, when a user utilizes any measurement (or combination) which is different from the reference combination, a bias appears in the clock estimate, which is what the DCB corrects.

    The DCB correction can be provided in two ways:

    1. Directly correcting the DCB for one specific measurement (note that DCB are always referred to a single measurement) to the reference

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measurement or combination (they are usually named DCB or TGD -Total Group Delay-, or in Galileo BGD -Broadcast Group Delay-)

2. Providing a correction that converts (i.e. adjust the bias) a measurement to another measurement which has a DCB that corrects the remaining bias (therefore multiple corrections will have to be applied to fully remove the bias). These are refered as Inter Signal Correction (ISC).

In the case of Galileo E1 (F1) - E5a (F5) DCB (or BGD or TGD) provided in F/NAV navigation message, it corrects the bias between the single measurement in E5a to the reference IF combination of E1 and E5a. As the exact measurements attributes are not specified, gLAB assumes it can be applied to all measurements in E5a (C5I, C5Q and C5X).

This DCB (or BGD or TGD) is provided in the RINEX Navigation file, where the Galileo E1 (F1) - E5a (F5) bias is given as the Broadcast Group Delay (BGD) located in the 3rd field of the 7th row of the F/NAV broadcast ephemerides.

- **Galileo DCB: E1 (F1) - E5b (F7):** Differential Code Biases (DCB) are the delays due to electronic, antennas and cables of receiver and transmitter devices which directly affect the measurements with a bias.

  When satellite orbits and clocks are estimated, a reference measurement or combination must be selected. For Galileo, broadcast orbits use two different iono-free (IF) combinations:

  - **I/NAV navigation message**: Uses E1 and E5b (F7) iono-free combination. The exact measurements attributes used to compute the IF are not specified.
  - **F/NAV navigation message**: Uses E1 and E5a (F5) iono-free combination. The exact measurements attributes used to compute the IF are not specified.

  In precise orbits and clocks, the IF based on E1-E5a (F5) is used by most providers (e.g MGEX), but the exact measurements attributes used to compute the IF are not specified.

  The reference measurement or combination, by definition, always has all satellite DCB=0. Therefore, when a user utilizes any measurement (or combination) which is different from the reference combination, a bias appears in the clock estimate, which is what the DCB corrects.

  The DCB correction can be provided in two ways:

  1. Directly correcting the DCB for one specific measurement (note that DCB are always referred to a single measurement) to the reference measurement or combination (they are usually named DCB or TGD -Total Group Delay-, but in Galileo they are named BGD -Broadcast Group Delay-)
  2. Providing a correction that converts (i.e. adjust the bias) a measurement to another measurement which has a DCB that corrects the remaining

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bias (therefore multiple corrections will have to be applied to fully remove the bias). These are refered as Inter Signal Correction (ISC).

In the case of Galileo E1 (F1) - E5b (7) DCB (or BGD or TGD) provided in I/NAV navigation message, it corrects the bias between the single measurement in E1 and E5b to the reference IF combination of E1 and E5b. As the exact measurements attributes are not specified, gLAB assumes it can be applied to all measurements in E1 (C1A, C1B, C1C, C1X, C1Z) and E5b (C7I, C7Q and C7X).

This DCB (or BGD or TGD) is provided in the RINEX Navigation file, where the Galileo E1 (F1) - E5b (F7) bias is given as the Broadcast Group Delay (BGD) located in the 3rd field of the 7th row of the I/NAV broadcast ephemerides.

- **GLONASS DCB Options:**
  - **GLONASS DCB: P1 - P2:** Differential Code Biases (DCB) are the delays due to electronic, antennas and cables of receiver and transmitter devices which directly affect the measurements with a bias.

    When satellite orbits and clocks are estimated, a reference measurement or combination must be selected. For GLONASS, broadcast orbits use the iono-free (IF) combination of measurements P1 and P2 (C1P and C2P in RINEX3 notation). In precise orbits and clocks, the IF based on C1P and C2P is used by most providers (e.g IGS).

    The reference measurement or combination, by definition, always has all satellite DCB=0. Therefore, when a user utilizes any measurement (or combination) which is different from the reference combination, a bias appears in the clock estimate, which is what the DCB corrects.

    The DCB correction can be provided in two ways:

    1. Directly correcting the DCB for one specific measurement (note that DCB are always referred to a single measurement) to the reference measurement or combination (they are usually named DCB or TGD - Total Group Delay-)
    2. Providing a correction that converts (i.e. adjust the bias) a measurement to another measurement which has a DCB that corrects the remaining bias (therefore multiple corrections will have to be applied to fully remove the bias). These are refered as Inter Signal Correction (ISC).

    In the case of GLONASS P1-P2, it corrects the bias between the single measurement P1 or P2 to the reference IF combination of P1 and P2. This DCB (or TGD) is provided in the following files:

    - A Precise .DCB file, where the International GNSS Service (IGS) gives an accurate estimation of the (P1-P2) bias. This file contains a monthly estimation of the (P1-P2) Differential Code Bias (DCB) for all Satellites.
    - A IONEX file, where a daily estimation of the (P2-P1) bias are given in the PRN / BIAS / RMS header lines.

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Note that the GLONASS navigation message does not provide this DCB, therefore a user without external data providers cannot correct this DCB. The GLONASS P1-P2 DCB is cancelled in the ionospheric-free combination. This effect can reach up to the meter level.

- **BDS DCB Options:**
  - **BeiDou-2 DCB: B1 (F2) - B3 (F6):** Differential Code Biases (DCB) are the delays due to electronic, antennas and cables of receiver and transmitter devices which directly affect the measurements with a bias.

    When satellite orbits and clocks are estimated, a reference measurement or combination must be selected. For BeiDou (2 and 3), it is used the single frequency measurement B3i (C6I). In precise orbits and clocks, for BeiDou-2 it is used the IF based on B1 (F2) and B2 (F7) is used by most providers (e.g MGEX), but the exact measurements attributes used to compute the IF are not specified. For BeiDou-3, it is used the IF based on B1 (F2) and B3 (F6) is used by most providers (e.g MGEX).

    The reference measurement or combination, by definition, always has all satellite DCB=0. Therefore, when a user utilizes any measurement (or combination) which is different from the reference combination, a bias appears in the clock estimate, which is what the DCB corrects.

    The DCB correction can be provided in two ways:

    1. Directly correcting the DCB for one specific measurement (note that DCB are always referred to a single measurement) to the reference measurement or combination (they are usually named DCB or TGD -Total Group Delay-)
    2. Providing a correction that converts (i.e. adjust the bias) a measurement to another measurement which has a DCB that corrects the remaining bias (therefore multiple corrections will have to be applied to fully remove the bias). These are refered as Inter Signal Correction (ISC).

    In the case of BeiDou-2 B1 (F2) - B3 (F6) DCB (or TGD) provided in both D1 and D2 navigation messages, it corrects the bias between the single measurement in B1 to the reference single measurement B3I (C6I). As the exact measurements attributes are not specified, gLAB assumes it can be applied to all measurements in B1 (C2I, C2Q and C2X).

    This DCB (or TGD) is provided in the RINEX Navigation file, where the Beidou-2 B1 (F2) - B3 (F6) bias is given as the Total Group Delay (TGD) located in the 3rd field of the 7th row of the D1 or D2 broadcast ephemerides.

  - **BeiDou-2 DCB: B2b (F7) - B3 (F6):** Differential Code Biases (DCB) are the delays due to electronic, antennas and cables of receiver and transmitter devices which directly affect the measurements with a bias.

    When satellite orbits and clocks are estimated, a reference measurement or

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combination must be selected. For BeiDou (2 and 3), it is used the single frequency measurement B3i (C6I). In precise orbits and clocks, for BeiDou-2 it is used the IF based on B1 (F2) and B2 (F7) is used by most providers (e.g MGEX), but the exact measurements attributes used to compute the IF are not specified. For BeiDou-3, it is used the IF based on B1 (F2) and B3 (F6) is used by most providers (e.g MGEX).

The reference measurement or combination, by definition, always has all satellite DCB=0. Therefore, when a user utilizes any measurement (or combination) which is different from the reference combination, a bias appears in the clock estimate, which is what the DCB corrects.

The DCB correction can be provided in two ways:

1. Directly correcting the DCB for one specific measurement (note that DCB are always referred to a single measurement) to the reference measurement or combination (they are usually named DCB or TGD -Total Group Delay-)
2. Providing a correction that converts (i.e. adjust the bias) a measurement to another measurement which has a DCB that corrects the remaining bias (therefore multiple corrections will have to be applied to fully remove the bias). These are refered as Inter Signal Correction (ISC).

In the case of BeiDou-2 B2b (F7) - B3 (F6) DCB (or TGD) provided in both D1 and D2 navigation messages, it corrects the bias between the single measurement in B1 to the reference single measurement B3I (C6I). As the exact measurements attributes are not specified, gLAB assumes it can be applied to all measurements in B1 (C2I, C2Q and C2X).

This DCB (or TGD) is provided in the RINEX Navigation file, where the Beidou-2 B2b (F7) - B3 (F6) bias is given as the Total Group Delay (TGD) located in the 4th field of the 7th row of the D1 or D2 broadcast ephemerides.

- **BeiDou-2 DCB for SP3/CLK:** BeiDou is the only constellation whose broadcast orbits and clocks use a single frequency measurement (B3I) as the reference. This creates a difference with respect the precise orbit and clock products, which use a dual frequency measurement as reference (usually the same as in broadcast orbits).

  When the broadcast orbits and clocks have the same reference as the precise orbits and clocks, the DCBs provided in the navigation messages can be used with both broadcast and precise orbits and clocks. As this is not the case of BeiDou, it is required to apply the following formulas to account for the different reference signals:

  - DCB to apply for single frequency B1 (F2) measurements:

$$DCB_{SP3\ B1\text{-}B3} = c \cdot DCB_{B1\text{-}B3} - c \cdot (f2^2 \cdot DCB_{B1\text{-}B3} - f6^2 \cdot DCB_{B2b\text{-}B3}) / (f2^2 - f6^2)$$

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- DCB to apply for single frequency B2b (F7) measurements:

  $DCB_{SP3\ B2b\text{-}B3} = c \cdot DCB_{B2b\text{-}B3} - c \cdot (f2^2 \cdot DCB_{B1\text{-}B3} - f6^2 \cdot DCB_{B2b\text{-}B3}) / (f2^2 - f6^2)$

Where:

- **$DCB_{B1\text{-}B3}$**: DCB between B1 (F2) - B3 (F6), as explained in tooltip *BeiDou -2 DCB: B1 (F2) - B3 (F6)*
- **$DCB_{B2b\text{-}B3}$**: DCB between B2b (F7) - B3 (F6), as explained in tooltip *BeiDou -2 DCB: B2b (F7) - B3 (F6)*
- **f2**: Frequency of B1 (F2) signal (1561.098 MHz)
- **f6**: Frequency of B3 (F6) signal (1268.52 MHz)
- **c**: Speed of light

- **Beidou DCB for Double Frequency:** Differential Code Biases (DCB) are the delays due to electronic, antennas and cables of receiver and transmitter devices which directly affect the measurements with a bias.

  When satellite orbits and clocks are estimated, a reference measurement or combination must be selected. For BeiDou (2 and 3), it is used the single frequency measurement B3i (C6I). In precise orbits and clocks, for BeiDou-2 it is used the IF based on B1 (F2) and B2 (F7) is used by most providers (e.g MGEX), but the exact measurements attributes used to compute the IF are not specified. For BeiDou-3, it is used the IF based on B1 (F2) and B3 (F6) is used by most providers (e.g MGEX).

  The reference measurement or combination, by definition, always has all satellite DCB=0. Therefore, when a user utilizes any measurement (or combination) which is different from the reference combination, a bias appears in the clock estimate, which is what the DCB corrects.

  The DCB correction can be provided in two ways:

  1. Directly correcting the DCB for one specific measurement (note that DCB are always referred to a single measurement) to the reference measurement or combination (they are usually named DCB or TGD -Total Group Delay-)
  2. Providing a correction that converts (i.e. adjust the bias) a measurement to another measurement which has a DCB that corrects the remaining bias (therefore multiple corrections will have to be applied to fully remove the bias). These are refered as Inter Signal Correction (ISC).

  Prior to the introduction of new frequencies and signals in GPS, GLONASS and the introduction of new constellations, when working with dual frequency combinations, the DCBs could be applied correct the measurement either to each single frequency signal (that is, before computing the dual frequency combination) or after computing the dual frequency combination (with the adequate conversion factor).

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With the introduction of new signals and frequencies, most of the dual frequency combinations do not match with the reference iono-free combination used to compute the orbits and clocks. In order to compute the adequate DCB correction, the ICD provides specific formulas which require some of the terms to be applied after computing the dual frequency combination. As gLAB used to apply the DCB terms before the iono-free computation, and print each DCB term applied in a single frequency measurement in the MODEL message, it was decided to print the computed DCB from the ICD formula in a different term, named "Double Frequency DCB" in order to have a clear separation.

In BeiDou-2, for broadcast orbits only (see tooltip *DCB for SP3/CLK*) the formulas for the DCBs are the following:

- B1 (F2) and B3 (F6):
  Dual Frequency $DCB_{B1-B3} = (c \cdot DCB_{B1-B3} - \gamma_{26}) / (1- \gamma_{26})$
- B2b (F7) and B3 (F6) (this combination is not in the ICD, but is analogous as the previous one):
  Dual Frequency $DCB_{B2b-B3} = (c \cdot DCB_{B2b-B3} - \gamma_{76}) / (1- \gamma_{76})$

Where:

- **DCB_{B1-B3}:** DCB explained in tooltip *DCB: B1 (F2) - B3 (F6)*
- **DCB_{B2b-B3}**: DCB explained in tooltip *DCB: B2b (F7) - B3 (F6)*
- **c**: Speed of light
- $\gamma_{26} = (f_{B1}/f_{B3})^2 = (1561.098/1268.52)^2$
- $\gamma_{76} = (f_{B2B}/f_{B3})^2 = (1207.14/1268.52)^2$

NOTE: As the ICD does not specify the measurment attributes from B1 and B2b, gLAB will apply the formulas to all signals (C2I, C2Q, C2X for B1 and C7I, C7Q and C7X for B2B).

- **QZSS DCB Options:**
  - **QZSS: DCB: Clock - L1 C/A (C1C):** Differential Code Biases (DCB) are the delays due to electronic, antennas and cables of receiver and transmitter devices which directly affect the measurements with a bias.

    When satellite orbits and clocks are estimated, a reference measurement or combination must be selected. For QZSS, broadcast orbits use the iono-free (IF) combination of L1 C/A (C1C) and L2C (for L2C it is not specified the exact measurement attributes). In precise orbits and clocks, the IF based on L1 C/A (C1C) and L2C (for L2C it is not specified the exact measurement attributes) is used by most providers (e.g MGEX).

    The reference measurement or combination, by definition, always has all satellite DCB=0. Therefore, when a user utilizes any measurement (or combination) which is different from the reference combination, a bias appears

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in the clock estimate, which is what the DCB corrects.

The DCB correction can be provided in two ways:

1. Directly correcting the DCB for one specific measurement (note that DCB are always referred to a single measurement) to the reference measurement or combination (they are usually named DCB or TGD -Total Group Delay-)
2. Providing a correction that converts (i.e. adjust the bias) a measurement to another measurement which has a DCB that corrects the remaining bias (therefore multiple corrections will have to be applied to fully remove the bias). These are refered as Inter Signal Correction (ISC).

In the case of QZSS Clock - L1 C/A (C1C), it corrects the bias between the single measurement C1C to the reference IF combination of L1 C/A (C1C) and L2C. This DCB (or TGD) is provided in the RINEX Navigation file, where the QZSS Clock - L1 C/A (C1C) bias is given as the Total Group Delay (TGD) located in the 3rd field of the 7th row of the broadcast ephemerides (LNAV and CNAV navigation messages).

NOTE: In case of using L1 C/B (C1E), the same criteria will apply as in L1 C/A (C1C).

- **QZSS ISC: L1 C/A - L2C (M or L):** Differential Code Biases (DCB) are the delays due to electronic, antennas and cables of receiver and transmitter devices which directly affect the measurements with a bias.

  When satellite orbits and clocks are estimated, a reference measurement or combination must be selected. For QZSS, broadcast orbits use the iono-free (IF) combination of L1 C/A (C1C) and L2C (for L2C it is not specified the exact measurement attributes). In precise orbits and clocks, the IF based on L1 C/A (C1C) and L2C (for L2C it is not specified the exact measurement attributes) is used by most providers (e.g MGEX).

  The reference measurement or combination, by definition, always has all satellite DCB=0. Therefore, when a user utilizes any measurement (or combination) which is different from the reference combination, a bias appears in the clock estimate, which is what the DCB corrects.

  The DCB correction can be provided in two ways:

  1. Directly correcting the DCB for one specific measurement (note that DCB are always referred to a single measurement) to the reference measurement or combination (they are usually named DCB or TGD -Total Group Delay-)
  2. Providing a correction that converts (i.e. adjust the bias) a measurement to another measurement which has a DCB that corrects the remaining bias (therefore multiple corrections will have to be applied to fully remove the bias). These are refered as Inter Signal Correction (ISC).

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ISC L1 C/A - L2C (M or L) is located in the 2nd field of the 8th row of the broadcast ephemerides CNAV navigation message and converts the bias from C2S or C2L to C1C.

NOTES:

- C2X measurement is not specified in QZSS ICD. gLAB will apply to C2X the same criteria as C2S or C2L as they all have the same reference signal according to RINEX standard.
- In case of using L1 C/B (C1E), the same criteria will apply as in L1 C/A.

- **QZSS ISC: L1 C/A - L5I5:** Differential Code Biases (DCB) are the delays due to electronic, antennas and cables of receiver and transmitter devices which directly affect the measurements with a bias.

  When satellite orbits and clocks are estimated, a reference measurement or combination must be selected. For QZSS, broadcast orbits use the iono-free (IF) combination of L1 C/A (C1C) and L2C (for L2C it is not specified the exact measurement attributes). In precise orbits and clocks, the IF based on L1 C/A (C1C) and L2C (for L2C it is not specified the exact measurement attributes) is used by most providers (e.g MGEX).

  The reference measurement or combination, by definition, always has all satellite DCB=0. Therefore, when a user utilizes any measurement (or combination) which is different from the reference combination, a bias appears in the clock estimate, which is what the DCB corrects.

  The DCB correction can be provided in two ways:

  1. Directly correcting the DCB for one specific measurement (note that DCB are always referred to a single measurement) to the reference measurement or combination (they are usually named DCB or TGD -Total Group Delay-)
  2. Providing a correction that converts (i.e. adjust the bias) a measurement to another measurement which has a DCB that corrects the remaining bias (therefore multiple corrections will have to be applied to fully remove the bias). These are refered as Inter Signal Correction (ISC).

- ISC L1 C/A - L2C (M or L) is located in the 2nd field of the 8th row of the broadcast ephemerides CNAV navigation message and converts the bias from C2S or C2L to C1C.

  NOTES:

  - C2X measurement is not specified in QZSS ICD. gLAB will apply to C2X the same criteria as C2S or C2L as they all have the same reference signal according to RINEX standard.
  - In case of using L1 C/B (C1E), the same criteria will apply as in L1 C/A.

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- **QZSS ISC: L1 C/A - L5Q5A:** Differential Code Biases (DCB) are the delays due to electronic, antennas and cables of receiver and transmitter devices which directly affect the measurements with a bias.

  When satellite orbits and clocks are estimated, a reference measurement or combination must be selected. For QZSS, broadcast orbits use the iono-free (IF) combination of L1 C/A (C1C) and L2C (for L2C it is not specified the exact measurement attributes). In precise orbits and clocks, the IF based on L1 C/A (C1C) and L2C (for L2C it is not specified the exact measurement attributes) is used by most providers (e.g MGEX).

  The reference measurement or combination, by definition, always has all satellite DCB=0. Therefore, when a user utilizes any measurement (or combination) which is different from the reference combination, a bias appears in the clock estimate, which is what the DCB corrects.

  The DCB correction can be provided in two ways:

  1. Directly correcting the DCB for one specific measurement (note that DCB are always referred to a single measurement) to the reference measurement or combination (they are usually named DCB or TGD -Total Group Delay-)
  2. Providing a correction that converts (i.e. adjust the bias) a measurement to another measurement which has a DCB that corrects the remaining bias (therefore multiple corrections will have to be applied to fully remove the bias). These are refered as Inter Signal Correction (ISC).

  ISC L1 C/A - L5Q5 is located in the 4th field of the 8th row of the broadcast ephemerides CNAV navigation message and converts the bias from C5Q to C1C.

  NOTE: In case of using L1 C/B (C1E), the same criteria will apply as in L1 C/A.

- **QZSS DCB for Double Frequency:** Differential Code Biases (DCB) are the delays due to electronic, antennas and cables of receiver and transmitter devices which directly affect the measurements with a bias.

  When satellite orbits and clocks are estimated, a reference measurement or combination must be selected. For QZSS, broadcast orbits use the iono-free (IF) combination of L1 C/A (C1C) and L2C (for L2C it is not specified the exact measurement attributes). In precise orbits and clocks, the IF based on L1 C/A (C1C) and L2C (for L2C it is not specified the exact measurement attributes) is used by most providers (e.g MGEX).

  The reference measurement or combination, by definition, always has all satellite DCB=0. Therefore, when a user utilizes any measurement (or combination) which is different from the reference combination, a bias appears

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in the clock estimate, which is what the DCB corrects.

The DCB correction can be provided in two ways:

1. Directly correcting the DCB for one specific measurement (note that DCB are always referred to a single measurement) to the reference measurement or combination (they are usually named DCB or TGD -Total Group Delay-)
2. Providing a correction that converts (i.e. adjust the bias) a measurement to another measurement which has a DCB that corrects the remaining bias (therefore multiple corrections will have to be applied to fully remove the bias). These are refered as Inter Signal Correction (ISC).

Prior to the introduction of new frequencies and signals in GPS, GLONASS and the introduction of new constellations, when working with dual frequency combinations, the DCBs could be applied correct the measurement either to each single frequency signal (that is, before computing the dual frequency combination) or after computing the dual frequency combination (with the adequate conversion factor).

With the introduction of new signals and frequencies, most of the dual frequency combinations do not match with the reference iono-free combination used to compute the orbits and clocks. In order to compute the adequate DCB correction, the ICD provides specific formulas which require some of the terms to be applied after computing the dual frequency combination. As gLAB used to apply the DCB terms before the iono-free computation, and print each DCB term applied in a single frequency measurement in the MODEL message, it was decided to print the computed DCB from the ICD formula in a different term, named "Double Frequency DCB" in order to have a clear separation. In QZSS, the formulas for the DCBs are the following:

- $L1C_P$ (C1L) and L2C (C2S or C2L):
  $DCB_{L1CP - L2C} = c \cdot (ISC_{L2C} - \gamma_{12} \cdot ISC_{L1CP}) / (1- \gamma_{12}) + c \cdot T_{GD}$
- $L1C_D$ (C1S) and L2C (C2S or C2L):
  $DCB_{L1CD - L2C} = c \cdot (ISC_{L2C} - \gamma_{12} \cdot ISC_{L1CD}) / (1- \gamma_{12}) + c \cdot T_{GD}$
- $L1C_P$ (C1L) and L5Q5 (C5Q):
  $DCB_{L1CP - L5Q5} = c \cdot (ISC_{L5Q5} - \gamma_{15} \cdot ISC_{L1CP}) / (1- \gamma_{15}) + c \cdot T_{GD}$
- $L1C_D$ (C1S) and L5Q5 (C5Q):
  $DCB_{L1CD - L5Q5} = c \cdot (ISC_{L5Q5} - \gamma_{15} \cdot ISC_{L1CD}) / (1- \gamma_{15}) + c \cdot T_{GD}$
- $L1C_P$ (C1L) and L5I5 (C5I):
  $DCB_{L1CP - L5I5} = c \cdot (ISC_{L5I5} - \gamma_{15} \cdot ISC_{L1CP}) / (1- \gamma_{15}) + c \cdot T_{GD}$
- $L1C_D$ (C1S) and L5Q5 (C5I):
  $DCB_{L1CD - L5I5} = c \cdot (ISC_{L5I5} - \gamma_{15} \cdot ISC_{L1CD}) / (1- \gamma_{15}) + c \cdot T_{GD}$

Where:

- **ISC_i**: Inter-signal correction for the channel indicated by the subscript
- **T_{GD}**: DCB correction explained in tooltip *QZSS DCB: Clock - L1 C/A*

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- **c**: Speed of light
- $\gamma_{12} = (f_{L1}/f_{L2})^2 = (77/60)^2$
- $\gamma_{15} = (f_{L1}/f_{L5})^2 = (154/115)^2$

NOTES:

- C1X is not specified in the ICD, but gLAB will apply to C1X the same criteria as C1S or C1L as they all have the same reference signal according to RINEX standard.
- C2X is not specified in the ICD, but gLAB will apply to C2X the same criteria as C2S or C2L as they all have the same reference signal according to RINEX standard.
- C5X is not specified in the ICD, but gLAB will apply to C5X the same criteria as C5X has the same reference signal as C5I according to RINEX standard.
- In case of using L1 C/B (C1E), the same criteria will apply as in L1 C/A.

- **IRNSS DCB Options:**
  - **IRNSS: DCB: S-SPS (C9A) - L5-SPS (C5A):** Differential Code Biases (DCB) are the delays due to electronic, antennas and cables of receiver and transmitter devices which directly affect the measurements with a bias.

    When satellite orbits and clocks are estimated, a reference measurement or combination must be selected. For IRNSS, broadcast orbits use the iono-free (IF) combination of S (F9) and L5 frequencies, but the exact reference measurements attributes are not specified (assumed C9A and C5A). Precise orbits and clocks are currently not provided for this constellation.

    The reference measurement or combination, by definition, always has all satellite DCB=0. Therefore, when a user utilizes any measurement (or combination) which is different from the reference combination, a bias appears in the clock estimate, which is what the DCB corrects.

    The DCB correction can be provided in two ways:

    1. Directly correcting the DCB for one specific measurement (note that DCB are always referred to a single measurement) to the reference measurement or combination (they are usually named DCB or TGD - Total Group Delay-)
    2. Providing a correction that converts (i.e. adjust the bias) a measurement to another measurement which has a DCB that corrects the remaining bias (therefore multiple corrections will have to be applied to fully remove the bias). These are refered as Inter Signal Correction (ISC).

    In the case of IRNSS S-SPS (C9) - L5-SPS (C5), it corrects the bias between the single measurement C9A and C5A to the reference IF combination of S (F9) and L5. It is assumed the reference measurements are C9A and C5A as these

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are the ones for SPS (Standard Positioning Service) and are also the reference signals specified in the RINEX standard. This DCB (or TGD) is provided in the RINEX Navigation file, where the IRNSS (C9A-C5A) bias is given as the Total Group Delay (TGD) located in the 3rd field of the 7th row of the broadcast ephemerides (LNAV navigation message). This estimation is generated by the Control Segment that monitorises all satellites.

- **Precise Products Data Interpolation:** This is the degree of the interpolation polynomial for the precise orbit and clocks (this option has no effect when using broadcast products).
  - **Interpolation Degree:** This value is only valid for orbits or clocks obtained from SP3 files (for clocks also from CLK files), as they require an interpolation.
    - **Orbit Interpolation Degree:** By default, the interpolation is done with a polynomial of degree 9, but this value can be adjusted with this parameter. Excessively low values would strongly affect the precision of the position obtained.
    - **Clock Interpolation Degree:** By default, no interpolation is done ("degree" 0), but you can chose to activate the interpolation by providing a number different than 0. Due to the unpredictability of clocks, and its non-smoothed nature, the interpolation of low sampling rate clocks (i.e., t>30 secs) would strongly affect the precision of the clocks obtained. Only clocks with sampling rate higher than 1/30s should be interpolated with a polynomial of degree 1.
  - **Max Consecutive Gaps Between Sample:** This value is only valid for orbits or clocks obtained from SP3 files (for clocks also from CLK files), as they require an interpolation.
    - For both orbits and clocks, when selecting the samples for interpolation, there may occur that there are data gaps in the file, which may produce that samples used for interpolation are very far in time from each other, thus reducing the accuracy of the interpolated value.
    - With this option, a maximum number of consecutive data gaps between samples is set (therefore protecting against large data gaps concentrated between few samples), and for any case that this threshold is surpassed, no interpolation is done for this epoch and satellites.
    - gLAB can detect data gaps in SP3 and CLK files by calculating the sampling rate of the data files.
  - **Total Gaps Allowed:** This value is only valid for orbits or clocks obtained from SP3 files (for clocks also from CLK files), as they require an interpolation.
    - For both orbits and clocks, when selecting the samples for interpolation, there may occur that there are data gaps in the file, which may produce that samples used for interpolation are very far in time from each other, thus reducing the accuracy of the interpolated value.

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- With this option, a maximum number of data gaps between the first and last sample used is set (therefore protecting against large data gaps equally distributed in all samples used), and for any case that this threshold is surpassed, no interpolation is done for this epoch and satellites.
- gLAB can detect data gaps in SP3 and CLK files by calculating the sampling rate of the data files.

- **Show Concatenated SP3/CLK options:** If sample at 0h 0m is present in both days, select which one to use:
  - **Current Day & Next Day:** This value is only valid for orbits obtained from SP3 or CLK files, as they require an interpolation.

    When interpolating orbits from precise products, when using single day orbit files, at the beginning and at the end of the day, the interpolated value will have an additional error of few centimetres due to a non homogenous distribution (in time) of the samples used for interpolation (Runge effect). To avoid this effect, the user can introduce a concatenated orbit file from several days (ideally, from the previous and the following day), so gLAB can interpolate using always samples with homogenous distribution (when a concatenated file is introduced, gLAB will read the file using a sliding data window of three days).

    In some orbit files (typically in MGEX files), the last sample given from one day is the sample at 0 hours and 0 minutes from the following day (i.e. the first sample from the next day). The problem is that this last sample has a similar (but not equal) value to the first sample of the next day (after concatenating an orbit files, this samples appears twice), therefore, depending on the sample used, the interpolation value will slightly vary during several hours (as orbit use a high interpolation degree, and date rate is typically of 15 minutes).

    If this option is set, the first sample read (the one at the end of the current day), will be used for interpolation.

    NOTE: To see the Runge effect in the interpolation, the user can do a comparation of the same SP3 file, but using one concatenated and another without concatenation in the 'Compare Orbits & Clocks' mode of gLAB (in the menu Mode->Compare Orbits & Clocks).

- **Receiver Antenna Phase Center:**
  - **Specify Correction:** Specify per constellation and frequency (in a new window), whether the correction is read in the ANTEX, set manually or copied from another constellation.

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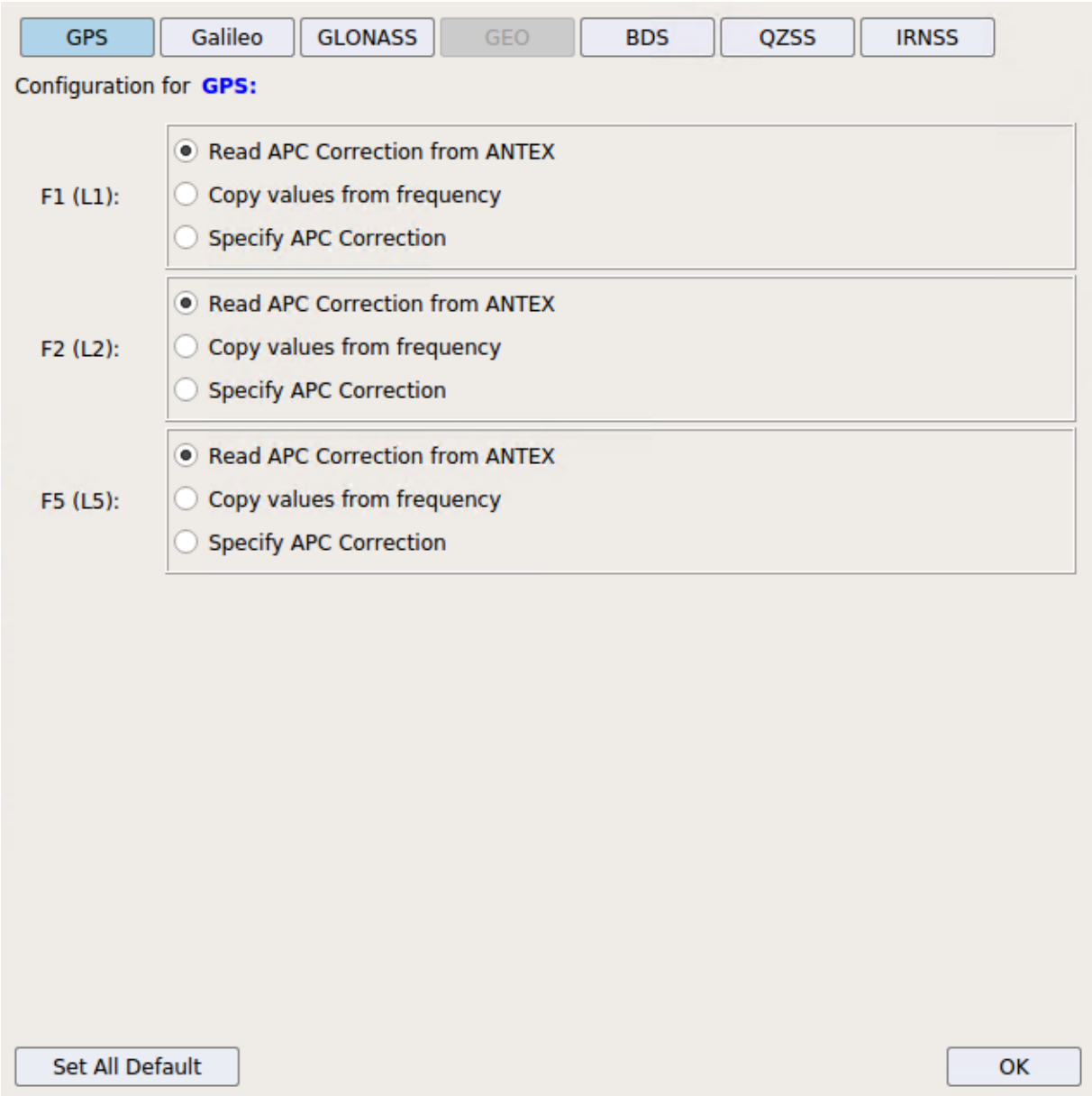

Figure 4-15 Receiver Antenna Phase center correction selection window.

- **Read Receiver APC Correction from ANTEX:** Read the Phase Center data of the receiver from the ANTEX file specified in the Input section. It tries to obtain the name of the antenna using the RINEX header record *ANT # / TYPE*, and seeks for that name in the ANTEX file.
- **Receiver Antenna Phase Centre Variation:** Antenna Reference Point Correction has an additional term which is dependent on the satellite elevation, and it is also provided in the ANTEX file. This additional term is provided in two ways in the ANTEX file: One set of corrections elevation dependent but independent of the azimuth, and another set dependent on elevation and azimuth. gLAB reads both corrections, but only applies the non azimuth dependent, as the correction variation between azimuth dependent and non

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azimuth dependent is typically around 0.5 mm. This correction can be up to 1-5 mm.

- **Stop processing if Antenna's Radome is not found in ANTEX:** When searching for Antenna Phase Centre data of the receiver in the ANTEX, gLAB will try to match the antenna type and radome read in the RINEX observation file header record ANT # / TYPE with the ones in the ANTEX records with TYPE / SERIAL NO. If this option is enabled, both antenna type and radome must match. If this option is disabled, if antenna type and radome do not match, then radome will be set to "NONE", which is always present for each antenna type given in the ANTEX file.

- **Receiver Antenna Reference Point:**
  - **Specify:** Specify in North/East/Up components the receiver Antenna Reference Point.
  - **Read from RINEX:** Read the receiver Antenna Reference Point from the RINEX file. It seeks for the *ANTENNA: DELTA H/E/N* RINEX header record.

  NOTE: In DGNSS mode, reference station ARP will always be read from reference RTCM or RINEX file (if ARP correction is enabled).

- **Broadcast Navigation Messages Types:** Select for each constellation, the order and usable navigation message types, as shown:

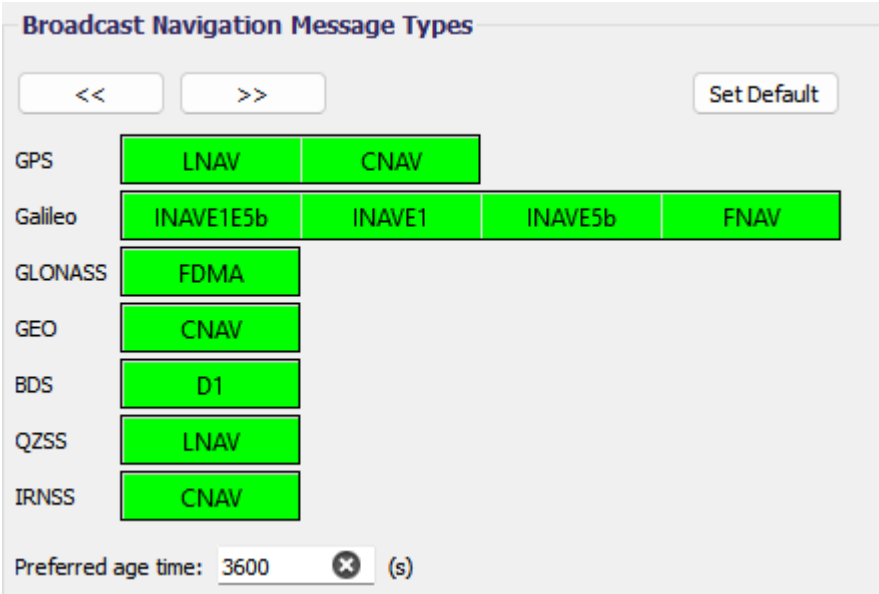

Figure 4-16 Broadcast navigation message types.

  - **Preferred age time:** When searching for a navigation message, set the threshold (in seconds) to decide if current valid navigation message found is recent enough (with respect to navigation message ToC -Time of Clock-) to select it or to keep searching in other navigation message types (according to the navigation message priority list) for more recent messages.

    The navigation message selection algorithm is the following:

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1. Select the navigation message type with higher priority.
2. Loop through the navigation messages and find the one with closest ToE (Time of Ephemerides) and valid transmission time (if *Check Broadcast Transmission Time* is enabled).
3. Check if difference between ToC (Time of Clock) and current is less than the value provided in *Preferred age time* (this parameter). If it is smaller, the algorithm ends. If it is greater, repeat steps 1 to 3 with the next navigation message in the priority type list.
4. If valid navigation messages are found but none of them are below the *Preferred age time* ToC difference, the navigation message with smaller ToC difference will be selected.

NOTES:

- If the value of this parameter is set very small (e.g. 1 second), this will make gLAB to loop through all available navigation message types in nearly all cases, as very rarely any navigation message will meet the condition.
- If the value of this parameter is set very high (e.g. 4 hours), gLAB will use the navigation message found in the first navigation type (even though it may be very old), as any navigation message will meet the condition.
- When a navigation message is searched by IOD (Issue Of Data) -which occurs in SBAS modes- the same algorithm applies, but only looping on the navigation messages with the given IOD (there may be more than one when concatenating multiple RINEX navigation files), as the navigation messages are also internally saved by IOD.
- Navigation message health check is not performed in this algorithm, it is checked after a navigation message is selected (according to *Discard Unhealthy Satellites* and *Discard Marginal Satellites*).
- In command line, there are the advanced options '-model:skipunhealthy' and '-model:skipunhealthymarg' which makes gLAB to skip unhealthy or unhealthy and marginal navigation message from the RINEX navigation files (i.e. not saving them in memory), so gLAB will only run the navigation selection algorithm with healthy and marginal or healthy only navigation messages.

- **SBAS Options (Using MOPS-D):**
  - **SBAS Application:** Select the target application for SBAS.
    - **Aviation:** Process SBAS according to MOPS standard for Aviation (standard SBAS processsing). This is the default mode.
    - **Maritime:** Process SBAS according to MOPS standard for Maritime (still in development, only applicable to SBAS 1F). The differences in Maritime mode are:
      - Messages type 10, 27 and 28 are disabled.

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- GEO switching is enabled.
- HDOP filter is enabled (with a threshold of 4).
- PDOP filter is enabled (with a threshold of 6).
- HDOP and PDOP filter conditions do not need to meet both in an epoch, only one of them is necessary (i.e. the HDOP and PDOP conditions are logically ORed).
- Alarm limits are not used (gLAB sets a threshold of 100Km)
- Window size is changed to 900 epochs (at 1 second data rate is equivalent to a 15 minute window).
- The continuity risk is computed using a fixed window, instead of a sliding window (gLAB will compute the continuity risk with both modes, regardless the SBAS Application set in this option).

- **Navigation Mode:** Select the initial navigation mode for SBAS:
  - **PA (Precission Approach):** This is the default mode. It guarantees integrity in navigation and maximum precission (around 1 metre). In order to be able to use a satellite for navigation in PA mode, all the SBAS conditions for fast, slow and ionosphere corrections must be fulfilled. If navigation mode switching is enabled, gLAB will switch to NPA mode when there are less than 4 satellites available for navigation and GEO switch is not possible.
  - **NPA (Non Precission Approach):** This mode does not guarantee integrity or precission, and can be used in non critical operations. In this mode, if fast or slow corrections are not available, it will not use them (but it will set a sigma for these of 60 metres). If ionosphere correction is not available, it will use GPS Klobuchar model instead with a large sigma. If no corrections at all are available, navigation will be equal to SPP mode, but with sigmas larger than 60 metres). If this mode is set as the initial mode, it will be maintained during all the processing.
- **GEO Selection:** Select the initial SBAS GEO for reading SBAS corrections.
  - **First Read:** Select the first GEO read in the SBAS data file. This is the default.
  - **All Mixed:** Data from all GEOs will be all mixed together, as if all messages from all GEOs in the data file were sent from a unique GEO. This unique GEO has a PRN '0' inside gLAB.
  - **Highest Elevation:** Use the GEO with highest elevation. With this option, gLAB will not be able to select any GEO until almanacs (message type 17) or navigation messages (message type 9) with data from all available GEO are received.
  - **Select PRN:** Manually select a GEO by its PRN.
- **GEO Exclusion:** When a GEO is excluded, its data will not be read (as if there were no messages in the data file). This option is useful if we want to exclude GEOs sending alarm messages continuosly, or avoid switching to GEOs that

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are in test mode. In the GUI, the maximum number of GEO to be excluded is three, but in command line, it is possible to exclude any number of GEO by providing the parameter **'-pre:geoexclude'** as many times as necessary or by providing a comma separated list of GEO to the same parameter.

- **Allow Mixed GEO Data:** Enable this option to allow during a GEO switching to select the GEO with the mixed data (a fake GEO in gLAB that uses data from all the GEO in the data file, that is, as if all data in the file was sent from the same GEO).
    - If in GEO Selection option All Mixed is selected, this option is automatically enabled.
    - If this option enabled, it will not replace other GEO. For instance, if a SBAS data file contains GEOs 120 and 123, gLAB will have in memory data for GEO 120, 123 and 0 (the mixed one), thus allowing gLAB to switch between a nominal GEO and the mixed one (if GEO switching is enabled).
    - If option 'Select Best GEO' is enabled, this option will automatically be disabled.
- **GEO Switching:** Enable GEO switching during the SBAS processing. The GEO switch will be triggered when any of these conditions are met:
    - An alarm for the current GEO is received, or an alarm for any GEO is received and data from mixed GEO is being used.
    - These three conditions are met:
        - Less than 4 satellites available to compute the navigation solution.
        - The number of satellites discarded by SBAS criteria plus the number of available satellites sum 4 or more (if satellites were discarded by non SBAS criteria, such as cycle-slips, switching GEOs will be useless).
        - Current GEO is not under acquisition time. Acquisition time is the time necessary to receive enough messages from a GEO for computing a navigation solution in PA mode (by default is 5 minutes). For example, at the beginning of the day, if we started receiving data from the GEO one second ago, no corrections wil be available.

  When a GEO switch is triggered, GEOs which are under alarm or are under acquisition time (except if the current GEO received an alarm) will not be selected. If both GEO and navigation switch are enabled, GEO switching will always have priority, as a GEO switch allows to maintain PA navigation mode.
- **Select Best GEO:** When this option is enabled, gLAB will compute in each epoch the full SBAS model and the protection levels with all the GEOs available, and then select the best GEO according to the following criteria:

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- Select the GEOs which have PA solution with protection levels under the alarm limits, and from these ones, select the GEO whose sum of the horizontal and vertical protection levels is smaller.
- If no GEOs had PA solution with protection levels under the alarm limits, select the GEOs with PA solution and then select the GEO whose sum of the horizontal and vertical protection levels is smaller.
- If no GEOs had PA solution, select the GEOs with NPA solution and then select the GEO whose sum of the horizontal and vertical protection levels is smaller.

- **Navigation Mode Switching:** Enable switching between PA and NPA navigation modes during the SBAS processing. Navigation mode switching will only take effect if initial navigation mode is PA. The navigation mode switch will be triggered when any of these conditions are met:
  - An alarm for the current GEO is received, or an alarm for any GEO is received and data from mixed GEO is being used.
  - These three conditions are met:
    - Less than 4 satellites available to compute the navigation solution.
    - The number of satellites discarded by SBAS criteria plus the number of available satellites sum 4 or more (if satellites were discarded by non SBAS criteria, such as cycle-slips, switching navigation mode will be useless).
    - GEO switching is disabled or no other GEO is available.

  After a navigation mode switch to NPA, gLAB will try to go back to PA mode as soon as possible.

- **Airborne Receiver Type:** Set the receiver type in order to compute its σi,air for each satellite . The receiver types available are:
  - Class 1: $\sigma_{i,air}$ = 5 metres.
  - Class 2, 3, 4: The $\sigma_{i,air}$ is divided in three components:
    - $\sigma_{multipath}$: This is the sigma to account for multipath error. It is computed with the following formula:

      $$\sigma_{multipath[i]} = 0.13 + 0.53 \cdot e^{(-\theta[i]/10)} \text{ (metres)}$$

      θ[i] is the satellite elevation (in degrees).
    - $\sigma_{divergence}$: This is the sigma to account for possible biases and ionospheric divergence in the receiver. MOPS does not provide any formula to compute this sigma (it is left to the receiver manufactarer).
    - σ_{noise}: This is the sigma to account for noise and signals conditions in the receiver. MOPS does not provide any formula to compute this sigma (it is left to the receiver manufactarer)..

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MOPS does provide upper and lower bounds for $\sigma_{divergence}$ and σ_{noise}. gLAB will use the upper bound for these sigmas (which is the worst case). The upper bounds in MOPS for GPS and SBAS GEOs are:

- GPS satellites:

  $(\sigma^2_{divergence} + \sigma^2_{noise})^{1/2} \leq 0.36$ (metres)

- SBAS GEO satellites:

  $(\sigma^2_{divergence} + \sigma^2_{noise})^{1/2} \leq 1.8$ (metres)

Therefore, the values for the sigmas applied in gLAB will be:

- GPS satellites:

  $\sigma_{divergence} = 0$

  $\sigma_{noise} = 0.36$ (metres)

- SBAS GEO satellites:

  $\sigma_{divergence} = 0$

  $\sigma_{noise} = 1.8$ (metres)

The total sigma of a class 2, 3, 4 receiver will be:

- GPS satellites:

  $\sigma_{i,air} = (\sigma^2_{multipath[i]} + \sigma^2_{divergence} + \sigma^2_{noise})^{1/2}$ (metres)

- User defined: Let the user define its own receiver sigmas. The user defined receiver will have the same sigma components as a class 2 receiver, and gLAB will use the same default values as the class 2 if any of its components is not defined.

- **Show User Defined Receiver Sigmas:**
  - **User defined Sigma Multipath Model:** Use the user defined sigma multipath model defined thorugh the input text file Sigma Multipath File: in the INPUT section to compute the satellite's $\sigma_{multipath[i]}$. In this file ,a sigma multipath is defined in function of the satellite elevation or SNR (Signal to Noise Ratio). In both cases, the user must set a table of samples (ordered from lowest elevation -or SNR- to highest) with its correspondent sigma value. If $\sigma_{multipath}$ is not set (either with this option or with the fixed sigma multipath option), the default value for a class 2, 3, 4 receiver will be used.
  - **Fixed Sigma Multipath:** Apply the following formula for the $\sigma_{multipath}$:

    $\sigma_{multipath\ [i]}=a+b \cdot e^{(-\theta[i]/c)}$ (metres)

    a, b and c are the values provided by the user (being a and b in metres and c in degrees). θ[i] is the satellite's elevation. To set $\sigma_{multipath}$ to a fixed value, set b = 0 and a to the fixed value. If $\sigma_{multipath}$ is not set (either with this option or with the user defined sigma multipath model option), the default value for a class 2, 3, 4 receiver will be used.

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- **Sigma Divergence:** Apply a fixed value to $\sigma_{divergence}$. If $\sigma_{divergence}$ is not set, the default value for a class 2, 3, 4 receiver will be used.
- **Sigma Noise:** Apply a fixed value to σ_{noise}. If σ_{noise} is not set, the default value for a class 2, 3, 4 receiver will be used.

- **Show Message Time-outs (SBAS 1F):**
  - **Do Not Use for Safety Applications:** Message type 0. This message to inform the user that there is a problem in the GEO that has sent this message. When the user receives this message, an alarm is triggered, and the user has to erase all information received from this GEO (except for the almanac), and also wait for one minute until the user can start using this GEO again (during this minute of cooldown, all messages from this GEO must be ignored).

    NOTES:

    - The alarm is triggered just after reading the message.
    - If user has enabled the option Parse Alarm Message as Type 2 Message, then this message will be read as a type 2 message (no alarm triggered), except for the case that this message is filled with all zeros, which means that the user is forced to read it as an alarm message.
    - If user has enabled the option Ignore All Alarm Messages, then this message will be ignored and no alarm will be triggered.
    - When an alarm is triggered, after the cooldown minute, the GEO acquisition time will be restarted.
    - The time-out of 9999999 seconds is to indicate that is has an infinite time-out (due to, as explained above, the message is applied instantaneously)
  - **PRN Mask Assignments:** Message type 1. This message has 210 ordered slots, each one corresponding to a given satellite PRN and constellation. Each slot is one bit, if the bit is 1, the satellite is monitored, otherwise the satellite is not monitored. This set of ordered slots is called the PRN mask. The order is important, as the order of the monitored satellites in the mask will be the order in which the corrections will be sent in other messages. Currently, the slots are assigned in the following way:

    - Slots 1- 37: For GPS satellites.
    - Slots 38- 61: For Glonass satellites (Glonass PRN +37).
    - Slots 62- 119: For future GNSS.
    - Slots 120- 138: For GEO/SBAS satellites.
    - Slots 139- 210: For future GNSS/GEO/SBAS satellites.

    NOTES:

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- Each message has an IODP (Issue Of Data PRN Mask), which identifyies each PRN mask. If any bit of the PRN mask changes, the IODP will change (which will be rare).
- The maximum number of concurrent monitored satellites is 51 (including all constellations), due to the limited space in the SBAS messages. PRN Mask messages with more than 51 satellites monitored will be rejected by gLAB.
- All messages that need a PRN mask (to get the order for the satellite corrections), they will also have an IODP associated. Thence, the user must have the mask with the given IODP to read the message.
- When a PRN mask occurs (am ask with a different IODP), the user will have to save the previous mask and also all messages associated to the old IODP until new corrections with new IODP are received or the old corrections time-out. This assures that a PRN mask transition is smooth and there is continuity of corrections. In practice, SBAS provider usually prefer to send alarm messages during some minutes when a PRN mask occurs, to force the user clear all the data and switch to another GEO.Fast Corrections:

- **Fast Corrections:** Fast corrections are given in messages type 2, 3, 4 ,5 and 6. Messages type 2, 3, 4 and 5 provide each of a set of corrections for 13 satellites. These corrections include a PRC (PseudoRange Correction), which is added directly to the satellite computed model, and a sigma or UDREI (User Differential Range Error Indicator) for the correction. The distribution of corrections sent are as follows:

  - Message type 2: Corrections from satellite 1 to 13 in the PRN mask.
  - Message type 3: Corrections from satellite 14 to 26 in the mask.
  - Message type 4: Corrections from satellite 27 to 39 in the mask.
  - Message type 5: Corrections from satellite 40 to 51 in the mask.

  Message type 6 sends only the sigmas for the 51 satellites in the mask. Each time this message arrives, it is considered that PRC for all satellites remain constant, while the sigmas are updated.

  Messages type 2, 3 ,4 ,5 will have each one an IODF (Issue Of Data Fast corrections), independent from each other-, value which will change every time a PRC changes. The IODFs in message type 6 must match the ones sent in messages type 2, 3, 4, 5. If a message type 6 is received and the IODFs do not match with the ones in messages type 2, 3, 4, 5, then the user must ignore message type 6 until new messages type 2, 3, 4 and 5 with the new IODFs are received.

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Time-outs for all satellite fast correction are independent from each other. These time-outs are sent in message type 7 (but are typically set to 6 seconds). If user sets a time-out for fast corrections, then all satellites will have the same time-out (message type 7 will be ignored).

NOTES:

- When a message type 6 is received, as a sigma is received for all satellites, time-outs for all satellites are reset (except for the case that IODFs do not match, which in this case user must ignore message type 6).
- If a message type 6 is received and the IODFs do not match, but one or more IODFs have a value of 3 (IODF in normal conditions only have values from 0 to 2), then any satellite under this IODF is under alarm condition. In this condition, the sigma (UDREI) from message type 6 must be used, but the timeout of the fast corrections must be computed using the epoch of the last message type 2, 3, 4 or 5 (the one associated with that IODF).
- If an UDREI with value 14 or 15 is received, then the satellite must not be used for ranging, and all other previous fast corrections received from this satellite must be erased. An UDREI=14 means that the satellite is not monitored, and UDREI=15 means that the satellite must not be used.
- Fast correction messages have an IODP, which must match with the one received in the message type 1 (PRN mask). If they don't match, these messages cannot be decoded.

- **RRC Corrections:** RRC (Range-Rate Corrections) are not sent by the SBAS system. The user has to compute them using the PRC (PseudoRange Correction) provided in messages type 2, 3, 4, 5 and 24. The formula to compute the RRC correction is:

$$RRC(t) = (PRC_{current} - PRC_{previous})/\Delta t \cdot (t-t_{of})$$

Where:

$PRC_{current}$: The most recent fast correction received.

$PRC_{previous}$: The previous fast correction received.

t: The current epoch.

Δt: tof - tof,previous

t_{of}: Time of applicability of the most recent fast correction received.

$t_{of,previous}$: Time of applicability of the previous fast correction received.

Time of applicability: Is the epoch where the first bit of the message was sent in the SBAS GEO

RRC corrections must time-out if any of these conditions are met:

$$\Delta t > I_{fc} \text{ OR } (t - t_{of} - 1) > 8 \cdot \Delta t$$

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Where:

I_{fc}: Is the shortest time-out of all satellites included in a fast correction message.

t: The current epoch.

Δt : tof - tof,previous

t_{of} : Time of applicability of the most recent fast correction received.

$t_{of,previous}$: Time of applicability of the previous fast correction received.

When user sets a time-out for RRC corrections, the conditions stated above will also be evaluated, but with I_{fc} set to the user's value.

NOTES:

- When a IODF with value 3 is received (satellite under alarm), then, instead of using the previous PRC correction, the user should search for the PRC closest to Ifc/2 seconds prior to the last PRC received and has not timed-out (this is to minimize the noise effect in RRC, as during an alarm, it is likely that fast corrections will be updated very frequently).
- EGNOS system does not implement the alarm for fast corrections (no IODF=3 will be sent), but WAAS system does have it.

- **RRC Corrections:** RRC (Range-Rate Corrections) are not sent by the SBAS system. The user has to compute them using the PRC (PseudoRange Correction) provided in messages type 2, 3, 4, 5 and 24. The formula to compute the RRC correction is:
- **Integrity Info:** Message type 6. This message transmits the sigma or UDREI (User Differential Range Error Indicator) for the 51 monitored satellites, along with IODF (Issue of Data Fast corrections) of messages type 2, 3, 4, 5. If IODFs in message type 6 does not match with the ones of messages type 2, 3, 4 and 5, then the user is aware that he has lost a fast correction message, and will have to keep using the PRC and UDREIs from the last messages type 2, 3, 4 and 5.

  If IODFs match, then the user updates the UDREIs of all satellites and resets the time-outs for messages type 2, 3, 4 and 5, as message type 6 indicates that the PRC of all satellites have not changed.

  NOTE: This message has an IODP, which must match with the one received in the message type 1 (PRN mask). If they don't match, it cannot be decoded.
- **Fast Correction Degradation Factor:** Message type 7. This message contains the time-out to be applied to each of the 51 monitored satellites, as well as the system latency (tlat) value, used for computing the fast correction degradation.

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NOTE: This message has an IODP, which must match with the one received in the message type 1 (PRN mask). If they don't match, it cannot be decoded.

- **GEO Navigation Message:** Message type 9. This message contains the navigation message for one SBAS GEO. It can be used to compute the GEOs position and clock correction if it used in the navigation solution. With this message a RINEX navigation for GEOs (type H) can be generated (actually, when converting a RINEX-B or EMS to Pegasus format with gLAB, the RINEX navigation message is generated).

  NOTE: GEO navigation message include a URA (User Range Accuracy) index. If URA index is 15 or greater, then the GEO should not be used for ranging.

- **Degradation Parameters:** Message type 10. This message contains a series of values necessary to compute the degradation terms for all corrections. If PA navigation mode is selected, and this message is not available, no SBAS correction is available, but if option Disable Message Type 10 (Degradation parameters) is enabled or navigation mode is NPA, then a SBAS correction will be computed, but the fast and long term corrections degradation will be greatly increased. In concrete, if message type 10 is available, the fast and long term corrections degradation is computed with the following formula:

  If RSS_{UDRE} = 0 (from message type 10):

  $$\sigma^2_{flt} = (\sigma_{UDRE} \cdot \delta_{UDRE} + \varepsilon_{fc} + \varepsilon_{rrc} + \varepsilon_{ltc} + \varepsilon_{er})^2$$

  If RSS_{UDRE} = 1 (from message type 10):

  $$\sigma^2_{flt} = (\sigma_{UDRE} \cdot \delta_{UDRE})^2 + \varepsilon^2_{fc} + \varepsilon^2_{rrc} + \varepsilon^2_{ltc} + \varepsilon^2_{er}$$

  Where:

  RSS_{UDRE}: Root Sum Square flag in message type 10.

  σ_{UDRE}: Sigma received in fast corrections messages type 2-6.

  δ_{UDRE}: σUDRE factor computed from message type 27 or 28.

  ε_{fc}: Degradation parameter for fast correction data.

  ε_{rrc}: Degradation parameter for range rate correction data.

  ε_{ltc}: Degradation parameter for long term correction or GEO navigation message data.

  ε_{er}: Degradation parameter for en route through NPA applications.

  If message type 10 is not available (in NPA mode only), or is disabled with the option Disable Message Type 10 (Degradation parameters), the fast and long term corrections degradation is computed with the following formula:

  $$\sigma^2_{flt} = (\sigma_{UDRE} \cdot \delta_{UDRE} + 8)^2$$

  NOTES:

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- All units for all elements in the formulas above are in metres (except for δUDRE, which is adimensional)
- See MOPS for details on how to compute the degradation terms.

- **Network Time Parameters:** Message type 12. This message contains time parameters in UTC to synchronize receiver time. It is decoded but not used in gLAB, as time is set by the RINEX observation file.
- **GEO Satellite Almanacs:** Message type 17. This message contains the almanac for the SBAS GEO transmitting signals. This message allows the user be aware of all the SBAS GEO available, and also compute a rough position of each GEO (this is useful if user wants to use the GEO with highest elevation in the minimum time possible).

  NOTE: The timeout of 9999999 seconds is to indicate an infinite timeout.
- **Ionospheric Grid Points Mask:** Message type 18. In order to provide a ionospheric model for users, MOPS defines a (irregular) grid of points covering all the world, and the SBAS providers must trnasmit then which points of this grid are they monitoring, and send the ionospheric delay estimation and its sigma to the user. As the number of points is too large to be transmitted in a single message, the points are divided in 11 bands (9 vertical and 2 horizontal). Each band will have a given number of points,and only some of the points in a band may be monitorized.

  To inform the user which grid points are monitorized, each message type 18 will send the number of bands monitored, and a mask of 201 bits (each bit corresponds to one point). If the bit is 1, then the grid point is monitored. The conversion from the bit position to the grid point is fixed. It is explained in MOPS document.

  All band mask have the same associated IODI (Issue of Data Ionosphere), which will only change if the monitored IGPs change in any of the bands (which will be rare).

  NOTE: In the first version of MOPS there were no horizontal bands. They were added in MOPS-B due to the few amount of grid points at high latitudes in the vertical bands.
- **Long Term Satellite Corrections:** Message type 25. This message contains corrections to orbit coordinates and clock correction. This correction is tied to a specific GPS navigation message, which is uniquely identified by the IODE (Issue Of Data Ephemerides) field. If the user cannot find a navigation message with the same IODE as in the message type 25, then no SBAS correction can be computed. If the IODE matches, the computed corrections (clock and orbit corrections) have to be added directly to the orbit and clock values computed with the navigation message.

  NOTES:

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- Long term correction messages have an IODP, which must match with the one received in the message type 1 (PRN mask). If they don't match, this messages cannot be decoded.
- For SBAS GEOs, no corrections are sent, as message type 9 is the navigation message for GEOs, which already include the necessary corrections.

- **Ionospheric Delay Corrections:** Message type 26. This message contains the ionospheric delay estimations and its sigma. As explained in message type 18 tooltip, the grid points are divided into maps in order to be sent to the user. Therefore, each message type 26 will have a band number indicator. Furthermore, all the corrections for all the grid points monitored in a band do no fit in a single message type 18, so tthe corrections are sent by blocks identified by the "Block ID" in the message.

  Only the corrections for the monitored grid points monitored are given, and they are sent in the same order as they appear in the band mask sent in message type 18.

  NOTE: All messages type 26 have an IODI (Issue of Data Ionosphere), which must match with the one given in message type 18 in order to decode the message. If the IODI does not match, the user must save the message and wait to receive the band mask with the right IODI in order to decode message type 26.

- **Service Message:** Message type 27. This message contains data for computing the σ_{UDRE} for the fast and long term correction degradation. The σ_{UDRE} is a adimensional factor that multiplies the σ_{UDRE} received in the fast correction message (see Degradation Parameters tooltip above). This factor will never be smaller than 1, and can be computed in two ways (one way is with message type 27, and the other with message type 28). The way to compute the σ_{UDRE} is decided by the SBAS service provider. For the case that the service provider sends message type 27:

  A series of regions are defined in this message (which can be squared or triangular, and can be split in several message type 27), along with values of the σ_{UDRE} inside and outside of these regions. The user must select the appropiate σ_{UDRE} value according to his position and the regions defined.

  NOTES:

  - EGNOS system sends message type 27 for computing the σ_{UDRE}.
  - SBAS service providers can only send either message type 27 or 28, but not both. If user receives both messages, a σ_{UDRE} equal to 1 will be used.

- **Clock Ephemeris Covariance Matrix:** Message type 28. This message contains data for computing the σ_{UDRE} for the fast and long

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term correction degradation. The σ_{UDRE} is an adimensional factor that multiplies the σ_{UDRE} received in the fast correction message (see Degradation Parameters tooltip above). This factor will never be smaller than 1, and can be computed in two ways (one way is with message type 27, and the other with message type 28). The way to compute the σ_{UDRE} is decided by the SBAS service provider. For the case that the service provider sends message type 28:

For each satellite a covariance matrix from which the σ_{UDRE} can be computed. This covariance matrix can be updated at the same rate of the slow corrections.

NOTES:

- WAAS system sends message type 28 for computing the σ_{UDRE}.
- SBAS service providers can only send either message type 27 or 28, but not both. If user receives both messages, a σ_{UDRE} equal to 1 will be used.

- **Show Message Time-outs (SBAS DFMC):**
  - **Do Not Use for Safety Applications:** Message type 0. This message to inform the user that there is a problem in the GEO that has sent this message. When the user receives this message, an alarm is triggered, and the user has to erase all information received from this GEO (except for the almanac), and also wait for one minute until the user can start using this GEO again (during this minute of cooldown, all messages from this GEO must be ignored).

    NOTES:

    - The alarm is triggered just after reading the message
    - If user has enabled the option Parse Alarm Message as Type 34/35/36 Message, then this message will be read as a type 34/35/36 messages (no alarm triggered), except for the case that this message is filled with all zeros, which means that the user is forced to read it as an alarm message.
    - If user has enabled the option Ignore All Alarm Messages, then this message will be ignored and no alarm will be triggered.
    - When an alarm is triggered, after the cooldown minute, the GEO acquisition time will be restarted.
    - The time-out of 9999999 seconds is to indicate that is has an infinite time-out (due to, as explained above, the message is applied instantaneously).

- **Satellite Mask:** Message type 31. This message has 214 ordered slots, each one corresponding to a given satellite PRN and constellation. Each slot is one bit, if the bit is 1, the satellite is monitored, otherwise the satellite is not monitored. This set of ordered slots is called the PRN mask. The order is

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important, as the order of the monitored satellites in the mask will be the order in which the corrections will be sent in other messages. Currently, the slots are assigned in the following way:

- Slots 1- 37: For GPS satellites. Slots 33 to 37 are GPS reserved slots.
- Slots 38- 74: For GLONASS satellites (GLONASS PRN +37). Slots 70 to 74 are GLONASS reserved slots.
- Slots 75- 111: For Galileo satellites (Galileo PRN +74). Slot 111 is Galileo reserved slot.
- Slots 112- 119: Spare bits.
- Slots 120- 158: For SBAS satellites (bit slot matches SBAS GEO PRN).
- Slots 159- 195: For BeiDou satellites (BeiDou PRN +158).
- Slots 196- 214: For future GNSS satellites.

NOTES:

- Each message has an IODM (Issue Of Data Mask), which identifies each mask. If any bits of the mask changes, the IODM will change (which will be rare).
- The maximum number of concurrent monitored satellites is 92 (including all constellations), due to the limited space in the SBAS messages. Mask messages with more than 92 satellites monitored will be rejected by gLAB.
- All messages that need a mask (to get the order for the satellite corrections), they will also have an IODM associated. Thence, the user must have the mask with the given IODM in order to read the message.
- When a mask change occurs (a mask with a different IODM), the user will have to save the previous mask and also all messages associated to the old IODM until new corrections with the new IODM are received or the old corrections time-out. This assures that a mask transition is smooth and there is continuity of corrections. In practice, SBAS providers usually prefer to send alarm messages during some minutes when a mask change occurs, to force the user clear all the data and switch to another GEO.

- **Clock Ephemeris Corrections and Covariance Matrix:** Message type 32 is sent for each monitored satellite, and each message contains information only for one satellite. This message contains the orbit and clock corrections related to a specific navigation message, identified by the IODN (Issue Of Data Navigation), matching in each constellation:
  - **GPS**: IODN matches the L1 LNAV broadcast IODC (Issue Of Data Clock).
  - **Galileo**: IODN matches the E5a F/NAV IODnav (Issue Of Data Navigation).

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- **SBAS**: IODN matches the E1 CNAV IODG (Issue Of Data GEO).
- Message type 32 also contains the DFREI (Dual Frequency Range Error Indicator), the parameters to compute the clock-ephemeris covariance matrix and the δRCORR multiplier (to be used with RCORR parameter in message type 37 -OBAD Parameters and DFREI Scale Table- for sigma degradation computation).

NOTE: The SBAS satellite sending the corrections, if it is providing a ranging service, it will send messages type 39/40 (SBAS Satellite Ephemeris Corrections and Covariance Matrix) instead of message type 32 for its ephemeris and covariance matrix parameters.

- **Integrity Messages**: Integrity corrections are given in messages type 34, 35 and 36. Messages type 34, 35, and 36 send DFRECI (Dual Frequency Range Error Change Indicator) for all satellites in the mask (92 DFRECI) and 7 DFREI (Dual Frequency Range Error Indicator). DFREI value is used to get the σ_{DFRE} using a conversion table sent in message type 37 (*OBAD Parameters and DFREI Scale Table*).
  DFRECI is a flag to indicate if the DFREI has changed, occupies 2 bits each and can have the following values:
  - **0**: DFREI has not changed (only when 0 ≤ DFREI ≤ 14).
  - **1**: DFREI value is changed (only when 0 ≤ new DFREI ≤ 14), and that the corresponding new DFREI value is transmitted within the DFREI section of the message (type 34).
  - **2**: DFREI is increased by 1 index (bump) (if the current DFREI value is 15, then the bumped DFREI value remains at 15).
  - **3**: Satellite corresponding to the Augmented Slot Index is set to "Not for use in SBAS mode".

  Messages type 35 and 36 just send the DFREI values for all satellites. Message type 35 sends DFREI for slots 1 to 53, while message type 36 sends DFREI for slots 54 to 92.

  Message type 34 is used to reduce bandwidth, as in many cases DFREI values on satellites will not change all at the same time. If 7 or less satellite DFREI change at a given time (changes different from being increased by 1), a message type 34 is enough to refresh all satellites sigmas.

  Moreover, DFREI is also sent within message type 32 (*Clock Ephemeris Corrections and Covariance Matrix*), which can be used to refresh a few more DFREI along with MT34 if time constraints are met. Otherwise, messages type 35 and 36 are sent with new DFREI values of all satellites.

  All three messages type 34, 35 and 36 send an IODM which must match with the one sent in message type 31 (*Satellite Mask*), otherwise these messages

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cannot be decoded.

The DFC (Dual Frequency Corrections) sigma is computed with the following formula:

$$\sigma^2_{DFC} = (\sigma_{DFRE} \cdot \delta_{DFRE})^2 + \varepsilon_{corr}^2 + \varepsilon_{er}^2$$

Where:

- $\boldsymbol{\sigma_{DFRE}}$: The sigma provided through DFREI parameters in MT 34/35/36.
- $\boldsymbol{\delta_{DFRE}}$: Factor dependent on user location computed from the covariance matrix, which is broadcast in MT 32 or MT 40 (the latter only for the SBAS satellite broadcasting the correction and integrity data in use).
- $\boldsymbol{\varepsilon_{corr}^2}$: Degradation parameter for the SBAS DFMC corrections.
- $\boldsymbol{\varepsilon_{er}^2}$: Degradation parameter for NPA (Non Precision Approach) applications.

- **OBAD Parameters and DFREI Scale Table:** Message type 37. This message sends the common (all constellation) OBAD (Old But Active Data) parameters (IVALID, CER, CCOVARIANCE) and three OBAD parameters (ICORR, CCORR, RCORR) for each constellation. These parameters are used for computing the degradation parameters for σDFC.

  Message type 37 also sends the conversion table for each value of the DFREI (Dual Frequency Range Error Indicator) to σDFRE in metres (for DFREI values from 0 to 14, as value 15 means to not use the satellite).

- **SBAS Satellite Ephemeris Corrections and Covariance Matrix:** Messages type 39 and 40 send a full set of Keplerian parameters, along with the covariance matrix parameters.

  This message is only sent for the SBAS satellite sending the corrections (it uses this message instead of message type 32 -*Clock Ephemeris Corrections and Covariance Matrix*-) and only if it is providing ranging service. If no ranging service is provided, then no message type 32, 39 or 40 is sent for the SBAS satellite sending the corrections.

  NOTE: As messages type 39 and 40 send a full set of Keplerian parameters, it allows to handle different types of orbits, like IGSO (Inclined Geo-Synchronous Orbit), HEO (High Earth Orbit), MEO (Medium Earth Orbit) or GEO (Geostationary Earth Orbit).

- **GNSS Time Offsets:** Message type 42. This message contains time parameters to synchronize each constellation time and UTC to SNT (SBAS Network Time). It is decoded but not used in gLAB, as time is set by the RINEX observation file.

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NOTE: This message was defined in ED-259 v0.3, but later undefined (set as reserved) in ED-259 v0.9.

- **SBAS Satellites Almanacs:** Message type 47. This message contains the almanac for the SBAS satellites broadcasting signals. This message allows the user to be aware of all the broadcasting SBAS satellites available, and also compute a rough position of each SBAS satellite (this is useful if user wants to use the SBAS satellite with highest elevation in the minimum time possible).

  Each message contains the almanac for two SBAS satellites.

- **Show SBAS 1F Advanced Options**
  - **Parse Alarm Message as Type 2 Message:** In GEOs in test mode, alarm messages (message type 0) may also contain the same data as message type 2 (fast corrections), although the integrity of the corrections are not guaranteed.

    If this option is enabled, Alarm messages will read as a fast correction (no alarm is triggered), except for the case that the message is filled with zeros, where MOPS states that in this case it must be treated as an alarm message.

  - **Ignore All Alarm Messages:** If this option is enabled, alarm messages (message type 0) will be skipped. Therefore, no alarms will be triggered.

  - **Allow Klobuchar Ionosphere During Coordinate Convergence:** If receiver position is set to Calculate (see *A Priori Receiver Position From* in the Input section), gLAB will need to compute the receiver coordinates, starting from the Earth's surface, or the RINEX observation position or the user provided coordinates. In either case, it will probably occur that during the coordinate convergence, the ionosphere pierce points of the satellites are out of the coverage area of the current SBAS provider. In this case, if navigation mode switching is disabled (which is the default), no satellites will be available due to the lack of ionosphere, so no solution will be computed.

    To overcome this issue, during the convergence of the coordinates, Klobuchar ionosphere model will be allowed.

    NOTES:

    - This option also applies when using SBAS ionosphere model but without SBAS processing (e.g. SPP with SBAS ionosphere).
    - The coordinates are considered to be converged when the current solution and the previous one differ in less than 100 metres.

  - **Discard Satellites over a given UDREI:** UDREI (User Differential Range Error Indicator) is provided in the fast corrections messages, giving an estimation of the satellite sigma. With this option, satellites with an UDREI equal or higher than the value provided will be discarded.

    The conversion between UDREI and its values in metres is in the following table (from MOPS-D):

$UDREI_i$	$UDREI_i$ (metres)	$\sigma^2_{i,UDRE}$ (metres)^2
0	0.75	0.0520
1	1.0	0.0924

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2	1.25	0.1444
3	1.75	0.2830
4	2.25	0.4678
5	3.0	0.8315
6	3.75	1.2992
7	4.5	1.8709
8	5.25	2.5465
9	6.0	3.3260
10	7.5	5.1968
11	15.0	20.7870
12	50.0	230.9661
13	150.0	2078.695
14	Not Monitored	Not Monitored
15	Do Not Use	Do Not Use

NOTES:

- In PA and NPA modes, gLAB will discard any satellites with UDREI 14 (Not Monitored) or 15 (Do Not Use) independently if this option is enabled or not.
- In PA mode, if UDREI is greater than 12, gLAB will automatically discard the satellite independently if this option is enabled or not or the value set in this option.

- **Sigma offset if MT10 is not used:** If message type 10 is not available (in NPA mode only), or is disabled with the option Disable Message Type 10 (Degradation parameters), the fast and long term corrections degradation is computed with the following formula:

$$\sigma^2_{flt} = (\sigma_{UDRE} \cdot \delta_{UDRE} + 8)^2$$

With this option, the fixed offset '8' in the formula above can be changed to any value.

NOTES:

- All units for all elements in the formulas above are in metres (except for σ_{UDRE}, which is adimensional).
- See MOPS for details on how to compute the degradation terms.

- **SBAS Signal Flight Time:** Set the SBAS signal flight time of each message read (default flight time applied is 0.12 seconds). This value overrides any flight time read in RINEX-B or EMS files.

When the signal flight time is greater than zero, the SBAS message si delayed by the signal flight time, and therefore the process of the SBAS message will be delayed until the epoch where the last bit of the message has arrived.

For instance, with a 1Hz receiver:

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- Message with RINEX-B timestamp (referred to first bit of the message) of 10:00:00.1:
  - **With 0.12 seconds signal flight time:** Message will be processed at epoch 10:00:02.
  - **With 0 seconds signal flight time**: Message will be processed at epoch 10:00:01.
- Message with EMS timestamp (referred to last bit of the message) of 10:00:00:
  - **With 0.12 seconds signal flight time:** Message will be processed at epoch 10:00:01.
  - **With 0 seconds signal flight time**: Message will be processed at epoch 10:00:00.

- **GEO & Mode Switch Options:**
  - **After GEO switch, Maintain the New Selected GEO:** After a successful GEO switch, if this option is enabled, the new GEO will be maintained as long as possible. Otherwise, gLAB will try to switch to the previous GEO (which may not be the initial one if consecutive GEO switches have been done) or to the initial one (if Return to Initial GEO option is enabled) after the switching cool time has expired.

    NOTE: If both options Return to Initial GEO and After GEO Switch, Maintain the New Selected GEO are enabled, the former will prevail (in the GUI these options are exclusive, but in command line both options can be enabled).
  - **Return to Initial GEO:** After a successful GEO switch, if this option is enabled, gLAB will try to switch to the initial GEO after the switching cool time has expired. If it is not possible, it will keep trying every time the switching cool time has expired.

    NOTE: If both options Return to Initial GEO and After GEO Switch, Maintain the New Selected GEO are enabled, the first one will prevail (in the GUI these options are exclusive, but in command line both options can be enabled).
  - **GEO Acquisition Time:** In a cold start, it takes some time since the receiver starts gathering messages from the SBAS GEO until it has enough data to compute SBAS corrections. This is the GEO acquisition time.

    gLAB will not make a GEO or mode switch if no solution could be computed during the acquisition time, as the cause is that we do not have enough data (so switching mode or GEO will be useless, as at the beginning of the processing, all GEOs available are under acquisition time). Furthermore, if a GEO switch is triggered, gLAB will not change to a GEO which is under acquisition time (except if we are switching GEO due to an alarm message and the GEO under acquisition time is the only one available).

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NOTE: GEO acquisition time is reset every time an alarm is received, and it will be started again when the first message is read after the one minute cooldown (when an alarm is received, the user must ignore during one minute all messages from the GEO that received the alarm).

- **Switching Cool time:** Each time a GEO or mode switch is triggered, gLAB will not try another GEO or mode switch after the switching cool time has expired. This to avoid constant switches during consecutive epochs, and also to permit the current (or previous) GEO used to gather more messages, so in the following mode or GEO switch there are higher possibility that a navigation solution can be computed after doing the switch.

  In other words, the switching cool time is the countdown between consecutive GEO or mode switches in order to allow the GEO data to be updated.

  NOTES:

  - If switching cooldown is set to 0, a maximum of fifty switches (counting both GEO and navigation mode) per epoch will be allowed during one epoch, in order to prevent infinite loops.
  - If option 'Select Best GEO' is enabled, this option will automatically be set to 0, as in one epoch there will be multiple GEO changes.

- **Show K factor values:**
  - **K_H PA:** The horizontal protection level is computed with the following formula:

    $$K \cdot d_{major}$$

    $K \cdot d_{major}$ corresponds to the semimajor axis of the error ellipse, and is obtained using a formula from Appendix J in MOPS-D, which uses values computed from the matrix $(GWG)^{-1}$.

    K is the factor for bounding the error with a given probability, which is fixed in Appendix J of MOPS-D. The value is dependent on the navigation mode (PA or NPA). The default K factor for the horizontal component in PA mode is 6 (assuming a Normal distribution in one dimension, it corresponds to a probability of $2 \cdot 10^{-9}$).

  - **K_V PA:** The vertical protection level is computed with the following formula:

    $$K \cdot d_u$$

    d_u corresponds to the error in the UP component, and is obtained using a formula from Appendix J in MOPS-D, obtained from the matrix $(GWG)^{-1}$.

    K is the factor for bounding the error with a given probability, which is fixed in Appendix J of MOPS-D. The value is dependent on the navigation mode (PA or NPA). The default K factor for the vertical

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component in PA mode is 5.33 (assuming a Normal distribution in one dimension, it corresponds to a probability of $1 \cdot 10^{-7}$).

- **K_H NPA:** The horizontal protection level is computed with the following formula:

  $$K \cdot d_{major}$$

  d_{major} corresponds to the semimajor axis of the error ellipse, and is obtained using a formula from Appendix J in MOPS-D, which uses values computed from the matrix $(GWG)^{-1}$.

  K is the factor for bounding the error with a given probability, which is fixed in Appendix J of MOPS-D. The value is dependent on the navigation mode (PA or NPA). The default K factor for the horizontal component in NPA mode is 6.18 (assuming a Rayleigh distribution in two dimensions, it corresponds to a probability of $2 \cdot 10^{-9}$).

  NOTE: The assumption of Rayleigh distribution in two dimensions and the probability of $5 \cdot 10^{-9}$ is detailed in MOPS-C.

- **K_V NPA:** The vertical protection level is computed with the following formula:

  $$K \cdot d_u$$

  d_u corresponds to the error in the UP component, and is obtained using a formula from Appendix J in MOPS-D, obtained from the matrix $(GWG)^{-1}$.

  K is the factor for bounding the error with a given probability, which is fixed in Appendix J of MOPS-D. The value is dependent on the navigation mode (PA or NPA). The default K factor for the vertical component in PA mode is 5.33 (assuming a Normal distribution in one dimension, it corresponds to a probability of $1 \cdot 10^{-7}$).

- **Show Disable Specific Messages:**
  - **Disable Fast Corrections:** Fast corrections will be set to zero, but the conditions to apply a fast correction must be fulfilled (if they are not fulfilled, fast corrections will be declared as not available). This would be equivalent as if the correction received from the SBAS message was zero.

    NOTE: RRC corrections will also be set to 0 if this option is enabled (range rate corrections are for taking into account the variation of the fast corrections in time. If fast corrections are zero, their variation in time will also be zero).

  - **Disable RRC Corrections:** Range Rate Correction will be set to zero, but the conditions to apply a range rate correction must be fulfilled (if they are not fulfilled, RRC corrections will be declared as not available).

  - **Disable Slow Corrections:** Slow corrections will be set to zero, but the conditions to apply a slow correction must be fulfilled (if they are not fulfilled, slow corrections will be declared as not available). This would

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be equivalent as if the correction received from the SBAS message was zero.

- **Disable Ionosphere Corrections:** Ionosphere correction will be set to zero, but the conditions to apply a ionosphere correction must be fulfilled (if they are not fulfilled, ionosphere corrections will be declared as not available). This would be equivalent as if the correction received from the SBAS message was zero.

  NOTE: If the user want to apply a ionosphere model different from SBAS or no ionosphere model (effectively ignoring messages type 18 and 26), the user should leave this option unchecked and set the appropriate ionosphere model in the Ionospheric Correction option.

- **Show Disable Specific Sigmas**
  - **Disable Fast Corrections Sigma and Degradation term:** Set σ_{UDRE} and ε_{fc} to 0 if they are applied (see Degradation Parameters tooltip in Message Time-outs groupbox). RRC degradation term (ε_{rrc}) will be also set to 0, as a RRC degradation term is tied to fast corrections). The conditions to apply a fast correction must be fulfilled (if they are not fulfilled, fast corrections will be declared as not available).

    NOTE: If all sigmas and degradation terms are set to 0, the total sigma computed for the satellite will be 0. In this case, gLAB will use a sigma of 1 centimetre to avoid division by zero.

  - **Disable Fast Corrections Sigma and Degradation term:** Set ε_{rrc} to 0 if it is applied (see Degradation Parameters tooltip in Message Time-outs groupbox). The conditions to apply a range rate correction must be fulfilled (if they are not fulfilled, RRC corrections will be declared as not available).

    NOTE: If all sigmas and degradation terms are set to 0, the total sigma computed for the satellite will be 0. In this case, gLAB will use a sigma of 1 centimetre to avoid division by zero

  - **Disable Slow Corrections Degradation term:** Set ε_{ltc} to 0 if it is applied (see Degradation Parameters tooltip in Message Time-outs groupbox). The conditions to apply a slow correction must be fulfilled (if they are not fulfilled, slow corrections will be declared as not available).

    NOTE: If all sigmas and degradation terms are set to 0, the total sigma computed for the satellite will be 0. In this case, gLAB will use a sigma of 1 centimetre to avoid division by zero.

  - **Disable Ionosphere Sigma:** Set the satellite's computed ionosphere sigma (σionosphere) to 0. The conditions to apply a ionosphere correction must be fulfilled (if they are not fulfilled, ionosphere corrections will be declared as not available).

    NOTE: If all sigmas and degradation terms are set to 0, the total sigma computed for the satellite will be 0. In this case, gLAB will use a sigma of 1 centimetre to avoid division by zero.

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- **Disable Troposphere Sigma:** Set the satellite's computed troposphere sigma (σtroposphere) to 0.

  NOTE: If all sigmas and degradation terms are set to 0, the total sigma computed for the satellite will be 0. In this case, gLAB will use a sigma of 1 centimetre to avoid division by zero.

- **Disable En Route Through NPA Degradation Term:** Set ε_{er} to 0 if it is applied (see Degradation Parameters tooltip in Message Time-outs groupbox). The conditions to apply a fast or slow correction must be fulfilled (if they are not fulfilled, they will be declared as not available).

  NOTE: If all sigmas and degradation terms are set to 0, the total sigma computed for the satellite will be 0. In this case, gLAB will use a sigma of 1 centimetre to avoid division by zero.

- **Show SBAS DFMC Advanced options:**
  - **Parse Alarm Message as Type 34/35/36 Messages:** In GEOs in test mode, alarm messages (message type 0) may also contain the same data as messages type 34/35/36 (integrity messages), although the integrity of the corrections are not guaranteed.

    If this option is enabled, Alarm messages will read as a fast correction (no alarm is triggered), except for the case that the message is filled with zeros, where it will be treated as an alarm message.

    This behaviour is not implemented in ED-259, but it is an extension made in the Australian test bed.

    NOTE: Message types are distinguished by using the two spare bits in positions 222 and 223. Value "00", correspond to MT0, value "01" correspond to MT34, "10" to MT35 and "11" to MT36.

  - **Ignore All Alarm Messages:** If this option is enabled, alarm messages (message type 0) will be skipped. Therefore, no alarms will be triggered.

  - **Allow to Use None MOPS Measurements:** In SBAS DFMC, the ED-259 standard states that the following measurements must be used:

    - **GPS L1**: C1C and L1C.
    - **GPS L5**: C5Q and L5Q.
    - **Galileo E1:** C1C and L1C.
    - **Galileo E5a**: C5Q and L5Q.

    Depending on the RINEX observation file, C5I and L5I pair or C5X and L5X pair of measurements are available instead of C5Q and L5Q, which are not allowed by ED-259.

    By enabling this option, gLAB will use C5I or C5X whenever C5Q is not available instead of not computing any user navigation solution. This will slightly

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degrade the user navigation solution (as there is a bias between C5I or C5X with respect to C5Q).

- **SBAS Signal Flight Time:** Set the SBAS signal flight time of each message read (default flight time applied is 0.12 seconds). This value overrides any flight time read in RINEX-B or EMS files.

  When the signal flight time is greater than zero, the SBAS message si delayed by the signal flight time, and therefore the process of the SBAS message will be delayed until the epoch where the last bit of the message has arrived.

  For instance, with a 1Hz receiver:

  - Message with RINEX-B timestamp (referred to first bit of the message) of 10:00:00.1:
    - **With 0.12 seconds signal flight time:** Message will be processed at epoch 10:00:02.
    - **With 0 seconds signal flight time**: Message will be processed at epoch 10:00:01.
  - Message with EMS timestamp (referred to last bit of the message) of 10:00:00:
    - **With 0.12 seconds signal flight time:** Message will be processed at epoch 10:00:01.
    - **With 0 seconds signal flight time**: Message will be processed at epoch 10:00:00.

- **GEO & Mode Switch Options:**
  - **After GEO switch, Maintain the New Selected GEO:** After a successful GEO switch, if this option is enabled, the new GEO will be maintained as long as possible. Otherwise, gLAB will try to switch to the previous GEO (which may not be the initial one if consecutive GEO switches have been done) or to the initial one (if Return to Initial GEO option is enabled) after the switching cool time has expired.

    NOTE: If both options Return to Initial GEO and After GEO Switch, Maintain the New Selected GEO are enabled, the former will prevail (in the GUI these options are exclusive, but in command line both options can be enabled).
  - **Return to Initial GEO:** After a successful GEO switch, if this option is enabled, gLAB will try to switch to the initial GEO after the switching cool time has expired. If it is not possible, it will keep trying every time the switching cool time has expired.

    NOTE: If both options Return to Initial GEO and After GEO Switch, Maintain the New Selected GEO are enabled, the first one will prevail

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(in the GUI these options are exclusive, but in command line both options can be enabled).

- **GEO Acquisition Time:** In a cold start, it takes some time since the receiver starts gathering messages from the SBAS GEO until it has enough data to compute SBAS corrections. This is the GEO acquisition time.

  gLAB will not make a GEO or mode switch if no solution could be computed during the acquisition time, as the cause is that we do not have enough data (so switching mode or GEO will be useless, as at the beginning of the processing, all GEOs available are under acquisition time). Furthermore, if a GEO switch is triggered, gLAB will not change to a GEO which is under acquisition time (except if we are switching GEO due to an alarm message and the GEO under acquisition time is the only one available).

  NOTE: GEO acquisition time is reset every time an alarm is received, and it will be started again when the first message is read after the one minute cooldown (when an alarm is received, the user must ignore during one minute all messages from the GEO that received the alarm).

- **Switching Cool time:** Each time a GEO or mode switch is triggered, gLAB will not try another GEO or mode switch after the switching cool time has expired. This to avoid constant switches during consecutive epochs, and also to permit the current (or previous) GEO used to gather more messages, so in the following mode or GEO switch there are higher possibility that a navigation solution can be computed after doing the switch.

  In other words, the switching cool time is the countdown between consecutive GEO or mode switches in order to allow the GEO data to be updated.

  NOTES:

  - If switching cooldown is set to 0, a maximum of fifty switches (counting both GEO and navigation mode) per epoch will be allowed during one epoch, in order to prevent infinite loops.
  - If option 'Select Best GEO' is enabled, this option will automatically be set to 0, as in one epoch there will be multiple GEO changes.

- **Show K factor values:**

  - **K_H PA:** The horizontal protection level is computed with the following formula:

    $$K \cdot d_{major}$$

    $K \cdot d_{major}$ corresponds to the semimajor axis of the error ellipse, and is obtained using a formula from Appendix J in MOPS-D, which uses values computed from the matrix $(GWG)^{-1}$.

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K is the factor for bounding the error with a given probability, which is fixed in Appendix J of MOPS-D. The value is dependent on the navigation mode (PA or NPA). The default K factor for the horizontal component in PA mode is 6 (assuming a Normal distribution in one dimension, it corresponds to a probability of $2 \cdot 10^{-9}$).

- **K_V PA:** The vertical protection level is computed with the following formula:

  $$K \cdot d_u$$

  d_u corresponds to the error in the UP component, and is obtained using a formula from Appendix J in MOPS-D, obtained from the matrix $(GWG)^{-1}$.

  K is the factor for bounding the error with a given probability, which is fixed in Appendix J of MOPS-D. The value is dependent on the navigation mode (PA or NPA). The default K factor for the vertical component in PA mode is 5.33 (assuming a Normal distribution in one dimension, it corresponds to a probability of $1 \cdot 10^{-7}$).

- **K_H NPA:** The horizontal protection level is computed with the following formula:

  $$K \cdot d_{major}$$

  d_{major} corresponds to the semimajor axis of the error ellipse, and is obtained using a formula from Appendix J in MOPS-D, which uses values computed from the matrix $(GWG)^{-1}$.

  K is the factor for bounding the error with a given probability, which is fixed in Appendix J of MOPS-D. The value is dependent on the navigation mode (PA or NPA). The default K factor for the horizontal component in NPA mode is 6.18 (assuming a Rayleigh distribution in two dimensions, it corresponds to a probability of $2 \cdot 10^{-9}$).

  NOTE: The assumption of Rayleigh distribution in two dimensions and the probability of $5 \cdot 10^{-9}$ is detailed in MOPS-C.

- **K_V NPA:** The vertical protection level is computed with the following formula:

  $$K \cdot d_u$$

  d_u corresponds to the error in the UP component, and is obtained using a formula from Appendix J in MOPS-D, obtained from the matrix $(GWG)^{-1}$.

  K is the factor for bounding the error with a given probability, which is fixed in Appendix J of MOPS-D. The value is dependent on the navigation mode (PA or NPA). The default K factor for the vertical component in PA mode is 5.33 (assuming a Normal distribution in one dimension, it corresponds to a probability of $1 \cdot 10^{-7}$).

- **Show Set OBAD Parameters:**

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- **Set Cer OBAD Parameter from MT 37:** Message type 37 sends OBAD (Old But Active Data) parameters for computing degradation parameters (as described in *OBAD Parameters and DFREI Scale Table*). C_{er} is a common parameter to all constellations.

  With this parameter, C_{er} set by user (in metres) will be used instead of reading it from MT37.

  C_{er} is used for computing ε_{er} with the following formula:
  - $\varepsilon_{er} = 0$ when corrections have not timed out for PA mode.
  - $\varepsilon_{er} = C_{er}$ (metres) when corrections have timed out for PA mode but not for NPA mode.

- **Set Ccovariance OBAD Parameter from MT 37:** Message type 37 sends OBAD (Old But Active Data) parameters for computing degradation parameters (as described in *OBAD Parameters and DFREI Scale Table*). $C_{covariance}$ is a common parameter to all constellations.

  With this parameter, $C_{covariance}$ set by user (adimensional) will be used instead of reading it from MT37.

  $C_{covariance}$ is used for computing ε_c with the following formula:

  $$\varepsilon_c = C_{covariance} \cdot 2^{scale_exponent-5} \text{ (adimensional)}$$

  scale_exponent is a parameter transmitted in message type 32 (*Clock Ephemeris Corrections and Covariance Matrix*) along with the covariance matrix parameters.

- **Set Icorr OBAD Parameter from MT 37:** Message type 37 sends OBAD (Old But Active Data) parameters for computing degradation parameters (as described in *OBAD Parameters and DFREI Scale Table*). I_{corr} is a constellation based parameter.

  With this parameter, I_{corr} set by user (in seconds) will be used instead of reading it from MT37.

  I_{corr} is used for computing ε_{corr} with the following formula:

  $$\varepsilon_{corr} = \text{int}((t - t_{corr}) / I_{corr}) \cdot C_{corr} + (t - t_{corr}) \cdot R_{corr_sv}/1000 \text{ (metres)}$$

  Where:
  - **t**: Current time (seconds)
  - $\mathbf{t_{corr}}$: Time of applicability (in seconds) of the last received MT32 (or MT39/40 if it is the SBAS satellite sending the corrections).
  - $\mathbf{C_{corr}}$: OBAD parameter sent in message type 37 applicable for current constellation.
  - $\mathbf{R_{corr_sv}}$: Parameter computed with the following formula:

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- If $(t - t_{corr}) \leq I_{corr}$

  $R_{corr_sv} = R_{corr} \cdot \delta R_{corr}$ (mm/s)
- If $(t - t_{corr}) > I_{corr}$

  $R_{corr_sv} = R_{corr}$ (mm/s)

Where:

- **R_{corr}**: OBAD parameter sent in message type 37 applicable for current constellation.
- **δR_{corr}**: R_{corr} scale factor sent in message type 32 or 39/40 (different per each satellite).

As I_{corr} is a constellation based parameter, it can be provided as a unique value for all constellations or in a per constellation basis through the *Advanced* button on the right.

- **Set Ccorr OBAD Parameter from MT 37:** Message type 37 sends OBAD (Old But Active Data) parameters for computing degradation parameters (as described in *OBAD Parameters and DFREI Scale Table*). C_{corr} is a constellation based parameter.

  With this parameter, C_{corr} set by user (in metres) will be used instead of reading it from MT37.

  C_{corr} is used for computing ε_{corr} with the following formula:

  $$\varepsilon_{corr} = \text{int}((t - t_{corr}) / I_{corr}) \cdot C_{corr} + (t - t_{corr}) \cdot R_{corr_sv}/1000 \text{ (metres)}$$

  Where:

  - **t**: Current time (seconds)
  - **t_{corr}**: Time of applicability (in seconds) of the last received MT32 (or MT39/40 if it is the SBAS satellite sending the corrections).
  - **C_{corr}**: OBAD parameter sent in message type 37 applicable for current constellation.
  - **R_{corr_sv}**: Parameter computed with the following formula:
  - If $(t - t_{corr}) \leq I_{corr}$

    $R_{corr_sv} = R_{corr} \cdot \delta R_{corr}$ (mm/s)
  - If $(t - t_{corr}) > I_{corr}$

    $R_{corr_sv} = R_{corr}$ (mm/s)

  Where:

  - **R_{corr}**: OBAD parameter sent in message type 37 applicable for current constellation.
  - **δR_{corr}**: R_{corr} scale factor sent in message type 32 or 39/40 (different per each satellite).

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As C_{corr} is a constellation based parameter, it can be provided as a unique value for all constellations or in a per constellation basis through the *Advanced* button on the right.

- **Set Rcorr OBAD Parameter from MT 37:** Message type 37 sends OBAD (Old But Active Data) parameters for computing degradation parameters (as described in *OBAD Parameters and DFREI Scale Table*). R_{corr} is a constellation based parameter.

  With this parameter, R_{corr} set by user (in metres/second) will be used instead of reading it from MT37.

  R_{corr} is used for computing ε_{corr} with the following formula:

  $$\varepsilon_{corr} = \text{int}((t - t_{corr}) / I_{corr}) \cdot C_{corr} + (t - t_{corr}) \cdot R_{corr_sv}/1000 \text{ (metres)}$$

  Where:
  - **t**: Current time (seconds)
  - $\mathbf{t_{corr}}$: Time of applicability (in seconds) of the last received MT32 (or MT39/40 if it is the SBAS satellite sending the corrections).
  - $\mathbf{C_{corr}}$: OBAD parameter sent in message type 37 applicable for current constellation.
  - $\mathbf{R_{corr_sv}}$: Parameter computed with the following formula:
  - If $(t - t_{corr}) \leq I_{corr}$

    $$R_{corr_sv} = R_{corr} \cdot \delta R_{corr} \text{ (mm/s)}$$
  - If $(t - t_{corr}) > I_{corr}$

    $$R_{corr_sv} = R_{corr} \text{ (mm/s)}$$

  Where:
  - $\mathbf{R_{corr}}$: OBAD parameter sent in message type 37 applicable for current constellation.
  - $\mathbf{\delta R_{corr}}$: R_{corr} scale factor sent in message type 32 or 39/40 (different per each satellite).

  As R_{corr} is a constellation based parameter, it can be provided as a unique value for all constellations or in a per constellation basis through the *Advanced* button on the right.

- **Show Set DFREI Corrections:**
  - **Set one DFREI Sigma Conversion Value**: Manually set the conversion value to metres for one DFREI (Dual Frequency Range Error Indicator) value, ignoring the conversion formula defined in MT37 (OBAD Parameters and DFREI Scale Table) for the selected DFREI value only. This conversion value will be applied to all satellites of all constellations.

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If user needs to set the conversion value for more than one DFREI, then option below Set All DFREI Conversion Values must be used instead (which sets conversion value for all DFREI).

NOTE: In command line, it is possible to set conversion values for multiple DFREI by providing parameter '-model:sbasdfmc:dfrei' as many times as DFREI conversion values need to be set.

- **Set All DFREI Conversion Values:** Manually set conversion values to metres for all values of DFREI (Dual Frequency Range Error Indicator), ignoring the conversion formula defined in MT37 (*OBAD Parameters and DFREI Scale Table*).

  This option requires to set the conversion values for all values of DFREIs, therefore, a set of values are provided by default as a guidance to the user. These values correspond to the intermidiate value between the mininum and maximum values set in ED-259 (see tooltips for each DFREI for additional details).

- **Show Set Specific Sigmas:**
  - **Set Delta Rcorr Parameter:** Set the δRcorr (adimensional) for all satellites and constellations.

    When this option is set, δRcorr sent in message type 32 (Clock Ephemeris Corrections and Covariance Matrix) or message type 39/40 (SBAS Satellite Ephemeris Corrections and Covariance Matrix) will be ignored.

    See tooltip *Set Rcorr OBAD Parameter from MT 37* for details on how this parameter is applied.

  - **Set Delta DFRE Factor:** Set the δDFRE (Delta Dual Frequency Range Error) factor (adimensional) for all satellites and constellations instead of using the formula set in ED-259 (explained below).

    In ED-259, the following formula is used for computing δDFRE:

    $$\delta DFRE = \mathrm{sqrt}(IT \cdot C \cdot I) + \varepsilon c \text{ (adimensional)}$$

    Where:
    - $\mathbf{I}^T$: Tthe 4-D line of sight vector from the user to the satellite in the WGS-84 coordinate frame, where the first three components are the unit vector from the user to the satellite and the fourth component is a one.
    - **C**: The clock-ephemeris covariance matrix.
    - **εc**: Degradation parameter for δDFRE. See tooltip Set Ccovariance OBAD Parameter from MT 37 for details on how to compute this degradation factor.

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- **Set Sigma UIRE Value:** Set the σ_{UIRE} (sigma User Ionospheric Range Error) (in metres) instead of using the formula in ED-259 (explained below). This sigma is to account for the residual ionospheric error when a ionosphere-free combination is used.

  Ionosphere-free combination removes the first order ionospheric delay (responsible of around 99% of the ionospheric delay), therefore second or higher order ionospheric delay remain. These higher order terms are very small (millimetres), but can become none negligible in case of high ionospheric activity (e.g. ionospheric storm).

  The formula in ED-259 to compute σ_{UIRE} is the following:

  $$\sigma_{UIRE} = 40.0 / (261.0 + El_{deg}^2) +0.018 \text{ (in metres)}$$

  Where El_{deg} is the satellite elevation (in degrees).

- **Set Tropospheric Sigma:** Set the tropospheric sigma, σ_{tropo} (in metres) instead of using the formula in ED-259 (explained below). This sigma is to account for the tropospheric error.

  The formula in ED-259 to compute σ_{tropo} is the following:

  $$\sigma_{tropo} = \sigma_{TVE} \cdot m(El) \text{ (metres)}$$

  Where:
  - $\boldsymbol{\sigma_{TVE}}$: = 0.12 (metres)
  - **m(El)**: The mapping function for satellite elevation, computed with the following formula:

    $$m(El) = 1.001 / (sqrt(0.002001 + \sin^2(El)) \text{ (adimensional)}$$

    Where El is the satellite elevation (in radians).

- **Show Old Messages:**

  - **Decode Message Type 37 using ED-259 version ≤ 0.4**: In ED-259 version 0.5 message type 37 (OBAD Parameters and DFREI Scale Table) had the following changes:
    - σDFREI=14 parameter size changed from 2 to 4 bits.
    - σDFREI=14 scale factor changed from 30 to 6 metres.

    gLAB by default will decode MT37 message using the last version defined in gLAB code. Enabling this option will make gLAB decode MT37 with ED-259 version 0.4.

  - **Decode Message Type 39/40 using ED-259 version ≤ 0.4:** In ED-259 version 0.5 message type 39 and 40 (*SBAS Satellite Ephemeris Corrections and Covariance Matrix*) had the following changes:
    - *a* parameter is moved from MT39 to MT40.

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- *a* parameter size changed from 32 to 31 bits.
- *a* scale factor changed from 0.01 to 0.02 metres.
- ω parameter size changed from 35 to 34 bits.
- ω scale factor changed from $\pi \cdot 2^{-34}$ to $\pi \cdot 2^{-33}$ radians.
- Ω_0 parameter size changed from 35 to 34 bits.
- Ω_0 scale factor changed from $\pi \cdot 2^{-34}$ to $\pi \cdot 2^{-33}$ radians.
- M_0 parameter size changed from 35 to 34 bits.
- M_0 scale factor changed from $\pi \cdot 2^{-34}$ to $\pi \cdot 2^{-33}$ radians.
- a_{Gf0} parameter is moved from MT40 to MT39.
- a_{Gf0} parameter size changed from 15 to 25 bits.
- a_{Gf1} parameter is moved from MT40 to MT39.
- a_{Gf1} parameter size changed from 11 to 16 bits.
- a_{Gf1} scale factor changed from 5E-5 to 4E-5 metres/second.
- *i* parameter size changed from 34 to 33 bits.
- *i* scale factor changed from $\pi \cdot 2^{-34}$ to $\pi \cdot 2^{-33}$ radians.
- *e* parameter size changed from 31 to 30 bits.
- *e* scale factor changed from 2^{-31} to 2^{-30} (adimensional).

gLAB by default will decode MT39 and 40 messages using the last version defined in gLAB code. Enabling this option will make gLAB decode MT39 and 40 with ED-259 version 0.4.

- **Decode Message Type 42 using ED-259 version ≤ 0.7:** In ED-259 version 0.8 message type 42 (*GNSS Time Offsets*) had the following change:
  - DN parameter size changed from 8 to 3 bits.

  gLAB by default will decode MT42 message using the last version defined in gLAB code. Enabling this option will make gLAB decode MT42 with ED-259 version 0.7.

- **Decode Message Type 47 using ED-259 version ≤ 0.4:** In ED-259 version 0.5 message type 47 (*SBAS Satellites Almanacs*) had the following change:
  - Added parameter $WNRO_{count}$ (Week Number Roll Over count).

  gLAB by default will decode MT47 message using the last version defined in gLAB code. Enabling this option will make gLAB decode MT47 with ED-259 version 0.5.

- **Process Australian Test Bed Messages:** Australian Test Bed is based on ED-259 v0.3 along with two in-house modifications:
  - Messages type 34, 35 and 36 (*Integrity Messages*) are also sent within MT0 (see *Parse Alarm Message as Type 34/35/36 Messages*).
  - GPS DCB P1 - P2 is included in the corrections, therefore it must not be applied in the modelling, contrary to what ED-259 states.
  - To properly process Australian Test Bed messages, the following options must be set (all of them are automatically set when this option is set) which are different from the SBAS DFMC default template:

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- Enable *Parse Alarm Message as Type 34/35/36 Messages*.
- Disable GPS *DCB for Double Frequency*.
- Enable *Decode Message Type 37 using ED-259 version ≤ 0.4*.
- Enable *Decode Message Type 39/40 using ED-259 version ≤ 0.4*.
- Enable *Decode Message Type 42 using ED-259 version ≤ 0.7*.
- Enable *Decode Message Type 47 using ED-259 version ≤ 0.4*.

- **DGNSS Options:**
  - **Inflate Sigma During the Smoothing Convergence:** If this option is enabled, during the satellite smoothing convergence, the satellite sigma is inflated with the following formula:

    $\sigma_{inflated} = f(n)/N_{steady} \cdot \sigma_{satellite}$

    $n<N \quad f(n) = \sqrt{(1/n)}$

    $n \geq N \quad f(n) = \sqrt{(1/(2N-1) \cdot (1+((N-1)/N)^{2\cdot(n-N)+1})}$

    Where:

    n: Number of processed samples.

    N: Number of samples of the smoothing window.

    N_{steady}: Number of samples when reaching the steady state: In gLAB, Nstdy = tointeger(3.6*N)

    $\sigma_{satellite}$: The computed sigma for the satellite. See StdDev from DGNSS in the FILTER section for details on how to compute the sigma in DGNSS.

    For instance, with 1 second sampling rate and N=100, the stationary state (Nstdy) is assumed to be reached after 360 seconds.

    NOTE: The term '$f(n)/N_{steady}$' is the inflation factor for the satellite sigma. It is adimensional, and it may be referred as K_{inf}.
  - **Maximum Age for Corrections:** Set the maximum lifetime for the DGNSS corrections. As corrections get old (time passes since the correction is received or computed), a degradation term will be added to these corrections until they reach the maximum age and get discarded or are replaced by new corrections.
  - **Maximum value for DGNSS corrections:** When computing DGNSS corrections from a RTCM v3 or RINEX file, if a correction for a satellite is higher than this threshold, it will be automatically discarded /typically corrections are of few metres.

    This limit is particularly useful if the user makes a reference station change, as from one epoch to another the reference station will change, but the message with the new reference station coordinates will take some seconds to arrive, making the computed corrections during this interval totally incorrect (as corrections from the new station will be computed using the coordinates from the previous reference station).

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4.2.4 Filter

This section provides all the configuration options to specify the behaviour of the Kalman Filter. In particular, the selection of measurement and the parameters to be estimated can be chosen in this section. Figure 4-17 shows a screenshot of the FILTER section.

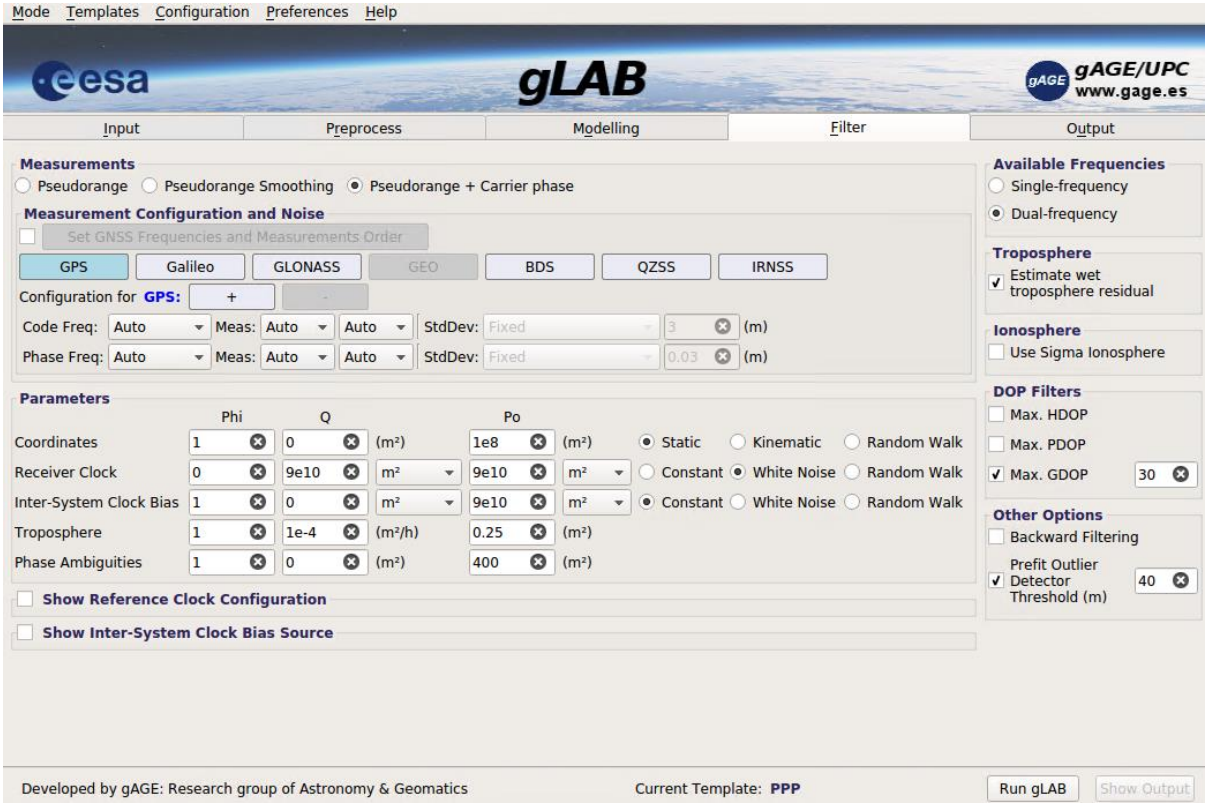

Figure 4-17: Filter section screenshot

- **Available Frequencies:** Select which frequencies are available.
  - **Single Frequency:** Use this option to configure the navigation filter to single-frequency. For conditions with the rest of the values of this window, see *SPP/PPP Navigation Mode Templates*.
  - **Dual Frequency:** Use this option to have the measurements for both frequencies (F1 and F2) available. For conditions with the rest of the values of this window, see *SPP/PPP Navigation Mode Templates* tooltips.
- **Troposphere:**
  - **Estimate wet troposphere residual:** Activates the estimation of the wet troposphere residual. This estimation tries to remove the part of the wet troposphere delay not removed by the nominal modelling (see Modelling section). The estimation depends on the model chosen to compute the $m_{wet}(elev)$ function (Niell mapping should be used for more realistic results).

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IMPORTANT: Reliable troposphere estimation can only be obtained following options:

Navigation Mode: PPP Template

Measurements: Pseudorange + Carrier phase

Available frequencies: Dual Frequency

Outside this specific case, the troposphere estimation should be disabled.

- **Ionosphere:** Use Sigma Ionosphere, Add the ionosphere correction sigma in the measurement weight.

  NOTE: This option will only have effect when using IONEX or SBAS ionosphere models in SPP or PPP navigation modes.

- **Receiver Kinematics:** Select which is the supposed movement of the receiver.
  - **Static**: Select this option to do a processing supposing that the receiver is static. This modifies the filter parameters **Phi** (propagation) and **Q** (process noise) for the positions to: **Phi** = 1 and **Q** = 0.
  - **Kinematic:** Select this option to do a processing supposing that the receiver is in movement. This modifies the filter parameters **Phi** (propagation) and **Q** (process noise) for the positions to: **Phi** = 0 and **Q** = inf.

    NOTES:

    Receiver Coordinates **Q** = **Po** = $1 \cdot 10^8$ correspond to $(10\ \text{km})^2$

    Receiver Clock **Q** = **Po** = $9 \cdot 10^{10}$ correspond to $(1\ \text{msec})^2$

  - **Randow Walk: S**elect this option to perform a processing supposing that the receiver is in small movement, so the filter can keep some coordinate correlation between epochs. In order for random walk to make a difference with respect to kinematic positioning, the movement rate (set by process noise) must be small.

    This modifies the filter parameters **Phi** (propagation) and **Q** (process noise) for the coordinates estimation to:
    - Phi = 1
    - Q = 70 m^2/s

    NOTE: Units for process noise (**Q**) are changed from m^2 to m^2/s in order to be dependent on time.

- **Measurement configuration and noise:** Section to specify the input measurements used in the filter, and its corresponding standard deviation noise (to be used for the filter weights).
  - **Measurements:**
    - **Pseudorange:** Use only pseudorange measurements for the processing. The ambiguity estimation in the filter will be disconnected with this option set. For conditions with the rest of the values of this window, see *SPP/PPP Navigation Mode Templates*.

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- **Pseudorange Smoothing:** Use the Hatch filter to smooth the pseudorange measurements with carrier phase measurements. This option will decrease the noise of the measurements included in the filter. This should only be activated when processing with pseudorange only (no carrier phase), as the carrier phase is better included in the filter in that other way better than using smoothing. The use of smoothing allows to enhance the pseudorange without the cost of the increased filter complexity for carrier phase ambiguities estimations.

  The Hatch filter is defined as:

  $$P_{i,smoothed} = mean(P-L)_i + L_i$$

  Being the mean() a function that computes the mean of pseudorange and carrier phase measurements. This mean at epoch i is obtained from:

  $$P_{i,smoothed} = mean(P-L)_i + L_i$$

  $$mean(P-L)_i = ((n-1)*mean(P-L)_i-1 + (P-L)_i)/n$$

  Being n the arc length at epoch i limited to a maximum value. This limitation is to avoid problems with ionospheric divergence between pseudorange and carrier phase measurements. If both measurements do not have ionospheric divergence (i.e. PC, LC and DF), the parameter can be as high as desired.

  The smoothing window in terms of time is the multiplication of the smoothing samples (selected with this parameter) by the data interval of the RINEX file. When smoothing C1C with L1P getting data separated more than about 300 seconds will be affected from ionospheric divergence. In this case good values for smoothing are 100 samples for 1 second data rate, and 10 samples for 30 seconds data rate.

- **Pseudorange + Carrier phase:** Use both pseudorange and carrier phase measurements for the processing. For conditions with the rest of the values of this window, see *SPP/PPP Navigation Mode Templates*.

- **Graphic Combination:** Use a Graphic Combination (GC) in the filter. This single frequency combination removes the ionosphere and has the pseudorange code noise halved. It is obtained with the following formula:

  GC = (*Pseudorange* + *Carrier_phase*)/2

- **Smoothing:**
  - **Samples:** Set the size of the sliding window (in epochs) for smoothing.

    NOTE: With single frequency measurements, it is not recommended to use a sliding windows greater than 100 seconds (100 epochs at 1Hz or

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3 epochs with a 30 second file) due to the ionosphere divergence (except when smoothing with a Divergence-Free measurement).

- **Exclude satellites before reaching steady-state at (epochs):** When using smoothing in DGNSS, wait for the steady-state (smoothing converges) until the satellite is used for the navigation solution. The steady-state is defined by 360 epochs of continuous smoothing, and is reset every time a cycle-slip occurs.

  The steady-state is applied by default to the reference station measurements (in RTCM v3.x or RINEX observation files), but it can be applied also to the Rover. If this option is applied to both Rover and Reference station, each one will operate independently (that is, a cycle-slip in the rover will not affect the steady-state in the reference station and viceversa), but for a satellite to be used, in both sides the satellite must have reached steady-state.

- **Set GNSS Frequencies and Measurements Order:** Set the priority order for frequencies and measurements in a per constellation basis.

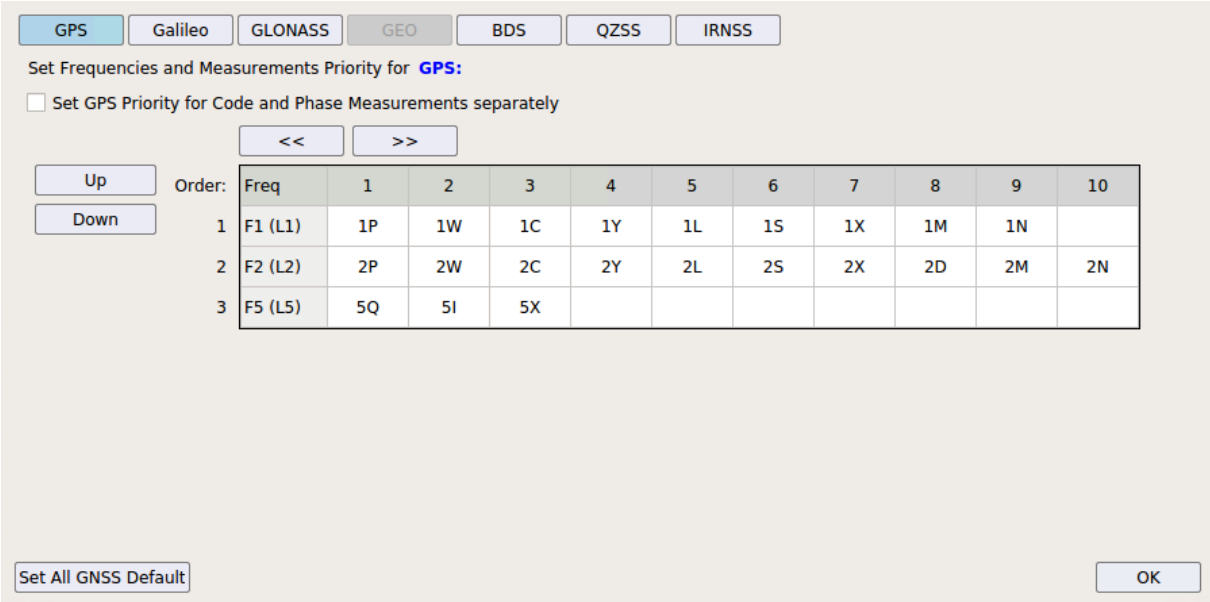

Figure 4-18 Frequencies and Measurements Order Configuration

- **Configuration:**
  - **Frequency:** For each code, phase or graphic combination, select the frequency of the measurement to use or set it to “Auto” for automatic selection.
  - **Measurements:** For each code, phase or graphic combination, once a frequency is selected, set the single measurement (for single frequency combinations), dual measurements (for dual frequency combinations) or a code and a phase for graphic combinations.
  - **stdDev (non SBAS or DGNSS modes):** For each code, phase or graphic combination, once a frequency is selected, set the weight type. The following weight types are available:

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- **Fixed:** The standard deviation is a fixed constant:

  $$\sigma = a \text{ (metres)}$$

  a is provided by the user (in metres).
  The default value for *a* is 1 metre for single frequency and 3 metres for dual frequency combination.

- **Elevation:** The standard deviation is dependent on satellite's elevation using an exponential:

  $$\sigma = a + b \cdot e^{(-\theta/c)} \text{ (metres)}$$

  a, *b* and *c* are the values provided by the user (being *a* and *b* in metres and *c* in degrees). θ is the satellite's elevation (in degrees). The default value for *a* is 1 metre for single frequency and 3 metres for dual frequency combination, for *b* is 0.53 metres and for *c* is 10 degrees. *b* and *c* default values are from MOPS.

- **sin(elevation):** The standard deviation is dependent on the inverse of the square of the satellite's elevation:

  $$\sigma^2 = a + b/(\sin^2(\theta)) \text{ (metres}^2\text{)}$$

  a and *b* are the values provided by the user (being *a* and *b* in metres^2). θ is the satellite's elevation (in degrees). The default value for *a* is 1 metre^2 for single frequency and 9 metres^2 for dual frequency combination, for *b* is 2.5E-3 metres^2. The *b* value is chosen for having similar values as the MOPS exponential.

- **SNR:** The standard deviation is dependent on the satellite's SNR (Signal to Noise Ratio):

  $$\sigma^2 = a + b \cdot 10^{(-SNR/10)} \text{ (metres}^2\text{)}$$

  a and *b* are the values provided by the user (being *a* in metres^2 and *b* in metres^2·Hz). *SNR* is the satellite's SNR (in dBHz). The default value for *a* is 1 metre^2 for single frequency and 9 metres^2 for dual frequency combination, for *b* is 4 metres^2. The *b* value is chosen for having similar values as the MOPS exponential.

- **SNR + sin(elevation):** The standard deviation is dependent on the inverse of the square of the satellite's elevation and SNR:

  $$\sigma^2 = a + b \cdot 10^{(-SNR/10)}/(\sin^2(\theta)) \text{ (metres}^2\text{)}$$

  a and *b* are the values provided by the user (being *a* in metres^2 and *b* in metres^2·Hz). θ is the satellite's elevation (in degrees) and *SNR* the satellite's SNR (in dBHz).

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The default value for *a* is 1 metre^2 for single frequency and 9 metres^2 for dual frequency combination, for *b* is 4 metres^2. The *b* value is chosen for having similar values as the MOPS exponential.

NOTES:

- In command line, the constant parameter *a* can be set (in all weight modes) to the text *URA*. With this option, parameter *a* is set to the URA (User Range Accuracy) provided in the navigation message (therefore, this option can only be used when a navigation message is used for satellite orbits).
- For weights involving the SNR, in command line it is possible to control how the SNR measurement is computed for a combination (e.g using the SNR of a specific frequency, using the minimum or maximum SNR of all signals involved, using the mean SNR of all signals involved or weighting each signal SNR with a user defined ratio) using option '**-filter:snrweight:comb**'. The default method is to use mean SNR value of all signals.

- **StdDev from SBAS 1F messages:** In SBAS 1F mode, the standard deviation is computed using the messages from SBAS 1F. The standard deviation from SBAS 1F is obtained from the deviation of the fast and slow corrections, ionosphere, troposphere and the receiver model. The formula to obtain the standard deviation in SBAS 1F is:

$$\sigma^2_{sat} = \sigma^2_{flt} + \sigma^2_{ionosphere} + \sigma^2_{troposphere} + \sigma^2_{air}$$

Where:

- $\boldsymbol{\sigma^2_{flt}}$**:** Variance for fast and long term corrections. See *Degradation Parameters* in the MODELLING section for details on how to compute it.
- $\boldsymbol{\sigma^2_{ionosphere}}$**:** Variance of the ionosphere. When SBAS 1F iono messages are used, the variance is computed with an interpolation from the variance of the grid points used for computing the ionosphere delay (with an specific degradation term applied), or if Klobuchar model is used, a specific formula is utilized (see MOPS for details on how to compute the ionosphere variance).
- $\boldsymbol{\sigma^2_{troposphere}}$**:** Variance of the troposphere (see MOPS for details on how to compute it).
- $\boldsymbol{\sigma^2_{air}}$**:** Variance of the airborne receiver. See *Airborne Receiver Type* in the MODELLING section for details on how to compute it.

NOTE: In command line it is possible to override the default SBAS weight (i.e. use any of the gLAB available weight functions) or to add the SBAS weight to the weight computed with any of the gLAB available weight functions. Use

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option '-filter:sbasdgnssweightmode' to overrride the default SBAS weight and any of the options '-filter:fixedweight', '-filter:elevweight', ' -filter:sinelevweight', '-filter:snrweight' or '-filter:snrelevweight' to set the new weight function.

- **StdDev from SBAS DFMC messages**: In SBAS DFMC mode, the standard deviation is computed using the messages from SBAS DFMC. The standard deviation from SBAS DFMC is obtained from the DFRE (Dual Frequency Range Error) parameters, ionosphere residual, troposphere and the receiver model. The formula to obtain the standard deviation in SBAS DFMC is:

$$\sigma^2_{sat} = \sigma^2_{DFC} + \sigma^2_{UIRE} + \sigma^2_{troposphere} + \sigma^2_{air}$$

Where:

  - **σ^2_{DFC}:** Variance for SBAS DFMC correction or DFC (Dual Frequency Corrections). See *Integrity Messages* in the MODELLING section for details on how to compute it.
  - **σ^2_{UIRE}**: Variance of the residual of the ionosphere. See *Set Sigma UIRE Value* in the MODELLING section for details on how to compute it.
  - **$\sigma^2_{troposphere}$:** Variance of the troposphere (see MOPS for details on how to compute it).
  - **σ^2_{air}:** Variance of the airborne receiver. See *Airborne Receiver Type* in the MODELLING section for details on how to compute it.

NOTE: In command line it is possible to override the default SBAS weight (i.e. use any of the gLAB available weight functions) or to add the SBAS weight to the weight computed with any of the gLAB available weight functions. Use option '**-filter:sbasdgnssweightmode**' to overrride the default SBAS weight and any of the options '**-filter:fixedweight'**, '**-filter:elevweight'**, ' **-filter:sinelevweight'**, '**-filter:snrweight**' or **'-filter:snrelevweight'** to set the new weight function.

- **Parameters:**
  - **Phi:** Phi sets the propagation of parameters between epochs (transition state matrix). '1' means that the value estimated in the epoch *i+1* is used as a priori value in the epoch *i*, '0', means that the a priori value is always '0'.
  - **Q:** The process noise parameter (Q) sets the stability of a parameter along time. The process noise is included after the estimation when propagating the parameters to the next epoch, and is an increase in the covariance of the parameter. A process noise of '0' means that the parameter is a constant, and thence its estimated covariance (uncertainty) will decrease along time, a process noise different than '0' can be understood as a minimum covariance, thence leaving its uncertainty always above a specific value, and allowing the parameter to vary along time.
  - **P_0:** The Kalman filter requires initial values for all its parameters:

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- **Position:** $1 \cdot 10^8$ (m^2) value is assigned due to the unknown difference between the initial a priori valiue and the real position.
- **Clock:** A $9 \cdot 10^{10}$ (m^2) value is assigned due to its high variability.
- **Inter-System Clock Bias:** A $9 \cdot 10^{10}$ (m^2) value is assigned due to its unknown value.
- **Troposphere**: Due to the fact that about 90% of the troposphere is corrected by a proper modelling, and only a 10% has to be estimated (and is usually no higher than about 10 cm), a 0.25 (m^2) value is used for a priori.
- **Carrier phase ambiguities:** As carrier phase is prealigned with code, the value 400 (m^2) is used as a priori.

The parameter $\mathbf{P_0}$ sets the initial uncertainty of these a priori values.

- **Coordinates:** This comprises the 3 parameters with the 3D position [XYZ] of the receiver. Typical values:
  - **A priori value**: A priori receiver position, configured in Input section.
  - **Phi**: '1' [Static positioning], '0' [Kinematic positioning].
  - **Process noise**: '0' [Static positioning], 'inf' [Kinematic positioning].
  - **Initial covariance**: 'inf' (A smaller value for the initial covariance will increase the convergence time, but would require a good initial position).

  NOTE: Receiver Coordinates Q = Po = $1 \cdot 10^8$ correspond to $(10\ km)^2$.

- **Receiver Clock:** This parameter is the receiver clock synchronism error referring to the reference constellation time scale. Typical values:
  - **A priori value**: '0'.
  - **Phi**: '0'.
  - **Process noise**: '0' [Constant], $9 \cdot 10^{10}$ m^2 or $1 \cdot 10^{12}$ ns^2 [White noise], 9 m^2/day or 9 ns^2/day [Random walk].
  - **Initial covariance**: 'inf'.

  NOTE: Receiver Clock Q = Po = $9 \cdot 10^{10}$ correspond to $(1\ msec)^2$.

- **Inter-System Clock Bias:** This parameter is the offset between the receiver clock (which will be aligned to one constellation) and the reference clock for the other constellations (there will be an inter-system clock bias unknown for each constellation different from the reference one) . Typical values:
  - **A priori value:** '0'
  - **Phi:** '0'
  - **Process noise:** '0' [Constant], $9 \cdot 10^{10}$ m^2 or $1 \cdot 10^{12}$ ns^2 [White noise], 9 m^2/day or 9 ns^2/day [Random walk]
  - **Initial covariance (Po):** $9 \cdot 10^{10}$ m^2 or $1 \cdot 10^{12}$ ns^2

  NOTE: Inter-System Clock Bias Q = Po = $9 \cdot 10^{10}$ correspond to $(1\ msec)^2$

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- **Troposphere:** This parameter estimates part of the troposphere not taken into account in the nominal model (see Modelling section). This 10% is mostly associated with the wet component of the troposphere, which is due to the water vapor of the atmosphere. The mapping $m_{wet}(elev)$ function described in the Modelling section is used in the troposphere estimation. Typical values:
  - **A priori value**: '0'.
  - **Phi**: '1'.
  - **Process noise**: '1e-4' in units of [m²/h]. Contrary to the rest of parameters, troposphere process noise is given as increase of **Q** per time unit.
  - **Initial covariance**: '0.025' (equivalent to 0.5 meters of uncertainty).
- **Phase ambiguities:** Carrier phase ambiguities are the parameters which estimates the ambiguities of the carrier phase measurements (or combinations) used in the filter. Each epoch, there is one parameter for each satellite. Additionally, when a cycle-slip is detected, the carrier phase ambiguity is reset (by providing a new initial value and covariance). Typical values:
  - **A priori value**: '0'.
  - **Phi**: '1'
  - **Process noise**: '0'.
  - **Initial covariance**: '400' (equivalent to 20 metres in relation to the pseudorange measurement used to prealign the carrier phase).

For the Coordinates, Receiver Clock and Inter-system clock bias, three stochastic behaviours can be assigned independently:

- **Static (coordinates) or Constant (receiver clock and inter-system clock bias):** The filter will assume that the receiver coordinates or clocks will not change between epochs, therefore the value estimated in previous epoch can be used in current epoch.

- **Kinematic (coordinates) or White Noise (receiver clock and inter-system clock bias):** The filter will assume that the receiver coordinates or clocks are very different from epoch to epoch, therefore each epoch the value is estimated without any previous information. Setting this option will make the Kalman filter behave as a Weighted Least Square (WLS).

- **Random walk:** The filter will assume that the receiver coordinates or clocks are close to the previous epoch but not the same, therefore the value from previous epoch is a very good a priori value to be used.

- **DOP Filters:**

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- **Max. HDOP:** Set the maximum value for the HDOP (Horizontal Dilution of Precision) factor. The HDOP factor is an approximate ratio factor between the precision in the measurements due to satellites geometry (in respect to the user) and the precision in the horizontal positioning. A very high HDOP will mean that the solution will have a great error, so it is better to skip the epoch. In gLAB, the HDOP is computed before entering the filter, so if HDOP is greater than the exceeds the maximum value, the following actions will be done:
  - In SPP or PPP modes, the epoch will be skipped.
  - In SBAS mode, if GEO or SBAS navigation mode switching are enabled, a GEO or SBAS navigation mode switching will be done. If the HDOP after doing the switch is under the maximum, the navigation solution is computed. Else, the epoch is skipped.
  - In DGNSS mode, navigation mode will be switched to SPP. If HDOP in SPP is under the maximum, the navigation solution is computed in SPP mode. Else, the epoch is skipped.

  NOTES:
  - If an epoch is skipped due to high HDOP, an INFO message will be shown.
  - If multiple DOP filters are enabled and in an epoch more than DOP threshold is exceeded, the INFO message will contain all the DOP thresholds exceeded.
- **Max. PDOP:** Set the maximum value for the PDOP (Position Dilution of Precision) factor. The PDOP factor is an approximate ratio factor between the precision in the measurements due to satellites geometry (in respect to the user) and the precision in the positioning. A very high PDOP will mean that the solution will have a great error, so it is better to skip the epoch. In gLAB, the PDOP is computed before entering the filter, so if PDOP is greater than the exceeds the maximum value, the following actions will be done:
  - In SPP or PPP modes, the epoch will be skipped.
  - In SBAS mode, if GEO or SBAS navigation mode switching are enabled, a GEO or SBAS navigation mode switching will be done. If the PDOP after doing the switch is under the maximum, the navigation solution is computed. Else, the epoch is skipped.
  - In DGNSS mode, navigation mode will be switched to SPP. If PDOP in SPP is under the maximum, the navigation solution is computed in SPP mode. Else, the epoch is skipped.

  NOTES:
  - If an epoch is skipped due to high PDOP, an INFO message will be shown.
  - If multiple DOP filters are enabled and in an epoch more than DOP threshold is exceeded, the INFO message will contain all the DOP thresholds exceeded.

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- **HDOP OR PDOP:** If HDOP and PDOP filters are enabled, in an epoch, instead of having to fulfil both requirements, accept any epoch which fulfils only one of the two requirements (i.e. doing a logical OR of the two conditions).
- **Max. GDOP:** Set the maximum value (in metres) for the GDOP (Geometry Dilution of Precision) factor. The GDOP factor is an approximate ratio factor between the precision in the measurements due to satellites geometry (in respect to the user) and the precision in the positioning and timing (receiver clock estimation). A very high GDOP will mean that the solution will have a great error, so it is better to skip the epoch. In gLAB, the GDOP is computed before entering the filter, so if GDOP is greater than the exceeds the maximum value, the following actions will be done:
  - In SPP or PPP modes, the epoch will be skipped.
  - In SBAS mode, if GEO or SBAS navigation mode switching are enabled, a GEO or SBAS navigation mode switching will be done. If the GDOP after doing the switch is under the maximum, the navigation solution is computed. Else, the epoch is skipped.
  - In DGNSS mode, navigation mode will be switched to SPP. If GDOP in SPP is under the maximum, the navigation solution is computed in SPP mode. Else, the epoch is skipped.

  NOTES:
  - If an epoch is skipped due to high GDOP, an INFO message will be shown.
  - If multiple DOP filters are enabled and in an epoch more than DOP threshold is exceeded, the INFO message will contain all the DOP thresholds exceeded.

- **Other options:**
  - **Backward filtering:** This kind of processing reverses the input observation RINEX file when it reaches the end of the file, and processes it backwards. This is also called smoothing and it allows to have good estimation of the parameters (such as the troposphere, and the position in a kinematic receiver) in the beginning of the file, what would be the convergence period.

    NOTES:
    - Backward filtering is not allowed in SBAS and DGNSS modes.
    - This kind of process is not considered a real-time emulation, as for the backward filtering it is using future information.
  - **Prefit Outlier Detector:** Sometimes, for some satellites (typically the ones with very low elevation or not a clear line of sight), the pseudorange measurements written in the RINEX observation file can be with a great amount of bias (sometimes of than a hundred metres). These biased measurements can last for a noticeable amount of time (more than 6 minutes), and during this period of time they are consistent (so no cycle-slip is detected), and therefore are elegible to be used in the filter, therefore introducing an important error in the navigation solution.

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A method to detect these cases is comparing the prefits (the measured pseudorange minus the modelled pseudorange). The prefits for all satellites should be very similar between them (typically less than 10 metres of difference for fixed receivers), so if a satellite has a prefit value much more different than the rest, then that satellite should be discarded.

In gLAB, it is implemented with the following algorithm:

- 1. Compute the median of all prefits.
- 2. For each satellite:
  - 2a. Compute the absolute value of the difference between the satellite's prefit and the median.
  - 2b. If the difference is higher than the threshold, unselect the satellite.

NOTES:

- If the number of discarded satellites is more than half of the initially available satellites, then no satellites will be discarded at all. This last check is to account for receivers in movement and for receiver solution convergence time, which in both cases will produce satellite prefits very different from each other.
- The prefit outlier detector threshold only works with pseudorange measurements, as carrier phase measurements will have very different prefit values due to the ambiguities.
- If the computed navigation solution error is very high, enabling this option may fix it (this option is not enabled by default due to it would interfere with the gLAB GNSS courses).

- **Step Detector:** The step detector is a function to detect large jumps in the pseudorange measurements from consecutive epochs. The step detector works in the following way:
  - Compute the difference of prefits between the current and previous epoch (only with satellites that have been used in the navigation solution in both epochs) with reference satellites (the two ones with highest elevation in current epoch).
  - Compute the difference between prefit difference with both satellites. If both differences are over the threshold, then there has been a step.

  With this method a big step will not affect other satellites, but it has the drawback that it assumes that only one satellite will fail or that more than one satellite may fail but not the reference ones.

  The problem with any step detector is that it will only trigger when there is a jump due to the change of ephemerides to ones which have incorrect values, but in the following epochs, where previous and current epoch use the same bad ephemerides, the step detector will not trigger.

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NOTES:

- The threshold for the step detector is designed to detect jumps over 700 metres.
- The reason to make differences between prefits is for taking into account the receiver clock, which will be different in each epoch.
- The step detector will only detect jumps on the navigation message due to large jumps in the pseudorange measurement will be detected by the cycle-slip detector.
- The step detector can only be applied to pseudorange measurements, as carrier phase measurements have the ambiguity.

- **Show Reference Clock Configuration:** Select constellations to be used as reference clock. gLAB will loop through this list (from left to right) with the enabled (in green) constellations. If there is at least one satellite available for the navigation solution, the constellation is selected. Otherwise try with the next constellation until one is selected or the list of exhausted (in this case the epoch will be skipped).

  NOTES:

  - Reference clock constellation selection process will be evaluated on each epoch in order to maximize navigation solution availability.
  - To make gLAB always use the same reference constellation, just leave one constellation enabled (in green) in this list.

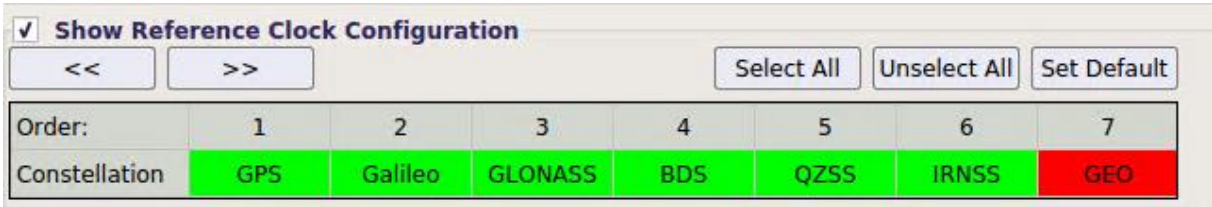

Figure 4-19 Refence Clock Configuration

- **Show Inter-system Clock Bias Source:** Set the ISCB (Inter System Clock Bias) between constellations to “Estimate” (estimated by the filter) or to a fixed value set by the user.

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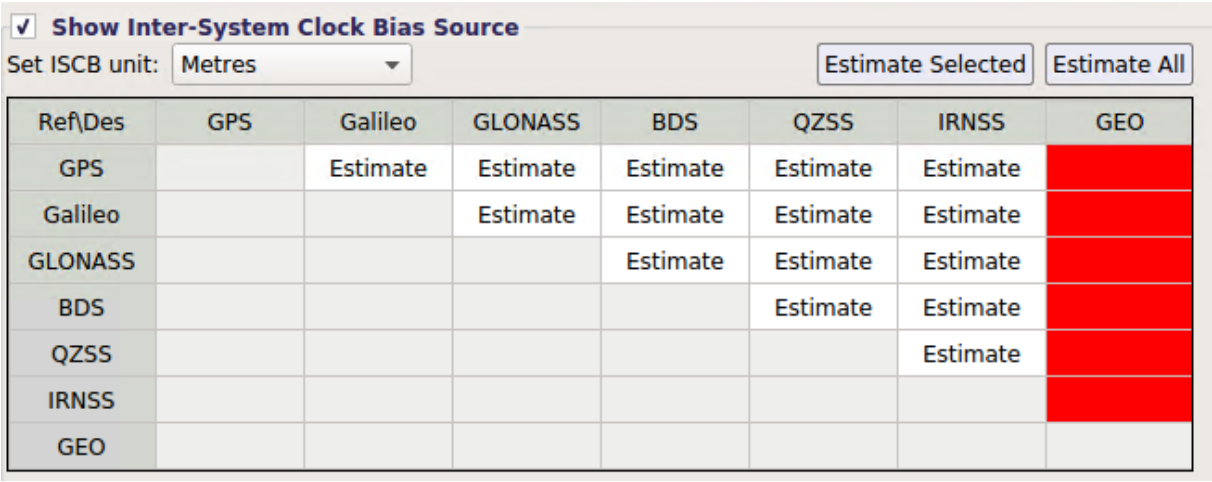

Ref\Des	GPS	Galileo	GLONASS	BDS	QZSS	IRNSS	GEO
GPS		Estimate	Estimate	Estimate	Estimate	Estimate	
Galileo			Estimate	Estimate	Estimate	Estimate	
GLONASS				Estimate	Estimate	Estimate	
BDS					Estimate	Estimate	
QZSS						Estimate	
IRNSS							
GEO							

Figure 4-20 Inter-System Clock Bias Configuration¡

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4.2.5 Output

This section provides all the configuration options to select which messages are output. Figure 4-21 shows a screenshot of the OUTPUT section.

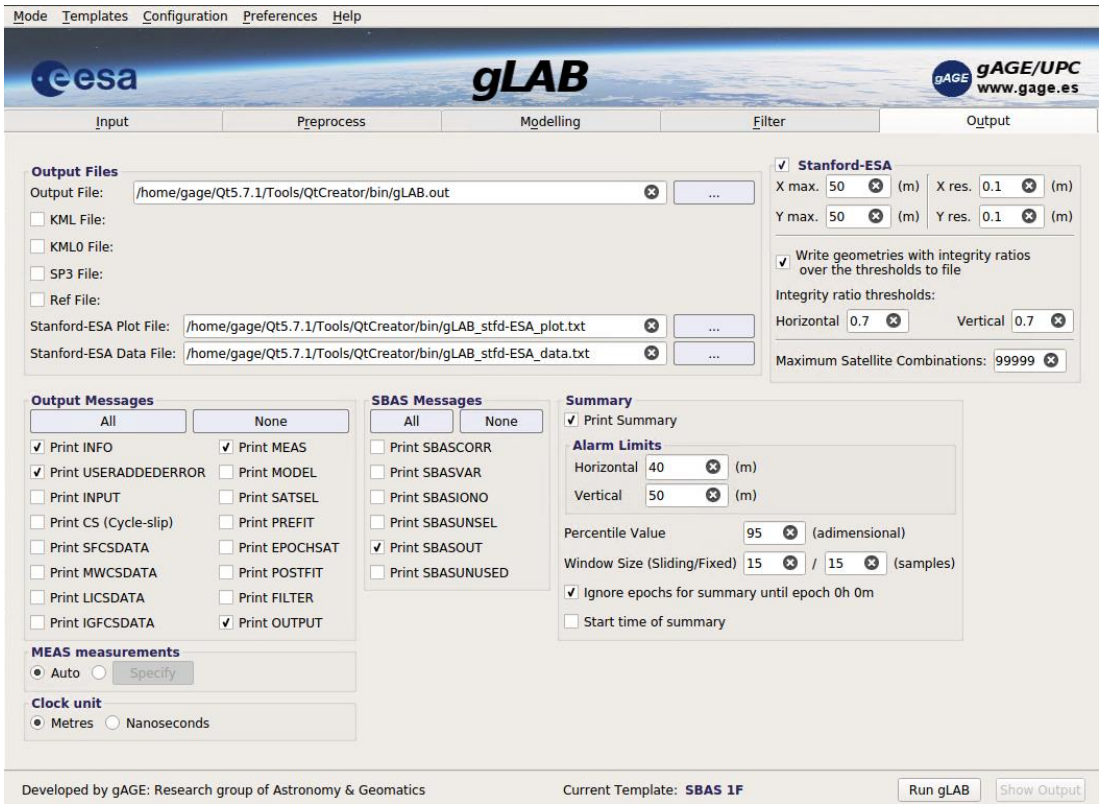

Figure 4-21: Output section screenshot

- **Output Destination:**
  - **Output File:** Sets the output file where all messages will be written. If a right click is done in the “Output File” text, a menu appears with an option to open the selected file.
  - **KML File:** set the output KML file which will be generated with gLAB's solution at the same rate as the Data Decimation parameter in the PREPROCESS section. Optionally, it can apply EGM96 geoid height model, and it may include also timestamps. If a right click is done in the “KML File” text, a menu appears with an option to open the selected file.
    - **Add Reference Station:** If user is creating a KML file in DGNSS, add a PlaceMark (in its geographic position) for each reference station found during the processing.

      NOTE: This option applies to both KML and KML0 files.
    - **Geoid Height:** GPS coordinate system, WGS84, uses a reference ellipsoid as an Earth model. In order to account the Earth irregularities,

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a geoid model is necessary. This geoid model provides (in ellipsoidal coordinates) the geoidal height (undulations) which is the difference between the geodetic height (h) to the orthometric height (H). Therefore, the equation to apply to the geoid model is:

$$H_{orthometric} = h_{WGS84} - N_{EGM96} \quad (m)$$

Where:

$H_{orthometric}$: Height from the geoid earth surface (orthometric height).

h_{WGS84}: Geodetic height provided from the GPS coordinates in the WGS84 coordinate system.

N_{EGM96}: Geoidal height or difference between the geoid and the WGS84 reference ellipsoid.

If this option is enabled, the height coordinate written in the KML file will be the orthometric height value (instead of the WGS84 geodetic height).

NOTES:

- The geoid model applied is EGM96 (with a resolution of 1ºx1º), which is the model applied in Google Earth.
- The EGM96 model is provided through a grid of values in latitude and longitude. The final value applied is computed by linear interpolation.
- EGM96 height correction values can vary from -106 to +85 metres.
- EGM96 grid values can be obtained from AD-12.

- **TimeStamps:** Add timestamps to KML file. Each timestamp will have as the name the timestamp (in format YYYY DoY Seconds_of_Day), and in its description, the timestamp in format "DD/MM/YYYY HH:MM:SS". All timestamps are in GPS time.

  NOTE: This option applies to both **KML** and **KML0 Files**.

- **Range:** Set a time range for timestamps. The user must give the start and ending epoch (in seconds of day of GPS time). When a range is set, only timestamp inside the range will be written to the KML file. Inside this range, the timestamp decimation also applies, but the first and last epoch of the range will also be written independently if these epochs match the decimation rate.

  NOTES:

  - A "-" value in the start epoch means to start the range from the beginning of the file.
  - A "-" value in the ending epoch means to end the range at the end of the file.

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- To account for files with multiple days, add 86400 seconds for each day passed (the starting day corresponds to the day of the first data read in the RINEX observation file).
- In command line, the user can set any number of time ranges by using the parameter **'-output:kml:tstamprange'** as many times as necessary.
- This option applies to both KML and **KML0 Files**.

NOTES:

- In SBAS mode, if switching mode is enabled, epochs computed in NPA mode will be shown in red colour.
- In DGNSS mode, epochs computed in SPP mode will be shown in red colour.
- In DGNSS mode, if more than one reference station was used, a PlaceMark will be set in the position were the new reference station started to be used. This PlaceMark will have as title "Started to use reference station #Nsta" (being Nsta the number of the reference station used (in the same order as they appear in the DGNSS file), and in its description there will be the timestamp for that epoch (in format YYYY DoY Seconds_of_Day HH:MM:SS) in GPS time.

- **KML0 File:** Same as KML file, but projected to the ground (i.e. the height will be 0). The same options for a KML file are applied to the KML0 file. If a right click is done in the “KML0 File” text, a menu appears with an option to open the selected file (see figure 4-11).
- **SP3 File:** Set the output SP3 file which will be generated with gLAB's solution. The SP3 will include the computed coordinates and receiver clock at the same rate as the Data Decimation parameter in the PREPROCESS section. If a right click is done in the “SP3 File” text, a menu appears with an option to open the selected file.

  - **Constellation Letter:** In SP3 files, the list of satellites in the file is given in the header. As the data written is the receiver solution but it has to follow the SP3 standard, at least one satellite has to be set (which in this case will correspond to the receiver solution).

    With this option, the constellation letter of the satellite in the SP3 is set. By default is 'L', which stands for "LEO".

    NOTE: If gLAB reads an unknown constellation letter (such as 'L') in SP3 files, it will manage it as a GPS satellite.

  - **PRN Number:** In SP3 files, the list of satellites in the file is given in the header. As the data written is the receiver solution but it has to follow the SP3 standard, at least one satellite has to be set (which in this case will correspond to the receiver solution).

    With this option, the PRN number of the satellite in the SP3 is set. By default is '9'.

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- **Write only DGNSS solutions:** In DGNSS mode, when DGNSS solution cannot be computed, gLAB will automatically switch to SPP mode and compute the solution.

  With this option it can be set whether to write the SPP solutions or not to the output SP3 file, as probably this file will be used to compare gLAB's output with another solution, and, most probably, only the DGNSS solutions are the ones of interest.

- **Ref File:** Set the output reference file which will be generated with gLAB's solution. The reference file will include the computed coordinates at the same rate as the Data Decimation parameter in the PREPROCESS section.

  A text file containing only the solution. This file is useful for using it as a reference position for another processing (e.g compute a PPP solution and use to compare it with a SPP solution). The timestamps can be in Year/DoY/SoD, GPSWeek/SoW or calendar format, and the coordinates can be in XYZ or Geodetic formats.

  - **Date:** Set the date format in the output reference file to Year, DoY (Day of Year) and SoD (Seconds of Day) or GPSWeek and SoW (Seconds of Week).
  - **Year/DoY:** Set the date format in the output reference file to Year, DoY (Day of Year) and SoD (Seconds of Day).
  - **GPSWeek:** Set the date format in the output reference file to GPSWeek and SoW (Seconds of Week).
  - **Calendar:** Set the date format in the output reference file to calendar format (YYYY/MM/DD HH:MM:SS.zzz). 'zzz' stands for milliseconds.
  - **Coordinates:** Set the coordinate format in the output reference file to cartesian (XYZ) or geodetic (longitude, latitude, height).
  - **Cartesian:** Set the coordinate format in the output reference file to cartesian (XYZ).
  - **Geodetic:** Set the coordinate format in the output reference file to geodetic (longitude, latitude, height).

    NOTE: The height does not include the EGM96 geoid model.
  - **Write only DGNSS solutions:** In DGNSS mode, when DGNSS solution cannot be computed, gLAB will automatically switch to SPP mode and compute the solution.

    With this option it can be set whether to write the SPP solutions or not to the output reference file, as probably this file will be used to compare gLAB's output with another solution, and, most probably, only the DGNSS solutions are the ones of interest.

- **Stanford-ESA:**
  - **X/Y max:** Set the maximum value for the X/Y range (in metres) in the Stanford-ESA plot (the minimum is always 0). All values over this threshold will be mapped to the to this maximum value.

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- **X/Y res:** Set the the pixel resolution (in metres) for the X/Y coordinate in the Stanford-ESA plot.
- **Write geometries with integrity ratios over the thresholds to file:** For each iteration in the the Stanford-ESA computation, if any of the integrity ratios (either horizontal or vertical) are equal or larger than their thresholds, detailed information of this iteration will be written in a columnar text file (see Stanford-ESA Data File option for details).
- **Integrity ratio thresholds:** Set the horizontal or vertical integrity ratio threshold. When this threshold is equal or greater than the one computed in the current iteration of the Stanford-ESA computation, then detailed information of this iteration will be written in a columnar text file (see Stanford-ESA Data File option for details).
- **Maximum Satellite Combinations:** Set the threshold (adimensional) of the maximum number of satellites a solution combination can have in order to be processed. This is for reducing processing time where there are many satellites available.

  NOTES:

  - gLAB will always loop through all possible combinations, but the ones with a higher number of satellites than this threshold will be skipped (i.e. no positioning error or protection levels are computed).
  - Skipping combinations with high number of satellites do not limit the detection of faulty combinations (positioning error equal or greater than protection levels), as usually faulty combination are the ones with smaller number of satellites. Moreover, once the faulty satellite(s) are detected with the smaller combinations (always processed), all other combinations with these faulty satellites are very likely to be faulty too.
- **Stanford-ESA Plot File:** Sets the output file for the plotting data of the Stanford-ESA plot. This file is a columnar text file which will be read by the plotting tool (graph).

  This file contains three header lines at the beginning indicating the plot ranges, the axes pixel resolution (with labels for each of the values in the files). From the fourth line until the end, each line contains the X,Y coordinates, and the number of occurrences in that coordinate for the horizontal and vertical components.
- **Stanford-ESA Data File:** Sets the output file for the information about each iteration in the Stanford-ESA computation that had any integrity ratio (either horizontal or vertical) equal or greater than their respective thresholds (see options in the right side). It is a columnar text file, and each line will have the following data: epoch, computed integrity ratios, satellites available in the current epoch and satellites used in the current iteration.

- **Output Messages:** Individually select which messages are printed. See section gLAB output messages for details on the output messages.

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- **Clock Unit:** Print the estimated clock and DCB terms in the output messages in metres (this is the default) or nanoseconds. The following messages will be affected:
  - MODEL message:
    - **Field 28:** Satellite clock correction [m]
    - **Field 43:** Inter system clock bias [m]
    - **Field 44:** P1-C1 DCB (GPS only) [m]
    - **Field 45:** Total Group Delay (TGD) correction [m]
    - **Field 46:** Inter Signal Correction (if applied) [m]
    - **Field 47:** Computed DCB for single frequency and precise orbits (BeiDou only) [m]
    - **Field 48:** Sum of all DCB corrections applied (Field 44 + Field 45 + Field 46 + Field 47) [m]
    - **Field 52-:** Dual-frequency DCB computed for current dual-frequency combination [m]
  - POSTFIT message:
    - **Field 20:** Estimated inter-system clock bias [m]
    - **Field 23:** Estimated satellite DCB [metres of the signal frequency]
    - **Field 24:** Estimated receiver DCB [metres of the signal frequency]
  - FILTER message:
    - **Field 12:** Receiver clock offset [m]
    - **Field 13:** GPS inter-system clock bias [m]
    - **Field 14:** Galileo inter-system clock bias [m]
    - **Field 15:** GLONASS inter-system clock bias [m]
    - **Field 16:** GEO inter-system clock bias [m]
    - **Field 17:** BeiDou inter-system clock bias [m]
    - **Field 18:** QZSS inter-system clock bias [m]
    - **Field 19:** IRNSS inter-system clock bias [m]
  - OUTPUT message:
    - **Field 34:** Receiver clock offset [m]
    - **Field 35:** Receiver clock formal error [m]

NOTE: If option *Print messages in gLAB v5 format* is enabled, this option will have no effect.

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- **Summary:** Individually select which Summary messages are printed.
  - **Print Summary:** The processing summary is printed at the end of the output file if the summary option is enabled. The contents of the summary are:

    Number of epochs processed, along with the number epochs that had a solution.

    Number of epochs skipped (epochs without solution).

    Number of epochs missing during the summary period (if decimation is enabled, the epochs missing will be separated into the epochs which would have been decimated or not decimated.

    Number of epochs missing in the whole file.

    Number of data gaps during the summary period.

    Number of data gaps in the whole file.

    Maximum data gap size during the summary period and the epoch where it occurred.

    Maximum data gap size in the whole file and the epoch where it occurred.

    Time to first fix (first epoch with solution.

    The 95 Percentile (or user defined percentile) of the PDOP, GDOP, TDOP, HDOP and VDOP.

    The minimum and maximum value of PDOP, GDOP, TDOP, HDOP and VDOP and the epochs where it occurred.

    The 95 Percentile (or user defined percentile) of the errors.

    The epoch with highest errors and the epoch where it occurred.

    The total processing time, providing also the percentages of processing time in user mode and in kernel mode.

      In the non-mutithread version of gLAB, the processing times are provided by the system function that provided thread CPU time.

      In multi-thread version of gLAB, the CPU time provided by the system function is the sum of all CPU time of all threads, which can yield a total time greater than the real time (user perceived time) passed. In this case, gLAB will show the real time passed (but using the user and Kernel time percentages from the system functions).

      The processing time is computed just at the end of the summary, where still the print with the processing time and the last line of the summary are to be done, and also the last lines of gLAB code which are for freeing memory. These last instructions add less than 1ms of processing time for user time and less than to 0.2 seconds of Kernel time.

    A single line at the end with the previous info in columnar format (with the column number). This line is useful for plotting results from multiple runs (after joining in one file the last line of the summary from multiple runs).

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Additionally, for PPP processing, the following information is provided:

Convergence time (counting from the first epoch with solution) using the formal error.

Convergence time (counting from the first epoch with solution) using the formal error and maintained during a given period.

Convergence time (counting from the first epoch with solution) using the positioning error.

Convergence time (counting from the first epoch with solution) using the positioning error and maintained during a given period.

Additionally, for SBAS processing, the following information is provided:

Number of epochs with solution under alarm limits.

Number of epochs with MIs.

The 95 Percentile (or user defined percentile) of the integrity ratio.

The Best Integrity Ratio (BIR) and Worst Integrity Ratio (WIR) and the epochs where it occurred.

The epoch with minimum and maximum protection levels and the epochs where it occurred.

The 95 Percentile (or user defined percentile) of the protection levels.

Additionally, for DGNSS processing, the following information is provided:

Number of epochs missing during the summary period in the reference station file (RINEX only).

Number of epochs missing in the whole file in the reference station file (RINEX only).

Number of data gaps during the summary period in the reference station file (RINEX only).

Number of data gaps in the whole file in the reference station file (RINEX only).

Maximum data gap size during the summary period and the epoch where it occurred in the reference station file (RINEX only).

Maximum data gap size in the whole file and the epoch where it occurred in the reference station file (RINEX only).

See examples of Summary messages inside gLAB output messages, section Summary.

- **Alarm Limits:** The alarm limits are the maximum value of the protection levels (which are the estimation of the user error using the sigma provided by the SBAS system) computed in the navigation solution to consider that the system is available. That is, if the any of the horizontal or vertical protection levels are

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equal or greater to their respective horizontal or vertical alarm limits, it is considered that the SBAS system is not providing a solution good enough to meet the navigation precision or integrity requirements.

Alarm limits are set by the navigation modes (e.g. APV-I, CAT-I) defined by ICAO, and they do not affect in any way in the computation of the navigation solution or protection levels. Alarm limits only affect the computation of the post-process statistics, in concrete:

- **Availability:** The percentage of epochs where there was a solution in PA navigation mode with protection levels under both horizontal and vertical limits,
- **Continuity Risk:** Is the probability to have a discontinuity (no solution in PA mode under alarm limits) during a time window. Typically the sliding window is set to 15 epochs.

NOTE: APV-1 navigation mode sets the horizontal alarm limit to 40 metres.

- **Percentile Value:** Set the percentile value for the SBAS summary. For example, if using the default value of 95, and the computed 95 percentile of the horizontal error is 1 metre, it states that 95% of the epochs processed with solution had an horizontal error of 1 metre or less.

  NOTE: If receiver position is not fixed or provided with a reference file, this option is hidden, as no error can be computed (except in SBAS mode, as protection levels percentiles can be computed without reference position).

- **Window Size (Sliding/Fixed):** Set the window size to compute the continuity risk. The continuity risk is the probability to have a discontinuity (no solution under alarm limits) during a time window. There are two methods to compute the continuity risk:

  - **Sliding Window:** When using a sliding window size of N samples, if in the current epoch a discontinuity occurs, all the previous N-1 samples (or the samples until the last discontinuity, whatever first occurs) plus the current one will be counted as epochs with continuity risk. Otherwise, if an epoch did not have a discontinuity, and during the following N samples no discontinuity occurred, that epoch will not be counted as epochs with discontinuity risk. The continuity risk is computed by dividing the number of epochs with continuity risk ($N_{EpochRisk}$) divided by the number of epochs with solution under alarm limits ($N_{EpochAvail}$):

    $$\text{Continuity Risk} = N_{EpochRisk}/N_{EpochAvail}$$

  - **Fixed Window:** When using a fixed window size of N samples, every time a discontinuity occurs, all the previous N epochs are counted as epochs with discontinuity, independently of the previous discontinuities. This is a more simple computation, but has the disadvantage that if several discontinuities occur in less than N epochs, the discontinuities will be counted more than once (this is typical in the SBAS coverage border), which may do that the total continuity risk become greater than 1. This effect can be mitigated by using large time spans. Moreover, if

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several discontinuities larger than the window size occur, the continuity risk value will be smaller compared to the sliding window continuity risk, as several epochs will not be counted to have discontinuities (the ones larger than the window size), and also due to that the continuity risk is computed using the total epochs processed, not the total epochs with solution. The continuity risk with fixed window is computed with the following formula:

Continuity Risk = CTI/MTBF = $WindowSize \cdot N_{Discontinuities}/N_{Processed_epochs}$

Where:

CTI: Continuity Time Interval, which is the size of the fixed window.

MTBF: Mean Time Between Failures, which is computed as the total epochs processed (NProcessed_epochs) divided by the number of discontinuities (NDiscontinuities)

This formula is from IALA (International Association of Marine Aids to Navigation and Lighthouse Authorities) document shown at RD-17.

NOTES:

- The Sliding Window is the method used in Airborne applications, while the Fixed Window is the method used for Maritime applications.
- gLAB will always compute the continuity risk with both methods.
- See SBAS maps manual (Help >User manuals >gLAB command line SBAS maps description) for more info on continuity risk computation.

- **Ignore epochs for summary until epoch 0h 0m:** All systems have a common step: the transitory (or convergence) time. For example, for SBAS systems, in a cold start with standard configuration, the user has to wait around 5 minutes to get enough data from the GEO (this is what gLAB considers the GEO acquisition time) or 6 minutes for the measurement smoothing to converge. Therefore, if a user wants to process 24 hours of data without convergence time, it has to add at least 6 minutes (but it is recommended to put at least 15 minutes) of measurements (in the RINEX observation file) and SBAS messages from the previous day.

  Once this extra epochs are added to the input, at the start of the day gLAB will have already converged, but this extra epochs will affect the computation of the statistics in the summary. In order to get around this issue, if this option is set, gLAB will detect if the RINEX observation files starts at 22h or later, and in that case, it will automatically consider that all the epochs from 22h to 23h 59m 59s are for convergence and they will be automatically skipped in the computation of the summary statistics. (note that the first epoch used in the summary will be printed in the summary).

  NOTE: If option 'Start time of summary' below is set, this option has no effect.

- **Start time of summary:** Set the first epoch (in GPS time) to be considered for the summary.

  NOTES:

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- In order to set an end epoch for the summary, set the last processed epoch in the INPUT section ('End Time' option) to the desired epoch.
- If this option is set, parameter 'Ignore epochs for summary until epoch 0h 0m' above will be ignored.

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4.3 ANALYSIS MODE

The analysis mode allows configuring all the visualization options for the DAT. Figure 4-22 shows a screenshot of the Analysis interface.

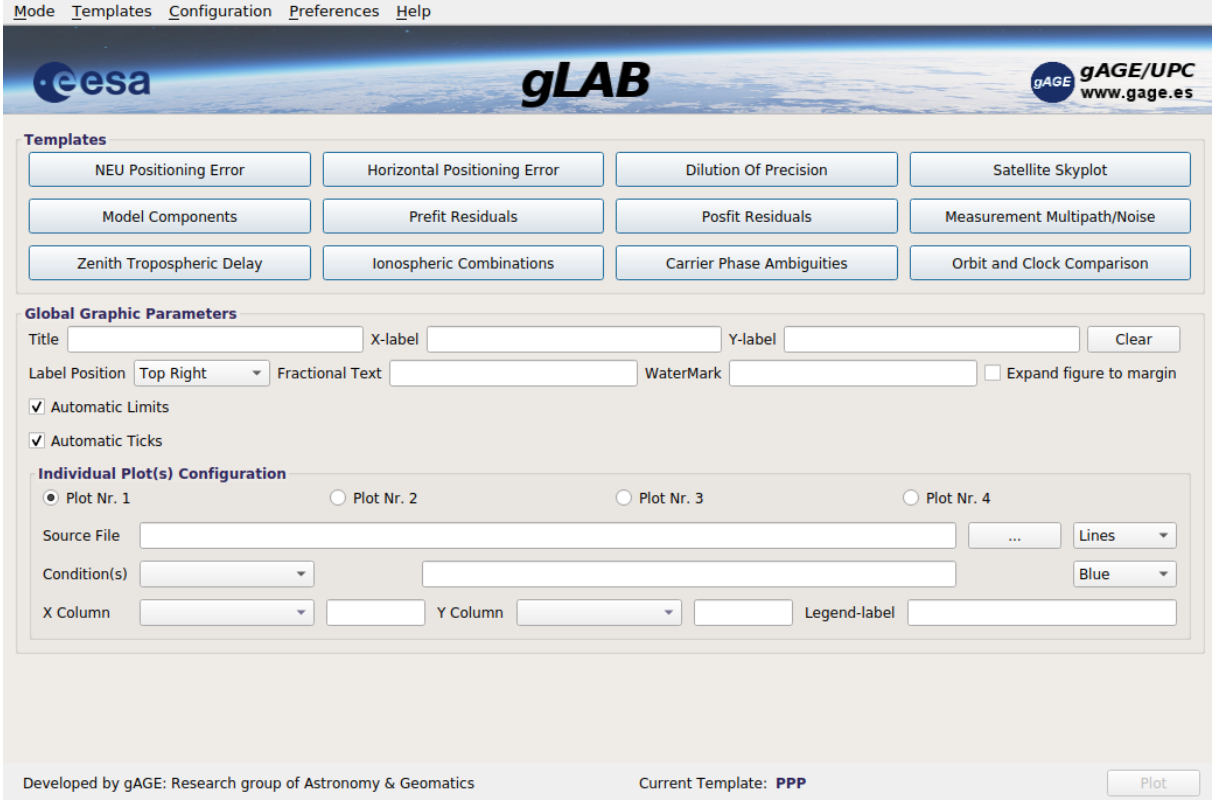

Figure 4-22: Analysis screenshot

- Templates: The templates are a set of preconfigured plotting options for the *Graphic Details* section. Clicking on any button will load the options in that section, allowing modifying or plotting them directly.
    - NEU position error: The NEU position error template sets the options to print the three components (North, East and Up) of the error of the receiver positioning obtained by the filter. This error is computed by the difference between the direct filter estimation and the Apriori Receiver Position in the Input section of Calculus. Thence to obtain a reliable error estimation, this apriori position should be precise.

      If you do not have any precise position of the receiver, you can obtain it by doing a PPP processing (*SP3/Static/Dual frequency/Pseudorange+Carrier phase*). The XYZ position (fields 6 to 8 of OUTPUT message) of the last epoch should have an accuracy in the order of the centimeter, and can be used as a good reference position.
    - Horizontal Positioning Error: The Horizontal positioning error template sets the options to print the North vs East position error components. This provides an

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insight of the horizontal dispersion and bias of the errors. To see more details on how the error is computed, see the NEU positioning error button template.

- Dilution Of Precision: The DOP template sets the options to print Geometric Dilution of Precision (GDOP), Horizontal Dilution of Precision (HDOP), Vertical Dilution of Precision (VDOP), Time Dilution of Precision (TDOP). This computations take into account the geometry matrix (G), which is linked only to the receiver-satellite(s) ray geometry. This factor impacts the accuracy of the filter solution.
- Satellite skyplot: The Satellite skyplot template sets the options to print the elevation/azimuth of the satellites in a skyplot, being the center of the plot the zenith of the satellite, and the extremes, the lower elevations. This is a special plot which makes use of sin and cos in the X column and Y column to obtain a polar plot.
- Model components: The Model components template sets the options to print a component of the model as a function of time. By default, it selects the Relativity effect, but it can easily be chosen which model to print, by selecting it in the Y Column option.
- Prefit Residuals: The Prefit residuals template sets the options to print the measurement-model values prefits, which is the input to each filter execution as a function of time. It prints both pseudorange and carrier phase prefits. In general Prefit = Measurement - Model, but this is no longer true when using smoothing, as the first is the raw measurement without smoothing, but the second term takes smoothing into account.
- Postfit residuals: The Postfit residuals template sets the options to print the filter residuals (postfits) as a function of the satellite elevation. It prints both pseudorange and carrier phase postfits. This plot allows observing the dependence of residuals from elevation. In general, carrier phase residuals will be quite independent from elevation, and pseudorange residuals can have a large dependence on elevation.
- Measurement Multipath/Noise: The Measurements Multipath/Noise template sets the options to print the measurement multipath for: C1 code measurement, the Geometry-Free combination, the Melbourne-Wübenna and the GRAPHIC combination. In addition to these combinations, raw measurements present in the file can also be plotted.

For SPP/PPP model:

- Zenith Tropospheric Delay: The Zenith Tropospheric Delay template sets the options to print the tropospheric estimations as a function of time. It includes the nominal part corrected in the modelling and the estimated part computed in the filter.
- Ionospheric combinations: The Ionospheric combinations template sets the options to print the two ionospheric (geometric-free) combinations: P_I (P2-P1) [pseudorange] and L_I (L1-L2) [carrier phase].
- Carrier phase ambiguities: The Carrier phase ambiguities template sets the options to print the estimation of carrier phase measurements in the filter. This

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is only possible in a processing with the *Pseudorange + carrier phase* measurements (in the Filter section).

- Orbit and Clock Comparison: The Orbits and Clock comparison template sets the options to print the discrepancies between two orbit product files (RINEX navigation or SP3 files). Note: The comparison between these two orbit product files has to be done in the Compare Orbits mode.

For DGNSS model:

- Differential Corrections (PRC): The Differential Corrections (PRC) template sets the options to print the the differential correction (obtained from the reference station data) applied to the satellite modelling.
- Sigma of PRC: The Sigma of PRC template sets the options to print the the total weight applied to each satellite (see *StdDev from DGNSS* tooltip in the FILTER section for details on how to compute the weight in DGNSS).

For SBAS model:

- HPE + HPL + #SAT: The HPE + HPL + #SAT template sets the options to print the horizontal positioning error (HPE) and horizontal protection level (HPL), along with the number of satellites used to compute the navigation solution. This plot is useful to compare the horizontal component of the error obtained in the navigation solution with the estimation of the error (the protection level) given by the SBAS provider.
- VPE + VPL + #SAT: The VPE + VPL + #SAT template sets the options to print the vertical positioning error (VPE) and vertical protection level (VPL), along with the number of satellites used to compute the navigation solution. This plot is useful to compare the vertical component of the error obtained in the navigation solution with the estimation of the error (the protection level) given by the SBAS provider.
- Horizontal Stanford Plot: The Horizontal Stanford Plot template sets the options to print the Stanford Plot for the horizontal component. The Stanford Plot is a heatmap, where each coordinate (being the X axis the positioning error and the Y axis the protection level) represents the number of occurrences in the navigation solution of each combination of positioning error and protection level. With this plot, it is easy to see if there was any occurrence where the positioning error was equal or greater than the protection level.
- Vertical Stanford Plot: The Vertical Stanford Plot template sets the options to print the Stanford Plot for the Vertical component. The Stanford Plot is a heatmap, where each coordinate (being the X axis the positioning error and the Y axis the protection level) represents the number of occurrences in the navigation solution of each combination of positioning error and protection level. With this plot, it is easy to see if there was any occurrence where the positioning error was equal or greater than the protection level.
- Stanford-ESA: The Stanford-ESA is a special template, as the input data is read from the Stanford-ESA Plot File (which the user has to enable in the OUTPUT section). In the Stanford-ESA, instead of the ocurrences which appear in the navigation solution, it is shown all the ocurrences with all possible combinations

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of satellites used for computing the navigation solution for all epochs (for each satellite, all satellites can be used or only some of them when computing the navigation solution).

- SBAS Model Components: The SBAS Model Components template sets the options to print a component of the SBAS modelling as a function of time. By default, it selects the Pseudorange correction, but it can easily be chosen which model to print, by choosing it in the Y Column option.
- SBAS Sigma Components: The SBAS Sigma Components template sets the options to print a component of the SBAS sigmas as a function of time. By default, it selects the Total Sigma (the total sigma applied to the satellite after appliying all SBAS corrections), but it can easily be chosen which model to print, by choosing it in the Y Column option.
- SBAS Ionospheric Components: The SBAS Ionospheric Components template sets the options to print a component used in the computation of the SBAS Ionosphere as a function of time. By default, it selects the Slant Delay (the total ionosphere correction applied to the satellite), but it can easily be chosen which model to print, by choosing it in the Y Column option.

- Global Graphic Parameters: Specify the different options of the graphic.
  - Title: Sets the title of the graphic.
  - X-label: Sets the X label of the graphic.
  - Y-label: Sets the Y label of the graphic.
  - Clear: Clear all the options in the *Graphic Details* section.
  - Label Position: Set the label position in the plot.
    - In Stanford and Stanford-ESA plots no label is set, therefore this option is disabled in this templates.
    - In command line, the user can specify the label coordinates in the plot with the parameter **'--labelpos'**.
  - Fractional Text: Set a small title in the upper left corner of the plot. This option is disabled in Stanford and Stanford-ESA plots.
  - WaterMark: Set a small watermark text in the bottom right side of the figure.
  - Expand figure to margin: When creating the plot, resize the figure as big as possible inside the margins, even if the resize is not proportional in both horizontal and vertical axis.
  - Automatic Plot Limits: The limits of the graphic axis can be automatically or user set:
    - Xmin & Xmax
    - Ymin & Ymax
  - Individual Plot(s) Configuration: Options for the different plots that can contain a graphic (up to four plots).

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- Plot 1/2/3/4: Selector for each plot. The options below this one are plot-dependent.
- Source File: Selects the source input file for the plot.
- Lines/Dot list: Allows changing the style of the plot, using Lines or Dots among many plot marker styles.
- Color Selection: Allows changing the color of the plot.
- Condition: The condition is a way to insert one or more conditions in order to select which lines of the source file will be used in the plotting. This has a space to write the required conditions and two comboboxes, which automatically sets the condition text. The text is the only that matters and the combo boxes only configure the text.

  To specify a column, it should be done as '$x' being x the number of the column. For example if you would like to specify the condition that the sixth column must be greater or equal than 10, you should do it as: ($6>=10)

  You can specify a set of conditions by using AND [&] and OR [|] operators, such as: ($6>=10) &($6<=20)|($8==2)

  You can specify that a column matches a specific string by surrounding the string by \", such as: ($1==\"OUTPUT\")

  You can specify mathematical operations and constants, as: math.pi, math.e, math.sin() and math.cos(), as example: ($1==\"POSTFIT\")&(math.cos($11+5)>0.707)

  You can specify a specific character inside a column, by using $x[y], being x the column and y the character position beginning by 0, such as: ($1==\"POSTFIT\")&($7[0]==\"P\") [First character of seventh column is 'P']

  You can also operate between columns, such as: (($9-$11)<2)
- X Column: This allows specifying the column for the x values for the selected plot. The combo box will be updated by the First condition, but the text part is the one that matters. As in the conditions, you can specify several things. In general if it is required to plot a column it can be done by putting its column position, such as: 4. It can also be used the $4 to plot the forth column. As before, operations between scalars and columns can be done (and even use functions), such as: ($9*2-$11*3-1.5).
- Y Column: This allows specifying the column for the y values for the selected plot. The format is the same as in *X Column*.
- Label: Sets the label for the selected plot.

- Plot button: This button executes the plotting tool of gLAB with the specified options.

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4.4 CONVERTER MODE

The converter mode allows converting SBAS and RTCM files to other file formats such as RINEX, SBAS or PEGASUS, besides plain text files. Figure 4-23 shows a screenshot of the converter interface.

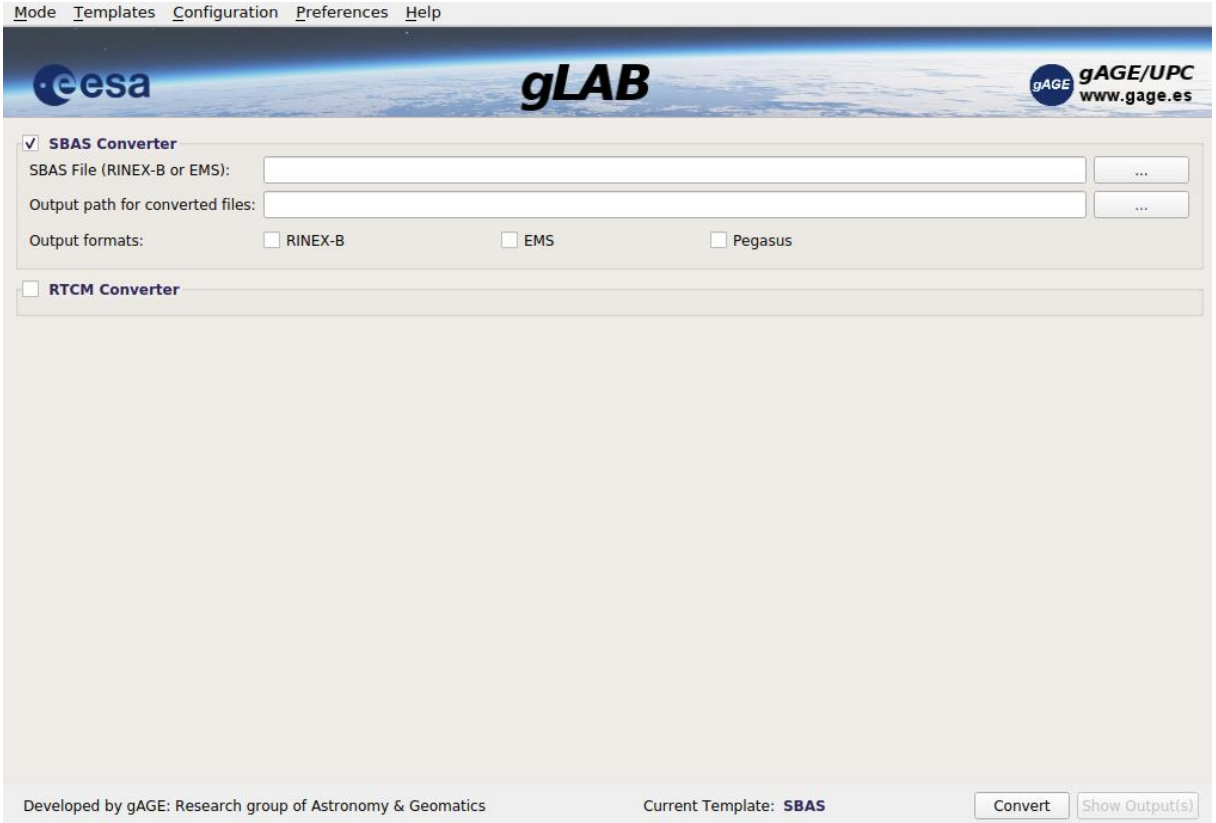

Figure 4-23: Converter screenshot

- **SBAS Converter:**
  - **SBAS File (RINEX-B or EMS):** Selects the input SBAS messages file. Supported formats are RINEX-B 2.11 or EMS. SBAS message file may have data for multiple GEOs.
  - **Output path for converted files:** Select the output path for converted files and the conversion log. RINEX-B and EMS converted files are a single file each one, but Pegasus format produces 14 output text files.
  - **Output formats:** Select the output formats for conversion. More than one format can be selected at once.
    - **RINEX-B:** Write SBAS messages in RINEX-B format, see AD-04.
    - **EMS:** Write SBAS messages in EMS format, see AD-05.

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- **Pegasus:** Write SBAS messages in Pegasus format. Pegasus is the Eurocontrol propietary software for computing solution using SBAS and GBAS augmentation systems.

  The advantage of Pegasus format is that corrections are written in decimal format and in several columnar text files (according to message types), thus it is human readable.

  A slightly obsolete Pegasus ICD can be found at the following link, where the file format description is valid, but not the header name records. Pegasus format description can be found at AD-11.

  - **Space as column delimeter:**

    Use a space (' ') instead of a semicolon (';') as a field separator. This enhances human readibility.

    NOTE: Pegasus software will not be able to read the output files if this option is enabled.

  - **Align columns:**

    Make fields have always the same width, so the first character of each field is always in the same position in all the lines, instead of writing each field with the minium size possible. This enhances human readibility.

    NOTE: Pegasus software will not be able to read the output files if this option is enabled.

- **RTCM Converter:**
  - **Input:** Selects the input reference station file. Supported formats are:
    - RTCM Auto: In this mode gLAB will autodetect if RTCM file is version 2.x or 3.x.
    - RTCM 2.x: RTCM version 2. In this mode, the initial date and hour of the data has to be provided, as this information is not in the binary file.
    - RTCM v3.x: RTCM version 3. In this mode, the initial date of the data has to be provided, as this information is not in the binary file.
  - **Output:** Select the output file.
    - **See description in Section 10.6.2.**

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4.5 COMPARE ORBITS & CLOCKS MODE

This mode reads and compares two different sources of orbit and clock products. Figure 4-24 shows a screenshot of the compare orbits and clock interface.

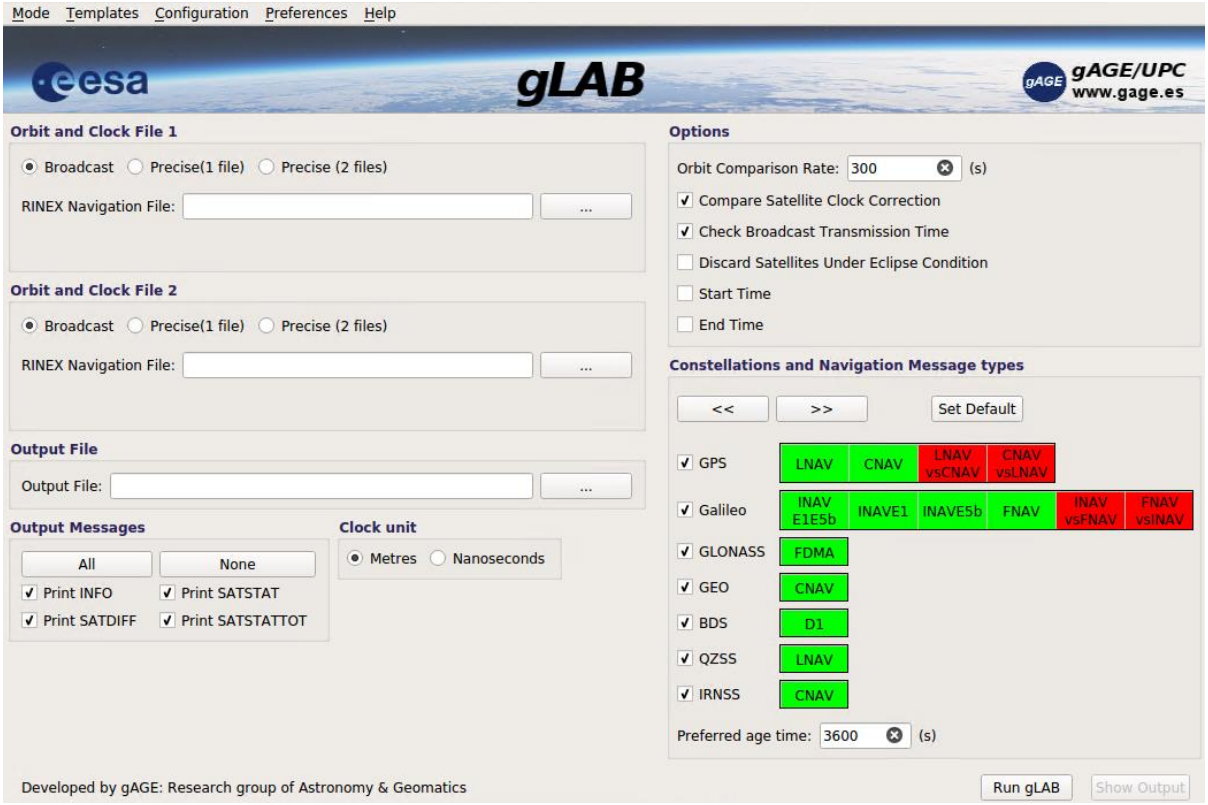

Figure 4-24: Compare Orbits & Clocks screenshot

- **Orbit and Clock File 1 & 2:**
  - **Broadcast:** Selects as orbit and clock product source the navigation message. This message is included inside the GPS signal. For processing purposes, you can select the input file where the navigation message is stored in navigation RINEX format.
  - **Precise (1 file):** Selects as orbit and clock products source an SP3 file. This file contains the orbits and clocks of the satellite at specific times. The orbit and clock interpolation degrees in the Modelling section affects the computation of orbit and clocks in this mode[3].
  - **Precise (2 files):** Selects as orbit and clock products source an SP3 file (for orbits) and a CLK file (for clocks). These files contain the orbits and clocks of the satellite at specific times. The use of a CLK file provides a higher rate of the clocks, and thence a higher rate processing step. The orbit and clock

[3] SP3 files can be found at the IGS site: [RD-6].

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interpolation degrees in the Modelling section affects the computation of orbit and clocks in this mode.

- Orbits SP3 File: Source of orbit data.
- Clocks Rinex File: Source of clock data.

- **ANTEX file:** Selects the input ANTEX file. This file contains information on the antenna phase centre of the GNSS satellites and ground stations.
- **Output file:** Sets the output file where all messages will be written.
- **Clock unit:** Print the estimated clock and DCB terms in the output messages in metres (this is the default) or nanoseconds. The following messages will be affected:
  - SATDIFF message:
    - **Field 11:** Clock difference [m]
    - **Field 12:** GPS P1-P2 DCB difference or QZSS C1C DCB difference. If not GPS or QZSS, this value is 0 [L1 m]
  - SATSTAT message:
    - **Field 14-16:** Clock comparisons (mean [m], RMS [m], stdDev [m])
    - **Field 17-19:** DCB comparisons (mean [L1 m], RMS [L1 m], stdDev [L1 m])
  - SATSTATTOT message:
    - **Field 12-14:** Clock comparisons (mean [m], RMS [m], stdDev [m])
    - **Field 15-17:** DCB comparisons (mean [L1 m], RMS [L1 m], stdDev [L1 m])

NOTE: If option *Print messages in gLAB v5 format* is enabled, this option will have no effect.

- **Options:**
  - **Orbit Computation Rate:** Set the orbit computation time rate (in seconds). It can be decimal (up to 0.0001 seconds resolution) and it must greater than 0.
  - **Compare Satellite Clock Correction:** Compare the clock offsets of the two different files. If this option is disabled, only the orbits are compared. Thus, the result of the clock comparison field is set to zero. This option is useful when one of the SP3 files contains 9999 values for the satellite clocks.
  - **Check Broadcast Transmission Time:** Each RINEX navigation message has a transmission time field in it, which refers to the first time that the satellites send the current navigation message, but receivers set it to the first time they receive the message. Therefore, receivers on different locations will set different transmission times in their RINEX navigation files, as satellite visibility will be different.

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gLAB uses this time to check whether it can use or not use a navigation message, as if current epoch is previous to the transmission time, this means that the package was not available yet.

In SBAS and DGNSS this check is disabled, as in these modes corrections sent to the user are referred to a navigation message (with the IOD (Issue of Data)), therefore these navigation message had to be already sent by the satellite in order to compute the corrections.

- **Discard satellites under eclipse condition:** This parameter allows to activate the discard of satellites if they are under eclipse conditions:
  - They do not have direct visibility of the Su
  - They have been in the former condition at some time of the last 30 minutes.
- **Start time:** Set the first epoch (in GPS time) for comparing orbital data.

  NOTE: In the GUI, the date format is fixed, but in command line there are four different date formats:
  - YYYYMMDD HH:MM:SS (in 24 hour format)
  - YYYY/MM/DD HH:MM:SS (in 24 hour format)
  - YYYY/DoY SoD
  - GPSWeek SoW
- **End time:** Set the last epoch (in GPS time) for comparing orbital data.

  NOTE: In the GUI, the date format is fixed, but in command line there are four different date formats:
  - YYYYMMDD HH:MM:SS (in 24 hour format)
  - YYYY/MM/DD HH:MM:SS (in 24 hour format)
  - YYYY/DoY SoD
  - GPSWeek SoW

- **Constellations and Navigation Message Types:** Set the priority order for the navigation message types per constellation. The navigation message types “vs” are only available when both input files are broadcast files and they are to compare two different navigation message types. Furthermore, unselecting the constellation in this groupbox will remove the constellation from orbit comparison.
- **Precise Products Data Interpolation:** This is the degree of the interpolation polynomial for the precise orbit and clocks (this option has no effect when using broadcast products).
  - **Interpolation Degree:** This value is only valid for orbits or clocks obtained from SP3 files (for clocks also from CLK files), as they require an interpolation.

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        - **Orbit Interpolation Degree:** By default, the interpolation is done with a polynomial of degree 9, but this value can be adjusted with this parameter. Excessively low values would strongly affect the precision of the position obtained.
        - **Clock Interpolation Degree:** By default, no interpolation is done ("degree" 0), but you can chose to activate the interpolation by providing a number different than 0. Due to the unpredictability of clocks, and its non-smoothed nature, the interpolation of low sampling rate clocks (i.e., t>30 secs) would strongly affect the precision of the clocks obtained. Only clocks with sampling rate higher than 1/30s should be interpolated with a polynomial of degree 1.
    - **Max Consecutive Gaps Between Sample:** This value is only valid for orbits or clocks obtained from SP3 files (for clocks also from CLK files), as they require an interpolation.
        - For both orbits and clocks, when selecting the samples for interpolation, there may occur that there are data gaps in the file, which may produce that samples used for interpolation are very far in time from each other, thus reducing the accuracy of the interpolated value.
        - With this option, a maximum number of consecutive data gaps between samples is set (therefore protecting against large data gaps concentrated between few samples), and for any case that this threshold is surpassed, no interpolation is done for this epoch and satellites.
        - gLAB can detect data gaps in SP3 and CLK files by calculating the sampling rate of the data files.
    - **Total Gaps Allowed:** This value is only valid for orbits or clocks obtained from SP3 files (for clocks also from CLK files), as they require an interpolation.
        - For both orbits and clocks, when selecting the samples for interpolation, there may occur that there are data gaps in the file, which may produce that samples used for interpolation are very far in time from each other, thus reducing the accuracy of the interpolated value.
        - With this option, a maximum number of data gaps between the first and last sample used is set (therefore protecting against large data gaps equally distributed in all samples used), and for any case that this threshold is surpassed, no interpolation is done for this epoch and satellites.
        - gLAB can detect data gaps in SP3 and CLK files by calculating the sampling rate of the data files.
- **Show Concatenated SP3/CLK options:** If sample at 0h 0m is present in both days, select which one to use:
    - **Current Day & Next Day:** This value is only valid for orbits obtained from SP3 or CLK files, as they require an interpolation.

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When interpolating orbits from precise products, when using single day orbit files, at the beginning and at the end of the day, the interpolated value will have an additional error of few centimetres due to a non homogenous distribution (in time) of the samples used for interpolation (Runge effect). To avoid this effect, the user can introduce a concatenated orbit file from several days (ideally, from the previous and the following day), so gLAB can interpolate using always samples with homogenous distribution (when a concatenated file is introduced, gLAB will read the file using a sliding data window of three days).

In some orbit files (typically in MGEX files), the last sample given from one day is the sample at 0 hours and 0 minutes from the following day (i.e. the first sample from the next day). The problem is that this last sample has a similar (but not equal) value to the first sample of the next day (after concatenating an orbit files, this samples appears twice), therefore, depending on the sample used, the interpolation value will slightly vary during several hours (as orbit use a high interpolation degree, and date rate is typically of 15 minutes).

If this option is set, the first sample read (the one at the end of the current day), will be used for interpolation.

NOTE: To see the Runge effect in the interpolation, the user can do a comparation of the same SP3 file, but using one concatenated and another without concatenation in the 'Compare Orbits & Clocks' mode of gLAB (in the menu Mode->Compare Orbits & Clocks).

- **Output Messages:** Individually select which messages are printed. See section gLAB output messages for details on the output messages.

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4.6 SHOW ORBITS & CLOCKS MODE

This mode reads a single source of orbit and clock products and generates an output text file with the satellite coordinates, velocity and clock offsets. Figure 4-25 shows a screenshot of the GUI with the show orbit and clock mode.

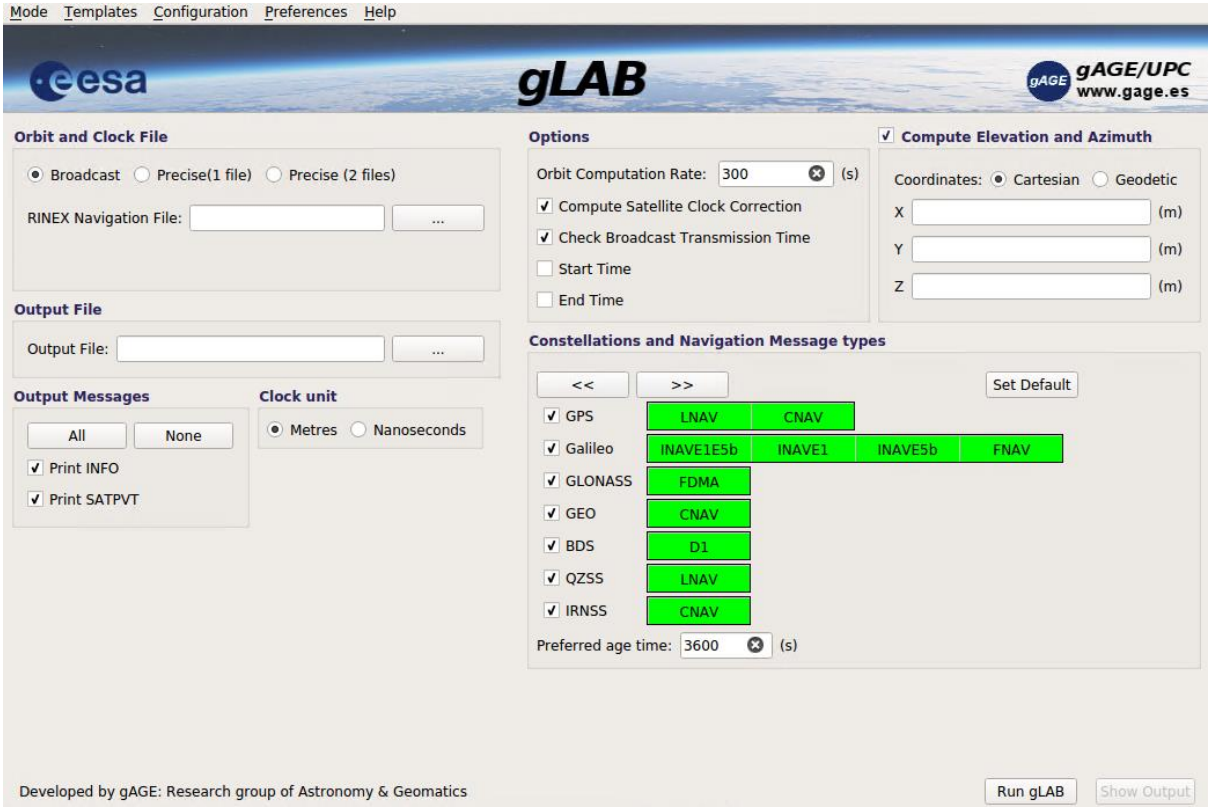

Figure 4-25: Show Orbits & Clocks screenshot

- **Orbit File:**
  - **Broadcast:** Selects as orbit and clock product source the navigation message. This message is included inside the GPS signal. For processing purposes, you can select the input file where the navigation message is stored in navigation RINEX format.
  - **Precise (1 file):** Selects as orbit and clock products source an SP3 file. This file contains the orbits and clocks of the satellite at specific times. The orbit and clock interpolation degrees in the Modelling section affects the computation of orbit and clocks in this mode[4].
  - **Precise (2 files):** Selects as orbit and clock products source an SP3 file (for orbits) and a CLK file (for clocks). These files contains the orbits and clocks of the satellite at specific times. The use of a CLK file provides a higher rate of the

[4] SP3 files can be found at the IGS site: [RD-6].

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clocks, and thence a higher rate processing step. The orbit and clock interpolation degrees in the Modelling section affects the computation of orbit and clocks in this mode.

- Orbits SP3 File: Source of orbit data.
- Clocks Rinex File: Source of clock data.

- **ANTEX file:** Selects the input ANTEX file. This file contains information on the antenna phase centre of the GNSS satellites and ground stations.
- **Output File:** Sets the output file where all messages will be written.
- **Clock unit:** Print the estimated clock and DCB terms in the output messages in metres (this is the default) or nanoseconds. The following message will be affected:
  - SATPVT message:
    - Field 16: Satellite clock offset [m]

NOTE: If option Print messages in gLAB v5 format is enabled, this option will have no effect.

- **Options:**
  - **Orbit Computation Rate:** Set the orbit computation time rate (in seconds). It can be decimal (up to 0.0001 seconds resolution) and it must greater than 0.
  - **Compute Satellite Clock Correction:** Compute the satellite clock offsets from the selected file. If this option is disabled, only the satellite coordinates and velocity are computed. Thus, the result of the clock field is set to zero. This option is useful when SP3 file contains 9999 values for the satellite clocks
  - **Check Broadcast Transmission Time:** Each RINEX navigation message has a transmission time field in it, which refers to the first time that the satellites sends the current navigation message, but receivers set it to the first time they receive the message. Therefore, receivers on different locations will set different transmission times in their RINEX navigation files, as satellite visibility will be different.

    gLAB uses this time to check wheter it can use or not use a navigation message, as if current epoch is previous to the transmission time, this means that the package was not available yet.

    In SBAS and DGNSS this check is disabled, as in these modes corrections sent to the user are referred to a navigation message (with the IOD (Issue of Data)), therefore these navigation message had to be already sent by the satellite in order to compute the corrections.
  - **Start time:** Set the first epoch (in GPS time) for comparing orbital data.

    NOTE: In the GUI, the date format is fixed, but in command line there are four different date formats:

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        - YYYYMMDD HH:MM:SS (in 24 hour format)
        - YYYY/MM/DD HH:MM:SS (in 24 hour format)
        - YYYY/DoY SoD
        - GPSWeek SoW

    - **End time:** Set the last epoch (in GPS time) for comparing orbital data.

      NOTE: In the GUI, the date format is fixed, but in command line there are four different date formats:

        - YYYYMMDD HH:MM:SS (in 24 hour format)
        - YYYY/MM/DD HH:MM:SS (in 24 hour format)
        - YYYY/DoY SoD
        - GPSWeek SoW

- **Compute Elevation and Azimuth:** Provide a position (in cartesian or geodetic coordinates) to compute the satellite's elevation and azimuth.
- **Constellations and Navigation Message Types:** Set the priority order for the navigation message types per constellation. Furthermore, unselecting the constellation in this groupbox will remove the constellation from orbit comparison.

- **Precise Products Data Interpolation:** This is the degree of the interpolation polynomial for the precise orbit and clocks (this option has no effect when using broadcast products).
    - **Interpolation Degree:** This value is only valid for orbits or clocks obtained from SP3 files (for clocks also from CLK files), as they require an interpolation.
        - **Orbit Interpolation Degree:** By default, the interpolation is done with a polynomial of degree 9, but this value can be adjusted with this parameter. Excessively low values would strongly affect the precision of the position obtained.
        - **Clock Interpolation Degree:** By default, no interpolation is done ("degree" 0), but you can chose to activate the interpolation by providing a number different than 0. Due to the unpredictability of clocks, and its non-smoothed nature, the interpolation of low sampling rate clocks (i.e., t>30 secs) would strongly affect the precision of the clocks obtained. Only clocks with sampling rate higher than 1/30s should be interpolated with a polynomial of degree 1.
    - **Max Consecutive Gaps Between Sample:** This value is only valid for orbits or clocks obtained from SP3 files (for clocks also from CLK files), as they require an interpolation.

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        - For both orbits and clocks, when selecting the samples for interpolation, there may occur that there are data gaps in the file, which may produce that samples used for interpolation are very far in time from each other, thus reducing the accuracy of the interpolated value.
        - With this option, a maximum number of consecutive data gaps between samples is set (therefore protecting against large data gaps concentrated between few samples), and for any case that this threshold is surpassed, no interpolation is done for this epoch and satellites.
        - gLAB can detect data gaps in SP3 and CLK files by calculating the sampling rate of the data files.
    - **Total Gaps Allowed:** This value is only valid for orbits or clocks obtained from SP3 files (for clocks also from CLK files), as they require an interpolation.
        - For both orbits and clocks, when selecting the samples for interpolation, there may occur that there are data gaps in the file, which may produce that samples used for interpolation are very far in time from each other, thus reducing the accuracy of the interpolated value.
        - With this option, a maximum number of data gaps between the first and last sample used is set (therefore protecting against large data gaps equally distributed in all samples used), and for any case that this threshold is surpassed, no interpolation is done for this epoch and satellites.
        - gLAB can detect data gaps in SP3 and CLK files by calculating the sampling rate of the data files.
- **Show Concatenated SP3/CLK options:** If sample at 0h 0m is present in both days, select which one to use:
    - **Current Day & Next Day:** This value is only valid for orbits obtained from SP3 or CLK files, as they require an interpolation.

      When interpolating orbits from precise products, when using single day orbit files, at the beginning and at the end of the day, the interpolated value will have an additional error of few centimetres due to a non homogenous distribution (in time) of the samples used for interpolation (Runge effect). To avoid this effect, the user can introduce a concatenated orbit file from several days (ideally, from the previous and the following day), so gLAB can interpolate using always samples with homogenous distribution (when a concatenated file is introduced, gLAB will read the file using a sliding data window of three days).

      In some orbit files (typically in MGEX files), the last sample given from one day is the sample at 0 hours and 0 minutes from the following day (i.e. the first sample from the next day). The problem is that this last sample has a similar (but not equal) value to the first sample of the next day (after concatenating an orbit files, this samples appears twice), therefore, depending on the sample used, the interpolation value will slightly vary during several hours (as orbit use a high interpolation degree, and date rate is typically of 15 minutes).

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If this option is set, the first sample read (the one at the end of the current day), will be used for interpolation.

NOTE: To se the Runge effect in the interpolation, the user can do a comparation of the same SP3 file, but using one concatenated and another without concatenation in the 'Compare Orbits & Clocks' mode of gLAB (in the menu Mode->Compare Orbits & Clocks).

- **Output Messages:** Individually select which messages are printed. See section gLAB output messages for details on the output messages.

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4.7 ADD USER ERROR TO RINEX MODE

This mode reads a RINEX observation file, a user added error file and creates a new RINEX observation file with the same header, version and number of measurements, but the measurements have the user error added into them, see Figure 4-26.

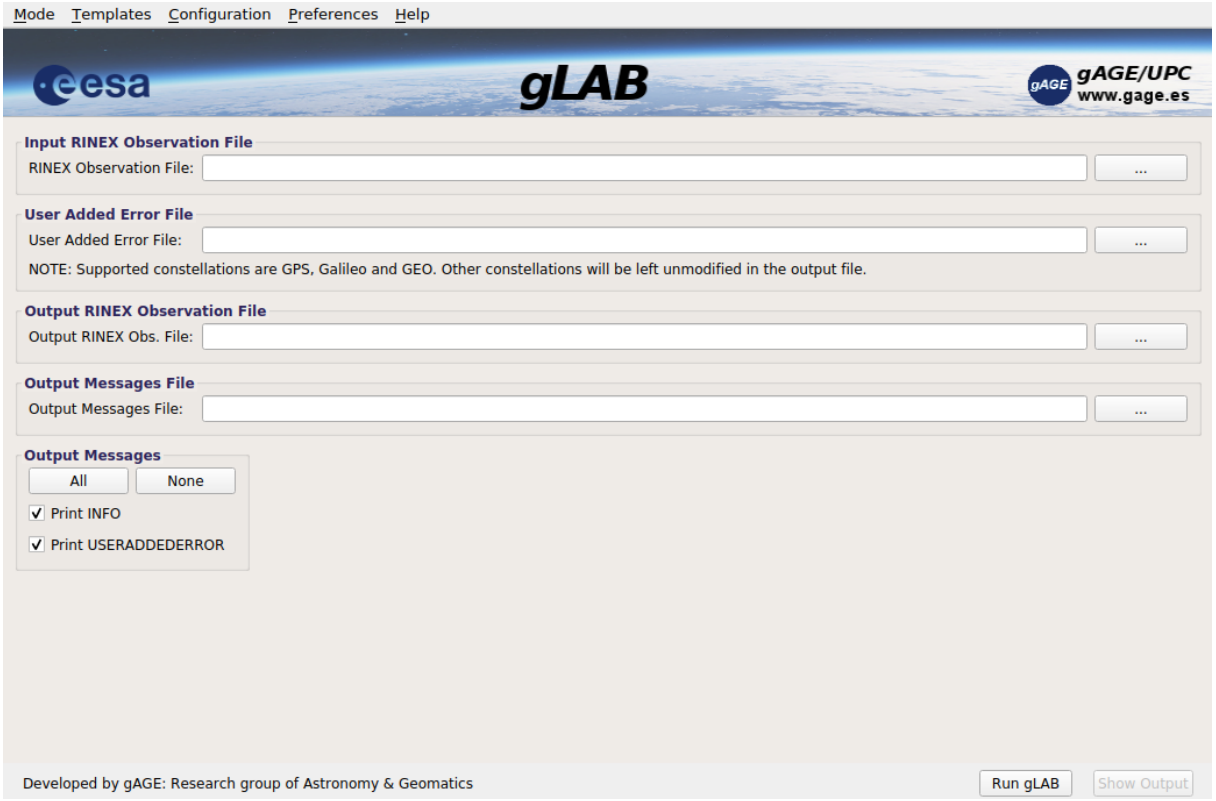

Figure 4-26: Add User Error to Rinex screenshot

- **Input RINEX Observation File:**
  - **RINEX Observation File:** Selects the input RINEX observation file. This file contains the GNSS measurements for a given station. It supports RINEX formats 2.11, 3.00, 3.01, 3.02, 3.02, 3.03 and 3.04.
- **User Added Error File:**
  - **User Added Error File:** Text file for adding error to satelite raw measurements on certain epochs. Using an adder error file is equivalent to modifying the measurement values in the RINEX observation file.

    NOTE: For details on how to generate a user added error file, refer to Section 8.1.
- **Output RINEX Observation File:**
  - **Output RINEX Observation File:** Sets the output RINEX observation file with the user added error values in the measurements.

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NOTE: Output RINEX observation version will be the same as the input RINEX observation file.

- **Output Messages:** Individually select which messages are printed. See section gLAB output messages for details on the output messages.

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4.8 GUI LIMITATIONS

For an increased easiness in use, the GUI does not include all the different options that the DPC is able to cope. In order to use these GUI-excluded features, the command-line DPC program should be used instead (see section 5 *gLAB* Data Processing Core (DPC)). In particular, the GUI does not cover the following cases:

- The GUI *Available Frequencies* option of Filter section, can only take two different values: Single or Dual Frequency. With the DPC it is possible the specify availability of each frequency (for example setting as available F1 and F2 of GPS) by means of the ' **'-pre:availf'** option.
- In the current version, SBAS processing and Stanford/Stanford-ESA plots are available in the GUI, but the world maps, integrity ratio maps and the SBAS availability maps (for both processing and plotting) are only available through command line.
- SNR threshold in the GUI is set for all satellites, but through command line, a different SNR threshold can be set for each satellite.
- Only one timestamp range in the output KML file can be set through the GUI, but in command line, any number of timestamp ranges can be set.
- There are only two filter weights computation modes in the GUI (fixed weight and exponential elevation weight), but in command line there are also the following weight modes: Inverse of the sinus of the elevation, SNR weight and SNR divided by the sinus of the elevation.
- Filter weights in the GUI are applied to all satellites for a specific measurement, but in the command line each satellite can have a different weight.
- URA value from broadcast message can be used as the constant term in all weight modes, but only on command line.
- SBAS and DGNSS weights can not be overridden in the GUI, but in the command line they can be replaced by any weight type or combining both values. This option can be applied for each satellite individually.
- Weights involving SNR for dual frequency measurements can be set to use only the SNR of one of the measurements, or the highest value, or the smallest, or the mean of both values. This option is only on command line and can be set each satellite individually.
- There is an option to filter GPS satellites that have an URA value (from the navigation message) equal or higher than a user defined threshold. This option is only available in command line.
- In the GUI, only three GEO can be unselected. In command line there is no limit.

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5 *gLAB* DATA PROCESSING CORE (DPC)

The DPC is the processing tool of gLAB, it has been programmed in C with special care for the following objectives:

- Easy to use for an advanced user.
- Modularized, in order to incorporate future updates.
- Optimized for minimizing processing time.

The options of the DPC are basically the same as the options of the GUI, with the exceptions taken in consideration in section 4.8 GUI Limitations. The DPC can be executed with the argument **'-help'**, which will provide detailed information of the different arguments that can be used.

The following lines are an extract of the **'-help'** inline information:

NOTE: A few options are shared within sections **SPP/PPP OPTIONS**, **SBAS OPTIONS** and **DGNSS OPTIONS**. Therefore, in order to avoid duplication, these options in section **SBAS OPTIONS** and **DGNSS OPTIONS** are linked to their description in section **SPP/PPP OPTIONS** with blue hyperlinks.

5.1 WORK MODES

gLAB can work in nine different modes:

- Positioning Mode	'Standard' mode, where all the processing is done, and a solution for a receiver is provided as OUTPUT messages. The minimum parameters required for this mode are an input observation file (**'-input:obs'**) and orbit and clock products (**'-input:nav'**, **'-input:sp3'** or **'-input:orb'/'-input:clk'**). Using precise products will also require the use of an ANTEX file (**'-input:ant'**). For SBAS processing, an additional input SBAS file (**'-input:sbas1f'**) is needed. For DGNSS processing, an additional input file (**'-input:dgnss'** or **'-input:rtcm'**) is needed.
- Show Input Mode	This mode only reads an input RINEX observation file and print its measurements. The parameter required for this mode is **'-input:obs'**, and specifically, no orbit and clock products should be provided (if provided, gLAB will switch to Positioning Mode).
- Product Comparison Mode	This mode reads and compares two different sources of orbit and clock products. In order to use this mode, **'-input:obs'** must be avoided, and two different orbit and clock products should be provided. This mode outputs the SATDIFF, SATSTAT and STASTATTOT messages.
- Show Product Mode	This mode reads a single source of orbit and clock products.

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	In order to use this mode, **'-input:obs'** must be avoided, and a single orbit and clock product should be provided. This mode output SAT messages
- Convert mode	Only for SBAS. If the parameter **'-onlyconvert'** is given, gLAB will just generate a RINEX-B 2.11 or EMS or Pegasus files (depending on the parameters) and it will not process any GNSS data. The minimum parameters for this mode are an SBAS file (**'-input:sbas1f'**), the **'-onlyconvert'** parameter and an output file format (**'-output:rinexb'**, **'-output:ems'**, **'-output:pegasus'**)
- SBAS Plots Mode	This mode is activated when only a navigation file and a SBAS file are given. In this mode, three plots are computed: SBAS Availability, SBAS Continuity Risk and SBAS Ionosphere Corrections Availability. The three plots are computed in PA mode in the delimited (squared) region and resolution during one day (the Availability and Continuity Risk are computed at a one second rate, while the Ionosphere Corrections Availability is computed at a 300 seconds rate by default). For the three plots the values are computed for a Fault-Free receiver (no data gaps, no cycle-slips). For SBAS Availability plots, an epoch at a given latitude and longitude and height (by default is the WGS84 geoid level -0 metres-) is considered to be available when both the Horizontal and Vertical Protection Levels are below their respective alarm limits. For SBAS Continuity Risk plot, it is computed the probability of having a discontinuity (i.e. no SBAS PA solution) during the next 15 seconds (i.e. using a sliding window of 15 seconds) in aviation mode. In maritime processing, it is followed the IMO (International Maritime Organization) resolution A.1046 (27), which states that there will be only one discontinuity every 15 minutes, so each discontinuity will affect the previous 15 minutes (even if two consecutive discontinuity events occur in less than 15 minutes). See notes for SBAS maritime below. For SBAS Ionosphere Corrections Availability plot, each coordinate in the map is considered as a pierce point at 350 km height, and it is considered as available when a SBAS ionosphere can be computed at the given pierce point. The minimum parameters to activate this mode are the input navigation file (**'-input:nav'**) and the input SBAS message file (**'-input:sbas1f'**). The output files have to be processed with graph program (with **'--sbas'** parameter) in order to generate the plots. The available output messages in this mode are INFO [default on], SBASIONO [default off] and SBASUNSEL [default off]. **Note:** With the default configuration, the computation time is around 2 hours. Increasing resolution or map size will significantly increase computation time.
- Add User Error to RINEX	This mode reads a RINEX observation file, a user added error file and creates a new RINEX observation file with the same

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	header, version and number of measurements, but the measurements have the user error added into them. This mode is enabled by providing only and observation file and a user added error file with the parameters **'-input:obs'** and **'-input:usererror'**. Optionally, a GLONASS navigation file may be provided (with parameter **'-input:navglo'**) for reading frequency offsets.
- Date Conversion	When **'-dateconv:calendar'** or **'-dateconv:doy'** or **'-dateconv:gpsweek'** or **'-dateconv:mjdn'** are provided, gLAB will read the date from user input and convert it to all other date formats, print them in screen and exit.
- Coordinate Conversion	When **'-coordconv:cartesian'** or **'-coordconv:geodetic'** or **'-coordconv:spherical'** are provided, gLAB will read the coordinates from user input and convert it to all other coordinate systems, print them in screen and exit.

5.2 GENERAL OPTIONS

-help	Shows gLAB help in the command prompt
-messages	Shows the fields of each output message (see Section 7).
-examples	Shows some examples to call the program.
-faq	Shows a FAQ (Frequently Asked Questions).
-autofillscript	Shows a bash script for enabling autofilling gLAB options with a Bash terminal. Read the comments on top of the script for instructions on how to install it.
-config	Shows some info on the configuration file.
-usererrorfile	Shows an example of user-defined error configuration file.
-sigmamultipathfile	Shows an example of user multipath model configuration file.
-rtcmv2conversioninfo	Shows detailed information of the text files generated from a RTCM v2.x conversion.
-referenceposfile	Shows an example of reference position file.
-sbasplotsinfo	Shows detailed info on how to generate SBAS maps.

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5.3 SPP/PPP OPTIONS

This section gathers the gLAB options of processing of a GNSS RINEX observation data file under the Standard Point Posiitoning (SPP) and Precise Point Positonig (PPP) modes

NOTE: Some options have changed its name of argument format from version 5. This old name or argument format are still accepted (as it has backwards compatibility). gLAB will automatically detect them and parse them accordingly. For the options that apply to satellites, they will only be applied to GPS constellation.

5.3.1 Input options

-input:cfg <file>	Sets the input configuration file.
-input:obs <file>	Sets the input RINEX observation file.
-input:nav <file> [...]	Sets the input RINEX navigation message files. Up to 7 files may be provided (one per constellation). **Note:** If two RINEX navigation files are provided and no observation file is given, gLAB will enter in orbit comparison mode. If one RINEX navigation file is provided and one SP3 file is provided file and no observation file is given, gLAB will enter in orbit comparison mode.
-input:navglo <file>	Sets the input RINEX navigation message file for reading GLONASS frequency offset.
-input:navhealth <file> [...]	Sets the input RINEX navigation message files for reading satellite health (only when using precise products). Up to 7 files may be provided (one per constellation).
--input:sp3 <file> [<file>]	Sets the input SP3 orbits and clocks file. **Note:** If two SP3 files are provided and no observation file is given, gLAB will enter in orbit comparison mode.
-input:orb <file> [<file>]	Sets the input SP3 orbits (only reads the satellite coordinates, but not the clocks). **Note:** If two SP3 files are provided and no observation file is given, gLAB will enter in orbit comparison mode.
-input:clk <file>	Sets the input clock file. The number of clock files must match the number of SP3 files provided with option **'-input:orb'**.
-input:con <file>	Sets the input constellation status file (default GPSConstellationStatus.txt).
-input:ant <file>	Sets the input ANTEX satellite/receiver antenna data file.
-input:antrec <file> [<file>]	Sets the input ANTEX receiver antenna data file. If this file contains data for satellites, this data will be skipped. Up to two receiver ANTEX files may be provided. **Note:**

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	If a receiver read with this ANTEX had been also read with the ANTEX provided with parameter **'-input:ant'**, the data will be overwritten with the last data read. Up to two receiver ANTEX files may be provided.
-input:antsatblock <file>	Sets the input ANTEX file for reading the satellites block type (e.g. GPS BLOCK II-A, II-R, etc.). **Note:** With the satellite block type, gLAB can know which measurements has available each satellite (e.g. which GPS satellites have or do not have L5 frequency), and thus auto remove all unavailable measurements of the satellite from the priority list. The typical use case for this option is when the user sets, for instance, in the filter, the option **'-filter:select G0-PC15 G0-PC12 G0-LC15 G0-LC12'**, which is a typical PPP with three frequencies. Without an ANTEX file (provided with parameter **'-input:ant'** or **'-input:antsatblock'** all GPS satellites with no L5 measurements would be discarded, as it will be detected that there are measurements missing (L5 ones) for cycle-slip and the filter. With the ANTEX file, all L5 measurements will be removed (in cycle-slips and filter) in all satellites without L5, and therefore gLAB will use L1,L2,L5 measurements in satellites with L5 and only L1,L2 in satellites without L5. If **'-input:ant'** parameter is provided, there is no need to provide this parameter (as satellite blocks can be read from **'-input:ant'** ANTEX file), unless the user wants to use an ANTEX file different from the one provided in **'-input:ant'** parameter.
-input:klb <file>	Sets the input RINEX navigation file for Klobuchar corrections, if this parameter is avoided, it is used the -input:nav file.
-input:neq <file>	Sets the input RINEX navigation file for NeQuick corrections, if this parameter is avoided, it is used the -input:nav file.
-input:bds <file>	Sets the input RINEX navigation file for BeiDou corrections, if this parameter is avoided, it is used the -input:nav file.
-input:inx <file>	Sets the input IONEX file for ionospheric corrections.
-input:fppp <file>	Sets the input FPPP file for ionospheric corrections.
-input:sbasiono <file>	Sets the input RINEX-B or EMS SBAS file for ionospheric corrections.
-input:dcb <file> [...]	Sets the input DCB source from a .DCB file, a RINEX navigation file, a IONEX file or a FPPP file. **Note:** If more than one file is given for the same model, the last one will be used.
-input:rec <file>	Sets the input GPS receiver types file (default GPS_Receiver_Types) for DCB usage.
-input:snx <file>	Sets the input SINEX file for receiver position.
Note: - The use of **'-input:nav'** file will preconfigure the parameters to work in the Standard Point Positioning (SPP).	

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- The use of **'-input:sp3'/'-input:orb'/'-input:clk'** will preconfigure the parameters to work in the Precise Point Positioning (PPP) approach. All the values can be overridden by specifying the parameters. See below for more details which are the defaults for each mode. - The use of **'-input:sbas1f'** will preconfigure the parameters to work in SBAS 1 Frequency mode. - The use of **'-input:sbasdfmc'** will preconfigure the parameters to work in SBAS DFMC mode. - The use of any **'-input:rtcm'** without a **'-input:obs'** will result into converting the input RTCM to its corresponding output.

5.3.2 Preprocessing options

-pre:starttime <date>	Set the start time (in GPS time) for processing data. The following date formats are accepted: YYYYMMDD HH:MM:SS (HH in 24 hour format); YYYY/MM/DD HH:MM:SS (HH in 24 hour format); YYYY/DoY SoD; GPSWeek SoW. Example: -pre:starttime 2015/183 62000
-pre:endtime <date>	Set the end time (in GPS time) for processing data. See **'-pre:starttime'** option above for date formats.
-pre:dec #	**# = number:** Decimate input data by # seconds. [default 0 for SPP/PPP/DGNSS, 1 for SBAS] **Note:** Maximum resolution is 4 decimals digits. If # is 0, all epochs are processed. In product comparison mode (see below, in 'WORK MODES'), it sets the time step of the comparisons.
-pre:sat [+-]g[g]#[-#][.#[-#]][,[+-]g[g]#[-#][.#[-#]]] [...]	
	Include/exclude satellites from processing in a comma separated list. **[+-]** = Optional symbols for selecting (with a plus '+') or unselecting (with a minus '-'). If no symbol is provided, the default behavior is to unselect satellites. **g** = Character determining GNSS constellation (G->GPS). If g=0, apply it to all constellations. If character is '0', all satellites from all constellations will be selected or unselected. **[g]** = More than one character for GNSS constellation may be provided, so multiple GNSS can be selected at once. **#** = PRN number (If #=0, all satellites of the selected GNSS constellation will be unselected).

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	[-#] = Optionally, a minus sign ('-') and a second PRN number can be provided in order to set a range of satellites (of the same constellation). **[.#[-#]]**= Optionally, more than one satellite PRN or satellite range can be given, by separating each value with a dot ('.').
-pre:minsnr	Set a minimum SNR (Signal to Noise Ratio) value for using a satellite. **Note:** The SNR is read from the observation file. [default on in SBAS and DGNSS] If no SNR is present in the observation file, no deselection is done. The default threshold is 33 dBHz.
-pre:minsnrsel g[g]#[-#][.#[-#]] <val> [#[.#.#]][-<meas1>[-<meas2>]] [g[g]#[-#][.#[-#]] <val> [#[.#.#]][-<meas1>[-<meas2>]]] [...]	
	Set a minimum SNR threshold for a given satellite. If this option is given, SNR deselection will be activated. **g** = Character determining GNSS constellation (G->GPS). If g=0, apply it to all constellations. **[g]** = More than one character for GNSS constellation may be provided, so multiple GNSS can be selected at once. **#** = PRN number. If #=0, then the threshold will be applied to all satellites of the selected GNSS constellation. **[-#]** = Optionally, a minus sign ('-') and a second PRN number can be provided in order to set a range of satellites (of the same constellation). **[.#[-#]]**= Optionally, more than one satellite PRN or satellite range can be given, by separating each value with a dot ('.'). **<val>** = Value for SNR threshold in dBHz. This value is compared to the SNR obtained from the RINEX file in all code, carrier phase and Doppler measurements. If no SNR value is present in the RINEX file, this value will be omitted. **[#[.#.#]][-<meas1>[-<meas2>]]** = Optionally, the user can set a list of frequencies or measurements (or both) where to apply this threshold. If a frequency is given, all measurements from that frequency will have the threshold applied. If no frequency or measurement is given, it will be applied to all measurements. Any number of frequencies or measurements can be given, as long as frequencies are grouped and separated by dots, and separated from measurements with a dash ('-'). Each measurement given has to be separated with a dash ('-'). The list of frequencies may be given in any position, not necessarily before the measurements or after the measurements. If a measurement is provided (code, carrier phase or Doppler), the threshold will be applied to code, carrier phase and Doppler measurements of the same type (for instance C1C, L1C and D1C), as in the RINEX observation file these measurements share the SNR value. **Sample:**

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	' -pre:minsnrsel G0 33' => Set a threshold of 33 dbHz to all GPS measurements. **'-pre:minsnrsel GE0 33 1.5'** => Set a threshold of 33 dbHz to all GPS and Galileo satellites in measurements in frequencies 1 and 5. **'-pre:minsnrsel GR0 33 C1C-C5I'** => Set a threshold of 33 dbHz to all GPS and GLONASS satellites in measurements C1C and C5I. **'-pre:minsnrsel CJ0 33 2.7-C1C-C5I'** => Set a threshold of 33 dbHz to all BeiDou and QZSS satellites in measurements C1C and C5I BeiDou and QZSS satellites in measurements in frequencies 2 and 7. **'-pre:minsnrsel GE0 33 1.5 C0 34'** => Set a threshold of 33 dbHz to all GPS and Galileo satellites in measurements in frequencies 1 and 5 and a threshold of 34 dbHz to all BeiDou satellites and measurements.
-pre:maxsnr	Set a maximum SNR (Signal to Noise Ratio) value for using a satellite. **Note:** Discarding satellites with high SNR can be useful for filtering satellites under spoofing. The SNR is read from the observation file. [default off] If no SNR is present in the observation file, no deselection is done. The default threshold is 54 dBHz.
-pre:maxsnrsel g[g]#[-#][.#[-#]] <val> [#[.#.#]][-<meas1>[-<meas2>]] [g[g]#[-#][.#[-#]] <val> [#[.#.#]][-<meas1>[-<meas2>]]] [...]	
	Set a maximum SNR threshold for a given satellite. If this option is given, SNR deselection will be activated. **g** = Character determining GNSS constellation (G->GPS). If g=0, apply it to all constellations. **[g]** = More than one character for GNSS constellation may be provided, so multiple GNSS can be selected at once. **#** = PRN number. If #=0, then the threshold will be applied to all satellites of the selected GNSS constellation. **[-#]** = Optionally, a minus sign ('-') and a second PRN number can be provided in order to set a range of satellites (of the same constellation). **[.#[-#]]**= Optionally, more than one satellite PRN or satellite range can be given, by separating each value with a dot ('.'). **<val>** = Value for SNR threshold in dBHz. This value is compared to the SNR obtained from the RINEX file in all code, carrier phase and Doppler measurements. If no SNR value is present in the RINEX file, this value will be omitted. **[#[.#.#]][-<meas1>[-<meas2>]]** = Optionally, the user can set a list of frequencies or measurements (or both) where to apply this threshold. If a frequency is given, all measurements from that frequency will have the threshold applied. If no frequency or measurement is given, it will be applied to all measurements. Any number of frequencies or measurements can be given, as long as frequencies are grouped and separated by dots,

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	and separated from measurements with a dash ('-'). Each measurement given has to be separated with a dash ('-'). The list of frequencies may be given in any position, not necessarily before the measurements or after the measurements. If a measurement is provided (code, carrier phase or Doppler), the threshold will be applied to code, carrier phase and Doppler measurements of the same type (for instance C1C, L1C and D1C), as in the RINEX observation file these measurements share the SNR value. **Sample:** **' -pre:maxsnrsel G0 60'** => Set a threshold of 60 dbHz to all GPS measurements. **'-pre:maxsnrsel GE0 60 1.5'** => Set a threshold of 60 dbHz to all GPS and Galileo satellites in measurements in frequencies 1 and 5. **'-pre:maxsnrsel GR0 60 C1C-C5I'** => Set a threshold of 60 dbHz to all GPS and GLONASS satellites in measurements C1C and C5I. **'-pre:maxsnrsel CJ0 60 2.7-C1C-C5I'** => Set a threshold of 60 dbHz to all BeiDou and QZSS satellites in measurements C1C and C5I BeiDou and QZSS satellites in measurements in frequencies 2 and 7. **'-pre:maxsnrsel GE0 60 1.5 C0 64'** => Set a threshold of 60 dbHz to all GPS and Galileo satellites in measurements in frequencies 1 and 5 and a threshold of 64 dbHz to all BeiDou satellites and measurements.
-pre:elevation <val>	Elevation mask. Satellites below this threshold will be discarded (in degrees). [default 5]
-pre:eclipse	Discard satellites under Earth eclipse. [default: enabled for PPP, disabled for SPP]
-pre:availf [+-]g[g]#[-#][.#[-#]]-#[,g[g]#[-#][.#[-#]]-#] [...]	
	Mark frequencies available. [default all] **[+-]** = Optional symbols for adding to current list (with a plus '+') or unselecting (with a minus '-'). If no symbol is provided, the behaviour is to remove all frequencies (from the selected satellites) and enable only the frequencies provided in the argument of the parameter. **g** = Character determining GNSS constellation (G->GPS). **[g]** = More than one character for GNSS constellation may be provided, so multiple GNSS can be selected at once. # = PRN number. If #=0, then the threshold will be applied to all satellites of the selected GNSS constellation. **[-#]** = Optionally, a minus sign ('-') and a second PRN number can be provided in order to set a range of satellites (of the same constellation). **[.#[-#]]**= Optionally, more than one satellite PRN or satellite range can be given, by separating each value with a dot ('.'). # = frequencies available. More than one frequency can be provided.

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	Sample: **'-pre:availf G0-12'** => Frequencies 1 and 2 of GPS available for all satellites. **'-pre:availf G10-20-1'** => Frequency 1 of GPS available, 2 and 5 unavailable for PRNs 10 to 20. **'-pre:availf G9.8.11-13-1'** => Frequency 1 of GPS available, 2 and 5 unavailable for PRNs 8,9,11,12,13. **'-pre:availf -RG0-2'** => Remove frequency 2 from the available frequencies (leave the rest untouched) for all GPS and GLONASS satellites.
-pre:smooth <val>	Number of epochs of smoothing. [default 0 (disabled) for non SBAS processing, default 100 for SBAS processing]
-pre:smoothauto	Enable automatic selection of measurements for smoothing [default off] This option will auto disable if option **'-pre:smoothmeas'** to avoid interferring in user selected smoothing. The criteria to select the measurement to smooth with is to use the same measurement or combination and frequency(ies) as the code measurement to be smoothed but with carrier phase measurements. Smoothing time will be set to 100 epochs if none set.
-pre:smoothmeas <filtermeas> <smoothWith> [<filtermeas> <smoothWith> ...]	
	Smooth the filter measurement **<filtermeas>** with <smoothWith> carrier phase measurement or combination. **<filtermeas>** = Set the filter measurement in the same way as in parameter **'-filter:select'**. **<smoothWith>** = Measurent to smooth with. If it is a combination, the measurements for building the combination may be specified afterwards. **Sample:** **'-pre:smoothMeas'** => G0-C1P L1P. **'-pre:smoothMeas'** => G0-C1P L1P E0-C5X L5X -E15-C5X L5X. **'-pre:smoothMeas'** => G0-PC12 LC12 G12-PC15 LC15-L1X-L5X. **'-pre:smoothMeas'** => G0-SIF1224 LC17-L1X-L7X. **'-pre:smoothMeas'** => G0-C5X SIF1268-L1X-L2I-L6Q-L8D.
-pre:smoothmin <val>	Number of epochs of continuous code smoothing before steady-state operation. [default 0 for non SBAS processing, 360 for SBAS processing] **Note:** Satellites will be excluded until reaching this steady-state.
-pre:refpos:deg <val>	Set the interpolation degree for the reference position values. [default 0]
-pre:setrecpos <val>	**<val> = RINEX:** Set the user receiver a priori position as the one specified in the RINEX observation file. [default] RINEX position will be used for modelling and for NEU error.

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	<val> = SINEX: Set the user receiver a priori position to be read from a SINEX file (to be specified by the **'-input:snx'** parameter). SINEX position will be used for modelling and for NEU error. **<val> = <x> <y> <z>:** **<val> = Set <x> <y> <z>:** Specify the receiver a priori position in metres. Sample: **'-pre:setrecpos 4789032.7143 176594.9690 4195013.2268'**. Specified position will be used for modelling and for NEU error. In show Products mode, specified position will be used to compute satellite elevation and azimuth. **<val> = SetGeod <Lon> <Lat> <Height>:** Same as **'SetGeod'**, but the initial coordinates are given in geodetic coordinates. Longitude and latitude are given in degrees, within the ranges [-180..180] and [-90..90] respectively. The height is given in metres. **<val> = SetRef:** Read reference position for each epoch from reference position file Specified position will be used for modelling and for NEU error. See parameters **'-referenceposfile'**, **'-input:refpos'** and **'-pre:refpos:deg'** for help on the reference file. **<val> = calculate:** The user receiver a priori position will be calculated by the program and used for modelling, starting from (6378137,0,0). This is especially useful when processing moving receivers (trajectories) or when the approximate receiver position is not known. With this option activated, the differential fields of the OUTPUT message will be zero. **<val> = calculateRef:** Same as **'calculate'**, but instead of printing (0,0,0) in the output NEU error, it will compute the NEU error using the coordinates from the reference file. See parameters **'-referenceposfile'**, **'-input:refpos'** and **'-pre:refpos:deg'** for help on the reference file. **<val> = calculateRINEX:** Same as calculate, but the initial coordinates will be the one read in the RINEX observation header. If RINEX coordinates are are (0,0,0), then Earth's surface will be used as initial coordinates. **<val> = calculateRINEXRef:** Same as **'calculateRINEX'**, but instead of printing (0,0,0) in the output NEU error, it will compute the NEU error using the coordinates from the reference file. See parameters **'-referenceposfile'**, **'-input:refpos'** and **'-pre:refpos:deg'** for help on the reference file. **<val> = calculateUSER <x> <y> <z>:** Same as **'calculate'**, but the initial coordinates will be the one given by the user in this parameter (in metres). **<val> = calculateUSERGeod <Lon> <Lat> <Height>:**

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	Same as **'calculateUser'**, but the initial coordinates are given in geodetic coordinates. Longitude and latitude are given in degrees, within the ranges [-180..180] and [-90..90] respectively. The height is given in metres. **<val> = calculateUSERRef <x> <y> <z>:** Same as **'calculateUSER'**, but instead of printing (0,0,0) in the output NEU error, it will compute the NEU error using the coordinates from the reference file. See parameters **'-referenceposfile'**, **'-input:refpos'** and **'-pre:refpos:deg'** for help on the reference file. **<val> = calculateUSERGeodRef <Lon> <Lat> <Height>:** Same as **'calculateUSERRef'**, but the initial coordinates are given in geodetic coordinates. Longitude and latitude are given in degrees, within the ranges [-180..180] and [-90..90] respectively. The height is given in metres. **<val> = DGNSSbaseline:** The user receiver (rover) a priori position will be calculated by the program as in option **'calculat**e', but the differential fields in the OUTPUT message will computed against the reference antenna position (baseline vector from user to reference station), and the reference station coordinates will be read from RINEX or RTCM input file. **<val> = DGNSSRinexRover:** Same as **'DGNSSbaseline'**, but instead of comparing with the reference station, it will compare the user receiver (rover) coordinates with the coordinates read from the rover RINEX observation file. **<val> = DGNSSRoverUSER <RoverX> <RoverY> <RoverZ>:** Same as **'DGNSSbaseline'**, but instead of comparing with the reference station, it will compare the user receiver (rover) with the position given in this parameter. **<val> = DGNSSRoverUSERGeod <RoverLon> <RoverLat> <RoverHeight>:** Same as **'DGNSSRoverUSER'**, but the rover coordinates are given in geodetic coordinates. Longitude and latitude are given in degrees, within the ranges [-180..180] and [-90..90] respectively. The height is given in metres. **<val> = DGNSSRoverUSERRef:** Same as **'DGNSSbaseline'**, but instead of comparing with the reference station, it will compare the user receiver (rover) solution with the position given by the reference file. See parameters **'-referenceposfile'**, **'-input:refpos'** and **'-pre:refpos:deg'** for help on the reference file. **<val> = DGNSSUserRoverRef <RefX> <RefY> <RefZ>:** Same as **'DGNSSRoverUSERRef'**, but the reference station coordinates will be provided in this parameter (this mode only works when computing DGNSS with a RINEX file). **<val> = DGNSSUserGeodRoverRef <RefLon> <RefLat> <RefHeight>:** Same as **'DGNSSUserRoverRef'**, but the reference station coordinates are given in geodetic coordinates. Longitude and

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	latitude are given in degrees, within the ranges [-180..180] and [-90..90] respectively. The height is given in metres. **<val> = DGNSSUserbaseline <RefX> <RefY> <RefZ>:** Same as **'DGNSSbaseline'**, but the reference station coordinates will be provided in this parameter (this mode only works when computing DGNSS with a RINEX file). **<val> = DGNSSUserGeodbaseline <RefLon> <RefLat> <RefHeight>:** Same as **'DGNSSUserbaseline'**, but the reference station coordinates are given in geodetic coordinates. Longitude and latitude are given in degrees, within the ranges [-180..180] and [-90..90] respectively. The height is given in metres. **<val> = DGNSSUserRinexRover <RefX> <RefY> <RefZ>:** Same as **'DGNSSRinexRover'**, but the reference station coordinates will be provided in this parameter (this mode only works when computing DGNSS with a RINEX file). **<val> = DGNSSUserGeodRinexRover <RefLon> <RefLat> <RefHeight>:** Same as **'DGNSSUserRinexRover'**, but the reference station coordinates are given in geodetic coordinates. Longitude and latitude are given in degrees, within the ranges [-180 .180] and [-90..90] respectively. The height is given in metres. **<val> = DGNSSRefRoverUSER <RefX> <RefY> <RefZ> <RoverX> <RoverY> <RoverZ>:** Same as **'DGNSSRoverUSER'**, but the reference station coordinates will be provided in this parameter (this mode only works when computing DGNSS with a RINEX file). **<val> = DGNSSRefGeodRoverUSERGeod <RefLon> <RefLat> <RefHeight> <RoverLon> <RoverLat> <RoverHeight>:** Same as **'DGNSSRefRoverUSER'**, but the rover and reference station coordinates are given in geodetic coordinates. Longitude and latitude are given in degrees, within the ranges [-180..180] and [-90..90] respectively. The height is given in metres. **<val> = DGNSSRefCarRoverUSERGeod <RefX> <RefY> <RefX> <RoverLon> <RoverLat> <RoverHeight>:** Same as **'DGNSSRefRoverUSER'**, but the rover coordinates are given in geodetic coordinates and the reference station in cartesian coordinates. Longitude and latitude are given in degrees, within the ranges [-180..180] and [-90..90] respectively. The height is given in metres. **<val> = DGNSSRefGeodRoverUSERCar <RefLon> <RefLat> <RefHeight> <RoverX> <RoverY> <RoverZ>:** Same as **'DGNSSRefRoverUSER'**, but the reference station coordinates are given in geodetic coordinates and the rover in cartesian coordinates. Longitude and latitude are given in degrees, within the ranges [-180..180] and [-90..90] respectively. The height is given in metres.
-pre:setrectype <val>	**<val> = gpsrt:**

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	Set the receiver type as the one specified in the GPS_Receiver_Types file (provided by **'-input:rec'**). [default if **'-input:rec'** provided] **<val> = 0:** Set the receiver type as 'Unknown'. [default] **<val> = 1:** Set the receiver type as 'Cross-correlated'. In this mode, P2 will be corrected with the DCB of P1-C1. **<val> = 2:** Set the receiver type as 'No P1'. In this mode, C1 will be used instead of P1. **<val> = 3:** Set the receiver type as 'Consistent measurements'.
-pre:prealign	Prealign carrier phase measurements with its corresponding pseudorange. [default on]
-pre:checkcodejumps	Check for pseudorange jumps and adjust the phase accordingly. See **'Notes for preprocessing'** below. [default on]
--pre:checkcodejumps	Do not check for pseudorange jumps.
-pre:cs:datagap <val>	Data gap. Maximum period of time, without measurements, allowed before declaring cycle-slip (in seconds). [default 40 in SPP/PPP, 10 in SBAS and DGNSS] **Note:** If <val> is shorter than the sampling rate, all measurements will be discarded
-pre:cs:lli	Use Loss of Lock Indicator for cycle-slip detection. [default off]
--pre:cs:lli	Do not use Loss of Lock Indicator for cycle-slip detection. [default off]
-pre:cs:ncon	Use N-consecutive epochs for cycle-slip detection. [default on in SPP and PPP]
--pre:cs:ncon	Do not use N-consecutive epochs for cycle-slip detection. [default off in SBAS and DGNSS]
-pre:cs:ncon:min <val>	After a short data gap (i.e., shorter than the value set in **'-pre:cs:datagap'** with default of 40 seconds) discard the first <val> epochs. **Note:** If sampling interval is greater than 15 seconds, gLAB will automatically disable this option. [default 2]
-pre:cs:li	Use the carrier phase geometry-free combination (LI) for cycle-slip detection (2 frequencies). [default in PPP]
--pre:cs:li	Do not use carrier phase geometry-free combination (LI) for cycle-slip detection (2 frequencies). [default in SPP] **Note:** LI combination is a slow varying function which only has ambiguity and ionosphere. Each epoch and satellite an expected LI value is computed and compared against the measured one, if this difference is above a certain threshold, a cycle-slip is marked.

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	This threshold is (max + (min-max)*exp(-dt/t)), being dt the time between epochs.
-pre:cs:li:freq [+-]g[g]#[-#][.#[-#]]-<freq1><freq2>[.<freq1><freq2>] [[+-]g[g]#[-#][.#[-#]]-<freq1><freq2>[.<freq1><freq2>] ...]	
	Set the list of frequency combinations (per satellite) where to run the LI cycle-slip detector. Each entry must be separated by a blank space (' '). **[+-]** = Optional symbols for selecting (with a plus '+') or unselecting (with a minus '-'). If no symbol is provided, the default behaviour is to select frequencies. **g** = Character determining GNSS constellation (G->GPS). If g=0, apply it to all constellations. [g] = More than one character for GNSS constellation may be provided, so multiple GNSS can be selected at once. **#** = PRN number. If #=0, then the detector will be applied to all satellites of the selected GNSS constellation. **[-#]** = Optionally, a minus sign ('-') and a second PRN number can be provided in order to set a range of satellites (of the same constellation). **[.#[-#]]**= Optionally, more than one satellite PRN or satellite range can be given, by separating each value with a dot ('.') **<freq1><freq2>[.<freq1><freq2>]** = List of frequency combinations. Each frequency pair must be separated by a dot. Frequencies provided will be checked against measurements provided in **'-pre:cs:li:meas'** parameter, and if the frequencies are already in any of the measurements given in **'-pre:cs:li:meas'**, these frequencies will be omitted in order to avoid duplication. **Sample:** **'-pre:cs:li:freq G0-12.25.15'.** **'-pre:cs:li:freq E1-36-15.57.78 R0-12.23'.**
-pre:cs:li:freqlist [+-]g[g]#[-#][.#[-#]]-<freq1><freq2>[.<freq1><freq2>] [,[+-]g[g]#[-#][.#[-#]]-<freq1><freq2>[.<freq1><freq2>],...]	
	Same as **'-pre:cs:li:freq'**, but each entry separated by commas (',') instead of blank spaces. **Sample:** **'-pre:cs:li:freq G0-12.25.15'** **'-pre:cs:li:freq E1-36-15.57.78 R0-12.23'** **Note:** Measurements for cycle-slip detection will be automatically selected if not defined with **'-pre:cs:li:meas'**.
-pre:cs:li:meas [+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2> [[+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2> ...]	
	Set the list of combinations (per satellite) where to run the LI cycle-slip detector. Each entry must be separated by a blank space (' '). **[+-]** = Optional symbols for selecting (with a plus '+') or unselecting (with a minus '-'). If no symbol is provided, the default behaviour is to select measurements.

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	g = Character determining GNSS constellation (G->GPS). If g=0, apply it to all constellations. **[g]** = More than one character for GNSS constellation may be provided, so multiple GNSS can be selected at once. **#** = PRN number. If #=0, then the detector will be applied to all satellites of the selected GNSS constellation. **[-#]** = Optionally, a minus sign ('-') and a second PRN number can be provided in order to set a range of satellites (of the same constellation). **[.#[-#]]**= Optionally, more than one satellite PRN or satellite range can be given, by separating each value with a dot ('.') **<meas1>-<meas2>:** Set the pair of measurements to use for the LI cycle-slip detector. Each pair of measurements must a be a two carrier phases (in any order) from different frequencies or from same frequency but from different signals (for instance L2C and L2W). It can be set as many pair of measurements as desired (independently if the measurement is used in the filter or not). Measurements may be from any frequency (there can be as many frequencies as desired) and there can be also several pairs of measurements sharing frequencies. **Sample:** **'-pre:cs:li:meas G0-L1P-L2P'** **'-pre:cs:li:meas G1-10-L1P-L1L R0-L1C-L2C'**
-pre:cs:li:measlist [+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2> [[+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2> ...]	
	Same as **'-pre:cs:li:meas'**, but each entry separated by commas (',') instead of blank spaces. **Sample:** **'-pre:cs:li:measlist G0-L1P-L2P'** **'-pre:cs:li:measlist G1-10-L1C-L5X,R0-L1C-L2C'**
-pre:cs:li:maxjump <val>	Maximum jump threshold (in metres) between two consecutive measured LI values. [default 1]
-pre:cs:li:max <val>	Maximum threshold (in metres) between estimated and measured LI values. [default 0.08]
-pre:cs:li:t0 <val>	Time constant (in seconds) to set the threshold between maximum and minimum [default 60]
-pre:cs:li:samples <val>	Minimum number of epochs needed to fit the second-degree polynomial. [default 7]
-pre:cs:li:nooutliers	Disable outlier declaration in LI cycle-slip detector [default off] An outlier is declared the first time the LI detectors triggers. The sample is discarded and waits for the next epoch. If the detector triggers again, a cycle-slip is declared, otherwise the arc continues (but the outlier sample is discarded). When this option is enabled, when the LI detector triggers for the first time, a cycle-slip will declared.
-pre:cs:mw	Use Melbourne-Wubbena (MW) for cycle-slip detection (2 frequencies). [default in PPP]

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--pre:cs:mw	Do not use Melbourne-Wubbenna (MW) for cycle-slip detection (2 frequencies). [default in SPP] **Note:** MW combination is a mixed combination between carrier phase and pseudoranges. This combination is free of ionosphere and geometry, thence constant, but has a high noise (due to the pseudorange measurements used). If this noise is low enough, it is straightforward to detect cycle-slips, but in noisy environments, MW is not able to detect cycle-slips. The algorithm using MW computes the mean and the standard deviation of the last epochs in order to obtain an estimated value and the noise level of the combination. The estimated value is compared against the measured value, and the noise level is used for the threshold of this difference. Difference must be lower than standard deviation multiplied by a number (k-factor). This threshold has minimum (min) and maximum (max) saturation values.
-pre:cs:mw:freq [+-]g[g]#[-#][.#[-#]]-<freq1><freq2>[.<freq1><freq2>] [[+-]g[g]#[-#][.#[-#]]-<freq1><freq2>[.<freq1><freq2>] ...]	
	Set the list of frequency combinations (per satellite) where to run the MW cycle-slip detector. Each entry must be separated by a blank space (' '). **[+-]** = Optional symbols for selecting (with a plus '+') or unselecting (with a minus '-'). If no symbol is provided, the default behaviour is to select frequencies. **g** = Character determining GNSS constellation (G->GPS). If g=0, apply it to all constellations. **[g]** = More than one character for GNSS constellation may be provided, so multiple GNSS can be selected at once. **#** = PRN number. If #=0, then the detector will be applied to all satellites of the selected GNSS constellation. **[-#]** = Optionally, a minus sign ('-') and a second PRN number can be provided in order to set a range of satellites (of the same constellation). **[.#[-#]]**= Optionally, more than one satellite PRN or satellite range can be given, by separating each value with a dot ('.'). **<freq1><freq2>[.<freq1><freq2>]** = List of frequency combinations. Each frequency pair must be separated by a dot. Frequencies provided will be checked against measurements provided in '-pre:cs:mw:meas' parameter, and if the frequencies are already in any of the measurements given in '-pre:cs:mw:meas', these frequencies will be omitted in order to avoid duplication. **Sample:** **'-pre:cs:mw:freq G0-12.25.15'** **'-pre:cs:mw:freq E1-36-15.57.78 R0-12.23'** **Note:** Measurements for cycle-slip detection will be automatically selected if not defined with '-pre:cs:mw:meas'.
-pre:cs:mw:freqlist [+-]g[g]#[-#][.#[-#]]-<freq1><freq2>[.<freq1><freq2>] [,[+-]g[g]#[-#][.#[-#]]-<freq1><freq2>[.<freq1><freq2>],...]	

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	Same as **'-pre:cs:mw:freq'**, but each entry separated by commas (',') instead of blank spaces. **Sample:** **'-pre:cs:mw:freq G0-12.25.15'** **'-pre:cs:mw:freq E1-36-15.57.78 R0-12.23'**
-pre:cs:mw:meas [+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2>-<meas3>-<meas4> [[+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2>-<meas3>-<meas4> ...]	
	Set the list of combinations (per satellite) where to run the Melbourne-Wubbena cycle-slip detector. Each entry must be separated by a blank space (' ') **[+-]** = Optional symbols for selecting (with a plus '+') or unselecting (with a minus '-'). If no symbol is provided, the default behaviour is to select measurements **g** = Character determining GNSS constellation (G->GPS). If g=0, apply it to all constellations **[g]** = More than one character for GNSS constellation may be provided, so multiple GNSS can be selected at once # = PRN number. If #=0, then the detector will be applied to all satellites of the selected GNSS constellation **[-#]** = Optionally, a minus sign ('-') and a second PRN number can be provided in order to set a range of satellites (of the same constellation) **[.#[-#]]**= Optionally, more than one satellite PRN or satellite range can be given, by separating each value with a dot ('.') **<meas1>-<meas2>-<meas3>-<meas4>:** Set the two pair of measurements to use for the Melbourne-Wubbena cycle-slip detector. The four measurements must be a pair of pseudoranges and a pair carrier phases (in any order) from different different signals (for instance L2C and L2W). It can be set as many pair of measurements as desired frequencies. (independently if the measurement is used in the filter or not). Measurements may be from any frequency (there can be as many frequencies as desired) and there can be also several groups of measurements sharing frequencies. **Sample:** **'-pre:cs:mw:meas G0-C1P-C2P-L1P-L2P'** **'-pre:cs:mw:meas G1-10-C1C-L1C-C5X-L5X R0-L1C-L2C-C1C-C2C'**
-pre:cs:mw:measlist [+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2>-<meas3>-<meas4> [[+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2>-<meas3>-<meas4> ...]	
	Same as **'-pre:cs:mw:meas'**, but each entry separated by commas (',') instead of blank spaces. **Sample:** **'-pre:cs:mw:measlist G0-C1P-C2P-L1P-L2P'** **'-pre:cs:mw:measlist G1-10-C1C-L1C-C5X-L5X,R0-L1C-L2C-C1C-C2C'**
-pre:cs:mw:nooutliers	Disable outlier declaration in MW cycle-slip detector [default off] An outlier is declared the first time the MW detectors triggers. The sample is discarded and waits for the next epoch.

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	If the detector triggers again, a cycle-slip is declared, otherwise the arc continues (but the outlier sample is discarded). When this option is enabled, when the MW detector triggers for the first time, a cycle-slip will declared.
-pre:cs:sf:unconcheck	Use the unconsistency check in single frequency cycle-slip detection (Phase-Code). [default]
--pre:cs:sf:unconcheck	Do not use the unconsistency check in single frequency cycle-slip detection (Phase-Code).
-pre:cs:mw:siginit <val>	Initial standard deviation (in metres) to use in MW after a cycle-slip. [default 2]
-pre:cs:mw:sigmin <val>	Minimum threshold (in metres) between estimated and measured MW values in relation to its standard deviation. [default 0.8]
-pre:cs:mw:timewindow <val>	Number of epochs to compute the mobile mean over the Hatch filter. [default 300]
-pre:cs:mw:kfactor <val>	Relation between estimated and measured MW values in relation to its standard deviation. [default 5]
-pre:cs:mw:samples <val>	Minimum number of epochs needed to stabilize the mean and sigma in the MW cycle-slip detector. [default 2]
-pre:cs:sf	Use the Phase-Code combination for single frequency cycle-slip detection. [default in SBAS 1F/DGNSS]
--pre:cs:sf	Do not use the Phase-Code combination for single frequency cycle-slip detection. [default in SPP/PPP/SBAS DFMC]
-pre:cs:sf:freq [+-]g[g]#[-#][.#[-#]]-<freq>[.<freq>] [[+-]g[g]#[-#][.#[-#]]-<freq>[.<freq>] ...]	
	Set the list of frequencies (per satellite) where to run the single frequency cycle-slip detector. Each entry must be separated by a blank space (' '). **[+-]** = Optional symbols for selecting (with a plus '+') or unselecting (with a minus '-'). If no symbol is provided, the default behaviour is to select frequencies. **g** = Character determining GNSS constellation (G->GPS). If g=0, apply it to all constellations. **[g]** = More than one character for GNSS constellation may be provided, so multiple GNSS can be selected at once. **#** = PRN number. If #=0, then the detector will be applied to all satellites of the selected GNSS constellation. **[-#]** = Optionally, a minus sign ('-') and a second PRN number can be provided in order to set a range of satellites (of the same constellation). **[.#[-#]]**= Optionally, more than one satellite PRN or satellite range can be given, by separating each value with a dot ('.'). **<freq>[.<freq>]** = List of frequencies. Each frequency must be separated by a dot. Frequency provided will be checked against measurements provided in **'-pre:cs:sf:meas'** parameter, and if the frequency is already in any of the measurements given in **'-pre:cs:sf:meas'**, this frequency will be omitted in order to avoid duplication. **Sample:** **'-pre:cs:sf:freq G0-1.2.5'**

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	'-pre:cs:sf:freq E1-36-1.5.7.8 R0-1.2'. **Note:** Measurements for cycle-slip detection will be automatically selected if not defined with **'-pre:cs:sf:meas'**.
-pre:cs:sf:freqlist [+-]g[g]#[-#][.#[-#]]-<freq>[.<freq>][,[+-]g[g]#[-#][.#[-#]]-<freq>[.<freq>],...]	
	Same as **'-pre:cs:sf:freq'**, but each entry separated by commas (',') instead of blank spaces. **Sample:** **'-pre:cs:sf:freqlist G0-1.2.5'** **'-pre:cs:sf:freqlist E1-36-1.5.7.8,R0-1.2'**
-pre:cs:sf:meas [+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2> [[+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2> ...]	
	Set the list of combinations (per satellite) where to run the single frequency cycle-slip detector. Each entry must be separated by a blank space (' '). **[+-]** = Optional symbols for selecting (with a plus '+') or unselecting (with a minus '-'). If no symbol is provided, the default behaviour is to select measurements. **g** = Character determining GNSS constellation (G->GPS). If g=0, apply it to all constellations. **[g]** = More than one character for GNSS constellation may be provided, so multiple GNSS can be selected at once. **#** = PRN number. If #=0, then the detector will be applied to all satellites of the selected GNSS constellation. **[-#]** = Optionally, a minus sign ('-') and a second PRN number can be provided in order to set a range of satellites (of the same constellation). **[.#[-#]]**= Optionally, more than one satellite PRN or satellite range can be given, by separating each value with a dot ('.'). **<meas1>-<meas2>:** Set the pair of measurements to use for the single frequency cycle-slip detector. Each pair of measurements must a be a pseudorange and a carrier phase (in any order) from the same frequency. It can be set as many pair of measurements as desired (independently if the measurement is used in the filter or not). Measurements may be from any frequency (there can be as many frequencies as desired) and there can be also several pairs of measurements sharing frequencies. **Sample:** **'-pre:cs:sf:meas G0-L1P-C1P'** **'-pre:cs:sf:meas G1-10-L2P-C2P R0-L2C-C2C'**
-pre:cs:sf:measlist [+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2> [[+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2> ...]	
	Same as **'-pre:cs:sf:meas'**, but each entry separated by commas (',') instead of blank spaces. **Sample:** **'-pre:cs:sf:measlist G0-L1P-C1P'** **'-pre:cs:sf:measlist G1-10-L2P-C2P,R0-L2C-C2C'**

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-pre:cs:sf:unconcheck	Use the unconsistency check in single frequency cycle-slip detection (Phase-Code). [default]
--pre:cs:sf:unconcheck	Do not use the unconsistency check in single frequency cycle-slip detection (Phase-Code).
-pre:cs:sf:unconcheck:th <val>	Threshold (in metres) for the unconsistency check in single frequency cycle-slip detection (Phase-Code). [default 20] **Note:** The single frequency cycle-slip detector averages the difference between carrier phase and pseudorange measurements for several epochs. This cycle-slip detection method is very useful for single-frequency receivers, as it only requires measurements from one frequency. As a counterpart, the ionospheric term is different for code and phase, thence, this combination will tend to diverge. It becomes necessary to set a smoothing window to limit this divergence (-pre:cs:sf:timewindow). This makes that this method becomes a bit limited with data rates too low. Ideally this method should be used with rates of 1 Hz.
-pre:cs:sf:kfactor <val>	Relation between estimated and measured Phase-Code values in relation to its standard deviation. [default 5]
-pre:cs:sf:timewindow <val>	Number of epochs to limit the Phase-Code ionosphere divergence. [default 300]
-pre:cs:sf:samples <val>	Minimum number of epochs needed to stabilize the mean and sigma in the single frequency cycle-slip detector. [default 2]
-pre:cs:sf:init <val>	Initial standard deviation for the threshold calculation in the single frequency cycle-slip detector. [default 3] (m)
-pre:cs:igf	Use triple or quadruple frequencies to build a Ionospheric and Geometry Free (IGF) combination for cycle-slip detection. [default off]
--pre:cs:igf	Do not use triple or quadruple frequencies to build a Ionospheric and Geometry Free (IGF) combination for cycle-slip detection. [default]
-pre:cs:igf:minnoise	Construct the Iono-Geometry combination with the formula 'M=α·L1+β·L2+γ·L3' instead of combining two iono-free combination. The parameters alpha, beta, gamma are computed by gLAB. If this option is enabled, IGF combinations can be build only with three frequencies. See below for details on Iono-Geometry combinations. **Warning:** using this method for computing the IGF combination may lead to not detect some cycle-slips
-pre:cs:igf:freq [+-]g[g]#[-#][.#[-#]]-<freq1><freq2><freq3><freq4> [[+-]g[g]#[-#][.#[-#]]-<freq1><freq2><freq3><freq4>] ...]	
	Set the list of frequency combinations (per satellite) where to run the IGF cycle-slip detector. Each entry must be separated by a blank space (' '). **[+-]** = Optional symbols for selecting (with a plus '+') or unselecting (with a minus '-'). If no symbol is provided, the default behaviour is to select frequencies.

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	g = Character determining GNSS constellation (G->GPS). If g=0, apply it to all constellations. **[g]** = More than one character for GNSS constellation may be provided, so multiple GNSS can be selected at once. **#** = PRN number. If #=0, then the detector will be applied to all satellites of the selected GNSS constellation. **[-#]** = Optionally, a minus sign ('-') and a second PRN number can be provided in order to set a range of satellites (of the same constellation). **[.#[-#]]**= Optionally, more than one satellite PRN or satellite range can be given, by separating each value with a dot ('.'). **<freq1><freq2><freq3><freq4>** = List of frequency combinations. Each frequency group must be separated by a dot Frequencies provided will be checked against measurements provided in **'-pre:cs:igf:meas'** parameter, and if the frequencies are already in any of the measurements given in **'-pre:cs:igf:meas'**, these frequencies will be omitted in order to avoid duplication. **Sample:** **'-pre:cs:igf:freq G0-1225'** **'-pre:cs:igf:freq E1-36-1557.1567 R0-1223'** **Note:** Measurements for cycle-slip detection will be automatically selected if not defined with **'-pre:cs:igf:meas'**.
-pre:cs:igf:freqlist [+-]g[g]#[-#][.#[-#]]-<freq1><freq2><freq3><freq4> [,[+-]g[g]#[-#][.#[-#]]-<freq1><freq2><freq3><freq4>],...]	
	Same as **'-pre:cs:igf:freq'**, but each entry separated by commas (',') instead of blank spaces. **Sample:** **'-pre:cs:igf:freq G0-1225'** **'-pre:cs:igf:freq E1-36-1557.1567 R0-1223'**
-pre:cs:igf:meas [+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2>-<meas3>-<meas4> [[+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2>-<meas3>-<meas4> ...]	
	Set the list of combinations (per satellite) where to run the IGF cycle-slip detector. Each entry must be separated by a blank space (' '). **[+-]** = Optional symbols for selecting (with a plus '+') or unselecting (with a minus '-'). If no symbol is provided, the default behaviour is to select measurements. **g** = Character determining GNSS constellation (G->GPS). If g=0, apply it to all constellations. **[g]** = More than one character for GNSS constellation may be provided, so multiple GNSS can be selected at once. **#** = PRN number. If #=0, then the detector will be applied to all satellites of the selected GNSS constellation **[-#]** = Optionally, a minus sign ('-') and a second PRN number can be provided in order to set a range of satellites (of the same constellation). **[.#[-#]]**= Optionally, more than one satellite PRN or satellite range can be given, by separating each value with a dot ('.').

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	<meas1>-<meas2>-<meas3>-<meas4>: Set the two pair of measurements to use for the IGF cycle-slip detector. The four measurements must be a pair of pseudoranges and a pair carrier phases (in any order) from different different signals (for instance L2C and L2W). It can be set as many pair of measurements as desired frequencies. (independently if the measurement is used in the filter or not). Measurements may be from any frequency (there can be as many frequencies as desired) and there can be also several groups of measurements sharing frequencies. **Sample:** **'-pre:cs:igf:meas G0-L1P-L2P-L2P-L5P'** **'-pre:cs:igf:meas G1-10-L1C-L1P-L2X-L5X R0-L1C-L2C-L1C-L3X'**
-pre:cs:igf:measlist [+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2>-<meas3>-<meas4> [[+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2>-<meas3>-<meas4> ...]	
	Same as **'-pre:cs:igf:meas'**, but each entry separated by commas (',') instead of blank spaces. **Sample:** **'-pre:cs:igf:measlist G0-L1P-L2P-L2P-L5P'** **'-pre:cs:igf:measliest G1-10-L1C-L1P-L2X-L5X,R0-L1C-L2C-L1C-L3X'**
-pre:cs:igf:allowcodes	Allow to enter pseudoranges in the IGF detector in options **'-pre:cs:igf:meas'** and **'-pre:cs:igf:measlist'**. **WARNING:** Do not use this option for navigation, as IGF cycle-slip detection with codes will behave randomly. This option is intended for users who want to study code-carrier incoherency, and want to print in the IGFCSDATA message the iono-geometry combination with pseudoranges. When using this option, it is recommended to set a very high threshold in IGF detector with **'-pre:cs:igf:max'** and **'-pre:cs:igf:max'** options.
-pre:cs:igf:maxjump <val>	Maximum jump threshold (in metres) between two consecutive measured IGF values. [default 1]
-pre:cs:igf:max <val>	Maximum threshold (in metres) between estimated and measured IGF values. [default 0.08 if option **'-pre:cs:igf:minnoise'** is set, otherwise 0.16]
-pre:cs:igf:t0 <val>	Time constant (in seconds) to set the threshold between maximum and minimum. [default 60]
-pre:cs:igf:samples <val>	Minimum number of epochs needed to fit the second-degree polynomial. [default 7]
-pre:cs:sf:noautofill	If single frequency cycle-slip detection is enabled, and user does not set measurements or frequencies, or the user selected measurements or frequencies that do not detect all frequencies of carrier phase measurements used in the filter, gLAB will detect it and automatically add them to the single frequency cycle slip detector. To avoid this auto measurement filling, set this option. [default off] If this option is set, the frequencies not checked by the SF cycle slip detector will be printed.

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-pre:cs:mw:noautofill	If Melbourne-Wubbena cycle-slip detection is enabled, and user does not set measurements or frequencies, or the user selected measurements or frequencies that do not detect all frequencies of carrier phase measurements used in the filter, gLAB will detect it and automatically add them to the MW cycle slip detector. To avoid this auto measurement filling, set this option. [default off] If this option is set, the frequencies not checked by the MW cycle slip detector will be printed.
-pre:cs:li:noautofill	If LI cycle-slip detection is enabled, and user does not set measurements or frequencies, or the user selected measurements or frequencies that do not detect all frequencies of carrier phase measurements used in the filter, gLAB will detect it and automatically add them to the LI cycle slip detector. To avoid this auto measurement filling, set this option. [default off] If this option is set, the frequencies not checked by the LI cycle slip detector will be printed.
-pre:cs:igf:noautofill	If IGF cycle-slip detection is enabled, and user does not set measurements or frequencies, or the user selected measurements or frequencies that do not detect all frequencies of carrier phase measurements used in the filter, gLAB will detect it and automatically add them to the IGF cycle slip detector. To avoid this auto measurement filling, set this option. [default off] If this option is set, the frequencies not checked by the IGF cycle slip detector will be printed.
-pre:csigf:nooutliers	Disable outlier declaration in IGF cycle-slip detector [default off] An outlier is declared the first time the IGF detectors triggers. The sample is discarded and waits for the next epoch. If the detector triggers again, a cycle-slip is declared, otherwise the arc continues (but the outlier sample is discarded). When this option is enabled, when the IGF detector triggers for the first time, a cycle-slip will declared.
-pre:cs:noautofill	This parameter is a shortcut for enabling parameters **'-pre:cs:sf:noautofill'**, **'-pre:cs:mw:noautofill'**, **'-pre:cs:li:noautofill'** and **'-pre:cs:igf:noautofill'** at once. [default off]
-pre:cs:nooutliers	Disable outlier declaration for MW, LI and IGF cycle-slip detectors [default off] This parameter is a shortcut for providing '-pre:cs:mw:nooutliers', '-pre:cs:li:nooutliers' and '-pre:cs:igf:nooutliers' at once.
-pre:allcson	Enable all cycle-slip detectors (LLI, SF, MW, LI, IGF) [default off]. This option can be useful to activate all cycle-slip detectors or enable all of them except specific detectors, by disabling them after this parameter is provided.
-pre:allcsoff	Disable all cycle-slip detectors (LLI, SF, MW, LI, IGF) [default off]. This option can be useful to disable all cycle-slip detectors or disable all of them except specific detectors, by enabling them after this parameter is provided.

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-pre:freqorder [+-]g[g]#[-#][.#[-#]]-<freq>[<freq>...] [...]	
	If filter measurements are to be automatically set (that is, user did not enter any filter measurement with option **'-filter:select'**), gLAB will add measurements using the frequencies in the order of frequency priority list, which can be modified with this parameter. If any of the frequencies in this list does not exist, or it is set as not available by the user (option **'-pre:availf'**) or it is not in the RINEX observation file, it will be skipped. **[+-]** = Optional symbols for selecting (with a plus '+') or unselecting (with a minus '-'). If no symbol is provided, the default behaviour is to select measurements. The whole list will be replaced by the list of frequencies provided by the user. If unselect symbol ('-') is provided, the measurements will be removed from default list if none defined. **g** = Character determining GNSS constellation (G->GPS). If g=0, apply it to all constellations. **[g]** = More than one character for GNSS constellation may be provided, so multiple GNSS can be selected at once. **#** = PRN number. If #=0, then the detector will be applied to all satellites of the selected GNSS constellation. **[-#]** = Optionally, a minus sign ('-') and a second PRN number can be provided in order to set a range. **[.#[-#]]**= Optionally, more than one satellite PRN or satellite range can be given, by separating each value with a dot ('.'). **<freq>**= Frequency number. The list of frequencies is used for selecting a measurement for navigation when user has not set any. For instance, in SPP, gLAB adds a measurement (using the measurement priority order defined in option **'-pre:measorder'**) with the frequency given by this list. gLAB will try to use the first frequency in the list. If the frequency does not exist, or it is set as unavailable by the user or it is not available in the RINEX observation file, it will be skipped and continue with the next frequency in the list. For PPP, gLAB follows the same procedure, but selecting two frequencies for the ionosphere-free combination. This frequency list order is also used when filling dual/triple frequency combinations for MW, LI and IGF cycle-slip detectors when the number of frequencies to be added to the detectors does not coincide with the number of the frequencies needed in each of these detectors. **Sample:** **'-pre:freqorder G0-152'** **'-pre:freqorder GE0-15'** **'-pre:freqorder -GR1-3-12'** **Note:** The default frequency order (from highest priority to lowest) is: **GPS** - L1 (F1), L2 (F2), L5 (F5). **Galileo** - E1 (F1), E5a (F5), E6 (F6), E5b (F7), E5 (F8). **GLONASS** - G1 (F1), G2 (F2), G3 (F3), G1a (F4), G2a (F6). **GEO** - L1 (F1), L5 (F5).

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	BeiDou - B1-2 (F2), B2b (F7), B3 (F6), B2a (F5), B1 (F1), B2 (F8). **QZSS** - L1 (F1), L2 (F2), L5 (F5), L6 (F6). **IRNSS** - L5 (F5), S (F9).
-pre:measorder [+-]g[g]#[-#][.#[-#]]-<meastype><freqs>-<attr1>[<attr2><attr3>...] [[+-]g[g]#[-#][.#[-#]]-<meastype><freqs>-<attr1>[<attr2><attr3>...] ...]	
	Set the list of measurements to use in order of priority, by satellite and frequency. [+-] =Optional symbols for selecting (with a plus '+') or unselecting (with a minus '-'). If no symbol is provided, the default behaviour is to select measurements. If selecting measurements, the whole list will be replaced by the list of frequencies provided by the user. If unselect symbol ('-') is set, the measurements provided will be removed from the last list provided or the default list if none defined. **g** = Character determining GNSS constellation (G->GPS). If g=0, apply it to all constellations. **[g]** = More than one character for GNSS constellation may be provided, so multiple GNSS can be selected at once. # = PRN number. If #=0, then the detector will be applied to all satellites of the selected GNSS constellation **[-#]** = Optionally, a minus sign ('-') and a second PRN number can be provided in order to set a range. [.#[-#]]= Optionally, more than one satellite PRN or satellite range can be given, by separating each value with a dot ('.'). **<meastype>** = Measurement type. Values can be 'C' (for pseudoranges), 'L' (for carrier phases) and 'D' (for Doppler) or a combination of these. For instance, to apply to both pseudoranges and carrier phases, use 'LC' or 'CL'. To apply to Doppler and carrier phase measurements, use 'DL' or 'LD'. To apply to Doppler and pseudoranges, use 'DC' or 'CD'. To apply to pseudoranges, carrier phase measurements or Doppler, use the three letters in any order, for instance, 'CLD'. This convention follows the letters used in the RINEX observation files for pseudoranges, carrier phases and Doppler measurements. **<freqs>**= List of frequencies where to apply the priority list. **<attr>**= List of measurement attributes in order of priority (from highest to lowest). The list of attributes is used for selecting a measurement for the navigation filter when user has not set any. The criteria for the auto selection of measurement is to use the first measurement with the given attribute in the list that is available in the observation file. This selection is done independently for pseudorange and carrier phase, therefore, the pair of measurements (pseudoranges and carrier phase) used may be from different types (for instance, it could select C1W and L1C). To force using only pair of measurements from the same attribute, set option **'-pre:meassel:pairedmeas'**. **Sample:** **'-pre:measorder G0-C15-PWCX'** **'-pre:measorder -G0-C15-P'**

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	'-pre:measorder 0-L2-WXC GE1-10-LC23-PWCL ER12.31-CL23-PWCX' The default measurement order list (from highest priority to lowest) is: **Pseudoranges:** **GPS:** F1 | C1P,C1W,C1C,C1Y,C1L,C1S,C1X,C1M F2 | C2P,C2W,C2C,C2Y,C2L,C2S,C2X,C2D,C2M F5 | C5Q,C5I,C5X **Galileo**: F1 | C1C,C1X,C1Z,C1B,C1A F5 | C5Q,C5I,C5X F6 | C6C,C6X,C6Z,C6B,C6A F7 | C7Q,C7I,C7X F8 | C8Q,C8I,C8X **GLONASS:** F1 | C1P,C1C F2 | C2P,C2C F3 | C3Q,C3I,C3X F4 | C4A,C4B,C4X F6 | C6A,C6B,C6X **GEO:** F1 | C1C F5 | C5Q,C5I,C5X **BeiDou:** F1 | C1P,C1D,C1L,C1S,C1X,C1Z,C1A F2 | C2Q,C2I,C2X F5 | C5P,C5D,C5X F6 | C6Q,C6I,C6P,C6D,C6X,C6Z,C6A F7 | C7Q,C7I,C7P,C7D,C7X,C7Z F8 | C8P,C8D,C8X **QZSS:** F1 | C1C,C1L,C1S,C1X,C1Z,C1B F2 | C2L,C2S,C2X F5 | C5Q,C5I,C5P,C5D,C5X,C5Z F6 | C6L,C6S,C6X,C6E,C6Z **IRNSS**: F5 | C5A,C5B,C5C,C5X F9 | C9A,C9C,C9B,C9X **Carrier phases:** **GPS:** L1P,L1W,L1C,L1Y,L1L,L1S,L1X,L1M,L1N L2P,L2W,L2C,L2Y,L2L,L2S,L2X,L2D,L2M,L2N L5Q,L5I,L5X **Galileo**: L1C,L1X,L1Z,L1B,L1A L5Q,L5I,L5X

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	L6C,L6X,L6Z,L6B,L6A L7Q,L7I,L7X L8Q,L8I,L8X **GLONASS:** L1P,L1C L2P,L2C L3Q,L3I,L3X L4A,L4B,L4X L6A,L6B,L6X **GEO:** L1C L5Q,L5I,L5X **BeiDou:** L1P,L1D,L1L,L1S,L1X,L1Z,L1A,L1N L2Q,L2I,L2X L5P,L5D,L5X L6Q,L6I,L6P,L6D,L6X,L6Z,L6A L7Q,L7I,L7P,L7D,L7X,L7Z L8P,L8D,L8X **QZSS:** L1C,L1L,L1S,L1X,L1Z,L1B L2L,L2S,L2X L5Q,L5I,L5P,L5D,L5X,L5Z L6L,L6S,L6X,L6E,L6Z **IRNSS**: L5A,L5B,L5C,L5X L9A,L9C,L9B,L9X **Doppler:** **GPS:** D1P,D1W,D1C,D1Y,D1L,D1S,D1X,D1M,D1N D2P,D2W,D2C,D2Y,D2M,D2X,D2S,D2L,D2D,D2N D5Q,D5I,D5X **Galileo**: D1C,D1X,D1Z,D1B,D1A D5Q,D5I,D5X D6C,D6X,D6Z,D6B,D6A D7Q,D7I,D7X D8Q,D8I,D8X **GLONASS:** D1P,D1C D2P,D2C D3Q,D3I,D3X D4A,D4B,D4X D6A,D6B,D6X **GEO:** D1C D5Q,D5I,D5X **BeiDou:**

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	D1P,D1D,D1L,D1S,D1X,D1A,D1N D2Q,D2I,D2X D5P,D5D,D5X D6Q,D6I,D6P,D6D,D6X,D6Z,D6A D7Q,D7I,D7P,D7D,D7X,D7Z D8P,D8D,D8X **QZSS:** D1C,D1L,D1S,D1X,D1Z,D1B D2L,D2S,D2X D5Q,D5I,D5P,D5D,D5X,D5Z D6L,D6S,D6X,D6E,D6Z **IRNSS**: D5A,D5B,D5C,D5X D9A,D9C,D9B,D9X BeiDou measurements C1A,L1A,D1A,L1N,D1N,C6A,L6A,D6A only appear on RINEX 3.04
-pre:measorderlist [+-]g[g]#[-#][.#[-#]]-<meastype><freqs>-<attr1>[<attr2><attr3>...] [,[+-]g[g]#[-#][.#[-#]]-<meastype><freqs>-<attr1>[<attr2><attr3>...],...]	
	Same as **'-pre:measorder'**, but each entry is separated by commas (',') instead of blank spaces. **Sample:** **'-pre:measorderlist G0-C15-PWCX'** **'-pre:measorderlist 0-L2-XC,GE1-10-LC23-PWCL,ER12-CL23-PWCX'**
-pre:meassel:pairedmeas	When gLAB automatically selects the measurements to be used, force to use only paired measurements for pseudorange and carrier phases. [default disabled] **Note:** For instance, if rover RINEX observation file version 3.X has measurements C1C, L1C and C1W, C1W pseudorange measurement will not be used as L1W carrier phase measurement is not available (it usually occurs with Septentrio receivers). For RINEX v2, this option has no effect, as C1/P1/L1 and C2/P2/L2 are never paired (there are two codes but only one phase). This option also has no effect for Doppler measurements. If this option is set and rover RINEX observation file is version 2, it will auto disable.
-pre:meassel:noblocktypeunsel	Do not remove measurements from priority list according to satellite block type when an ANTEX file is provided either with **'-input:ant'** or **'-input:antsatblock'** (e.g. auto removing L5 from GPS satellites without this frequency). This parameter has preference over **'-input:antsatblock'**.
-pre:usererrorafter	Add user defined error after prealigning, checking cycle-slips and smoothing. [default off]
-pre:intseconds	Ignore decimals when reading the epoch timestamp in RINEX observation file [default off]

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5.3.3 Modelling options

(use -model:... to activate, --model:... to deactivate)

-model:iono <val>	**<val> = no:** Do not correct ionosphere. [default in PPP] (equivalent to **'--model:iono'**) **<val>=Klobuchar:** Correct measurements with Klobuchar model. [default in SPP] **<val> = NeQuick :** Correct measurements with NeQuick model. **<val> = BeiDou:** Correct measurements with BeiDou model. **<val> = IONEX:** Correct measurements with IONEX file data. **<val> = FPPP:** Correct measurements with FPPP file data. **<val> = SBAS:** Correct measurements with SBAS iono corrections (but do not apply any other SBAS correction). **Note:** If more than one iono model option is given, the last one will be used.
-model:trop	Correct troposphere delay. [default on]
--model:trop	Do not correct troposphere delay.
-input:navglo <file>	Sets the input RINEX navigation message file for reading GLONASS frequency offset.
-model:trop:nominal <val>	**<val> = Simple:** Compute a simple tropospheric nominal depending on receiver's height over the sea level. [default in PPP] **<val> = UNB3:** Troposphere nominals are calculated from the receiver's height and estimates of five meteorological parameters: pressure, temperature, water vapour pressure, temperature lapse rate and water vapour lapse rate. **Note:** It is adopted by SBAS systems (see RTCA-MOPS, 2006). [default in SPP]
-model:trop:mapping <val>	**<val> = Simple:** Compute the mapping as the obliquity factor described in Black and Eisner, 1984. This mapping only depends on satellite elevation and it is common for wet and dry components. [default in SPP] **<val> = Niell:** Compute the mapping described in A.E. Niell, 1996. This mapping considers different obliquity factors for the wet and dry components. [default in PPP]

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-model:satclocks	Correct the measurements with the satellite clock offsets estimations. [default on]
-model:relclock	Correct the measurements with the relativistic clock model. [default on]
-model:satmovinflight	Consider satellite movement during signal flight time. [default on]
-model:earthrotinflight	Consider Earth rotation during signal flight time. [default on]
-model:satphasecenter	Correct satellite phase centre to mass centre corrections [default on in PPP, off in SPP]
-model:satphasevar	Correct satellite phase centre to mass centre corrections variations with zenith angle. [default off for SPP, on for PPP]
-model:recphasecenter <val>	**<val> = no:** Do not correct antenna receiver phase centre. [default in SPP] **<val> = ANTEX:** Use the ANTEX file to correct the antenna phase center. [default in PPP] **<val> = g[g]<nfreq>[<nfreq>] <val2>** **[g[g]<nfreq>[<nfreq>] <val2>]** Set the receiver antenna phase centre source or its dN, dE and dU components for the frequencies and constellations provided. Note that when user manually selects any constellation or frequency, the non set constellations or frequencies will be set to 'ANTEX'. **g** = Character determining GNSS constellation (G->GPS). If g=0, apply it to all constellations. **[g]** = More than one character for GNSS constellation may be provided, so multiple GNSS can be selected at once. **<nfreq>** = Frequency number (typical for GPS, 1 and 2). **[<nfreq>]** = More than one frequency number may be provided. **<val2> = ANTEX** If word 'ANTEX' (without the quotes) is provided, these frequencies will be read from the ANTEX file. **= g** If a constellation letter is provided (e.g. 'G' for GPS), then it will use the same values (including the receiver phase centre variation) as in the selected constellation. **= g<nfreq>** If a constellation letter and a frequency is provided (e.g. 'G1' for GPS frequency 1) all the selected frequencies will have the same value (including the receiver phase centre variation) as the constellation and frequency given. **= <dN> <dE> <dU>** Set the North, East and Up receiver phase centre components (in metres). **Sample:** **-model:recphasecenter G1 0 0 0.11** **-model:recphasecenter GR2 0 0 0.128** **-model:recphasecenter E15 0 0 0.11**

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	-model:recphasecenter J12 G → Receiver phase centre corrections (and variations) for QZSS frequencies 1 and 2 will be the same as GPS frequencies 1 and 2. **-model:recphasecenter J12 G1** → Receiver phase centre corrections (and variations) for QZSS frequencies 1 and 2 will be the same as GPS frequency 1. **-model:recphasecenter 0 0 0 0** → Set receiver phase centre corrections for all frequencies of all constellations to 0 (no ANTEX file is used). **-model:recphasecenter 0 0 0 0 G12 0 0 0.11** → Set first receiver phase centre corrections for all frequencies of all constellations to 0 (so ANTEX file is not used) and then GPS L1 and L2 to 0 0 0.11. **Note:** Typical AOAD/M_T antenna phase centre correction, 11 cm and 12.8 cm in the Up component for frequencies 1 and 2.
-model:recphasevar	Correct antenna receiver phase centre variations. [default off in SPP, on in PPP]
-model:strictradome	When using ANTEX file to correct the receiver phase centre, this option will force a perfect match between the antenna name and radome reported in the receiver RINEX file and the ones in the ANTEX file. If this option is disabled, and the radome is not found, the corrections will be used considering the radome "NONE". [default off]
-model:arp <val>	**<val> = no:** Do not apply any Antenna Reference Point (ARP) correction [default in SPP] (equivalent to **'--model:arp'**). **<val> = RINEX:** Use as ARP the information on the RINEX file (field 'ANTENNA: DELTA H/E/N'). [default in SBAS, DGNSS and PPP] <**val> = <dN> <dE> <dU>:** Set dN, dE, dU as the ARP: <dN> = North correction [in metres]. <dE> = East correction [in metres]. <dU> = Up correction [in metres]. **Note:** In DGNSS mode, if ARP correction is enabled, reference station coordinates will be always be read from reference. RINEX or RTCM file, while rover ARP will be read from RINEX or set from user values.
-model:dcb:sf:gps:p1c1 <val>	GPS DCB to convert C1 to P1 or for correcting P2 measurements (depending on GPS receiver type). It may be applied to C1 or P2 measurements in single frequency or dual frequency combinations. **<val> = no:** Do not correct Differential Code Biases between P1 and C1 codes (equivalent to **'--model:dcb:sf:gps:p1c1'**). [default] **<val> = strict:**

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	Correct Differential Code Biases between P1 and C1 codes for obtaining P1 from C1 or to obtain a consistent P2 when applicable (defined by the receiver type).
-model:dcb:sf:gps:p1p2 <val>	GPS Differential DCB between P1 and P2 (or L1P(Y) and L2 P(Y)). To be applied in single frequency measurements. **<val> = no:** Do not correct Differential Code Biases between codes (equivalent to **'--model:dcb:sf:gps:p1p2'**). [default in PPP] **<val> = RINEX:** Correct Differential Code Biases between codes using TGDs from the RINEX navigation file. [default in SPP, EGNOS, DGNSS] **<val> = DCBFILE:** Correct Differential Code Biases between codes P1 and P2 from a precise CODE DCB file Identify C1 and P1 when applicable (defined by the receiver type). **<val> = IONEX:** Correct Differential Code Biases between codes P1 and P2 using DCB from IONEX file. **<val> = FPPP:** Correct Differential Code Biases between codes P1 and P2 using DCB from FPPP file. **Note:** p1p2 DCB is also applied to frequency 5, as stated in the GPS ICD. Disabling this option will also prevent applying the p1p2 DCB to GPS frequency 5 signals.
-model:dcb:sf:gps:isc:l1ca <val>	
	GPS Inter-Signal correction between L1 C/A and L1 P(Y). To be applied in single frequency measurements. **<val> = no:** Do not apply L1C/A Inter-Signal correction (ISC) (equivalent to **'--model:dcb:sf:gps:isc:l1ca'**). [default in PPP] **<val> = RINEX:** Apply L1C/A Inter-Signal correction (ISC) between codes using ISC from the CNAV RINEX navigation messages. [default in SPP, DGNSS]
-model:dcb:sf:gps:isc:l2c <val>	GPS Inter-Signal correction between L2C (M) or L2C (L) and L1 P(Y). To be applied in single frequency measurements. Note that L2C (M) and L2C (L) are coded in the same signal, as L2C (M) is a fraction of the whole L2C (L) code. **<val> = no:** Do not apply L2C Inter-Signal correction (ISC) between codes (equivalent to **'--model:dcb:sf:gps:isc:l2c'**). [default in PPP] **<val> = RINEX:** Apply L2C Inter-Signal correction (ISC) between codes using ISC from the CNAV RINEX navigation messages. It is applied to C2S and C2L signals. [default in SPP, DGNSS]
-model:dcb:sf:gps:isc:l5i5 <val>	

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	GPS Inter-Signal correction between L5I5 and L1 P(Y). To be applied in single frequency measurements. **<val> = no:** Do not apply L5I5 Inter-Signal correction (ISC) between codes (equivalent to **'--model:dcb:sf:gps:isc:l5i5'**). [default in PPP] **<val> = RINEX:** Apply L5I5 Inter-Signal correction (ISC) between codes using ISC from the CNAV RINEX navigation messages. [default in SPP, DGNSS]
-model:dcb:sf:gps:isc:l5q5 <val>	
	GPS Inter-Signal correction between L5Q5 and L1 P(Y). To be applied in single frequency measurements. **<val> = no:** Do not apply L5Q5 Inter-Signal correction (ISC) between codes (equivalent to **'--model:dcb:sf:gps:isc:l5q5'**). [default in PPP] **<val> = RINEX:** Apply L5Q5 Inter-Signal correction (ISC) between codes using ISC from the CNAV RINEX navigation messages. [default in SPP, DGNSS]
-model:dcb:sf:gps:isc:all <val>	**<val> = no:** Do not apply any Inter-Signal correction (ISC) between codes for single frequency measurements (equivalent to provide **'--model:dcb:sf:gps:isc:all'** or **'-model:dcb:sf:gps:isc:l1ca'**, **'-model:dcb:sf:gps:isc:l2c'**, **'--model:dcb:sf:gps:isc:l5i5'**, and **'--model:dcb:sf:gps:isc:l5q5'**). [default in PPP] **<val> = RINEX:** Apply all necessary Inter-Signal correction (ISC) (on their respective measurements) between codes using ISC from the CNAV RINEX navigation messages. [default in SPP]
-model:dcb:sf:gps:all <val>	**<val> = no:** Do not apply any DCBs between codes in single frequency for GPS (except for P1-C1 DCB) (equivalent to provide **'-model:dcb:sf:gps:p1c1'**, **'--model:dcb:sf:gps:p1p2'** and **'--model:dcb:sf:gps:isc:all'**). [default in PPP] **<val> = RINEX:** Apply all necessary DCB and ISC for GPS (on their respective measurements) between codes from RINEX navigation messages (except for P1-C1 DCB). [default in SPP]
-model:dcb:sf:gal:e1e5a <val>	Galileo Differential DCB between E1 and E5a frequencies. To be applied in single frequency measurements. **<val> = no:** Do not correct E1-E5a Differential Code Biases (equivalent to **'--model:dcb:sf:gal:e1e5a'**). [default in PPP] **<val> = RINEX:** Correct E1-E5a Differential Code Biases using BGDs from the RINEX navigation file. [default in SPP, DGNSS]

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-model:dcb:sf:gal:e1e5b <val>	Galileo Differential DCB between E1 and E5b frequencies. To be applied in single frequency measurements. **<val> = no:** Do not correct E1-E5b Differential Code Biases (equivalent to **'--model:dcb:sf:gal:e1e5b'**). [default in PPP] **<val> = RINEX:** Correct E1-E5b Differential Code Biases using BGDs from the RINEX navigation file. [default in SPP, DGNSS]
-model:dcb:sf:gal:all <val>	**<val> = no:** Do not apply any DCBs between codes for Galileo for single frequency measurements (equivalent to provide **'--model:dcb:sf:gal:e1e5a'** and **'--model:dcb:sf:gal:e1e5b'**). [default in PPP] **<val> = RINEX:** Apply all necessary DCB and ISC for Galileo (on their respective measurements) between codes from RINEX navigation messages. [default in SPP]
-model:dcb:sf:glo:p1p2 <val>	Glonass Differential DCB between P1 and P2 measurements. To be applied in single frequency measurements. **<val> = no:** Do not correct Differential Code Biases between C1P and C2P codes for GLONASS (equivalent to **'--model:dcb:sf:glo:p1p2'**). **<val> = RINEX:** Correct Differential Code Biases between codes using TGDs from the navigation file (only for RINEX navigation 3.05 or greater) [default in SPP, EGNOS, DGNSS] **<val> = DCBFILE:** Correct Differential Code Biases between codes P1 and P2 from a precise CODE DCB file. **<val> = IONEX:** Correct Differential Code Biases between C1P and C2P codes using DCB from IONEX file.
-model:dcb:sf:glo:all <val>	**<val> = no:** Do not apply any DCBs between codes for GLONASS (equivalent to provide **'--model:dcb:sf:glo:p1p2'**). [default in PPP]
-model:dcb:sf:bds:b2b6 <val>	BeiDou Differential DCB between B1_2-B3 (frequencies 2 and 6). To be applied in single frequency measurements. **<val> = no:** Do not correct B1_2-B3 (frequencies 2 and 6) Differential Code Biases (equivalent to **'--model:dcb:sf:bds:b2b6'**). [default in PPP]. **<val> = RINEX:** Correct B1_2-B3 (frequencies 2 and 6) Differential Code Biases using BGDs from the RINEX navigation file. [default in SPP, DGNSS]
-model:dcb:sf:bds:b7b6 <val>	BeiDou Differential DCB between B2b-B3 (frequencies 7 and 6). To be applied in single frequency measurements.

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	<val> = no: Do not correct B2b-B3 (frequencies 7 and 6) Differential Code Biases (equivalent to **'--model:dcb:sf:bds:b7b6'**). [default in PPP] **<val> = RINEX:** Correct B2b-B3 (frequencies 7 and 6) Differential Code Biases using BGDs from the RINEX navigation file. [default in SPP, DGNSS]
-model:dcb:sf:bds:sp3 <val>	When using single frequency measurements with precise files (SP3/CLK), precise orbits and clocks are computed with B1_2-B2b iono-free combination (frequencies 2,7), but DCBs are referred to combinations with B3 signal (frequency 6). Therefore, a special DCB (a combination of available DCB) has to be computed. [default enabled in single frequency PPP, otherwise disabled] **<val> = no:** Do not correct DCB for single frequency measurements with precise orbits and clocks. [default in all modes except single frequency PPP] **<val> = RINEX:** Correct DCB for single frequency measurements with precise orbits and clocks reading the necessary DCBs from the RINEX navigation file. [default in single frequency PPP]
-model:dcb:sf:bds:all <val>	**<val> = no:** Do not apply any DCBs between codes for BeiDou (equivalent to provide **'--model:dcb:sf:bds:b2b6'**, **'--model:dcb:sf:bds:b7b6'**, **'--model:dcb:sf:bds:sp3'** and **'--model:dcb:sf:bds:isc:all'**. [default in PPP] **<val> = RINEX:** Apply all necessary DCB and ISC for BeiDou (on their respective measurements) between codes from RINEX navigation messages. [default in SPP]
-model:dcb:sf:qzs:c1c <val>	QZSS Differential DCB between satellite clock and L1 C/A. To be applied in single frequency measurements. **<val> = no:** Do not correct Differential Code Biases between codes (equivalent to **'--model:dcb:sf:qzs:c1c'**). [default in PPP] **<val> = RINEX:** Correct Differential Code Biases between codes using TGDs from the RINEX navigation file. [default in SPP, EGNOS, DGNSS] **Note:** C1C DCB is also applied to frequency 5, as stated in the QZSS ICD. Disabling this option will also prevent applying the C1C DCB to QZSS frequency 5 signals.
-model:dcb:sf:qzs:isc:l2c <val>	QZSS Inter-Signal correction between L1 C/A and L2C (M) or L2C (L). To be applied in single frequency measurements. Note that L2C (M) and L2C (L) are coded in the same signal, as L2C (M) is a fraction of the whole L2C (L) code. **<val> = no:**

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	Do not apply L2C Inter-Signal correction (ISC) between codes (equivalent to **'--model:dcb:sf:qzs:isc:l2c'**). [default in PPP] **<val> = RINEX:** Apply L2C Inter-Signal correction (ISC) between codes using ISC from the CNAV RINEX navigation messages. It is applied to C2S and C2L signals. [default in SPP, DGNSS]
-model:dcb:sf:qzs:isc:l5i5 <val>	QZSS Inter-Signal correction between L1 C/A and L5I5. To be applied in single frequency measurements. **<val> = no**: Do not apply L5I5 Inter-Signal correction (ISC) between codes (equivalent to **'--model:dcb:sf:qzs:isc:l5i5'**). [default in PPP] **<val> = RINEX**: Apply L5I5 Inter-Signal correction (ISC) between codes using ISC from the CNAV RINEX navigation messages. [default in SPP, DGNSS]
-model:dcb:sf:qzs:isc:l5q5 <val>	QZSS Inter-Signal correction between L1 C/A and L5Q5. To be applied in single frequency measurements. **<val> = no**: Do not apply L5Q5 Inter-Signal correction (ISC) between codes (equivalent to **'--model:dcb:sf:qzs:isc:l5q5'**). [default in PPP] **<val> = RINEX**: Apply L5Q5 Inter-Signal correction (ISC) between codes using ISC from the CNAV RINEX navigation messages. [default in SPP, DGNSS]
-model:dcb:sf:qzs:isc:all <val>	**<val> = no**: Do not apply any Inter-Signal correction (ISC) between codes (equivalent to provide **'--model:dcb:sf:qzs:isc:l2c'**, **'--model:dcb:sf:qzs:isc:l5i5'** and **'--model:dcb:sf:qzs:isc:l5q5'**). [default in PPP] **<val> = RINEX**: Apply all necessary Inter-Signal correction (ISC) (on their respective measurements) between codes using ISC from the CNAV RINEX navigation messages. [default in SPP]
-model:dcb:sf:qzs:all <val>	**<val> = no**: Do not apply any DCBs between codes for QZSS (equivalent to provide **'--model:dcb:sf:qzs:c1c'** and **'--model:dcb:sf:qzs:isc:all'**). [default in PPP] **<val> = RINEX**: Apply all necessary DCB and ISC for QZSS (on their respective measurements) between codes from RINEX navigation messages. [default in SPP]
-model:dcb:sf:irn:c9c5 <val>	IRNSS Differential DCB between S-SPS and L5-SPS (C9A - C5A). To be applied in single frequency measurements. **<val> = no**: Do not correct Differential Code Biases between codes (equivalent to **'--model:dcb:sf:irn:c9c5'**). [default in PPP] **<val> = RINEX**:

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	Correct Differential Code Biases between codes using TGDs from the RINEX navigation file. [default in SPP, EGNOS, DGNSS]
-model:dcb:sf:irn:all <val>	**<val> = no:** Do not apply any DCBs between codes for IRNSS (equivalent to provide **'--model:dcb:sf:irn:c9c5'**). [default in PPP] **<val> = RINEX:** Apply all necessary DCB for IRNSS (on their respective measurements) between codes from RINEX navigation messages. [default in SPP]
--model:dcb:sf:isc:all	Do not apply any ISC DCB type to any constellation for single frequency measurements. This is a shorcut for providing the parameters **'--model:dcb:sf:gps:isc:all'**, **'--model:dcb:sf:bds:isc:all'**, **'--model:dcb:sf:qzs:isc:all'.**
--model:dcb:sf:all	Do not apply any DCB type (ISC and non ISC, except for GPS P1-C1) to any constellation for single frequency measurements. This is a shorcut for providing the parameters: **'--model:dcb:sf:gps:all'**, **'--model:dcb:sf:gal:all'**, **'--model:dcb:sf:glo:all'**, **'--model:dcb:sf:bds:all'**, **'--model:dcb:sf:qzs:all'**, **'--model:dcb:sf:irn:all'**.
-model:dcb:df:gps <val>	Compute the DCBs necessary for GPS iono-free combinations different than the one used in the reference orbits and clocks. **<val> = no:** Do not correct DCB for GPS dual frequency combinations (equivalent to **'--model:dcb:df:gps'**). [default in PPP] **<val> = RINEX:** Correct DCBs for GPS dual frequency combinations using TGDs from the RINEX navigation file. [default in PPP] **Note:** The DCBs for dual frequency that gLAB supports for GPS are: **IF12** **IF25** **IF15**
-model:dcb:df:bds <val>	Compute the DCBs necessary for BeiDou iono-free combinations different than the one used in the reference orbits and clocks. **<val> = no:** Do not correct DCB for BeiDou dual frequency combinations (equivalent to **'--model:dcb:df:bds'**). [default in PPP] **<val> = RINEX:** Correct DCBs for BeiDou dual frequency combinations using TGDs from the RINEX navigation file. [default in PPP] The DCBs for dual frequency that gLAB supports for BeiDou are: **IF27 (B1_2-B2b, Necessary for broadcast orbits only)** **IF26 (B1_2-B3)** **IF67 (B3-B2b)**

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-model:dcb:df:qzs <val>	Compute the DCBs necessary for QZSS iono-free combinations different than the one used in the reference orbits and clocks **<val> = no:** Do not correct DCB for QZSS dual frequency combinations (equivalent to **'--model:dcb:df:qzs'**). [default in PPP] **<val> = RINEX:** Correct DCBs for QZSS dual frequency combinations using TGDs from the RINEX navigation file. [default in PPP] The DCBs for dual frequency that gLAB supports for QZSS are: **IF12** **IF25** **IF15**
--model:dcb:df:all	Do not apply any dual frequency DCB for any constellations. This is a shortcut for providing the parameters: **'--model:dcb:df:gps'**, **'--model:dcb:df:bds'** and **'--model:dcb:df:qzs'**.
-model:windup	Correct the wind up term for carrier phase measurements. [default in PPP, off in SPP, SBAS, DGNSS]
-model:solidtides	Correct the Earth surface deformation due to solid tides. [default in PPP, off in SPP, SBAS, DGNSS]
-model:relpath	Correct the path range delay term due to the gravitational gradient between receiver and transmitter. [default on in PPP, off in SPP, SBAS, DGNSS]
-model:sathealth	Only valid when using broadcast products. Use only satellites that are healthy (i.e. not marginal or unhealthy) [default enabled in all modes except SBAS] This selection is done when looking for a navigation message for orbits or DCBs and only applies in navigation mode, as in show orbits or comparison modes the health is printed in the output message
-model:allowmarginal	Only valid when using broadcast products. Allow using satellites with a 'Marginal' health status [default off if '**-model:sathealth**' is enabled, on if '**-model:sathealth**' is disabled] Same behaviour as option '**-model:sathealth**', but satellites used will be in healthy or marginal modes
-model:skipunhealthymarg	Only valid when using broadcast products. Skip unhealthy and marginal messages [default off] The difference with '**-model:sathealth**' is that unhealthy or marginal will not be saved in internal buffers (as if the unhealthy/marginal did not appear in RINEX navigation file). This option is useful when you want to check how the last transmitted healthy message performed until it timed-out (e.g. for fear event analysis)
-model:skipunhealthy	Only valid when using broadcast products. Ignore unhealthy messages [default off] Same behaviour as '**-model:skipunhealthymarg**' but only skips unhealthy messages
-model:brdctranstime	Only valid when using broadcast products. Check that transmission time of message is equal or before the current

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	epoch of current time. [default on for non SBAS processing, off for SBAS processing]
-model:maxurabrdc <val>	Only valid when using broadcast products. Set the discard threshold for satellites which have an URA value equal or greater than this value (in metres). [default off]
-model:globrdcintstep <val>	Set the Runge-Kutta interpolation step (in seconds) when computing GLONASS orbit with broadcast products [default 30] gLAB will interpolate from the initial conditions with this given step size until the distance is lower than this step size, and then interpolate with the remaining step size to the desired epoch.
-model:brdcpreferagetime <val>	When searching for a navigation message, set the threshold (in seconds) to decide if current valid navigation message found is recent enough (with respect to navigation message ToC -Time of Clock-) to select it or to keep searching in other navigation message types (according to the navigation message priority list) for more recent messages [default 3600]
-model:brdc:gps <val>	Only valid when using broadcast products. This option only applies to GPS: **<val> = PreferLNAV:** Use LNAV, CNAV and CNAV2 broadcast messages, but use LNAV whenever possible. [default] **<val> = PreferCNAV:** Use LNAV, CNAV and CNAV2 broadcast messages, but use CNAV whenever possible. **<val> = PreferCNAV2:** Use LNAV, CNAV and CNAV2 broadcast messages, but use CNAV2 whenever possible. **<val> = LNAV:** Use only LNAV broadcast messages. **<val> = CNAV**: Use only CNAV broadcast messages. **<val> = CNAV2**: Use only CNAV2 broadcast messages. **<val> = AnyCNAV**: Use only CNAV or CNAV2 broadcast messages. **<val> = <val1>,<val2>,... :** Set the list of broadcast messages to be used (in order of preference). The following modes are for orbit comparison mode only: **<val> = LNAVvsCNAV:** Use only LNAV broadcast messages in the first file and only CNAV on the second file. **<val> = CNAVvsLNAV:** Use only CNAV broadcast messages in the first file and only LNAV on the second file. **<val> = LNAVvsCNAV2:** Use only LNAV broadcast messages in the first file and only CNAV2 on the second file.

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	<val> = CNAV2vsLNAV: Use only CNAV2 broadcast messages in the first file and only LNAV on the second file. **<val> = CNAVvsCNAV2:** Use only CNAV broadcast messages in the first file and only CNAV2 on the second file. **<val> = CNAV2vsCNAV:** Use only CNAV2 broadcast messages in the first file and only CNAV on the second file.
-model:brdc:gal <val>	Only valid when using broadcast products. This option only applies to Galileo: **<val> = PreferINAV:** Use INAV, FNAV, CNAV and GNAV broadcast messages, but use INAV whenever possible. [default] **<val> = PreferFNAV:** Use INAV, FNAV, CNAV and GNAV broadcast messages, but use FNAV whenever possible. **<val> = INAV:** Use only INAV broadcast messages (INAV with E1 and E5b, INAV only with E1 or INAV with E5b). **<val> = INAVE1:** Use only INAV broadcast messages (with information only on E1). **<val> = INAVE5b:** Use only INAV broadcast messages (with information only on E5b). **<val> = INAVE1E5b:** Use only INAV broadcast messages (with information of E1 and E5b). **<val> = FNAV:** Use only FNAV broadcast messages. **<val> = <val1>,<val2>,...:** Set the list of broadcast messages to be used (in order of preference). The following modes are for orbit comparison mode only: **<val> = INAVvsFNAV:** Use only INAV broadcast messages in the first file and only FNAV on the second file. **<val> = FNAVvsINAV:** Use only FNAV broadcast messages in the first file and only INAV on the second file.
-model:brdc:bds <val>	Only valid when using broadcast products. This option only applies to BeiDou: **<val> = PreferD1:** Use D1, D2, CNAV1 and CNAV2 broadcast messages, but use D1 whenever possible. **<val> = PreferD2:**

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	Use D1, D2, CNAV1 and CNAV2 broadcast messages, but use D2 whenever possible. **<val> = PreferCNAV1:** Use D1, D2, CNAV1 and CNAV2 broadcast messages, but use CNAV1 whenever possible. **<val> = PreferCNAV2:** Use D1, D2, CNAV1 and CNAV2 broadcast messages, but use CNAV2 whenever possible. **<val> = D1:** Use only D1 broadcast messages (default). **<val> = D2:** Use only D2 broadcast messages. **<val> = CNAV1:** Use only CNAV1 broadcast messages. **<val> = CNAV2:** Use only CNAV2 broadcast messages. **<val> = <val1>,<val2>,...:** Set the list of broadcast messages to be used (in order of preference). The following modes are for orbit comparison mode only: **<val> = D1vsD2:** Use only D1 broadcast messages in the first file and only D2 on the second file. **<val> = D2vsD1:** Use only D2 broadcast messages in the first file and only D1 on the second file. **<val> = D1vsCNAV1:** Use only D1 broadcast messages in the first file and only CNAV1 on the second file. **<val> = CNAV1vsD1:** Use only CNAV1 broadcast messages in the first file and only D1 on the second file. **<val> = D1vsCNAV2:** Use only D1 broadcast messages in the first file and only CNAV2 on the second file. **<val> = CNAV2vsD1:** Use only CNAV2 broadcast messages in the first file and only D1 on the second file. **<val> = D2vsCNAV1:** Use only D2 broadcast messages in the first file and only CNAV1 on the second file. **<val> = CNAV1vsD2:** Use only CNAV1 broadcast messages in the first file and only D2 on the second file. **<val> = D2vsCNAV2:** Use only D2 broadcast messages in the first file and only CNAV2 on the second file. **<val> = CNAV2vsD2:**

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	Use only CNAV2 broadcast messages in the first file and only D2 on the second file. **<val> = CNAV1vsCNAV2:** Use only CNAV1 broadcast messages in the first file and only CNAV2 on the second file. **<val> = CNAV2vsCNAV1:** Use only CNAV2 broadcast messages in the first file and only CNAV1 on the second file.
-model:brdc:qzss <val>	Only valid when using broadcast products. This option only applies to QZSS: **<val> = PreferLNAV:** Use LNAV, CNAV and CNAV2 broadcast messages, but use LNAV whenever possible. **<val> = PreferCNAV:** Use LNAV, CNAV and CNAV2 broadcast messages, but use CNAV whenever possible. **<val> = PreferCNAV2:** Use LNAV, CNAV and CNAV2 broadcast messages, but use CNAV2 whenever possible. **<val> = LNAV:** Use only LNAV broadcast messages. [default] **<val> = CNAV:** Use only CNAV broadcast messages. **<val> = CNAV2:** Use only CNAV2 broadcast messages. **<val> = AnyCNAV:** Use only CNAV or CNAV2 broadcast messages. **<val> = <val1>,<val2>,...:** Set the list of broadcast messages to be used (in order of preference). The following modes are for orbit comparison mode only: **<val> = LNAVvsCNAV:** Use only LNAV broadcast messages in the first file and only CNAV on the second file. **<val> = CNAVvsLNAV:** Use only CNAVbroadcast messages in the first file and only LNAV on the second file. **<val> = LNAVvsCNAV2:** Use only LNAV broadcast messages in the first file and only CNAV2 on the second file. **<val> = CNAV2vsLNAV:** Use only CNAV2 broadcast messages in the first file and only LNAV on the second file. **<val> = CNAVvsCNAV2:** Use only CNAV broadcast messages in the first file and only CNAV2 on the second file. **<val> = CNAV2vsCNAV:**

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	Use only CNAV2 broadcast messages in the first file and only CNAV on the second file.
-model:orbit:deg <val>	Precise orbit interpolation degree. [default 10]
-model:clk:deg <val>	Precise clock interpolation degree. [default 1]
-model:orbmaxgaps <val>	Set maximum number of gaps between samples used for precise orbit interpolation. [default 8]
-model:clkmaxgaps <val>	Set maximum number of gaps between samples used for precise clock interpolation. [default 2]
-model:orbtotmaxgaps <val>	Set the maximum number of gaps between all samples used for precise orbit interpolation. [default 16]
-model:clktotmaxgaps <val>	Set the maximum number of gaps between all samples used for precise clock interpolation. [default 4]
-model:orbprevsample	When a concatenated SP3 file is read for orbit data, if the last epoch of the previous day is the same as the first epoch of the current day, use the last orbit sample of the previous day instead of the first sample of the current day. [default off] **Note:** This typically occurs with samples at epoch 0h 0m. This option will only have effect if both repeated samples have valid values.
-model:clkprevsample	When a concatenated SP3/Clock file is read for clock data, if the last epoch of the previous day is the same as the first epoch of the current day, use the last orbit sample of the previous day instead of the first sample of the current day. [default off] **Note:** This typically occurs with samples at epoch 0h 0m. This option will only have effect if both repeated samples have valid values.
-model:allfilemeas	If this option is enabled, it will compute the model value (and print the MODEL message if enabled) for all measurements available in the RINEX observation. This was the behaviour in gLAB<6.0.0. [default off] **Note:** The default mode is to model only the measurements which will be used in the filter. In SBAS and DGNSS modes, this option will be automatically disabled.

5.3.4 Filtering options

-filter:stepdetector	Check for jumps in measurements using the prefits residuals (only for C1C measurement). [default off] **Note:** Use **'--filter:stepdetector'** to disable it.

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-filter:prefitoutliers:median <val>	
	<val> Check for outliers in the prefits residuals using the median, with **<val>** (in metres) as the threshold. [default off] **Note:** Use **'--filter:prefitoutliers:median'** or **'-filter:prefitoutliers:median 0'** to disable it. See notes on prefit outlier detectors below.
-filter:prefitoutliers:abs <val>	**<val>** Check for outliers in the prefits residuals comparing absolute values, with **<val>** (in metres) as the threshold. [default off] **Note:** Use **'--filter:prefitoutliers:abs'** or **'-filter:prefitoutliers:abs 0'** to disable it. See notes on prefit outlier detectors below.
-filter:absolutephases	Assume carrier phase measurements are absolute measurements. [default off] **Note:** If this option is enabled, gLAB will assume that carrier phase measurements are absolute measurements (i.e. the ambiguity has been already been added, either modifying the RINEX observation file or by adding it as a user defined error with option **'-input:usererror'**. When this option is enabled, cycle-slip detection, code jumps detection and carrier phase alignment will be switched off. Furthermore, carrier phase will be used to computed signal flight time and for detection outliers in the prefit outlier detectors. In order to use this option correctly, check in the FAQ the question 'CAN gLAB PROCESS CARRIER PHASE MEASUREMENTS AS ABSOLUTE MEASUREMENTS?'
-filter:trop	Estimate the troposphere of the station. [default in PPP with carrier phase] (**'--filter:trop'** to disable it)
-filter:iscb g1g2-<val> [g1g2-<val> ...]	
	Set from which source the inter-system clock bias has to be read or to be estimated by the filter. **g1:** Reference constellation used for the receiver clock (one letter). **g2:** Destination constellation (one letter). **<val>=estimate:** Estimate inter-system clock bias in the filter. [default for all constellations] **<val> = [u-]<number>:** Set inter-system clock bias to **<number>**. Default unit is metres, but it can be changed by adding a unit letter and a dash prior to the value. The accepted unit letters are: **u** = m Set input unit to metres (default). **u** = s Set input unit to seconds. **u** = n Set input unit to nanoseconds. **Samples:**

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	-filter:iscb GE-estimate **-filter:iscb GR-1.55** **-filter:iscb GR-m-1.55** **-filter:iscb EC-s-6.24e-9** **-filter:iscb RC-n-6.5**
-filter:nav <nav>	**<nav> = static:** Process supposing a static receiver. [default in PPP] **<nav> = kinematic:** Process supposing a moving receiver. [default in SPP/SBAS/DGNSS] **<nav> = randomwalk:** Process supposing a slowly moving receiver (less than 30 Km/h)
-filter:meastype <meastype>	**<meastype> = pseudorange:** Use only pseudorange (or smoothed pseudorange) for positioning. [default in SPP/SBAS/DGNSS] **<meastype> = carrierphase:** Use pseudorange and carrier phase for positioning. [default in PPP]
-filter:combtype <combtype>	Set the measurement combination types (single or dual frequency combinations) to be used when gLAB sets the default combinations to use (i.e. the user does not provide any measurement for the filter with parameter '-filter:select'). This option only applies for SPP and PPP modes. **<combtype> = auto:** gLAB decides which combinations to use (single frequency for SPP, dual frequency in PPP) [default] **<combtype> = singlefreq:** Use single frequency measurements in the filter [default in SPP] **<combtype> = dualfreq:** Use dual frequency measurements in the filter [default in PPP] **<combtype> = graphic:** Use graphic combination measurements in the filter
-filter:select [+-]g[g]#[-#][.#[-#]]-<filtermeas>-[<meas1>-<meas2>[-<meas3>-<meas4>]] [...]	
	Set the measurements or combinations to be used in the filter. Each entry must be separated by a blank space (' '). **[+-]** = Optional symbols for selecting (with a plus '+') or unselecting (with a minus '-') If no symbol is provided, the default behaviour is to select measurements. **g** = Character determining GNSS constellation (G->GPS). If g=0, apply it to all constellations. **[g]** = More than one character for GNSS constellation may be provided, so multiple GNSS can be selected at once. **#** = PRN number. If #=0, then the detector will be applied to all satellites of the selected GNSS constellation. **[-#]** = Optionally, a minus sign ('-') and a second PRN number can be provided in order to set a range of satellites (of the same constellation).

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	[.#[-#]] = Optionally, more than one satellite PRN or satellite range can be given, by separating each value with a dot ('.'). **<filtermeas>:** Set the measurement or combination to be used in the filter. For single measurement and user selected measurement, the measurement name must be provided (in RINEX 2 or 3 format). For single measurement and the measurement to be selected by gLAB: Set value 'Pseudorange' or 'Code' (case insensitive), a hyphen ('-') and the frequency number to use, OR set value 'Phase' or 'Carrierphase' (case insensitive), a hyphen ('-') and the frequency number to use. For dual/triple/quadruple combinations, the combination name with its frequencies must be given. **[<meas1>-<meas2>[-<meas3>-<meas4>]]:** If measurement is a combination, optionally set the measurements to use. For dual frequency combinations, two measurements are needed. For triple or quadruple frequency combinations, four measurements are needed. If measurements are not set, they will be automatically selected using the measurement list (see parameter **'-pre:measorderlist'**). In the case of dual, triple or quadruple measurements, if user does not set the measurements, the type of measurements (pseudorange or carrier phase) to use is undefined. The user can set by appending '-code' or '-pseudorange' (for pseudorange) or '-phase' or '-carrierphase' (for carrier phase). For setting pseudorange and carrierphase at once (in two different measurements), use the word '-codephase' or '-phasecode'. All arguments are case insensitive. If not set, gLAB will assume that the type to be used is a carrier phase. **[...]**: User can set multiple filter measurements. **Sample: '-filter:select G0-L1P ER0-auto'** **'-filter:select G0-Code-1 GE0-Phase-5'** **'-filter:select G0-G1 -G1-G1-C1C-L1C E0-G5'** **'-filter:select GE0-IF12-CodePhase'** **'-filter:select G0-L1P -G1-L1P +G1-L1C'** **'-filter:select GR0-IF12-code EJ0-IF15-code REC1-10-IF12-code REC1-10-IF12-phase''-filter:select GR0-PC12 EJ0-PC15 REC1-10-PC12'** **'-filter:select GR0-PC12 EJ0-PC15 REC1-10-PC12'** **'-filter:select 0-IF15-C1X-C5X 0-IF15-L1X-L5X' -filter:select 0-IF15-C1X-C5X 0-IF15-L1X-L5X'** **Note:** To set a graphic combination, use the letter 'G' plus the frequency. To set also the measurements, add them after the frequency between dashes. Example: '**-filter:select G0-G1 G0-E1-C1C-L1C E0-G5**'

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	To set a ionospheric-free combination, use the letters 'IF' plus the frequencies and type or the measurements. Example: '**-filter:select G0-IF12-code E0-IF15-phase R0-IF12-codephase C0-IF15-C1C-C5Q C0-IF15-L1C-L5Q**' Note that for ionospheric-free combination, letters 'PC' and 'LC' can also be used (the former for code and the latter for carrier phase) Example: '**-filter:select G0-PC12 E0-LC15 R0-PC12 R0-LC12 C0-PC15-C1C-C5Q C0-LC15-L1C-L5Q**' For triple/quadruple frequency combinations, the first two frequencies are used for building one dual frequency combination, and next two frequencies are used for building the second dual frequency combination. For dual/triple/quadruple frequency combinations, gLAB will internally reorder the frequency number in order to match its internal order for the combination (in the output messages it will be printed with its internal order). In quadruple combinations, the internal frequency reordering does respect the pair of frequencies used for making the combinations. In gLAB versions 5 and below, this parameter had the following format: **-filter:select <num> <meas1> <meas2> ...** This old format is deprecated, but it is still supported for compatibility with previous versions.
-filter:selectlist [+-]g[g]#[-#][.#[-#]]-<filtermeas>-[<meas1>-<meas2>[-<meas3>-<meas4>]][,...]	
	Same as **'-filter:select'**, but each entry is separated by commas (',') instead of blank spaces. **Sample:** **'-filter:selectlist G0-L1P'** **'-filter:selectlist G0-L1P,-G1-L1P,+G1-L1C'** **'-filter:selectlist G0-IF12-code,E0-IF15-code,R1-10-IF12-code'** **'-filter:selectlist G0-PC12,E0-PC15,R1-10-PC12'** **'-filter:selectlist I10-IF15-C1X-C5X,R1-13-IF15-L1X-L5X'**
-filter:fixedweight g[g]#[-#][.#[-#]]-<filtermeas>-[<meas1>-<meas2>[-<meas3>-<meas4>]] <a> [...]	
	Apply the specified standard deviation to the filter measurement **<filtermeas>**, to be used as weight in the filter. Filter measurement must be specified the same way as in parameters **'-filter:select'** or **'-filter:selectlist'** . **std = a** **<a>** = URA, Use the URA value from the broadcast message (not valid in PPP); = #, Value for the standard deviation of the measurement (metres). **[...]** **:** User can set multiple times a filter measurement and a **<a>** value. The filter shall apply as weight = 1/(<a>^2). **Sample:** **'-filter:fixedweight G0-C1P 2'**: Set 2 metres of standard deviation to measurement C1P in filter.

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	'-filter:fixedweight GE0-L1P 0.01': Set 1 centimetre of standard deviation to measurement L1P in filter. **Defaults:** **PPP:** Pseudorange -> 3m, Carrierphase -> 0.03m. **SPP:** Pseudorange -> 1m, Carrierphase -> 0.10m.
-filter:elevweight g[g]#[-#][.#[-#]]-<filtermeas>-[<meas1>-<meas2>[-<meas3>-<meas4>]] <a> <b> <c> [...]	
	Apply the specified standard deviation to the filter measurement **<filtermeas>**, to be used as weight in the filter. Filter measurement must be specified the same way as in parameters **'-filter:select'** or **'-filter:selectlist'**. **std = a + b * e^(-elevation/c)** **<a>** = URA, Use the URA value from the broadcast message (not valid in PPP); = #, Value for minimum standard deviation of the measurement [weight at elevation 90 degrees] (metres). **<b>** **:** Multiplier to e [standard deviation at elevation 0 degrees] (metres). **<c>** **:** Elevation constant (degrees). **[...]** **:** User can set multiple times a filter measurement and a **<a>**, **<b>**, and **<c>** values. The filter shall apply as weight = 1/(std^2). **Sample (default values):** **'-filter:elevweightG0-C1P1 0.13 0.53 10'** Apply to C1P measurement in all GPS satellites the standard deviation: 0.13+0.53*e^(-elevation/10). **Note:** **'-filter:elevweight G0-C1P x 0 y'** equals to **'-filter:fixedweight G0-C1P x'.**
-filter:sinelevweight g[g]#[-#][.#[-#]]-<filtermeas>-[<meas1>-<meas2>[-<meas3>-<meas4>]] <a> <b> [...]	
	Apply the specified standard deviation to the filter measurement **<filtermeas>**, to be used as weight in the filter. Filter measurement must be specified the same way as in parameters **'-filter:select'** or **'-filter:selectlist'**. **std^2 = a + b/((sin(elevation))^2)** **<a>** = URA, Use the URA value from the broadcast message (not valid in PPP); = #, Value for minimum variance of the measurement (m^2). **<b>** **:** Multiplier to fraction (m^2). **[...]** **:** User can set multiple times a filter measurement and a **<a>** and **<b>** values. The filter shall apply as weight = 1/(std^2). **Sample (default values):** **'-filter:sinelevweight G3-C1P 0 1' :** Apply to C1P measurement in satellite GPS 3 the variance: 0+1/((sin(elevation))^2).

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-filter:snrweight g[g]#[-#][.#[-#]]-<filtermeas>-[<meas1>-<meas2>[-<meas3>-<meas4>]] <a> <b> [...]	
	Apply the specified standard deviation to the filter measurement **<filtermeas>**, to be used as weight in the filter. Filter measurement must be specified the same way as in parameters **'-filter:select'** or **'-filter:selectlist'**. **std^2 = a + b * 10^(-SNR/10)** **<a>** = URA, Use the URA value from the broadcast message (not valid in PPP); = #, Value for minimum variance of the measurement [weight at max SNR] (m^2). **<b>** **:** Multiplier to e xponential [variance at SNR 0 dBHz] (m^2*Hz). **[...]** **:** User can set multiple times a filter measurement and a **<a>** and **<b>** values. The filter shall apply as weight = 1/(std^2). The filter shall apply as weight = 1/(std^2). **Sample (default L1):** **'-filter:snrweight G0-C1C 0 0.244' :** Apply to C1C measurement in all GPS satellites the variance: 0+0.244*10^(-SNR/10). **Sample (default L2):** **'-filter:snrweight G3-L2P 0.88E-6 0.77E-3' :** Apply to L2P measurement in satellite GPS 3 the variance: 0.88E-6+0.77E-3*10^(-SNR/10).
-filter:snrelevweight g[g]#[-#][.#[-#]]-<filtermeas>-[<meas1>-<meas2>[-<meas3>-<meas4>]] <a> <b> [...]	
	Apply the specified standard deviation to the filter measurement **<filtermeas>**, to be used as weight in the filter. Filter measurement must be specified the same way as in parameters **'-filter:select'** or **'-filter:selectlist'**. **std^2 = a + b * 10^(-SNR/10)/((sin(elevation)^2)** **<a>** = URA, Use the URA value from the broadcast message (not valid in PPP); = #, Value for minimum variance of the measurement [weight at max SNR] (m^2). **<b>** **:** Multiplier to exponential [variance at SNR 0 dBHz] (m^2*Hz). **[...]** **:** User can set multiple times a filter measurement and a **<a>** and **<b>** values. The filter shall apply as weight = 1/(std^2). **Sample:** **'-filter:snrelevweight G0-L1C 0 1' :** Apply to L1C measurement in all GPS satellites the variance: 0 + 1*10^(-SNR/10)/((sin(elevation))^2).
-filter:snrweight:comb g[g]#[-#][.#[-#]]-<filtermeas>-[<meas1>-<meas2>[-<meas3>-<meas4>]] <val> [...]	
	When the weight is computed using any method involving the SNR (options **'-filter:snrweight'** or **'-filter:snrelevweight'**),

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	when computing the weight for combinations, select how to get the SNR value: **<val> = SNRi:** For a combination with frequencies ij or ijkl, use SNR from measurement of frequency i. **<val> = SNRj:** For a combination with frequencies ij or ijkl, use SNR from measurement of frequency j. **<val> = SNRk:** For a combination with frequencies ijkl, use SNR from measurement of frequency k. **<val> = SNRl:** For a combination with frequencies ijkl, use SNR from measurement of frequency l. **<val> = MaxSNR:** Use the highest SNR of the measurements used in the combination. **<val> = MinSNR:** Use the lowest SNR of the measurements used in the combination. **<val> = MeanSNR:** Use the mean SNR value of the two measurements used in the combination. [default] **0 <= <val> <=:** If <val> is a number between [0,1], combine the SNR with the following formula: **SNR = SNRi*<val> + SNRj*(1-<val>)** This combination only works for dual frequency combinations. **<val> = <val1>-<val2>-<val3>-<val4>:** Set the values for combining the SNR in a triple or quadruple frequency combinations. The order of the frequencies must be the same as the one given in the measurement name in the previous value of this parameter. The SNR will be combined with the following formula: **SNR = SNRi*<val1> + SNRj*<val2> + SNRk*<val3> + SNRl*<val4>** Values <val1>, <val2>, <val3> and <val4> must all be between [0-1], and that the sum of the four values must be equal to one (<val1> + <val2> + <val3> + <val4> = 1). **[...]:** User can set multiple times a filter measurement and <val> value. **Sample:** **'-filter:snrweight:comb G0-LC12 SNRi' :** In combination LC12 (carrier phase iono free combination) in all GPS satellites, the SNR of the combination must be computed as the value of the measurement used for frequency 1. **Note:**

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	For a dual frequency combination with frequencies 'i' and 'j', 'i' is always the smallest frequency number and 'j' the highest, except for frequency '0', which will be always the highest (it it treated as frequency number '10'). For example, for combination PC12, i=1 and j=2. For combination LC10, i=1, j=0. For a triple or quadruple frequency combination, for instance, combination SIF1234, ijkl values would correspond to i=1, j=2, k=3, l=4.
-filter:sbasdgnssweightmode g[g]#[-#][.#[-#]]-<filtermeas>-[<meas1>-<meas2>[-<meas3>-<meas4>]] <val> [...]	
	In SBAS and DGNSS modes, select how the provided sigma is combined with the user selected weight computation mode (with options **'-filter:fixedweight'**, **'-filter:elevweight'**, **'-filter:sinelevweight'**, **'-filter:snrweight'** and **'-filter:snrelevweight'**). **<val> = ComputedOnly:** Use only the variance computed with SBAS or DGNSS corrections. [default if user does not select a weight method] <**val> = ComputedPlusUser:** Use the variance computed with SBAS or DGNSS corrections plus the sigma computed with the user selected weight method. **<val> = UserOnly:** Use only the variance computed with the user selected weight method. [default if user selects a weight method] **[...]:** User can set multiple times a filter measurement and **<val>** value. **Sample:** **'-filter:sbasdgnssweightmode G0-C1C ComputedPlusUser':** Apply to C1C measurement in all GPS satellites the variance computed by SBAS and the one set by user (with any of the parameters to set types of weight shown above).
-filter:refclkorder g[g...]	Set the preference list of GNSS constellations (using the constellation character) used as the reference clock. [default GERCJIS] The list can have a maximum of 7 constellations (one letter each). If number of constellations provided are less than the maximum, it will fill the remaining gaps with the remaining constellation in the same order as the default one. Note that independently of this option, gLAB always uses its internal timestamp (epoch being processed) in GPS time. **Sample:** **'-filter:refclkorder EG'** **Note:** The default constellation order to use for reference clock is: GPS, Galileo, GLONASS, BDS, QZSS, IRNSS, GEO
-filter:refclkonlyorder g[g...]	Same as **'-filter:refclkorder'** option, but the only available GNSS constellations to be used for the reference clock will be those constellations provided by the user in this parameter.

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	Sample: **'-filter:refclkonlyorder EG'**
-filter:nochangerefclk	If the reference GNSS constellation used (by default the first constellation in parameter **'-filter:refclkorder'**) for the clock is not available in a given epoch, skip the epoch instead of changing the reference constellation. [default disabled]
-filter:sigmaiono	Use standard deviation data from IONEX or FPPP or SBAS if these iono models are used. [default on] (**'--filter:sigmaiono'** to disable it). The IONEX or F-PPP sigma will be added to the computed satellite standard deviation.
-filter:dr:randomwalk	Estimate user coordinates as a random walk. When this option is enabled, units in **'-filter:q:dr'** option is in m^2/s. [default disabled]
-filter:clk:randomwalk	Estimate receiver clock as a random walk. When this option is enabled, units in **'-filter:q:clk'** option is in m^2/d. [default disabled]
-filter:iscb:randomwalk	Estimate inter system clock biases as a random walk. When this option is enabled, units in **'-filter:q:ggto'** option is in m^2/d. [default disabled]
-filter:phi:dr <val>	Specify the Phi value for position unknowns [defaults static: 1 randomwalk: 1 kinematic: 0]
-filter:phi:clk <val>	Specify the Phi value for clock unknown. [defaults static: 0 randomwalk: 1 kinematic: 0]
-filter:phi:iscb <val>	Specify the Phi value for inter-constellation clock bias unknowns [defaults SPP/SBAS/DGNSS: 0 PPP/randomwalk: 1]
-filter:phi:trop <val>	Specify the Phi value for troposphere unknown. [default 1]
-filter:phi:amb <val>	Specify the Phi value for ambiguity unknowns. [default 1]
-filter:q:dr <val>	Specify the Q noise value for position unknowns [defaults static: 0 m^2 randomwalk: 70 m^2/s kinematic: 1e8 m^2]
-filter:q:clk <val>	Specify the Q noise value for clock unknown in metres squared [default 9e10 m^2 or 9 m^2/d if option **'-filter:clk:randomwalk'** is set]
-filter:q:clk:ns <val>	Specify the Q noise value for clock unknown in nanoseconds squared [default 1e12 ns^2 or 100 ns^2/d if option **'-filter:clk:randomwalk'** is set]
-filter:q:iscb <val>	Specify the Q noise value for inter-constellation clock bias unknowns in metres squared [default 9e10 m^2 or 9 m^2/d if option **'-filter:iscb:randomwalk'** is set]
-filter:q:iscb:ns <val>	Specify the Q noise value for inter-constellation clock bias unknowns in nanoseconds squared [default 1e12 ns^2 or 100 ns^2/d if option **'-filter:iscb:randomwalk'** is set]
-filter:q:trop <val>	Specify the Q noise variation value for troposphere unknown. [default 1e-4] (m^2/h)
-filter:q:amb <val>	Specify the Q noise value for ambiguity unknowns. [default 0] (m^2)
-filter:p0:dr <val>	Specify the P0 initial value for position unknowns. [default 1e8] (m^2)

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-filter:p0:clk <val>	Specify the P0 initial value for clock unknown. [default 9e10] (m^2)
-filter:p0:clk:ns <val>	Specify the P0 initial value for clock unknown in nanoseconds squared [default 1e12] (ns^2)
-filter:p0:iscb <val>	Specify the P0 initial value for inter-constellation clock bias unknowns. [default 9e10] (m^2)
-filter:p0:iscb:ns <val>	Specify the P0 initial value for inter-constellation clock bias unknowns in nanoseconds squared [default 1e12] (ns^2)
-filter:p0:trop <val>	Specify the P0 initial value for troposphere unknown. [default 0.25] (m^2)
-filter:p0:amb <val>	Specify the P0 initial value for ambiguity unknowns (for prealigned carrier phases). [default 400] (m^2)
-filter:backward	Specify that the filter does a backward processing after the forward one is finished. This means that it processes the data backwards. The "turn point" is defined as the latest point where orbits and clocks are available or when the observation RINEX ends (whatever is first) (**'--filter:backward'** to disable it). [default disabled]
-filter:maxhdop <val>	Set the HDOP threshold which will make gLAB do the following when the threshold is exceeded: **In SPP/PPP:** Skip the epoch. [default disabled] **In SBAS:** It will try to switch mode or GEO (if allowed), otherwise it will skip the epoch [default disabled in SBAS aviation mode, 4.0 in maritime SBAS mode]. **In DGNSS:** Switch from DGNSS to SPP. [default 30.0]
-filter:maxpdop <val>	Set the PDOP threshold which will make gLAB do the following when the threshold is exceeded: **In SPP/PPP:** Skip the epoch. [default disabled] **In SBAS:** It will try to switch mode or GEO (if allowed), otherwise it will skip the epoch [default disabled in SBAS aviation mode, 6.0 in maritime SBAS mode]. **In DGNSS:** Switch from DGNSS to SPP. [default 30.0]
-filter:hdoporpdop	If HDOP and PDOP thresholds are enabled, set the option to only need to fulfill one the two requirements (HDOP or PDOP) instead of both (i.e. HDOP and PDOP conditions are ORed -logical OR-). [default disabled in all modes except in maritime SBAS mode]
-filter:maxgdop <val>	Set the GDOP threshold which will make gLAB do the following when the threshold is exceeded: **In SPP:** Skip the epoch. [default disabled] **In PPP:** Skip the epoch. [default 30.0]

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	In SBAS: It will try to switch mode or GEO (if allowed), otherwise it will skip the epoch. [default disabled] **In DGNSS:** Switch from DGNSS to SPP [default 30.0]. Use **'--filter:maxgdop'** to disable it.
-filter:stfdesa	Compute values for Stanford-ESA plot (only for SPP, SBAS and DGNSS). [default disabled] The output data is written in a separate file (which has to be processed with graph.py). See parameter **'-output:stfdesa'**.
-filter:stfdesaloi	If Stanford-ESA computation is enabled, write to file all geometries which produce an integrity ratio equal or higher than the horizontal or vertical thresholds (any of them). See parameter **'-output:stfdesaloi'**. [default enabled]
-filter:stfdesa:xmax <val>	Set the maximum value for the horizontal axis (error axis, in metres) for Stanford-ESA plot. [default 50]
-filter:stfdesa:ymax <val>	Set the maximum value for the vertical axis (protection level axis, in metres) for Stanford-ESA plot. [default 50]
-filter:stfdesa:xres <val>	Set the horizontal resolution (error axis, in metres) for Stanford-ESA plot. [default 0.1]
-filter:stfdesa:yres <val>	Set the vertical resolution (protection level axis, in metres) for Stanford-ESA plot. [default 0.1]
-filter:stfdesa:hwir <val>	Set the horizontal integrity ratio threshold for which the geometry info will be written to file. [default 0.7] See parameters **'-filter:stfdesaloi'** and **'-output:stfdesaloi'** for more details.
-filter:stfdesa:vwir <val>	Set the vertical integrity ratio threshold for which the geometry info will be written to file. [default 0.7] See parameters **'-filter:stfdesaloi'** and **'-output:stfdesaloi'** for more details.
-filter:stfdesa:maxsat <val>	Set the maximum number of satellites to be used during the Stanford-ESA combination. [default 999999] **Note:** This parameter allows to skip computation of combinations with many satellites, which will not have problems if all their subsets behave correctly. This filter may be necessary if too many satellites are in view, as the number of combinations will increase exponentially. Minimum value for parameter is 4.

5.3.5 Output options

-output:file <file>	Sets the output file. [default stdout]
--output:file	Sets the output to stdout. [default]

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-output:kml <file>	Generate a KML file to be opened with Google Earth. [default off]
-output:kml0 <file>	Generate a KML file with all height set to 0 (ground projection) to be opened with Google Earth. [default off]
-output:kml:egm96geoid	Add geoid height from EGM96 model (used by Google Earth). Use **'--output:kml:egm96geoid'** to disable it. [default on]
-output:kml:refsta	Add reference stations in KML file (in DGNSS mode only). Use **'--output:kml:refsta'** to disable it. [default on]
-output:kml:tstamp	Add time stamp in KML file (in GPS time). [default off]
-output:kml:tstampdec	Decimation (in seconds) for time stamps in KML files. [default 30]
-output:kml:tstamprange <val1> <val2>	
	Set a time range for time stamps. Only during this time range KML timestamps will be written. [default off] **<val1>:** Start epoch (in seconds of day of GPS time). If "-" is given, it will be interpreted as the beginning of the file. **<val2>:** Start epoch (in seconds of day of GPS time). If "-" is given, it will be interpreted as the end of the file. If the observation file spans for more than one day, add an offset of 86400 seconds to the start or end epoch. To set multiple ranges, set this parameter as many times as the number of ranges needed (one for each range). This parameter is combinable with **'-output:kml:tstampdec'** option.
-output:sp3 <file>	Generate a SP3 file with the computed coordinates. [default off]
-output:sp3:letter <val>	Constellation letter to be written in the SP3. [default 'L']
-output:sp3:prn <val>	PRN number to be written in the SP3. [default '9']
-output:sp3:dgnssonly	In DGNSS mode, do not write SPP solutions in the output SP3 file. [default on]
--output:sp3:dgnssonly	In DGNSS mode, write SPP solutions in the output SP3 file. [default off]
-output:refpos <file>	Generate a columnar text file with the computed coordinates. [default off]
-output:refpos:doy	Write timestamp (in GPS time) as 'Year DoY SoD' in the output reference position text file. [default on]
-output:refpos:gpsweek	Write timestamp (in GPS time) as 'GPSWeek SoW' in the output reference position text file. [default off]
-output:refpos:caltime	Write timestamp (in GPS time) as 'Year/Month/Day HH:MM:SS.zzz' in the output reference position text file. [default off]
-output:refpos:geodetic	Write solution in WGS84 geodetic coordinates (Lon, Lat, Height), instead of WGS84 cartesian coordinates (X, Y, Z). [default off] The output coordinates of the reference do not include the EGM96 geoid height model.

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-output:refpos:dgnssonly	In DGNSS mode, do not write SPP solutions in the output reference position text file. [default on]
--output:refpos:dgnssonly	In DGNSS mode, write SPP solutions in the output reference position text file. [default off]
-output:rinex <file>	Sets the RINEX observation output file name. In conversion mode, if this option is not specified, the default output filename will be **<ssssddd0.YYo>**, where 'ssss' are the first 4 characters of the filename, 'ddd' is the day of year with three digits and 'YY' is the last two digits of the year (from the RTCM file). In Add user error to RINEX mode, if this option is not specified, the default output filename will be **<obsfilename>_usererror>**.
-output:rinexversion <val>	**<val> = 2:** Generates a RINEX v2.11 from the binary file RTCM v3.x **<val> = 3:** Generates a RINEX v3.00 from the binary file RTCM v3.x, [default]
-output:corrections <file>	Sets the ASCII Plain Text output file name for the corrections when converting RTCM v2 files.
-output:antenna <file>	Sets the ASCII Plain Text output file name for the antenna information when converting RTCM v2 files.
-output:satvel <val>	**<val> = inertial:** Prints the inertial velocity in the messages where satellite velocity is given. **<val> = ITRF (ECEF):** Prints the ECEF velocity in the messages where satellite velocity is given. [default]
-output:stfdesa <file>	Set the filename where to write the output data for Stanford-ESA plots. [default "observationfilename_stdESA.txt"] **Note:** The output file is a columnar text file to be processed with graph program (with **'--sf'** parameter) for generating the Stanford-ESA plots. The first line of the output file contains, in this order the resolution in X axis (error), resolution in Y axis (protection level), maximum value in X axis and maximum value in Y axis. All the values are in metres. From the second line until then end, each line contains, in this order, the X coordinate, Y coordinate (both in metres), the number of points in the horizontal component in that coordinate and the number of points in the vertical component in that coordinate. See an example of the generated figures with graph program in Section 10.3.3) Setting this option enables Stanford-ESA computation.
-output:stfdesaloi <file>	Set the filename where to write the geometries of Stanford-ESA whose integrity ratio are over the horizontal or vertical integrity ratio (any of them). [default "observationfilename_stdESA_LOI.txt"]

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	This option sets enables the following parameter automatically: **'-filter:stfdesaloi'**.
Note: - In case of not setting **'-output:rinex'**, **'-output:corrections'** and/**or '-output:antenna'** gLAB will set automatically a name for the output file[s]. These previous options are effective only if an RTCM file is converted. Therefore, there will be no RTCM converted files if the input RTCM file is processed. - A KML with a 1 second rate data and 1 second timestamp rate may be too big for Google Earth.	

5.3.6 Verbose options

Tehe following list of extra output messages can be activated with “-print:...” or deactivated with “--print:...” as follows:

-print:info	Print INFO messages. [default on]
-print:cycleslips	Print CS messages. [default off]
-print:cs	Equivalent to parameter **'-print:cycleslips'**.
-print:sfcsdata	Print SFCSDATA messages. [default off]
-print:mwcsdata	Print MWCSDATA messages. [default off]
-print:licsdata	Print LICSDATA messages. [default off]
-print:igfcsdata	Print IGFCSDATA messages. [default off]
-print:allcsdata	Print SFCSDATA, MWCSDATA and LICSDATA messages. [default off]
-print:input	Print INPUT messages. INPUT messages are deprecated. [default off]
-print:meas	Print MEAS messages. By default, prints all measurements except Doppler and LLI flags. [default off]
-print:meas:snr	Print SNR measurement in MEAS messages. [default on]
-print:meas:doppler	Print Doppler measurement in MEAS messages. [default off]
-print:meas:select [+-]g[g]#[-#][.#[-#]]-<meas1>[-<meas2>...] [[+-]g[g]#[-#][.#[-#]]-<meas1>[-<meas2>...] ...]	
	Select the measurements to print in MEAS message by constellation and satellite. Each entry must be separated by a blank space (' '). This options overrides any other **'print:meas:'** option or default. If any satellite is not set by these option, it will use the default values or the ones set with **'print:meas:'** options. Measurements to be printed can be pseudoranges, carrier phases, SNR, Doppler and LLI flags. Repeated measurements for one satellite will be silently skipped. For SNR, it is available as a measurement, it will use this value. Otherwise, if SNR is only available as a flag, it will print the SNR from the flag (converted to decimal).

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	To print LLI flag, use the name 'LLI' plus the frequency and attribute of the measurement. **[+-]** = Optional symbols for selecting (with a plus '+') or unselecting (with a minus '-') If no symbol is provided, the default behaviour is to select measurements. **g** = Character determining GNSS constellation (G->GPS). If g=0, apply it to all constellations. **[g]** = More than one character for GNSS constellation may be provided, so multiple GNSS can be selected at once. # = PRN number. If #=0, then the detector will be applied to all satellites of the selected GNSS constellation. **[-#]** = Optionally, a minus sign ('-') and a second PRN number can be provided in order to set a range of satellites (of the same constellation). **[.#[-#]]**= Optionally, more than one satellite PRN or satellite range can be given, by separating each value with a dot ('.') <meas1> Set the measurement(s) to print in MEAS message. **Example:** **-print:meas:select G0-C1C-L1C-LLI1C-D1C-S1C** **-print:meas:select G10-32-C1C-L1C-C2L-S2L E0-C1C-C5C**
-print:meas:selectlist g[g]#[-#][.#[-#]]-<meas1>[-<meas2>...] [,g[g]#[-#][.#[-#]]-<meas1>[-<meas2>...],...]	
	Same as **'-print:meas:select'** but separated by commas instead of spaces **Example:** **-print:meas:selectlist G0-C1C-L1C-LLI1C-D1C-S1C** **-print:meas:selectlist G10-32-C1C-L1C-C2L-S2L,E0-C1C-C5C**
-print:model	Print MODEL messages. [default off]
-print:sat	Print EPOCHSAT messages. [default off]
-print:epochsat	Equivalent to parameter **'-print:sat'.**
-print:sateliites	Equivalent to parameter **'-print:sat'.**
-print:prefit	Print PREFIT messages. [default off]
-print:prefit:unsel	Print unselected measurements in PREFIT messages. [default off]
-print:postfit	Print POSTFIT messages. [default off]
-print:filter	Print FILTER messages. [default off]
-print:output	Print OUTPUT messages. [default on]
-print:satdiff	Print SATDIFF messages in comparison mode (see section WORK MODES). [default on]
-print:satstat	Print SATSTAT messages in comparison mode (see section WORK MODES). [default on]
-print:satstattot	Print SATSTATTOT messages in comparison mode (see section WORK MODES). [default on]
-print:satpvt	Print SATPVT messages in show product mode (see section WORK MODES). [default on]

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-print:satsel	Print satellite selection information. [default off]
-print:usererror	Print user added error to raw measurements. [default on]
-print:summary	Print a summary at the end of the files with the statistics of the processing. [default on]
-print:sumonly	Print only summary (disables all other output prints).
-print:progress	Print to terminal the current epoch being processed. [default on]
-print:progressalways	Print to terminal the current epoch being processed even if standard output is piped. [default off]
-print:pa	Same as **'-print:progressalways'**, but with a shorter name. [default off]
-print:all	Print all messages.
-print:none	Do not print anything, except the progress bar (**'--print:none'** is also accepted). More information on print messages can be seen with the **'-messages'** option.
-print:v5format	Print all output messages in the format of gLAB versions lower than 6.0.0 (before multiconstellation). The INFO messages (except for the summary) are not affected by this option.
-print:clkns	Print the receiver clock offset (in FILTER and OUTPUT messages) and the inter-system clock biases (in MODEL and FILTER messages) in nanoseconds instead of metres. [default off]

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5.4 SBAS OPTIONS

Options with **green** background are applicable for SBAS 1F only.

Options with **blue** background are applicable for SBAS DFMC only.

Options with **white** background are applicable for both SBAS 1F and DFMC.

NOTE: Some options have changed its name of argument format from version 5. This old name or argument format are still accepted (as it has backwards compatibility). gLAB will automatically detect them and parse them accordingly. For the options that apply to satellites, they will only be applied to GPS constellation.

5.4.1 Input options

-input:sbas1f <file>	Sets the SBAS data file (RINEX-B v2.11 or EMS). Activates SBAS 1F processing mode.
-input:sbasdfmc <file>	Sets the SBAS data file (RINEX-B v2.11 or EMS). Activates SBAS DFMC processing mode.
-input:sigmpath <file>	Sets the data file for user sigma multipath model for SBAS (execute 'gLAB -sigmamultipathfile' for details). **Note:** This option will set receiver positioning mode to 'calculate' if non set. See **'-pre:setrecpos'** option below for details.

5.4.2 Preprocessing options

-pre:geoexclude #[,#..] [...]	Exclude GEO satellite for SBAS. Data from this GEO will be ignored for SBAS corrections. **#** = PRN number. **[,#..]** = Optionally, a list of GEO can be provided by separating the numbers with commas (',').
-pre:geosel #	Select GEO satellite for SBAS corrections. **#= 0** => Use data from all GEO (all GEO mixed). **# = 1** => Use GEO from the first line of SBAS data read [default in SBAS maps mode]. **# = 2** => Use the GEO with highest elevation. [default in SBAS processing mode] **120 <= # <= 210** => Use the GEO with the given PRN.
-pre:smoothmin <val>	See in **'-pre:smoothmin <val>'** in in Section 5.3.2.

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5.4.3 Modelling options

-model:sbasmaritime	Configure SBAS parameters for SBAS 1F maritime mode (see notes on SBAS maritime below). [default off]
-model:sbassignalflighttime #	Set the default signal flight time (in seconds) [default 0.12]. Value ranges are from [0,0.3].
-model:usealarmmsgcorr	When reading an SBAS 1F message type 0, parse it as type 2, or when reading an SBAS DFMC message type 0, parse it as type 34, 35 or 36 (except if all bits are 0). [default off]
-model:ignoretype0	Ignore all SBAS messages type 0. [default off]
-model:udreithreshold #	Set the UDREI threshold (from fast corrections) for discarding satellites. Satellites with UDREI equal or higher than this threshold will be discarded. Threshold values have to be in the range [1-13].[default no threshold]
-model:sigfltnomt10offset #	When message type 10 is not available or disabled, the fast correction sigma is computed as UDRE sigma plus an offset of 8 metres. With this parameter the offset of 8 metres can be changed to any value (in metres).
-model:sbasmode <val>	Select navigation mode for SBAS processing: **<val> = PA:** Precision Approach. [default] **<val> = NPA:** Non Precision Approach.
-model:geoswitch	Enable GEO switch for SBAS processing. See **'Mode and GEO switch notes'** below. [default off]
-model:selectbestgeo	If GEO switching for SBAS processing is enabled, gLAB will compute the protection levels for all GEO available and will select the one with lower protection levels. [default off] **Note:** Enabling this option will noticeably increase the computation time (especially if there are many GEOs in the SBAS data file), as gLAB needs to compute the SBAS modelling with each GEO, and then select the best one. =Read section "Selection of best GEO:" below for details on the criteria of how the best GEO is selected.
-model:maintaingeo	If GEO switch for SBAS is enabled, maintain current GEO while possible independently if it is the GEO selected by the user or it has been selected due to a GEO switch. [default on]
-model:geofallback	If GEO switch for SBAS is enabled, always try to return to the initial selected GEO. [default off]
-model:sbasmodeswitch	Enable navigation mode switching (between PA and NPA) in SBAS processing. [default off]
-model:mixedgeo	Enable the usage of mixed GEO data (messages from all GEO are treated as if there were from a unique GEO). [default off]
-model:initcoordnpa	In SBAS mode, if receiver coordinates are to be calculated without giving any initial condition (parameter **'-pre:setrecpos'**

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	calculate), compute the first epochs using Klobuchar until the receiver coordinates have converged. This is useful due to the initial gLAB coordinate may do that the IPPs (Ionospheric Pierce Point) fall outside the SBAS region, making all satellites unavailable due to the lack of ionosphere. This option only has effect if SBAS mode switch is disabled and receiver coordinates are set to 'calculate'. [default on]
-model:sbasreceiver #	Set receiver class type for SBAS (for computing variance of the airborne receiver). **# = 0:** User defined receiver model (defined with parameters **'-model:sigmpath'**, **'-model:sigdiv'**, **'-model:signoise'** and **'-input:sigmpath'**). The receiver sigmas not defined by the user (with the previous parameters) will use the default values for class 2 receiver. **# = 1:** Class 1 equipment. **# = 2,3,4:** Class 2, 3, 4 equipment (all equivalent). [default 2]
-model:geoacqtime #	Set the minimum time (in seconds) to consider that gLAB has received enough SBAS corrections from a GEO counting from the first message received. [default 300] **Note:** This timer is set to ensure that we have received enough corrections from the GEO we want to switch to. If this timer is set too low (few seconds), it may happen that we switch to a GEO with not enough data (due to we are in initialization or the GEO has received an alarm message. gLAB will not switch to any GEO before this time, except for when an alarm message is received and there is no other GEO available.
-model:switchtime #	Set the minimum time (in seconds) between a GEO or mode switch and the following one. [default 0] **Note:** If this timer is set to zero, a maximum of 50 switches per epoch (for both mode and GEO) will be done.
-model:sbastmout <n> <val>	**<n> <val>** Set time out value for SBAS messages (except for fast and range rate corrections) in both modes, PA and NPA. **<n>** is the message type number. **<val>** is the time out value (in seconds).
-model:sbastmoutpa <n> <val>	Set time out value for SBAS messages (except for fast and range rate corrections) in PA mode. **<n>** is the message type number. **<val>** is the time out value (in seconds).
-model:sbastmoutnpa <n> <val>	Set time out value for SBAS messages (except for fast and range rate corrections) in NPA mode. **<n>** is the message type number. **<val>** is the time out value (in seconds).

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-model:sbastmoutfc <val>	Set time out value for fast corrections in both modes, PA and NPA. **<val>** is the time out value (in seconds).
-model:sbastmoutfcpa <val>	Set time out value for fast corrections in PA mode. **<val>** is the time out value (in seconds).
-model:sbastmoutfcnpa <val>	Set time out value for fast corrections in NPA mode **<val>** is the time out value (in seconds).
-model:sbastmoutrrc <val>	**<val>** Set time out value for range rate corrections in both modes, PA and NPA. **<val>** is the time out value (in seconds).
-model:sbastmoutrrcpa <val>	**<val>** Set time out value for range rate corrections in PA mode. **<val>** is the time out value (in seconds).
-model:sbastmoutrrcnpa <val>	**<val>** Set time out value for range rate corrections in NPA mode. **<val>** is the time out value (in seconds).
-model:sigmpath <val1> <val2> [<val3>]	
	Set parameters a, b, c for sigma multipath for SBAS (1F or DFMC) airborne receiver, being sigma=a+b*e^(-satelevation/c) and satelevation in degrees. **<val1>** is a value (in metres). [default 0.13 for class 2/3/4 receiver] **<val2>** is b value (in metres). [default 0.53 for class 2/3/4 receiver] **[<val3>]** is c value (in degrees). [default 10 for class 2/3/4 receiver] **Note:** This argument is optional in order to maintain compatibility with previous versions.
-model:sigdiv <val>	Set a fixed value (in metres) for sigma divergence for SBAS (1F or DFMC) airborne receiver.
-model:signoise <val>	Set a fixed value (in metres) for sigma noise for SBAS (1F or DFMC) airborne receiver.
-model:khpa <val>	Set the Kh factor value used when computing the horizontal protection level in PA mode. [default 6]
-model:khnpa <val>	Set the Kh factor value used when computing the horizontal protection level in NPA mode. [default 6.18]
-model:kvpa <val>	Set the Kv factor value used when computing the vertical protection level in PA mode. [default 5.33]
-model:kvnpa <val>	Set the Kv factor value used when computing the vertical protection level in NPA mode. [default 5.33]
-model:nofastcor	Set SBAS fast and RRC corrections values to 0. [default off]
-model:norrccor	Set SBAS RRC correction value to 0. [default off]
-model:noslowcor	Set SBAS slow corrections values to 0. [default off]
-model:noionocor	Set SBAS ionosphere correction value to 0. [default off]
-model:nofastsigma	Set SBAS fast and RRC sigmas (sigma UDRE and degradation terms) values to 0. [default off]
-model:nofastdeg	Set SBAS fast degradation term value to 0. [default off]

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-model:norrcsigma	Set SBAS RRC degradation term value to 0. [default off]
-model:noslowsigma	Set SBAS slow correction degradation term to 0. [default off]
-model:noionosigma	Set SBAS ionosphere sigma to 0. [default off]
-model:notroposigma	Set SBAS troposphere sigma to 0. [default off]
-model:noenroutesigma	Set SBAS En Route Through NPA degradation term to 0. [default off]
-model:nodeltaudre	Set SBAS Delta UDRE factor to 1. [default off]
-model:nomt10	Disable use of message type 10 in all modes. [default off]
-model:nomt2728	Disable use of messages type 27 and 28 in all modes (this is equivalent to parameter **'-model:nodeltaudre'**). [default off]
-model:sbasdfmc:mt37v04	When reading a SBAS DFMC message type 37, decode it using ED-259 version <=0.4. [default disabled]
-model:sbasdfmc:mt3940v04	When reading a SBAS DFMC message type 39/40, decode it using ED-259 version <=0.4. [default disabled]
-model:sbasdfmc:mt42v07	When reading a SBAS DFMC message type 42, decode it using ED-259 version <=0.7. [default disabled]
-model:sbasdfmc:mt47v04	When reading a SBAS DFMC message type 47, decode it using ED-259 version <=0.4. [default disabled]
-model:sbasdfmc:cer <val>	Set the value (in metres) of Cer parameter in SBAS DFMC MT 37. [default read from MT37]
-model:sbasdfmc:ccovariance <val>	Set the value (unitless) of Ccovariance parameter in SBAS DFMC MT 37. [default read from MT37]
-model:sbasdfmc:icorr g[g]-<val>	
	Set the value (in seconds) of Icorr (per constellation) parameter in SBAS DFMC MT 37. [default read from MT37] **g** = Character determining GNSS constellation (G->GPS). If g=0, apply it to all constellations. **[g]** = More than one character for GNSS constellation may be provided, so multiple GNSS can be selected at once. **<val>** = Icorr value (in seconds).
-model:sbasdfmc:ccorr g[g]-<val>	
	Set the value (in metres) of Ccorr (per constellation) parameter in SBAS DFMC MT 37. [default read from MT37] **g** = Character determining GNSS constellation (G->GPS). If g=0, apply it to all constellations. **[g]** = More than one character for GNSS constellation may be provided, so multiple GNSS can be selected at once. **<val>** = Ccorr value (in metres).
-model:sbasdfmc:rcorr g[g]-<val>	
	Set the value (in metres/second) of Rcorr (per constellation) parameter in SBAS DFMC MT 37. [default read from MT37] **g** = Character determining GNSS constellation (G->GPS). If g=0, apply it to all constellations. **[g]** = More than one character for GNSS constellation may be provided, so multiple GNSS can be selected at once. **<val>** = Rcorr value (in metres/second).

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-model:sbasdfmc:dfrei <n> <val>	
	Set the value (in metres) for the DFREI sigma when DFREI=<n> in SBAS DFMC MT 37. [default read from MT37] **<n>** = DFREI value, valid values are [0.14]. **<val>** = DFREI value (in metres).
-model:sbasdfmc:dfreilist <val0>,<val1>,...,<val14>	Set the value (in metres) for all possible DFREI values in a comma separated list. **Note:** The list must contain 15 values in DFREI ascending order, from DFREI=0 to DFREI=14. **Example:** 0.125,0.25,0.375,0.5,0.625,0.75,1,1.25,1.5,1.75,2,2.5,3,4,10
-model:sbasdfmc:deltarcorr <val>	
	Set the value (unitless) of Delta Rcorr parameter in SBAS DFMC MT 32 or MT39/40. [default read from MT32 or MT39/40]
-model:sbasdfmc:deltadfre <val>	
	Set the value (unitless) of Delta DFRE instead of computing it from MT 32 or MT39/40 [default compute from MT32 or MT39/40]
-model:sbasdfmc:sigmauire <val>	
	Set the value (in metres) of UIRE sigma instead of using MOPS formula. [default use MOPS formula]
-model:sbasdfmc:sigmatropo <val>	
	Set the value (in metres) of troposphere sigma instead of using MOPS formula. [default use MOPS formula]
-model:sbasdfmc:sigmpathfactor <val>	
	Set the value (adimensional) for the factor to convert the receiver sigma multipath from single frequency to dual frequency. [default 2.59] **Note:** This factor is to account for the noise increase in the ionosphere-free combination, as the receiver sigma multipath is computed the one for SBAS 1 frequency (as described in parameter **'-model:sigmpath'**).
-model:sbasdfmc:anymeas	Allow to use any measurement for processing in SBAS DFMC mode in the default measurements are not available. [default off] **Note**: In SBAS DFMC, measurements for navigation are fixed to GPS C1C-L1C, C5Q-L5Q and Galileo C1C-L1C, C5Q-L5Q. If these measurements are not available, gLAB by default will refuse to process in SBAS DFMC. If this option is enabled, gLAB will allow to use any measurement from the same frequency as substitute for the default ones. For instance, some receivers only provide the combined L5 measurements (C5X-L5X) for both GPS and Galileo, so it is necessary to enable this option to process data with them. If this option is enabled and measurements different from the defaults are used, a bias will appear between the estimated

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	SBAS DFMC corrections and the used measurments, degrading the navigation solution.
-model:sbasdfmc:austestbed	Configure gLAB to process Australian SBAS DFMC test bed messages, which uses messages format from SBAS DFMC MOPS 0.3.8 (March 2017) and sends MT0 to send MT34, MT35 and MT36. This parameter is a shortcut for providing parameters **'-model:sbasdfmc:mt37v04'**, **'-model:sbasdfmc:mt3940v04'**, **'-model:sbasdfmc:mt42v07'**, **'-model:sbasdfmc:mt47v04'**, **'-model:usealarmmsgcorr'** and **'--model:dcb:df:gps'**.

Note:

- When setting any fast, slow, ionosphere correction or their sigmas to 0, gLAB will still check all the conditions for the current mode. For example, if gLAB is in PA mode and the **'-model:nofastcor'** parameter is set, then it will search for a fast correction, and if it is available, it will set the value to 0 instead of the one given in the SBAS message. If there is no SBAS fast correction available, the satellite will not be used.

- The SBAS timeouts given by the user will override the defaults stated in MOPS-D.

5.4.4 Filtering options

-filter:stfdesa	See in **'-filter:stfdesa'** in Section 5.3.4.
-filter:stfdesaloi	See in **'-filter:stfdesaloi'** in Section 5.3.4.
-filter:stfdesa:xmax <val>	See in **'-filter:stfdesa:xmax <val>'** in Section 5.3.4.
-filter:stfdesa:ymax <val>	See in **'-filter:stfdesa:ymax <val>'** in Section 5.3.4.
-filter:stfdesa:xres <val>	See in **'-filter:stfdesa:xres <val>'** in Section 5.3.4.
-filter:stfdesa:yres <val>	See in **'-filter:stfdesa:yres <val>'** in Section 5.3.4.
-filter:stfdesa:hwir <val>	See in **'-filter:stfdesa:hwir <val>'** in Section 5.3.4.
-filter:stfdesa:vwir <val>	See in **'-filter:stfdesa:vwir <val>'** in Section 5.3.4.
-filter:stfdesa:maxsat <val>	See in **'-filter:stfdesa:maxsat <val>'** in Section 5.3.4.

5.4.5 Output options

-output:rinexb	Generate a RINEX-B file from the SBAS data (only for SBAS). [default off]
-output:ems	Generate a EMS file from the SBAS data (only for SBAS). [default off]
-output:pegasus	Generate Pegasus file format from the SBAS data (only for SBAS 1F). See notes on Pegasus format below. [default off]
-output:pegstrictrinex	When generating a RINEX-H file for Pegasus, follow the RINEX 2.11 rules for transmission time, health flag and URA (only active if **'-output:pegasus'** has been set). [default off]

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-output:pegspace	Set the field separator in Pegasus files to space character (' ') instead of a semicolon (';'). [default off]
-output:pegfilealign	Print Pegasus files with all columns aligned [default off]
-output:sbasdir <name>	Set the directory where to write the output SBAS files ('.' for current directory). [default "SBAS"]
-onlyconvert	Convert EMS or RINEX-B file to RINEX-B, EMS or Pegasus and exit without processing any GNSS data. [default off]
Note: - Incorrect messages from RINEX-B or EMS files are messages which grant any of these conditions: CRC mismatch, invalid header, unknown message type, invalid time of applicability (time is over 86400 seconds).	

5.4.6 Verbose options

-print:sbascor	Print SBASCORR messages (only for SBAS 1F). [default off]
-print:sbascorr	Equivalent to parameter **'-print:sbascor'**.
-print:sbasvar	Print SBASVAR messages (only for SBAS 1F). [default off]
-print:sbasiono	Print SBASIONO messages (only for SBAS 1F). [default off]
-print:sbasunsel	Print SBASUNSEL messages (only for SBAS 1F). [default off]
-print:sbasdfmccor	Print SBASDFMCCORR messages (only for SBAS DFMC). [default off]
-print:sbasdfmccorr	Equivalent to parameter **'-print:sbasdfmccor'**
-print:sbasdfmcvar	Print SBASDFMCVAR messages (only for SBAS DFMC). [default off]
-print:sbasdfmcunsel	Print SBASDFMCUNSEL messages (only for SBAS DFMC). [default off]
-print:sbasunused	Print messages from discarded satellites due to SBAS GEO switch (only for SBAS 1F and DFMC). [default off] The discarded messages are MODEL, SBASCORR, SBASVAR, SBASIONO and SBASUNSEL, but only the ones selected from user parameters will be printed. Also, an asterisk '*' will be added at the end of the first field to indicate that it is a discarded measurement.
-print:sbasout	Print SBASOUT messages (only for SBAS 1F and DFMC). [default on]

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5.5 DGNSS OPTIONS

NOTE: Some options have changed its name of argument format from version 5. This old name or argument format are still accepted (as it has backwards compatibility). gLAB will automatically detect them and parse them accordingly. For the options that apply to satellites, they will only be applied to GPS constellation.

5.5.1 Input options

-input:dgnss <file>	Sets the input RINEX observation file of the Reference Station for DGNSS.
-input:rtcm <file>	Sets the input RTCM binary file, gLAB will automatically detect the RTCM version.
-input:rtcm2 <file>	Sets the input RTCM v2.x binary file.
-input:rtcm3 <file>	Sets the input RTCM v3.x binary file.
-input:rtcm:initdate <date>	Sets the date when the record of the binary file RTCM began (YYYYMMDD), required only when processing or converting RTCM v2.x and RTCM v3.x.
-input:rtcm:inithour <hour>	Sets the hour in GPST, when the record of the binary file RTCM began (HH 24-hour format), required when processing or converting RTCM v2.x.

5.5.2 Preprocessing options

-pre:smoothmin <val>	See in **'-pre:smoothmin <val>'** in in Section 5.3.2.
-pre:smoothmeasdgnss <filtermeas> <smoothWith> [<filtermeas> <smoothWith> ...]	
	Same as **'-pre:smoothmeas'** but applied to the reference station instead of the rover.
-pre:dgnss:excludeSmoothingConvergenceUser	
	Exclude satellites during the smoothing convergence in the User Station. [default off]
--pre:dgnss:excludeSmoothingConvergenceUser	
	Do not exclude satellites during the smoothing convergence in the User Station.
-pre:dgnss:excludeSmoothingConvergenceRef	
	Exclude satellites during the smoothing convergence in the Reference Station, it will be effective if at least one cycle-slip detector is activated. [default on]
--pre:dgnss:excludeSmoothingConvergenceRef	
	Do not exclude satellites during the smoothing convergence in the Reference Station.

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-pre:setrecpos <val>	**<val> = RINEX:** Set the user receiver a priori position as the one specified in the RINEX observation file. [default] RINEX position will be used for modelling and for NEU error. **<val> = SINEX:** Set the user receiver a priori position to be read from a SINEX file (to be specified by the **'-input:snx'** parameter). SINEX position will be used for modelling and for NEU error. **<val> = <x> <y> <z>:** **<val> = Set <x> <y> <z>:** Specify the receiver a priori position in metres. Sample: **'-pre:setrecpos 4789032.7143 176594.9690 4195013.2268'**. Specified position will be used for modelling and for NEU error. In show Products mode, specified position will be used to compute satellite elevation and azimuth. **<val> = SetGeod <Lon> <Lat> <Height>:** Same as **'SetGeod'**, but the initial coordinates are given in geodetic coordinates. Longitude and latitude are given in degrees, within the ranges [-180..180] and [-90..90] respectively. The height is given in metres. **<val> = SetRef:** Read reference position for each epoch from reference position file Specified position will be used for modelling and for NEU error. See parameters **'-referenceposfile'**, **'-input:refpos'** and **'-pre:refpos:deg'** for help on the reference file. **<val> = calculate:** The user receiver a priori position will be calculated by the program and used for modelling, starting from (6378137,0,0). This is especially useful when processing moving receivers (trajectories) or when the approximate receiver position is not known. With this option activated, the differential fields of the OUTPUT message will be zero. **<val> = calculateRef:** Same as **'calculate'**, but instead of printing (0,0,0) in the output NEU error, it will compute the NEU error using the coordinates from the reference file. See parameters **'-referenceposfile'**, **'-input:refpos'** and **'-pre:refpos:deg'** for help on the reference file. **<val> = calculateRINEX:** Same as calculate, but the initial coordinates will be the one read in the RINEX observation header. If RINEX coordinates are are (0,0,0), then Earth's surface will be used as initial coordinates. **<val> = calculateRINEXRef:** Same as **'calculateRINEX'**, but instead of printing (0,0,0) in the output NEU error, it will compute the NEU error using the coordinates from the reference file. See parameters **'-referenceposfile'**, **'-input:refpos'** and **'-pre:refpos:deg'** for help on the reference file.

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	<val> = calculateUSER <x> <y> <z>: Same as **'calculate'**, but the initial coordinates will be the one given by the user in this parameter (in metres). **<val> = calculateUSERGeod <Lon> <Lat> <Height>:** Same as **'calculateUser'**, but the initial coordinates are given in geodetic coordinates. Longitude and latitude are given in degrees, within the ranges [-180..180] and [-90..90] respectively. The height is given in metres. **<val> = calculateUSERRef <x> <y> <z>:** Same as **'calculateUSER'**, but instead of printing (0,0,0) in the output NEU error, it will compute the NEU error using the coordinates from the reference file. See parameters **'-referenceposfile'**, **'-input:refpos'** and **'-pre:refpos:deg'** for help on the reference file. **<val> = calculateUSERGeodRef <Lon> <Lat> <Height>:** Same as **'calculateUSERRef'**, but the initial coordinates are given in geodetic coordinates. Longitude and latitude are given in degrees, within the ranges [-180..180] and [-90..90] respectively. The height is given in metres. **<val> = DGNSSbaseline:** The user receiver (rover) a priori position will be calculated by the program as in option **'calculat**e', but the differential fields in the OUTPUT message will computed against the reference antenna position (baseline vector from user to reference station), and the reference station coordinates will be read from RINEX or RTCM input file. **<val> = DGNSSRinexRover:** Same as **'DGNSSbaseline'**, but instead of comparing with the reference station, it will compare the user receiver (rover) coordinates with the coordinates read from the rover RINEX observation file. **<val> = DGNSSRoverUSER <RoverX> <RoverY> <RoverZ>:** Same as **'DGNSSbaseline'**, but instead of comparing with the reference station, it will compare the user receiver (rover) with the position given in this parameter. **<val> = DGNSSRoverUSERGeod <RoverLon> <RoverLat> <RoverHeight>:** Same as **'DGNSSRoverUSER'**, but the rover coordinates are given in geodetic coordinates. Longitude and latitude are given in degrees, within the ranges [-180..180] and [-90..90] respectively. The height is given in metres. **<val> = DGNSSRoverUSERRef:** Same as **'DGNSSbaseline'**, but instead of comparing with the reference station, it will compare the user receiver (rover) solution with the position given by the reference file. See parameters **'-referenceposfile'**, **'-input:refpos'** and **'-pre:refpos:deg'** for help on the reference file. **<val> = DGNSSUserRoverRef <RefX> <RefY> <RefZ>:** Same as **'DGNSSRoverUSERRef'**, but the reference station coordinates will be provided in this parameter (this mode only works when computing DGNSS with a RINEX file).

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	<val> = DGNSSUserGeodRoverRef <RefLon> <RefLat> <RefHeight>: Same as **'DGNSSUserRoverRef'**, but the reference station coordinates are given in geodetic coordinates. Longitude and latitude are given in degrees, within the ranges [-180..180] and [-90..90] respectively. The height is given in metres. **<val> = DGNSSUserbaseline <RefX> <RefY> <RefZ>:** Same as **'DGNSSbaseline'**, but the reference station coordinates will be provided in this parameter (this mode only works when computing DGNSS with a RINEX file). **<val> = DGNSSUserGeodbaseline <RefLon> <RefLat> <RefHeight>:** Same as **'DGNSSUserbaseline'**, but the reference station coordinates are given in geodetic coordinates. Longitude and latitude are given in degrees, within the ranges [-180..180] and [-90..90] respectively. The height is given in metres. **<val> = DGNSSUserRinexRover <RefX> <RefY> <RefZ>:** Same as **'DGNSSRinexRover'**, but the reference station coordinates will be provided in this parameter (this mode only works when computing DGNSS with a RINEX file). **<val> = DGNSSUserGeodRinexRover <RefLon> <RefLat> <RefHeight>:** Same as **'DGNSSUserRinexRover'**, but the reference station coordinates are given in geodetic coordinates. Longitude and latitude are given in degrees, within the ranges [-180 .180] and [-90..90] respectively. The height is given in metres. **<val> = DGNSSRefRoverUSER <RefX> <RefY> <RefZ> <RoverX> <RoverY> <RoverZ>:** Same as **'DGNSSRoverUSER'**, but the reference station coordinates will be provided in this parameter (this mode only works when computing DGNSS with a RINEX file). **<val> = DGNSSRefGeodRoverUSERGeod <RefLon> <RefLat> <RefHeight> <RoverLon> <RoverLat> <RoverHeight>:** Same as **'DGNSSRefRoverUSER'**, but the rover and reference station coordinates are given in geodetic coordinates. Longitude and latitude are given in degrees, within the ranges [-180..180] and [-90..90] respectively. The height is given in metres. **<val> = DGNSSRefCarRoverUSERGeod <RefX> <RefY> <RefX> <RoverLon> <RoverLat> <RoverHeight>:** Same as **'DGNSSRefRoverUSER'**, but the rover coordinates are given in geodetic coordinates and the reference station in cartesian coordinates. Longitude and latitude are given in degrees, within the ranges [-180..180] and [-90..90] respectively. The height is given in metres. **<val> = DGNSSRefGeodRoverUSERCar <RefLon> <RefLat> <RefHeight> <RoverX> <RoverY> <RoverZ>:** Same as **'DGNSSRefRoverUSER'**, but the reference station coordinates are given in geodetic coordinates and the rover in cartesian coordinates. Longitude and latitude are given in

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	degrees, within the ranges [-180..180] and [-90..90] respectively. The height is given in metres.
-pre:setrectypedgnss <val>	Same as **'-pre:setrectype'**, but applied to the reference station
-pre:cs:li:freqdgnss [+-]g[g]#[-#][.#[-#]]-<freq1><freq2>[.<freq1><freq2>] [[+-]g[g]#[-#][.#[-#]]-<freq1><freq2>[.<freq1><freq2>] ...]	
	Same as **'-pre:cs:li:freq'**, but it is applied to the reference station instead of the rover.
-pre:cs:li:freqlistdgnss [+-]g[g]#[-#][.#[-#]]-<freq1><freq2>[.<freq1><freq2>] [,[+-]g[g]#[-#][.#[-#]]-<freq1><freq2>[.<freq1><freq2>],...]	
	Same as **'-pre:cs:li:freqlist'**, but it is applied to the reference station instead of the rover.
-pre:cs:li:measdgnss [+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2> [[+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2> ...]	
	Same as **'-pre:cs:li:meas'**, but it is applied to the reference station instead of the rover.
-pre:cs:li:measlistdgnss [+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2> [[+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2> ...]	
	Same as **'-pre:cs:li:measlist'**, but it is applied to the reference station instead of the rover.
-pre:cs:mw:freqdgnss [+-]g[g]#[-#][.#[-#]]-<freq1><freq2>[.<freq1><freq2>] [[+-]g[g]#[-#][.#[-#]]-<freq1><freq2>[.<freq1><freq2>] ...]	
	Same as **'-pre:cs:mw:freq'**, but it is applied to the reference station instead of the rover.
-pre:cs:mw:freqlistdgnss [+-]g[g]#[-#][.#[-#]]-<freq1><freq2>[.<freq1><freq2>] [,[+-]g[g]#[-#][.#[-#]]-<freq1><freq2>[.<freq1><freq2>],...]	
	Same as **'-pre:cs:mw:freqlist'**, but it is applied to the reference station instead of the rover.
-pre:cs:mw:measdgnss [+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2>-<meas3>-<meas4> [[+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2>-<meas3>-<meas4> ...]	
	Same as **'-pre:cs:mw:meas'**, but it is applied to the reference station instead of the rover.
-pre:cs:mw:measlistdgnss [+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2>-<meas3>-<meas4> [[+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2>-<meas3>-<meas4> ...]	
	Same as **'-pre:cs:mw:measlist'**, but it is applied to the reference station instead of the rover.
-pre:cs:sf:freqdgnss [+-]g[g]#[-#][.#[-#]]-<freq>[.<freq>] [[+-]g[g]#[-#][.#[-#]]-<freq>[.<freq>] ...]	
	Same as **'-pre:cs:sf:freq'**, but it is applied to the reference station instead of the rover.
-pre:cs:sf:freqlistdgnss [+-]g[g]#[-#][.#[-#]]-<freq>[.<freq>] [,[+-]g[g]#[-#][.#[-#]] <freq>[.<freq>],...]	
	Same as **'-pre:cs:sf:freqlist'**, but it is applied to the reference station instead of the rover.
-pre:cs:sf:measdgnss [+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2> [[+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2> ...]	
	Same as **'-pre:cs:sf:meas'**, but it is applied to the reference station instead of the rover.

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-pre:cs:sf:measlistdgnss [+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2> [[+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2> ...]	
	Same as **'-pre:cs:sf:measlist'**, but it is applied to the reference station instead of the rover.
-pre:cs:igf:freqdgnss [+-]g[g]#[-#][.#[-#]]-<freq1><freq2><freq3><freq4> [[+-]g[g]#[-#][.#[-#]]-<freq1><freq2><freq3><freq4>] ...]	
	Same as **'-pre:cs:igf:freq'**, but it is applied to the reference station instead of the rover.
-pre:cs:igf:freqlistdgnss [+-]g[g]#[-#][.#[-#]]-<freq1><freq2><freq3><freq4> [,[+-]g[g]#[-#][.#[-#]]-<freq1><freq2><freq3><freq4>],...]	
	Same as **'-pre:cs:igf:freqlist'**, but it is applied to the reference station instead of the rover.
-pre:cs:igf:measdgnss [+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2>-<meas3>-<meas4> [[+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2>-<meas3>-<meas4> ...]	
	Same as **'-pre:cs:igf:meas'**, but it is applied to the reference station instead of the rover.
-pre:cs:igf:measlistdgnss [+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2>-<meas3>-<meas4> [[+-]g[g]#[-#][.#[-#]]-<meas1>-<meas2>-<meas3>-<meas4> ...]	
	Same as **'-pre:cs:igf:measlist'**, but it is applied to the reference station instead of the rover.
-pre:measorderdgnss [+-]g[g]#[-#][.#[-#]]-<meastype><freqs>-<attr1>[<attr2><attr3>...] [[+-]g[g]#[-#][.#[-#]]-<meastype><freqs>-<attr1>[<attr2><attr3>...] ...]	
	Same as **'-pre:measorder'**, but it is applied to the reference station instead of the rover.
-pre:measorderlistdgnss [+-]g[g]#[-#][.#[-#]]-<meastype><freqs>-<attr1>[<attr2><attr3>...] [,[+-]g[g]#[-#][.#[-#]]-<meastype><freqs>-<attr1>[<attr2><attr3>...], ...]	
	Same as **'-pre:measorderlist'**, but it is applied to the reference station instead of the rover.
-pre:meassel:pairedmeasdgnss	Same as **'-pre:meassel:pairedmeas'**, but applied only to the reference station. [default disabled]

5.5.3 Modelling options

-model:dgnss:sigmainflation	The sigma is inflated during the smoother convergence (see DGNSS notes at the end). [default on]
--model:dgnss:sigmainflation	Do not use the sigma inflation during the smoother convergence
-model:dgnss:maxage <val>	Set the maximum age value (in seconds) to stop applying DGNSS corrections. [default 31]
-model:dgnss:maxcorrval <val>	
	Set the maximum value for a DGNSS correction to be considered valid (in metres). [default 500]
-model:dgnss:measprc [+-]g[g]#[-#][.#[-#]]-<PRCmeas>- [<meas1>-<meas2>[-<meas3>-<meas4>]] [...]	

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	Set the measurements to use for computing the corrections in the reference station in DGNSS mode. **Note:** Measurements are set in the same way as in option **'-filter:select'**.
-model:dgnss:measprclist [+-]g[g]#[-#][.#[-#]]-<PRCmeas>-[<meas1>-<meas2>[-<meas3>-<meas4>]],...]	
	Same as **'-model:dgnss:measprclist'**, but each entry is separated by commas (',') instead of blank spaces.

5.5.4 Filtering options

-filter:stfdesa	See in **'-filter:stfdesa'** in Section 5.3.4.
-filter:stfdesaloi	See in **'-filter:stfdesaloi'** in Section 5.3.4.
-filter:stfdesa:xmax <val>	See in **'-filter:stfdesa:xmax <val>'** in Section 5.3.4.
-filter:stfdesa:ymax <val>	See in **'-filter:stfdesa:ymax <val>'** in Section 5.3.4.
-filter:stfdesa:xres <val>	See in **'-filter:stfdesa:xres <val>'** in Section 5.3.4.
-filter:stfdesa:yres <val>	See in **'-filter:stfdesa:yres <val>'** in Section 5.3.4.
-filter:stfdesa:hwir <val>	See in **'-filter:stfdesa:hwir <val>'** in Section 5.3.4.
-filter:stfdesa:vwir <val>	See in **'-filter:stfdesa:vwir <val>'** in Section 5.3.4.
-filter:stfdesa:maxsat <val>	See in **'-filter:stfdesa:maxsat <val>'** in Section 5.3.4.

5.5.5 Output options

Please See **OUTPUT OPTIONS** in Section 5.3.5.

5.5.6 Verbose options

-print:dgnss	Print DGNSS global information (only for DGNSS). [default on]
-print:dgnssunused	Print messages from discarded satellites due to DOP switch (from DGNSS to SPP). [default off] An asterisk '*' will be added at the end of the first field to indicate that it is a discarded measurement.

NOTE: The DGNSS mode switches to SPP when there are not enough satellites for computing the navigation solution, or the GDOP is over the threshold (if any threshold is set).

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Before switching to SPP mode, this verbose option can print the MODEL and DGNSS messages generated in this iteration (if options '**-print:model**' and **'-print:dgnss'** are enabled).

The MODEL and DGNSS messages will have a star ('*') at the end of the first field (message name) to indicate that these messages belong to a discarded DGNSS iteration.

Once printed, the modelling is recomputed to complete the switching to SPP, and the MODEL message is printed again if options '**-print:model**' is enabled.

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5.6 SUMMARY OPTIONS

When processing in SPP/PPP/SBAS/DGNSS modes, if summary is enabled a statistical summary will be printed at the end of the output file. If receiver position is not fixed, error percentiles messages will not be shown.

The options for generating this summary are:

-summary:percentile <val>	Sets the value for computing the error percentile. [default 95]
-summary:waitfordaystart	If the observation file starts at 22 hours or later, gLAB will assume that from the first epoch until epoch 23 hours 59 minutes 59 seconds are given just to fill the messages buffer and wait for the smoothing and filter to converge, and the following epochs from the next day are the ones of interest. During this convergence period, Stanford-ESA values will not be computed and they will not be taken into account for the summary. This option is useful to avoid high error epoch in the summary during the convergence time. [default on] This option can be disabled with **'--summary:waitfordaystart'**. This option will have no effect if **'-summary:starttime'** is set.
-summary:starttime <date>	Set the first epoch (in GPS time) to be used in the summary. See parameter **'-pre:starttime'** for details on date format.
-summary:stationnetworkname <name>	
	Sets the station network name to be printed in the last line of summary. This is useful for doing stations maps with each station network having different marker type, colour or size with the graphical tool (after merging the last line of the summary of several processed stations in a single file). [default 'Other']
Note: - The last line of the summary contains all the values of the previous lines along with the station coordinates. This line is useful for plotting world maps with data from each station. - An example of a summary can be seen executing gLAB with **'-messages'** parameter.	

5.6.1 Additional summary options for PPP

In PPP mode, there are additional options for the summary:

-summary:formalerrorver <val>	Sets the threshold (in metres) for the vertical formal error to consider the filter converged. [default 0.4]
-summary:formalerror3d <val>	Sets the threshold (in metres) for the 3D formal error to consider the filter converged. [default 0.4]
-summary:poserrorver <val>	Sets the threshold (in metres) for the vertical positioning error to consider the solution converged. [default 0.4]
-summary:poserror3d <val>	Sets the threshold (in metres) for the 3D positioning error to consider the solution converged. [default 0.4]

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-summary:errorhor <val>	Sets the threshold (in metres) for the horizontal for both formal and positioning error to consider the solution converged. This parameter is a shortcut for providing **'-summary:formalerrorhor'** and **'-summary:poserrorhor'** parameters.
-summary:errorver <val>	Sets the threshold (in metres) for the vertical for both formal and positioning error to consider the solution converged. This parameter is a shortcut for providing **'-summary:formalerrorver'** and **'-summary:poserrorver'** parameters.
-summary:error3d <val>	Sets the threshold (in metres) for the 3D for both formal and positioning error to consider the solution converged. This parameter is a shortcut for providing **'-summary:formalerror3d'** and **'-summary:poserror3d'** parameters.
-summary:errorhv3d <val>	Sets the threshold (in metres) for all the components for both formal and positioning error to consider the solution converged. This parameter is a shortcut for providing **'-summary:errorhor'**, **'-summary:errorver'** and **'-summary:error3d'** parameters
-summary:formalerrorperiodhor <val>	
	Sets the continuous time period (in seconds) for the horizontal formal error to be under the threshold. [default 300]
-summary:formalerrorperiodver <val>	
	Sets the continuous time period (in seconds) for the vertical formal error to be under the threshold. [default 300]
-summary:formalerrorperiod3d <val>	
	Sets the continuous time period (in seconds) for the 3D formal error to be under the threshold. [default 300]
-summary:poserrorperiodhor <val>	
	Sets the continuous time period (in seconds) for the horizontal positioning error to be under the threshold. [default 300]
-summary:poserrorperiodver <val>	
	Sets the continuous time period (in seconds) for the vertical positioning error to be under the threshold. [default 300]
-summary:poserrorperiod3d <val>	
	Sets the continuous time period (in seconds) for the 3D positioning error to be under the threshold. [default 300]
-summary:errorperiodhor <val>	Sets the continuous time period (in seconds) for horizontal for both the formal and positioning error to be under the threshold. This parameter is a shortcut for providing **'-summary:formalerrorperiodhor'** and **'-summary:poserrorperiodhor'** parameters.
-summary:errorperiodver <val>	Sets the continuous time period (in seconds) for vertical for both the formal and positioning error to be under the threshold. This parameter is a shortcut for providing **'-summary:formalerrorperiodver'** and **'-summary:poserrorperiodver'** parameters.

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-summary:errorperiod3d <val>	Sets the continuous time period (in seconds) for 3D for both the formal and positioning error to be under the threshold. This parameter is a shortcut for providing **'-summary:formalerrorperiod3d'** and **'-summary:poserrorperiod3d'** parameters.
-summary:errorperiodhv3d <val>	
	Sets the continuous time period (in seconds) for all the components for both the formal and positioning error to be under the threshold. This parameter is a shortcut for providing **'-summary:errorperiodhor'**, **'-summary:errorperiodver'** and **'-summary:errorperiod3d'** parameters.

5.6.2 Additional options for SBAS

In SBAS mode, there are additional options for the summary:

-summary:percentile <val>	Sets the value for computing the error percentile. [default 95]
-summary:val <val>	Sets the Vertical Alarm Limit (in metres) for computing availability and continuity risk. [default 50]
-summary:windowsize <val>	Sets the sliding window size (in epochs) for computing the continuity risk. [default 15 for aviation, 900 for maritime]
-summary:windowsizemar <val>	
	Sets the fixed window size (in epochs) for computing the continuity risk for maritime. [default 15 for aviation, 900 for maritime]
Note: - The computation of the continuity risk takes into account the sampling rate and data gaps in the observation file.	

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5.7 SBAS PLOTS OPTIONS

SBAS PLOTS OPTIONS

This mode is activated when only a navigation file and a SBAS file are given (see description below in WORK MODES).

The following options are specific for this mode:

-sbasplots:minlat <val>	Sets the minimum latitude (in degrees) for the SBAS plots. The minimum resolution is 0.01. [default 25.0]
-sbasplots:maxlat <val>	Sets the maximum latitude (in degrees) for the SBAS plots. The minimum resolution is 0.01. [default 70.0]
-sbasplots:minlon <val>	Sets the minimum longitude (in degrees) for the SBAS plots. The minimum resolution is 0.01. [default -30.0]
-sbasplots:maxlon <val>	Sets the maximum longitude (in degrees) for the SBAS plots. The minimum resolution is 0.01. [default 40.0]
-sbasplots:plotarea <minlon> <maxlon> <minlat> <maxlat>	
	This parameter is a shorter way to provide the same values as in **'-sbasplots:minlon'**, **'-sbasplots:maxlon'**, **'-sbasplots:minlat'** and **'-sbasplots:maxlat'** parameters.
-sbasplots:recheight <val>	Sets the receiver height (in metres). [default 0 (over the WGS84 geoid)]
-sbasplots:hal <val>	Sets the Horizontal Alarm Limit (in metres) for computing the Availability plots. [default 40]
-sbasplots:val <val>	Sets the Vertical Alarm Limit (in metres) for computing the Availability plots. [default 50]
-sbasplots:availstep <val>	Sets the resolution (in degrees) for both longitude and latitude for Availability and Continuity Risk maps. The minimum resolution is 0.01. [default 1.0]
-sbasplots:availtimestep <val>	Sets the time step (in seconds) for availability plot. [default 1]
-sbasplots:ionostep <val>	Sets the resolution (in degrees) for both longitude and latitude for Ionosphere Corrections Availability map. The minimum resolution is 0.01. [default 0.3]
-sbasplots:ionotimestep <val>	Sets the time step (in seconds) for ionosphere availability plot. [default 300]
-sbasplots:windowsize <val>	Sets the sliding window size (in seconds) for computing the continuity risk. [default 15 for aviation, 900 for maritime]
-sbasplots:windowsizemar <val>	
	Sets the sliding window size (in seconds) for computing the continuity risk with maritime rules. [default 15 for aviation, 900 for maritime]
-output:sbasavailplots <file>	Sets the output file for the SBAS Availability plots data. The output file is a columnar text file to be processed by graph program (with **'--sbas'** parameter). [default "SBASAvailPlots_sbasfilename.txt"]
-output:sbasriskplots <file>	Sets the output file for the SBAS Continuity Risk plot data. The output file is a columnar text file to be processed by graph program (with **'--sbas'** parameter). [default "SBASRiskPlots_sbasfilename.txt"]
-output:sbasriskmarplots <file>	Sets the output file for the SBAS Continuity Risk (maritime mode) plot data. The output file is a columnar text file to be

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	processed by graph program (with **'--sbas'** parameter). [default "SBASRiskMarPlots_sbasfilename.txt"]
-output:sbasionoplots <file>	Sets the output file for the SBAS Ionosphere availability plot data. The output file is a columnar text file to be processed by graph program (with **'--sbas'** parameter). [default "SBASIonoPlots_sbasfilename.txt"]
-output:sbasriskdisc <file>	Sets the output file for the list of SBAS solution discontinuities found during the computation of SBAS Continuity Risk plot. The output file is a columnar text file. [default "SBASRiskDisc_sbasfilename.txt"]
-output:sbashdopplots <file>	Sets the output file for the SBAS HDOP plot data. The output file is a columnar text file to be processed by graph program (with **'--sbas'** parameter) [default "SBASHDOPPlots_sbasfilename.txt"]
-output:sbaspdopplots <file>	Sets the output file for the SBAS PDOP plot data. The output file is a columnar text file to be processed by graph program (**with '--sbas'** parameter). [default "SBASPDOPPlots_sbasfilename.txt"]
-output:sbasgdopplots <file>	Sets the output file for the SBAS GDOP plot data. The output file is a columnar text file to be processed by graph program (with **'--sbas'** parameter) [default "SBASGDOPPlots_sbasfilename.txt"]
-output:sbascombdopplots <file>	
	Sets the output file for the combined SBAS HDOP, PDOP and GDOP plot data. The output file is a columnar text file to be processed by graph program (with **'--sbas'** parameter). [default "SBASCombDOPPlots_sbasfilename.txt"]
-sbasplots:hourlymaps	Print the hourly availability maps. The files will have the same name as the daily maps, but with '_HHh' added before the file extension (being HH the hour with two digits).
-sbasplots:noavailplot	Do not compute the SBAS Availability and Continuity Risk plots. [default off]
-sbasplots:noriskplot	Do not compute the SBAS Continuity Risk plot. [default off]
-sbasplots:noriskmarplot	Do not compute the SBAS Continuity Risk for maritime plot. [default off]
-sbasplots:noionoplot	Do not compute the SBAS Ionosphere corrections availability plot. [default off]
-sbasplots:noionomodel	Do not use SBAS ionosphere during the computation of Availability and Continuity Risk plot. [default off] This parameter is equivalent to **'-model:iono no'**.
-sbasplots:hdopplot	Compute SBAS HDOP plots. This option is automatically set if **'-output:sbashdopplots'** is set. [default off] In order to do HDOP plots, SBAS Availability plots must be enabled.
-sbasplots:pdopplot	Compute SBAS PDOP plots. This option is automatically set if **'-output:sbaspdopplots'** is set. [default off] In order to do PDOP plots, SBAS Availability plots must be enabled.
-sbasplots:gdopplot	Compute SBAS GDOP plots. This option is automatically set if **'-output:sbasgdopplots'** is set. [default off] In order to do GDOP plots, SBAS Availability plots must be enabled.

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-sbasplots:combdopplot	Compute combined SBAS DOP file with HDOP, PDOP and GDOP plots. This option is automatically set if **'-output:sbascombdopplots'** is set. [default off]
-sbasplots:doppercentile	Enable computation of DOP percentile for DOP maps. Warning: Each DOP map requires around 1GB of memory (with the default map size). [default off]
-sbasplots:percentile <val>	Sets the value for computing the percentile in DOP maps. [default 95] In order to do combined HDOP, PDOP and GDOP plots, SBAS Availability plots must be enabled.
-sbasplots:exclusionarea <minlon> <maxlon> <minlat> <maxlat> [<minlon> <maxlon> <minlat> <maxlat> ...]	
	Set a square area where SBAS availability and SBAS iono availability will be set to 0 (the area is skipped during computation). This is useful when processing large areas (e.g. areas with multiple SBAS and want to exclude the sea between them). The user can set any number of exclusion area by providing this parameter as many times as necessary. The area must be given with these four values (in this order): minimum longitude, maximum longitude, minimum latitude, maximum latitude. The four values must be in degrees, with the longitude between -180 and 180 degrees, and the latitude between -90 and 90 degrees.
-sbasplots:inclusionarea <minlon> <maxlon> <minlat> <maxlat> [<minlon> <maxlon> <minlat> <maxlat> ...]	
	Set a square area where SBAS availability and SBAS iono availability will be computed (the rest is skipped). This area must be inside the region defined by parameters **'-sbasplots:minlon'**, **'-sbasplots:maxlon'**, **'-sbasplots:minlat'** and **'-sbasplots:maxlat'**. The user can set any number of inclusion area by providing this parameter as many times as necessary. The area must be given with these four values (in this order): minimum longitude, maximum longitude, minimum latitude, maximum latitude. The four values must be in degrees, with the longitude between -180 and 180 degrees, and the latitude between -90 and 90 degrees.
-sbasplots:mingeoelev <val>	Set the elevation mask (in degrees) for the GEO providing the corrections. [default 5] The elevation angle for GEO ensures that GEO corrections are only used where the GEO is visible (GEO footprint). Use **'--sbasplots:mingeoelev'** to disable it.
-sbasplots:usegeosat	Use GEO SBAS satellites for ranging when computing Availability maps. [default off]

Note:

- If both inclusion and exclusion areas are provided, then an area which is processed must be inside of any inclusion area and outside of any exclusion area.
- The default region defined in gLAB corresponds to EGNOS coverage area.
- The available output messages in this mode are INFO [default on], SBASIONO [default off] and SBASUNSEL. [default off]
- Most of the options applied for normal SBAS processing can also be applied for this mode, except for those which apply to measurement corrections (due to there are none in this mode)

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	and the option to use Klobuchar while solution converges (**'-model:initcoordNPA'**) as we consider we are always in strict PA mode.

5.8 DATE CONVERSION OPTIONS

This mode is for converting a date format (in GPS time) to all other GNSS date formats and exits the program.

The accepted date formats are: YYYY/MM/DD HH:MM:SS.zzz ('zzz' are milliseconds), Year/DoY/SoD, GPSWeek/SoW, MJDN/SoD (MJDN is Modified Julian Day Number).

Minimum accepted date is 1980/01/06 (YYYY/MM/DD) or 1980/006 (Year/DoY) or 0/0 (GPSWeek/SoW) or 44244/0 (MJDN/SoD).

This mode is activated when any of the following parameter is provided:

-dateconv:calendar <year> <month_number> <day> <hour> <minute> <seconds>	
	<year> has to be equal or greater than 1980, **<hour>** is in 24 hour format and **<seconds>** can have decimal values.
-dateconv:doy <year> <DoY> <SoD>	
	<year> has to be equal or greater than 1980, **<DoY>** is in range 1 to 366.
-dateconv:gpsweek <GPSWeek> <SoW>	
-dateconv:mjdn <MJDN> <SoD>	
	<MJDN> must be equal or greater than 44244.

5.9 COORDINATE CONVERSION OPTIONS

This mode is for converting a coordinate system to all supported coordinate systems (cartesian, geodetic -or ellipsoidal- and spherical) and exit.

This mode is activated when any of the following parameters is provided:

-coordconv:cartesian <x> <y> <z>	
	X, Y and Z coordinates unit is metres.
-coordconv:geodetic <lon> <lat> <height>	
	Longitude is in degrees (range [-180..180]), latitude is in degrees (range [-90..90]) and height is in metres.
-coordconv:spherical <lon> <lat> <radius>	
	Longitude is in degrees (range [-180..180]), latitude is in degrees (range [-90..90]) and radius is in metres.

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5.10 PROCESSING FLOW DIAGRAM

The main steps in the gLAB processing are depicted in Figure 5-1.

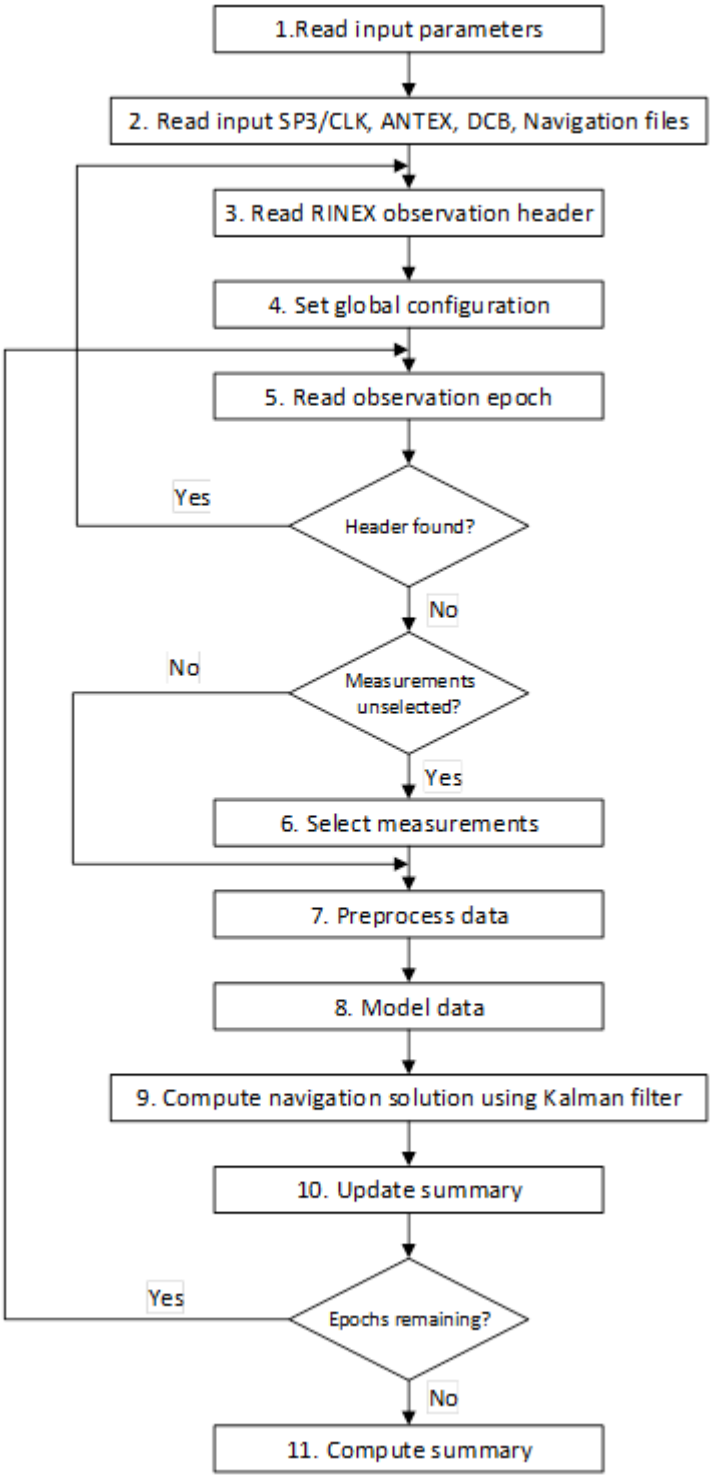

Figure 5-1. gLAB data processing flow diagram. See explanatory notes for each module.

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NOTES FOR EACH PROCESSING STEP

1. Measurement priority list (shared by filter and cycle-slip detectors) is updated or replaced according to user input. Any repeated cycle-slip or filter measurement provided by the user is silently removed.
2. Basic navigation data validation check is done when reading (e.g. fields not being zero, GPS IODC and IODE matching, etc).
    - If navigation file is concatenated, gLAB reads until a header is found. The following set of data will be read when the day of the observation file changes. Up to two navigation days of data (two data sets read) are held in memory.
    - If SP3 or CLK files are concatenated, up to three days will be read at once (so it has data in memory for the previous, current and next days) in order to avoid orbit interpolation errors at the beginning and at the end of the day.
    - If more data is available, a new day will be read each time the day of the observation file changes.
3. All single and double frequency DCBs whose navigation message type is not available will be automatically disabled.
4. Update measurement priority list with the available measurement in the RINEX observation header file.
    - If an ANTEX was provided, gLAB will look for the satellite block type for each PRN and unselect all measurements not available in that block type (e.g. GPS BLOCK IIRM do not have L5 frequency).
    - If user did not select measurements in the filter or cycle-slips, thee default measurements (depending on processing mode) will be set. This check is only done the first time this function is called.
    - If user selected measurements for the filter or cycle-slips, unselect all measurements which are not in priority list, or it is not a defined frequency or it is not available in the RINEX observation header.
    - By default, gLAB will add to each enabled cycle-slip detectors all frequencies with carrier phase measurements set in the filter. This check is only done the first time this function is called.
    - All DCBs used in single and double frequency processing whose navigation message type is not available will be automatically disabled.
    - Starting from the second iteration of this function (following a second header in the RINEX observation), unselect all measurements previously selected which are not available anymore and reselect previous unselected measurements if they become available.
5. Unknown constellations will be converted to GPS (to allow experimental tests). PRN values check is done to avoid invalid PRN values (e.g. errors in file) make gLAB crash or behave incorrectly.
    - If an event epoch occurs including a line with 'APPROX POSITION XYZ', the a priori position (if used) will be updated.
6. Selection is done per every satellite, per frequency and per measurement type (code, phase) in both cycle-slip detectors and the filter.
    - By default, gLAB will add all filter carrier phase measurements to each enabled cycle-slip detector.
    - Internal lists with measurement info ordered according to any function needs (i.e. SNR list, modelling list, etc.) for greatly reducing processing time (as these

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lists are built once), but in turn, it has high memory consumption due to these lists are in a per satellite basis.

- If DGNSS mode with RINEX file is used, the process is repeated for the RINEX reference observation file. The criteria for measurement selection is:
    - If no measurement is available, unselect measurement.
    - If only one measurement is available, select it regardless there is data in the observation file or not.
    - If multiple measurements are available, loop through the measurement priority list until a measurement with data in the observation file is found. If no measurement has data, selection is postponed to the next epoch. When selecting measurements for the cycle-slips, measurements selected in the filter will be prioritized.

7. Prealign carrier phase measurements (if enabled).
    - If any of the measurements used in cycle-slip detectors and the filter are not available in the current epoch, unselect satellite.
    - If any of the measurements used in cycle-slip detectors and the filter do not meet SNR requirements, unselect satellite.
    - If any cycle-slip detector detects a cycle-slip, a cycle-slip will be declared in all frequencies of the satellite. Compute code smoothing measurements.
8. Compute all modelling terms (geometric distance, ionosphere, troposphere, DCBs, etc)
    - In SBAS mode, if after modelling there are not enough available satellites and GEO or mode switching is enabled, change mode or GEO and repeat modelling.
    - In DGNSS, if after modelling there are not enough available satellites, it will switch to SPP mode and repeat modelling.
9. If the constellation used as reference clock is not available, the next constellation available in the reference clock priority list will be used.

NOTES FOR PEGASUS OUTPUT FORMAT

Pegasus is a GNSS data processing tool from Eurocontrol. Pegasus does not read the RINEX-B or EMS SBAS files, it converts them to columnar text files and later processes with these text files. Each text file contains one message type -except for fast correction messages, which are all grouped in the same file; and the GEO navigation data, which is RINEX 2 format.

Each columnar text file has a header line with the name of each value, and the values are printed in decimal format.

A full explanation of the Pegasus format can be found in appendixes I.5-I.16 in their ICD at AD-11.

NOTES FOR PREPROCESSING

Pseudorange Jumps:

Some receivers, after updating the clock, they adjust the code but not the carrier phase measurement, producing a jump in the code but not in the carrier phase. Therefore, code and carrier phase are not consistent (the difference between code and carrier phase is not continuous). If the carrier phase is not adjusted, it will be detected as a cycle-slip.

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NOTES FOR SBAS PROCESSING

When processing with SBAS corrections, gLAB will use MOPS-D standard values and configuration by default.

Most of these parameters and configuration can be modified by the user, regardless if these parameters are MOPS compliant or not.

The specific SBAS parameters that can be modified by the user are:

- Smoothing: Can be disabled or changed the number of epochs [default 100 epochs].
- Steady-state: Can be disabled or changed the number of epochs [default 360 epochs].
- Ionosphere: Any ionosphere model available in gLAB (e.g. IONEX) can be applied instead of the SBAS ionosphere model.
- Time outs: Time outs for all corrections can be user defined.
- Mode switch: Switching from PA to NPA can be enabled or disabled [default disabled].
- GEO switch: GEO switching can be enabled or disabled [default disabled]. Furthermore, after a GEO switch, the user can decide if to stay in the new GEO or try to fall-back to the initial GEO when possible.
- Decimation: gLAB can process at any data rate. In order to keep integrity of results with 1Hz SBAS data rate, messages will be read every second, and special events will be handled every second.
- The special events are: receive an alarm message or an UDREI>=14, miss 4 consecutive messages or receive 4 consecutive messages with wrong CRC. Decimation is useful for studying slow varying corrections, such as long term corrections or ionosphere.

Navigation: Both kinematic and static navigation mode can be selected. Default is kinematic.

Mode and GEO switch notes:

- If both mode and GEO switch are enabled, GEO switch is tried first always, as switching GEO keeps PA mode.
- If option **'-model:geofallback'** is enabled, gLAB will try to switch to the first GEO used in processing afte the time between switches (defined by parameter **'-model:switchtime'**) after a GEO switch occurs.
- If option **'-model:maintaingeo'** is enabled gLAB will maintain the current GEO (independently if it was selected by the user or by a GEO switch) during all the processing while it can provide a PA solution.
- If both options **'-model:maintaingeo'** and **'-model:geofallback'** are enabled, **'-model:geofallback'** option behaviour will prevail.
- If both options **'-model:maintaingeo'** and **'-model:geofallback'** are disabled, after a GEO switch, gLAB will try to switch to the previous GEO independently if it was the first one used or not. If there are only two GEOs available (and the use of mixed GEO data is disabled), this behaviour is equivalent as in the **'-model:geofallback'** option, due to the previous GEO will be always the first GEO used.

Selection of best GEO:

When option **'-model:selectbestgeo'** is enabled, gLAB will compute in each epoch the full SBAS model and the protection levels with all the GEOs available, and then select the best GEO according to the following criteria:

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1 - Select the GEOs which have PA solution with protection levels under the alarm limits, and from these ones, select the GEO whose sum of the horizontal and vertical protection levels is smaller.

2 - If no GEOs had PA solution with protection levels under the alarm limits, select the GEOs with PA solution and then select the GEO whose sum of the horizontal and vertical protection levels is smaller.

3 - If no GEOs had PA solution, select the GEOs with NPA solution and then select the GEO whose sum of the horizontal and vertical protection levels is smaller.

This option will noticeably increase computation load, especially if there are many GEOs in the SBAS data file.

If INFO messages are enabled (option **'-print:info'**), an INFO message with the epoch, GEO PRN and its protection levels will be printed for each iteration that provided a solution. The unselected iteration will have a '(Not selected)' text to indicate that it was not selected. The selected iteration will be printed last, with the text '(Selected)'.

If option **'-print:sbasunused'** is enabled, the 'MODEL', 'SBASCORR', 'SBASVAR', 'SBASUNSEL' and 'SATSEL' messages for each discarded iteration will be printed. All messages from discarded iterations will have an '*' next to message name to indicate it was discarded. The iterations without solution will be printed first, and the last ones printed will be the iterations discarded but had solution.

If selection of best GEO is set, the options **'-model:geoswitch'** will be automatically set. Moreover, option **'-model:switchtime'** must be set to 0 (if not set, it will be automatically set to 0), as in an epoch multiple GEO changes will be done, and also option '' must be disabled.

SBAS Maritime mode:

Maritime mode is a special configuration for SBAS. In this configuration, message type 10 (degradation parameters), type 27 (service message) and type 28 (clock ephemeris covariance matrix) are not used. Therefore, the sigma of fast and long term corrections is computed with the following formula:

Sigmaflt = SigmaUDRE + 8 (all units are in metres)

Alarm limits in maritime mode are not used (in gLAB alarm limits cannot be disabled, so they are set to 100 km), and a filter for HDOP (Horizontal Dilution of Precision) and PDOP (Position Dilution of Precision). A valid epoch must have a HDOP<4 or a PDOP<6 (it only needs to fulfil one of these two conditions).

Furthermore, for maritime mode, another mode for computing the continuity risk is used. Instead of a sliding windows of 15 seconds, it is used a fixed window of 15 minutes (900 seconds). That is, every time a discontinuity event occurs, it will affect the previous 15 minutes, independently if there had been a discontinuity within the previous 15 minutes (where as in aviation mode, each discontinuity only affects the last seconds until the previous discontinuity -up to the window size-). This is an optimistic computation of the continuity risk, but maritime mode has more relaxed requirements, as seen above. If desired, the user can change the size of the 15 minutes window to any value.

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The disadvantages of this mode of continuity risk computation are that if several discontinuities occur in a time span smaller than the window size (which usually happens in the SBAS coverage border), then epochs with discontinuities may be counted more than one, which may do that the continuity risk ends up being greater than 1 (this effect can be mitigated by using large time spans). The other disadvantage is that if some discontinuities occur but each of them have a duration larger than the window size, the total continuity risk will be much smaller compared to the aviation continuity risk, as only the epochs of the size of the window will be counted for the discontinuity, but the other epochs in a discontinuity but greater than the window will not be counted. This effect is also maximized as the continuity risk is computed using the number of epochs processed, not the number of epochs with solution in PA mode.

The formula to compute the maritime continuity risk is:

$$\begin{aligned}\text{Maritime Continuity Risk} &= \text{CTI/MTBF}\\ &= \text{Window_Size}/(\text{Num}_{\text{EpochsProcessed}}/\text{Num}_{\text{Discontinuities}})\\ &= \text{Window_Size}*\text{Num}_{\text{Discontinuities}}/\text{Num}_{\text{EpochsProcessed}}\end{aligned}$$

Where:

CTF: Continuity Time Interval, which is the window size.

MTBF: Mean Time Between Failures, which is computed as the total epochs processed divided by the number of discontinuities.

This formula is from IALA (International Association of Marine Aids to Navigation and Lighthouse Authorities) document shown at RD-17.

Maritime mode is configured with parameter **'-model:sbasmaritime'**, which is a shortcut for providing these parameters: **'-model:nomt10'**, **'-model:nomt2728'**, **'-model:geoswitch'**, **'-filter:maxhdop 4'**, **'-filter:maxpdop 6'**, **'-filter:hdoporpdop'**, **'-summary:hal 100000'**, **'-summary:val 100000'**, **'-summary:windowsize 900'** and **'-summary:windowsizemar 900'**.

Furthermore, parameter **'-model:sbasmaritime'** will also set maritime options in SBAS plots mode.

NOTES FOR DOP MAPS:

When computing the mean and percentile in DOP maps, since version 5.4.0, only the epochs whose protection levels are below the alarm limits are used. In version 5.3.0, any epoch with solution, independently of the protection levels, was always taken into account for the mean and percentile computation. In this case, if an epoch had a very big DOP (e.g. more than 1 million), this value (a clear outlier) would totally bias the mean value to a higher value.

NOTES FOR SBAS PLOTS:

See option **'-sbasplotsinfo'** for detailed help on how to generate SBAS plots.

NOTES FOR PREFIT OUTLIER DETECTION

There are two prefit outlier detectors in gLAB:

- Prefit outlier detector comparing against the median (by default disabled):

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The procedure for this detector is:
Compute the median of all prefits
For each satellite:
Compute absolute value of the difference between the prefit and the median.
If the difference is higher than the threshold, unselect the satellite.

- Prefit outlier detector comparing the absolute values (by default disabled):
The procedure for this detector is:
For each satellite available:
Compute the absolute value of its prefit (ReferencePrefit)
Set a range for all other satellite prefits defined as:
Range=[abs(ReferencePrefit)-threshold,abs(ReferencePrefit)+threshold]
For each satellite (except the reference one):
Check if prefits are inside the range
If half or more of the satellites are unvalid, then the current satellite is an outlier
Else discard the satellites with prefits outside the range.

If receiver position is fixed, gLAB will allow the outlier detector to discard all satellites in the current epoch.

If receiver position is not fixed, if more than half of the available satellites are discarded, then, the prefit outlier detector will not discard any satellite, as it will assume that the solution still has to converge.

A recommended value for the thresholds of the prefit outlier detectors is 30 metres.

NOTES FOR DGNSS PROCESSING

Sigma inflation: During the transient period until the smoother converges, the measurement noise sigma is inflated according to the next equation:

Sigma_inflat= f(n)/f(Nstdy) * sigma

n<N f(n)=sqrt(1/n)

n≥N f(n)=sqrt(1/(2*N-1)*(1+((N-1)/N)^(2*(n-N)+1)))

where:

n: number of processed samples

N: number of samples of the smoothing window

Nstdy: number of samples when reaching the steady state: In gLAB, Nstdy=(int)(3.6*N)

For instance, with 1 second sampling rate and N=100, the stationary state (Nstdy) is assumed to be reached after 360 seconds.

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6 *gLAB* DATA ANALYSIS TOOL (DAT)

The DAT is an advanced plotting utility prepared to graph different combinations of columns taking into account several user-defined conditions. Figure 6-1 shows a screenshot of the DAT.

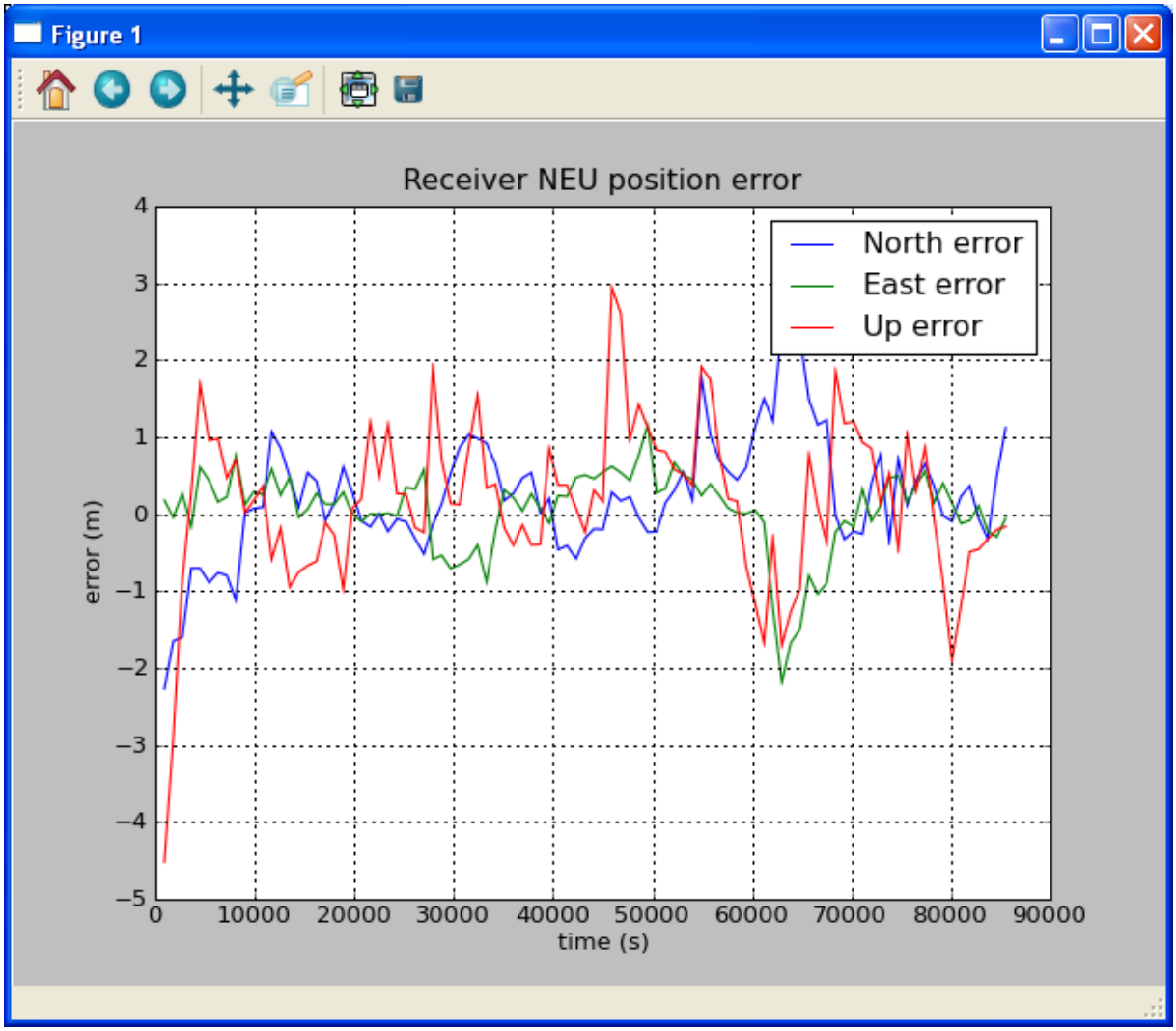

Figure 6-1: DAT screenshot. It can be seen the position error for a PPP kinematic positioning for a single-frequency receiver.

The available options are explained in what follows.

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6.1 GRAPHIC GENERAL OPTIONS

The General Options are the ones that can be specified once per graphic, and will affect the entire graphic window.

A hash ('#') means that the parameter expects a numerical value.
A comma (',') or semicolon (';') means that the parameter expects a list of values separated by comma or semicolon (the list may be of numerical values if it has hashes or strings if it has the symbols '<' and '>'. If the list has a variable number of items, the "..." are shown.
A '<text>' or any word between '<' and '>' means that the parameter expects a string (without the '<' and '>' symbols).

-h, --help	Show this help message and exit.
-t, --title, --tit <text>	Set the title of the Graphic.
--Xlabel, --xlab, --xl <text>	Set the x-axis label.
--Ylabel, --ylab, --yl <text>	Set the y-axis label.
--Xmin, --xmin, --xn #	The minimum value for the x axis to be plot, if no value is provided, automatic limits are set.
--Xmax, --xmax, --xx #	The maximum value for the x axis to be plot, if no value is provided, automatic limits are set.
--Ymin, --ymin, --yn #	The minimum value for the y axis to be plot, if no value is provided, automatic limits are set.
--Ymax, --ymax, --yx #	The maximum value for the y axis to be plot, if no value is provided, automatic limits are set.
--Xticks, --xticks, --xt #,#,#	Set the ticks for x axis. The values must be given in this format: Xmin, Xmax, NumberOfTicks (this parameter is incompatible with –XticksStep and --XTicksList). See note below.
--Yticks, --yticks, --yt #,#,#	Set the ticks for y axis. The values must be given in this format: Ymin, Ymax, NumberOfTicks (this parameter is incompatible with –YticksStep and --YTicksList). See note below
--XticksStep, --xticksstep, --xts #	
	Set the ticks step for x axis (this parameter is incompatible with --Xticks and --XTicksList).
--YticksStep, --yticksstep, --yts #	
	Set the ticks step for y axis (this parameter is incompatible with --Yticks and --YTicksList).
--XTicksList, --xtickslist, --xtl #,#,...	
	Set the list of ticks for x axis. The list does not to be ordered and must be comma (',') separated. (this parameter is incompatible --Xticks and --XticksStep).
--YTicksList, --ytickslist, --ytl #,#,...	
	Set the list of ticks for y axis. The list does not to be ordered and must be comma (',') separated. (this parameter is incompatible --Yticks and --YticksStep).
--Ftitle, --ftitle, --ft <text>	Add a fractional title to the upper left corner.

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--wm, --watermark <text>	Add a watermark with the given text.
--wmc, --watermarkcolor <colour>	
	Sets the watermark colour [DEFAULT 'black']. See option **'--color'** for the full list of colours.
--wms, --watermarksize #	Set the size of the watermark text. [DEFAULT 8]
--wmp, --watermarkposition #,#	Set the X and Y position of the watermark. The position must be given relative to the lower left corner of the plot, and with the X and Y values given a comma (',') separated string. For example, to set the default position of the watermark in SBAS plots (lower right corner), the parameter values should be provided as ".87,.03".
--textmark <text>	Add a text mark with the given text. For adding multiple text marks, set this option as many times as necessary.
--textmarkc, --textmarkcolor <colour>	
	Sets the text mark colour [DEFAULT 'black']. Set this option for each text mark set with option **'--textmark'**. See option **'--color'** for the full list of colours.
--textmarks, --textmarksize #	Set the size of the text mark [DEFAULT 10]. Set this option for each annotation text set with option **'--textmark'**.
--textmarkp, --textmarkposition #,#	
	Set the X and Y position of the text mark. Set this option for each annotation text set with option **'--textmark'**. The position must be given relative to the lower left corner of the plot, and with the X and Y values given a comma (',') separated string. For example, to set the default position of the text mark in the center of the image, the parameter values should be provided as ".5,.5".
--atm, --adjusttomargin	Expand the figure to fit the image margin (works for python versions greater or equal to 2.7).
--no-lock-file	Do not create the "plot.lock" file. This file is necessary to synchronize graph.py with the GUI, but not in command line. This option is recommended when multiple instances of this tool are executed in parallel.
--colormap, --ColorMap <colourmapname>	
	Set the colour map used. [DEFAULT: 'jet'] See full list of colormaps at RD-18.

Note:

- In **'--Xticks'** or **'--Yticks'** options, the maximum and minimum can be different from the plot range (it is an independent range). The number of ticks (NumberOfTicks) shall be computed with the following formula:

  NumberOfTicks = 1 + ToInteger((MaxTick-MinTick)/TickResolution)

Example:

graph.py -t "Graphic title" --xl "time (s)" --yl "Altitude [m]" --xmin -3.0 --ymax 5.0 --xticks 0,24,7

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PLOT DEPENDENT OPTIONS (default options):

The Plot Dependent Options are specific to each plot.
One new plot is considered from the point that a **'-f'** or '**--file'** is found.
All the options coming after this parameter belong to that specific plot.

-f, --file <filename>	Set the input file name for the specific plot.
-x, -X, --Xcol <val>	Set the source of the x axis: **-x 4 or -x '$4'**: will take as x axis the 4th column of the input file. Operations can be done in this parameter, such as: **-x '($4-$5)'**: This will take the difference between the 4th and the 5th column. Mathematical functions and constants are supported: **-x '(math.sin($12*math.pi/180)'**.
-y, -Y, --Ycol <val>	Set the source of the y axis Identical properties as x column.
-c, --cond <condition>	Specify the plotting condition: **-c '($6>=10)**' Include the 6th column if it is equal or greater than 10 **-c '($1==\"OUTPUT\")'** Include the 1st column by a specific string: surrounding the string by \" Mathematical functions, booleans and constants are supported: **-c '($1==\"POSTFIT\")&(math.e($12+$5)>5.0)'** **Note:** Windows users have to exchange the **'** for **\"** and the **\"** for **'** when specifying a condition. For example, the following condition: **-c '($1==\"POSTFIT\")&(math.e($12+$5)>5.0)'** is valid in Linux, but in Windows it shall be written like this: **-c \"($1=='POSTFIT')&(math.e($12+$5)>5.0)\"**
-l, --label, --plotlabel <text>	Enables the label for the current plot.
--npl, --numpointslabel #	Set the number of points to be shown in the label. If no value is provided, it is set to 2, except for stations map, which the default is one.
--lp, --labelpos, --labelPos <val>	Set the position of the label in the plot. The following values are supported: **'tl'** top left **'tc'** top center **'tr'** top right [DEFAULT] **'bl'** bottom left **'bc'** bottom center **'br'** bottom right **'cl'** center left **'c'** center **'cr'** center right

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	'coordX,coordY' user defined position coordX values must be between [-0.05,1.3] coordY values must be between [-0.05,1.15].
-s, --style <style>	Sets the style for the current plot. The following styles are supported: **'.'** circle marker [DEFAULT] **'-'** solid line style **'--'** dashed line style **'-.'** dash-dot line style **'.-'** dots joined with lines **':'** dotted line style **','** pixel marker **'o'** point marker **'s'** square marker **'p'** pentagon marker **'+'** plus marker **'x'** x marker **'^'** triangle up marker **'>'** triangle right marker **'<'** triangle left marker **'v'** triangle down marker **'*'** star marker **'h'** hexagon1 marker (top part with edge) **'H'** hexagon2 marker (top part straight) **'D'** diamond marker **'d'** thin diamond marker **'|'** vertical line marker **'_'** horizontal line marker **'1'** tri_down marker **'2'** tri_up marker **'3'** tri_left marker **'4'** tri_right marker
--color, --cl <color>	Sets the colour for the current plot. Here is a provided a short list of the colours supported: **'b'** blue [DEFAULT] **'g'** green **'r'** red **'c'** cyan **'m'** magenta **'y'** yellow **'k'** black **'w'** white OR Any colour in HTML format. For a full list of colours at RD-18
--markersize, --ms #	Sets the plot maker size. [DEFAULT 5]
--linewidth, --lw #	Sets the plot line width. [DEFAULT 1]
-g, --grid <val>	Set the plot grid [DEFAULT on]. It could be turn off by 'off' or 'no.'
Example:	

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graph.py -f /home/gLAB/Example -x '(math.sin($1*math.pi/180))' -y 2 -l "Plot Label" --style p --color cyan

MULTIPLE PLOTS:

Each graphic window can contain several plots. One new plot is considered from the point that a **'-f'** or **'--file'** is found:

Graphic General Options: will apply to all the plots present.

Plot Dependent options: parameters specific to each plot.

Example:
graph.py -f /home/gLAB/Example -x '1' -y '2' -f /home/gLAB/Example -x '2' -y '1'

SAVE CURRENT GRAPHIC:

User can save the entire graphic window into the path specified. If no path is specified, it will be allocated in the current working directory.

The graphic output format is deduced from the extension of the file name, if no extension is provided a 'png' extension type will be used:

--save, --sv <filename>	Stores the graphic window given a file name. The graphic output format is deduced from the extension of the file name. Supported formats are: emf, eps, jpeg, jpg, pdf, png [DEFAULT], ps, raw, rgba, svg, svgz.
Example: **graph.py -f /home/gLAB/Example -x 1 -y 2 --save Figure_Example** **graph.py -f /home/gLAB/Example -x 1 -y 2 --sv /home/Desktop/Figure_Example.eps**	

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6.2 STANFORD PLOT OPTIONS

In this mode:

For GRAPHIC GENERAL OPTIONS, all the options work the same way as in the default plots, except the options **"--Ftitle"** (add a fractional title), **"--xt"** and **"--yt"** (for setting ticks) which are disabled.

For PLOT DEPENDENT OPTIONS, the options **"-f"**, **"-x"**, **"-y"**, **"-c"**, **"-g"** work the same way as in the default plots, while the other options in this part are disabled in this mode. **"-x"** and **"-y"** options can also be written as **"--error"** and **"--pl"** respectively.

MULTIPLE PLOTS are disabled in this mode.

For SAVE CURRENT GRAPHIC, it works the same way as for the other kind of plots.

--stanford, --sf, --sp	Make a stanford plot.
--AL, --al #	Set the alarm limit for the protection level. [DEFAULT 40]
--clean	Make a stanford Plot without failure patches.
--xr, --xresolution #	Set the resolution in x-direction of the plot. [DEFAULT 0.5]
--yr, --yresolution #	Set the resolution in y-direction of the plot. [DEFAULT 0.5]
--percentilex, --percentileX	Show ticks where the percentiles 68, 95 and 99.9 of the points are reached in the horizontal axis.
--percentiley, --percentileY	Show ticks where the percentiles 68, 95 and 99.9 of the points are reached in the vertical axis.
--percentilexlist, --percentileXList #,#,...	
	Show ticks where the user provided percentiles of the points are reached in the horizontal axis. **Note:** The list of points must be a comma separated list. If this parameter is provided along with parameter **'--percentilex'**, the latter will be ignored.
--percentileylist, --percentileYList #,#,...	
	Show ticks where the user provided percentiles of the points are reached in the vertical axis. **Note:** The list of points must be a comma separated list. If this parameter is provided along with parameter **'--percentiley'**, the latter will be ignored.
--noepochsintitle, --NoEpochsInTitle	
	Do not add the number of epochs in the title. Alternatively, the user can set the number of epochs by adding in the title (with option **'-t'**) the following texts (without quotes) which will be substituted with the values shown: **{0:d}** -> Print the total number of epochs. **{1:d}** -> Print the total number of epochs that are not MI. **{2:d}** -> Print the total number of epochs that are MIs. **{3:d}** -> Print the total number of epochs that are below the alarm limit and are not MIs.

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	{4:d} -> Print the total number of epochs that are over the alarm limit and are not MIs. **{5:d}** -> Print the total number of epochs that are MI and are below the alarm limit in both axis. **{6:d}** -> Print the total number of epochs that are HMI. **{7:d}** -> Print the total number of epochs that are MI and are over the alarm limit.
--availepochpos, --AvailEpochPos #,#	
	Set the position (in X,Y components) in the plot of the text for the available epochs or 'normal operation'.
--unavailepochpos, --UnAvailEpochPos #,#	
	Set the position (in X,Y components) in the plot of the text for the unavailable epochs (over the alarm limit) and not MI.
--hmiepochpos, --HMIEpochPos #,#	
	Set the position (in X,Y components) in the plot of the text for the HMI epochs.
--miavailpochpos, --MIAvailEpochPos #,#	
	Set the position (in X,Y components) in the plot of the text for the MI epochs under alarm limit and not HMI
--miunavailpochpos, --MIUnAvailEpochPos #,#	
	Set the position (in X,Y components) in the plot of the text for the MI epochs over alarm limit.
--percentilex, --percentileX	Show ticks where the percentiles 68, 95 and 99.9 of the points are reached in the horizontal axis.
--percentiley, --percentileY	Show ticks where the percentiles 68, 95 and 99.9 of the points are reached in the vertical axis.
--percentilexlist, --percentileXList #,#,...	
	Show ticks where the user provided percentiles of points are reached in the horizontal axis. **Note:** The list of points must be a comma separated list. If this parameter is provided along with parameter **'--percentilex'**, the latter will be ignored.
--percentileylist, --percentileYList #,#,...	
	Show ticks where the user provided percentiles of the points are reached in the vertical axis. **Note:** The list of points must be a comma separated list. If this parameter is provided along with parameter **'--percentiley'**, the latter will be ignored.
Example: **graph.py -f /home/gLAB/Example -x 1 -y 2 --sf**	

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6.3 STANFORD-ESA PLOT OPTIONS

In this mode:

The input file should have this fixed format (this is gLAB's output format):

The first three lines have the header with this format (numerical values can vary according to the plot):

```
#XSTEP  YSTEP  XMAX  YMAX
 0.100  0.100  50.0  50.0
# XPOS   YPOS  NUM_HOR  NUM_VER
```

Since the fourth row, each row should provide the values: positioning error (the horizontal axis), protection level (the vertical axis), number of horizontal vertical occurences (at the given coordinate of positioning error and protection level).

For GRAPHIC GENERAL OPTIONS, all the options work the same way as in the default plots except the option **"--Ftitle"** (add a fractional title), **"--xt"** and **"--yt"** (for setting ticks) which are disabled.

For PLOT DEPENDENT OPTIONS, the options **"-f"** works the same way as in the default plots, while the other options in this part are disabled in this mode.

MULTIPLE PLOTS are disabled in this mode.

For SAVE CURRENT GRAPHIC, since it has two plots, then two save paths should be provided. If only one path is provided, only the vertical plot will be saved.

--stanfordESA, --sfesa, --spesa	Make a stanford-ESA plot.
--sfesawithepochs, --sfESAWithEpochs	
	In the title and texts, set the word 'Epochs' instead of 'Geometries'
--nogeometriesintitle, --NoGeometriesInTitle, --noepochsintitle, --NoEpochsInTitle	
	Do not add the number of geometries (or epochs) in the title. Alternatively, the user can set the number of geometries (or epochs) by adding in the title (with option **'-t'**) the following texts (without quotes) which will be substituted with the values shown: **{0:d}** -> Print the total number of geometries or epochs. **{1:d}** -> Print the total number of geometries or epochs that are not MI. **{2:d}** -> Print the total number of geometries or epochs that are MIs. **{3:d}** -> Print the total number of geometries or epochs that are below the alarm limit and are not MIs. **{4:d}** -> Print the total number of geometries or epochs that are over the alarm limit and are not MIs. **{5:d}** -> Print the total number of geometries or epochs that are MI and are below the alarm limit in both axis. **{6:d}** -> Print the total number of geometries or epochs that are HMI. **{7:d}** -> Print the total number of geometries or epochs that are MI and are over the alarm limit.

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--sfesawithregions, --sfESAWithRegions	
	Add the regions 'MI', 'HMI' and 'System Unavailable' as in the Stanford plots. The number of geometries/epochs in each area will be printed as in the Stanford Plots.
--hal, --HAL #	Set the alarm limit for the horizontal plot. This option only has effect if option **'--sfesawithregions'** is set. [Default 40]
--val, --VAL #	Set the alarm limit for the vertical plot. This option only has effect if option **'--sfesawithregions'** is set. [Default 50]
--availepochpos, --AvailEpochPos #,#	
	Set the position (in X,Y components) in the plot of the text for the available epochs or 'normal operation'.
--unavailepochpos, --UnAvailEpochPos #,#	
	Set the position (in X,Y components) in the plot of the text for the unavailable epochs (over the alarm limit) and not MI.
--hmiepochpos, --HMIEpochPos #,#	
	Set the position (in X,Y components) in the plot of the text for the HMI epochs.
--miavailepochpos, --MIAvailEpochPos #,#	
	Set the position (in X,Y components) in the plot of the text for the MI epochs under alarm limit and not HMI.
--miunavailepochpos, --MIUnAvailEpochPos #,#	
	Set the position (in X,Y components) in the plot of the text for the MI epochs over alarm limit.
--percentilex, --percentileX	Show ticks where the percentiles 68, 95 and 99.9 of the points are reached in the horizontal axis.
--percentiley, --percentileY	Show ticks where the percentiles 68, 95 and 99.9 of the points are reached in the vertical axis.
--percentilexlist, --percentileXList #,#,...	
	Show ticks where the user provided percentiles of the points are reached in the horizontal axis. **Note:** The list of points must be a comma separated list. If this parameter is provided along with parameter **'--percentilex'**, the latter will be ignored.
--percentileylist, --percentileYList #,#,...	
	Show ticks where the user provided percentiles of the points are reached in the vertical axis. **Note:** The list of points must be a comma separated list. If this parameter is provided along with parameter **'--percentiley'**, the latter will be ignored.
Examples: **graph.py -f /home/gLAB/Example --sfesa --sv /home/Desktop/Figure_Vertical.eps --sv /home/Desktop/Figure_Horizontal.eps** **graph.py -f /home/gLAB/Example --sfesa**	

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6.4 WORLD MAP / STATION NAME MAP / WORST INTEGRITY RATIO PLOTS OPTIONS

In this mode: One, two or three plots can be generated depending on the input.

The input file should contain the following fields: station name, geodetic coordinates (in degrees) and the values to be plotted.
Parameter **"-x"**: longitude (degrees)
Parameter **"-y"**: latitude (degrees)

For GRAPHIC GENERAL OPTIONS, all the options work as in the default plots except:
the setting of **"--xmax"**, **"--xmin"**, **"--ymax"**, **"--ymin"** only works properly with the 'Equidistant Cylindrical Projection'.
the option **"--Ftitle"**, add a fractional title, is disabled.
the options **"--xt"** and **"--yt"** (for setting ticks) which are disabled.
the option **"--AdjustToMargin"** will only take effect on station maps.

For PLOT DEPENDENT OPTIONS, the options **"-f"**, **"-x"**, **"-y"**, **"--ms"** work as in the default plots, while the other options in this part are blocked in this mode.

For SAVE CURRENT GRAPHIC:
In the case of one plot, it works the same way as for default plots
In the case of two plots, two save paths should be provided. If only one path is provided, only the vertical map will be saved.
In the case of three plots, three save paths should be provided. If only one path is provided, only the vertical map will be saved. If only two path are provided, only the vertical and horizontal maps will be saved.

--map --Map	Make a world map plot with the given values.
--wir, --WIR	Make a worst integrity ratio plot. This is a world map, but sets a fixed scale (with a minimum of 0 and a maximum of 2 independently of user input), and a fixed set of colors for the colourbar.
--rv, --ratioV, --RV <val>	Set the source of the vertical values or worst integrity ratio. Identical properties as x,y column in the default plots.
--rh, --ratioH, --RH <val>	Set the source of the horizontal values or worst integrity ratio. Identical properties as x,y column in the default plots.
--miv, --MIV <val>	Set the source of the vertical MIs. Identical properties as x,y column in the default plots.
--mih, --MIH <val>	Set the source of the horizontal MIs. Identical properties as x,y column in the default plots.
--projection, --pj <projection>	Set the projection of the map. [DEFAULT 'Equidistant Cylindrical Projection'] User can set the value of projection as 'lcc' or 'lambert' to switch to "Lambert Conformal Projection".
--cbarMin,--cbarmin,--cmin #	The minimum value for the colourbar, if no value is provided, automatic limits are set.

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--cbarMax,--cbarmax,--cmax #	The maximum value for the colourbar, if no value is provided, automatic limits are set.
--cbarInterval,--cbarN,--cn #	The value of interval for colourbar's tick. [DEFAULT 8]
--continentColor,--cc <color>	The continent's colour. [DEFAULT 'yellow']
--lakeColor, --lc <color>	The lake's colour. [DEFAULT 'white']
--boundaryColor,--bc <color>	The continent's colour, if no value is provided, 'white' is set as [DEFAULT].
--mapres, --MapResolution <val>	
	Sets the world map resolution. Valid values are 'c', 'l' [DEFAULT], 'i', 'h' or 'f' (ordered from lower to higher resolution).
--sn, --staName, --SN <val>	Set the source for the station name. Setting this value will make a new plot with the stations positions. The plot may have the name or a marker (or both) in the station coordinates.
--stanetwithnames, --staNetWithNames	
	Add the station name in the station map. This is the default behaviour if this option (**'--stanetwithnames'**) and marker option (**'--stanetwithmarkers'**) are not set. Also, this option is automatically set if options **'--stanetdefaultnamesize'**, **'--stanetdefaultnamecolor'**, **'--stanetdefaultnamealign'**, **'--stanetnamesize'**, **'--stanetnamecolor'** or **'--stanetnamealign'** are provided.
--stanetdefaultnamesize, --staNetDefaultNameSize #	
	Change the default letter size for the station names. [DEFAULT 9]
--stanetdefaultnamecolor, --staNetDefaultNameColor <color>	
	Change the default letter colour for the station names. [DEFAULT blue]
--stanetdefaultnamealign, --staNetDefaultNameAlign <val1> <val2>	
	Change the default letter alignment for the station names. There are two alignments, horizontal and vertical alignment. The two values must be provided, first the horizontal alignment and then the vertical alignment. The possible values for horizontal alignment are: **'left'** **'right'** **'center'** [DEFAULT] The possible values for vertical alignment are: **'top'** [DEFAULT] **'bottom'** **'center'** **'baseline'**
--stanetwithmarkers, --staNetWithMarkers	
	Add a marker for each station in the station map. The marker properties can be set with the following options: **'--stanetdefaultmarkertype'**, **'--stanetdefaultmarkersize'**, **'--stanetdefaultmarkercolor'** and **'--stanetmarkersize'** shown

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	below. This option is automatically set if any of the marker properties option are set. If this option is set but no marker properties are set, the default values for the markers are to be a circular shape, with blue color and size 5.
--stanetdefaultmarkertype, --staNetDefaultMarkerType <val>	
	Change the default marker type [DEFAULT 'o']. See parameter **'-s'** or **'--style'** for the list of marker types.
--stanetdefaultmarkersize, --staNetDefaultMarkerSize #	
	Change the default marker size. [DEFAULT '5']
--stanetdefaultmarkercolor, --staNetDefaultMarkerColor <val>	
	Change the default marker color [DEFAULT 'blue']. See parameter **'--color'** for the list of colours.
--stanet,--staNetwork, --staNetwork <val>	
	Set the source for the station network name. This option is for allowing to add labels in the plot with the station map, as gLAB will be able to read from this column to what network each station belongs to.
--stanetautolabel, --stanetAutoLabel	
	Add an automatic label for each station network, which will be read from the column set in parameter **'--stanet'**.
--stanetlabelnumsta, --staNetLabelNumSta	
	Add to the label of each station network the number of stations read. The number will be added at the end of the label name, adding a space (' ') and the number of station between parenthesis. This options works even if user sets a custom label for any network.
--stanetdefaultlabel, --staNetDefaultLabel <label>	
	Change the default label for the station network. [DEFAULT 'Other']
--stanetlabel, --staNetworkLabel <stanetname> <label>	
	Set the label for a station network. Two values must be provided: the name read from the input data (in the column specified with parameter **'--stanet'**) and the label to be applied. To set a label to each station network that appears on the file, set this parameter as many times as necessary.
--stanetmarkertype, --staNetworkMarkerType <stanetname> <val>	
	Set the marker type for a station network. Two values must be provided: the name read from the input data (in the column specified with parameter **'--stanet'**) and the marker type to be applied (see parameter **'-s'** for marker options). In order to set a marker type to each station network that appears on the file, set this parameter as many times as necessary.
--stanetmarkercolor, --staNetworkMarkerColor <stanetname> <val>	
	Set the marker colour for a station network. Two values must be provided: the name read from the input data (in the column specified with parameter **'--stanet'**) and the marker colour to be applied (see parameter **'--cl'** for colours).

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	In order to set a marker colour to each station network that appears on the file, set this parameter as many times as necessary.
--stanetmarkersize, --staNetworkMarkerSize <stanetname> #	
	Set the marker size for a station network. Two values must be provided: the name read from the input data (in the column specified with parameter **'--stanet'**) and the marker size to be applied. In order to set a marker size to each station network that appears on the file, set this parameter as many times as necessary.
--stanetnamecolor, --staNetNameColor <stanetname> <val>	
	Set the colour for the station name for a given network. All the station name from the same network will have the same letter colour. Two values must be provided: the name read from the input data (in the column specified with parameter **'--stanet'**) and the letter colour to be applied. In order to set a letter colour to each station network that appears on the file, set this parameter as many times as necessary.
--stanetnamesize, --staNetNameSize <stanetname> #	
	Set the letter size for the station name for a given network. All the station name from the same network will have the same letter size. Two values must be provided: the name read from the input data (in the column specified with parameter **'--stanet'**) and the letter size to be applied. In order to set a letter size to each station network that appears on the file, set this parameter as many times as necessary.
--stanetnamealign, --staNetNameAlign <stanetname> <val1> <val2>	
	Set the letter alignment for the station name for a given network. All the station name from the same network will have the same alignment. Three values must be provided: the name read from the input data (in the column specified with parameter **'--stanet'**) the horizontal and vertical alignment -in this order- (see parameter **'--stanetdefaultnamealign'**). In order to set a letter alignment to each station network that appears on the file, set this parameter as many times as necessary.

Note:

- If only one of the parameters **'--rh'** or **'--rv'** is given, only the horizontal or vertical plots will be shown.
- If both parameters **'--rh'** or **'--rv'** are given, two plots will be shown.
- If any of **'--mih'** or **'--miv'** parameters are given. a coloured ring around the coloured circles will appear on the corresponding plot.
- If only **'--sn'** parameter is given, a single plot with the station map will be shown.
- It is recommended to save station name maps in pdf format, as station names will be searchable inside the file.
- A horizontal label will only fit if no MIs are plotted, as the second colourbar for the MIs will occupy the free space.

The European and American FIRs areas can also be added to these plots. See options **'--fireu'**, **'--firconus'**, **'--firalaska'**, **'--fircanada'** and **'--firmexico'** in "SBAS AVAILABILITY" plots below.

Example:

Generate one plot:

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graph.py -f /home/gLAB/Example --wir -x 5 -y 7 --rh 139

Generate two plots:

graph.py -f /home/gLAB/Example --wir -x 5 -y 7 --rh 139 --rv 141 --mih 149 --grid off

Generate three plots:

graph.py -f /home/gLAB/Example --wir -x 5 -y 7 --rh 139 --rv 141 --sn 3 --mih 149 --miv 151

Example for saving the plots:

graph.py -f /home/gLAB/Example --wir -x 5 -y 7 --rv 141 --miv 151 --rh 139 --mih 149 --xmin -30 --xmax 40 --ymin 25 --ymax 75 --sv /home/Desktop/Figure_V.eps --sv /home/Desktop/Figure_H.eps --sv /home/Desktop/Figure_Station_Map.pdf

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6.5 SBAS AVAILABILITY, CONTINUITY AND DOP PLOTS OPTIONS

In this mode:
The input file should have this fixed format (this is gLAB's output format):
The first three lines have the header with this format (numerical values can vary according to the plot):

For SBAS Availability map:

```
#MINLAT MAXLAT  MINLON  MAXLON RESOLUTION REC-HEIGHT    HAL    VAL DoY YEAR
NUMEPOCHS GEO-PRN ELEV-MASK
  25.00  70.00  -30.00   40.00       1.00       0.00  40.00  50.00 315 2016
86400     120      5.00
#  LAT     LON AVAIL% NUMAVAIL NUMEPOCHS
```

NOTE: Previous versions of gLAB (5.2.0 and below) only had 4 fields in the third header line of the availability map (e.g. '# LAT LON AVAIL%'). This old file format is also accepted.

For SBAS Continuity Risk map:

```
#MINLAT MAXLAT  MINLON  MAXLON RESOLUTION REC-HEIGHT    HAL    VAL DoY YEAR
NUMEPOCHS GEO-PRN ELEV-MASK WINDOW_SIZE
  25.00  70.00  -30.00   40.00       1.00       0.00  40.00  50.00 315 2016
86400     120      5.00          15
#  LAT     LON      CONT-RISK    NUMRISK NUMEPOCHS
```

NOTE: Previous versions of gLAB (5.2.0 and below) only had 4 fields in the third header line of the continuity risk map (e.g. '# LAT LON CONT-RISK'). This old file format is also accepted.

For SBAS Maritime Continuity Risk map:

```
#MINLAT MAXLAT  MINLON  MAXLON RESOLUTION REC-HEIGHT    HAL    VAL DoY YEAR
NUMEPOCHS GEO-PRN ELEV-MASK WINDOW_SIZE
  25.00  70.00  -30.00   40.00       1.00       0.00 100000 100000 315 2016
86400     120      5.00         900
#  LAT     LON      CONT-RISK NUMDISCONT NUMEPOCHS
```

For SBAS Ionosphere Availability map:

```
#MINLAT MAXLAT  MINLON  MAXLON RESOLUTION DoY YEAR NUMEPOCHS GEO-PRN
  65.00  73.00   30.00   40.00       0.10 255 2016       288     120
#  LAT     LON AVAIL% NUMAVAIL NUMEPOCHS
```

NOTE: Previous versions of gLAB (5.2.0 and below) only had 4 fields in the third header line of the ionosphere availability map (e.g. '# LAT LON AVAIL%'). This old file format is also accepted.

For SBAS HDOP map:

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```
#MINLAT MAXLAT  MINLON  MAXLON RESOLUTION REC-HEIGHT    HAL    VAL DoY YEAR
NUMEPOCHS GEO-PRN ELEV-MASK
  25.00  70.00  -30.00   40.00       1.00       0.00  40.00  50.00 026 2018
86400       0      5.00
#  LAT     LON    MEANHDOP       TOTALHDOP NUMEPOCHS    PERCENT95
```

For SBAS PDOP map:

```
#MINLAT MAXLAT  MINLON  MAXLON RESOLUTION REC-HEIGHT    HAL    VAL DoY YEAR
NUMEPOCHS GEO-PRN ELEV-MASK
  25.00  70.00  -30.00   40.00       1.00       0.00  40.00  50.00 026 2018
86400       0      5.00
#  LAT     LON    MEANPDOP       TOTALPDOP NUMEPOCHS    PERCENT95
```

For SBAS GDOP map:

```
#MINLAT MAXLAT  MINLON  MAXLON RESOLUTION REC-HEIGHT    HAL    VAL DoY YEAR
NUMEPOCHS GEO-PRN ELEV-MASK
  25.00  70.00  -30.00   40.00       1.00       0.00  40.00  50.00 026 2018
86400       0      5.00
#  LAT     LON    MEANGDOP       TOTALGDOP NUMEPOCHS    PERCENT95
```

For SBAS combined DOP map (file with HDOP, PDOP and GDOP):

```
#MINLAT MAXLAT  MINLON  MAXLON RESOLUTION REC-HEIGHT    HAL    VAL DoY YEAR
NUMEPOCHS GEO-PRN ELEV-MASK
  25.00  70.00  -30.00   40.00       1.00       0.00  40.00  50.00 026 2018
86400       0      5.00
#  LAT     LON    MEANHDOP       TOTALHDOP    PERCENT95    MEANPDOP
TOTALPDOP    PERCENT95    MEANGDOP       TOTALGDOP    PERCENT95 NUMEPOCHS
```

Graph program will automatically detect which type of input file is given using the header, and will read the map size from the header.

Since the fourth row, each row should provide the following values: latitude, longitude, value.

For DOP files, the default option is to do only the mean DOP map. To do an additional map with the percentile values, set option **'--doppercentileplot'**.

The combined DOP file will make a plot for HDOP, PDOP and GDOP in a single run.

For GRAPHIC GENERAL OPTIONS, only the option to set the title "--title" is enabled. If non set, a title will be set automatically. The plot region will be automatically set from the header values.

For PLOT DEPENDENT OPTIONS, the options "-f" works the same way as in the default plots, while the other options in this part are disabled in this mode.

MULTIPLE PLOTS are disabled in this mode.

For SAVE CURRENT GRAPHIC, it works the same way as for the default plots.

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--sbas, --SBAS	Make a SBAS map.
--bineqcond, --BinEqCond, --binequalcondition, --BinEqualCondition	
	When assigning values to the bins, the condition thresholds will be 'equal or greater than' (for availability and ionosphere plots) and 'equal or less than' (for continuity and DOP plots) instead of 'greater than' or 'less than'.
--disablebineqcond, --DisableBinEqCond, --disablebinequalcondition, --DisableBinEqualCondition	
	Option **'--bineqcond'** is by default disabled, but the options **'--sbasserviceformat'**, **'--sbasservicemaritimeformat'**, **'--sbasservicebinaryformat'** or **'--sbasservicemaritimebinaryformat'** will enable **'--bineqcond'** option. With this option you can force the program to keep it disabled.
--disablenotavailbin, --DisableNotAvailBin	
	Disable the bin at the bottom of the colourbar with the text "NA" (Not Available) The values in this bin were set according to this criteria: - In availability and ionosphere availability maps, all values larger than 100 or with the number of epochs equal to 0. - In continuity and continuity risk maps, all values larger than 1 or with the number of epochs equal to 0. - In DOP maps, all values with the number of epochs equal to 0.
--notavailbincolor, --NotAvailBinColor <color>	
	Set the colour for the "NA" (Not Available) bin. The colour must be using the rgb code with a hash ('#') at the beginning or with one values shown in the **'--color'** option.
--notavailbintext, --NotAvailBinText <text>	
	Set the text for the "NA" (Not Available) bin to be shown in the colourbar.
--contriskaspercentage, --ContRiskAsPercentage	
	In continuity risk and maritime continuity risk plots, show the bin values as the continuity percentage instead of the continuity risk. That is, the bin values shown will computed as: 100*(1-binvalue), converting also the symbols "<" and "<=" to ">" and ">=" respectively.
--availmapbins, --AvailMapBins #,#,...	
	et a custom list of bins for the availability plot. The list must be comma (',') separated. The program will automatically add a bin in the beginning as all values smaller or equal than the smallest bin value provided. Values may be provided in any order, as they will be automatically sorted. **DEFAULT:** 20.0,50.0,75.0,90.0,95.0,97.5,99.0,99.5,99.9.
--contriskmapbins, --ContRiskMapBins #,#,...	
	Set a custom list of bins for the continuity risk plot. The list must be comma (',') separated. The program will automatically add a

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	bin in the beginning as all values equal or greater than the greater bin value provided. Values may be provided in any order, as they will be automatically sorted. **DEFAULT:** 1e-2,7.5e-3,5e-3,2.5e-3,1e-3,7.5e-4,5e-4,2.5e-4,1e-4,1e-5
--contriskmarmapbins, --ContRiskMarMapBins #,#,...	
	Set a custom list of bins for the maritime continuity risk plot. The list must be comma (',') separated. The program will automatically add two bins: one for all values greater than one ('1') and a bin with all values equal or greater than the greater bin value provided but smaller than 1. Values may be provided in any order, as they will be automatically sorted. **DEFAULT:** 1e-2,7.5e-3,5e-3,2.5e-3,1e-3,7.5e-4,5e-4,2.5e-4,1e-4,1e-5
--ionoavailmapbins, --IonoAvailMapBins #,#,...	
	Set a custom list of bins for the ionosphere availability plot. The list must be comma (',') separated. The program will automatically add a bin in the beginning as all values smaller or equal than the smallest bin value provided. Values may be provided in any order, as they will be automatically sorted. **DEFAULT:** 20.0,50.0,75.0,90.0,95.0,97.5,99.0,99.5,99.9
--hdopmapbins, --HDOPMapBins #,#,...	
	Set a custom list of bins for the Horizontal DOP (HDOP) plot. The list must be comma (',') separated. The program will automatically add a bin in the beginning as all values greater or equal than the greater bin value provided. Values may be provided in any order, as they will be automatically sorted. **DEFAULT:** 4,2
--pdopmapbins, --PDOPMapBins #,#,...	
	Set a custom list of bins for the Position DOP (PDOP) plot. The list must be comma (',') separated. The program will automatically add a bin in the beginning as all values greater or equal than the greater bin value provided. Values may be provided in any order, as they will be automatically sorted. **DEFAULT:** 6,3.5
--gdopmapbins, --GDOPMapBins #,#,...	
	Set a custom list of bins for the Geometric DOP (GDOP) plot. The list must be comma (',') separated. The program will automatically add a bin in the beginning as all values greater or equal than the greater bin value provided. Values may be provided in any order, as they will be automatically sorted. **DEFAULT:** 7,5
--availmapbinstext, --AvailMapBinsText <text1>;<text2>;...	
	Set a custom list with the text to be shown in the bins of the colourbar for the availability plot. The list must be semicolon (';') separated, with the same number of items plus one as in the default colourbar or the same number plus one as set with parameter **'--availmapbins'**. The additional bin is to account for

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	the bin that gLAB adds for all values smaller than the minimum bin provided.
--contriskmapbinstext, --ContRiskMapBinsText <text1>;<text2>;...	
	Set a custom list with the text to be shown in the bins of the colourbar for the continuity risk plot. The list must be semicolon (';') separated, with the same number of items plus one as in the default colourbar or the same number plus one as set with parameter **'--contriskmapbins'**. The additional bin is to account for the bin that gLAB adds for all values greater than the maximum bin provided.
--contriskmarmapbinstext, --ContRiskMarMapBinsText <text1>;<text2>;...	
	Set a custom list with the text to be shown in the bins of the colourbar for the maritime continuity risk plot. The list must be semicolon (';') separated, with the same number of items plus one as in the default colourbar or the same number plus one as set with parameter **'--contriskmarmapbins'**. The additional bin is to account for the bin that gLAB adds for all values greater than the maximum bin provided.
--ionoavailmapbinstext, --IonoAvailMapBinsText <text1>;<text2>;...	
	Set a custom list with the text to be shown in the bins of the colourbar for the ionosphere availability plot. The list must be semicolon (';') separated, with the same number of items plus one as in the default colourbar or the same number plus one as set with parameter **'--ionoavailmapbins'**. The additional bin is to account for the bin that gLAB adds for all values smaller than the minimum bin provided.
--hdopmapbinstext, --HDOPMapBinsText <text1>;<text2>;...	
	Set a custom list with the text to be shown in the bins of the colourbar for Horizontal DOP (HDOP) plot. The list must be semicolon (';') separated, with the same number of items plus one as in the default colourbar or the same number plus one as set with parameter **'--hdopmapbins'**. The additional bin is to account for the bin that gLAB adds for all values greater than the maximum bin provided.
--pdopmapbinstext, --PDOPMapBinsText <text1>;<text2>;...	
	Set a custom list with the text to be shown in the bins of the colourbar for the Position DOP (PDOP) plot. The list must be semicolon (';') separated, with the same number of items plus one as in the default colourbar or the same number plus one as set with parameter **'--pdopmapbins'**. The additional bin is to account for the bin that gLAB adds for all values greater than the maximum bin provided.
--gdopmapbinstext, --GDOPMapBinsText <text1>;<text2>;...	
	Set a custom list with the text to be shown in the bins of the colourbar for the Geometric DOP (GDOP) plot. The list must be semicolon (';') separated, with the same number of items plus one as in the default colourbar or the same number plus one as set with parameter **'--gdopmapbins'**. The additional bin is to account for the bin that gLAB adds for all values greater than the maximum bin provided.

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--availcontourlevels, --AvailContourLevels, --availcontourlines, --AvailContourLines #,#,...	
	Set the levels list for drawing the availability map contour lines. The list must be comma (',') separated, and the values provided must be in the list of bins provided with **'--availmapbins'** parameter (or the default bins if not provided. Values may be provided in any order, as they will be automatically sorted. **DEFAULT:** 95.0,97.5,99.9
--contriskcontourlevels, --ContRiskContourLevels, --contriskcontourlines, --ContRiskContourLines #,#,...	
	Set the levels list for drawing the continuity risk map contour lines. The list must be comma (',') separated, and the values provided must be in the list of bins provided with **'--contriskmapbins'** parameter (or the default bins if not provided. Values may be provided in any order, as they will be automatically sorted. **DEFAULT:** 1e-3,5e-4
--contriskmarcontourlevels, --ContRiskMarContourLevels, --contriskmarcontourlines, --ContRiskMarContourLines #,#,...	
	Set the levels list for drawing the continuity maritime risk map contour lines. The list must be comma (',') separated, and the values provided must be in the in the list of bins provided with **'--contriskmarmapbins'** parameter (or the default bins if not provided. Values may be provided in any order, as they will be automatically sorted. **DEFAULT:** 1e-3,5e-4
--availbincolors, --AvailBinColors <val1>,<val2>,...	
	Set the colours to be used in the colour bar in a comma (',') separated list for each bin in the availability map. The number of colours must be the number of bins plus 1 provided in the **'--availmapbins'** parameter (by default 10 colours). The extra colour is due to gLAB adds an extra bin for all values smaller than the minimum bin provided. The list of colours MUST be ordered, starting with the colour of the smallest bin and ending with the colour of the highest bin. The colour must be set using the rgb code with a hash ('#') at the beginning or with one the values shown in the **'--color'** option.
--contriskbincolors, --ContRiskBinColors <val1>,<val2>,...	
	Set the colours to be used in the colour bar in a comma (',') separated list for each bin in the continuity risk map. The number of colours must be the number of bins plus 1 provided in the **'--contriskmapbins'** parameter (by default 10 colours). The extra colour is due to gLAB adds an extra bin for all values greater than the maximum bin provided. The list of colours MUST be ordered, starting with the colour of the smallest bin and ending with the colour of the highest bin. The colour must be set using the rgb code with a hash ('#') at the beginning or with one the values shown in the **'--color'** option.
--contriskmarbincolors, --ContRiskMarBinColors <val1>,<val2>,...	
	Set the colours to be used in the colour bar in a comma (',') separated list for each bin in the maritime continuity risk map.

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	The number of colours must be the number of bins plus 2 provided in the **'--contriskmarmapbins'** parameter (by default 11 colours). gLAB adds an extra bin for all values greater than the maximum bin provided. The list of colours MUST be ordered, starting with the colour of the smallest bin and ending with the colour of the highest bin. The colour must be set using the rgb code with a hash ('#') at the beginning or with one the values shown in the **'--color'** option. For example, the default colours used for the maritime continuity risk map are: "#000080,#0000F3,#004DFF,#00B3FF,#29FFCE,#7BFF7B, #CEFF29,#FFC600,#FF6800,#F30900"
--ionoavailbincolors, --IonoAvailBinColors <val1>,<val2>,...	
	Set the colours to be used in the colour bar in a comma (',') separated list for each bin in the ionosphere availability map. The number of colours must be the number of bins plus 1 provided in the **'--ionoavailmapbins'** parameter (by default 10 colours). The extra colour is due to gLAB adds an extra bin for all values smaller than the minimum bin provided. The list of colours MUST be ordered, starting with the colour of the smallest bin and ending with the colour of the highest bin. The colour must be set using the rgb code with a hash ('#') at the beginning or with one the values shown in the **'--color'** option.
--hdopbincolors, --HDOPBinColors <val1>,<val2>,...	
	Set the colours to be used in the colour bar in a comma (',') separated list for each bin in the Horizontal DOP (HDOP) map. The number of colours must be the number of bins plus 1 provided in the **'--hdopmapbins'** parameter (by default 10 colours). The extra colour is due to gLAB adds an extra bin for all values greater than the maximum bin provided. The list of colours MUST be ordered, starting with the colour of the smallest bin and ending with the colour of the highest bin. The colour must be set using the rgb code with a hash ('#') at the beginning or with one the values shown in the **'--color'** option.
--pdopbincolors, --PDOPBinColors <val1>,<val2>,...	
	Set the colours to be used in the colour bar in a comma (',') separated list for each bin in the Position DOP (PDOP) map. The number of colours must be the number of bins plus 1 provided in the **'--pdopmapbins'** parameter (by default 10 colours). The extra colour is due to gLAB adds an extra bin for all values greater than the maximum bin provided. The list of colours MUST be ordered, starting with the colour of the smallest bin and ending with the colour of the highest bin. The colour must be set using the rgb code with a hash ('#') at the beginning or with one the values shown in the **'--color'** option.
--gdopbincolors, --GDOPBinColors <val1>,<val2>,...	
	Set the colours to be used in the colour bar in a comma (',') separated list for each bin in the Geometric DOP (GDOP) map.

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	The number of colours must be the number of bins plus 1 provided in the **'--gdopmapbins'** parameter (by default 10 colours). The extra colour is due to gLAB adds an extra bin for all values greater than the maximum bin provided. The list of colours MUST be ordered, starting with the colour of the smallest bin and ending with the colour of the highest bin. The colour must be set using the rgb code with a hash ('#') at the beginning or with one the values shown in the **'--color'** option.
--sbasserviceformat, --SBASServiceFormat	
	Set the SBAS maps to an alternative format. In this format, contour lines are disabled by default, but can be enabled by manually setting the contour levels with any of these parameters: **'--availcontourlevels'**, **'--contriskcontourlevels'** or **'--contriskmarcontourlevels'**. **Availability Maps:** Bin values: >=99.9,>=99,>=98,>=95,>=90,>=80,>=70,<70 Bin colours: #00008b,#0040ff,#00ffff,#00ff00,#ffff00,#ffa500,#ff0000,#8b0000 Not Avail bin is enabled and with default colour. **Continuity Risk Maps:** Bin values: <=1e-4,<=5e-4,<=1e-3,<=5e-3,<=1e-2,<=2e-2,<=3e-2,>3e-2 Bin colours: #00008b,#0040ff,#00ffff,#00ff00,#ffff00,#ffa500,#ff0000,#8b0000 Not Avail bin is enabled and with default colour. **Maritime Continuity Risk Maps:** Bin values: <=1e-4,<=5e-4,<=1e-3,<=5e-3,<=1e-2,<=2e-2,<=3e-2,>3e-2 Bin colours: #00008b,#0040ff,#00ffff,#00ff00,#ffff00,#ffa500,#ff0000,#8b0000 Not Avail bin is enabled and with default colour. **Ionosphere Availability Maps:** Bin values: >=99.9,>=99,>=98,>=95,>=90,>=80,>=70,<70 Bin colours: #00008b,#0040ff,#00ffff,#00ff00,#ffff00,#ffa500,#ff0000,#8b0000 Not Avail bin is enabled and with default colour. **HDOP Maps:** Bin values: <2,<4,>=4 (same as the default ones) Bin colours:

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	#00008b,#ffa500,#8b0000 Not Avail bin is enabled and with default colour. **PDOP Maps:** Bin values: <3.5,<6,>=6 (same as the default ones) Bin colours: #00008b,#ffa500,#8b0000 Not Avail bin is enabled and with default colour. **GDOP Maps:** Bin values: <5,<7,>=7 (same as the default ones) Bin colours: #00008b,#ffa500,#8b0000 Not Avail bin is enabled and with default colour. **Note:** - If user manually sets the bin values or bin colours, the user options will prevail. - The user change the bin thresholds from ">=" or "<=" to ">" or "<" respectively by setting the option **'--disablebineqcond'**.
--sbasservicemaritimeformat, --SBASServiceMaritimeFormat	
	Set the SBAS maps to an alternative format. In this format, contour lines are disabled by default, but can be enabled by manually setting the contour levels with any of these parameters: **'--availcontourlevels'**, **'--contriskcontourlevels'** or **'--contriskmarcontourlevels'**. **Availability Maps:** Bin values: >=99.8,>=99.5,>=99,>=97.5,>=95,>=90,>=70,<70 Bin colours: #00008b,#0040ff,#00ffff,#00ff00,#ffff00,#ffa500,#ff0000,#8b0000 Not Avail bin is enabled and with default colour. **Continuity Risk Maps:** Bin values: <=3e-4,<=4e-4,<=5e-4,<=7e-4,<=1e-3,<=1e-2,>1e-1 Bin colours: #00008b,#0040ff,#00ffff,#00ff00,#ffff00,#ffa500,#ff0000,#8b0000 Not Avail bin is enabled and with default colour. **Maritime Continuity Risk Maps:** Bin values: <=3e-4,<=4e-4,<=5e-4,<=7e-4,<=1e-3,<=1e-2,>1e-1 Bin colours: #00008b,#0040ff,#00ffff,#00ff00,#ffff00,#ffa500,#ff0000,#8b0000 Not Avail bin is enabled and with default colour. **Ionosphere Availability Maps:** Bin values:

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	>=99.8,>=99.5,>=99,>=97.5,>=95,>=90,>=70,<70 Bin colours: #00008b,#0040ff,#00ffff,#00ff00,#ffff00,#ffa500,#ff0000,#8b0000 Not Avail bin is enabled and with default colour. **HDOP Maps:** Bin values: <2,<4,>=4 (same as the default ones) Bin colours: #00008b,#ffa500,#8b0000 Not Avail bin is enabled and with default colour. **PDOP Maps:** Bin values: <3.5,<6,>=6 (same as the default ones) Bin colours: #00008b,#ffa500,#8b0000 Not Avail bin is enabled and with default colour. **GDOP Maps:** Bin values: <5,<7,>=7 (same as the default ones) Bin colours: #00008b,#ffa500,#8b0000 Not Avail bin is enabled and with default colour. **Note:** - If user manually sets the bin values or bin colours, the user options will prevail. - The user change the bin thresholds from ">=" or "<=" to ">" or "<" respectively by setting the option **'--disablebineqcond'**.
--sbasservicebinaryformat, --SBASServiceBinaryFormat	
	Set the SBAS maps to an alternative format that only has two bins (plus the 'Not Avail' bin). The bin texts are 'Not \\n Compliant' and 'Compliant'. This format is useful for visually checking if a condition is met or not (e.g. availability >=99.8). The user may change the bin value to set the desired condition. Also, contour lines are disabled by default, but can be enabled by manually setting the contour levels with any of these parameters: **'--availcontourlevels'**, **'--contriskcontourlevels'** or **'--contriskmarcontourlevels'**. The default values for this format are: **Availability Maps:** Bin values: >=99.9,<99.9 Bin colours: #ffffff,#006400 Colourbar title: " >=99.9%" (the spaces are for padding the text to the right) **Continuity Risk Maps:** Bin values: <=1e-4,>1e-4 Bin colours: #ffffff,#006400 Colourbar title: " <=1e-4" (the spaces are for padding the text to the right)

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	Maritime Continuity Risk Maps: Bin values: <=1e-4,>1e-4 Bin colours: #ffffff,#006400 Colourbar title: " <=1e-4" (the spaces are for padding the text to the right) **Ionosphere Availability Maps:** Bin values: >=99.9,<99.9 Bin colours: #ffffff,#006400 Colourbar title: " >=99.9%" (the spaces are for padding the text to the right) **HDOP Maps:** Bin values: <4,>=4 Bin colours: #ffffff,#006400 Colourbar title: " <4" (the spaces are for padding the text to the right) **PDOP Maps:** Bin values: <6,>=6 Bin colours: #ffffff,#006400 Colourbar title: " <6" (the spaces are for padding the text to the right) **GDOP Maps:** Bin values: <7,>=7 Bin colours: #ffffff,#006400 Colourbar title: " <7" (the spaces are for padding the text to the right) **Note:** - If user manually sets the bin values, bin colours or bin texts, the user options will prevail - If user changes the bin value, the colourbar title will show the user defined bin value - The user change the bin thresholds from ">=" or "<=" to ">" or "<" respectively by setting the option **'--disablebineqcond'**.
--sbasservicemaritimebinaryformat, --SBASServiceMaritimeBinaryFormat	
	Set the SBAS maps to an alternative format that only has two bins (plus the 'Not Avail' bin). The bin texts are 'Not \\n Compliant' and 'Compliant'. This format is useful for visually checking if a condition is met or not (e.g. availability >=99.8). The user may change the bin value to set the desired condition. Also, contour lines are disabled by default, but can be enabled by manually setting the contour levels with any of these parameters: **'--availcontourlevels'**, **'--contriskcontourlevels'** or **'--contriskmarcontourlevels'**. The default values for this format are: **Availability Maps:** Bin values: >=99.8,<99.8 Bin colours: #ffffff,#006400 Colourbar title: " >=99.8%" (the spaces are for padding the text to the right) **Continuity Risk Maps:**

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	Bin values: <=3e-4,>3e-4 Bin colours: #ffffff,#006400 Colourbar title: " <=3e-4" (the spaces are for padding the text to the right) **Maritime Continuity Risk Maps:** Bin values: <=3e-4,>3e-4 Bin colours: #ffffff,#006400 Colourbar title: " <=3e-4" (the spaces are for padding the text to the right) **Ionosphere Availability Maps:** Bin values: >=99.8,<99.8 Bin colours: #ffffff,#006400 Colourbar title: " >=99.8%" (the spaces are for padding the text to the right) **HDOP Maps:** Bin values: <4,>=4 Bin colours: #ffffff,#006400 Colourbar title: " <4" (the spaces are for padding the text to the right) **PDOP Maps:** Bin values: <6,>=6 Bin colours: #ffffff,#006400 Colourbar title: " <6" (the spaces are for padding the text to the right) **GDOP Maps:** Bin values: <7,>=7 Bin colours: #ffffff,#006400 Colourbar title: " <7" (the spaces are for padding the text to the right) **Note:** - If user manually sets the bin values, bin colours or bin texts, the user options will prevail - If user changes the bin value, the colourbar title will show the user defined bin value - The user change the bin thresholds from ">=" or "<=" to ">" or "<" respectively by setting the option **'--disablebineqcond'**.
--availcbartitle, --AvailCbarTitle <text>	
	Set the title for the colourbar in the availability maps.
--contriskcbartitle, --ContRiskCbarTitle <text>	
	Set the title for the colourbar in the continuity risk maps.
--contriskmarcbartitle, --ContRiskMarCbarTitle <text>	
	Set the title for the colourbar in the maritime continuity risk maps.
--ionoavailcbartitle, --IonoAvailCbarTitle <text>	
	Set the title for the colourbar in the ionosphere availability maps.
--hdopcbartitle, --HDOPCbarTitle <text>	
	Set the title for the colourbar in the Horizontal DOP (HDOP) maps.

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--pdopcbartitle, --PDOPCbarTitle <text>	
	Set the title for the colourbar in the Position DOP (PDOP) maps.
--gdopcbartitle, --GDOPCbarTitle <text>	
	Set the title for the colourbar in the Geometric DOP (GDOP) maps.
--nocontourlines, --NoContourLines, --nocontourlevels, --NoContourLevels	
	Do not show contour lines in Availability, Continuity Risk or Maritime Continuity Risk Maps.
--nocbarpercent, --NoCbarPercent	
	Do not put the '%' sign in top of the colourbar.
--doppercentileplot, --DOPPercentilePlot	
	In DOP maps, also do percentile DOP plots.
--CbarLabel, --cbarlabel <text>	
	Add a label next to the colourbar.
--SBASSystemname, --sbassystemname <text>	
	Set the name of the SBAS system in the title, replacing the default "SBAS" text in the default title.
--PRNtext, --prntext <text>	Replace the "PRN <number>" text in the default title with the given text. This is useful when the plot is from multiple PRNs, where the default PRN is 0.
--PRNtextnewline, --prntextnewline	
	Move the "PRN <number>" to a newline below (instead of being next to the alarm limits and the pixel resolution).
--firuser, --FIRUser <filename>	Add a user defined FIR area through a text file. The text file must contain no header and each line at least two columns (separated by any number of spaces): one with the longitude and another with the latitude (in degrees, in ellipsoidal coordinates). Additional columns will be ignored. Also, lines starting with a hash ('#') will be ignored. In order to be able to compute the degradation percentage inside the area, the FIR area must be closed by repeating the initial point at the end of the file. For setting multiple FIR areas, set this parameter as many times as necessary
--fireu, --FIREu, --FIREU	Add the external borders of the European FIR (Flight Information Region) area in the map (the European FIR coordinates are hardcoded in the program).
--firconus, --FIRCONUS	Add the external borders of the CONUS FIR (Flight Information Region) area in the map (the CONUS FIR coordinates are hardcoded in the program).
--firalaska, --FIRAlaska	Add the external borders of the Alaska FIR (Flight Information Region) area in the map (the Alaska FIR coordinates are hardcoded in the program).
--fircanada, --FIRCanada	Add the external borders of the Canada FIR (Flight Information Region) area in the map (the Canada FIR coordinates are hardcoded in the program).

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--firmexico, --FIRMexico	Add the external borders of the Mexico FIR (Flight Information Region) area in the map (the Mexico FIR coordinates are hardcoded in the program).
--firlinetype, --FIRLineType <val>	
	Set the linewidth for FIR area border (see option **'-s'**) [DEFAULT '--']. Set this option for each user defined FIR area drawn (option **'--firuser'**). If only one FIR area is drawn (including the European FIR area), this option will be set for that area (so it keeps compatibility with previous versions).
--firlinetypeeu, --FIRLineTypeEu <val>	
	Same as **'--firlinetype'**, but only applies to the European FIR area defined in option **'--fireu'**.
--firlinetypeconus, --FIRLineTypeCONUS <val>	
	Same as **'--firlinetype'**, but only applies to the CONUS FIR area defined in option **'--firconus'**.
--firlinetypealaska, --FIRLineTypeAlaska <val>	
	Same as **'--firlinetype'**, but only applies to the Alaska FIR area defined in option **'--firalaska'**.
--firlinetypecanada, --FIRLineTypeCanada <val>	
	Same as **'--firlinetype'**, but only applies to the Canada FIR area defined in option **'--fircanada'**.
--firlinetypemexico, --FIRLineTypeMexico <val>	
	Same as **'--firlinetype'**, but only applies to the Mexico FIR area defined in option **'--firmexico'**.
--firlinewidth, --FIRLineWidth #	Set the linewidth for FIR area border [DEFAULT 2]. Set this option for each user defined FIR area drawn (option **'--firuser'**). If only one FIR area is drawn (including the European FIR area), this option will be set for that area (so it keeps compatibility with previous versions).
--firlinewidtheu, --FIRLineWidthEu #	
	Same as **'--firlinewidth'**, but only applies to the European FIR area defined in option **'--fireu'**.
--firlinewidthconus, --FIRLineWidthCONUS #	
	Same as **'--firlinewidth'**, but only applies to the CONUS FIR area defined in option **'--firconus'**.
--firlinewidthalaska, --FIRLineWidthAlaska #	
	Same as **'--firlinewidth'**, but only applies to the Alaska FIR area defined in option **'--firalaska'**.
--firlinewidthcanada, --FIRLineWidthCanada #	
	Same as **'--firlinewidth'**, but only applies to the Canada FIR area defined in option **'--fircanada'**.
--firlinewidthmexico, --FIRLineWidthMexico #	
	Same as **'--firlinewidth'**, but only applies to the Mexico FIR area defined in option **'--firmexico'**.
--firlinecolor, --FIRLineColor <color>	

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	Set the colour for the FIR area border [DEFAULT 'white' for availability maps, 'black' for world maps]. Set this option for each user defined FIR area drawn (option **'--firuser'**). If only one FIR area is drawn (including the European FIR area), this option will be set for that area (so it keeps compatibility with previous versions).
--firlinecoloreu, --FIRLineColorEu <color>	
	Same as **'--firlinecolor'**, but only applies to the European FIR area defined in option **'--fireu'**.
--firlinecolorconus, --FIRLineColorCONUS <color>	
	Same as **'--firlinecolor'**, but only applies to the CONUS FIR area defined in option **'--firconus'**.
--firlinecoloralaska, --FIRLineColorAlaska <color>	
	Same as **'--firlinecolor'**, but only applies to the Alaska FIR area defined in option **'--firalaska'**.
--firlinecolorcanada, --FIRLineColorCanada <color>	
	Same as **'--firlinecolor'**, but only applies to the Canada FIR area defined in option **'--fircanada'**.
--firlinecolormexico, --FIRLineColorMexico <color>	
	Same as **'--firlinecolor'**, but only applies to the Mexico FIR area defined in option **'--firmexico'**.
--firmarkersize, --FIRMarkerSize #	
	Set the marker size for FIR area border [DEFAULT 5]. Set this option for each user defined FIR area drawn (option **'--firuser'**). If only one FIR area is drawn (including the European FIR area), this option will be set for that area (so it keeps compatibility with previous versions).
--firmarkersizeeu, --FIRMarkerSizeEu #	
	Same as **'--firmarkersize'**, but only applies to the European FIR area defined in option **'--fireu'**.
--firmarkersizeconus, --FIRMarkerSizeCONUS #	
	Same as **'--firmarkersize'**, but only applies to the CONUS FIR area defined in option **'--firconus'**.
--firmarkersizealaska, --FIRMarkerSizeAlaska #	
	Same as **'--firmarkersize'**, but only applies to the Alaska FIR area defined in option **'--firalaska'**.
--firmarkersizecanada, --FIRMarkerSizeCanada #	
	Same as **'--firmarkersize'**, but only applies to the Canada FIR area defined in option **'--fircanada'**.
--firmarkersizemexico, --FIRMarkerSizeMexico #	
	Same as **'--firmarkersize'**, but only applies to the Mexico FIR area defined in option **'--firmexico'**.
--nofirborder, --NoFIRBorder #	Do not show the user defined FIR in the map. This option is useful if the user is only interested in computing the degradation percentage inside the FIR area (and printing it in the plot), but not the FIR area border itself.

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	The parameter must come with the number of the user defined FIR that shall not be plotted. For instance, if user defines two FIR areas, and the second FIR area does not have to be plotted, then the parameter should be **'--nofirborder 2'**. This parameter must be provided for each user defined FIR area that shall not be plotted. **Note:** If the number provided is 0, all user defined FIR areas will not be plotted
--nofirbordereu, --NoFIRBorderEu	
	Same as **'--nofirborder'**, but only applies to the European FIR area defined in option **'--fireu'**.
--nofirborderconus, --NoFIRBorderCONUS	
	Same as **'--nofirborder'**, but only applies to the CONUS FIR area defined in option **'--firconus'**.
--nofirborderalaska, --NoFIRBorderAlaska	
	Same as **'--nofirborder'**, but only applies to the Alaska FIR area defined in option **'--firalaska'**.
--nofirbordercanada, --NoFIRBorderCanada	
	Same as **'--nofirborder'**, but only applies to the Canada FIR area defined in option **'--fircanada'**.
--nofirbordermexico, --NoFIRBorderMexico	
	Same as **'--nofirborder'**, but only applies to the Mexico FIR area defined in option **'--firmexico'**.
--firdegradation, --FIRDegradation	
	Compute the availability degradation inside the FIR area and plot it in the map.
--firdegtextheader, --FIRDegTextHeader <text>	
	Set the header for the FIR availability degradation. This text will be printed once for each availability area defined by the user, on top of the degradation text. Set this option for each user defined FIR area (option **'--firuser'**). If option **'--firdegtexttable'** is set, it will change the header title for this FIR
--firdegtextheadereu, --FIRDegTextHeaderEu <text>	
	Set the header for the European FIR availability degradation. This text will be printed on top of the European area degradation text. If option **'--firdegtexttable'** is set, it will change the header title for this FIR
--firdegtextheaderconus, --FIRDegTextHeaderCONUS <text>	
	Set the header for the CONUS FIR availability degradation. This text will be printed on top of the CONUS area degradation text. If option **'--firdegtexttable'** is set, it will change the header title for this FIR
--firdegtextheaderalaska, --FIRDegTextHeaderAlaska <text>	

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	Set the header for the Alaska FIR availability degradation. This text will be printed on top of the Alaska area degradation text. If option **'--firdegtexttable'** is set, it will change the header title for this FIR
--firdegtextheadercanada, --FIRDegTextHeaderCanada <text>	
	Set the header for the Canada FIR availability degradation. This text will be printed on top of the Canada area degradation text. If option **'--firdegtexttable'** is set, it will change the the header title for this FIR
--firdegtextheadermexico, --FIRDegTextHeaderMexico <text>	
	Set the header for the Mexico FIR availability degradation. This text will be printed on top of the Mexico area degradation text. If option **'--firdegtexttable'** is set, it will change the header title for this FIR
--firdegtextheaderfirsum, --FIRDegTextHeaderFIRSum <text>	
	Set the header for all FIR availability degradation. This text will be printed on top of all FIR area degradation text. This option also sets **'--firsumdeg'**. If option **'--firdegtexttable'** is set, it will change the header title for this FIR
--firdegtextfooter, --FIRDegTextFooter <text>	
	Set the footer for the FIR availability degradation. This text will be printed once for each availability area defined by the user, below the last degradation text. Set this option for each user defined FIR area drawn (option **'--firuser'**).
--firdegtextfootereu, --FIRDegTextFooterEu <text>	
	Set the footer for the European FIR availability degradation. This text will be printed below the European area degradation text.
--firdegtextfooterconus, --FIRDegTextFooterCONUS <text>	
	Set the footer for the CONUS FIR availability degradation. This text will be printed below the CONUS area degradation text.
--firdegtextfooteralaska, --FIRDegTextFooterAlaska <text>	
	Set the footer for the Alaska FIR availability degradation. This text will be printed below the Alaska area degradation text.
--firdegtextfootercanada, --FIRDegTextFooterCanada <text>	
	Set the footer for the Canada FIR availability degradation. This text will be printed below the Canada area degradation text.
--firdegtextfootermexico, --FIRDegTextFooterMexico <text>	
	Set the footer for the Mexico FIR availability degradation. This text will be printed below the Mexico area degradation text.
--firdegtextfooterfirsum, --FIRDegTextFooterFIRSum <text>	
	Set the footer for all FIR availability degradation. This text will be printed below the all FIR area degradation text. This option also sets **'--firsumdeg'**.
--firdegtext, --FIRDegText <text>	
	Set the text for the FIR availability degradation (only if option **'--firdegtexttable'** is not set). This text will be printed for each bin

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	defined with parameter **'--firdegtextbins'**, or if none defined, using the bin at the top of the colourbar. The default text is: **'>{2:.1f}: {0:.2f}%** **<={2:.1f}: {1:.2f}%'** Note that '{0:.2f} sets to write the availability percentage value with two decimals, '{1:.2f}' sets to write the unavailability percentage with two decimals and {2:.1f} sets to write the current bin value with one decimal. If any of these are not set, the value missing will not be printed. For example, to print only the availability percentage with one decimal and no other text but a percentage, the string would be: **'{0:.1f}%'** For example, to print the unavailability percentage with one decimal to get text such as "<99.9: 1.2%", the string would be: **'<{2:.1f}: {1:.1f}%'** **Note:** - To print a literal curly-brace ('{' or '}'), set double number of curly braces. For example, if the desired text is 'Avail {80%}', the string to be passed by parameter shall be 'Avail {{{0:.0f}%}}'. - The total number of points inside the FIR area, the number of points over the bin value and below the bin value (inside the FIR area) can be also printed (the values used to compute the percentages). Use the following formats: **{0:.1f}**-> Percentage of points over the bin value inside the FIR area. **{1:.1f}**-> Percentage of points below the bin value inside the FIR area. **{2:.1f}**-> Value of the current bin (for continuity risk bins, use the exponential format, for instance: {2:.1e}). **{3:d}** -> Number of points over the bin value inside the FIR area. **{4:d}** -> Number of points below the bin value inside the FIR area. **{5:d}** -> Total number of points inside the FIR area. **{6:d}** -> Total number of points in the whole plot. Set this option for each user defined FIR area drawn (option **'--firuser'**).
--firdegtexteu, --FIRDegTextEu <text>	
	Same as **'--firdegtext'**, but only applies to the European FIR area defined in option **'--fireu'**.
--firdegtextconus, --FIRDegTextCONUS <text>	
	Same as **'--firdegtext'**, but only applies to the CONUS FIR area defined in option **'--firconus'**.
--firdegtextalaska, --FIRDegTextAlaska <text>	
	Same as **'--firdegtext'**, but only applies to the Alaska FIR area defined in option **'--firalaska'**.

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--firdegtextcanada, --FIRDegTextCanada <text>	
	Same as **'--firdegtext'**, but only applies to the Canada FIR area defined in option **'--fircanada'**.
--firdegtextmexico, --FIRDegTextMexico <text>	
	Same as **'--firdegtext'**, but only applies to the Mexico FIR area defined in option **'--firmexico'**.
--firdegtextfirsum, --FIRDegTextFIRSum <text>	
	Same as **'--firdegtext'**, but applies to the degradation which is the total sum of all FIR areas defined and set to be added. When setting this option (computing the total degradation of all FIR areas), the bins used in each FIR area must be the same for all of them. This option also sets **'--firsumdeg'**.
--firsumdeg, --FIRSumDeg	Compute the total degradation for all FIR areas defined and print the result. If any of the options **'--firdegtextfirsum'**, **'--firdegtextsizefirsum'**, **'--firdegtextcolorfirsum'** or **'--firdegtextpositionfirsum'** are set, default values will be set. **Note:** - If none of these options **'--firsumdegeu'**, **'--firsumdegconus'**, **'--firsumdegAlaska'**, **'--firsumdegcanada'**, **'--firsumdegmexico'**, **'--firsumdeguserfir'** are provided, it will select all FIR areas enabled. Otherwise, if any of these options are provided, only the selected FIR areas will be used - If several FIR areas overlap, each overlapped point will count only once, and the value used will be the best of all FIRs (as it is enough for any area in the map to be covered by one system or GEO). - If this option is set and the degradation text is not printed in a table, all degradation bins must have the same values. - If option **'--firsumdegtexttitle'** is not set. the default title is "All FIRs".
--firsumdegeu, --FIRSumDegEu	Select Eu FIR area to be added to the total degradation sum.
--firsumdegconus, --FIRSumDegCONUS	
	Select CONUS FIR area to be added to the total degradation sum.
--firsumdegalaska, --FIRSumDegAlaska	
	Select Alaska FIR area to be added to the total degradation sum.
--firsumdegcanada, --FIRSumDegCanada	
	Select Canada FIR area to be added to the total degradation sum.
--firsumdegmexico, --FIRSumDegMexico	
	Select Mexico FIR area to be added to the total degradation sum.
--firsumdeguserfir, --FIRSumDegUserFIR #,#,...	
	Select user defined FIR areas (defined with parameter **'--firuser'**) to be added to the total degradation sum (in a comma separated list).

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	If value is 0, it will select all user defined FIR areas.
--firdegtextbins, --FIRDegTextBins #,#,...	
	Set the bins for which the degradation will be computed and written (using the text provided with **'--firdegtext'** or the default value). The bins values must be comma (',') separated, and must be any of the bins provided with parameters **'--availmapbins'**, **'--contriskmapbins'**, **'--contriskmarmapbins'**,**'--ionoavailmapbins'**, **'--hdopmapbins'**, **'--pdopmapbins'** or **'--gdopmapbins'**. The order is not important as they will be automatically sorted. **Note:** - If option **'--contriskaspercentage'** is set and it is a Continuity Risk or Maritime Continuity Risk plot, the bins can also be set as a percentage. - If option **'--firdegtexttable'** is set, this parameter will set the bin values of the table.
--firdegtextbinseu, --FIRDegTextBinsEu #,#,...	
	Same as **'--firdegtextbins'**, but only applies to the European FIR area defined in option **'--fireu'**.
--firdegtextbinsconus, --FIRDegTextBinsCONUS #,#,...	
	Same as **'--firdegtextbins'**, but only applies to the CONUS FIR area defined in option **'--firconus'**.
--firdegtextbinsalaska, --FIRDegTextBinsAlaska #,#,...	
	Same as **'--firdegtextbins'**, but only applies to the Alaska FIR area defined in option **'--firalaska'**.
--firdegtextbinscanada, --FIRDegTextBinsCanada #,#,...	
	Same as **'--firdegtextbins'**, but only applies to the Canada FIR area defined in option **'--fircanada'**.
--firdegtextbinsmexico, --FIRDegTextBinsMexico #,#,...	
	Same as **'--firdegtextbins'**, but only applies to the Mexico FIR area defined in option **'--firmexico'**.
--firdegtextsize, --FIRDegTextSize #	
	Set the text size for the FIR availability degradation [DEFAULT 5]. Set this option for each user defined FIR area drawn (option **'--firuser'**). If only one FIR area is drawn (including the European FIR area), this option will be set for that area (so it keeps compatibility with previous versions). **Note:** If option **'--firdegtexttable'** is set, this parameter will set the text size of the table.
--firdegtextsizeeu, --FIRDegTextSizeEu #	
	Same as **'--firdegtextsize'**, but only applies to the European FIR area defined in option **'--fireu'**.
--firdegtextsizeconus, --FIRDegTextSizeCONUS #	

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	Same as **'--firdegtextsize'**, but only applies to the CONUS FIR area defined in option **'--firconus'**.
--firdegtextsizealaska, --FIRDegTextSizeAlaska #	
	Same as **'--firdegtextsize'**, but only applies to the Alaska FIR area defined in option **'--firalaska'**.
--firdegtextsizecanada, --FIRDegTextSizeCanada #	
	Same as **'--firdegtextsize'**, but only applies to the Canada FIR area defined in option **'--fircanada'**.
--firdegtextsizemexico, --FIRDegTextSizeMexico #	
	Same as **'--firdegtextsize'**, but only applies to the Mexico FIR area defined in option **'--firmexico'**.
--firdegtextsizefirsum, --FIRDegTextSizeFIRSum #	
	Same as **'--firdegtextsize'**, but only applies to the text for the sum of the degradation for all of the FIR areas defined. This option also sets **'--firsumdeg'**.
--firdegtextcolor, --FIRDegTextColor <color>	
	Set the text colour for the FIR availability degradation [DEFAULT 'white']. Set this option for each user defined FIR area drawn (option **'--firuser'**). If only one FIR area is drawn (including the European FIR area), this option will be set for that area (so it keeps compatibility with previous versions). **Note:** If option **'--firdegtexttable'** is set, this parameter will set the text colour of the table.
--firdegtextcoloreu, --FIRDegTextColorEu <color>	
	Same as **'--firdegtextcolor'**, but only applies to the European FIR area defined in option **'--fireu'**.
--firdegtextcolorconus, --FIRDegTextColorCONUS <color>	
	Same as **'--firdegtextcolor'**, but only applies to the CONUS FIR area defined in option **'--firconus'**.
--firdegtextcoloralaska, --FIRDegTextColorAlaska <color>	
	Same as **'--firdegtextcolor'**, but only applies to the Alaska FIR area defined in option **'--firalaska'**.
--firdegtextcolorcanada, --FIRDegTextColorCanada <color>	
	Same as **'--firdegtextcolor'**, but only applies to the Canada FIR area defined in option **'--fircanada'**.
--firdegtextcolormexico, --FIRDegTextColorMexico <color>	
	Same as **'--firdegtextcolor'**, but only applies to the Mexico FIR area defined in option **'--firmexico'**.
--firdegtextcolorfirsum, --FIRDegTextColorFIRSum <color>	
	Same as **'--firdegtextcolor'**, but only applies to the text for the sum of the degradation for all of the FIR areas defined. This option also sets **'--firsumdeg'**.
--firdegtextposition, --FIRDegTextPosition #,#	

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	Set the text position for the FIR availability degradation. Position must be given in x and y coordinates, separated by a comma (',') (for example "0.3,0.5"). The coordinates are respect to the lower left corner of the plot [DEFAULT 0.245,0.88]. Set this option for each user defined FIR area drawn (option **'--firuser'**). If only one FIR area is drawn (including the European FIR area), this option will be set for that area (so it keeps compatibility with previous versions). **Note:** If option **'--firdegtexttable'** is set, this parameter will set the position of the table.
--firdegtextpositioneu, --FIRDegTextPositionEu #,#	
	Same as **'--firdegtextposition'**, but only applies to the European FIR area defined in option **'--fireu'**.
--firdegtextpositionconus, --FIRDegTextPositionCONUS #,#	
	Same as **'--firdegtextposition'**, but only applies to the CONUS FIR area defined in option **'--firconus'**.
--firdegtextpositionalaska, --FIRDegTextPositionAlaska #,#	
	Same as **'--firdegtextposition'**, but only applies to the Alaska FIR area defined in option **'--firalaska'**.
--firdegtextpositioncanada, --FIRDegTextPositionCanada #,#	
	Same as **'--firdegtextposition'**, but only applies to the Canada FIR area defined in option **'--fircanada'**.
--firdegtextpositionmexico, --FIRDegTextPositionMexico #,#	
	Same as **'--firdegtextposition'**, but only applies to the Mexico FIR area defined in option **'--firmexico'**.
--firdegtextpositionfirsum, --FIRDegTextPositionFIRSum #,#	
	Same as **'--firdegtextposition'**, but only applies to the text for the sum of the degradation for all of the FIR areas defined. This option also sets **'--firsumdeg'**.
--nofirdegtext, --NoFIRDegText #,#,...	
	Do not print the degradation text in the map. This option is useful if the user is only interested in showing the FIR border but does not want any degradation text to be printed (this FIR will also be skipped in the degradation table if option **'--firdegtexttable'**). The parameter must come with a comma separated list with the number of the user defined FIR that shall not have degradation text. For instance, if user defines two FIR areas, and the second FIR area does not have to be plotted, then the parameter should be **'--nofirdegtext 2'**. **Note:** If the number provided is 0, all user defined FIR areas will not have degradation text printed.
--nofirdegtexteu, --NoFIRDegTextEu	
	Same as **'--nofirdegtext'**, but only applies to the European FIR area defined in option **'--fireu'**.

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--nofirdegtextconus, --NoFIRDegTextCONUS	
	Same as **'--nofirdegtext'**, but only applies to the CONUS FIR area defined in option **'--firconus'**.
--nofirdegtextalaska, --NoFIRDegTextAlaska	
	Same as **'--nofirdegtext'**, but only applies to the Alaska FIR area defined in option **'--firalaska'**.
--nofirdegtextcanada, --NoFIRDegTextCanada	
	Same as **'--nofirdegtext'**, but only applies to the Canada FIR area defined in option **'--fircanada'**.
--nofirdegtextmexico, --NoFIRDegTextMexico	
	Same as **'--nofirdegtext'**, but only applies to the Mexico FIR area defined in option **'--firmexico'**.
--firdegtextmonospacefont, --FIRDegTextMonospaceFont	
	Set the FIR degradation type (for all FIRs texts in the plots) font to monospace. The monospace font preserves the alignment of text (default 'sans-serif' font has, for instance, different widths for '1' and '0' characters). The monospace font is always used when option **'--firdegtexttable'** is set.
--firdegtexttable, --FIRDegTextTable	
	Show all degradation text FIR values in a table. The names for the user defined areas will be the filename (without extension). Each row of data will be for each bin defined with parameter **'--firdegtextbins'**, and each column will be a different FIR area. Use parameters **'--firdegtextsize'**, **'--firdegtextcolor'** and **'--firdegtextposition'** for setting its properties. If these parameters are set multiple times, the values provided the first time will prevail.
--printfirdegtext, --PrintFIRDegText	
	Print the degradation text to standard output (does not work on Windows). If the FIR values are shown in table format (parameter **'--firdegtexttable'** is set), the whole table will be printed. Otherwise, each line of data will have its name of the FIR region prepended to the line, so as it can be distinguished from which FIR regions the current line belongs to. This option is compatible with **'--writetofilefirdegtext'** option. **Note:** Output text is encoded with 'utf-8'.
--writetofilefirdegtext, --WriteToFileFIRDegText <filename>	
	Same as **'--printfirdegtext'** option, but instead of printing the FIR values to standard output, it will be written to the file provided (the output file will be truncated). This option is compatible with **'--printfirdegtext'** option. **Note:** Output text is encoded with 'utf-8'.
--onlyprintfirdegtext, --OnlyPrintFIRDegText	

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	Do not show the plots, just print the degradation text to standard output or to a file (as in options **'--printfirdegtext'** and **'--writetofilefirdegtext'**). If option **'--sv'** is set (save picture to file), then this option has no effect, as with **'--sv'** option plots are not shown.
--sbasplotsize, --SBASPlotSize #,#	
	Set the plotting area size, by providing the horizontal and vertical (in centimetres). The two values must be comma (',') separated. [DEFAULT 20.32,15.24]
--sbastopfiguremargin, --SBASTopFigureMargin #	
	Set the top figure margin by providing the fraction of image size to be left as margin (starting from the top). The range values are [0-0.5], being 0 no top margin. Adding top margin makes the figure move downwards in the plot area (shrinking if necessary).
--sbasbottomfiguremargin, --SBASBottomFigureMargin #	
	Set the bottom figure margin by providing the fraction of image size to be left as margin (starting from the bottom). The range values are [0-0.5], being 0 no bottom margin. Adding bottom margin makes the figure move upwards in the plot area (shrinking if necessary).
--sbasleftfiguremargin, --SBASLeftFigureMargin #	
	Set the left figure margin by providing the fraction of image size to be left as margin (starting from the left). The range values are [0-0.5], being 0 no left margin. Adding left margin makes the figure move to the right in the plot area (shrinking if necessary).
--sbasrightfiguremargin, --SBASRightFigureMargin #	
	Set the right figure margin by providing the fraction of image size to be left as margin (starting from the right). The range values are [0-0.5], being 0 no right margin. Adding right margin makes the figure move to the left in the plot area (shrinking if necessary).
--countries, --Countries	Draw the country borders in the map.
--usastates, --USAStates	Draw the USA states borders in the map.
Note: - If user sets a vertical label, the **'--atm'** option (adjust to margin) will be disabled in order to fit the vertical label **Examples:** **graph.py -f /home/gLAB/Example --sbas --sv /home/Desktop/SBASAvailMap.eps** **graph.py -f /home/gLAB/Example --SBAS**	

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6.6 SETTING THE AXIS

As seen in section 4.3 Analysis in general the axis source will be one column, and this can be specified that way:

-x 4

This will take as x axis the 4th column of the input file. This can also be expressed as:

-x '$4'

This also means 4th column of the input file (The ' signs have been included for linux users. Windows users do not need to used them). Operations can be done in this parameter, such as:

-x '($4-$5)'

This will take as x axis origin the difference between the 4th and 5th columns. This operation is also valid:

-x '($4*2-1)'

Mathematical functions and constants can be also used here, such as:

-x '(math.sin($12*math.pi/180)*(90-$11)/90)'

6.7 SETTING THE CONDITIONS

As seen in section 4.3 Analysis , the conditions are a way to insert one or more conditionals in order to select which lines of the source file are going to be used in the plotting.

The rules for this are as follows:

-c ($6>=10)

This will only include the line if the 6th column is equal or greater than 10. It is also possible to specify a ser of conditions using AND [&] and OR [|] operators, such as:

-c ($6>=10)&($6<=20)|($8==2)

It is possible to specify that a column matches a specific string by surrounding the string by \", such as:

-c ($1==\"OUTPUT\")

It is possible to specify mathematical operations and constants, as: math.pi, math.e, math.sin() and math.cos(), as example:

-c ($1==\"POSTFIT\")&(math.cos($11+5)>0.707)

It is possible to specify a specific character inside a column, by using $x[y], being x the column and y the character position beginning by 0, such as:

-c ($1==\"POSTFIT\")&($7[0]==\"P\") [First character of seventh column is 'P']

It is possible to operate between columns, such as:

-c (($9-$11)<2)

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Linux users, should use the ‘ signs to surround the parameter. Besides they should use “ instead of \” when comparing strings. Sample:

-c ‘($1=="OUTPUT”)’

This is due to the difference when treating arguments between Windows and Linux Operating Systems.

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7 gLAB OUTPUT MESSAGES

7.1 INFO MESSAGE

INFO messages are shown at several points in the program and provide information on the program configuration, events and problems it may encounter, which are:

- At the start of the file, showing information about gLAB configuration.
- An inconsistent clock update on the receiver.
- A data gap in the RINEX observation file.
- A change in the a priori receiver coordinates (only when receiver coordinates are computed by gLAB).
- The new position to be used from the reference position file (only when a reference file is provided).
- No solution was computed, along with the reason for not being able to compute the solution (not enough satellites available, singular geometry matrix or DOP too high).
- In SBAS processing, the elevation of each GEO and the one selected (if GEO selection with highest elevation is enabled).
- In SBAS processing, a GEO or mode switch.
- In SBAS processing, if option '-mode:selectbestgeo' is enabled, in each epoch, for each GEO which a solution can be computed, the GEO PRN, its protection levels and a message if the GEO was selected is printed. The selected GEO will be always the last one.
- In DGNSS processing, a switch from DGNSS to SPP solution mode.
- In DGNSS processing, a data gap in the reference station RINEX observation file

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7.2 USERADDEDERROR MESSAGE

User-defined error are added to measurements before cycle-slip detection and smoothing (or after if option "Insert User Added Error after preprocessing" is enabled). Messages will be sorted by constellation, with this order: GPS, Galileo, GLONASS, GEO, BeiDou, QZSS, IRNSS. All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	USERADDEDERROR	Fixed word indicating the data stored.	-
2	Year	Year number (4 digits).	years
3	DoY	Day of Year (3 digits).	days
4	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
5	Time of day	Time in HH:MM:SS.zz format	-
6	GPS week	Week number in GPS Time. This field is related to the GPS week of the data snapshot used for the computations.	weeks
7	Time of week	Seconds elapsed since the beginning of the week. This field is related to the GPS number of seconds of the data snapshot used for the computations.	seconds
8	GNSS	Satellite constellation.	-
9	PRN	Satellite identifier.	-
10	Measurement identifier (as string)	String with the measurement observation code.	-
11	Raw measurement	Raw measurement (phase measurements are prealigned)	metres
12	Modified measurement	Raw measurement plus total user-defined error (phase measurements are prealigned)	metres
13	Active user-defined error functions	Total number of active user-defined errors in the current epoch.	-
14	Total user-defined error functions	Total user-defined error in the current epoch.	metres
15	Active Step function error	Number of active Step function error in the current epoch.	metres
16	Step function error value	Sum of all Step function errors in the current epoch.	metres
17	Active Ramp function error	Total number of active Ramp function error in the current epoch.	metres
18	Ramp function error value	Sum of all Ramp function errors in the current epoch.	metres
19	Active Sinusoidal function error	Number of active Sinusoidal function error in the current epoch.	-
20	Sinusoidal function error value	Sum of all Sinusoidal function errors in the current epoch.	metres
21	Active AWGN function error	Number of active AWGN function error in the current epoch.	-
22	AWGN function error value	Sum of all AWGN function errors in the current epoch.	metres

Sample:

```
USERADDEDERROR   2015 161     0.00 00:00:00.00 1848 259200.00 GPS   4 C1C
23140309.8200  23140314.8200  1         5.0000  1         5.0000  0         0.0000
0         0.0000  0         0.0000
```


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7.3 INPUT MESSAGE

Input data message. It is shown after an epoch is read, decimated and added user-defined error. It contains the measurements for each satellite for this epoch. Messages will be sorted by constellation, with this order: GPS, Galileo, GLONASS, GEO, BeiDou, QZSS, IRNSS. All time tags are in GPS time.

NOTE: INPUT message is deprecated, use MEAS message instead

#	FIELD	DESCRIPTION	UNITS
1	INPUT	Fixed word indicating the data stored	-
2	Year	Year number (4 digits)	years
3	DoY	Day of Year (3 digits)	days
4	Seconds of day	Seconds elapsed since the beginning of the day	seconds
5	Time of day	Time in HH:MM:SS.zz format	-
6	GNSS	Satellite constellation	-
7	PRN	Satellite identifier	-
8	Arc number	Number of arc (continuous measurements without CS) since the start of the processing	-
9	Arc length	Number of undecimated epochs after the last cycle-slip	-

For GPS:

#	FIELD	DESCRIPTION	UNITS
10	Measurement	C1 [C1C]	metres
11	Measurement	P1 [C1P]	metres
12	Measurement	P2 [C2P]	metres
13	Measurement	L1 [L1P] (prealigned)	metres
14	Measurement	L2 [L2P] (prealigned)	metres

For Galileo (GAL):

#	FIELD	DESCRIPTION	UNITS
10	Measurement	C1A	metres
11	Measurement	C1B	metres
12	Measurement	C1C	metres
13	Measurement	C7Q	metres
14	Measurement	C8Q	metres
15	Measurement	L1A (prealigned)	metres
16	Measurement	L1B (prealigned)	metres
17	Measurement	L1C (prealigned)	metres
18	Measurement	L7Q (prealigned)	metres
19	Measurement	L8Q (prealigned)	metres

For GLONASS (GLO):

#	FIELD	DESCRIPTION	UNITS
10	Measurement	C1 [C1C]	metres
11	Measurement	C2 [C2C]	metres
12	Measurement	L1 [L1P] (prealigned)	metres
13	Measurement	L2 [L2P] (prealigned)	metres

For GEO:

#	FIELD	DESCRIPTION	UNITS

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10	Measurement	C1 [C1C]	metres

Sample:

```
INPUT     2006 200     0.00 00:00:00.00 GPS 19   1      1  23119003.9020
23119002.6110  23119004.0750  23119002.7507  23119004.0925
```


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7.4 CYCLE SLIP MESSAGE

Cycle-slip message information. It is shown when a cycle-slip is found by any detector. A line will be printed for each CS detector that has found a CS. The first 7 fields are common, afterwards, there are five possible different CS messages depending on the cycle-slip detector activated. Messages will be sorted by constellation, with this order: GPS, Galileo, GLONASS, GEO, BeiDou, QZSS, IRNSS. All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	CS	'CS' or 'CS_USER' for Rover Station (user) 'CS_REF' for Reference Station	-
2	Year	Year number (4 digits)	years
3	DoY	Day of Year (3 digits)	days
4	Seconds of day	Seconds elapsed since the beginning of the day	seconds
5	Time of day	Time in HH:MM:SS.zz format	-
6	GNSS	Satellite constellation	-
7	PRN	Satellite identifier	-

If cycle-slip detector is Data gap:

#	FIELD	DESCRIPTION	UNITS
8	'-'	Hyphen to align with SF, MW, LI and IGF detectors	-
9	CS Detector	'DATA_GAP'	-
10	Field separator	'='	-
11	Delta time	Difference of time between current and last available epochs	seconds
12	CS threshold label	'THRESHOLD'	-
13	Field separator	'='	-
14	CS threshold value	Maximum time allowed data gap threshold	seconds

Sample:

```
CS        2014 288 44997.00 12:29:57.00 GPS 32 - DATA_GAP = 45.00 THRESHOLD = 40.00
```

If cycle-slip detector is Loss of Lock Indicator:

#	FIELD	DESCRIPTION	UNITS
8	'-'	Hyphen to align with SF, MW, LI and IGF detectors	-
9	CS Detector	'LLI'	-
10-	CS Detector value	List of measurements and its LLI flag value	-

Sample:

```
CS        2019 031 72340.00 20:05:40.00 GPS  9 - LLI L1C-1 L2L-1 L5Q-1
```

If cycle-slip detector is Carrier minus code difference (single frequency detector):

#	FIELD	DESCRIPTION	UNITS
8	CS measurements	List of measurements used to build the carrier minus code combination, separated by dashes	-
9	CS detector	'SF'	-
10	Field separator	'='	-

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#	FIELD	DESCRIPTION	UNITS
11	CS difference	Squared value of carrier phase minus code minus its mean computed in the current arc	metres^2
12	CS threshold label	'THRESHOLD'	-
13	Field separator	'='	-
14	CS threshold value	Maximum SF difference allowed as threshold	metres^2

Sample:

```
CS        2019 032 19600.00 05:26:40.00 GAL   1 C5Q-L5Q SF = 39.8400 THRESHOLD =
25.4303
```

If cycle-slip detector is Melbourne-Wubbena:

#	FIELD	DESCRIPTION	UNITS
8	CS measurements	List of measurements used to build the MW combination, separated by dashes	-
9	CS detector	'MW'	-
10	Field separator	'='	-
11	CS difference	Absolute value of the difference between the current MW and the mean value of MW of current arc	metres
12	CS threshold label	'THRESHOLD'	-
13	Field separator	'='	-
14	CS threshold value	Maximum MW difference allowed as threshold	metres

Sample:

```
CS       2019 032 10780.00 02:59:40.00 GPS 10 C1C-C5Q-L1C-L5Q MW = 1.1744
THRESHOLD = 1.1304
```

If cycle-slip detector is Geometry-free (LI=L1-L2) carrier phase:

#	FIELD	DESCRIPTION	UNITS
8	CS measurements	List of measurements used to build the LI combination, separated by dashes	-
9	CS detector	'LI'	-
10	Field separator	'='	-
11	CS difference	Absolute value of the difference between the computed LI and the measured LI. If LI could not be estimated, value will be '999999.0000'	metres
12	CS threshold label	'THRESHOLD'	-
13	Field separator	'='	-
14	CS threshold value	Maximum LI difference allowed as threshold	metres

Sample:

```
CS       2019 032 17310.00 04:48:30.00 GPS 32 L1C-L2W LI = 0.1134 THRESHOLD =
0.0528
```

If cycle-slip detector is Iono-geometry-free carrier phase:

#	FIELD	DESCRIPTION	UNITS
8	CS measurements	List of measurements used to build the IGF combination, separated by dashes	-

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#	FIELD	DESCRIPTION	UNITS
9	CS detector	'IGF	-
10	Field separator	'='	-
11	CS difference	Absolute value of the difference between the computed IGF and the measured IGF. If IGF could not be estimated, value will be '999999.0000'	metres
12	CS threshold label	'THRESHOLD'	-
13	Field separator	'='	-
14	CS threshold value	Maximum IGF difference allowed as threshold	metres

Sample:

```
CS       2019 031 67660.00 18:47:40.00 GAL  3 L1C-L5Q-L6C-L8Q IGF = 0.0760
THRESHOLD = 0.0528
```


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7.5 SFCSDATA MESSAGE

Internal values used in the computation of the single frequency carrier minus code cycle-slip detector. Messages will be sorted by constellation, with this order: GPS, Galileo, GLONASS, GEO, BeiDou, QZSS, IRNSS. All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	SFCSDATA	'SFCSDATA' or 'SFCSDATA_USER' for Rover Station (user) 'SFCSDATA_REF' for Reference Station	-
2	Year	Year number (4 digits)	years
3	DoY	Day of Year (3 digits)	days
4	Seconds of day	Seconds elapsed since the beginning of the day	seconds
5	Time of day	Time in HH:MM:SS.zz format	-
6	GNSS	Satellite constellation	-
7	PRN	Satellite identifier	-
8	Arc number	Number of arc (continuous measurements without CS) since the start of the processing	-
9	Arc length	Number of undecimated epochs after the last cycle-slip	-
10	CS measurements	List of measurements used to build the carrier minus code combination, separated by dashes	-
11	Code measurement	Code measurement	metres
12	Carrier phase measurement	Carrier phase measurement	metres
13	Delta Code	Difference between current code measurement and previous epoch code measurement	metres
14	Delta Phase	Difference between current carrier phase measurement and previous epoch carrier phase measurement	metres
15	Absolute difference	Absolute value of the difference between fields 13 and 14	metres
16	Mean difference	Mean value of the difference between code and carrier phase measurement inside the sliding window	metres
17	Standard deviation difference	Sigma value of the difference between code and carrier phase measurement inside the sliding window	m^2
18	Computed difference	It is the squared value of (field 12 minus field 11 minus field 16) squared	m^2
19	Computed threshold	It is the minimum value between the current sigma (field 17) and the initial sigma multiplied by the k factor	m^2
20	Maximum threshold	The maximum value of the single-frequency cs detector threshold for declaring a measurement unconsistent	metres
21	Unconsistency flag	If an unconsistency is found, value is '1'. In all other cases, value is '0'	-
22	Cycle-slip flag	If a cycle-slip is found, value is '1'. In all other cases, value is '0'	-

An unconsistency is triggered when field 15 is greater than field 20. In this case, all satellites samples are skipped (it is considered as a data gap but without triggering N-consecutive check) Consistency check cannot be triggered two consecutive epochs.

A cycle-slip is triggered when field 18 is greater than field 19.

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The cycle-slip flag in field 22 will only be enabled if the single frequency detector detects a cycle-slip, but not if another cycle-slip running in parallel detects a cycle-slip trigger and the single frequency detector doesn't.

Sample:

```
SFCSDATA 2019 031 61530.00 17:05:30.00 GAL 24   1     2 C8Q-L8Q  24042582.3540
24042582.4685    -10183.8650    -10183.8300        0.0350      0.0795      9.0000
0.0012    225.0000  20.0000 0 0
```


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7.6 MWCSDATA MESSAGE

Internal values used in the computation of the Melbourne-Wubbena cycle-slip detector. Messages will be sorted by constellation, with this order: GPS, Galileo, GLONASS, GEO, BeiDou, QZSS, IRNSS. All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	MWCSDATA	'MWCSDATA' or 'MWCSDATA_USER' for Rover Station (user) 'MWCSDATA_REF' for Reference Station	-
2	Year	Year number (4 digits)	years
3	DoY	Day of Year (3 digits)	days
4	Seconds of day	Seconds elapsed since the beginning of the day	seconds
5	Time of day	Time in HH:MM:SS.zz format	-
6	GNSS	Satellite constellation	-
7	PRN	Satellite identifier	-
8	Arc number	Number of arc (continuous measurements without CS) since the start of the processing	-
9	Arc length	Number of undecimated epochs after the last cycle-slip	-
10	CS measurements	List of measurements used to build the carrier minus code combination, separated by dashes	-
11	MW measurement 1	First code measurement for building the narrow lane combination	metres
12	MW measurement 2	Second code measurement for building the narrow lane combination	metres
13	MW measurement 3	First carrier phase measurement the wide lane combination	metres
14	MW measurement 4	Second carrier phase measurement the wide lane combination	metres
15	MW value	Melbourne-Wubbena combination with current measurements	metres
16	MW mean 1	Mean value of Melbourne-Wubbena in the current arc	metres
17	MW mean 2	Mean value of Melbourne-Wubbena in the sliding window (for instance in the last 300 s)	metres
18	Accumulated sigma	Standard deviation of Melbourne-Wubbena in the current arc	m^2
19	Computed difference 1	Absolute value of the difference between field 15 and field 16 (current value vs accumulated mean)	metres
20	Computed difference 2	Absolute value of the difference between field 15 and field 17 (current value vs mean within sliding window)	metres
21	Computed threshold 1	It is the square root of field 18 (sdev of the accumulated samples) multiplied by the k factor set by the user	metres
22	Computed threshold 2	Minimum standard deviation provided by the user	metres
23	Outlier flag	If an outlier is declared, value is '1'. In all other cases, value is '0'	-
24	Cycle-slip flag	If a cycle-slip is found, value is '1'. In all other cases, value is '0'	-

A cycle-slip is triggered when fields 19 and 20 are greater than field 21 and the square root of field 18 is smaller than field 22 or if field 18 is greater than ten times field 22.

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The first time a cycle-slip is detected, the samples are considered as 'outlier' and samples are skipped (it is considered as data gap but without triggering N-consecutive check). If the next sample a cycle-slip is triggered, then a new arc is declared. Otherwise, if no cycle-slip is detected the next epoch, the arc continues with the previous epoch skipped.

The cycle-slip flag in field 24 will only be enabled if the Melbourne-Wubbena detector detects a cycle-slip, but not if another cycle-slip running in parallel detects a cycle-slip trigger and the Melbourne-Wubbena detector doesn't.

Sample:

```
MWCSDATA 2019 031 61660.00 17:07:40.00 GAL 24   2    12 C6C-C8Q-L6C-L8Q
24210219.9290  24210239.3620  24210219.9516  24210239.7865   281.2079   281.1575
281.1575     0.3692      0.0503      0.0503      3.0381   0.8000 0 0
```


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7.7 LICSDATA MESSAGE

Internal values used in the computation of the geometry-free cycle-slip detector. Messages will be sorted by constellation, with this order: GPS, Galileo, GLONASS, GEO, BeiDou, QZSS, IRNSS. All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	LICSDATA	'LICSDATA' or 'LICSDATA_USER' for Rover Station (user) 'LICSDATA_REF' for Reference Station	-
2	Year	Year number (4 digits)	years
3	DoY	Day of Year (3 digits)	days
4	Seconds of day	Seconds elapsed since the beginning of the day	seconds
5	Time of day	Time in HH:MM:SS.zz format	-
6	GNSS	Satellite constellation	-
7	PRN	Satellite identifier	-
8	Arc number	Number of arc (continuous measurements without CS) since the start of the processing	-
9	Arc length	Number of undecimated epochs after the last cycle-slip	-
10	CS measurements	List of measurements used to build the carrier minus code combination, separated by dashes	-
11	GF measurement 1	First carrier phase measurement for building the geometry-free combination	metres
12	GF measurement 2	Second carrier phase measurement for building the geometry-free combination	metres
13	GF initial value	First LI measurement saved in the LI buffer sliding window	metres
14	GF current value	LI combination with current measurements	metres
15	GF Difference 1	Absolute value of the difference between field 13 (initial value of the buffer) and field 14 (current value)	metres
16	Geometry-Free value	Estimated LI value using a second degree least square adjustment	metres
17	Difference 2	Absolute value of the difference between field 14 (current value) and field 16 (estimated value)	metres
18	Postfit residual	Absolute value of two times the residual of the LI estimation	metres
19	GF Threshold 1	Threshold for maximum value of field 15, computed from the paramenters set by the user	metres
20	GF Threshold 2	Threshold for maximum value of field 17, computed from the postfit residual value from field 18	meters
21	Outlier flag	If an outlier is declared, value is '1'. In all other cases, value is '0'	-
22	Cycle-slip flag	If a cycle-slip is found, value is '1'. In all other cases, value is '0'	-

A cycle-slip is triggered when field 15 is greater than field 19 or field 17 is greater than fields 18 and 20. If a cycle-slip is declared with the first condition, no outlier is declared, as it is a check for large phase jumps. If a cycle-slip triggers with the second condition, an outlier is declared. If in the next epoch a cycle-slip is triggered, then a new arc is declared. Otherwise, if no cycle-slip is detected the next epoch, the arc continues with the previous epoch skipped.

The cycle-slip flag in field 22 will only be enabled if the geometry-free detector detects a cycle-slip, but not if another cycle-slip running in parallel detects a cycle-slip trigger and the geometry-free detector doesn't.

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Sample:

```
LICSDATA 2019 031 61610.00 17:06:50.00 GAL  4   1    10 L6C-L8Q  28902058.4672
28902058.4607   0.0040   0.0065   0.0025      0.0059      0.0006      0.0005
1.0000   0.0529 0 0
```


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7.8 IGFCSDATA MESSAGE

Internal values used in the computation of the iono-geometry-free cycle-slip detector. Messages will be sorted by constellation, with this order: GPS, Galileo, GLONASS, GEO, BeiDou, QZSS, IRNSS. All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	IGFCSDATA	'IGFCSDATA' or 'IGFCSDATA_USER' for Rover Station (user) 'IGFCSDATA_REF' for Reference Station	-
2	Year	Year number (4 digits)	years
3	DoY	Day of Year (3 digits)	days
4	Seconds of day	Seconds elapsed since the beginning of the day	seconds
5	Time of day	Time in HH:MM:SS.zz format	-
6	GNSS	Satellite constellation	-
7	PRN	Satellite identifier	-
8	Arc number	Number of arc (continuous measurements without CS) since the start of the processing	-
9	Arc length	Number of undecimated epochs after the last cycle-slip	-
10	CS measurements	List of measurements used to build the carrier minus code combination, separated by dashes	-
11	IGF measurement 1	Carrier phase measurement for building the iono-geometry-free combination	metres
12	IGF measurement 2	Carrier phase measurement for building the iono-geometry-free combination	metres
13	IGF measurement 3	Carrier phase measurement for building the iono-geometry-free combination	metres
14	IGF measurement 4	Carrier phase measurement for building the iono-geometry-free combination	metres
15	IGF initial value	First IGF measurement saved in the IGF buffer sliding window	metres
16	IGF current value	IGF combination with current measurements	metres
17	IGF difference 1	Absolute value of the difference between field 15 (intitial value at the buffer) and field 16 (current value)	metres
18	IGF prediction	Estimated IGF value using a second degree least square adjustment	m^2
19	IGF difference 2	Absolute value of the difference between field 16 (current value) and field 18 (estimated value)	metres
20	Postfit residual	Absolute value of two times the residual of the IGF estimation (threshold for maximum value of field 19)	metres
21	IGF threshold 1	Threshold for maximum value of field 17	metres
22	IGF threshold 2	Threshold for maximum value of field 19, computed from the postfit residual value in field 20	metres
23	Outlier flag	If an outlier is declared, value is '1'. In all other cases, value is '0'	-
24	Cycle-slip flag	If a cycle-slip is found, value is '1'. In all other cases, value is '0'	-

If option **'-pre:cs:igf:minnoise'** is set, the IGF is computed with the following formula:

$$IGF = Alpha \bullet L1 + Beta \bullet L2 + Gamma \bullet L3$$

With this option, field 14 will be 999999.0000, as only three measurements are used.

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The next three fields are the computed values for Alpha, Beta and Gamma (adimensional factors)

#	FIELD	DESCRIPTION	UNITS
25	Alpha factor	To be multiplied with field 11	-
26	Beta factor	To be multiplied with field 12	-
27	Gamma factor	To be multiplied with field 13	-

A cycle-slip is triggered when field 17 is greater than field 21 or field 19 is greater than fields 20 and 22. If a cycle-slip is declared with the first condition, no outlier is declared, as it is a check for large phase jumps. If a cycle-slip triggers with the second condition, an outlier is declared. If in the next epoch a cycle-slip is triggered, then a new arc is declared. Otherwise, if no cycle-slip is detected the next epoch, the arc continues with the previous epoch skipped.

The cycle-slip flag in field 24 will only be enabled if the iono-geometry-free detector detects a cycle-slip, but not if another cycle-slip running in parallel detects a cycle-slip trigger and the iono-geometry-free detector doesn't.

Sample:

```
IGFCSDATA  2019  031  61640.00  17:07:20.00  GAL  26     1       13  L1C-L5Q-L6C-L8Q
23994292.6633  23994294.1164  23994293.2320  23994294.0525   3.0103   3.0243   0.0140
3.0077      0.0166      0.0020   1.0000   0.1057 0 0
```

Or:

```
IGFCSDATA 2019 031 61640.00 17:07:20.00 GAL 26   1    13 L1C-L8Q-L5Q     23994292.6633
23994294.0525  23994294.1164    999999.0000  -0.0149  -0.0147   0.0002     -0.0144
0.0003      0.0002   1.0000   0.0529 0 0  0.0421 -0.7272  0.6851
```


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7.9 MEAS MESSAGE

Information of the input measurements in a variable format, and azimuth/elevation of the satellite. It is written after modelling the message. Messages will be sorted by constellation, with this order: GPS, Galileo, GLONASS, GEO, BeiDou, QZSS, IRNSS. All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	MEAS	Fixed word indicating the data stored.	-
2	Year	Year number (4 digits).	years
3	DoY	Day of Year (3 digits).	days
4	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
5	Time of day	Time in HH:MM:SS.zz format	-
6	GNSS	Satellite constellation.	-
7	PRN	Satellite identifier.	-
8	Block	Satellite block type	-
9	SVN	Space Vehicle Number	-
10	Arc number	Number of arc (continuous measurements without CS) since the start of the processing	-
11	Arc length	Number of undecimated epochs after the last cycle-slip	-
12	Satellite elevation	Elevation angle between the satellite and the receiver location.	degrees
13	Satellite azimuth	Azimuth angle between the satellite and the receiver location.	degrees
14	Measurements Total	Number of measurements	-
15	Measurements List	String containing the measurements included	-
16-	Measurements Value	Each following column is the value of the measurement specified in field 15	-

If there is no data available on azimuth and elevation, the fields 12 and 13 will be fixed to zero.

User can define the measurements to be printed (in fields 14 and onwards) on a per satellite basis, by using the parameter **'-print:meas:select'**.

The MEAS message can be used as a way to convert a RINEX file to a columnar text file

Sample:

```
MEAS      2019 182     0.00 00:00:00.00 GPS 26       BLOCK_IIF   71   1      1
29.689  -85.121 15 C1C:L1C:S1C:C1W:L1W:S1W:C2X:L2X:S2X:C2W:L2W:S2W:C5X:L5X:S5X
22797916.2960  22797916.3449 44.750  22797915.8300  22797915.9666 34.250
22797918.6020  22797918.7745 46.500  22797918.6990  22797918.7748 34.250
22797919.1480  22797919.3039 53.000
```


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7.10 MODEL MESSAGE

Model break down message. It is shown when a model can be fully computed for each measurement. Messages will be sorted by constellation, with this order: GPS, Galileo, GLONASS, GEO, BeiDou, QZSS, IRNSS. Satellite coordinates are in WGS84 system. All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	MODEL	Fixed word indicating the data stored: 'MODEL' if the satellite is used in the computation or 'MODEL*' if it is not.	-
2	Year	Year number (4 digits)	years
3	DoY	Day of Year (3 digits)	days
4	Seconds of day	Seconds elapsed since the beginning of the day	seconds
5	Time of day	Time in HH:MM:SS.zz format	-
6	GNSS	Satellite constellation	-
7	PRN	Satellite identifier	-
8	Block	Satellite block type	-
9	SVN	Space Vehicle Number	
10	Arc number	Number of arc (continuous measurements without CS) since the start of the processing	-
11	Arc length	Number of undecimated epochs after the last cycle-slip	-
12	Satellite elevation	Elevation angle between the satellite and the receiver location.	degrees
13	Satellite azimuth	Azimuth angle between the satellite and the receiver location.	degrees
14	Measurement	Identifier string	-
15	Orbit type	Information of the orbit used to compute the satellite position and clock. For instance “LNAV” or “CNAV” when using broadcast orbits, otherwise “SP3” when using precise products	-
16	IOD	IOD of the broadcast message used for orbit and clock computation, -1 when using precise products.	-
17		GLONASS frequency number (k) Other GNSS: zero	-
18	GNSS time offsets	GLO: the number of leap seconds BDS: time offset with respect to GPS Other GNSS: zero	seconds
19	Measurement	Measured value (as in the RINEX file), but scaled to metres for carrier phase measurements	metres
20	Signal flight time	Distance between satellite (in transmission time) and receiver position divided by the speed of light	seconds
21	Satellite position	X coordinate. See explanation below.	metres
22	Satellite position	Y coordinate. See explanation below.	metres
23	Satellite position	Z coordinate. See explanation below.	metres
24	Satellite velocity	X component of satellite velocity. See explanation below.	metres
25	Satellite velocity	Y component of satellite velocity. See explanation below.	metres
26	Satellite velocity	Z component of satellite velocity. See explanation below.	metres
27	Range	Satellite-receiver geometric distance	metres

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#	FIELD	DESCRIPTION	UNITS
28	Clock Offset	Satellite clock correction	metres
29	Phase centre	Satellite phase centre projection	metres
30	Phase centre	Satellite phase centre variation projection	metres
31	Phase centre	Receiver phase centre projection	metres
32	Phase centre	Receiver phase centre variation projection	metres
33	Antenna Offset	Receiver Antenna Reference Point (ARP) projection	metres
34	Relativity	Relativity clock correction due to orbit eccentricity	metres
35	Wind-up	Wind-up correction (for carrier phase measurements)	metres
36	Troposphere	Slant Troposphere nominal correction	metres
37	Ionosphere	Slant Ionosphere correction	metres
38	Relativity	Gravitational path delay correction	metres
39	Tides	Solid tides correction	metres
40	-	(Reserved for future fields)	-
41	-	(Reserved for future fields)	-
42	-	(Reserved for future fields)	-
43	Clock Bias	Inter system clock bias	metres
44	Code Bias	P1-C1 DCB (GPS only)	metres
45	Code Bias	Total Group Delay (TGD) correction	metres
46	Code Bias	Inter Signal Correction (if applied)	metres
47	Code Bias	Computed DCB for single frequency and precise orbits (BeiDou only)	metres
48	Code Bias	Sum of all DCB corrections applied (Field 44 + Field 45 + Field 46 + Field 47)	metres
49	SNR	Measurement Signal to Noise Ratio	dbHz
50	Model value	Addition of all model terms, except for dual-frequency DCB processing.	metres

If measurement needs to be applied a dual-frequency DCB, for each dual frequency combination where the measurement is used, the following three fields will be provided:

#	FIELD	DESCRIPTION	UNITS
51-	Measurement ID	Measurements used for the dual frequency combination	-
52-	Code Bias	Dual-frequency DCB computed for current dual-frequency combination	metres
53-	Model value	Full model value with dual-frequency DCB applied	metres

If precise products are used, fields 15 and 16 will have the fixed values 'SP3' and '-1' respectively.

Field 18, for GLONASS satellites will have the number of leap seconds. For BeiDou satellites, the value will be the fixed offset to GPS. For other constellations value is 0.

The satellite coordinates (fields 21-26) are given in the transmission epoch if the model of the signal transmission time is enabled (if it is disabled, they are given in the reception time). The coordinates are relative to the antenna phase centre or satellite mass centre, depending on the products input:

* Broadcast: Antenna Phase Centre

* Precise: Satellite Mass Centre

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Field 19 is the direct measurement (as in the RINEX file), but scaled to metres for carrier phase measurements. Field 48 is the model computed for this measurement, which is the direct sum of fields 27 to 47.

When the '*' appears in field 1, it is due to smoothed code of the satellite has not reached steady-state, a SBAS processing mode switch or SBAS GEO switch. When a mode or GEO switch occurs, the SBAS corrections have to be computed again.

The SNR value in field 49 may be any of these values (in this order): the "S" measurement in the observation file, or if it is not present, it will be the SNR flag in the current measurement (converted to numerical value).

If no SNR is available, 999 will be printed in this field.

Sample:

```
MODEL      2019 025 85862.00 23:51:02.00 GPS 15 BLOCK_IIR-M        55    1     363
9.133   56.540 C1C      LNAV    1  0  0 39110018.66000        0.0817  -5849446.9671
19529241.5438   16560946.2782        -1025.8786        -1939.4413         1934.8478
24502508.9762      99139.2638    0.00000    0.00000    0.00000    0.00000   -0.00000
1.12021    0.00000   13.46324    1.71706    0.00000    0.00000    0.00000    0.00000
0.00000    0.00000    0.00000   -3.21084    0.00000    0.00000   -3.21084    53.000
24601663.5797
```


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7.11 SATSEL MESSAGE

Message with debug information of the reason why a satellite has been discarded (or selected) for processing. If multiple discard conditions are met in a single satellite, then a SATSEL message for each condition will be printed. Messages will be sorted by constellation, with this order: GPS, Galileo, GLONASS, GEO, BeiDou, QZSS, IRNSS. All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	SATSEL	Fixed word indicating the data stored. 'SATSEL' (if navigation solution is computed), 'SATSEL*' (if model parametres will be recomputed before the navigation solution, only in SBAS mode)	-
2	Year	Year number (4 digits)	years
3	DoY	Day of Year (3 digits)	days
4	Seconds of day	Seconds elapsed since the beginning of the day	seconds
5	Time of day	Time in HH:MM:SS.zz format	-
6	GNSS	Satellite constellation	-
7	PRN	Satellite identifier	-
8	Error code	A number which identifies the discard reason with a range from 1 to 115, see below.	
9	Status	"Selected" if satellite used or "Discard reason" if satellite unused. Field 9 will be always between quotes in order to ease parsing purposes.	

The error code in field 8 is a number which identifies the discard reason with a range from 1 to 120. Useful for parsing purposes.

Field 9 will be always between quotes in order to ease parsing purposes.

Fields 8 and 9 may have the following values:

Error Code	VALUES MESSAGE
0	Selected
1	Deselection forced
2	Measurement selection for rover not finished
3	Measurements missing: <measurements>
4	SNR not met [<snr>]
5	Not enough consecutive samples (current <value>, minimum <value>)
6	Arc too short (<arclength>). Min arc length: <minarclength>
7	Inconsistency of measurements
8	Outlier in MW detector
9	Outlier in LI detector
10	Outlier in IGF detector
11	Cycle-slip
12	Steady-state operation not reached. <value> epochs passed, still <value> epochs to achieve <value>
19	Satellite missing in reference station
20	Measurement selection for reference station not finished
21	Measurements missing in reference station: <measurements>
22	SNR not met in reference station [<snr>]
23	Not enough consecutive samples in reference station (current <value>, minimum <value>)

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Error Code	VALUES MESSAGE
24	Arc too short (<arclength>) in reference station. Min arc length: <minarclength>
25	Inconsistency of measurements in reference station
26	Outlier in MW detector in reference station
27	Outlier in LI detector in reference station
28	Outlier in IGF detector in reference station
29	Cycle-slip in reference station
40	No code measurement available for computing transmission time
41	No code and carrier phase measurement available for computing transmission time
42	Ephemerides unavailable
43	Satellite phase centre corrections unavailable
44	GPS P1-C1 DCB unavailable
45	DCBs unavailable
46	Satellite under eclipse
47	Satellite was under eclipse <value> seconds ago
48	Elevation too low (<value> degrees)
49	Elevation too low (<value> degrees) for applying weight 1/(sin(elev)^2)
50	Elevation too low (<value> degrees) for applying weight 10^(-SNR/10)/(sin(elev)^2)
51	No SNR available for computing the weight for measurement <measurement>
52	Missing IONEX data
53	Missing FPPP data
54	SBAS iono unavailable
55	URA value (<value>) is equal or greater than the threshold (<threshold>)
56	Satellite is in marginal mode <healthtext>
57	Satellite is unhealthy <healthtext>
58	No measurements selected for the filter due to missing frequency number (k)
59	No measurements selected for the filter
80	STEP detected (jump of <value> greater than <threshold>)
81	Prefit too high for measurement <meas> in comparison with other satellites
82	Prefit too high for measurement <meas> in comparison with other satellites (threshold <threshold> metres)
83	Prefit too different (<value>) for measurement <meas> with respect to the prefit median (<median>), threshold <threshold> metres
84	NeQuick ionosphere could not be computed
100	SBAS corrections unavailable (GEO <PRN>)
101	C1C measurement unavailable
102	<value> constellation not monitored by SBAS (GEO <PRN>)
110	No DGNSS corrections
111	No DGNSS corrections: Time out
112	No DGNSS corrections: Excluded during the smoother conversion in the Reference Station
113	No DGNSS corrections: Excluded during the smoother conversion in the Rover Station
114	No DGNSS corrections: IODE from BRDC and RTCM do not match
115	No DGNSS corrections: Excluded due to differential correction is too large
116	No DGNSS corrections: Epoch in reference station (last read <ref_station_epoch>) cannot be aligned with rover

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Note: Error codes values are grouped by type, with empty slots for future additions. Errors 1 to 18 are for rover preprocessing, 19 to 39 for reference station preprocessing, 40 to 79 for modelling, 80 to 99 for the filter, 100 to 109 for SBAS and 110 to 121 for DGNSS

Sample:

```
SATSEL    2019 025 85862.00 23:51:02.00 GPS 18  12 "Steady-state operation not
reached. 348 epochs passed, still 12 epochs to achieve 360"
```


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7.12 PREFIT MESSAGE

Prefilter values message. It provides the measurement-model values. It is shown in each filter execution. Messages will be sorted by constellation, with this order: GPS, Galileo, GLONASS, GEO, BeiDou, QZSS, IRNSS. All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	PREFIT	Fixed word indicating the data stored: 'PREFIT' (if the satellite is used in the computation) or 'PREFIT*' (if it is not)	-
2	Year	Year number (4 digits).	years
3	DoY	Day of Year (3 digits).	days
4	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
5	Time of day	Time in HH:MM:SS.zz format	-
6	GNSS	Satellite constellation	-
7	PRN	Satellite identifier	-
8	Block	Satellite block type	-
9	SVN	Space Vehicle Number	-
10	Arc number	Number of arc (continuous measurements without CS) since the start of the processing	-
11	Arc length	Number of undecimated epochs after the last cycle-slip	-
12	Satellite elevation	Elevation angle between the satellite and the receiver location.	degrees
13	Satellite azimuth	Azimuth angle between the satellite and the receiver location.	degrees
14	Measurement	Measurement identifier (as string)	
15	Smoothing Measurement	Measurement identifier for smoothing (as string). If no smoothing is enabled, field 14 will be a dash ('-')	-
16	Prefit value	Measurement-model value: If no smoothing: Field 16 = Field 17 - Field 19. If smoothing Field 16 = Field 17 - Field 18.	metres
17	Measurement	Measurement value	metres
18	Smoothed Measurement	Smoothed measurement value. If not using smoothing: the value is 0.	metres
19	Model value	Model value	metres
20	X-partial derivative	-X component of the satellite line-of-sight vector	-
21	Y-partial derivative	-Y component of the satellite line-of-sight vector	-
22	Z-partial derivative	-Z component of the satellite line-of-sight vector	-
23	T-partial derivative	One	-
24	Weight Inverse	Standard deviation of the measurement (for the filter)	metres
25	Mapping	Troposphere wet mapping	-
26	Wavelength corresponding to the measurement	Wavelength of the frequency measurement. When a iono-free combination is used, the wavelength is computed with the formula 'lambda=c/(f1+f2)'	metres
27	GLONASS frequency number	GLONASS frequency number 'k' read from navigation message. For other constellations, value is 0.	-
28	Conversion factor from TECUs to metres	Conversion factor from TECUs to metres	metres/ TECU

If no smoothing is enabled, field 15 will be a dash ('-'), field 18 will be 0 and Field 16 = Field 17 - Field 19

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If smoothing is enabled, field 15 is the measurement used for smoothing, field 18 will be the smoothed value and Field 16 = Field 18 - Field 19

Field 26 is the frequency wavelength. When a iono-free combination is used, the wavelength is computed with the formula 'lambda=c/(f1+f2)'

Field 27 is the GLONASS frequency number 'k' read from navigation message. For other constellations, value is 0

Sample:

```
PREFIT    2019 025 85862.00 23:51:02.00 GPS 15 BLOCK_IIR-M       55   1    363
9.133   56.540          C1C          L1P  14508353.7082  39110017.2878
39110017.0467  24601663.5797         0.4131        -0.7708        -0.4850
1.0000    2.7740    6.0697    0.1903  0 0.1624
```


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7.13 EPOCHSAT MESSAGE

Message with the satellites used to compute the solution. It is shown for each measurement in the filter plus an additional one with the whole measurements (shown at the end). Messages will be sorted by constellation, with this order: GPS, Galileo, GLONASS, GEO, BeiDou, QZSS, IRNSS. All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	EPOCHSAT	Fixed word indicating the data stored.	
2	Year	Year number (4 digits).	years
3	DoY	Day of Year (3 digits).	days
4	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
5	Time of day	Time in HH:MM:SS.zz format	-
6	Measurement	Measurement identifier (as string) **Note:** If EPOCHSAT line refers to all measurements used in the filter, field 5 will have the value "ALL"	-
7	Smoothing Measurement	Measurement identifier used for smoothing (as string). If no smoothing is enabled, field 7 is a dash ('-').	-
8	Satellites observed	Total number of satellites **selected and unselected** for the current measurement	-
9	Satellites selected	Total number of satellites **selected** for the current measurement	-
10	GPS Identifier	GPS constellation letter ('G')	-
11	Selected GPSs	Total number of GPS satellites selected for the current measurement	-
12	GAL Identifier	Galileo constellation letter ('E')	-
13	Selected GALs	Total number of Galileo satellites selected for the current measurement	-
14	GLO Identifier	GLONASS constellation letter ('R')	-
15	Selected GLOs	Total number of GLONASS satellites selected for the current measurement	-
16	SBAS Identifier	GEO constellation letter ('S')	-
17	Selected SBASs	Total number of GEO satellites selected for the current measurement	-
18	BDS Identifier	BeiDou constellation letter ('C')	-
19	Selected BDSs	Total number of BeiDou satellites selected for the current measurement	-
20	QZSS Identifier	QZSS constellation letter ('J')	-
21	Selected QZSs	Total number of QZSS satellites selected for the current measurement	-
22	IRNSS Identifier	IRNSS constellation letter ('I')	-
23	Selected IRNSSs	Total number of IRNSS satellites selected for the current measurement	-
24	Satellites unselected	Total number of satellites **unselected** for the current measurement	-
25	GPS Identifier	GPS constellation letter ('G')	-
26	Unselected GPSs	Total number of GPS satellites unselected for the current measurement	-
27	GAL Identifier	Galileo constellation ('E')	-
28	Unselected GALs	Total number of Galileo satellites unselected for the current measurement	-

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#	FIELD	DESCRIPTION	UNITS
29	GLO Identifier	GLONASS constellation letter ('R')	-
30	Unselected GLOs	Total number of GLONASS satellites unselected for the current measurement	-
31	SBAS Identifier	GEO constellation letter ('S')	-
32	Unselected SBASs	Total number of GEO satellites unselected for the current measurement	-
33	BDS Identifier	BeiDou constellation letter ('C')	-
34	Unselected BDSs	Total number of BeiDou satellites unselected for the current measurement	-
35	QZSS Identifier	QZSS constellation letter ('J')	-
36	Unselected QZSs	Total number of QZSS satellites unselected for the current measurement	-
37	IRNSS Identifier	IRNSS constellation letter ('I')	-
38	Unselected IRNSSs	Total number of IRNSS satellites unselected for the current measurement	-
39-	Satellite list	Each following column is a '+' or '-' sign, the satellite system and the PRN identifier. The '+' sign indicates that the satellite has been used in the solution computation. The '-' sign indicates that the satellite has not been used in the solution computation The satellite list will show first all the satellites with the '+' and after the ones with the '-' sign (ordered by constellation).	-

If the EPOCHSAT line refers to all measurements used in the filter, field 6 will have the value "ALL"

If no smoothing is enabled, field 7 will be a dash ('-').

If smoothing is enabled, field 7 is the measurement used for smoothing.

Sample:

```
EPOCHSAT  2018 130 86280.00 23:58:00.00          C5X            - 20  +8 G  4 E  4
R  0 S  0 C  0 J  0 I  0 -12 G 10 E  1 R  0 S  0 C  0 J  1 I  0 +G01 +G09 +G06
+G03 +E05 +E24 +E26 +E03 -G31 -G12 -G23 -G17 -G18 -G14 -G25 -G11 -G19 -G22 -E08 -
J02
```


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7.14 POSTFIT MESSAGE

Postfilter values message. It provides the corrected prefits with the filter estimation. It is shown in each filter execution. Messages will be sorted by constellation, with this order: GPS, Galileo, GLONASS, GEO, BeiDou, QZSS, IRNSS. All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	POSTFIT	Fixed word indicating the data stored.	
2	Year	Year number (4 digits).	years
3	DoY	Day of Year (3 digits).	days
4	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
5	Time of day	Time in HH:MM:SS.zz format	-
6	GNSS	Satellite constellation	-
7	PRN	Satellite identifier	-
8	Block	Satellite block type	-
9	SVN	Space Vehicle Number	-
10	Arc number	Number of arc (continuous measurements without CS) since the start of the processing	-
11	Arc length	Number of undecimated epochs after the last cycle-slip	-
12	Satellite elevation	Elevation angle between the satellite and the receiver location.	degrees
13	Satellite azimuth	Azimuth angle between the satellite and the receiver location.	degrees
14	Measurement	Measurement identifier (as string)	-
15	Smoothing Measurement	Measurement identifier for smoothing (as string)	-
16	Post-fit value	Measurement minus the fited model	metres
17	Measurement	Measurement value	metres
18	Smoothed Measurement	Smoothed measurement value	metres
19	Fitted Measurement	Corrected model value with the filter estimations	metres
20	Clock Bias	Estimated inter-system clock bias	metres
21-	Ambiguities	Only given for carrier phase measurements. It is the estimated carrier phase ambiguity	metres

If no smoothing is enabled, field 15 will be a dash ('-') and field 18 will be 0.

If smoothing is enabled, field 15 is the measurement used for smoothing.

Sample:

```
POSTFIT   2019 025 85862.00 23:51:02.00 GPS 21 BLOCK_IIR-A       45   1    363
      38.373   61.866          C1C          L1P         0.0803  37372802.1720
      37372802.0569  37372801.9021         0.0000
```


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7.15 FILTER MESSAGE

Filter solution message. This message provides direct information on the filter estimates. It is shown in each filter execution. All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	FILTER	Fixed word indicating the data stored.	
2	Year	Year number (4 digits).	years
3	DoY	Day of Year (3 digits).	days
4	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
5	Time of day	Time in HH:MM:SS.zz format	-
6	GNSS reference	Constellation used as reference clock	-
7	Clocks	Number of inter-system clock bias estimated in the filter	-
8	Unknowns	Number of unknowns estimated in the filter	
9	Receiver position	X coordinate	metres
10	Receiver position	Y coordinate	metres
11	Receiver position	Z coordinate	metres
12	Receiver clock	Receiver clock offset	metres
13	Clock bias	GPS inter-system clock bias	metres
14	Clock bias	Galileo inter-system clock bias	metres
15	Clock bias	GLONASS inter-system clock bias	metres
16	Clock bias	GEO inter-system clock bias	metres
17	Clock bias	BeiDou inter-system clock bias	metres
18	Clock bias	QZSS inter-system clock bias	metres
19	Clock bias	IRNSS inter-system clock bias	metres

If troposphere is estimated in the filter, the next field will appear:

#	FIELD	DESCRIPTION	UNITS
20	Troposphere	Zenith Tropospheric Delay (vertical wet component)	metres

If any of the inter-system clock biases in Fields 13-19 is not estimated in the filter, the value will be 0.

Sample:

```
FILTER    2018 130     7.00 00:00:07.00 GPS 3 38   3924697.5020    301125.3025
5001905.0392       -10.2643         0.0000         1.8811         5.6634
0.0000         3.0240         0.0000         0.0000         2.4869
```


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7.16 OUTPUT MESSAGE

Receiver solution message. This message provides the estimated receiver position in WGS84 system. It is shown in each filter execution. All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	OUTPUT	Fixed word indicating the data stored.	
2	Year	Year number (4 digits).	years
3	DoY	Day of Year (3 digits).	days
4	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
5	Time of day	Time in HH:MM:SS.zz format	-
6	Navigation mode	Processing mode indicator	-
7	Direction mode	Processing direction indicator	-
8	Total satellites	Number of satellites used in the navigation solution	-
9	Total GNSSs	Number of constellations used in the navigation solution	-
10	GNSSs used	List of constellations used in the filter (separated by dashes ('-')	-
11	Formal error	Square root of the sum of X, Y and Z components of the covariance matrix. This is a measure of the convergence of the filter	
12	Receiver position	X coordinate	metres
13	Receiver position	Y coordinate	metres
14	Receiver position	Z coordinate	metres
15	ΔX	Receiver X position - Nominal a priori X position	metres
16	ΔY	Receiver Y position - Nominal a priori Y position	metres
17	ΔZ	Receiver Z position - Nominal a priori Z position	metres
18	Formal error	Receiver X formal error	metres
19	Formal error	Receiver Y formal error	metres
20	Formal error	Receiver Z formal error	metres
21	Receiver position	Receiver latitude	degrees
22	Receiver position	Receiver longitude	degrees
23	Receiver position	Receiver height	metres
24	ΔN	Receiver North difference in relation to nominal a priori position	metres
25	ΔE	Receiver East difference in relation to nominal a priori position	metres
26	ΔU	Receiver Up difference in relation to nominal a priori position	metres
27	Formal error	Receiver formal error in North direction	metres
28	Formal error	Receiver formal error in East direction	metres
29	Formal error	Receiver formal error in Up direction	metres
30	ΔH	Receiver horizontal difference in relation to nominal a priori position	metres
31	ΔV	Receiver vertical difference in relation to nominal a priori position	metres
32	Δ3D	Receiver 3D difference in relation to nominal a priori position	metres
33	GNSS	Constellation used as reference clock	-
34	Receiver clock	Receiver clock offset	metres
35	Formal error	Receiver clock formal error	metres
36	GDOP	Geometric Dilution of Precision	-

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#	FIELD	DESCRIPTION	UNITS
37	PDOP	Positioning Dilution of Precision	-
38	TDOP	Time Dilution of Precision	-
39	HDOP	Horizontal Dilution of Precision	-
40	VDOP	Vertical Dilution of Precision	-
41	ZTD	Zenith Tropospheric Delay (including nominal value)	metres
42	ZTD	Zenith Tropospheric Delay (excluding nominal value)	metres
43	ZTD	Zenith Tropospheric Delay formal error	metres

The fields 41, 42 and 43 will be zero if troposphere is not estimated (only estimated in PPP mode).

Processing mode indicator in field 6 may have the following values:

VALUES	MESSAGE VALUES
0	SPP
1	PPP
2	Reserved
3	Reserved
4	Reserved
5	SBAS 1 Frequency
6	SBAS DFMC
7	DGNSS

Processing direction indicator in field 7 may have the following values:

VALUES	MESSAGE VALUES
0	Forward processing
1	Backwards processing (not possible in SBAS and DGNSS modes)

The nominal a priori position is a prerequisite of the processing, and can be specified or read from the RINEX input file. See the option **'-pre:setrecpos'** in the help (**'-help'**) for more details.

Sample:

```
OUTPUT    2019 099 86100.00 23:55:00.00 1 0 30 5 GPS+GAL+GLO+BDS+QZS    0.0040  -
6257572.1031    950333.4266    785215.5957     0.0265    -0.0182    -0.0044
0.0036     0.0016     0.0009    7.119151644  171.364514044        33.6692    -
0.0008     0.0140    -0.0292     0.0013     0.0015     0.0035 GPS         1.4242
0.0573    0.0000    0.0000    0.0000    0.0000    0.0000     2.7166     0.3260
0.0035
```


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7.17 SBASCORR MESSAGE

SBAS corrections breakdown (SBAS 1F processing mode). It is shown when a model can be fully computed using SBAS corrections for GPS C1C measurement. All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	SBASCORR	Fixed word indicating the data stored. ' SBASCORR' (if it is used in computation) or 'SBASCORR*' (if it is not)	-
2	Year	Year number (4 digits).	years
3	DoY	Day of Year (3 digits).	days
4	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
5	Time of day	Time in HH:MM:SS.zz format	-
6	GNSS	Satellite constellation	-
7	PRN	Satellite identifier	-
8	Block	Satellite block type	-
9	SVN	Space Vehicle Number	-
10	Arc number	Number of arc (continuous measurements without CS) since the start of the processing	-
11	Arc length	Number of undecimated epochs after the last cycle-slip	-
12	Satellite elevation	Elevation angle between the satellite and the receiver location.	degrees
13	Satellite azimuth	Azimuth angle between the satellite and the receiver location.	degrees
14	mode	SBAS processing mode (PA or NPA)	
15	GEO PRN	GEO from which the SBAS corrections are used ('0' means all GEOs).	-
16	Prefit Residual	Measurement-model value (prefit)	metres
17	Measurement	Measurement value without smoothing	metres
18	Smoothed Measurement	Measurement value with smoothing	metres
19	Geometric range (ρ)	Satellite-receiver geometric distance (with SBAS corrections).	metres
20	Relativity correction	Delay associated to relativistic effects (with SBAS corrections).	metres
21	Satellite clock correction	It includes the clock offset correction broadcast by the satellite itself together with the satellite clock offset broadcast in the Long Term Corrections for the satellite.	metres
22	Total Group Delay (TGD) correction	Delay associated to the group of GPS satellites. From GPS navigation message.	metres
23	IPP Latitude	Latitude corresponding to the Ionospheric Pierce Point used to compute the ionospheric delay.	degrees (-90..90º)
24	IPP Longitude	Longitude corresponding to the Ionospheric Pierce Point used to compute the ionospheric delay.	degrees (0..360º)
25	Ionospheric correction	Delay associated to ionospheric effects	metres
26	Troposphere nominal correction		metres
27	PRC	Pseudorange correction (fast correction) to be applied to the satellite.	metres
28	RRC	Range-rate correction to be applied to the satellite.	metres

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#	FIELD	DESCRIPTION	UNITS
29	a_i	Fast Correction degradation factor.	metres/ seconds^2
30	PRC time-out	Time-out interval for current pseudorange correction.	seconds
31	RRC time-out	Time-out interval for current range rate correction (smallest PRC time out for all satellites).	seconds
32	PRC time reference	Time (seconds of day) used for computing PRC timeout.	seconds
33	UDRE time reference	Time (seconds of day) used for computing sigma UDRE (User Differential Range Error) timeout.	seconds
34	Fast correction degradation time reference	Time (seconds of day) used for computing fast correction degradation.	seconds
35	X	X component of the satellite position in WGS84 system at emission time with SBAS corrections.	metres
36	Y	Y component of the satellite position in WGS84 system at emission time with SBAS corrections.	metres
37	Z	Z component of the satellite position in WGS84 system at emission time with SBAS corrections.	metres
38	LTC-X	Long term correction to be applied to the X component of the satellite.	metres
39	LTC-Y	Long term correction to be applied to the Y component of the satellite.	metres
40	LTC-Z	Long term correction to be applied to the Z component of the satellite.	metres
41	LTC-Δt	Long term correction to be applied to the satellite clock.	metres
42	IODP fast corrections	IODP (Issue of Data PRN mask) used for fast corrections. If no IODP is available, the value is -1.	-
43	IODF	IODF (Issue of Data Fast Correction) in messages type 2-5, 24 for fast corrections. If no IODF is available, the value is -1.	-
44	Fast correction satellite slot	Satellite slot in the fast correction mask (1..51). If no IODP is available, the value is -1.	-
45	IODP long term corrections	IODP used for long term corrections. If no IODP is available, the value is -1.	-
46	Long term corrections satellite slot	Satellite slot in the long term correction mask (1..51). If no IODP is available, the value is -1.	-
47	IODE	IODE (Issue of Data Ephemeris) used for broadcast ephemeris. If no IODE is available, the value is 999. If an IODE is used that does not match the one broadcast in the long term corrections (only in NPA mode), the value will negative.	-
48	IODS	IODS (Service Issue of Data) used for service message. If no IODS is available or it is not used, the value is -1.	-
49	IODP clock-ephemeris covariance matrix	IODP used for clock-ephemeris covariance matrix. If no IODP is available or it is not used, the value is -1.	-
50	Clock-ephemeris covariance matrix slot	Satellite slot in the clock-ephemeris covariance mask (1..51). If no IODP is available or it is not used, the value is -1.	-

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#	FIELD	DESCRIPTION	UNITS
51	Ionosphere model flag	Flag to indicate which ionosphere model is used. Its possible values are '-1' for no ionosphere model, '0' for SBAS ionosphere model, '1' for Klobuchar ionosphere model and '2' for any other ionosphere model.	-

When the '*' appears in field 1, it is due to smoothed code of the satellite has not reached steady-state, a SBAS processing mode switch or SBAS GEO switch. When a mode or GEO switch occurs, the SBAS corrections have to be computed again.

Field 47 is the IODE value from the broadcast message matched with the SBAS long term corrections. If the field value is negative, it means that the IODE used does not match any SBAS long term correction message available (only in NPA mode). A value of 999 means that no valid broadcast message was found for the current epoch.

Field 51 is a flag to indicate which ionosphere model is used. Its possible values are '-1' for no ionosphere model, '0' for SBAS ionosphere model, '1' for Klobuchar ionosphere model and '2' for any other ionosphere model

Sample:

```
SBASCORR    2019 025 85862.00 23:51:02.00 GPS  10 BLOCK_IIF         73   1    363
46.442  148.754  PA 136  14508354.8230  36155216.6800  36155216.4923  21685564.5283
0.0277    -38710.0294         0.5584        45.0657        10.6000         1.1513
3.0581 -2.3750         0.0000 0.00580        12.0000        12.0000 85858.1 85858.1
85858.1  22933506.0221  11292690.1329   7615397.5010  -0.25000  -2.12500   0.25000
1.81482  1  0  9  1  9   49  0 -1 -1  0
```


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7.18 SBASVAR MESSAGE

SBAS variance contributions breakdown (SBAS 1F processing mode). It is shown when a model can be fully computed using SBAS corrections for GPS C1C measurement. All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	SBASVAR	Fixed word indicating the data stored. 'SBASVAR' (if it is used in computation) or 'SBASVAR*' (if it is not)	-
2	Year	Year number (4 digits).	years
3	DoY	Day of Year (3 digits).	days
4	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
5	Time of day	Time in HH:MM:SS.zz format	-
6	GNSS	Satellite constellation	-
7	PRN	Satellite identifier	-
8	Block	Satellite block type	-
9	SVN	Space Vehicle Number	-
10	Arc number	Number of arc (continuous measurements without CS) since the start of the processing	-
11	Arc length	Number of undecimated epochs after the last cycle-slip	-
12	Satellite elevation	Elevation angle between the satellite and the receiver location.	degrees
13	Satellite azimuth	Azimuth angle between the satellite and the receiver location.	degrees
14	SBAS mode	SBAS processing mode (PA or NPA)	-
15	GEO PRN	GEO from which the SBAS corrections are used ('0' means all GEOs).	-
16	σ_{total}	Sigma of the total residual error associated to the satellite.	metres
17	σ_{flt}	Sigma of the residual error associated to the fast and long-term corrections.	metres
18	σ_{UDRE}	Sigma of the UDRE (User Differential Range Error) factor.	metres
19	δ_{UDRE}	Delta UDRE (User Differential Range Error) factor.	-
20	δ_{UDRE} data source	Data source (SBAS message type number) for Delta UDRE. It may have the following values: 27 or 28 for their respective message type, -27 or -28 if received any of these message types but there was missing data for current satellite or was timed out, 0 if no message type received or both received.	-
21	ε_{fc}	Degradation parameter for fast correction data.	metres
22	ε_{rrc}	Degradation parameter for range rate correction data.	metres
23	ε_{ltc}	Degradation parameter for long term correction data or GEO navigation message data.	metres
24	ε_{er}	Degradation parameter for en route through NPA applications.	metres
25	RSS_{UDRE}	RSS (Root-Sum-Square) flag in message type 10.	-
26	σ_{UIVE}	Sigma of the residual error associated to the ionospheric corrections.	metres
27	σ_{tropo}	Sigma of the residual error associated to the tropospheric corrections.	metres
28	σ_{air}	Sigma of the total airborne receiver error.	metres

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#	FIELD	DESCRIPTION	UNITS
29	σ_{noise}	Sigma of the airborne receiver noise.	metres
30	$\sigma_{multipath}$	Sigma of the airborne receiver multipath.	metres
31	σ_{divg}	Sigma of the airborne receiver divergence.	metres

The data source indicator for Delta UDRE in field 20 may have the following values:

VALUES	VALUES MESSAGE
27 or 28	for their respective message type
-27 or -28	if received any of these message types but there was missing data for current satellite or was timed out
0	if no message type received or both received

When the '*' appears in field 1, it is due to smoothed code of the satellite has not reached steady-state, a SBAS processing mode switch or SBAS GEO switch. When a mode or GEO switch occurs, the SBAS corrections have to be computed again.

Sample:

```
SBASVAR     2019 025 85862.00 23:51:02.00 GPS   8 BLOCK_IIF         72   1    363
29.725  -64.905  PA 136         1.8196         1.0975         0.9119    1.000  27
0.1856         0.0000         0.0000         0.0000 0         1.3762         0.2413
0.3928    0.360    0.157    0.000
```


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7.19 SBASIONO MESSAGE

SBAS ionosphere breakdown (SBAS 1F processing mode). It is shown when SBAS ionosphere can be computed. All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	SBASIONO	Fixed word indicating the data stored.	-
2	Year	Year number (4 digits).	years
3	DoY	Day of Year (3 digits).	days
4	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
5	Time of day	Time in HH:MM:SS.zz format	-
6	GNSS	Satellite constellation.	-
7	PRN	Satellite identifier.	-
8	Satellite elevation	Elevation angle between the satellite and the receiver location.	degrees
9	Satellite azimuth	Azimuth angle between the satellite and the receiver location.	degrees
10	mode	SBAS processing mode (PA or NPA)	
11	GEO PRN	GEO from which the SBAS corrections are used ('0' means all GEOs).	-
12	IPP Latitude	Latitude corresponding to the Ionospheric Pierce Point used to compute the ionospheric delay.	degrees (-90..90º)
13	IPP Longitude	Longitude corresponding to the Ionospheric Pierce Point used to compute the ionospheric delay.	degrees (0..360º)
14	Interpolation mode	Interpolation mode. 0 for square interpolation, [1-4] indicates the vertex not used in triangle interpolation.	-
15	IODI vertex 1	IODI (Issue of Data Ionospheric) for vertex 1.	-
16	Band Number for vertex 1	Band Number for vertex 1.	-
17	IGP vertex 1	IGP Number for vertex 1.	-
18	Vertex 1 IGP reception time	Time of reception of last bit of vertex 1 IGP (seconds of day).	seconds
19	Vertex 1 IGP latitude	Latitude of the IGP for vertex 1 (-90..90º).	degrees
20	Vertex 1 IGP longitude	Longitude of the IGP for vertex 1 (0..360º).	degrees
21	Vertex 1 delay	Ionosphere delay (raw value from MT26) for vertex 1.	L1 metres
22	Vertex 1 variance	Ionosphere variance (raw value from MT26) for vertex 1.	L1 metres^2
23	Vertex 1 ε_{iono}	Degradation term for vertex 1.	L1 metres
24	Vertex 1 delay interpolated	Ionosphere delay after interpolation (if required) for vertex 1.	L1 metres
25	Vertex 1 variance interpolated	Ionosphere variance after applying degradation and interpolation (if required) for vertex 1.	L1 metres^2
26	Vertex 1 weight	Interpolation weight for vertex 1.	-
27	IODI vertex 2	IODI (Issue of Data Ionospheric) for vertex 2.	-
28	Band Number for vertex 2	Band Number for vertex 2.	-
29	IGP vertex 2	IGP Number for vertex 2.	-
30	Vertex 2 IGP reception time	Time of reception of last bit of vertex 2 IGP (seconds of day).	seconds
31	Vertex 2 IGP latitude	Latitude of the IGP for vertex 2 (-90..90º).	degrees

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#	FIELD	DESCRIPTION	UNITS
32	Vertex 2 IGP longitude	Longitude of the IGP for vertex 2 (0..360º).	degrees
33	Vertex 2 delay	Ionosphere delay (raw value from MT26) for vertex 2.	L1 metres
34	Vertex 2 variance	Ionosphere variance (raw value from MT26) for vertex 2.	L1 metres^2
35	Vertex 2 ε_{iono}	Degradation term for vertex 2.	L1 metres
36	Vertex 2 delay interpolated	Ionosphere delay after interpolation (if required) for vertex 2.	L1 metres
37	Vertex 2 variance interpolated	Ionosphere variance after applying degradation and interpolation (if required) for vertex 2.	L1 metres^2
38	Vertex 2 weight	Interpolation weight for vertex 2.	-
39	IODI vertex 3	IODI (Issue of Data Ionospheric) for vertex 3.	-
40	Band Number for vertex 3	Band Number for vertex 3.	-
41	IGP vertex 3	IGP Number for vertex 3.	-
42	Vertex 3 IGP reception time	Time of reception of last bit of vertex 3 IGP (seconds of day).	seconds
43	Vertex 3 IGP latitude	Latitude of the IGP for vertex 3 (-90..90º).	degrees
44	Vertex 3 IGP longitude	Longitude of the IGP for vertex 3 (0..360º).	degrees
45	Vertex 3 delay	Ionosphere delay (raw value from MT26) for vertex 3.	L1 metres
46	Vertex 3 variance	Ionosphere variance (raw value from MT26) for vertex 3.	L1 metres^2
47	Vertex 3 ε_{iono}	Degradation term for vertex 3.	L1 metres
48	Vertex 3 delay interpolated	Ionosphere delay after interpolation (if required) for vertex 3.	L1 metres
49	Vertex 3 variance interpolated	Ionosphere variance after applying degradation and interpolation (if required) for vertex 3.	L1 metres^2
50	Vertex 3 weight	Interpolation weight for vertex 3.	-
51	IODI vertex 4	IODI (Issue of Data Ionospheric) for vertex 4.	-
52	Band Number for vertex 4	Band Number for vertex 4.	-
53	IGP vertex 4	IGP Number for vertex 4.	-
54	Vertex 4 IGP reception time	Time of reception of last bit of vertex 4 IGP (seconds of day).	seconds
55	Vertex 4 IGP latitude	Latitude of the IGP for vertex 4 (-90..90º).	degrees
56	Vertex 4 IGP longitude	Longitude of the IGP for vertex 4 (0..360º).	degrees
57	Vertex 4 delay	Ionosphere delay (raw value from MT26) for vertex 4.	L1 metres
58	Vertex 4 variance	Ionosphere variance (raw value from MT26) for vertex 4.	L1 metres^2
59	Vertex 4 ε_{iono}	Degradation term for vertex 4.	L1 metres
60	Vertex 4 delay interpolated	Ionosphere delay after interpolation (if required) for vertex 4.	L1 metres
61	Vertex 4 variance interpolated	Ionosphere variance after applying degradation and interpolation (if required) for vertex 4.	L1 metres^2
62	Vertex 4 weight	Interpolation weight for vertex 4.	-
63	Mapping function	Value of the mapping function.	L1 metres
64	Slant delay	Total slant delay.	L1 metres
65	Slant sigma	Total slant sigma.	L1 metres

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Vertex 1 is the IGP north east to IPP, vertex 2 is the IGP north west to IPP, vertex 3 is the IGP south west to IPP, vertex 4 is the IGP south east to IPP. This order is shown in the following figure:

```
                    NORTH
                v2..............v1
                .              .
                .              .
                .              .
WEST            .    IPP       .        EAST
                .     *        .
                .              .
                .              .
                v3..............v4
                    SOUTH
```

When the '*' appears in field 1, it is due to smoothed code of the satellite has not reached steady-state, a SBAS processing mode switch or SBAS GEO switch. When a mode or GEO switch occurs, the SBAS corrections have to be computed again.

Sample:

```
SBASIONO     2019 025 85862.00 23:51:02.00 GPS  21   38.373   61.866  PA 136   49.061
13.442 0 0  4 200 85795.1  50  15  0.625   0.5322  0.000   0.6250   0.5322 0.5591 0
4 175 85795.1   50   10   0.625    0.5322   0.000    0.6250    0.5322 0.2531 0   4 174
85795.1  45  10  0.875 0.5322  0.000   0.8750   0.5322 0.0585 0  4 199 85795.1  45
15  0.875   0.5322  0.000   0.8750   0.5322 0.1293   1.4946   1.0043   1.0904
```


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7.20 SBASUNSEL MESSAGE

SBAS satellite unselection message (SBAS 1F processing mode). When a satellite is discarded due to MOPS criteria, this message details the reason. All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	SBASUNSEL	Fixed word indicating the data stored.	-
2	Year	Year number (4 digits).	years
3	DoY	Day of Year (3 digits).	days
4	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
5	Time of day	Time in HH:MM:SS.zz format	-
6	GNSS	Satellite constellation.	-
7	PRN	Satellite identifier.	-
8	SBAS mode	SBAS processing mode (PA or NPA)	
9	GEO PRN	GEO from which the SBAS corrections are used ('0' means all GEOs).	-
10	Error code	Number identifying the reason for discarding the satellite.	-
11	Error message	Message detailing the reason for discarding the satellite.	-

The error code in field 10 is a number which identifies the discard reason with a range from 1 to 48. Useful for parsing purposes.

Field 11 will be always between quotes in order to ease parsing purposes.

Fields 10 and 11 may have the following values:

ERROR CODE	ERROR MESSAGE
1	"No GEO satellites available"
2	"No data for user selected GEO"
3	"Not enough almanac or GEO navigation message to determine the GEO with highest elevation"
4	"Received alarm message for current GEO at epoch <YYYY DoY SoD>. Time remaining to finish alarm: <seconds> seconds"
5	"Received 4 or more consecutive messages with errors"
6	"Missed 4 or more consecutive messages"
7	"No PRN mask"
8	"PRN mask timed out"
9	"Satellite is not monitored in any of the PRN mask available"
10	"No message type 10 available [PA only]"
11	"Message type 10 timed out [PA only]"
12	"No fast correction data received for current PRN [PA only]"
13	"Sigma UDRE timed out [PA only]"
14	"Satellite flagged as 'Not monitored' (UDREI=14)"
15	"Satellite flagged as 'Do not use' (UDREI=15)"
16	"Satellite has an UDREI value of <value> [PA only]
17	"No fast correction degradation data [PA only]"
18	"Fast correction degradation data timed out [PA only]"
19	"Last PRC received timed out [PA only]"
20	"Only one PRC received. RRC calculation not possible [PA only]"

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ERROR CODE	ERROR MESSAGE
21	"RRC timed out (under alarm condition) due to time difference between PRC used [PA only]"
22	"RRC timed out (under alarm condition) due to excessive PRC propagation in time [PA only]"
23	"RRC timed out due to time difference between PRC used [PA only]"
24	"RRC timed out due to excessive PRC propagation in time [PA only]"
25	"Service message timed out [PA only]"
26	"Not received a full set of service messages with the same IODS [PA only]"
27	"No clock-ephemeris covariance matrix data for current satellite [PA only]"
28	"Clock-ephemeris covariance matrix data timed out [PA only]"
29	"No navigation data for ranging GEO"
30	"Ranging GEO navigation data timed out"
31	"URA index value of <value> for ranging GEO satellite"
32	"No long term correction data for current satellite [PA only]"
33	"Long term correction data timed out [PA only]"
34	"No broadcast block with IOD <value> [PA only]"
35	"No broadcast block available for current satellite (regardless of SBAS IOD) [NPA only]"
36	"Could not compute transmission time for current PRN measurement"
37	"No ionospheric grid mask [PA only]"
38	"Ionospheric grid mask timed out [PA only]"
39	"IGPs around ionospheric pierce point not found in MOPS grid [PA only]"
40	"Not enough IGPs available in ionospheric grid mask [PA only]"
41	"One IGP is set as don't use [PA only]"
42	"One or more IGPs is set as not monitored or has timed out [PA only]"
43	"Data not available for one or more IGPs [PA only]"
44	"Ionospheric pierce point is outside triangle [PA only]"
45	"External ionosphere model not available"
46	"Satellite is not in view (elevation <value>º)"
47	"Satellite elevation (<value>º) is too low"
48	"Satellite has an UDREI value of <value> (user threshold is <value>)"

Error code number 45 will only appear if user has selected another ionosphere model for SBAS processing

Error codes number 46 and 47 will only appear in SBAS plots mode

Sample:

```
SBASUNSEL   2019 026  4102.00 01:08:22.00 GPS  26  PA 136 15 "Satellite flagged as 'Do not use' (UDREI=15)"
```


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7.21 SBASDFMCCORR MESSAGE

SBAS corrections breakdown (SBAS DFMC processing mode). It is shown when a model can be fully computed using SBAS DFMC corrections with iono-free measurements. Messages will be sorted by constellation, with this order: GPS, Galileo, GLONASS, GEO, BeiDou, QZSS, IRNSS. All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	SBASDFMCCORR	Fixed word indicating the data stored. 'SBASDFMCCORR' (if it is used in computation) or 'SBASDFMCCORR*' (if it is not)	-
2	Year	Year number (4 digits).	years
3	DoY	Day of Year (3 digits).	days
4	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
5	Time of day	Time in HH:MM:SS.zz format	-
6	GNSS	Satellite constellation	-
7	PRN	Satellite identifier	-
8	Block	Satellite block type	-
9	SVN	Space Vehicle Number	-
10	Arc number	Number of arc (continuous measurements without CS) since the start of the processing	-
11	Arc length	Number of undecimated epochs after the last cycle-slip	-
12	Satellite elevation	Elevation angle between the satellite and the receiver location.	degrees
13	Satellite azimuth	Azimuth angle between the satellite and the receiver location.	degrees
14	SBAS mode	SBAS processing mode (PA or NPA)	
15	GEO PRN	GEO from which the SBAS corrections are used ('0' means all GEOs).	-
16	Measurement	Measurement identifier (as string)	-
17	Smoothing Measurement	Measurement identifier for smoothing (as string)	
18	Prefit value	Measurement-model value (prefit)	metres
19	Measurement	Measurement value without smoothing	metres
20	Smoothed Measurement	Measurement value with smoothing	metres
21	Modelled range	Satellite-receiver geometric distance (with SBAS corrections)	metres
22	Relativity	Relativity correction (with SBAS corrections)	metres
23	Clock Offset	Satellite clock correction (with SBAS corrections)	metres
24	TGD	GPS LNAV TGD (Total Group Delay) correction	L1 metres
25	Troposphere	Troposphere nominal correction	metres
26	Satellite position	X component of the satellite position in WGS84 system at emission time with SBAS corrections	metres
27	Satellite position	Y component of the satellite position in WGS84 system at emission time with SBAS corrections	metres
28	Satellite position	Z component of the satellite position in WGS84 system at emission time with SBAS corrections	metres
29	Satellite position correction	Correction to be applied to the X component of the satellite	metres
30	Satellite position correction	Correction to be applied to the Y component of the satellite	metres

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#	FIELD	DESCRIPTION	UNITS
31	Satellite position correction	Correction to be applied to the Z component of the satellite	metres
32	Satellite clock correction	Correction to be applied to the satellite clock	metres
33	DFREI	Dual Frequency Residual Error Indicator for the current satellite	-
34	DFREI time	Time (seconds of day) of last DFREI received	seconds
35	MT32 time	Time (seconds of day) of last MT32 received	seconds
36	MT39/40 time	Time (seconds of day) of last MT39/40 pair received	seconds
37	MT32 validity	Validity time of MT32	seconds
38	MT39/40 validity	Validity time of MT39/40 message pair	seconds
39	IODM	Issue of Data Mask used for corrections	-
40	IODN	Issue of Data Navigation for non GEO satellites or IODG (Issue of Data GEO) for GEO satellites	-
41	Slot Number	Slot Number in PRN mask	-

When the '*' appears in field 1, it is due to smoothed code of the satellite has not reached steady-state, a SBAS processing mode switch or SBAS GEO switch. When a mode or GEO switch occurs, the SBAS corrections have to be computed again.

If no smoothing is enabled, field 17 will be a dash ('-')

Field 24 will be 0 for non GPS satellites, as TGD is only applied in GPS constellation.

Field 35 will be -1 when ranging satellite is the same as the GEO providing the corrections.

Field 36 will be -1 when ranging satellite is not a GEO satellite.

Field 37 will be 0 when ranging satellite is the same as the GEO providing the corrections.

Field 38 will be 0 when ranging satellite is not a GEO satellite.

Field 40 is the IODE value from the broadcast message matched with the SBAS corrections.

Sample:

```
SBASDFMCCORR    2019 183   366.00 00:06:06.00 GAL  12 GALILEO-1        102   1
367   56.240 -131.144  PA 122 PC15-C1C-C5Q LC15-L1C-L5Q    -77661.5914
22118290.4022  22118290.5451  24090622.3075    -0.2348  -1894344.7968     0.0000
2.8714   1063555.2596  20678074.5523 -21146925.6105   0.5000  -0.1250  -0.0625
1.5938  6   365.12   331.12    -1.00   240.00     0.00 0   30  86
```


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7.22 SBASDFMCVAR MESSAGE

SBAS variance contributions breakdown (SBAS DFMC processing mode). It is shown when a model can be fully computed using SBAS DFMC corrections with iono-free measurements. Messages will be sorted by constellation, with this order: GPS, Galileo, GLONASS, GEO, BeiDou, QZSS, IRNSS. All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	SBASDFMCVAR	Fixed word indicating the data stored. 'SBASDFMCVAR' (if it is used in computation) or 'SBASCORR*' (if it is not)	-
2	Year	Year number (4 digits).	years
3	DoY	Day of Year (3 digits).	days
4	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
5	Time of day	Time in HH:MM:SS.zz format	-
6	GNSS	Satellite constellation	-
7	PRN	Satellite identifier	-
8	Block	Satellite block type	-
9	SVN	Space Vehicle Number	-
10	Arc number	Number of arc (continuous measurements without CS) since the start of the processing	-
11	Arc length	Number of undecimated epochs after the last cycle-slip	-
12	Satellite elevation	Elevation angle between the satellite and the receiver location.	degrees
13	Satellite azimuth	Azimuth angle between the satellite and the receiver location.	degrees
14	SBAS mode	SBAS processing mode (PA or NPA)	
15	GEO PRN	GEO from which the SBAS corrections are used ('0' means all GEOs).	-
16	σ_{total}	Sigma of the total residual error associated to the satellite	metres
17	DFC	Dual Frequency Corrections sigma (residual error associated to SBAS corrections)	metres
18	DFREI	Dual Frequency Residual Error Indicator for the current satellite	-
19	DFREI flag	Flag to indicate if DFREI has been bumped by 1 (0->not bumped, 1->bumped) through MT34	-
20	DFRE	Dual Frequency Residual Error sigma converted from DFREI	metres
21	Δ DFRE	Delta DFRE factor	
22		Degradation parameter for corrections	metres
23		Degradation parameter for en route through NPA applications	metres
24	σ_{iono}	Sigma of the residual error associated to the ionosheric corrections	metres
25	σ_{tropo}	Sigma of the residual error associated to the tropospheric corrections	metres
26	σ_{total}	Sigma of the total receiver error	metres
27	σ_{noise}	Sigma of the receiver noise	metres
28	$\sigma_{multipath}$	Sigma of the receiver multipath	metres
29	$\sigma_{divergence}$	Sigma of the receiver divergence	metres
30		Ccorr used for computing degradation terms	metres

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#	FIELD	DESCRIPTION	UNITS
31		Icorr used for computing degradation terms	seconds
32		Rcorr used for computing degradation terms	m/s
33		DeltaRcorr factor used for computing degradation terms	
34		Computed RcorrSV used for computing degradation terms	m/s
35		Cer used for computing degradation terms	metres
36		Ccovariance used for computing degradation terms	metres

When the '*' appears in field 1, it is due to smoothed code of the satellite has not reached steady-state, a SBAS processing mode switch or SBAS GEO switch. When a mode or GEO switch occurs, the SBAS corrections have to be computed again.

Fields 30, 31, 32, 33, 35 and 36 may be provided by MT37 or by parameter.

Sample:

```
SBASDFMCVAR     2019 183   366.00 00:06:06.00 GAL  26 GALILEO-2        203   1
367   14.645   32.278  PA 122         1.3482         1.0003  5 0   1.0000   1.0000
0.0230   0.0000   0.1021   0.4678   0.7667   0.4000   0.6541   0.0000   0.1900
36.0000   0.0010   1.0000   0.0010   0.0000   0.0000
```


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7.23 SBASDFMCUNSEL MESSAGE

SBAS satellite unselection message (SBAS DFMC processing mode). When a satellite is discarded due to MOPS DFMC criteria, this message details the reason. Messages will be sorted by constellation, with this order: GPS, Galileo, GLONASS, GEO, BeiDou, QZSS, IRNSS. All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	SBASDFMCUNSEL	Fixed word indicating the data stored. 'SBASDFMCUNSEL' (if it is the definitive reason for discarding) or 'SBASDFMCUNSEL*' (if there has been a GEO or mode switch or not reached smoothed code steady-state operation)	-
2	Year	Year number (4 digits).	years
3	DoY	Day of Year (3 digits).	days
4	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
5	Time of day	Time in HH:MM:SS.zz format	-
6	GNSS	Satellite constellation.	-
7	PRN	Satellite identifier.	-
8	SBAS mode	SBAS processing mode (PA or NPA)	
9	GEO PRN	GEO from which the SBAS corrections are used (‘0’ means all GEOs).	-
10	Error code	Number identifying the reason for discarding the satellite.	-
11	Error message	Message detailing the reason for discarding the satellite.	-

The error code in field 10 is a number which identifies the discard reason with a range from 1 to 27. Useful for parsing purposes.

Field 11 will be always between quotes in order to ease parsing purposes.

Fields 10 and 11 may have the following values:

ERROR CODE	ERROR MESSAGE
1	"No GEO satellites available"
2	"No data for user selected GEO"
3	"Not enough almanac or GEO navigation message to determine the GEO with highest elevation"
4	"Received alarm message for current GEO at epoch <YYYY DoY SoD>. Time remaining to finish alarm: <seconds> seconds"
5	"Received <value> consecutive messages with errors (DFREI data has been forced to timeout)"
6	"Missed <value> consecutive messages"
7	"No PRN mask"
8	"PRN mask timed out"
9	"Satellite is not monitored in any of the PRN mask available"
10	"No message type 37 available"
11	"Message type 37 timed out"
12	"No DFREI data received for current PRN"
13	"DFREI timed out"
14	"Satellite flagged as 'Do not use' (DFREI=15)"
15	"Received DFRECI=1 in MT34 but no new DFREI value"
16	"Satellite has an DFREI value of <value> (user threshold is <value>)"

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ERROR CODE	ERROR MESSAGE
17	"No MT39/40 from GEO <value> received (same GEO as source corrections)"
18	"No data from GEO <value> received for MT39/40"
19	"No MT39/40 message pair from GEO <value> received"
20	"Message type 39/40 pair timed out"
21	"No message type 32 received for current PRN"
22	"Message type 32 timed out"
23	"IODN in Message type 32 does not match with IODG in message type 39/40"
24	"Could not compute transmission time for current PRN"
25	"No broadcast block with IOD <value>"
26	"Satellite is not in view (elevation <value> degrees)"
27	"Satellite elevation (<value> degrees) is too low"

Error code number 15 should never occur, as SARPS requirements state that in MT34 a maximum of 7 DFRECI values can be equal to 1.

Error codes number 26 and 27 will only appear in SBAS plots mode.

Sample:

```
SBASDFMCUNSEL   2019 183   366.00 00:06:06.00 GPS  22  PA 122 14 "Satellite
flagged as 'Do not use' (DFREI=15)"
```


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7.24 SBASOUT MESSAGE

Receiver solution message (SBAS 1F/DFMC processing mode). This message provides the estimated receiver position, protection levels and satellites used in solution computation. All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	SBASOUT	Fixed word indicating the data stored.	-
2	Year	Year number (4 digits).	years
3	DoY	Day of Year (3 digits).	days
4	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
5	Time of day	Time in HH:MM:SS.zz format	-
6	GPS week	Week number in GPS Time. This field is related to the GPS week of the data snapshot used for the computations.	weeks
7	Time of week	Seconds elapsed since the beginning of the week. This field is related to the GPS number of seconds of the data snapshot used for the computations.	seconds
8	Receiver id	Receiver identification.	-
9	Mode indicator	Processing mode indicator	-
10	Mode	SBAS processing mode: PA, NPA.	-
11	GEO PRN	GEO from which the SBAS corrections are used ('0' means all GEOs).	-
12	ΔN	Receiver North difference in relation to nominal a priori position.	metres
13	ΔE	Receiver East difference in relation to nominal a priori position.	metres
14	ΔU	Receiver Up difference in relation to nominal a priori position.	metres
15	HPE	Horizontal positioning error.	metres
16	HPL	Horizontal protection level.	metres
17	HAL	Horizontal alarm limit	metres
18	VPE	Receiver vertical positioning error.	metres
19	VPL	Vertical protection level.	metres
20	VAL	Vertical alarm limit	metres
21	3D positioning error		
22	Receiver clock offset	Offset associated to the receiver clock.	metres
23	Satellites in view	Number of satellites in view suitable for SBAS.	-
24	Satellites used in filter	Number of satellites used in SBAS solution computation.	-
25-	List of satellites	Satellite list. Each following column is a '+' or '-' sign, the satellite system and the PRN identifier. The '+' sign indicates that the satellite has been used in the solution computation for SBAS. The '-' sign indicates that the satellite has not been used in the solution computation for SBAS. The satellite list will show first all the satellite with the '+' and after the ones with the '-' sign.	-

Processing mode indicator in field 9 may have the following values:

VALUES	VALUES MESSAGE
0	SPP (this mode will never occur when using SBAS processing)

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1	PPP (this mode will never occur when using SBAS processing)
2	Reserved
3	Reserved
4	Reserved
5	SBAS 1 Frequency
6	SBAS DFMC
7	DGNSS (this mode will never occur when using SBAS processing)

The nominal a priori position is a prerequisite of the processing, and can be specified or read from the RINEX input file. See the option **'-pre:setrecpos'** in the help (**'-help'**) for more details.

Sample:

```
SBASOUT     2015 165   386.00 00:06:26.00 1849    386.00 vigo  PA 120
0.7862         1.4262        -0.2907         1.6285        20.9835  40.00
0.2907        21.8638  50.00    -94936.8129 11 10 +G23 +G17 +G01 +G04 +G10 +G11
+G03 +G06 +G31 +G32 -G09
```


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7.25 DGNSS MESSAGE

DGNSS corrections breakdown (DGNSS processing mode). It is shown when a model can be fully computed using DGNSS corrections for GPS C1C measurement. Messages will be sorted by constellation, with this order: GPS, Galileo, GLONASS, GEO, BeiDou, QZSS, IRNSS. All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	DGNSS	Fixed word indicating the data stored. 'DGNSS' (if it is used in computation) or 'DGNSS*' (if it is not, switched to SPP)	-
2	Year	Year number (4 digits).	years
3	DoY	Day of Year (3 digits).	days
4	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
5	Time of day	Time in HH:MM:SS.zz format	-
6	GNSS	Satellite constellation.	-
7	PRN	Satellite identifier.	-
8	PRC	Pseudorange correction to be applied to the satellite.	metres
9	RRC	Range rate correction to be applied to the satellite.	metres
10	RRC time	Seconds elapsed since the reception of the RRC correction.	seconds
11	Delta PRC	Delta of PRC to be applied in case of change in case of a change in ephemeris.	metres
12	Delta RRC	Delta of RRC to be applied in case of change in case of a change in ephemeris.	metres
13	Delta RRC time	Seconds elapsed since the reception of the delta RRC correction.	seconds
14	Total sigma	Sigma of the total residual error associated to the satellite Sigma of the total residual error = sigma of the UDRE + sigma degradation + sigma air	metres
15	Sigma UDRE	Sigma of the UDRE (User Differential Range Error).	metres
16	Sigma degradation	Sigma degradation consists of the URA (User Range Accuracy) degradation factor (we assume epsURA = 1 cm/s), and the satellite elevation. It only applies for RTCM v3.x Sigma degradation = (epsURA · dt) / tan(satellite elevation)	metres
17	Sigma air	Sigma air consists of the sigma multipath, the sigma to noise GPS (we assume 0.25 m) and the sigma inflation (equal to 1 if deactivated) Sigma degradation = (sigma multipath + sigma to noise GPS) * sigma inflation	metres
18	Sigma multipath	Sigma multipath = 0.0625 / tan(elev) / tan(elev)	metres
19	Sigma inflation	Sigma inflation during the convergence of the smoothing	-

Sample:

```
DGNSS     2016 294  5407.000 01:30:07.00 GPS  6  -4.1800   0.0000   1.5999   0.0000
0.0000   0.0000   0.6053   0.3000   0.0000   0.5257   0.0264   1.0000
```


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7.26 SATSTAT MESSAGE

Satellite difference summary message for products comparison mode (orbit and clock comparison). This message shows the differences between orbit and clocks for two different OC products fonts for a specific satellite. It is shown after all the comparisons are done, and presents a summary for each satellite.

#	FIELD	DESCRIPTION	UNITS
1	SATSTAT	Fixed word indicating the data stored.	-
2	GNSS	Satellite constellation.	-
3	PRN	Satellite identifier.	-
4	Total epochs	Number of samples	-
5-7	SISRE	SISRE comparisons (mean, RMS, stdDev)	metres
8-10	SISRE	SISRE orbit-only comparisons (mean, RMS, stdDev)	metres
11-13	3D	3D orbit comparisons (mean, RMS, stdDev)	metres
14-16	Clock	Clock comparisons (mean, RMS, stdDev)	metres
17-19	DCB	DCB comparisons (mean, RMS, stdDev)	L1 metres
20-22	Radial	Radial position comparisons (mean, RMS, stdDev)	metres
23-25	Along-Track	Along-track position comparisons (mean, RMS, stdDev)	metres
26-28	Cross-Track	Cross-track position comparisons (mean, RMS, stdDev)	metres

Sample:

```
SATSTAT  1   95     1.5530     2.1112     1.4302     0.9279     1.0058     0.3881
1.4115     1.4714     0.4155    -0.3357     1.9280     1.8985     0.8988
0.9938     0.4239     0.6081     0.9604     0.7433     0.1717     0.5050
0.4750
```


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7.27 SATSTATOT MESSAGE

Difference summary message for products comparison mode (orbit and clock comparison). This message shows the statistics of the differences between orbit and clocks for two different OC products fonts. It is shown after all the comparisons are done, and presents a summary for all of them.

#	FIELD	DESCRIPTION	UNITS
1	SATSTATTOT	Fixed word indicating the data stored.	-
3-5	SISRE	SISRE comparisons (mean, RMS, stdDev)	metres
6-8	SISRE	SISRE orbit-only comparisons (mean, RMS, stdDev	metres
9-11	3D	3D orbit comparisons (mean, RMS, stdDev)	metres
12-14	Clock	Clock comparisons (mean, RMS, stdDev)	metres
15-17	DCB	DCB comparisons (mean, RMS, stdDev)	L1 metres
18-20	Radial	Radial position comparisons (mean, RMS, stdDev)	metres
21-23	Along-Track	Along-track position comparisons (mean, RMS, stdDev	metres
24-26:	Cross-Track	Cross-track position comparisons (mean, RMS, stdDev	metres

Sample:

```
SATSTATTOT 2660     1.2971     1.6206     0.9714     1.0207     1.1478     0.5250
1.6623     1.7701     0.6083    -0.1909     1.3835     1.3702     0.9488
1.1312     0.6160     0.0514     1.1930     1.1918    -0.0345     0.6560
0.6551
```


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7.28 SATDIFF MESSAGE

Satellite difference message for products comparison mode (orbit and clock comparison). This message shows the difference between both orbit and clocks for two different OC products fonts for a specific time. It is shown each time step.

The SISRE fields are the Signal-in-Space Range Error, it is a measure of how the error impact a general receiver found in the Earth's surface. It is computed as:

SISRE = sqrt((radDiff-clkDiff)^2 + 1/49*(ctDiff^2 + atDiff^2))

Being:

radDiff, the difference of satellite positions in the radial component

clkDiff, the difference of satellite clock offsets

ctDiff, the difference of satellite positions in the cross-track component

atDiff, the difference of satellite positions in the along-track component

All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	SATDIFF	Fixed word indicating the data stored.	-
2	Year	Year number (4 digits).	years
3	DoY	Day of Year (3 digits).	days
4	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
5	Time of day	Time in HH:MM:SS.zz format	-
6	GNSS	Satellite constellation.	-
7	PRN	Satellite identifier.	-
8	SISRE	SISRE difference	metres
9	SISRE	SISRE orbit-only difference	metres
10	3D	3D orbit difference	metres
11	Clock	Clock difference	metres
12	DCB	GPS P1-P2 DCB difference or QZSS C1C DCB difference. If not GPS or QZSS, this value is 0 [L1 m]	metres
13	Radial	Radial position difference	
14	Along-Track	Along-track position difference	metres
15	Cross-Track	Cross-track position difference	metres
16	ΔX	X position difference	metres
17	ΔY	Y position difference	metres
18	ΔZ	Z position difference	metres
19	Orbit type	Ephemerides block type name (LNAV, CNAV, etc.) or 'SP3' if precise products are used	-
20	IODE first orbit source	IOD number or '-1' if no IOD in broadcast message or precise products are used for first orbit source	-
21	IODE second orbit source	IOD number or '-1' if no IOD in broadcast message or precise products are used for second orbit source	-
22	Health status first orbit source	Health letter (H=Healthy, M=Marginal, U=Unhealthy), health value. If unhealthy, health flags are shown by frequency for first orbit source	-

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23	Health status second orbit source	Health letter (H=Healthy, M=Marginal, U=Unhealthy), health value. If unhealthy, health flags are shown by frequency for second orbit source	-

Sample:

```
SATDIFF 2018 026   300.00 00:05:00.00 GPS  1     0.3205     0.7588     1.0104    -
0.4470    -0.7526     0.2982    -0.6046     0.3084     0.9177     0.2892
LNAV-SP3        73  -1 H-0
```


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7.29 SATPVT MESSAGE

Satellite data messages for show product mode. This message show the PVT data for a specific time and satellite. All time tags are in GPS time.

Messages will be sorted by constellation and PRN, with this constellation order: GPS, Galileo, GLONASS, GEO, BeiDou, QZSS, IRNSS.

Coordinates are in WGS84 system except for Galileo and BeiDou with broadcast orbits, which are in GTRF and CGCS2000 systems respectively.

GTRF and CGCS2000 systems are aligned to WGS84 to a few centimetres, therefore, it is assumed that GTRF=WGS84 and CGCS2000=WGS84.

#	FIELD	DESCRIPTION	UNITS
1	SATPVT	Fixed word indicating the data stored.	-
2	Year	Year number (4 digits).	years
3	DoY	Day of Year (3 digits).	days
4	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
5	Time of day	Time in HH:MM:SS.zz format	-
6	GNSS	Satellite constellation.	-
7	PRN	Satellite identifier.	-
8	Satellite block type		-
9	SVN	Space Vehicle Number	-
10	Satellite elevation	Elevation angle between the satellite and the user defined position.	degrees
11	Satellite azimuth	Azimuth angle between the satellite and the user defined position.	degrees
12	Satellite position	X coordinate.	metres
13	Satellite position	Y coordinate.	metres
14	Satellite position	Z coordinate.	metres
15	Satellite velocity	X component of satellite velocity.	m/s
16	Satellite velocity	Y component of satellite velocity.	m/s
17	Satellite velocity	Z component of satellite velocity.	m/s
18	Satellite position	Latitude coordinate.	degrees
19	Satellite position	Longitude coordinate.	degrees
20	Satellite position	Height coordinate.	metres
21	Satellite clock	Satellite clock offset	metres
22	Orbit type	Ephemerides block type name (LNAV, CNAV, etc.) or 'SP3' if precise products are used	-
23	IODE	IOD number or '-1' if no IOD in broadcast message or precise products are used	-
24	Health status	Health letter (H=Healthy, M=Marginal, U=Unhealthy), health value. If unhealthy, health flags are shown by frequency.	-

Fields 10 and 11 will only be non zero if a user defined position is set with parameter '**-pre:setrecpos**'.

Sample:

```
SATPVT 2019 182 64830.00 18:00:30.00 GPS  4 BLOCK_IIIA        74  15726758.8543 -
11721444.2647 -17893256.4825      2263.5069       284.8536      1801.6815  -
42.418676449  -36.697844087  20181374.7732      50617.846188      LNAV    2 U-
63_(L1-U_L2-U)
```


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7.30 SUMMARY

The processing summary is printed at the end of the output file if the summary option is enabled.

The contents of the summary are:

- Number of epochs processed, along with the number epochs that had a solution.
- Number of epochs skipped (epochs without solution) in total and per each possible reason for skipping the epoch.
- Number of epochs missing during the summary period (if decimation is enabled, the epochs missing will be separated into the epochs which would have been decimated or not decimated.
- Number of epochs missing in the whole file.
- Number of data gaps during the summary period.
- Number of data gaps in the whole file.
- Maximum data gap size during the summary period and the epoch where it occurred.
- Maximum data gap size in the whole file and the epoch where it occurred.
- The number of used constellation mean value, 50 and 95 percentile (or user defined percentile).
- The number of not used constellation mean value, 50 and 95 percentile (or user defined percentile). User unselected constellations will not count as not used.
- The number of epochs and the percentage in respect of total epochs with solution of each set of constellations used.
- The number of epochs and the percentage in respect of total epochs with solution of each set of constellations not used. User unselected constellations will not count as not used.
- The number of used satellites (in total and per constellation) mean value, 50 and 95 percentile (or user defined percentile).
- The number of not used satellites (in total and per constellation) mean value, 50 and 95 percentile (or user defined percentile). User unselected satellites will not count as not used.
- The maximum and minimum number of satellites used (in total and per constellation) and the epochs were it ocurred.
- The maximum and minimum number of satellites not used (in total and per constellation) and the epochs were it ocurred. User unselected satellites will not count as not used.
- Time to first fix (first epoch with solution).
- The 95 Percentile (or user defined percentile) of the PDOP,GDOP,TDOP,HDOP and VDOP.

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- The minimum and maximum value of PDOP,GDOP,TDOP,HDOP and VDOP and the epochs were it ocurred.
- The 95 Percentile (or user defined percentile) of the horizontal, vertical, east, north and 3D errors.
- The maximum highest horizontal, vertical, east, north and 3D errors and the epochs were it ocurred.
- The total processing time, providing also the percentages of processing time in user mode and in kernel mode.
    - In the non-mutithread version of gLAB, the processing times are provided by the system function that provided thread CPU time.
    - In multi-thread version of gLAB, the CPU time provided by the system function is the sum of all CPU time of all threads, which can can yield a total time greater than than the real time (user perceived time) passed. In this case, gLAB will show the real time passed (but using the user and Kernel time percentages from the system functions).
    - The processing time is computed just at the end of the summary, where still the print with the processing time and the last line of the summary are to be done, and also the last lines of gLAB code which are for freeing memory. These last instructions add less than 1ms of processing time for user time and less than to 0.2 seconds of Kernel time.
- A single line at the end with the previous info in columnar format. This is line is useful for doing plots.

Additionally, for PPP processing, the following information is provided:

- Convergence time (counting from the first epoch with solution) using the horizontal, vertical and 3D formal error.
- Convergence time (counting from the first epoch with solution) using the horizontal, vertical and 3D formal error and maintained during a given period.
- Convergence time (counting from the first epoch with solution) using the horizontal, vertical and 3D positioning error.
- Convergence time (counting from the first epoch with solution) using the horizontal, vertical and 3D positioning error and maintained during a given period.

Additionally, for SBAS processing, the following information is provided:

- Number of epochs with solution under alarm limits.
- Number of epochs with MIs.
- The 95 Percentile (or user defined percentile) of the integrity ratio.
- The Best Integrity Ratio (BIR) and Worst Integrity Ratio (WIR) and the epochs were it ocurred.
- The epoch with minimum and maximum protection levels and the epochs were it ocurred.

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- The 95 Percentile (or user defined percentile) of the protection levels.

Additionally, for DGNSS processing, the following information is provided:

- Number of epochs missing during the summary period in the reference station file (RINEX only).
- Number of epochs missing in the whole file in the reference station file (RINEX only).
- Number of data gaps during the summary period in the reference station file (RINEX only).
- Number of data gaps in the whole file in the reference station file (RINEX only)..
- Maximum data gap size during the summary period and the epoch where it occurred in the reference station file (RINEX only).
- Maximum data gap size in the whole file and the epoch where it occurred in the reference station file (RINEX only).

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7.30.1 SPP statistical summary

It is printed at the end of the output file if summary is enabled. All time tags are in GPS time.

```
INFO --------------------- SPP Summary ---------------------

INFO First epoch of summary: 02/07/2019 00:00:00.00 / 2019 183     0.00 /
2060 172800.00

INFO Last  epoch of summary: 02/07/2019 23:59:59.00 / 2019 183 86399.00 /
2060 259199.00

INFO Total epochs processed: 86400

INFO Total epochs processed with solution: 86320 ( 99.907% )

INFO Total epochs skipped due to less than 4 valid satellites available: 2
( 0.002% )

INFO Total epochs skipped due to singular geometry matrix: 78 ( 0.090% )

INFO Total epochs skipped due to reference constellation not available: 0 (
0.000% )

INFO Total epochs skipped (any reason): 80 ( 0.093% )

INFO Total epochs missing in observation file (during summary period):   0

INFO Total epochs missing in observation file (all the file):            0

INFO Number of data gaps in observation file (during summary period):   0

INFO Number of data gaps in observation file (all the file):            0

INFO Maximum data gap size in observation file (during summary period):   0

INFO Maximum data gap size in observation file (all the file):            0

INFO Time To First Fix: 2 seconds (3 epochs) at epoch 02/07/2019 00:00:02.00
/ 2019 183     2.00 / 2060 172802.00

INFO Constellations     used 50 Percentile:  5 |  95 Percentile:  5 | Mean:
4.99

INFO Constellations not used 50 Percentile:  1 |  95 Percentile:  1 | Mean:
1.01

INFO Number of epochs with constellations used: GPS+QZS 13 ( 0.015% )
GPS+BDS+QZS 25 ( 0.029% ) GPS+GEO+BDS+QZS 625 ( 0.724% ) GPS+GAL+GEO+BDS+QZS
85657 ( 99.232% )

INFO Number of epochs with constellations not used: GAL+GLO+GEO+BDS 13 (
0.015% ) GAL+GLO+GEO 25 ( 0.029% ) GAL+GLO 625 ( 0.724% ) GLO 85657 ( 99.232%
)

INFO Constellations used as reference clock: GPS 86320 ( 100% )

INFO Satellites used (all constellations) 50 Percentile: 31 |  95 Percentile:
27 | Mean: 30.56

INFO Satellites used (GPS)               50 Percentile:  8 |  95 Percentile:
7 | Mean:  8.75

INFO Satellites used (GAL)               50 Percentile:  7 |  95 Percentile:
5 | Mean:  6.61
```


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```
INFO Satellites used (GEO)              50 Percentile:  3 |  95 Percentile:
2 | Mean:  2.77

INFO Satellites used (BDS)              50 Percentile: 10 |  95 Percentile:
8 | Mean:  9.77

INFO Satellites used (QZS)              50 Percentile:  3 |  95 Percentile:
2 | Mean:  2.66

INFO Satellites not used (all constellations) 50 Percentile: 14 |   95
Percentile: 17 | Mean: 14.11

INFO Satellites not used (GPS)                  50 Percentile:  1 |   95
Percentile:  2 | Mean:  0.74

INFO Satellites not used (GAL)                  50 Percentile:  1 |   95
Percentile:  2 | Mean:  0.90

INFO Satellites not used (GLO)                  50 Percentile:  7 |   95
Percentile:  9 | Mean:  7.48

INFO Satellites not used (GEO)                  50 Percentile:  3 |   95
Percentile:  4 | Mean:  3.23

INFO Satellites not used (BDS)                  50 Percentile:  0 |   95
Percentile:  2 | Mean:  0.42

INFO Satellites not used (QZS)                  50 Percentile:  1 |   95
Percentile:  2 | Mean:  1.34

INFO Minimum satellites used (all constellations) 24 (G 5 E 5 S 3 C 8 J 3)
at epoch 02/07/2019 06:28:03.00 / 2019 183 23283.00 / 2060 196083.00

INFO Minimum satellites used (GPS)                5                      at
epoch 02/07/2019 06:29:57.00 / 2019 183 23397.00 / 2060 196197.00

INFO Minimum satellites used (GAL)                4                      at
epoch 02/07/2019 16:16:00.00 / 2019 183 58560.00 / 2060 231360.00

INFO Minimum satellites used (GEO)                1                      at
epoch 02/07/2019 22:37:27.00 / 2019 183 81447.00 / 2060 254247.00

INFO Minimum satellites used (BDS)                7                      at
epoch 02/07/2019 19:53:01.00 / 2019 183 71581.00 / 2060 244381.00

INFO Minimum satellites used (QZS)                2                      at
epoch 02/07/2019 23:31:21.00 / 2019 183 84681.00 / 2060 257481.00

INFO Maximum satellites used (all constellations) 36 (G 12 E 8 S 3 C 11 J
2) at epoch 02/07/2019 21:22:18.00 / 2019 183 76938.00 / 2060 249738.00

INFO Maximum satellites used (GPS)               13                      at
epoch 02/07/2019 02:45:09.00 / 2019 183  9909.00 / 2060 182709.00

INFO Maximum satellites used (GAL)               10                      at
epoch 02/07/2019 10:35:40.00 / 2019 183 38140.00 / 2060 210940.00

INFO Maximum satellites used (GEO)                3                      at
epoch 02/07/2019 23:59:59.00 / 2019 183 86399.00 / 2060 259199.00

INFO Maximum satellites used (BDS)               13                      at
epoch 02/07/2019 16:54:06.00 / 2019 183 60846.00 / 2060 233646.00
```


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```
INFO Maximum satellites used (QZS)                3                       at
epoch 02/07/2019 23:59:59.00 / 2019 183 86399.00 / 2060 259199.00

INFO Minimum satellites not used (all constellations) 10 (R 5 S 3 J 2) at
epoch 02/07/2019 12:39:53.00 / 2019 183 45593.00 / 2060 218393.00

INFO Minimum satellites not used (GPS)                  0               at
epoch 02/07/2019 23:50:17.00 / 2019 183 85817.00 / 2060 258617.00

INFO Minimum satellites not used (GAL)                  0               at
epoch 02/07/2019 23:59:59.00 / 2019 183 86399.00 / 2060 259199.00

INFO Minimum satellites not used (GLO)                  5               at
epoch 02/07/2019 14:38:40.00 / 2019 183 52720.00 / 2060 225520.00

INFO Minimum satellites not used (GEO)                  3               at
epoch 02/07/2019 23:59:59.00 / 2019 183 86399.00 / 2060 259199.00

INFO Minimum satellites not used (BDS)                  0               at
epoch 02/07/2019 23:59:59.00 / 2019 183 86399.00 / 2060 259199.00

INFO Minimum satellites not used (QZS)                  1               at
epoch 02/07/2019 23:59:59.00 / 2019 183 86399.00 / 2060 259199.00

INFO Maximum satellites not used (all constellations) 37 (G 4 E 7 R 8 S 6 C
10 J 2) at epoch 02/07/2019 00:00:06.00 / 2019 183     6.00 / 2060 172806.00

INFO Maximum satellites not used (GPS)              4                     at
epoch 02/07/2019 06:21:01.00 / 2019 183 22861.00 / 2060 195661.00

INFO Maximum satellites not used (GAL)              7                     at
epoch 02/07/2019 00:11:04.00 / 2019 183   664.00 / 2060 173464.00

INFO Maximum satellites not used (GLO)             10                     at
epoch 02/07/2019 18:58:55.00 / 2019 183 68335.00 / 2060 241135.00

INFO Maximum satellites not used (GEO)              6                     at
epoch 02/07/2019 00:00:39.00 / 2019 183    39.00 / 2060 172839.00

INFO Maximum satellites not used (BDS)             10                     at
epoch 02/07/2019 00:00:14.00 / 2019 183    14.00 / 2060 172814.00

INFO Maximum satellites not used (QZS)              2                     at
epoch 02/07/2019 23:31:21.00 / 2019 183 84681.00 / 2060 257481.00

INFO PDOP  95 Percentile:   1.31

INFO GDOP  95 Percentile:   1.53

INFO TDOP  95 Percentile:   0.80

INFO HDOP  95 Percentile:   0.67

INFO VDOP  95 Percentile:   1.14

INFO Minimum PDOP   0.79 with 36 satellites (G 12 E  8 S  3 C 11 J  2) at
epoch 02/07/2019 21:22:18.00 / 2019 183 76938.00 / 2060 249738.00

INFO Minimum GDOP   0.91 with 36 satellites (G 12 E  8 S  3 C 11 J  2) at
epoch 02/07/2019 21:22:18.00 / 2019 183 76938.00 / 2060 249738.00

INFO Minimum TDOP   0.44 with 36 satellites (G 12 E  8 S  3 C 11 J  2) at
epoch 02/07/2019 21:22:18.00 / 2019 183 76938.00 / 2060 249738.00
```


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```
INFO Minimum HDOP   0.46 with 36 satellites (G 12 E  8 S  3 C 11 J  2) at
epoch 02/07/2019 21:21:25.00 / 2019 183 76885.00 / 2060 249685.00

INFO Minimum VDOP   0.65 with 36 satellites (G 12 E  8 S  3 C 11 J  2) at
epoch 02/07/2019 21:22:18.00 / 2019 183 76938.00 / 2060 249738.00

INFO Maximum PDOP   4.57 with  9 satellites (G  7 J  2)                at
epoch 02/07/2019 00:00:02.00 / 2019 183     2.00 / 2060 172802.00

INFO Maximum GDOP   5.74 with  9 satellites (G  7 J  2)                at
epoch 02/07/2019 00:00:02.00 / 2019 183     2.00 / 2060 172802.00

INFO Maximum TDOP   3.48 with  9 satellites (G  7 J  2)                at
epoch 02/07/2019 00:00:02.00 / 2019 183     2.00 / 2060 172802.00

INFO Maximum HDOP   2.54 with  9 satellites (G  7 J  2)                at
epoch 02/07/2019 00:00:02.00 / 2019 183     2.00 / 2060 172802.00

INFO Maximum VDOP   3.80 with  9 satellites (G  7 J  2)                at
epoch 02/07/2019 00:00:02.00 / 2019 183     2.00 / 2060 172802.00

INFO First epoch of summary for computing positioning error percentiles:
02/07/2019 00:00:02.00 / 2019 183     2.00 / 2060 172802.00

INFO Last  epoch of summary for computing positioning error percentiles:
02/07/2019 23:59:59.00 / 2019 183 86399.00 / 2060 259199.00

INFO Horizontal  95 Positioning Error Percentile:   1.46 metres

INFO Vertical    95 Positioning Error Percentile:   3.49 metres

INFO North       95 Positioning Error Percentile:   1.22 metres

INFO East        95 Positioning Error Percentile:   1.11 metres

INFO 3D          95 Positioning Error Percentile:   3.59 metres

INFO Maximum Horizontal Positioning Error:   5.89 metres with 27 satellites
(G  8 E  5 S  2 C 10 J  2) at epoch 02/07/2019 14:31:07.00 / 2019 183
52267.00 / 2060 225067.00

INFO Maximum Vertical   Positioning Error:   5.56 metres with 30 satellites
(G 10 E  6 S  3 C  9 J  2) at epoch 02/07/2019 21:47:00.00 / 2019 183
78420.00 / 2060 251220.00

INFO Maximum North      Positioning Error:   2.01 metres with 26 satellites
(G 10 S  3 C 10 J  3)       at epoch 02/07/2019 00:10:13.00 / 2019 183
613.00 / 2060 173413.00

INFO Maximum East       Positioning Error:   5.68 metres with 27 satellites
(G  8 E  5 S  2 C 10 J  2) at epoch 02/07/2019 14:31:07.00 / 2019 183
52267.00 / 2060 225067.00

INFO Maximum 3D         Positioning Error:   6.52 metres with 27 satellites
(G  8 E  5 S  2 C 10 J  2) at epoch 02/07/2019 14:31:07.00 / 2019 183
52267.00 / 2060 225067.00

INFO Total Processing time: 59.078 seconds [User time: 54.891 seconds
(92.912%) Kernel time: 4.188 seconds (7.088%)]

INFO  (2)_Station:  nnor  (4)_Lon:  116.19272381  (6)_Lat:    -31.04872771
(8)_Height:  234.8044 (10)_Day:  2 (12)_Month:  7 (14)_Year: 2019 (16)_DoY:
183 (18)_GPSWeek: 2060 (20)_DoW: 2 (22)_Percentile:  95 (24)_HPE_Percentile:
1.46   (26)_VPE_Percentile:        3.49   (28)_NPE_Percentile:        1.22
```


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```
(30)_EPE_Percentile:   1.11 (32)_3DPE_Percentile:   3.59 (34)_MaxHPE:   5.89
(36)_MaxVPE:    5.56 (38)_MaxNPE:    2.01 (40)_MaxEPE:    5.68 (42)_Max3DPE:
6.52 (44)_Avail%:  99.907 (46)_PDOP_Percentile:   1.31 (48)_Min_PDOP:   0.79
(50)_Max_PDOP:    4.57 (52)_GDOP_Percentile:    1.53 (54)_Min_GDOP:    0.91
(56)_Max_GDOP:    5.74 (58)_TDOP_Percentile:    0.80 (60)_Min_TDOP:    0.44
(62)_Max_TDOP:    3.48 (64)_HDOP_Percentile:    0.67 (66)_Min_HDOP:    0.46
(68)_Max_HDOP:    2.54 (70)_VDOP_Percentile:    1.14 (72)_Min_VDOP:    0.65
(74)_Max_VDOP:            3.80    (76)_Sat_used_All_Const_Percentile:    31
(78)_Sat_not_used_All_Const_Percentile: 14 (80)_Min_sat_used_All_Const: 24
(82)_Min_sat_not_used_All_Const:    10    (84)_Max_sat_used_All_Const:    36
(86)_Max_sat_not_used_All_Const:     37     (88)_Epochs_processed:    86400
(90)_Epochs_with_solution: 86320 (92)_Epochs_with_solution_reference_file:
86320             (94)_Epochs_omitted_no_data_reference_file:             0
(96)_Epochs_skipped_no_data_reference_file: 0 (98)_Epochs_no_satellites: 2
(100)_Epochs_singular_matrix:    78    (102)_Epochs_No_Reference_GNSS:    0
(104)_Epochs_Over_HDOPorPDOP:       0       (106)_Epochs_Over_HDOP:       0
(108)_Epochs_Over_PDOP:         0         (110)_Epochs_Over_GDOP:         0
(112)_Total_Epochs_skipped:    80    (114)_Epochs_missing_Sum:            0
(116)_Epochs_missing_All_file:         0   (118)_Num_DataGaps_Sum:        0
(120)_Num_DataGaps_All_file:        0   (122)_MaxSize_DataGap_Sum:        0
(124)_MaxSize_DataGap_All_file:      0   (126)_Station_Network_Name:  Other
(128)_Time_To_First_Fix: 2 (130)_Epochs_First_Fix: 3 (132)_Processing_time:
59.078
```

NOTES:

- If observation file starts at 22 hours or later, gLAB will automatically assume that all the epochs until the start of the next day (midnight) are for convergence time. During this convergence time, all the epochs computed will not be taken into account for the summary and the Stanford-ESA computation will be skipped. This behaviour can be disabled with the parameter **'--summary:waitfordaystart'**.
- If backwards processing is active, epochs missing and data gaps will only be counted during the forward processing.
- If receiver position is not fixed or provided by a reference file, the percentile lines will not appear.
- If user provides a reference file for comparing the solution and if at a certain epoch the reference file position is not available, the epoch will be skipped from the summary.
- The last line of the summary contains all the values of the previous lines along with the station coordinates.
- The day printed in the last line of the summary corresponds to the day of the first epoch in the summary.
- If receiver position is not fixed, the station coordinates will be the solution from the last computed epoch.
- The last line is useful for plotting world maps with data from each station.
- Stanford-ESA messages will not appear if Stanford-ESA computation has not been enabled.
- HDOP, PDOP and GDOP threshold messages will not appear if HDOP, PDOP or GDOP thresholds have not been enabled respectively.
- The lines referring to a reference file will only appear if a user sets a reference file. If user sets the reference file just for comparing the solution, the line "Total epochs omitted in ..." will appear. Otherwise, if the reference file was set to be used as the a priori

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position for the modelling computation, the line "Total epochs skipped due to no position from reference file ..." will appear.

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7.30.2 PPP statistical summary

It is printed at the end of the output file if summary is enabled. All time tags are in GPS time.

```
INFO --------------------- PPP Summary ---------------------

INFO GDOP Threshold:  30.00

INFO First epoch of summary: 02/07/2019 00:00:00.00 / 2019 183     0.00 /
2060 172800.00

INFO Last  epoch of summary: 02/07/2019 23:59:59.00 / 2019 183 86399.00 /
2060 259199.00

INFO Total epochs processed: 86400

INFO Total epochs processed with solution: 86393 ( 99.992% )

INFO Total epochs skipped due to less than 4 valid satellites available: 7
( 0.008% )

INFO Total epochs skipped due to singular geometry matrix: 0 ( 0.000% )

INFO Total epochs skipped due to reference constellation not available: 0 (
0.000% )

INFO Total epochs skipped due to any DOP exceeding the threshold: 0 ( 0.000%
)

INFO Total epochs skipped due to GDOP exceeding the threshold:    0 ( 0.000%
)

INFO Total epochs skipped (any reason): 7 ( 0.008% )

INFO Total epochs missing in observation file (during summary period):   0

INFO Total epochs missing in observation file (all the file):            0

INFO Number of data gaps in observation file (during summary period):   0

INFO Number of data gaps in observation file (all the file):             0

INFO Maximum data gap size in observation file (during summary period):   0

INFO Maximum data gap size in observation file (all the file):            0

INFO Time To First Fix: 7 seconds (8 epochs) at epoch 02/07/2019 00:00:07.00
/ 2019 183     7.00 / 2060 172807.00

INFO Constellations     used 50 Percentile:  5 |  95 Percentile:  4 | Mean:
4.82

INFO Constellations not used 50 Percentile:  0 |  95 Percentile:  1 | Mean:
0.18

INFO Number of epochs with constellations used: GPS+GAL+GLO+BDS+QZS 70920 (
82.090% ) GPS+GAL+BDS+QZS 15473 ( 17.910% )

INFO Number of epochs with constellations not used: GLO 15473 ( 17.910% )

INFO Constellations used as reference clock: GPS 86393 ( 100% )

INFO Satellites used (all constellations) 50 Percentile: 26 |  95 Percentile:
21 | Mean: 25.86
```


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```
INFO Satellites used (GPS)                50 Percentile:  9 |  95 Percentile:
6 | Mean:  8.57

INFO Satellites used (GAL)                50 Percentile:  7 |  95 Percentile:
5 | Mean:  6.57

INFO Satellites used (GLO)                50 Percentile:  2 |  95 Percentile:
0 | Mean:  2.39

INFO Satellites used (BDS)                50 Percentile:  6 |  95 Percentile:
4 | Mean:  5.67

INFO Satellites used (QZS)                50 Percentile:  3 |  95 Percentile:
2 | Mean:  2.66

INFO Satellites not used (all constellations) 50 Percentile:   8 |   95
Percentile: 12 | Mean:  8.31

INFO Satellites not used (GPS)                    50 Percentile:   1 |   95
Percentile:  2 | Mean:  0.92

INFO Satellites not used (GAL)                    50 Percentile:   1 |   95
Percentile:  2 | Mean:  0.95

INFO Satellites not used (GLO)                    50 Percentile:   0 |   95
Percentile:  2 | Mean:  0.58

INFO Satellites not used (BDS)                    50 Percentile:   4 |   95
Percentile:  7 | Mean:  4.52

INFO Satellites not used (QZS)                    50 Percentile:   1 |   95
Percentile:  2 | Mean:  1.34

INFO Minimum satellites used (all constellations) 18 (G 6 E 5 C 4 J 3) at
epoch 02/07/2019 06:28:10.00 / 2019 183 23290.00 / 2060 196090.00

INFO Minimum satellites used (GPS)                 5                    at
epoch 02/07/2019 18:59:08.00 / 2019 183 68348.00 / 2060 241148.00

INFO Minimum satellites used (GAL)                 4                    at
epoch 02/07/2019 19:54:06.00 / 2019 183 71646.00 / 2060 244446.00

INFO Minimum satellites used (GLO)                 0                    at
epoch 02/07/2019 12:45:19.00 / 2019 183 45919.00 / 2060 218719.00

INFO Minimum satellites used (BDS)                 4                    at
epoch 02/07/2019 22:27:15.00 / 2019 183 80835.00 / 2060 253635.00

INFO Minimum satellites used (QZS)                 2                    at
epoch 02/07/2019 23:31:33.00 / 2019 183 84693.00 / 2060 257493.00

INFO Maximum satellites used (all constellations) 33 (G 11 E 7 R 7 C 5 J 3)
at epoch 02/07/2019 00:57:29.00 / 2019 183  3449.00 / 2060 176249.00

INFO Maximum satellites used (GPS)               14                     at
epoch 02/07/2019 02:45:09.00 / 2019 183  9909.00 / 2060 182709.00

INFO Maximum satellites used (GAL)               10                     at
epoch 02/07/2019 10:24:01.00 / 2019 183 37441.00 / 2060 210241.00

INFO Maximum satellites used (GLO)                7                     at
epoch 02/07/2019 01:14:50.00 / 2019 183  4490.00 / 2060 177290.00
```


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```
INFO Maximum satellites used (BDS)                9                       at
epoch 02/07/2019 13:47:47.00 / 2019 183 49667.00 / 2060 222467.00

INFO Maximum satellites used (QZS)                3                       at
epoch 02/07/2019 23:59:59.00 / 2019 183 86399.00 / 2060 259199.00

INFO Minimum satellites not used (all constellations)  4 (E 1 C 2 J 1) at
epoch 02/07/2019 10:34:38.00 / 2019 183 38078.00 / 2060 210878.00

INFO Minimum satellites not used (GPS)                  0                 at
epoch 02/07/2019 23:50:17.00 / 2019 183 85817.00 / 2060 258617.00

INFO Minimum satellites not used (GAL)                  0                 at
epoch 02/07/2019 23:59:59.00 / 2019 183 86399.00 / 2060 259199.00

INFO Minimum satellites not used (GLO)                  0                 at
epoch 02/07/2019 19:41:24.00 / 2019 183 70884.00 / 2060 243684.00

INFO Minimum satellites not used (BDS)                  2                 at
epoch 02/07/2019 13:18:02.00 / 2019 183 47882.00 / 2060 220682.00

INFO Minimum satellites not used (QZS)                  1                 at
epoch 02/07/2019 23:59:59.00 / 2019 183 86399.00 / 2060 259199.00

INFO Maximum satellites not used (all constellations) 15 (G 4 E 1 R 2 C 7 J
1) at epoch 02/07/2019 17:01:00.00 / 2019 183 61260.00 / 2060 234060.00

INFO Maximum satellites not used (GPS)               5                    at
epoch 02/07/2019 18:30:06.00 / 2019 183 66606.00 / 2060 239406.00

INFO Maximum satellites not used (GAL)               4                    at
epoch 02/07/2019 18:43:49.00 / 2019 183 67429.00 / 2060 240229.00

INFO Maximum satellites not used (GLO)               3                    at
epoch 02/07/2019 23:56:34.00 / 2019 183 86194.00 / 2060 258994.00

INFO Maximum satellites not used (BDS)               8                    at
epoch 02/07/2019 16:54:06.00 / 2019 183 60846.00 / 2060 233646.00

INFO Maximum satellites not used (QZS)               2                    at
epoch 02/07/2019 23:31:33.00 / 2019 183 84693.00 / 2060 257493.00

INFO Convergence time with horizontal formal error from first fix to 0.2
metres:                                  150 seconds (151 epochs) at epoch
02/07/2019 00:02:37.00 / 2019 183   157.00 / 2060 172957.00

INFO Convergence time with horizontal formal error from first fix to 0.2
metres and maintained 300 seconds:       150 seconds (151 epochs) at epoch
02/07/2019 00:02:37.00 / 2019 183   157.00 / 2060 172957.00

INFO Convergence time with horizontal positioning error from first fix to
0.2 metres:                               62 seconds  (63 epochs) at epoch
02/07/2019 00:01:09.00 / 2019 183    69.00 / 2060 172869.00

INFO Convergence time with horizontal positioning error from first fix to
0.2 metres and maintained 300 seconds: 879 seconds (880 epochs) at epoch
02/07/2019 00:14:46.00 / 2019 183   886.00 / 2060 173686.00

INFO Convergence time with vertical formal error from first fix to 0.4
metres:                                   15 seconds  (16 epochs) at epoch
02/07/2019 00:00:22.00 / 2019 183    22.00 / 2060 172822.00
```


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```
INFO Convergence time with vertical formal error from first fix to 0.4
metres and maintained 300 seconds:         15 seconds  (16 epochs) at epoch
02/07/2019 00:00:22.00 / 2019 183    22.00 / 2060 172822.00

INFO Convergence time with vertical positioning error from first fix to 0.4
metres:                                     7 seconds   (8 epochs) at epoch
02/07/2019 00:00:14.00 / 2019 183    14.00 / 2060 172814.00

INFO Convergence time with vertical positioning error from first fix to 0.4
metres and maintained 300 seconds:    300 seconds (301 epochs) at epoch
02/07/2019 00:05:07.00 / 2019 183   307.00 / 2060 173107.00

INFO Convergence time with 3D formal error from first fix to 0.4 metres:
81 seconds  (82 epochs) at epoch 02/07/2019 00:01:28.00 / 2019 183    88.00
/ 2060 172888.00

INFO Convergence time with 3D formal error from first fix to 0.4 metres and
maintained 300 seconds:                  81 seconds  (82 epochs) at epoch
02/07/2019 00:01:28.00 / 2019 183    88.00 / 2060 172888.00

INFO Convergence time with 3D positioning error from first fix to 0.4 metres:
59 seconds  (60 epochs) at epoch 02/07/2019 00:01:06.00 / 2019 183    66.00
/ 2060 172866.00

INFO Convergence time with 3D positioning error from first fix to 0.4 metres
and maintained 300 seconds:            308 seconds (309 epochs) at epoch
02/07/2019 00:05:15.00 / 2019 183   315.00 / 2060 173115.00

INFO PDOP  95 Percentile:   1.56

INFO GDOP  95 Percentile:   1.81

INFO TDOP  95 Percentile:   0.95

INFO HDOP  95 Percentile:   0.81

INFO VDOP  95 Percentile:   1.37

INFO Minimum PDOP   0.85 with 32 satellites (G 11 E  7 R  6 C  6 J  2) at
epoch 02/07/2019 21:22:18.00 / 2019 183 76938.00 / 2060 249738.00

INFO Minimum GDOP   0.98 with 32 satellites (G 11 E  7 R  6 C  6 J  2) at
epoch 02/07/2019 21:22:18.00 / 2019 183 76938.00 / 2060 249738.00

INFO Minimum TDOP   0.47 with 32 satellites (G 11 E  7 R  6 C  6 J  2) at
epoch 02/07/2019 21:22:18.00 / 2019 183 76938.00 / 2060 249738.00

INFO Minimum HDOP   0.51 with 29 satellites (G  8 E  7 R  5 C  6 J  3) at
epoch 02/07/2019 18:17:07.00 / 2019 183 65827.00 / 2060 238627.00

INFO Minimum VDOP   0.68 with 32 satellites (G 11 E  7 R  6 C  6 J  2) at
epoch 02/07/2019 21:22:18.00 / 2019 183 76938.00 / 2060 249738.00

INFO Maximum PDOP   1.87 with 20 satellites (G  6 E  4 R  2 C  5 J  3) at
epoch 02/07/2019 16:02:50.00 / 2019 183 57770.00 / 2060 230570.00

INFO Maximum GDOP   2.19 with 18 satellites (G  6 E  5 C  4 J  3)      at
epoch 02/07/2019 06:28:10.00 / 2019 183 23290.00 / 2060 196090.00

INFO Maximum TDOP   1.24 with 18 satellites (G  6 E  5 C  4 J  3)      at
epoch 02/07/2019 06:28:10.00 / 2019 183 57770.00 / 2060 196090.00

INFO Maximum HDOP   1.03 with 19 satellites (G  6 E  4 R  1 C  6 J  2) at
epoch 02/07/2019 14:24:20.00 / 2019 183 51860.00 / 2060 224660.00
```


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```
INFO Maximum VDOP   1.65 with 20 satellites (G  6 E  4 R  2 C  5 J  3) at
epoch 02/07/2019 16:02:50.00 / 2019 183 57770.00 / 2060 230570.00

INFO First epoch of summary for computing positioning error percentiles:
02/07/2019 00:00:07.00 / 2019 183     7.00 / 2060 172807.00

INFO Last  epoch of summary for computing positioning error percentiles:
02/07/2019 23:59:59.00 / 2019 183 86399.00 / 2060 259199.00

INFO Horizontal  95 Positioning Error Percentile:   0.02 metres

INFO Vertical    95 Positioning Error Percentile:   0.03 metres

INFO North       95 Positioning Error Percentile:   0.01 metres

INFO East        95 Positioning Error Percentile:   0.02 metres

INFO 3D          95 Positioning Error Percentile:   0.04 metres

INFO Maximum Horizontal Positioning Error:   1.71 metres with 30 satellites
(G 10 E  6 R  6 C  5 J  3) at epoch 02/07/2019 00:00:10.00 / 2019 183
10.00 / 2060 172810.00

INFO Maximum Vertical   Positioning Error:   1.89 metres with 30 satellites
(G 10 E  6 R  6 C  5 J  3) at epoch 02/07/2019 00:00:07.00 / 2019 183
7.00 / 2060 172807.00

INFO Maximum North      Positioning Error:   0.24 metres with 30 satellites
(G 10 E  6 R  6 C  5 J  3) at epoch 02/07/2019 00:00:07.00 / 2019 183
7.00 / 2060 172807.00

INFO Maximum East       Positioning Error:   1.71 metres with 30 satellites
(G 10 E  6 R  6 C  5 J  3) at epoch 02/07/2019 00:00:10.00 / 2019 183
10.00 / 2060 172810.00

INFO Maximum 3D         Positioning Error:   2.39 metres with 30 satellites
(G 10 E  6 R  6 C  5 J  3) at epoch 02/07/2019 00:00:07.00 / 2019 183
7.00 / 2060 172807.00

INFO Total Processing time: 1 minute and 2.563 seconds (62.563 seconds)
[User time: 58.250 seconds (93.107%) Kernel time: 4.313 seconds (6.893%)]

INFO  (2)_Station:  nnor  (4)_Lon:  116.19272381  (6)_Lat:    -31.04872771
(8)_Height:  234.8044 (10)_Day:  2 (12)_Month:  7 (14)_Year: 2019 (16)_DoY:
183 (18)_GPSWeek: 2060 (20)_DoW: 2 (22)_Percentile:  95 (24)_HPE_Percentile:
0.02   (26)_VPE_Percentile:        0.03   (28)_NPE_Percentile:        0.01
(30)_EPE_Percentile:  0.02 (32)_3DPE_Percentile:  0.04 (34)_MaxHPE:  1.71
(36)_MaxVPE:   1.89 (38)_MaxNPE:   0.24 (40)_MaxEPE:   1.71 (42)_Max3DPE:
2.39 (44)_Avail%:  99.992 (46)_PDOP_Percentile:  1.56 (48)_Min_PDOP:  0.85
(50)_Max_PDOP:   1.87 (52)_GDOP_Percentile:   1.81 (54)_Min_GDOP:   0.98
(56)_Max_GDOP:   2.19 (58)_TDOP_Percentile:   0.95 (60)_Min_TDOP:   0.47
(62)_Max_TDOP:   1.24 (64)_HDOP_Percentile:   0.81 (66)_Min_HDOP:   0.51
(68)_Max_HDOP:   1.03 (70)_VDOP_Percentile:   1.37 (72)_Min_VDOP:   0.68
(74)_Max_VDOP:           1.65    (76)_Sat_used_All_Const_Percentile:    26
(78)_Sat_not_used_All_Const_Percentile:  8  (80)_Min_sat_used_All_Const:  18
(82)_Min_sat_not_used_All_Const:    4    (84)_Max_sat_used_All_Const:    33
(86)_Max_sat_not_used_All_Const:    15    (88)_Epochs_processed:    86400
(90)_Epochs_with_solution: 86393 (92)_Epochs_with_solution_reference_file:
86393            (94)_Epochs_omitted_no_data_reference_file:            0
(96)_Epochs_skipped_no_data_reference_file: 0 (98)_Epochs_no_satellites: 7
(100)_Epochs_singular_matrix:    0    (102)_Epochs_No_Reference_GNSS:    0
```


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```
(104)_Epochs_Over_HDOPorPDOP:       0       (106)_Epochs_Over_HDOP:       0
(108)_Epochs_Over_PDOP:         0         (110)_Epochs_Over_GDOP:         0
(112)_Total_Epochs_skipped:    7    (114)_Epochs_missing_Sum:             0
(116)_Epochs_missing_All_file:        0   (118)_Num_DataGaps_Sum:        0
(120)_Num_DataGaps_All_file:        0   (122)_MaxSize_DataGap_Sum:       0
(124)_MaxSize_DataGap_All_file:      0  (126)_Station_Network_Name:  Other
(128)_Time_To_First_Fix: 7 (130)_Epochs_First_Fix: 8 (132)_Processing_time
62.563     (134)_Convergence_Time_&_Epochs_Formal_Error_Hor:     150     151
(137)_Convergence_Time_&_Epochs_Period_Formal_Error_Hor:      150      151
(140)_Convergence_Time_&_Epochs_Position_Error_Hor:          62          63
(143)_Convergence_Time_&_Epochs_Period_Position_Error_Hor:     879     880
(146)_Convergence_Time_&_Epochs_Formal_Error_Ver:           15           16
(149)_Convergence_Time_&_Epochs_Period_Formal_Error_Ver:       15       16
(152)_Convergence_Time_&_Epochs_Position_Error_Ver:           7           8
(155)_Convergence_Time_&_Epochs_Period_Position_Error_Ver:     300     301
(158)_Convergence_Time_&_Epochs_Formal_Error_3D:           81           82
(161)_Convergence_Time_&_Epochs_Period_Formal_Error_3D:        81        82
(164)_Convergence_Time_&_Epochs_Position_Error_3D:          59          60
(167)_Convergence_Time_&_Epochs_Period_Position_Error_3D: 308 309
```

NOTES:

- If observation file starts at 22 hours or later, gLAB will automatically assume that all the epochs until the start of the next day (midnight) are for convergence time. During this convergence time, all the epochs computed will not be taken into account for the summary.
- This behaviour can be disabled with the parameter **'--summary:waitfordaystart'**.
- If backwards processing is active, epochs missing and data gaps will only be counted during the forward processing.
- If receiver position is not fixed or provided by a reference file, the percentile lines will not appear.
- If user provides a reference file for comparing the solution and if at a certain epoch the reference file position is not available, the epoch will be skipped from the summary.
- The last line of the summary contains all the values of the previous lines along with the station coordinates.
- The day printed in the last line of the summary corresponds to the day of the first epoch in the summary.
- If receiver position is not fixed, the station coordinates will be the solution from the last computed epoch.
- The last line is useful for plotting world maps with data from each station.
- HDOP, PDOP and GDOP threshold messages will not appear if HDOP, PDOP or GDOP thresholds have not been enabled respectively.
- The lines referring to a reference file will only appear if a user sets a reference file. If user sets the reference file just for comparing the solution, the line "Total epochs omitted in ..." will appear. Otherwise, if the reference file was set to be used as the a priori position for the modelling computation, the line "Total epochs skipped due to no position from reference file ..." will appear.

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7.30.3 SBAS statistical summary

It is printed at the end of the output file if summary is enabled. All time tags are in GPS time.

```
INFO --------------------- SBAS Summary ---------------------

INFO Horizontal Alarm limit:  40.00 metres

INFO Vertical   Alarm limit:  50.00 metres

INFO First epoch of summary: 21/04/2020 00:00:00.00 / 2020 112     0.00 /
2102 172800.00

INFO Last  epoch of summary: 21/04/2020 23:59:59.00 / 2020 112 86399.00 /
2102 259199.00

INFO Total epochs processed: 86372

INFO Total epochs processed with PA solution: 85650 ( 99.164% )

INFO Total epochs processed with PA solution under alarm limits: 85648 (
99.162% )

INFO Total epochs skipped due to less than 4 valid satellites available:
722 ( 0.836% )

INFO Total epochs skipped due to singular geometry matrix: 0 ( 0.000% )

INFO Total epochs skipped due to reference constellation not available: 0 (
0.000% )

INFO Total epochs skipped (any reason): 722 ( 0.836% )

INFO Total epochs missing in observation file (during summary period):  28

INFO Total epochs missing in observation file (all the file):           28

INFO Number of data gaps in observation file (during summary period):   3

INFO Number of data gaps in observation file (all the file):             3

INFO Maximum data gap size in observation file (during summary period):   11
at epoch 21/04/2020 23:50:08.00 / 2020 112 85808.00 / 2102 258608.00

INFO Maximum data gap size in observation file (all the file):            11
at epoch 21/04/2020 23:50:08.00 / 2020 112 85808.00 / 2102 258608.00

INFO Time To First Fix: 361 seconds (362 epochs) at epoch 20/04/2020
23:51:01.00 / 2020 111 85861.00 / 2102 172261.00

INFO Number of epochs with constellations used: GPS 85650 ( 100% )

INFO Number of epochs with constellations not used: 0 ( 0% )

INFO Constellations used as reference clock: GPS 85650 ( 100% )

INFO Satellites used (all constellations) 50 Percentile:  8 |  95 Percentile:
7 | Mean:  8.10

INFO Satellites used (GPS)              50 Percentile:  8 |  95 Percentile:
7 | Mean:  8.10

INFO Satellites not used (all constellations) 50 Percentile:  2 |  95
Percentile:  4 | Mean:  2.36
```


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```
INFO Satellites not used (GPS)                    50 Percentile:   2 |   95
Percentile:  4 | Mean:  2.36

INFO Minimum satellites used (all constellations)   6  (G  6)  at  epoch
21/04/2020 23:18:39.00 / 2020 112 83919.00 / 2102 256719.00

INFO Minimum satellites used (GPS)                6      at epoch 21/04/2020
23:18:39.00 / 2020 112 83919.00 / 2102 256719.00

INFO  Maximum  satellites  used  (all  constellations)  12  (G  12)  at  epoch
21/04/2020 18:17:45.00 / 2020 112 65865.00 / 2102 238665.00

INFO Maximum satellites used (GPS)                   12          at epoch
21/04/2020 18:17:45.00 / 2020 112 65865.00 / 2102 238665.00

INFO  Minimum  satellites  not  used  (all  constellations)   0     at  epoch
21/04/2020 20:47:19.00 / 2020 112 74839.00 / 2102 247639.00

INFO Minimum satellites not used (GPS)               0   at epoch 21/04/2020
20:47:19.00 / 2020 112 74839.00 / 2102 247639.00

INFO Maximum satellites not used (all constellations)  7  (G  7)  at  epoch
21/04/2020 17:55:02.00 / 2020 112 64502.00 / 2102 237302.00

INFO Maximum satellites not used (GPS)                   7        at epoch
21/04/2020 17:55:02.00 / 2020 112 64502.00 / 2102 237302.00

INFO PDOP  95 Percentile:   2.98

INFO GDOP  95 Percentile:   3.44

INFO TDOP  95 Percentile:   1.79

INFO HDOP  95 Percentile:   1.53

INFO VDOP  95 Percentile:   2.57

INFO  Minimum  PDOP    1.24  with  12  satellites  (G  12)  at  epoch  21/04/2020
18:17:45.00 / 2020 112 65865.00 / 2102 238665.00

INFO  Minimum  GDOP    1.36  with  12  satellites  (G  12)  at  epoch  21/04/2020
18:17:45.00 / 2020 112 65865.00 / 2102 238665.00

INFO  Minimum  TDOP    0.56  with  12  satellites  (G  12)  at  epoch  21/04/2020
18:17:45.00 / 2020 112 65865.00 / 2102 238665.00

INFO  Minimum  HDOP    0.72  with  12  satellites  (G  12)  at  epoch  21/04/2020
18:17:45.00 / 2020 112 65865.00 / 2102 238665.00

INFO  Minimum  VDOP    1.01  with  12  satellites  (G  12)  at  epoch  21/04/2020
18:17:45.00 / 2020 112 65865.00 / 2102 238665.00

INFO  Maximum  PDOP    5.27  with   7  satellites  (G   7)  at  epoch  21/04/2020
23:28:58.00 / 2020 112 84538.00 / 2102 257338.00

INFO  Maximum  GDOP    5.97  with   7  satellites  (G   7)  at  epoch  21/04/2020
23:28:49.00 / 2020 112 84529.00 / 2102 257329.00

INFO  Maximum  TDOP    3.02  with   6  satellites  (G   6)  at  epoch  21/04/2020
02:20:49.00 / 2020 112 84532.00 / 2102 181249.00

INFO  Maximum  HDOP    2.68  with   6  satellites  (G   6)  at  epoch  21/04/2020
01:30:12.00 / 2020 112  5412.00 / 2102 178212.00
```


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```
INFO Maximum VDOP    4.83 with   7 satellites (G   7) at epoch 21/04/2020
23:28:52.00 / 2020 112 84532.00 / 2102 257332.00

INFO Continuity Risk Airborne (15 epochs sliding window): 7.0054E-04
(NumEpochsRisk:        60 TotalEpochsAvailable: 85648)

INFO Continuity Risk Maritime (15 epochs fixed window):     6.9444E-04
(NumDiscontinuities:    4 TotalEpochsSummary:   86400)

INFO First epoch of summary for computing MIs, PE, PL and percentiles:
21/04/2020 00:00:00.00 / 2020 112     0.00 / 2102 172800.00

INFO Last  epoch of summary for computing MIs, PE, PL and percentiles:
21/04/2020 23:59:59.00 / 2020 112 86399.00 / 2102 259199.00

INFO Total epochs with MIs: 0 ( 0.000% )

INFO Total epochs with Horizontal MIs: 0 ( 0.000% )

INFO Total epochs with Vertical   MIs: 0 ( 0.000% )

INFO Horizontal  95 Positioning Error Percentile:   0.87 metres

INFO Vertical    95 Positioning Error Percentile:   1.26 metres

INFO North       95 Positioning Error Percentile:   0.69 metres

INFO East        95 Positioning Error Percentile:   0.66 metres

INFO 3D          95 Positioning Error Percentile:   1.42 metres

INFO Horizontal  95 Protection  Level Percentile:  12.68 metres

INFO Vertical    95 Protection  Level Percentile:  23.05 metres

INFO Maximum Horizontal Positioning Error:   1.52 metres with  7 satellites
(G  7) at epoch 21/04/2020 05:00:22.00 / 2020 112 18022.00 / 2102 190822.00

INFO Maximum Vertical   Positioning Error:   2.51 metres with  8 satellites
(G  8) at epoch 21/04/2020 16:30:19.00 / 2020 112 59419.00 / 2102 232219.00

INFO Maximum North      Positioning Error:   1.22 metres with  6 satellites
(G  6) at epoch 21/04/2020 23:02:47.00 / 2020 112 82967.00 / 2102 255767.00

INFO Maximum East       Positioning Error:   0.99 metres with  7 satellites
(G  7) at epoch 21/04/2020 05:00:50.00 / 2020 112 18050.00 / 2102 190850.00

INFO Maximum 3D         Positioning Error:   2.69 metres with  7 satellites
(G  7) at epoch 21/04/2020 23:17:52.00 / 2020 112 83872.00 / 2102 256672.00

INFO Minimum Horizontal Protection  Level:   7.16 metres with 12 satellites
(G 12) at epoch 21/04/2020 18:17:37.00 / 2020 112 65857.00 / 2102 238657.00

INFO Minimum Vertical   Protection  Level:  10.01 metres with 10 satellites
(G 10) at epoch 21/04/2020 09:45:32.00 / 2020 112 35132.00 / 2102 207932.00

INFO Maximum Horizontal Protection  Level:  25.00 metres with  6 satellites
(G  6) at epoch 21/04/2020 01:27:48.00 / 2020 112  5268.00 / 2102 178068.00

INFO Maximum Vertical   Protection  Level:  50.63 metres with  6 satellites
(G  6) at epoch 21/04/2020 23:18:39.00 / 2020 112 83919.00 / 2102 256719.00

INFO Horizontal  95 Integrity Ratio Percentile: 0.0923

INFO Vertical    95 Integrity Ratio Percentile: 0.0848
```


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```
INFO Best  Horizontal Integrity Ratio:  4.1355E-04 with  7 satellites (G
7) at epoch 21/04/2020 00:39:35.00 / 2020 112  2375.00 / 2102 175175.00

INFO Best  Vertical   Integrity Ratio:  1.3388E-06 with  9 satellites (G
9) at epoch 21/04/2020 21:11:36.00 / 2020 112 76296.00 / 2102 249096.00

INFO Worst Horizontal Integrity Ratio:       0.1519 with 10 satellites (G
10) at epoch 21/04/2020 19:30:12.00 / 2020 112 70212.00 / 2102 243012.00

INFO Worst Vertical   Integrity Ratio:       0.1731 with  8 satellites (G
8) at epoch 21/04/2020 16:30:19.00 / 2020 112 59419.00 / 2102 232219.00

INFO  Total  Processing  time:  8.266  seconds  [User  time:  7.969  seconds
(96.408%) Kernel time: 0.297 seconds (3.592%)]

INFO  (2)_Station:  cace  (4)_Lon:    -6.34177927  (6)_Lat:      39.47886540
(8)_Height:  436.4878 (10)_Day: 21 (12)_Month:  4 (14)_Year: 2020 (16)_DoY:
112 (18)_GPSWeek: 2102 (20)_DoW: 2 (22)_Percentile:  95 (24)_HPE_Percentile:
0.87   (26)_VPE_Percentile:        1.26   (28)_NPE_Percentile:        0.69
(30)_EPE_Percentile:  0.66 (32)_3DPE_Percentile:  1.42 (34)_MaxHPE:  1.52
(36)_MaxVPE:   2.51 (38)_MaxNPE:   1.22 (40)_MaxEPE:   0.99 (42)_Max3DPE:
2.69 (44)_Avail%:  99.162 (46)_PDOP_Percentile:  2.98 (48)_Min_PDOP:  1.24
(50)_Max_PDOP:   5.27 (52)_GDOP_Percentile:   3.44 (54)_Min_GDOP:   1.36
(56)_Max_GDOP:   5.97 (58)_TDOP_Percentile:   1.79 (60)_Min_TDOP:   0.56
(62)_Max_TDOP:   3.02 (64)_HDOP_Percentile:   1.53 (66)_Min_HDOP:   0.72
(68)_Max_HDOP:   2.68 (70)_VDOP_Percentile:   2.57 (72)_Min_VDOP:   1.01
(74)_Max_VDOP:            4.83    (76)_Sat_used_All_Const_Percentile:    8
(78)_Sat_not_used_All_Const_Percentile:  2  (80)_Min_sat_used_All_Const:  6
(82)_Min_sat_not_used_All_Const:    0    (84)_Max_sat_used_All_Const:    12
(86)_Max_sat_not_used_All_Const:    7    (88)_Epochs_processed:    86372
(90)_Epochs_with_solution:   0   (92)_Epochs_with_solution_reference_file:
85650             (94)_Epochs_omitted_no_data_reference_file:            0
(96)_Epochs_skipped_no_data_reference_file:  0  (98)_Epochs_no_satellites:
722  (100)_Epochs_singular_matrix:  0  (102)_Epochs_No_Reference_GNSS:  0
(104)_Epochs_Over_HDOPorPDOP:       0       (106)_Epochs_Over_HDOP:       0
(108)_Epochs_Over_PDOP:         0         (110)_Epochs_Over_GDOP:         0
(112)_Total_Epochs_skipped:    722    (114)_Epochs_missing_Sum:         28
(116)_Epochs_missing_All_file:      28   (118)_Num_DataGaps_Sum:         3
(120)_Num_DataGaps_All_file:        3   (122)_MaxSize_DataGap_Sum:      11
(124)_MaxSize_DataGap_All_file:    11   (126)_Station_Network_Name:  Other
(128)_Time_To_First_Fix:       361       (130)_Epochs_First_Fix:       362
(132)_Processing_time:          8.266     (134)_HIR_Percentile:     0.0923
(136)_VIR_Percentile:  0.0848  (138)_HWIR:    0.1519  (140)_VWIR:    0.1731
(142)_HBIR: 4.1355E-04 (144)_VBIR: 1.3388E-06 (146)_MIs:   0 (148)_Hor_MIs:
0  (150)_Ver_MIs:     0  (152)_HWIR_ESA:   0.0000  (154)_VWIR_ESA:   0.0000
(156)_MIs_ESA:      0  (158)_Hor_MIs_ESA:      0  (160)_Ver_MIs_ESA:      0
(162)_HPL_Percentile:   12.68  (164)_VPL_Percentile:   23.05  (166)_MinHPL:
7.16  (168)_MaxHPL:   25.00  (170)_MinVPL:   10.01  (172)_MaxVPL:   50.63
(174)_Cont_Risk: 7.0054E-04 (176)_Cont_Risk_Mar: 6.9444E-04
```

NOTES:

- If observation file starts at 22 hours or later, gLAB will automatically assume that all the epochs until the start of the next day (midnight) are for convergence time. During this convergence time, all the epochs computed will not be taken into account for the SBAS

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summary and the Stanford-ESA computation will be skipped. This behaviour can be disabled with the parameter **'--summary:waitfordaystart'**.

- If receiver position is not fixed or provided by a reference file, the percentile lines will not appear.
- If user provides a reference file for comparing the solution and if at a certain epoch the reference file position is not available, the epoch will be skipped from the summary.
- The last line of the SBAS summary contains all the values of the previous lines along with the station coordinates.
- The last line is useful for plotting world maps with data from each station.
- The day printed in the last line of the summary corresponds to the day of the first epoch in the summary.
- If receiver position is not fixed, the station coordinates will be the solution from the last computed epoch.
- The fields at the end of the last line 'HWIR_ESA', 'VWIR_ESA', 'MIs_ESA', 'Hor_MIs_ESA' and 'Ver_MIs_ESA' correspond to the values computed in Stanford-ESA.
- These fields will appear even if Stanford-ESA has not been enabled, but with a value of 0 (so its column number is fixed).
- Stanford-ESA messages will not appear if Stanford-ESA computation has not been enabled.
- HDOP, PDOP and GDOP threshold messages will not appear if HDOP, PDOP or GDOP thresholds have not been enabled respectively.
- Number of epochs with NPA epoch message will not appear if mode switching has not been enabled.
- If user forced NPA processing through parameters, then all values in SBAS summary will be referred to NPA mode.
- The lines referring to a reference file will only appear if a user sets a reference file. If user sets the reference file just for comparing the solution, the line "Total epochs omitted in ..." will appear. Otherwise, if the reference file was set to be used as the a priori position for the modelling computation, the line "Total epochs skipped due to no position from reference file ..." will appear.

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7.30.4 DGNSS statistical summary

It is printed at the end of the output file if summary is enabled. All time tags are in GPS time.

```
INFO --------------------- DGNSS Summary ---------------------

INFO GDOP Threshold:  30.00

INFO First epoch of summary: 26/01/2020 00:00:00.00 / 2020 026     0.00 /
2090      0.00

INFO Last  epoch of summary: 26/01/2020 23:59:59.00 / 2020 026 86399.00 /
2090  86399.00

INFO Total epochs processed: 86389

INFO Total epochs processed with DGNSS solution: 86017 ( 99.569% )

INFO Total epochs processed with SPP solution: 370 ( 0.428% )

INFO Total epochs skipped due to less than 4 valid satellites available: 2
( 0.002% )

INFO Total epochs skipped due to singular geometry matrix: 0 ( 0.000% )

INFO Total epochs skipped due to reference constellation not available: 0 (
0.000% )

INFO Total epochs skipped due to any DOP exceeding the threshold: 0 ( 0.000%
)

INFO Total epochs skipped due to GDOP exceeding the threshold:    0 ( 0.000%
)

INFO Total epochs skipped (any reason): 2 ( 0.002% )

INFO Total epochs missing  in rover observation file (during summary period):
11

INFO  Total  epochs  missing   in  rover  observation  file  (all  the  file):
11

INFO Number of data gaps in rover observation file (during summary period):
1

INFO  Number  of  data  gaps  in  rover  observation  file  (all  the  file):
1

INFO Maximum data gap size in rover observation file (during summary period):
11 at epoch 26/01/2020 11:37:59.00 / 2020 026 41879.00 / 2090  41879.00

INFO  Maximum  data  gap  size  in  rover  observation  file  (all  the  file):
11 at epoch 26/01/2020 11:37:59.00 / 2020 026 41879.00 / 2090  41879.00

INFO  Total  epochs  missing   in  reference  station  RINEX  observation  file
(during summary period):  11

INFO Total epochs missing  in reference station RINEX observation file (all
the file):           11

INFO  Number  of  data  gaps    in  reference  station  RINEX  observation  file
(during summary period):   1

INFO Number of data gaps   in reference station RINEX observation file (all
the file):            1
```


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```
INFO Maximum data gap size in reference station RINEX observation file
(during summary period):  11 at epoch 26/01/2020 18:20:43.00 / 2020 026
66043.00 / 2090  66043.00

INFO Maximum data gap size in reference station RINEX observation file (all
the file):          11 at epoch 26/01/2020 18:20:43.00 / 2020 026 66043.00
/ 2090  66043.00

INFO Time To First Fix: 359 seconds (360 epochs) at epoch 25/01/2020
23:50:59.00 / 2020 025 85859.00 / 2089 604259.00

INFO Number of epochs with constellations used: GPS 86017 ( 100% )

INFO Number of epochs with constellations not used: 0 ( 0% )

INFO Constellations used as reference clock: GPS 86017 ( 100% )

INFO Satellites used (all constellations) 50 Percentile:  9 |  95 Percentile:
7 | Mean:  9.25

INFO Satellites used (GPS)              50 Percentile:  9 |  95 Percentile:
7 | Mean:  9.25

INFO Satellites not used (all constellations) 50 Percentile:  1 |  95
Percentile:  3 | Mean:  1.24

INFO Satellites not used (GPS)                  50 Percentile:  1 |  95
Percentile:  3 | Mean:  1.24

INFO Minimum satellites used (all constellations)  6 (G 6) at epoch
26/01/2020 19:36:22.00 / 2020 026 70582.00 / 2090  70582.00

INFO Minimum satellites used (GPS)              6      at epoch 26/01/2020
19:36:22.00 / 2020 026 70582.00 / 2090  70582.00

INFO Maximum satellites used (all constellations) 12 (G 12) at epoch
26/01/2020 15:45:12.00 / 2020 026 56712.00 / 2090  56712.00

INFO Maximum satellites used (GPS)                  12         at epoch
26/01/2020 15:45:12.00 / 2020 026 56712.00 / 2090  56712.00

INFO Minimum satellites not used (all constellations)  0     at epoch
26/01/2020 23:09:06.00 / 2020 026 83346.00 / 2090  83346.00

INFO Minimum satellites not used (GPS)              0   at epoch 26/01/2020
23:09:06.00 / 2020 026 83346.00 / 2090  83346.00

INFO Maximum satellites not used (all constellations)  6 (G 6) at epoch
26/01/2020 19:28:27.00 / 2020 026 70107.00 / 2090  70107.00

INFO Maximum satellites not used (GPS)                  6        at epoch
26/01/2020 19:28:27.00 / 2020 026 70107.00 / 2090  70107.00

INFO PDOP  95 Percentile:   2.44

INFO GDOP  95 Percentile:   2.83

INFO TDOP  95 Percentile:   1.43

INFO HDOP  95 Percentile:   1.32

INFO VDOP  95 Percentile:   2.06

INFO Minimum PDOP    1.19 with 12 satellites (G 12) at epoch 26/01/2020
15:45:08.00 / 2020 026 56708.00 / 2090  56708.00
```


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```
INFO Minimum GDOP    1.29 with 12 satellites (G 12) at epoch 26/01/2020
15:45:08.00 / 2020 026 56708.00 / 2090  56708.00

INFO Minimum TDOP    0.49 with 12 satellites (G 12) at epoch 26/01/2020
15:45:08.00 / 2020 026 21221.00 / 2090  56708.00

INFO Minimum HDOP    0.68 with 12 satellites (G 12) at epoch 26/01/2020
15:45:08.00 / 2020 026 56708.00 / 2090  56708.00

INFO Minimum VDOP    0.94 with 12 satellites (G 12) at epoch 26/01/2020
05:53:41.00 / 2020 026 21221.00 / 2090  21221.00

INFO Maximum PDOP    3.05 with  6 satellites (G  6) at epoch 26/01/2020
11:06:20.00 / 2020 026 39980.00 / 2090  39980.00

INFO Maximum GDOP    3.66 with  6 satellites (G  6) at epoch 26/01/2020
11:06:27.00 / 2020 026 39987.00 / 2090  39987.00

INFO Maximum TDOP    2.02 with  6 satellites (G  6) at epoch 26/01/2020
11:06:42.00 / 2020 026 39982.00 / 2090  40002.00

INFO Maximum HDOP    1.49 with  7 satellites (G  7) at epoch 26/01/2020
22:12:36.00 / 2020 026 79956.00 / 2090  79956.00

INFO Maximum VDOP    2.66 with  6 satellites (G  6) at epoch 26/01/2020
11:06:22.00 / 2020 026 39982.00 / 2090  39982.00

INFO First epoch of summary for computing positioning error percentiles:
26/01/2020 00:00:00.00 / 2020 026     0.00 / 2090      0.00

INFO Last  epoch of summary for computing positioning error percentiles:
26/01/2020 23:59:59.00 / 2020 026 86399.00 / 2090  86399.00

INFO Horizontal  95 Positioning Error Percentile:   0.23 metres

INFO Vertical    95 Positioning Error Percentile:   0.46 metres

INFO North       95 Positioning Error Percentile:   0.19 metres

INFO East        95 Positioning Error Percentile:   0.17 metres

INFO 3D          95 Positioning Error Percentile:   0.48 metres

INFO Maximum Horizontal Positioning Error:   0.86 metres with 11 satellites
(G 11) at epoch 26/01/2020 06:11:02.00 / 2020 026 22262.00 / 2090  22262.00

INFO Maximum Vertical   Positioning Error:   2.79 metres with  7 satellites
(G  7) at epoch 26/01/2020 11:50:43.00 / 2020 026 42643.00 / 2090  42643.00

INFO Maximum North      Positioning Error:   0.85 metres with 11 satellites
(G 11) at epoch 26/01/2020 06:11:02.00 / 2020 026 22262.00 / 2090  22262.00

INFO Maximum East       Positioning Error:   0.63 metres with  7 satellites
(G  7) at epoch 26/01/2020 11:50:43.00 / 2020 026 42643.00 / 2090  42643.00

INFO Maximum 3D         Positioning Error:   2.86 metres with  7 satellites
(G  7) at epoch 26/01/2020 11:50:43.00 / 2020 026 42643.00 / 2090  42643.00

INFO Total Processing time: 8.750 seconds [User time: 8.422 seconds
(96.250%) Kernel time: 0.328 seconds (3.750%)]

INFO (2)_Station: gras (4)_Lon:     6.92057654 (6)_Lat:     43.75473918
(8)_Height: 1319.2344 (10)_Day: 26 (12)_Month:  1 (14)_Year: 2020 (16)_DoY:
26 (18)_GPSWeek: 2090 (20)_DoW: 0 (22)_Percentile:  95 (24)_HPE_Percentile:
0.23   (26)_VPE_Percentile:        0.46   (28)_NPE_Percentile:        0.19
```


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```
(30)_EPE_Percentile:   0.17 (32)_3DPE_Percentile:   0.48 (34)_MaxHPE:   0.86
(36)_MaxVPE:    2.79 (38)_MaxNPE:    0.85 (40)_MaxEPE:    0.63 (42)_Max3DPE:
2.86 (44)_Avail%:  99.569 (46)_PDOP_Percentile:   2.44 (48)_Min_PDOP:   1.19
(50)_Max_PDOP:    3.05 (52)_GDOP_Percentile:    2.83 (54)_Min_GDOP:    1.29
(56)_Max_GDOP:    3.66 (58)_TDOP_Percentile:    1.43 (60)_Min_TDOP:    0.49
(62)_Max_TDOP:    2.02 (64)_HDOP_Percentile:    1.32 (66)_Min_HDOP:    0.68
(68)_Max_HDOP:    1.49 (70)_VDOP_Percentile:    2.06 (72)_Min_VDOP:    0.94
(74)_Max_VDOP:            2.66    (76)_Sat_used_All_Const_Percentile:    9
(78)_Sat_not_used_All_Const_Percentile:  1  (80)_Min_sat_used_All_Const:  6
(82)_Min_sat_not_used_All_Const:    0    (84)_Max_sat_used_All_Const:    12
(86)_Max_sat_not_used_All_Const:     6     (88)_Epochs_processed:     86389
(90)_Epochs_with_solution:   0    (92)_Epochs_with_solution_reference_file:
86017             (94)_Epochs_omitted_no_data_reference_file:             0
(96)_Epochs_skipped_no_data_reference_file: 0 (98)_Epochs_no_satellites: 2
(100)_Epochs_singular_matrix:    0    (102)_Epochs_No_Reference_GNSS:    0
(104)_Epochs_Over_HDOPorPDOP:       0       (106)_Epochs_Over_HDOP:       0
(108)_Epochs_Over_PDOP:         0         (110)_Epochs_Over_GDOP:         0
(112)_Total_Epochs_skipped:     2     (114)_Epochs_missing_Sum:          11
(116)_Epochs_missing_All_file:      11   (118)_Num_DataGaps_Sum:          1
(120)_Num_DataGaps_All_file:         1   (122)_MaxSize_DataGap_Sum:      11
(124)_MaxSize_DataGap_All_file:     11   (126)_Station_Network_Name:  Other
(128)_Time_To_First_Fix:       359       (130)_Epochs_First_Fix:       360
(132)_Processing_time:      8.750    (134)_Epochs_missing_Ref_Sum:      11
(136)_Epochs_missing_Ref_All_file:    11  (138)_Num_DataGaps_Ref_Sum:     1
(140)_Num_DataGaps_Ref_All_file:     1  (142)_MaxSize_DataGap_Ref_Sum:   11
(144)_MaxSize_DataGap_Ref_All_file:  11
```

NOTES:

- If observation file starts at 22 hours or later, gLAB will automatically assume that all the epochs until the start of the next day (midnight) are for convergence time. During this convergence time, all the epochs computed will not be taken into account for the summary and the Stanford-ESA computation will be skipped. This behaviour can be disabled with the parameter **'--summary:waitfordaystart'**.
- If rover position is not provided, the percentile lines will not appear.
- If user provides a reference file for comparing the solution and if at a certain epoch the reference file position is not available, the epoch will be skipped from the summary.
- If rover position is not provided, the station coordinates will be the solution from the last computed epoch.
- The last line of the summary contains all the values of the previous lines along with the station coordinates.
- The last line is useful for plotting world maps with data from each station.
- The day printed in the last line of the summary corresponds to the day of the first epoch in the summary.
- Stanford-ESA messages will not appear if Stanford-ESA computation has not been enabled.
- HDOP, PDOP and GDOP threshold messages will not appear if HDOP, PDOP or GDOP thresholds have not been enabled respectively.
- The lines referring to a reference file will only appear if a user sets a reference file.

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8 AUXILIARY DATA FILES

8.1 CONFIGURATION FILE

The config file can be specified by the **'-input:cfg <file>'** command-line parameter. This file is an alternative way to configure the behaviour of the tool. In case that there are parameters in the config file and in the command-line arguments, the command-line parameters will have priority over the config file ones.

The order to read the parameters is:

- Check if the **'-input:cfg'** parameter exist in the command-line arguments
- If it exists, parse config file parameters
- Parse command-line parameters

The config file is basically a mirror of the command-line parameters. The only difference is that in the configuration file only one parameter is provided by line. For example, for the parameters **'-input:obs upc42000_10s.06o'** and **'-filter:select G0-PC12 G0-LC12'**, the config file shall be:

```
-input:obs upc42000_10s.06o
-filter:select G0-PC12 G0-LC12
```

There can be any number of spaces between parameters and the arguments. For instance, the example above can also be written as:

```
-input:obs     upc42000_10s.06o
   -filter:select              G0-PC12 G0-LC12
```

Arguments of parameters which contain filenames (with or without pathes) can contain spaces in their filenames. If there is only one argument (one file), it is optional to write the filename between quotes (single or double). If there are multiple arguments or files and the filenames have spaces, it is compulsory to set them between quotes (single or double), as otherwise it would be impossible to disguish a space character being part of the filename or being a separator between arguments. Furthermore, it is possible to add the quote character inside the filename, by preceeding it with a backslash ('\'). The delimiter quotes will be removed from the filename internally in gLAB.

All lines beginning with the hash symbol ('#') in the config file shall be interpreted as a comment, and ignored in the parsing process.

Blank lines are ignored.

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Comments -starting with the hash symbol ('#')- next to the options are allowed (since version 5.2.0). There is no need to set a space character between the end of the parameter or argument and the hash symbol ('#').

This is an example of configuration file:

```
# INPUT
-input:obs madr2000.06o
-input:nav brdc2000.06n "Glo Nav file 200.06g"
-input:antsatblock igs_pre1400.atx

# PREPROCESS
-pre:elevation 5

# FILTER
-filter:prefitoutliers:median 30#Set the prefit outlier detector threshold to 30 metres

# OUTPUT
-print:all  #This parameter enables all output messages
```

This config file is **equivalent** to the following command line executions:

Linux/Cygwin:

```
gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n "Glo Nav file 200.06g" -input:antsatblock igs_pre1400.atx -pre:elevation 5 -filter:prefitoutliers:median 30 -print:all
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n "Glo Nav file 200.06g" -input:antsatblock igs_pre1400.atx -pre:elevation 5 -filter:prefitoutliers:median 30 -print:all
```


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8.2 USER ADDED ERROR

Text file for adding error to satelite raw measurements on certain epochs. Using an adder error file is equivalent to modifying the measurement values in the RINEX observation file. Here is the description of **USER ADDED ERROR FILE**:

- Lines with comments start with a # at the beginning of line.
- If the symbol # is found in the middle of the line, the rest of the line will be omitted, as it will be considered a comment.
- Empty lines will be skipped.
- By executing '**gLAB -usererrorfile > usererrorfile.txt**' a valid user-defined error configuration file is created (this file). Only dates need to be adjusted by user.

The following lines explain the rules for creating a user defined error configuration file:

- Lines with comments start with a # at the beginning of line.
- First line (non empty or without '#') will have two words:
  - The first word indicates if time is given in [GPS week and ToW (Time of Week)] or in [GPS Year, DoY (Day of Year) and SoD (Seconds of Day)]:
    - **ToW** -> Time of week (case insensitive)
    - **SoD** -> Seconds of Day (case insensitive)
  - The second word indicates if the user wants to indicate the duration of the user-defined error either by specifying the length (in seconds) with the word "Length" or by giving the date where the error ends (in the same time format as the initial time) with the word "Time".
    - **Length** -> Length of user-defined error (case insensitive)
    - **Time** -> End time (case insensitive)
- The second line indicates the seed (random function initial value) for the AWGN (Additive White Gaussian Noise) noise (applied just after being read). It can be the system time, specified with the word "Time" or by a number given by user. This line will start with the word "Seed" (or "seed") and then the word to specify the seed type:
  - **CurrentTime** -> Use current execution time (from system) as seed (case insensitive)
  - **<number>** -> Use this number as seed. It must be a positive integer. Floating values will be truncated, but negative values will make gLAB show an error and exit.
- Each line will contain a type of user-defined error to be generated for a given time period. The entries MUST be sorted by time (from earliest to latest). If entries are not sorted, user-defined errors from previous epochs will be ignored.
  - The first word of each line will indicate the type of user-defined error to be generated. The type of user-defined error possible are:

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- **Step** for a step function
- **Ramp** for a ramp function
- **Sinu** for a sinusoidal function
- **AWGN** for AWGN noise

- The second word will be to indicate the constellation and PRN in which the error is added. The constellation will be given with one the following letters:
  - **G** GPS
  - **R** GLONASS
  - **E** Galileo
  - **S** SBAS
  - **C** BeiDou
  - **J** QZSS

  The PRN number is from 0 to 32. A PRN of 0 means that all satellites in the constellation will have this added noise.
- The third word is to indicate the signal where to add the error. The signal code must be one of the observation codes from RINEX version 3.03, (e.g. C1C, L1P, etc.). For a full list of observation codes, refer to AD-02.

- Data lines with wrong number of columns will be ignored (except for the initial two lines with time format and seed).
- Data lines with a user-defined error model different from the ones listed above will be ignored.
- Data columns do not need to have a specific number of spaces between them, as well as leading and trailing spaces at the beginning or end of line respectively are ignored. Furthermore, leading zero for values lower than 1 is optional.
- Data columns may have as column separator white spaces (' '), commas (',') or semicolon (';'). gLAB, internally, will replace all commas and semicolons by spaces, therefore, these column separators can be combined in different or in the same line.
- Numbers MUST have decimals with a dot ('.'), as commas are treated as a column separator. For example, this line:

  ```
  Step G10 C1C 5 2016 1 300 50
  ```

  Can also be written like this:

  ```
  Step   G10  C1C     5    2016    1 300        50
  ```

- gLAB will print the user-defined error in the lines starting with 'USERADDEDERROR' (which are enabled by default). The description of each field in the message is shown in section 7.2.
- For RINEX 2 files, the user must use the equivalent measurements for RINEX 3. The measurement conversion table is:

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C1 → C1C
P1 → C1P
L1 → L1P
D1 → D1P
S1 → S1P

C2 → C2C
P2 → C2P
L2 → L2P
D2 → D2P
S2 → S2P

C5 → C5X
L5 → L5X
D5 → D5X
S5 → S5X

C6 →C6X
L6 →L6X
D6 → D6X
S6 → S6X

C7 → C7X
L7 → L7X
D7 → D7X
S7 → S7X

C8 → C8X
L8 → L8X
D8 → D8X
S8 → S8X

Description of the four types of first word of each line:

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- **Step** function definition:

  Step(t)=A*(u(t-t0)-u(t-t1))

  Where:

  - A is the amplitude of step, which is a constant value. It is defined by the user (in metres).
  - t is the current epoch (in seconds of day).
  - t0 is the epoch where the step function begins (in seconds of day). It is defined by the user.
  - t1 is the epoch where the step function ends (in seconds of day). It is defined by the user.
  - u(t) is the unit step or Heavyside function, defined as:

    t>=0 u(t)=1

    t<0 u(t)=0

  Step(t) is the added error to the measurement (in metres).

  Example (using **SoD** and **Length**):

  ```
  Step G3 C1C 5 2016 1 300 500
  ```

  Where

  - "G3" indicates satellite with PRN 3 from GPS constellation
  - "C1C" is the observation code for GPS L1 frequency civil psudorange measurement
  - "5" is the amplitude (in metres) of the step function
  - "2016" is the year when the step starts
  - "1" is the day of year when the step starts
  - "300" is the seconds of day when the step starts
  - "500" is the duration (in seconds) of the step

- **Ramp** function definition:

  Ramp(t)=B*(t-t0)*(u(t-t0)-u(t-t1))

  Where:

  - B is the amplitude of ramp, which is a constant value. It is defined by the user (in metres).
  - t is the current epoch (in seconds of day).
  - t0 is the epoch where the ramp function begins (in seconds of day). It is defined by the user.
  - t1 is the epoch where the ramp function ends (in seconds of day). It is defined by the user.

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- u(t) is the unit step or Heavyside function, defined as:

  t>=0 u(t)=1

  t<0 u(t)=0

Ramp(t) is the added error to the measurement (in metres).

Example (using **SoD** and **Time**):

```
Ramp G0 L1P 5 2016 1 300 2016 1 500
```

Where

- "G0" indicates all satellites from GPS constellation
- "L1P" is the observation code for GPS L1 frequency carrier phase measurement
- "5" is the amplitude (in metres/second) of the ramp function
- "2016" is the year when the ramp starts
- "1" is the day of year when the ramp starts
- "300" is seconds of day when the ramp starts
- "2016" is the year when the ramp ends
- "1" is the day of year when the ramp ends
- "500" is the seconds of day when the ramp ends

- **Sinusoidal** (**Sinu**) function definition:

  Sinusoidal(t)=C*sin(2*Pi*t/T + alpha)*(u(t-t0)-u(t-t1))

Where:

- C is the amplitude of sinusoidal, which is a constant value. It is defined by the user (in metres).
- T is the period of the sinusoidal, which is a constant value. It is defined by the user (in seconds).
- alpha is the offset of the sinusoidal, which is a constant value. It is defined by the user (in degrees).
- t is the current epoch (in seconds of day).
- t0 is the epoch where the sinusoidal function begins (in seconds of day). It is defined by the user.
- t1 is the epoch where the sinusoidal function ends (in seconds of day). It is defined by the user.
- u(t) is the unit step or Heavyside function, defined as:

  t>=0 u(t)=1

  t<0 u(t)=0

sin(t) is the nominal sinusoidal function.

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Sinusoidal(t) is the added error to the measurement (in metres).

Example (using **ToW** and **Length**):

```
Sinu G12 C1C 5 20E-6 90 1848 259200 500
```

Where

- "G12" indicates satellite with PRN 12 from GPS constellation
- "C1C" is the observation code for GPS L1 frequency
- "5" is the amplitude (in metres) of the sinusoidal function
- "20E-6" is the period of the signal (in seconds).
- "90" is the offset (in degrees) to be added in the sinusoidal function
- "1848" is the GPS week when the sinusoidal starts
- "259200" is the seconds of week when the sinusoidal starts
- "500" is the duration (in seconds) of the sinusoidal

- **AWGN** function definition:

  AWGN(t)=w(t)*(u(t-t0)-u(t-t1))

Where:

- w(t) is an Additive White Gaussian Noise (AWGN) random process. In particular:
- w(t) samples has an associated sigma which can be defined by the user (in metres).The mean value of w(t) samples is zero.
- t is the current epoch (in seconds of day).
- t0 is the epoch where the ramp function begins (in seconds of day). It is defined by the user.
- t1 is the epoch where the ramp function ends (in seconds of day). It is defined by the user.
- u(t) is the unit step or Heavyside function, defined as:

  t>=0 u(t)=1

  t<0 u(t)=0

AWGN(t) is the added error to the measurement (in metres).

Example (using **ToW** and **Time**):

```
AWGN G31 C1C 5 1848 259200 1848 259700
```

Where

- "G31" indicates satellite with PRN 31 from GPS constellation
- "C1C" is the observation code for GPS L1 frequency
- "5" is the standard deviation (in metres) of the AWGN random process

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- ""1848" is the GPS week when the AWGN starts
- "259200" is the seconds of week when the AWGN starts
- "1848" is the GPS week when the AWGN ends
- "259700" is the seconds of week when the AWGN ends

This is an example of user-defined error configuration file:

```
#
#Usage Example:
SoD Length
Seed 10
#Add all user-defined errors at the same time
Step G10 C1C 5 2016 1 300 50
Ramp G20 C1C 5 2016 1 300 500
Sinu G15 L1P 5 20E-6 90 2016 1 300 500
AWGN G10 C1C 5 2016 1 300 500
#Add some more user-defined error later
Ramp G0 C1C 5 2016 1 500 400
Sinu G32 L1P 5 20E-6 90 2016 1 5000 300
```


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8.3 USER SIGMA MULTIPATH

Text file for setting a user defined model for sigma multipath model for a SBAS receiver, which can be elevation or SNR dependent. This model consists of a set of elevation or SNR samples with its corresponding sigma values. With this set, gLAB will linearly interpolate the sigma value from the closest samples to the current value. Here is the description of **SIGMA MULTIPATH FILE**:

- Lines with comments start with a # at the beginning of line.
- If the symbol # is found in the middle of the line, the rest of the line will be omitted, as it will be considered a comment.
- Empty lines will be skipped.
- This file is for introducing a user defined model for sigma multipath model for a SBAS receiver, which can be elevation or SNR dependent.
- By executing '**gLAB -sigmamultipathfile > usermultipathfile.txt**' a valid user multipath model configuration file is created (this file).

The following lines explain the rules for creating this configuration file:

- First line (non empty or without '#') indicates if the following values are for an elevation or S/N ratio model. Values for first line are: 'Elevation' or 'SNR' (values are case insensitive). For example:

  Elevation

  SNR
- Values will be given in the same manner for both cases: For each line, the first column will be either the elevation or the SNR sample, the second column will be the relevant sigma value for the sample.
- There will be as many lines as the number of available samples.
- Lines must be sorted from lower to higher range values. If lines are not sorted, gLAB will show an error and exit.
- The unit for the samples are:
  - degrees for an elevation dependent model
  - dBHz for a S/N ratio dependent model
- The unit for the sigma values are metres.
- Sigma values between intervals will be linearly interpolated.
- If a value to be interpolated is below the minimum sample, the minimum sample value will be used. The same criteria will be used for values over the maximum sample.
- Range step does not need to be constant.
- If SNR model is selected and no SNR from RINEX is available, the highest SNR sample will be used.

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- Data columns do not need to have a specific number of spaces between them, as well as leading and trailing spaces at the beginning or end of line respectively are ignored. Furthermore, leading zero for values lower than 1 is optional.
- Data columns may have as column separator white spaces (' '), commas (',') or semicolon (';'). gLAB, internally, will replace all commas and semicolons by spaces, therefore, these column separators can be set combined in different or in the same line.
- Numbers MUST have decimals with a dot ('.'), as commas are treated as a column separator. For example, this line:

  ```
  20   0.5
  ```

  Can also be written like this:

  ```
   20   .5
  ```

Example for an **elevation** dependent model:

```
Elevation
20   0.7
30   0.6
40   0.5
60   0.3
78   0.2
80   0.1
```

Example for a **SNR** dependent model:

```
SNR
30   0.6
40   0.5
56   0.4
60   0.3
```

This is an example of user multipath model configuration file:

```
#
Elevation
10  0.8
20  0.7
30  0.6
40  0.5
50  0.4
60  0.3
70  0.2
80  0.1
90  0.1
```


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8.4 REFERENCE POSITION

The reference position file contains timely-ordered coordinates, to be used as apriori receiver position in the linearizaztion done in the gLAB filter and in the computation of the gLAB models. The differential fields within the OUTPUT message compute the differences of this apriori position with respect to the position estimated by the filter.

- Lines with comments start with a # at the beginning of line.
- If the symbol # is found in the middle of the line, the rest of the line will be omitted, as it will be considered a comment.
- Empty lines will be skipped.
- By executing '**gLAB -referenceposfile > referencepositionfile.txt**' a valid reference position file is created (this file). Dates and positions have to be adjusted by user.

The following lines explain the rules for creating a reference position file:

- Data columns do not need to have a specific number of spaces between them, as well as leading and trailing spaces at the beginning or end of line respectively are ignored. Furthermore, leading zero for values lower than 1 is optional.
- Data columns may have as column separator white spaces (' '), commas (',') or semicolon (';'). gLAB, internally, will replace all commas and semicolons by spaces, therefore, these column separators can be set combined in different or in the same line.
- Numbers MUST have decimals with a dot ('.'), as commas are treated as a column separator.
- The first line of data (first line non empty or without a '#') must have the names of the elements of each column.
- Names of columns are case insensitive, and must be given in the same order as the data (so gLAB what type of data has each column).
- The order of the data is not important as long as the data type matches the position of the name of the data in the first line.
- The accepted names of columns are (all time tags must be in GPS time):
    - Year : Year
    - DoY : Day of Year
    - SoD : Seconds of Day
    - GPSWeek : The number of week elapsed from GPS start time (6/1/1980)
    - SoW : Seconds of Day
    - Date : Date in calendar format (YYYY/MM/DD)
    - Time : Time in calendar format (HH:MM:SS.zzz). 'zzz' are milliseconds
    - X : X coordinate (metres)

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- Y : Y coordinate (metres)
- Z : Z coordinate (metres)
- Lon : Longitude (degrees). Range is [-180..180]. Values outside of this range will be rejected
- Longitude : Longitude (degrees). Range is [-180..180]. Values outside of this range will be rejected
- Lat : Latitude (degrees). Range is [-90..90]. Values outside of this range will be rejected
- Latitude : Latitude (degrees). Range is [-90..90]. Values outside of this range will be rejected
- Height : Height (metres).

  X, Y and Z are in cartesian ECEF WGS84 reference frame.

  Latitude, Longitude and Height are in geodetic ECEF WGS84 reference frame.

- The file must contain a full set of valid date and coordinates. That is, it must have at least the fields 'Year, DoY, SoD' or 'GPSWeek, SoW' or 'Date Time' for the date, and fields 'X, Y ,Z' or 'Lon, Lat, Height' for the coordinates
- If file contains more than one date formats or both coordinate systems, gLAB will prefer 'Year, DoY, SoD' format for date and 'X, Y, Z' for coordinates (it has less computational cost)
- All other columns that do not match any of the accepted names will be ignored.There will be as many lines as the number of available samples.
- Lines must be sorted from lower to higher range values. If lines are not sorted, gLAB will show an error and exit.
- Furthermore, RTKlib output file is also supported (output must be in 'Lat/Lon/Height' - in ellipsodial or geodetic height- or 'X/Y/Z-ECEF' formats).

Example: the first line could be like the following samples (note that order and number of column separators is not important):

```
Year DoY SoD  X Y Z
Year, DoY, SoD,  X, Y, Z
GPSWeek  SoW    Y  X      Z
DoY   SoD   Year  Lon   Lat    Height
SoW    GPSWeek  Lat Lon Height
DoY  Year  Lon  Height  SoD  Lat
```

This is an example of a reference position file:

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```
#
#The lines below are a valid set of data lines:
Year DoY       SoD              X              Y              Z
2014 067 21200.000   3219920.5954   4672079.7551   3465886.3080
2014 067 21500.000   3219919.9508   4672079.7847   3465887.1434
2014 067 21800.000   3219920.2422   4672080.7439   3465887.0480
```


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9 SBAS MAPS DESCRIPTION

SBAS plots mode is a processing mode (available only in command line) where, instead of computing the navigation solution, gLAB loops through a grid of points (in longitude and latitude) in the map (by default the EGNOS coverage area), during a 24 hour period. In each point, gLAB checks how many satellites are available for SBAS solution (by computing its SBAS corrections). If there are 4 or more satellites with SBAS corrections (and the geometry matrix can be inverted), the protection levels are computed. If the protection levels are below the alarm limits, then there is PA solution available for the current point and epoch. When the selected GEO is below the elevation mask or has no PA (Precision Approach) solution, if GEO switching is enabled, gLAB will loop through all GEO until a GEO is over the elevation mask and provides a PA solution or no unprocessed GEO remain.

In order to compute the geometry matrix, receiver a priori coordinates are needed. The a priori coordinates are the longitude and latitude of the current point in the grid, and the height is a fixed for all points (by default 0 metres -over the WGS84 geoid-). The geometry matrix also contains the measurements weights provided by the SBAS corrections.

In SBAS plots mode, no RINEX observation file is used (as it is not necessary to compute the navigation solution). In order to select which satellites are available at each point in each epoch, gLAB has to loop through all available PRN (for GPS, PRNs 1 to 32) and try to compute its SBAS corrections.

The number of epochs to be processed for the SBAS maps depends on the data files and the software used. gLAB computes daily (24 hours) SBAS map, with the possibility to generate hourly maps (use option **'-sbasplots:hourlymaps'**).

Two data files are necessary for computing a daily SBAS map (24 hours): a SBAS corrections file and a navigation file. In order to account for the convergence time (in this case, wait for the SBAS data buffers get filled), the SBAS data file must contain additional corrections from the previous day. The minimum amount of data is 15 minutes, but gLAB accepts up to two hours of data of convergence time. That is, if the SBAS data file starts at 22h or later, gLAB will automatically assume that all the data from 22h (or later) until 23:59h is data for convergence time and will read all this corrections at once for filling its internal SBAS data memory buffers. Once it reaches 0:00h of the following day it will start the data processing until 23:59h. Since version 5.4.0, gLAB shows an INFO message with the amount of convergence time detected in the SBAS file. If it less than 15 minutes, gLAB warns the user by stating that there is not enough convergence time.

Regarding the navigation file, it is necessary for the user to create a consolidated navigation data file using data from many different stations (for instance, all IGS stations). This is due to each station does not have all of the navigation messages (selected by the IODE) used by SBAS (this can even occur with the 'brdc' consolidated file). One way to check that the navigation file has missing messages is to do a standard SBAS processing (using a RINEX observation file from any station) and enable the "SBASUNSEL" output message. In this message it should appear messages with the text "No broadcast block with IOD...". Since version 5.4.0, gLAB prints an INFO message about the need to create a consolidated file (except if the navigation filename's first 4 characters are "mixn" or "gage", as these are the navigation files created by the gAGE research group). Aside, for the navigation file, it is necessary to include 2 hours of navigation messages from the previous day and 2 hours from the following day. This is due as some of the navigation messages used by SBAS at the start

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or end of the day are saved in the previous or following day. Since version 5.4.0, gLAB checks the start and end time of the navigation file for these 2 hours of data from the previous and following day. If not included, a warning message is printed. Furthermore, it is recommended to apply a data cleansing algorithm to the navigation messages when creating the consolidated navigation message file, in order to remove data logging errors. An algorithm for data cleansing is described in chapter 3.3 of the thesis "Safe satellite navigation with multiple constellations: global monitoring of GPS and GLONASS signal-in-space anomalies", available at "https://web.stanford.edu/group/scpnt/gpslab/pubs/theses/LHengThesisFinalSignedSecured.pdf"

As stated above, gLAB can only process a single day in each run. When the user wants to process a range of days, it will need to process each day independently and join the results following the instructions below. Processing only a single day per run has the following advantages and disadvantages:

Advantages:

- More efficient code as it does not need to deal with day changes.
- Multiple instances of gLAB can be run independently in parallel (one for each CPU available). It is much more efficient than running a single instance with multi-threading for multiple days.
- If the results are not as expected, it is easier to identify the day(s) with problems (e.g. an ionospheric storm), as each day is an independent run.
- If one processed day fails (e.g. missing data), only that day has to be reprocessed.
- Data files remain the same size independently of the data range size processed.

Disadvantages:

- More efficient code as it does not need to deal with day changes.
- Data files with the convergence time have to be created for each day.
- An external script to run gLAB for each day must be generated by the user.
- Percentiles for DOP can only be computed for a single day, as DOP samples are not printed. Nevertheless, the DOP percentile cannot be computed for a long range of days, as for each day, each DOP component (HDOP, PDOP or GDOP) needs around 1GB of memory. For instance, computing HDOP, PDOP and GDOP percentiles for 10 days would need around 30GB of memory.
- Data for each day has to be added up in order to get the statistics for the whole period (explained below).

In order to join the results from multiple days, it is necessary to build a script that reads the gLAB output files and adds everything up. The user can generate this script in many ways (e.g. a Python script). Below is provided some Bash scripts (which can be executed in Linux, Mac or in Windows -using the Cygwin terminal-). In these scripts, the following assumptions are made:

- The output files have the day of year (padded with zeros) and the year in its filenames. This is very important, as this allows to select all the files at once in chronological order

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(as the bash interpreter automatically orders the selected files). In the examples the filenames used are (user can set the output filenames using the appropriate parameters):

Daily files:

AvailMap_001_2017.txt, RiskMap_002_2017.txt, RiskMarMap_003_2017.txt, IonoMap_004_2017.txt, ...

HDOPMap_001_2017.txt, PDOPMap_002_2017.txt, GDOPMap_003_2017.txt, Discontinuities_List_004_2017.txt, ...

Hourly files:

AvailMap_001_2017_00h.txt, RiskMap_002_2017_01h.txt, RiskMarMap_003_2017_10h.txt, IonoMap_004_2017_11h.txt, ...

HDOPMap_001_2017_12h.txt, PDOPMap_002_2017_13h.txt, GDOPMap_003_2017_14h.txt, Discontinuities_List_004_2017_23h.txt, ...

- Data files are saved in a different folder for each day. The folder structure is "YYYY/DoY/", being "YYYY" the year with four digits and "DoY" the day of year padded with zeros.
- This example will join data from two years (2017 and 2018).

9.1 ADDING UP SBAS AVAILABILITY MAPS

SBAS Availability map data is easy to add up, as the output file contains the number of epochs with PA solution under both alarm limits (horizontal and vertical) and the number of epochs processed. These values are independent from day to day, therefore it is only needed to add to total number of epochs with solution and the total number of epochs processed for each day and location, and divide these values in order to get the availability percentage for the whole period. The following bash script does this computation:

```
cat ./201?/???/AvailMap_???_201?.txt|awk -v OFMT="%9.5f" '$1=="#MINLAT" {getline;getline;getline} {avail[$1" "$2]+=$4;numepochs[$1" "$2]+=$5} END {for (i in avail) {print i,avail[i],numepochs[i],numepochs[i]==0?0:100*avail[i]/numepochs[i]}}'|awk '{printf "%6.2f %7.2f %9.5f %8d %8d\n",$1,$2,$5,$3,$4}'|sort -g -k1 -k2 > Avail_added_no_header.txt
```

NOTES:

- For selecting all the hourly maps, change the filename in the previous command from './201?/???/AvailMap_???_201?.txt' to './201?/???/AvailMap_???_201?_??h.txt'
- For selecting some hourly maps (not necessarily continuous hours), a comma separated list of hours (padded with zeros) inside curly braces must be given in the filenames.

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For instance, for selecting hours "1,3,16,17,18,23", the filename should be: './201?/???/AvailMap_???_201?_{01,03,16,17,18,23}h.txt'

The previous command line creates a new file in the gLAB format with all the values added, but with no header. Any header from any of the output files for availability maps can be used. The following command reads the header from the file "AvailMap_001_2017.txt" and copy it to the previous file:

```
head -3 ./2017/001/AvailMap_001_2017.txt|cat - Avail_added_no_header.txt >
Avail_added_with_header.txt
```

The file created, 'Avail_added_with_header.txt' can now be processed by the gLAB plotting tool as a normal SBAS availability plot file. The user will have to change the plot title to state that the file has data for the two years (using the '-t' parameter).

9.2 ADDING UP SBAS IONOSPHERE AVAILABILITY MAPS

The process is identical as the SBAS availability maps. The same scripts are used, but changing the filenames:

```
cat ./201?/???/IonoMap_???_201?.txt|awk -v OFMT="%9.5f" '$1=="#MINLAT"
{getline;getline;getline} {avail[$1" "$2]+=$4;numepochs[$1" "$2]+=$5} END
{for (i in avail) {print
i,avail[i],numepochs[i],numepochs[i]==0?0:100*avail[i]/numepochs[i]}}'|awk
'{printf "%6.2f %7.2f %9.5f %8d %8d\n",$1,$2,$5,$3,$4}'|sort -g -k1 -k2 >
IonoAvail_added_no_header.txt
```

NOTES:

- For selecting all the hourly maps, change the filename in the previous command from './201?/???/IonoMap_???_201?.txt' to './201?/???/IonoMap_???_201?_??h.txt'
- For selecting some hourly maps (not necessarily continuous hours), a comma separated list of hours (padded with zeros) inside curly braces must be given in the filenames.

  For instance, for selecting hours "1,3,16,17,18,23", the filename should be: './201?/???/IonoMap_???_201?_{01,03,16,17,18,23}h.txt'

The previous command line creates a new file in the gLAB format with all the values added, but with no header. Any header from any of the output files for availability maps can be used. The following command reads the header from the file "IonoAvailMap_001_2017.txt" and copy it to the previous file:

```
head -3 ./2017/001/IonoAvailMap_001_2017.txt|cat -
IonoAvail_added_no_header.txt > IonoAvail_added_with_header.txt
```


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The file created, 'IonoAvail_added_with_header.txt' can now be processed by the gLAB plotting tool as a normal SBAS ionosphere availability plot file. The user will have to change the plot title to state that the file has data for the two years (using the '-t' parameter).

9.3 ADDING UP SBAS HDOP MAPS

SBAS HDOP output files contain the mean value, the total HDOP and the number of epochs with PA solution. Note that all epochs with protection levels over the alarm limits are not counted for the DOP percentile or mean value, as most of them will be outliers (this is the behaviour since version 5.4.0, whereas in version 5.3.0 all epochs with PA solution were included in the mean computation). The mean value for each day is independent from each day, therefore we just need to add the total HDOP value for each day and position and the total number of epochs with PA solution, and compute the global mean for the two years. In some positions (in the edges), the number of epochs with PA solution may be 0, so it is necessary to check for this value in order to avoid dividing by zero:

```
cat  ./201?/???/HDOPMap_???_201?.txt|awk  -v  OFMT="%9.5f"  '$1=="#MINLAT"
{getline;getline;getline}        {mean[$1"        "$2]+=$3;numepochs[$1"
"$2]+=$5;total[$1"  "$2]+=$4;percent[$1"  "$2]+=$6}  END  {for  (i  in  total)
{print
i,total[i],numepochs[i],numepochs[i]==0?0:total[i]/numepochs[i],percent[i
]}}'|awk     '{printf     "%6.2f     %7.2f     %15.2f     %17.2f     %8d
%10.2f\n",$1,$2,$5,$3,$4,$6}'|sort -g -k1 -k2 > HDOP_added_no_header.txt
```

NOTES:

- For selecting all the hourly maps, change the filename in the previous command from './201?/???/HDOPMap_???_201?.txt' to './201?/???/HDOPMap_???_201?_??h.txt'
- For selecting some hourly maps (not necessarily continuous hours), a comma separated list of hours (padded with zeros) inside curly braces must be given in the filenames.

  For instance, for selecting hours "1,3,16,17,18,23", the filename should be: './201?/???/HDOPMap_???_201?_{01,03,16,17,18,23}h.txt'

The previous command line creates a new file in the gLAB format with all the values added, but with no header. Any header from any of the output files for HDOP maps can be used. The following command reads the header from the file "HDOPMap_001_2017.txt" and copy it to the previous file:

```
head  -3  ./2017/001/HDOPMap_001_2017.txt|cat  -  HDOP_added_no_header.txt  >
HDOP_added_with_header.txt
```

The file created, 'HDOP_added_with_header.txt' can now be processed by the gLAB plotting tool as a normal SBAS HDOP plot file. The user will have to change the plot title to state that the file has data for the two years (using the '-t' parameter).

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9.4 ADDING UP SBAS PDOP MAPS

Identical to HDOP maps, but changing the filenames to PDOP files:

```
cat ./201?/???/PDOPMap_???_201?.txt|awk -v OFMT="%9.5f" '$1=="#MINLAT"
{getline;getline;getline} {mean[$1" "$2]+=$3;numepochs[$1"
"$2]+=$5;total[$1" "$2]+=$4;percent[$1" "$2]+=$6} END {for (i in total)
{print
i,total[i],numepochs[i],numepochs[i]==0?0:total[i]/numepochs[i],percent[i
]}}'|awk '{printf "%6.2f %7.2f %15.2f %17.2f %8d
%10.2f\n",$1,$2,$5,$3,$4,$6}'|sort -g -k1 -k2 > PDOP_added_no_header.txt
```

NOTES:

- For selecting all the hourly maps, change the filename in the previous command from './201?/???/PDOPMap_???_201?.txt' to './201?/???/PDOPMap_???_201?_??h.txt'
- For selecting some hourly maps (not necessarily continuous hours), a comma separated list of hours (padded with zeros) inside curly braces must be given in the filenames.

  For instance, for selecting hours "1,3,16,17,18,23", the filename should be: './201?/???/PDOPMap_???_201?_{01,03,16,17,18,23}h.txt'

The previous command line creates a new file in the gLAB format with all the values added, but with no header. Any header from any of the output files for PDOP maps can be used. The following command reads the header from the file "PDOPMap_001_2017.txt" and copy it to the previous file:

```
head -3 ./2017/001/PDOPMap_001_2017.txt|cat - PDOP_added_no_header.txt >
PDOP_added_with_header.txt
```

The file created, 'PDOP_added_with_header.txt' can now be processed by the gLAB plotting tool as a normal SBAS PDOP plot file. The user will have to change the plot title to state that the file has data for the two years (using the '-t' parameter).

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9.5 ADDING UP SBAS GDOP MAPS

Identical to HDOP maps, but changing the filenames to GDOP files:

```
cat  ./201?/???/GDOPMap_???_201?.txt|awk  -v  OFMT="%9.5f"  '$1=="#MINLAT"
{getline;getline;getline}        {mean[$1"        "$2]+=$3;numepochs[$1"
"$2]+=$5;total[$1"  "$2]+=$4;percent[$1"  "$2]+=$6}  END  {for  (i  in  total)
{print
i,total[i],numepochs[i],numepochs[i]==0?0:total[i]/numepochs[i],percent[i
]}}'|awk     '{printf     "%6.2f     %7.2f     %15.2f     %17.2f     %8d
%10.2f\n",$1,$2,$5,$3,$4,$6}'|sort -g -k1 -k2 > GDOP_added_no_header.txt
```

NOTES:

- For selecting all the hourly maps, change the filename in the previous command from './201?/???/GDOPMap_???_201?.txt' to './201?/???/GDOPMap_???_201?_??h.txt'
- For selecting some hourly maps (not necessarily continuous hours), a comma separated list of hours (padded with zeros) inside curly braces must be given in the filenames.

  For instance, for selecting hours "1,3,16,17,18,23", the filename should be: './201?/???/GDOPMap_???_201?_{01,03,16,17,18,23}h.txt'

The previous command line creates a new file in the gLAB format with all the values added, but with no header. Any header from any of the output files for GDOP maps can be used. The following command reads the header from the file "GDOPMap_001_2017.txt" and copy it to the previous file:

```
head  -3  ./2017/001/GDOPMap_001_2017.txt|cat  -  GDOP_added_no_header.txt  >
GDOP_added_with_header.txt
```

The file created, 'GDOP_added_with_header.txt' can now be processed by the gLAB plotting tool as a normal SBAS GDOP plot file. The user will have to change the plot title to state that the file has data for the two years (using the '-t' parameter).

9.6 ADDING UP SBAS AVIATION CONTINUITY RISK MAPS (SLIDING WINDOW)

When computing the total continuity risk for multiple continuous days from several single day files (or hourly files), data files are not independent from each other, as each discontinuity (defined as the transition from an epoch with PA solution -under both alarm limits- to an epoch without PA solution or with PA solution over any alarm limits) found affects previous samples. In the case of the sliding window, every time a discontinuity is found, the epochs with PA solution (under alarm limits) previous to the current discontinuity are counted as "in risk" or affected by the current discontinuity.

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The number of samples "in risk" is the size of the window if the number of continuous epochs with PA solution under alarm limits (prior to the previous discontinuity) is equal or greater than the window size, otherwise, only the number of continuous epochs with PA solution under alarm limits (prior to the previous discontinuity) are "in risk". The total discontinuity risk is finally computed by dividing the total number of epochs "in risk" by the total number of epochs with PA solution under alarm limits. Discontinuities can occur, for instance, at the beginning of the day, which would affect samples from the previous day. To account for these cases, a script (attached at the end of this manual) has to read the discontinuities (from the discontinuity list file generated by gLAB) and count the number of samples which were "in risk" by discontinuities but not counted as "in risk" due to the day or hour change.

In order to understand how to count these samples, two facts about how gLAB computes the number of discontinuities for the sliding window:

- For daily and hourly files, if the processing ended with discontinuity, the epochs "in risk" for this discontinuity are accounted in the statistics.
- For hourly files, at the beginning of each hour, internal counters are all reset, therefore, discontinuities from each hour do not affect the previous hour or the following one.

An example is shown below on how to compute the continuity risk, using a sliding window of 5 epochs (this is a very small window size, used for explanatory purposes. Default aviation sliding window size is 15 seconds):

NOTE: the following symbols are used:

- '||' is a separator for a day or hour transition
- 'X' is an epoch with PA solution under alarm limits (or in short, "epoch with PA solution")
- 'O' is an epoch without PA solution or with PA limits over any alarm limit (or in short, "epoch without PA solution")

```
O O O X X X X X X X X O O O O X X X X X O O O O O O X X X O O O X X
            |       |         |       |             |   |
            - - - - -         - - - - -             - - -
                |                 |                   |
                v                 v                   v
      5 epochs "in risk"   5 epochs "in risk"  3 epochs "in risk"

              Total epochs "in risk":        13 epochs
              Total epochs with PA solution: 18 epochs
              Continuity Risk = 13/18 = 0.72
```

The following cases can occur during a day or hour transition:

- Case 1: Day/hour ends without PA solution

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```
      X O O||O O O
or    X X O||X X O   (all epochs "in risk" are correctly accounted)
or    X X O||X X X
```

As stated above, when the day or hour ends with discontinuity, the previous epochs with PA solution are counted for the number of epochs "in risk". No additional epochs "in risk" have to be accounted to the global counter.

- Case 2: Day/hour ends with PA solution and the next day/hour file starts without PA solution

```
X X X||O O O   or   X X X||O O X
|   |               |   |
- - -               - - -
  |                   |
  v                   v
These epochs are not accounted as "in risk" due to the day/hour change
```

The discontinuity at the beginning of the next day/hour affects the epochs with PA solution from the previous day. The number of epochs "in risk" from the previous day will be the size of the window (if the number of continuous epoch with PA solution is equal or larger than the window size) or the number of continuous epoch with PA solution if it is smaller than the window size.

- Case 3: Day/hour ends with PA solution, the next day/hour starts with PA solution and a discontinuity occurs in an epoch which is smaller than the window size:

```
X X X||X X X O   or   O X X||X X X O
|   |                   | |
- - -                   - -
  |                     |
  v                     v
These epochs are not accounted as "in risk" due to the day/hour change
```

- When a day/hour ends with PA solution, the following day starts with PA solution, and a discontinuity occurs, if the epoch of the discontinuity is equal or larger than the window size, all epochs "in risk" will be accounted (as they will all be from the next day), but if the epoch of the discontinuity is smaller than the window size, some of the epochs "in risk" will be in the previous day. Precisely, the number of epochs in "in risk" from the previous day that need to be added to the global counter will be the difference between the window size and the number of epochs with PA solution in the current day. If this

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difference is greater than the number of continuous epochs until the end of the day in the previous day, then the number of epochs "in risk" to be added to the global counter will be the number of continuous epochs until the end of the previous day.

To count the total continuity risk (sliding window) for the whole period, it has to be done in four steps. First, add the total number of epochs "in risk" and the total number of epochs with PA solution. This can be done with the following command line instruction:

```
cat ./201?/???/RiskMap_???_201?.txt| awk -v OFMT="%9.5f" '$1=="#MINLAT" {getline;getline;getline} {numdiscont[$1" "$2]+=$4;numepochs[$1" "$2]+=$5} END {for (i in numdiscont) {print i,numdiscont[i],numepochs[i],numepochs[i]==0?1:numdiscont[i]/numepochs[i] }}'|awk '{printf "%6.2f %7.2f %9.5f %8d %8d\n",$1,$2,$5,$3,$4}'|sort -g -k1 -k2 > Risk_added_no_header.txt
```

NOTES:

- For selecting all the hourly maps, change the filename in the previous command from './201?/???/RiskMap_???_201?.txt' to './201?/???/RiskMap_???_201?_??h.txt'
- For selecting some hourly maps (not necessarily continuous hours), a comma separated list of hours (padded with zeros) inside curly braces must be given in the filenames.

  For instance, for selecting hours "1,3,16,17,18,23", the filename should be: './201?/???/RiskMap_???_201?_{01,03,16,17,18,23}h.txt'

The previous command line creates a new file in the gLAB format with all the values added, but with no header. The second step is to count the number of epochs "in risk" missing in the global counter due to the day/hour transitions.

The AWK script 'count_samples_sliding_window.awk' at the end of this help) does the counting. To run it, execute the following command line:

```
cat ./201?/???/Discontinuities_List_???_201?.txt|awk -f count_samples_sliding_window.awk > epochs_to_add_in_risk.txt
```

NOTES:

- For selecting all the hourly maps, change the filename in the previous command from './201?/???/Discontinuities_List_???_201?.txt' to './201?/???/Discontinuities_List_???_201?_??h.txt'
- For selecting some hourly maps (not necessarily continuous hours), a comma separated list of hours (padded with zeros) inside curly braces must be given in the filenames.

  For instance, for selecting hours "1,3,16,17,18,23", the filename should be: './201?/???/Discontinuities_List_???_201?_{01,03,16,17,18,23}h.txt'

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- The script 'count_samples_sliding_window.awk' will automatically recognize if files are daily or hourly and count epochs accordingly

The script 'count_samples_sliding_window.awk' creates an output file with the same format as the file 'Risk_added_no_header.txt'.

The third step is to add the epochs "in risk" from the 'epochs_to_add_in_risk.txt' file (generated by the AWK) script to the total epoch counter in 'Risk_added_no_header.txt' file. It can be done with the following command:

```
awk -v OFMT="%9.5f" 'NR==FNR {numdiscont[$1" "$2]+=$4;numepochs[$1" "$2]+=$5;next} {numdiscont[$1" "$2]+=$3} END{for (i in numdiscont) {print i,numdiscont[i],numepochs[i],numepochs[i]==0?1:numdiscont[i]/numepochs[i]}}' Risk_added_no_header.txt epochs_to_add_in_risk.txt|awk '{printf "%6.2f %7.2f %9.5f %8d %8d\n",$1,$2,$5,$3,$4}'|sort -g -k1 -k2 > Risk_added_allriskepochs_no_header.txt
```

The previous command line creates a new file in the gLAB format with all the values added, but with no header. Any header from any of the output files for continuity risk maps can be used. The following command reads the header from the file "RiskMap_001_2017.txt" and copy it to the previous file:

```
head -3 ./2017/001/RiskMap_001_2017.txt|cat - Risk_added_allriskepochs_no_header.txt > Risk_added_allriskepochs_header.txt
```

The file created, 'Risk_added_allriskepochs_header.txt' can now be processed by the gLAB plotting tool as a normal SBAS Continuity Risk plot file. The user will have to change the plot title to state that the file has data for the two years (using the '-t' parameter).

NOTE: To ensure the steps were done correctly, it is recommended to execute the previous commands twice. Once using only the daily files, and the next time using only the hourly files. The resulting files created by both executions should be equal, as the total number of epochs "in risk" has to be equal independently if the total number of epochs "in risk" are counted using daily or hourly files.

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9.7 ADDING UP SBAS MARITIME CONTINUITY RISK MAPS (FIXED WINDOW)

The continuity risk for the fixed window is computed as the number of discontinuities multiplied by the window size and divided by the total number of epochs in the processed range (independently if any epoch had PA solution under alarm limits or not). For instance, if the processed range is two non-gap years, the total number of epochs is 2*365*86400=63072000 (or 63158400 if there is a leap year). When adding up the total number of discontinuities for several days/hours, it can occur that some discontinuities are not accounted or other are counted twice. Prior to explain what these cases are, it is necessary first to detail three facts about how gLAB computes the discontinuities for the fixed window:

- For daily and hourly files, if the processing ended with discontinuity, this last discontinuity is accounted in the statistics.
- For hourly files, at the beginning of each hour, internal counters are all reset, therefore, discontinuities from each hour do not affect the previous hour or the following one.
- If one day or hour has no epochs with PA solution, the number of discontinuities and number of epochs will be 0.

An example is shown below on how to compute the continuity risk, using a fixed window of 5 epochs (this is a very small window size, used for explanatory purposes. Default maritime fixed window size is 900 seconds or 15 minutes):

NOTE: the following symbols are used:

- '||' is a separator for a day or hour transition
- 'X' is an epoch with PA solution under alarm limits (or in short, "epoch with PA solution")
- 'O' is an epoch without PA solution or with PA limits over any alarm limit (or in short, "epoch without PA solution")

```
 O O O X X X X X X X X O O O O X X X X X O O O O O O X X X O O O X X
 |   |                |     |           |         |       |   |
 - - -                - - - -           - - - - - -       - - -
   |                     |                   |             |
   v                     v                   v             v
1 discontinuity      1 discontinuity     1 discontinuity  1 discontinuity

                    Total number of discontinuities:     4 discontinuities
                    Total number of epochs processed:   34 epochs
                    Window Size:                         5 epochs
                    Continuity Risk = 4*5/34 = 0.59
```


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The following cases can occur during a day or hour transition:

- Case 1: Day/hour ends without PA solution and the next epoch with PA solution is at the beginning of day/hour:

```
        O X O||X X O
or      X X O||X X X          (All discontinuities are correctly accounted)
or      X X O||O O O||X X X
```

When the day or hour ends with discontinuity, the discontinuity is accounted in the global counter of total discontinuities. As the following day starts with PA solution (or if the discontinuity spans for multiple days but the first epoch with PA solution is at the beginning of the day/hour), only one discontinuity is accounted (as days without any epoch with PA solution have zero discontinuities). Therefore, no discontinuities have to be subtracted from the global counter.

- Case 2: Day/hour ends without PA solution and the following day starts without PA solution:

```
O X O||O X O   or   X X O||O X X   or   X X O||O O O||O X X   or   X O O||O O O||O O X
    |  |                |  |                |         |              |             |
    -  -                -  -                - - - - - -              - - - - - - - -
     |                   |                      |                          |
     v                   v                      v                          v
The discontinuity is counted twice due to the day/hour change (at the end and at the beginning
of next day)
```

In this case, there is one discontinuity that start spans in multiple days/hours. This discontinuity is accounted at the end of the day/hour and at the beginning of the next day/hour with PA solution (if the discontinuity spans for multiple days/hours, days without any epochs with PA solution have zero discontinuities). That is, it is counted twice. Therefore it is necessary to subtract one discontinuity to the global counter of discontinuities.

- Case 3: At the beginning of the data range, a discontinuity lasts a full day/hour and the next day starts with PA solution:

```
||O O O||X X O   or   ||O O O||X X X   or   ||O O O||O O O||X X X   or   ||O O O||O O O||X X O
  |   |                |   |                |         |                  |         |
  - - -                - - -                - - -   - - -                - - -   - - -
    |                    |                      |                            |
```


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```
   v                    v                      v                          v
The discontinuity is not counted due to it starts with the first epoch processed and ends at the end of
a day
```

If in the first day/hour of the data range processed (or every time there is a reset due to the data considered is not a range of continuous days or hours), the discontinuity lasts for the full day (and it may span to multiple days) and the first epoch with PA solution is at the beginning of the day, then this initial discontinuity is not accounted in the global counter. It is necessary to add one to the global counter.

- Case 4: A discontinuity lasts a full day/hour (or several days/hours) and the next day starts with PA solution:

```
X X X||O O O||X X X   or   X X X||O O O||O O O||X X X
       |   |                     |         |
       - - -                     - - -  - - -
         |                             |
         v                             v
      The discontinuity is not counted due to it starts at the beginning of a day
and ends at the end of a day
```

If a discontinuity lasts for multiple days/hours, and it starts at the beginning of a day/hour and ends at the end of a day/hour, this discontinuity will not be accounted in the global counter of discontinuities, as days without PA solution have zero discontinuities. It is necessary to add one to the global counter.

- Case 5: At the end of the data range, a discontinuity starts at the beginning of day/hour and last until the end of the data range:

```
X X X||O O O||   or   O X X||O O O||O O O||
       |   |                 |         |
       - - -                 - - -  - - -
         |                       |
         v                       v
     The discontinuity is not counted due to it starts at the beginning of a day
and ends in the last epoch processed
```

At the end of the data range, if a discontinuity starts at the beginning of day and lasts for a full day or hour (or multiple full days or hours) until the end of data, then this

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discontinuity is not accounted in the global counter of discontinuities, as days without PA solution have zero discontinuities. Therefore it is necessary to add one discontinuity to the global counter of discontinuities.

To count the total continuity risk (fixed window) for the whole period, it has to be done in four steps. First, add the total total number of discontinuities. This can be done with the following command line instruction:

```
cat ./201?/???/RiskMarMap_???_201?.txt| awk -v totalepochs=63072000 -v
windowsize=900 -v OFMT="%9.f" '$1=="#MINLAT" {getline;getline;getline}
{numdiscont[$1" "$2]+=$4;numepochs[$1" "$2]+=$5} END {for (i in numdiscont)
{print
i,numdiscont[i],numepochs[i],numepochs[i]==0?1:windowsize*numdiscont[i]/t
otalepochs}}'|awk '{printf "%6.2f %7.2f %9.5f %8d
%8d\n",$1,$2,$5,$3,$4}'|sort -g -k1 -k2 > RiskMar_added_no_header.txt
```

NOTES:

- The size of the window must be set (in seconds). By default is 900. To change it, change the text 'windowsize=900' to another value.

  For instance, to set the window size to 15, the text should be 'windowsize=15'

- The total number of epochs of the processed must be set (in this example it is two years, which are 63072000 epochs). To change it, change the text 'totalepochs=63072000' to another value.

- For selecting all the hourly maps, change the filename in the previous command from './201?/???/RiskMarMap_???_201?.txt' to './201?/???/RiskMarMap_???_201?_??h.txt'

- For selecting some hourly maps (not necessarily continuous hours), a comma separated list of hours (padded with zeros) inside curly braces must be given in the filenames.

  For instance, for selecting hours "1,3,16,17,18,23", the filename should be: './201?/???/RiskMarMap_???_201?_{01,03,16,17,18,23}h.txt'

The second step is to count the number of discontinuities counted twice and the number of discontinuities not counted due to the day/hour transitions. As the cases of discontinuities not being counted only occur if there were any epochs with PA solution and are less frequent than the number of discontinuities counted twice, the AWK script 'count_samples_fixed_window.awk' will count both cases and provide the number of discontinuities to be subtracted from the global counter of discontinuities, as there will be more case of discontinuities counted twice. To run the script, execute the following command line:

```
cat ./201?/???/Discontinuities_List_???_201?.txt|awk -f
count_samples_fixed_window.awk > epochs_to_subtract_riskmar.txt
```

NOTES:

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- For selecting all the hourly maps, change the filename in the previous command from './201?/???/Discontinuities_List_???_201?.txt' to './201?/???/Discontinuities_List_???_201?_??h.txt'
- For selecting some hourly maps (not necessarily continuous hours), a comma separated list of hours (padded with zeros) inside curly braces must be given in the filenames.

  For instance, for selecting hours "1,3,16,17,18,23", the filename should be: './201?/???/Discontinuities_List_???_201?_{01,03,16,17,18,23}h.txt'
- The script 'count_samples_fixed_window.awk' will automatically recognize if files are daily or hourly and count discontinuities accordingly

The script 'count_samples_fixed_window.awk' creates an output file with the same format as the file 'RiskMar_added_no_header.txt'.

The third step is to subtract the discontinuities from the 'epochs_to_subtract_riskmar.txt' file (generated by the AWK) script to the total epoch counter in 'RiskMar_added_no_header.txt' file. It can be done with the following command:

```
awk -v totalepochs=63072000 -v windowsize=900 -v OFMT="%9.5f" 'NR==FNR
{numdiscont[$1] "$2]+=$4;numepochs[$1] "$2]+=$5;next} {numdiscont[$1"
"$2]-=$3} END{for (i in numdiscont) {print
i,numdiscont[i],numepochs[i]==0?0:totalepochs,numepochs[i]==0?1:windowsiz
e*numdiscont[i]/63072000}}' RiskMar_added_no_header.txt
epochs_to_subtract_riskmar.txt|awk '{printf "%6.2f %7.2f %9.5f %8d
%8d\n",$1,$2,$5,$3,$4}'|sort -g -k1 -k2 >
RiskMar_subtracted_alldiscontinuities_no_header.txt
```

NOTES:

- The size of the window must be set (in seconds). By default is 900. To change it, change the text 'windowsize=900' to another value.

  For instance, to set the window size to 15, the text should be 'windowsize=15' (the default for aviation is 15 seconds, for maritime is 900 seconds or 15 minutes).
- The total number of epochs of the processed must be set (in this example it is two years, which are 63072000 epochs). To change it, change the text 'totalepochs=63072000' to another value.

The previous command line creates a new file in the gLAB format with all the values added, but with no header. Any header from any of the output files for maritime continuity risk maps can be used. The following command reads the header from the file "RiskMarMap_001_2017.txt" and copy it to the previous file:

```
head -3 ./2017/001/RiskMarMap_001_2017.txt|cat -
RiskMar_subtracted_alldiscontinuities_no_header.txt >
RiskMar_subtracted_alldiscontinuities_header.txt
```


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The file created, 'RiskMar_subtracted_alldiscontinuities_header.txt' can now be processed by the gLAB plotting tool as a normal SBAS Maritime Continuity Risk plot file. The user will have to change the plot title to state that the file has data for the two years (using the '-t' parameter).

NOTE: To ensure the steps were done correctly, it is recommended to execute the previous commands twice. One time using only the daily files, and the second time using only the hourly files. The resulting files created by both executions should be equal, as the total number of discontinuities has to be equal independently if the total number of discontinuities are counted using daily or hourly files.

9.8 AWK SCRIPT FOR ADDING SEVERAL DAYS OF CONTINUITY RISK MAPS WITH SLIDING WINDOW

AWK script 'count_samples_sliding_window.awk' for counting the number of samples that have to be added to the total number of epochs with continuity risk when computing the total number of of epochs with continuity risk for a multiple day period with a sliding window.

NOTES:

- Before running the script, the window size has to be set in the second line of the script.
- This script works in gLAB version 5.4.0 and onwards.

```
-----------------------------------------------------------------------------------------------
BEGIN {
    WinSize=15 #Set the size of the window size (in seconds)
   #Default window size of SBAS Aviation: 15
   #Default window size of SBAS Maritime: 900
    FirstFile=0
    Firstday=1
    HourlyMap=0
}

$1=="#MINLAT" {
    #Check if we are joining hourly files
    if ($NF=="HOUR") {
        HourlyMap=1
    }
    getline
    Hour23to0=0
    if (HourlyMap==1 && ($9!=DoY || $10!=Year)) {
```


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```
    if (Hour==23 && $NF==0 && ($9==(DoY+1) || (DoY==1 && $10==(Year+1)))) {
        Offset=3600*23
        Hour23to0=1
        #Reset lastValidEpoch values that are previous to 23 hour
        for (i in lastValidEpochHour) {
            if (lastValidEpochHour[i]<23) {
                lastValidEpoch[i]=0
                lastValidEpochHour[i]=0
            }
        }
    } else {
        #New day found. Don't take into account discontinuities
        #from previous day as when joining hourly maps we do not
        #join the whole day (except when hour 23 and hour 0 is used)
        FirstFile=0
        Firstday=1
        Offset=3600
        #Reset lastValidEpoch values
        for (i in lastValidEpoch) {
            lastValidEpoch[i]=0
            lastValidEpochHour[i]=0
        }
    }
} else if (HourlyMap==1 && $9==DoY && $10==Year) {
    if ((Hour+1)!=$NF) {
        #For the case we are joining hourly files but hourly files
        #are not consecutive hours
        FirstFile=0
        Firstday=1
        #Reset lastValidEpoch values
        for (i in lastValidEpoch) {
            lastValidEpoch[i]=0
            lastValidEpochHour[i]=0
```


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```
            }
        }
        Offset=3600
    } else if (HourlyMap==0) {
        if ($9==(DoY+1) || (DoY==1 && $10==(Year+1))) {
            #New day, which is the following one
        } else {
            #New day, but it is not a continuous day. Don't take into account
            #discontinuities from the previous days
            FirstFile=0
            Firstday=1
            #Reset lastValidEpoch values
            for (i in lastValidEpoch) {
                lastValidEpoch[i]=0
                lastValidEpochHour[i]=0
            }
        }
    }
    DoY=$9
    Year=$10
    if (HourlyMap==1) {
        Hour=$NF
        TotalEpochs=3600*Hour
    } else {
        TotalEpochs=86400
        Hour=0
        Offset=0
    }
    getline
    for (i in TodayAlreadyComputed) {
        TodayAlreadyComputed[i]=0
    }
    FirstFile++
```


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```
    if (FirstFile>1) {
        Firstday=0
    }
    next
}

($3-3600*Hour)<WinSize && Firstday==0 {
    NumAffectedToday=$3-3600*Hour
    StablePeriod=$6
    NumToAffectYesterday=WinSize-NumAffectedToday
    if (Hour23to0==1) {
        LastEpochsAvailYesterday=86400-lastValidEpoch[$1" "$2]
    } else if (HourlyMap==1 && lastValidEpoch[$1" "$2]>TotalEpochs) {
        LastEpochsAvailYesterday=WinSize
    } else {
        LastEpochsAvailYesterday=TotalEpochs-lastValidEpoch[$1" "$2]
    }
    #Check that last epoch of previous day was not in a discontinuity
    if (TodayAlreadyComputed[$1" "$2]==0 && lastValidEpoch[$1" "$2]!=(TotalEpochs+Offset)) {
        #Check if the continuity duration was from the start of the file
        if (NumAffectedToday<WinSize) {
            if (LastEpochsAvailYesterday>0) {
                #Check that discontinuity started at epoch 0 or that is is the first
                #discontinuity found in the file
                if ((NumAffectedToday-StablePeriod)==0) {
                    if (LastEpochsAvailYesterday>=NumToAffectYesterday) {
                        TotalExtraAffected[$1" "$2]+=NumToAffectYesterday
                    } else {
                        TotalExtraAffected[$1" "$2]+=LastEpochsAvailYesterday
                    }
                }
            }
        }
```


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```
    }
    TodayAlreadyComputed[$1" "$2]=1
}

{
    lastValidEpoch[$1" "$2]=$4+1 #Add 1 as the available epoch starts the next epoch
    lastValidEpochHour[$1" "$2]=Hour
}

END {
    for (i in TotalExtraAffected) {
        split(i,coord)
        printf "%6.2f %7.2f %6d\n",coord[1],coord[2],TotalExtraAffected[i]
    }
}
```

9.9 AWK SCRIPT FOR ADDING SEVERAL DAYS OF CONTINUITY RISK MAPS WITH FIXED WINDOW

AWK script 'count_samples_fixed_window.awk' for counting the number of samples that have to be subtracted to the total number of discontinuities when computing the total number of discontinuities for a multiple day period with a fixed window.

NOTES:

- Before running the script, the window size has to be set in the second line of the script.
- This script works in gLAB version 5.4.0 and onwards.

```
-----------------------------------------------------------------------------------------
BEGIN {
    WinSize=900 #Set the size of the window size (in seconds)
   #Default window size of SBAS Aviation: 15
   #Default window size of SBAS Maritime: 900
    FirstFile=0
    Firstday=1
    HourlyMap=0
```


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```
}

$1=="#MINLAT" {
    #For the case that the files has no discontinuity data
    if (NumLinesReadFile<=3) {
        for (i in SubtractDiscon) {
            if (SubtractDiscon[$1" "$2]==1) {
                EpochAvailStartFile[$1" "$2]=1
            }
        }
    }
    NumLinesReadFile=1
    #Check if we are joining hourly files
    if ($NF=="HOUR") {
        HourlyMap=1
    }
    getline
    if (HourlyMap==1 && ($9!=DoY || $10!=Year)) {
        if (Hour==23 && $NF==0 && ($9==(DoY+1) || (DoY==1 && $10==(Year+1)))) {
            Offset=86400
        } else {
            #New day found. Don't take into account discontinuities
            #from previous day as when joining hourly maps we do not
            #join the whole day (except when hour 23 and hour 0 is used)
            FirstFile=0
            Firstday=1
            Offset=0
            #Reset lastValidEpoch values
            for (i in lastValidEpoch) {
                lastValidEpoch[i]=0
                DataAvailAndEndedWithDiscontinuity[i]=0
                SubtractDiscon[i]=0
                EpochAvailStartFile[i]=0
```


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```
            }
        }
    } else if (HourlyMap==1 && $9==DoY && $10==Year) {
        if ((Hour+1)!=$NF) {
            #For the case we are joining hourly files but hourly files
            #are not consecutive hours
            FirstFile=0
            Firstday=1
            #Reset lastValidEpoch values
            for (i in lastValidEpoch) {
                lastValidEpoch[i]=0
                DataAvailAndEndedWithDiscontinuity[i]=0
                SubtractDiscon[i]=0
                EpochAvailStartFile[i]=0
            }
        }
        Offset=0
    } else if (HourlyMap==0) {
        if ($9==(DoY+1) || (DoY==1 && $10==(Year+1))) {
            #New day, which is the following one
        } else {
            #New day, but it is not a continuous day. Don't take into account
            #discontinuities from the previous days
            FirstFile=0
            Firstday=1
            #Reset lastValidEpoch values
            for (i in lastValidEpoch) {
                lastValidEpoch[i]=0
                DataAvailAndEndedWithDiscontinuity[i]=0
                SubtractDiscon[i]=0
                EpochAvailStartFile[i]=0
            }
        }
```


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```
    }
    DoY=$9
    Year=$10
    if (HourlyMap==1) {
        Hour=$NF
        TotalEpochs=3600*Hour
        MaxDisconDuration=3600
    } else {
        TotalEpochs=86400
        MaxDisconDuration=86400
        Hour=0
        Offset=0
    }
    getline
    for (i in TodayAlreadyComputed) {
        TodayAlreadyComputed[i]=0
    }
    FirstFile++
    if (FirstFile>1) {
        Firstday=0
    }
    next
}

{
    NumLinesReadFile++
}

#If the first day has no available epochs, we need to check if the first
#day with valid data, the valid data starts at the first hour or day
(($3-3600*Hour-$6)==0 || ($3-$6)==0)) && $6>0 {
    if (SubtractDiscon[$1" "$2]==1) {
        EpochAvailStartFile[$1" "$2]=1
```


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```
    }
}

SubtractDiscon[$1" "$2]==1 && $5!=MaxDisconDuration {
    SubtractDiscon[$1" "$2]=0
}

($3-3600*Hour)==0 && Firstday==0 {
    #Discontinuities that are counted double are only in the case that previous day ends
    #with a discontinuity and the next day starts with a discontinuity. Also, the
    #discontinuity from the previous day must be one that did not last the hole day,
    #as in this case, the number of discontinuities (NUMDISCONT) is set to 0, as no PA
    #epochs were available, no discontinuity events occurred
    if (lastValidEpoch[$1" "$2]==(TotalEpochs+Offset) && TodayAlreadyComputed[$1" "$2]==0 && $5!=MaxDisconDuration) {
        #if (HourlyMap==0 || (HourlyMap==1 && DataAvailAndEndedWithDiscontinuity[$1" "$2]==1) ) {
        if (DataAvailAndEndedWithDiscontinuity[$1" "$2]==1) {
            if (EpochAvailStartFile[$1" "$2]==0) {
                TotalExtraAffected[$1" "$2]++
            }
            SubtractDiscon[$1" "$2]=0
            EpochAvailStartFile[$1" "$2]=0
        }
        DataAvailAndEndedWithDiscontinuity[$1" "$2]=0
    }
    TodayAlreadyComputed[$1" "$2]=1
}

{
    if ($5==MaxDisconDuration) {
        #if (Firstday==1) {
        if (lastValidEpoch[$1" "$2]!=86400) {
```


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```
            #If the discontinuity lasts the whole day and the previous day ended without discontinuity,
            #and the next day starts with valid data, this discontinuity will not be counted
            #Therefore we need to subtract one from the total count when necessary
            #The check for if the following day starts with data is done later
            if ((lastValidEpoch[$1" "$2]!=(3600*Hour) && Hour>0) || (lastValidEpoch[$1" "$2]==0 && Hour==0 ) ) {
                SubtractDiscon[$1" "$2]=1
            }
        }
        #Discontinuity lasts the hole day or hour
        if (HourlyMap==0) {
            lastValidEpoch[$1" "$2]=86400
        } else {
            lastValidEpoch[$1" "$2]=3600*(Hour+1)
        }
    } else if ((HourlyMap==1 && ($4+1)==(3600*(Hour+1))) || (HourlyMap==0 && ($4+1)==86400) ) {
        lastValidEpoch[$1" "$2]=$4+1 #Add 1 as the avail epoch starts the next epoch
        DataAvailAndEndedWithDiscontinuity[$1" "$2]=1
        HasHadDataAvail[$1" "$2]=1
    } else {
        lastValidEpoch[$1" "$2]=$4+1 #Add 1 as the avail epoch starts the next epoch
        DataAvailAndEndedWithDiscontinuity[$1" "$2]=0
        HasHadDataAvail[$1" "$2]=1
    }
}
END {
    for (i in SubtractDiscon) {
        #If the last day(s) or hour(s) ends had discontinuity for the hole day/hour and the
        #last available epoch was at the end of a day/hour, then the discontinuity that lasted
        #all the hour(s) or day(s) is not accounted for, so it is necessary to subtract one
        #to the total count so it is taken into account
        if (SubtractDiscon[i]==1 && TotalExtraAffected[i]>0 && HasHadDataAvail[i]==1) {
```


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```
            TotalExtraAffected[i]--
        }
    }
    for (i in TotalExtraAffected) {
        split(i,coord)
        printf "%6.2f %7.2f %6d\n",coord[1],coord[2],TotalExtraAffected[i]
    }
}
```


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10 EXAMPLES OF USE

10.1 STANDARD POINT POSITIONING

10.1.1 Graphical User Interface

Step 1: Open the GUI, open the “Templates” menu in the top and click in “SPP”:

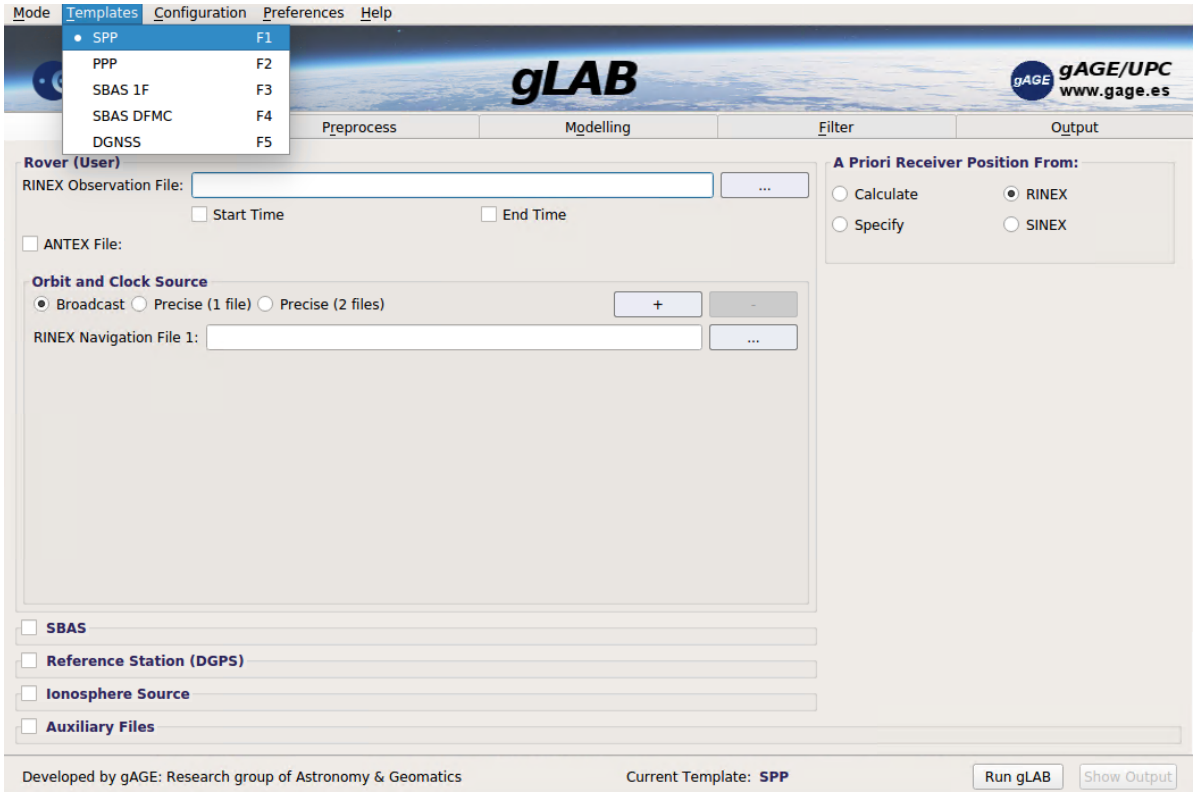

Figure 10-1: GUI Splash screen and select SPP mode

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Step 2: Select an input RINEX observation, a RINEX navigation file:

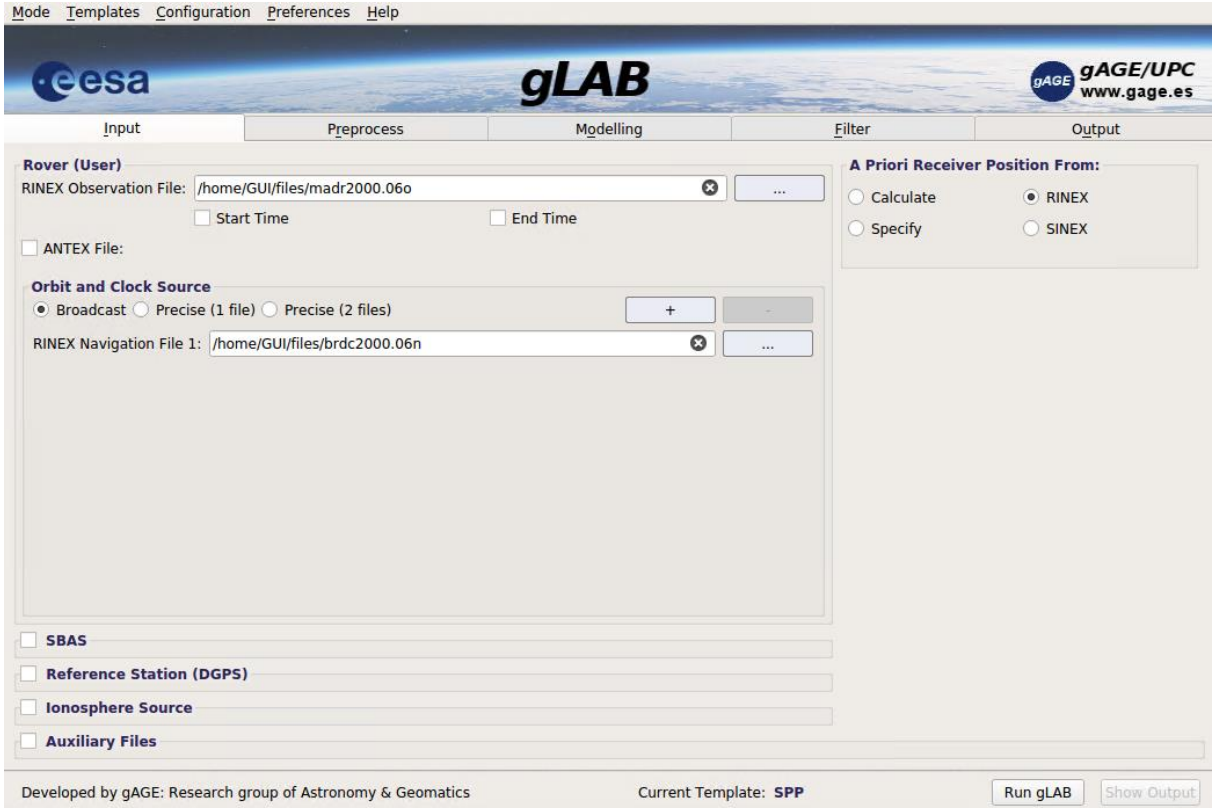

Figure 10-2: Input section

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Step 3: Click in the “Output” tab in the upper part of the screen. Set the name of the output file (or leave the default one):

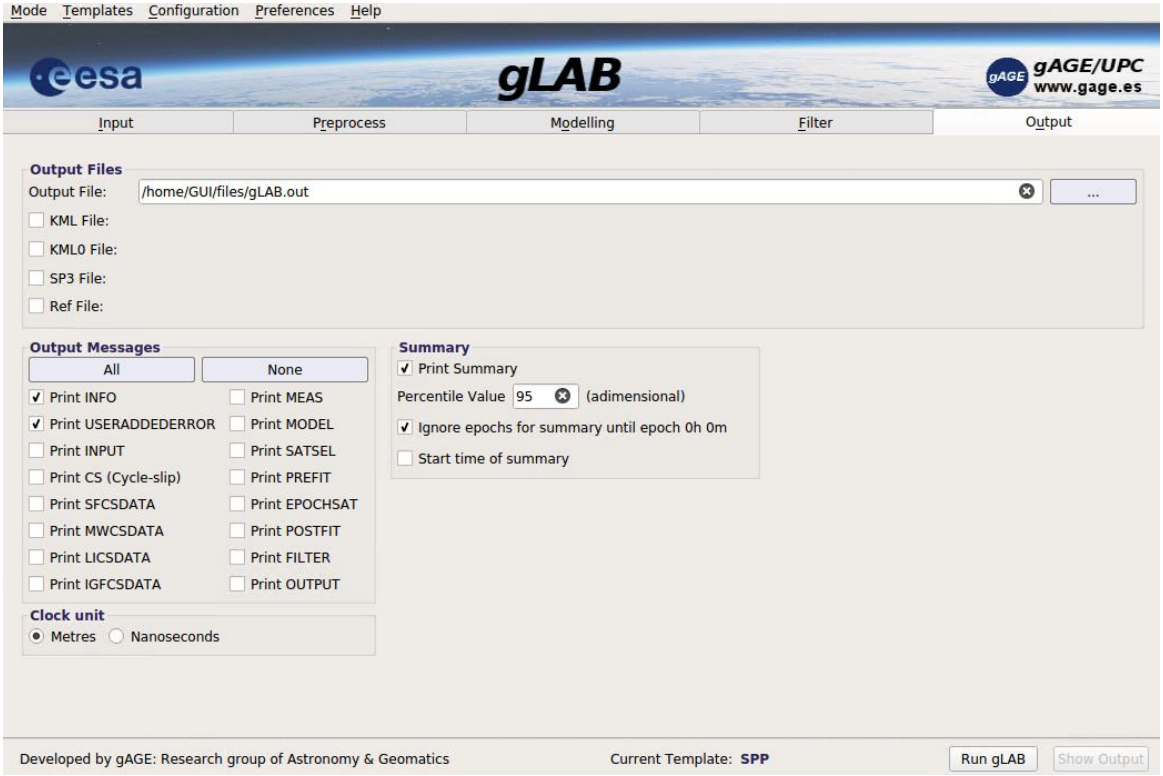

Figure 10-3: Output section

Step 4: Click in the “Run gLAB” button in the bottom part of the screen in order to process the data.

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Step 5: Some plots can be done by going to the “Analysis” mode (In the top menu, click in Mode->Analysis) and using any of the plot templates. For example, for doing the North, East, Up error, click in the “NEU positioning error” template button and the in the “Plot” button in the bottom right corner of the screen:

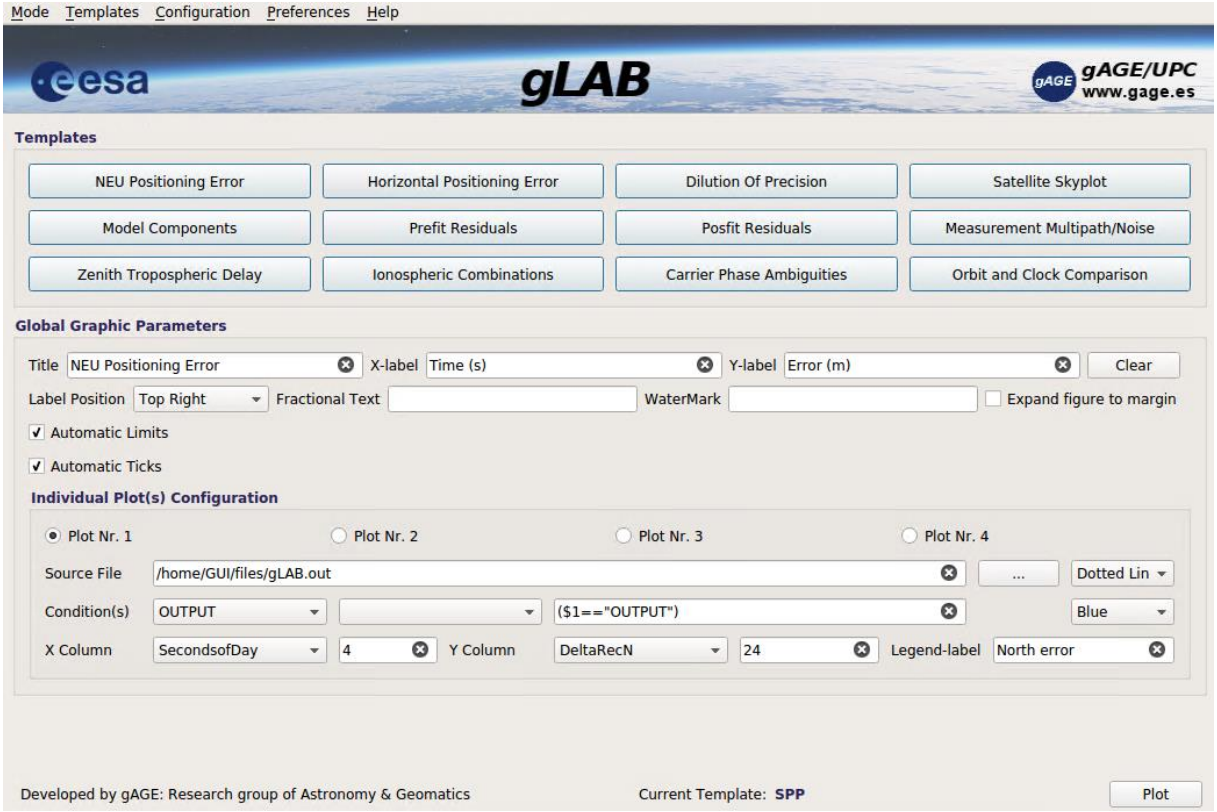

Figure 10-4: Analysis tab

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10.1.2 Command line

Standard Point Positioning Processing with single GPS:

Linux/Cygwin:

```
gLAB_linux -input:obs nnor1830.19o -input:nav BRDC00IGS_R_20191830000_01D_MN.rnx -filter:nav kinematic -filter:select G0-C1C -pre:dec 30 -filter:prefitoutliers:median 30 -pre:setrecpos set -2414152.359994 4907778.631444 -3270644.228824 > /home/gage/gLAB_G.out
```

Windows:

```
gLAB.exe -input:obs nnor1830.19o -input:nav BRDC00IGS_R_20191830000_01D_MN.rnx -filter:nav kinematic -filter:select G0-C1C -pre:dec 30 -filter:prefitoutliers:median 30 -pre:setrecpos set -2414152.359994 4907778.631444 -3270644.228824 > C:\gLAB\win\gLAB_G.out
```

Standard Point Positioning Processing with GPS+GAL+BDS+QZS:

Linux/Cygwin:

```
gLAB_linux -input:obs nnor1830.19o -input:nav BRDC00IGS_R_20191830000_01D_MN.rnx -filter:nav kinematic -filter:select GERJ0-C1C C0-C2I -pre:dec 30 -filter:prefitoutliers:median 30 -pre:setrecpos set -2414152.359994 4907778.631444 -3270644.228824 > /home/gage/gLAB_GRECJ.out
```

Windows:

```
gLAB.exe -input:obs nnor1830.19o -input:nav BRDC00IGS_R_20191830000_01D_MN.rnx -filter:nav kinematic -filter:select GERJ0-C1C C0-C2I -pre:dec 30 -filter:prefitoutliers:median 30 -pre:setrecpos set -2414152.359994 4907778.631444 -3270644.228824 > C:\gLAB\win\gLAB_GRECJ.out
```


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Plotting:

Standard Point Positioning Plotting with single GPS:

Linux/Cygwin:

```
graph.py -f "/home/gage/gLAB_G.out" -t "NEU Positioning Error" -xl "Time (s)" -yl "Error (m)" --xn 0 --xx 90000 --yn -10.0 --yx 10.0 -X 4 -Y 23 -c '($1==\"OUTPUT\")' -l 'North error' --cl b -s '-' -f "/home/gage/gLAB_G.out" -X 4 -Y 24 -c '($1==\"OUTPUT\")' -l 'East error' --cl g -s '-' -f "/home/gage/gLAB_G.out" -X 4 -Y 25 -c '($1==\"OUTPUT\")' -l 'Up error' --cl r -s '-'
```

Windows:

```
graph.exe -f "C:\gLAB\win\gLAB_G.out" -t "NEU Positioning Error" -xl "Time (s)" --yl "Error (m)" -c "($1=='OUTPUT')" -x 4 -y 23 -l "North error" -s .- --cl b -f "C:\gLAB\win\gLAB_G.out" -c "($1=='OUTPUT')" -x 4 -y 24 -l "East error" -s .- --cl g -f "C:\gLAB\win\gLAB_G.out" -c "($1=='OUTPUT')" -x 4 -y 25 -l "Up error" -s .- --cl r --lp tr
```

Standard Point Positioning Plotting with GPS+GLO+GAL+BDS+QZS:

Linux/Cygwin:

```
graph.py -f "/home/gage/gLAB_GRECJ.out" -t "NEU Positioning Error" -xl "Time (s)" -yl "Error (m)" --xn 0 --xx 90000 --yn -10.0 --yx 10.0 -X 4 -Y 23 -c '($1==\"OUTPUT\")' -l 'North error' --cl b -s '-' -f "/home/gage/gLAB_GRECJ.out" -X 4 -Y 24 -c '($1==\"OUTPUT\")' -l 'East error' --cl g -s '-' -f "/home/gage/gLAB_GRECJ.out" -X 4 -Y 25 -c '($1==\"OUTPUT\")'-l 'Up error' --cl r -s '-'
```

Windows:

```
graph.exe -f "C:\gLAB\win\gLAB_GRECJ.out" -t "NEU Positioning Error" -xl "Time (s)" --yl "Error (m)" -c "($1=='OUTPUT')" -x 4 -y 23 -l "North error" -s .- --cl b -f "C:\gLAB\win\gLAB_GRECJ.out" -c "($1=='OUTPUT')" -x 4 -y 24 -l "East error" -s .- --cl g -f "C:\gLAB\win\gLAB_GRECJ.out" -c "($1=='OUTPUT')" -x 4 -y 25 -l "Up error" -s .- --cl r --lp tr
```


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10.1.3 Graphical results

Standard Point Positioning comparison between single GPS and GPS+GLO+GAL+BDS+QZS:

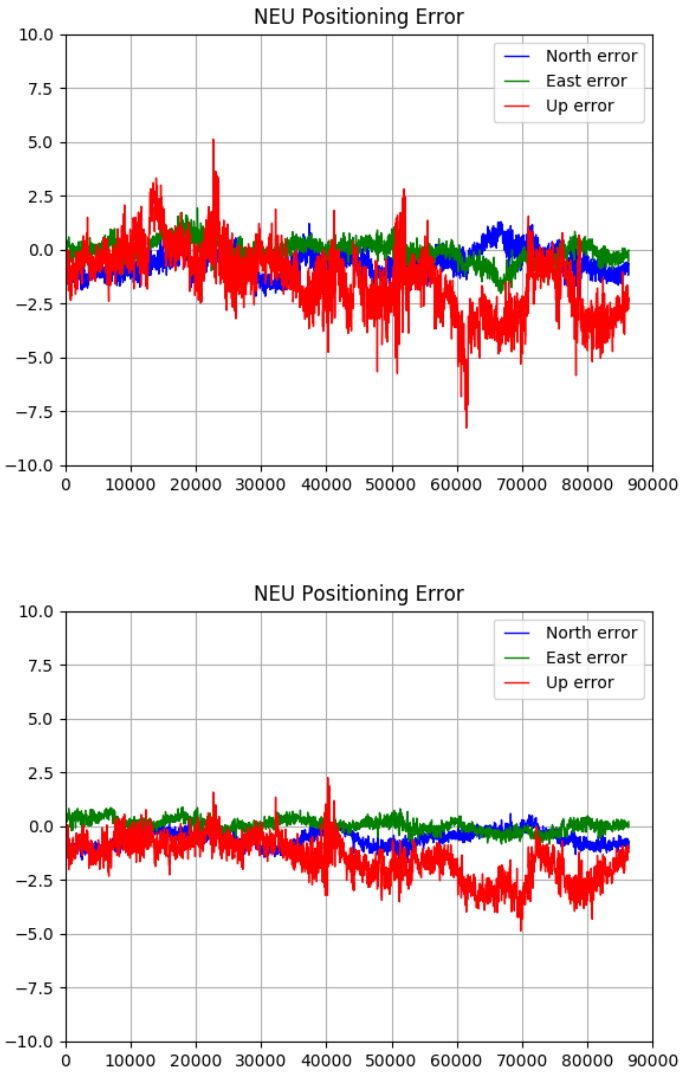

Figure 10-5: Single GPS (top) and GPS+GAL+BDS+QZS (bottom) SPP plot sample

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10.2 PRECISE POINT POSITIONING

10.2.1 Graphical User Interface

The next example gives an overview of a simple processing using gLAB, following all the steps from selecting input files to generating plots to analyse the data. The sample will cover a precise static positioning to obtain the precise coordinates of a station.

After opening the gLAB, the splash screen is shown (Figure 10-6). Clicking the *Input* tab will open the *Input* section (Figure 10-7). Clicking the *PPP Template* in the drop-down men will preconfigure the GUI for a basic PPP. Clicking the *Examine* button for the *RINEX Observation File* will allow selecting which RINEX observation file will be used.

Figure 10-6: GUI Splash screen

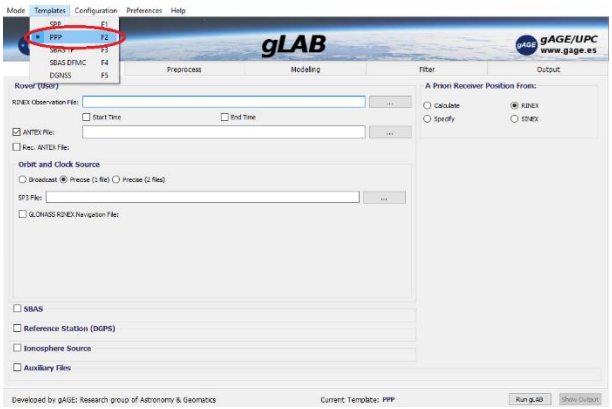
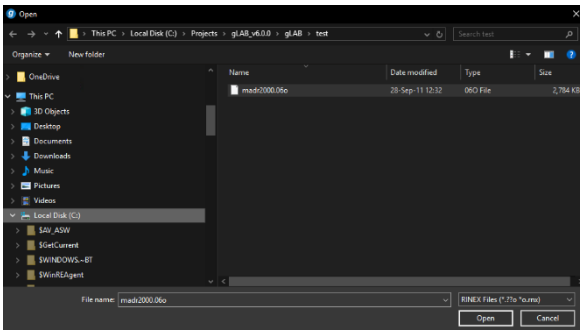


Figure 10-7: Input section

A file dialog will open (Figure 10-8). In Windows, there is the “test” folder with example files. Double clicking on “madr2000.06o” will select this file and include it in the *Input* section (Figure 10-9). In order to include the rest of the required files, it should be clicked the *Examine* of *ANTEX File* (selecting the file “igs_pre1400.atx”), and the *Examine* of *SP3 File* (selecting the file “igs13843.sp3”).



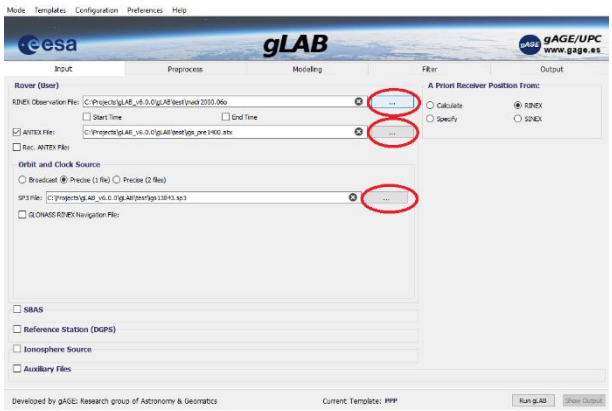


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Figure 10-8: File Open dialog

Figure 10-9: Updated Input section

Once input files are selected (Figure 10-10), *Filter* section button should be clicked in order to configure all the filter parameters. Once in this screen (Figure 10-11), the following parameters should be used (if not already checked):

- Current Template: PPP
- Estimate wet tropospheric residual: Yes
- Available frequencies: Dual frequency
- Receiver Kinematics: Static
- Measurement selection: Pseudorange + Carrier phase

All these parameters are the default ones, so no special change should be done if the program has just started. After being sure all parameters are properly selected, the output file should be selected by clicking in the *Output* section.

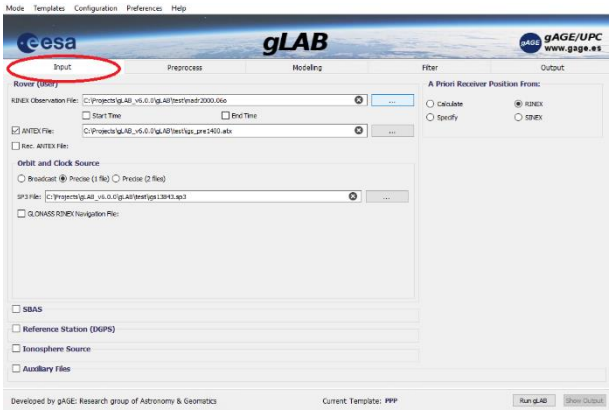

Figure 10-10: All input files are selected

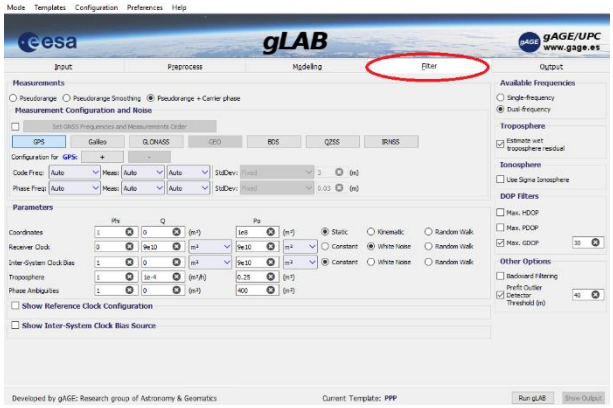

Figure 10-11: Filter section

The *RUN gLAB* button will execute gLAB DPC with the selected options. While the DPC is running, a progress bar will be shown. After some seconds, the processing will end. To analyse the results, click on the *Analysis* tab (Figure 10-13).

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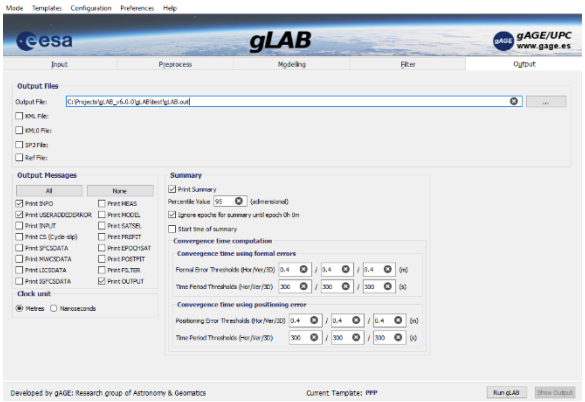

Figure 10-12: Output selected

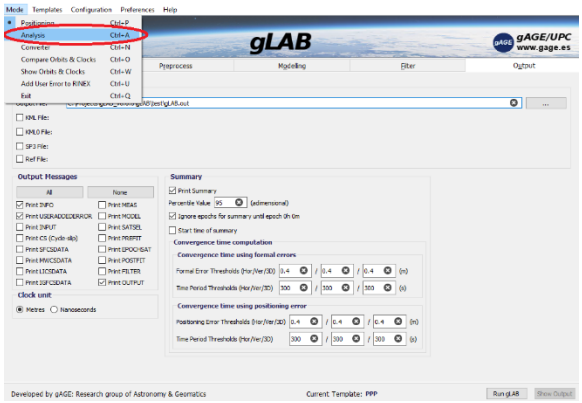

Figure 10-13: DPC has been executed

As explained in section 4.3 the *Analysis* mode (Figure 10-14) contains several templates in order to ease the generation of plots, in this sense, to plot the evolution of the receiver position in North/East/Up components the button *Receiver NEU position error* should be clicked. Figure 10-15 shows the configuration of the *Graphic Details* with this template. The *Source File* is the file selected in the *Output* section of the *Calculus* tab. Clicking the *Plot* button will generate this plot. While the program is processing the source file, the *Plot* button will be kept grey.

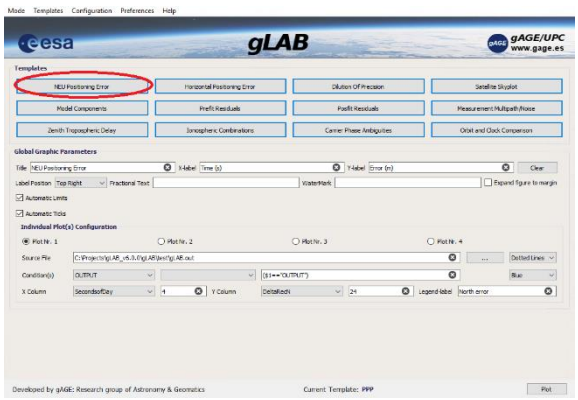

Figure 10-14: Analysis tab

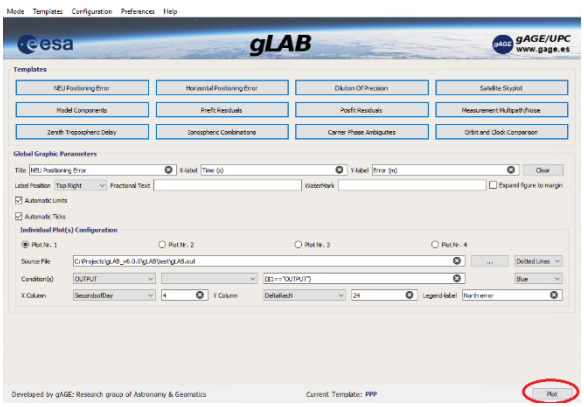

Figure 10-15: Receiver NEU position error configuration

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10.2.2 Command line

Kinematic Precise Point Positioning Processing with single GPS:

Linux/Cygwin:

```
gLAB_linux -input:obs nnor1830.19o -input:orb COD0MGXFIN_20191830000_01D_05M_ORB.SP3 -input:clk COD0MGXFIN_20191830000_01D_30S_CLK.CLK -input:ant igs14_2097.atx -filter:nav kinematic -filter:select G0-PC12 G0-LC12 -pre:dec 30 -filter:prefitoutliers:median 30 -pre:setrecpos set -2414152.359994 4907778.631444 -3270644.228824 > /home/gage/gLAB_G.out
```

Windows:

```
gLAB.exe -input:obs nnor1830.19o -input:orb COD0MGXFIN_20191830000_01D_05M_ORB.SP3 -input:clk COD0MGXFIN_20191830000_01D_30S_CLK.CLK -input:ant igs14_2097.atx -filter:nav kinematic -filter:select G0-PC12 G0-LC12 -pre:dec 30 -filter:prefitoutliers:median 30 -pre:setrecpos set -2414152.359994 4907778.631444 -3270644.228824 > C:\gLAB\win\gLAB_G.out
```

Kinematic Precise Point Positioning Processing with GPS+GLO+GAL+BDS+QZS:

Linux/Cygwin:

```
gLAB_linux -input:obs nnor1830.19o -input:orb COD0MGXFIN_20191830000_01D_05M_ORB.SP3 -input:clk COD0MGXFIN_20191830000_01D_30S_CLK.CLK -input:navglo brdc1830.19g -input:ant igs14_2097.atx -filter:nav kinematic -filter:select G0-PC12 E0-PC15 R0-PC12 C0-PC27 J0-PC15 G0-LC12 E0-LC15 R0-LC12 C0-LC27 J0-LC15 --model:dcb:df:bds -pre:dec 30 -filter:prefitoutliers:median 30 -pre:setrecpos set -2414152.359994 4907778.631444 -3270644.228824 > /home/gage/gLAB_GRECJ.out
```

Windows:

```
gLAB.exe -input:obs nnor1830.19o -input:orb COD0MGXFIN_20191830000_01D_05M_ORB.SP3 -input:clk COD0MGXFIN_20191830000_01D_30S_CLK.CLK -input:navglo brdc1830.19g -input:ant igs14_2097.atx -filter:nav kinematic -filter:select G0-PC12 E0-PC15 R0-PC12 C0-PC27 J0-PC15 G0-LC12 E0-LC15 R0-LC12 C0-LC27 J0-LC15 --model:dcb:df:bds -pre:dec 30 -filter:prefitoutliers:median 30 -pre:setrecpos set -2414152.359994 4907778.631444 -3270644.228824 > C:\gLAB\win\gLAB_GRECJ.out
```

Static Precise Point Positioning Processing with single GPS:

Linux/Cygwin:

```
gLAB_linux -input:obs nnor1830.19o -input:orb COD0MGXFIN_20191830000_01D_05M_ORB.SP3 -input:clk COD0MGXFIN_20191830000_01D_30S_CLK.CLK -input:ant igs14_2097.atx -filter:nav static -filter:select G0-PC12 G0-LC12 -pre:dec 30 -filter:prefitoutliers:median 30 -pre:setrecpos set -2414152.359994 4907778.631444 -3270644.228824 > /home/gage/gLAB_G.out
```


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Windows:

```
gLAB.exe -input:obs nnor1830.19o -input:orb COD0MGXFIN_20191830000_01D_05M_ORB.SP3 -input:clk COD0MGXFIN_20191830000_01D_30S_CLK.CLK -input:ant igs14_2097.atx -filter:nav static -filter:select G0-PC12 G0-LC12 -pre:dec 30 -filter:prefitoutliers:median 30 -pre:setrecpos set -2414152.359994 4907778.631444 -3270644.228824 > C:\gLAB\win\gLAB_G.out
```

Static Precise Point Positioning Processing with GPS+GLO+GAL+BDS+QZS:

Linux/Cygwin:

```
gLAB_linux -input:obs nnor1830.19o -input:orb COD0MGXFIN_20191830000_01D_05M_ORB.SP3 -input:clk COD0MGXFIN_20191830000_01D_30S_CLK.CLK -input:navglo brdc1830.19g -input:ant igs14_2097.atx -filter:nav kinematic -filter:select G0-PC12 E0-PC15 R0-PC12 C0-PC27 J0-PC15 G0-LC12 E0-LC15 R0-LC12 C0-LC27 J0-LC15 --model:dcb:df:bds -pre:dec 30 -filter:prefitoutliers:median 30 -pre:setrecpos set -2414152.359994 4907778.631444 -3270644.228824 > /home/gage/gLAB_GRECJ.out
```

Windows:

```
gLAB.exe -input:obs nnor1830.19o -input:orb COD0MGXFIN_20191830000_01D_05M_ORB.SP3 -input:clk COD0MGXFIN_20191830000_01D_30S_CLK.CLK -input:navglo brdc1830.19g -input:ant igs14_2097.atx -filter:nav kinematic -filter:select G0-PC12 E0-PC15 R0-PC12 C0-PC27 J0-PC15 G0-LC12 E0-LC15 R0-LC12 C0-LC27 J0-LC15 --model:dcb:df:bds -pre:dec 30 -filter:prefitoutliers:median 30 -pre:setrecpos set -2414152.359994 4907778.631444 -3270644.228824 > C:\gLAB\win\gLAB_GRECJ.out
```

Plotting Command lines:

Precise Point Positioning Plotting with single GPS:

Linux/Cygwin:

```
graph.py -f "/home/gage/gLAB_G.out" -t "NEU Positioning Error" -xl "Time (s)" -yl "Error (m)" --xn 0 --xx 90000 --yn -10.0 --yx 10.0 -X 4 -Y 23 -c '($1==\"OUTPUT\")' -l 'North error' --cl b -s '-' -f "/home/gage/gLAB_G.out" -X 4 -Y 24 -c '($1==\"OUTPUT\")' -l 'East error' --cl g -s '-' -f "/home/gage/gLAB_G.out" -X 4 -Y 25 -c '($1==\"OUTPUT\")'-l 'Up error' --cl r -s '-'
```

Windows:

```
graph.exe -f "C:\gLAB\win\gLAB_G.out" -t "NEU Positioning Error" -xl "Time (s)" --yl "Error (m)" -c "($1=='OUTPUT')" -x 4 -y 23 -l "North error" -s .- --cl b -f "C:\gLAB\win\gLAB_G.out" -c "($1=='OUTPUT')" -x 4 -y 24 -l "East error" -s .- --cl g -f "C:\gLAB\win\gLAB_G.out" -c "($1=='OUTPUT')" -x 4 -y 25 -l "Up error" -s .- --cl r --lp tr
```


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Precise Point Positioning Plotting with GPS+GLO+GAL+BDS+QZS:

Linux/Cygwin:

```
graph.py -f "/home/gage/gLAB_GRECJ.out" -t "NEU Positioning Error" -xl "Time (s)" -yl "Error (m)" --xn 0 --xx 90000 --yn -10.0 --yx 10.0 -X 4 -Y 23 -c '($1==\"OUTPUT\")' -l 'North error' --cl b -s '-' -f "/home/gage/gLAB_GRECJ.out" -X 4 -Y 24 -c '($1==\"OUTPUT\")' -l 'East error' --cl g -s '-' -f "/home/gage/gLAB_GRECJ.out" -X 4 -Y 25 -c '($1==\"OUTPUT\")'-l 'Up error' --cl r -s '-'
```

Windows:

```
graph.exe -f "C:\gLAB\win\gLAB_GRECJ.out" -t "NEU Positioning Error" -xl "Time (s)" --yl "Error (m)" -c "($1=='OUTPUT')" -x 4 -y 23 -l "North error" -s .- --cl b -f "C:\gLAB\win\gLAB_GRECJ.out" -c "($1=='OUTPUT')" -x 4 -y 24 -l "East error" -s .- --cl g -f "C:\gLAB\win\gLAB_GRECJ.out" -c "($1=='OUTPUT')" -x 4 -y 25 -l "Up error" -s .- --cl r --lp tr
```


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10.2.3 Graphical results

Kinematic Precise Point Positioning comparison between single GPS and GPS+GLO+GAL+BDS+QZS:

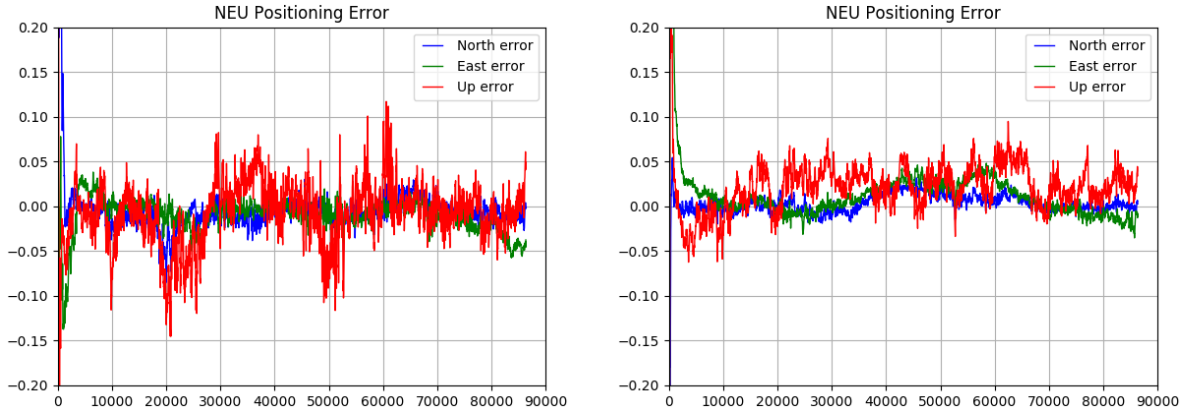

Figure 10-16: Single GPS (left) and GPS+GLO+GAL+BDS+QZS (right) kinematic PPP plot sample

Static Precise Point Positioning comparison between single GPS and GPS+GLO+GAL+BDS+QZS:

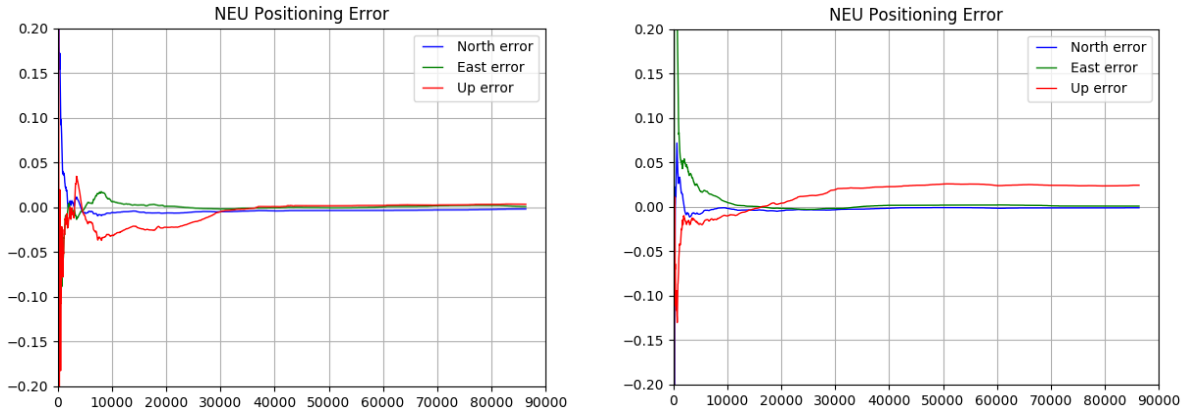

Figure 10-17: Single GPS (left) and GPS+GLO+GAL+BDS+QZS (right) static PPP plot sample

The bias in the “Up” component for the multi-constellation static PPP is due to ANTEX file does not contain the receiver antenna phase center correction for Galileo L1/L5, BeiDou L2/L7 and QZSS L1/L2.

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10.3 SATELLITE BASED AUGMENTATION SYSTEMS

10.3.1 Graphical User Interface

Example for processing in SBAS 1F mode with the GUI:

Step 1: Open the GUI, open the “Templates” menu in the top and click in “SBAS 1F”:

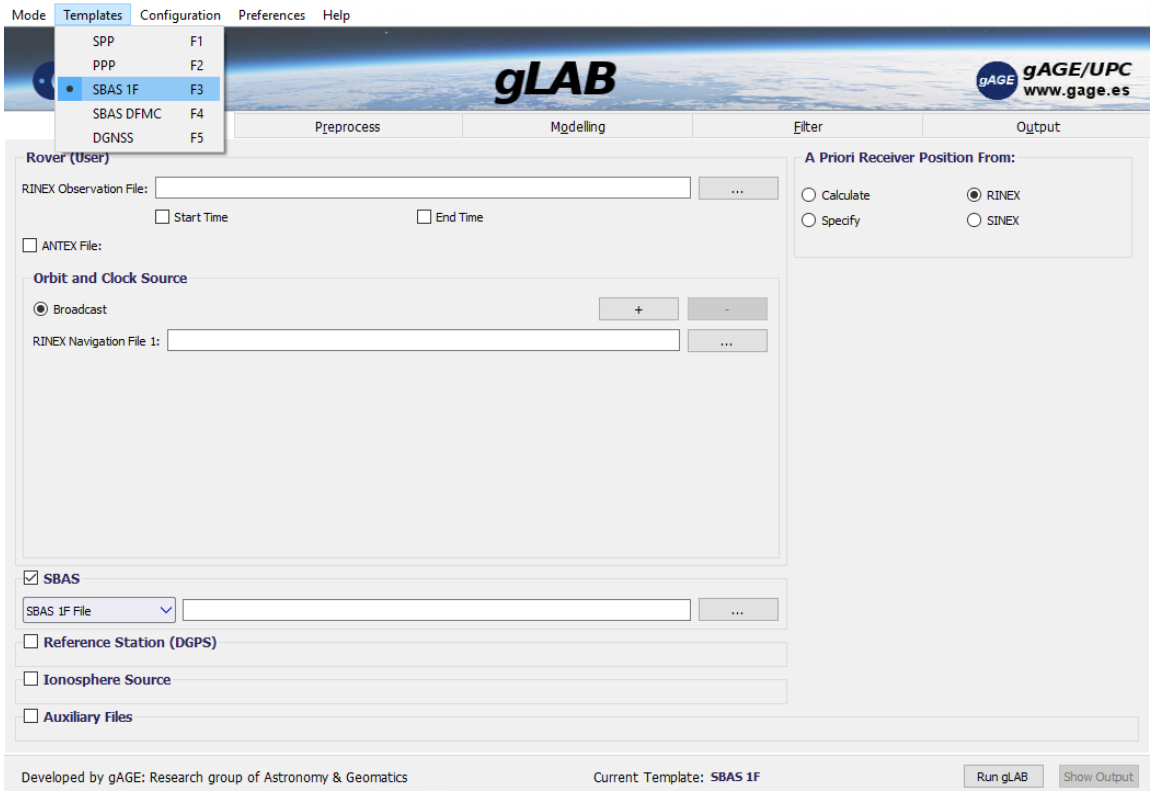

Figure 10-18: GUI Splash screen and select SBAS mode

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Step 2: Select an input RINEX observation, a RINEX navigation file and a SBAS message file (it can be a RINEX-B or an EMS file):

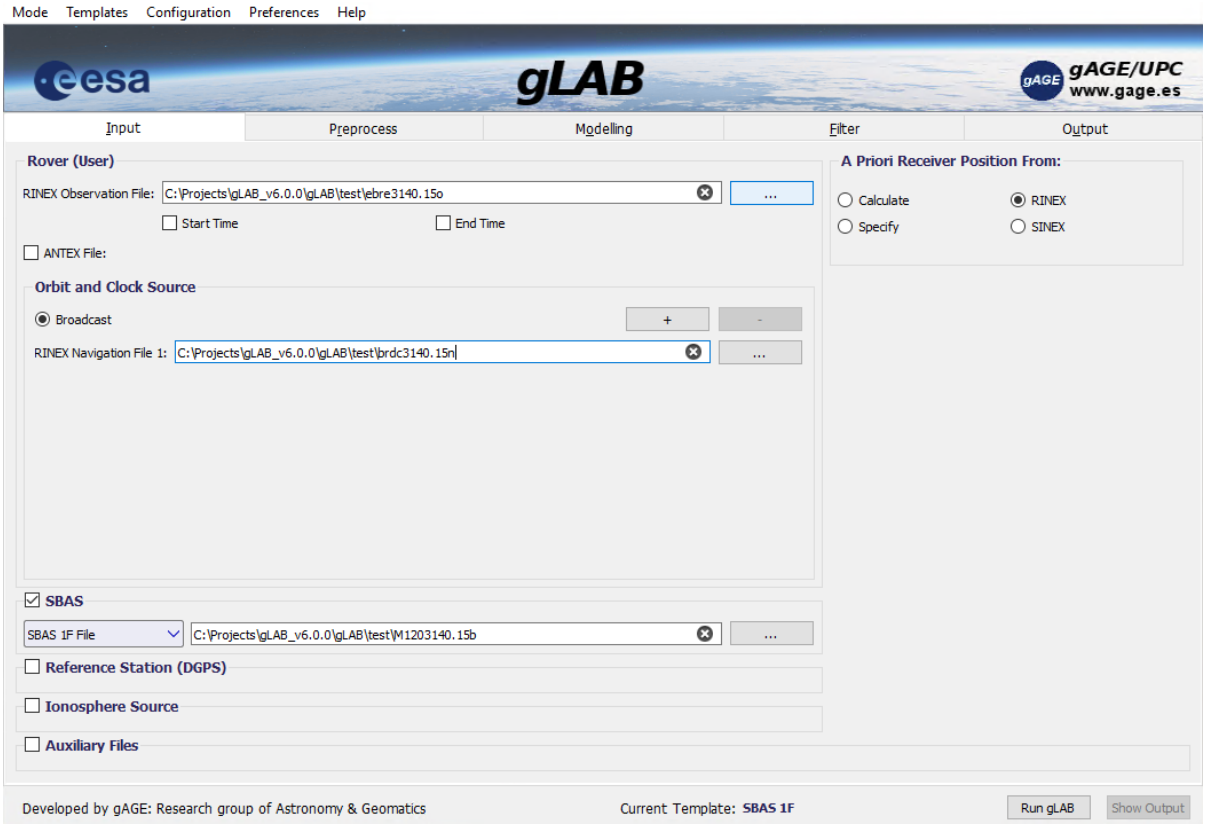

Figure 10-19: Input section

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Step 3: Click in the “Output” tab in the upper part of the screen. Set the name of the output file (or leave the default one). Furthermore, in SBAS mode, the Stanford-ESA plot can be computed by clicking in the “Stanford-ESA” button:

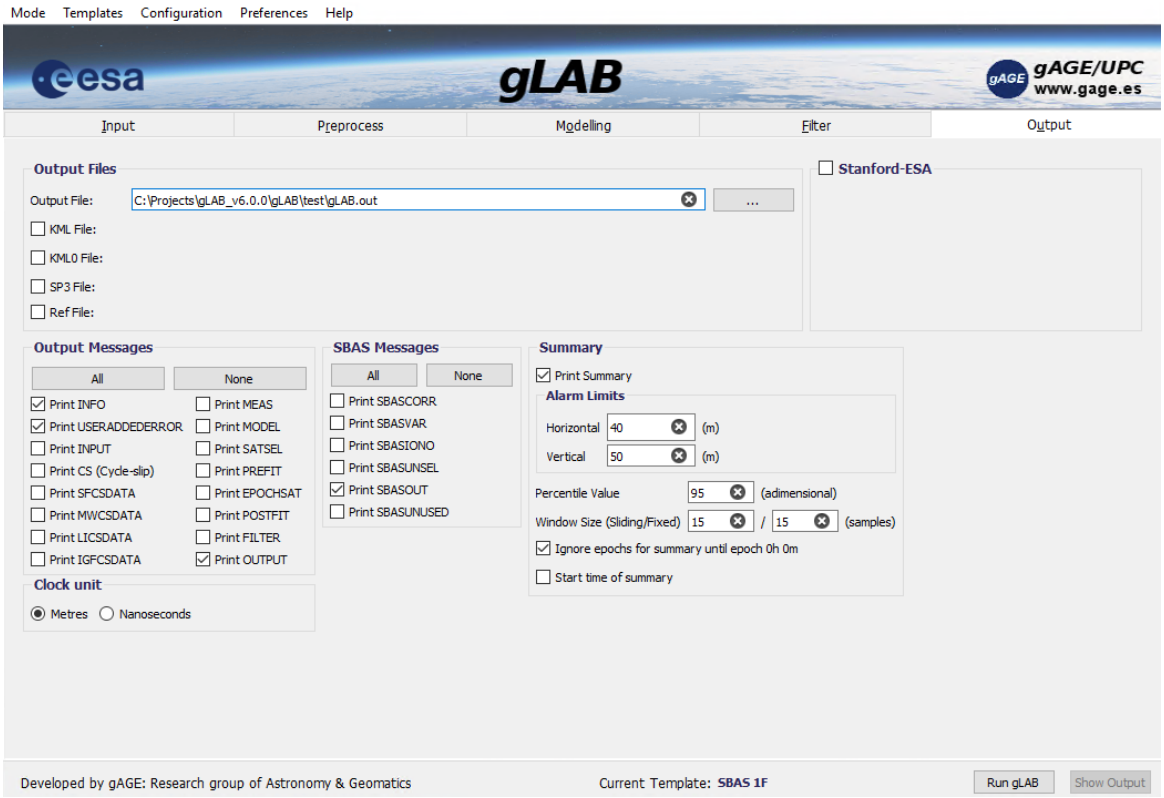

Figure 10-20: Output section

Step 4: Click in the “Run gLAB” button in the bottom part of the screen in order to process the data.

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Step 5: Some plots can be done by going to the “Analysis” mode (In the top menu, click in Mode->Analysis) and using any of the plot templates. For example, for doing the North, East, Up error, click in the “NEU positioning error” template button and the in the “Plot” button in the bottom right corner of the screen:

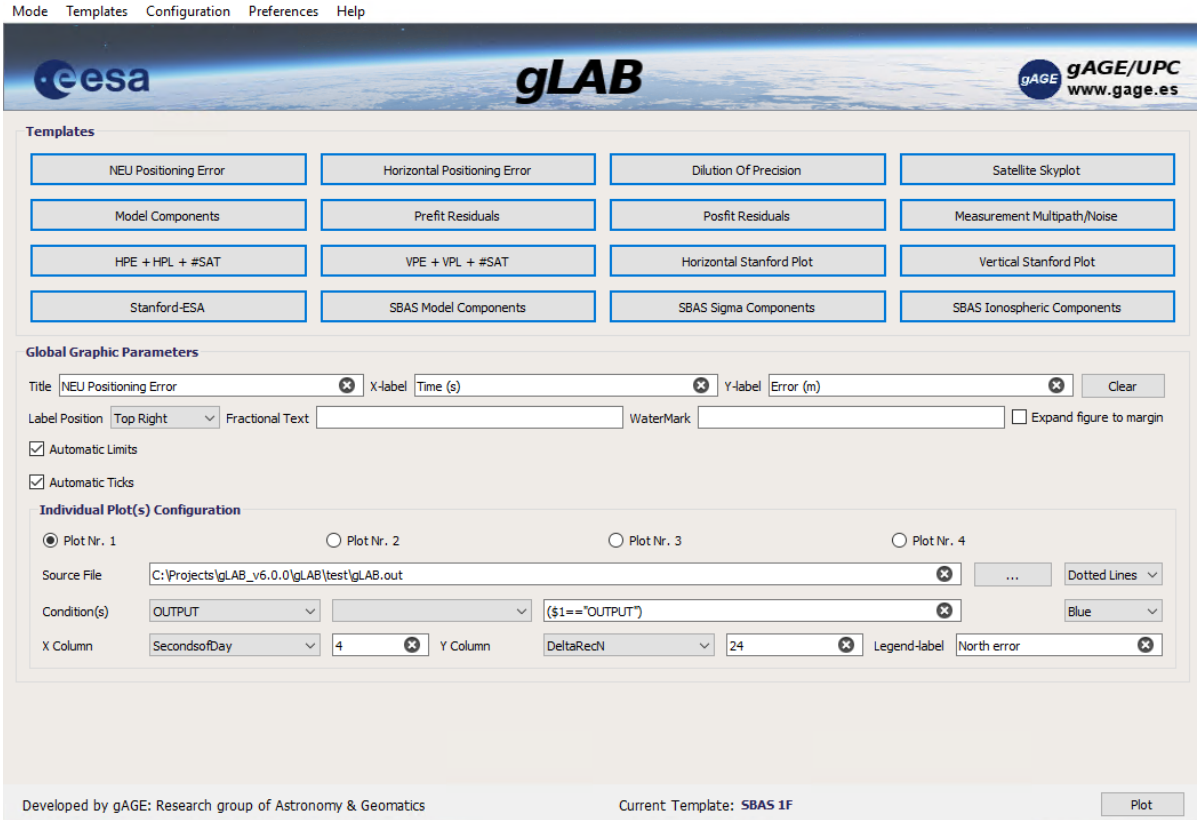

Figure 10-21: Analysis tab

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10.3.2 Command line

10.3.2.1 SBAS data processing

Usage examples to run gLAB with SBAS data processing:

Standalone navigation with SBAS ionosphere (without any other SBAS correction):

Linux/Cygwin:

```
gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbasiono M1202000.06b -model:iono SBAS > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbasiono M1202000.06b -model:iono SBAS > outputfile.txt
```

Standard SBAS processing (SBAS summary is printed):

Linux/Cygwin:

```
gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b > outputfile.txt
```

Standard SBAS processing with file conversion from RINEX-B to Pegasus:

Linux/Cygwin:

```
gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -output:pegasus > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -output:pegasus > outputfile.txt
```

Standard SBAS processing printing only SBASOUT messages (no SBAS summary):

Linux/Cygwin:

```
gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -print:none -print:sbasout > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -print:none -print:sbasout > outputfile.txt
```


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Standard SBAS processing enabling the step detector and also compute the Stanford-ESA plot values:

Linux/Cygwin:

```
gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -filter:stfdesa -filter:stepdetector > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -filter:stfdesa -filter:stepdetector > outputfile.txt
```

NOTE: The Stanford-ESA plot values will be written in the file "`<observationfilename>_stdESA.txt`" (which in this case would be "`madr2000.06o_stdESA.txt`")

Standard SBAS processing enabling the step detector and also compute the Stanford-ESA plot values, printing the Stanford-ESA samples with a horizontal or vertical worst integrity ratio higher than 0.85:

Linux/Cygwin:

```
gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -filter:stfdesa -filter:stfdesaloi -filter:stfdesa:hwir 0.85 -filter:stfdesa:vwir 0.85 -filter:stepdetector > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -filter:stfdesa -filter:stfdesaloi -filter:stfdesa:hwir 0.85 -filter:stfdesa:vwir 0.85 -filter:stepdetector > outputfile.txt
```

NOTE: The Stanford-ESA samples data will be written in the file "`<observationfilename>_stdESA_LOI.txt`" (which in this case would be "`madr2000.06o_stdESA_LOI.txt`")

Standard SBAS processing computing the Stanford-ESA plot values with the output file for Stanford-ESA plot values as "`std-ESA-madr`",and set the maximum values for the 'x' axis (error axis) to 40 metres, the 'y' axis (protection level) to 70 metres, the 'x' pixel resolution to 1 meter and the 'y' pixel resolution to 1 meter:

Linux/Cygwin:

```
gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -filter:stfdesa -output:stfdesa "std-ESA-madr" -filter:stfdesa:xmax 40 -filter:stfdesa:ymax 60 -filter:stfdesa:xres 1 -filter:stfdesa:yres 1 > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -filter:stfdesa -output:stfdesa "std-ESA-madr"
```


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```
-filter:stfdesa:xmax 40 -filter:stfdesa:ymax 60 -filter:stfdesa:xres 1 -
filter:stfdesa:yres 1 > outputfile.txt
```

SBAS processing disabling the steady state operation for smoothing and decimating at a 30 second rate:

Linux/Cygwin:

```
gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas
M1202000.06b -pre:dec 30 -pre:smoothmin 0 > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas
M1202000.06b -pre:dec 30 -pre:smoothmin 0 > outputfile.txt
```

SBAS processing using the GEO with highest elevation, enabling SNR deselection to all GPS satellites with a threshold of 38 dBHz and fixing the $\sigma_{multipath}$ of the airborne receiver to 5 metres:

Linux/Cygwin:

```
gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas
M1202000.06b -pre:geosel 2 -pre:snr -pre:snrsel G0 38 -model:sigmpath 5 0 >
outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas
M1202000.06b -pre:geosel 2 -pre:snr -pre:snrsel G0 38 -model:sigmpath 5 0 >
outputfile.txt
```

SBAS processing with timeout for message type 26 to 10 minutes in NPA, timeout for fast corrections of 30 seconds in both PA and NPA, timeout for range rate corrections to 40 seconds in PA, enabling mode switching, setting the $\sigma_{multipath}$ of the receiver to a fixed value of $\sigma_{multipath} = 5 + 3e^{-satelevation/10}$, the $\sigma_{divergence}$ to a fixed value of 10 metres and the σ_{noise} to 13 metres:

Linux/Cygwin:

```
gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas
M1202000.06b -model:sbastmoutnpa 26 600 -model:sbastmoutfc 30
-model:sbastmoutrrcpa 40 -model:sbasmodeswitch -model:sigmpath 5 3
-model:sigdiv 10 -model:signoise 13 > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas
M1202000.06b -model:sbastmoutnpa 26 600 -model:sbastmoutfc 30
-model:sbastmoutrrcpa 40 -model:sbasmodeswitch -model:sigmpath 5 3
-model:sigdiv 10 -model:signoise 13 > outputfile.txt
```


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SBAS processing enabling GEO switch and mode switch, deselecting GEO 136, selecting GEO 120 as primary GEO, ignore type 0 messages and setting the GEO acquisition time to 100 seconds and the switch time to 10 seconds:

Linux/Cygwin:

```
gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -model:geoswitch -model:sbasmodeswitch -pre:geoexclude 136 -pre:geosel 120 -model:ignoretype0 -model:geoadqtime 100 -model:switchtime 10 > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -model:geoswitch -model:sbasmodeswitch -pre:geoexclude 136 -pre:geosel 120 -model:ignoretype0 -model:geoadqtime 100 -model:switchtime 10 > outputfile.txt
```

SBAS processing in NPA mode, treating MT0 as MT2, using data from mixed GEO and enabling the step detector:

Linux/Cygwin:

```
gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -model:sbasmode NPA -pre:geosel 0 -filter:stepdetector > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -model:sbasmode NPA -pre:geosel 0 -filter:stepdetector > outputfile.txt
```

SBAS processing enabling GEO switch, enabling GEO switch to mixed GEO data, setting timeout for MT10 to 100 seconds for both PA and NPA and setting the SBAS receiver to type 1:

Linux/Cygwin:

```
gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -model:geoswitch -model:mixedgeo -model:sbastmout 10 100 -model:sbasreceiver 1 > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -model:geoswitch -model:mixedgeo -model:sbastmout 10 100 -model:sbasreceiver 1 > outputfile.txt
```


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Show help message and an example on how to create a user-defined error file for adding error to raw measurements:

Linux/Cygwin:

```
gLAB_linux -usererrorfile
```

Windows:

```
gLAB.exe -usererrorfile
```

Show help message and an example on how to create a user-defined sigma multipath model:

Linux/Cygwin:

```
gLAB_linux –sigmamultipathfile
```

Windows:

```
gLAB.exe –sigmamultipathfile
```

SBAS processing with user-defined error:

Linux/Cygwin:

```
gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas
M1202000.06b -input:usererror usererrorfile > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas
M1202000.06b -input:usererror usererrorfile > outputfile.txt
```

SBAS processing with user-defined sigma multipath model:

Linux/Cygwin:

```
gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas
M1202000.06b -input:sigmpath usersigmamultipathmodelfile > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas
M1202000.06b -input:sigmpath usersigmamultipathmodelfile > outputfile.txt
```


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SBAS processing with user-defined sigma multipath model, user-defined error, $\sigma_{divergence}$ to a fixed value of 10 metres and the σ_{noise} to 13 metres:

Linux/Cygwin:

```
gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -input:sigmpath usersigmamultipathmodelfile -input:usererror usererrorfile -model:sigdiv 10 -model:signoise 13 > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -input:sigmpath usersigmamultipathmodelfile -input:usererror usererrorfile -model:sigdiv 10 -model:signoise 13 > outputfile.txt
```

SBAS processing but using IONEX ionosphere model instead of SBAS ionosphere model:

Linux/Cygwin:

```
gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -input:inx igrg2000.06i –model:iono IONEX > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -input:inx igrg2000.06i –model:iono IONEX > outputfile.txt
```

Standard SBAS processing, but changing in the SBAS summary the vertical and horizontal alarm limit to 45 meters, setting the percentile to 96 and a sliding window of 10 epochs for the computation of the continuity risk:

Linux/Cygwin:

```
gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -summary:hal 45 -summary:val 45 -summary:percentile 96 -summary:windowsize 15 > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -summary:hal 45 -summary:val 45 -summary:percentile 96 -summary:windowsize 15 > outputfile.txt
```

Standard SBAS processing, but setting to 0 the slow correction but not its degradation term:

Linux/Cygwin:

```
gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b –model:noslowcor > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b –model:noslowcor > outputfile.txt
```


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Standard SBAS processing, but disabling MT10 message:

Linux/Cygwin:

```
gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -model:nomt10 > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -model:nomt10 > outputfile.txt
```

Standard SBAS processing, but disabling MT27 and MT28 messages:

Linux/Cygwin:

```
gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -model:nomt2728 > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -model:nomt2728 > outputfile.txt
```

NOTE: Parameter '–model:nomt2728' is equivalent to parameter '**-model:nodeltaudre**'.

Standard SBAS processing, but disabling MT10, MT27 and MT28 messages:

Linux/Cygwin:

```
gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -model:nomt10 -model:nomt2728 > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -model:nomt10 -model:nomt2728 > outputfile.txt
```

Maritime SBAS processing:

Linux/Cygwin:

```
gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -model:sbasmaritime > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -model:sbasmaritime > outputfile.txt
```

Standard SBAS processing but setting the station network name in the summary:

Linux/Cygwin:

```
gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -summary:stationnetworkname IGS > outputfile.txt
```


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Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -summary:stationnetworkname IGS > outputfile.txt
```

A SBAS DFMC computation example on the 02/07/2019 (DoY 183) with NNOR station in Australia:

Linux/Cygwin:

```
./gLAB_linux -input:obs nnor1830.19o -input:nav gage1830.19p -input:sbasdfmc M1221830.ems -model:sbasdfmc:austestbed -pre:setrecpos -2414152.3600 4907778.6314 -3270644.2288 -summary:val 35 -output:file nnor183.txt
```

Windows:

```
gLAB.exe -input:obs nnor1830.19o -input:nav gage1830.19p -input:sbasdfmc M1221830.ems -model:sbasdfmc:austestbed -pre:setrecpos -2414152.3600 4907778.6314 -3270644.2288 -summary:val 35 -output:file nnor183.txt
```


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10.3.2.2 SBAS data plotting

10.3.2.2.1 SBAS North, East, Up errors

Plot the North, East Up error using the output file of gLAB after doing a normal SBAS processing. The figure appears in the screen.

Linux/Cygwin:

```
graph.py -t "NEU Positioning Error" --xl "Time (s)" --yl "Error (m)" -f "/home/gage/gLAB.out" -c '($1=="OUTPUT")' -x 4 -y 23 -l "North error" -s .- --cl b -f "/home/gage/gLAB.out" -c '($1=="OUTPUT")' -x 4 -y 24 -l "East error" -s .- --cl g -f "/home/gage/gLAB.out" -c '($1=="OUTPUT")' -x 4 -y 25 -l "Up error" -s .- --cl r --lp tr
```

Windows:

```
graph.exe -t "NEU Positioning Error" --xl "Time (s)" --yl "Error (m)" --yn -2.5 --yx 2.5 -f "C:\gLAB\win\gLAB.out" -c "($1=='OUTPUT')" -x 4 -y 23 -l "North error" -s .- --cl b -f "C:\gLAB\win\gLAB.out" -c "($1=='OUTPUT')" -x 4 -y 24 -l "East error" -s .- --cl g -f "C:\gLAB\win\gLAB.out" -c "($1=='OUTPUT')" -x 4 -y 25 -l "Up error" -s .- --cl r --lp tr
```

A SBAS DFMC processing example of solution computation on the 02/07/2019 (DoY 183) with NNOR station in Australia:

10.3.2.2.2 SBAS HPE-HPL and VPE-VPL plots

Plot the Horizontal Positioning Error (HPE) and Horizontal Protection Level (HPL) using the output file of gLAB after doing a normal SBAS processing. The figure appears in the screen.

Linux/Cygwin:

```
graph.py -t "HPE vs HPL #Sat" --xl "Time (s)" --yl "HPE/HPL (m)" -f "/home/gage/gLAB.out" -c '($1=="SBASOUT")' -x 4 -y 15 -l "HPE" -s .- --cl b -f "/home/gage/gLAB.out" -c '($1=="SBASOUT")' -x 4 -y 16 -l "HPL" -s .- --cl g -f "/home/gage/gLAB.out" -c '($1=="SBASOUT")' -x 4 -y 24 -l "NSAT" -s .- --cl r --lp tr
```

Windows:

```
graph.exe -t "HPE vs HPL #Sat" --xl "Time (s)" --yl "HPE/HPL (m)" -f "C:\gLAB\win\gLAB.out" -c "($1=='SBASOUT')" -x 4 -y 15 -l "HPE" -s .- --cl b -f "C:\gLAB\win\gLAB.out" -c "($1=='SBASOUT')" -x 4 -y 16 -l "HPL" -s .- --cl g -f "C:\gLAB\win\gLAB.out" -c "($1=='SBASOUT')" -x 4 -y 24 -l "NSAT" -s .- --cl r --lp tr
```


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Plot the Vertical Positioning Error (VPE) and Vertical Protection Level (VPL) using the output file of gLAB after doing a normal SBAS processing. The figure appears in the screen.

Linux/Cygwin:

```
graph.py -t "VPE vs VPL #Sat" --xl "Time (s)" --yl "VPE/VPL (m)" -f "/home/gage/gLAB.out" -c '($1=="SBASOUT")' -x 4 -y 18 -l "VPE" -s .- --cl b -f "/home/gage/gLAB.out" -c '($1=="SBASOUT")' -x 4 -y 19 -l "VPL" -s .- --cl g -f "/home/gage/gLAB.out" -c '($1=="SBASOUT")' -x 4 -y 24 -l "NSAT" -s .- --cl r --lp tr
```

Windows:

```
graph.exe -t "VPE vs VPL #Sat" --xl "Time (s)" --yl "VPE/VPL (m)" -f "C:\gLAB\win\gLAB.out" -c "($1=='SBASOUT')" -x 4 -y 18 -l "VPE" -s .- --cl b -f "C:\gLAB\win\gLAB.out" -c "($1=='SBASOUT')" -x 4 -y 19 -l "VPL" -s .- --cl g -f "C:\gLAB\win\gLAB.out" -c "($1=='SBASOUT')" -x 4 -y 24 -l "NSAT" -s .- --cl r --lp tr
```

10.3.2.2.3 SBAS Stanford plots

Create a Stanford plot with HPE and HPL (using the output file of gLAB after doing a normal SBAS processing) and show it in the screen:

Linux/Cygwin:

```
graph.py --sf -t "Horizontal Stanford Plot" --xl "Horizontal Positioning Error (m)" --yl "Horizontal Protection Level (m)" -f "/home/gage/gLAB.out" -c '($1=="SBASOUT")' -x 15 -y 16
```

Windows:

```
graph.exe --sf -t "Horizontal Stanford Plot" --xl "Horizontal Positioning Error (m)" --yl "Horizontal Protection Level (m)" -f " C:\gLAB\win\gLAB.out" -c "($1=='SBASOUT')" -x 18 -y 19
```

10.3.2.2.4 SBAS Stanford-ESA plots

Create a Stanford-ESA plot (using the dedicated output file of gLAB for Stanford-ESA plots) and show it in the screen (it will show two plots, one for the HPE and HPL and another for the VPE and VPL):

Linux/Cygwin:

```
graph.py -f “glabStanfordESAFile” --sfesa
```

Windows:

```
graph.exe -f “glabStanfordESAFile” --sfesa
```


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Create a Stanford-ESA plot (using the dedicated output file of gLAB for Stanford-ESA plots) and save the VPE and VPL plot to file “stfd-ESA-VPE.png” and the HE and HPL plot to file “stfd-ESA-HPE.png”:

Linux/Cygwin:

```
graph.py -f “glabStanfordESAFile” --sfesa --sv “stfd-ESA-VPE.png” --sv “stfd-ESA-HPE.png”
```

Windows:

```
graph.exe -f “glabStanfordESAFile” --sfesa --sv “stfd-ESA-VPE.png” --sv “stfd-ESA-HPE.png”
```

10.3.2.2.5 SBAS Worst Integrity Ratio plots

NOTE: For creating worst integrity ratio plots or world maps, a text file is needed with at least the station geodetic coordinates and its values to be shown in the plot (typically these values are the worst integrity ratios, the number of MIs, the error and the protection level percentile). The easiest way to get these values is from the last line of the SBAS summary printed by gLAB in the output files from the several stations processed. Therefore, we have to merge the last line of the gLAB output files to a new text file. If we are in Linux or Cygwin, we can do it by executing this command (assuming all files have “.txt” extension and are in the same directory):

Linux/Cygwin:

```
tail -q -n -1 *.txt > sta_data.txt
```

In Windows command line there is no equivalent instruction, hence the user will have to create manually the file.

The previous command creates the file “sta_data.txt” with this format (using the last line of the SBAS summary):

```
INFO Station: zura Lon:   8.56488897 Lat:   47.45374806 Height:  514.5864 Day: 26
Month:  1 Year: 2019 DoY:  26 GPSWeek: 2037 DoW: 6 Percentile:  95 HPE_Percentile:
0.81  VPE_Percentile:     1.64  NPE_Percentile:     0.78  EPE_Percentile:     0.34
3DPE_Percentile:   1.71 MaxHPE:   1.63 MaxVPE:   2.63 MaxNPE:   1.57 MaxEPE:   0.73
Max3DPE:   2.76 Avail%: 100.000 PDOP_Percentile:   2.34 Min_PDOP:   1.22 Max_PDOP:
3.63  GDOP_Percentile:    2.68  Min_GDOP:    1.34  Max_GDOP:    4.05  TDOP_Percentile:
1.31  Min_TDOP:    0.56  Max_TDOP:    1.92  HDOP_Percentile:    1.37  Min_HDOP:    0.73
Max_HDOP:     2.31  VDOP_Percentile:     1.93  Min_VDOP:     0.93  Max_VDOP:     3.19
Sat_used_All_Const_Percentile:     9     Sat_not_used_All_Const_Percentile:     0
Min_sat_used_All_Const: 6 Min_sat_not_used_All_Const: 0 Max_sat_used_All_Const: 12
Max_sat_not_used_All_Const:  4  Epochs_processed:  86399  Epochs_with_solution:  0
Epochs_with_solution_reference_file: 86399 Epochs_omitted_no_data_reference_file: 0
Epochs_skipped_no_data_reference_file:       0       Epochs_no_satellites:       0
Epochs_singular_matrix:  0  Epochs_No_Reference_GNSS:  0  Epochs_Over_HDOPorPDOP:  0
Epochs_Over_HDOP: 0 Epochs_Over_PDOP: 0 Epochs_Over_GDOP: 0 Total_Epochs_skipped: 0
Epochs_missing_Sum:     1  Epochs_missing_All_file:     1  Num_DataGaps_Sum:     1
Num_DataGaps_All_file:   1 MaxSize_DataGap_Sum:   1 MaxSize_DataGap_All_file:   1
Station_Network_Name:   Other   Time_To_First_Fix:   361   Epochs_First_Fix:   362
Processing_time 89.219 HIR_Percentile: 0.0983 VIR_Percentile: 0.1314 HWIR:  0.1435
VWIR:  0.2013 HBIR: 2.8464E-004 VBIR: 4.2407E-007 MIs:   0 Hor_MIs:   0 Ver_MIs:
0 HWIR_ESA:  0.1764 VWIR_ESA:  0.2230 MIs_ESA:    0 Hor_MIs_ESA:    0 Ver_MIs_ESA:
```


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```
0 HPL_Percentile:  11.64 VPL_Percentile:  17.11 MinHPL:   5.65 MaxHPL:  20.37 MinVPL:
9.05 MaxVPL:  35.49 Cont_Risk: 0.0000E+000 Cont_Risk_Mar: 0.0000E+000
```

The examples shown below for worst integrity ratio plots or world maps will be referred to this file ("sta_data.txt"), but if the user creates a text file with the necessary data in another format, it will just need to change the number of the columns in the parameters:

FIELD	DESCRIPTION
25	Horizontal Positioning Error Percentile
27	Vertical Positioning Error Percentile
65	Horizontal Dilution Of Precision Percentile
71	Vertical Dilution Of Precision Percentile
139	Horizontal Worst Integrity Ratio
141	Vertical Worst Integrity Ratio
149	Horizontal Misleading Information
151	Vertical Misleading Information
163	Horizontal Protection Level Percentile
165	Vertical Protection Level Percentile

Create a worst integrity ratio plot for horizontal component only using the input file "sta_data.txt" and showing the map for the whole world in the screen:

Linux/Cygwin:

```
graph.py -f "sta_data.txt" --wir -x 5 -y 7 --rh 139
```

Windows:

```
graph.exe -f "sta_data.txt" --wir -x 5 -y 7 --rh 139
```

Create a worst integrity ratio plot for both horizontal and vertical components using the input file "sta_data.txt" and showing the map for the whole world in the screen:

Linux/Cygwin:

```
graph.py -f "sta_data.txt" --wir -x 5 -y 7 --rh 139 --rv 141
```

Windows:

```
graph.exe -f "sta_data.txt" --wir -x 5 -y 7 --rh 139 --rv 141
```

Create a worst integrity ratio plot only for horizontal components with its MIs using the input file "sta_data.txt" and showing the map for the whole world and saving it to "horizontal_map.png":

Linux/Cygwin:

```
graph.py -f "sta_data.txt" --wir -x 5 -y 7 --rh 139 --mih 149 --sv
"horizontal_map.png"
```

Windows:

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```
   graph.exe -f "sta_data.txt" --wir -x 5 -y 7 --rh 139 --mih 149 --sv
"horizontal_map.png"
```

Create a worst integrity ratio plot for both horizontal and vertical components, but only with vertical MIs, using the input file "sta_data.txt" and showing the map for the whole world in the screen:

Linux/Cygwin:

```
   graph.py -f "sta_data.txt" --wir -x 5 -y 7 --rh 139 --rv 141 --miv 151
```

Windows:

```
   graph.exe -f "sta_data.txt" --wir -x 5 -y 7 --rh 139 --rv 141 --miv 151
```

Create a worst integrity ratio plot with the MIs for both horizontal and vertical components using the input file "sta_data.txt" and showing the map for the whole world in the screen:

Linux/Cygwin:

```
   graph.py -f "sta_data.txt" --wir -x 5 -y 7 --rh 139 --rv 141 --mih 149 -
-miv 151
```

Windows:

```
   graph.exe -f "sta_data.txt" --wir -x 5 -y 7 --rh 139 --rv 141 --mih 149
--miv 151
```

Create a worst integrity ratio plot using the input file "sta_data.txt", showing the map only for latitudes between 20º and 80º and for longitudes between -60º and 60º and show it in the screen:

Linux/Cygwin:

```
   graph.py -f "sta_data.txt" --wir -x 5 -y 7 --rh 139 --rv 141 --xmax 60 -
-xmin -60 --ymin 20 --ymax 80
```

Windows:

```
   graph.exe -f "sta_data.txt" --wir -x 5 -y 7 --rh 139 --rv 141 --xmax 60
--xmin -60 --ymin 20 --ymax 80
```

Create a worst integrity ratio using the input file "sta_data.txt", showing the map for the whole world the horizontal and vertical components, with Lambert projection and high quality for the world map:

Linux/Cygwin:

```
   graph.py -f "sta_data.txt" --wir -x 5 -y 7 --rh 139 --rv 141 --pj lambert
--mapres h
```

Windows:

```
   graph.exe -f "sta_data.txt" --wir -x 5 -y 7 --rh 139 --rv 141  --pj
lambert --mapres h
```


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10.3.2.2.6 SBAS World Maps

NOTE: For creating worst integrity ratio plots or world maps, a text file is needed with at least the station geodetic coordinates and its values to be shown in the plot (typically these values are the worst integrity ratios, the number of MIs, the error and the protection level percentile). The easiest way to get these values is from the last line of the SBAS summary printed by gLAB in the output files from the several stations processed. Therefore, we have to merge the last line of the gLAB output files to a new text file. If we are in Linux or Cygwin, we can do it by executing this command (assuming all files have ".txt" extension and are in the same directory):

Linux/Cygwin:

```
tail -q -n -1 *.txt > sta_data.txt
```

In Windows command line there is no equivalent instruction, hence the user will have to create manually the file.The previous command creates the file "sta_data.txt" with this format (using the last line of the SBAS summary):

Create a world map using the input file "sta_data.txt", showing the map for the whole world, with the horizontal and vertical error percentile and show it in the screen:

Linux/Cygwin:

```
graph.py -f "sta_data.txt" --map -x 5 -y 7 --rh 25 --rv 27
```

Windows:

```
graph.exe -f "sta_data.txt" --map -x 5 -y 7 --rh 25 --rv 27
```

Create a world map using the input file "sta_data.txt" showing the map for the whole world, with the horizontal and vertical error percentiles, with the colourbar divided in 10 intervals, a maximum value of 3 and saving the file to "error_percentile_V.png" and "error_percentile_H.png":

Linux/Cygwin:

```
graph.py -f "sta_data.txt" --map -x 5 -y 7 --rh 25 --rv 27 --cn 10 --
cmax 3 --sv "error_percentile-V.png" --sv "error_percentile-H.png"
```

Windows:

```
graph.exe -f "sta_data.txt" --map -x 5 -y 7 --rh 25 --rv 27 --cn 10 --
cmax 3 --sv "error_percentile_V.png" --sv "error_percentile-H.png"
```

Create a world map using the input file "sta_data.txt", showing the map for the whole world, with horizontal and vertical protection level percentiles and show it in the screen:

Linux/Cygwin:

```
graph.py -f "sta_data.txt" --map -x 5 -y 7 --rh 163 --rv 165
```


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Windows:

```
graph.exe -f "sta_data.txt" --map -x 5 -y 7 --rh 163 --rv 165
```

Create a world map using the input file "sta_data.txt", showing the map for the whole world, with Lambert projection, with horizontal and vertical protection level percentiles, intermediate resolution for the world map and a waterwark with the text "gAGE/UPC":

Linux/Cygwin:

```
graph.py -f "sta_data.txt" --map -x 5 -y 7 --rh 163 --rv 165 --pj lambert
--mapres i --wm "gAGE/UPC"
```

Windows:

```
graph.exe -f "sta_data.txt" --map -x 5 -y 7 --rh 163 --rv 165 --pj lambert
--mapres i --wm "gAGE/UPC"
```

Create a station name map using the input file "sta_data.txt", showing the map for the whole world, and show it in the screen:

Linux/Cygwin:

```
graph.py -f "sta_data.txt" --map -x 5 -y 7 --sn 3
```

Windows:

```
graph.exe -f "sta_data.txt" --map -x 5 -y 7 --sn 3
```

Create a station name map using the input file "sta_data.txt", showing the map for the whole world, and save it to a file:

Linux/Cygwin:

```
graph.py -f "sta_data.txt" --map -x 5 -y 7 --sn 3 --sv "map.pdf"
```

Windows:

```
graph.exe -f "sta_data.txt" --map -x 5 -y 7 --sn 3 --sv "map.pdf"
```

Create a world map using the input file "sta_data.txt", showing the map for the whole world, and the vertical error percentile and save them in files:

Linux/Cygwin:

```
graph.py -f "sta_data.txt" --map -x 5 -y 7 --sn 3 --rv 27 --sv
"error_percentile_V.png" --sv "map.pdf"
```

Windows:

```
graph.exe -f "sta_data.txt" --map -x 5 -y 7 --sn 3 --rv 27 --sv
"error_percentile_V.png" --sv "map.pdf"
```


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Create a world map using the input file “sta_data.txt”, showing the map for the whole world, with the horizontal and vertical error percentile and save them in files:

Linux/Cygwin:

```
graph.py -f “sta_data.txt” --map -x 5 -y 7 --sn 3 --rh 25 --rv 27 --sv “error_percentile_V.png” --sv “error_percentile-H.png” --sv “map.pdf”
```

Windows:

```
graph.exe -f “sta_data.txt” --map -x 5 -y 7 --sn 3 --rh 25 --rv 27 --sv “error_percentile_V.png” --sv “error_percentile-H.png” --sv “map.pdf”
```

Create a world map using the input file “sta_data.txt”, showing the map for the whole world, with the horizontal and vertical error percentile and save them in files:

Linux/Cygwin:

```
graph.py -f “sta_data.txt” --map -x 5 -y 7 --sn 3 --rh 25 --rv 27 --sv “error_percentile_V.png” --sv “error_percentile-H.png” --sv “map.pdf”
```

Windows:

```
graph.exe -f “sta_data.txt” --map -x 5 -y 7 --sn 3 --rh 25 --rv 27 --sv “error_percentile_V.png” --sv “error_percentile-H.png” --sv “map.pdf”
```

Create a world map using the input file “sta_data.txt”, showing the map for the whole world, with the horizontal and vertical DOP percentile sand save them in files:

Linux/Cygwin:

```
graph.py -f “sta_data.txt” --map -x 5 -y 7 --rh 65 --rv 71 --sv “VDOP_percentile.png” --sv “HDOP_percentile.png”
```

Windows:

```
graph.exe -f “sta_data.txt” --map -x 5 -y 7 --rh 65 --rv 71 --sv “VDOP_percentile.png” --sv “HDOP_percentile.png”
```


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10.3.3 Graphical results

10.3.3.1 SBAS Nort, East, Up Errors

North, East Up error plot example:

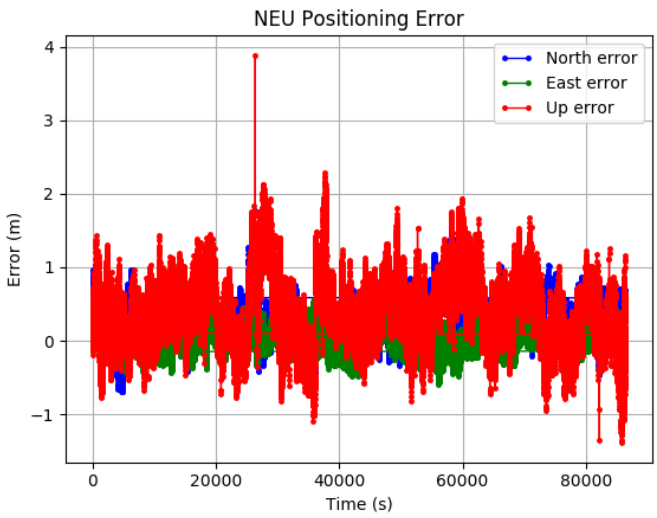

Figure 10-22 SBAS Plot sample depicting the NEU positioning error

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10.3.3.2 SBAS HPE-HPL and VPE-VPL plots

Example for horizontal positioning error vs. horizontal protection level (with the number of satellites used in computation):

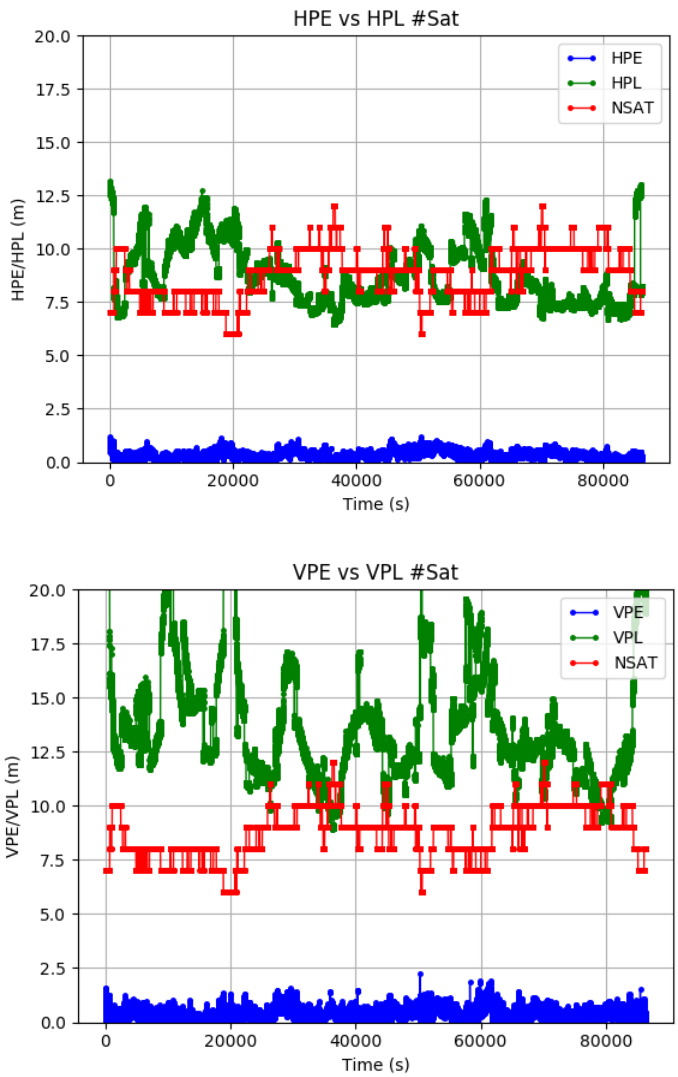

Figure 10-23. Horizontal (top) and Vertical (bottom) plots depicting the error and protection levels computed with the SBAS mode.

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SBAS DFMC plots example for horizontal positioning error vs. horizontal protection level (with the number of satellites used in computation):

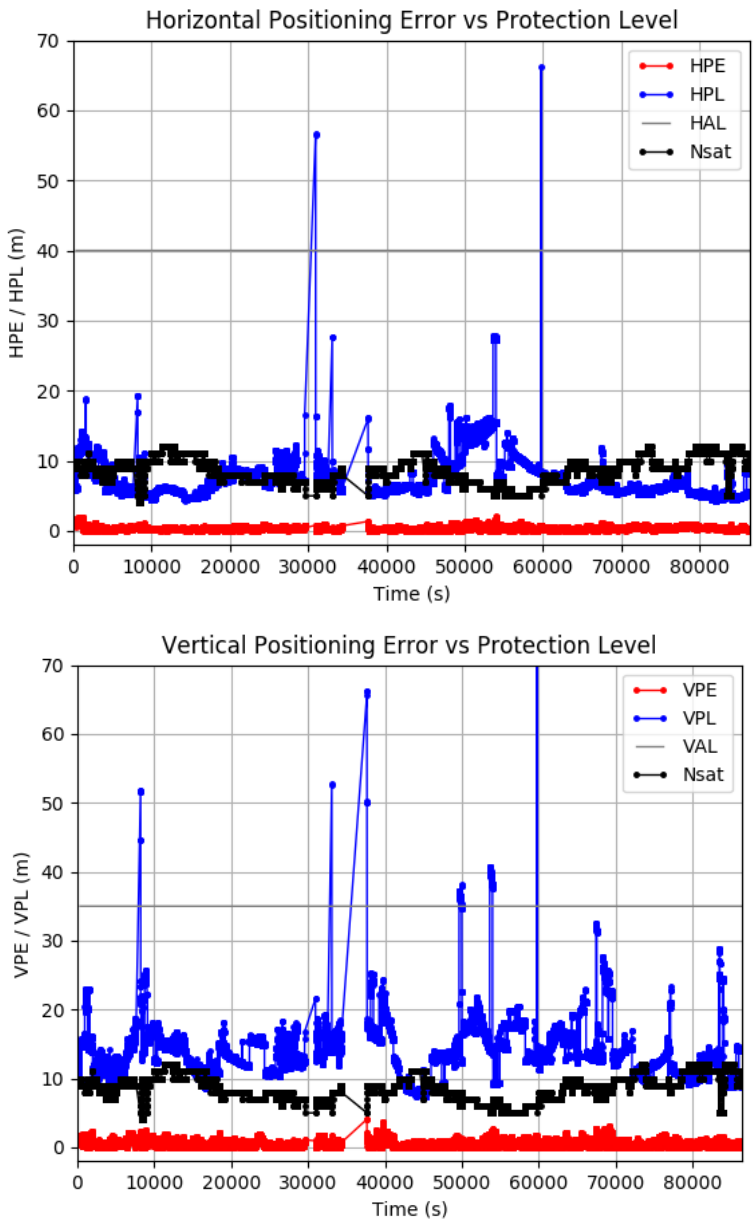

Figure 10-24: Horizontal (top) and Vertical (bottom) plots depicting the error and protection levels computed with the SBAS DFMC mode

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10.3.3.3 SBAS Stanford plots

Example for Stanford plot for horizontal and vertical component:

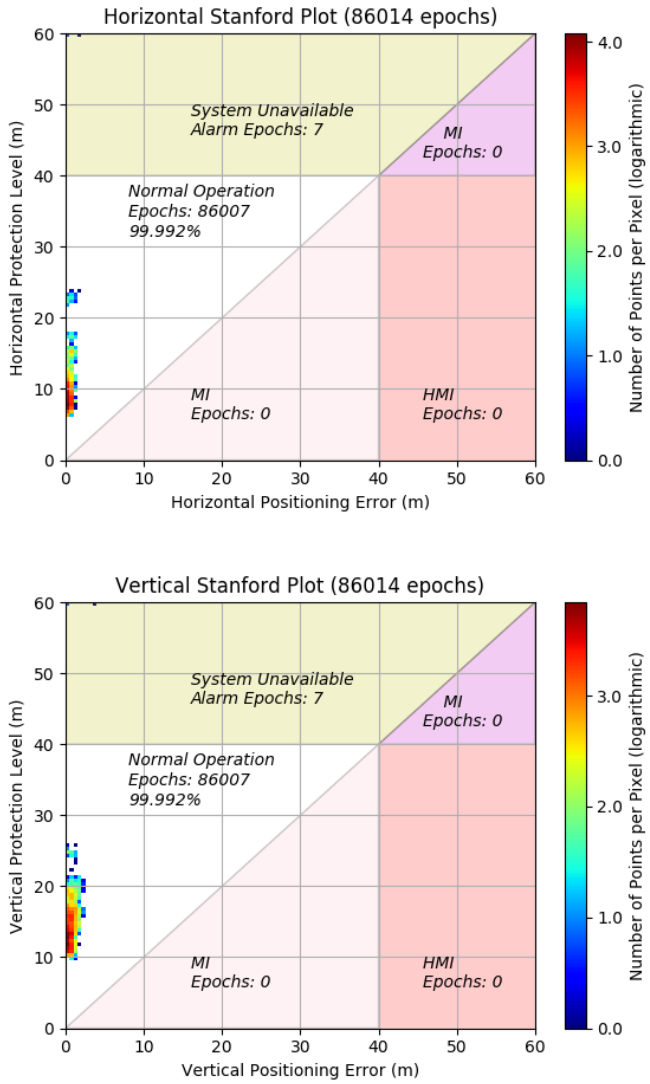

Figure 10-25. Horizontal (top) and Vertical (bottom) Stanford plots

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10.3.3.4 SBAS Stanford-ESA plots

Example for Stanford-ESA plot for horizontal and vertical component:

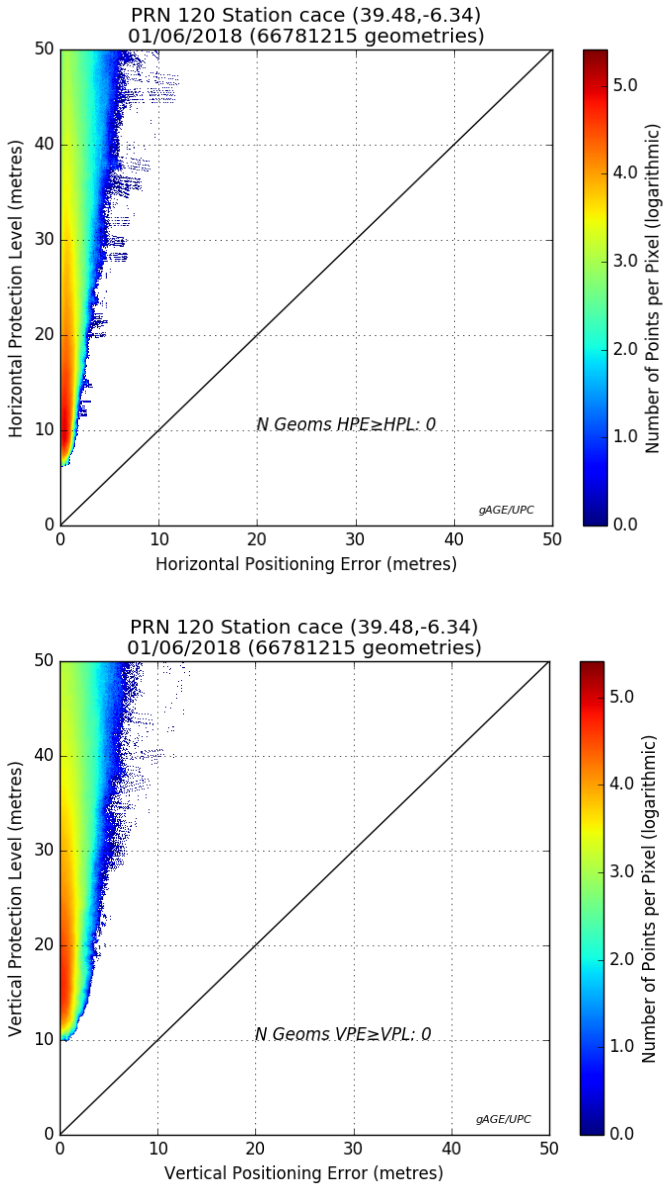

Figure 10-26: Horizontal (top) and Vertical (bottom) Stanford-ESA plots

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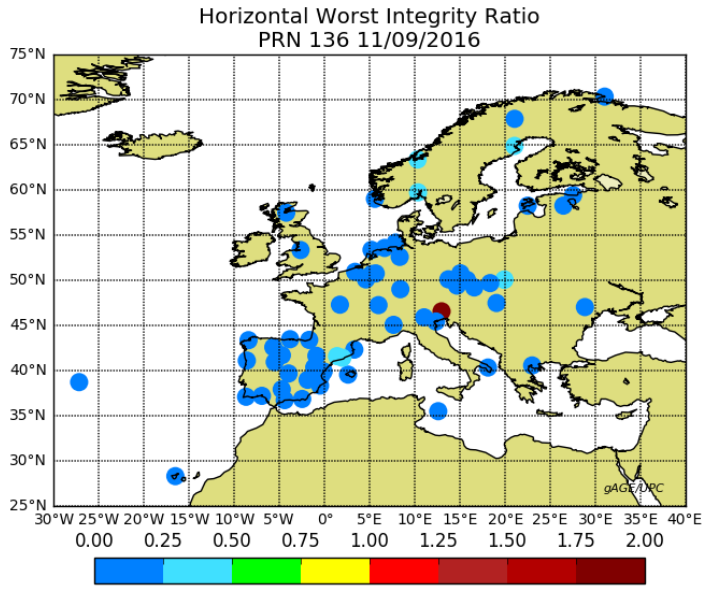
10.3.3.5 SBAS Worst Integrity Ratio plots

Example for worst integrity ratio plot for horizontal and vertical component:



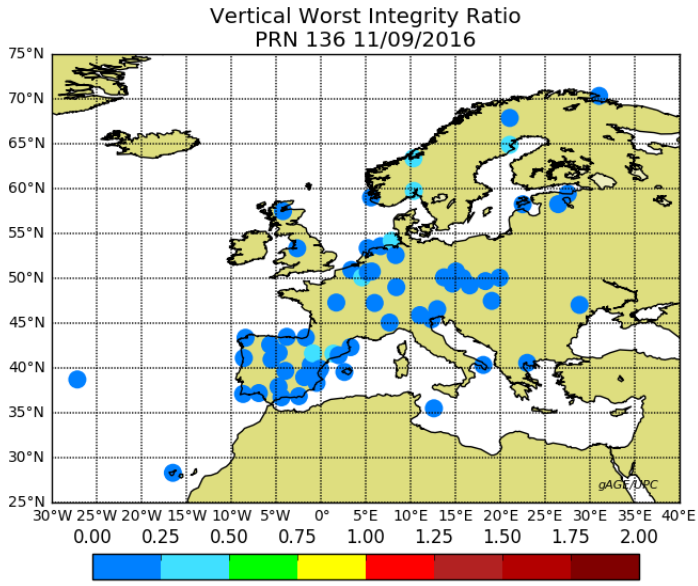


Figure 10-27: Horizontal (top) and Vertical (bottom) worst integrity ratio plots

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Example for worst integrity ratio plot for horizontal and vertical component with rings showing the number of horizontal MIs:

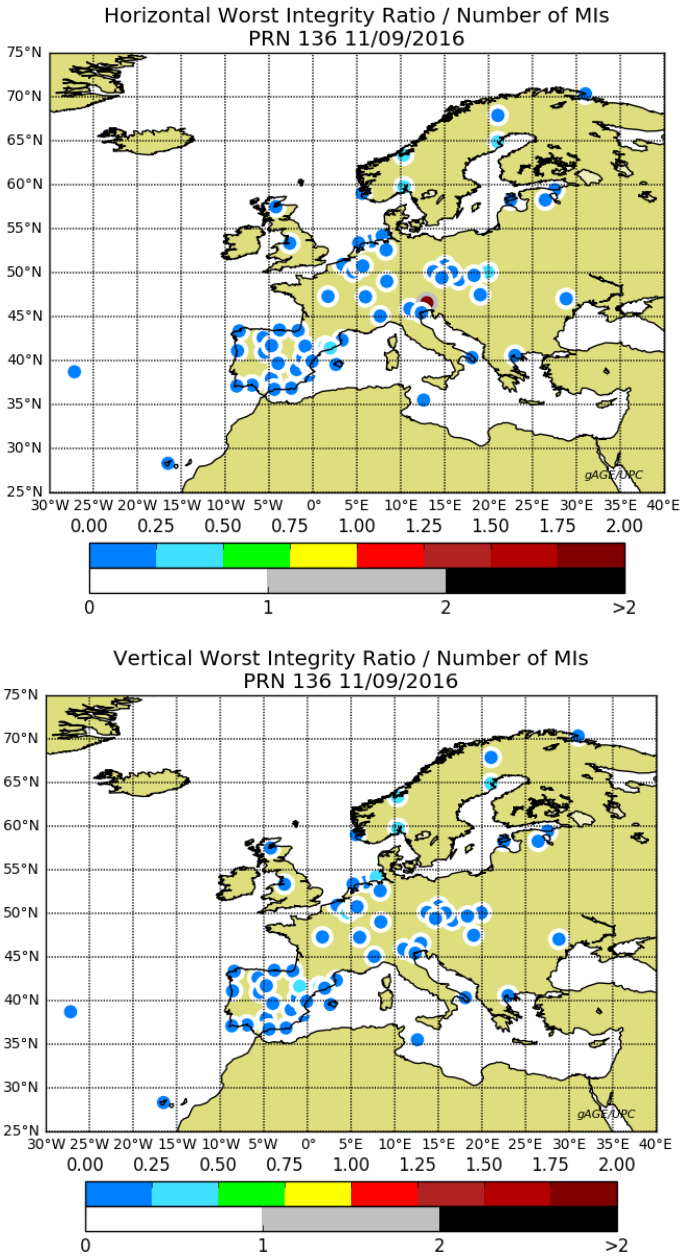

Figure 10-28: Horizontal (top) and Vertical (bottom) worst integrity ratio plots with rings showing the number of horizontal MIs

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10.3.3.6 SBAS World Maps

Example for world map showing the horizontal and vertical 95 error percentile:

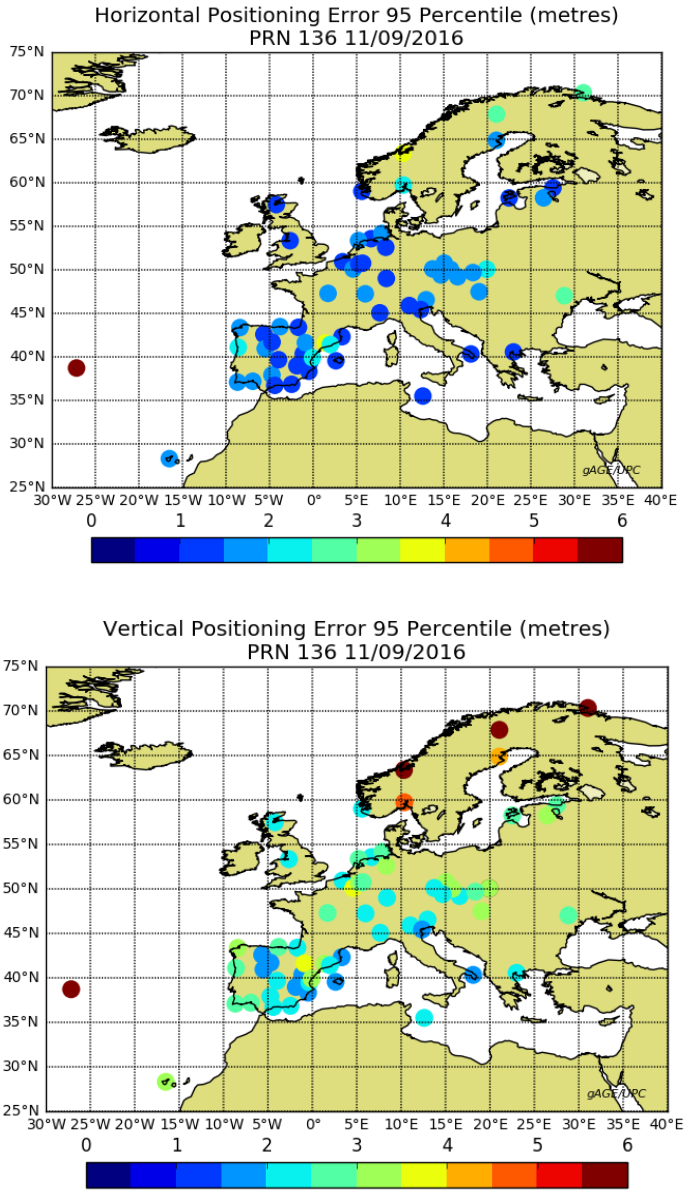

Figure 10-29: Horizontal (top) and Vertical (bottom) 95 error percentile world map

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Example for world map showing the horizontal and vertical 95 protection level percentile:

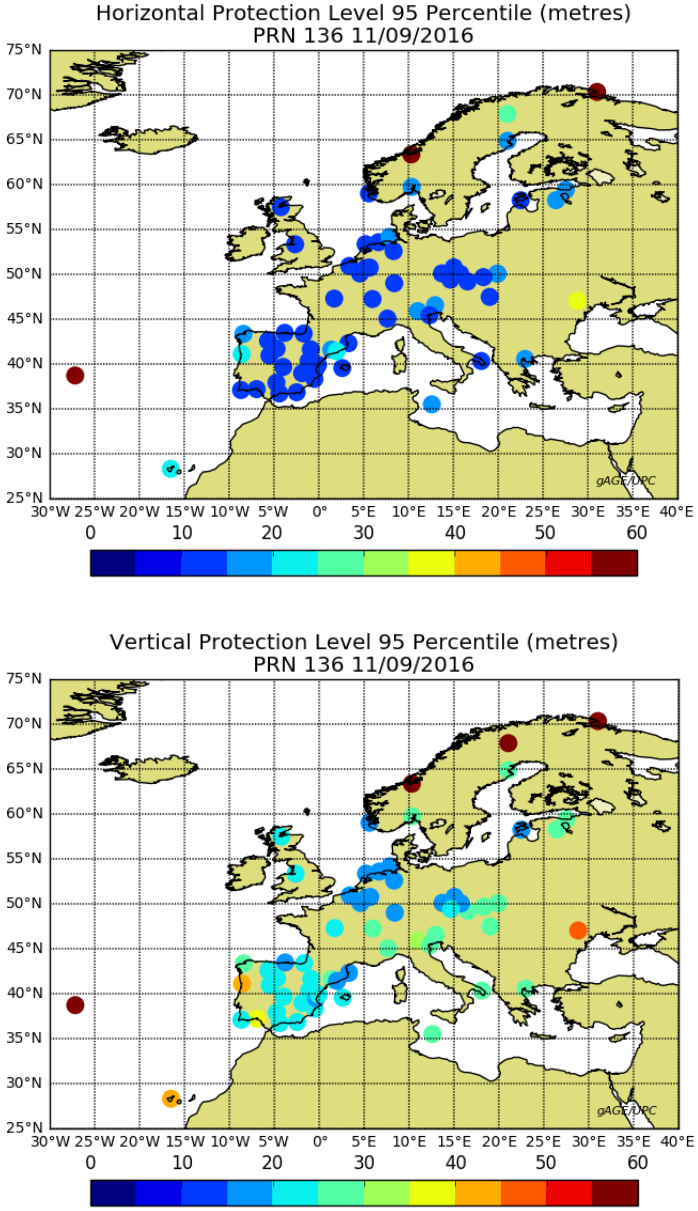

Figure 10-30: Horizontal (top) and Vertical (bottom) 95 protection level percentile world map

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Example for station name map:

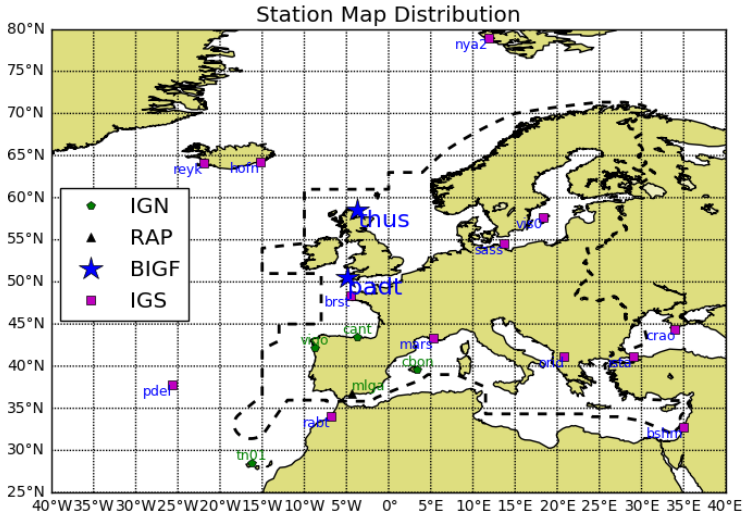

Figure 10-31: station name map

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10.4 DIFFERENTIAL GNSS POSITIONING

10.4.1 Graphical User Interface

Example for processing in DGNSS mode with the GUI:

Step 1: Open the GUI, open the “Templates” menu in the top and click in “DGNSS”:

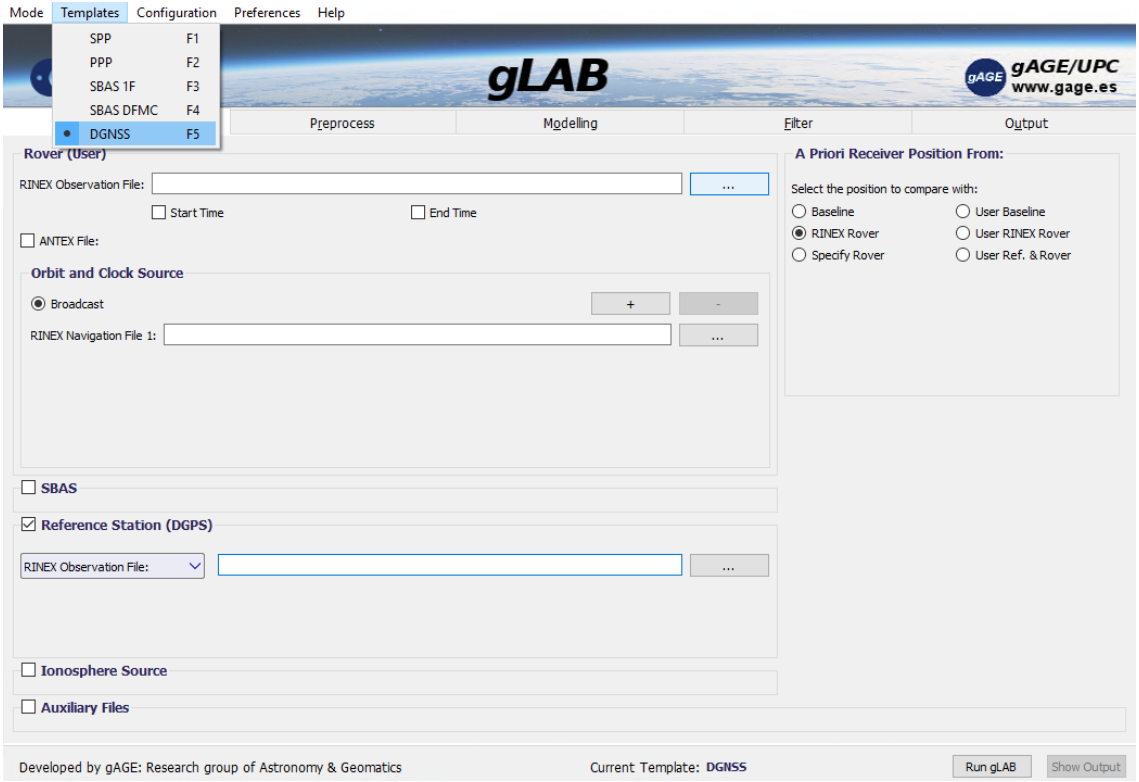

Figure 10-32: GUI Splash screen

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Step 2: Select an input RINEX observation, a RINEX navigation file and a reference station file. The reference station type file can be a RINEX observation file or an RTCM (it must be specified as seen on the screenshot). If the reference station file is of RTCM type, then it the starting date and hour must be specified.

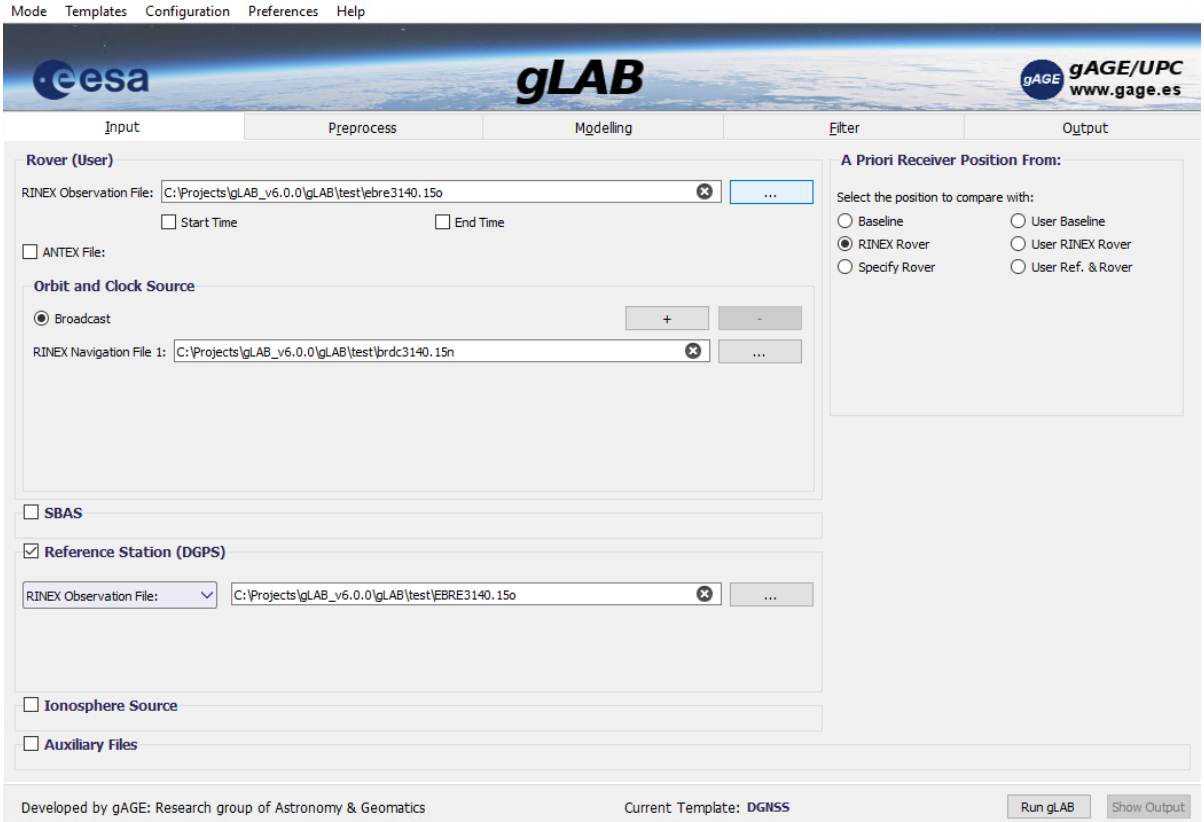

Figure 10-33: Input section

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Step 3: Click in the “Output” tab in the upper part of the screen. Set the name of the output file (or leave the default one). Furthermore, in DGNSS mode, it is recommended to create a KML file (in order to visualize the result in Google Earth). To create a KML file, just in in the “KML File” checkbox, and set the filename for the file.

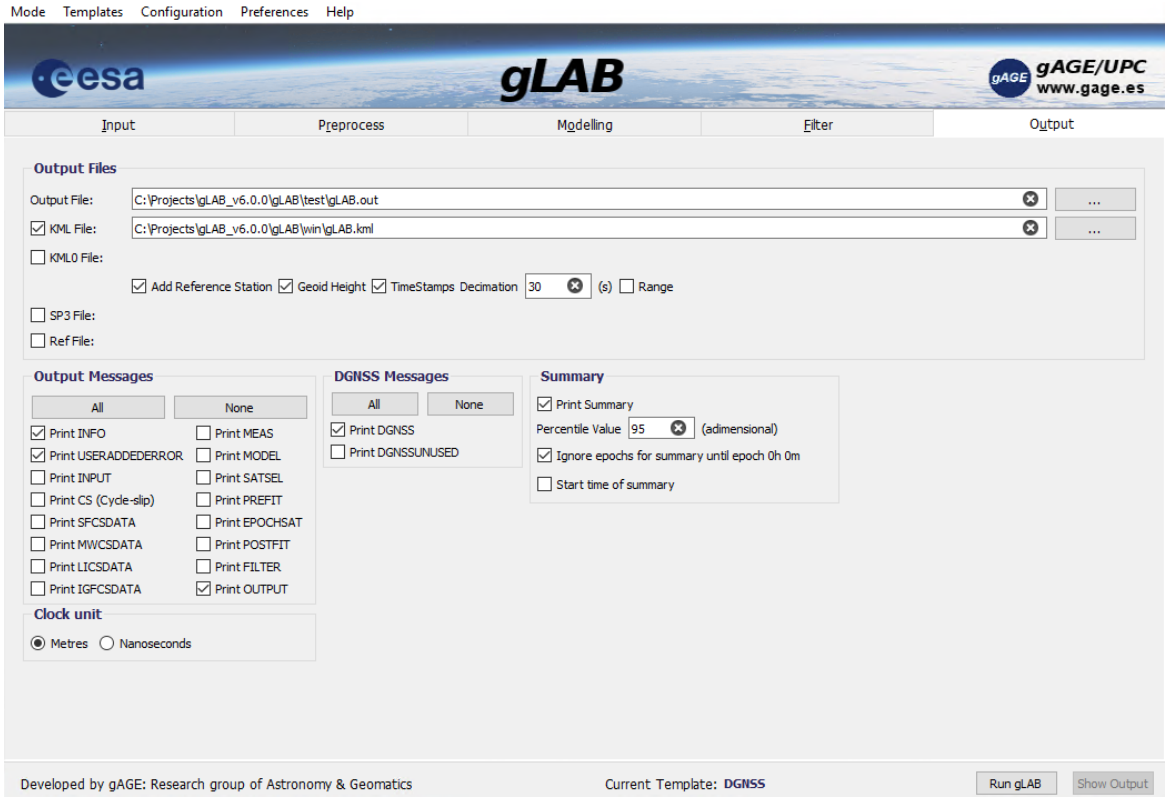

Figure 10-34: Output section

Step 4: Click in the “Run gLAB” button in the bottom part of the screen in order to process the data. If the KML was created, just open Google Earth and open the KML file in it.

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Step 5: Some plots can be done by going to the “Analysis” mode (In the top menu, click in Mode->Analysis) and using any of the plot templates. For example, for doing the North, East, Up error, click in the “NEU positioning error” template button and the in the “Plot” button in the bottom right corner of the screen:

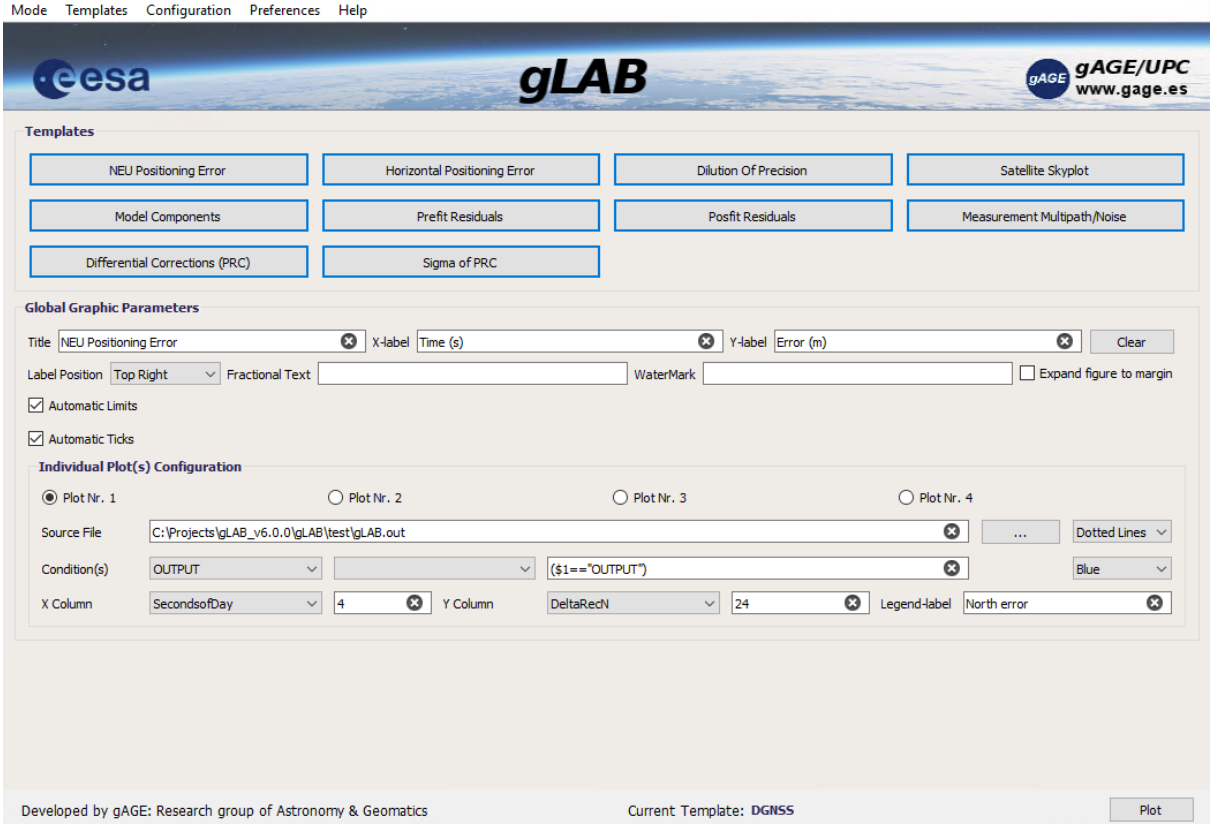

Figure 10-35: Analysis tab

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10.4.2 Command line

10.4.2.1 DGNSS data processing

Usage examples to run gLAB with DGNSS data processing:

Process DGNSS corrections through two RINEX files

Linux/Cygwin:

```
gLAB_linux -input:obs ebre3140.15o -input:nav brdc3140.15n
-input:dgnss EBRE3140.15o > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs ebre3140.15o -input:nav brdc3140.15n
-input:dgnss EBRE3140.15o > outputfile.txt
```

Process DGNSS corrections through two RINEX files

Linux/Cygwin:

```
gLAB_linux -input:obs ebre3140.15o -input:nav brdc3140.15n
-input:dgnss EBRE3140.15o > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs ebre3140.15o -input:nav brdc3140.15n
-input:dgnss EBRE3140.15o > outputfile.txt
```

Process DGNSS corrections through a binary RTCM v2.x file

Linux/Cygwin:

```
gLAB_linux -input:obs ebre3140.15o -input:nav brdc3140.15n
-input:rtcm2 ebre3140.15rtcm2 -input:rtcm:initdate 20151110
-input:rtcm:inithour 08 > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs ebre3140.15o -input:nav brdc3140.15n
-input:rtcm2 ebre3140.15rtcm2 -input:rtcm:initdate 20151110
-input:rtcm:inithour 08 > outputfile.txt
```

Process DGNSS corrections through a binary RTCM v3.x file

Linux/Cygwin:

```
gLAB_linux -input:obs ebre3140.15o -input:nav brdc3140.15n
-input:rtcm3 ebre3140.15rtcm3 -input:rtcm:initdate 20151110 >
outputfile.txt
```

Windows:

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```
gLAB.exe -input:obs ebre3140.15o -input:nav brdc3140.15n
-input:rtcm2 ebre3140.15rtcm2 -input:rtcm:initdate 20151110 >
outputfile.txt
```

Process DGNSS corrections through an input RTCM binary file, gLAB will automatically detect the RTCM version

Linux/Cygwin:

```
gLAB_linux -input:obs ebre3140.15o -input:nav brdc3140.15n
-input:rtcm ebre3140.15rtcm -input:rtcm:initdate 20151110
-input:rtcm:inithour 08 > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs ebre3140.15o -input:nav brdc3140.15n
-input:rtcm ebre3140.15rtcm -input:rtcm:initdate 20151110
-input:rtcm:inithour 08 > outputfile.txt
```

10.4.2.2 DGNSS data plotting

Linux/Cygwin:

```
graph.py -t "NEU Positioning Error" --xl "Time (s)" --yl "Error (m)" -
f "/home/gage/gLAB.out" -c '($1=="OUTPUT")' -x 4 -y 23 -l "North error" -s
.- --cl b -f "/home/gage/gLAB.out" -c '($1=="OUTPUT")' -x 4 -y 24 -l "East
error" -s .- --cl g -f "/home/gage/gLAB.out" -c '($1=="OUTPUT")' -x 4 -y 25
-l "Up error" -s .- --cl r --lp tr
```

Windows:

```
graph.exe -t "NEU Positioning Error" --xl "Time (s)" --yl "Error (m)"
--yn -2.5 --yx 2.5 -f "C:\gLAB\win\gLAB.out" -c "($1=='OUTPUT')" -x 4 -y 23
-l "North error" -s .- --cl b -f "C:\gLAB\win\gLAB.out" -c "($1=='OUTPUT')"
-x 4 -y 24 -l "East error" -s .- --cl g -f "C:\gLAB\win\gLAB.out" -c
"($1=='OUTPUT')" -x 4 -y 25 -l "Up error" -s .- --cl r --lp tr
```

Linux/Cygwin:

```
graph.py -t "DGNSS - Pseudorange Corrections" --xl "Time (s)" --yl "PRC
(m)" -f "/home/gage/gLAB.out" -c '($1=="DGNSS")' -x 4 -y 8 -l "All PRN" -s
. --cl b --lp tr
```

Windows:

```
graph.exe -t "DGNSS - Pseudorange Corrections" --xl "Time (s)" --yl
"PRC (m)" -f "C:\gLAB\win\gLAB.out" -c "($1=='DGNSS')" -x 4 -y 8 -l "All
PRN" -s . --cl b --lp tr
```


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10.4.3 Graphical results

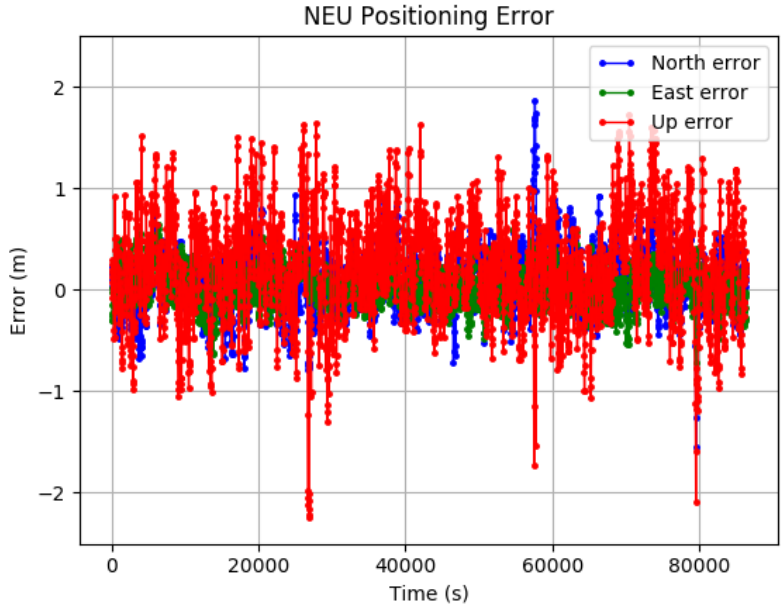

Figure 10-36. DGNSS Plot sample depicting the NEU positioning error

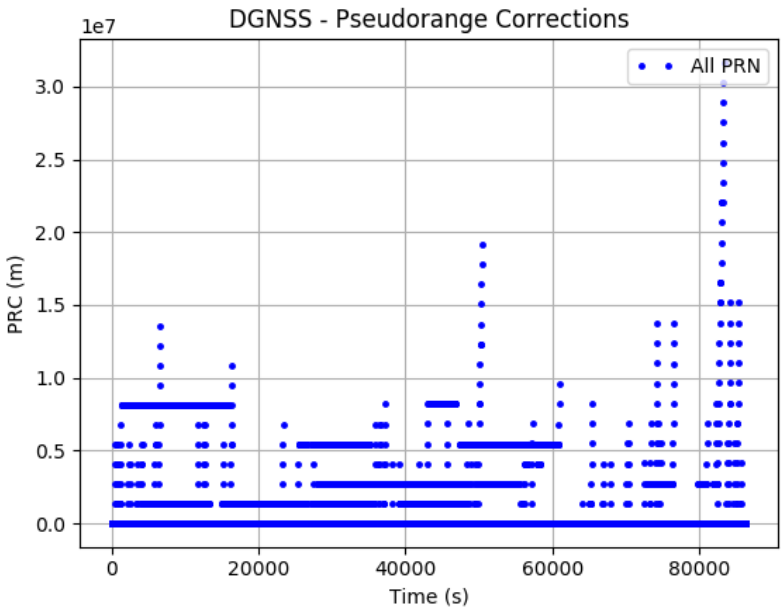

Figure 10-37. DGNSS Plot sample depicting the differential corrections

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10.5 SBAS MAPS

10.5.1 SBAS 1F

10.5.1.1 Computation of maps

Usage examples to run gLAB in SBAS **maps** mode:

Compute all SBAS plots (Availability, Continuity Risk and Ionosphere Availability) in EGNOS region (default region):

Linux/Cygwin:

```
gLAB_linux -input:nav brdc2000.06n -input:sbas M1202000.06b > outputfile.txt
```

Windows:

```
gLAB.exe -input:nav brdc2000.06n -input:sbas M1202000.06b > outputfile.txt
```

Compute only SBAS Availability plot in EGNOS region (default region):

Linux/Cygwin:

```
gLAB_linux -input:nav brdc2000.06n -input:sbas M1202000.06b -sbasplots:noriskplot -sbasplots:noionoplot > outputfile.txt
```

Windows:

```
gLAB.exe -input:nav brdc2000.06n -input:sbas M1202000.06b -sbasplots:noriskplot -sbasplots:noionoplot > outputfile.txt
```

Compute only SBAS Availability and Continuity Risk plots in EGNOS region (default region):

Linux/Cygwin:

```
gLAB_linux -input:nav brdc2000.06n -input:sbas M1202000.06b -sbasplots:noionoplot> outputfile.txt
```

Windows:

```
gLAB.exe -input:nav brdc2000.06n -input:sbas M1202000.06b -sbasplots:noriskplot -sbasplots:noionoplot > outputfile.txt
```

Compute only SBAS Ionosphere availability plot in EGNOS region (default region):

Linux/Cygwin:

```
gLAB_linux -input:nav brdc2000.06n -input:sbas M1202000.06b -sbasplots:noavailplot -sbasplots:noriskplot > outputfile.txt
```

Windows:

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```
gLAB.exe -input:nav brdc2000.06n -input:sbas M1202000.06b -sbasplots:noavailplot -sbasplots:noriskplot > outputfile.txt
```

Compute all SBAS plots (Availability, Continuity Risk and Ionosphere Availability) in a user defined region (Latitude [-30º - 40º], longitude [-10º - 10º]):

Linux/Cygwin:

```
gLAB_linux -input:nav brdc2000.06n -input:sbas M1202000.06b -sbasplots:minlat 30 -sbasplots:maxlat 40 -sbasplots:minlon -10 -sbasplots:maxlon 10 > outputfile.txt
```

Windows:

```
gLAB.exe -input:nav brdc2000.06n -input:sbas M1202000.06b -sbasplots:minlat 30 -sbasplots:maxlat 40 -sbasplots:minlon -10 -sbasplots:maxlon 10 > outputfile.txt
```

Compute all SBAS plots (Availability, Continuity Risk and Ionosphere Availability) in EGNOS region (default region), with a vertical alarm limit of 40 metres, horizontal alarm limit of 30 metres, receiver height set to 100 metres, resolution for Availability plots of 2º and resolution for Ionosphere plot of 1º:

Linux/Cygwin:

```
gLAB_linux -input:nav brdc2000.06n -input:sbas M1202000.06b -sbasplots:hal 30 -sbasplots:val 40 -sbasplots:recheight 100 -sbasplots:availstep 2 -sbasplots:ionostep 1 > outputfile.txt
```

Windows:

```
gLAB.exe -input:nav brdc2000.06n -input:sbas M1202000.06b -sbasplots:hal 30 -sbasplots:val 40 -sbasplots:recheight 100 -sbasplots:availstep 2 -sbasplots:ionostep 1 > outputfile.txt
```

Compute all SBAS plots (Availability, Continuity Risk and Ionosphere Availability) in EGNOS region (default region) setting the output files for the plots:

Linux/Cygwin:

```
gLAB_linux -input:nav brdc2000.06n -input:sbas M1202000.06b -output:sbasavailplots AvailPlotsFile.txt -output:sbasriskplots RiskPlotsFile.txt -output:sbasionoplots IonoPlotsFile.txt -output:sbasriskdisc Discontinuities.txt > outputfile.txt
```

Windows:

```
gLAB.exe -input:nav brdc2000.06n -input:sbas M1202000.06b -output:sbasavailplots AvailPlotsFile.txt -output:sbasriskplots RiskPlotsFile.txt -output:sbasionoplots IonoPlotsFile.txt -output:sbasriskdisc Discontinuities.txt > outputfile.txt
```

Compute all SBAS plots (Availability, Continuity Risk and Ionosphere Availability) in EGNOS region (default region) without printing any INFO messages:

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Linux/Cygwin:

```
gLAB_linux -input:nav brdc2000.06n -input:sbas M1202000.06b --print:info
```

Windows:

```
gLAB.exe -input:nav brdc2000.06n -input:sbas M1202000.06b --print:info
```

Compute all SBAS plots (Availability, Continuity Risk and Ionosphere Availability) in EGNOS region (default region) printing INFO and SBASUNSEL messages (INFO message is enabled by default):

Linux/Cygwin:

```
gLAB_linux -input:nav brdc2000.06n -input:sbas M1202000.06b -
print:sbasunsel > outputfile.txt
```

Windows:

```
gLAB.exe -input:nav brdc2000.06n -input:sbas M1202000.06b -
print:sbasunsel > outputfile.txt
```

NOTE: Enabling SBASUNSEL messages or SBASIONO messages in SBAS plots mode will generate a lot of output messages!

Compute all SBAS plots (Availability, Continuity Risk and Ionosphere Availability) in EGNOS region (default region) but without using any ionosphere model in Availability and Continuity Risk plots:

Linux/Cygwin:

```
gLAB_linux -input:nav brdc2000.06n -input:sbas M1202000.06b -
sbasplots:noionomodel > outputfile.txt
```

Windows:

```
gLAB.exe -input:nav brdc2000.06n -input:sbas M1202000.06b -
sbasplots:noionomodel > outputfile.txt
```

Compute all SBAS plots (Availability, Continuity Risk and Ionosphere Availability) in EGNOS region (default region) but setting the ionosphere time step (decimation) to 100 seconds and the sliding window size for the continuity risk to 10 seconds:

Linux/Cygwin:

```
gLAB_linux -input:nav brdc2000.06n -input:sbas M1202000.06b -
sbasplots:ionotimestep 100 -sbasplots:windowsize 10 > outputfile.txt
```

Windows:

```
gLAB.exe -input:nav brdc2000.06n -input:sbas M1202000.06b -
sbasplots:ionotimestep 100 -sbasplots:windowsize 10 > outputfile.txt
```

Compute all SBAS plots (Availability, Continuity Risk and Ionosphere Availability) in EGNOS region (default region), but writing the results for each hour:

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Linux/Cygwin:

```
gLAB_linux -input:nav brdc2000.06n -input:sbas M1202000.06b -sbasplots:hourlymaps > outputfile.txt
```

Windows:

```
gLAB.exe -input:nav brdc2000.06n -input:sbas M1202000.06b -sbasplots:hourlymaps > outputfile.txt
```

NOTE: The hourly files will have the same name as the daily output file, but with the characters '_HH' added before the file extension (being HH the hour in two-digit format).

Compute all SBAS plots (Availability, Continuity Risk and Ionosphere Availability) and DOP plots (using the combined DOP file) in EGNOS region (default region), and writing the results for each hour:

Linux/Cygwin:

```
gLAB_linux -input:nav brdc2000.06n -input:sbas M1202000.06b -sbasplots:hourlymaps -sbasplots:combdopplot > outputfile.txt
```

Windows:

```
gLAB.exe -input:nav brdc2000.06n -input:sbas M1202000.06b -sbasplots:hourlymaps -sbasplots:combdopplot > outputfile.txt
```

Compute all SBAS plots (Availability, Continuity Risk and Ionosphere Availability), HDOP, PDOP and GDOP plots (in independent files) and computing also the default DOP percentile (95) in EGNOS region (default region), and writing the results for each hour:

Linux/Cygwin:

```
gLAB_linux -input:nav brdc2000.06n -input:sbas M1202000.06b -sbasplots:hourlymaps -sbasplots:hdopplot -sbasplots:pdopplot -sbasplots:gdopplot -sbasplots:doppercentile > outputfile.txt
```

Windows:

```
gLAB.exe -input:nav brdc2000.06n -input:sbas M1202000.06b -sbasplots:hourlymaps -sbasplots:hdopplot -sbasplots:pdopplot -sbasplots:gdopplot -sbasplots:doppercentile > outputfile.txt
```

Compute all SBAS plots (Availability, Continuity Risk and Ionosphere Availability), HDOP, and PDOP plots (in independent files), the combined DOP plot file and computing also the 99 DOP percentile in EGNOS region (default region), and writing the results for each hour:

Linux/Cygwin:

```
gLAB_linux -input:nav brdc2000.06n -input:sbas M1202000.06b -sbasplots:hourlymaps -sbasplots:hdopplot -sbasplots:pdopplot -sbasplots:combdopplot -sbasplots:percentile 99 > outputfile.txt
```

Windows:

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```
gLAB.exe -input:nav brdc2000.06n -input:sbas M1202000.06b -sbasplots:hourlymaps -sbasplots:hdopplot -sbasplots:pdopplot -sbasplots:combdopplot -sbasplots:percentile 99 > outputfile.txt
```

Compute all SBAS plots (Availability, Continuity Risk and Ionosphere Availability) in the north hemisphere (all SBAS systems). The plot area is set to the north hemisphere, but several sea zones will be skipped in order to accelerate the plot.

Linux/Cygwin:

```
gLAB_linux -input:nav brdc0760.15n -input:sbas M000760.15b --sbasplots:hourlymaps -model:geoswitch -sbasplots:minlat 0 -sbasplots:maxlat 90 -sbasplots:minlon -180 -sbasplots:maxlon 180 -sbasplots:exclusionarea -180 -150 0 40 -sbasplots:exclusionarea -180 55 0 10 -sbasplots:exclusionarea -50 -30 0 30 -sbasplots:exclusionarea -50 40 70 80 -sbasplots:exclusionarea 95 180 0 10 > outputfile.txt
```

Windows:

```
gLAB.exe -input:nav brdc2000.06n -input:sbas M1202000.06b -sbasplots:hourlymaps -model:geoswitch -sbasplots:minlat 0 -sbasplots:maxlat 90 -sbasplots:minlon -180 -sbasplots:maxlon 180 -sbasplots:exclusionarea -180 -150 0 40 -sbasplots:exclusionarea -180 55 0 10 -sbasplots:exclusionarea -50 -30 0 30 -sbasplots:exclusionarea -50 40 70 80 -sbasplots:exclusionarea 95 180 0 10 > outputfile.txt
```

NOTE: GEO switching must be enabled in order to be able to process more than one SBAS system, and the SBAS file must contain data from GEOs of all SBAS system.

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10.5.1.2 Plotting of maps

Plot a SBAS Availability map from the gLAB output file (with the default output filename from gLAB):

Linux/Cygwin:

```
graph.py --sbas -f "SBASAvailPlots_M0003150.16b.txt"
```

Windows:

```
graph.exe --sbas -f "SBASAvailPlots_M0003150.16b.txt"
```

Plot a SBAS Continuity Risk map from the gLAB output file (with the default output filename from gLAB):

Linux/Cygwin:

```
graph.py --sbas -f "SBASRiskPlots_M0003150.16b.txt"
```

Windows:

```
graph.exe --sbas -f "SBASRiskPlots_M0003150.16b.txt"
```

Plot a SBAS Ionosphere Availability map from the gLAB output file (with the default output filename from gLAB):

Linux/Cygwin:

```
graph.py --sbas -f "SBASIonoPlots_M0003150.16b.txt"
```

Windows:

```
graph.exe --sbas -f "SBASIonoPlots_M0003150.16b.txt"
```

Plot a SBAS Availability map from the gLAB output file (with the default output filename from gLAB) without contour lines:

Linux/Cygwin:

```
graph.py --sbas -f "SBASAvailPlots_M0003150.16b.txt" --nocontourlines
```

Windows:

```
graph.exe --sbas -f "SBASAvailPlots_M0003150.16b.txt" --nocontourlines
```

Plot a SBAS Continuity Risk map from the gLAB output file (with the default output filename from gLAB) without contour lines and save it to file “risk.png”:

Linux/Cygwin:

```
graph.py --sbas -f "SBASRiskPlots_M0003150.16b.txt" --nocontourlines  --
sv "risk.png"
```

Windows:

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```
   graph.exe --sbas -f "SBASRiskPlots_M0003150.16b.txt" --nocontourlines  -
-sv "risk.png"
```

Plot a SBAS Availability map from the gLAB output file (with the default output filename from gLAB) with the thresholds being "greater equal" instead of "greater than:

Linux/Cygwin:

```
   graph.py --sbas -f "SBASAvailPlots_M0003150.16b.txt" --bineqcond
```

Windows:

```
   graph.exe --sbas -f "SBASAvailPlots_M0003150.16b.txt" --bineqcond
```

Plot a SBAS Continuity Risk map from the gLAB output file (with the default output filename from gLAB) with the thresholds being "less equal" instead of "less than" and adding the European FIR:

Linux/Cygwin:

```
   graph.py --sbas -f "SBASRiskPlots_M0003150.16b.txt" --bineqcond --fireu
```

Windows:

```
   graph.exe --sbas -f "SBASRiskPlots_M0003150.16b.txt" --bineqcond --fireu
```

Plot a SBAS Availability map from the gLAB output file (with the default output filename from gLAB) with the European FIR and the degradation percentage inside the FIR area:

Linux/Cygwin:

```
   graph.py --sbas -f "SBASAvailPlots_M0003150.16b.txt" --fireu --firdeg
```

Windows:

```
   graph.exe --sbas -f "SBASAvailPlots_M0003150.16b.txt" --fireu --firdeg
```

Plot a SBAS Availability map from the gLAB output file (with the default output filename from gLAB) with the European FIR, the degradation percentage inside the FIR area, and changing the degradation percentage text colour to black and its text to "Avail <val>%" (being "<val>" the availability percentage formatted with one decimal):

Linux/Cygwin:

```
   graph.py --sbas -f "SBASAvailPlots_M0003150.16b.txt" --fireu --firdeg  -
-firdegtextcolor k --firdegtext "Avail {0:.1f}%"
```

Windows:

```
   graph.exe --sbas -f "SBASAvailPlots_M0003150.16b.txt" --fireu --firdeg
--firdegtextcolor k --firdegtext "Avail {0:.1f}%"
```


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Plot a SBAS Availability map from the gLAB output file (with the default output filename from gLAB) with the colour bar bins at 99.0 and 99.9, and only one contour line at 99.9:

Linux/Cygwin:

```
graph.py --sbas -f "SBASAvailPlots_M0003150.16b.txt" --availmapbin 99.0,99.9 --availcontourlevels 99.9
```

Windows:

```
graph.exe --sbas -f "SBASAvailPlots_M0003150.16b.txt" --availmapbin 99.0,99.9 --availcontourlevels 99.9
```

Plot a SBAS Maritime Continuity Risk map from the gLAB output file (with the default output filename from gLAB):

Linux/Cygwin:

```
graph.py --sbas -f "SBASRiskMarPlots_M0003150.16b.txt"
```

Windows:

```
graph.exe --sbas -f "SBASRiskMarPlots_M0003150.16b.txt"
```

Plot a SBAS HDOP median map from the gLAB HDOP output file (with the default output filename from gLAB):

Linux/Cygwin:

```
graph.py --sbas -f "SBASHDOPPlots_M0003150.16b.txt"
```

Windows:

```
graph.exe --sbas -f "SBASHDOPPlots_M0003150.16b.txt"
```

Plot a SBAS PDOP median map from the gLAB PDOP output file (with the default output filename from gLAB):

Linux/Cygwin:

```
graph.py --sbas -f "SBASPDOPPlots_M0003150.16b.txt"
```

Windows:

```
graph.exe --sbas -f "SBASPDOPPlots_M0003150.16b.txt"
```


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Plot a SBAS GDOP median map from the gLAB GDOP output file (with the default output filename from gLAB):

Linux/Cygwin:

```
graph.py --sbas -f "SBASGDOPPlots_M0003150.16b.txt"
```

Windows:

```
graph.exe --sbas -f "SBASGDOPPlots_M0003150.16b.txt"
```

Plot a SBAS PDOP median map from the gLAB PDOP output file (with the default output filename from gLAB) with the bins at 3 and 4.5:

Linux/Cygwin:

```
graph.py --sbas -f "SBASPDOPPlots_M0003150.16b.txt" --pdopmapbins 3,4.5
```

Windows:

```
graph.exe --sbas -f "SBASPDOPPlots_M0003150.16b.txt" --pdopmapbins 3,4.5
```

Create a SBAS GDOP median and percentile map from the gLAB GDOP output file (with the default output filename from gLAB):

Linux/Cygwin:

```
graph.py --sbas -f "SBASGDOPPlots_M0003150.16b.txt" --doppercentile
```

Windows:

```
graph.exe --sbas -f "SBASGDOPPlots_M0003150.16b.txt" -doppercentile
```

Plot a SBAS HDOP, PDOP and GDOP median map from the gLAB combined DOP output file (with the default output filename from gLAB):

Linux/Cygwin:

```
graph.py --sbas -f "SBASCombDOPPlots_M0003150.16b.txt"
```

Windows:

```
graph.exe --sbas -f "SBASCombDOPPlots_M0003150.16b.txt"
```

Plot a SBAS HDOP, PDOP, GDOP median and percentile map from the gLAB combined DOP output file (with the default output filename from gLAB):

Linux/Cygwin:

```
graph.py --sbas -f "SBASCombDOPPlots_M0003150.16b.txt" --doppercentile
```

Windows:

```
graph.exe --sbas -f "SBASCombDOPPlots_M0003150.16b.txt" --doppercentile
```


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Plot a SBAS HDOP, PDOP, GDOP median and percentile map from the gLAB combined DOP output file (with the default output filename from gLAB) and save them to PNG files:

Linux/Cygwin:

```
graph.py --sbas -f "SBASCombDOPPlots_M0003150.16b.txt" --doppercentile --sv HDOP_median.png --sv HDOP_percentile.png --sv PDOP_median.png --sv PDOP_percentile.png --sv GDOP_median.png --sv GDOP_percentile.png
```

Windows:

```
graph.exe --sbas -f "SBASCombDOPPlots_M0003150.16b.txt" -doppercentile --sv HDOP_median.png --sv HDOP_percentile.png --sv PDOP_median.png --sv PDOP_percentile.png --sv GDOP_median.png --sv GDOP_percentile.png
```


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10.5.1.3 Graphical Results

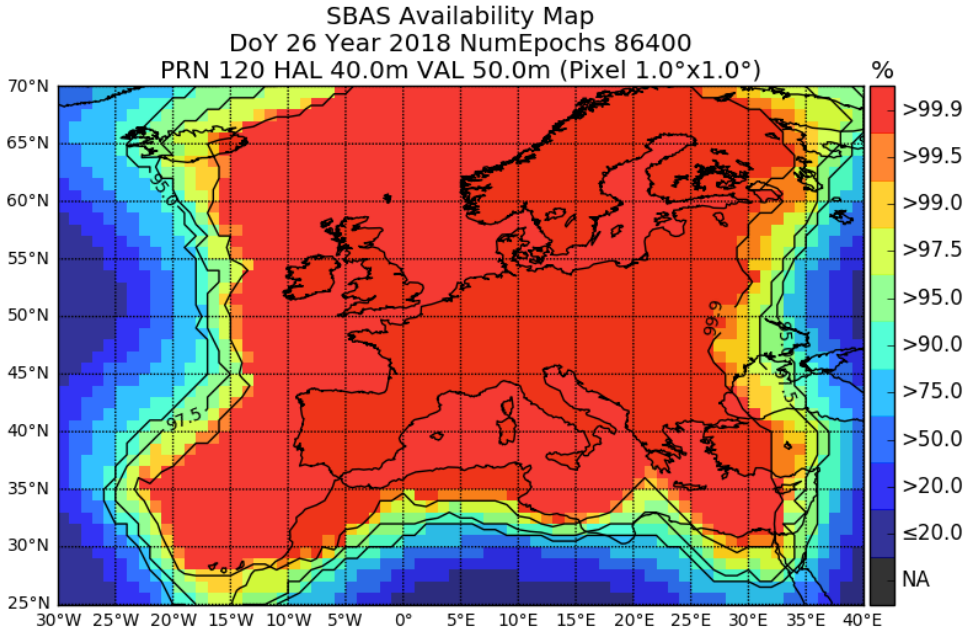

Figure 10-38: Example for SBAS Availability map (with default configuration)

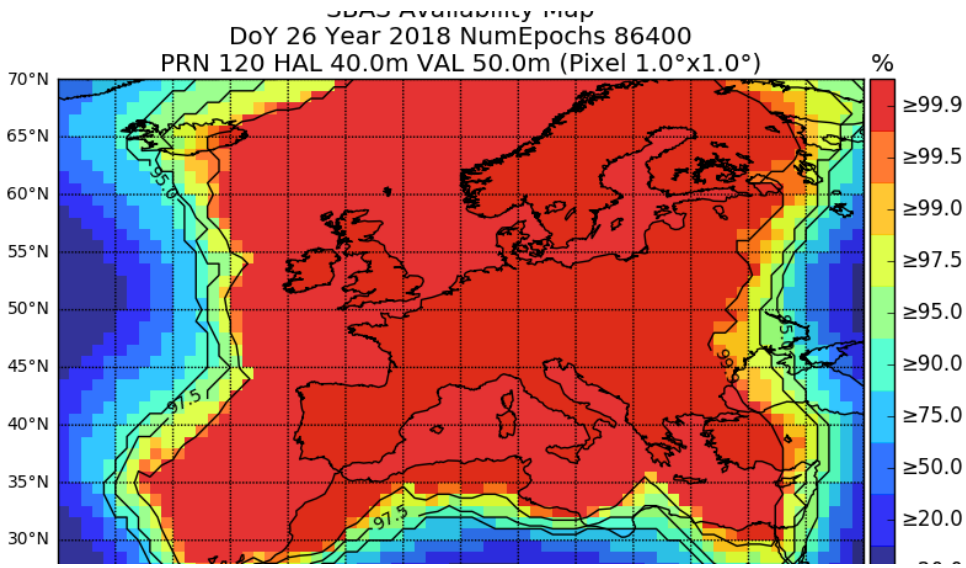

Figure 10-39: Example for SBAS Availability map with thresholds being "greater equal" instead of "greater than" and without the "Not Available" (NA) bin

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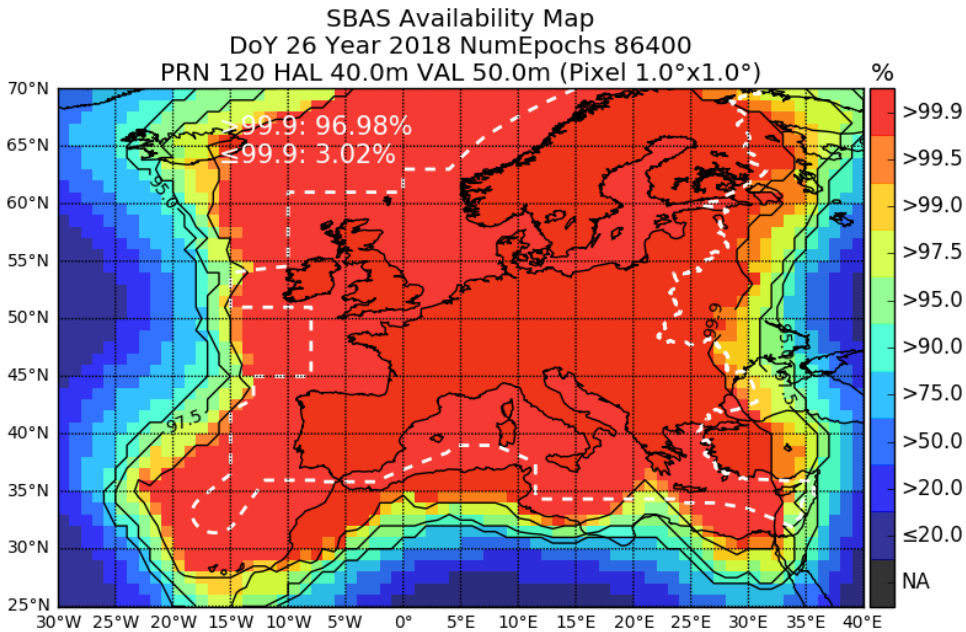

Figure 10-40: Example for SBAS Availability map with European FIR area, the availability degradation inside this area

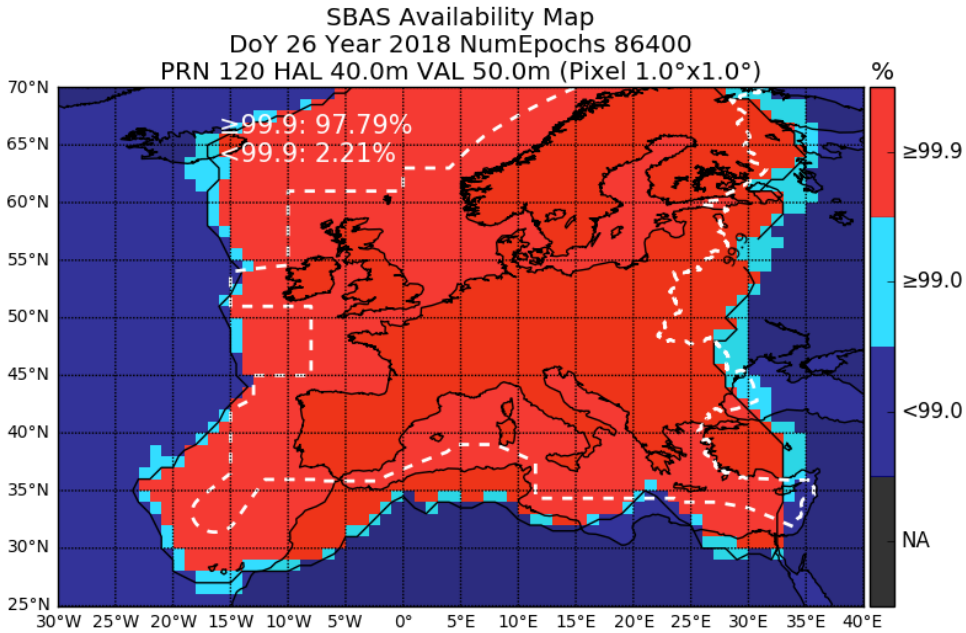

Figure 10-41: Example for SBAS Availability map with thresholds being "greater equal" instead of "greater than", the bins manually assigned to "99.0 and 99.9", with only one contour line at level "99.9", the European FIR region, its degradation and the "Not Available" (NA) bin

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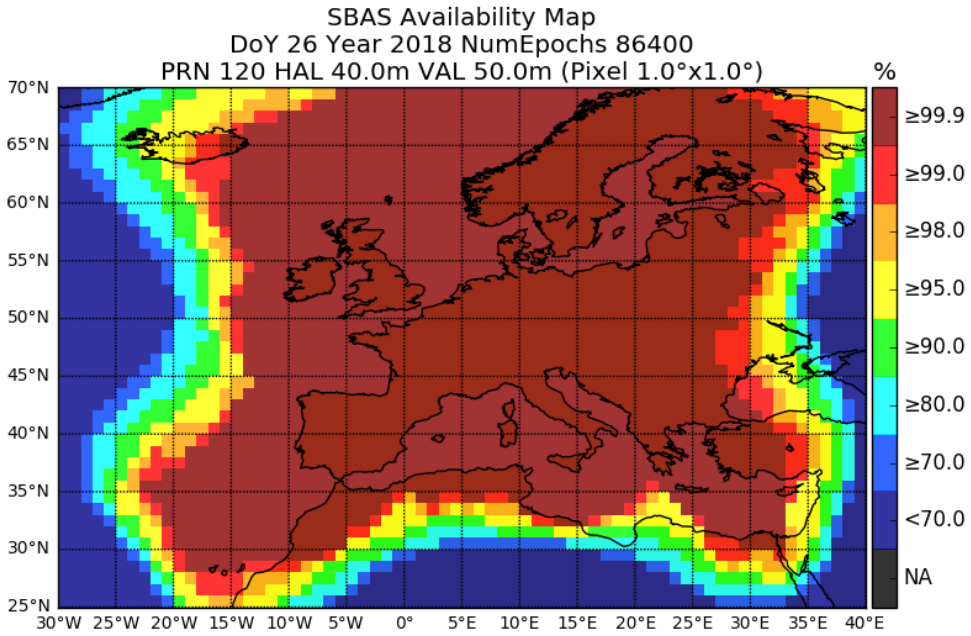

Figure 10-42: Example for SBAS Availability map with default options but with alternative "service format" enabled with parameter "--sbasserviceformat"

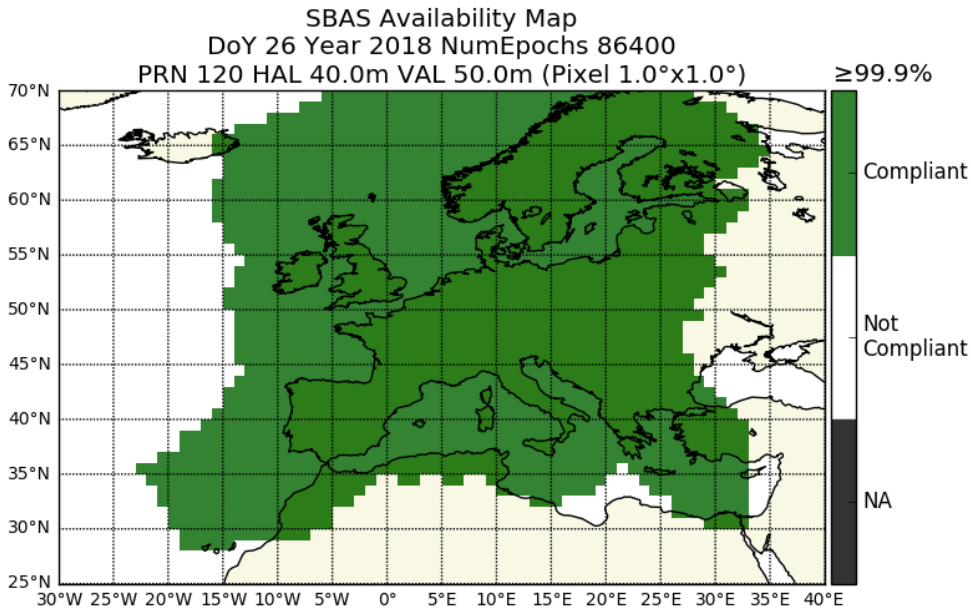

Figure 10-43: Example for SBAS Availability map with default options but with alternative "service binary format" enabled with parameter "--sbasservicebinaryformat"

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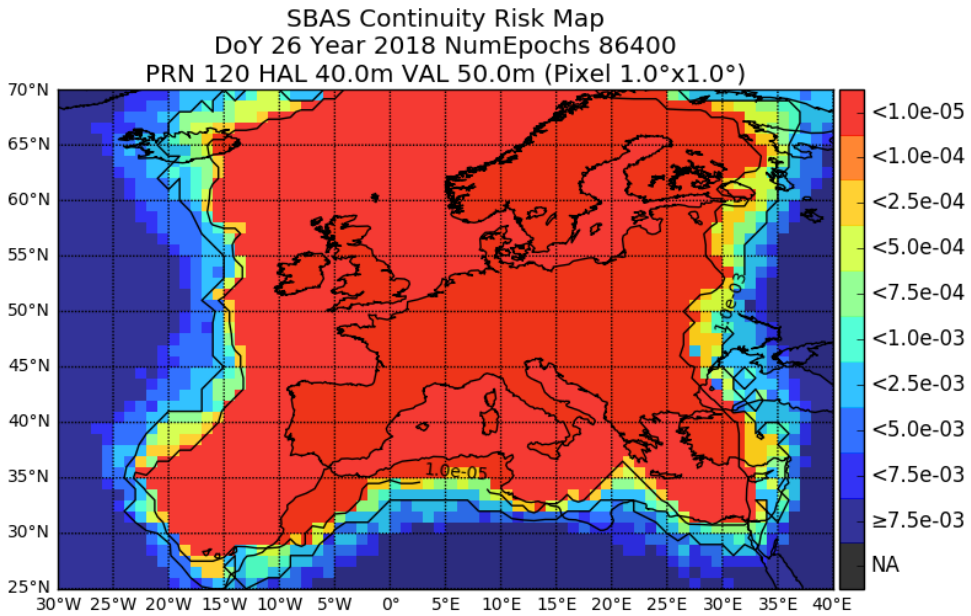

Figure 10-44: Example for SBAS Continuity Risk map (with default configuration)

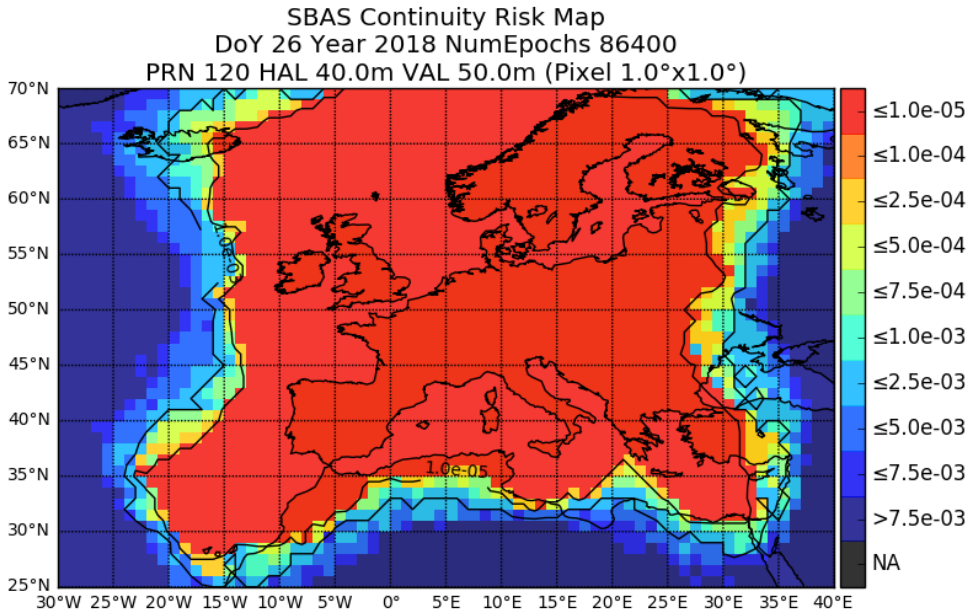

Figure 10-45: Example for SBAS Continuity Risk map with thresholds being “less equal” instead of “less than”

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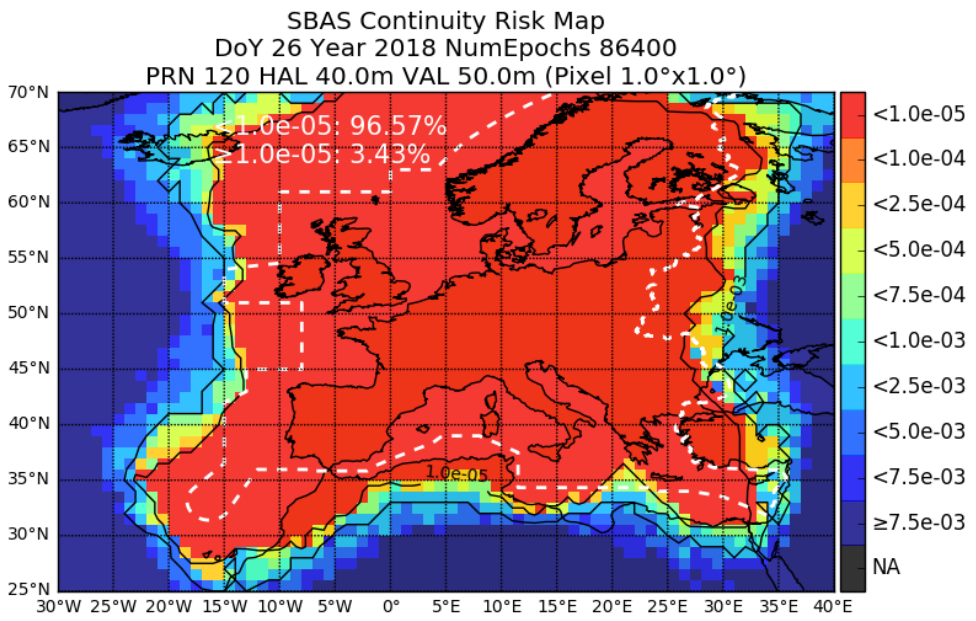

Figure 10-46: Example for SBAS Continuity Risk map with European FIR area, the availability degradation inside this area and the "Not Available" (NA) bin

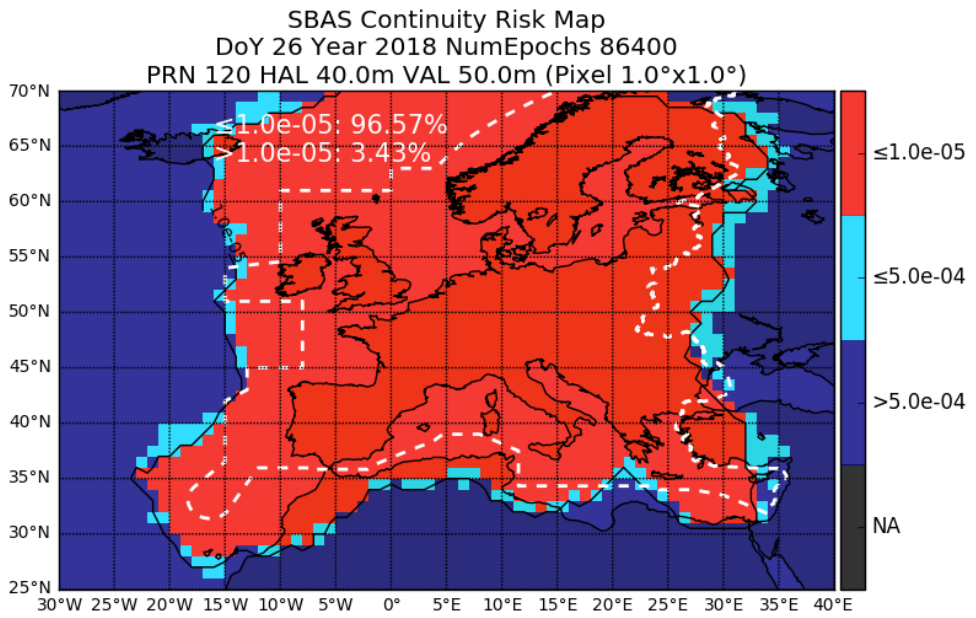

Figure 10-47: Example for SBAS Continuity Risk map with the bins manually assigned to "5e-4 and 1e-5", with only one contour line at level "1e-5, the European FIR region, its degradation and the "Not Available" (NA) bin

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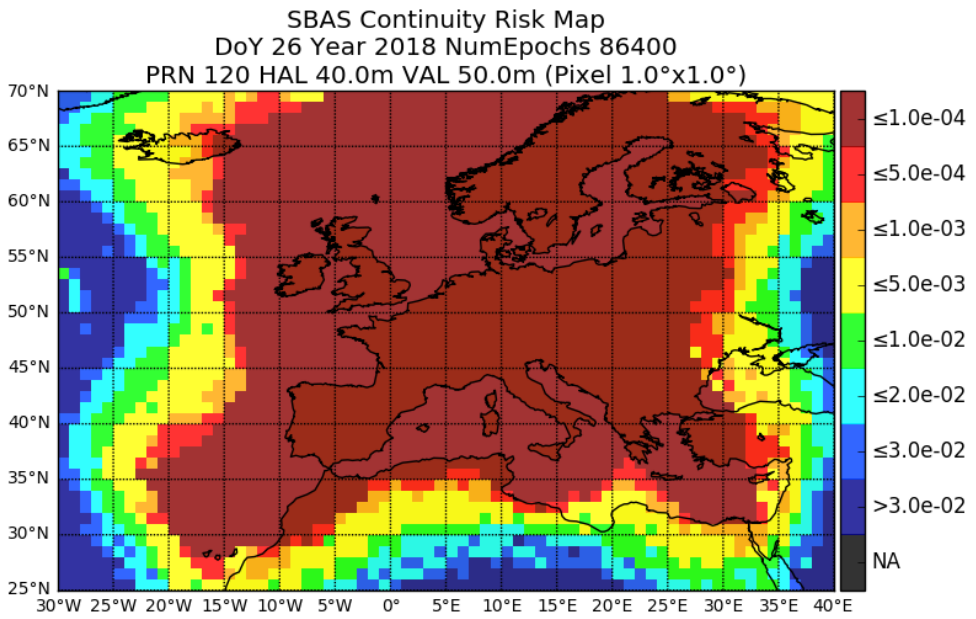

Figure 10-48: Example for SBAS Continuity Risk map with default options but with alternative "service format" enabled with parameter "--sbasserviceformat"

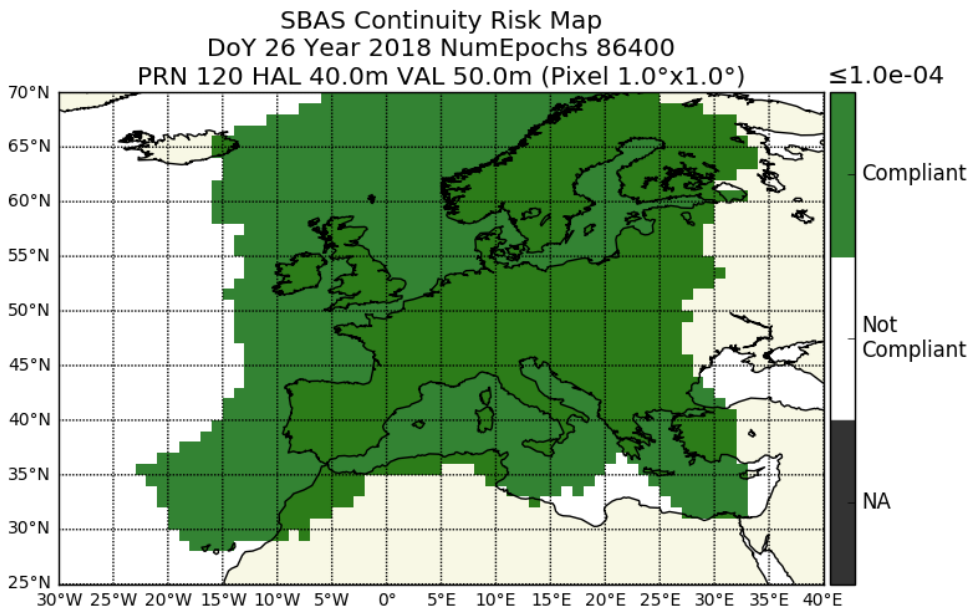

Figure 10-49: Example for SBAS Continuity Risk map with default options but with alternative "service binary format" enabled with parameter "--sbasservicebinaryformat"

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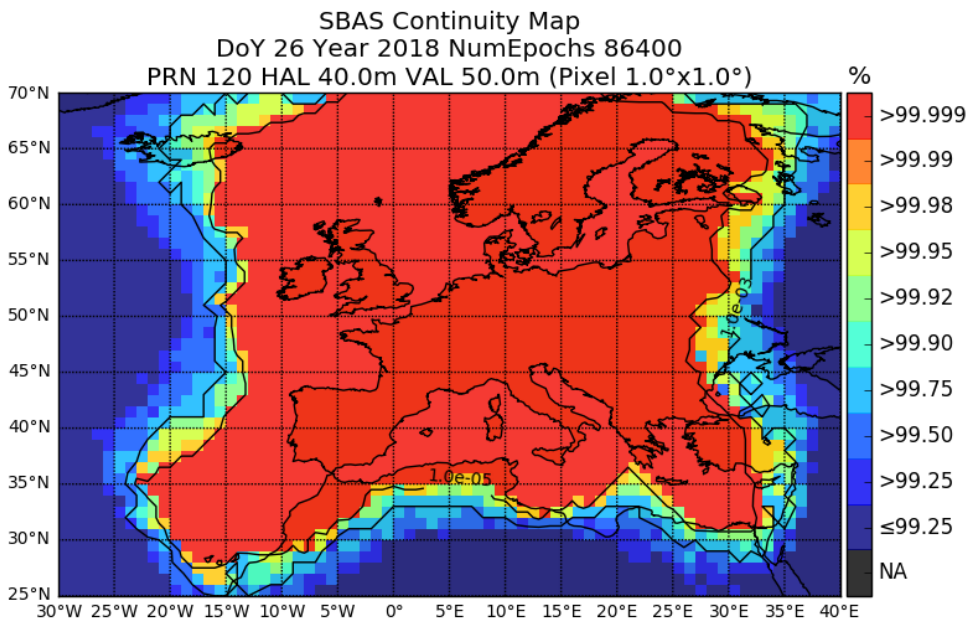

Figure 10-50: Example for SBAS Continuity Risk map with default options but printing the continuity value (with percentages) instead of the continuity risk (option --contriskaspercentage)

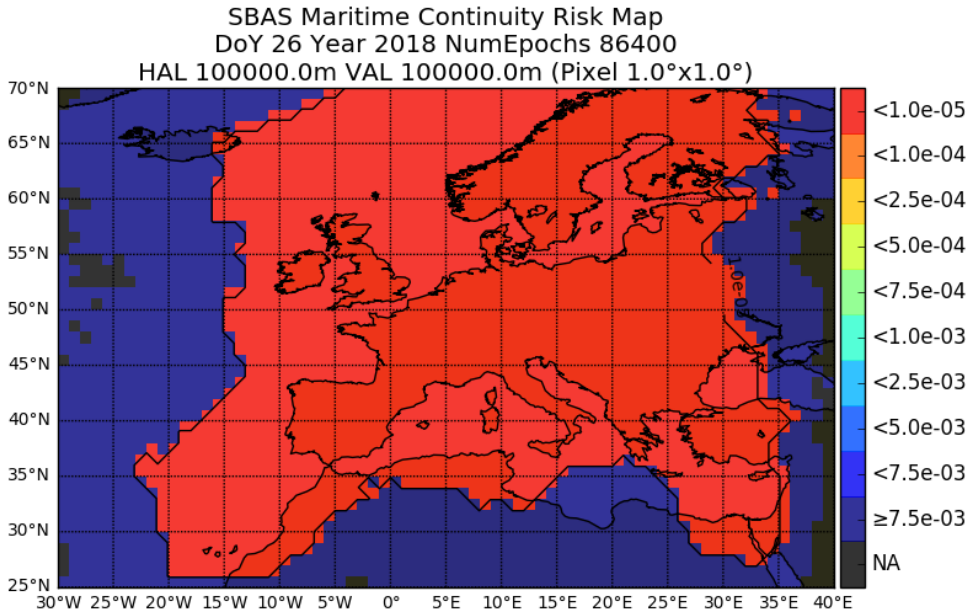

Figure 10-51: Example for SBAS Maritime Continuity Risk map (with default configuration)

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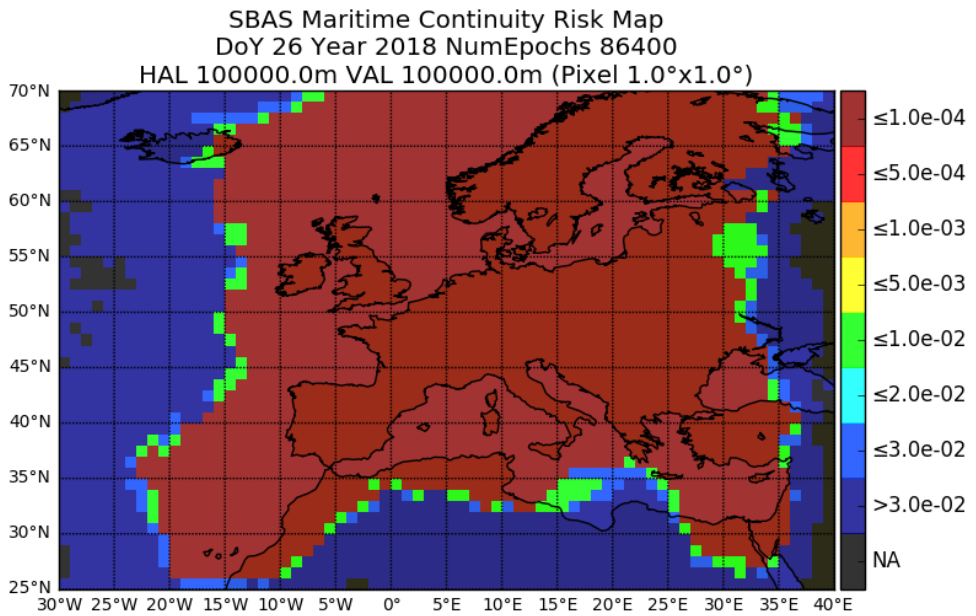

Figure 10-52: Example for SBAS Maritime Continuity Risk map with default options but with alternative "service format" enabled with parameter "--sbasserviceformat"

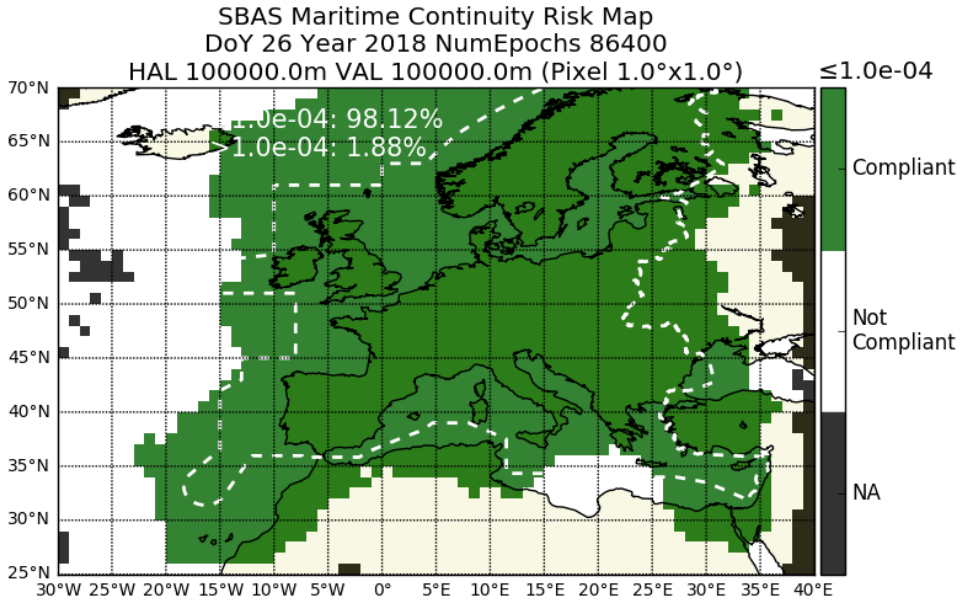

Figure 10-53: Example for SBAS Continuity Risk map with default options but with alternative "service binary format" enabled with parameter "--sbasservicebinaryformat" and with European FIR area and the availability degradation inside this area

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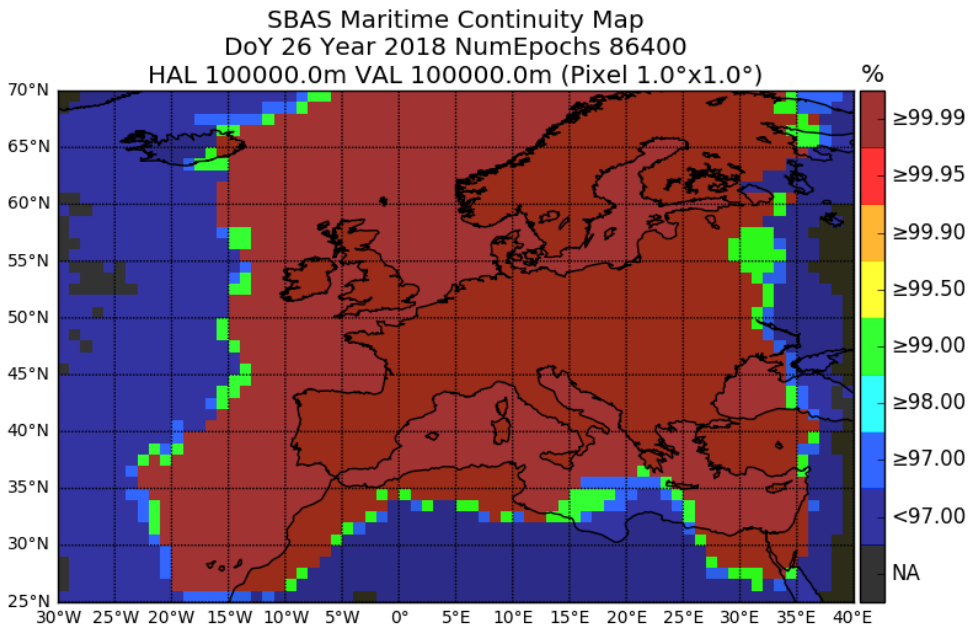

Figure 10-54: Example for SBAS Maritime Continuity Risk map with default options, with alternative "service format" enabled with parameter "--sbasserviceformat" but printing the continuity value (with percentages) instead of the continuity risk (option --contriskaspercentage)

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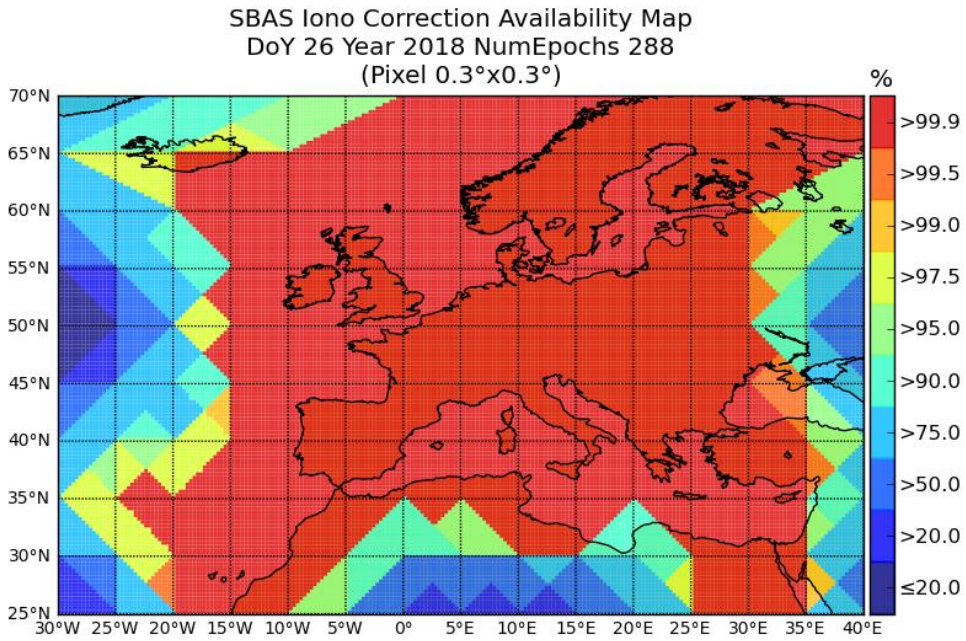

Figure 10-55: Example for SBAS Ionosphere correction availability map

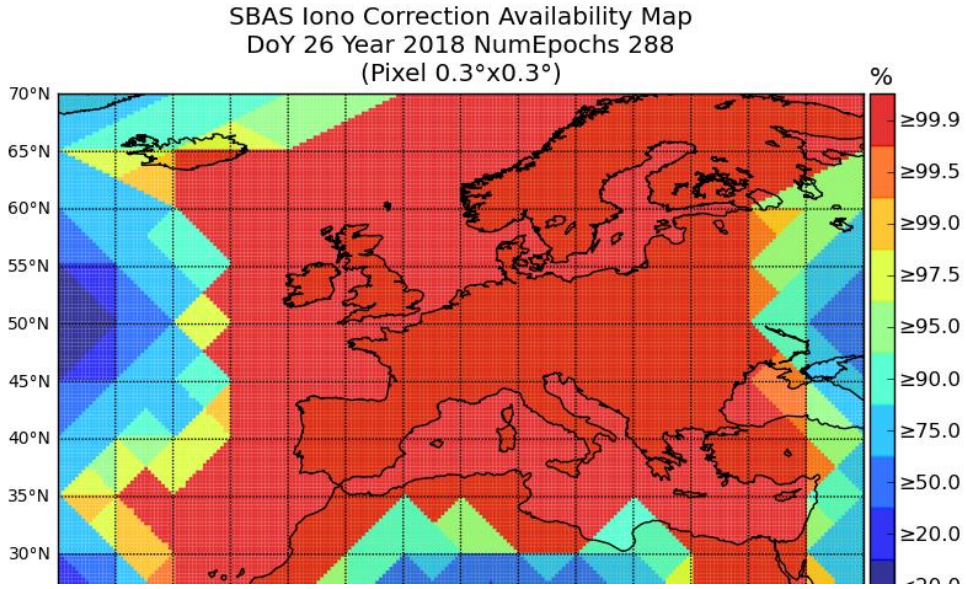

Figure 10-56: Example for SBAS Ionosphere correction availability map with "greater equal" thresholds instead of "greater than"

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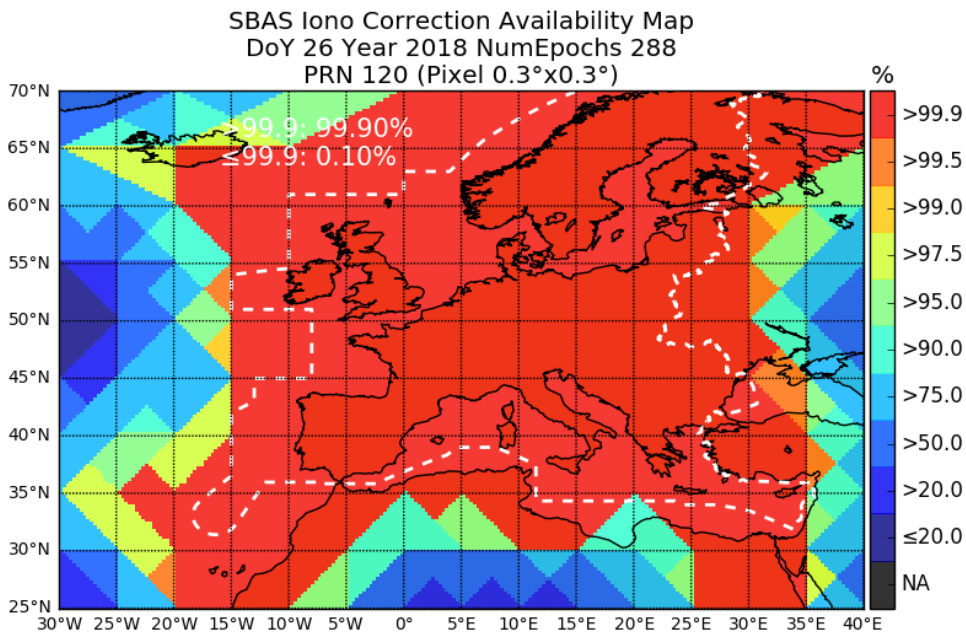

Figure 10-57: Example for SBAS Ionosphere correction availability map with European FIR area and the availability degradation inside this area

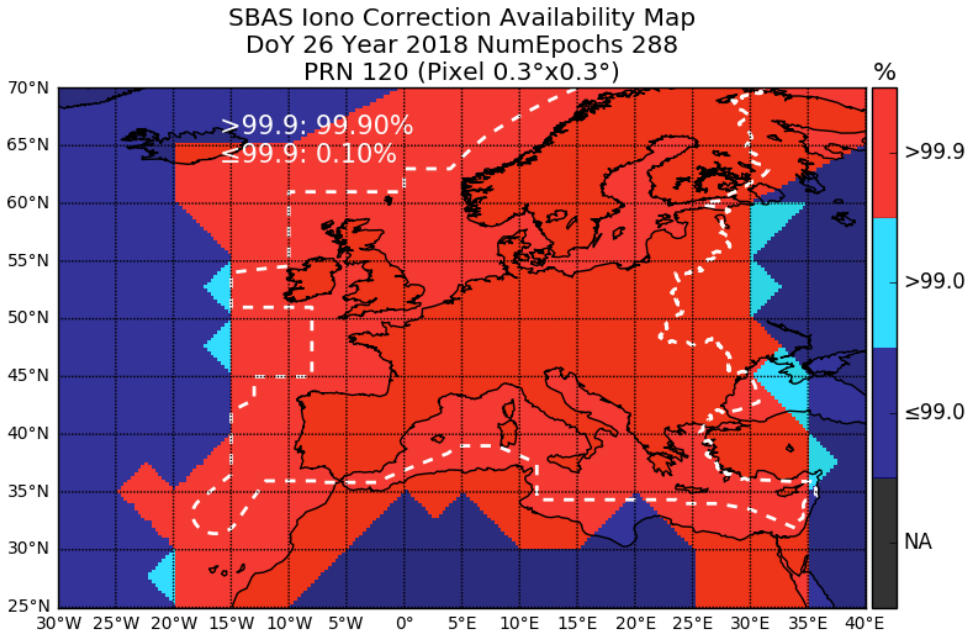

Figure 10-58: Example for SBAS Ionosphere correction with bins at 99.9 and 99.0, European FIR area and the availability degradation inside this area

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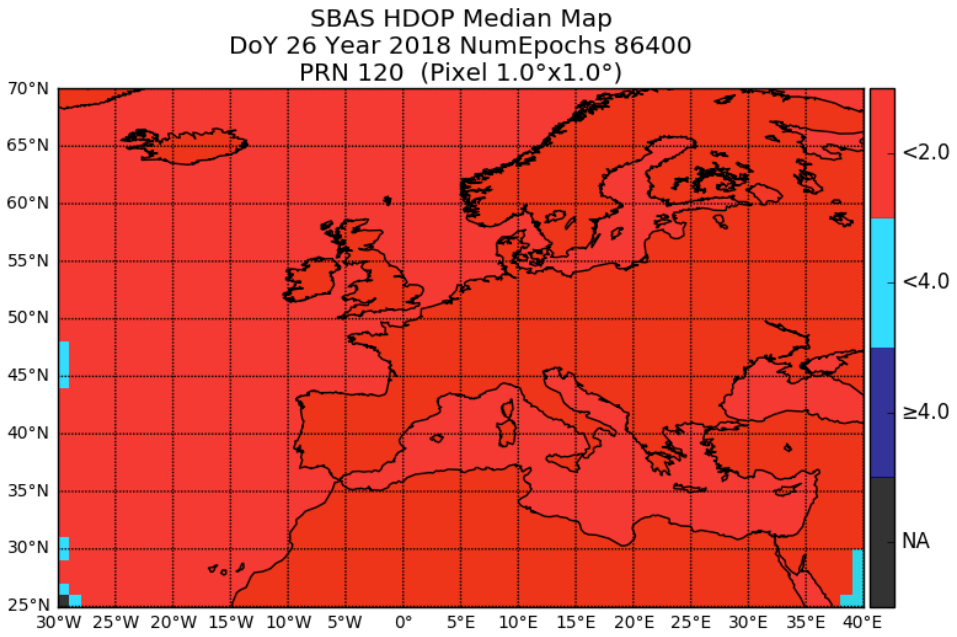

Figure 10-59: Example for SBAS HDOP Median plot

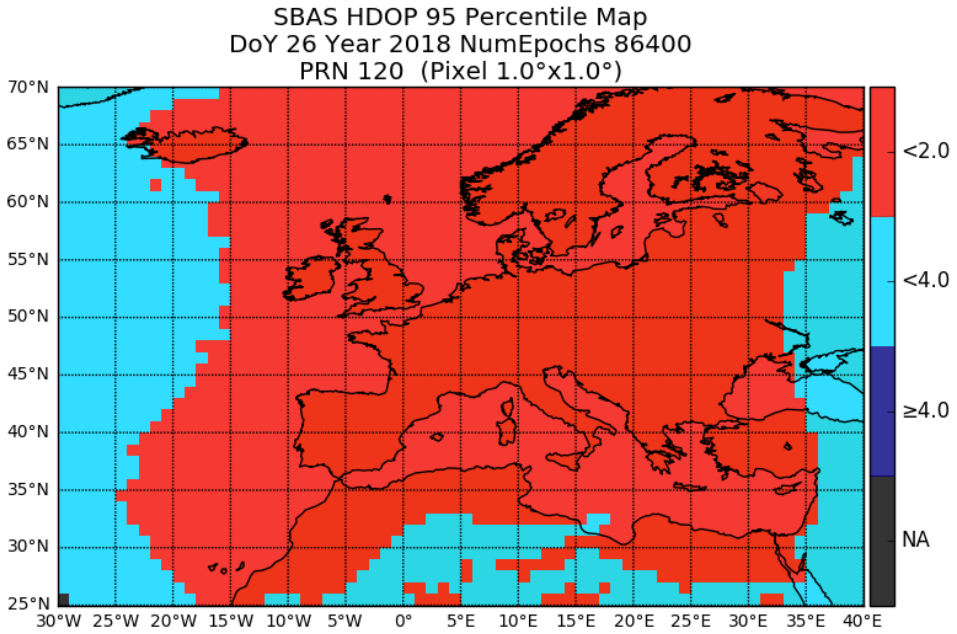

Figure 10-60: Example for SBAS HDOP 95 Percentile plot

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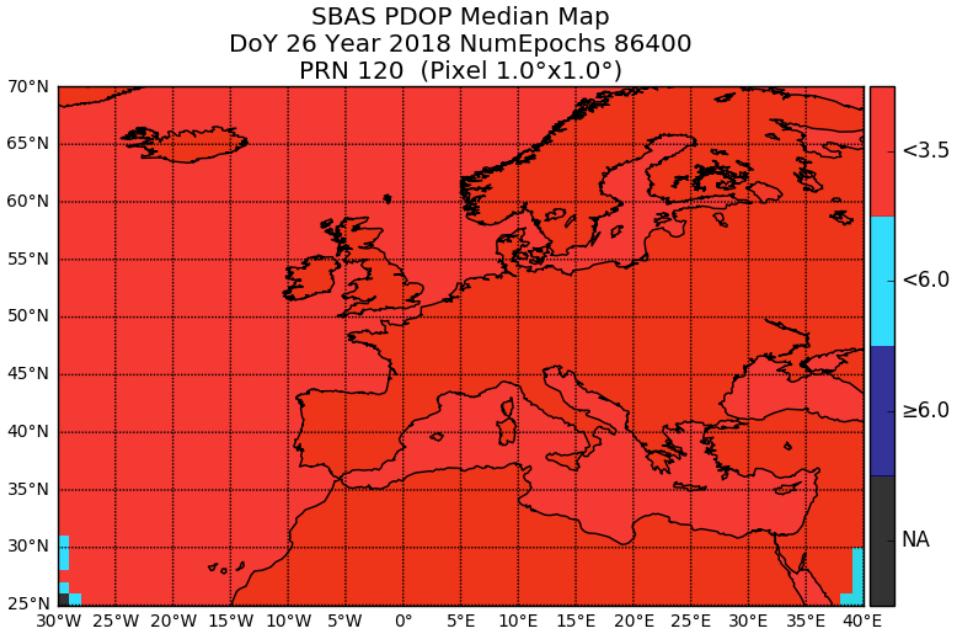

Figure 10-61: Example for SBAS PDOP Median plot

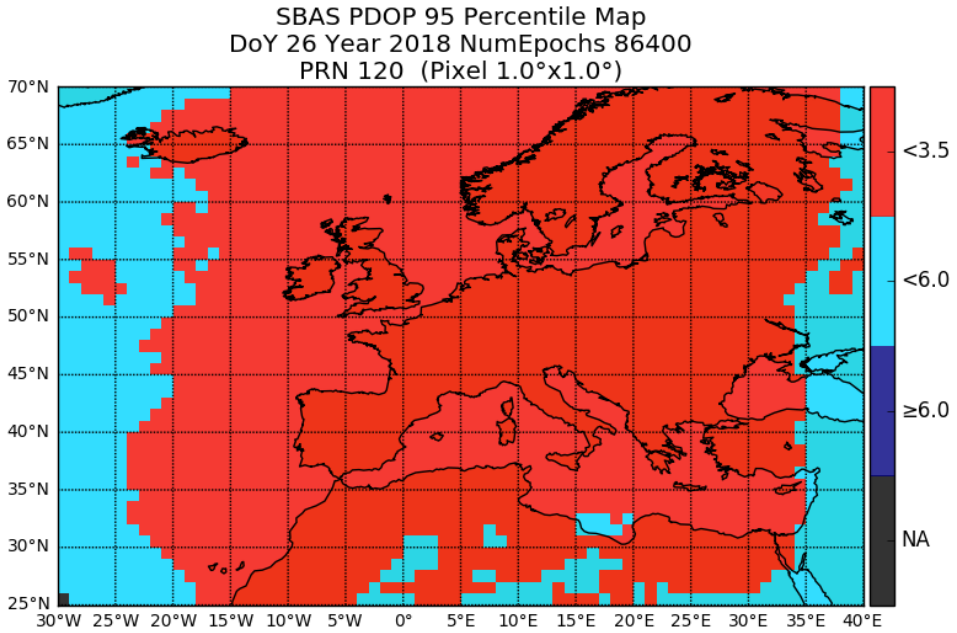

Figure 10-62: Example for SBAS PDOP 95 Percentile plot

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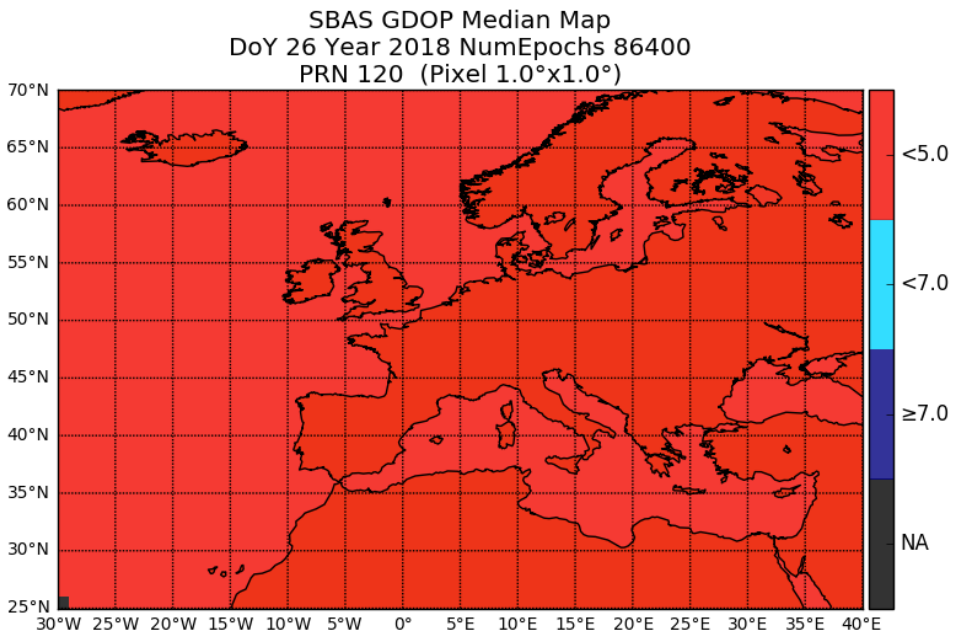

Figure 10-63: Example for SBAS GDOP Median plot

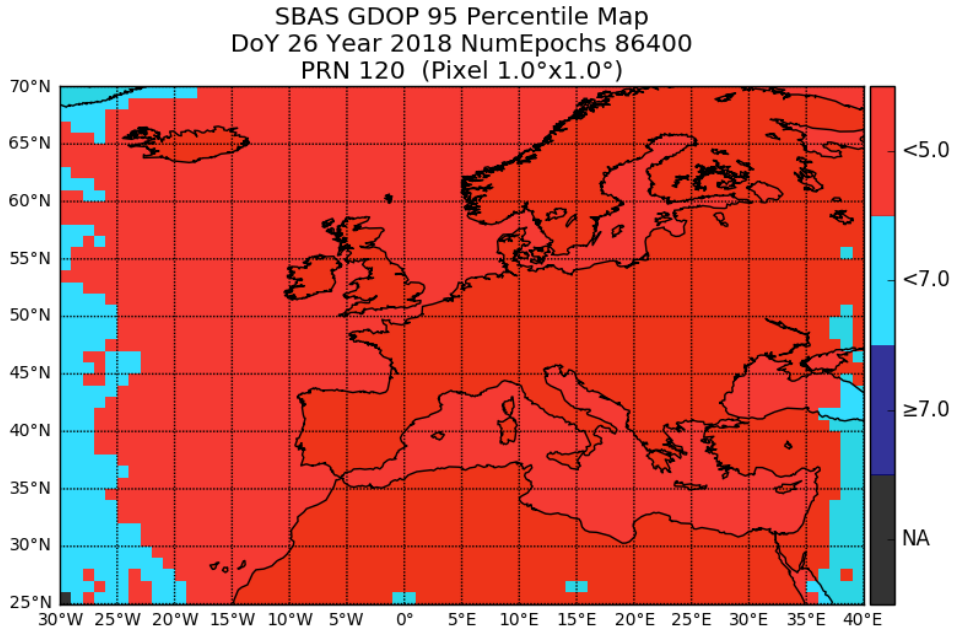

Figure 10-64: Example for SBAS GDOP 95 Percentile plot

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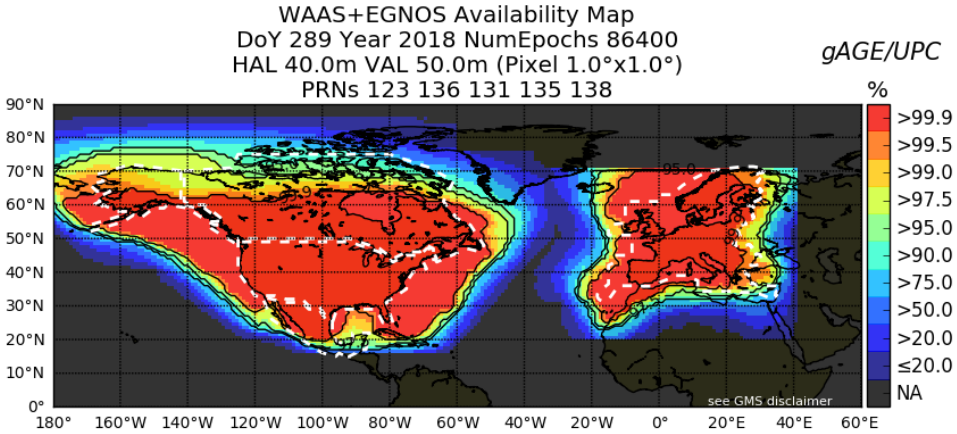

Avail. Percent	Europe Coverage	CONUS Coverage	Alaska Coverage	Canada Coverage	Mexico Coverage	All WAAS Coverage
>75.0	100%	100%	100%	100%	93.47%	99.55%
>90.0	99.10%	100%	100%	97.93%	92.24%	98.27%
>95.0	98.86%	100%	99.74%	90.28%	86.53%	93.43%
>97.5	97.71%	100%	99.47%	81.15%	78.78%	87.60%
>99.0	96.00%	100%	82.28%	70.35%	69.80%	79.04%
>99.5	94.04%	100%	65.34%	64.48%	64.08%	73.50%
>99.9	84.56%	99.59%	48.15%	58.26%	58.37%	67.59%

Figure 10-65: Example for SBAS Availability map for WAAS plus EGNOS with the European, CONUS, Alaska, Canada and Mexico FIRs (these FIRs are all hardcoded in the plotting tool) and the percentage of points inside each FIR which are above the bin value indicated in the first column in the table (these bins match with the ones of the colour bar)

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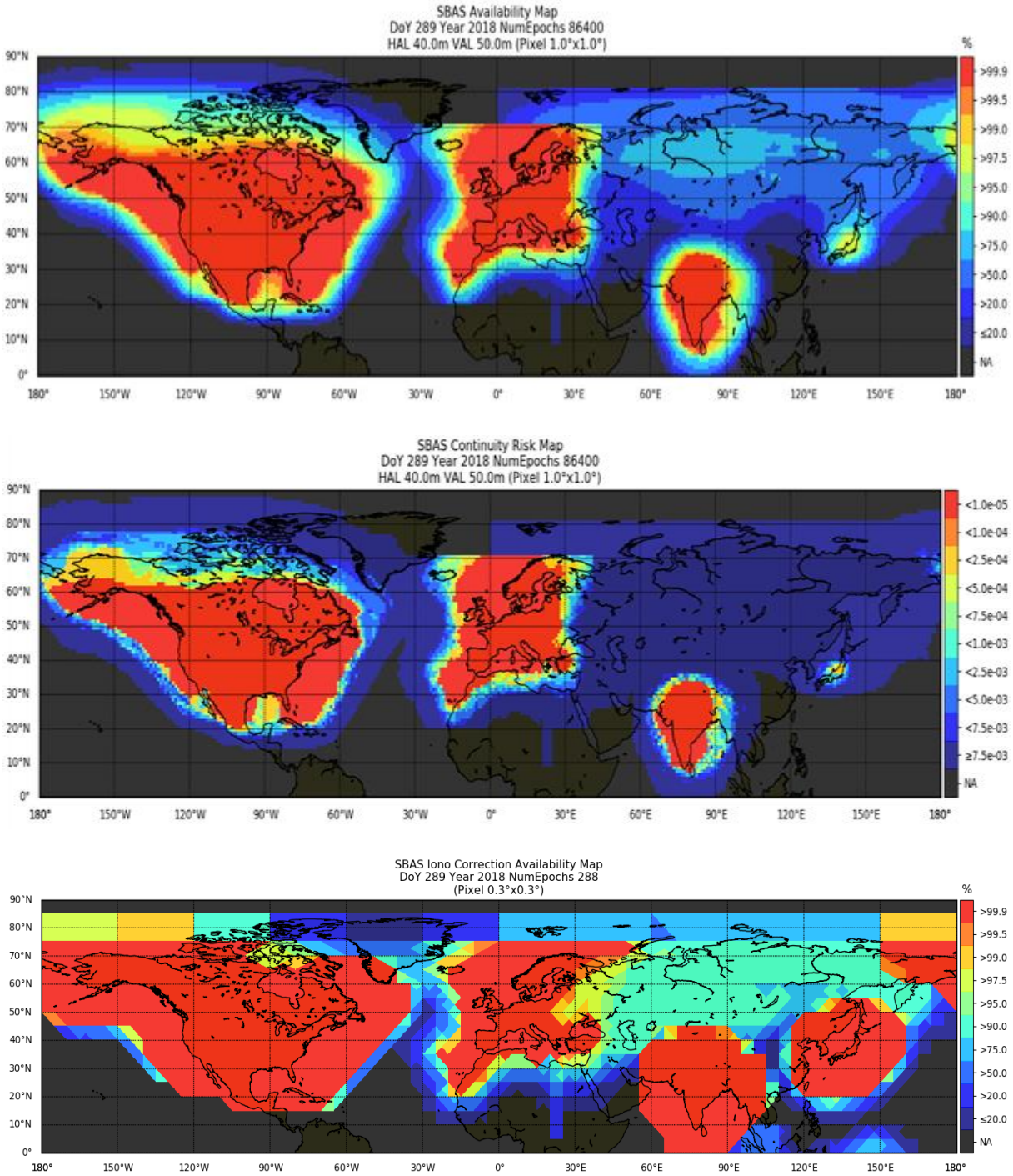

Figure 10-66: Example for SBAS Availability, Continuity and Ionosphere Availability worldwide map.

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10.5.2 SBAS DFMC

10.5.2.1 Computation of maps

Compute SBAS DFMC LPV200 Daily and Hourly Availability maps (over Australia) with multithreading (2 threads):

Linux/Cygwin:

```
   gLAB_linux_Multithread -input:nav gage1830.19p -input:sbasdfmc
M1221830.ems -model:sbasdfmc:austestbed -sbasplots:plotarea 110 160 -50 10
-sbasplots:availstep 10 -sbasplots:val 35 -sbasplots:hourlymaps
-output:sbasavailplots Maps/Australia_AvailPlots_183_2019_GEO_122.txt
-output:sbasriskplots Maps/Australia_RiskPlots_183_2019_GEO_122.txt
-output:sbasriskmarplots Maps/Australia_RiskMarPlots_183_2019_GEO_122.txt
-output:sbasriskdisc Maps/Australia_Disc_183_2019_GEO_122.txt
```

Windows:

```
   gLAB_Multithread.exe -input:nav gage1830.19p -input:sbasdfmc
M1221830.ems -model:sbasdfmc:austestbed -sbasplots:plotarea 110 160 -50 10
-sbasplots:availstep 10 -sbasplots:val 35 -sbasplots:hourlymaps
-output:sbasavailplots Maps\Australia_AvailPlots_183_2019_GEO_122.txt
-output:sbasriskplots Maps\Australia_RiskPlots_183_2019_GEO_122.txt
-output:sbasriskmarplots Maps\Australia_RiskMarPlots_183_2019_GEO_122.txt
-output:sbasriskdisc Maps\Australia_Disc_183_2019_GEO_122.txt
```

Compute SBAS DFMC LPV200 Daily and Hourly Availability maps (worldwide) with multithreading (2 threads):

Linux/Cygwin:

```
   gLAB_linux -input:nav gage1830.19p -input:sbasdfmc M1221830.ems
-model:sbasdfmc:austestbed -sbasplots:plotarea -180 180 -90 90
-sbasplots:availstep 10 -sbasplots:val 35 -output:sbasriskplots
-output:sbasavailplots Maps/Australia_AvailPlots_183_2019_GEO_122.txt
-sbasplots:hourlymaps Maps/Australia_RiskPlots_183_2019_GEO_122.txt
-output:sbasriskmarplots Maps/Australia_RiskMarPlots_183_2019_GEO_122.txt
-output:sbasriskdisc Maps/Australia_Disc_183_2019_GEO_122.txt
```

Windows:

```
   gLAB_Multithread.exe -input:nav gage1830.19p -input:sbasdfmc
M1221830.ems -model:sbasdfmc:austestbed -sbasplots:hourlymaps
-sbasplots:plotarea -180 180 -90 90 -sbasplots:availstep 10 -sbasplots:val
35 -output:sbasavailplots Maps\Australia_AvailPlots_183_2019_GEO_122.txt
-output:sbasriskplots Maps\Australia_RiskPlots_183_2019_GEO_122.txt
-output:sbasriskmarplots Maps\Australia_RiskMarPlots_183_2019_GEO_122.txt
-output:sbasriskdisc Maps\Australia_Disc_183_2019_GEO_122.txt
```


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10.5.2.2 Plotting of maps

Plot SBAS DFMC Availability maps on 02/07/2019 (DoY 183) over Australia continent for Hour 0 (with a resolution of 10ºx10º for fast computation):

Linux/Cygwin:

```
graph.py --sbas -f Maps/Australia_AvailPlots_183_2019_GEO_122_00h.txt --sbasplotsize 30,20 --xts 10 --yts 5 --sv AvailMap_Australia_183_2019_GEO_122_00h.png
```

Windows:

```
graph.exe --sbas -f Maps\Australia_AvailPlots_183_2019_GEO_122_00h.txt --sbasplotsize 30,20 --xts 10 --yts 5 --sv AvailMap_Australia_183_2019_GEO_122_00h.png
```

Plot SBAS DFMC Continuity Risk maps on 02/07/2019 (DoY 183) over Australia continent for Hour 0 (with a resolution of 10ºx10º for fast computation):

Linux/Cygwin:

```
graph.py --sbas -f Maps/Australia_RiskPlots_183_2019_GEO_122_00h.txt --sbasplotsize 30,20 --xts 10 --yts 5 --sv ContRiskMap_Australia_183_2019_GEO_122_00h.png
```

Windows:

```
graph.exe --sbas -f Maps\Australia_RiskPlots_183_2019_GEO_122_00h.txt --sbasplotsize 30,20 --xts 10 --yts 5 --sv ContRiskMap_Australia_183_2019_GEO_122_00h.png
```

Plot SBAS DFMC Availability maps on 02/07/2019 (DoY 183) worldwide continent for Hour 0 (with a resolution of 10ºx10º for fast computation):

Linux/Cygwin:

```
graph.py --sbas -f Maps/Australia_AvailPlots_183_2019_GEO_122_00h.txt --sbasplotsize 90,40 --xts 10 --yts 10 --sv AvailMap_Australia_183_2019_GEO_122_00h.png
```

Windows:

```
graph.exe --sbas -f Maps\Australia_AvailPlots_183_2019_GEO_122_00h.txt --sbasplotsize 90,40 --xts 10 --yts 10 --sv AvailMap_Australia_183_2019_GEO_122_00h.png
```


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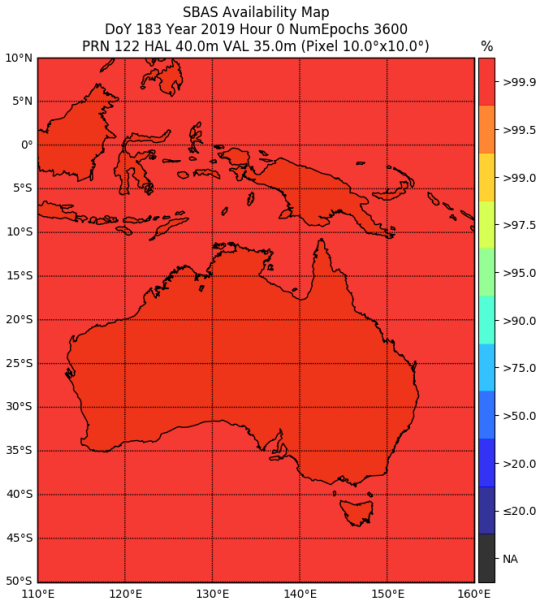
10.5.2.3 Graphical Results

Examples of SBAS DFMC Availability and Continuity Risk maps on 02/07/2019 (DoY 183) over Australia continent for Hour 0 (with a resolution of 10ºx10º for fast computation):



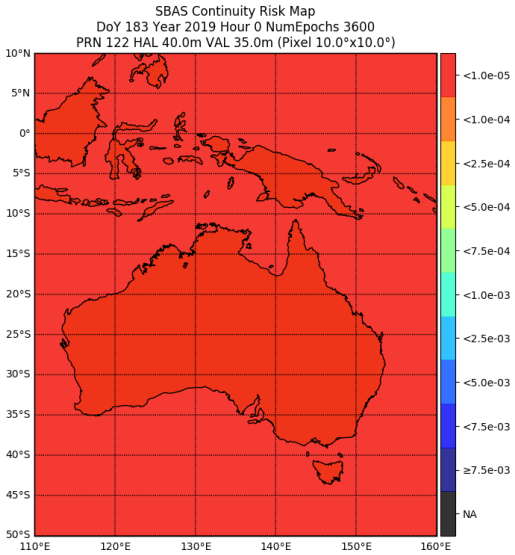


Figure 10-67: Examples of SBAS DFMC Availability (top) and Continuity Risk (bottom) maps over Australia continent for Hour 0

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An example of SBAS DFMC Availability maps on 02/07/2019 (DoY 183) worldwide (with a resolution of 10ºx10º for fast computation):

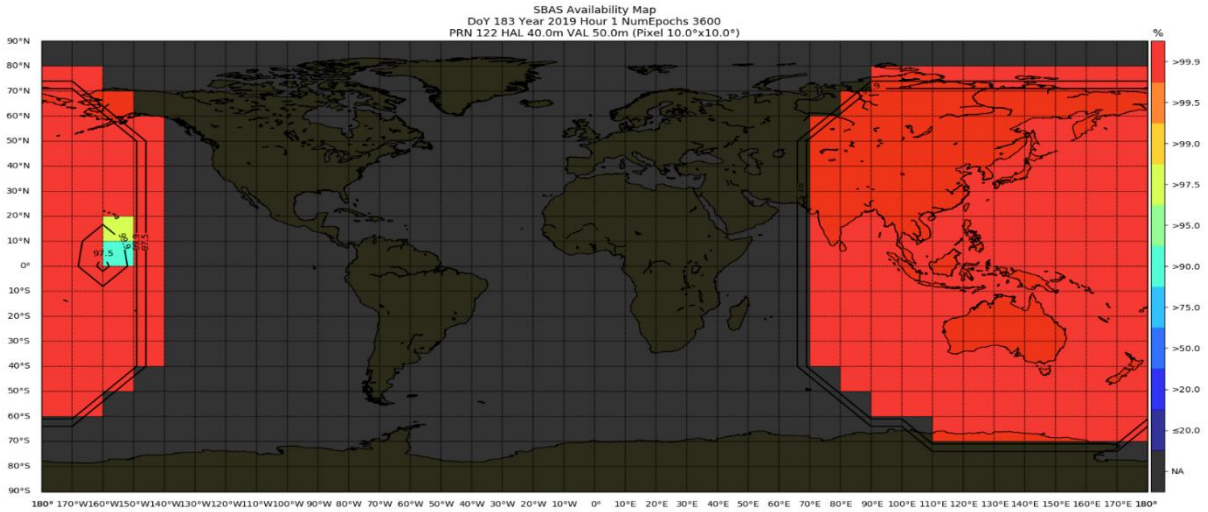

Figure 10-68: Examples of SBAS DFMC Availability maps worldwide continent for hour 0

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10.6 CONVERTERS

gLAB allows converting SBAS and RTCM files to other file formats such as RINEX, SBAS or PEGASUS, besides plain text files.

10.6.1 SBAS Converter

Usage examples to convert a RINEX-B 2.11 or EMS file (depending on the parameters) to other formats (RINEX-B 2.11, EMS or Pegasus):

- **Input format:**
  - **SBAS File (RINEX-B or EMS):** Selects the input SBAS messages file. Supported formats are RINEX-B 2.11 or EMS. SBAS message file may have data for multiple GEOs.
- **Output formats:**
  - **RINEX-B:** Write SBAS messages in RINEX-B format, see AD-04.
  - **EMS:** Write SBAS messages in EMS format, see AD-05.
  - **Pegasus:** Write SBAS messages in Pegasus format. Pegasus is the Eurocontrol propietary software for computing solution using SBAS and GBAS augmentation systems.

    The advantage of Pegasus format is that corrections are written in decimal format and in several columnar text files (according to message types), thus it is human readable.

    A slightly obsolete Pegasus ICD can be found at the following link, where the file format description is valid, but not the header name records. Pegasus format description can be found at AD-11.

    gLAB has two different options for PEGASUS output:

    - **Space as column delimiter:**

      Use a space (' ') instead of a semicolon (';') as a field separator. This enhances human readability.

      NOTE: Pegasus software will not be able to read the output files if this option is enabled.
    - **Align columns:**

      Make fields have always the same width, so the first character of each field is always in the same position in all the lines, instead of writing each field with the minimum size possible. This enhances human readability.

      NOTE: Pegasus software will not be able to read the output files if this option is enabled.

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10.6.1.1 Graphical User Interface

Step 1: Open the GUI, open the “Mode” menu in the top and click in “Converter”:

Figure 10-69: GUI Splash screen

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Step 2: Select an input SBAS file in RINEX-B 2.11 or EMS format. Set the name of the output file, and chose the output file format (RINEX-B 2.11, EMS or Pegasus):

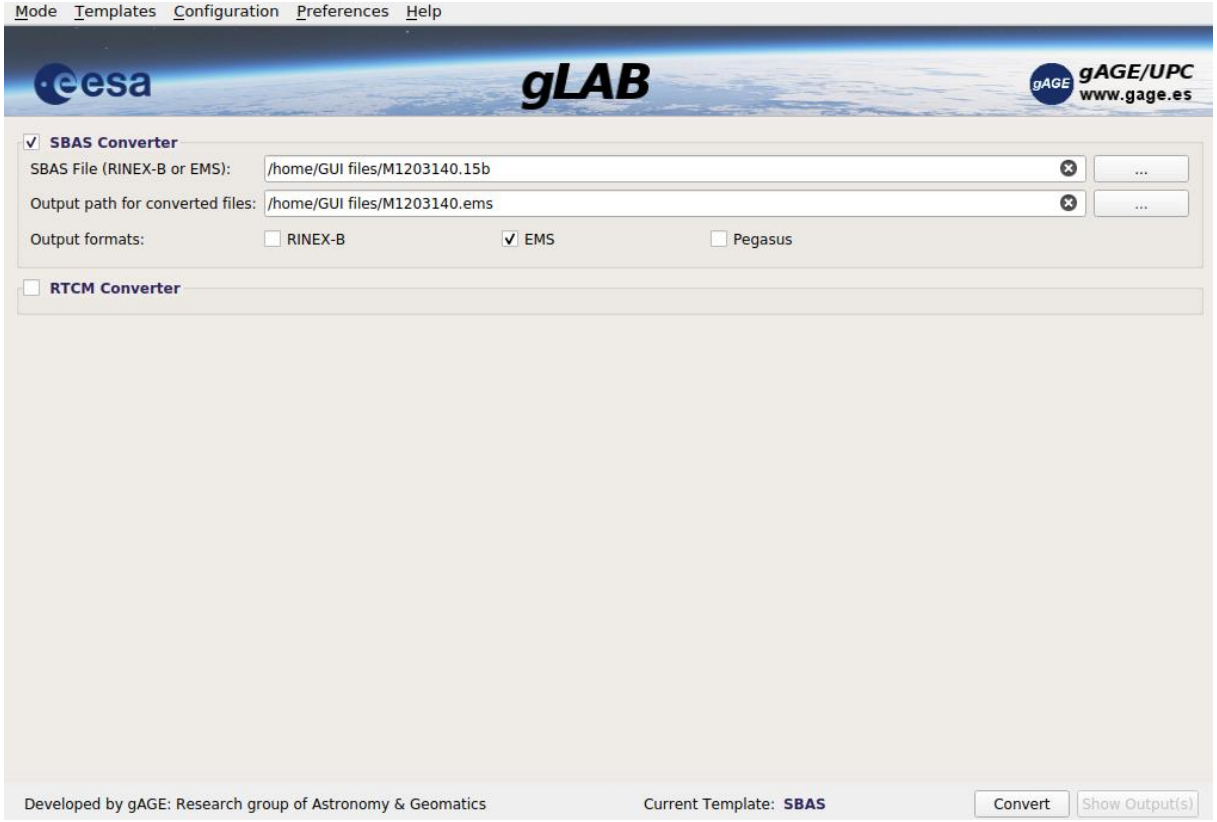

Figure 10-70: Converter section (SBAS)

Step 4: Click in the “Convert” button in the bottom part of the screen in order to process the data.

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10.6.1.2 Command Line

Convert RINEX-B file to EMS and Pegasus format and exit without processing:

Linux/Cygwin:

```
gLAB_linux -input:sbas M1202000.06b -output:ems -output:pegasus -onlyconvert
```

Windows:

```
gLAB.exe -input:sbas M1202000.06b -output:ems -output:pegasus -onlyconvert
```

Convert EMS file to RINEX-B and Pegasus format and exit without processing:

Linux/Cygwin:

```
gLAB_linux -input:sbas M1202000.ems -output:rinexb -output:pegasus -onlyconvert
```

Windows:

```
gLAB.exe -input:sbas M1202000.ems -output:rinexb -output:pegasus -onlyconvert
```

Convert RINEX-B file to Pegasus format (using space as column separator) and exit without processing:

Linux/Cygwin:

```
gLAB_linux -input:sbas M1202000.06b -output:pegasus -output:pegspace -onlyconvert
```

Windows:

```
gLAB.exe -input:sbas M1202000.06b -output:pegasus -output:pegspace -onlyconvert
```

Convert RINEX-B file to Pegasus format (aligning all columns with spaces), exit without processing and write files Pegasus files in current directory:

Linux/Cygwin:

```
gLAB_linux -input:sbas M1202000.06b -output:pegasus -output:pegfilealign -output:sbasdir "." -onlyconvert
```

Windows:

```
gLAB.exe -input:sbas M1202000.06b -output:pegasus -output:pegfilealign -output:sbasdir "." -onlyconvert
```

Convert RINEX-B file to Pegasus format (using space as column separator and aligning all columns with spaces) and exit without processing:

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Linux/Cygwin:

```
gLAB_linux -input:sbas M1202000.06b -output:pegasus -output:pegspace -output: pegfilealign -onlyconvert
```

Windows:

```
gLAB.exe -input:sbas M1202000.06b -output:pegasus -output:pegspace -output:pegfilealign -onlyconvert
```


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10.6.2 DGNSS Converter

gLAB allows converting RTCM files to RINEX or plain text files.

- **Input:** Selects the input reference station file. Supported formats are:
  - RTCM Auto: In this mode gLAB will auto detect if RTCM file is version 2.x or 3.x.
  - RTCM 2.x: RTCM version 2. In this mode, the initial date and hour of the data has to be provided, as this information is not in the binary file.
  - RTCM v3.x: RTCM version 3. In this mode, the initial date of the data has to be provided, as this information is not in the binary file.
- **Output:**
  - RINEX File: RINEX observation version can be 2.11 or 3.00.
  - Corrections File: Sets the ASCII Plain Text output file name for the corrections read from a RTCM v2.x file.
  - Antenna File: RTCM version 2. In this mode, the initial date and hour of the data has to be provided, as this information is not in the binary file.

The format for the Corrections and Antenna files are provided next:

10.6.2.1 Corrections file

In this file, the corrections to be applied to the satellites from the RTCM v2.x files are written. The fields are the following:

#	FIELD	DESCRIPTION	UNITS
1	GPS_week	GPS week of the RTCM message.	Weeks
2	SoW	Second of week of the RTCM message (the epoch is not given in the message except for the seconds of hour in Z-count value).	Seconds
3	MSG_number	Message type number (appears in the header of all messages).	-
4	Station_ID	Station ID of the RTCM v2.x message (appears in the header of all messages).	-
5	Z-count	Seconds of hour (appears in the header of all messages). As this is only the time reference in RTCM v2.x messages, the user must provide the inital date and hour to convert it to a normal date format.	Seconds
6	SV_health	Station health status (appears in the header of all messages). The values for the health status are a scale factor for the measurement UDRE, with the following values: • **0:** UDRE scale factor = 1. • **1:** UDRE scale factor = 0.75.	-

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#	FIELD	DESCRIPTION	UNITS
		• **2:** UDRE scale factor = 0.5. • **3:** UDRE scale factor = 0.3. • **4:** UDRE scale factor = 0.2. • **5:** UDRE scale factor = 0.1. • **6:** Reference station transmission not monitored (a UDRE scale factor = 1 is applied if corrections are used). • **7:** Reference station not working (a UDRE scale factor = 1 is applied if corrections are used).	
7	PRN	Satellite PRN to apply the corrections.	-
8	PRC	Pseudorange correction to be applied to the satellite.	m
9	RRC	Range- rate corrections to be applied to the satellite.	m
10	IOD	IOD (Issue of Data) of the navigation message used to compute the corrections. The user must also use the same IOD when applying the corrections.	-
11	UDRE	UDRE (User Differential Range Error). Provides a rough estimation of the error in the measurements. This estimation must be multiplied by the UDRE scale factor read in the message header. The possible values for the UDRE are: • 0: 1 metre. • 1: 4 metres. • 2: 8 metres. 3: 10 metres.	-

10.6.2.2 Antenna file

In this file, the reference antenna coordinates are written from the RTCM v2.x files. The fields are the following:

#	FIELD	DESCRIPTION	UNITS
1	Station_ID	Station ID of the RTCM v2.x message (appears in the header of all messages).	Weeks
2	SoW	Second of week of the RTCM message (the epoch is not given in the message except for the seconds of hour in Z-count value).	Seconds
3	X_coordinate	X coordinate component of the reference antenna.	m
4	Y_coordinate	Y coordinate component of the reference antenna.	m
5	Z_coordinate	Z coordinate component of the reference antenna.	m
6	MSG_number	Message type number (appears in the header of all messages). The possible values of message type number in this file are: • **MT03:** In message type 3, reference station antenna coordinates are in GPS computed coordinates (in ECEF -Earth Centered Earth Fixed-)	-

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#	FIELD	DESCRIPTION	UNITS
		• **MT24:** In message type 24, reference station antenna coordinates are referred to the Antenna Reference Point (ARP) in (in ECEF)	

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10.6.2.3 Graphical User Interface

Step 1: Open the GUI, open the “Mode” menu in the top and click in “Converter”:

Figure 10-71: GUI Splash screen

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Step 2: Select an input RTCM file in RTCM 2.x or 3.x format and set the date and time when the log of the RTCM began. Then set the name of the output RINEX, Correction and Antenna files (or leave the default one) in, and the RINEX 2.11 or 3.00 are supported:

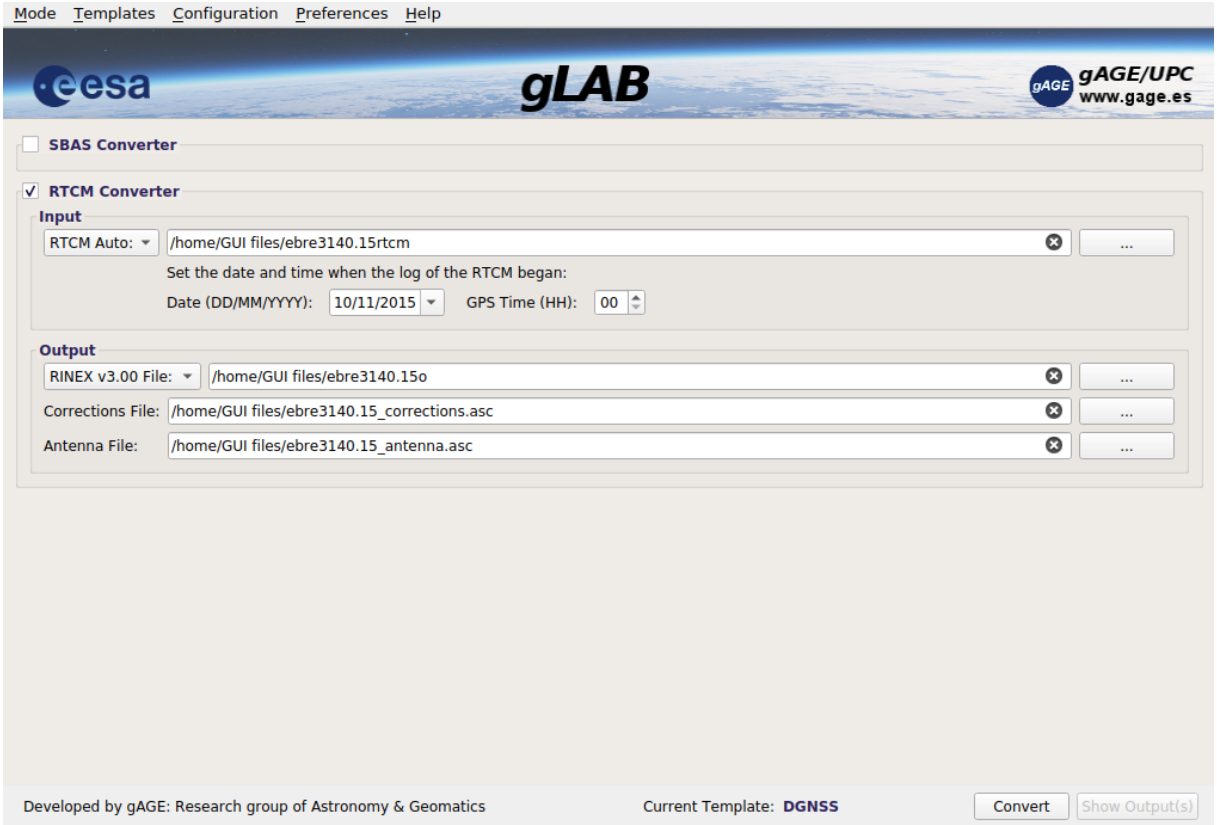

Figure 10-72: Converter section (DGNSS)

Step 4: Click in the “Convert” button in the bottom part of the screen in order to process the data.

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10.6.2.4 Command Line

Convert a RTCM v2.x to an ASCII Plain Text

Linux/Cygwin:

```
gLAB_linux -input:rtcm2 ebre3140.15rtcm2 -input:rtcm:initdate 20151110 -input:rtcm:inithour 08
```

Windows:

```
gLAB.exe -input:rtcm2 ebre3140.15rtcm2 -input:rtcm:initdate 20151110 -input:rtcm:inithour 08
```

Convert a RTCM v2.x to an ASCII Plain Text, setting the output name

Linux/Cygwin:

```
gLAB_linux -input:rtcm2 ebre3140.15rtcm2 -input:rtcm:initdate 20151110 -input:rtcm:inithour 08 -output:corrections ebre3140.15corr.asc -output:antenna ebre3140.15ant.asc
```

Windows:

```
gLAB.exe -input:rtcm2 ebre3140.15rtcm2 -input:rtcm:initdate 20151110 -input:rtcm:inithour 08 -output:corrections ebre3140.15corr.asc -output:antenna ebre3140.15ant.asc
```

Convert a RTCM v3.x to a RINEX file (default v3.00)

Linux/Cygwin:

```
gLAB_linux -input:rtcm3 ebre3140.15rtcm3 -input:rtcm:initdate 20151110
```

Windows:

```
gLAB.exe -input:rtcm3 ebre3140.15rtcm3 -input:rtcm:initdate 20151110
```

Convert a RTCM v3.x to a RINEX v2.11 file

Linux/Cygwin:

```
gLAB_linux -input:rtcm3 ebre3140.15rtcm3 -input:rtcm:initdate 20151110 -output:rinexversion 2
```

Windows:

```
gLAB.exe -input:rtcm3 ebre3140.15rtcm3 -input:rtcm:initdate 20151110 -output:rinexversion 2
```

Convert a RTCM v3.x to a RINEX v3.00 file, setting the output file name

Linux/Cygwin:

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```
  gLAB_linux -input:rtcm3 ebre3140.15rtcm3 -input:rtcm:initdate 20151110 -output:rinexversion 3 -output:rinex EBRE3140.15o
```

Windows:

```
     gLAB.exe -input:rtcm3 ebre3140.15rtcm3 -input:rtcm:initdate 20151110 -output:rinexversion 3 -output:rinex EBRE3140.15o
```

Convert an input RTCM binary file, gLAB will automatically detect the RTCM version

Linux/Cygwin:

```
    gLAB_linux -input:rtcm ebre3140.15rtcm -input:rtcm:initdate 20151110 -input:inithour 08
```

Windows:

```
     gLAB.exe  -input:rtcm  ebre3140.15rtcm  -input:rtcm:initdate  20151110 -output:rinexversion 3 -input:inithour 08
```


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11 FREQUENTLY ASKED QUESTIONS (FAQ)

11.1 KNOWN ISSUES

IN WINDOWS 11, WHY IS THE PROCESSING TIME MUCH SMALLER THAN THE REAL PROCESSING TIME?

This is a Windows 11 bug since Windows 11 version 22H2, which makes processing time reported by function 'GetProcessTimes' (the only Windows function that provides processing time separated by user and kernel times) be much smaller than the real wall time. The only workaround for this issue is to launch gLAB (without multi-threading) from command line with CPU affinity set to CPU 0 only, which can be done in the following way:

- Windows command line:

```
start /affinity 1 gLAB.exe <gLAB_parameters>
```

- Linux/Cygwin command line:

```
taskset -c 0 ./gLAB_linux <gLAB_parameters>
```

When using the Windows command line method, the standard output redirection (with the '>' symbol) will not work, so it is mandatory to use **'-output:file'** parameter to redirect the gLAB output.

Moreover, it possible to compute the total processing time (without separating user and kernel modes) in Windows Powershell, with the following command:

```
Measure-Command {gLAB.exe <gLAB_parameters>}
```

With this method, the gLAB output must be redirected to a file, otherwise it is not shown in the terminal. It can be done by either using the redirection sign ('>') inside the curly brackets ('}') or using parameter '**-output:file'**.

WHY THE GUI IN SOME NEWER VERSIONS OF LINUX STARTS WITH A VERTICAL SCROLLBAR?

It is not known why this graphical bug occurs, as there is enough space to fit the elements without a vertical scrollbar, but for some reason vertical space is added, which does not occur in older versions of Linux (where no vertical scrollbar appears at launch). It does not seem a

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Qt issue, as it is embedded in the executable (statically compiled), but an issue with system libraries. Note that Linux is forward compatible but not backward compatible, that is, a software compiled in a given Linux version will work in newer Linux versions but not in older ones, therefore it is necessary to compile the GUI in older versions of Linux (the GUI is compiled in Ubuntu 14.04).

If this bug occurs, just increase the vertical size of the application until the scrollbar disappears, as it is only a graphical bug which does not affect any functionality.

WHY THE GUI IN MAC IS NOT AESTHETICALLY AS GOOD AS IN WINDOWS AND LINUX?

This is mainly due to Qt libraries in Mac, which create a very different result with respect to Windows and Linux.
To set the GUI in Mac similar level as in Windows and Linux, a lot of manual tweaking would be necessary, which we have no time and interest to fix.
We only provide Mac for convenience for our users, and only commit to fix functional or visual (e.g. text not visible) breaking bugs in the Mac GUI.

11.2 GLAB GENERAL QUESTIONS

HOW TO CONTACT gAGE GROUP FOR SUPPORT WITH gLAB?

In case you need support for gLAB, you can contact us at glab.gage @ upc.edu.

Before writing the request, please check that your doubt is not answered in the FAQ below. Please provide as much information as possible. The easiest it is for us to understand your problem, the faster we can help you. If the issue is related to the output of gLAB, please attach all the files used and the configuration file (you can create one with the GUI in the menu 'Configuration->Save Configuration file') or the command line used. If files are large, you can use online services such as WeTransfer (https://wetransfer.com) to send the files. With this info, we will be able to reproduce the problem and provide a quicker answer.

HOW TO REFERENCE gLAB?

For referencing the gLAB tool, please cite the following paper:.

Ibáñez D., Rovira-García A., Sanz J., Juan JM., Gonzalez-Casado G., Jimenez-Baños D., López-Echazarreta C., Lapin I. The GNSS Laboratory Tool Suite (gLAB) updates: SBAS, DGNSS and Global Monitoring System. 9th ESA Workshop on Satellite Navigation Technologies (NAVITEC 2018), Noordwijk, The Netherlands. December 5 - 7, 2018. DOI: 10.1109/NAVITEC.2018.8642707.

WHICH ARE THE INPUT FILES SUPPORTED?

- **RINEX OBSERVATION FILE:** 2.10, 2.11, 3.00, 3.01, 3.02, 3.03, 3.04, 3.05

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- **RINEX NAVIGATION FILE:** 2.10, 2.11, 3.00, 3.01, 3.02, 3.03, 3.04, 3.05
- **SP3 FILE:** a, b, c, d
- **RINEX CLOCK FILE:** 2.00, 3.00, 3.01, 3.02, 3.04
- **ANTEX FILE:** 1.0, 1.1, 1.2, 1.3, 1.4
- **IONEX FILE:** 1.00, 1.1 (including support for multi-layer maps and irregular time spacing between samples)
- **CODE DCB FILE:** P1-C1 and P1-P2 DCB files (no version number on these files)
- **RINEX-B FILE:** 2.00, 2.10, 2.11
- **EMS FILE:** version for SBAS 1F messages and version for SBAS 1F and DFMC messages is supported (no version number in these files)
- **RTCM FILE:** 2.0, 2.1, 2.2, 2.3, 3.0, 3.1, 3.2, 3.3 (it only decodes GPS data for any of the RTCM versions)

Although RINEX 4 is not supported, RINEX 4 observation file does not change the file format, so it should work fine.

The unofficial MGEX RINEX navigation version '4.00' with GPS CNAV data is supported, but has different format as the official RINEX 4.

WHICH ARE THE OPERATIVE SYSTEMS AND ARCHITECTURES SUPPORTED?

- **WINDOWS (x86):** The GUI, core and graphical tool can run on x86, but must be compiled by the user.
- **WINDOWS (x86_64):** 7, 8, 8.1, 10, 11
- **LINUX (x86):** The GUI, core and graphical tool can run on x86, but must be compiled by the user.
- **LINUX (x86_64, ARMv7, ARM64):** Ubuntu 16.04 and above. Compatible with other Linux distributions.
- **MAC (x86_64):** OS X 10.11 (El Capitan) and above.

Note that this list corresponds to the whole gLAB software (core, GUI and graph tool).

The core uses standard C99 libraries, therefore any platform and operative system with a C99 compiler should be able to run the core.

HOW TO RUN GLAB WITH A CONFIGURATION FILE (GENERATED WITH THE GUI OR MANUALLY)?

To run gLAB with a configuration file, use the following command:

```
gLAB.exe -input:cfg configuration_file
```

Note that using a configuration file does not prevent to provide additional parameters in command line. For instance, the configuration file can be used to set the processing parameters and then in command line provide the input files. For instance:

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```
gLAB.exe -input:cfg configuration_file -input:obs rinex_file -input:nav nav_file
```

WHAT CONSTELLATIONS CAN AND CANNOT PROCESS gLAB IN VERSION 6.0.0 (FIRST MULTICONSTELLATION VERSION)?

- **SPP mode:** Process all constellations.
- **PPP mode:** Process all constellations.
- **SBAS 1F mode:** Only GPS SBAS processing (same as previous versions).
- **SBAS DFMC mode:** GPS and Galileo as in current SBAS DFMC version (although it should work with other constellations if the message structure is the same).
- **DGNSS mode:** Only GPS DGNSS processing (same as previous versions, including RTCM decoding), although internal architecture for DGNSS processing has been prepared for multi-constellation.
- **Add User Error to RINEX mode:** All constellations supported.

WHAT ARE THE MEASUREMENT SELECTION MODES IN gLAB?

In SPP and PPP modes (SBAS and DGNSS have fixed measurements), gLAB internally works in three modes for measurement selection:

- **Automatic mode:** gLAB automatically selects which measurements (or combinations) and frequencies to use based on the processing mode (SPP, PPP).
  The frequencies and measurements selected are based on the frequency and measurement priority lists, which can be modified by the user a per satellite basis. In SPP mode, automatic mode will select single frequency measurements, while in PPP mode it will select dual frequency measurements. The user can force gLAB to autoselect single frequency, dual frequency or graphical combination measurements independently of the processing mode using parameter '**-filter:combtype'**.
  Moreover, If an ANTEX file is provided, gLAB will autoremove all measurements not available on each satellite (e.g. L5 for GPS).
  Automatic mode is triggered when the user does not set any measurement to be used in the navigation filter or it sets some measurements for some satellites and for the rest it is explicitly stated to 'auto' (e.g. **-filter:select G0-code-1 E0-auto**). In the latter case, satellites without any information in the parameter will not be used.
- **Semi-automatic mode:** This mode is triggered when the user sets a measurement type (or combination) to use (and its frequency) to be used in the filter, but not the measurement names (eg. G0-PC12). In this case, gLAB selects the measurement to use according to the measurement priority list (which can be modified by the user in a per satellite basis) and the available measurements in the RINEX observation file. Furthermore, the user can set satellite measurements 'auto' (as in previous case) for automatic selection.
- **Manual mode:** This mode is triggered when the user sets the measurement types and measurement names (e.g. G0-PC12-C1C-C2P) to be used in the navigation filter.

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Note that semi-automatic and manual mode can both co-exist at the same time if user sets for the navigation filter measurement types (without the measurement names) and also measurement types with measurement names.

In semi-automatic and manual modes, the measurement selection will be done after reading the first epoch of data, as satellites may not have all measurements listed in the header. The first epoch of data is read after the INFO messages with gLAB configuration printed at the start of the output file. Therefore, to check the measurements selected by gLAB, the user must check any of the MODEL, PREFIT, POSTFIT or EPOCHSAT messages.

The frequency and measurement priority lists are available in the menu 'Set GNSS Frequencies and Measurements Order' in the 'Filter' tab in the GUI or in the description of parameters '-pre:freqorder' and '-pre:measorder' in the command line help.

CAN gLAB AUTOMATICALLY SELECT SMOOTHED MEASUREMENTS?

Yes, but the user needs to explicitly provide parameter '**-pre:smoothauto**' in order to use smoothed measurements (except in SBAS and DGNSS modes, which is the default). The default smoothing time is 100 epochs if none set (it can be changed in the GUI or with parameter '**-pre:smooth'**).

If user provides both parameters '**-pre:smoothauto**' and '**-pre:smoothmeas**', the former will be ignored to avoid interfering with user selection of smoothed measurements.

IS IT NECESSARY TO SELECT MEASUREMENTS FOR CYCLE-SLIP DETECTORS WHEN MEASUREMENTS FOR THE FILTER ARE MANUALLY SET?

No, gLAB will check that all carrier phases used in the filter are processed by all enabled cycle-slip detectors. If any carrier phase measurement is missing in any cycle-slip detector, gLAB will automatically add it to each cycle-slip detector without it. Note that each cycle-slip detector can run multiple iterations with different measurements, so it will not remove any other iteration already set.

It is possible to disable the auto measurement filling in the cycle-slip detectors by providing parameter '**-pre:cs:noautofill'**.

CAN gLAB AUTO DETECT THE MEASUREMENTS AVAILABLE IN EACH SATELLITE?

Yes, but only if an ANTEX is provided. From the ANTEX, it detects the satellite block, which determines the available frequencies and measurements for a given satellite. In PPP mode it will use the provided ANTEX file. If no ANTEX is provided or it is not PPP mode, the option **'-input:antsatblock'** can be used to provide an ANTEX for this purpose.

An example of use case of this feature: the user wants process with a iono-free combination with L1/L5 for all GPS with L5, otherwise use L1/L2 instead. To accomplish this, the only additional command line parameter required is to change the frequency priority list to 1-5-2 (or any order where frequency 5 is in first or second position) with parameter **'-pre:freqorder G0-152'**.

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CAN gLAB PROCESS MULTIPLES DAYS IN A SINGLE RUN IN FORWARD AND BACKWARDS MODES?

Yes, it can process multiple days in a row (without reset between days) as long as the input files (observation, navigation or precise files) are concatenated in a single file.

- For forward processing mode only, all the files (observation, navigation, precise files, SBAS files) can all be concatenated with or without headers.
    - For the special case of IONEX file, or either it is concatenated with the header, or with only the first header but modifying it to include the total number of maps after concatenating.
    - CODE DCB GPS P1-C1 and GPS P1-P2 files do not support concatenation, but this should be not much of a problem, as P1-C1 DCB files are monthly files, while P1-P2 DCB can be read from navigation files instead.

- For backward processing mode, it is compulsory to concatenate all files without headers, as input cannot be read backwards. There are a few exceptions:
    - The RINEX observation file is the only file that supports backwards reading (with or without headers). The only limitation is that when reading backwards, it will skip all headers found, as when reading backwards the headers found refer to the data already read. Therefore, it is compulsory that the observation file always keeps the same order and number of measurements (only for backwards mode).
    - If using SP3 or CLK files and the number of concatenated files is equal or below 3, it is not necessary to remove headers as gLAB reads up to three days of SP3 and CLK data at a time.
    - If using navigation files and the number of concatenated files is equal or below 2, it is not necessary to remove headers as gLAB reads up to two days of navigation data at a time.
- SBAS and DGNSS modes do not support backwards processing mode.

For concatenating files, see question **'HOW TO CONCATENATE FILES?'** below.

CAN MEAS MESSAGE BE USED AS A CONVERTER FROM RINEX OBSERVATION TO A COLUMNAR TEXT FILE?

Yes, since version v6, MEAS message can print all measurements in RINEX observation file (pseudorange, carrier phase, SNR, Doppler and LLI flag). Moreover, for the case of the SNR, if the SNR as a measurement is provided, it will print the measurement. Otherwise, it will print the SNR read as a flag (converted to a number).

Also, since version 6 the user can select which measurements to print (and in which order) in a per satellite basis, independently of the RINEX observation contents.

Moreover, the user can select which satellites to print. This is done by selecting the satellites with option '**-pre:sat**'.

Last but not least, since version 6 the MEAS message also includes the arc number and length, the block type and the SVN, therefore the MEAS message contains information from the RINEX observation file, ANTEX file (if provided) and the cycle-slips.

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IS IT POSSIBLE TO PRINT CLOCK ESTIMATES IN NANOSECONDS?

Yes, by providing the parameter '-print:clkns'. When this parameter is provided, the receiver clock offset in FILTER and OUTPUT messages will be printed in nanoseconds instead of metres, and the inter-sytem clock bias in FILTER and MODEL messages will also be printed in nanoseconds.

Furthermore, in the INFO messages at the beginning, the Q and P0 values for the receiver clock and inter-system clock bias in the filter will also be printed in nanoseconds. Note that there are also specific parameters for providing these values in nanoseconds, instead of metres.

HOW TO CONCATENATE FILES?

As gLAB accepts multiple headers in data files, we just need to concatenate the files directly. The only requirement is to do it chronological order.

- Windows command line (the user can concatenate as many files as wanted at once):

```
copy /b file1+file2+file3 concatenated_file
```

- Linux/Cygwin command line (the user can concatenate as many files as wanted at once):

```
cat file1 file2 file3 > concatenated_file
```

Moreover, for the case of RINEX navigation files, it is convenient to concatenate files without the header (except for the first file) in SBAS modes, as in this case gLAB will read all the three day as a single day, which is useful to avoid missing packages at the beginning or end of day (specially for SBAS modes). It can be done with the following command in Linux or Cygwin terminal (valid for RINEX navigation v2 and v3):

```
cat file2 file3 | sed -n '/[A-Z#][ ]\{0,\}$/!p' | sed '/WAVELENGTH FACT/d' | sed '/GLONASS SLOT/d' | cat file1 - > concatenated_brc_file_with_first_file_header
```

With the previous command, the remaining header will be from the first file. To keep the header of the second file, just swap file1 with file2. Otherwise, if only the 'IONOSPHERIC CORR' header lines are need for the Klobuchar, Nequick or BeiDou Klobuchar models, gLAB can read them from a different file than the source file of navigation messages (parameter '-input:nav') by providing parameter '-input:klb', '-input:neq' or '-input:bds' for each model respectively.

HOW TO MERGE MULTIPLE SBAS DATA FILES (RINEX-B OR EMS) FROM DIFFERENT GEOS TO CREATE A SINGLE MULTI-GEO FILE?

In order for gLAB to process SBAS and be able to switch GEOs, it needs to have data from all the GEOs to be used in the same file, with data ordered in chronological order, but usually SBAS messages file are given in a file per each GEO. To join the files, follow the next steps:

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- Convert file from RINEX-B to EMS format (if file is in EMS format, the user can skip this step). Use gLAB to convert from RINEX-B to EMS, as both files do not have the same timestamp reference.

  ```
  gLAB.exe -input:sbas rinexbfile -output:ems -onlyconvert -output:dir conversionfolder
  ```

  Parameter **'-output:dir'** is optional and specifies and output directory (which will be created by gLAB if it doesn't exist). If not specified or directory is '.', output file will be written in current directory.
  Repeat the process for each file to be converted.

- Concatenate files and sort them by timestamp. This command must be executed in a Linux or Cygwin terminal. In Windows, it is necessary to downloaded precompiled version of UNIX 'cat' and 'sort' programs to execute the same command as in Linux/Cygwin. The command is (the user can execute the command with as many files at a time as necessary):

  ```
  cat emsfile1 emsfile2 emsfile |sort -n -k2 -k3 -k4 -k5 -k6 -k7 -k1 > multigeo_ems_file
  ```

- (Optional) Convert the merged EMS file back to RINEX-B:

  ```
  gLAB.exe -input:sbas multigeo_ems_file -output:rinexb -onlyconvert
  ```

The user can later concatenate merged files from different days to create a multi-GEO and multi-day SBAS file.

HOW TO PROCESS A FULL DAY OF DATA WITHOUT CONVERGENCE TIME?

Convergence time occurs in both PPP (for cycle-slip detection and the carrier phase ambiguities convergence) and SBAS modes (smoothing and SBAS message buffering).

To process a full day without convergence time, it is necessary to concatenate two days (see question **'HOW TO CONCATENATE FILES?'**), the first day for the convergence and the second day with the results of interest. In the case of SBAS (or PPP for only the cycle-slip convergence), a 15 minute convergence suffices, so the user can either concatenate 15 minutes of data (not explained in this FAQ) or set the start time in gLAB (with parameter **'-pre:starttime'**) to 23:45 of the first day and the summary start time (with parameter **'-summary:starttime'**) to 00:00 of the second day.

WHY GLAB NEEDS TO CONCATENATE FILES INSTEAD OF READING MULTIPLE FILES TO PROCESS MULTIPLE DAYS?

This is a usual question from professional users, where tools are designed with very specific purposes and requirements. Indeed, reading multiple files for multiple days is convenient as the user only needs to provide the input files, but comes with the disadvantage that the user

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must also provide to the tool a folder when to find the files and a strict file convention so the tool reads only the files of interest and in the correct order. This rigidity is a problem for both educational and research users. For the former usage, only having to provide an input file makes new gLAB users first contact much easier (specially with the GUI). For the latter usage, researcher perform many tests by modifying existing files, and being able to use any filename (as gLAB does not care about filenames and extensions) is a crucial feature. As gLAB was first designed with these two usages in mind, this was the approach chosen and it will not change.

WHAT ARE THE 'DUAL FREQUENCY DCB'?

To explain what are 'dual frequency DCBs', first it is need to explain what is a DCB (Differential Code Bias). Broadcast navigation messages or precise products provide orbits and clock products. These are computed using a reference measurement or a combination (usually a ionospheric-free). For instance, broadcast BeiDou products that are referred to the B3 signal). whereas GPS products are referred to the iono-free combination built with measurements C1P and C2P.

Therefore, the satellite clock correction is referred to this combination. In the case of using any single frequency measurement or any iono-free combination with different measurements (even if they are different attributes, like C5I or C5Q), it is necessary an additional term to convert the measurement used (in terms of clock correction only) to the reference measurement used by the orbit and clock products used. This term is called the DCB.

When GPS and GLONASS where available with only two frequencies and few measurements, the DCB provided in the navigation message were to convert from a single frequency measurement (C1P or C2P) to the reference iono-free combination with C1P and C2P. For this reason, gLAB applied this DCB in the modelling of the measurement prior to performing any measurement combination (if necessary). Therefore, if a iono-free combination was computed later in the gLAB processing, the DCBs would cancel if they had been applied.

With the current paradigm of multiple frequencies and measurements, there are several different measurements and iono-free combinations available. However, the measurements used as a reference in the orbit and clock products have not changed. Therefore, it is needed additional DCBs or provide additional correction terms to the existing DCBs (which will also be DCBs). The latter approach has been used, and these terms are named ISC (Inter Signal Correction), and can be used to convert single frequency measurements or iono-free combinations to the reference clock. In the case of iono-free combinations, according to the ICDs, they have to be applied after computing the iono-free combination, not before, with a specific formula which may use multiple DCBs. For instance, the ICD for GPS uses iono-free combination built with frequencies F1 and F5 uses two DCBs: the TGD and an ISC DCB). The specific formula to be applied in such iono-free combinations is what gLAB defines as 'dual frequency DCBs'.

WHAT IS THE 'BEIDOU SINGLE FREQUENCY PRECISE ORBITS DCB MODEL' DCB TERM SHOWN IN THE INFO MESSAGES?

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As commented in the previous question "**WHAT ARE THE 'DUAL FREQUENCY DCB'?",** DCBs for BeiDou (for BDS-2 signals) are a special case, because the satellite clock broadcast in the navigation message is referred to the B3 measurement, instead to an iono-free combination. Then, when using single frequency measurement with precise orbits and clocks (e.g. IGS), it is necessary to apply a DCB, because the precise products are referred to the iono-free combination of signals B1-B2b, whilst the DCB provided in the navigation message is referred to the B3 measurement.

Therefore, when using precise products, it is necessary to add a correction factor instead of applying directly the DCB from the navigation message. The correction factor is computed as follows:

$$Correction_factor = \frac{TGD26 \cdot f_2^2 - TGD76 \cdot f_7^2}{f_2^2 - f_7^2}$$

Where:

- **TGD26:** DCB term (in seconds) provided in D1 or D2 broadcast navigation messages which corrects signal B1 (frequency 2) to B3 (frequency 6)
- **TGD76:** DCB term (in seconds) provided in D1 or D2 broadcast navigation messages which corrects signal B2b (frequency 7) to B3 (frequency 6)
- **f_2:** Frequency (in hertz) of signal B1
- **f_7:** Frequency (in hertz) of signal B2b

Once correction factor has been computed, the DCB to be applied to a single frequency measurement with precise orbits is computed as follows:

$$DCB_{to_{apply}} = TGDX6 - Correction_factor$$

Where:

- **TGDX6:** DCB term (in seconds) in any navigation message which corrects a signal (from frequency X) to B3 (frequency 6)

Note that both terms 'Correction_factor' and 'DCB_to_apply' are in seconds, as the TGD applied were in seconds.

WHY DOES GLAB SOMETIMES REPORT THAT GPS C1P MEASUREMENT IS AVAILABLE (AND MAY ALSO BE USED IN THE FILTER) WHEN THE MEASUREMENT IS NOT IN THE RINEX OBSERVATION FILE?

Receivers tracking the legacy GPS signals (L1 and L2), can be classified in three different types:

- **Type 1:** Cross-correlated receiver. This receiver type provides C1C and C2P measurement (but not C1P). To obtain C1P and a consistent C2P measurement, the P1-C1 DCB (or ISC L1C/A) must be applied to C1C (to obtain C1P) and to C2P (to obtain a consisten C2P measurement).

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- **Type 2:** No P1 (C1P). This receiver provides C1C and C2P, but does not provide C1P. To obtain C1P, the P1-C1 DCB (or ISC L1C/A) must be applied to obtain C1P.

- **Type 3:** Consistent measurements. This receiver provides C1C, C1P and C2P and no correction is needed.

When receiver type is unknown, type 3 is assumed (no correction applied). When receiver is set to type 1 or 2 (either with parameter '**-pre:setrectype**' or by providing a GPS Receiver file with option '**-input:rec**'), gLAB knows that C1P will never be provided, so internally creates the GPS C1P measurement by copying the values read from C1C (as if C1P had been provided in the RINEX observation file).

Later, in the modelling step, the P1-C1 DCB or the ISC L1C/A (in this order of preference) will be applied if they are available. The logic for this behaviour is to allow the user to be able to select between C1C (the provided measurement) and C1P (the resulting measurement of adding C1C plus the DCB).

WHEN COMPUTING THE NAVIGATION SOLUTION WITH A MOVING RECEIVER, WHY DOES THE POSITIONING ERROR IS VERY HIGH OR KEEPS INCREASING OVER TIME?

gLAB by default has the a priori receiver set to 'RINEX', which means that it will always use the same a priori position read from the RINEX observation header for both modelling and computing the positioning error. This implicitly means that the receiver is always in the same position (static).

To compute the navigation solution with moving receiver, the user will need to set the a priori position to **'calculate'**. If the user has a text or SP3 file with the receiver trajectory to compare the solution, it can be provided with parameter **'-input:refpos'** (this option will automatically set the a priori receiver position to **'calculateRef'**.

Also, in PPP mode, make sure to select 'kinematic' mode in the filter (in command line, with parameter '**-filter:nav kinematic**').

WHY THE POSITIONING ERROR COMPONENTS IN THE OUTPUT MESSAGE ARE ZERO WHEN SETTING THE A PRIORI RECEIVER POSITION TO 'CALCULATE'?

In order to compute the position error, gLAB needs a reference position. By default, gLAB uses the a priori position, but when the user sets the a priori receiver position to 'calculate', the user make gLAB calculate it (that is it can not trust the position of the RINEX observation because it is not good enough or because the receiver is moving). If the receiver is moving and the user has a text or SP3 file with the trajectory, the user can provide it to gLAB (with option **'-input:refpos'**) to use a reference position only for computing the positioning error.

THE NAVIGATION SOLUTION HAS A VERY HIGH ERROR, EITHER FROM THE BEGINNING OR FROM A PARTICULAR EPOCH. HOW CAN I IMPROVE IT?

If you are computing the navigation solution with a moving receiver, check first question **'WHEN COMPUTING THE NAVIGATION SOLUTION WITH A MOVING RECEIVER, WHY DOES**

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THE POSITIONING ERROR IS VERY HIGH OR KEEPS INCREASING OVER TIME?'. Otherwise, try the following steps:

- Enable minimum SNR filtering (only enabled by default in SBAS and DGNSS modes). By default the threshold is 33 dBHz, but this value can be changed in a per satellite a per measurement basis. For instance, for GPS L2P measurement, which transmits 3dB less power,the threshold could be set to 30dBHz.
- Enable DOP filters. By default, only GDOP is enabled in PPP and DGNSS modes. For instance, the user can enable GDOP to the default threshold of 30 or reduce it.
- If only code measurements are used, enable cycle-slip detectors and manually set the corresponding carrier phase measurements to the codes used in the filter (if they are not manually set, gLAB will not automatically select any carrier phase as no carrier phase is used in the filter).
- Enable the prefit outlier detector with option '**-filter:prefitouliers:median 30'** (by default is enabled). This should remove most of the incorrect measuremerents (outliers) that degrade the solution. The value '30' is the usual threshold of 30 metres.

CAN THE NAVIGATION SOLUTION BE IMPROVED USING RANDOM WALK?

Random walk will not necessarily improve the navigation solution, as it will only make a difference if the uncertainty between epochs (Q) is very small (i.e. a receiver moving slowly) and the value Q is well adjusted. In gLAB, it is fixed for the whole processing, but in order to exploit random walk it would be necessary to adjust the Q each epoch according to the previous epoch receiver speed and acceleration plus a margin of error (which gLAB does not perform). Even if this adjusted is performed, it would still not make a difference if the receiver does not move slowly or the Q value is below or at the same level as the error in your data. For instance, if your receiver moves one meter between epochs but you are processing in SPP, where meter error measurements are used (i.e. pseudoranges), then there will be no differences as only noise is being correlated between epochs.

Note also that random walk will be exactly as a static positioning if Q is set to zero, and equivalent to a kinematic positioning if the Q has a high value. Therefore, it makes no sense to use random walk and use high values of Q. In that case, just use default kinematic processing.

WHY SOMETIMES THE ELEVATION AND AZIMUTH VALUES SUDDENLY CHANGE TO ZERO?

This occurs when gLAB discards a satellite for the navigation solution for a reason prior to be able to compute the azimuth and elevation values, which are the following: missing measurements, missing navigation message or missing precise orbits. When any of these cases occur, the elevation and azimuth will be set to zero, as they could not be computed.

IN SPP or PPP, WHY I AM GETTING OR ERROR OR BIAS AROUND METRE LEVEL WITH CERTAIN SIGNALS OR FREQUENCY COMBINATIONS?

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Broadcast orbits or precise orbits are referred to a reference signal or combination (depends on the constellation). If the measurements used in the filter do not match the reference signal or combination, an error or bias can occur. These errors can be compensated with DCBs, but on the one hand, there not DCBs for all possible combinations, and on the other hand, gLAB (in version 6) cannot read all navigation messages or the SINEX BIAS file.

For this case, the user can either use another measurement matching the reference signal or has a DCB available in gLAB, or manually provide the DCB correction through the 'User Added Error' option.

IN STATIC PPP, WHY DOES IT APPEAR A BIAS (SPECIALLY IN THE UP COMPONENT) IN THE SOLUTION WHEN USING GPS L5 OR ANY CONSTELLATION DIFFERENT THAN GPS OR GLONASS?

Prior to ANTEX file "igs14_2112.atx", it did not contain receiver antenna phase centre data for frequency L5 of GPS and for any frequency for Galileo, GEO, BeiDou, QZSS or IRNSS.

Users can set these values manually with option '**-model:recphasecenter**' independently if the ANTEX provides them or not. If the user wants to add the receiver antenna phase centre correction for a iono-free combination, it will have to set the same correction values for the two frequencies used.

IS THERE ANY DIFFERENCE BETWEEN COMPUTING THE SOLUTION FORWARDS AND BACKWARDS?

There are a few sections that can make the solution from a same epoch slightly differ if calculated in forward direction or in backwards direction. They are the following:

- **The 'N-consecutive' sample filter:** This option is enabled with '**-pre:cs:ncon**', and is enabled by default. It unselects the first two samples after a data gap. This blind filter is to avoid selecting the first two samples after a data gap, which usually are not good. It also removes satellites which may appear one or two epochs with bad measurements and then disappear and then appear again. This errors are common for high rate files (<15 sec), therefore this option will auto-disable if the input observation file has a sampling rate smaller than 15 seconds. The problem is that in backwards mode, it will discard the samples prior to the data gap, not after (as the processing in the opposite direction), therefore the bad samples are processed and the good ones prior to the data gap are discarded.
- **Cycle-slips:** For cycle-slip detection, a buffer of samples are filled (and during the time the buffer is filling, the satellite is discarded). In backwards mode, the epochs discarded due to the buffer when a cycle-slip is detected are the ones prior to the cycle-slip, instead of the ones after the cycle-slip. Therefore, the samples that enter in the filter in one direction or the other will not be the same.
- **Satellite eclipse:** gLAB discards satellites under eclipse and 30 minutes after the eclipse finished. This is because during an eclipse the satellite may have more problems to orientate itself due to the lack of sun. The error is very slow, so this option can be disabled quite safely. In backwards mode, it does not apply any safe guard time after or before the eclipse. To be consistent, it should also apply the safe guard time after the eclipse, but the fix is very complicated to implement and it would barely make any difference.

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- **Satellite wind-up:** The wind-up is an accumulative effect which resets in each cycle-slip. To model this value, it is used the previous computed value. When going backwards, it keeps accumulating (including from forward direction, until a cycle-slip occurs), but in the opposite direction.

IN PPP, WHY NO GLONASS SATELLITES ARE SELECTED BY DEFAULT ON MANY CASES?

GLONASS signals G1 and G2 use FDMA (Frequency Division Multiple Access), which means that instead of using a different PRN (Pseudo-Random Noise) code for each satellite, it uses a different frequency for each satellite. Each frequency is computed as a central frequency plus a frequency offset. The frequency offset with a frequency factors ('k') that are provided in the navigation message or in the header of RINEX observation files (since version 3.01). As these frequency factors are needed, if they are not in the header of the RINEX observation file, the user must provide them with a GLONASS navigation file, using parameter '**-input:navglo**'.

IN PPP, WHY DURING THE LAST 15 MINUTES THERE IS NO SOLUTION?

Precise products files (SP3 and CLK files), provide data for a single day. For instance, the data rate is 15 minutes, the last sample provided will be at at epoch 23h 45 minutes (this occurs for both SP3 and CLK), therefore the last 15 minutes there is no data for orbit or clock interpolation, as gLAB will not extrapolate orbits and clocks. To fix this, the user must concatenate data for the next day in both orbit and clock files (see question **'HOW TO CONCATENATE FILES?'** above for more info on concatenating files).

IN PPP, IS IT USEFUL TO CONCATENATE PRECISE ORBIT AND CLOCKS FILES WITH PREVIOUS AND NEXT DAY DATA EVEN IF USER PROCESSES A SINGLE DAY?

Yes, it is highly recommended to concatenate orbit and clock files with the previous and next day, as in order to get the best interpolation results it is needed to have equally distanced samples around the centre, which does not occur at the beginning and at the end of the day when the precise orbit and clocks files only contain data for a single day.

IN PPP, WHY DOES IT TAKE 7 SAMPLES TO START COMPUTING THE NAVIGATION SOLUTION?

In PPP, the Melbourne-Wubbena and Geometry Free cycle slip detector need to fill their data buffers before they can check if a cycle-slip occurred.

By default, the buffer size is 7 samples, but it can be increased or decreased with parameter **'-pre:cs:mw:samples'** for Melbourne-Wubbena detector and **'-pre:cs:li:samples'** for Geometry Free detector.

IN SPP OR AFTER A DATA GAP (IN ANY MODE) WITH HIGH RATE FILES (<15s), WHY DOES IT TAKE 3 SAMPLES UNTIL THE SATELLITE IS USED AGAIN?

The N-consecutive (or N-con) data filter will force to discard the next N-1 samples after a data gap (by default N=3), so the satellite is not used again until N consecutive samples are read.

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This is done because at high rate files, usually the first one or two samples after a data gap are very low quality, adding a considerable error to the navigation solution. There are also cases where a satellite appears one or two samples, then disappears, then reappears again during a short time. When this occurs, the samples are really bad. In these cases, the N-consecutive filter removes all this low quality samples even if there is no cycle-slip detector (as it is by default in SPP). As these cases only occur in high rate files, the N-consecutive will auto disable if the RINEX observation file rate is larger than 15 seconds.

IN SPP OR PPP, IS IT POSSIBLE TO USE ANY MEASUREMENT OR COMBINATION?

In SPP or PPP, the user can use multiple measurement types (e.g C2W, C2L, C2S, C5I, C5Q, etc.) or frequency combinations (e.g 12, 15, 25, etc.). gLAB is able to handle any of these combinations and in general they are all valid to compute the navigation solution, but there is a catch: if the measurements used to compute the navigation solution are not the same as the ones used to compute the orbit and clock data used, a bias will appear (e.g. for GPS, for both broadcast and IGS precise products the measurements used are the iono-free combination with frequencies 1,2 and measurements C1W,C2W,L1W,L2W. This DCBs may be provided in the navigation message (for instance the GPS L5I5 ISC) or not. In PPP this DCB can be corrected or else it may be partially or totally integrated into the carrier phase ambiguity (only if the DCB is constant during an arc), as gLAB estimates carrier phase ambiguities as real values.

IN SBAS MODE, WHY THERE IS NO SOLUTION AT THE BEGINNING AND AT THE END OF FILE?

SBAS processing requires to use navigation messages with the IODE indicated in the SBAS messages. Usually, the messages used by SBAS at the beginning of the day are stored at the end of the navigation file from previous day, and the messages at the end are stored at the beginning of the navigation file of the next day. Therefore, it is necessary to add to the current day navigation file messages from the last two hours of the previous day and of the first two hours of the previous day. Another option instead of manually adding the two hours of data from previous and the next day is to concatenate the navigation files. In order to work correctly, the concatenation must be done without headers in between. This is because the current version only stores up to two days of data in memory, so when it detects a third header, it will not read any more data until the epoch of the observation day changes. This behaviour may be changed in the future (so as it matches the behaviour with precise orbits and clocks, which store in memory three days at a time).

To make sure that reason for not having navigation solution in SBAS is due to the missing navigation messages, execute gLAB with the SBASUNSEL message (enabled in SBAS 1F, with option **'-print:sbasunsel'**) or with SBASDFMCUNSEL message enabled (in SBAS DFMC, with option **'-print:sbasdfmcunsel'**) and the text 'No broadcast block with IOD <iode>' should appear.

IN SBAS AND DGNSS MODES, WHY IT TAKES 360 SECONDS TO COMPUTE THE FIRST NAVIGATION SOLUTION?

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In SBAS (1F and DFMC), it is compulsory to wait 360 seconds in order for the smoothing to converge.

In DGNSS, it is used to wait for the smoothing to converge in the reference station, although there is not any formal requirement for this.

It is possible change or disable this waiting time with parameter **'-pre:smoothmin'**.

IN SBAS AND DGNSS MODES, WHY THERE IS NO NAVIGATION SOLUTION WHEN PROCESSING WITH 30 SECONDS FILES?

The default options for SBAS and DGNSS is to use a data gap of 10 seconds. With a 30 seconds file, a data gap will be detected in each epoch, as more than 10 seconds have passed between epoch. To avoid this problem, set the data gap size to 40 seconds in the GUI or with parameter '**-pre:cs:datagap 40'**.

Moreover, the default smoothing is set to 100 epochs with a minimum continuous smoothing time of 360 epochs. With a 1 second file, it is a 100 second smoothing with 360 seconds excluding time, but at slower data rates (like 30 seconds), the time span gets very high and nearly impossible due to the cycle-slips.

Therefore, it is necessary to reduce the smoothing and exclusion by the data rate or to completely disable it. The latter recommended, as with very small smoothing times and distance between epochs the smoothing can be even worst that no smoothing at all. To disable smoothing and smoothing exclusion during convergence time, use parameters '**-pre:smooth 0**' and '**-pre:smoothmin 0**'. In DGNSS, also provide '**-pre:dgnss:smoothmin 0**' to disable smoothing exclusion during convergence time in the reference station.

Since gLAB v6, when the RINEX observation file has a data rate of 1Hz, the smoothing and smoothing convergence time will be automatically reduced by the data rate of the observation file (e.g. a factor 30 for 30s RINEX observation file) only if user did not set any smoothing option. Furthermore, the data gap will also automatically adapt to the RINEX observation file data rate. Therefore, by default gLAB will autoconfigure to provide a solution. Nevertheless, the current question is written as if gLAB did not autoconfigure as many users had this problem in previous versions.

See also question **'IN SBAS OR DGNSS, IS IT EQUIVALENT TO PROCESS WITH A 30 SECOND FILE THAN TO PROCESS AT A 30 SECOND RATE WITH A 1 HZ FILE?'**

IN SBAS OR DGNSS, IS IT EQUIVALENT TO PROCESS WITH A 30 SECOND FILE THAN TO PROCESS AT A 30 SECOND RATE WITH A 1 HZ FILE?

No, it isn't equivalent. This is a very common error, rather for avoiding to download a 1Hz file or to try to reduce processing time with smaller files. The difference is due to smoothing:

- With a 30 second file, you have to either reduce the smoothing epochs to a factor 30 (the file data rate) in order to keep the smoothing time window (if the number of epochs were maintained, there would be noticeable ionospheric divergence in the smoother). Reducing so much the number of samples for the smoothing makes the smoothing be useless or even worst, so it is recommended to completely disable in these cases (see question above **'IN SBAS AND DGNSS MODES, WHY THERE IS NO NAVIGATION SOLUTION WHEN PROCESSING WITH 30 SECONDS FILES?'**).

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- With a 1 Hz file, gLAB will compute cycle-slip and smoothing at 1 Hz (or the data file rate) independently of the decimation set by the user. The navigation solution will be computed at 30 second rate (at the user defined decimation), but it will have the same cycle-slips and smoothing as in a 1 Hz decimation.

WHY IS SOME INFORMATION (SUCH AS ARC NUMBER OR SVN) REPEATED IN SEVERAL MESSAGES?

In gLAB version <=5.5.1, the criteria was to split info in different messages and repeat as minimum as possible. The problem with this approach is that many cases the user wants to do a quick analysis and needs info splitted in different messages, which is quite annoying to join, even for experienced programmers. Having the info repeated in several messages will make very probably that all the info the user needs is in the message, so parsing is straightforward.

This criteria has the side effect that output files get bigger, but if necessary, the usually can extract only the fields needed from the gLAB output before saving it to a file, by piping to the Awk command. For instance, if a user only wants the seconds of day (field 4) and the north (field 24) east (field 25) and up (field 26) errors from the OUTPUT message. the following command line would apply (for Linux and Cygwin, for Windows command line the user will have to install the 'awk' command first):

```
    gLAB.exe <parameters> | awk '$1=="OUTPUT" {print $4,$24,$25,$26}'
> outputfile.txt
```

WHY DOES THE ARC LENGTH VALUE SOMETIMES DOES NOT INCREASE EVEN IF THERE IS DATA AVAILABLE?

Arc length can remain unchanged in the following cases:

- If option 'N-consecutive' ('**-pre:cs:ncon'**) is enabled, the first N-1 samples after a small data gap will be ignored.
- The Melbourne-Wubbena, Geometry-Free and Iono-Geometry Free cycle-slip detectors have a built-in 'outlier' flag. When any of these detectors detect a cycle-slip, the sample is discarded for the current and future epochs (as if it were a data gap) and thus the arc length does not increase. If in the next sample a cycle-slip is detected again, then a cycle-slip is declared. Otherwise, the arc is maintained (but the outlier sample is discarded).
  It is possible to disable the outlier detection in each detector independently (with options '**-pre:cs:mw:nooutliers**', '**-pre:cs:li:nooutliers**' and '**-pre:cs:igf:nooutliers**') or to all detectors at once (with option '**-pre:cs:nooutliers**').

WHY THE PROGRESS BAR IS DISABLED WHEN THE STANDARD OUTPUT IS PIPED TO ANOTHER COMMAND?

gLAB can detect if the standard output is redirected to a file or to a pipe. When it is redirected to a pipe, gLAB does not know to which program it is piped.

Writing the progress bar could mess with the output of the next program, for instance, 'less' or 'more' programs. Therefore gLAB takes the safe approach to disable the progress bar.

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Nevertheless, there are many cases where printing the progress bar is perfectly compatible with piped output (as the progress bar is printed in a different channel than the pipe), such as an 'awk' or 'grep' command that later end up writing to a file. For instance, the following command will have no problem or interference with printing the progress bar:

```
gLAB.exe <parameters> | awk '$1=="OUTPUT" {print $4,$24,$25,$26}' > outputfile.txt
```

For these cases, there is the option **'-print:progressalways'** (or in a shorter form, **'-print:pa'**), which will make gLAB to print the progress bar regardless the standard output redirection. The command will now be:

```
gLAB.exe <parameters> -print:pa | awk '$1=="OUTPUT" {print $4,$24,$25,$26}' > outputfile.txt
```

WHY PROCESSING TIME IN MULTI-THREADED gLAB VERSION IS SOMETIMES SLOWER THAN SINGLE THREADED gLAB VERSION?

There are two reasons:

1. Multi-threading is only used during cycle-slip computation and modelling, as these are the tasks that can be done per satellite in parallel.
2. When using multi-threading, the program has to create multiple threads and synchronize them, which is expensive in processing power. This can be seen when checking the processing time in the summary, where the kernel time is greatly increased with respect to single thread.

Therefore, it is recommended to use the multi-threaded version only where there a lot of satellites in view or in SBAS maps mode.

IS IT POSSIBLE TO USE A DIFFERENT ANTEX FOR THE SATELLITES AND THE RECEIVER ANTENNA PHASE CENTER?

Yes. By default, gLAB will the APC for satellites and receiver from the ANTEX provided with parameter **'-input:ant'**.

In order to use a different ANTEX for the receiver, just provide the parameter **'-input:antrec'** with the receiver ANTEX file.

DOES gLAB CARE ABOUT FILENAME FORMAT OR EXTENSIONS?

No. You can set the input and output names with any filename or extension (or no extension at all). As the user has to set in the parameters what type of data contains each filename (e.g. **'-input:nav brdc2000.16n'**), gLAB will check that the content of the file matches with the type set in the parameter. As an example, the following command line:

```
gLAB.exe -input:obs vigo1650.19o -input:nav vigo1650.18n
```

Will work exactly the same if the filenames are changed to something such as 'foo' and 'foo2', as it can be seen below:

```
gLAB.exe -input:obs foo -input:nav foo2
```


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WHAT IS GPS RECEIVER TYPES FILES FOR?

For GPS only, some receivers used cross-correlation techniques to track legacy P1 (C1P) and P2 (C2P) measurements, or they don't print P1 (C1P) measurement in the observation file. For these cases, it is necessary to correct P2 (C2P) measurement or to generate P1 (C1) measurement from C1 (C1C) measurement using the P1-C1 DCB. As from the RINEX observation file it is not possible to know what receiver type is, gLAB will set it to 'unknown' and will assume it is a receiver that does not need any correction. When a GPS Receiver Type file is provided (with parameter '**-input:rec**'), it will be able to determine what type of receiver is and apply the P1-C1 correction (if P1-C1 DCB file is provided with parameter '**-input:dcb**').

IS IT POSSIBLE TO PROCESS ONLY IN BACKWARDS MODE?

Yes. Just set the start time (with option '**-pre:starttime**' in command line) to the last epoch in the RINEX observation file.

IS gLAB VERSION 6+ BACKWARDS COMPATIBLE?

Yes. gLAB v6+ is fully backwards compatible, both in the input and in the output messages.

For the input options, even though option names may have changed (e.g **'-input:sbas'** to **'-input:sbas1f'**) or arguments formats have changed (e.g. option **'-filter:select'**) and the old format does not appear in the gLAB help, if the user uses the version v5 parameters, gLAB will detect it automatically and correctly parse them. When gLAB detects an v5 parameter or argument, it will apply it only to GPS satellites.

For the output messages (which have been noticeably expanded), use option **'-print:v5format'** for printing output messages with the version 5 format.

WHAT ARE THE MAIN DIFFERENCES BETWEEN gLAB VERSION 5 ans 6+?

Some of the default behaviour in gLAB has changed in versíon 6+. They are explained in the table below:

Behaviour definition	gLAB version ≤ 5.5.1	gLAB version ≥ 6+	Reason
Measurements used for navigation	GPS only, hardcoded to P1,P2,L1, L2 (or C1P,C2P,L1P,L2P). C1 (C1C) was used if P1 was not available in the header of receiver was type 1 or type 2	Measurement selection is done according to user parameters and available measurements in the RINEX observation file in a per satellite basis (each satellite may have different measurements)	Satellites now have multiple frequencies and multiples signals per frequency, and satellites from same constellations may have different signals tracked
Cycle-slip measurement selection	GPS only, measurements to use in detectors were hardcoded to C1P (or	Measurements selection for all constellations follow the configuration of the	Multi-constellation and multi-frequency provide a large amount of different signals and

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	C1C if C1P was missing or SBAS mode selected) and C2P, independently of the filter	filter. That is, all carrier phase measurements will be added in each enabled CS (adding multiple iterations if needed). If the filter does not have carrier phase measurement selected, no CS will be run (unless manually set or in showINPUT mode, were configuration will be set as default PPP mode)	possible combinations, therefore CS has to adapt to whatever the filter is using
Measurements modelled	All measurements were modelled	Only the measurements used in the filter are modelled (with parameter **'-model:allfilemeas'** the user can force to model all measurements)	Save computation time, as multi-constellation files can have dozens of different measurements
Enabled output prints in default configuration	INFO, CS, INPUT, MODEL, EPOCHSAT, PREFIT, POSTFIT, FILTER, OUTPUT messages and summary enabled	Only INFO, CS, OUTPUT and summary enabled	Save computation time and disk as with multi-constellation the number of lines to print have multiplied
Satellites printed in PREFIT output message	All satellites (selected or unselected) are printed	Only selected satellites are printed. With option **'-print:prefit:unsel'** it is possible to print also unselected satellites	Save computation time and disk as multi-constellation files have a lot more available satellites

WHY gLAB DISCARDS A SATELLITE WHEN ANY OF THE MEASUREMENTS IS MISSING?

For a satellite to be used in the navigation solution, all the measurements selected for the filter and the cycle-slip detector must be available in each epoch.Otherwise, the satellite is unselected. As a user, the first thought normally is "if a measurement is missing, try to use the remaining ones so the satellite can be still used".

This approach, although theoretically is good, has not been followed due to the following reasons:

- **Short version:** It will be too complicated to implemented, it would greatly increase processing time and the solution improvement will be, in general, very low (specially in multiconstellation). It would only make sense to implement it in the case there is a complete knowledge of how the receiver works.
- **Long version:** Discarding a satellite when a measurement is missing allows the following steps:

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- Skip cycle-slip detection, modelling and prefit computation for the satellite
- Build measurements lists only once (there are multiple list according to several function needs), instead of every epoch.
- Remove measurement availability checks in each step as it is guaranteed that all measurements are available.
- Add code flow optimizations based on that it is guaranteed that all measurements to be used are available.

For the reasons listed above, discarding a satellite when a measurement is missing allows the reduction of the processing time.

In the current implementation it is necessary to check the behaviour in each processing mode:

- **SPP:** In SPP mode, precision is few metres level or greater, therefore removing one satellite will not make much difference, except if the user has very few satellites available (which will be infrequent when using multi-constellation). Furthermore, in SPP, using more than one measurement per satellite does not improve the navigation solution, as precision is limited due to code multipath and orbit error.
- **PPP:** In PPP it is necessary to use the ionosphere-free combination, therefore, if one the code or phase measurements is missing, the combination cannot be built. Furthermore, for the carrier phases, it is necessary to detect cycle-slips. If a missing measurement is used only in cycle-slip detection, then cycle-slip detection cannot be done, and it would be a high risk to use carrier phase measurements in the filter without the guarantee of no cycle-slips. Furthermore, there is the estimation of the carrier phase ambiguity, as using satellites whose measurements are not continuously available would make much more difficult to estimate them.
- **SBAS:** The SBAS template forces which measurements are to be used. Then, if any of them is not available, the SBAS MOPS forces to unselect to the satellite.
- **DGNSS:** As data is used from both the rover and the reference station, if missing any measurement or model component, then the differential correction cannot be computed. Therefore, the satellite needs to be unselected.

IS IT POSSIBLE TO CHANGE MEASUREMENTS TO PROCESS DURING A RUN?

It is not possible to change the selected measurements in the filter during a run, but gLAB can be forced to add or discard measurements by adding or removing them in the RINEX observation file using headers with different measurements. Every time an observation RINEX header is found, measurement selection is triggered for all satellites. If a measurement to be used (set by default or by parameter) is available after reading the new header, it is added to the measurements to use (in the case of a carrier phase measurement, a forced cycle-slip will be triggered to ensure that all cycle-slip buffers are filled before using the new measurement). Otherwise, if a measurement that was being used is no longer present in the RINEX observation file, it will be removed from the measurements to use (and not accounted as missing measurement).

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For instance, if a receiver is tracking GPS L1 and L2 only, and at some point it switches to L1 and L5 only, the procedure (for a PPP) is the following:

- In the input parameters for the filter, set it to use both GPS iono-free with L1/L2 and L1/L5. For instance (assuming all GPS satellites have L5):

```
-filter:select G0-PC12 G0-LC12 G0-PC15 G0-LC15
```

- In the first observation header, in the list of measurements, remove all L5 measurements (and also from subsequent epoch data). As L5 measurements are not available, they will be discarded and gLAB will only try to use PC12 and LC12.
- Prior to the epoch where the receiver switches to L5, add a header in the observation file. In this header, L5 measurements shall be added and L2 measurements have to be removed (and also from subsequent epoch data). In this way, gLAB will discard L2 measurements and only use PC15 and LC15.
- Repeat this procedure as many times as necessary (every time available measurements change).

Note:

- In the previous example, if the user adds L5 measurements but does not remove L2 measurements, gLAB will then use both combinations (PC12, PC15, LC12, LC15) and if any is missing, the satellite will not be used.

CAN gLAB PROCESS CARRIER PHASE MEASUREMENTS AS ABSOLUTE (UNAMBIGUOUS) MEASUREMENTS?

Yes, there is the option '**-filter:absolutephases**' for this issue. When this option is provided, gLAB assumes that carrier phase measurements are absolute measurements, that is, the ambiguity has been already been added to the carrier phase measurement, either by modifying the RINEX observation file or by adding it as a user defined error with option '**-input:usererror**'. Setting this option will also disable code jumps detection and carrier phase alignment.

When using carrier phase measurements, there is a caveat: the wind-up correction, as this correction is cumulative and needs to be reset every time there is a cycle-slip. If carrier phases are provided as absolute measurements, cycle-slips will not be detected properly. To work around this issue, three possibilities are possible:

1. Use the RINEX observation file without modification and provide the carrier phase ambiguities values as an 'error' to the measurements, using parameter '**-input:usererror**'. Also, provide the parameter '**-pre:usererrorafter**', which will make to add the error to the measurements after the preprocessing. In this way, during the cycle-slip detection, it will use the RINEX observation carrier phase measurements (which will allow to correctly detect cycle-slip), but in the modelling and filter the absolute measurements will be used.

2. Use the RINEX observation file without modification and provide the carrier phase ambiguities values and wind-up correction as an 'error' to the measurements, using parameter '**-input:usererror**'. Both corrections can be added a single error or as multiple errors, as gLAB supports multiple error sources for the same satellite and epoch. When this mode is used, it is necessary to disable wind-up correction with

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parameter '**--model:windup**' and to disable all cycle-slip detectors by using the option '**-pre:allcsoff**'.

3. Provide a RINEX observation file with carrier phase measurements already corrected with the carrier phase ambiguity and the wind-up correction. When this mode is used, it is necessary to disable wind-up correction with parameter '**--model:windup**' and to disable all cycle-slip detectors by using the option '**-pre:allcsoff**'.

As a last comment, the user can retrieve the wind-up correction from the MODEL message (in field 35), when processing in PPP mode with non absolute carrier phase measurements.

HOW ARE RINEX 2 OBSERVABLE MEASUREMENTS TREATED IN gLAB?

When reading a RINEX observation file version 2, gLAB converts internally the measurements to the RINEX 3 nomenclature, with the following hardcoded table:

GNSS	Freq 1	Freq 2	Freq 3	Freq 4	Freq 5	Freq 6	Freq 7	Freq 8	Freq 9
GPS	C1->C1C	C2->C2C	C3->C3X	C4->C4X	C5->C5X	C6->C6X	C7->C1X	C8->C8X	C9->C9X
GPS	P1->C1P	P2->C2P	P3->C3P	P4->C4P	P5->C5P	P6->C6P	P7->C7P	P8->C8P	P9->C9P
GPS	L1->L1C	L2->L2P	L3->L3X	L4->L4X	L5->L5X	L6->L6X	L7->L1X	L8->L8X	L9->L9X
GPS	D1->D1C	D2->D2P	D3->D3X	D4->D4X	D5->D5X	D6->D6X	D7->D1X	D8->D8X	D9->D9X
GPS	S1->S1C	S2->S2P	S3->S3X	S4->S4X	S5->S5X	S6->S6X	S7->S1X	S8->S8X	S9->S9X
Galileo	C1->C1C	C2->C2X	C3->C3X	C4->C4X	C5->C5X	C6->C6X	C7->C7X	C8->C8X	C9->C9X
Galileo	P1->C1P	P2->C2P	P3->C3P	P4->C4P	P5->C5P	P6->C6P	P7->C7P	P8->C8P	P9->C9P
Galileo	L1->L1C	L2->L2X	L3->L3X	L4->L4X	L5->L5X	L6->L6X	L7->L7X	L8->L8X	L9->L9X
Galileo	D1->D1C	D2->D2X	D3->D3X	D4->D4X	D5->D5X	D6->D6X	D7->D7X	D8->D8X	D9->D9X
Galileo	S1->S1C	S2->S2X	S3->S3X	S4->S4X	S5->S5X	S6->S6X	S7->S7X	S8->S8X	S9->S9X
GLONASS	C1->C1C	C2->C2C	C3->C3X	C4->C4X	C5->C5X	C6->C6X	C7->C3X	C8->C8X	C9->C9X
GLONASS	P1->C1P	P2->C2P	P3->C3P	P4->C4P	P5->C5P	P6->C6P	P7->C3P	P8->C8P	P9->C9P
GLONASS	L1->L1C	L2->L2P	L3->L3X	L4->L4X	L5->L5X	L6->L6X	L7->L3X	L8->L8X	L9->L9X
GLONASS	D1->D1C	D2->D2P	D3->D3X	D4->D4X	D5->D5X	D6->D6X	D7->D3X	D8->D8X	D9->D9X
GLONASS	S1->S1C	S2->S2P	S3->S3X	S4->S4X	S5->S5X	S6->S6X	S7->S3X	S8->S8X	S9->S9X
GEO	C1->C1C	C2->C2X	C3->C3X	C4->C4X	C5->C5X	C6->C6X	C7->C7X	C8->C8X	C9->C9X
GEO	P1->C1P	P2->C2P	P3->C3P	P4->C4P	P5->C5P	P6->C6P	P7->C7P	P8->C8P	P9->C9P
GEO	L1->L1C	L2->L2X	L3->L3X	L4->L4X	L5->L5X	L6->L6X	L7->L7X	L8->L8X	L9->L9X
GEO	D1->D1C	D2->D2X	D3->D3X	D4->D4X	D5->D5X	D6->D6X	D7->D7X	D8->D8X	D9->D9X
GEO	S1->S1C	S2->S2X	S3->S3X	S4->S4X	S5->S5X	S6->S6X	S7->S7X	S8->S8X	S9->S9X
BeiDou	C1->C1C	C2->C2X	C3->C3X	C4->C4X	C5->C5X	C6->C6X	C7->C7X	C8->C8X	C9->C9X

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BeiDou	P1->C1P	P2->C2P	P3->C3P	P4->C4P	P5->C5P	P6->C6P	P7->C7P	P8->C8P	P9->C9P
BeiDou	L1->L1C	L2->L2X	L3->L3X	L4->L4X	L5->L5X	L6->L6X	L7->L7X	L8->L8X	L9->L9X
BeiDou	D1->D1C	D2->D2X	D3->D3X	D4->D4X	D5->D5X	D6->D6X	D7->D7X	D8->D8X	D9->D9X
BeiDou	S1->S1C	S2->S2X	S3->S3X	S4->S4X	S5->S5X	S6->S6X	S7->S7X	S8->S8X	S9->S9X
QZSS	C1->C1C	C2->C2X	C3->C3X	C4->C4X	C5->C5X	C6->C6X	C7->C7X	C8->C8X	C9->C9X
QZSS	P1->C1P	P2->C2P	P3->C3P	P4->C4P	P5->C5P	P6->C6P	P7->C7P	P8->C8P	P9->C9P
QZSS	L1->L1C	L2->L2X	L3->L3X	L4->L4X	L5->L5X	L6->L6X	L7->L7X	L8->L8X	L9->L9X
QZSS	D1->D1C	D2->D2X	D3->D3X	D4->D4X	D5->D5X	D6->D6X	D7->D7X	D8->D8X	D9->D9X
QZSS	S1->S1C	S2->S2X	S3->S3X	S4->S4X	S5->S5X	S6->S6X	S7->S7X	S8->S8X	S9->S9X
IRNSS	C1->C1C	C2->C2X	C3->C3X	C4->C4X	C5->C5A	C6->C6X	C7->C7X	C8->C8X	C9->C9A
IRNSS	P1->C1P	P2->C2P	P3->C3P	P4->C4P	P5->C5P	P6->C6P	P7->C7P	P8->C8P	P9->C9P
IRNSS	L1->L1C	L2->L2X	L3->L3X	L4->L4X	L5->L5A	L6->L6X	L7->L7X	L8->L8X	L9->L9A
IRNSS	D1->D1C	D2->D2X	D3->D3X	D4->D4X	D5->D5A	D6->D6X	D7->D7X	D8->D8X	D9->D9A
IRNSS	S1->S1C	S2->S2X	S3->S3X	S4->S4X	S5->S5A	S6->S6X	S7->S7X	S8->S8X	S9->S9A

Note that the equivalent measurement in RINEX 3 does not need to exist for a given constellation, it just has to be the same measurement type (code, carrier phase, Doppler or SNR) and any attribute supported in RINEX 3.04. Moreover, the frequency in the RINEX 2 measurement does not have to match the RINEX 3 frequency. This is allowed in order to support 'teqc' program extended measurements, which for instance, converts frequency 7 to the equivalent L1C signal.

Most of the measurements are converted to RINEX 3 with the 'X' attribute. This is due to in RINEX 2 it is not possible to know with what component of the signal the measurement was tracked.

WHEN COMPUTING SBAS (1F OR DFMC) MAPS, WHY 99.9% OR HIGHER AVAILABILITY IS NOT ACHIEVED ANYWHERE, EVEN IN A NOMINAL DAY?

This is due to there is not enough data in the SBAS message file or in the RINEX navigation file. They should contain the following:

- SBAS message file: SBAS messages for the full day to be processed plus 15 minutes of messages of the previous day. These messages are necessary to fill the SBAS message data buffer, so when processing starts at epoch 0, all SBAS corrections are available.
- RINEX Navigation file: It must contain data for the current day plus two hours of data from the previous and following day. This is due to navigation messages used by SBAS at the beginning and the end of day are stored in the navigation files from the previous and following day respectively.

If your file does have the data pointed above, it will be due to in the RINEX navigation file there are still messages missing. You can check it with two methods:

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- Enable the SBASUNSEL message when computing the SBAS map. Messages with the content 'No broadcast block with IOD <IOD> [PA only]' will be printed. The downside is that for each epoch and position in the scanned area several will be printed.
- Process one station inside the SBAS area with the SBASUNSEL message enabled. when computing the SBAS map.

For more info on SBAS maps, check SBAS maps help, section 'SBAS Maps Description' in the manual or with parameter '**-sbasplotsinfo**' in command line.

WHY ARE GEO SATELLITES (IN ALL MODES) UNSELECTED BY DEFAULT?

GEO satellites ranging quality are usually not as good as other satellites, due to its position. Furthermore, the improvement in the DOP is barely noticeable, as most of its improvement is cancelled by the need to compute an inter-system clock bias. The user can enable GEO satellites for navigation by providing parameter '**-pre:sat +S0**'.

HOW TO OBTAIN MORE INFO ABOUT GNSS POSITIONING?

For obtaining more information about the algorithms or about GNSS positioning, there are the following sources:

- GNSS BOOK Vol I and II, freely available at https://gage.upc.edu/en/learning-materials/library/gnss-books/gnss-data-processing-book.

- A complete GNSS course, with theory and practical exercises, freely available at https://gage.upc.edu/en/learning-materials/software-tools/glab-tool-suite-links/glab-tutorials/gnss-tutorials.

- An HTML interactive description to RINEX, ANTEX and SP3 files, with tooltips for each field. Available at https://gage.upc.edu/en/learning-materials/library/gnss-format-descriptions.

- The 'Help' menu in the gLAB GUI, which contains links to download GNSS files, links to file standards, file extension description, date and coordinate converters.

- The GUI tooltips, which provide complete explanation for each option and its effect on positioning.

DOES THE GUI HAVE ALL GLAB MODES?

No, the GUI does not have SBAS PLOTS and SHOW INPUT modes. The former mode is for computing SBAS plots and the latter for converting a RINEX observation file to columnar text format using MEAS message (see question **'CAN MEAS MESSAGE BE USED AS A CONVERTER FROM RINEX OBSERVATION TO A COLUMNAR TEXT FILE?**').

DOES THE GUI HAVE ALL GLAB COMMAND LINE OPTIONS?

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No, the GUI has most of the command line options, but a few of them are only command line (the most rare). Moreover, options that can be set in a per satellite basis, the GUI only allows to use them in a per constellation basis (to avoid cluttering the GUI).
The parameters that are only on command line for positioning mode are the following:

-autofillscript, -pre:cs:sf:noautofill, -pre:cs:mw:noautofill, -pre:cs:li:noautofill, -pre:cs:igf:noautofill, -pre:cs:noautofill, -pre:allcson, -pre:allcsoff, -pre:meassel:pairedmeas, -pre:intseconds, -model:skipunhealthymarg, -model:skipunhealthy, -model:maxurabrdc, -model:globrdcintstep, -model:allfilemeas, -filter:prefitoutliers:abs, -filter:gloifb, -filter:recwindup, -filter:noambiguities, -filter:snrweight:comb, -filter:sbasdgnssweightmode, -print:meas:snr, -print:meas:doppler, -print:meas:lli, -print:progressalways, -print:pa and *-summary:stationnetworkname*.

Additionally, there are these DGNSS options which are not usually necessary as they are set according to the rover automatically:

-pre:smoothmeasdgnss, -pre:setrectypedgnss, -pre:cs:li:freqdgnss, -pre:cs:li:freqlistdgnss, -pre:cs:li:measdgnss, -pre:cs:li:measlistdgnss, -pre:cs:mw:freqdgnss, -pre:cs:mw:freqlistdgnss, -pre:cs:mw:measdgnss, -pre:cs:mw:measlistdgnss, -pre:cs:sf:freqdgnss, -pre:cs:sf:measdgnss, -pre:cs:igf:freqdgnss, -pre:cs:igf:freqlistdgnss, -pre:cs:igf:measdgnss, -pre:cs:igf:measlistdgnss, -pre:measorderdgnss, -pre:measorderlistdgnss and *-pre:meassel:pairedmeasdgnss*

ARE THE SNR OPTIONS ACTUALLY REFERRED TO THE C/N0?

Yes, as the RINEX observation provides the C/N0 (Carrier-to-Noise density) instead of the SNR (Signal to Noise Ratio), as the C/N0 is the only term that can be directly compared between receivers. This is because the C/N0 is the SNR value divided by the bandwidth used by the receiver. As the bandwidth in each receiver varies, the SNR will vary according to the bandwidth, while the C/N0 will be consistent across all receivers.

At processing level, there is no difference as the values are used directly without any conversion and the units are correctly set.
Due to all the options and tooltips are currently named with the SNR, there is no plan to rename them as there is no practical difference for gLAB use cases.

IS IT POSSIBLE TO REDUCE RAM USAGE WITHOUT LOSING FUNCTIONALITY?

Yes, but the user will need to rebuild gLAB core. The selected strategy is to reduce constant sizes in dataHandling.h for different purposes.
The following constant changes are SAFE to change, as gLAB checks if read values are over the its internal limits (defined by these constants), and in that case, an error message is shown and gLAB execution terminates.

- If user is not using BeiDou, or it knows the maximum PRN value to be read, the following constants can be changed:
    - Set MAX_SATELLITES_PER_GNSS to the maximum PRN value read plus one (e.g. if maximum PRN value is 36, set constant to 37).

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- Set MAX_SAT_GAL, MAX_SAT_GEO and MAX_SAT_BDS to the maximum PRN value read (e.g. if maximum PRN value is 36, set constants to 36). Setting the previous constants to 37 and 36 saves about 30MB of RAM.

- If user knows the total number of different satellites (from all constellations) that the receiver will have in view during the entire processing, then the following constant can be changed:

  - Set MAX_SATELLITES_VIEWED to the maximum number of satellites viewed plus one (e.g. if maximum number of satellites viewed is 60, set constant to 61). Setting the previous constant to 61 saves about 20MB of RAM.

- Reducing the maximum number of runs for each of the cycle-slip detectors. Each cycle-slip detector, will run as many times as necessary for checking all carrier phase measurements used in the filter. Typically, only or two runs are needed.
  - Set MAX_CS_LIST to the number of runs needed (e.g. if only one run is needed, set constant to 1). Setting the previous constant to 1 saves about 40MB of RAM.

- Reducing the maximum number of measurements to process in the filter per each satellite. Typically, in SPP/SBAS/DGNSS only one measurement is necessary, and in PPP two measurements are necessary.
  - Set MAX_FILTER_MEASUREMENTS_SAT to the number of measurements needed in the gLAB execution (e.g. if only one measurement is needed, set constant to 1). Setting the previous constant to 1 saves about 20MB of RAM.

Additionally, if the user will only print any of these messages INFO, INPUT, MEAS, OUTPUT, SBASOUT, SATDIFF, SATSTAT, SATSTATTOT and SATPVT, it is possible to reduce to 1 byte the size of the internal buffers used for storing the not used messages types. This method is not safe, as if the user enables any of the CS, SFCSDATA, MWCSDATA, LICSDATA, IGFCSDATA, MODEL, PREFIT, EPOCHSAT, POSTFIT, FILTER, SBASCORR, SBASVAR, SBASIONO, SBASUNSEL or DGNSS messages, the program will crash or have undefined behaviour.
For reducing the internal buffers, set the constants MAX_PRINT_LINE, MAX_PRINT_LINE_MODEL and MAX_PRINT_LINE_FILTER to 1 (do not modify MAX_PRINT_LINE_TEPOCH constant). This saves around 70MB of RAM.

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12 APPENDIX

12.1 gLAB OUTPUT MESSAGES (DPC INTERFACE) IN VERSION 5

12.1.1 INFO

Messages: Individually select which messages are printed.

- Print INFO Messages: INFO messages are shown at several points in the program and provide information on the program configuration, events and problems it may encounter, which are:

  At the start of the file, information about gLAB configuration.

  An inconsistent clock update on the receiver.

  A data gap in the RINEX observation file.

  A change in the a priori receiver coordinates (only when receiver coordinates are computed by gLAB).

  The new position to be used from the reference position file (only when a reference file is provided).

  No solution was computed, along with the reason for not being able to compute the solution (not enough satellites available, singular geometry matrix or GDOP too high).

  In SBAS processing, a GEO or mode switch.

  In DGNSS processing, a switch from DGNSS to SPP solution mode.

  In DGNSS processing, a data gap in the reference station RINEX observation file.

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12.1.2 User Added Error

User-defined error are added to measurements before cycle-slip detection and smoothing (or after if option "Insert User Added Error after preprocessing" is enabled). All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	USERADDEDERROR	Fixed word indicating the data stored.	-
2	Year	Year number (4 digits).	years
3	DoY	Day of Year (3 digits).	days
4	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
5	GPS week	Week number in GPS Time. This field is related to the GPS week of the data snapshot used for the computations.	weeks
6	Time of week	Seconds elapsed since the beginning of the week. This field is related to the GPS number of seconds of the data snapshot used for the computations.	seconds
7	GNSS	Satellite constellation.	-
8	PRN	Satellite identifier.	-
9	Measurement identifier (as string)	String with the measurement observation code.	-
10	Raw measurement	Raw measurement (phase measurements are prealigned)	metres
11	Modified measurement	Raw measurement plus total user-defined error (phase measurements are prealigned)	metres
12	Active user-defined error functions	Total number of active user-defined errors in the current epoch.	-
13	Total user-defined error functions	Total user-defined error in the current epoch.	metres
14	Active Step function error	Number of active Step function error in the current epoch.	metres
15	Step function error value	Sum of all Step function errors in the current epoch.	metres
16	Active Ramp function error	Total number of active Ramp function error in the current epoch.	metres
17	Ramp function error value	Sum of all Ramp function errors in the current epoch.	metres
18	Active Sinusoidal function error	Number of active Sinusoidal function error in the current epoch.	-
19	Sinusoidal function error value	Sum of all Sinusoidal function errors in the current epoch.	metres
20	Active AWGN function error	Number of active AWGN function error in the current epoch.	-
21	AWGN function error value	Sum of all AWGN function errors in the current epoch.	metres

Sample:

```
USERADDEDERROR 2015 161 0.00 1848 259200.00 GPS 4 C1C 23140309.8200 23140314.8200
1 5.0000 1 5.0000 0 0.0000 0 0.0000 0 0.0000
```


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12.1.3 INPUT

Print INPUT Messages: Input data message. It is shown after an epoch is read, decimated and added user-defined error. It contains the measurements for each satellite for this epoch[5].

#	FIELD	DESCRIPTION	UNITS
1	INPUT	Fixed word indicating the data stored	-
2	Year	Year number (4 digits)	years
3	DoY	Day of Year (3 digits)	days
4	Seconds of day	Seconds elapsed since the beginning of the day	seconds
5	GNSS	Satellite constellation	-
6	PRN	Satellite identifier	-
7	Arc length	Number of undecimated epochs after the last cycle-slip	-

For GPS:

#	FIELD	DESCRIPTION	UNITS
8	Measurement	C1 [C1C]	metres
9	Measurement	P1 [C1P]	metres
10	Measurement	P2 [C2P]	metres
11	Measurement	L1 [L1P] (prealigned)	metres
12	Measurement	L2 [L2P] (prealigned)	metres

For Galileo (GAL):

#	FIELD	DESCRIPTION	UNITS
8	Measurement	C1A	metres
9	Measurement	C1B	metres
10	Measurement	C1C	metres
11	Measurement	C7Q	metres
12	Measurement	C8Q	metres
13	Measurement	L1A (prealigned)	metres
14	Measurement	L1B (prealigned)	metres
15	Measurement	L1C (prealigned)	metres
16	Measurement	L7Q (prealigned)	metres
17	Measurement	L8Q (prealigned)	metres

For GLONASS (GLO):

#	FIELD	DESCRIPTION	UNITS
8	Measurement	C1 [C1C]	metres
9	Measurement	C2 [C2C]	metres
10	Measurement	L1 [L1P] (prealigned)	metres
12	Measurement	L2 [L2P] (prealigned)	metres

For GEO:

#	FIELD	DESCRIPTION	UNITS
8	Measurement	C1 [C1C]	metres

[5] These measurements are the ones that are shown in the INPUT message. Nevertheless all the measurements included in the RINEX are read and stored by gLAB for its later use, in case of need, even if they are not printed in the INPUT message.

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Sample:

```
INPUT     2006 200     0.00 GPS 19      1  23119003.9020  23119002.6110
23119004.0750  23119002.7507  23119004.0925
```

12.1.4 Cycle slip

Print CS (Cycle-Slip) Messages: Cycle-slip message information. It is shown when a cycle-slip is found by any detector. A line will be printed for each CS detector that has found a CS. The first 6 fields are common, afterwards, there are five possible different CS messages depending on the cycle-slip detector activated.

#	FIELD	DESCRIPTION	UNITS
1	CS	'CS' or 'CS_USER' for Rover Station (user) 'CS_REF' for Reference Station	-
2	Year	Year number (4 digits)	years
3	DoY	Day of Year (3 digits)	days
4	Seconds of day	Seconds elapsed since the beginning of the day	seconds
5	GNSS	Satellite constellation	-
6	PRN	Satellite identifier	-

If cycle-slip detector is Data gap:

#	FIELD	DESCRIPTION	UNITS
7	CS Detector	'DATA_GAP'	-
8	Field separator	'='	-
9	Delta time	Difference of time between current and last available epochs	seconds
10	CS threshold label	'THRESHOLD'	-
11	Field separator	'='	-
12	CS threshold value	Maximum time allowed data gap threshold	seconds

Sample:

```
CS        2014 288 44997.00 GPS 32  DATA_GAP = 45.000000 THRESHOLD = 40.000000
```

If cycle-slip detector is Loss of Lock Indicator:

#	FIELD	DESCRIPTION	UNITS
7	CS Detector	'LLI'	-

Sample:

```
CS        2014 288 44942.00 GPS 32  LLI
```

If cycle-slip detector is Geometry-free carrier phase:

#	FIELD	DESCRIPTION	UNITS
7	CS detector	'LI'	-
8	Field separator	'='	-
9	CS difference	Absolute value of the difference between the computed LI and the measured LI. If LI could not be estimated, value will be '999999.0000'	metres

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#	FIELD	DESCRIPTION	UNITS
10	CS threshold label	'THRESHOLD'	-
11	Field separator	'='	-
12	CS threshold value	Maximum LI difference allowed as threshold	metres

Sample:

```
CS        2014 288 42092.00 GPS  7  LI = 0.119386 THRESHOLD = 0.052861
```

If cycle-slip detector is Melbourne-Wubbena:

#	FIELD	DESCRIPTION	UNITS
7	CS detector	'Bw'	-
8	Field separator	'='	-
9	CS difference	Absolute value of the difference between the computed Bw and the measured Bw. If the difference could not be estimated, value will be '999999.0000'	metres
10	CS threshold label	'THRESHOLD'	-
11	Field separator	'='	-
12	CS threshold value	Maximum Bw difference allowed as threshold	metres

Sample:

```
CS        2014 288 42092.00 GPS  7  Bw = 1.992188 THRESHOLD = 1.839927
```

If cycle-slip detector is L1-C1 difference:

#	FIELD	DESCRIPTION	UNITS
7	CS detector	'L1C1'	-
8	Field separator	'='	-
9	CS difference	Absolute value of the difference between the computed L1-C1 and the measured L1-C1. If L1-C1 could not be estimated, value will be '999999.0000'	metres
10	CS threshold label	'THRESHOLD'	-
11	Field separator	'='	-
12	CS threshold value	Maximum L1-C1 difference allowed as threshold	metres

Sample:

```
CS        2014 365 55344.00 GPS  7  L1C1 = 747.078356 THRESHOLD = 0.876845
```


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12.1.5 MEAS

Print MEAS Messages: Information of the input measurements in a variable format, and azimuth/elevation of the satellite. It is written after modelling the message.

#	FIELD	DESCRIPTION	UNITS
1	MEAS	Fixed word indicating the data stored.	-
2	Year	Year number (4 digits).	years
3	DoY	Day of Year (3 digits).	days
4	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
5	GNSS	Satellite constellation.	-
6	PRN	Satellite identifier.	-
7	Satellite elevation	Elevation angle between the satellite and the receiver location.	degrees
8	Satellite azimuth	Azimuth angle between the satellite and the receiver location.	degrees
9	Measurements Total	Number of measurements	-
10	Measurements List	String containing the measurements included	-
11-	Measurements Value	Each following column is the value of the measurement specified in Field 10	-

If there is no data available on azimuth and elevation, the fields 7 and 8 will be fixed to zero.

Sample:

```
MEAS      2006 200     0.00 GPS 19   26.66  -79.62  6  C1C:L1C:C1P:L1P:C2P:L2P
23119003.9020         0.0000  23119002.6110  23119002.7507  23119004.0750
23119004.0925
```


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12.1.6 MODEL

Print MODEL Messages: Model break down message. It is shown when a model can be fully computed for each measurement.

#	FIELD	DESCRIPTION	UNITS
1	MODEL	Fixed word indicating the data stored: 'MODEL' if the satellite is used in the computation or 'MODEL*' if it is not.	-
2	Year	Year number (4 digits)	years
3	DoY	Day of Year (3 digits)	days
4	Seconds of day	Seconds elapsed since the beginning of the day	seconds
5	GNSS	Satellite constellation	-
6	PRN	Satellite identifier	-
7	Measurement	Identifier string	-
8	GNSS time offsets	GLO: the number of leap seconds BDS: time offset with respect to GPS Other GNSS: zero	seconds
9	Measurement	Measured value (as in the RINEX file), but scaled to metres for carrier phase measurements	metres
10	Model value	Addition of all model terms, except for dual-frequency DCB processing.	metres
11	Satellite position	X coordinate. See explanation below.	metres
12	Satellite position	Y coordinate. See explanation below.	metres
13	Satellite position	Z coordinate. See explanation below.	metres
14	Satellite velocity	X component of satellite velocity. See explanation below.	metres
15	Satellite velocity	Y component of satellite velocity. See explanation below.	metres
16	Satellite velocity	Z component of satellite velocity. See explanation below.	metres
17	Range	Satellite-receiver geometric distance	metres
18	Clock Offset	Satellite clock correction	metres
19	Phase centre	Satellite phase centre projection	metres
20	Phase centre	Receiver phase centre projection	metres
21	Antenna Offset	Receiver Antenna Reference Point (ARP) projection	metres
22	Relativity	Relativity clock correction due to orbit eccentricity	metres
23	Wind-up	Wind-up correction (for carrier phase measurements)	metres
24	Troposphere	Slant Troposphere nominal correction	metres
25	Ionosphere	Slant Ionosphere correction	metres
26	Relativity	Gravitational path delay correction	metres
27	Code Bias	Total Group Delay (TGD) correction	metres
28	Tides	Solid tides correction	metres
29	Satellite elevation	Elevation angle between the satellite and the receiver location.	degrees
30	Satellite azimuth	Azimuth angle between the satellite and the receiver location.	degrees
31	SNR	Measurement Signal to Noise Ratio	dbHz

The satellite coordinates (fields 11-16) are given in the transmission epoch if the model of the signal transmission time is enabled (if it is disabled, they are given in the reception time). The

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coordinates are relative to the antenna phase centre or satellite mass centre, depending on the products input:

- Broadcast: Antenna Phase Centre
- Precise: Satellite Mass Centre

Field 9 is the direct measurement (as in the RINEX file), but scaled to metres for carrier phase measurements. Field 10 is the model computed for this measurement. Field 10 is the direct sum of fields 17 to 28. When the '*' appears in field 1, it is due to smoothed code of the satellite has not reached steady-state, a SBAS processing mode switch or SBAS GEO switch. When a mode or GEO switch occurs, the SBAS corrections have to be computed again.

The SNR value in field 31 may be any of these values (in this order): the "S" measurement in the observation file, or if it is not present, it will be the SNR flag in the current measurement. If no SNR is available, 999 will be printed in this field.

Sample:

```
MODEL     2006 200     0.00 GPS 19 L1P     0.07712  23119002.7507  23119008.7501
8811456.7780 -21033910.1687  13675922.8867      1828.7339      2353.7679
2467.3576  23119457.7652     -456.31787   0.00000  -0.04936  -0.01140   2.32333
0.10671   4.85412  -0.00000   0.01544   0.00000   0.06394   9.164  79.274
```


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12.1.7 SATSEL

Print SATSEL Messages: Message with debug information of the reason why a satellite has been discarded (or selected) for processing.

#	FIELD	DESCRIPTION	UNITS
1	SATSEL	Fixed word indicating the data stored. 'SATSEL' (if navigation solution is computed), 'SATSEL*' (if model parametres will be recomputed before the navigation solution, only in SBAS mode)	-
2	Year	Year number (4 digits)	years
3	DoY	Day of Year (3 digits)	days
4	Seconds of day	Seconds elapsed since the beginning of the day	seconds
5	GNSS	Satellite constellation	-
6	PRN	Satellite identifier	-
7	Status	"Selected" if satellite used or "Discard reason" if satellite unused. Field 8 will be always between quotes in order to ease parsing purposes.	

Sample:

```
SATSEL    2006 200     0.00 GPS 7 discarded: Elevation too low (3.04)
```

The possible values for field 7 are:

DESCRIPTION
Arc too short (<arclength>)
Pre-Check; measurements missing for CS detection
Not enough consecutive samples (current <value>, minimum <value>)
Unconsistency of measurements
Outlier in LI detector
Outlier in Bw detector
Cycle-slip
Measurement unavailable (<meas>)
Deselection forced
SNR too low (<value>)
Steady-state operation not reached. <value> epochs passed, still <value> epochs to achieve <value>
No code measurement available
C1C measurement unavailable
Ephemerides unavailable
Satellite phase center corrections unavailable
DCBs unavailable (strict TGD treatment)
SBAS corrections unavailable
Elevation too low (<value>)
Satellite under eclipse
Satellite was under eclipse <value> seconds ago
URA value (<value>) is equal or greater than the threshold (<threshold>)
Missing IONEX data
Missing FPPP data

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DESCRIPTION
SBAS iono unavailable
STEP detected (jump of <value> greater than <threshold>)
Prefit too high in comparation with other satellites
Prefit too high in comparation with other satellites (threshold <threshold> metres)
Prefit too different (<value>) with respect to the prefit median (<median>), threshold <threshold> metres
No DGNSS corrections
No DGNSS corrections: Time out
No DGNSS corrections: Excluded during the smoother conversion in the Reference Station
No DGNSS corrections: IODE from BRDC and RTCM do not match
No DGNSS corrections: Excluded due to differential correction is too large
Invalid GNSS: <system>

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12.1.8 PREFIT

Print PREFIT Messages: Prefilter values message. It provides the measurement-model values. It is shown in each filter execution.

#	FIELD	DESCRIPTION	UNITS
1	PREFIT	Fixed word indicating the data stored: 'PREFIT' (if the satellite is used in the computation) or 'PREFIT*' (if it is not)	-
2	Year	Year number (4 digits).	years
3	DoY	Day of Year (3 digits).	days
4	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
5	GNSS	Satellite constellation	-
6	PRN	Satellite identifier	-
7	Measurement	Measurement identifier (as string)	
8	Prefit value	Measurement-model value: If no smoothing: Field 15 = Field 16 - Field 18. If smoothing Field 15 = Field 16 - Field 17.	metres
9	Measurement	Measurement value	metres
10	Model value	Model value	metres
11	X-partial derivative	-X component of the satellite line-of-sight vector	-
12	Y-partial derivative	-Y component of the satellite line-of-sight vector	-
13	Z-partial derivative	-Z component of the satellite line-of-sight vector	-
14	T-partial derivative	One	-
15	Satellite elevation	Elevation angle between the satellite and the receiver location.	degrees
16	Satellite azimuth	Azimuth angle between the satellite and the receiver location.	degrees
17	Weight Inverse	Standard deviation of the measurement (for the filter)	metres
18	Mapping	Troposphere wet mapping	-
19	Arc number	Number of arc (continuous measurements without CS) since the start of the processing	-

In general Field 8 = Field 9 - Field 10, but this is no longer true when using smoothing, as the Field 9 is the raw measurement without smoothing, but the Field 8 computation takes smoothing into account.

Sample:

```
PREFIT    2006 200   300.00 GPS 19  LC        -7.3029  22982271.7155  22982279.0184
28.28   0.3931  -0.4834   0.7822   1.0000   77.912   130.010    17.883     2
```


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12.1.9 EPOCHSAT

Print EPOCHSAT Messages: Message with the satellites used to compute the solution. It is shown when the filter is run, and is given for each measurement.

#	FIELD	DESCRIPTION	UNITS
1	EPOCHSAT	Fixed word indicating the data stored.	
2	Year	Year number (4 digits).	years
3	DoY	Day of Year (3 digits).	days
4	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
5	Measurement	Measurement identifier (as string) **Note:** If EPOCHSAT line refers to all measurements used in the filter, field 5 will have the value "ALL"	-
6	Satellites observed	Total number of satellites **selected and unselected** for the current measurement	-
7-	Satellite list	Each following column is a '+' or '-' sign, the satellite system and the PRN identifier. The '+' sign indicates that the satellite has been used in the solution computation. The '-' sign indicates that the satellite has not been used in the solution computation The satellite list will show first all the satellites with the '+' and after the ones with the '-' sign (ordered by constellation).	-

Sample:

```
EPOCHSAT  2006 200   300.00  PC  7 15  3 19 16 18 21 22
```


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12.1.10 POSTFIT

Print POSTFIT Messages: Postfilter values message. It provides the corrected prefits with the filter estimation. It is shown in each filter execution.

#	FIELD	DESCRIPTION	UNITS
1	POSTFIT	Fixed word indicating the data stored.	
2	Year	Year number (4 digits).	years
3	DoY	Day of Year (3 digits).	days
4	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
5	GNSS	Satellite constellation	-
6	PRN	Satellite identifier	-
7	Measurement	Measurement identifier (as string)	-
8	Post-fit value	Measurement minus the fited model	metres
9	Measurement	Measurement value	metres
10	Fitted Measurement	Corrected model value with the filter estimations	metres
11	Satellite elevation	Elevation angle between the satellite and the receiver location.	degrees
12	Satellite azimuth	Azimuth angle between the satellite and the receiver location.	degrees
13-	Ambiguities	Only given for carrier phase measurements. It is the estimated carrier phase ambiguity	metres

As with PREFIT messages, Field 8 is not necessary Field 9 - Field 10 when using smoothing.

Sample:

```
POSTFIT   2006 200   300.00 GPS 19  LC        0.0000  22982271.7155
22982271.7155   77.912   130.010   0.3029
```


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12.1.11 FILTER

Print FILTER Messages: Filter solution message. This message provides direct information on the filter estimates. It is shown in each filter execution.

#	FIELD	DESCRIPTION	UNITS
1	FILTER	Fixed word indicating the data stored.	
2	Year	Year number (4 digits).	years
3	DoY	Day of Year (3 digits).	days
4	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
5-	Filter estimates	The order is: 3D estimated position, clock, troposphere and ambiguities	-

The number of fields is variable in this message. With a full filter (troposphere and ambiguities estimation), the fields are as follows:

#	FIELD	DESCRIPTION	UNITS
5	Receiver position	X coordinate	metres
6	Receiver position	Y coordinate	metres
7	Receiver position	Z coordinate	metres
8	Receiver clock	Receiver clock offset	metres
9	Troposphere	Zenith Tropospheric Delay (vertical wet component)	metres
10	ambiguities	Carrierphase ambiguities	metres

Sample:

```
FILTER    2006 200   300.00   4849203.0770   -360328.5730   4114913.9184        -
7.4867         2.1946         -0.0001         1.1079         -1.1073         0.3029
0.4555         0.0897          0.0001         0.3845          0.2136
```


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12.1.12 OUTPUT

Print OUTPUT Messages: Receiver solution message. This message provides the estimated receiver position. It is shown in each filter execution.

#	FIELD	DESCRIPTION	UNITS
1	OUTPUT	Fixed word indicating the data stored.	-
2	Year	Year number (4 digits).	years
3	DoY	Day of Year (3 digits).	days
4	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
5	Formal error	Square root of the sum of X, Y and Z components of the covariance matrix. This is a measure of the convergence of the filter	-
6	Receiver position	X coordinate	metres
7	Receiver position	Y coordinate	metres
8	Receiver position	Z coordinate	metres
9	ΔX	Receiver X position - Nominal a priori X position	metres
10	ΔY	Receiver Y position - Nominal a priori Y position	metres
11	ΔZ	Receiver Z position - Nominal a priori Z position	metres
12	Formal error	Receiver X formal error	metres
13	Formal error	Receiver Y formal error	metres
14	Formal error	Receiver Z formal error	metres
15	Receiver position	Receiver latitude	degrees
16	Receiver position	Receiver longitude	degrees
17	Receiver position	Receiver height	metres
18	ΔN	Receiver North difference in relation to nominal a priori position	metres
19	ΔE	Receiver East difference in relation to nominal a priori position	metres
20	ΔU	Receiver Up difference in relation to nominal a priori position	metres
21	Formal error	Receiver formal error in North direction	metres
22	Formal error	Receiver formal error in East direction	metres
23	Formal error	Receiver formal error in Up direction	metres
24	GDOP	Geometric Dilution of Precision	-
25	PDOP	Positioning Dilution of Precision	-
26	TDOP	Time Dilution of Precision	-
27	HDOP	Horizontal Dilution of Precision	-
28	VDOP	Vertical Dilution of Precision	-
29	ZTD	Zenith Tropospheric Delay (including nominal value)	metres
30	ZTD	Zenith Tropospheric Delay (excluding nominal value)	metres
31	ZTD	Zenith Tropospheric Delay formal error	metres
32	Total satellites	Number of satellites used in the navigation solution	-
33	Navigation mode	Processing mode indicator	-

Fields 29, 30 and 31 will be zero if troposphere is not estimated (only estimated in PPP mode).

Processing mode indicator in field 33 may have the following values:

VALUES	VALUES MESSAGE
0	SPP
1	PPP
2	SBAS
3	DGNSS

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The nominal a priori position is a prerequisite of the processing, and can be specified or read from the RINEX input file. See the option **'-pre:setrecpos'** in the help (**'-help'**) for more details.

Sample:

```
OUTPUT    2006 200   300.00    2.6219   4849203.1236   -360328.5229   4114913.9535
0.7693     0.4145     0.7580     1.9353     0.6998     1.6246   40.429162956   -
4.249653155  830.480629026     0.0993     0.4704     1.0522     1.1365     0.6772
2.2637     0.9572     12.2743     5.0975     7.2205     3.5866     3.0880
0.0097     0.4995 6 1
```

Providing a nominal a priori position is optional for the processing, but if it is given, fields 9, 10, 11, 18, 19 and 20 will be related to this a priori position. See the option *A priori Receiver Position* in the INPUT section.

Print INPUT Messages: Input data message. It is shown after an epoch is read, decimated

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12.1.13 SBASCORR

Print SBASCORR: SBAS corrections breakdown. It is shown when a model can be fully computed using SBAS corrections for GPS C1C measurement. All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	SBASCORR	Fixed word indicating the data stored. ' SBASCORR' (if it is used in computation) or 'SBASCORR*' (if it is not)	-
2	Receiver id	Receiver identification.	-
3	Mode	SBAS processing mode: PA, NPA.	-
4	GNSS	Satellite constellation (GPS, GAL, GLO or GEO).	
5	PRN	Satellite identifier	PRN
6	Year	Year number (4 digits).	years
7	DoY	Day of Year (3 digits).	days
8	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
9	GPS week	Week number in GPS Time. This field is related to the GPS week of the data snapshot used for the computations.	weeks
10	Time of week	Seconds elapsed since the beginning of the week. This field is related to the GPS number of seconds of the data snapshot used for the computations.	seconds
11	GEO PRN	GEO from which the SBAS corrections are used ('0' means all GEOs).	-
12	Prefit Residual	Measurement-model value (prefit)	metres
13	Measurement	Measurement value without smoothing	metres
14	Smoothed Measurement	Measurement value with smoothing	metres
15	Geometric range (ρ)	Satellite-receiver geometric distance (with SBAS corrections).	metres
16	Relativity correction	Delay associated to relativistic effects (with SBAS corrections).	metres
17	Satellite clock correction	It includes the clock offset correction broadcast by the satellite itself together with the satellite clock offset broadcast in the Long Term Corrections for the satellite.	metres
18	Total Group Delay (TGD) correction	Delay associated to the group of GPS satellites. From GPS navigation message.	metres
19	IPP Latitude	Latitude corresponding to the Ionospheric Pierce Point used to compute the ionospheric delay.	degrees (-90..90º)
20	IPP Longitude	Longitude corresponding to the Ionospheric Pierce Point used to compute the ionospheric delay.	degrees (0..360º)
21	Ionospheric correction	Delay associated to ionospheric effects	metres
22	Troposphere nominal correction		metres
23	PRC	Pseudorange correction (fast correction) to be applied to the satellite.	metres
24	RRC	Range-rate correction to be applied to the satellite.	metres
25	a_i	Fast Correction degradation factor.	metres/ seconds^2
26	PRC time-out	Time-out interval for current pseudorange correction.	seconds
27	RRC time-out	Time-out interval for current range rate correction (smallest PRC time out for all satellites).	seconds

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#	FIELD	DESCRIPTION	UNITS
28	PRC time reference	Time (seconds of day) used for computing PRC timeout.	seconds
29	UDRE time reference	Time (seconds of day) used for computing sigma UDRE (User Differential Range Error) timeout.	seconds
30	Fast correction degradation time reference	Time (seconds of day) used for computing fast correction degradation.	seconds
31	X	X component of the satellite position in WGS84 system at emission time with SBAS corrections.	metres
32	Y	Y component of the satellite position in WGS84 system at emission time with SBAS corrections.	metres
33	Z	Z component of the satellite position in WGS84 system at emission time with SBAS corrections.	metres
34	LTC-X	Long term correction to be applied to the X component of the satellite.	metres
35	LTC-Y	Long term correction to be applied to the Y component of the satellite.	metres
36	LTC-Z	Long term correction to be applied to the Z component of the satellite.	metres
37	LTC-Δt	Long term correction to be applied to the satellite clock.	metres
38	IODP fast corrections	IODP (Issue of Data PRN mask) used for fast corrections. If no IODP is available, the value is -1.	-
39	IODF	IODF (Issue of Data Fast Correction) in messages type 2-5, 24 for fast corrections. If no IODF is available, the value is -1.	-
40	Fast correction satellite slot	Satellite slot in the fast correction mask (1..51). If no IODP is available, the value is -1.	-
41	IODP long term corrections	IODP used for long term corrections. If no IODP is available, the value is -1.	-
42	Long term corrections satellite slot	Satellite slot in the long term correction mask (1..51). If no IODP is available, the value is -1.	-
43	IODE	IODE (Issue of Data Ephemeris) used for broadcast ephemeris. If no IODE is available, the value is 999. If an IODE is used that does not match the one broadcast in the long term corrections (only in NPA mode), the value will negative.	-
44	IODS	IODS (Service Issue of Data) used for service message. If no IODS is available or it is not used, the value is -1.	-
45	IODP clock-ephemeris covariance matrix	IODP used for clock-ephemeris covariance matrix. If no IODP is available or it is not used, the value is -1.	-
46	Clock-ephemeris covariance matrix slot	Satellite slot in the clock-ephemeris covariance mask (1..51). If no IODP is available or it is not used, the value is -1.	-
47	Ionosphere model flag	Flag to indicate which ionosphere model is used. Its possible values are '-1' for no ionosphere model, '0' for SBAS ionosphere model, '1' for Klobuchar ionosphere model and '2' for any other ionosphere model.	-

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#	FIELD	DESCRIPTION	UNITS
48	Satellite elevation	Elevation angle between the satellite and the receiver location.	degrees
49	Satellite azimuth	Azimuth angle between the satellite and the receiver location.	degrees

Sample:

```
SBASCORR vigo PA GPS 23 2015 165 5088.00 1849 5088.00 120 60577.5787 20948474.4600
20948474.4600 20853522.4567 -4.3086 34379.4657 -6.0029 42.7112 -7.1281 2.3087
2.7117 -0.2500 0.0000 0.00580 12.0000 12.0000 5084.1 5084.1 5084.1 17496575.5944
5306168.63534 19563205.09708 -1.00000 0.62500 0.12500 0.69801 0 1 22 0 22 99 0 -1
-1 0 65.512 66.455
```

NOTES:

- When the '*' appears in field 1, it is due to smoothed code of the satellite has not reached steady-state, a SBAS processing mode switch or SBAS GEO switch. When a mode or GEO switch occurs, the SBAS corrections have to be computed again.
- Field 43 is the IODE value from the broadcast message matched with the SBAS long term corrections. If the field value is negative, it means that the IODE used does not match any SBAS long term correction messagea available (only in NPA mode). A value of 999 means that no valid broadcast message was found for the current epoch.
- Field 47 is a flag to indicate which ionosphere model is used. Its possible values are '-1' for no ionosphere model, '0' for SBAS ionosphere model, '1' for Klobuchar ionosphere model and '2' for any other ionosphere model.

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12.1.14 SBASVAR

Print SBASVAR: SBAS variance contributions breakdown, shown when a model can be fully computed using SBAS corrections for GPS C1C measurement. All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	SBASVAR	Fixed word indicating the data stored. 'SBASVAR' (if it is used in computation) or 'SBASVAR*' (if it is not)	-
2	Receiver id	Receiver identification.	-
3	Mode	SBAS processing mode: PA, NPA.	-
4	GNSS	Satellite constellation (GPS, GAL, GLO or GEO).	
5	PRN	Satellite identifier	PRN
6	Year	Year number (4 digits).	years
7	DoY	Day of Year (3 digits).	days
8	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
9	GPS week	Week number in GPS Time. This field is related to the GPS week of the data snapshot used for the computations.	weeks
10	Time of week	Seconds elapsed since the beginning of the week. This field is related to the GPS number of seconds of the data snapshot used for the computations.	seconds
11	GEO PRN	GEO from which the SBAS corrections are used ('0' means all GEOs).	-
12	σ_{total}	Sigma of the total residual error associated to the satellite.	metres
13	σ_{flt}	Sigma of the residual error associated to the fast and long-term corrections.	metres
14	σ_{UDRE}	Sigma of the UDRE (User Differential Range Error) factor.	metres
15	δ_{UDRE}	Delta UDRE (User Differential Range Error) factor.	-
16	δ_{UDRE} data source	Data source (SBAS message type number) for Delta UDRE. It may have the following values: 27 or 28 for their respective message type, -27 or -28 if received any of these message types but there was missing data for current satellite or was timed out, 0 if no message type received or both received.	-
17	ε_{fc}	Degradation parameter for fast correction data.	metres
18	ε_{rrc}	Degradation parameter for range rate correction data.	metres
19	ε_{ltc}	Degradation parameter for long term correction data or GEO navigation message data.	metres
20	ε_{er}	Degradation parameter for en route through NPA applications.	metres
21	RSS_{UDRE}	RSS (Root-Sum-Square) flag in message type 10.	-
22	σ_{UIVE}	Sigma of the residual error associated to the ionospheric corrections.	metres
23	σ_{tropo}	Sigma of the residual error associated to the tropospheric corrections.	metres
24	σ_{air}	Sigma of the total airborne receiver error.	metres
25	σ_{noise}	Sigma of the airborne receiver noise.	metres
26	$\sigma_{multipath}$	Sigma of the airborne receiver multipath.	metres
27	σ_{divg}	Sigma of the airborne receiver divergence.	metres
28	Satellite elevation	Elevation angle between the satellite and the receiver location.	degrees
29	Satellite azimuth	Azimuth angle between the satellite and the receiver location.	degrees

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Sample:

```
SBASVAR vigo PA GPS 23 2015 165 5088.00 1849 5088.00 120 1.4270 1.0975 0.9119
1.000 27 0.1856 0.0000 0.0000 0.0000 0 0.8173 0.1318 0.3830 0.360 0.131 0.000
65.512 66.455
```

The data source indicator for Delta UDRE in field 16 may have the following values:

- 27 or 28 for their respective message type
- -27 or -28 if received any of these message types but there was missing data for current satellite or was timed out, 0 if no message type received or both received.

When the '*' appears in field 1, it is due to smoothed code of the satellite has not reached steady-state, a SBAS processing mode switch or SBAS GEO switch. When a mode or GEO switch occurs, the SBAS corrections have to be computed again.

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12.1.15 SBASIONO

Print SBASIONO: SBAS ionosphere breakdown. It is shown when SBAS ionosphere can be computed. All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	SBASIONO	Fixed word indicating the data stored.	-
2	Receiver id	Receiver identification.	-
3	Mode	SBAS processing mode: PA, NPA.	-
4	GNSS	Satellite constellation (GPS, GAL, GLO or GEO).	
5	PRN	Satellite identifier	PRN
6	Year	Year number (4 digits).	years
7	DoY	Day of Year (3 digits).	days
8	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
9	GPS week	Week number in GPS Time. This field is related to the GPS week of the data snapshot used for the computations.	weeks
10	Time of week	Seconds elapsed since the beginning of the week. This field is related to the GPS number of seconds of the data snapshot used for the computations.	seconds
11	GEO PRN	GEO from which the SBAS corrections are used ('0' means all GEOs).	-
12	IPP Latitude	Latitude corresponding to the Ionospheric Pierce Point used to compute the ionospheric delay.	degrees (-90..90º)
13	IPP Longitude	Longitude corresponding to the Ionospheric Pierce Point used to compute the ionospheric delay.	degrees (0..360º)
14	Interpolation mode	Interpolation mode. 0 for square interpolation, [1-4] indicates the vertex not used in triangle interpolation.	-
15	IODI vertex 1	IODI (Issue of Data Ionospheric) for vertex 1.	-
16	Band Number for vertex 1	Band Number for vertex 1.	-
17	IGP vertex 1	IGP Number for vertex 1.	-
18	Vertex 1 IGP reception time	Time of reception of last bit of vertex 1 IGP (seconds of day).	seconds
19	Vertex 1 IGP latitude	Latitude of the IGP for vertex 1 (-90..90º).	degrees
20	Vertex 1 IGP longitude	Longitude of the IGP for vertex 1 (0..360º).	degrees
21	Vertex 1 delay	Ionosphere delay (raw value from MT26) for vertex 1.	L1 metres
22	Vertex 1 variance	Ionosphere variance (raw value from MT26) for vertex 1.	L1 metres^2
23	Vertex 1 ε_{iono}	Degradation term for vertex 1.	L1 metres
24	Vertex 1 delay interpolated	Ionosphere delay after interpolation (if required) for vertex 1.	L1 metres
25	Vertex 1 variance interpolated	Ionosphere variance after applying degradation and interpolation (if required) for vertex 1.	L1 metres^2
26	Vertex 1 weight	Interpolation weight for vertex 1.	-
27	IODI vertex 2	IODI (Issue of Data Ionospheric) for vertex 2.	-
28	Band Number for vertex 2	Band Number for vertex 2.	-
29	IGP vertex 2	IGP Number for vertex 2.	-
30	Vertex 2 IGP reception time	Time of reception of last bit of vertex 2 IGP (seconds of day).	seconds

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#	FIELD	DESCRIPTION	UNITS
31	Vertex 2 IGP latitude	Latitude of the IGP for vertex 2 (-90..90º).	degrees
32	Vertex 2 IGP longitude	Longitude of the IGP for vertex 2 (0..360º).	degrees
33	Vertex 2 delay	Ionosphere delay (raw value from MT26) for vertex 2.	L1 metres
34	Vertex 2 variance	Ionosphere variance (raw value from MT26) for vertex 2.	L1 metres^2
35	Vertex 2 ε_{iono}	Degradation term for vertex 2.	L1 metres
36	Vertex 2 delay interpolated	Ionosphere delay after interpolation (if required) for vertex 2.	L1 metres
37	Vertex 2 variance interpolated	Ionosphere variance after applying degradation and interpolation (if required) for vertex 2.	L1 metres^2
38	Vertex 2 weight	Interpolation weight for vertex 2.	-
39	IODI vertex 3	IODI (Issue of Data Ionospheric) for vertex 3.	-
40	Band Number for vertex 3	Band Number for vertex 3.	-
41	IGP vertex 3	IGP Number for vertex 3.	-
42	Vertex 3 IGP reception time	Time of reception of last bit of vertex 3 IGP (seconds of day).	seconds
43	Vertex 3 IGP latitude	Latitude of the IGP for vertex 3 (-90..90º).	degrees
44	Vertex 3 IGP longitude	Longitude of the IGP for vertex 3 (0..360º).	degrees
45	Vertex 3 delay	Ionosphere delay (raw value from MT26) for vertex 3.	L1 metres
46	Vertex 3 variance	Ionosphere variance (raw value from MT26) for vertex 3.	L1 metres^2
47	Vertex 3 ε_{iono}	Degradation term for vertex 3.	L1 metres
48	Vertex 3 delay interpolated	Ionosphere delay after interpolation (if required) for vertex 3.	L1 metres
49	Vertex 3 variance interpolated	Ionosphere variance after applying degradation and interpolation (if required) for vertex 3.	L1 metres^2
50	Vertex 3 weight	Interpolation weight for vertex 3.	-
51	IODI vertex 4	IODI (Issue of Data Ionospheric) for vertex 4.	-
52	Band Number for vertex 4	Band Number for vertex 4.	-
53	IGP vertex 4	IGP Number for vertex 4.	-
54	Vertex 4 IGP reception time	Time of reception of last bit of vertex 4 IGP (seconds of day).	seconds
55	Vertex 4 IGP latitude	Latitude of the IGP for vertex 4 (-90..90º).	degrees
56	Vertex 4 IGP longitude	Longitude of the IGP for vertex 4 (0..360º).	degrees
57	Vertex 4 delay	Ionosphere delay (raw value from MT26) for vertex 4.	L1 metres
58	Vertex 4 variance	Ionosphere variance (raw value from MT26) for vertex 4.	L1 metres^2
59	Vertex 4 ε_{iono}	Degradation term for vertex 4.	L1 metres
60	Vertex 4 delay interpolated	Ionosphere delay after interpolation (if required) for vertex 4.	L1 metres
61	Vertex 4 variance interpolated	Ionosphere variance after applying degradation and interpolation (if required) for vertex 4.	L1 metres^2
62	Vertex 4 weight	Interpolation weight for vertex 4.	-
63	Mapping function	Value of the mapping function.	L1 metres
64	Slant delay	Total slant delay.	L1 metres
65	Slant sigma	Total slant sigma.	L1 metres

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#	FIELD	DESCRIPTION	UNITS
66	Satellite elevation	Elevation angle between the satellite and the receiver location.	degrees
67	Satellite azimuth	Azimuth angle between the satellite and the receiver location.	degrees

Vertex 1 is the IGP north east to IPP, vertex 2 is the IGP north west to IPP, vertex 3 is the IGP south west to IPP, vertex 4 is the IGP south east to IPP. This order is shown in the following figure:

```
                    NORTH
                v2.............v1
                .             .
                .             .
                .             .
WEST            .    IPP      .        EAST
                .     *       .
                .             .
                .             .
                v3.............v4
                    SOUTH
```

When the '*' appears in field 1, it is due to smoothed code of the satellite has not reached steady-state, a SBAS processing mode switch or SBAS GEO switch. When a mode or GEO switch occurs, the SBAS corrections have to be computed again.

Sample:

```
SBASIONO    vigo  PA GPS  23 2015 165  5088.00 1849   5088.00 120   42.711
352.872 0 0  4  98  4899.1  45 355  2.000   0.5322  0.000   2.0000   0.5322 0.3114
0  4  73  4963.1  45 350  2.000   0.6735  0.000   2.0000   0.6735 0.2308 0  4  72
4963.1  40 350  2.125   0.5322  0.000   2.1250   0.5322 0.1948 0  4  97  4899.1
40 355  2.375   0.5322  0.000   2.3750   0.5322 0.2629   1.0875   2.3087   0.8173
65.51 66.46
```


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12.1.16 SBASUNSEL

Print SBASUNSEL: SBAS satellite unselection message. When a satellite is discarded due to MOPS criteria, this message details the reason. All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	SBASUNSEL	Fixed word indicating the data stored.	-
2	Receiver id	Receiver identification.	-
3	Mode	SBAS processing mode: PA, NPA.	-
4	GNSS	Satellite constellation (GPS, GAL, GLO or GEO).	
5	PRN	Satellite identifier	PRN
6	Year	Year number (4 digits).	years
7	DoY	Day of Year (3 digits).	days
8	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
9	GPS week	Week number in GPS Time. This field is related to the GPS week of the data snapshot used for the computations.	weeks
10	Time of week	Seconds elapsed since the beginning of the week. This field is related to the GPS number of seconds of the data snapshot used for the computations.	seconds
11	GEO PRN	GEO from which the SBAS corrections are used ('0' means all GEOs).	-
12	Error code	Number identifying the reason for discarding the satellite.	-
13	Error message	Message detailing the reason for discarding the satellite.	-

The error code in field 12 is a number which identifies the discard reason with a range from 1 to 48. Useful for parsing purposes.

Field 13 will be always between quotes in order to ease parsing purposes.

Fields 9 and 10 may have the following values:

ERROR CODE	ERROR MESSAGE
1	"No GEO satellites available"
2	"No data for user selected GEO"
3	"Not enough almanac or GEO navigation message to determine the GEO with highest elevation"
4	"Received alarm message for current GEO at epoch <YYYY DoY SoD>. Time remaining to finish alarm: <seconds> seconds"
5	"Received 4 or more consecutive messages with errors"
6	"Missed 4 or more consecutive messages"
7	"No PRN mask"
8	"PRN mask timed out"
9	"Satellite is not monitored in any of the PRN mask available"
10	"No message type 10 available [PA only]"
11	"Message type 10 timed out [PA only]"
12	"No fast correction data received for current PRN [PA only]"
13	"Sigma UDRE timed out [PA only]"
14	"Satellite flagged as 'Not monitored' (UDREI=14)"
15	"Satellite flagged as 'Do not use' (UDREI=15)"
16	"Satellite has an UDREI value of <value> [PA only]
17	"No fast correction degradation data [PA only]"

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ERROR CODE	ERROR MESSAGE
18	"Fast correction degradation data timed out [PA only]"
19	"Last PRC received timed out [PA only]"
20	"Only one PRC received. RRC calculation not possible [PA only]"
21	"RRC timed out (under alarm condition) due to time difference between PRC used [PA only]"
22	"RRC timed out (under alarm condition) due to excessive PRC propagation in time [PA only]"
23	"RRC timed out due to time difference between PRC used [PA only]"
24	"RRC timed out due to excessive PRC propagation in time [PA only]"
25	"Service message timed out [PA only]"
26	"Not received a full set of service messages with the same IODS [PA only]"
27	"No clock-ephemeris covariance matrix data for current satellite [PA only]"
28	"Clock-ephemeris covariance matrix data timed out [PA only]"
29	"No navigation data for ranging GEO"
30	"Ranging GEO navigation data timed out"
31	"URA index value of <value> for ranging GEO satellite"
32	"No long term correction data for current satellite [PA only]"
33	"Long term correction data timed out [PA only]"
34	"No broadcast block with IOD <value> [PA only]"
35	"No broadcast block available for current satellite (regardless of SBAS IOD) [NPA only]"
36	"Could not compute transmission time for current PRN measurement"
37	"No ionospheric grid mask [PA only]"
38	"Ionospheric grid mask timed out [PA only]"
39	"IGPs around ionospheric pierce point not found in MOPS grid [PA only]"
40	"Not enough IGPs available in ionospheric grid mask [PA only]"
41	"One IGP is set as don't use [PA only]"
42	"One or more IGPs is set as not monitored or has timed out [PA only]"
43	"Data not available for one or more IGPs [PA only]"
44	"Ionospheric pierce point is outside triangle [PA only]"
45	"External ionosphere model not available"
46	"Satellite is not in view (elevation <value>º)"
47	"Satellite elevation (<value>º) is too low"
48	"Satellite has an UDREI value of <value> (user threshold is <value>)"

Error code number 45 will only appear if user has selected another ionosphere model for SBAS processing.

Error codes number 46 and 47 will only appear in SBAS plots mode.

Sample:

```
SBASUNSEL   vigo  PA  31 2015 165   397.00 1849    397.00 120 16 "Satellite has an
UDREI value of 12 [PA only]".
```


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12.1.17 SBASOUT

Print SBASOUT: Receiver solution message. This message provides the estimated receiver position, protection levels and satellites used in solution computation. All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	SBASOUT	Fixed word indicating the data stored.	-
2	Receiver id	Receiver identification.	-
3	Mode	SBAS processing mode: PA, NPA.	-
4	Year	Year number (4 digits).	years
5	DoY	Day of Year (3 digits).	days
6	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
7	GPS week	Week number in GPS Time. This field is related to the GPS week of the data snapshot used for the computations.	weeks
8	Time of week	Seconds elapsed since the beginning of the week. This field is related to the GPS number of seconds of the data snapshot used for the computations.	seconds
9	GEO PRN	GEO from which the SBAS corrections are used ('0' means all GEOs).	-
10	ΔN	Receiver North difference in relation to nominal a priori position.	metres
11	ΔE	Receiver East difference in relation to nominal a priori position.	metres
12	ΔU	Receiver Up difference in relation to nominal a priori position.	metres
13	HPE	Horizontal positioning error.	metres
14	HPL	Horizontal protection level.	metres
15	VPE	Receiver vertical positioning error.	metres
16	VPL	Vertical protection level.	metres
17	Receiver clock offset	Offset associated to the receiver clock.	metres
18	Satellites in view	Number of satellites in view suitable for SBAS.	-
19	Satellites used in filter	Number of satellites used in SBAS solution computation.	-
20	List of satellites	Satellite list. Each following column is a '+' or '-' sign, the satellite system and the PRN identifier. The '+' sign indicates that the satellite has been used in the solution computation for SBAS. The '-' sign indicates that the satellite has not been used in the solution computation for SBAS. The satellite list will show first all the satellite with the '+' and after the ones with the '-' sign.	-

Sample:

```
SBASOUT vigo PA 2015 165 386.00 1849 386.00 120 0.3565 1.0723 -0.3439 1.1300
20.9835 21.8638 -94936.8124 11 10 +G23 +G17 +G01 +G04 +G10 +G11 +G03 +G06 +G31
+G32 -G09
```


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12.1.18 DGNSS Corrections

DGNSS corrections breakdown (DGNSS processing mode). It is shown when a model can be fully computed using DGNSS corrections for GPS C1C measurement. All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	DGNSS	Fixed word indicating the data stored. 'DGNSS' (if it is used in computation) or 'DGNSS*' (if it is not, switched to SPP)	-
2	Year	Year number (4 digits).	years
3	DoY	Day of Year (3 digits).	days
4	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
5	GNSS	Satellite constellation.	-
6	PRN	Satellite identifier.	-
7	PRC	Pseudorange correction to be applied to the satellite.	metres
8	RRC	Range rate correction to be applied to the satellite.	metres
9	RRC time	Seconds elapsed since the reception of the RRC correction.	seconds
10	Delta PRC	Delta of PRC to be applied in case of change in case of a change in ephemeris.	metres
11	Delta RRC	Delta of RRC to be applied in case of change in case of a change in ephemeris.	metres
12	Delta RRC time	Seconds elapsed since the reception of the delta RRC correction.	seconds
13	Total sigma	Sigma of the total residual error associated to the satellite Sigma of the total residual error = sigma of the UDRE + sigma degradation + sigma air	metres
14	Sigma UDRE	Sigma of the UDRE (User Differential Range Error).	metres
15	Sigma degradation	Sigma degradation consists of the URA (User Range Accuracy) degradation factor (we assume epsURA = 1 cm/s), and the satellite elevation. It only applies for RTCM v3.x Sigma degradation = (epsURA · dt) / tan(satellite elevation)	metres
16	Sigma air	Sigma air consists of the sigma multipath, the sigma to noise GPS (we assume 0.25 m) and the sigma inflation (equal to 1 if deactivated) Sigma degradation = (sigma multipath + sigma to noise GPS) * sigma inflation	metres
17	Sigma multipath	Sigma multipath = 0.0625 / tan(elev) / tan(elev)	metres
18	Sigma inflation	Sigma inflation during the convergence of the smoothing	-

Sample:

```
DGNSS     2016 294  5407.000 GPS  6  -4.1800   0.0000   1.5999   0.0000   0.0000
0.0000   0.6053   0.3000   0.0000   0.5257   0.0264   1.0000
```


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12.1.19 SATDIFF

Satellite difference message for products comparison mode (orbit and clock comparison). This message shows the difference between both orbit and clocks for two different OC products fonts for a specific time. It is shown each time step.

The SISRE fields are the Signal-in-Space Range Error, it is a measure of how the error impact a general receiver found in the Earth's surface. It is computed as:

SISRE = sqrt((radDiff-clkDiff)^2 + 1/49*(ctDiff^2 + atDiff^2))

Being:

radDiff, the difference of satellite positions in the radial component

clkDiff, the difference of satellite clock offsets

ctDiff, the difference of satellite positions in the cross-track component

atDiff, the difference of satellite positions in the along-track component

All time tags are in GPS time.

#	FIELD	DESCRIPTION	UNITS
1	SATDIFF	Fixed word indicating the data stored.	-
2	Year	Year number (4 digits).	years
3	DoY	Day of Year (3 digits).	days
4	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
5	GNSS	Satellite constellation.	-
6	PRN	Satellite identifier.	-
7	SISRE	SISRE difference	metres
8	SISRE	SISRE orbit-only difference	metres
9	3D	3D orbit difference	metres
10	Clock	Clock difference	metres
11	Radial	Radial position difference	metres
12	Along-Track	Along-track position difference	metres
13	Cross-Track	Cross-track position difference	metres
14	ΔX	X position difference	metres
15	ΔY	Y position difference	metres
16	ΔZ	Z position difference	metres

Sample:

```
SATDIFF 2006 200     0.00 GPS  1     4.1082     0.5359     1.1019    -3.5883
0.5176     0.5497     0.8025      1.527     0.4156     3.7061
```


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12.1.20 SATSTAT

Satellite difference summary message for products comparison mode (orbit and clock comparison). This message shows the differences between orbit and clocks for two different OC products fonts for a specific satellite. It is shown after all the comparisons are done, and presents a summary for each satellite.

#	FIELD	DESCRIPTION	UNITS
1	SATSTAT	Fixed word indicating the data stored.	-
2	GNSS	Satellite constellation.	-
3	PRN	Satellite identifier.	-
4	Total epochs	Number of samples	-
5-7	SISRE	SISRE comparisons (mean, RMS, stdDev)	metres
8-10	SISRE	SISRE orbit-only comparisons (mean, RMS, stdDev)	metres
11-13	3D	3D orbit comparisons (mean, RMS, stdDev)	metres
14-16	Clock	Clock comparisons (mean, RMS, stdDev)	metres
17-19	DCB	DCB comparisons (mean, RMS, stdDev)	L1 metres
20-22	Radial	Radial position comparisons (mean, RMS, stdDev)	metres
23-25	Along-Track	Along-track position comparisons (mean, RMS, stdDev)	metres
26-28	Cross-Track	Cross-track position comparisons (mean, RMS, stdDev)	metres

Sample:

```
SATSTAT  1   95     1.5530     2.1112     1.4302     0.9279     1.0058     0.3881
1.4115     1.4714     0.4155    -0.3357     1.9280     1.8985     0.8988
0.9938     0.4239     0.6081     0.9604     0.7433     0.1717     0.5050
0.4750
```


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12.1.21 SATSTATTOT

Difference summary message for products comparison mode (orbit and clock comparison). This message shows the statistics of the differences between orbit and clocks for two different OC products fonts. It is shown after all the comparisons are done, and presents a summary for all of them.

#	FIELD	DESCRIPTION	UNITS
1	SATSTATTOT	Fixed word indicating the data stored.	-
3-5	SISRE	SISRE comparisons (mean, RMS, stdDev)	metres
6-8	SISRE	SISRE orbit-only comparisons (mean, RMS, stdDev	metres
9-11	3D	3D orbit comparisons (mean, RMS, stdDev)	metres
12-14	Clock	Clock comparisons (mean, RMS, stdDev)	metres
15-17	DCB	DCB comparisons (mean, RMS, stdDev)	L1 metres
18-20	Radial	Radial position comparisons (mean, RMS, stdDev)	metres
21-23	Along-Track	Along-track position comparisons (mean, RMS, stdDev	metres
24-26:	Cross-Track	Cross-track position comparisons (mean, RMS, stdDev	metres

Sample:

```
SATSTATTOT 2660     1.2971     1.6206     0.9714     1.0207     1.1478     0.5250
1.6623     1.7701     0.6083    -0.1909     1.3835     1.3702     0.9488
1.1312     0.6160     0.0514     1.1930     1.1918    -0.0345     0.6560
0.6551
```


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12.1.22 SATPVT

Satellite data messages for show product mode. This message show the PVT data for a specific time and satellite. All time tags are in GPS time.

Coordinates are in WGS84 system except for BeiDou with broadcast orbits, which are in CGCS2000 system.

CGCS2000 system is aligned to WGS84 to a few centimetres, therefore, it is assumed that CGCS2000=WGS84.

#	FIELD	DESCRIPTION	UNITS
1	SATPVT	Fixed word indicating the data stored.	-
2	Year	Year number (4 digits).	years
3	DoY	Day of Year (3 digits).	days
4	Seconds of day	Seconds elapsed since the beginning of the day.	seconds
5	GNSS	Satellite constellation.	-
6	PRN	Satellite identifier.	-
7	Satellite position	X coordinate.	metres
8	Satellite position	Y coordinate.	metres
9	Satellite position	Z coordinate.	metres
10	Satellite velocity	X component of satellite velocity.	m/s
11	Satellite velocity	Y component of satellite velocity.	m/s
12	Satellite velocity	Z component of satellite velocity.	m/s
13	Satellite clock	Satellite clock offset	metres

Sample:

```
SATPVT 2006 199 79500.00 GPS  1  15340446.1662 -20066066.3778  -7929249.6479
1191.6479      2132.5615     -3023.0448     19826.4736
```


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12.1.23 SUMMARY

Print a statistical summary with the number of epochs processed, the number of epochs without solution and error percentiles (the latter only if receiver position is fixed). See section below.

- Print summary: The processing summary is printed at the end of the output file if the summary option is enabled. The contents of the summary are:
  - Number of epochs processed, along with the number epochs that had a solution.
  - Number of epochs skipped (epochs without solution).
  - Number of epochs missing during the summary period (if decimation is enabled, the epochs missing will be separated into the epochs which would have been decimated or not decimated.
  - Number of epochs missing in the whole file.
  - Number of data gaps during the summary period.
  - Number of data gaps in the whole file.
  - Maximum data gap size during the summary period and the epoch where it occurred.
  - Maximum data gap size in the whole file and the epoch where it occurred.
  - The 95 Percentile (or user defined percentile) of the PDOP,GDOP,TDOP,HDOP and VDOP.
  - The maximum value of PDOP,GDOP,TDOP,HDOP and VDOP and the epochs were it ocurred.
  - The 95 Percentile (or user defined percentile) of the errors.
  - The epoch with highest errors and the epoch were it ocurred.
  - A single line at the end with the previous info in columnar format. This is line is useful for doing plots.

  Additionally, for SBAS processing, the following information is provided:
  - Number of epochs with solution under alarm limits.
  - Number of epochs with MIs.
  - The Worst Integrity Ratio (WIR) and the epoch were it ocurred.
  - The epoch with highest protection levels and the epoch were it ocurred.
  - The 95 Percentile (or user defined percentile) of the protection levels.

  Additionally, for DGNSS processing, the following information is provided:
  - Number of epochs missing during the summary period in the reference station file (RINEX only).

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- Number of epochs missing in the whole file in the reference station file (RINEX only).
- Number of data gaps during the summary period in the reference station file (RINEX only)..
- Number of data gaps in the whole file in the reference station file (RINEX only)..
- Maximum data gap size during the summary period and the epoch where it occurred in the reference station file (RINEX only).
- Maximum data gap size in the whole file and the epoch where it occurred in the reference station file (RINEX only).

- Alarm Limits: The alarm limits are the maximum value of the protection levels (which are the estimation of the user error using the sigma provided by the SBAS system) computed in the navigation solution to consider that the system is available. That is, if the any of the horizontal or vertical protection levels are equal or greater to their respective horizontal or vertical alarm limits, it is considered that the SBAS system is not providing a solution good enough to meet the navigation precision or integrity requirements.

  Alarm limits are set by the navigation modes (APV-I, CAT-I, ...) defined by ICAO, and they do not affect in any way in the computation of the navigation solution or protection levels. Alarm limits only affect on the computation of the post-process statistics, in concrete:

  - Availability: The percentage of epochs where there was a solution in PA navigation mode with protection levels under both horizontal and vertical limits,
  - Continuity Risk: Is the probability to have a discontinuity (no solution in PA mode under alarm limits) during a time window. Typically the sliding window is set to 15 epochs.

  NOTE: APV-1 navigation mode sets the horizontal alarm limit to 40 metres.

- Precentile Value: Set the percentile value for the SBAS summary. For example, if using the default value of 95, and the computed 95 percentile of the horizontal error is 1 metre, it states that 95% of the epochs processed with solution had an horizontal error of 1 metre or less.

  NOTE: If receiver position is not fixed or provided with a reference file, this option is hidden, as no error can be computed (except in SBAS mode, as protection levels percentiles can be copmputed without reference position).

- Window Size (Sliding/Fixed): et the window size to compute the continuity risk. The continuity risk is the probability to have a discontinuity (no solution under alarm limits) during a time window. There are two methods to compute the continuity risk:

  - Sliding Window: When using a sliding window size of N samples, if in the current epoch a discontinuity occurs, all the previous N-1 samples (or the samples until the last discontinuity, whatever first occurs) plus the current one will be counted as epochs with continuty risk. Otherwise,

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if an epoch did not have a discontinuity, and during the following N samples no discontinuity occurred, that epoch will not be counted as epochs with discontinuity risk. The continuity risk is computed by dividing the number of epochs with continuity risk ($N_{EpochRisk}$) divided by the number of epochs with solution under alarm limits ($N_{EpochAvail}$):

$$\text{Continuity Risk} = N_{EpochRisk}/N_{EpochAvail}$$

- Fixed Window: When using a fixed window size of N samples, every time a discontinuity occurs, all the previous N epochs are counted as epochs with discontinuity, independently of the previous discontinuities. This is a more simple computation, but has the disadvantage that if several discontinuities occur in less than N epochs, the discontinuities will be counted more than once (this is typical in the SBAS coverage border), which may do that the total continuity risk become greater than 1. This effect can be mitigated by using large time spans. Moreover, if several discontinuities larger than the window size occur, the continuity risk value will be smaller compared to the sliding window continuity risk, as several epochs will not be counted to have discontinuities (the ones larger than the window size), and also due to that the continuity risk is computed using the total epochs processed, not the total epochs with solution. The continuity risk with fixed window is computed with the following formula:

  $$\text{Continuity Risk} = \text{CTI/MTBF} = \text{WindowSize}\cdot N_{Discontinuities}/N_{Processed_epochs}$$

  Where:

  CTI: Continuity Time Interval, which is the size of the fixed window.

  MTBF: Mean Time Between Failures, which is computed as the total epochs processed (NProcessed_epochs) divided by the number of discontinuities (NDiscontinuities)

This formula is from IALA (International Association of Marine Aids to Navigation and Lighthouse Authorities) document shown at RD-17.

NOTES:

- The Sliding Window is the method used in Airborne applications, while the Fixed Window is the method used for Maritime applications.
- gLAB will always compute the continuity risk with both methods.
- See SBAS maps manual (Help >User manuals >gLAB command line SBAS maps description) for more info on continuity risk computation.

- Ignore epochs for summary until epoch 0h 0m: All systems have a common step: the transitorian (or convergence) time. For example, for SBAS systems, in a cold start with standard configuration, the user has to wait around 5 minutes to get enough data from the GEO (this is what gLAB considers the GEO acquision time) or 6 minutes for the measurement smoothing to converge. Therefore, if a user wants to process 24 hours of data without convergence time, it has to add at least 6 minutes (but it recommend to put at least 15 minutes) of

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measurements (in the RINEX observation file) and SBAS messages from the previous day.

Once this extra epochs are added to the input, at the start of the day gLAB will have already converged, but this extra epochs will affect the computation of the statistics in the summary. In order to get around this issue, if this option is set, gLAB will detect if the RINEX observation files starts at 22h or later, and in that case, it will automatically consider that all the epochs from 22h to 23h 59m 59s are for convergence and they will be automatically skipped in the computation of the summary statistics. (note that the first epoch used in the summary will be printed in the summary).

NOTE: If option 'Start time of summary' below is set, this option has no effect.

- Start time of summary: Set the first epoch (in GPS time) to be considered for the summary.

  NOTES:

  - In order to set an end epoch for the summary, set the last processed epoch in the INPUT section ('End Time' option) to the desired epoch.
  - If this option is set, parameter 'Ignore epochs for summary until epoch 0h 0m' above will be ignored.

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12.1.23.1 SPP/PPP statistical summary

SPP or PPP statiscal summary. It is printed at the end of the output file if summary is enabled. All time tags are in GPS time.

```
SPP/PPP SUMMARY [SPP or PPP processing modes]

SPP or PPP statiscal summary. It is printed at the end of the output file if summary is enabled.

All time tags are in GPS time.

Sample:

INFO --------------------- SPP/PPP Summary ---------------------

INFO HDOP Threshold: 4.00

INFO PDOP Threshold: 6.00

INFO GDOP Threshold:30.00

INFO First epoch of summary: 27/10/2016 00:00:00.00 / 2016 301 0.00 / 1920 345600.00

INFO Lastepoch of summary: 27/10/2016 23:59:59.00 / 2016 301 86399.00 / 1920 431999.00

INFO Total epochs processed: 86293

INFO Total epochs processed with solution: 85932 ( 99.582% )

INFO Total epochs processed with solution and position from reference file: 85932 ( 99.582% )

INFO Total epochs omitted in summary due to no position from reference file: 0 ( 0.000% )

INFO Total epochs skipped due to no position from reference file for modelling: 0 ( 0.000% )

INFO Total epochs skipped due to less than 4 valid satellites available: 361 ( 0.418% )

INFO Total epochs skipped due to singular geometry matrix: 0 ( 0.000% )

INFO Total epochs skipped due to any DOP exceeding the threshold: 0 ( 0.000% )

INFO Total epochs skipped due to HDOP exceeding the threshold:0 ( 0.000% )

INFO Total epochs skipped due to PDOP exceeding the threshold:0 ( 0.000% )

INFO Total epochs skipped due to HDOP and PDOP exceeding the threshold: 0 ( 0.000% )

INFO Total epochs skipped due to GDOP exceeding the threshold:0 ( 0.000% )

INFO Total epochs skipped (any reason): 361 ( 0.418% )

INFO Total epochs missing in observation file (during summary period and not decimated): 1
```


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```
INFO Total epochs missing in observation file (during summary period and
decimated): 4

INFO Total epochs missing in observation file (during summary period): 5

INFO Total epochs missing in observation file (all the file): 13

INFO Number of data gaps in observation file (during summary period): 4

INFO Number of data gaps in observation file (all the file):7

INFO Maximum data gap size in observation file (during summary period):2 at
epoch 26/01/2018 23:50:04.00 / 2018 026 85804.00 / 1985 517804.00

INFO Maximum data gap size in observation file (all the file): 6 at epoch
25/01/2018 23:46:36.00 / 2018 025 85596.00 / 1985 431196.00

INFO PDOP95 Percentile: 2.33

INFO GDOP95 Percentile: 2.69

INFO TDOP95 Percentile: 1.34

INFO HDOP95 Percentile: 1.30

INFO VDOP95 Percentile: 1.98

INFO Maximum PDOP 3.04 at epoch 26/01/2018 23:52:30.00 / 2018 026 85950.00
/ 1985 517950.00

INFO Maximum GDOP 3.57 at epoch 26/01/2018 23:52:30.00 / 2018 026 85950.00
/ 1985 517950.00

INFO Maximum TDOP 1.87 at epoch 26/01/2018 23:52:30.00 / 2018 026 85950.00
/ 1985 517950.00

INFO Maximum HDOP 1.60 at epoch 26/01/2018 02:20:30.00 / 2018 0268430.00 /
1985 440430.00

INFO Maximum VDOP 2.66 at epoch 26/01/2018 23:52:30.00 / 2018 026 85950.00
/ 1985 517950.00

INFO First epoch of summary for computing positioning error percentiles:
27/10/2016 00:00:00.00 / 2016 301 0.00 / 1920 345600.00

INFO Lastepoch of summary for computing positioning error percentiles:
27/10/2016 23:59:59.00 / 2016 301 86399.00 / 1920 431999.00

INFO Total samples in Stanford-ESA processed: 111056799

INFO Total samples in Stanford-ESA processed with solution: 111056798 (
99.999% )

INFO Total samples in Stanford-ESA skipped due to singular geometry matrix:
1 ( 9.004E-07% )

INFO Horizontal95 Positioning Error Percentile: 0.80 metres

INFO Vertical95 Positioning Error Percentile: 1.73 metres

INFO Maximum Horizontal Positioning Error: 4.26 metres at epoch 27/10/2016
17:40:32.00 / 2016 301 63632.00 / 1920 409232.00

INFO Maximum Vertical Positioning Error: 7.53 metres at epoch 27/10/2016
17:40:32.00 / 2016 301 63632.00 / 1920 409232.00
```


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```
INFO Station: helg Lon: 7.89309376 Lat: 54.17448223 Height: 48.4689
HPE_Percentile:95 0.80 VPE_Percentile:95 1.73 MaxHPE: 0.00 MaxVPE: 0.00
Avail%: 0.000 PDOP_Percentile: 95 2.33 Max_PDOP: 3.04 GDOP_Percentile: 95
2.69 Max_GDOP: 3.57 TDOP_Percentile: 95 1.34 Max_TDOP: 1.87 HDOP_Percentile:
95 1.30 Max_HDOP: 1.60 VDOP_Percentile: 95 1.98 Max_VDOP: 2.66
Epochs_missing_Sum: 5 Epochs_missing_All_file:13 Num_DataGaps_Sum: 4
Num_DataGaps_All_file: 7 MaxSize_DataGap_Sum: 2 MaxSize_DataGap_All_file: 6
Station_Network_Name: Other
```

NOTES:

- If observation file starts at 22 hours or later, gLAB will automatically assume that all the epochs until the start of the next day (midnight) are for convergence time. During this convergence time, all the epochs computed will not be taken into account for the summary and the Stanford-ESA computation will be skipped. This behaviour can be disabled with the parameter '**--summary:waitfordaystart**'.
- If backwards processing is active, epochs missing and data gaps will only be counted during the forward processing.
- If receiver position is not fixed or provided by a reference file, the percentile lines will not appear.
- If user provides a reference file for comparing the solution and if at a certain epoch the reference file position is not available, the epoch will be skipped from the summary.
- The last line of the summary contains all the values of the previous lines along with the station coordinates.
- If receiver position is not fixed, the station coordinates will be the solution from the last computed epoch.
- The last line is useful for plotting world maps with data from each station.
- Stanford-ESA messages will not appear if Stanford-ESA computation has not been enabled.
- HDOP, PDOP and GDOP threshold messages will not appear if HDOP, PDOP or GDOP thresholds have not been enabled respectively.
- The lines referring to a reference file will only appear if a user sets a reference file. If user sets the reference file just for comparing the solution, the line "Total epochs omitted in ..." will appear. Otherwise, if the reference file was set to be used as the a priori position for the modelling computation, the line "Total epochs skipped due to no position from reference file ..." will appear.

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12.1.23.2 SBAS statistical summary

SBAS statistical summary. It is printed at the end of the output file if summary is enabled.

```
INFO --------------------- SBAS Summary ---------------------

INFO Horizontal Alarm limit:40.00 metres

INFO Vertical Alarm limit:50.00 metres

INFO HDOP Threshold: 4.00

INFO PDOP Threshold: 6.00

INFO GDOP Threshold: 100.00

INFO First epoch of summary: 27/10/2016 00:00:00.00 / 2016 301 0.00 / 1920
345600.00

INFO Lastepoch of summary: 27/10/2016 23:59:59.00 / 2016 301 86399.00 / 1920
431999.00

INFO Total epochs processed: 86293

INFO Total epochs processed with PA solution: 85932 ( 99.582% )

INFO Total epochs processed with PA solution under alarm limits: 85932 (
99.582% )

INFO Total epochs processed with PA solution and position from reference
file: 0 ( 0.000% )

INFO Total epochs processed with NPA solution: 0 ( 0.000% )

INFO Total epochs omitted in summary due to no position from reference file:
0 ( 0.000% )

INFO Total epochs skipped due to no position from reference file for
modelling: 0 ( 0.000% )

INFO Total epochs skipped due to less than 4 valid satellites available:
361 ( 0.418% )

INFO Total epochs skipped due to singular geometry matrix: 0 ( 0.000% )

INFO Total epochs skipped due to any DOP exceeding the threshold: 0 ( 0.000%
)

INFO Total epochs skipped due to HDOP exceeding the threshold:0 ( 0.000% )

INFO Total epochs skipped due to PDOP exceeding the threshold:0 ( 0.000% )

INFO Total epochs skipped due to HDOP and PDOP exceeding the threshold: 0 (
0.000% )

INFO Total epochs skipped due to GDOP exceeding the threshold:0 ( 0.000% )

INFO Total epochs skipped (any reason): 361 ( 0.418% )

INFO Total epochs missing in observation file (during summary period): 5

INFO Total epochs missing in observation file (all the file): 13

INFO Number of data gapsin observation file (during summary period): 4

INFO Number of data gapsin observation file (all the file):7
```


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```
INFO Maximum data gap size in observation file (during summary period):2 at
epoch 26/01/2018 23:50:04.00 / 2018 026 85804.00 / 1985 517804.00

INFO Maximum data gap size in observation file (all the file): 6 at epoch
25/01/2018 23:46:36.00 / 2018 025 85596.00 / 1985 431196.00

INFO PDOP95 Percentile: 2.33

INFO GDOP95 Percentile: 2.69

INFO TDOP95 Percentile: 1.34

INFO HDOP95 Percentile: 1.30

INFO VDOP95 Percentile: 1.98

INFO Maximum PDOP 3.04 at epoch 26/01/2018 23:52:30.00 / 2018 026 85950.00
/ 1985 517950.00

INFO Maximum GDOP 3.57 at epoch 26/01/2018 23:52:30.00 / 2018 026 85950.00
/ 1985 517950.00

INFO Maximum TDOP 1.87 at epoch 26/01/2018 23:52:30.00 / 2018 026 85950.00
/ 1985 517950.00

INFO Maximum HDOP 1.60 at epoch 26/01/2018 02:20:30.00 / 2018 0268430.00 /
1985 440430.00

INFO Maximum VDOP 2.66 at epoch 26/01/2018 23:52:30.00 / 2018 026 85950.00
/ 1985 517950.00

INFO Continuity Risk Airborne (15 epochs sliding window): 1.7456E-04

INFO Continuity Risk Maritime (15 epochs fixed window): 1.8156E-03

INFO First epoch of summary for computing MIs, PE, PL and percentiles:
27/10/2016 00:00:00.00 / 2016 301 0.00 / 1920 345600.00

INFO Lastepoch of summary for computing MIs, PE, PL and percentiles:
27/10/2016 23:59:59.00 / 2016 301 86399.00 / 1920 431999.00

INFO Total epochs with MIs: 0 ( 0.000% )

INFO Total epochs with Horizontal MIs: 0 ( 0.000% )

INFO Total epochs with Vertical MIs: 0 ( 0.000% )

INFO Total samples in Stanford-ESA processed: 111056799

INFO Total samples in Stanford-ESA processed with solution: 111056798 (
99.999% )

INFO Total samples in Stanford-ESA skipped due to singular geometry matrix:
1 ( 9.004E-07% )

INFO Total samples in Stanford-ESA with MIs: 219 ( 1.972E-04% )

INFO Total samples in Stanford-ESA with Horizontal MIs: 157 ( 1.414E-04% )

INFO Total samples in Stanford-ESA with Vertical MIs: 139 ( 1.252E-04% )

INFO Stanford-ESA Worst Horizontal Integrity Ratio: 1.6777

INFO Stanford-ESA Worst Vertical Integrity Ratio: 1.9140

INFO Horizontal95 Positioning Error Percentile: 0.80 metres
```


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```
INFO Vertical95 Positioning Error Percentile: 1.73 metres

INFO Horizontal95 ProtectionLevel Percentile:10.27 metres

INFO Vertical95 ProtectionLevel Percentile:16.50 metres

INFO Maximum Horizontal Positioning Error: 4.26 metres at epoch 27/10/2016
17:40:32.00 / 2016 301 63632.00 / 1920 409232.00

INFO Maximum Vertical Positioning Error: 7.53 metres at epoch 27/10/2016
17:40:32.00 / 2016 301 63632.00 / 1920 409232.00

INFO Maximum Horizontal ProtectionLevel:16.21 metres at epoch 27/10/2016
17:40:32.00 / 2016 301 63632.00 / 1920 409232.00

INFO Maximum Vertical ProtectionLevel:23.92 metres at epoch 27/10/2016
17:40:32.00 / 2016 301 63632.00 / 1920 409232.00

INFO Worst Horizontal Integrity Ratio: 0.5317 at epoch 27/10/2016
17:40:32.00 / 2016 301 63632.00 / 1920 409232.00

INFO Worst Vertical Integrity Ratio: 0.4763 at epoch 27/10/2016 17:40:32.00
/ 2016 301 63632.00 / 1920 409232.00

INFO Station: helg Lon: 7.89309376 Lat: 54.17448223 Height: 48.4689
HWIR:0.5317 VWIR:0.4763 MIs: 0 Hor_MIs: 0 Ver_MIs: 0 HPE_Percentile:95 0.80
VPE_Percentile:95 1.73 MaxHPE: 4.26 MaxVPE: 7.53 HPL_Percentile:9510.27
VPL_Percentile:9516.50 MaxHPL:16.21 MaxVPL:23.92 Avail%:99.582 Cont_Risk:
1.7456E-04 HWIR_ESA:1.6777 VWIR_ESA:1.9140 MIs_ESA:219 Hor_MIs_ESA:157
Ver_MIs_ESA:139 Cont_Risk_Mark: 0.0000E+00 PDOP_Percentile: 95 2.33
Max_PDOP: 3.04 GDOP_Percentile: 95 2.69 Max_GDOP: 3.57 TDOP_Percentile: 95
1.34 Max_TDOP: 1.87 HDOP_Percentile: 95 1.30 Max_HDOP: 1.60 VDOP_Percentile:
95 1.98 Max_VDOP: 2.66 Epochs_missing_Sum: 5 Epochs_missing_All_file:13
Num_DataGaps_Sum: 4 Num_DataGaps_All_file: 7 MaxSize_DataGap_Sum: 2
MaxSize_DataGap_All_file: 6 Station_Network_Name: Other
```

NOTES:

- If observation file starts at 22 hours or later, gLAB will automatically assume that all the epochs until the start of the next day (midnight are for convergence time. During this convergence time, all the epochs computed will not be taken into account for the SBAS summary and the Stanford-ESA computation will be skipped. This behaviour can be disabled with the parameter '**--summary:waitfordaystart**'.
- If receiver position is not fixed or provided by a reference file, the percentile lines will not appear.
- If user provides a reference file for comparing the solution and if at a certain epoch the reference file position is not available, the epoch will be skipped from the summary.
- The last line of the SBAS summary contains all the values of the previous lines along with the station coordinates.
- If receiver position is not fixed, the station coordinates will be the solution from the last computed epoch.
- The last line is useful for plotting world maps with data from each station.
- The fields at the end of the last line 'HWIR_ESA', 'VWIR_ESA', 'MIs_ESA', 'Hor_MIs_ESA' and 'Ver_MIs_ESA' correspond to the values computed in Stanford-ESA.

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- These fields will appear even if Stanford-ESA has not been enabled, but with a value of 0 (so its column number is fixed).
- Stanford-ESA messages will not appear if Stanford-ESA computation has not been enabled.
- HDOP, PDOP and GDOP threshold messages will not appear if HDOP, PDOP or GDOP thresholds have not been enabled respectively.
- Number of epochs with NPA epoch message will not appear if mode switching has not been enabled.
- If user forced NPA processing through parameters, then all values in SBAS summary will be referred to NPA mode.
- The lines referring to a reference file will only appear if a user sets a reference file. If user sets the reference file just for comparing the solution, the line "Total epochs omitted in ..." will appear. Otherwise, if the reference file was set to be used as the a priori position for the modelling computation, the line "Total epochs skipped due to no position from reference file ..." will appear.

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12.1.23.3 DGNSS statistical summary

DGNSS statistical summary. It is printed at the end of the output file if summary is enabled. All time tags are in GPS time.

```
INFO --------------------- DGNSS Summary ---------------------

INFO HDOP Threshold: 4.00

INFO PDOP Threshold: 6.00

INFO GDOP Threshold:30.00

INFO First epoch of summary: 27/10/2016 00:00:00.00 / 2016 301 0.00 / 1920 345600.00

INFO Last epoch of summary: 27/10/2016 23:59:59.00 / 2016 301 86399.00 / 1920 431999.00

INFO Total epochs processed: 86293

INFO Total epochs processed with DGNSS solution: 85932 ( 99.582% )

INFO Total epochs processed with SPP solution: 0 ( 0.000% )

INFO Total epochs processed with DGNSS solution and position from reference file: 85932 ( 99.582% )

INFO Total epochs omitted in summary due to no position from reference file: 0 ( 0.000% )

INFO Total epochs skipped due to less than 4 valid satellites available: 361 ( 0.418% )

INFO Total epochs skipped due to singular geometry matrix: 0 ( 0.000% )

INFO Total epochs skipped due to any DOP exceeding the threshold: 0 ( 0.000% )

INFO Total epochs skipped due to HDOP exceeding the threshold:0 ( 0.000% )

INFO Total epochs skipped due to PDOP exceeding the threshold:0 ( 0.000% )

INFO Total epochs skipped due to HDOP and PDOP exceeding the threshold: 0 ( 0.000% )

INFO Total epochs skipped due to GDOP exceeding the threshold: 0 ( 0.000% )

INFO Total epochs skipped (any reason): 361 ( 0.418% )

INFO Total epochs missingin rover observation file (during summary period):0

INFO Total epochs missingin rover observation file (all the file): 0

INFO Number of data gaps in rover observation file (during summary period):0

INFO Number of data gaps in rover observation file (all the file): 0

INFO Maximum data gap size in rover observation file (during summary period):0

INFO Maximum data gap size in rover observation file (all the file): 0

INFO Total epochs missingin reference station RINEX observation file (during summary period): 5
```


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```
INFO Total epochs missingin reference station RINEX observation file (all the file): 13

INFO Number of data gaps in reference station RINEX observation file (during summary period): 4

INFO Number of data gaps in reference station RINEX observation file (all the file):7

INFO Maximum data gap size in reference station RINEX observation file (during summary period): 2 at epoch 26/01/2018 23:50:04.00 / 2018 026 85804.00 / 1985 517804.00

INFO Maximum data gap size in reference station RINEX observation file (all the file):6 at epoch 25/01/2018 23:46:36.00 / 2018 025 85596.00 / 1985 431196.00

INFO PDOP95 Percentile: 2.33

INFO GDOP95 Percentile: 2.69

INFO TDOP95 Percentile: 1.34

INFO HDOP95 Percentile: 1.30

INFO VDOP95 Percentile: 1.98

INFO Maximum PDOP 3.04 at epoch 26/01/2018 23:52:30.00 / 2018 026 85950.00 / 1985 517950.00

INFO Maximum GDOP 3.57 at epoch 26/01/2018 23:52:30.00 / 2018 026 85950.00 / 1985 517950.00

INFO Maximum TDOP 1.87 at epoch 26/01/2018 23:52:30.00 / 2018 026 85950.00 / 1985 517950.00

INFO Maximum HDOP 1.60 at epoch 26/01/2018 02:20:30.00 / 2018 0268430.00 / 1985 440430.00

INFO Maximum VDOP 2.66 at epoch 26/01/2018 23:52:30.00 / 2018 026 85950.00 / 1985 517950.00

INFO First epoch of summary for computing positioning error percentiles: 27/10/2016 00:00:00.00 / 2016 301 0.00 / 1920 345600.00

INFO Lastepoch of summary for computing positioning error percentiles: 27/10/2016 23:59:59.00 / 2016 301 86399.00 / 1920 431999.00

INFO Total samples in Stanford-ESA processed: 111056799

INFO Total samples in Stanford-ESA processed with solution: 111056798 ( 99.999% )

INFO Total samples in Stanford-ESA skipped due to singular geometry matrix: 1 ( 9.004E-07% )

INFO Horizontal95 Positioning Error Percentile: 0.80 metres

INFO Vertical95 Positioning Error Percentile: 1.73 metres

INFO Maximum Horizontal Positioning Error: 4.26 metres at epoch 27/10/2016 17:40:32.00 / 2016 301 63632.00 / 1920 409232.00

INFO Maximum Vertical Positioning Error: 7.53 metres at epoch 27/10/2016 17:40:32.00 / 2016 301 63632.00 / 1920 409232.00
```


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```
INFO  Rover:  helg  Lon:  7.89309376  Lat:  54.17448223  Height:  48.4689
HPE_Percentile:95  0.80  VPE_Percentile:95  1.73  MaxHPE:  0.00  MaxVPE:  0.00
Avail%: 0.000 PDOP_Percentile: 95 2.33 Max_PDOP: 3.04 GDOP_Percentile: 95
2.69 Max_GDOP: 3.57 TDOP_Percentile: 95 1.34 Max_TDOP: 1.87 HDOP_Percentile:
95   1.30   Max_HDOP:   1.60   VDOP_Percentile:   95   1.98   Max_VDOP:   2.66
Epochs_missing_Rover_Sum:      0      Epochs_missing_Rover_All_file:      0
Num_DataGaps_Rover_Sum:       0       Num_DataGaps_Rover_All_file:       0
MaxSize_DataGap_Rover_Sum:     0     MaxSize_DataGap_Rover_All_file:     0
Epochs_missing_Ref_Sum:          5          Epochs_missing_Ref_All_file:13
Num_DataGaps_Ref_Sum:        4         Num_DataGaps_Ref_All_file:        7
MaxSize_DataGap_Ref_Sum:      2      MaxSize_DataGap_Ref_All_file:       6
Station_Network_Name: Other
```

NOTES:

- If observation file starts at 22 hours or later, gLAB will automatically assume that all the epochs until the start of the next day (midnight) are for convergence time. During this convergence time, all the epochs computed will not be taken into account for the summary and the Stanford-ESA computation will be skipped. This behaviour can be disabled with the parameter '--summary:waitfordaystart'.
- If rover position is not provided, the percentile lines will not appear.
- If user provides a reference file for comparing the solution and if at a certain epoch the reference file position is not available, the epoch will be skipped from the summary.
- If rover position is not provided, the station coordinates will be the solution from the last computed epoch.
- The last line of the summary contains all the values of the previous lines along with the station coordinates.
- The last line is useful for plotting world maps with data from each station.
- Stanford-ESA messages will not appear if Stanford-ESA computation has not been enabled.
- HDOP, PDOP and GDOP threshold messages will not appear if HDOP, PDOP or GDOP thresholds have not been enabled respectively.
- The lines referring to a reference file will only appear if a user sets a reference file.

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12.2 *gLAB* DATA PROCESSING OPTIONS IN VERSION 5

The DPC is the processing tool of gLAB, it has been programmed in C with special care for the following objectives:

- Easy to use for an advanced user.
- Modularized, in order to incorporate future updates.
- Optimized for CPU and memory usage.

The options of the DPC are basically the same as the options of the GUI, with the exceptions taken in consideration in section 4.8 GUI Limitations. The DPC can be executed with the argument '-help', which will provide detailed information of the different arguments that can be used.

The following lines are an extract of the '-help' inline information:

NOTE:

Options with **green** background have changed their argument format in Version 6.

Options with **blue** background have changed their name and argument format in Version 6.

Options with **red** background have been deprecated in Version 6.

This Version 5 old name or argument format are still accepted (as it has backwards compatibility). gLAB will automatically detect them and parse them accordingly. For the options that apply to satellites, they will only be applied to GPS constellation.

A few options are shared within sections **SPP/PPP OPTIONS**, **SBAS OPTIONS** and **DGNSS OPTIONS**. Therefore, in order to avoid duplication, these options in section **SBAS OPTIONS** and **DGNSS OPTIONS** are linked to their description in section **SPP/PPP OPTIONS** with blue hyperlinks.

12.2.1 Work modes

gLAB can work in nine different modes:

- Positioning Mode	'Standard' mode, where all the processing is done, and a solution for a receiver is provided as OUTPUT messages. The minimum parameters required for this mode are an input observation file (**'-input:obs'**) and orbit and clock products (**'-input:nav'**, **'-input:sp3'** or **'-input:orb'/'-input:clk'**). Using precise products will also require the use of an ANTEX file (**'-input:ant'**). For SBAS processing, an additional input SBAS file (**'-input:sbas1f'**) is needed. For DGNSS processing, an additional input file (**'-input:dgnss'** or **'-input:rtcm'**) is needed.
- Show Input Mode	This mode only reads an input RINEX observation file and print its measurements. The parameter required for this mode is **'-input:obs'**, and specifically, no orbit and clock products should be provided (if provided, gLAB will switch to Positioning Mode).

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- Product Comparison Mode	This mode reads and compares two different sources of orbit and clock products. In order to use this mode, **'-input:obs'** must be avoided, and two different orbit and clock products should be provided. This mode outputs the SATDIFF, SATSTAT and STASTATTOT messages.
- Show Product Mode	This mode reads a single source of orbit and clock products. In order to use this mode, **'-input:obs'** must be avoided, and a single orbit and clock product should be provided. This mode output SAT messages
- Convert mode	Only for SBAS. If the parameter **'-onlyconvert'** is given, gLAB will just generate a RINEX-B 2.11 or EMS or Pegasus files (depending on the parameters) and it will not process any GNSS data. The minimum parameters for this mode are an SBAS file (**'-input:sbas1f'**), the **'-onlyconvert'** parameter and an output file format (**'-output:rinexb'**, **'-output:ems'**, **'-output:pegasus'**)
- SBAS Plots Mode	This mode is activated when only a navigation file and a SBAS file are given. In this mode, three plots are computed: SBAS Availability, SBAS Continuity Risk and SBAS Ionosphere Corrections Availability. The three plots are computed in PA mode in the delimited (squared) region and resolution during one day (the Availability and Continuity Risk are computed at a one second rate, while the Ionosphere Corrections Availability is computed at a 300 seconds rate by default). For the three plots the values are computed for a Fault-Free receiver (no data gaps, no cycle-slips). For SBAS Availability plots, an epoch at a given latitude and longitude and height (by default is the WGS84 geoid level -0 metres-) is considered to be available when both the Horizontal and Vertical Protection Levels are below their respective alarm limits. For SBAS Continuity Risk plot, it is computed the probability of having a discontinuity (i.e. no SBAS PA solution) during the next 15 seconds (i.e. using a sliding window of 15 seconds) in aviation mode. In maritime processing, it is followed the IMO (International Maritime Organization) resolution A.1046 (27), which states that there will be only one discontinuity every 15 minutes, so each discontinuity will affect the previous 15 minutes (even if two consecutive discontinuity events occur in less than 15 minutes). See notes for SBAS maritime below. For SBAS Ionosphere Corrections Availability plot, each coordinate in the map is considered as a pierce point at 350 km height, and it is considered as available when a SBAS ionosphere can be computed at the given pierce point. The minimum parameters to activate this mode are the input navigation file (**'-input:nav'**) and the input SBAS message file (**'-input:sbas'**). The output files have to be processed with graph program (with **'--sbas'** parameter) in order to generate the plots.

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	The available output messages in this mode are INFO [default on], SBASIONO [default off] and SBASUNSEL [default off]. **Note:** With the default configuration, the computation time is around 2 hours. Increasing resolution or map size will significantly increase computation time.
- Add User Error to RINEX	This mode reads a RINEX observation file, a user added error file and creates a new RINEX observation file with the same header, version and number of measurements, but the measurements have the user error added into them. This mode is enabled by providing only and observation file and a user added error file with the parameters **'-input:obs'** and **'-input:usererror'**.
- Date Conversion	When **'-dateconv:calendar'** or **'-dateconv:doy'** or **'-dateconv:gpsweek'** or **'-dateconv:mjdn'** are provided, gLAB will read the date from user input and convert it to all other date formats, print them in screen and exit.
- Coordinate Conversion	When **'-coordconv:cartesian'** or **'-coordconv:geodetic'** or **'-coordconv:spherical'** are provided, gLAB will read the coordinates from user input and convert it to all other coordinate systems, print them in screen and exit.

12.2.1.1 GENERAL OPTIONS

-help	Shows gLAB help in the command prompt
-messages	Shows the fields of each output message (see Section 12.1).
-examples	Shows some examples to call the program.
-config	Shows some info on the configuration file.
-usererrorfile	Shows an example of user-defined error configuration file.
-sigmamultipathfile	Shows an example of user multipath model configuration file.
-rtcmv2conversioninfo	Shows detailed information of the text files generated from a RTCM v2.x conversion.
-referenceposfile	Shows an example of reference position file.
-sbasplotsinfo	Shows detailed info on how to generate SBAS maps.

12.2.2 SPP/PPP options

This section gathers the gLAB options of processing of a GNSS RINEX observation data file under the Standard Point Posiitoning (SPP) and Precise Point Positonig (PPP) modes

NOTE: Some options have changed its name of argument format from version 5. This old name or argument format are still accepted (as it has backwards compatibility). gLAB will automatically detect them and parse them accordingly. For the options that apply to satellites, they will only be applied to GPS constellation.

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12.2.2.1 INPUT OPTIONS

-input:cfg <file>	Sets the input configuration file.
-input:obs <file>	Sets the input RINEX observation file.
-input:nav <file> [...]	Sets the input RINEX navigation message files. Up to 7 files may be provided (one per constellation). **Note:** If two RINEX navigation files are provided and no observation file is given, gLAB will enter in orbit comparison mode. If one RINEX navigation file is provided and one SP3 file is provided file and no observation file is given, gLAB will enter in orbit comparison mode.
--input:sp3 <file> [<file>]	Sets the input SP3 orbits and clocks file. **Note:** If two SP3 files are provided and no observation file is given, gLAB will enter in orbit comparison mode.
-input:orb <file> [<file>]	Sets the input SP3 orbits (only reads the satellite coordinates, but not the clocks). **Note:** If two SP3 files are provided and no observation file is given, gLAB will enter in orbit comparison mode.
-input:clk <file>	Sets the input clock file. The number of clock files must match the number of SP3 files provided with option **'-input:orb'**.
-input:con <file>	Sets the input constellation status file (default GPSConstellationStatus.txt).
-input:ant <file>	Sets the input ANTEX satellite/receiver antenna data file.
-input:klb <file>	Sets the input RINEX navigation file for Klobuchar corrections, if this parameter is avoided, it is used the -input:nav file.
-input:neq <file>	Sets the input RINEX navigation file for NeQuick corrections, if this parameter is avoided, it is used the -input:nav file.
-input:bds <file>	Sets the input RINEX navigation file for BeiDou corrections, if this parameter is avoided, it is used the -input:nav file.
-input:inx <file>	Sets the input IONEX file for ionospheric corrections.
-input:fppp <file>	Sets the input FPPP file for ionospheric corrections.
-input:sbasiono <file>	Sets the input RINEX-B or EMS SBAS file for ionospheric corrections.
-input:dcb <file> [...]	Sets the input DCB source from a .DCB file, a RINEX navigation file, a IONEX file or a FPPP file. **Note:** If more than one file is given for the same model, the last one will be used.
-input:rec <file>	Sets the input GPS receiver types file (default GPS_Receiver_Types) for DCB usage.
-input:snx <file>	Sets the input SINEX file for receiver position.
Note:	

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- The use of **'-input:nav'** file will preconfigure the parameters to work in the Standard Point Positioning (SPP). - The use of **'-input:sp3'/'-input:orb'/'-input:clk'** will preconfigure the parameters to work in the Precise Point Positioning (PPP) approach. All the values can be overridden by specifying the parameters. See below for more details which are the defaults for each mode. - The use of **'-input:sbas'** will preconfigure the parameters to work in SBAS mode. - The use of any **'-input:rtcm'** without a **'-input:obs'** will result into converting the input RTCM to its corresponding output.

12.2.2.2 PREPROCESSING OPTIONS

-pre:starttime <date>	Set the start time (in GPS time) for processing data. The following date formats are accepted: YYYYMMDD HH:MM:SS (HH in 24 hour format); YYYY/MM/DD HH:MM:SS (HH in 24 hour format); YYYY/DoY SoD; GPSWeek SoW. Example: -pre:starttime 2015/183 62000
-pre:endtime <date>	Set the end time (in GPS time) for processing data. See **'-pre:starttime'** option above for date formats.
-pre:dec #	**# = number:** Decimate input data by # seconds. [default 0 for SPP/PPP/DGNSS, 1 for SBAS] **Note:** Maximum resolution is 4 decimals digits. If # is 0, all epochs are processed. In product comparison mode (see below, in 'WORK MODES'), it sets the time step of the comparisons.
-pre:sat [+-]g#[-#]	Include/exclude satellites from processing in a comma separated list. **[+-]** = Optional symbols for selecting (with a plus '+') or unselecting (with a minus '-'). If no symbol is provided, the default behavior is to unselect satellites. **g** = Character determining GNSS constellation (G->GPS). **#** = PRN number (If #=0, all satellites of the selected GNSS constellation will be unselected). **[-#]** = Optionally, a minus sign ('-') and a second PRN number can be provided in order to set a range of satellites (of the same constellation).

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-pre:snr	Enable SNR (Signal to Noise Ratio) deselection. The SNR is read from the observation file. [default on only in SBAS and DGNSS]. If no SNR is present in the observation file, no deselection is done. The default threshold is 33 dBHz If no SNR is present in the observation file, no deselection is done. The default threshold is 33 dBHz.
-pre:snrsel g#[-#] <val>	Set a SNR threshold for a given satellite. If this option is given, SNR deselection will be activated. **g** = Character determining GNSS system (G->GPS) **#** = PRN number. If #=0, then the threshold will be applied to all satellites of the selected GNSS system **[-#]** = Optionally, a minus sign ('-') and a second PRN number can be provided in order to set a range of satellites (of the same constellation) **<val>** = Value for SNR threshold in dBHz. This value is compared to the SNR obtained from the RINEX file in all code and carrier phase measurements. If no SNR value is present in the RINEX file, this value will be omitted.
-pre:elevation <val>	Elevation mask. Satellites below this threshold will be discarded (in degrees). [default 5]
-pre:eclipse	Discard satellites under Earth eclipse. [default: enabled for PPP, disabled for SPP]
-pre:availf g#	Mark frequencies available. [default all] **g** = Character determining GNSS constellation (G->GPS). **#** = PRN number. If #=0, then the threshold will be applied to all satellites of the selected GNSS constellation. **Sample:** **'-pre:availf G12'** => Frequencies 1 and 2 of GPS available for all satellites. **'-pre:availf G1'** => Frequency 1 of GPS available, 2 unavailable.
-pre:smooth <val>	Number of epochs of smoothing. [default 0 (disabled) for non SBAS processing, default 100 for SBAS processing]
-pre:smoothmeas <n> <meas>	Smooth measurement in filter **<n>** with measurement type **<meas>**. In general, **<n>** is a pseudorange and **<meas>** a carrier phase, see option **'-filter:select'** for more information in the selection of measurements to be used in the filter. **<meas>** values for carrier phase smoothing are: L1P, L2P, IF (Iono-free) and DF (divergence-free).
-pre:smoothmin <val>	Number of epochs of continuous code smoothing before steady-state operation. [default 0 for non SBAS processing, 360 for SBAS processing] **Note:** Satellites will be excluded until reaching this steady-state.
-pre:refpos:deg <val>	Set the interpolation degree for the reference position values. [default 0]

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-pre:setrectype <val>	**<val> = gpsrt:** Set the receiver type as the one specified in the GPS_Receiver_Types file (provided by **'-input:rec'**). [default if **'-input:rec'** provided] **<val> = 0:** Set the receiver type as 'Unknown'. [default] **<val> = 1:** Set the receiver type as 'Cross-correlated'. In this mode, P2 will be corrected with the DCB of P1-C1. **<val> = 2:** Set the receiver type as 'No P1'. In this mode, C1 will be used instead of P1. **<val> = 3:** Set the receiver type as 'Consistent measurements'.
-pre:prealign	Prealign carrier phase measurements with its corresponding pseudorange. [default on]
-pre:checkcodejumps	Check for pseudorange jumps and adjust the phase accordingly. See **'Notes for preprocessing'** below. [default on]
--pre:checkcodejumps	Do not check for pseudorange jumps.
-pre:cs:datagap <val>	Data gap. Maximum period of time, without measurements, allowed before declaring cycle-slip (in seconds). [default 40 in SPP/PPP, 10 in SBAS and DGNSS] **Note:** If <val> is shorter than the sampling rate, all measurements will be discarded
-pre:cs:lli	Use Loss of Lock Indicator for cycle-slip detection. [default off]
--pre:cs:lli	Do not use Loss of Lock Indicator for cycle-slip detection. [default off]
-pre:cs:ncon	Use N-consecutive epochs for cycle-slip detection. [default on in SPP and PPP]
--pre:cs:ncon	Do not use N-consecutive epochs for cycle-slip detection. [default off in SBAS and DGNSS]
-pre:cs:ncon:min <val>	After a short data gap (i.e., shorter than the value set in **'-pre:cs:datagap'** with default of 40 seconds) discard the first <val> epochs. **Note:** If sampling interval is greater than 15 seconds, gLAB will automatically disable this option. [default 2]
-pre:cs:li	Use the carrier phase geometry-free combination (LI) for cycle-slip detection (2 frequencies). [default in PPP]
--pre:cs:li	Do not use carrier phase geometry-free combination (LI) for cycle-slip detection (2 frequencies). [default in SPP] **Note:** LI combination is a slow varying function which only has ambiguity and ionosphere. Each epoch and satellite an expected LI value is computed and compared against the measured one, if this difference is above a certain threshold, a cycle-slip is marked.

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	This threshold is (max + (min-max)*exp(-dt/t)), being dt the time between epochs.
-pre:cs:li:maxjump <val>	Maximum jump threshold (in metres) between two consecutive measured LI values. [default 1]
-pre:cs:li:max <val>	Maximum threshold (in metres) between estimated and measured LI values. [default 0.08]
-pre:cs:li:t0 <val>	Time constant (in seconds) to set the threshold between maximum and minimum [default 60]
-pre:cs:li:samples <val>	Minimum number of epochs needed to fit the second-degree polynomial. [default 7]
-pre:cs:bw	Use Melbourne-Wubbena (BW) for cycle-slip detection (2 frequencies). [default in PPP]
--pre:cs:bw	Do not use Melbourne-Wubbenna (BW) for cycle-slip detection (2 frequencies). [default in SPP] **Note:** BW combination is a mixed combination between carrier phase and pseudoranges. This combination is free of ionosphere and geometry, thence constant, but has a high noise (due to the pseudorange measurements used). If this noise is low enough, it is straightforward to detect cycle-slips, but in noisy environments BW is not able to detect cycle-slips. The algorithm using BW computes the mean and the standard deviation of the last epochs in order to obtain an estimated value and the noise level of the combination. The estimated value is compared against the measured value, and the noise level is used for the threshold of this difference. Difference must be lower than standard deviation multiplied by a number (k-factor). This threshold has minimum (min) and maximum (max) saturation values.
-pre:cs:bw:siginit <val>	Initial standard deviation (in metres) to use in BW after a cycle-slip. [default 2]
-pre:cs:bw:sigmin <val>	Minimum threshold (in metres) between estimated and measured BW values in relation to its standard deviation. [default 0.8]
-pre:cs:bw:timewindow <val>	Number of epochs to compute the mobile mean over the Hatch filter. [default 300]
-pre:cs:bw:kfactor <val>	Relation between estimated and measured BW values in relation to its standard deviation. [default 5]
-pre:cs:bw:samples <val>	Minimum number of epochs needed to stabilize the mean and sigma in the BW cycle-slip detector. [default 2]
-pre:cs:l1c1	Use the L1-C1 combination for single frequency cycle-slip detection. [default in SPP]
--pre:cs:l1c1	Do not use the L1-C1 combination for single frequency cycle-slip detection. [default in PPP]
-pre:cs:l1c1:unconcheck	Use the unconsistency check in single frequency cycle-slip detection (L1-C1). [default]

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--pre:cs:l1c1:unconcheck	Do not use the unconsistency check in single frequency cycle-slip detection (L1-C1).
-pre:cs:l1c1:unconcheck:th <val>	
	Threshold (in metres) for the unconsistency check in single frequency cycle-slip detection (L1-C1). [default 20] **Note:** The single frequency cycle-slip detector averages the difference between carrier phase and pseudorange measurements for several epochs. This cycle-slip detection method is very useful for single-frequency receivers, as it only requires measurements from one frequency. As a counterpart, the ionospheric term is different for code and phase, thence, this combination will tend to diverge. It becomes necessary to set a smoothing window to limit this divergence (-pre:cs:sf:timewindow). This makes that this method becomes a bit limited with data rates too low. Ideally this method should be used with rates of 1 Hz.
-pre:cs:l1c1:kfactor <val>	Relation between estimated and measured L1-C1 values in relation to its standard deviation. [default 5]
-pre:cs:l1c1:timewindow <val>	Number of epochs to limit the L1-C1 ionosphere divergence. [default 300]
-pre:cs:l1c1:samples <val>	Minimum number of epochs needed to stabilize the mean and sigma in the L1-C1 cycle-slip detector [default 2]
-pre:cs:l1c1:init <val>	Initial standard deviation for the threshold calculation in the L1-C1 [default 3] (m)
-pre:usererrorafter	Add user defined error after prealigning, checking cycle-slips and smoothing. [default off]

12.2.2.3 MODELLING OPTIONS

(use -model:... to activate, --model:... to deactivate)

-model:iono <val>	**<val> = no:** Do not correct ionosphere. [default in PPP] (equivalent to **'--model:iono'**) **<val>=Klobuchar:** Correct measurements with Klobuchar model. [default in SPP] **<val> = NeQuick:** Correct measurements with NeQuick model. **<val> = BeiDou:** Correct measurements with BeiDou model. **<val> = IONEX:** Correct measurements with IONEX file data. **<val> = FPPP:** Correct measurements with FPPP file data.**<val> = SBAS:**

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	Correct measurements with SBAS iono corrections (but do not apply any other SBAS correction). **Note:** If more than one iono model option is given, the last one will be used.
-model:trop	Correct troposphere delay. [default on]
--model:trop	Do not correct troposphere delay.
-model:trop:nominal <val>	**<val> = Simple:** Compute a simple tropospheric nominal depending on receiver's height over the sea level. [default in PPP] **<val> = UNB3:** Troposphere nominals are calculated from the receiver's height and estimates of five meteorological parameters: pressure, temperature, water vapour pressure, temperature lapse rate and water vapour lapse rate. **Note:** It is adopted by SBAS systems (see RTCA-MOPS, 2006). [default in SPP]
-model:trop:mapping <val>	**<val> = Simple:** Compute the mapping as the obliquity factor described in Black and Eisner, 1984. This mapping only depends on satellite elevation and it is common for wet and dry components. [default in SPP] **<val> = Niell:** Compute the mapping described in A.E. Niell, 1996. This mapping considers different obliquity factors for the wet and dry components. [default in PPP]
-model:satclocks	Correct the measurements with the satellite clock offsets estimations. [default on]
-model:relclock	Correct the measurements with the relativistic clock model. [default on]
-model:satmovinflight	Consider satellite movement during signal flight time. [default on]
-model:earthrotinflight	Consider Earth rotation during signal flight time. [default on]
-model:satphasecenter	Correct satellite phase centre to mass centre corrections [default on in PPP, off in SPP]
-model:satphasevar	Correct satellite phase centre to mass centre corrections variations with zenith angle. [default off for SPP, on for PPP]
-model:recphasecenter <val>	**<val> = no:** Do not correct antenna receiver phase centre. [default in SPP] **<val> = ANTEX:** Use the ANTEX file to correct the antenna phase center. [default in PPP] **<val> = <nfreq> <dN> <dE> <dU> [...]:** Set dN, dE, dU as the receiver antenna phase centre for the frequencies and constellations provided: **<nfreq>** = Frequency number (typical for GPS, 1 and 2). **<dN>** = North correction [in metres].

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	<dE> = East correction [in metres]. **<dU>** = Up correction [in metres]. **Sample:** **-model:recphasecenter 1 0 0 0.11 -model:recphasecenter 2 0 0 0.128** **Note:** Typical AOAD/M_T antenna phase centre correction, 11 cm and 12.8 cm in the. Up component for frequencies 1 and 2.
-model:recphasevar	Correct antenna receiver phase centre variations. [default off in SPP, on in PPP]
-model:strictradome	When using ANTEX to correct the receiver phase centre, this option will force a perfect match between the antenna name and radome reported in the receiver RINEX file and the ones in the ANTEX file. If this option is disabled, and the radome is not found, the corrections will be used considering the radome "NONE". [default off]
-model:arp <val>	**<val> = no:** Do not apply any Antenna Reference Point (ARP) correction [default in SPP] (equivalent to **'--model:arp'**). **<val> = RINEX:** Use as ARP the information on the RINEX file (field 'ANTENNA: DELTA H/E/N'). [default in SBAS, DGNSS and PPP] <**val> = <dN> <dE> <dU>:** Set dN, dE, dU as the ARP: <dN> = North correction [in metres]. <dE> = East correction [in metres]. <dU> = Up correction [in metres]. **Note:** In DGNSS mode, if ARP correction is enabled, reference station coordinates will be always be read from reference. RINEX or RTCM file, while rover ARP will be read from RINEX or set from user values.
-model:dcb:p1c1 <val>	GPS DCB to convert C1 to P1 or for correcting P2 measurements (depending on GPS receiver type). It may be applied to C1 or P2 measurements in single frequency or dual frequency combinations. **<val> = no:** Do not correct Differential Code Biases between P1 and C1 codes (equivalent to **'--model:dcb:p1c1'**). Do not identify C1 and P1 never. **<val> = flexible:** Do not correct Differential Code Biases between P1 and C1 codes [default]. Identify C1 and P1 when one of them is missing. **<val> = strict:** Correct Differential Code Biases between P1 and C1 codes. Identify C1 and P1 when applicable (defined by the receiver type).

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-model:dcb:p1p2 <val>	GPS Differential DCB between P1 and P2 (or L1P(Y) and L2 P(Y)). To be applied in single frequency measurements. **<val> = no:** Do not correct Differential Code Biases between codes (equivalent to **'--model:dcb:p1p2'**). [default in PPP] **<val> = RINEX:** Correct Differential Code Biases between codes using TGDs from the RINEX navigation file. [default in SPP, EGNOS, DGNSS] **<val> = DCB:** Correct Differential Code Biases between codes P1 and P2 from a precise CODE DCB file Identify C1 and P1 when applicable (defined by the receiver type). **<val> = IONEX:** Correct Differential Code Biases between codes P1 and P2 using DCB from IONEX file. **<val> = FPPP:** Correct Differential Code Biases between codes P1 and P2 using DCB from FPPP file.
-model:windup	Correct the wind up term for carrier phase measurements. [default in PPP, off in SPP, SBAS, DGNSS]
-model:solidtides	Correct the Earth surface deformation due to solid tides. [default in PPP, off in SPP, SBAS, DGNSS]
-model:relpath	Correct the path range delay term due to the gravitational gradient between receiver and transmitter. [default on in PPP, off in SPP, SBAS, DGNSS]
-model:sathealth	Only valid when using broadcast products. Use the healthy flag of the navigation message. [default enabled in all modes except SBAS]
-model:brdctranstime	Only valid when using broadcast products. Check that transmission time of message is equal or before the current epoch of current time. [default on for non SBAS processing, off for SBAS processing]
-model:maxurabrdc <val>	Only valid when using broadcast products. Set the discard threshold for satellites which have an URA value equal or greater than this value (in metres). [default off]
-model:orbit:deg <val>	Precise orbit interpolation degree. [default 10]
-model:clk:deg <val>	Precise clock interpolation degree. [default 1]
-model:orbmaxgaps <val>	Set maximum number of gaps between samples used for precise orbit interpolation. [default 8]
-model:clkmaxgaps <val>	Set maximum number of gaps between samples used for precise clock interpolation. [default 2]
-model:orbtotmaxgaps <val>	Set the maximum number of gaps between all samples used for precise orbit interpolation. [default 16]
-model:clktotmaxgaps <val>	Set the maximum number of gaps between all samples used for precise clock interpolation. [default 4]
-model:orbprevsample	When a concatenated SP3 file is read for orbit data, if the last epoch of the previous day is the same as the first epoch of the

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	current day, use the last orbit sample of the previous day instead of the first sample of the current day. [default off] **Note:** This typically occurs with samples at epoch 0h 0m. This option will only have effect if both repeated samples have valid values.
-model:clkprevsample	When a concatenated SP3/Clock file is read for clock data, if the last epoch of the previous day is the same as the first epoch of the current day, use the last orbit sample of the previous day instead of the first sample of the current day. [default off] **Note:** This typically occurs with samples at epoch 0h 0m. This option will only have effect if both repeated samples have valid values.

12.2.2.4 FILTERING OPTIONS

-filter:stepdetector	Check for jumps in measurements using the prefits residuals (only for C1C measurement). [default off] **Note:** Use **'--filter:stepdetector'** to disable it.
-filter:prefitoutliers:median <val>	
	<val> Check for outliers in the prefits residuals using the median, with **<val>** (in metres) as the threshold. [default off] **Note:** Use **'--filter:prefitoutliers:median'** or **'-filter:prefitoutliers:median 0'** to disable it. See notes on prefit outlier detectors below.
-filter:prefitoutliers:abs <val>	**<val>** Check for outliers in the prefits residuals comparing absolute values, with **<val>** (in metres) as the threshold. [default off] **Note:** Use **'--filter:prefitoutliers:abs'** or **'-filter:prefitoutliers:abs 0'** to disable it. See notes on prefit outlier detectors below.
-filter:trop	Estimate the troposphere of the station. [default in PPP with carrier phase] (**'--filter:trop'** to disable it)
-filter:nav <nav>	**<nav> = static:** Process supposing a static receiver. [default in PPP] **<nav> = kinematic:** Process supposing a moving receiver. [default in SPP]
-filter:meas <meastype>	**<meastype> = pseudorange:** Use only pseudorange for positioning. **<meastype> = = carrierphase:** Use pseudorange and carrier phase for positioning. [default]
-filter:select <num> <meas1> <meas2> ...	

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	Select the measurements or combinations to include in the filtering. **<num>** = Number of measurements/combinations **<measN>** = List of measurements/combinations **[Defaults]:** PPP - Pseudorange => 1 PC **[Defaults]:** PPP - Carrierphase => 2 PC LC **[Defaults]:** SPP - Pseudorange => 1 C1C **[Defaults]:** SPP - Carrierphase => 2 C1C L1P:
-filter:fixedweight <n> <a>	Apply the specified standard deviation to the measurement 'n', to be used as weight in the filter. **<n>** = Measurement number. If <n> is 0, it will be applied to all measurements in the filter. **<a>** = URA, Use the URA value from the broadcast message (not valid in PPP); = #, Value for the standard deviation of the measurement (metres). The filter shall apply as weight = 1/(<a>^2). **Sample:** **'-filter:fixedweight 1 2':** Set 2 metres of standard deviation to measurement 1 in filter **'-filter:fixedweight 2 0.01':** Set 1 centimetre of standard deviation to measurement 2 in filter. **Defaults:** **PPP:** Pseudorange->1m, Carrierphase->0.01m. **SPP:** Pseudorange->5m, Carrierphase->0.10m.
-filter:fixedweightsat g#[-#] <n> <a>	
	Apply the specified standard deviation to a specific satellite of the measurement 'n'. **g** Character determining GNSS system (G->GPS). **#** PRN number. If #=0, it will be applied to all satellites of the selected GNSS system. **[-#]** Optionally, a minus sign ('-') and a second PRN number can be provided in order to set a range of satellites (of the same constellation). **<n>** = Measurement number. If <n> is 0, it will be applied to all measurements in the filter. **<a>** = URA, Use the URA value from the broadcast message (not valid in PPP); = #, Value for the standard deviation of the measurement (metres). The filter shall apply as weight = 1/(<a>^2). **Note:** When this option is provided, it will override any other sigmas provided by **'-filter:fixedweight'** or **'-filter:elevweight'** or the sigmas provided by SBAS or DGNSS
-filter:elevweight <n> <a> <b> <c>	
	Apply the specified values to compute the standard deviation of the measurement 'n'. **std = a + b * e^(-elevation/c)**

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	<n> = Measurement number. If <n> is 0, it will be applied to all measurements in the filter. **<a>** = URA, Use the URA value from the broadcast message (not valid in PPP); = #, Value for minimum standard deviation of the measurement [weight at elevation 90 degrees] (metres). **<b>** **:** Multiplier to e [standard deviation at elevation 0 degrees] (metres). **<c>** **:** Elevation constant (degrees). The filter shall apply as weight = 1/(std^2). **Sample (default values):** **'-filter:elevweight 1 0.13 0.53 10':** Apply the standard deviation: 0.13+0.53*e^(-elevation/10). **Note:** **'-filter:elevweight 1 x 0 y'** equals to **'-filter:fixedweight 1 x'.**
-filter:elevweightsat g#[-#] <n> <a> <b> <c>	
	Apply the specified standard deviation to a specific satellite of the measurement 'n'. **g** Character determining GNSS system (G->GPS). **#** PRN number. If #=0, it will be applied to all satellites of the selected GNSS system. **[-#]** Optionally, a minus sign ('-') and a second PRN number can be provided in order to set a range of satellites (of the same constellation). **<n>** = Measurement number. If <n> is 0, it will be applied to all measurements in the filter. **<a>** = URA, Use the URA value from the broadcast message (not valid in PPP); = #, Value for the standard deviation of the measurement (metres). **<b>** **:** Multiplier to e [standard deviation at elevation 0 degrees] (metres). **<c>** **:** Elevation constant (degrees). The filter shall apply as weight = 1/(std^2). **Sample (default values):** **'-filter:elevweightsat G01 1 0.13 0.53 10':** Apply the standard deviation: 0.13+0.53*e^(-elevation/10). **Note:** **'-filter:elevweightsat g# 1 x 0 y'** equals to **'-filter:fixedweightsat g# 1 x'.**
-filter:sinelevweight <n> <a> <b>	
	pply the specified values to compute the variance of the measurement 'n'. **std^2 = a + b/((sin(elevation))^2)** **<n>** = Measurement number. If <n> is 0, it will be applied to all measurements in the filter. **<a>** = URA, Use the URA value from the broadcast message (not valid in PPP);

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	= #, Value for minimum variance of the measurement (m^2). **<b>** : Multiplier to fraction (m^2). The filter shall apply as weight = 1/(std^2). **Sample (default values):** **'-filter:sinelevweight 1 0 1'** : Apply the variance: 0+1/((sin(elevation))^2).
-filter:sinelevweightsat g#[-#] <n> <a> <b>	
	Apply the specified values to a specific satellite to compute the variance of the measurement 'n'. **g** Character determining GNSS system (G->GPS). **#** PRN number. If #=0, it will be applied to all satellites of the selected GNSS system. **[-#]** Optionally, a minus sign ('-') and a second PRN number can be provided in order to set a range of satellites (of the same constellation). **<n>** = Measurement number. If <n> is 0, it will be applied to all measurements in the filter. **<a>** = URA, Use the URA value from the broadcast message (not valid in PPP); = #, Value for the standard deviation of the measurement (metres). **<b>** : Multiplier to fraction (m^2). The filter shall apply as weight = 1/(std^2). **Sample (default values):** **'-filter:sinelevweight 1 0 1':** Apply the variance: 0+1/((sin(elevation))^2).
-filter:snrweight <n> <a> <b>	Apply the specified values to compute the variance of the measurement 'n'. **std^2 = a + b * 10^(-SNR/10)** **<a>** = URA, Use the URA value from the broadcast message (not valid in PPP); = #, Value for minimum variance of the measurement [weight at max SNR] (m^2). **<b>** : Multiplier to e xponential [variance at SNR 0 dBHz] (m^2*Hz). The filter shall apply as weight = 1/(std^2). **Sample (default L1):** **'-filter:snrweight 1 0 0.244'** : Apply the variance: 0+0.244*10^(-SNR/10). **Sample (default L2):** **'-filter:snrweight 1 0.88E-6 0.77E-3'** : Apply the variance: 0.88E-6+0.77E-3*10^(-SNR/10).
-filter:snrweightsat g#[-#] <n> <a> <b>	
	Apply the specified values to a specific satellite to compute the variance of the measurement 'n'. **g** Character determining GNSS system (G->GPS). **#** PRN number. If #=0, it will be applied to all satellites of the selected GNSS system.

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	[-#] Optionally, a minus sign ('-') and a second PRN number can be provided in order to set a range of satellites (of the same constellation). **<n>** = Measurement number. If <n> is 0, it will be applied to all measurements in the filter. **<a>** = URA, Use the URA value from the broadcast message (not valid in PPP); = #, Value for the standard deviation of the measurement (metres). **<b>** **:** Multiplier to e xponential [variance at SNR 0 dBHz] (m^2*Hz). The filter shall apply as weight = 1/(std^2). **Sample (default L1):** **'-filter:snrweightsat G01 1 0 0.244':** Apply the variance: 0+0.244*10^(-SNR/10). **Sample (default L2):** **'-filter:snrweightsat G01 1 0.88E-6 0.77E-3':** Apply the variance: 0.88E-6+0.77E-3*10^(-SNR/10).
-filter:snrelevweight <n> <a> <b>	
	Apply the specified values to compute the variance of the measurement 'n'. **std^2 = a + b * 10^(-SNR/10)/((sin(elevation)^2)** **<n>** = Measurement number. If <n> is 0, it will be applied to all measurements in the filter. **<a>** = URA, Use the URA value from the broadcast message (not valid in PPP); = #, Value for minimum variance of the measurement [weight at max SNR] (m^2). **<b>** **:** Multiplier to exponential [variance at SNR 0 dBHz] (m^2*Hz). The filter shall apply as weight = 1/(std^2). **Sample:** **'-filter:snrelevweight 1 0 1' :** Apply the variance: 0 + 1*10^(-SNR/10)/((sin(elevation))^2).
-filter:snrelevweightsat g#[-#] <n> <a> <b>	
	Apply the specified values to a specific satellite to compute the variance of the measurement 'n'. **std^2 = a + b * 10^(-SNR/10)/((sin(elevation)^2)** **g** Character determining GNSS system (G->GPS). **#** PRN number. If #=0, it will be applied to all satellites of the selected GNSS system. **[-#]** Optionally, a minus sign ('-') and a second PRN number can be provided in order to set a range of satellites (of the same constellation). **<n>** = Measurement number. If <n> is 0, it will be applied to all measurements in the filter. **<a>** = URA, Use the URA value from the broadcast message (not valid in PPP); = #, Value for the standard deviation of the measurement (metres).

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	<b> : Multiplier to exponential [variance at SNR 0 dBHz] (m^2*Hz). The filter shall apply as weight = 1/(std^2). **Sample (default values):** **'-filter:snrelevweightsat g# 1 0 1':** Apply the variance: 0 + 1*10^(-SNR/10)/((sin(elevation))^2).
-filter:snrweight:comb <n> <val>	
	When the weight is computed using any method involving the SNR (options **'-filter:snrweight'** or **'-filter:snrelevweight'**), when computing the weight for combinations, select how to get the SNR value: **<n>** = Measurement number. If <n> is 0, it will be applied to all measurements in the filter. **<val> = SNRi:** For a combination with frequencies ij or ijkl, use SNR from measurement of frequency i. **<val> = SNRj:** For a combination with frequencies ij or ijkl, use SNR from measurement of frequency j. **<val> = MaxSNR:** Use the highest SNR of the measurements used in the combination. **<val> = MinSNR:** Use the lowest SNR of the measurements used in the combination. **<val> = MeanSNR:** Use the mean SNR value of the two measurements used in the combination. [default] **0 <= <val> <=:** If <val> is a number between [0,1], combine the SNR with the following formula: **SNR = SNRi*<val> + SNRj*(1-<val>)** This combination only works for dual frequency combinations. **Note:** For a dual frequency combination with frequencies 'i' and 'j', 'i' is always the smallest frequency number and 'j' the highest, except for frequency '0', which will be always the highest (it it treated as frequency number '10'). For example, for combination PC12, i=1 and j=2. For combination LC10, i=1, j=0. For a triple or quadruple frequency combination, for instance, combination SIF1234, ijkl values would correspond to i=1, j=2, k=3, l=4.
-filter:snrweight:combsat g#[-#] <n> <val>	
	When the weight is computed using any method involving the SNR (options **'-filter:snrweight'** or **'-filter:snrelevweight'**), when computing the weight for combinations, select how to get the SNR value: **g** Character determining GNSS system (G->GPS).

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	# PRN number. If #=0, it will be applied to all satellites of the selected GNSS system. **[-#]** Optionally, a minus sign ('-') and a second PRN number can be provided in order to set a range of satellites (of the same constellation). **<n>** = Measurement number. If <n> is 0, it will be applied to all measurements in the filter. **<val> = SNRi:** For a combination with frequencies ij or ijkl, use SNR from measurement of frequency i. **<val> = SNRj:** For a combination with frequencies ij or ijkl, use SNR from measurement of frequency j. **<val> = MaxSNR:** Use the highest SNR of the measurements used in the combination. **<val> = MinSNR:** Use the lowest SNR of the measurements used in the combination. **<val> = MeanSNR:** Use the mean SNR value of the two measurements used in the combination. [default] **0 <= <val> <=:** If <val> is a number between [0,1], combine the SNR with the following formula: **SNR = SNRi*<val> + SNRj*(1-<val>)** This combination only works for dual frequency combinations. **Note:** For a dual frequency combination with frequencies 'i' and 'j', 'i' is always the smallest frequency number and 'j' the highest, except for frequency '0', which will be always the highest (it it treated as frequency number '10'). For example, for combination PC12, i=1 and j=2. For combination LC10, i=1, j=0. For a triple or quadruple frequency combination, for instance, combination SIF1234, ijkl values would correspond to i=1, j=2, k=3, l=4.
-filter:sbasdgnssweightmode <n> <val>	
	In SBAS and DGNSS modes, select how the provided sigma is combined with the user selected weight computation mode (with options **'-filter:fixedweight'**, **'-filter:elevweight'**, **'-filter:sinelevweight'**, **'-filter:snrweight'** and **'-filter:snrelevweight'**). **<n>** = Measurement number. If <n> is 0, it will be applied to all measurements in the filter. **<val> = ComputedOnly:** Use only the variance computed with SBAS or DGNSS corrections. [default if user does not select a weight method] **<val> = ComputedPlusUser:**

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	Use the variance computed with SBAS or DGNSS corrections plus the sigma computed with the user selected weight method. **<val> = UserOnly:** Use only the variance computed with the user selected weight method. [default if user selects a weight method]
-filter:sbasdgnssweightmodesat g#[-#] <n> <val>	
	In SBAS and DGNSS modes, select how the provided sigma is combined with the user selected weight computation mode (with options **'-filter:fixedweight'**, **'-filter:elevweight'**, **'-filter:sinelevweight'**, **'-filter:snrweight'** and **'-filter:snrelevweight'**). **g** Character determining GNSS system (G->GPS). **#** PRN number. If #=0, it will be applied to all satellites of the selected GNSS system. **[-#]** Optionally, a minus sign ('-') and a second PRN number can be provided in order to set a range of satellites (of the same constellation). **<n>** = Measurement number. If <n> is 0, it will be applied to all measurements in the filter. **<val> = ComputedOnly:** Use only the variance computed with SBAS or DGNSS corrections. [default if user does not select a weight method] <**val> = ComputedPlusUser:** Use the variance computed with SBAS or DGNSS corrections plus the sigma computed with the user selected weight method. **<val> = UserOnly:** Use only the variance computed with the user selected weight method. [default if user selects a weight method]
-filter:sigmaiono	Use standard deviation data from IONEX or FPPP or SBAS if these iono models are used. [default on] (**'--filter:sigmaiono'** to disable it). The IONEX or F-PPP sigma will be added to the computed satellite standard deviation.
-filter:phi:dr <val>	Specify the Phi value for position unknowns [defaults static:1 kinematic:0]
-filter:phi:clk <val>	Specify the Phi value for clock unknown. [default 0]
-filter:phi:trop <val>	Specify the Phi value for troposphere unknown. [default 1]
-filter:phi:amb <val>	Specify the Phi value for ambiguity unknowns. [default 1]
-filter:q:dr <val>	Specify the Q noise value for position unknowns. [defaults static:0 kinematic:1e8].
-filter:q:clk <val>	Specify the Q noise value for clock unknown. [default 9e10].
-filter:q:trop <val>	Specify the Q noise variation value for troposphere unknown. [default 1e-4] (m^2/h)
-filter:q:amb <val>	Specify the Q noise value for ambiguity unknowns. [default 0] (m^2)
-filter:p0:dr <val>	Specify the P0 initial value for position unknowns. [default 1e8] (m^2)

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-filter:p0:clk <val>	Specify the P0 initial value for clock unknown. [default 9e10] (m^2)
-filter:p0:trop <val>	Specify the P0 initial value for troposphere unknown. [default 0.5^2] (m^2)
-filter:p0:amb <val>	Specify the P0 initial value for ambiguity unknowns (for prealigned carrier phases). [default 20^2] (m^2)
-filter:backward	Specify that the filter does a backward processing after the forward one is finished. This means that it processes the data backwards. The "turn point" is defined as the latest point where orbits and clocks are available or when the observation RINEX ends (whatever is first) (**'--filter:backward'** to disable it). [default disabled]
-filter:maxhdop <val>	Set the HDOP threshold which will make gLAB do the following when the threshold is exceeded: **In SPP/PPP:** Skip the epoch. [default disabled] **In SBAS:** It will try to switch mode or GEO (if allowed), otherwise it will skip the epoch [default disabled in SBAS aviation mode, 4.0 in maritime SBAS mode]. **In DGNSS:** Switch from DGNSS to SPP. [default 30.0]
-filter:maxpdop <val>	Set the PDOP threshold which will make gLAB do the following when the threshold is exceeded: **In SPP/PPP:** Skip the epoch. [default disabled] **In SBAS:** It will try to switch mode or GEO (if allowed), otherwise it will skip the epoch [default disabled in SBAS aviation mode, 6.0 in maritime SBAS mode]. **In DGNSS:** Switch from DGNSS to SPP. [default 30.0]
-filter:hdoporpdop	If HDOP and PDOP thresholds are enabled, set the option to only need to fulfill one the two requirements (HDOP or PDOP) instead of both (i.e. HDOP and PDOP conditions are ORed -logical OR-). [default disabled in all modes except in maritime SBAS mode]
-filter:maxgdop <val>	Set the GDOP threshold which will make gLAB do the following when the threshold is exceeded: **In SPP:** Skip the epoch. [default disabled] **In PPP:** Skip the epoch. [default 30.0] **In SBAS:** It will try to switch mode or GEO (if allowed), otherwise it will skip the epoch. [default disabled] **In DGNSS:** Switch from DGNSS to SPP [default 30.0]. Use **'--filter:maxgdop'** to disable it.

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-filter:stfdesa	Compute values for Stanford-ESA plot (only for SPP, SBAS and DGNSS). [default disabled] The output data is written in a separate file (which has to be processed with graph.py). See parameter **'-output:stfdesa'**.
-filter:stfdesaloi	If Stanford-ESA computation is enabled, write to file all geometries which produce an integrity ratio equal or higher than the horizontal or vertical thresholds (any of them). See parameter **'-output:stfdesaloi'**. [default enabled]
-filter:stfdesa:xmax <val>	Set the maximum value for the horizontal axis (error axis, in metres) for Stanford-ESA plot. [default 50]
-filter:stfdesa:ymax <val>	Set the maximum value for the vertical axis (protection level axis, in metres) for Stanford-ESA plot. [default 50]
-filter:stfdesa:xres <val>	Set the horizontal resolution (error axis, in metres) for Stanford-ESA plot. [default 0.1]
-filter:stfdesa:yres <val>	Set the vertical resolution (protection level axis, in metres) for Stanford-ESA plot. [default 0.1]
-filter:stfdesa:hwir <val>	Set the horizontal integrity ratio threshold for which the geometry info will be written to file. [default 0.7] See parameters **'-filter:stfdesaloi'** and **'-output:stfdesaloi'** for more details.
-filter:stfdesa:vwir <val>	Set the vertical integrity ratio threshold for which the geometry info will be written to file. [default 0.7] See parameters **'-filter:stfdesaloi'** and **'-output:stfdesaloi'** for more details.

12.2.2.5 OUTPUT OPTIONS

-output:file <file>	Sets the output file. [default stdout]
--output:file	Sets the output to stdout. [default]
-output:kml <file>	Generate a KML file to be opened with Google Earth. [default off]
-output:kml0 <file>	Generate a KML file with all height set to 0 (ground projection) to be opened with Google Earth. [default off]
-output:kml:egm96geoid	Add geoid height from EGM96 model (used by Google Earth). Use **'--output:kml:egm96geoid'** to disable it. [default on]
-output:kml:refsta	Add reference stations in KML file (in DGNSS mode only). Use **'--output:kml:refsta'** to disable it. [default on]
-output:kml:tstamp	Add time stamp in KML file (in GPS time). [default off]
-output:kml:tstampdec	Decimation (in seconds) for time stamps in KML files. [default 30]
-output:kml:tstamprange <val1> <val2>	
	Set a time range for time stamps. Only during this time range KML timestamps will be written. [default off] **<val1>:**

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	Start epoch (in seconds of day of GPS time). If "-" is given, it will be interpreted as the beginning of the file. **<val2>:** Start epoch (in seconds of day of GPS time). If "-" is given, it will be interpreted as the end of the file. If the observation file spans for more than one day, add an offset of 86400 seconds to the start or end epoch. To set multiple ranges, set this parameter as many times as the number of ranges needed (one for each range). This parameter is combinable with **'-output:kml:tstampdec'** option.
-output:sp3 <file>	Generate a SP3 file with the computed coordinates. [default off]
-output:sp3:letter <val>	Constellation letter to be written in the SP3. [default 'L']
-output:sp3:prn <val>	PRN number to be written in the SP3. [default '9']
-output:sp3:dgnssonly	In DGNSS mode, do not write SPP solutions in the output SP3 file. [default on]
--output:sp3:dgnssonly	In DGNSS mode, write SPP solutions in the output SP3 file. [default off]
-output:refpos <file>	Generate a columnar text file with the computed coordinates. [default off]
-output:refpos:doy	Write timestamp (in GPS time) as 'Year DoY SoD' in the output reference position text file. [default on]
-output:refpos:gpsweek	Write timestamp (in GPS time) as 'GPSWeek SoW' in the output reference position text file. [default off]
-output:refpos:caltime	Write timestamp (in GPS time) as 'Year/Month/Day HH:MM:SS.zzz' in the output reference position text file. [default off]
-output:refpos:geodetic	Write solution in WGS84 geodetic coordinates (Lon, Lat, Height), instead of WGS84 cartesian coordinates (X, Y, Z). [default off] The output coordinates of the reference do not include the EGM96 geoid height model.
-output:refpos:dgnssonly	In DGNSS mode, do not write SPP solutions in the output reference position text file. [default on]
--output:refpos:dgnssonly	In DGNSS mode, write SPP solutions in the output reference position text file. [default off]
-output:rinex <file>	Sets the RINEX observation output file name. In conversion mode, if this option is not specified, the default output filename will be **<ssssddd0.YYo>**, where 'ssss' are the first 4 characters of the filename, 'ddd' is the day of year with three digits and 'YY' is the last two digits of the year (from the RTCM file). In Add user error to RINEX mode, if this option is not specified, the default output filename will be **<obsfilename>_usererror>**.
-output:rinexversion <val>	**<val> = 2:** Generates a RINEX v2.11 from the binary file RTCM v3.x **<val> = 3:** Generates a RINEX v3.00 from the binary file RTCM v3.x, [default]

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-output:corrections <file>	Sets the ASCII Plain Text output file name for the corrections when converting RTCM v2 files.
-output:antenna <file>	Sets the ASCII Plain Text output file name for the antenna information when converting RTCM v2 files.
-output:satvel <val>	**<val> = inertial:** Prints the inertial velocity in the messages where satellite velocity is given. **<val> = ITRF (ECEF):** Prints the ECEF velocity in the messages where satellite velocity is given. [default]
-output:stfdesa <file>	Set the filename where to write the output data for Stanford-ESA plots. [default "observationfilename_stdESA.txt"] **Note:** The output file is a columnar text file to be processed with graph program (with **'--sf'** parameter) for generating the Stanford-ESA plots. The first line of the output file contains, in this order the resolution in X axis (error), resolution in Y axis (protection level), maximum value in X axis and maximum value in Y axis. All the values are in metres. From the second line until then end, each line contains, in this order, the X coordinate, Y coordinate (both in metres), the number of points in the horizontal component in that coordinate and the number of points in the vertical component in that coordinate. See an example of the generated figures with graph program in the Section 10.3.3 or the Version 5 SBAS manual (file gLAB_SBAS_SUM.pdf) Setting this option enables Stanford-ESA computation.
-output:stfdesaloi <file>	Set the filename where to write the geometries of Stanford-ESA whose integrity ratio are over the horizontal or vertical integrity ratio (any of them). [default "observationfilename_stdESA_LOI.txt"] This option sets enables the following parameter automatically: **'-filter:stfdesaloi'**.

Note:

- In case of not setting **'-output:rinex'**, **'-output:corrections'** and/**or '-output:antenna'** gLAB will set automatically a name for the output file[s]. These previous options are effective only if an RTCM file is converted. Therefore, there will be no RTCM converted files if the input RTCM file is processed.
- A KML with a 1 second rate data and 1 second timestamp rate may be too big for Google Earth.

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12.2.2.6 VERBOSE OPTIONS

Tehe following list of extra output messages can be activated with “-print:...” or deactivated with “--print:...” as follows:

-print:info	Print INFO messages. [default on]
-print:cycleslips	Print CS messages. [default off]
-print:cs	Equivalent to parameter **'-print:cycleslips'**.
-print:input	Print INPUT messages. INPUT messages are deprecated. [default off]
-print:meas	Print MEAS messages. By default, prints all measurements except Doppler and LLI flags. [default off]
-print:model	Print MODEL messages. [default off]
-print:sat	Print EPOCHSAT messages. [default on]
-print:epochsat	Equivalent to parameter **'-print:sat'.**
-print:sateliites	Equivalent to parameter **'-print:sat'.**
-print:prefit	Print PREFIT messages. [default off]
-print:postfit	Print POSTFIT messages. [default off]
-print:filter	Print FILTER messages. [default off]
-print:output	Print OUTPUT messages. [default on]
-print:satdiff	Print SATDIFF messages in comparison mode (see section 12.2.1). [default on]
-print:satstat	Print SATSTAT messages in comparison mode (see section 12.2.1). [default on]
-print:satstattot	Print SATSTATTOT messages in comparison mode (see section 12.2.1). [default on]
-print:satpvt	Print SATPVT messages in show product mode (see section 12.2.1). [default on]
-print:satsel	Print satellite selection information. [default off]
-print:usererror	Print user added error to raw measurements. [default on]
-print:summary	Print a summary at the end of the files with the statistics of the processing. [default on]
-print:progress	Print to terminal the current epoch being processed. [default on]
-print:progressalways	Print to terminal the current epoch being processed even if standard output is piped. [default off]
-print:all	Print all messages.
-print:none	Do not print anything, except the progress bar (**'--print:none'** is also accepted). More information on print messages can be seen with the **'-messages'** option.

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12.2.3 SBAS options

In version 5, gLAB can only handle SBAS 1F data but not SBAS DFMC data.

NOTE: Some options have changed its name of argument format from version 5. This old name or argument format are still accepted (as it has backwards compatibility). gLAB will automatically detect them and parse them accordingly. For the options that apply to satellites, they will only be applied to GPS constellation.

12.2.3.1 INPUT OPTIONS

-input:sbas <file>	Sets the SBAS data file (RINEX-B v2.11 or EMS). Activates SBAS processing mode.
-input:sigmpath <file>	Sets the data file for user sigma multipath model for SBAS (execute 'gLAB -sigmamultipathfile' for details). **Note:** This option will set receiver positioning mode to 'calculate' if non set. See **'-pre:setrecpos'** option below for details.

12.2.3.2 PREPROCESSING OPTIONS

-pre:geoexclude #[,#..]	Exclude GEO satellite for SBAS. Data from this GEO will be ignored for SBAS corrections. **#** = PRN number. **[,#..]** = Optionally, a list of GEO can be provided by separating the numbers with commas (',').
-pre:geosel #	Select GEO satellite for SBAS corrections. **#= 0** => Use data from all GEO (all GEO mixed). **# = 1** => Use GEO from the first line of SBAS data read [default in SBAS maps mode]. **# = 2** => Use the GEO with highest elevation. [default in SBAS processing mode] **120 <= # <= 210** => Use the GEO with the given PRN.
-pre:smoothmin <val>	See in **'-pre:smoothmin <val>'** in Section 12.2.2.2.

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12.2.3.3 MODELLING OPTIONS

-model:sbasmaritime	Configure SBAS parameters for SBAS maritime mode (see notes on SBAS maritime below). [default off]
-model:alarmmsgtype2	When reading an SBAS message type 0, parse it as type 2 (except if all bits are 0). [default off]
-model:ignoretype0	Ignore all SBAS messages type 0. [default off]
-model:udreithreshold #	Set the UDREI threshold (from fast corrections) for discarding satellites. Satellites with UDREI equal or higher than this threshold will be discarded. Threshold values have to be in the range [1-13]. [default no threshold]
-model:sigfltnomt10offset #	When message type 10 is not available or disabled, the fast correction sigma is computed as UDRE sigma plus an offset of 8 metres. With this parameter the offset of 8 metres can be changed to any value (in metres).
-model:sbasmode <val>	Select navigation mode for SBAS processing: **<val> = PA:** Precision Approach. [default] **<val> = NPA:** Non Precision Approach.
-model:geoswitch	Enable GEO switch for SBAS processing. See **'Mode and GEO switch notes'** below. [default off]
-model:selectbestgeo	If GEO switching for SBAS processing is enabled, gLAB will compute the protection levels for all GEO available and will select the one with lower protection levels. [default off] **Note:** Enabling this option will noticeably increase the computation time (especially if there are many GEOs in the SBAS data file), as gLAB needs to compute the SBAS modelling with each GEO, and then select the best one. =Read section "Selection of best GEO:" below for details on the criteria of how the best GEO is selected.
-model:maintaingeo	If GEO switch for SBAS is enabled, maintain current GEO while possible independently if it is the GEO selected by the user or it has been selected due to a GEO switch. [default on]
-model:geofallback	If GEO switch for SBAS is enabled, always try to return to the initial selected GEO. [default off]
-model:sbasmodeswitch	Enable navigation mode switching (between PA and NPA) in SBAS processing. [default off]
-model:mixedgeo	Enable the usage of mixed GEO data (messages from all GEO are treated as if there were from a unique GEO). [default off]
-model:initcoordnpa	In SBAS mode, if receiver coordinates are to be calculated without giving any initial condition (parameter **'-pre:setrecpos'** calculate), compute the first epochs using Klobuchar until the receiver coordinates have converged. This is useful due to the initial gLAB coordinate may do that the IPPs (Ionospheric Pierce Point) fall outside the SBAS region, making all satellites unavailable due to the lack of ionosphere.

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	This option only has effect if SBAS mode switch is disabled and receiver coordinates are set to 'calculate'. [default on]
-model:sbasreceiver #	Set receiver class type for SBAS (for computing variance of the airborne receiver). **# = 0:** User defined receiver model (defined with parameters **'-model:sigmpath'**, **'-model:sigdiv'**, **'-model:signoise'** and **'-input:sigmpath'**). The receiver sigmas not defined by the user (with the previous parameters) will use the default values for class 2 receiver. **# = 1:** Class 1 equipment. **# = 2,3,4:** Class 2, 3, 4 equipment (all equivalent). [default 2]
-model:geoacqtime #	Set the minimum time (in seconds) to consider that gLAB has received enough SBAS corrections from a GEO counting from the first message received. [default 300] **Note:** This timer is set to ensure that we have received enough corrections from the GEO we want to switch to. If this timer is set too low (few seconds), it may happen that we switch to a GEO with not enough data (due to we are in initialization or the GEO has received an alarm message. gLAB will not switch to any GEO before this time, except for when an alarm message is received and there is no other GEO available.
-model:switchtime #	Set the minimum time (in seconds) between a GEO or mode switch and the following one. [default 0] **Note:** If this timer is set to zero, a maximum of 50 switches per epoch (for both mode and GEO) will be done.
-model:sbastmout <n> <val>	**<n> <val>** Set time out value for SBAS messages (except for fast and range rate corrections) in both modes, PA and NPA. **<n>** is the message type number. **<val>** is the time out value (in seconds).
-model:sbastmoutpa <n> <val>	Set time out value for SBAS messages (except for fast and range rate corrections) in PA mode. **<n>** is the message type number. **<val>** is the time out value (in seconds).
-model:sbastmoutnpa <n> <val>	Set time out value for SBAS messages (except for fast and range rate corrections) in NPA mode. **<n>** is the message type number. **<val>** is the time out value (in seconds).
-model:sbastmoutfc <val>	Set time out value for fast corrections in both modes, PA and NPA. **<val>** is the time out value (in seconds).
-model:sbastmoutfcpa <val>	Set time out value for fast corrections in PA mode. **<val>** is the time out value (in seconds).
-model:sbastmoutfcnpa <val>	Set time out value for fast corrections in NPA mode

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	<val> is the time out value (in seconds).
-model:sbastmoutrrc <val>	**<val>** Set time out value for range rate corrections in both modes, PA and NPA. **<val>** is the time out value (in seconds).
-model:sbastmoutrrcpa <val>	**<val>** Set time out value for range rate corrections in PA mode. **<val>** is the time out value (in seconds).
-model:sbastmoutrrcnpa <val>	**<val>** Set time out value for range rate corrections in NPA mode. **<val>** is the time out value (in seconds).
-model:sigmpath <val1> <val2> [<val3>]	
	Set parameters a, b, c for sigma multipath for SBAS (1F or DFMC) airborne receiver, being sigma=a+b*e^(-satelevation/c) and satelevation in degrees. **<val1>** is a value (in metres). [default 0.13 for class 2/3/4 receiver] **<val2>** is b value (in metres). [default 0.53 for class 2/3/4 receiver] **[<val3>]** is c value (in degrees). [default 10 for class 2/3/4 receiver] **Note:** This argument is optional in order to maintain compatibility with previous versions.
-model:sigdiv <val>	Set a fixed value (in metres) for sigma divergence for SBAS (1F or DFMC) airborne receiver.
-model:signoise <val>	Set a fixed value (in metres) for sigma noise for SBAS (1F or DFMC) airborne receiver.
-model:khpa <val>	Set the Kh factor value used when computing the horizontal protection level in PA mode. [default 6]
-model:khnpa <val>	Set the Kh factor value used when computing the horizontal protection level in NPA mode. [default 6.18]
-model:kvpa <val>	Set the Kv factor value used when computing the vertical protection level in PA mode. [default 5.33]
-model:kvnpa <val>	Set the Kv factor value used when computing the vertical protection level in NPA mode. [default 5.33]
-model:nofastcor	Set SBAS fast and RRC corrections values to 0. [default off]
-model:norrccor	Set SBAS RRC correction value to 0. [default off]
-model:noslowcor	Set SBAS slow corrections values to 0. [default off]
-model:noionocor	Set SBAS ionosphere correction value to 0. [default off]
-model:nofastsigma	Set SBAS fast and RRC sigmas (sigma UDRE and degradation terms) values to 0. [default off]
-model:nofastdeg	Set SBAS fast degradation term value to 0. [default off]
-model:norrcsigma	Set SBAS RRC degradation term value to 0. [default off]
-model:noslowsigma	Set SBAS slow correction degradation term to 0. [default off]
-model:noionosigma	Set SBAS ionosphere sigma to 0. [default off]
-model:notroposigma	Set SBAS troposphere sigma to 0. [default off]
-model:noenroutesigma	Set SBAS En Route Through NPA degradation term to 0. [default off]

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-model:nodeltaudre	Set SBAS Delta UDRE factor to 1. [default off]
-model:nomt10	Disable use of message type 10 in all modes. [default off]
-model:nomt2728	Disable use of messages type 27 and 28 in all modes (this is equivalent to parameter **'-model:nodeltaudre'**). [default off]
Note: - When setting any fast, slow, ionosphere correction or their sigmas to 0, gLAB will still check all the conditions for the current mode. For example, if gLAB is in PA mode and the **'-model:nofastcor'** parameter is set, then it will search for a fast correction, and if it is available, it will set the value to 0 instead of the one given in the SBAS message. If there is no SBAS fast correction available, the satellite will not be used. - The SBAS timeouts given by the user will override the defaults stated in MOPS-D.	

12.2.3.4 FILTERING OPTIONS

-filter:stfdesa	See in **'-filter:stfdesa'** in Section 12.2.2.4.
-filter:stfdesaloi	See in **'-filter:stfdesaloi'** in Section 12.2.2.4.
-filter:stfdesa:xmax <val>	See in **'-filter:stfdesa:xmax <val>'** in Section 12.2.2.4.
-filter:stfdesa:ymax <val>	See in **'-filter:stfdesa:ymax <val>'** in Section 12.2.2.4.
-filter:stfdesa:xres <val>	See in **'-filter:stfdesa:xres <val>'** in Section 12.2.2.4.
-filter:stfdesa:yres <val>	See in **'-filter:stfdesa:yres <val>'** in Section 12.2.2.4.
-filter:stfdesa:hwir <val>	See in **'-filter:stfdesa:hwir <val>'** in Section 12.2.2.4.
-filter:stfdesa:vwir <val>	See in **'-filter:stfdesa:vwir <val>'** in Section 12.2.2.4.

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12.2.3.5 OUTPUT OPTIONS

-output:rinexb	Generate a RINEX-B file from the SBAS data (only for SBAS). [default off]
-output:ems	Generate a EMS file from the SBAS data (only for SBAS). [default off]
-output:pegasus	Generate Pegasus file format from the SBAS data (only for SBAS 1F). See notes on Pegasus format below. [default off]
-output:pegstrictrinex	When generating a RINEX-H file for Pegasus, follow the RINEX 2.11 rules for transmission time, health flag and URA (only active if **'-output:pegasus'** has been set). [default off]
-output:pegspace	Set the field separator in Pegasus files to space character (' ') instead of a semicolon (';'). [default off]
-output:pegfilealign	Print Pegasus files with all columns aligned [default off]
-output:sbasdir <name>	Set the directory where to write the output SBAS files ('.' for current directory). [default "SBAS"]
-onlyconvert	Convert EMS or RINEX-B file to RINEX-B, EMS or Pegasus and exit without processing any GNSS data. [default off]
Note: - Incorrect messages from RINEX-B or EMS files are messages which grant any of these conditions: CRC mismatch, invalid header, unknown message type, invalid time of applicability (time is over 86400 seconds).	

12.2.3.6 VERBOSE OPTIONS

-print:sbascor	Print SBASCORR messages (only for SBAS 1F). [default off]
-print:sbascorr	Equivalent to parameter **'-print:sbascor'**.
-print:sbasvar	Print SBASVAR messages (only for SBAS 1F). [default off]
-print:sbasiono	Print SBASIONO messages (only for SBAS 1F). [default off]
-print:sbasunsel	Print SBASUNSEL messages (only for SBAS 1F). [default off]
-print:sbasunused	Print messages from discarded satellites due to SBAS GEO switch (only for SBAS 1F and DFMC). [default off] The discarded messages are MODEL, SBASCORR, SBASVAR, SBASIONO and SBASUNSEL, but only the ones selected from user parameters will be printed. Also, an asterisk '*' will be added at the end of the first field to indicate that it is a discarded measurement.
-print:sbasout	Print SBASOUT messages (only for SBAS 1F and DFMC). [default on]

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12.2.4 DGNSS options

NOTE: Some options have changed its name of argument format from version 5. This old name or argument format are still accepted (as it has backwards compatibility). gLAB will automatically detect them and parse them accordingly. For the options that apply to satellites, they will only be applied to GPS constellation.

12.2.4.1 INPUT OPTIONS

-input:dgnss <file>	Sets the input RINEX observation file of the Reference Station for DGNSS.
-input:rtcm <file>	Sets the input RTCM binary file, gLAB will automatically detect the RTCM version.
-input:rtcm2 <file>	Sets the input RTCM v2.x binary file.
-input:rtcm3 <file>	Sets the input RTCM v3.x binary file.
-input:rtcm:initdate <date>	Sets the date when the record of the binary file RTCM began (YYYYMMDD), required only when processing or converting RTCM v2.x and RTCM v3.x.
-input:rtcm:inithour <hour>	Sets the hour in GPST, when the record of the binary file RTCM began (HH 24-hour format), required when processing or converting RTCM v2.x.

12.2.4.2 PREPROCESSING OPTIONS

-pre:smoothmin <val>	See in **'-pre:smoothmin <val>'** in in Section 12.2.2.2..
-pre:smoothmeasdgnss	Same as **'-pre:smoothmeas'** but applied to the reference station instead of the rover.
-pre:dgnss:excludeSmoothingConvergenceUser	
	Exclude satellites during the smoothing convergence in the User Station. [default off]
--pre:dgnss:excludeSmoothingConvergenceUser	
	Do not exclude satellites during the smoothing convergence in the User Station.
-pre:dgnss:excludeSmoothingConvergenceRef	
	Exclude satellites during the smoothing convergence in the Reference Station, it will be effective if at least one cycle-slip detector is activated. [default on]
--pre:dgnss:excludeSmoothingConvergenceRef	
	Do not exclude satellites during the smoothing convergence in the Reference Station.
-pre:setrecpos <val>	**<val> = RINEX:**

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	Set the user receiver a priori position as the one specified in the RINEX observation file. [default] RINEX position will be used for modelling and for NEU error. **<val> = SINEX:** Set the user receiver a priori position to be read from a SINEX file (to be specified by the **'-input:snx'** parameter). SINEX position will be used for modelling and for NEU error. **<val> = <x> <y> <z>:** **<val> = Set <x> <y> <z>:** Specify the receiver a priori position in metres. Sample: **'-pre:setrecpos 4789032.7143 176594.9690 4195013.2268'**. Specified position will be used for modelling and for NEU error. **<val> = SetGeod <Lon> <Lat> <Height>:** Same as **'SetGeod'**, but the initial coordinates are given in geodetic coordinates. Longitude and latitude are given in degrees, within the ranges [-180..180] and [-90..90] respectively. The height is given in metres. **<val> = SetRef:** Read reference position for each epoch from reference position file Specified position will be used for modelling and for NEU error. See parameters **'-referenceposfile'**, **'-input:refpos'** and **'-pre:refpos:deg'** for help on the reference file. **<val> = calculate:** The user receiver a priori position will be calculated by the program and used for modelling, starting from (6378137,0,0). This is especially useful when processing moving receivers (trajectories) or when the approximate receiver position is not known. With this option activated, the differential fields of the OUTPUT message will be zero. **<val> = calculateRef:** Same as **'calculate'**, but instead of printing (0,0,0) in the output NEU error, it will compute the NEU error using the coordinates from the reference file. See parameters **'-referenceposfile'**, **'-input:refpos'** and **'-pre:refpos:deg'** for help on the reference file. **<val> = calculateRINEX:** Same as calculate, but the initial coordinates will be the one read in the RINEX observation header. If RINEX coordinates are are (0,0,0), then Earth's surface will be used as initial coordinates. **<val> = calculateRINEXRef:** Same as **'calculateRINEX'**, but instead of printing (0,0,0) in the output NEU error, it will compute the NEU error using the coordinates from the reference file. See parameters **'-referenceposfile'**, **'-input:refpos'** and **'-pre:refpos:deg'** for help on the reference file. **<val> = calculateUSER <x> <y> <z>:** Same as **'calculate'**, but the initial coordinates will be the one given by the user in this parameter (in metres).

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	<val> = calculateUSERGeod <Lon> <Lat> <Height>: Same as **'calculateUser'**, but the initial coordinates are given in geodetic coordinates. Longitude and latitude are given in degrees, within the ranges [-180..180] and [-90..90] respectively. The height is given in metres. **<val> = calculateUSERRef <x> <y> <z>:** Same as **'calculateUSER'**, but instead of printing (0,0,0) in the output NEU error, it will compute the NEU error using the coordinates from the reference file. See parameters **'-referenceposfile'**, **'-input:refpos'** and **'-pre:refpos:deg'** for help on the reference file. **<val> = calculateUSERGeodRef <Lon> <Lat> <Height>:** Same as **'calculateUSERRef'**, but the initial coordinates are given in geodetic coordinates. Longitude and latitude are given in degrees, within the ranges [-180..180] and [-90..90] respectively. The height is given in metres. **<val> = DGNSSbaseline:** The user receiver (rover) a priori position will be calculated by the program as in option **'calculat**e', but the differential fields in the OUTPUT message will computed against the reference antenna position (baseline vector from user to reference station), and the reference station coordinates will be read from RINEX or RTCM input file. **<val> = DGNSSRinexRover:** Same as **'DGNSSbaseline'**, but instead of comparing with the reference station, it will compare the user receiver (rover) coordinates with the coordinates read from the rover RINEX observation file. **<val> = DGNSSRoverUSER <RoverX> <RoverY> <RoverZ>:** Same as **'DGNSSbaseline'**, but instead of comparing with the reference station, it will compare the user receiver (rover) with the position given in this parameter. **<val> = DGNSSRoverUSERGeod <RoverLon> <RoverLat> <RoverHeight>:** Same as **'DGNSSRoverUSER'**, but the rover coordinates are given in geodetic coordinates. Longitude and latitude are given in degrees, within the ranges [-180..180] and [-90..90] respectively. The height is given in metres. **<val> = DGNSSRoverUSERRef:** Same as **'DGNSSbaseline'**, but instead of comparing with the reference station, it will compare the user receiver (rover) solution with the position given by the reference file. See parameters **'-referenceposfile'**, **'-input:refpos'** and **'-pre:refpos:deg'** for help on the reference file. **<val> = DGNSSUserRoverRef <RefX> <RefY> <RefZ>:** Same as **'DGNSSRoverUSERRef'**, but the reference station coordinates will be provided in this parameter (this mode only works when computing DGNSS with a RINEX file). **<val> = DGNSSUserGeodRoverRef <RefLon> <RefLat> <RefHeight>:** Same as **'DGNSSUserRoverRef'**, but the reference station coordinates are given in geodetic coordinates. Longitude and

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	latitude are given in degrees, within the ranges [-180..180] and [-90..90] respectively. The height is given in metres. **<val> = DGNSSUserbaseline <RefX> <RefY> <RefZ>:** Same as **'DGNSSbaseline'**, but the reference station coordinates will be provided in this parameter (this mode only works when computing DGNSS with a RINEX file). **<val> = DGNSSUserGeodbaseline <RefLon> <RefLat> <RefHeight>:** Same as **'DGNSSUserbaseline'**, but the reference station coordinates are given in geodetic coordinates. Longitude and latitude are given in degrees, within the ranges [-180..180] and [-90..90] respectively. The height is given in metres. **<val> = DGNSSUserRinexRover <RefX> <RefY> <RefZ>:** Same as **'DGNSSRinexRover'**, but the reference station coordinates will be provided in this parameter (this mode only works when computing DGNSS with a RINEX file). **<val> = DGNSSUserGeodRinexRover <RefLon> <RefLat> <RefHeight>:** Same as **'DGNSSUserRinexRover'**, but the reference station coordinates are given in geodetic coordinates. Longitude and latitude are given in degrees, within the ranges [-180 .180] and [-90..90] respectively. The height is given in metres. **<val> = DGNSSRefRoverUSER <RefX> <RefY> <RefZ> <RoverX> <RoverY> <RoverZ>:** Same as **'DGNSSRoverUSER'**, but the reference station coordinates will be provided in this parameter (this mode only works when computing DGNSS with a RINEX file). **<val> = DGNSSRefGeodRoverUSERGeod <RefLon> <RefLat> <RefHeight> <RoverLon> <RoverLat> <RoverHeight>:** Same as **'DGNSSRefRoverUSER'**, but the rover and reference station coordinates are given in geodetic coordinates. Longitude and latitude are given in degrees, within the ranges [-180..180] and [-90..90] respectively. The height is given in metres. **<val> = DGNSSRefCarRoverUSERGeod <RefX> <RefY> <RefX> <RoverLon> <RoverLat> <RoverHeight>:** Same as **'DGNSSRefRoverUSER'**, but the rover coordinates are given in geodetic coordinates and the reference station in cartesian coordinates. Longitude and latitude are given in degrees, within the ranges [-180..180] and [-90..90] respectively. The height is given in metres. **<val> = DGNSSRefGeodRoverUSERCar <RefLon> <RefLat> <RefHeight> <RoverX> <RoverY> <RoverZ>:** Same as **'DGNSSRefRoverUSER'**, but the reference station coordinates are given in geodetic coordinates and the rover in cartesian coordinates. Longitude and latitude are given in degrees, within the ranges [-180..180] and [-90..90] respectively. The height is given in metres.
-pre:setrectypedgnss <val>	Same as **'-pre:setrectype'**, but applied to the reference station.

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12.2.4.3 MODELLING OPTIONS

-model:dgnss:sigmainflation	The sigma is inflated during the smoother convergence (see DGNSS notes at the end). [default on]
--model:dgnss:sigmainflation	Do not use the sigma inflation during the smoother convergence
-model:dgnss:maxage <val>	Set the maximum age value (in seconds) to stop applying DGNSS corrections. [default 31]
-model:dgnss:maxcorrval <val>	
	Set the maximum value for a DGNSS correction to be considered valid (in metres). [default 500]

12.2.4.4 FILTERING OPTIONS

-filter:stfdesa	See in '**-filter:stfdesa**' in Section 12.2.2.4.
-filter:stfdesaloi	See in '**-filter:stfdesaloi**' in Section 12.2.2.4.
-filter:stfdesa:xmax <val>	See in '**-filter:stfdesa:xmax <val>**' in Section 12.2.2.4.
-filter:stfdesa:ymax <val>	See in '**-filter:stfdesa:ymax <val>**' in Section 12.2.2.4.
-filter:stfdesa:xres <val>	See in '**-filter:stfdesa:xres <val>**' in Section 12.2.2.4
-filter:stfdesa:yres <val>	See in '**-filter:stfdesa:yres <val>**' in Section 12.2.2.4.
-filter:stfdesa:hwir <val>	See in '**-filter:stfdesa:hwir <val>**' in Section 12.2.2.4.
-filter:stfdesa:vwir <val>	See in '**-filter:stfdesa:vwir <val>**' in Section 12.2.2.4.

12.2.4.5 OUTPUT OPTIONS

Please See OUTPUT OPTIONS in Section 12.2.2.5.

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12.2.4.6 VERBOSE OPTIONS

-print:dgnss	Print DGNSS global information (only for DGNSS). [default on]
-print:dgnssunused	Print messages from discarded satellites due to DOP switch (from DGNSS to SPP). [default off] An asterisk '*' will be added at the end of the first field to indicate that it is a discarded measurement.

Note: The DGNSS mode switches to SPP when there are not enough satellites for computing the navigation solution, or the GDOP is over the threshold (if any threshold is set).

Before switching to SPP mode, this verbose option can print the MODEL and DGNSS messages generated in this iteration (if options '**-print:model**' and **'-print:dgnss'** are enabled).

The MODEL and DGNSS messages will have a star ('*') at the end of the first field (message name) to indicate that these messages belong to a discarded DGNSS iteration.

Once printed, the modelling is recomputed to complete the switching to SPP, and the MODEL message is printed again if options '**-print:model**' is enabled.

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