



# GNSS Analysis Tools “GnssAnalysisApp”

Installation and User Manual, 20 Sept 2022, v4.5.0.0

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# 1 Overview

These tools provide analysis of your GNSS system implementation, including:

- GNSS Measurement and Clock APIs
- RF performance (C/No)
- Receiver clock behavior (both active and standby clocks)
- GNSS Measurement accuracy (raw pseudoranges, and pseudorange-rate or Doppler)

Follow the installation instructions for your platform: Linux, Mac, or Windows. Then test the tools [as described](#).

## 1.1 Version numbering

Versions are numbered: v2.6.0.0 = v a.b.c.d

a = Change in Raw Measurements API  
b = New Features  
c = Minor Changes/Features  
d = Bug Fixes

The first release of Android Raw Measurements was in the Android Nougat ("N") release, so a=1 corresponds to Android N, a = 2 corresponds to Android O, a = 3 corresponds to Android P.

## 1.2 Changes in released versions

Newest release first:

Version 4.5.0.0 release notes:

Built GAT on Matlab R2022a, giving access to new features:

- Status window auto scrolls: latest status message is always visible.

Added a table of C/N<sub>0</sub> comparisons, by constellation, and comparing L1 to L5.

Added pseudorange rate residual plot.

Simplified GAT

- Removed separate tabs for Reference PVT Stationary or Moving, making it easier to see which type of Reference PVT has been selected.
- Moved "Make Report" results from html to Status Window
- Removed mission planner tab. Please use [gnssmissionplanning.com/](http://gnssmissionplanning.com/) or [www.gnssplanning.com/](http://www.gnssplanning.com/).

Fixes related to RINEX Observation file parsing

Fallback to NASA CDDIS ephemeris source for GPS and GLO, when BKG is not working.

Move from [igs.bkg.bund.de](http://igs.bkg.bund.de) to [igs-ftp.bkg.bund.de](http://igs-ftp.bkg.bund.de)

Do not exit analysis if GAL, QZSS or BDS ephemeris download fail



Fixed the bug of a wrong xlim in the plots.  
Create Antenna CNo analysis even if chipset does not support BaseBandCNo  
Several GUI enhancements and other fixes.

#### Version 4.0.1.1 release notes:

Changed BKG ephemeris ftp site to match recent changes made by BKG (German Federal Agency for Cartography and Geodesy)  
Fallback to NASA CDDIS ephemeris source for GPS and GLO, when BKG is not working  
Fixed known bugs

#### Version 4.0.0.0 release notes:

Enhanced Cn0 plots with the new baseband Cn0 Android APIs

Added following Cn0 analysis:

- Average of top 4 Cn0s per epoch average
- Average of top 4 average Cn0s for L1 signals over entire observation period
- Average of top 4 average Cn0s for L5 signals over entire observation period

While computing delta WLS positions, made restrictions to have stronger previous ADR, so we only use ADR that was usable for two successive epochs  
Fixes some known bugs

#### v3.1.0.0

Supports GnssLogger files and RINEX v3 observation files collected from GnssLogger  
v3.0.0.0  
Supports more signals like BDS B2, GAL E5 in position computations  
Adapts to the connection change to NASA CDDIS site (now uses HTTPS instead of FTP)  
Fixes some known bugs

#### v3.0.3.0

Adds Plots:

Kalman Filter position from WLS PVT  
WLS relative position from ADR (Carrier Phase)  
ADR (Carrier Phase) Single Difference Residual  
Adds Refresh Positions to regenerate position plots based on selected satellites.  
Adds Elevation Mask control  
Optimized downloading of ephemeris files, uses native unzip inside Matlab runtime for all BKG \*.gz zip files  
Adds Device Position as an option for Reference PVT  
Adds CustomDataFilter.m capability, filter on any of the # Raw header values

#### v2.6.0.0

Adds L1/L5 analysis:

L1-L5 C/No difference  
L1-L5 group delay  
Ephemeris ftp sites are reported to status screen before attempting ftp,



so if ftp fails, you know where to get ephemeris files "by hand".  
Mission Planner (computes skyplot for any time and place).

Report: more analysis of API:

Pass/Fail based on mandatory fields

Warning if non-mandatory, but recommended, fields are missing

Optimized for execution speed

#### v2.5.0.0

Includes smoothing of pseudoranges with Doppler/carrier phase,  
plots positions from raw and smoothed pseudorange,  
plots measurement errors for raw and smoothed pseudorange,  
saves raw and smoothed pseudoranges to derived data file,  
saves inter-system time biases to derived data file.

#### v2.4.0.0

First publicly released version  
Supports GPS, GLO, GAL, BDS, QZS  
Supports L1 and L5



## 2 Linux installation

1. Uninstall any previous version of GNSS Analysis App:

Delete the following folders from .../GnssAnalysisFiles/:

```
/application  
/for_redistribution  
/for_redistribution_files_only  
/demofiles  
/planning
```

2. Download the Linux version of the GNSS Analysis App from the Android Raw GNSS Measurements Website, [g.co/GNSSTools](http://g.co/GNSSTools)
3. Create a folder on your Desktop: ~/Desktop/GnssAnalysisFiles/ and extract the contents of the zip files to it.

**Note:** "Desktop" is a folder that is common to all three platforms: Linux, Mac, and Windows, and the Analysis app will use it as a default. The program will run much better if you use this default directory instead of some other directory location.

You should now have the following folder

~/Desktop/GnssAnalysisFiles/, with subfolders:

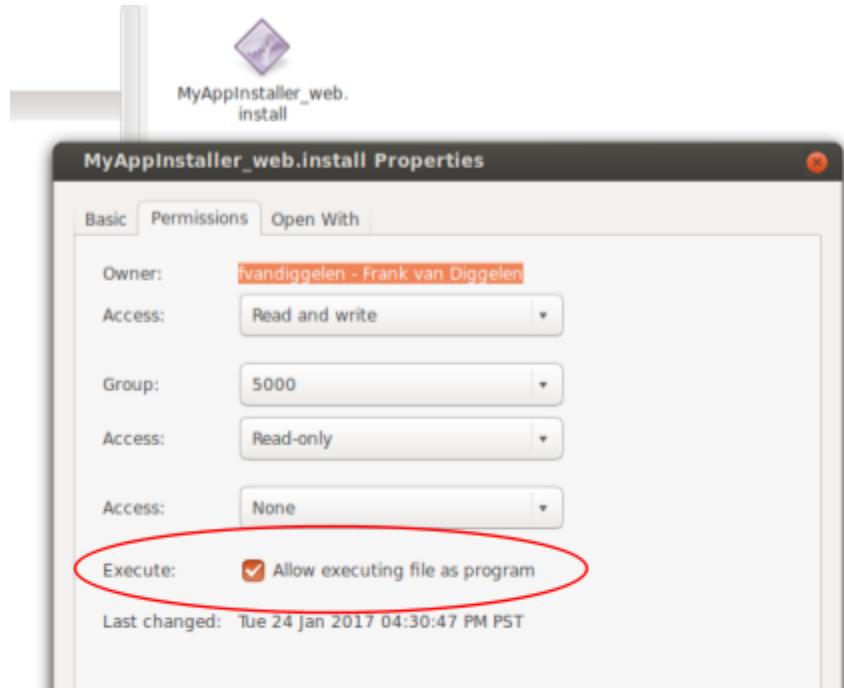
```
/for_redistribution  
/for_redistribution_files_only  
/demofiles  
/planning
```

### 2.1 Install with MATLAB runtime

1. Change permissions of

~/Desktop/GnssAnalysisFiles/for\_redistribution/MyAppInstaller\_web.install to executable

For example, from "Properties":



Or from Terminal:

```
$ chmod +x MyAppInstaller_web.install
```

2. Run the program `MyAppInstaller_web.install` in a Terminal window:

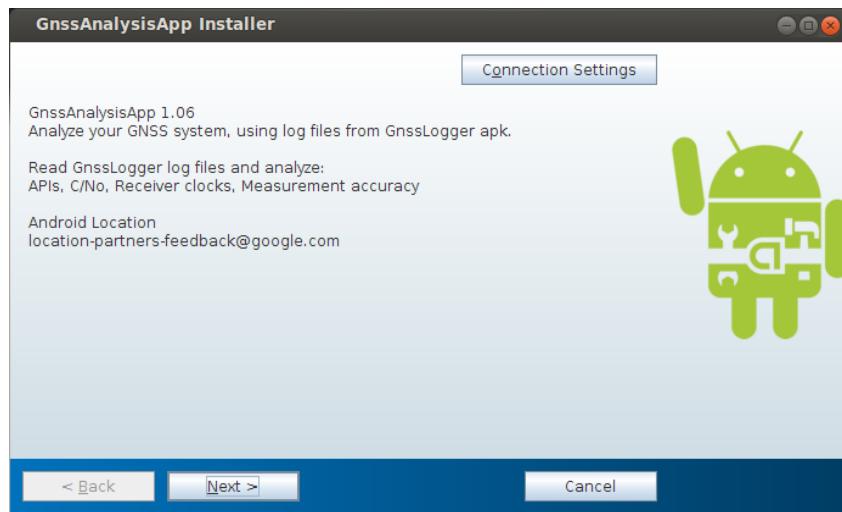
```
$ cd ~/Desktop/GnssAnalysisFiles/for_redistribution/  
$ ./MyAppInstaller_web.install
```

**BE PATIENT!** The load time of this installer can be many seconds. And the first time you install MATLAB Runtime it can take up to 30 minutes to download all the files from The MathWorks.

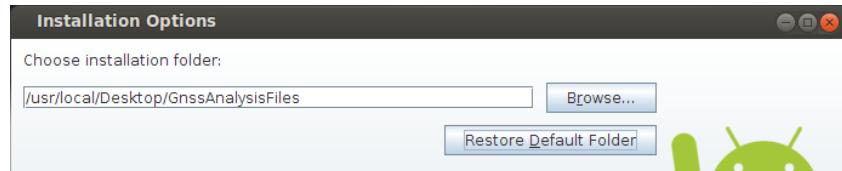
**NOTE:** if it fails right away you may need to run the command as root and provide your password

```
$ sudo ./MyAppInstaller_web.install
```

(Possibly after a minute or two) you should see installation screens similar to this:



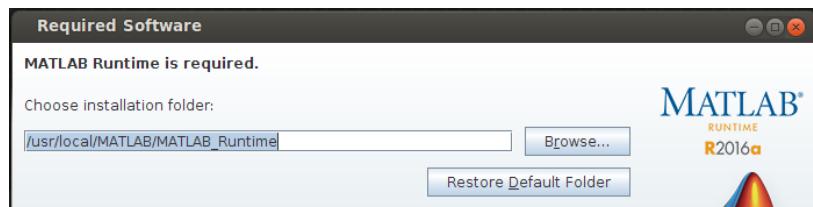
the default installation folder is: /usr/local/Desktop/GnssAnalysisFiles/



If your Desktop directory is /usr/local/...username etc .../Desktop/, then insert ...username etc .../ in the above installation folder, between "local/" and "Desktop".

**NOTE:** you could install the app in another directory, but it *must* be in a writable directory. Desktop is the most common writable directory; also the GnssAnalysis app uses your Desktop as the default directory for log files, so it is highly recommended you use this directory for installation.

### 3. Choose a *writable* directory to install MATLAB runtime.



If your home directory is /usr/local/...username etc .../, then insert ...username etc .../ in the above installation folder, between "local/" and "MATLAB".

#### **NOTE:**

- MATLAB runtime is license-free, it will download from The MathWorks.
- When you choose a directory for installing MATLAB\_runtime, the installer will add



a subdirectory “/v910”.

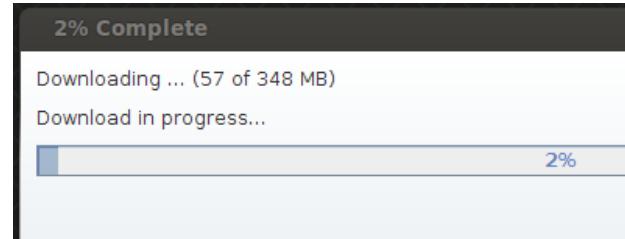
For example, if you chose: /usr/local/MATLAB/MATLAB\_Runtime, then the installer will create a directory:

/usr/local/MATLAB/MATLAB\_Runtime/v910

This is why you must choose a writable directory, else the installer will fail to create the subdirectories it needs.

- The first time you install MATLAB runtime v910 *it will take a long time* to download the license-free program from The MathWorks (up to 30 minutes):

... thereafter, any time you update GnssAnalysisApp, the installer will recognize that MATLAB runtime is already installed, and it will not download it again unless a new Runtime version has been released (see FAQs).



May 2018: MATLAB has released a new Runtime, which is required for v2.6.x.x and higher. This new MATLAB Runtime will be downloaded when you first install v2.6.x.x or higher. On future updates of the Analysis Tools you will not need to download MATLAB Runtime again, unless a new Runtime version has been released (this happens less often than once per year).

#### 4. Run the app:

The installation will create a subdirectory .../GnssAnalysisFiles/application/. From the Terminal, change directory this directory, e.g.

\$ cd ~/Desktop/GnssAnalysisFiles/application/  
and run the shell script:

```
$ ./run_GnssAnalysisApp.sh <mcr_directory>
```

<mcr\_directory> is the directory where MATLAB Runtime was installed, e.g.

~/MATLAB/MATLAB\_Runtime/v910/

For this example, cut and paste this into the command line:

```
$ ./run_GnssAnalysisApp.sh ~/MATLAB/MATLAB_Runtime/v910/
```

**Note:** you may need to run this command as root and provide your password

```
$ sudo ./run_GnssAnalysisApp.sh <mcr_directory>
```

See the section “[Test with supplied data](#)” for further information on how to run the application, and where to find the resulting reports.



## 2.2 If you already have MATLAB

Even if you have MATLAB on your computer, it is still useful to install MATLAB Runtime v910 so you don't have compatibility problems. We recommend you follow the steps 3 to 7 in Section 2.1.

However, if you are a super user and want to use your own version of MATLAB, and you have R2018a or later, you can run the shell program directly from

```
.../GnssAnalysisFiles/for_redistribution_files_only
```

To run the app, go to that folder in Terminal, and enter:

```
$ ./run_GnssAnalysisApp.sh <mcr_directory>
```

<mcr\_directory> is the directory where your copy of MATLAB is installed,  
e.g. /usr/local/MATLAB/R2018a

If you get a “permission error” then change permissions of run\_GnssAnalysisApp.sh in a similar way to what was described at the beginning of “[Install with MATLAB runtime](#)”

See the section “[Test with supplied data](#)” for further information on how to run the application, and where to find the resulting reports.



# 3 Mac installation

1. Uninstall any previous version of GNSS Analysis App:
  - a. Delete the following folders from ~/Desktop/GnssAnalysisFiles/ :  
/for\_redistribution  
/for\_redistribution\_files\_only  
/demofiles  
/planning
  - b. Delete /Applications/MyAppInstaller\_web.app
  - c. Delete the folder and contents of: /Applications/GnssAnalysisFiles
2. Download the Mac version of the GNSS Analysis App from the Android Raw GNSS Measurements Website, <http://g.co/GNSSTools>
3. Create a folder on your Desktop: ~/Desktop/GnssAnalysisFiles/ and extract the contents of the zip files to it.

**Note:** "Desktop" is a folder that is common to all three platforms: Linux, Mac, and Windows, and the Analysis app will use it as a default. We recommend that you use this default directory instead of some other directory location.

You should now have the following folder

~/Desktop/GnssAnalysisFiles/, with subfolders:

```
/for_redistribution  
/for_redistribution_files_only  
/demofiles  
/planning
```

## For Mac OS X 10.11 (El Capitan) or earlier skip to step 6

4. Navigate to the folder in Finder, and then to the sub-folder "for\_redistribution" where you will find MyAppInstaller\_web. Drag the app to the Applications folder, found in the column of Favorites on the left.

**Note:** DO NOT try to open or run the installer from this directory. If you do, the app will be quarantined, and you will have to delete everything and start over.

This is because starting with release 10.12, Apple has added an extra layer of security to prevent the installation of malicious apps. Step 5 shows how to remove the quarantine attribute.
5. Open a Terminal window, found in the Applications -> Utilities folder. At the prompt enter the following commands:
  - a. cd /Applications  
This takes you to the Applications folder
  - b. xattr MyAppInstaller\_web.app  
This determines what attributes have been set on the app. The command should return



"com.apple.quarantine", indicating that the quarantine attribute is set.

- c. `sudo xattr -r -d com.apple.quarantine MyAppInstaller_web.app` This is the command to remove the quarantine. The sudo part runs the command as Administrator. You will be prompted for your password before the command is allowed to execute. (You must have Administrator privileges for sudo.)

- d. `xattr MyAppInstaller_web.app`

This time the command should return nothing, indicating that the quarantine attribute has been unset. You can now proceed with the installation.

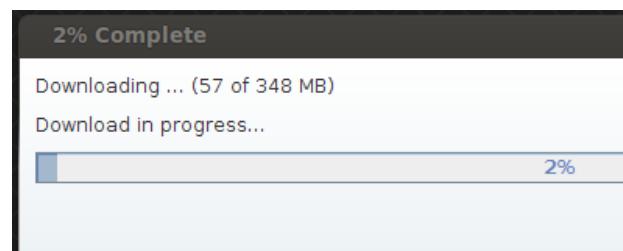
6. Open the program: `/Applications/MyAppInstaller_web` (To open: right click, Open)

**Note:** You might get the following message "Your security preferences allow installation of only apps from the Mac App Store and identified developers". This means the security settings won't allow you to install the Analysis App. To get around the error message, control-click the application and choose Open. Click the Open button in the warning dialog that appears.

7. Follow instructions to install, including downloading and installing MATLAB Runtime (you only have to download MATLAB Runtime *the first time* you install GnssAnalysisApp, unless there is a new release of MATLAB Runtime). Use the default directories for installation.

The first time you install MATLAB Runtime *it will take a long time* to download the license-free program from The MathWorks (like, 30 minutes):

... thereafter, unless there is a new release of MATLAB Runtime, any time you update GnssAnalysisApp, the installer will recognize that MATLAB runtime is already installed, and it will not download it again.



8. Once you have followed the above instructions, and used the appropriate directories, you can run the program from the Terminal window:

```
cd /Applications/GnssAnalysisFiles/application/  
.run_GnssAnalysisApp.sh /Applications/MATLAB/MATLAB_Runtime/v910/  
If you used different directories for installation, then make the appropriate changes to these commands.
```

If this does not work, read .../GnssAnalysisFiles/for\_redistribution\_files\_only/readme.txt for more detailed setup instructions



# 4 Windows installation

## 4.1 GnssAnalysis installation

1. Uninstall any previous version of GnssAnalysis.
2. Download the Windows version of the GNSS Analysis App from the Android Raw GNSS Measurements Website, <http://g.co/GNSSTools>
3. Create a folder on your Desktop: ~/Desktop/GnssAnalysisFiles/ and extract the contents of the zip files to it.

**Note:** "Desktop" is the one folder that is common to all three platforms: Linux, Mac, and Windows, and the Analysis app will use it as a default. The program will run much better if you use this default directory instead of some other directory location.

You should now have the following folders:

...\\Desktop\\GnssAnalysisFiles\\, with subfolders:

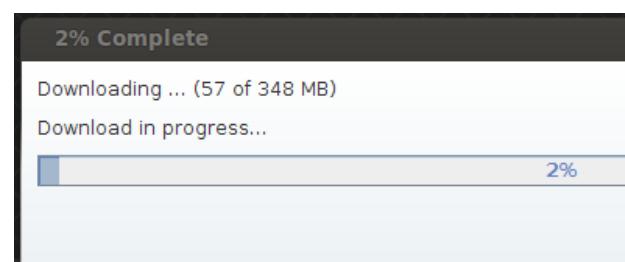
```
\for_redistribution  
\for_redistribution_files_only  
\demofiles  
\planning
```

4. Go to the subfolder ...\\Desktop\\GnssAnalysisFiles\\for\_redistribution\\ and double-click **MyAppInstaller\_web.exe**
5. Install the GnssAnalysisApp and MATLAB Runtime in the default installation folders.

**BE PATIENT!** The load time of this installer can be a minute or more. Hint: open Task Manager, and you can see that something is happening.

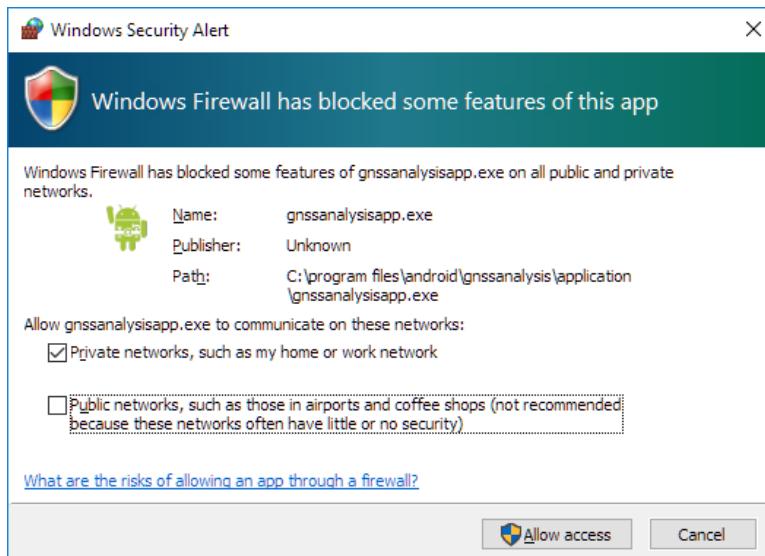
The first time you install MATLAB Runtime *it will take a long time* to download the license-free program from The MathWorks (like, 30 minutes):

... thereafter, unless there is a new release of MATLAB Runtime, any time you update GnssAnalysisApp, the installer will recognize that MATLAB runtime is already installed, and it will not download it again.





When the app runs, it fetches Ephemeris files from the BKG<sup>1</sup> ephemeris ftp site , and from the NASA ephemeris site<sup>2</sup>. On installation you must give permission to gnssanalysisapp.exe to communicate on a network, such as your home or work network:



## 4.2 gunzip installation

The automatic ftp code inside GnssAnalysis will download ephemeris zip files, and attempt to unzip them using gunzip.

- Download gzip.exe from here  
<http://gnuwin32.sourceforge.net/downlinks/gzip-bin-zip.php>
- Extract the files from the zip file, rename gzip.exe to gunzip.exe
- Move gunzip.exe to somewhere in your Windows path (type “path” in the Windows Command Prompt to see what your path is, typically you will find a directory “C:\\Windows\\system32” and you can put gunzip.exe there.)

## 4.3 Running the GnssAnalysis app

Go to \\Program Files\\Android\\GnssAnalysis\\application\\ and double-click GnssAnalysisApp.exe, or double click the shortcut on your desktop.

**BE PATIENT, again!** When you run the program in Windows it can take a minute or more to load.  
Hint: open Task Manager, and you can see that something is happening.

<sup>1</sup> Bundesamt für Kartographie und Geodäsie (BKG), Federal Agency for Cartography and Geodesy, Germany  
<ftp://igs-ftp.bkg.bund.de/IGS/BRDC/>

<sup>2</sup> <https://cddis.nasa.gov/archive/gnss/data>

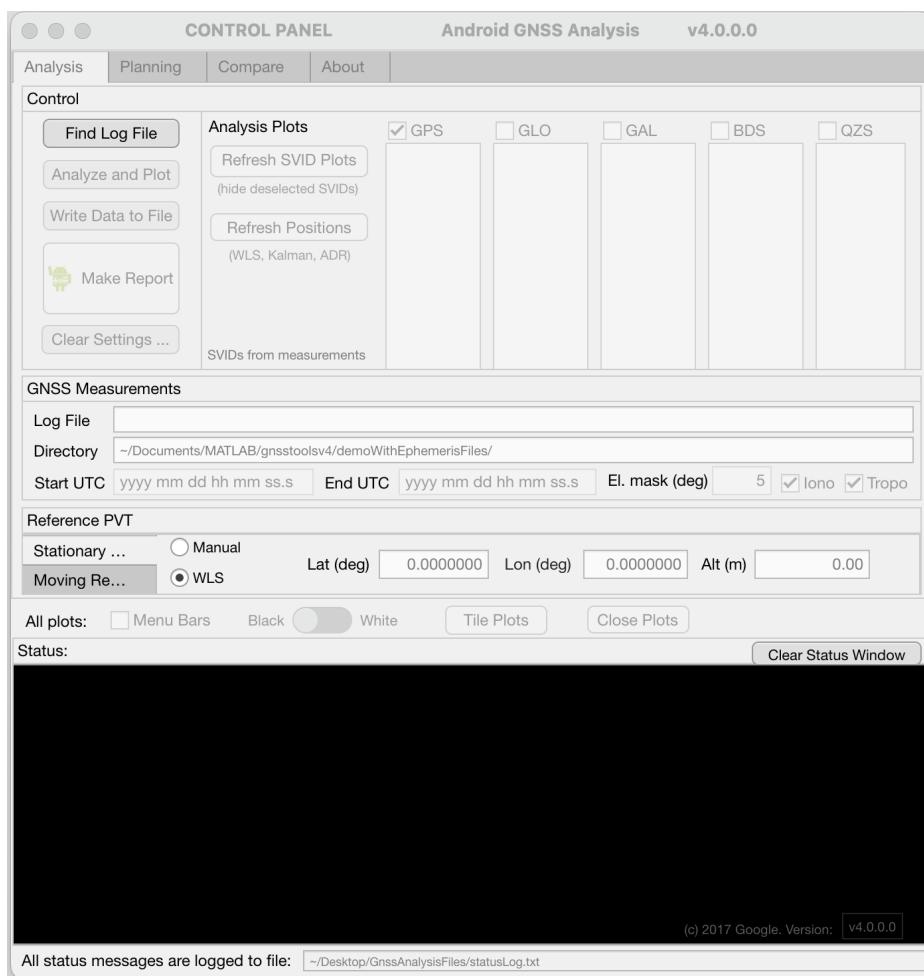


# 5 Test with supplied data

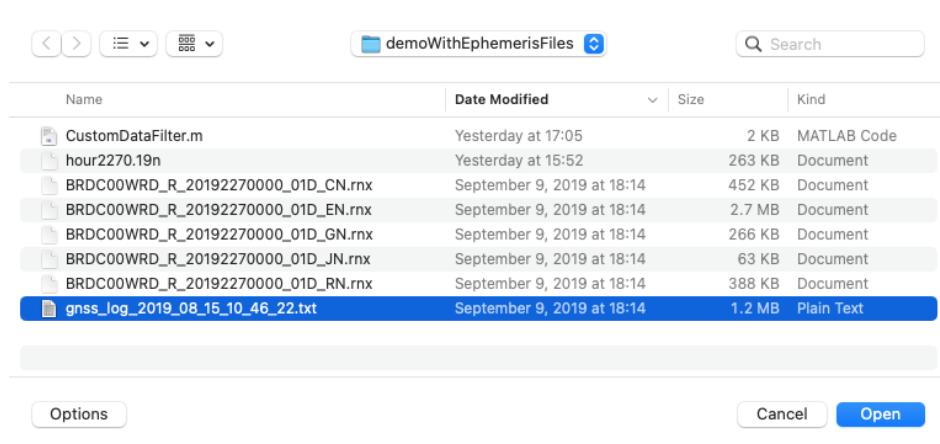
## 5.1 Load Log File with Ephemeris

Run the application (see details under Linux, Mac, or Windows installation sections).

You will see a screen like this:



Click “Find Log File”, click on the “demoWithEphemerisFiles” directory ...  
select the gnss\_log\_... .txt file, and click “Open”:



Click “Analyze and Plot”, the Analysis app will run, producing a 3x3 array of interactive plots.



When the ephemeris files are all present with the log file, as in this example, then the app reads them and applies them. No ftp is necessary.

## 5.2 Load Log File without Ephemeris

This next test does not have a local copy of the ephemeris. The app will go to BKG<sup>3</sup> and NASA<sup>4</sup> sites and try to download the ephemeris automatically. This is the most likely cause of problems

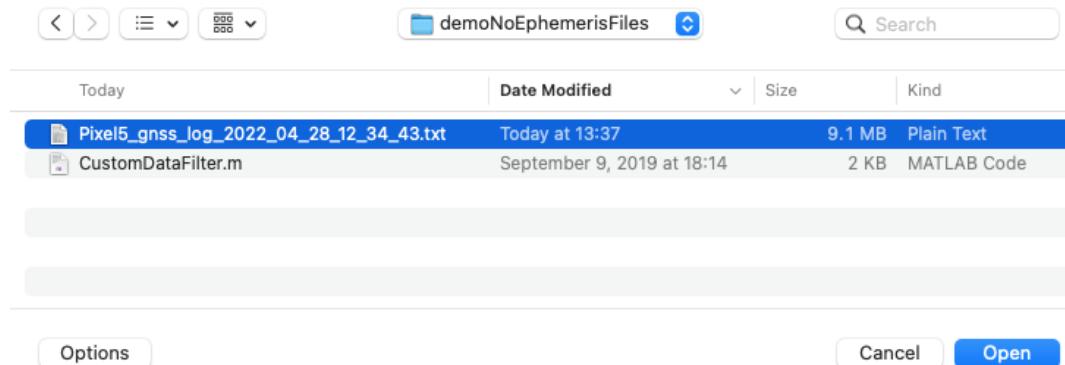
<sup>3</sup> Bundesamt für Kartographie und Geodäsie (BKG), Federal Agency for Cartography and Geodesy, Germany  
<ftp://igs-ftp.bkg.bund.de/IGS/BRDC/>

<sup>4</sup> <https://cddis.nasa.gov/archive/gnss/data>

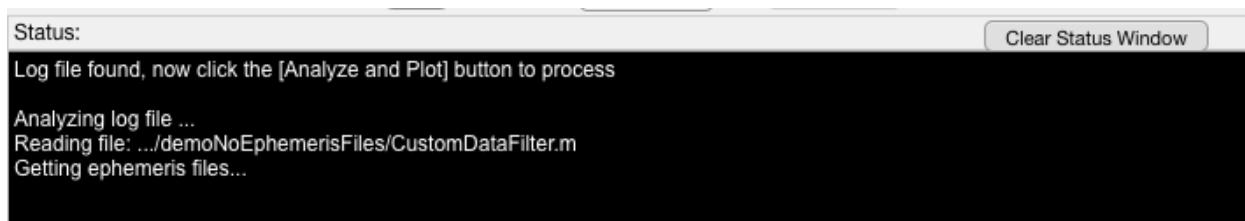


with the application, because many security features on your computer or network may stop the ftp downloads from happening. In that case you will get a message to download the files manually.

Click “Find Log File”, click on the “demoNoEphemerisFiles” directory ...  
select the gnss\_log\_... .txt file, and click “Open”:



Click “Analyze and Plot”, the Analysis app will run, and try to get ephemeris from the BKG and NASA sites:



If it is successful you will see this:



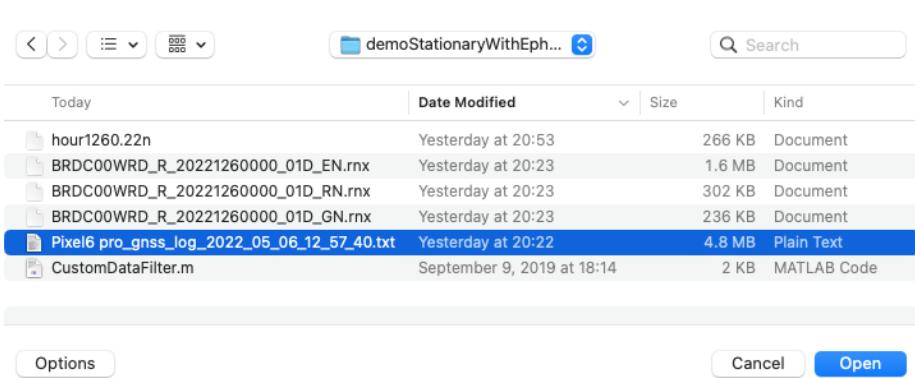
If it fails to get the ephemeris it will prompt you to go to the site - cut and paste the url from the Status Window, and get the ephemeris, download it to the directory with the gnss log file, and try again.

## 5.3 Load Log File and Create a Test Report

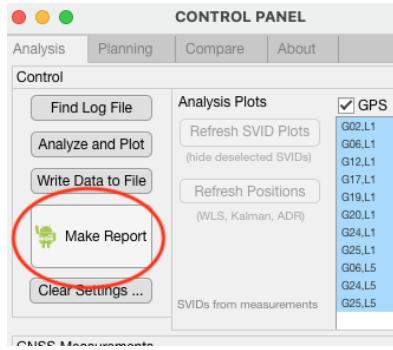
This test shows you how you can create a report summarizing the characteristics of a receiver.



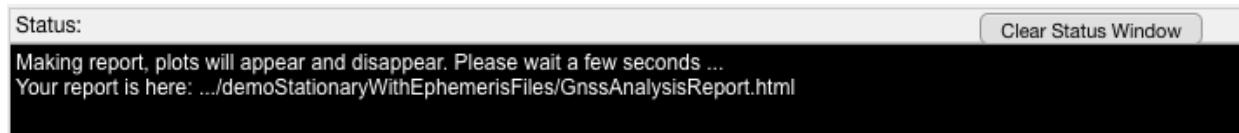
Click “Find Log File”, click on the “demoStationaryWithEphemerisFiles” directory ...  
select the gnss\_log\_... .txt file, and click “Open”:



Click “Analyze and Plot”, the Analysis app will run. After it has created the 3x3 array of plots, click “Make Report” to create the test report.



A report in html format will be created in the same directory where the log file is. The app prints the location of the report in the Status window:



**NOTE:** Many plots will appear and disappear while the report is created. Don't worry about plots disappearing, this happens automatically as part of the report generation; the app will leave the original interactive plots on the screen.



The report will look like this:

# Android GNSS Analysis

07-May-2022 12:34:19

---

## Table of Contents

- [Test Summary](#)
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## Test Summary

This analysis is for a stationary receiver, with open sky.

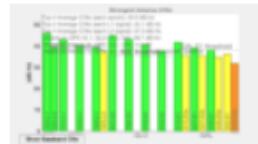
```
Data directory:  
-/Desktop/GnssAnalysisFiles/demoStationaryWithEphemerisFiles/  
Log file: Pixel6 pro_gnss_log_2022_05_06_12_57_40.txt  
GnssLogger: v3.0.3.1  
GNSS Analysis App: v4.0.0.0  
Phone: Google Model: Pixel 6 Pro  
Android version: 13
```

### API.

```
GnssClock Errors. None.  
GnssMeasurement Errors. None.  
WARNING, Recommended Fields Missing: AgcDb.
```

**PASS**

### Received Signal Analysis.



```
GPS(L1), mean of strongest 4 mean C/No = 42.1 dBHz  
Pass/fail reference threshold = 38.0 dBHz  
GPS(L5), mean of corresponding L5 C/No = 38.4 dBHz  
Error: mean(L5 signals) weaker than mean (L1 signals)  
FAIL BECAUSE L5 WEAKER THAN L1
```

```
GLO(L1), mean of strongest 4 mean C/No = 41.5 dBHz  
Pass/fail reference threshold = 35.5 dBHz  
PASS
```

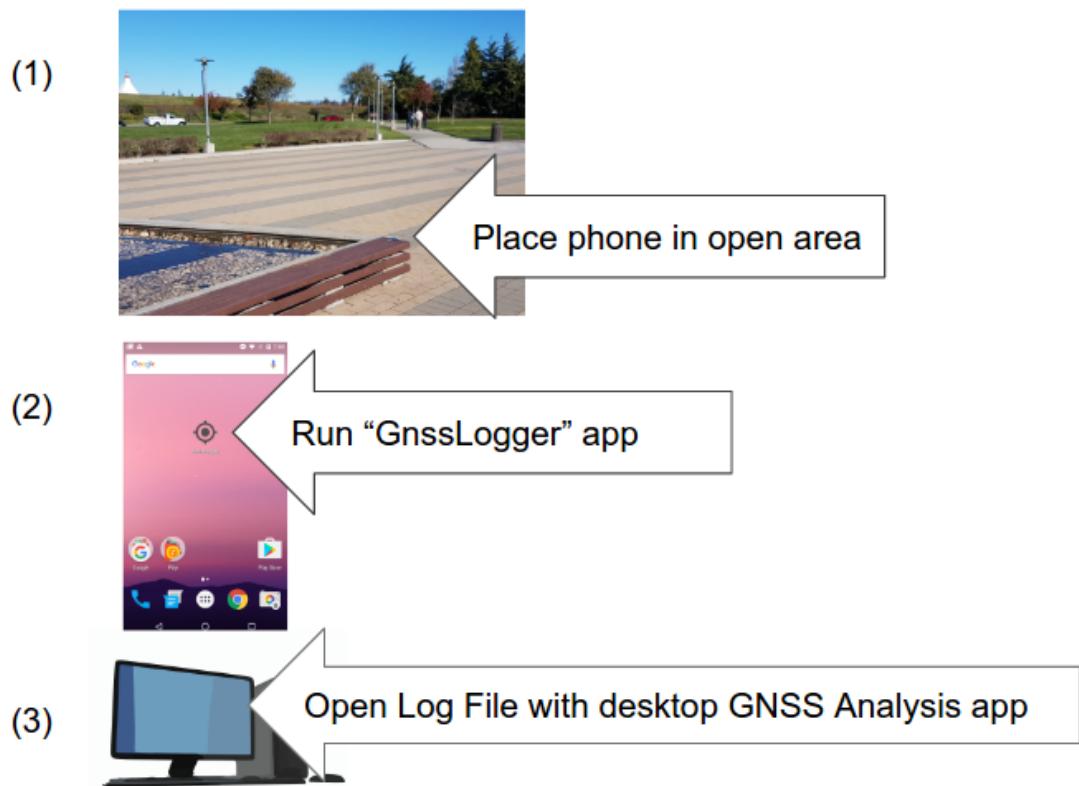
```
GAL(E1), mean of strongest 4 mean C/No = 38.7 dBHz  
Pass/fail reference threshold = 38.0 dBHz  
GAL(E5), mean of corresponding L5 C/No = 34.3 dBHz  
Error: mean(L5 signals) weaker than mean (L1 signals)  
FAIL BECAUSE L5 WEAKER THAN L1
```



You have now successfully installed the GNSS Analysis Tools, congratulations!  
You can now use these tools with log files you collect from the GnssLogger apk running on your phone.

## 6 Work with your own data

### 6.1 Basic data collection, static



Collect approximately 5 minutes of raw GNSS measurements using the [GnssLogger](#) app, copy the log file to a suitable directory on your desktop or laptop computer, and run the desktop GnssAnalysis app as described in the previous section. The app will create a report in the same directory that you specified for the Raw Measurements log file.

**Hint:**

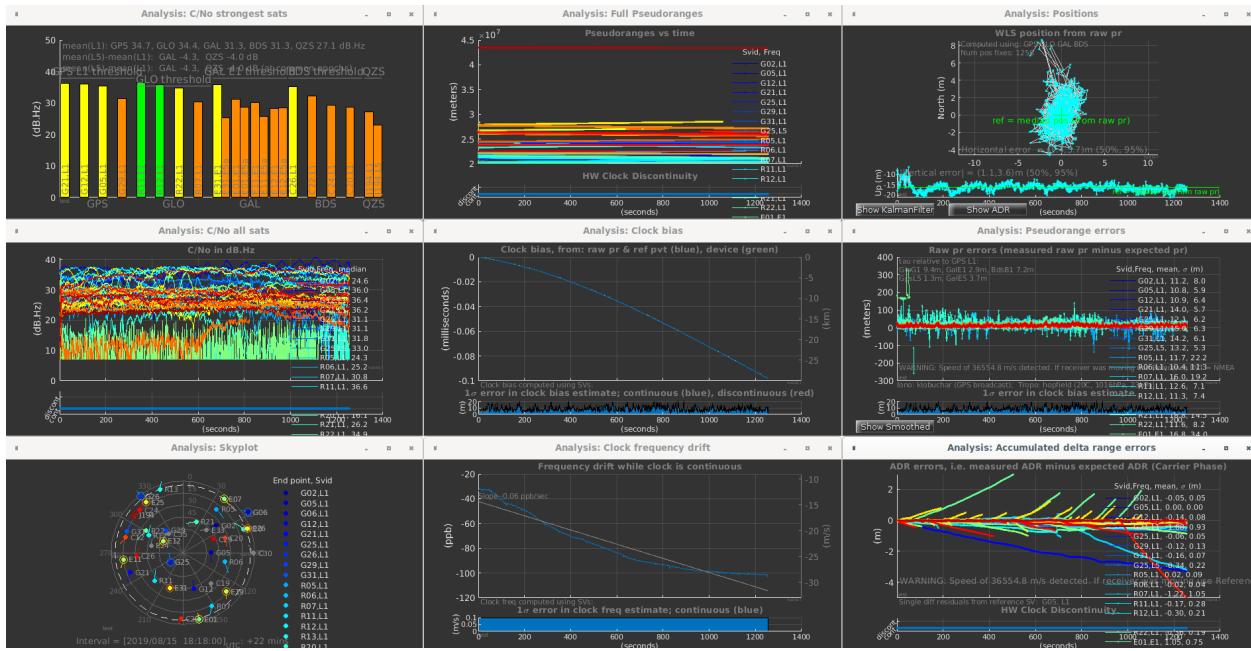
It is a good idea to store each measurement log file in its own subdirectory under  
.../Desktop/GnssAnalysisFiles/yourSubdirectory/

Because the orbit, csv, nmea, and report files will be stored in the location of the measurement log file, so it's convenient to have a separate subdirectory for each log file and its daughter files.



## 6.2 Interactive plots

When you click “Analyze and Plot”, the Analysis app produces a 3x3 array of interactive plots tiled across your primary display:



You can adjust the plots from the control panel. Including: change background color; enable the Menu Bars for printing or saving; and selecting specific satellites for the plots.

■ CONTROL PANEL      Android GNSS Analysis v3.0.3.0

Analysis   Planning   Compare   About

Control

Find Log File   Refresh SVID Plots   Refresh Positions   GPS   GLO   GAL   BDS   QZS

Analyze and Plot   Write Data to File   Make Report   Clear Settings ...

(hide deselected SVIDs)   (WLS, Kalman, ADR)

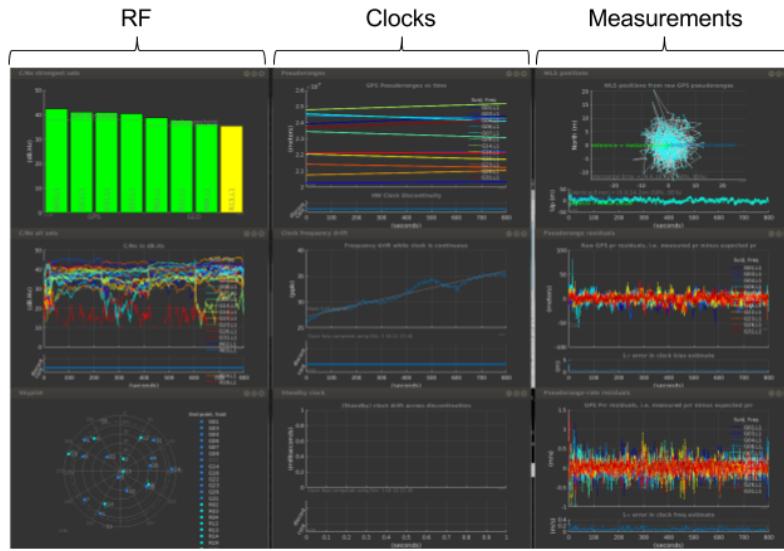
SVIDs from measurements

Hints:

1. The tools work best when you have two or more displays. The plots will appear in your primary display. Place the Control Panel in your secondary display.
2. If you only have one display, you can scale or move the plots to access the Control Panel. Then press “Tile Plots” to rearrange them as they originally were.



The interactive plots are organized in three columns:



- 1) The **RF** column shows C/N0 for the strongest satellites in each constellation, as well as a line plot for all satellites. The skyplot shows all satellites in view (whether we have measurements for them or not).
- 2) The **Clocks** column shows clock information. The top plot shows pseudoranges. If there is a dramatic change in a clock (like a jump of the order of milliseconds) you will see this in the pseudoranges. The second and third plots show the receiver clock offset and frequency.
- 3) The **Measurements** column shows pseudorange and ADR (Accumulated Delta Range, aka carrier phase) measurements. The top plot shows the position from weighted-least-squares; you can think of this as a projection of weighted measurement errors onto the 2D horizontal and vertical planes - thus it is a way to visualize the aggregate measurement errors. The top plot also has the Kalman Filtered positions, and positions computed from ADR (if ADR measurements are present in the log file). The next two plots show individual measurement residual errors. The residual error is the difference between the measurement and the expected value (of pseudorange in mid plot, and ADR in the bottom plot).

## 6.3 WLS, Kalman Filter, and ADR positions

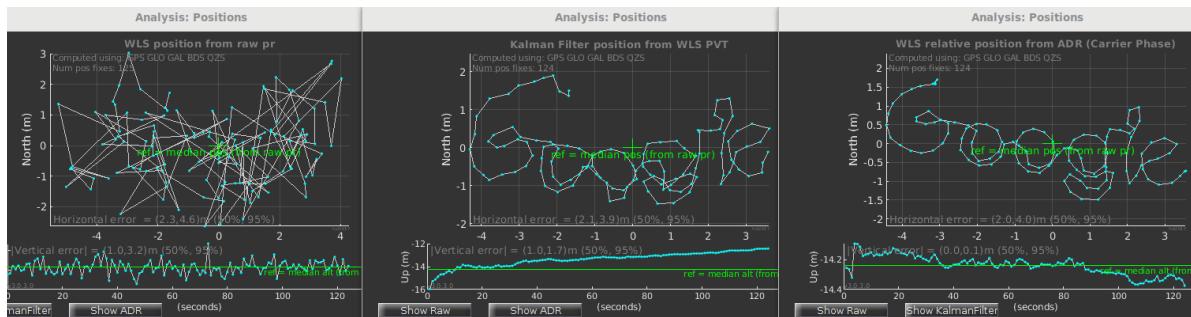
The Top Right plots show positions computed in three different ways:

- 1) WLS position from raw pr: This is the standard weighted least squares position solution, using the raw pseudoranges, with weights equal to the raw pseudorange uncertainty (which comes from ReceivedSvTimeUncertaintyNanos). The easiest way to replicate this result is to use the "Write Data to File" button, and then use the RawPrM and RawPrUncM columns of the MEAS data.

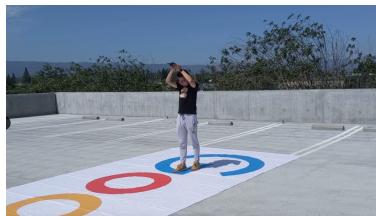


- 2) Kalman Filter position from WLS PVT: This is a standard position-domain Kalman Filter, that uses the WLS position and velocity results as inputs.
- 3) WLS relative position from ADR (Carrier Phase): If ADR is available, then this plot will show relative positions computed entirely from the ADR values, and plotted relative to the WLS positions.

Typically you will see that the WLS position is very noisy (because raw pseudoranges are noisy), the Kalman Filter is smoother, and the ADR, if available, is very precise. Such as this example, showing the WLS, Kalman Filter, and ADR positions computed from the same dataset:



This data was collected by walking over a “Google” sign, holding a phone, as shown in this picture:



## 6.3 Moving receiver

You can analyze measurement errors from a moving receiver by supplying an NMEA truth reference file. The Analysis Tool will read the NMEA file, and extract the GGA messages (for 3D position) and RMC messages (for velocity). With this information the Tool can compute clock offsets and frequency, and measurement residual errors.

Example:



GNSS Measurements

Log File: gnss\_log\_2019\_08\_26\_15\_02\_26.txt  
Directory: ~/Desktop/GnssAnalysisFiles/2019-08-27-HiwayTest1-L1L5/Mi9/  
Start UTC: yyyy mm dd hh mm ss.s End UTC: yyyy mm dd hh mm ss.s El. mask (deg): 5  Iono  Tropo

Reference PVT  
Stationary Receiver  Device  
Moving Receiver  NMEA NMEA File: groundTruth.nmea

All plots:  Menu Bars Black  White Tile Plots Close Plots

Status: Log file found, now click the [Analyze and Plot] button to process  
Reading NMEA file groundTruth.nmea...  
Now click [Analyze and Plot] button for Analysis with NMEA as reference PVT

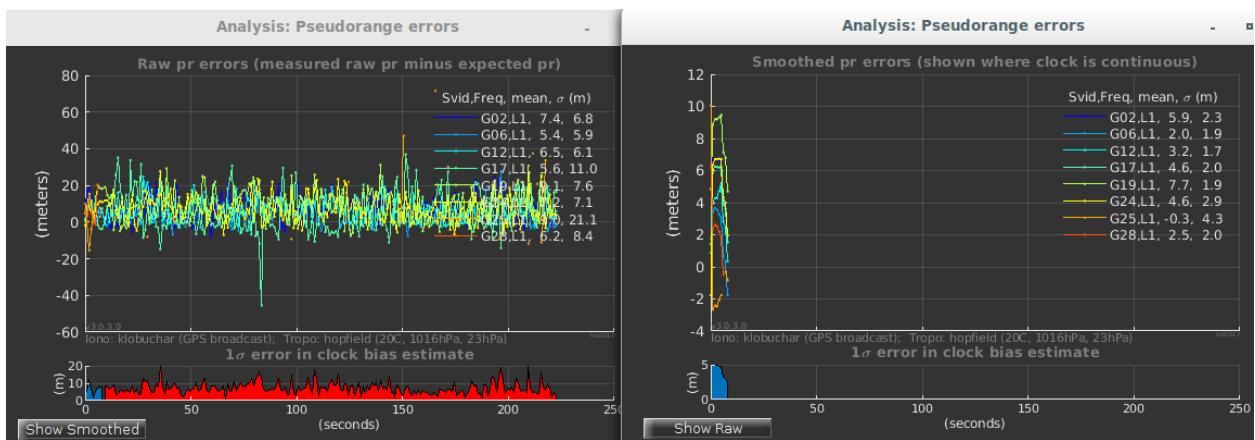
Clear Status Window

If you don't have a truth reference, you can use the device's own position (as reported by the device GNSS receiver), by clicking the "Device" button. This is not as good as using a hi-fidelity ground truth reference, but it can be useful to give a rough idea of the behavior of the measurement residuals.

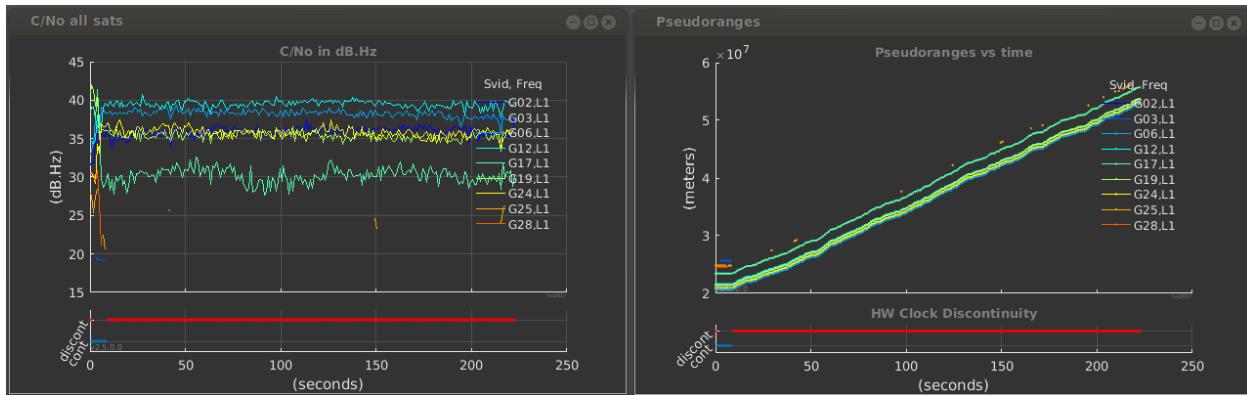
## 6.4 Smoothed pseudoranges

While the receiver clock is continuous we can smooth the raw pseudoranges with the pseudorange-rates (a.k.a. -Dopplers). This is done automatically by the Analysis App, and used for the smoothed-pseudorange residual error calculation, and derived data file.

The pseudorange error plots show the errors for raw and smoothed pseudoranges: raw for all epochs, smoothed where the clock is continuous.



You can also see where the receiver clock is continuous or not by the blue/red dots in the subplots below the C/No and Pseudorange plots:



Detail:



Different GNSS chips will follow different clock strategies, this is a function of hardware design, and duty cycling strategy.

## 6.5 Derived data

The GnssAnalysisApp will write the derived time-varying data to a file:

gnss\_log\_yyyy\_mm\_dd\_hh\_mm\_ss.derived

From this file you can generate all the line plots and the skyplot produced by the Analysis App.

This file has a header that describes the contents:

```
# Header Description:  
#  
# Version: v3.0.3.0  
# Start: UTC [2016,06,30,21,26,08.397], GPS [1903, 422785.397]  
# Intersystem bias (nanoseconds): TauGloG1 NaN, TauGaleE1 NaN, TauBdsB1 NaN, ...  
# WLSRAW,WlsRawTimeSinceStartNs,WlsRawLatitudeDeg,WlsRawLongitudeDeg,...  
# WLSKF,WlsKfTimeSinceStartNs,WlsKfLatitudeDeg,WlsKfLongitudeDeg,...  
# WLSADR,WlsAdrTimeSinceStartNs,WlsAdrLatitudeDeg,WlsAdrLongitudeDeg,...  
# REFPVT,RefTimeSinceStartNs,RefLatitudeDeg,RefLongitudeDeg,RefAltitudeM,...  
# CLOCK,ClockTimeSinceStartNs,ClockDiscontinuity,ClockBiasNanos,...  
# MEAS,MeasTimeSinceStartNs,TimeNanos,ConstellationType,Svid,CarrierFrequencyHz,...
```

Where the values are the same as in GnssLogger log files, we use exactly the same header description; for example: TimeNanos,ConstellationType,Svid,CarrierFrequencyHz,Cn0DbHz. The other values are derived values, such as RawPrM (raw pseudorange in meters), SmPrM (smoothed pseudorange in meters), and so on.



To pair derived measurements with the corresponding raw measurements in the original GnssLogger log file, use the TimeNanos field, which is the same in both files.

The header data includes the start time (in UTC and GPS time) corresponding to the start of the time-series plots.

The header data includes inter-system time biases in nanoseconds. When any system is not present in the log file, or there are not enough good measurements, then the corresponding value is reported as “NaN” (Not a Number).

The sense of the bias is explained by this example.

Example: Intersystem bias (nanoseconds) : TauGloG1 1000.000

- GLONASS time tag at a given time  $t_0$  is 1000 ns earlier (smaller) than the simultaneous GPS time tag.
- GLONASS pseudoranges will have a common bias 1000 ns larger than GPS pseudoranges, and this must be removed before combining measurements from the two systems.
- Similarly for TauGloG1, TauGalE1, TauBdsB1, TauQzsJ1, TauGpsL5, TauGalE5, TauBdsB2, TauQzsJ5
- Even though some signals are synchronized at the satellite (such as GPS L1 and GPS L5), there may be group delays in the channel and in the receiver processing. This will vary by receiver model, the measured value is what is shown by the above Tau values. This is the measured value after applying the Iono model. The particular iono model is shown in the text at the bottom of the Pseudorange error plots.
- The pseudoranges are adjusted by these tau values before being used in the residual calculations, position calculations, or written to the derived data file.

## 7 Defining custom parameters

You can customize some of the parameters used by the tool by adding a text file named **CustomParam.m** to the same directory of the log file.

You can think of this file as a script that matlab executes at the beginning of processing the log file.

Note that the GnssAnalysisApp will look for the file only in the log directory: this means that you can define a different CustomParam.m file for each dataset.

### 7.1 Satellites in clock bias computation

If you want to specify the satellites to use for the clock bias computation, you can build a **CustomParam.m** like the following one:

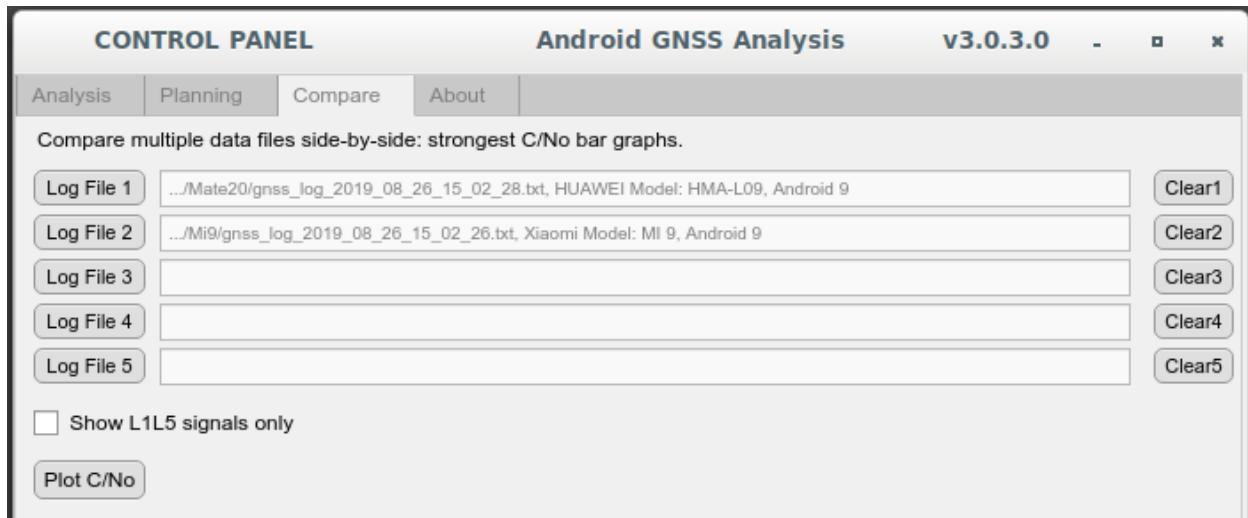


```
% Script file setting custom param values for use with GnssAnalysisApp  
%If this file is present where the GnssLog file is stored, then it is read  
%every time the user pushes 'Analyze and Plot'  
%So you can change these values and iterate on 'Analyze and Plot'  
  
%NOTE: because this is simply a script, if you make a typo then  
% GnssAnalysis will not work properly.  
  
%Currently supported:  
%param.losSvid = list of svid to use for computing clock (Bc and BcDot)  
%template for losSvid.Svid: must have .Id, .FreqBand, .Constellation  
  
Svid1.Id      = 7;  
Svid1.FreqBand = GnssConstants.L1_BAND;  
Svid1.Constellation = GnssConstants.GNSS_CONSTELLATION_GPS;  
  
Svid2.Id      = 11;  
Svid2.FreqBand = GnssConstants.L1_BAND;  
Svid2.Constellation = GnssConstants.GNSS_CONSTELLATION_GPS;  
  
param.losSvid.Svids = {Svid1,Svid2}; %pack in a cell array {}
```

This script encapsulates two satellites to use in the clock bias computation in the field **losSvid.Svids** of the param struct. It can be easily extended to contain an arbitrary number of satellites.

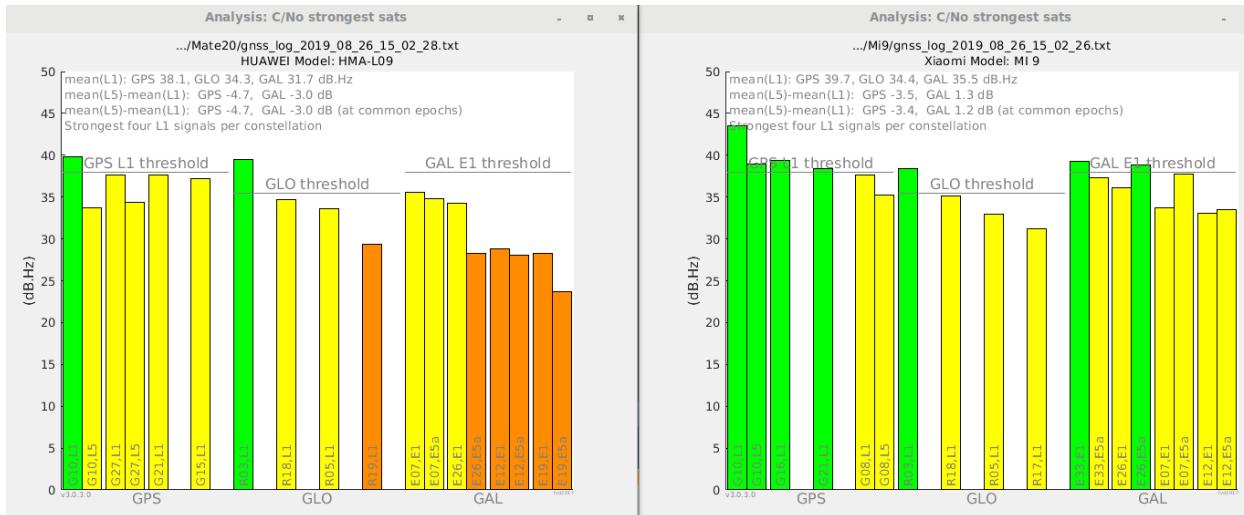
## 8 Compare log files

The “Compare” tab lets you load several different log files to compare against each other.





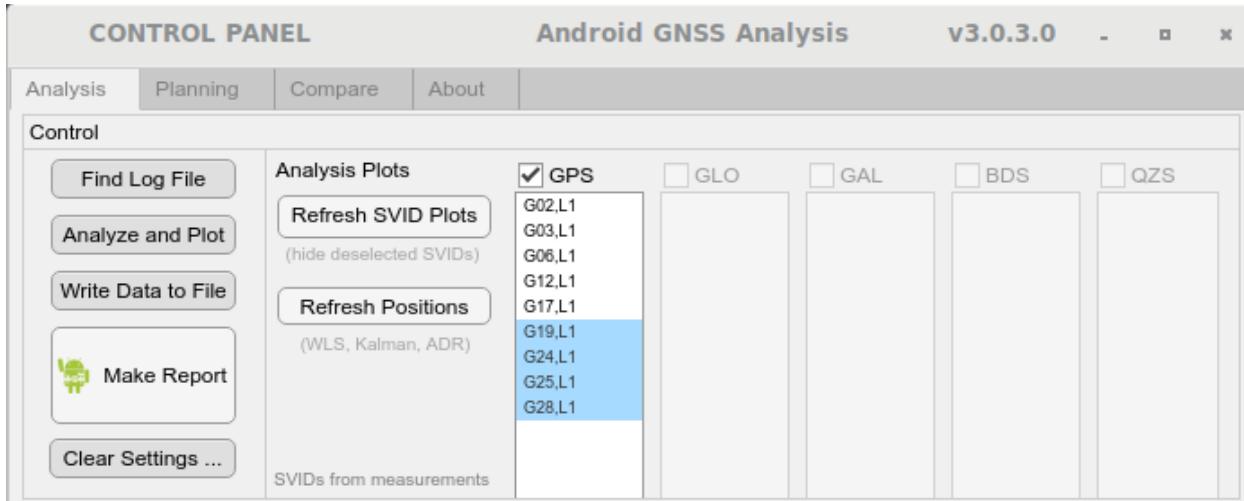
The [Plot C/No] button produces side-by-side plots of the strongest satellites from each log file:



## 9 Tips and Tricks

### 9.1 Processing with selected satellites only

When you check or uncheck satellites in the Interactive Plots control, you can redraw the SVID plots, or recompute positions using only the selected satellites. For example, with the demo file, you can compute positions with only four GPS signals by selecting those satellites alone, and clicking "Refresh Positions":



If you also click "Refresh SVID Plots" then all the plots will show only those satellites selected.

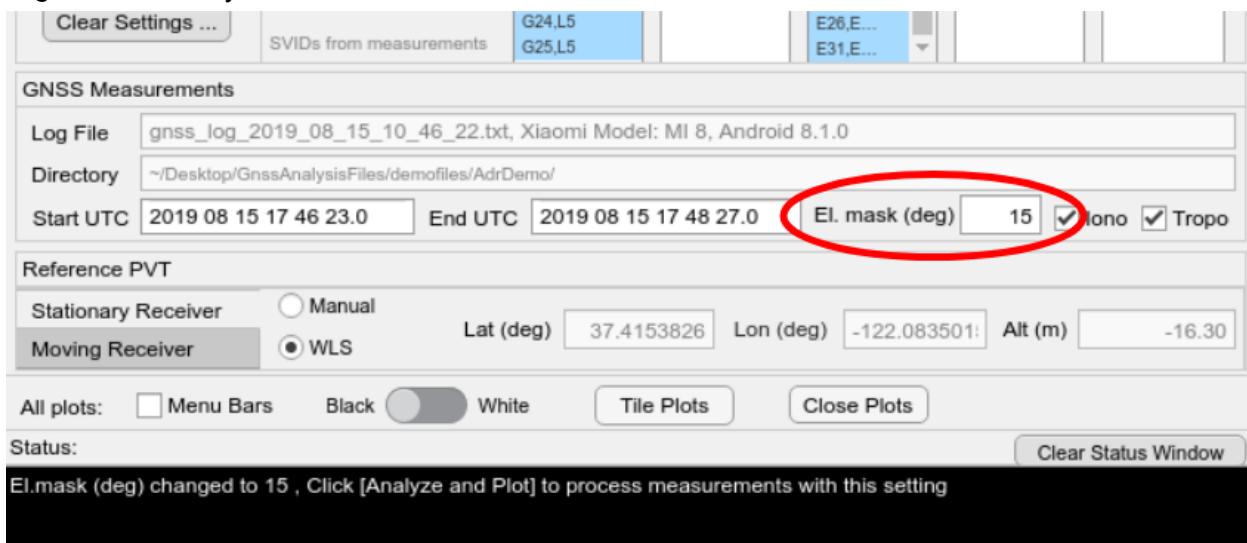
The satellites used in the position are shown in the \$GPGSV message in the NMEA files generated by the app. In this example:

\$GPGSV,1,1,4,**19**,48,043,40.9,**24**,58,251,30.5,**25**,08,303,27.9,**28**,09,110,30.5\*4E



## 9.2 Elevation mask angle

By default the elevation mask angle is set to 5 degrees above the horizon. Any satellites below the mask angle are not used in the analysis or position computation. You can change the mask angle and re-analyze the data.



## 9.3 CustomDataFilter

You can do further custom filtering of measurements by creating a script file called `CustomDataFilter.m` in the same directory as your log file.

Rules for `CustomDataFilter`:

- You may filter on any of the "# Raw" header values in the `GnssLogger` log file:  
# Raw,ElapsedRealtimeMillis,TimeNanos,LeapSecond,TimeUncertaintyNanos,...  
FullBiasNanos,BiasNanos,BiasUncertaintyNanos,DriftNanosPerSecond,...  
DriftUncertaintyNanosPerSecond,HardwareClockDiscontinuityCount,Svid,...  
TimeOffsetNanos,State,ReceivedSvTimeNanos,ReceivedSvTimeUncertaintyNanos,...  
Cn0DbHz,PseudorangeRateMetersPerSecond,PseudorangeRateUncertaintyMetersPerSecond,...  
AccumulatedDeltaRangeState,AccumulatedDeltaRangeMeters,...  
AccumulatedDeltaRangeUncertaintyMeters,CarrierFrequencyHz,...  
MultipathIndicator,SnrInDb,ConstellationType,AgcDb
- `dataFilter` is an  $n \times 2$  cell array, where each row defines a filter value.
- Each `dataFilter` entry must contain only one type of header value.
- You may use a header value e.g. 'ConstellationType' more than once, so long as you don't use different heading types in one `dataFilter{}` row.

The following examples show how to use these rules.



```
%% CustomDataFilter.m
dataFilter={}; %initialize dataFilter before adding values

%% Example, how to select satellites from GPS and GAL only:
dataFilter{end+1,1} = 'ConstellationType';
dataFilter{end,2}='(ConstellationType)==1 | (ConstellationType)==6';
%% Example, how to remove GLONASS:
dataFilter{end+1,1} = 'ConstellationType';
dataFilter{end,2} = '(ConstellationType)~=3';
% Constellation types are as specified in the Android GNSS Raw
Measurements API

%% Example: L1 only
dataFilter{end+1,1} = 'CarrierFrequencyHz';
dataFilter{end,2} = 'CarrierFrequencyHz > 1.5E9';

%% Example CNo > 23 dBHz only
dataFilter{end+1,1} = 'Cn0DbHz';
dataFilter{end,2} = 'Cn0DbHz>23';
```

## 10 Crash and Status Logs

### 10.1 Crash Log

If an error occurs, the basic crash report is displayed in the Status window, and the full crash report is written to .../crashLog.txt

The full path name on your platform is displayed in the Status window.

If you are reporting a crash, please send this log file to [location-partners-feedback@google.com](mailto:location-partners-feedback@google.com)

Example: here is a crash log report in the Status window:

Status:

```
Error occurred:
Error using ReadGnssLogger>MakeCsv (line 167)
Found "# Version: 1.0.0.0, Platform: L/M" in log file
See crash log in: C:\Users\Fvandigelen\Desktop\crashLog.txt
```

### 10.2 Status Log

All the text from the Status window is automatically recorded in .../statusLog.txt



The full path name is displayed in the text box below the Status window:

```
Status:  
File found, now click the [Analyze and Plot] button to process  
  
Analyzing log file ...  
Reading GnssLogger file: gnss_log_2016_06_30_21_26_07.txt  
Read 1379 raw measurements from 223 epochs  
Removed 3 bad meas: 3 with towUnc>500 ns  
Getting ephemeris, this may take a minute or two ...  
Reading GPS ephemeris from hour1820.16n ... Got valid ephemeris for 31 GPS satellites  
Reference Pos set to median WLS position  
Saved all settings to .../demo_files/gnss_log_2016_06_30_21_26_07-param.mat
```

(c) 2017 Google. Version: v2.4.0.0

The existing statusLog.txt file will be appended as long as you are running a single instance of GnssAnalysisApp. When you start a new instance of GnssAnalysisApp it will overwrite the previous statusLog.txt; so copy this log file to another directory if you want to save it after a session.

## 11 FAQs

**Q. Does Google get any data?**

**A.** No. The GnssLogger App on the phone stores the log files locally in the phone. Then you can share the log file in a way that you choose. The Desktop Analysis App does not share any data. The plots, derived data and files created by the Desktop App are all saved locally on your computer.

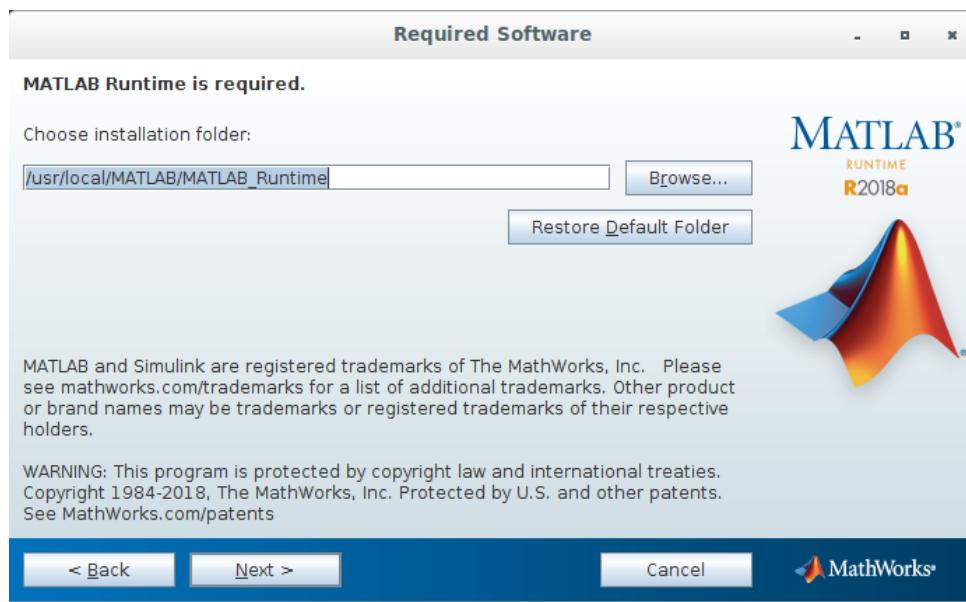
**Q. What's the difference between the test report and the interactive plots?**

**A.** The test report is meant as an easy way to interpret the results that does not require advanced knowledge of GNSS algorithms. It should provide you a clear indication of whether your GNSS system is passing or failing. The test report is meant to be run with a stationary receiver in open sky.

The interactive plots allow for advanced analysis. They can be used with a moving receiver, and the plots are interactive, for example you can choose which satellites to show.

**Q. If I install an update, do I need to download MATLAB\_Runtime again?**

**A.** No, not unless the MATLAB\_Runtime version has changed. From Analysis Tools v2.5.0.0 to v2.6.0.0 the MATLAB\_Runtime changed from v901 to v94; but after you have installed MATLAB\_Runtime v94 you do *not* have to download MATLAB\_Runtime it again, even though you will see this prompt ...



... don't worry, just click Next, and the installer will recognize that you already have the correct version of MATLAB\_Runtime/

**Q.** How is pseudorange smoothing done in the Gnss Analysis Tool?

**A.** For details of the mathematics of pseudorange smoothing within the GNSS Analysis Tool, read the section "Raw Measurements and Derived Data" of the attached "Inside GNSS" article. This gives details of how we do the smoothing:

<http://insidegnss.com/gnss-analysis-tools-from-google/>

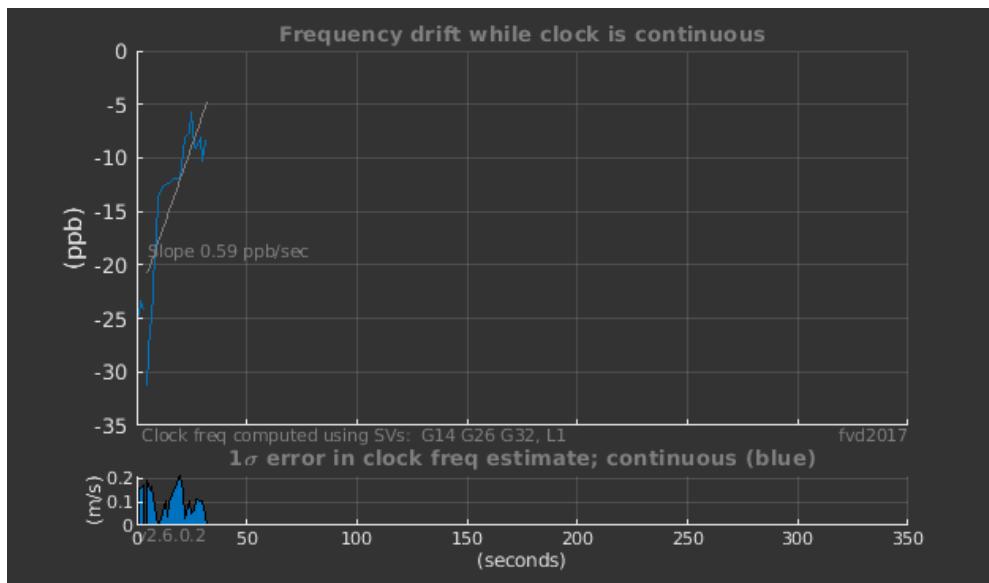
To get the results of smoothing from the tool, click on "Write Data to File" in the Gnss Analysis Tool GUI and you will get the smoothed pseudoranges for your log file.

**Q.** What's the difference between "GNSS receiver clock rate" (in the Analysis Report), "Frequency drift" (Interactive plot), and "DriftNanosPerSecond" (in the gnss\_log\*.txt and raw.csv files)?

**A.** They are different estimates of the same thing:

DriftNanosPerSecond is the real-time estimate of the receiver clock frequency offset (or drift), as reported by the receiver in the Raw Measurement API.

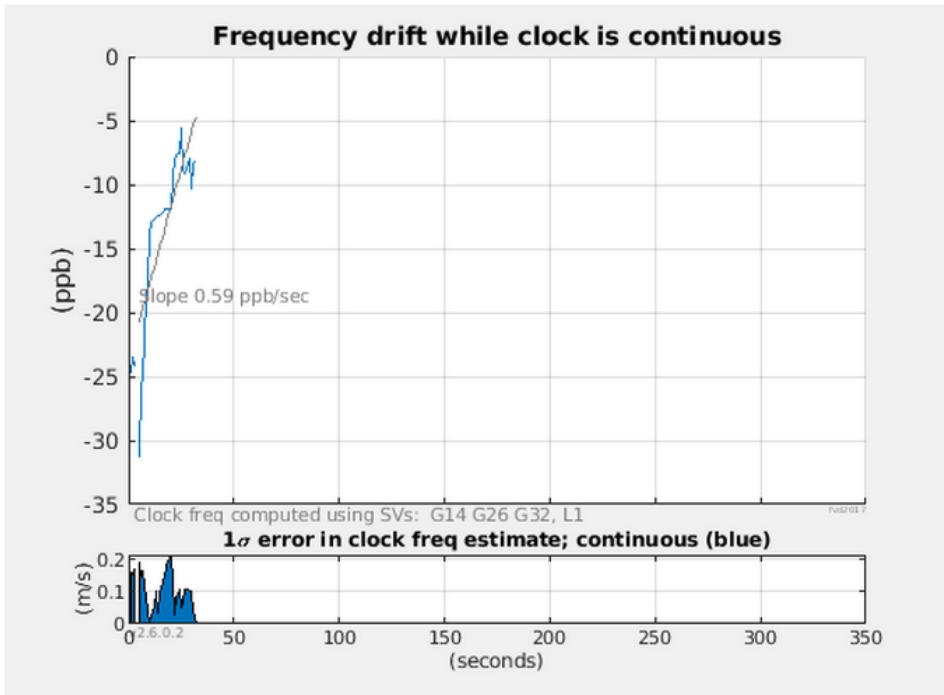
"Frequency drift" in the Interactive Plots is the Analysis Tool estimate of the same value, computed using the Reference Pvt:



Reference PVT

Stationary Receiver:	Lat (deg)	37.4225794	Lon (deg)	-122.0816792	Alt (m)	-30.27
Moving Receiver:	NMEA File:	*.nmea, *.txt				
<input type="radio"/> Manual <input checked="" type="radio"/> WLS <input type="radio"/> NMEA						

"|GNSS receiver clock rate|, max" in the reports, is the maximum absolute value of the above plot:

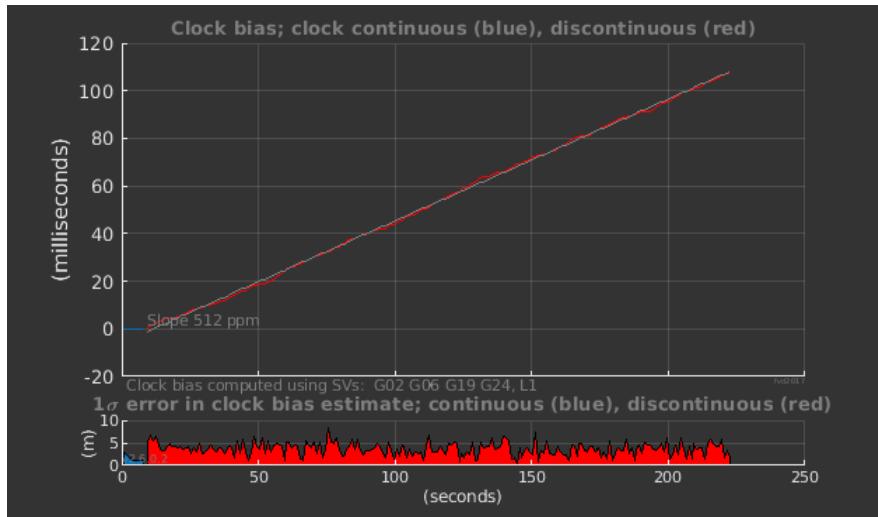


For your log file the continuous clock behavior is:  
|GNSS receiver clock rate|, max, 31.25 ppb  
|GNSS receiver clock drift rate|, 0.59 ppb/s  
PASS



Q. How do you calculate GNSS receiver clock bias and GNSS receiver clock frequency drift?

A. Receiver clock bias is shown by the Analysis Tool in a plot like this:



The values are worked out at each epoch as follows:

For each satellite, the receiver clock bias is estimated as the measured pseudorange minus the expected pseudorange (calculated using the Reference PVT shown in the GUI). The values for several high elevation satellites are averaged. The satellites that are used are printed in the above plot "Clock bias computed using SVs: ..."

GNSS receiver clock frequency drift is computed in a similar way. At each epoch that the clock is continuous: for each satellite, the receiver clock frequency is estimated as the measured pseudorange-rate minus the expected pseudorange-rate (calculated using the reference velocity: either zero, if the receiver is stationary, or read from the NMEA file provided). The values for several high elevation satellites are averaged. The satellites that are used are printed in the Frequency drift plot.

After estimating receiver clock bias and frequency at each epoch, these values are filtered to produce the final result shown in the plots.

The results of these calculations are available when you click "Write Data to File", the clock bias and frequency values appear in the `gnss_log*.derived` file, in the rows labeled "CLOCK".

## 12 Troubleshooting

If launching GnssAnalysis you see errors such as

```
MathWorks::System::IUserException [Error using matlab.internal.webwindow (line 310)
MATLABWindow application failed to launch. Unable to launch the MATLABWindow application]
```



Due to some library compatibility issues, MATLAB may not be able to launch MATLABWindow on your particular distribution/version of Linux. To detect and work around the incompatibility, see this page:

<https://www.mathworks.com/matlabcentral/answers/364551-why-is-matlab-unable-to-run-the-matlabwindow-application-on-linux>

Note: that this page assumes you have a MATLAB installation available, but you can locate the MATLABWindow file and run it from the runtime too.