# GIRAS (GNSS-IR ANALYSIS SOFTWARE)

USER MANUAL

*Written by*

*Cemali ALTUNTAS & Nursu TUNALIOGLU*

Yildiz Technical University

MAY, 2021

# CONTENTS

# 1. GIRAS user interface

GIRAS (GNSS-IR Analysis Software) is an open source software, with file reading, data analysis and data visualization tools. It is developed in MATLAB R2018b version. The software has a user-friendly interface consisting of three main modules and five sub-modules (Figure 1).

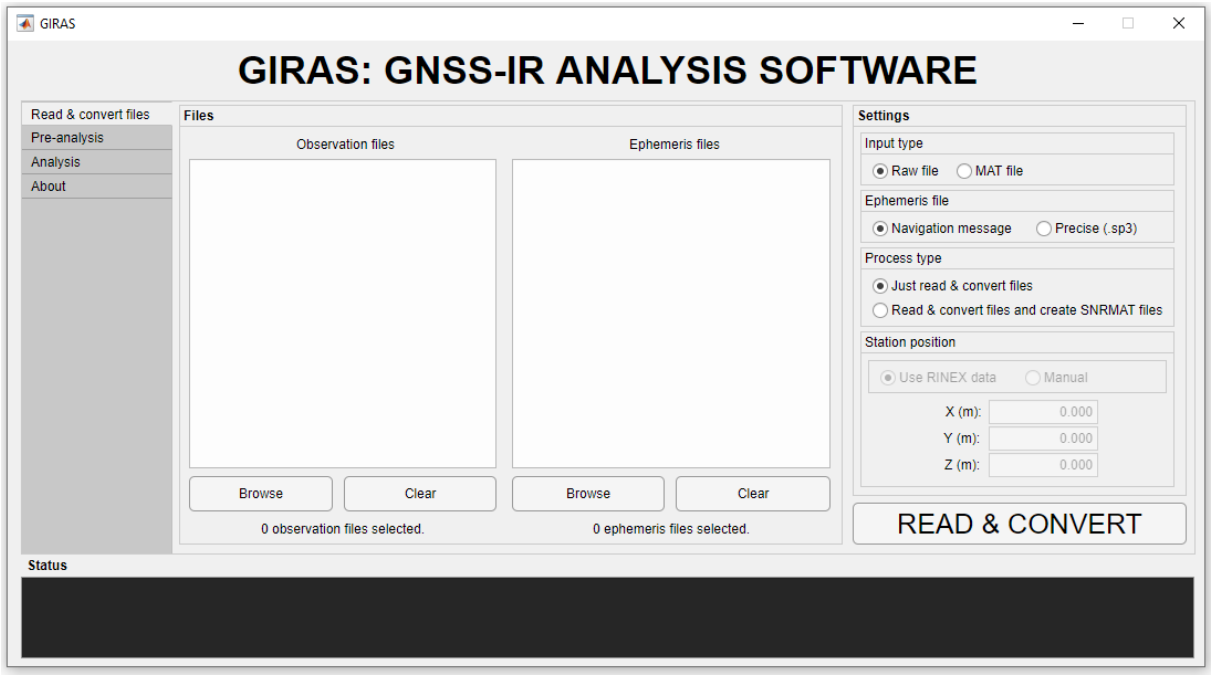



***Figure 1.*** *User interface of GIRAS*

The GIRAS interface is divided into two sections. While the first section comprises the part where the processes and settings are adjusted, the second section is process status screen (Figure 2).

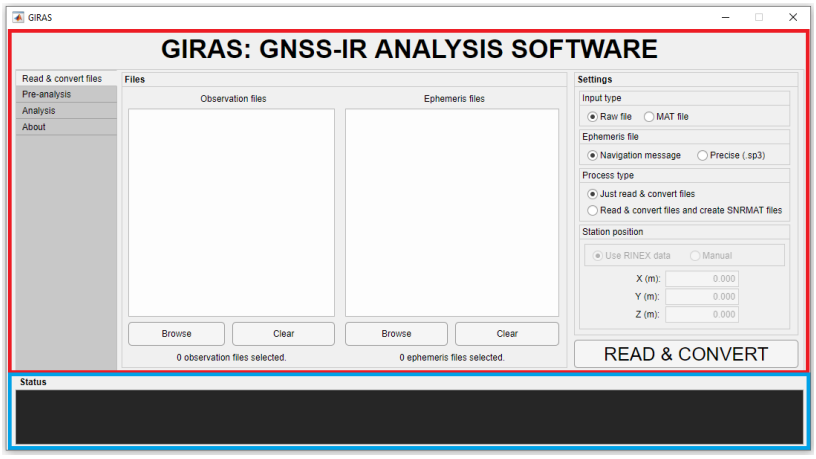



***Figure 2.*** *Red: Processing section, Blue: Status section*

The selection of the main modules and sub-modules of the software is carried out via the tabs on the left of the interface (Figure 3).

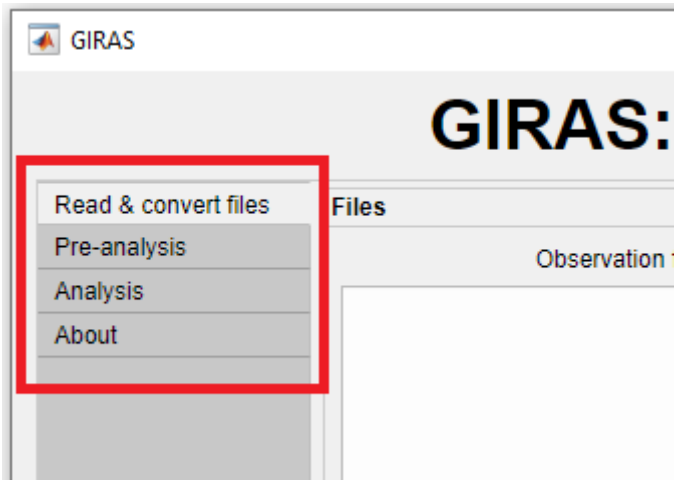



***Figure 3.*** *Module selection*

# 2. Modules

GIRAS consists of three main modules and five sub-modules. Main modules are; (1) ***Read & convert files***, (2) ***Pre-analysis***, (3) ***Analysis*** (Figure 4).

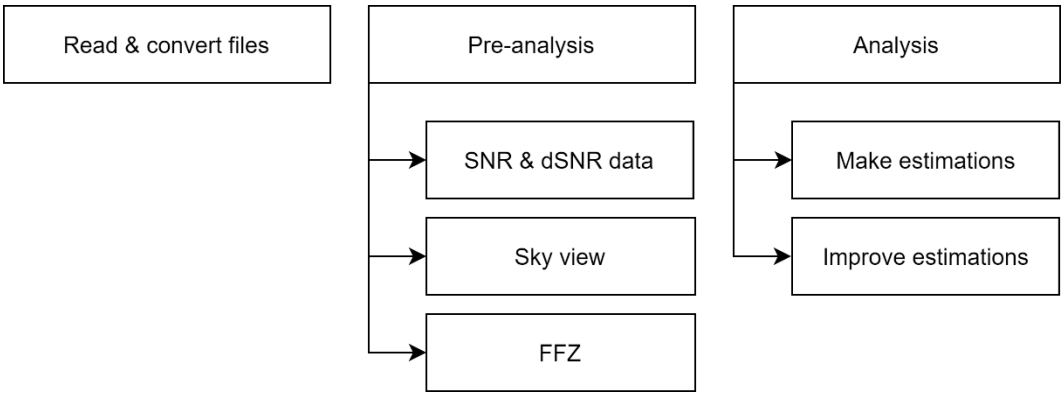



***Figure 4.*** *Modules and sub-modules of the GIRAS*

## 2.1. Main module 1: Read & convert files

This module is used to read and process raw GNSS data. RINEX 2 and RINEX 3 versions are supported as observation file. Broadcast ephemeris (navigation file) and precise ephemeris (sp3) files can be read to obtain orbit information. GIRAS is capable of reading and evaluating multi-GNSS (GPS, GLONASS, Galileo, Beidou) data. Files read through this module are saved as MAT files. In this way, observation files and ephemeris files can be read and processed separately at different times and then combined.

In the ***Read & convert files*** module, first of all, the type of input files and the type of the process to be performed must be selected from the ***Settings*** section located on the right hand side. If the input files

have not been read before and saved as MAT file, ***Raw file*** should be selected, otherwise the ***MAT file*** should be selected. The type of ephemeris file should also be chosen correctly in the ***Ephemeris files*** section.

There are two options for ***Process type***. If the first option is selected, GIRAS only reads the raw input files and saves them as MAT files. With this option, observation files or ephemeris files do not need to be read simultaneously, they can be read separately as well. If the second option is selected, the observation and ephemeris files should be selected in the same number, on the same days and in the same order. Following this process, if the inputs are raw, they are first converted to MAT format and saved, then the SNRMAT files are created and saved. If the user wants to use the station position in the RINEX file during this process, the ***Use RINEX data*** option should be selected. To enter station position manually, ***Manual*** is selected and coordinate values are entered into X, Y, Z edit fields (Figure 5). The processes, inputs, outputs, and directories used in this module are presented in Table 1.

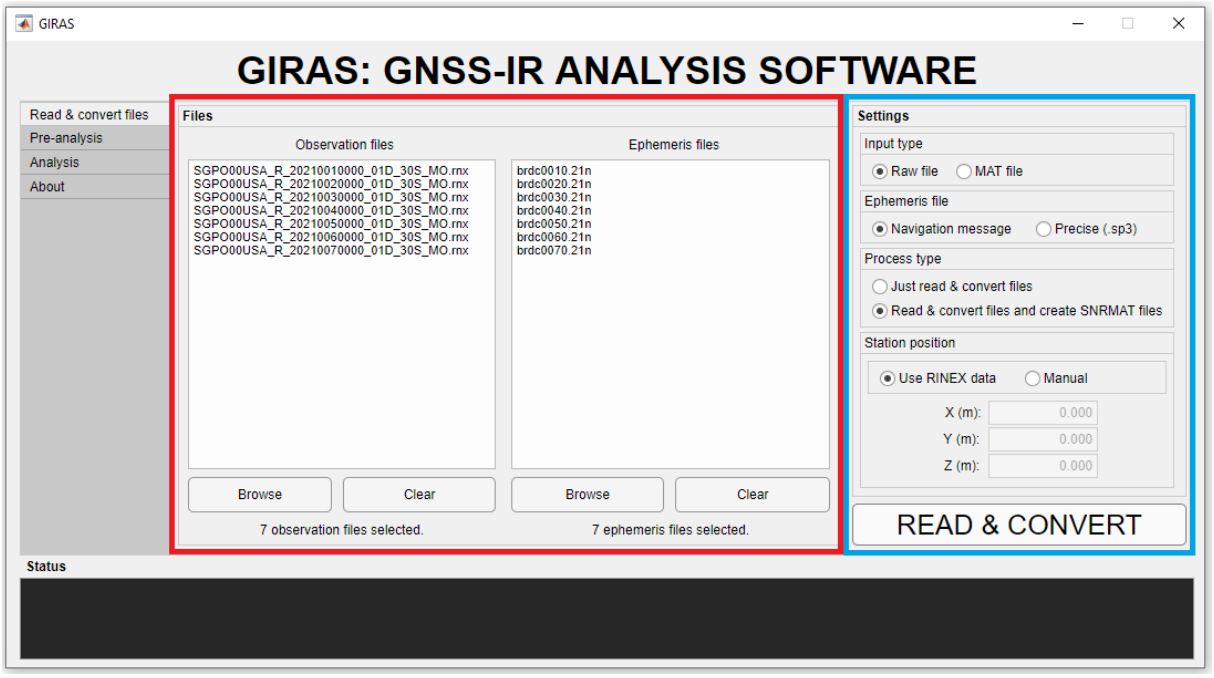



***Figure 5.*** *Main module 1: Read & convert files (Red: File selection, Blue: Settings)*

***Table 1.*** *Processing options and file directories on read & convert files module*

| Input file path | Input file(s) | Process | Output file path | Output file(s) |
|---|---|---|---|---|
| \data\inp_files\obs\ | RINEX 2 or RINEX 3 version observation files | Read observation files | \data\mat_files\obs\ | OBSMAT files |
| \data\inp_files\eph\ | Precise ephemeris files | Read ephemeris files | \data\mat_files\eph\ | EPHMAT files |
| \data\inp_files\nav\ | Broadcast ephemeris files | Read ephemeris files | \data\mat_files\nav\ | NAVMAT files |
| \data\inp_files\obs\<br>\data\inp_files\eph\<br>\data\inp_files\nav\ | (1) RINEX observation files<br>(2) Ephemeris files (broadcast or precise) | Read ephemeris files and create SNRMAT files | \data\mat_files\snr\ | SNRMAT files |
| \data\mat_files\obs\<br>\data\mat_files\eph\<br>\data\mat_files\nav\ | (1) OBSMAT files<br>(2) EPHMAT files or NAVMAT files | Read MAT files and create SNRMAT files | \data\mat_files\snr\ | SNRMAT files |

The processes performed in this module can be monitored from the ***Status*** screen at the bottom of the user interface. This screen facilitates the follow-up of tasks especially when a large amount of data is processed. When the whole process is completed, information on the duration of the process is presented to the user on the same screen.

## 2.2. Main module 2: Pre-analysis

This module reviews the content of the SNRMAT files, which is the output of the first module. It has three sub-modules: (1) ***SNR & dSNR data***, (2) ***Sky view***, (3) ***FFZ***.

### 2.2.1. SNR & dSNR data

This sub-module visualizes and pre-analyzes the SNR data from each satellite in the SNRMAT file. Options such as satellite and SNR observation, unit, angle limits, satellite track, and polynomial degree can be modified by the user. Figure 6 shows the situation in which the SNRMAT file called *SGPO00USA_snr_2021001.mat* is read and the S1C observation for the G03 satellite is selected. As ***SNR*** is selected in the ***Plot data*** section, the SNR graphic is plotted using the satellite elevation angle. The ***SNR/dSNR unit*** was selected in ***dB*** and ***Hours*** was selected as ***Time unit***. The angle limits are 0°-90° for satellite elevation angle and 0°-360° for the azimuth. The plot on the right is updated instantly

when the selections change. In this example, the ***Satellite track – Pol. degree*** option is disabled because the SNR data is plotted (Figure 6). Clicking on the ***Export plot*** button on the right will save the plot (Figure 7).

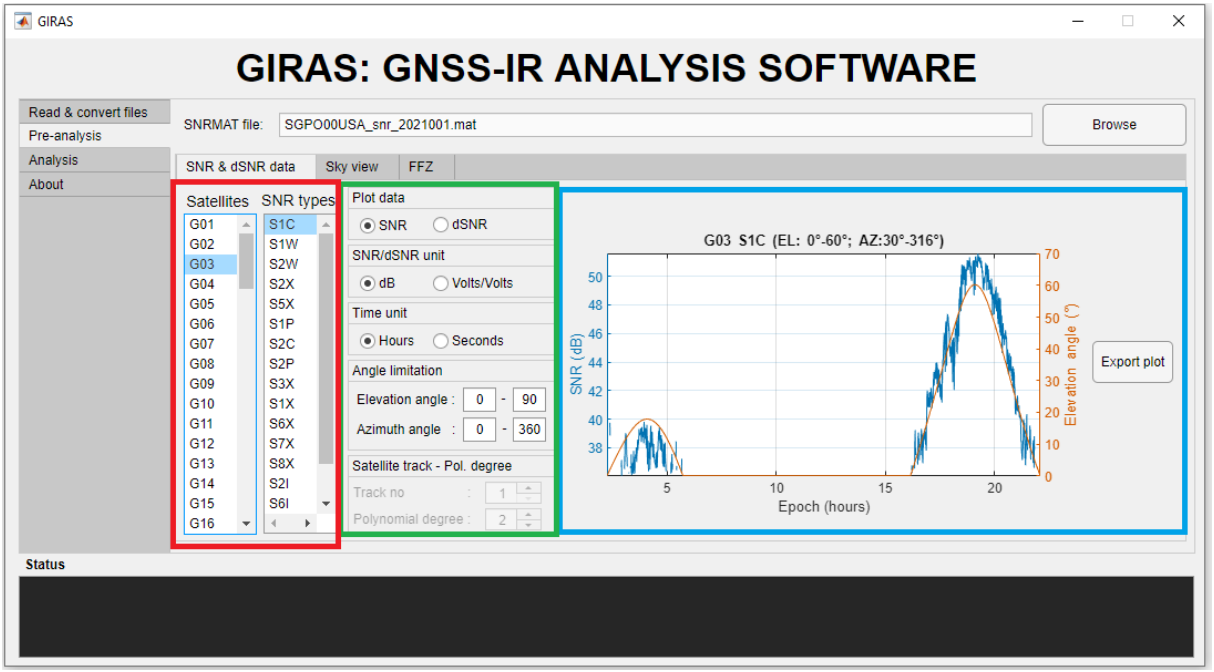



***Figure 6.*** *Pre-analysis: SNR & dSNR data (Red: Satellite and SNR type selection, Green: Unit & limitation selection, Blue: Plotting section)*

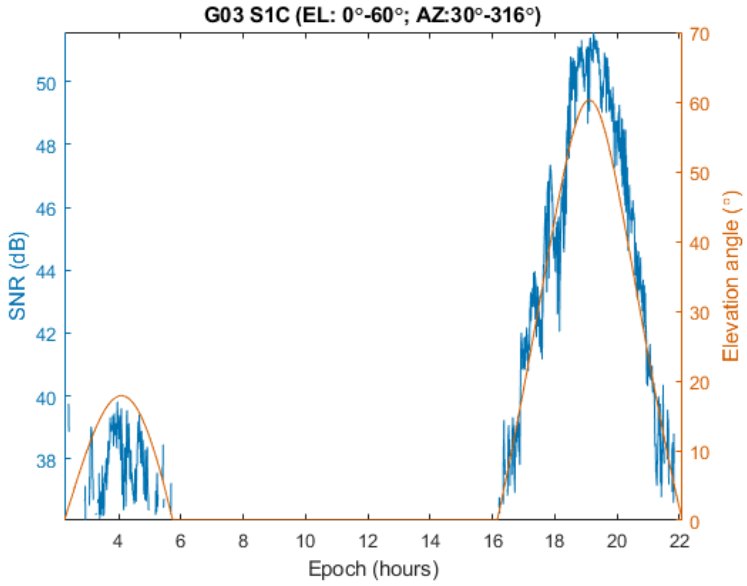



***Figure 7.*** *Exported SNR plot example*

When ***dSNR*** is selected as the ***Plot data*** option, ***Satellite track – Pol. degree*** option is enabled and the plot screen on the right is changed to include SNR, trend, and dSNR. The plot is updated simultaneously

when the polynomial degree and other settings change (Figure 8). The plot can be saved by clicking the ***Export plot*** button (Figure 9).

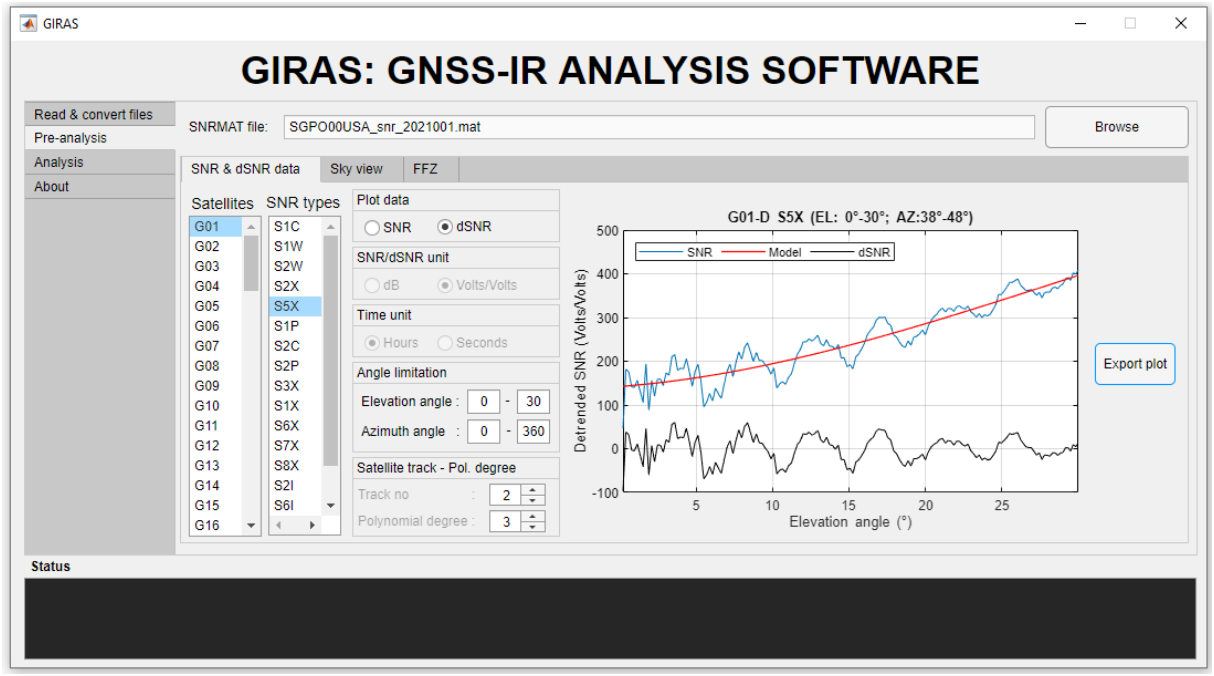



***Figure 8.*** *Pre-analysis: dSNR data*

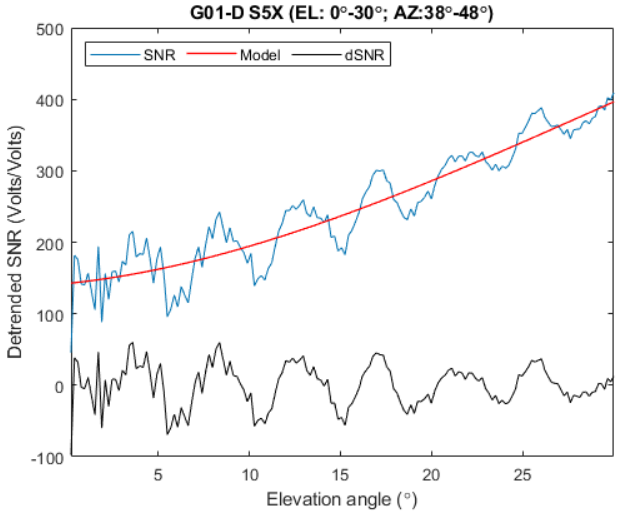



***Figure 9.*** *Exported dSNR plot example*

### 2.2.2. Sky view

This sub-module prepares the sky plot for the satellites found in the SNRMAT file. The user can choose which satellite systems to be included in the plot. The selected satellite's path is highlighted by a thick black line (Figure 10). Sky plot can be saved by clicking the ***Export plot*** button (Figure 11).

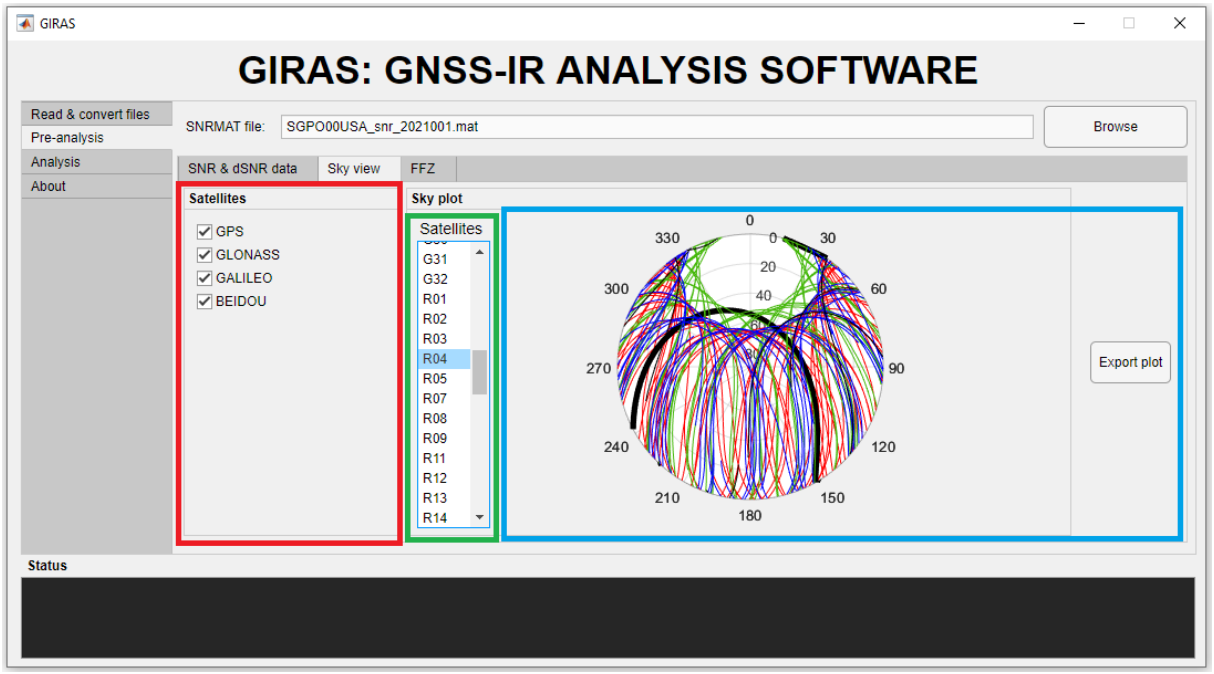



***Figure 10.*** *Pre-analysis: Sky view (Red: Satellite system selection, Green: Satellite selection, Blue: Plotting section)*

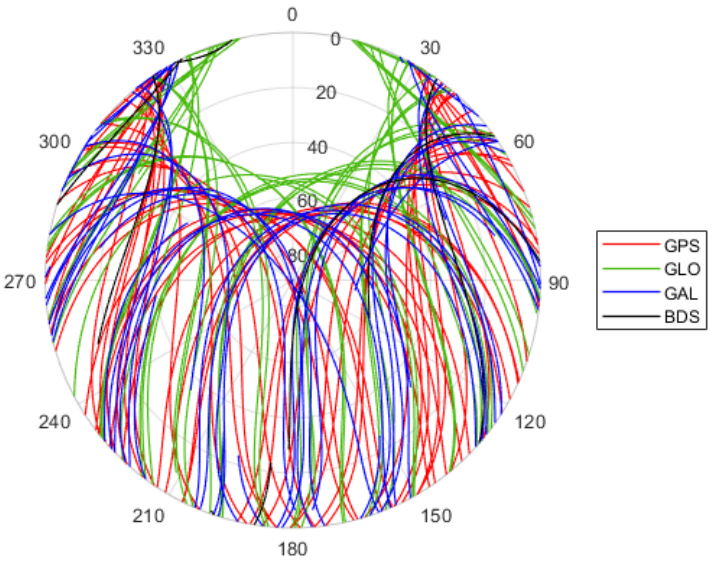



***Figure 11.*** *Exported sky view plot example*

### 2.2.3. FFZ

This sub-module provides the First Fresnel Zone (FFZ) graphic and quantities for observed satellites in the SNRMAT file, for the desired reflector height, the satellite elevation angle, and the selected signal type (Figure 12). The FFZ plot can be saved in the MATLAB environment by clicking on the ***Export plot*** button (Figure 13), and as a Google Earth file by clicking the ***Export KML*** button (Figure 14).

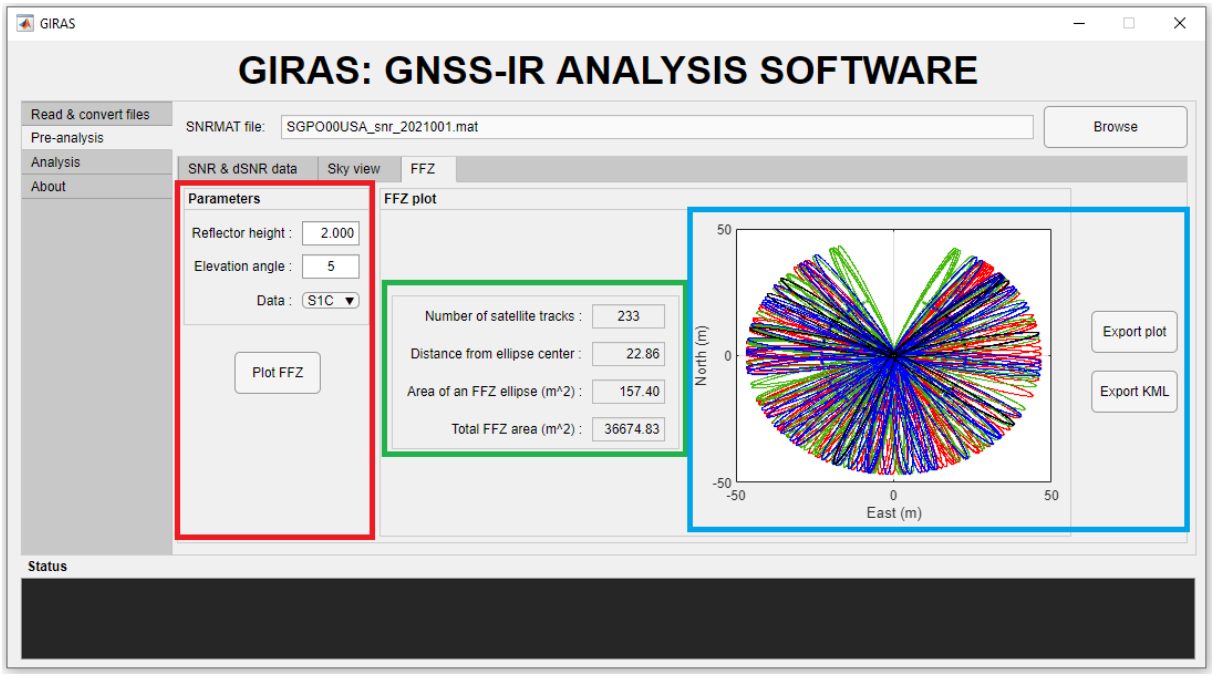



***Figure 12.*** *Pre-analysis: FFZ (Red: FFZ parameters, Green: FFZ quantities, Blue: Plotting section)*

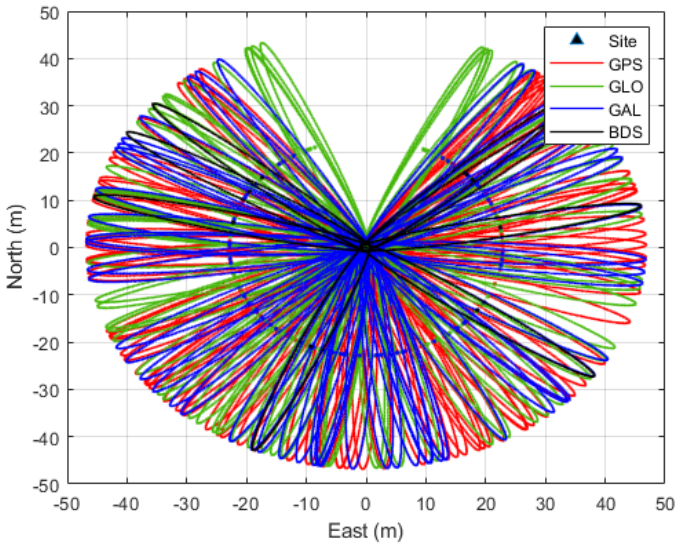



***Figure 13.*** *Exported FFZ MATLAB plot example*

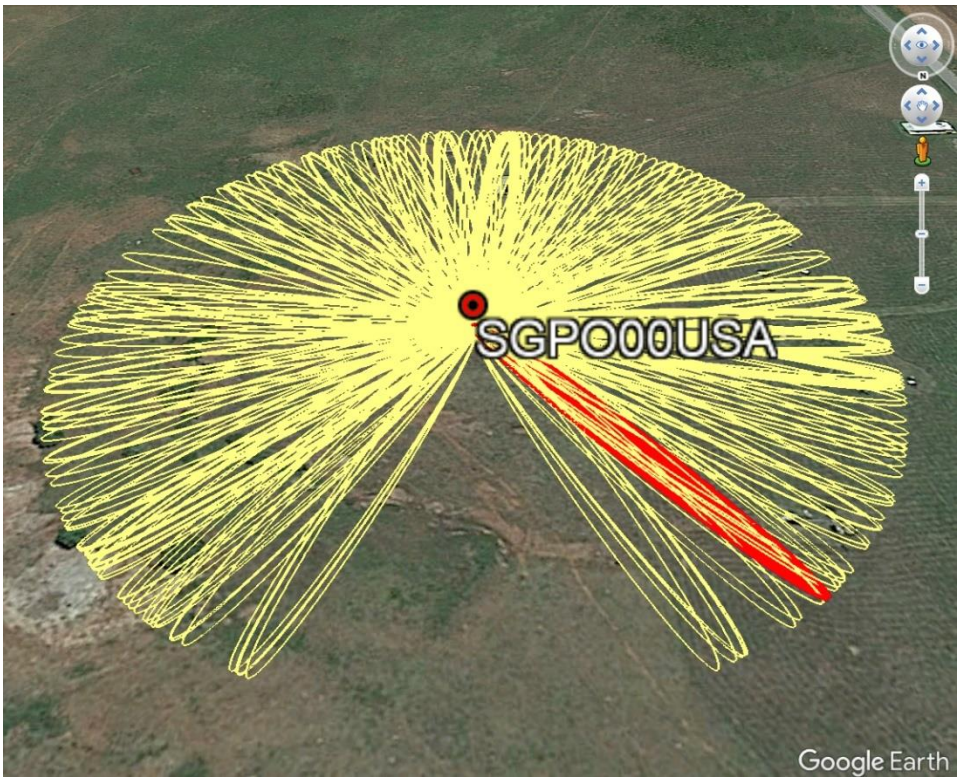



***Figure 14.*** *Exported FFZ Google Earth plot example*

## 2.3. Main module 3: Analysis

This module provides analysis and estimation of SNR metrics, using SNRMAT files based on the user's preferred settings. It has two sub-modules: (1) ***Make estimations***, (2) ***Improve estimations***.

### 2.3.1. Make estimations

SNRMAT files are selected first in this sub-module. Then, in the ***Settings*** section, the satellite systems to be included in the analysis, the SNR data type, and the degree of the polynomial to be used to detrend the SNR can be selected. Although only one range can be selected for the satellite elevation angle (eg. [0° 30°]), multiple ranges can be selected for azimuth (eg. [0° 140°; 230° 360°]).

In ***Estimation settings***, the maximum reflector height and the desired precision values should be entered. Finally, in the ***Filename*** section, the name of the result file should be written. If nothing is written, GIRAS will save the file with a default name. After all selections are made, the analysis can be started by clicking the ***RUN*** button. When processing multiple SNRMAT files, the processing order may be monitored from the ***Status*** screen. In addition, the satellite processing order of the associated SNRMAT file is displayed in the ***Processing status*** screen (Figure 15). Results are stored in both MAT and TXT

files (Figures 16 and 17). The structure of the result files (column numbers and descriptions) can be seen in Table 2.

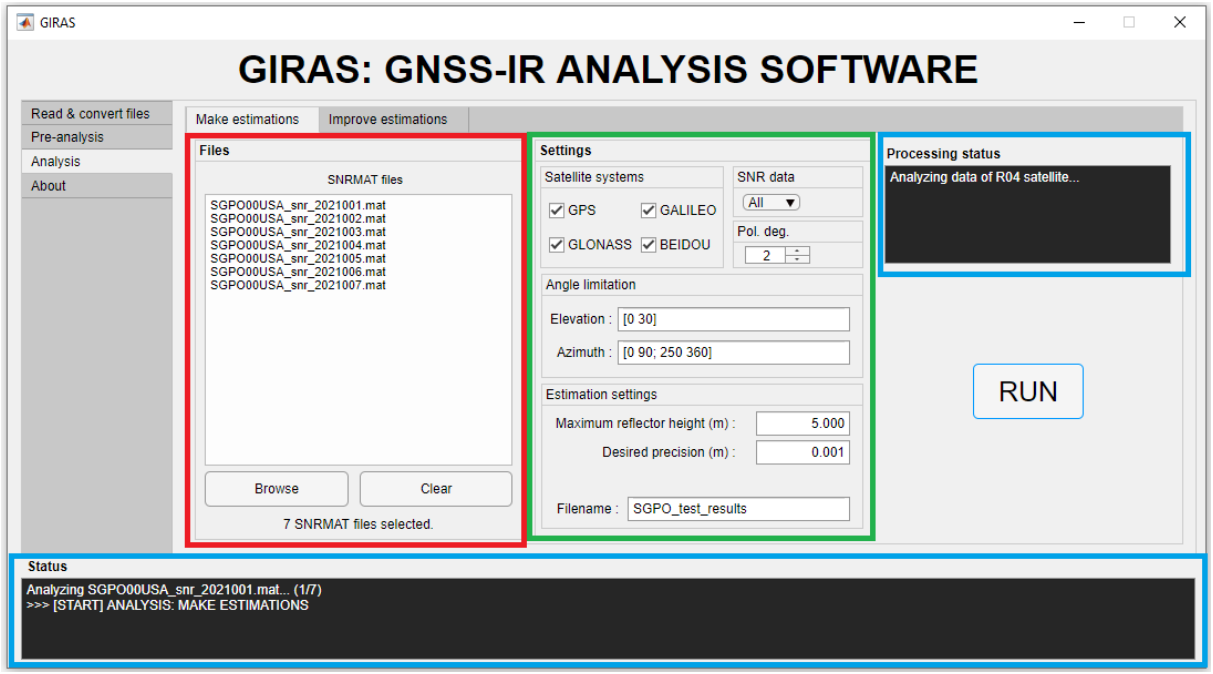


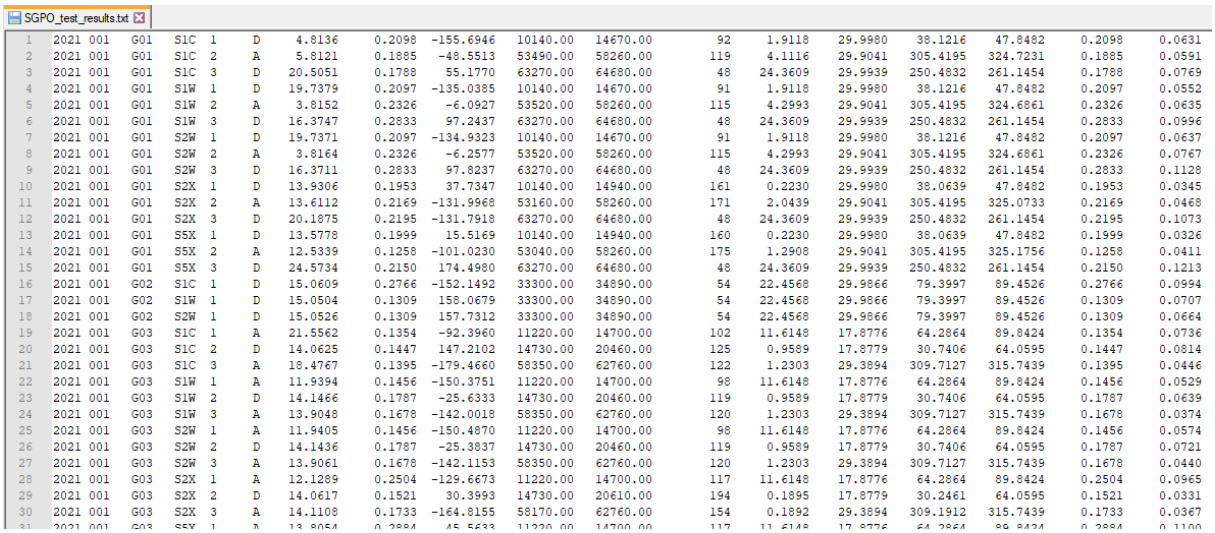

***Figure 15.*** *Analysis: Make estimations (Red: Input SNRMAT files, Green: Settings section, Blue: Status screens)*

resultsfile

5318x18 cell

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2021 | 1 | 'G01' | 'S1C' | 1 | 'D' | 4.813600000... | 0.209800000... | -155.694600... | 10140 | 14670 | 92 | 1.911800000... | 29.99800000... | 38.12160000... | 47.84820000... | 0.209800000... | 0.063100000... |
| 2 | 2021 | 1 | 'G01' | 'S1C' | 2 | 'A' | 5.812100000... | 0.188500000... | -48.5513000... | 53490 | 58260 | 119 | 4.111600000... | 29.90410000... | 305.4195000... | 324.7231000... | 0.188500000... | 0.059100000... |
| 3 | 2021 | 1 | 'G01' | 'S1C' | 3 | 'D' | 20.50510000... | 0.178800000... | 55.17700000... | 63270 | 64680 | 48 | 24.36090000... | 29.99390000... | 250.4832000... | 261.1454000... | 0.178800000... | 0.076900000... |
| 4 | 2021 | 1 | 'G01' | 'S1W' | 1 | 'D' | 19.73790000... | 0.209700000... | -135.038500... | 10140 | 14670 | 91 | 1.911800000... | 29.99800000... | 38.12160000... | 47.84820000... | 0.209700000... | 0.055200000... |
| 5 | 2021 | 1 | 'G01' | 'S1W' | 2 | 'A' | 3.815200000... | 0.232600000... | -6.09270000... | 53520 | 58260 | 115 | 4.299300000... | 29.90410000... | 305.4195000... | 324.6861000... | 0.232600000... | 0.063500000... |
| 6 | 2021 | 1 | 'G01' | 'S1W' | 3 | 'D' | 16.37470000... | 0.283300000... | 97.24370000... | 63270 | 64680 | 48 | 24.36090000... | 29.99390000... | 250.4832000... | 261.1454000... | 0.283300000... | 0.099600000... |
| 7 | 2021 | 1 | 'G01' | 'S2W' | 1 | 'D' | 19.73710000... | 0.209700000... | -134.932300... | 10140 | 14670 | 91 | 1.911800000... | 29.99800000... | 38.12160000... | 47.84820000... | 0.209700000... | 0.063700000... |
| 8 | 2021 | 1 | 'G01' | 'S2W' | 2 | 'A' | 3.816400000... | 0.232600000... | -6.25770000... | 53520 | 58260 | 115 | 4.299300000... | 29.90410000... | 305.4195000... | 324.6861000... | 0.232600000... | 0.076700000... |
| 9 | 2021 | 1 | 'G01' | 'S2W' | 3 | 'D' | 16.37110000... | 0.283300000... | 97.82370000... | 63270 | 64680 | 48 | 24.36090000... | 29.99390000... | 250.4832000... | 261.1454000... | 0.283300000... | 0.112800000... |
| 10 | 2021 | 1 | 'G01' | 'S2X' | 1 | 'D' | 13.93060000... | 0.195300000... | 37.73470000... | 10140 | 14940 | 161 | 0.223000000... | 29.99800000... | 38.06390000... | 47.84820000... | 0.195300000... | 0.034500000... |
| 11 | 2021 | 1 | 'G01' | 'S2X' | 2 | 'A' | 13.61120000... | 0.216900000... | -131.996800... | 53160 | 58260 | 171 | 2.043900000... | 29.90410000... | 305.4195000... | 325.0733000... | 0.216900000... | 0.046800000... |
| 12 | 2021 | 1 | 'G01' | 'S2X' | 3 | 'D' | 20.18750000... | 0.219500000... | -131.791800... | 63270 | 64680 | 48 | 24.36090000... | 29.99390000... | 250.4832000... | 261.1454000... | 0.219500000... | 0.107300000... |
| 13 | 2021 | 1 | 'G01' | 'S5X' | 1 | 'D' | 13.57780000... | 0.199900000... | 15.51690000... | 10140 | 14940 | 160 | 0.223000000... | 29.99800000... | 38.06390000... | 47.84820000... | 0.199900000... | 0.032600000... |
| 14 | 2021 | 1 | 'G01' | 'S5X' | 2 | 'A' | 12.53390000... | 0.125800000... | -101.023000... | 53040 | 58260 | 175 | 1.290800000... | 29.90410000... | 305.4195000... | 325.1756000... | 0.125800000... | 0.041100000... |
| 15 | 2021 | 1 | 'G01' | 'S5X' | 3 | 'D' | 24.57340000... | 0.215000000... | 174.4980000... | 63270 | 64680 | 48 | 24.36090000... | 29.99390000... | 250.4832000... | 261.1454000... | 0.215000000... | 0.121300000... |
| 16 | 2021 | 1 | 'G02' | 'S1C' | 1 | 'D' | 15.06090000... | 0.276600000... | -152.149200... | 33300 | 34890 | 54 | 22.45680000... | 29.98660000... | 79.39970000... | 89.45260000... | 0.276600000... | 0.099400000... |
| 17 | 2021 | 1 | 'G02' | 'S1W' | 1 | 'D' | 15.05040000... | 0.130900000... | 158.0679000... | 33300 | 34890 | 54 | 22.45680000... | 29.98660000... | 79.39970000... | 89.45260000... | 0.130900000... | 0.070700000... |
| 18 | 2021 | 1 | 'G02' | 'S2W' | 1 | 'D' | 15.05260000... | 0.130900000... | 157.7312000... | 33300 | 34890 | 54 | 22.45680000... | 29.98660000... | 79.39970000... | 89.45260000... | 0.130900000... | 0.066400000... |
| 19 | 2021 | 1 | 'G03' | 'S1C' | 1 | 'A' | 21.55620000... | 0.135400000... | -92.3960000... | 11220 | 14700 | 102 | 11.61480000... | 17.87760000... | 64.28640000... | 89.84240000... | 0.135400000... | 0.073600000... |
| 20 | 2021 | 1 | 'G03' | 'S1C' | 2 | 'D' | 14.06250000... | 0.144700000... | 147.2102000... | 14730 | 20460 | 125 | 0.958900000... | 17.87790000... | 30.74060000... | 64.05950000... | 0.144700000... | 0.081400000... |
| 21 | 2021 | 1 | 'G03' | 'S1C' | 3 | 'A' | 18.47670000... | 0.139500000... | -179.466000... | 58350 | 62760 | 122 | 1.230300000... | 29.38940000... | 309.7127000... | 315.7439000... | 0.139500000... | 0.044600000... |
| 22 | 2021 | 1 | 'G03' | 'S1W' | 1 | 'A' | 11.93940000... | 0.145600000... | -150.375100... | 11220 | 14700 | 98 | 11.61480000... | 17.87760000... | 64.28640000... | 89.84240000... | 0.145600000... | 0.052900000... |
| 23 | 2021 | 1 | 'G03' | 'S1W' | 2 | 'D' | 14.14660000... | 0.178700000... | -25.6333000... | 14730 | 20460 | 119 | 0.958900000... | 17.87790000... | 30.74060000... | 64.05950000... | 0.178700000... | 0.063900000... |

***Figure 16.*** *Results file (MAT)*



SGPO_test_results.txt

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2021 | 001 | G01 | S1C | 1 | D | 4.8136 | 0.2098 | -155.6946 | 10140.00 | 14670.00 | 92 | 1.9118 | 29.9980 | 38.1216 | 47.8482 | 0.2098 | 0.0631 |
| 2 | 2021 | 001 | G01 | S1C | 2 | A | 5.8121 | 0.1885 | -48.5513 | 53490.00 | 58260.00 | 119 | 4.1116 | 29.9041 | 305.4195 | 324.7231 | 0.1885 | 0.0591 |
| 3 | 2021 | 001 | G01 | S1C | 3 | D | 20.5051 | 0.1788 | 55.1770 | 63270.00 | 64680.00 | 48 | 24.3609 | 29.9939 | 250.4832 | 261.1454 | 0.1788 | 0.0769 |
| 4 | 2021 | 001 | G01 | S1W | 1 | D | 19.7379 | 0.2097 | -135.0385 | 10140.00 | 14670.00 | 91 | 1.9118 | 29.9980 | 38.1216 | 47.8482 | 0.2097 | 0.0552 |
| 5 | 2021 | 001 | G01 | S1W | 2 | A | 3.8152 | 0.2326 | -6.0927 | 53520.00 | 58260.00 | 115 | 4.2993 | 29.9041 | 305.4195 | 324.6861 | 0.2326 | 0.0635 |
| 6 | 2021 | 001 | G01 | S1W | 3 | D | 16.3747 | 0.2833 | 97.2437 | 63270.00 | 64680.00 | 48 | 24.3609 | 29.9939 | 250.4832 | 261.1454 | 0.2833 | 0.0996 |
| 7 | 2021 | 001 | G01 | S2W | 1 | D | 19.7371 | 0.2097 | -134.9323 | 10140.00 | 14670.00 | 91 | 1.9118 | 29.9980 | 38.1216 | 47.8482 | 0.2097 | 0.0637 |
| 8 | 2021 | 001 | G01 | S2W | 2 | A | 3.8164 | 0.2326 | -6.2577 | 53520.00 | 58260.00 | 115 | 4.2993 | 29.9041 | 305.4195 | 324.6861 | 0.2326 | 0.0767 |
| 9 | 2021 | 001 | G01 | S2W | 3 | D | 16.3711 | 0.2833 | 97.8237 | 63270.00 | 64680.00 | 48 | 24.3609 | 29.9939 | 250.4832 | 261.1454 | 0.2833 | 0.1128 |
| 10 | 2021 | 001 | G01 | S2X | 1 | D | 13.9306 | 0.1953 | 37.7347 | 10140.00 | 14940.00 | 161 | 0.2230 | 29.9980 | 38.0639 | 47.8482 | 0.1953 | 0.0345 |
| 11 | 2021 | 001 | G01 | S2X | 2 | A | 13.6112 | 0.2169 | -131.9968 | 53160.00 | 58260.00 | 171 | 2.0439 | 29.9041 | 305.4195 | 325.0733 | 0.2169 | 0.0468 |
| 12 | 2021 | 001 | G01 | S2X | 3 | D | 20.1875 | 0.2195 | -131.7918 | 63270.00 | 64680.00 | 48 | 24.3609 | 29.9939 | 250.4832 | 261.1454 | 0.2195 | 0.1073 |
| 13 | 2021 | 001 | G01 | S5X | 1 | D | 13.5778 | 0.1999 | 15.5169 | 10140.00 | 14940.00 | 160 | 0.2230 | 29.9980 | 38.0639 | 47.8482 | 0.1999 | 0.0326 |
| 14 | 2021 | 001 | G01 | S5X | 2 | A | 12.5339 | 0.1258 | -101.0230 | 53040.00 | 58260.00 | 175 | 1.2908 | 29.9041 | 305.4195 | 325.1756 | 0.1258 | 0.0411 |
| 15 | 2021 | 001 | G01 | S5X | 3 | D | 24.5734 | 0.2150 | 174.4980 | 63270.00 | 64680.00 | 48 | 24.3609 | 29.9939 | 250.4832 | 261.1454 | 0.2150 | 0.1213 |
| 16 | 2021 | 001 | G02 | S1C | 1 | D | 15.0609 | 0.2766 | -152.1492 | 33300.00 | 34890.00 | 54 | 22.4568 | 29.9866 | 79.3997 | 89.4526 | 0.2766 | 0.0994 |
| 17 | 2021 | 001 | G02 | S1W | 1 | D | 15.0504 | 0.1309 | 158.0679 | 33300.00 | 34890.00 | 54 | 22.4568 | 29.9866 | 79.3997 | 89.4526 | 0.1309 | 0.0707 |
| 18 | 2021 | 001 | G02 | S2W | 1 | D | 15.0526 | 0.1309 | 157.7312 | 33300.00 | 34890.00 | 54 | 22.4568 | 29.9866 | 79.3997 | 89.4526 | 0.1309 | 0.0664 |
| 19 | 2021 | 001 | G03 | S1C | 1 | A | 21.5562 | 0.1354 | -92.3960 | 11220.00 | 14700.00 | 102 | 11.6148 | 17.8776 | 64.2864 | 89.8424 | 0.1354 | 0.0736 |
| 20 | 2021 | 001 | G03 | S1C | 2 | D | 14.0625 | 0.1447 | 147.2102 | 14730.00 | 20460.00 | 125 | 0.9589 | 17.8779 | 30.7406 | 64.0595 | 0.1447 | 0.0814 |
| 21 | 2021 | 001 | G03 | S1C | 3 | A | 18.4767 | 0.1395 | -179.4660 | 58350.00 | 62760.00 | 122 | 1.2303 | 29.3894 | 309.7127 | 315.7439 | 0.1395 | 0.0446 |
| 22 | 2021 | 001 | G03 | S1W | 1 | A | 11.9394 | 0.1456 | -150.3751 | 11220.00 | 14700.00 | 98 | 11.6148 | 17.8776 | 64.2864 | 89.8424 | 0.1456 | 0.0529 |
| 23 | 2021 | 001 | G03 | S1W | 2 | D | 14.1466 | 0.1787 | -25.6333 | 14730.00 | 20460.00 | 119 | 0.9589 | 17.8779 | 30.7406 | 64.0595 | 0.1787 | 0.0639 |
| 24 | 2021 | 001 | G03 | S1W | 3 | A | 13.9048 | 0.1678 | -142.0018 | 58350.00 | 62760.00 | 120 | 1.2303 | 29.3894 | 309.7127 | 315.7439 | 0.1678 | 0.0374 |
| 25 | 2021 | 001 | G03 | S2W | 1 | A | 11.9405 | 0.1456 | -150.4870 | 11220.00 | 14700.00 | 98 | 11.6148 | 17.8776 | 64.2864 | 89.8424 | 0.1456 | 0.0574 |
| 26 | 2021 | 001 | G03 | S2W | 2 | D | 14.1436 | 0.1787 | -25.3837 | 14730.00 | 20460.00 | 119 | 0.9589 | 17.8779 | 30.7406 | 64.0595 | 0.1787 | 0.0721 |
| 27 | 2021 | 001 | G03 | S2W | 3 | A | 13.9061 | 0.1678 | -142.1153 | 58350.00 | 62760.00 | 120 | 1.2303 | 29.3894 | 309.7127 | 315.7439 | 0.1678 | 0.0440 |
| 28 | 2021 | 001 | G03 | S2X | 1 | A | 12.1289 | 0.2504 | -129.6673 | 11220.00 | 14700.00 | 117 | 11.6148 | 17.8776 | 64.2864 | 89.8424 | 0.2504 | 0.0965 |
| 29 | 2021 | 001 | G03 | S2X | 2 | D | 14.0617 | 0.1521 | 30.3993 | 14730.00 | 20610.00 | 194 | 0.1895 | 17.8779 | 30.2461 | 64.0595 | 0.1521 | 0.0331 |
| 30 | 2021 | 001 | G03 | S2X | 3 | A | 14.1108 | 0.1733 | -164.8155 | 58170.00 | 62760.00 | 154 | 0.1892 | 29.3894 | 309.1912 | 315.7439 | 0.1733 | 0.0367 |

***Figure 17.*** *Results file (TXT)*

***Table 2.*** *Column numbers and descriptions for results files*

| No | Description | No | Description |
|---|---|---|---|
| **1** | Year | **10** | First epoch |
| **2** | DoY | **11** | Last epoch |
| **3** | Satellite PRN | **12** | Number of epochs |
| **4** | SNR type | **13** | Minimum elevation angle |
| **5** | Satellite track no | **14** | Maximum elevation angle |
| **6** | Satellite track type | **15** | Minimum azimuth angle |
| **7** | Frequency | **16** | Maximum azimuth angle |
| **8** | Amplitude | **17** | Max(P) |
| **9** | Phase | **18** | Background noise |

### 2.3.2. Improve estimations

In this sub-module, the result file with the MAT extension is used as input. The options in the ***Settings*** section are as follows: (1) Minimum-maximum frequency, (2) Minimum elevation angle range, (3) Background noise condition (BNC), (4) Median Absolute Deviation (MAD). Here, the MAD can be applied to the frequency, amplitude, or phase by selecting to apply to the daily estimates or to the loaded complete data (Figure 18).

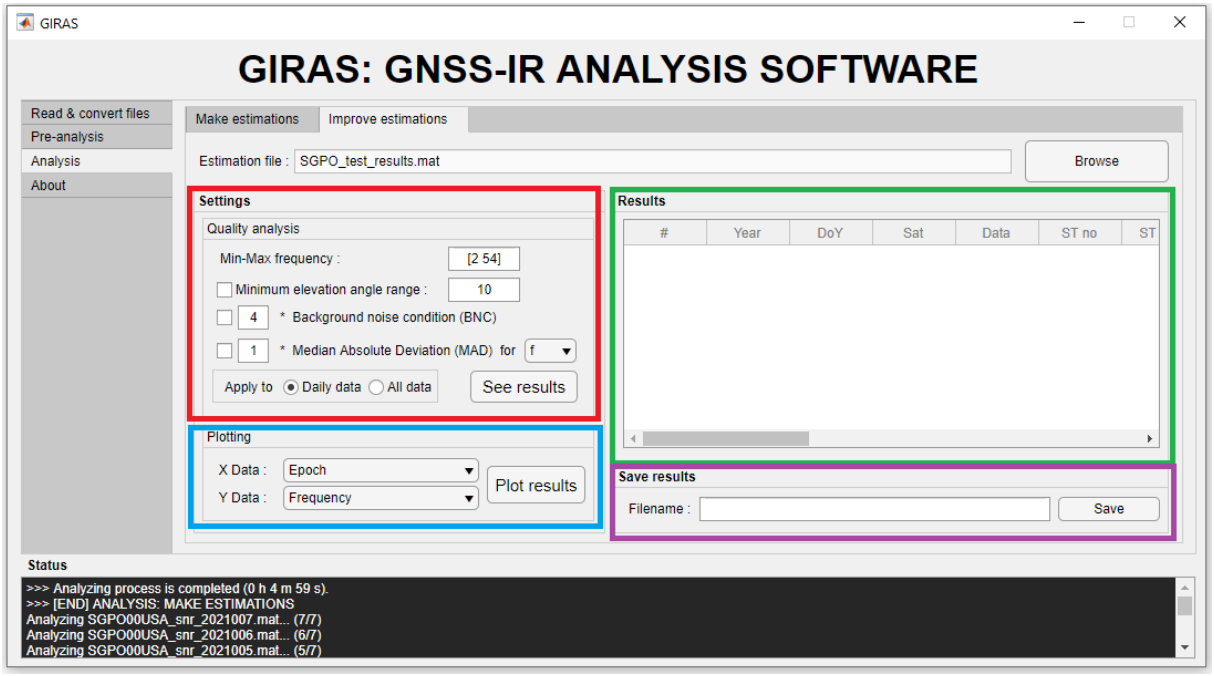



***Figure 18.*** *Analysis: Improve estimations (Red: Settings section, Green: Results table, Blue: Plotting section, Purple: Save results)*

When the user clicks the ***See results*** button after completing the settings, the filtered results appear in the table in the ***Results*** section (Figure 19).

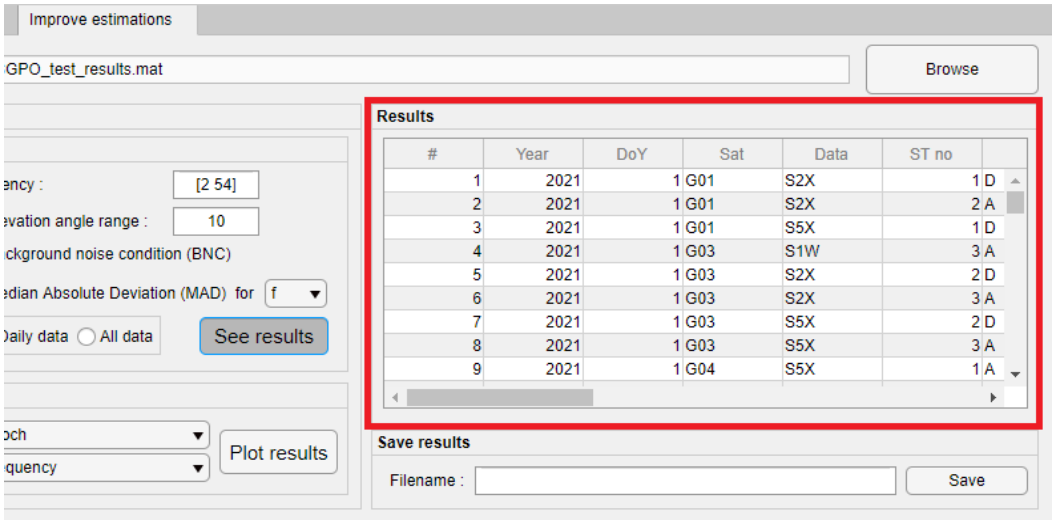



***Figure 19.*** *Analysis: Improve estimations – Results table*

Once the results are displayed in the table, the user can plot and examine the graphics by selecting the data for the X and Y axes from the ***Plotting*** section (Figure 20). Options for X and Y axes data are outlined in Table 3.

***Table 3.*** *Data options for plotting section*

| **X data options** | **Y data options** |
|---|---|
| Epoch, Mean elevation angle, mean azimuth angle, BNC ratio, elevation angle range, number of epochs, number of epochs per sin(elevation). | Frequency, amplitude, phase, frequency (daily mean), amplitude (daily mean), phase (daily mean). |

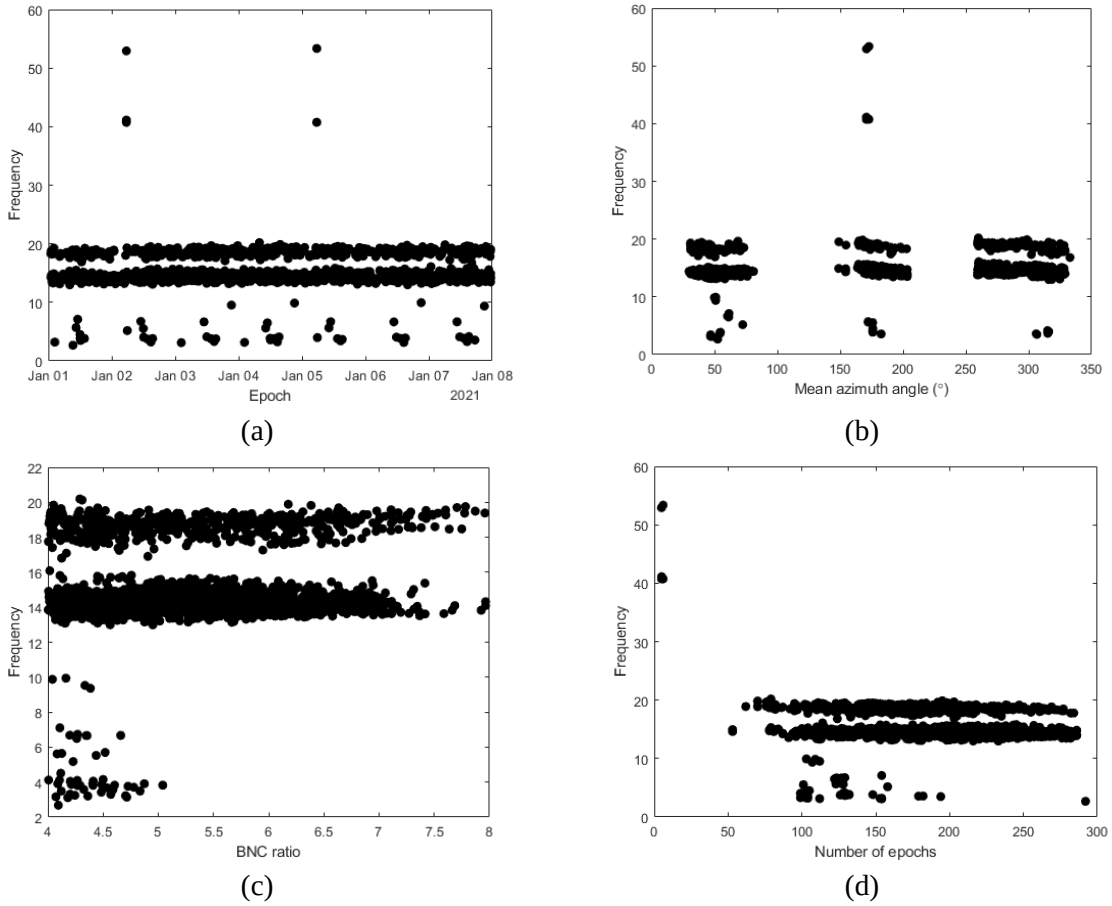



***Figure 20.*** *Analysis: Improve estimations – Plot examples (a) Epoch-frequency, (b) Mean azimuth angle-frequency, (c) BNC ratio-frequency, (d) Number of epochs-frequency*

After reviewing the results and removing the undesired estimations, the user can save them first by typing the file name in the ***Save results*** section (See Figure 19, bottom right), then clicking the ***Save*** button.

# 3. Mandatory files and directory structure

The GIRAS software has two pre-defined information files and four settings files. These files are listed in Table 4 with their names and details.

***Table 4.*** *Mandatory files*

| | **File name** | **Details** |
|---|---|---|
| **Pre-defined info files** | satellite_list.mat | It contains the satellite PRN list. |
| | wavelengths.mat | It contains frequency and wavelength information of satellite and observation types. |
| **Settings files** | ana.mat | It contains analysis-1 (make estimations) settings. |
| | ana2.mat | It contains analysis-2 (improve estimations) settings. |
| | pra.mat | It contains pre-analysis settings. |
| | rcf.mat | It contains settings for read & convert files operations. |

GIRAS has a directory structure for mandatory files, input & output files, results files to organize. The main directory contains the ***data***, ***FFZ***, ***functions***, ***results***, and ***settings*** folders (Figure 21).

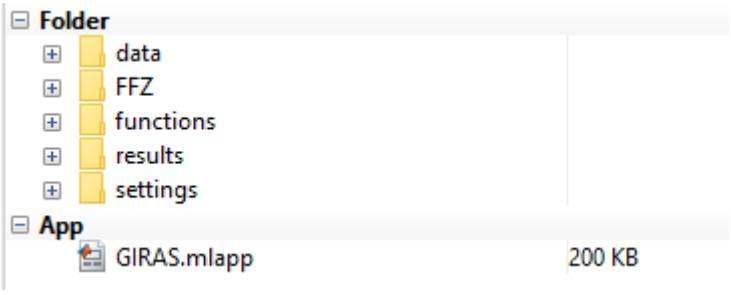



***Figure 21.*** *Main directory of the software*

The first folder, namely ***data*** contains mandatory, input, and output data (Figure 22).

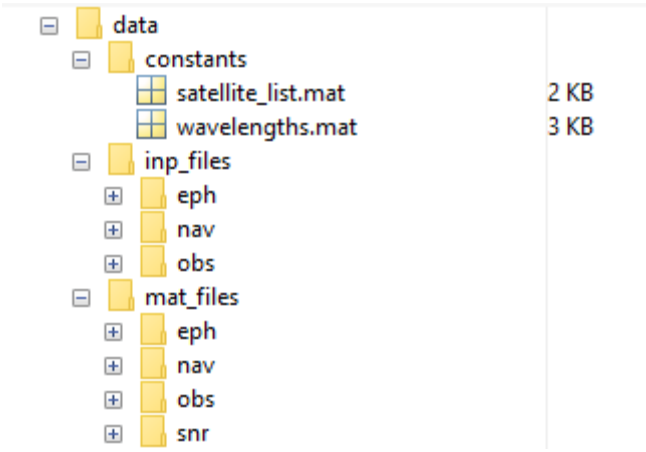



***Figure 22.*** *Sub-directory: data*

The second folder is called ***FFZ*** and contains the Google Earth FFZ files produced for the stations. The third folder, namely ***functions*** contains data reading, data analysis, and other functions (Figure 23).

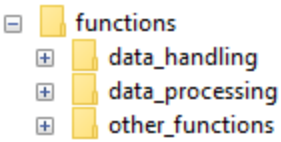



***Figure 23.*** *Sub-directory: functions*

The fourth folder is called ***results*** and contains the results files resulting from the processes performed in the ***Make estimations*** and ***Improve estimations*** sections (Figure 24). The last folder is the ***settings*** and contains settings files.

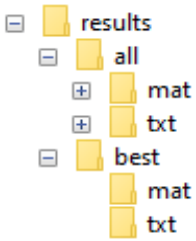



***Figure 24.*** *Sub-directory: results*

# 4. Example

For a sampling process, the results can be achieved using the sampling files and following the steps below.

***Step 1) Read & convert files***

- Run the software.

- In the ***Read & convert files*** module, select the 7-day sample files from the SGPO station as observation files.
- Choose the file type you will use as ***Ephemeris file*** from the ***Settings*** section on the right, then browse and select the ephemeris files.
- Click ***Read & convert files and create SNRMAT files*** in the ***Process type*** tab of the ***Settings*** section.
- Click the ***READ & CONVERT*** button and wait until the process is complete (you may view the working status on the ***Status*** screen).
- When you see the line "*100.00% of process is completed*" in the ***Status*** screen, the process is finished. You may proceed to the second step.

***Step 2) Analysis – Make estimations***

- Switch to the ***Analysis*** > ***Make estimations*** tab and select the SNRMAT files created in the first step.
- Select the satellite systems and SNR data type in the ***Settings***.
- Select the degree of polynomial.
- Enter the ***Angle limitation*** values (eg. [0° 30°] for elevation angle, [0° 140°; 230° 360°] for azimuth).
- Enter ***Estimation settings*** "5 m" for maximum reflector height, and "0.001 m" for desired precision.
- Write the name of the file to be saved in the ***Filename*** section.
- Click the ***RUN*** button and wait until the process is complete (you may view the working status on the ***Status*** and ***Processing status*** screens).
- When you see the line "*Analyzing process is completed*" on the ***Status*** screen, the process is completed and the result file is saved in the relevant directory.

***Step 3) Analysis – Improve estimations***

- Switch to ***Analysis*** **>** ***Improve estimations*** tab and select the results file with MAT extension created in the second step.
- Enter the value 10 for ***Minimum elevation angle range*** and check its box.
- Enter the value 4 for ***Background noise condition (BNC)*** and check its box.
- Uncheck the box of ***Median Absolute Deviation (MAD)***.
- Click on the ***See results*** button.
- After the results are displayed in the table on the right, select different data for the X and Y from the ***Plotting*** section and click the ***Plot results*** button, and examine the results.
- Enter a file name in the ***Save results*** section at the bottom right and click the ***Save*** button.
- Good results are saved with the file name you entered, in the relevant directories as MAT and TXT files.

# 5. Contact

If you have any question, please contact the authors using the following e-mail addresses:

***Cemali ALTUNTAS****, Yildiz Technical University, Istanbul, Turkey.*

- cemalialtuntas@gmail.com
- cemali@yildiz.edu.tr

***Nursu TUNALIOGLU****, Yildiz Technical University, Istanbul, Turkey.*

- ntunali@yildiz.edu.tr