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ESA GNSS Education

GNSS-Lab tool

Software User Manual

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Document Change Log

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1.10	05/03/2018	All	Revision and update with new gLAB v5.2.0

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1 INTRODUCTION

The GNSS-Lab Tool suite (gLAB) is an interactive educational multipurpose package to process and analyse GNSS data. The first release of this software package allowed processing only GPS data. The current release has been expanded to SBAS and differential processing (DGNSS). It is prepared to incorporate future module updates, such as an expansion to Galileo and GLONASS systems.

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 software package to support a practical GNSS course, where the fundamentals introduced in the theory are experimented through guided exercises. 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 which will be able to read RINEX data, process it and show the results in the form of data files and graphics. The processing options will be fully parametrizable through a GUI that will ease to understand the tool and its different options. The software is able to work in Windows, Linux and Mac Operating Systems.
- **Tutorial:** A book RD-15 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 component of the gLAB suite, 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.

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).

1.3 APPLICABLE AND REFERENCE DOCUMENTS

1.3.1 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	IONEX format: http://igscb.jpl.nasa.gov/igscb/data/format/ionex1.pdf
AD-04	SP3 format: http://igscb.jpl.nasa.gov/igscb/data/format/sp3.txt
AD-05	RINEX clock format: http://igscb.jpl.nasa.gov/igscb/data/format/rinex_clock.txt
AD-06	ANTEX format: ftp://igscb.jpl.nasa.gov/igscb/station/general/antex13.txt
AD-07	RTCA-MOPS, December 2006.
AD-08	PEGASUS Interface Control Document. PEG-ICD-02

1.3.2 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
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)

1.3.3 Acronyms and Terms

AD	Applicable Document
AWGN	Additive White Gaussian Noise
CRC	Cyclic Redundancy Check
DAT	Data Analysis Tool
DoY	Day of Year
DPC	Data Processing Core
EGNOS	European Geostationary Navigation Overlay Service
EMS	EGNOS Message Server
ESA	European Space Agency
FTP	File Transfer Protocol
gAGE	Research Group of Astronomy and Geomatics
gLAB	GNSS-Lab tool
GDOP	Geometric Dilution of Precision
GEO	GEOstationary
GLONASS	GLObal NAvigation Satellite System
GNSS	Global Navigation Satellite System
GUI	Graphic User interface
GPS	Global Positioning System
HE	Horizontal Error
HPE	Horizontal Positioning Error
HMI	Hazardous Misleading Information
HPL	Horizontal Protection Level
HWIR	Horizontal Worst Integrity Ratio
ICD	Interface Control Document
IGS	International GNSS Service
IGP	Ionospheric Grid Point
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
MOPS	Minimum Operational Performance Standards
NPA	Non Precision Approach
OS	Operative System
PA	Precision Approach
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
VE	Vertical Error
VPE	Vertical Positioning Error
VPL	Vertical Protection Level
VWIR	Vertical Worst Integrity Ratio
WIR	Worst Integrity Ratio

2 gLAB SOFTWARE TOOL

The gLAB software tool is able to run under Linux and Windows operating systems (OS). It is programmed in ANSI C, 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. The current release has been expanded to SBAS and differential processing (DGNSS). The software is ready to incorporate future updates to Galileo or GLONASS systems.

2.1.1 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.
- Capable to read:
  - Station measurements from Observation RINEX standard version 2.11 and 3.00.
  - Broadcast message from Navigation RINEX standard version 2.11 and 3.00.
  - Satellite clocks from Clocks RINEX standard.
  - Satellite orbits and clocks from SP3 standard.
  - Ionospheric maps from IONEX standard.
  - 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.

    - 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 if the format is RINEX 2.11 or 3.00.
- Fully capable to read Galileo (and other constellations) from RINEX.
- Able to process both pseudorange and carrier phase.
- Detection of cycle-slips in carrier phase measurements for GPS with three different methods:
    - Geometric-free carrier phase combination.
    - Melbourne-Wübbena combination.
    - Code-Phase difference (for single-frequency receivers),
- Time handling routines (The native 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 miliseconds). 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.
- Able to individually select/deselect each satellite for processing.
- Able to set an elevation mask to ignore low satellites for processing.
- Able to specifically mark which frequencies are available (to simulate single-frequency receivers from dual-frequency RINEX data).
- Pseudorange smoothing option.
- Orbit interpolation of SP3 data.
- Broadcast message support (orbit estimation, clock correction, TGD correction).
- 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]
  - P1 – P2 Differential Code Bias (DCB) correction.
  - P1 – C1 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].
- Able to choose different measurements (1 or more) for the filter estimation (both carrier phase and pseudorange). It could even work with a set of different pseudorange measurements from different signals. This can be useful in the future Galileo scenario, where some processing with different measurements can be desired.
- Able to assign different weights for different measurements.
- Able to assign elevation dependant weights.
- Able to translate from cartesian (native of the software) to geodetic coordinates.
- 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.
- 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 convertors.

2.1.2 Identified limitations

The current version gLAB only implements full processing capabilities for GPS data. Nevertheless, the reading of RINEX-3.00 Galileo and GLONASS data functionality is also included, allowing performing some exercises on data analysis with real or simulated Galileo and GLONASS measurements.

2.1.3 Minimum hardware requirements

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

- 1GB 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.

2.1.4 Minimum software requirements

The program runs under Windows (XP, Vista, 7, 8, 10) and Linux (Ubuntu 10.04 and above) Operating systems (in both 32 and 64 bit systems). It also works in Mac, from version 10.11 (El Capitan) and onwards.

2.1.4.1 Windows

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

2.1.4.2 Linux

For Linux users, the following programs are required:

- make 3.81
- gcc 4.4.3
- 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

2.1.4.3 Mac

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

3 INSTALLATION PROCEDURE

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

http://www.gage.es/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.

3.1.1 Manual binary generation

All the binaries of the Windows version of gLAB have been precompiled, so no need to compile them again would be required.

For the manual binary generation the following programs need to be installed (other versions may also work):

- MinGW v5.1.4 (http://sourceforge.net/projects/mingw/files/)
- Python(x,y) v2.1.14 (http://www.pythonxy.com). During its installation please select as “type of install”: *Full*.

Once these programs have been installed, the script “createEXE.bat” can be executed. This script can be found in the installation directory of gLAB, and will compile everything and create the proper binaries.

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, for this:

cd gLAB

make

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

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 python python-matplotlib python-tk python-mpltoolkits.basemap python-mpltoolkits.basemap-data python-numpy

NOTE: For executing graph.py program in Python3, the following additional packages have to be installed:

sudo apt-get install python3-matplotlib python3-tk python3-mpltoolkits.basemap python-mpltoolkits.basemap-data python3-numpy

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".

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.

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-08.
  - 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.

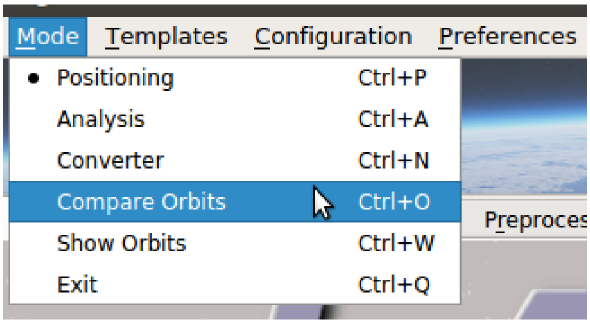

Figure 4-2: Mode drop-down menu

- **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 Precise Point Positioning (PPP) processing for the computation of precise satellite coordinates.
  - SBAS: to use the differential corrections from SBAS.
  - DGNSS: to perform a differential processing from a reference station.

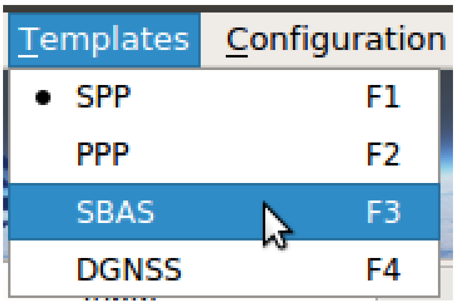

Figure 4-3: Templates drop-down menu

- **Configuration**: Allows saving and loading the configuration of the tool. 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.

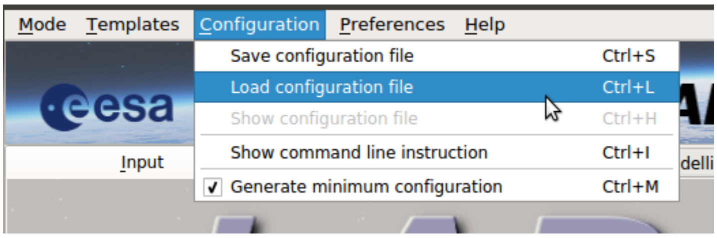

Figure 4-4: Configuration drop-down menu

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

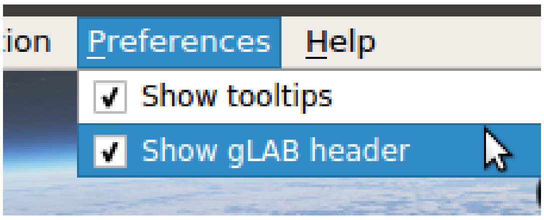

Figure 4-5: Preferences drop-down menu

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

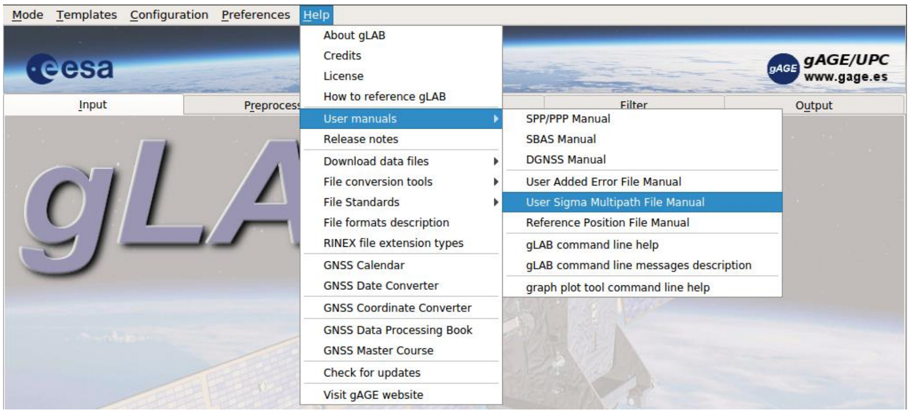

Figure 4-6: Help drop-down menu

4.2 POSITIONING (DPC INTERFACE)

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 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 outputs the data obtained from the FILTER.

4.2.1 Input

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

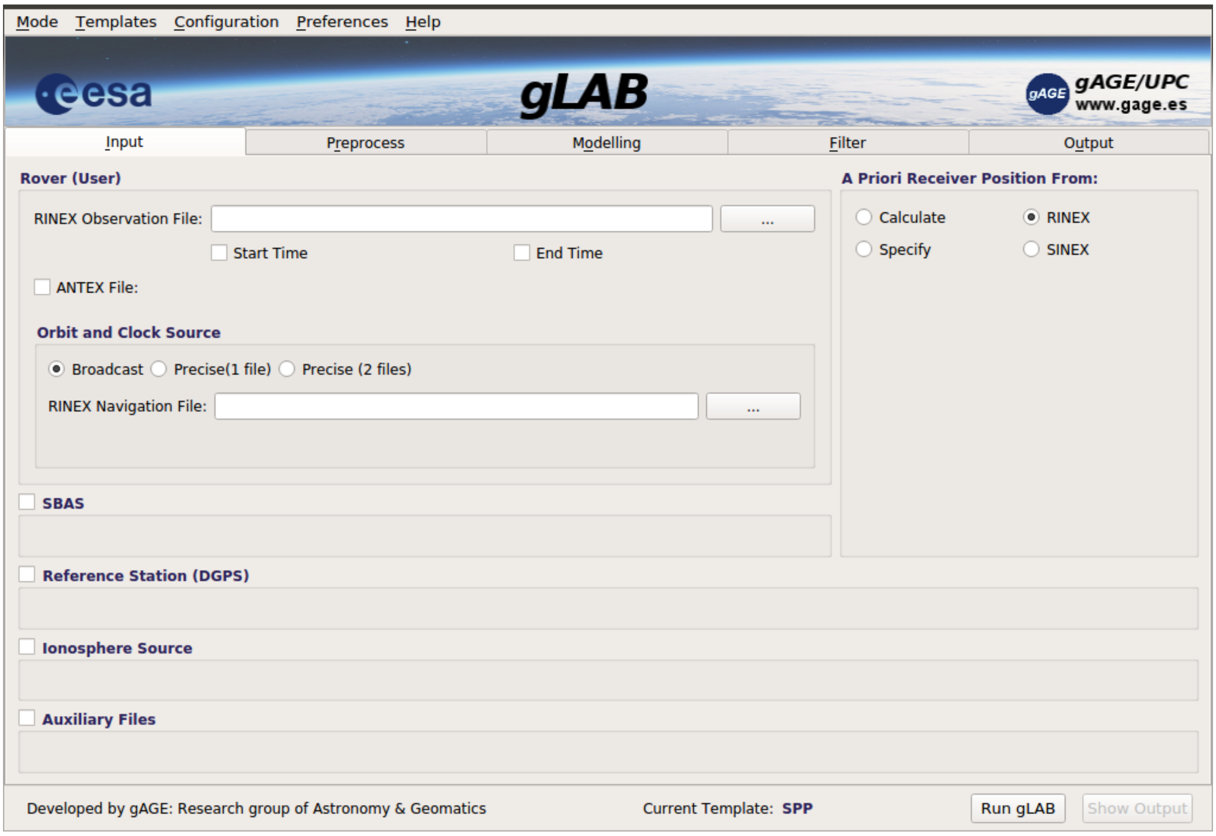

Figure 4-7: Screenshot of the INPUT section.

- Input files: Section to include all the files required for the proper functioning of the program.
  - RINEX Observation File: Source GNSS measurements data file in RINEX format (version 2.11 or 3.00).
  - ANTEX File: Antenna phase center information for both GNSS satellites and receiver antennas[1].

[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.

- Orbit and Clock Source: Origin of the orbit and clock products. The option selected here must be consistent with the *Navigation Mode* in the Filter section: Broadcast => Standalone, Precise (1 file) or Precise (2 files) => PPP
  - Broadcast: RINEX navigation file with the broadcasted message [Standalone option must be marked in the Filter section].
  - Precise (1 file): SP3 format file with the position/clock errors of GNSS satellites for a set of specific timestamps [PPP option must be marked in the Filter section][2].
  - Precise (2 files): The source of orbits will be an SP3 format file, and the clocks will be a RINEX clock format. While orbit data can be interpolated without much data degradation, clocks cannot be. The RINEX clock format allows providing clocks at a high rate, while reading the orbits at a lower rate from the SP3 file [PPP option must be marked in the Filter section].
    - Orbits SP3 File: Source of orbit data.
    - Clocks Rinex File: Source of clock data.
- Ionosphere Source: Origin of the ionosphere data when correcting it (see the

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

Modeling section (4.2.3) for more information).

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

- 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 apriori position. So if this position is accurate enough, the difference can be used as a direct measure of the error.
    - Specify:
        - Specify the receiver position in XYZ components (in meters) or geodetic components (in degrees and meters).
        - Provide a reference position file. The position of this file will be used as a priori position and for computing the differential fields in the OUTPUT message.
    - Use RINEX Position: Use the *APROX POSITION XYZ* field of the RINEX of measurements.

- 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 Header: gLAB will automatically calculate the a priori receiver position, but starting from the RINEX observation header record APPROX POSITION XYZ. If these coordinate are (0,0,0), then the Earth's surface (6378137,0,0) will be used as initial coordinates.
  - Specify: gLAB will automatically calculate the a priori receiver position, but starting from the user coordinates. These coordinates cannot be (0,0,0).

  A reference position file can also be provided. If it is given, the differential fields of the OUTPUT message will be compared with the position from the reference file. If no reference position file is given, this fields will be zero.
- Use SINEX File: Match the observation RINEX header record MARKER NAME with the marker position present in the SINEX file.
- Baseline (DGNSS mode only): gLAB will compute a priori receiver position. The differential fields of the OUTPUT message will be compared with the reference station coordinates, which is read from the reference station observation file or RTCM file.
- 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): gLAB will compute a priori receiver position. The differential fields of the OUTPUT message will be compared with the rover coordinates read from the Rover observation file. Reference station coordinates are read from the reference station observation file or RTCM file.
- 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): gLAB will compute a priori receiver position. The differential fields of the OUTPUT message will be compared with the rover coordinates provided by the user (in XYZ or geodetic) or with coordinates read from a reference position file. Reference station coordinates are read from the reference station observation file or RTCM file.
- 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 – P2 DCB Source files:
  - 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 different RINEX broadcasted file to obtain the codes (P1 – P2) digital bias.
  - Precise .DCB file: Specify a .DCB file for the (P1 – P2) biases for all satellites.
- P1 – C1 DCB Source files:
  - Receiver Type file: Specify a file with the receiver type information: Receivers, Antennas, Radomes, and Antenna+Radome manufacturer's name, model and code.
  - Precise .DCB files Specify a .DCB file for the (P1 – C1) biases for all satellites.
- User added error files: 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 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.

- Save Config button: Stores all the GUI configuration into a .cfg file, which can afterwards be read by the processing core by means of the '-inpu:cfg' parameter.

  In Linux:

  ./gLAB_linux –input:cfg gLAB.cfg

  In Windows:

  gLAB.exe –input:cfg gLAB.cfg

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

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.

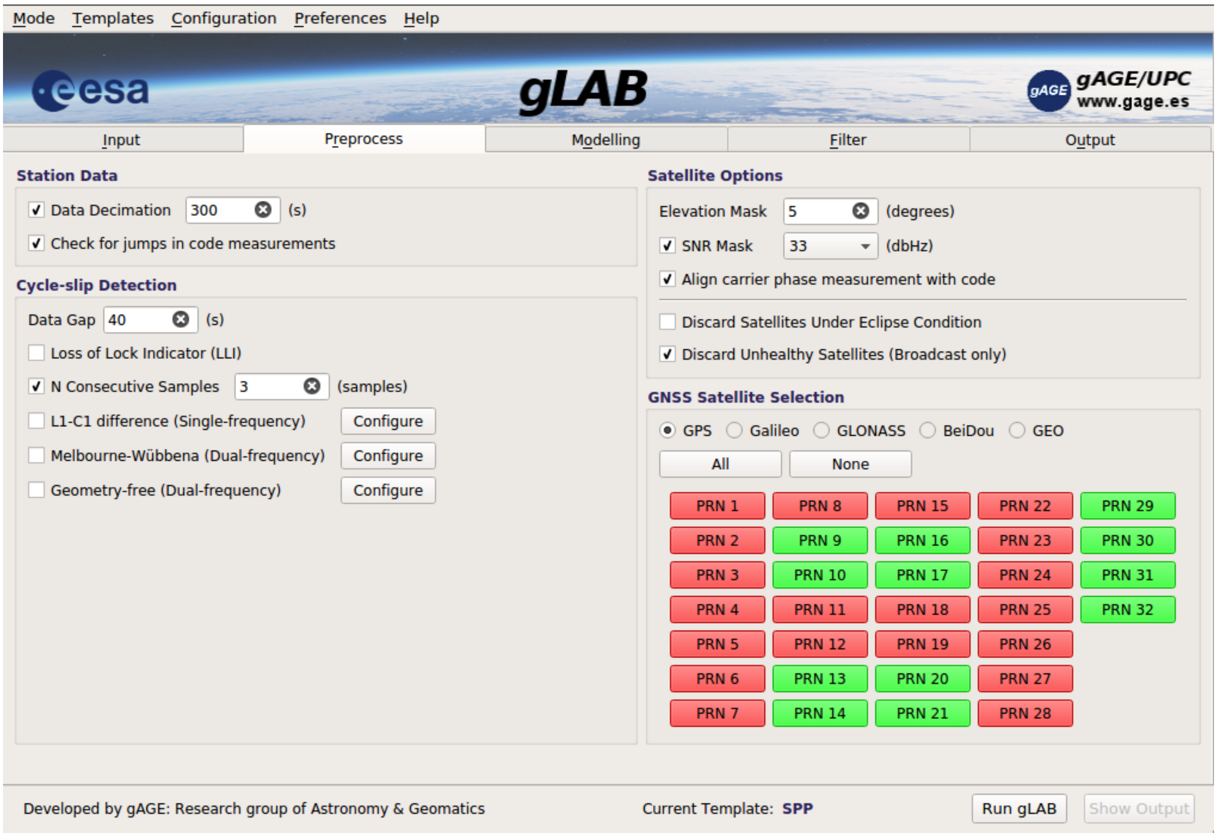

Figure 4-8: Preprocess section screenshot.

- Station Data.
  - Data Decimation [s]: This option will decimate the input data at the specified rate [in seconds]. 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 modeled. 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 modeling. This option is meant to be used to reduce computation time.
  - 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 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.
  - SNR Mask [dBHz]: This parameter allows to discard satellites below a SNR (Signal to Noise Ratio) threshold, which is included in the measurements of the RINEX observation file (in the last character of the measurement or as a separate measurement).
  - 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 discarding satellites based upon the healthy flag of the broadcasted navigation message.

- Cycle-slip Detection: This section provides all the configuration options for cycle-slip detection. This is only used for carrier phase measurements, and in the present version of the software for GPS only. 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.

  - 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.
  - 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, but it his is useful

for discarding measurements of satellites which are constantly appearing and disappearing (they usually have measurements with large error). The minimum value for N consecutive is 2 samples (wait until the second consecutive sample). Smaller values will disable this option.

- Geometric-free CP Combination [F1-F2]: 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 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 fulfill 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:

  n = maximum(N-sample of L1-C1 [if enabled], N-sample of Melbourne-Wübbena [if enabled], N-sample of 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 Combination [F1-F2]: 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. Notice that **N-sample** will be overriden by **n**, where:

n = maximum(N-sample of L1-C1 [if enabled], N-sample of Melbourne-Wübbena [if enabled], N-sample of 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.

- L1-C1 Difference [F1]: This cycle-slip detector for single-frequency receivers uses the difference between L1 and C1 (L1P and C1C). This difference contains basically noise coming from C1, 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 L1-C1 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 overriden by **n**, where:

n = maximum(N-sample of L1-C1 [if enabled], N-sample of Melbourne-Wübbena [if enabled], N-sample of Geometry-free [if enabled])

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

4.2.3 Modeling

This section provides the configuration options to set/unset each individual model that is used by gLAB. Figure 4-9 shows a screenshot of the MODEL section.

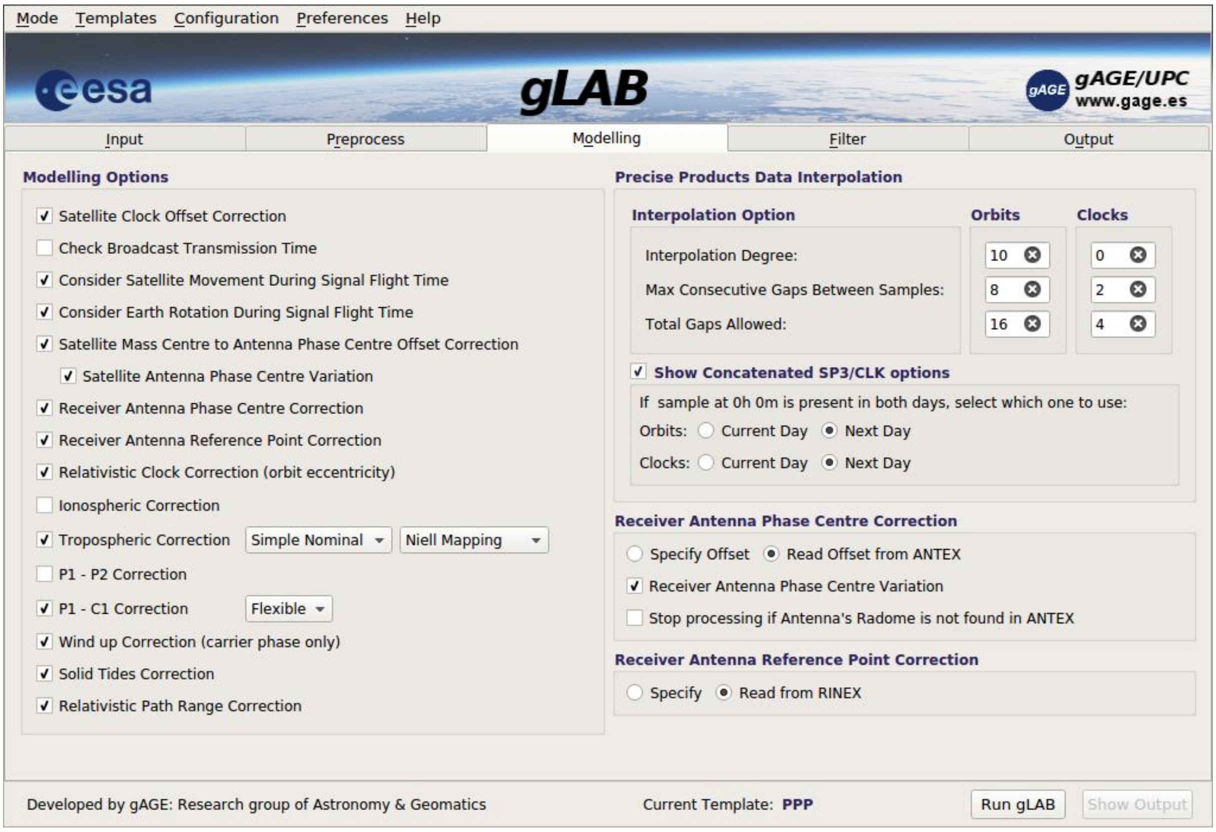

Figure 4-9: Modeling section screenshot

- Modeling 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 system 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 own navigation message, or some kind of external estimation, such as SP3 files. The effect of these clock errors can reach up hundreds of kilometers.
  - 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 meters.

- 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.
- 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.
- 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): 1) 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. 2) 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.

- Tropospheric correction: At the frequency which the GPS signal is emitted, the troposphere behaves like a non dispersive media, being its effect independent of the frequency. The tropospheric delay can be modelled in an approximate way (approximately 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-07).

  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.

- P1 – P2 correction: 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. This effect depends on the frequency and can be corrected using the information extracted from:

  - The RINEX Navigation file, where the (P2-P1) bias are given as the Total Group Delay (TGD).
  - Precise .DCB files, where the International GNSS Service (IGS) gives an accurate estimation of the (P1-P2) bias. This file contains a monthly estimation of this bias for all Satellites

- P1 – C1 DCB correction: 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. Because the code generation depends on the Receiver Type, this receiver-related information has to be given together with the corrections. gLAB works in two different modes:
  - Flexible: gLAB will use whichever C1 or P1 measurement is available in the receiver, without correcting DCB. If both code measures are available, P1 will be used as default. Used when receiver provides C1 but P1 is missing (or viceversa).
  - Strict: gLAB Data Processing Core (DPC) stops if both files are not provided:
    - Receiver Type File: To identify how codes are generated in the receiver, and how to remove these C1-P1 biases.
    - P1-C1 DCB File : Containing the P1-C1 DCB corrections.
- 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.

• 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 broadcasted products).
  - 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.

• Receiver Antenna Phase Center:
  - Specify: Specify in North/East/Up components the receiver antenna phase center. Different values can be specified for different frequencies.
    - F1/F2: Frequency selector.

            - North/East/Up [m]: Each of the components expressed in meters.
    - Read 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 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.

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 4-10 shows a screenshot of the FILTER section.

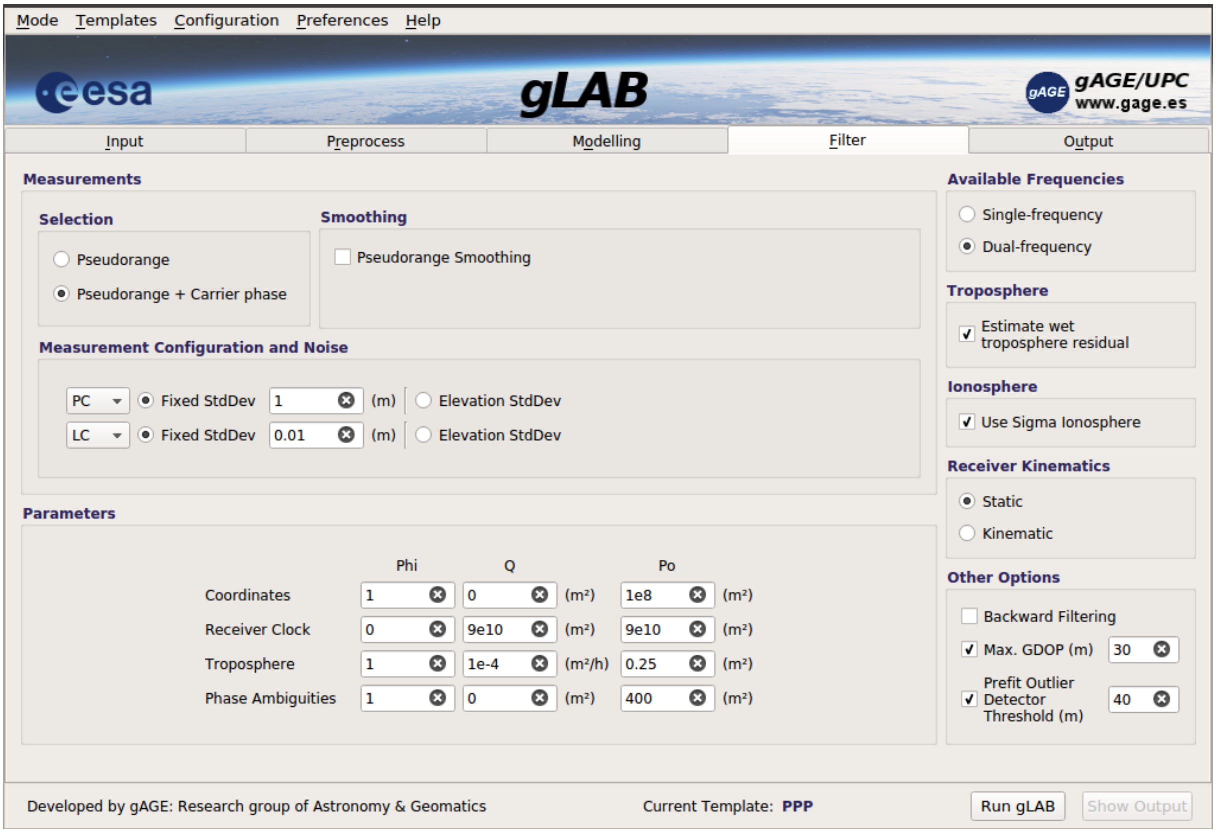

Figure 4-10: Filter section screenshot

- Troposphere: Activates the estimation of the troposphere. This estimation tries to remove the part of the wet troposphere delay not removed by the nominal modeling (see

Modeling section). The estimation depends on the model chosen to compute the $m_{wet}(elev)$ function (Niell mapping should be used for more realistic results).

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 troposhere estimation should be disabled.

- Available Frequencies: Select which frequencies are available.
  - Single Frequency: Use this option to force the receiver to be understood as a single-frequency one. Discarding all the measurements in the F2. 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.
- 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.
- 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).
  - Selection:
    - 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*.
    - 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*.
    - Pseudorange smoothing [epochs]: Use the Hatch filter to smooth the pseudorange measurements with carrier phase one. This option will reduce 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 amibiguities estimations. The Hatch filter is defined as:

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

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

$mean(P\text{-}L)_i = ((n\text{-}1)*mean(P\text{-}L)_{i\text{-}1} + (P\text{-}L)_i)/n$

being *n* the arc length at epoch *i* limited to a maximum value. This limitation is to reduce the effect of the ionospheric divergence between pseudorange and carrier phase measurements. If both measurements do not have ionospheric divergence (i.e. Pc and Lc), the parameter can be as high as desired.

- Configuration.
  - [Grayed option]: Selected measurements for the filter.
  - Fixed stdDev [m]: This sets the standard deviation of the corresponding measurement to be used as weight in the filter. The weight is computed as:

    $W = 1/(stdDev)^2$
  - Elevation stdDev: This sets the standard deviation of the corresponding measurement to be used as weight in the filter as a function of the elevation. The standard deviation is computed as:

    $stdDev = \mathbf{a} + \mathbf{b} \cdot e\hat{}(elev/\mathbf{c})$

    Being **a**, **b** and **c** the three parameters, and *elev* the elevation in degrees of the satellite. The filter weight is finally computed as:

    $W = 1/(stdDev)^2$

- 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 apriori value in the epoch *i*, '0', means that the apriori 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.
  - P_0: The Kalman filter requires initial values for all its parameters:

    Position: The *Apriori receiver position* in the Input section is used.

    Clock: A '0' value is assigned due to its high variability.

    Troposphere: Due to the fact that about 90% of the troposphere is corrected by a proper modeling, and only about a 10% has to be estimated (and is usually around 10 cm), a '0' value is used for apriori.

Carrier phase ambiguities: As carrier phase is prealigned with code, the ambiguities are not far from '0', thence this value is used as apriori.

The parameter **P_0** sets the initial uncertainty of these apriori values.

- Position: This comprises the 3 parameters with the 3D position [XYZ] of the receiver. Typical values:

  Apriori value: Apriori 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).

- Receiver Clock: This parameter is the receiver clock synchronism error referring to GPS time scale. Typical values:

  Apriori value: '0'.

  Phi: '0'.

  Process noise: 'inf'.

  Initial covariance: 'inf'.

- Troposphere: This parameter estimates part of the troposphere not taken into account in the nominal model (see Modeling 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 Modeling section is used in the troposhere estimation. Typical values:

  Apriori value: '0'.

  Phi: '1'.

  Process noise: '1e-4' in units of [m^2/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:

  Phi: '1'

  Process noise: '0'.

  Initial covariance: '400' (equivalent to 20 meters in relation to the pseudorange measurement used to prealign the carrier phase).

- 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.

  - 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. 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.

    NOTE: If an epoch is skipped due to high threshold, an INFO message will be shown.

  - 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). This 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.

    A method to detect this 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).

4.2.5 Output

This section provides all the configuration options to select which messages are output. Figure 4-11 shows a screenshot of the OUTPUT section.

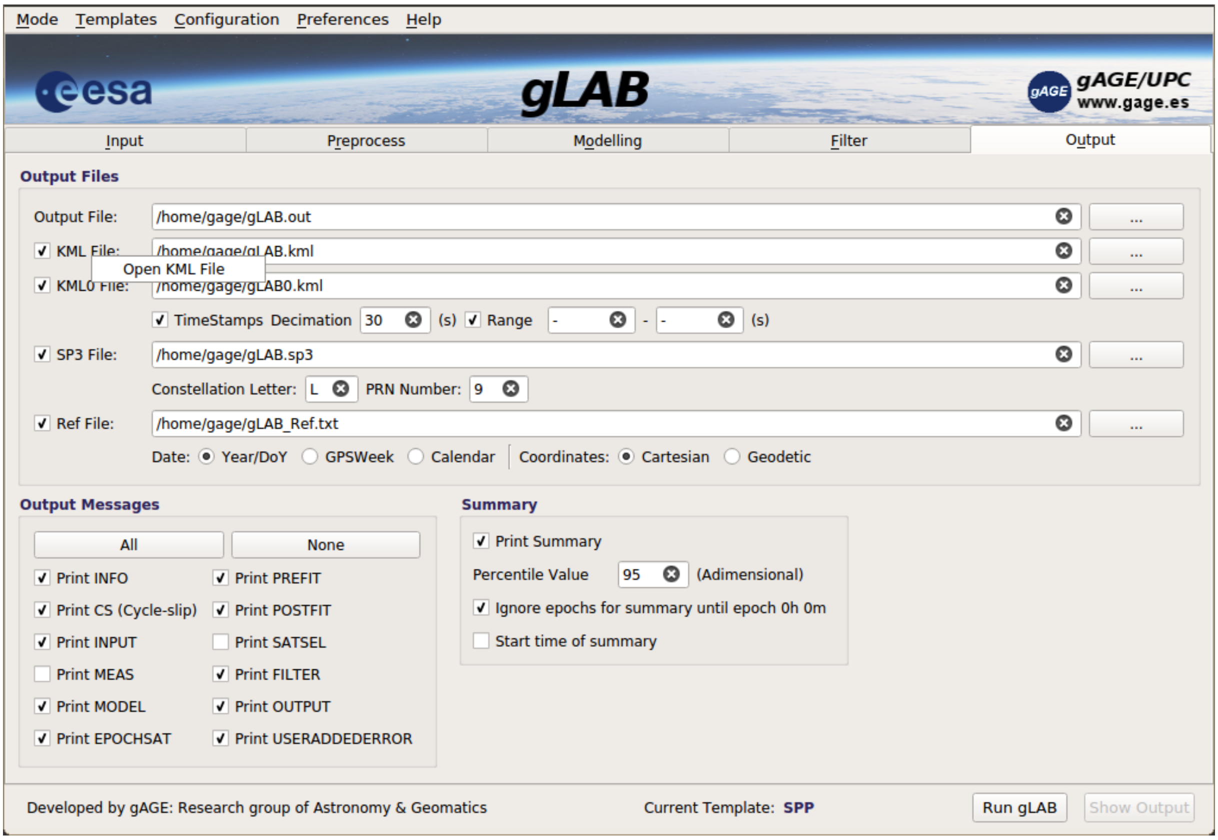

Figure 4-11: Output section screenshot

- Output Destination:
  - 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 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.
  - 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.

- Ref File: 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.

- 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.

    In SBAS processing, a GEO or mode switch.

    In DGNSS processing, a switch from DGNSS to SPP solution mode.

    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).

  - 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 1: 'CS' or 'CS_USER' for Rover Station (user)

    Field 1: 'CS_REF' for Reference Station

    Field 2: Year

    Field 3: Doy

    Field 4: Seconds of day

    Field 5: GNSS System (GPS, GAL, GLO or GEO)

    Field 6: PRN satellite identifier

    If cycle-slip detector is Data gap:

      Field 7: 'DATA_GAP'

      Field 8: '='

Field 9: Delta time between usable epochs

Field 10: 'THRESHOLD'

Field 11: '='

Field 12: Data gap threshold

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 7: 'LLI'

Sample: CS 2014 288 44942.00 GPS 32 LLI

If cycle-slip detector is Geometry-free carrier phase:

Field 7: 'LI'

Field 8: '='

Field 9: LI value

Field 10: 'THRESHOLD'

Field 11: '='

Field 12: LI threshold

Sample: CS 2014 288 42092.00 GPS 7 LI = 0.119386 THRESHOLD = 0.052861

If cycle-slip detector is Melbourne-Wubbena:

Field 7: 'LI'

Field 8: '='

Field 9: Bw value

Field 10: 'THRESHOLD'

Field 11: '='

Field 12: Bw threshold

Sample: CS 2014 288 42092.00 GPS 7 Bw = 1.992188 THRESHOLD = 1.839927

If cycle-slip detector is L1-C1 difference:

Field 7: 'LI'

Field 8: '='

Field 9: L1C1 value

Field 10: 'THRESHOLD'

Field 11: '='

Field 12: L1C1 threshold

Sample: CS 2014 365 55344.00 GPS 7 L1C1 = 747.078356 THRESHOLD = 0.876845

- 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[3].

  Field 1: 'INPUT'

  Field 2: Year

  Field 3: Doy

  Field 4: Seconds of day

  Field 5: GNSS System (GPS, GAL, GLO or GEO)

  Field 6: PRN satellite identifier

  Field 7: Arc length (number of undecimated epochs after the last cycle-slip)

  For GPS:

  Field 8: C1 [C1C]

  Field 9: P1 [C1P]

  Field 10: P2 [C2P]

  Field 11: L1 [L1P] (prealigned, in metres)

  Field 12: L2 [L2P] (prealigned, in metres)

  For Galileo (GAL):

  Field 8: C1A

  Field 9: C1B

  Field 10: C1C

  Field 11: C7Q

  Field 12: C8Q

  Field 13: L1A (prealigned, in metres)

  Field 14: L1B (prealigned, in metres)

  Field 15: L1C (prealigned, in metres)

  Field 16: L7Q (prealigned, in metres)

  Field 17: L8Q (prealigned, in metres)

  For GLONASS (GLO):

  Field 8: C1 [C1C]

[3] 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.

Field 9: C2 [C2C]

Field 10: L1 [L1P](prealigned, in metres)

Field 11: L2 [L2P](prealigned, in metres)

For GEO:

Field 8: C1 [C1C]

Sample: INPUT 2006 200 0.00 GPS 19 1 23119003.9020 23119002.6110 23119004.0750 23119002.7507 23119004.0925

- 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 1: 'MEAS'

  Field 2: Year

  Field 3: Doy

  Field 4: Seconds of day

  Field 5: GNSS System (GPS, GAL, GLO or GEO)

  Field 6: PRN satellite identifier

  Field 7: Elevation of the satellite [degrees]

  Field 8: Azimuth of the satellite [degrees]

  Field 9: Number of measurements

  Field 10: List of measurements included

  Field 11-: 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

- Print MODEL Messages: Model break down message. It is shown when a model can be fully computed for each measurement.

  Field 1: 'MODEL' (if the satellite is used in the computation) or 'MODEL*' (if it is not)

  Field 2: Year

  Field 3: Doy

  Field 4: Seconds of day

  Field 5: GNSS System (GPS, GAL, GLO or GEO)

  Field 6: PRN satellite identifier

Field 7: Measurement identifier (as string)

Field 8: Signal flight time [sec]

Field 9: Measured value [m]

Field 10: Full model value [m]

Field 11: Satellite X position [m]

Field 12: Satellite Y position [m]

Field 13: Satellite Z position [m]

Field 14: Satellite X velocity [m]

Field 15: Satellite Y velocity [m]

Field 16: Satellite Z velocity [m]

Field 17: Satellite-receiver geometric distance [m]

Field 18: Satellite clock correction [m]

Field 19: Satellite phase centre projection [m]

Field 20: Receiver phase centre projection [m]

Field 21: Receiver Antenna Reference Point (ARP) projection [m]

Field 22: Relativity correction [m]

Field 23: Wind-up correction [m] (for carrier phase measurements)

Field 24: Troposphere nominal correction [m]

Field 25: Ionosphere correction [m]

Field 26: Gravitational delay correction [m]

Field 27: Total Group Delay (TGD) correction [m]

Field 28: Solid tides correction [m]

Field 29: Satellite elevation [degrees]

Field 30: Satellite azimuth [degrees]

Field 31: Satellite SNR (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 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.

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

- 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 1: 'EPOCHSAT'

  Field 2: Year

  Field 3: Doy

  Field 4: Seconds of day

  Field 5: Measurement identifier (as string)

  Field 6: Number of satellites used in solution computation

  Field 7-: Each following column is the identifier of a satellite

  Sample: EPOCHSAT 2006 200 300.00 PC 7 15 3 19 16 18 21 22

- Print SATSEL Messages: Message with debug information of the reason why a satellite has been discarded (or selected) for processing.

  Field 1: 'SATSEL' (if navigation solution will be computed), 'SATSEL*' (if model parameters will be recomputed before the navigation solution, only in SBAS mode)

  Field 2: Year

  Field 3: Doy

  Field 4: Seconds of day

  Field 5: GNSS System (GPS, GAL, GLO or GEO)

  Field 6: PRN satellite identifier

  Field 7: 'selected' if satellite is used or 'discarded:' if satellite is not used

  Field 8: Discard reason if satellite is not used

  Sample: SATSEL 2006 200 0.00 GPS 7 discarded: Elevation too low (3.04)

  The possible values for field 8 are:

  - 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
- 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: <system>

- Print PREFIT Messages: Prefilter values message. It provides the measurement-model values. It is shown in each filter execution.

  Field 1: 'PREFIT' (if the satellite is used in the computation) or 'PREFIT*' (if it is not)

  Field 2: Year

  Field 3: Doy

  Field 4: Seconds of day

  Field 5: GNSS System (GPS, GAL, GLO or GEO)

  Field 6: PRN satellite identifier

  Field 7: Measurement identifier (as string)

  Field 8: Measurement-model value (prefit) [m]

  Field 9: Measurement value [m]

  Field 10: Model value [m]

  Field 11: X-partial derivative (-X component of the satellite line-of-sight vector)

  Field 12: Y-partial derivative (-Y component of the satellite line-of-sight vector)

  Field 13: Z-partial derivative (-Z component of the satellite line-of-sight vector)

  Field 14: T-partial derivative

  Field 15: Elevation of the satellite [degrees]

  Field 16: Azimuth of the satellite [degrees]

  Field 17: Standard deviation of the measurement (for the filter) [m]

  Field 18: Troposphere wet mapping

  Field 19: Arc number

  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

- Print POSTFIT Messages: Postfilter values message. It provides the corrected prefits with the filter estimation. It is shown in each filter execution.

  Field 1: 'POSTFIT'

  Field 2: Year

  Field 3: Doy

Field 4: Seconds of day

Field 5: GNSS System (GPS, GAL, GLO or GEO)

Field 6: PRN satellite identifier

Field 7: Measurement identifier (as string)

Field 8: Measurement-corrected model value (postfit) [m]

Field 9: Measurement value [m]

Field 10: Corrected model value with the filter estimations[m]

Field 11: Elevation of the satellite [degrees]

Field 12: Azimuth of the satellite [degrees]

Field 13: Only given for carrier phase measurements. It is the estimated carrier phase ambiguity. [m]

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

- Print FILTER Messages: Filter solution message. This message provides direct information on the filter estimates. It is shown in each filter execution.

Field 1: 'FILTER'

Field 2: Year

Field 3: Doy

Field 4: Seconds of day

Field 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 5: Receiver X position [m]

Field 6: Receiver Y position [m]

Field 7: Receiver Z position [m]

Field 8: Receiver clock [m]

Field 9: Zenith Tropospheric Delay [m]

Field 10: Carrierphase ambiguities [m]

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

- Print OUTPUT Messages: Receiver solution message. This message provides the estimated receiver position. It is shown in each filter execution.

  Field 1: 'OUTPUT'

  Field 2: Year

  Field 3: Doy

  Field 4: Seconds of day

  Field 5: Square root of the sum of the covariance matrix. This is a measure of the convergence of the filter

  Field 6: Receiver X position [m]

  Field 7: Receiver Y position [m]

  Field 8: Receiver Z position [m]

  Field 9: Receiver X position - Nominal a priori X position [m]

  Field 10: Receiver Y position - Nominal a priori Y position [m]

  Field 11: Receiver Z position - Nominal a priori Z position [m]

  Field 12: Receiver X formal error [m]

  Field 13: Receiver Y formal error [m]

  Field 14: Receiver Z formal error [m]

  Field 15: Receiver latitude [degrees]

  Field 16: Receiver longitude [degrees]

  Field 17: Receiver height [m]

  Field 18: Receiver North difference in relation to nominal a priori position [m]

  Field 19: Receiver East difference in relation to nominal a priori position [m]

  Field 20: Receiver Up difference in relation to nominal a priori position [m]

  Field 21: Receiver formal error in North direction [m]

  Field 22: Receiver formal error in East direction [m]

  Field 23: Receiver formal error in Up direction [m]

  Field 24: Geometric Dilution of Precision (GDOP)

  Field 25: Positioning Dilution of Precision (PDOP)

  Field 26: Time Dilution of Precision (TDOP)

  Field 27: Horizontal Dilution of Precision (HDOP)

  Field 28: Vertical Dilution of Precision (VDOP)

  Field 29: Zenith Tropospheric Delay (including nominal value) [m]

Field 30: Zenith Tropospheric Delay (excluding nominal value) [m]

Field 31: Zenith Tropospheric Delay formal error [m]

Field 32: Number of satellites used in the navigation solution

Field 33: Processing mode indicator

The 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:

0 -> SPP

1 -> PPP

2 -> SBAS

3 -> DGNSS

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

- Print 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.

4.2.6 Summary

The summary has the following fixed format for SPP /PPP:

```
INFO --------------------- SPP/PPP Summary ---------------------

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 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 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 GDOP exceeding the threshold: 0 ( 0.000%
)

INFO Total epochs skipped (any reason): 361 ( 0.418% )

INFO First epoch of summary for computing percentiles: 27/10/2016
00:00:00.00 / 2016 301     0.00 / 1920 345600.00

INFO Last  epoch of summary for computing 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 Horizontal  95 Positioning Error Percentile:   0.80 metres

INFO Vertical    95 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
```

```
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
```

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 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.
- GDOP messages will not appear if GDOP threshold has not been enabled.
- The lines referring to a reference file will only appear if a user sets a reference file.

4.3 ANALYSIS (DAT INTERFACE)

The analysis mode allows configuring all the visualization options for the DAT. Figure 4-12 shows a screenshot of the Analysis interface.

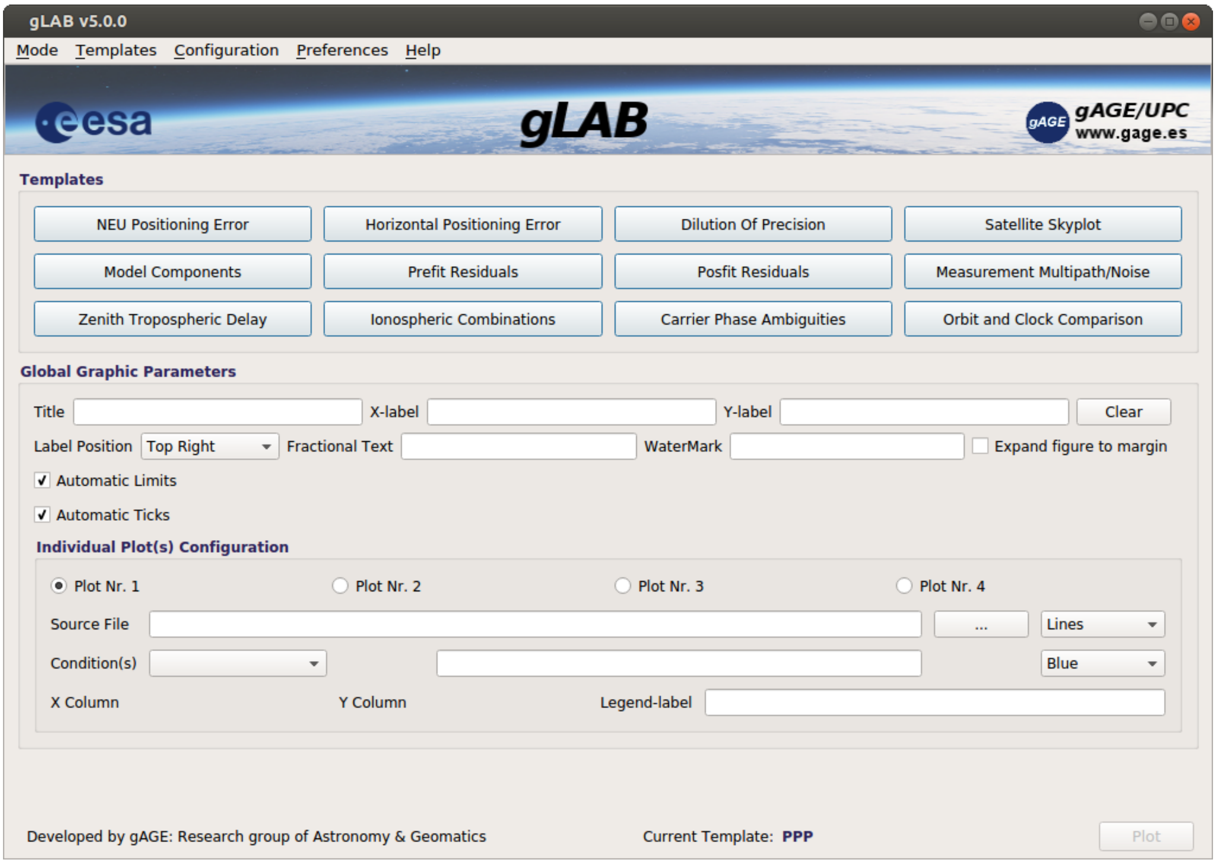

Figure 4-12: Analysis screenshot

- 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.

  - North-East dispersion: The North-East dispersion template sets the options to print the North vs East position error components. This provides an insight of the horizontal dispersion and bias of the errors.
  - 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.
  - 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].
  - 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.
  - 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.
  - 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.
  - Carrier phase ambiguities: The Carrier phase ambiguities template sets the options to print the estimation of carrier phase measurements in the filter. This is only possible in a processing with the *Pseudorange + carrier phase* measurements (in the Filter section).
- 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.
  - 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).
    - 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.

4.4 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 following cases are not covered by the GUI:

- Besides from ANTEX, the DPC can also read the GPSConstellationStatus.txt file (which can be found in [RD-12]), compiled and updated by Richard B. Langley. This file provides a dictionary between satellite PRN and SVN, and its corresponding GPS Block. This allows correcting the phase centres of the satellites.
- 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.

4.5 PROCESSING EXAMPLE

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 4-13). Clicking the *Input* tab will open the *Input* section (Figure 4-14). 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 4-13: GUI Splash screen

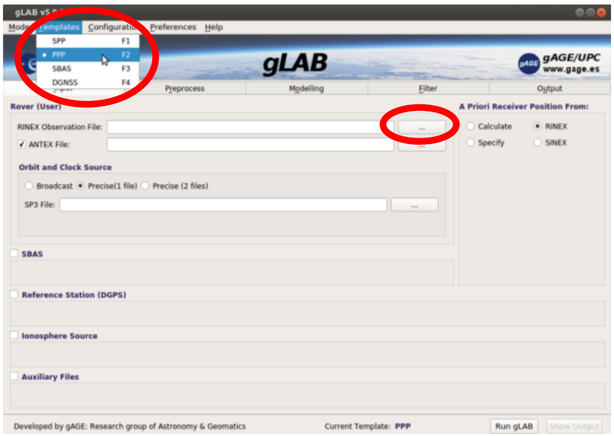

Figure 4-14: *Input* section

A file dialog will open (Figure 4-15), in order to go to the test directory (where all sample data files are found), the "Go Back one directory" button should be pressed, and afterwards doubleclick in "test" (Figure 4-16).

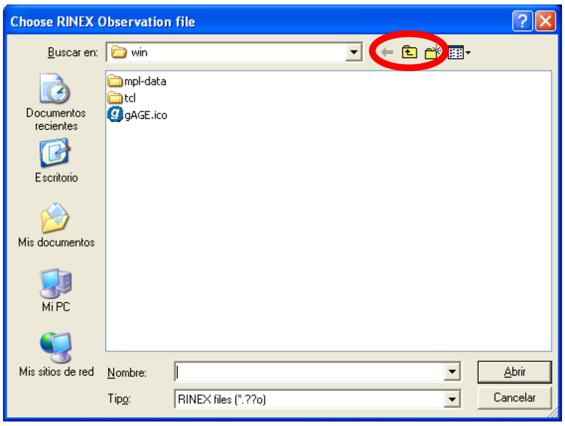

Figure 4-15: File Open dialog (1/3)

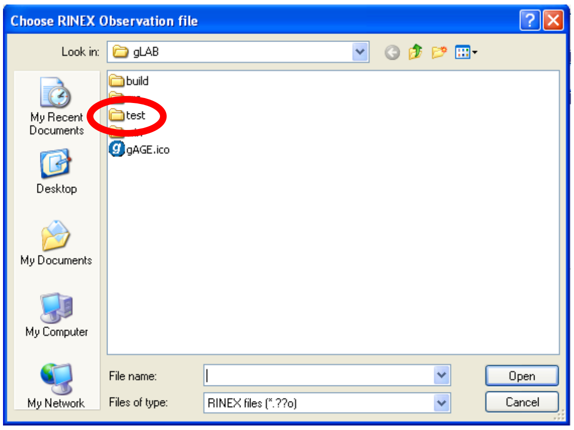

Figure 4-16: File Open dialog (2/3)

The directory where all the data is stored will be the one active (Figure 4-17). Double clicking on “madr2000.06o” will select this file and include it in the *Input* section (Figure 4-18). 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”).

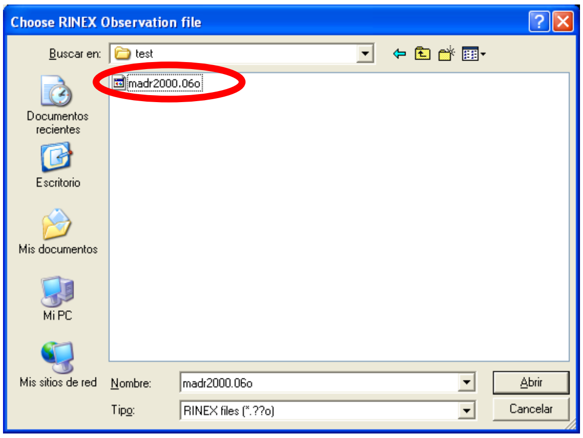

Figure 4-17: File Open dialog (3/3)

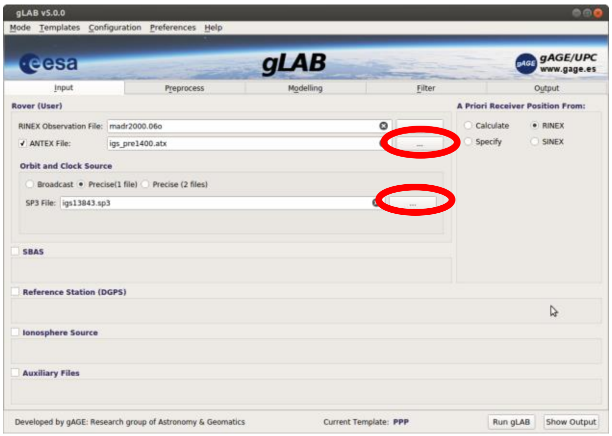

Figure 4-18: Updated *Input* section

Once input files are selected (Figure 4-19), *Filter* section button should be clicked in order to configure all the filter parameters. Once in this screen (Figure 4-20), the following parameters should be used (if not already checked):

- Navigation mode: PPP Template
- 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.

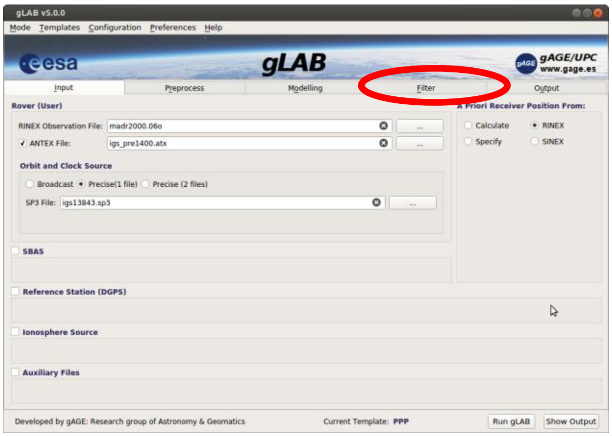

Figure 4-19: All input files are selected

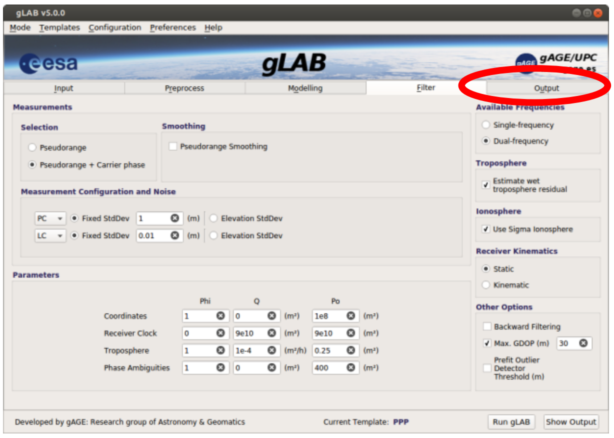

Figure 4-20: *Filter* section

In the *Output* section (Figure 4-21), the Examine button can be clicked to select the output file, Figure 4-22 shows the File Open dialog that will open. Writing “gLAB.out” and clicking enter will select this file name as output for the processing.

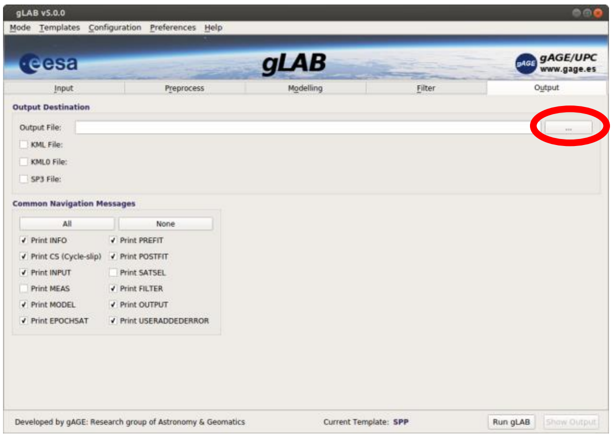

Figure 4-21: *Output* section

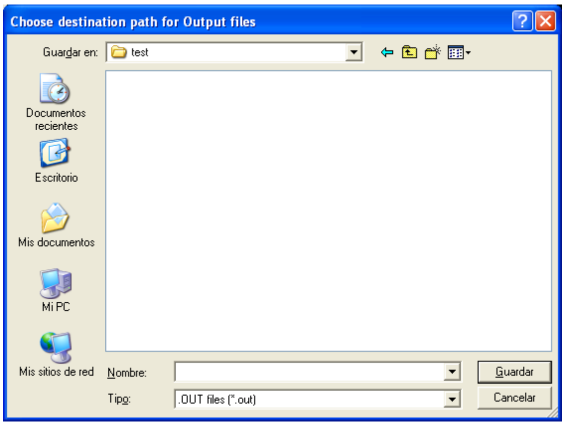

Figure 4-22: File open dialog for selecting the output file

After selecting the output (Figure 4-23) the *RUN* button will execute gLAB DPC with the selected options. While the DPC is running, the *RUN* button will be grey in order to avoid multiple clicks. After some seconds, the processing will end. To analyse the results click on the *Analysis* tab (Figure 4-24).

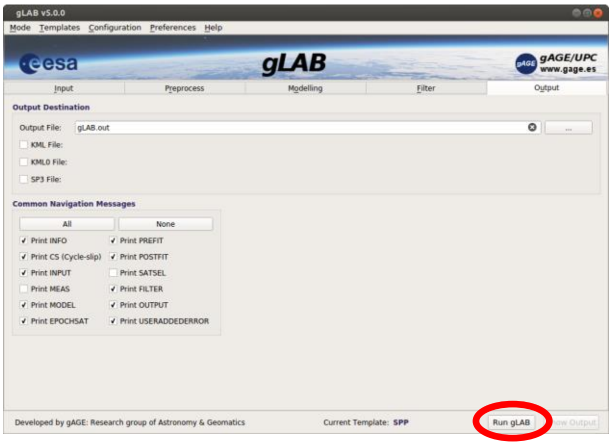

Figure 4-23: Output selected

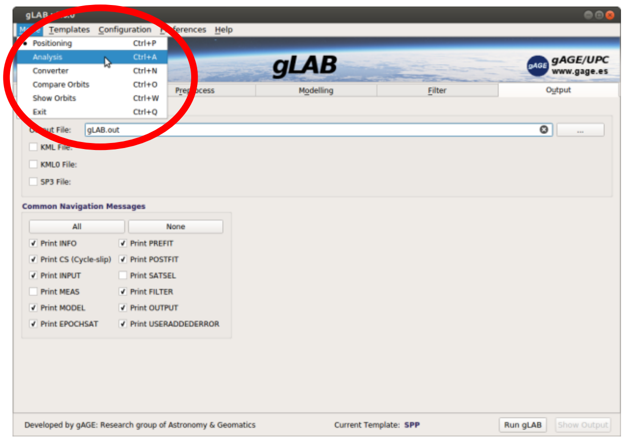

Figure 4-24: DPC has been executed

As explained in section 4.3 the *Analysis* mode (Figure 4-25) 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 4-26 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.

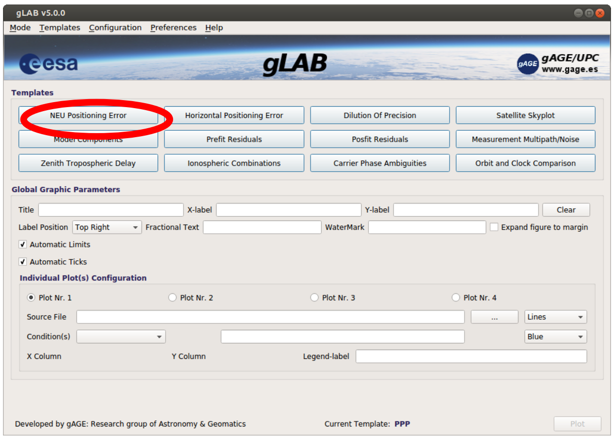

Figure 4-25: *Analysis* tab

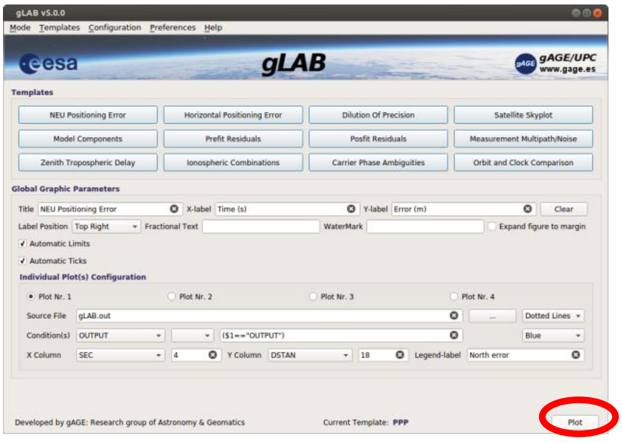

Figure 4-26: Receiver NEU position error configuration

When the processing is finished, a window will open (Figure 4-27) showing the generated plot, and the *Plot* button will be again available.

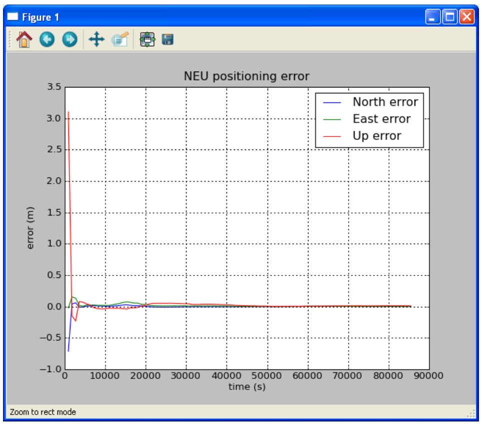

Figure 4-27: Plot sample

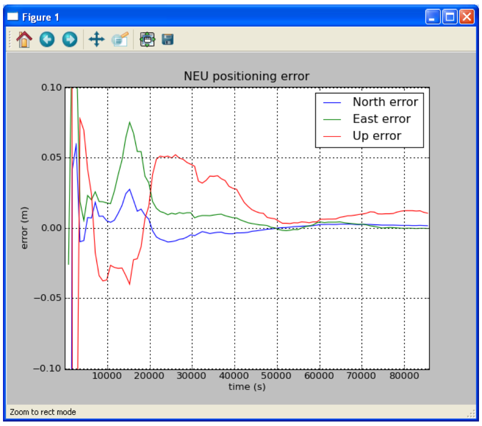

Figure 4-28: Plot sample (zoom)

The plotting utility allows zooming, moving and saving the current plot as a picture. All these functions can be accessed through the top toolbar. Figure 4-28 shows a zoom of the y axis. As would be expected for a PPP processing, the final position error is in the order of 1 cm.

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 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 4.4 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:

GENERAL OPTIONS:

-help	*Shows this help*
-messages	*Shows the fields of each output message (see below, 'VERBOSE OPTIONS')*
-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*

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 file
-input:sp3 <file>	Sets the input SP3 orbits and clocks file
-input:orb <file>	Sets the input SP3 orbits
-input:clk <file>	Sets the input clock file
-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: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:neq <file>	Sets the input RINEX navigation file for NeQuick corrections, if this parameter is avoided, it is used the -input:nav file
-input:sbasiono <file>	Sets the input RINEX-B or EMS SBAS file for ionospheric corrections

-input:dcb <file>	Sets the input DCB source as a .DCB file, a RINEX navigation file, a IONEX file or a FPPP file. 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
-input:sbas <file>	Sets the SBAS data file (RINEX-B v2.11 or EMS). Activates SBAS processing mode
-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
-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 and RTCM v3.x
-input:sigmpath <file>	Sets the data file for user sigma multipath model for SBAS (execute 'gLAB -sigmamultipathfile' for details)
-input:usererror <file>	Sets the data file for adding user defined error signal to raw measurements (execute 'gLAB -usererrorfile' for details) 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 on 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.
-input:refpos <file>	Sets the reference position file. It can be a SP3 or a columnar text file (execute 'gLAB -referencefile' for details) This option will set receiver positioning mode to 'calculate' if non set. See '-pre:setrecpos' option below for details

PREPROCESSING OPTIONS

-pre:starttime <date>	Set the start 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

-pre:endtime <date>	Set the end time for processing data. See '-pre:starttime' option above for date formats
-pre:dec #	# = number Decimate input data by # seconds [default 300 for SPP/PPP, 1 for SBAS, 0 for DGNSS] In product comparison mode (see below, in 'WORK MODES'), it sets the time step of the comparisons
-pre:sat [+-]g#[-#]	Exclude satellite from processing [+-] Optional symbols for selecting (with a plus '+') or unselecting (with a minus '-'). If no symbol is provided, the default behaviour is to unselect satellites. g = character determining GNSS system (G->GPS) # = PRN number (If #=0, all satellites of the selected GNSS system 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).
-pre:geoexclude #[,#,…]	Exclude GEO satellite from 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) [default in NPA if mixing GEO data is enabled] # = 1 => Use GEO from the first line of SBAS data read [default in PA] # = 2 => Use the GEO with highest elevation 120 <= # <= 210 => Use the GEO with the given PRN
-pre:snr	Enable SNR (Signal to Noise Ratio) deselection. 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 30 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 system (G->GPS)
# = frequencies available
Sample: '-pre:availf G12' Frequencies 1 and 2 of GPS available
'-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 type <meas> 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]
Satellites will be excluded until reaching this steady-state

-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:dgnss:smoothmin <val>
Number of seconds of continuous code smoothing before steady-state operation [default 360]

-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.
<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)

<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 'calculate', 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 ingeodetic 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 ingeodetic 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 degrees, within the ranges [-180..180] and [-90..90] respectively. The height is given in metres
-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] 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]
--pre:cs:ncon	Do not use N-consecutive epochs for cycle-slip detection [default off]

-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] 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. This threshold is (max + (min-max)*exp(-dt/t)), being dt the time between epochs
-pre:cs:li:maxjump <val>	Maximum jump threshold between two consecutive measured LI values [default 1]
-pre:cs:li:max <val>	Maximum threshold between estimated and measured LI values [default 0.08]
-pre:cs:li:t0 <val>	Time constant 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] 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 cycle-slip detection (1 frequency) [default in PPP]
--pre:cs:l1c1	Do not use the L1-C1 combination for cycle-slip detection (1 frequency) [default in SPP]
-pre:cs:l1c1:unconcheck	Use the unconsistency check in L1-C1 cycle-slip detection (1 frequency) [default]
--pre:cs:l1c1:unconcheck	Do not use the unconsistency check in L1-C1 cycle-slip detection (1 frequency)
-pre:cs:l1c1:unconcheck:th <val>	
	Threshold (in metres) for the unconsistency check in L1-C1 cycle-slip detection (1 frequency) [default 20] The L1-C1 averages the difference between carrier phase and pseudorange measurements in F1 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 C1 and L1 thence, this combination will tend to diverge. It becomes necessary to set a smoothing window to limit this divergence (-pre:cs:l1c1: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 L1C1 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]

MODELING OPTIONS (use -model:... to activate, --model:... to deactivate)

-model:iono <val>	<val> = no	Do not correct ionosphere [default in PPP] (equivalent to '--model:iono')
	= Klobuchar	Correct measurements with Klobuchar model [default in SPP]
	= BeiDou	Correct measurements with BeiDou model
	= IONEX	Correct measurements with IONEX file data
	= FPPP	Correct measurements with FPPP file data

	= SBAS Correct measurements with SBAS iono corrections (but do not apply any other SBAS correction) 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. It is adopted by SBAS systems (see RTCA-MOPS, 2006). [default in SPP] <val> = TropoGal Use Galileo's tropospheric model
-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 zenital 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 antenna phase centre for the frequency <nfreq> <nfreq> = Frequency number (typical for GPS, 1 and 2) <dN> = North correction [in metres] <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' 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 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]
-model:dcb:p1c1 <val>	<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 on] 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)
-model:dcb:p1p2 <val>	<val> = no Do not correct Differential Code Biases between codes P1 and P2 (equivalent to '--model:dcb:p1p2') <val> = RINEX Correct Differential Code Biases between codes P1 and P2 using TGDs from the RINEX navigation file [default in SPP, off in PPP] <val> = DCB Correct Differential Code Biases between codes P1 and P2 from a precise 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]
-model:solidtides	Correct the Earth surface deformation due to solid tides [default in PPP, off in SPP]
-model:relpath	Correct the path range delay term due to the gravitational gradient between receiver and transmitter [default on in PPP, off in SPP]
-model:satellitehealth	Only valid when using broadcast products. Use the healthy flag of the navigation message [default on]
-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:clock:deg <val>	Precise clock interpolation degree [default 0 - no interpolation]
-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] 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] This typically occurs with samples at epoch 0h 0m. This option will only have effect if both repeated samples have valid values.
-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: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 for SBAS processing [default off]
-model:mixedgeo	Enable the usage of mixed GEO data (messages from all GEO are treated as if there were from an 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. 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] 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 20] This timer is set to avoid continuous switching in the same epoch when all GEO do not have enough data. If this timer is set to zero, a maximum of 2 switches per epoch (for both mode and GEO) will be done
-model:sbastmout	<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
<val> is the time out value (in seconds)

-model:sbastmoutrrc <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>
Set time out value for range rate corrections in PA mode
<val> is the time out value (in seconds)

-model:sbastmoutrrcnpa <val>
Set time out value for range rate corrections in NPA mode
<val> is the time out value (in seconds)

-model:sigmpath <val1> <val2>
Set parameters a,b for sigma multipath for SBAS airborne receiver, being sigma=a+b*e^(-satelevation/10) and satelevation in degrees.
<val1> a value (in metres)
<val1> b value (in metres)

-model:sigdiv <val>	Set a fixed value (in metres) for sigma divergence for SBAS airborne receiver
-model:signoise <val>	Set a fixed value (in metres) for sigma noise for SBAS airborne receiver
-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]
-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: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]
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.
NOTE: The SBAS timeouts given by the user will override the defaults stated in MOPS-D.

FILTERING OPTIONS

-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)

-filter:stepdetector
Check for jumps in measurements using the prefits residuals (only for C1C measurement) [default off]
Use '--filter:stepdetector' to disable it

-filter:prefitoutliers:median <val>
Check for outliers in the prefits residuals using the median, with <val> (in metres) as the threshold [default off]
Use '--filter:prefitoutliers:median' or '-filter:prefitoutliers:median 0' to disable it. See notes on prefit outlier detectors below

-filter:prefitoutliers:abs <val>
Check for outliers in the prefits residuals comparing absolute values, with <val> (in metres) as the threshold [default off]
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]
= kinematic — Process supposing a moving receiver [default in SPP]

-filter:meas <meas>
<meas> = pseudorange — Use only pseudorange for positioning
= carrierphase — Use pseudorange and carrier phase for positioning [default]

-filter:select <num> <meas1> <meas2> ...
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 in the filter. 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 (in 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)
<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 values to a specific satellite to compute the standard deviation of measurement 'n'
std = a + b * e^(-elevation/c)
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 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: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> Apply 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)
= # 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'
std^2 = a + b/((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 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:snrweight <n> <a> <b> Apply the specified values to compute the variance of the measurement 'n'
std^2 = a + b * 10^(-SNR/10)
<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 (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'
std^2 = a + b * 10^(-SNR/10)
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 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 (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 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: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 (which are combinations) in the filter.

<val> = SNRi For a combination with frequencies ij, use SNR from measurement of frequency i

<val> = SNRj For a combination with frequencies ij, use SNR from measurement of frequency j

<val> = MaxSNR Use the highest SNR of the two measurements used in the combination

<val> = MinSNR Use the lowest SNR of the two measurements used in the combination

<val> = MeanSNR Use the mean SNR value of the two measurements used in the combination [default]

0 <= <val> <= 1 If <val> is a number between [0,1], combine the SNR with the following formula:

SNR = SNRi*<val> + SNRj*(1-<val>)

NOTE: For a 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

-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 for a specific satellite , select how to get the SNR value:

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 (which are combinations) in the filter.

<val> = SNRi For a combination with frequencies ij, use SNR from measurement of frequency i

<val> = SNRj For a combination with frequencies ij, use SNR from measurement of frequency j

<val> = MaxSNR Use the highest SNR of the two measurements used in the combination

<val> = MinSNR Use the lowest SNR of the two measurements used in the combination

<val> = MeanSNR Use the mean SNR value of the two measurements used in the combination [default]

0 <= <val> <= 1 If <val> is a number between (0,1), combine the SNR with the following formula:

SNR = SNRi*<val> + SNRj*(1-<val>)

NOTE: For a 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

-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** 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') to a specific satellite and measurement 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: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] (m^2)
-filter:q:clk <val>	Specify the Q noise value for clock unknown [default 9e10] (m^2)
-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)
-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 meas that it process 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:maxgdop <val>	Set the GDOP threshold (in metres) 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
-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 parameters '-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.

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: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 [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). If "-" is given, it will be intepreted as the beginning of the file. <val2> Start epoch (in seconds of day). If "-" is given, it will be intepreted 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 parameters an number of ranges needed.

	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	Constellation letter to be written in the SP3 [default 'L']
-output:sp3:prn	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 as 'Year DoY SoD' in the output reference position text file [default on]
-output:refpos:gpsweek	Write timestamp as 'GPSWeek SoW' in the output reference position text file [default off]
-output:refpos:caltime	Write timestamp 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]
-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 output file name
-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
-output:antenna <file>	Sets the ASCII Plain Text output file name for the antenna information
-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: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). 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"]
-output:stfdesa <file>	Set the filename where to write the output data for Stanford-ESA plots [default "observationfilename_stdESA.txt"] 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 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'.
-onlyconvert	Convert EMS or RINEX-B file to RINEX-B, EMS or Pegasus and exit without processing any GNSS data [default off] 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) 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 NOTE: A KML with a 1 second rate data and 1 second time stamp rate may be too big for Google Earth

VERBOSE OPTIONS (use -print:... to activate, --print:... to deactivate)

-print:info	Print INFO messages [default on]
-print:cycleslips	Print CS messages [default on]
-print:cs	Equivalent to parameter '-print:cycleslips'
-print:input	Print INPUT messages [default on for non SBAS processing, off for SBAS processing]
-print:meas	Print MEAS messages [default off]
-print:model	Print MODEL messages [default on for non SBAS processing, off for SBAS processing]
-print:satellites	Print EPOCHSAT messages [default on for non SBAS processing, off for SBAS processing]

-print:epochsat	Equivalent to parameter '-print:satellites'
-print:sat	Equivalent to parameter '-print:satellites'
-print:prefit	Print PREFIT messages [default on for non SBAS processing, off for SBAS processing]
-print:postfit	Print POSTFIT messages [default on for non SBAS processing, off for SBAS processing]
-print:filter	Print FILTER messages [default on for non SBAS processing, off for SBAS processing]
-print:output	Print OUTPUT messages [default on]
-print:satdiff	Print SATDIFF messages in comparison mode (see below) [default on]
-print:satstat	Print SATSTAT messages in comparison mode (see below) [default on]
-print:satstattot	Print SATSTATTOT messages in comparison mode (see below) [default on]
-print:satpvt	Print SATPVT messages in show product mode (see below) [default on]
-print:satsel	Print satellite selection information [default off for non SBAS processing, on for SBAS processing]
-print:sbascor	Print SBASCORR messages (only for SBAS) [default off]
-print:sbascorr	Equivalent to parameter '-print:sbascor'
-print:sbasvar	Print SBASVAR messages (only for SBAS) [default off]
-print:sbasiono	Print SBASIONO messages (only for SBAS) [default off]
-print:sbasout	Print SBASOUT messages (only for SBAS) [default on]
-print:sbasunsel	Print SBASUNSEL messages (only for SBAS) [default off]
-print:sbasunused	Print messages from discarded satellites due to SBAS GEO switch (only for SBAS) [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:usererror	Print user added error to raw measurements [default on]
-print:dgnss	Print DGNSS global information (only for DGNSS) [default on]
-print:dgnssunused	Print messages from discarded satellites due to GDOP 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
-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:all	Print all messages
-print:none	Do not print anything More information on print messages can be seen with the '-messages' option

SUMMARY OPTIONS

When processing in SPP/PPP/SBAS/DGNSS corrections, if summary 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 and protection level 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 SBAS message buffer and wait for the smoothing and filter 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 SBAS summary. This option is useful to avoid false MIs or high error epoch in the summary during the convergence time. [default on]
This option can be disabled with '--sbassummary:waitfordaystart'
NOTE: The computation of the continuity risk takes into account the sampling rate and data gaps in the observation file.
NOTE: The last line of the SBAS 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.
NOTE: An example of a SBAS summary can be seen executing gLAB with '-messages' parameter

-summary:starttime <date> Set the first epoch to be used in the SBAS summary. See parameter '-pre:starttime' for details on date format

ADDITIONAL SUMMARY OPTIONS FOR SBAS
In SBAS mode, there are additional options for the summary:

-summary:hal <val> Sets the Horizontal Alarm Limit (in metres) for computing availability and continuity risk [default 40]

-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]

NOTE: The computation of the continuity risk takes into account the sampling rate and data gaps in the observation file.

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 (at sea level)]

-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: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]

-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: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"]

-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: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:exclusionarea <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>
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

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) and

the option to use Klobuchar while solution converges ('-model:initcoordNPA') as we consider we are always in strict PA mode. An example of the generated figures with graph program is in the SBAS manual (file gLAB_SBAS_SUM.pdf)

DATE CONVERSION OPTIONS

This mode is for converting a date format to all other GNSS date formats and exit.
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.

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 parameter 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.

WORK MODES

gLAB can work in six 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:sbas') 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.
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:sbas'), 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 plot, an epoch at a given latitude and longitude and height (by default is is sea level -0 metres-)

is consired to be available when both the Horizontal and Vertical Protection Levels are below their respective thresholds.
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).
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.
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

- 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.

NOTES FOR PEGASUS OUTPUT FORMAT

Pegasus is GNSS data processing 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 http://www.icao.int/Meetings/AMC/MA/2004/GNSS/icd.pdf

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 detected as a cycle-slip.

NOTES FOR SBAS PROCESSING

When processing with SBAS corrections, gLAB will use MOPS-D standard values (see AD-07) 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 fallback 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 after 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.

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 [metres]
Maritime mode is configured with parameter '-model:sbasmaritime', which is a shortcut for providing these parameters: '-model:nomt10' and '-model:nomt2728'.

Furthermore, if the receiver position is fixed and INFO messages are enabled, INFO messages at the end will be printed with a statistical summary of the processing. Execute 'gLAB -sbassummaryexample' for an example of the summary.

NOTES FOR PREFIT OUTLIER DETECTION
There are two prefit outlier detectors in gLAB:
- Prefit outlier detector comparing against the median (by default disabled):
    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

5.1 PROCESSING EXAMPLE

The following example gives an overview of a simple processing using the gLAB DPC component. The sample covers a precise static positioning to obtain the precise coordinates of a station and provides exactly the same results as the sample generated in section 4.5.

Opening a command line window in the gLAB directory (in Windows this can be directly done by the option “Command line in directory” in the program group installed in the Start menu). Using this option a command line window will open (Figure 5-1) in the proper directory.

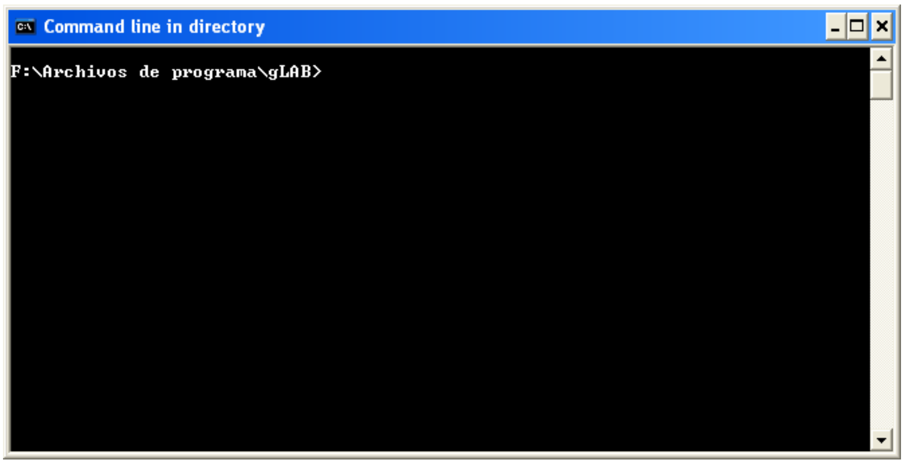

Figure 5-1: Command line screenshot

In order to generate the selected processing, the following command should be executed:

```
win\gLAB.exe -input:obs test\madr2000.06o -input:ant test\igs_pre1400.atx -input:SP3 test\igs13843.SP3 -output gLAB_DPC.out
```

After a few seconds the file “gLAB_DPC.out” will be generated with the all the output details.

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.

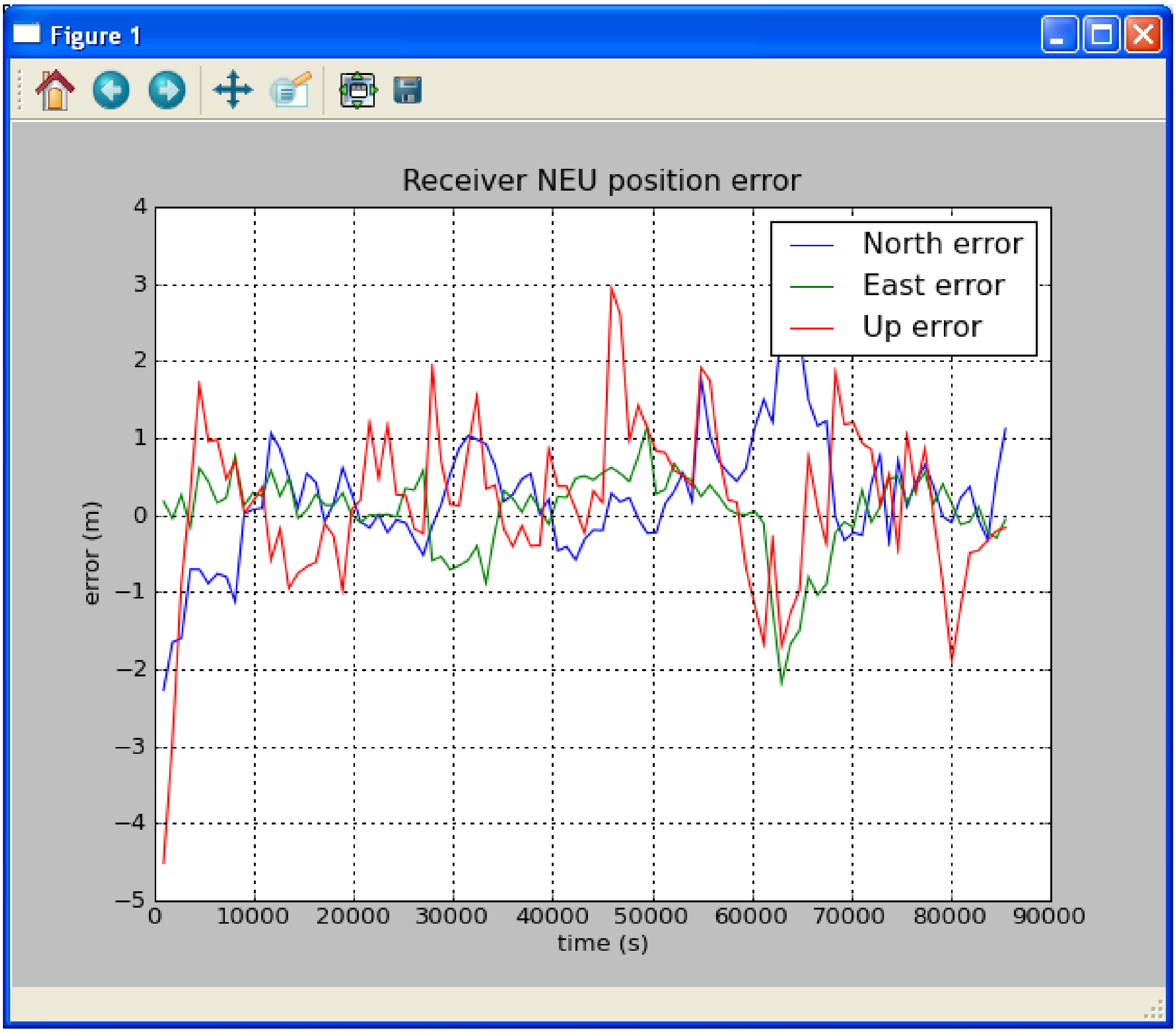

Figure 6-1: DAT screenshot. It can be seen the position error for a PPP kinematic positioning for a single-frequency receiver.

The available options are:

GRAPHIC GENERAL OPTIONS:

The General Options are the ones that can be specified once per graphic, and will affect the entire graphic window:

-h, --help	Show this help message and exit
-t, --title, --tit	Set the title of the Graphic
--Xlabel, --xlab, --xl	Set the x-axis label
--Ylabel, --ylab, --yl	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
--Yticks, --yticks, --yt	Set the ticks for y axis. The values must be given in this format: Ymin,Ymax,NumberOfTicks
--Ftitle, --ftitle, --ft	Add a fractional title to the upper left corner.
--wm, --watermark	Add a watermark with the given label.
--AdjustToMargin, --atm, --adjusttomargin	Expand the figure to fit the image margin.

Example:

```
graph.py -t "Graphic title" --xl "time (s)" --yl "Altitude [m]"
--xmin -3.0 --ymax 5.0 --xticks 0,24,7
```

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 Set the input file name for the specific plot.

-x, -X, --Xcol 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 Set the source of the y axis
Identical properties as x column

-c, --cond 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 exmaple, the following condition:
-c '($1=="POSTFIT")&(math.e($12+$5)>5.0)'
is valid in Linux, but in Windows it should be written like this:
-c "($1=='POSTFIT')&(math.e($12+$5)>5.0)"

-l, --label, --plotlabel 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 [DEFAULT]

--lp, --labelpos, --labelPos 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
'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            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
                       'o'    point marker
                       's'    square marker
                       'p'    pentagon marker
                       '+'    plus marker
                       'x'    x marker
```

For a full list of styles, see http://matplotlib.org/api/pyplot_api.html#matplotlib.pyplot.plot

```
--color, --cl          Sets the colour for the current plot
                       The following colours are supported:
                       'b'    blue [DEFAULT]
                       'g'    green
                       'r'    red
                       'c'    cyan
                       'm'    magenta
                       'y'    yellow
                       'k'    black
                       'w'    white

--markersize, --ms         Sets the plot maker size 5 by [DEFAULT]

--linewidth, --lw          Sets the plot maker size 0 by [DEFAULT]

-g, --grid             Set the plot with grid by [DEFAULT]
                       It could be turn off by 'off' or 'no'
```

Example:

```
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   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

STANFORD PLOT:

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, if
                              no value is provided, AL is set to 40 [DEFAULT].
--clean   Make a stanford Plot without failure patches.
--xr,   --xresolution   Set the resolution in x-direction of the plot.
                              If no value is provided, it is set to 0.5 [DEFAULT].
--yr,   --yresolution   Set the resolution in y-direction of the plot.
                              If no value is provided, it is set to 0.5 [DEFAULT].

Example:
graph.py -f /home/gLAB/Example -x 1 -y 2 --sf

STANFORD-ESA PLOT:

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, protection level, number of horizontal values (at the given coordinate), number of vertical values

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.

Example:

graph.py -f /home/gLAB/Example --sfesa --sv /home/Desktop/Figure_Vertical.eps --sv /home/Desktop/Figure_Horizontal.eps

Example:
graph.py -f /home/gLAB/Example --sfesa

WORLD MAP / STATION NAME MAP / WORST INTEGRITY RATIO PLOTS:
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 Set the source of the vertical values or worst integrity ratio.
Identical properties as x,y column in the default plots.

--rh, --ratioH, --RH Set the source of the horizontal values or worst integrity ratio.
Identical properties as x,y column in the default plots.

--miv, --MIV Set the source of the vertical MIs.
Identical properties as x,y column in the default plots.

--mih, --MIH Set the source of the horizontal MIs.
Identical properties as x,y column in the default plots.

--sn, --staName, --SN Set the source for the station name. Setting this value will make a new
plot with the name of the stations in their coordinates.

--projection, --pj Set the projection of the map.
'Equidistant Cylindrical Projection' is set as [DEFAULT]
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.

--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, if no value is provided,
8 is set as [DEFAULT]

--continentColor,--cc The continent's colour, if no value is provided, 'yellow' is
set as [DEFAULT]

--lakeColor, --lc The lake's colour, if no value is provided, 'white' is
set as [DEFAULT]

--boundaryColor,--bc The continent's colour, if no value is provided, 'white' is
set as [DEFAULT]

--mapres, --MapResolution Sets the world map resolution. Valid values are 'c', 'l' [DEFAULT],
'i', 'h' or 'f' (ordered from lower to higher resolution).

NOTES on World Maps / Worst Integrity Ratio Maps:
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.

Example:
Generate one plot: graph.py -f /home/gLAB/Example --wir -x 5 -y 7 --rh 11
Generate two plots: graph.py -f /home/gLAB/Example --wir -x 5 -y 7 --rh 11 --rv 13 --mih 17 --grid off
Generate three plots: graph.py -f /home/gLAB/Example --wir -x 5 -y 7 --rh 11 --rv 13 --sn 3 --mih 17 --miv 19
Example for saving the plots:
graph.py -f /home/gLAB/Example --wir -x 5 -y 7 --rv 13 --miv 19 --rh 11 --mih 17 --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

SBAS AVAILABILITY AND CONTINUITY PLOT:

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%

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

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%

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 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.

--sbas, --SBAS Make a SBAS map

--nocontourlines, --NoContourLines Do not show contour lines in Availability and Continuity Risk maps

Example:
graph.py -f /home/gLAB/Example --sbas --sv /home/Desktop/SBASAvailMap.eps

Example:
graph.py -f /home/gLAB/Example --SBAS

Options:
-h, --help show this help message and exitSetting the axis
As seen in section 4.3 Analysis (DAT Interface) 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)’

6.1 SETTING THE CONDITIONS

As seen in section 4.3 Analysis (DAT Interface), 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)

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.

6.2 PROCESSING EXAMPLE

The following example gives an overview of a simple plot generated using the gLAB DAT component. The sample uses a .out file generated by the DPC. In particular, uses the one generated in the example of section 5.1.

This example generates the same plot that would generate the template button of *Receiver NEU position error* of the GUI (Analysis tab).

Opening a command line window in the gLAB directory (in Windows this can be directly done by the option “Command line in directory” in the program group installed in the Start menu. Using this option a command line window will open (Figure 5-1) in the proper directory.

In order to generate the plot, the following command should be executed:

```
win\graph.exe -t "Receiver NEU position error" --xl="time (s)"
--yl="error (m)" -f gLAB_DPC.out -x 4 -y 18 -c "($1=='OUTPUT')"
-l "North error" -f gLAB_DPC.out -x 4 -y 19 -c "($1=='OUTPUT')"
-l "East error" -f gLAB_DPC.out -x 4 -y 20 -c "($1=='OUTPUT')"
-l "Up error"
```

This will generate the plot seen in Figure 4-27.

End of Document