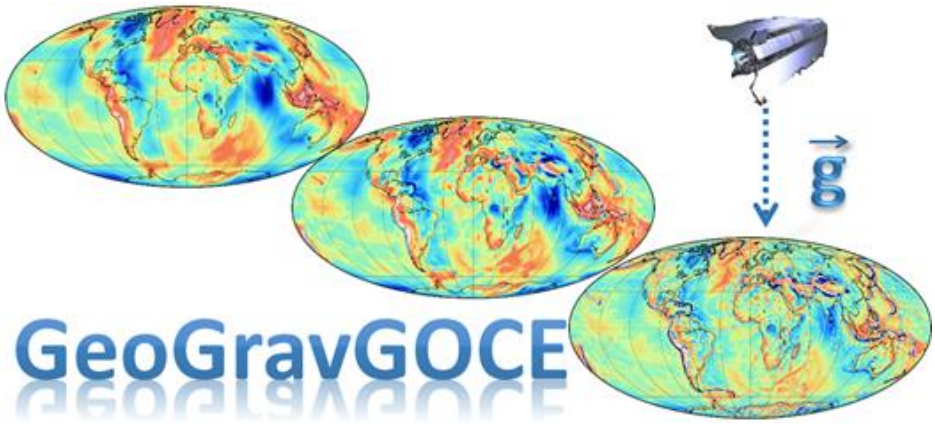
GeoGravGOCE

A standalone Matlab GUI for processing GOCE satellite gradient data

Software Guide



Contents:

 # Generalization of the GeoGravGOCE app

The GeoGravGOCE app is designed to pre-process the Satellite Gravity Gradiometry (SGG) data, reduce the gravity field's systematic trends of the SGGs, filter the reduced GOCE signals, and transform them to the conventional reference frames. The app is visually divided into the four following tabs:

1st tab: The Satellite Gravity Gradiometry Pre-processing.

2nd tab: The transformation of the Global Geopotential Models (GGMs) from the Local North Oriented Frame (LNOF) to Gradiometer Reference Frame (GRF).

3rd tab: The Filtering, which includes the Finite Impulse Response (FIR), the Infinite Impulse Response (IIR), and the Wavelet filtering options.

4th tab: The Reference Systems (RSs) transformations from the LNOF to the GRF and vice-versa.

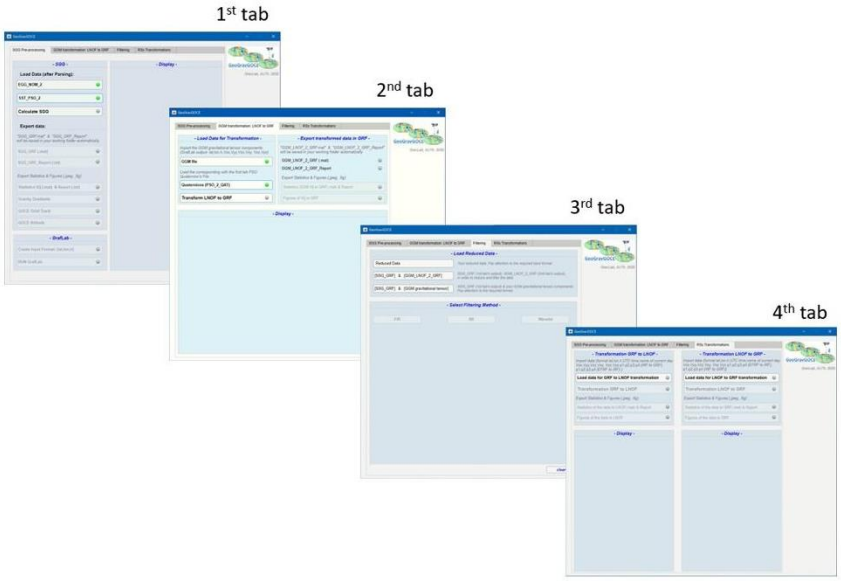


Figure 1: The four main windows of the developed GeoGravGOCE app.

 # Requirements

To run the GeoGravGOCE app you need a version of the Matlab software and the Wavelet Toolbox™. Note that we used the Matlab R2019b to develop the app.

 # Optional tools

It is optional to have the following tools to run the GeoGravGOCE app to the fullest.

1. The M_Map, a mapping package for Matlab (https://www.eoas.ubc.ca/~rich/map.html).
2. The GrafLab (GRAvity Field LABoratory), a program for computing functionals of the geopotential up to ultra-high degrees and orders. (http://www.svf.stuba.sk/en/departments/department-of-theoretical-geodesy/science-and-research/downloads.html?page_id=4996)

 # Installation Instructions

1. Launch the Matlab.
2. Locate in your local directory the app installation file which is characterized by the suffix mlappinstall.
3. Double-click on GeoGravGOCE.mlappinstall.
4. A dialog box is opened. Click install.
5. Once installed, the app is added to the MATLAB Toolstrip named APPS.
6. In the APPS find the GeoGravGOCE icon to run the program.

 # Run the GeoGravGOCE app step by step:

1st tab – SGG Pre-processing

The SGG Pre-Processing tab pre-processes the Level 2 GOCE products (EGG_NOM_2 & SST_PSO_2) in ASCII format. We recommend using the GOCEPARSER tool for transforming the Earth Explorers File format into ASCII format (e.g: .sgg, .kin, .qat). The parser is kindly provided by ESA and Dr. Kirco Arsov, and it is freely available from here: https://earth.esa.int/eogateway/tools/goceparser.

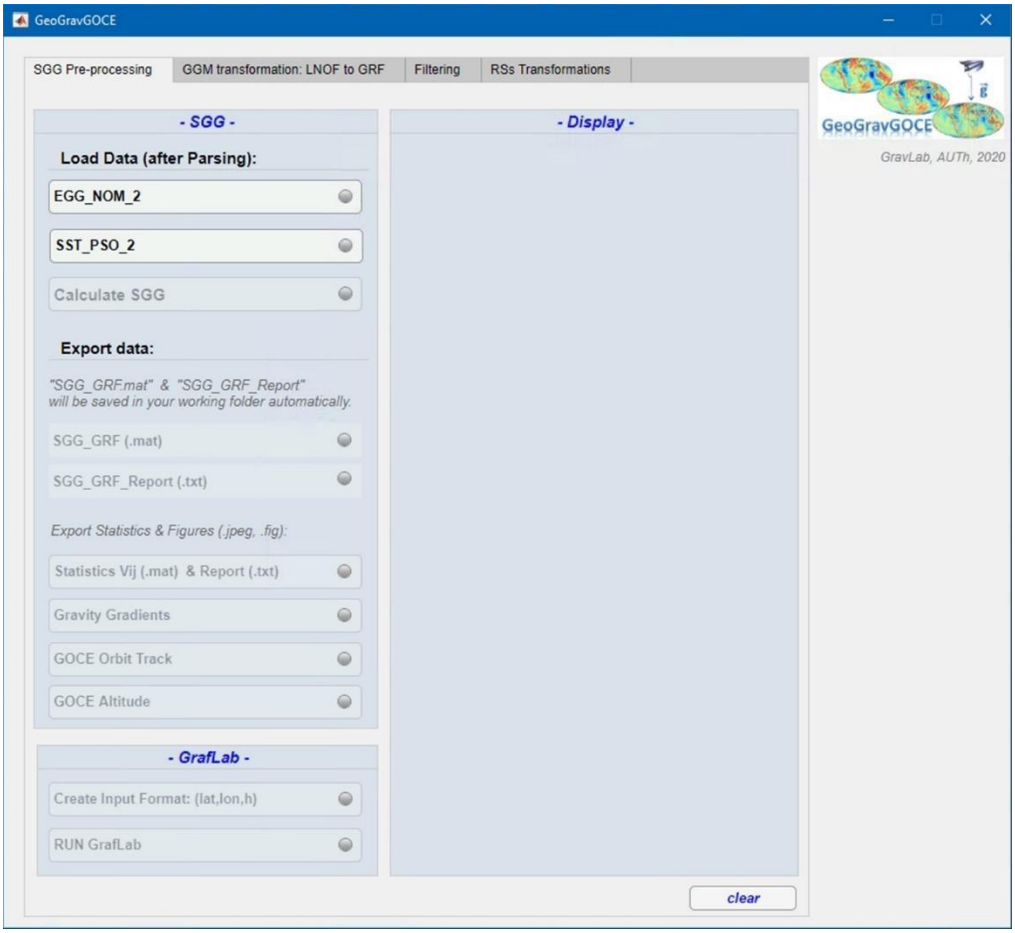


Figure 2: The SGG Pre-Processing tab.

In the SGG panel, there are two active pushbuttons.

- In the **EGG_NOM_2 pushbutton:** load the EGG_NOM_2 gravity gradients in GRF, in ASCII format.
- In the **SST_PSO_2 pushbutton:** load the SST_PSO_2 precise science orbits, in ASCII format.

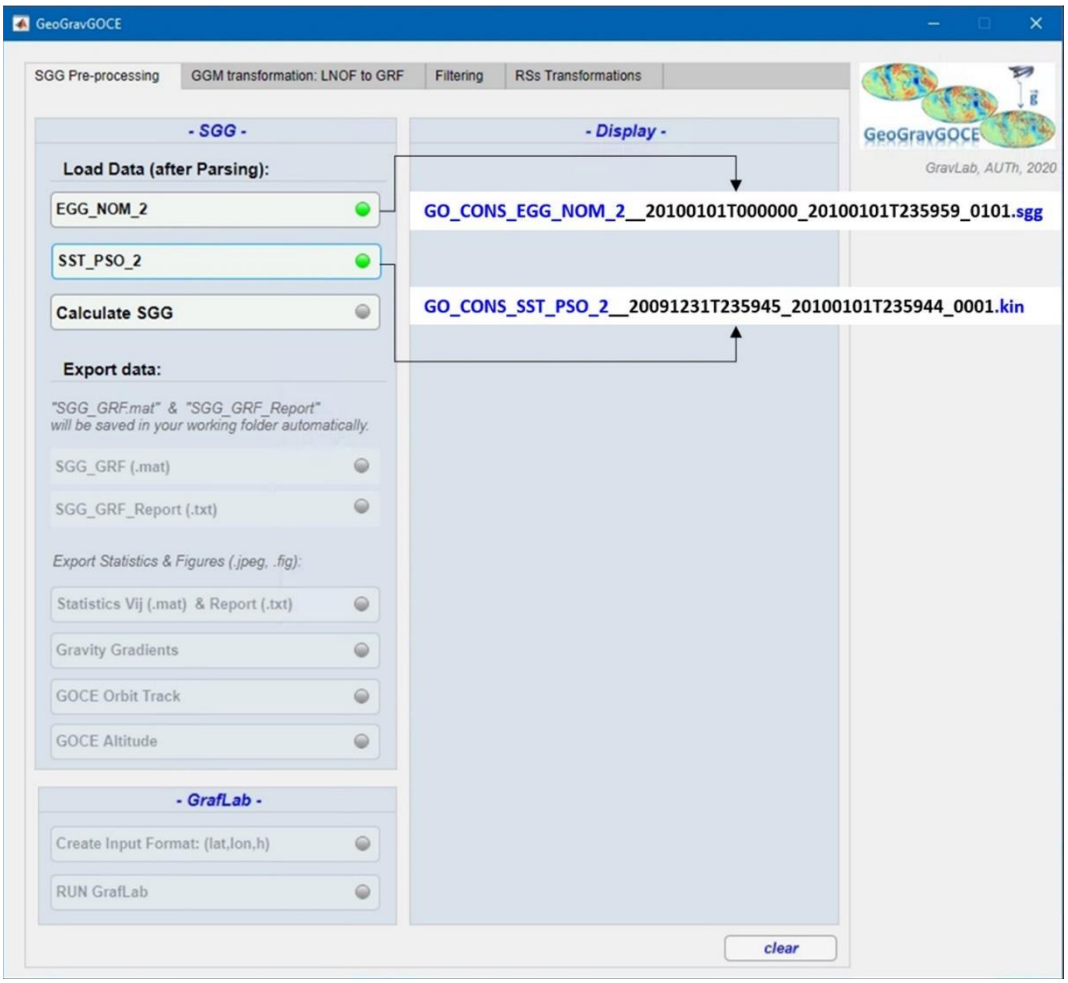


Figure 3: Load the EGG_NOM_2 (.sgg) and SST_PSO_2 (.kin) files.

- **Calculate SGG pushbutton:**

Please press the Calculate SGG pushbutton and wait for the processing. Once the process is over, the green lamp will light, and the outputs (SGG_GRF.mat and SGG_GRF_Report.txt) will automatically be saved to the SGG Pre-Processing folder. The SGG_GRF.mat file includes the latitude and longitude in degrees, the GOCE altitude in meters, the GPS time in seconds, the SGGs in Eötvös, the quaternions in GRF, and the names of the processed files.

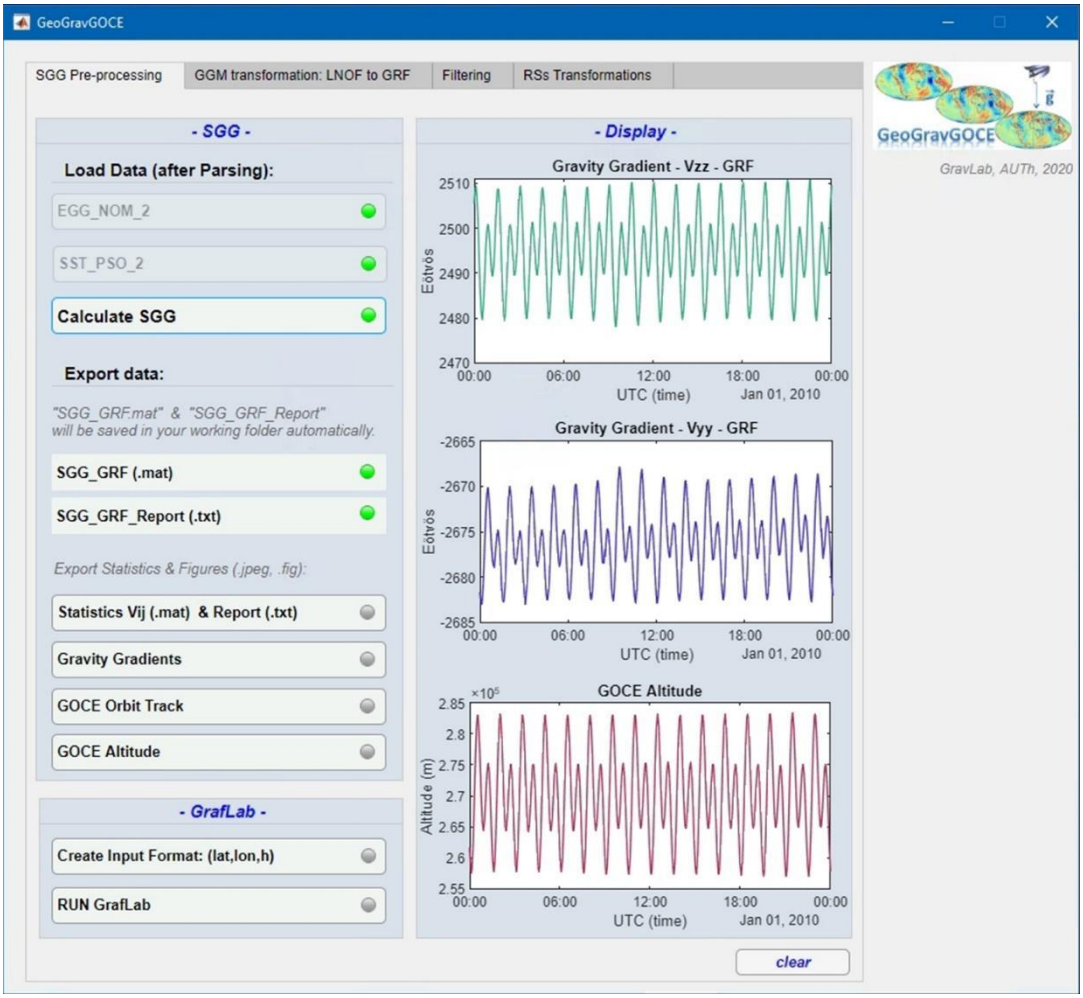


Figure 4: The SGG Pre-Processing tab, after a successful data processing.

After a successful data processing, the following six pushbuttons are activated:

- **Statistics Vij (.mat) & Report (.txt) pushbutton:**

This button computes the statistics of the data. When the statistical computation is over, the green lamp will light, and the outputs (stats_Vij_GRF.mat and stats_Vij_GRF_Report.txt) will automatically be saved in the Statistics Vij GRF folder. The stats_Vij_GRF.mat contains the statistics of the SGGs (Eötvös) in the GRF, and its dimensions are [Nx6] cells, where: N (rows) depict the number of the processed files, and the six (columns) present the six gravity gradients ($V_{xx}, V_{yy}, V_{zz}, V_{xy}, V_{xz}, V_{yz}$). Each interior cell includes the minimum (min), the maximum (max), the mean (mean), the standard deviation (std), and the root mean square (rms) value of the GGs.

- **Gravity gradients pushbutton:**

This button creates figures with the GOCE GGs ($Vxx, Vyy, Vzz, Vxy, Vxz, Vyz$). When the creation of the graphs is over, the green lamp will light, and the figures will automatically be saved in the Gravity Gradients GRF folder. The output of this pushbutton is presented in Figure 5.

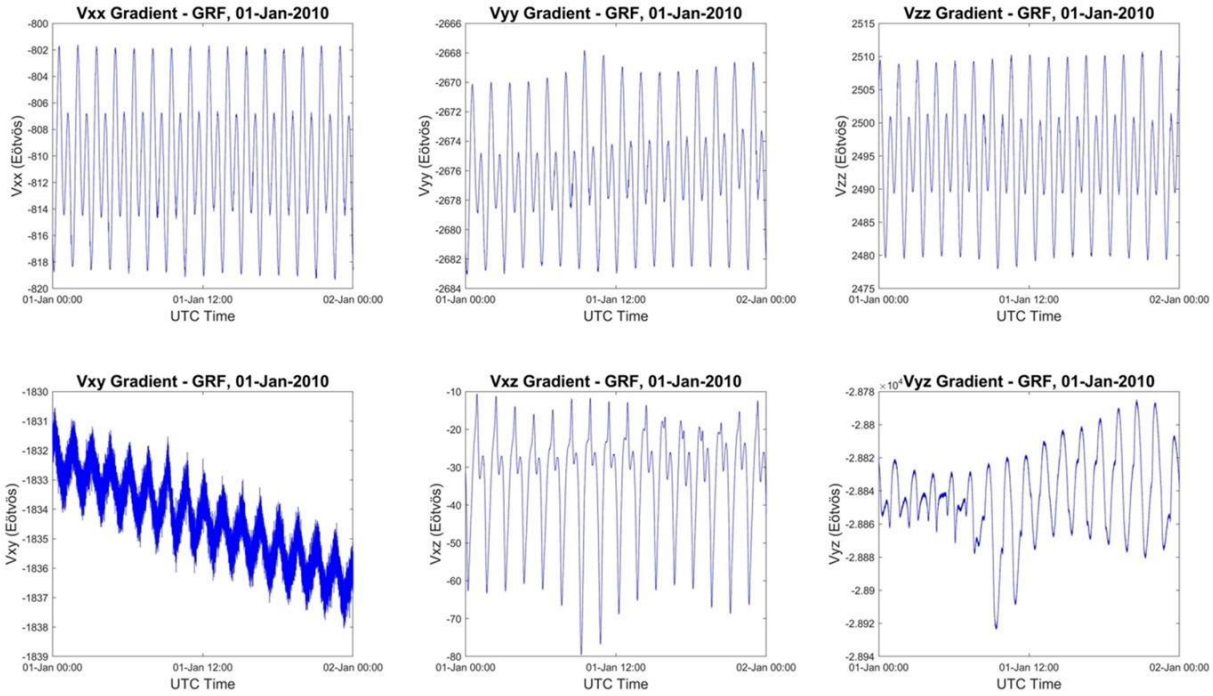


Figure 5: The output of the Gravity Gradients pushbutton, (unit: Eötvös).

- **GOCE Orbit Track pushbutton:**

This button creates global maps with the GOCE orbit track and saves them automatically in the GOCE Orbit Track folder. Due to loading high coastline resolution on the maps, the creation of figures might take several minutes. The output of this pushbutton is presented in Figure 6. It should be mentioned that the maps are created via the m_map mapping toolbox (Pawlowicz 2020) with the condition that the M-file exists in the user's search path. If the m_map file does not exist in the user's path, the GUI will inform the user with an appropriate pop-up message. It is optional to download the M_Map toolbox from here: https://www.eoas.ubc.ca/~rich/map.html.

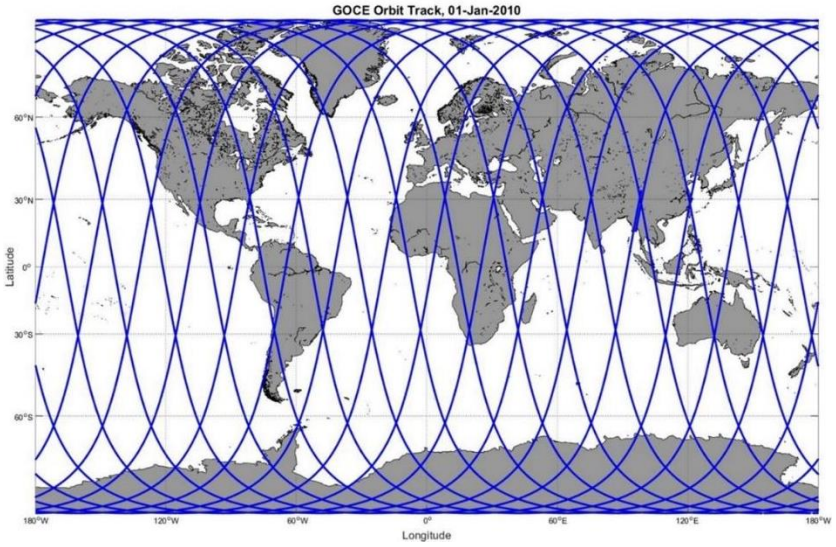


Figure 6: The output of the GOCE Orbit Track pushbutton.

- **GOCE Altitude pushbutton:**

This button creates figures with the GOCE altitude and saves them automatically in the GOCE Altitude folder. The output of this pushbutton is presented in Figure 7.

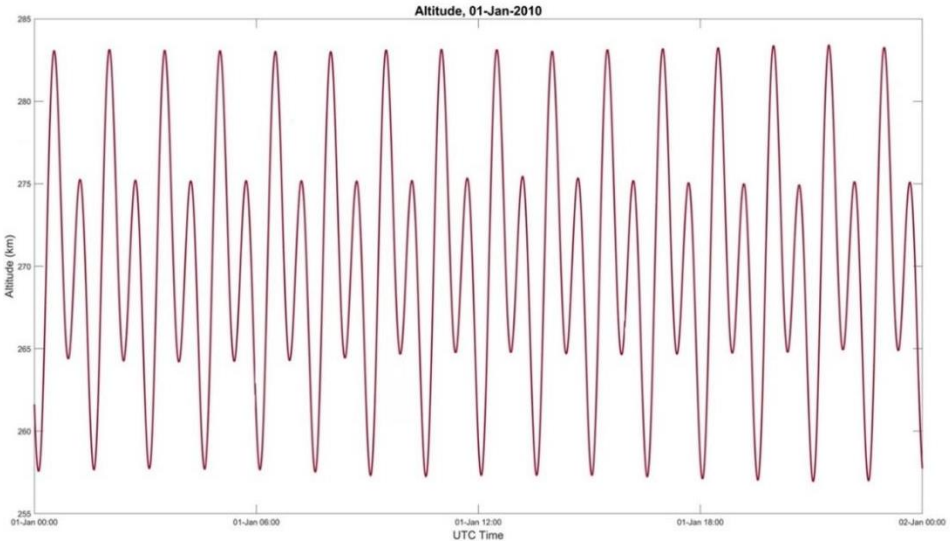


Figure 7: The output of the GOCE Altitude pushbutton, (unit: Km).

- **Create Input Format (lat,lon,h) pushbutton:**

This button creates a TXT-file with the gravity gradient's geodetic coordinates in an appropriate format $(latitude,\ longitude,\ height)$, the latitude and the longitude in degrees, and the ellipsoid height in meters. This output format is the compatible input format for the GrafLab software (Bucha and Janák 2013). The produced TXT-files are automatically saved in the Input_for_GrafLab folder.

- **RUN GrafLab pushbutton:**

This button computes the gravitational tensor components $(Vxx, Vyy, Vzz, Vxy, Vxz, Vyz)$ via GrafLab software (Bucha and Janák 2013). It should be mentioned that the GrafLab's calculations are executed with the condition that the GrafLab M-file already exists in the user's search path. If the GrafLab M-file does not exist in the user's folder, the GUI informs the user with a pop-up message. It is optional to download the GrafLab software from here: http://www.svf.stuba.sk/en/departments/department-of-theoretical-geodesy/science-and-research/downloads.html?page_id=4996.

When you click the RUN GrafLab pushbutton:

1. In the first open file selection dialog box: select the file of Global Gravity Model (GGM) (.gfc).
2. In the second dialog box: enter the required parameters for the GrafLab software. Such as the minimum degree of the spherical harmonic expansion (nmin), the maximum degree of the spherical harmonic expansion (nmax), the geocentric gravitational constant of the GGM $(m^3 * s^{-2})$, the radius of the reference sphere of the GGM in meters, and the reference ellipsoid (GRS80/WGS84).

3. In the third open file selection dialog box: select the .TXT file with geodetic coordinates in the following format: latitude in degrees, longitude in degrees and the ellipsoid height in meters. Note that the output of the previous pushbutton is matching here.

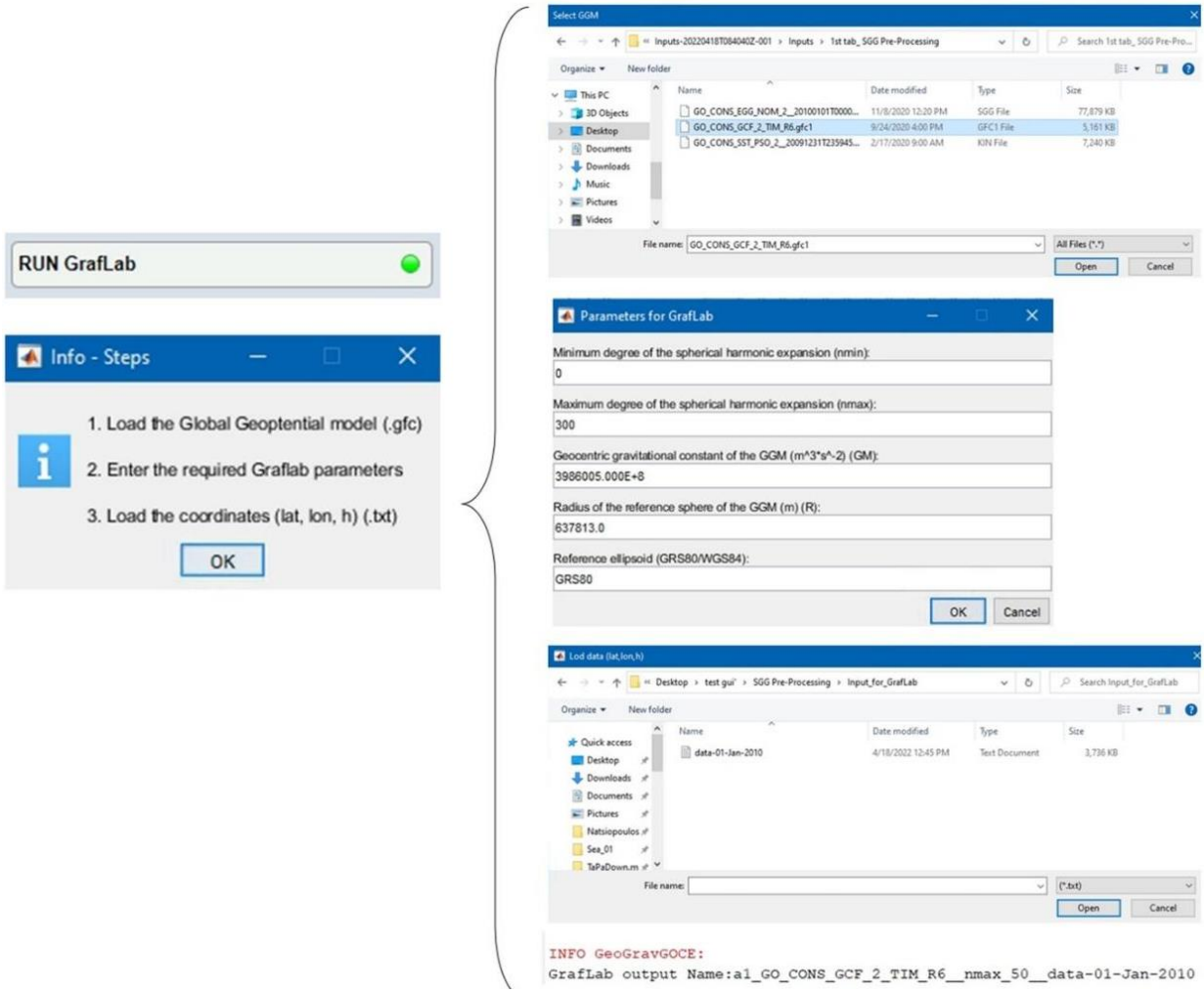


Figure 8: The dialog boxes of the Run GrafLab pushbutton.

Throughout the calculation process, we recommend checking Matlab's command window in order to stay informed. The green lamp will light once the computation is over, and the output will automatically be saved in your current folder.

2nd tab – GGM Transformations from LNOF to GRF

The second tab of the GUI is used to transform GGM gravity gradients from the LNOF to GRF, as the gravity gradients exported from Graflab (Bucha and Janák 2013) are computed in LNOF in the North-West Up system.

- In the **GGM file pushbutton:** load the GGM gravity gradients in LNOF, in ASCII format (Graflab output as extracted in first tab - latitude, longitude, altitude, $Vxx, Vyy, Vzz, Vxy, Vxz, Vyz$).

- In the **file Quaternions (PSO_2_QAT) pushbutton:** load the SST_PSO_2 (.qat) quaternions, in ASCII format.

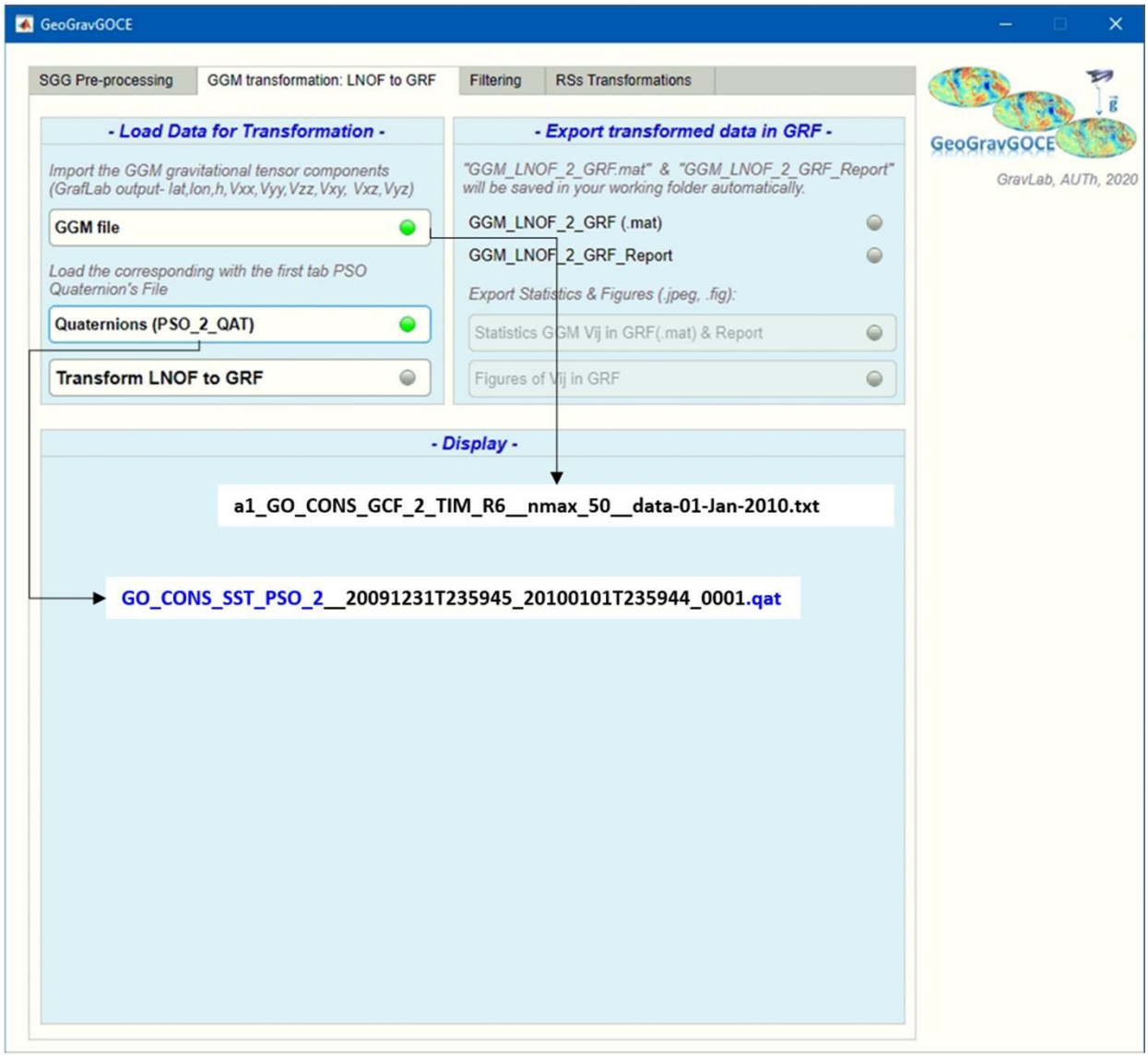


Figure 9: Load the GGM file (.txt) and the quaternions (.qat).

- **Transform LNOF to GRF pushbutton:**

Please, press the Transform LNOF to GRF pushbutton and wait for the processing. Once the transformation is over, the green lamp will light, and the outputs (GGM_LNOF_2_GRF.mat and GGM_LNOF_2_GRF_Report.txt) will automatically be saved to the GGM Transformations folder.

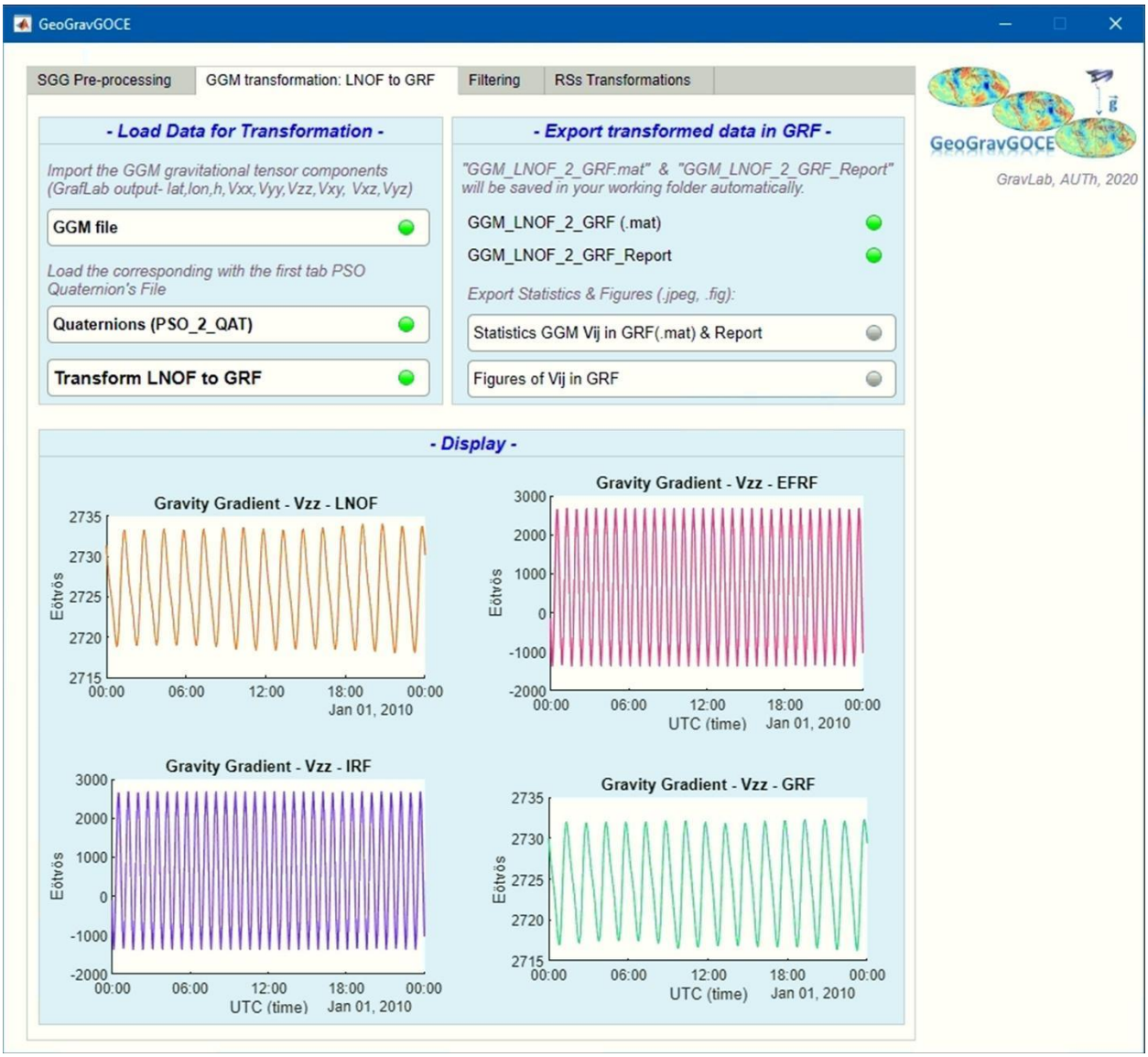


Figure 10: The GGM Transformations from LNOF to GRF tab.

- **Statistics GGM Vij in GRF(.mat) & Report pushbutton:**

This button computes the statistical values of the transformed data. When the statistical computation is over, the green lamp will light, and the outputs (GGM_LNOF_2_GRF.mat and GGM_LNOF_2_GRF _Report.txt) will automatically be saved in the Statistics_Vij_GGM_GRF folder. The GGM_LNOF_2_GRF.mat contains the statistics of the SGGs (Eötvös) in the GRF, and its dimensions are [Nx6] cells, where: N (rows) depict the number of the processed files, and the six (columns) present the six gravity gradients ($V_{xx}, V_{yy}, V_{zz}, V_{xy}, V_{xz}, V_{yz}$). Each interior cell includes the minimum (min), the maximum (max), the mean (mean), the standard deviation (std), and the root mean square (rms) value of the GGs.

- **Figures of Vij in GRF pushbutton:**

This button creates figures of the transformed GGs ($Vxx, Vyy, Vzz, Vxy, Vxz, Vyz$). When the creation of the graphs is over, the green lamp will light, and the figures will automatically be saved in the Gravity Gradients GGM GRF folder. The output of this pushbutton is presented in Figure 11.

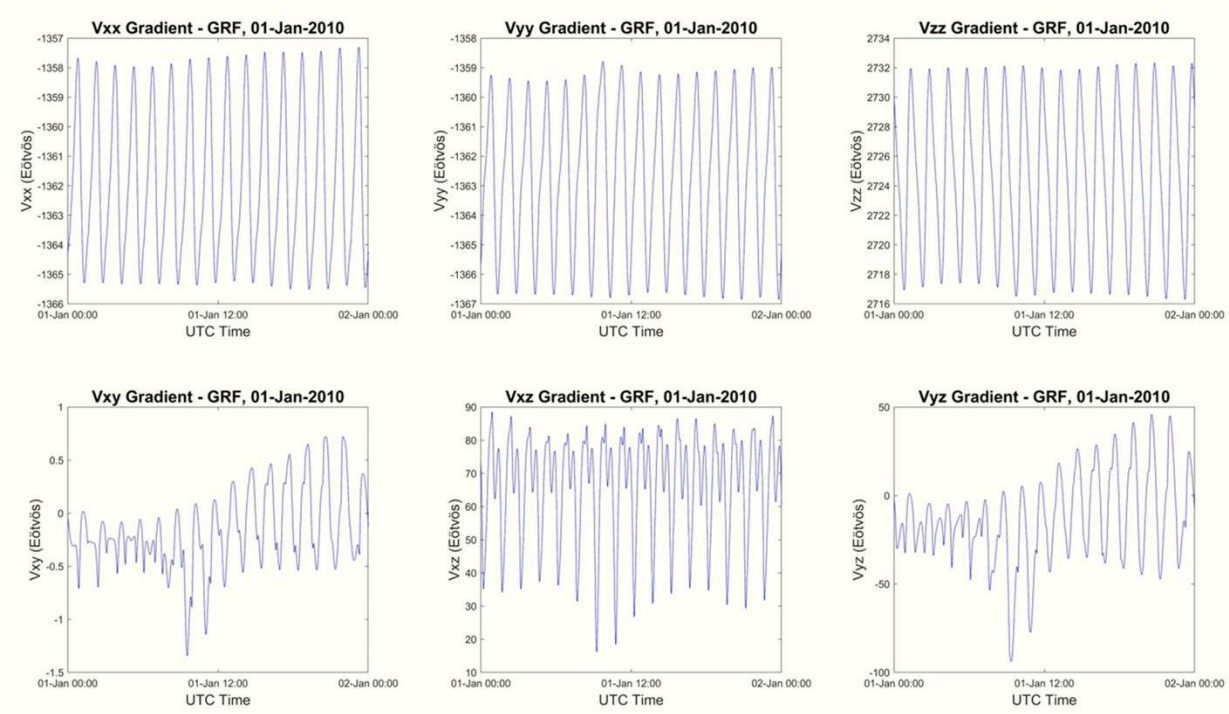


Figure 11: The output of the Figures of Vij in GRF pushbutton, (unit: Eötvös).

3rd tab – Filtering

The third tab was designed to filter the gravity gradients for users' diversified needs. The GeoGravGOCE app allows three different input data options (MAT-files) for the upcoming filtering via the following pushbuttons.

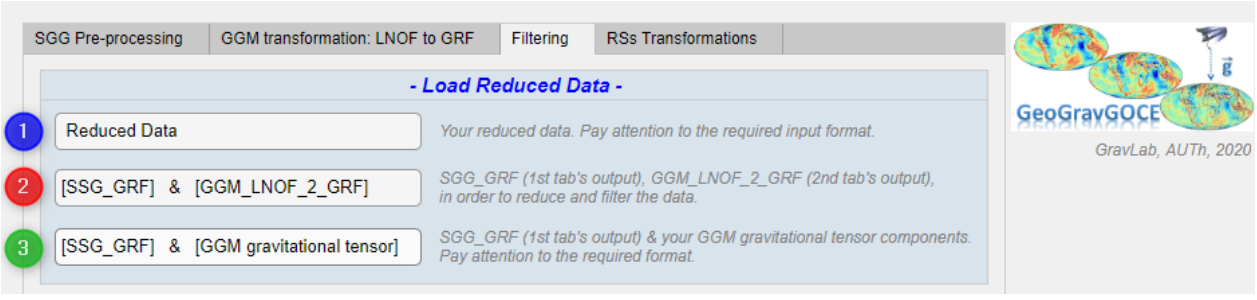


Figure 12: Input data options (MAT-files) for the upcoming filtering.

- **Reduced Data pushbutton:**

With this button, you can load your already processed and reduced data in GRF. Please pay attention to the proper input format and the right content (see Readme.txt).

- **[SGG_GRF] & [GGM_LNOF_2_GRF] pushbutton:**

In this button, you should load the first and second tabs' outputs. To be more specific, the SGG_GRF.mat and the GGM_LNOF_2_GRF.mat, respectively.

- **[SGG_GRF] & [GGM gravitational tensor] pushbutton:**

In this button, you should load the first tab output (SGG_GRF.mat) and your already computed GGM gravitational tensor components ($Vxx, Vyy, Vzz, Vxy, Vxz, Vyz$) in GRF in a MAT-file. Please pay attention to the input format and the right content (see Readme.txt).

Once the input data is successfully loaded, the three filtering options (FIR, IIR, and Wavelet) are activated, as shown in Figure 13.

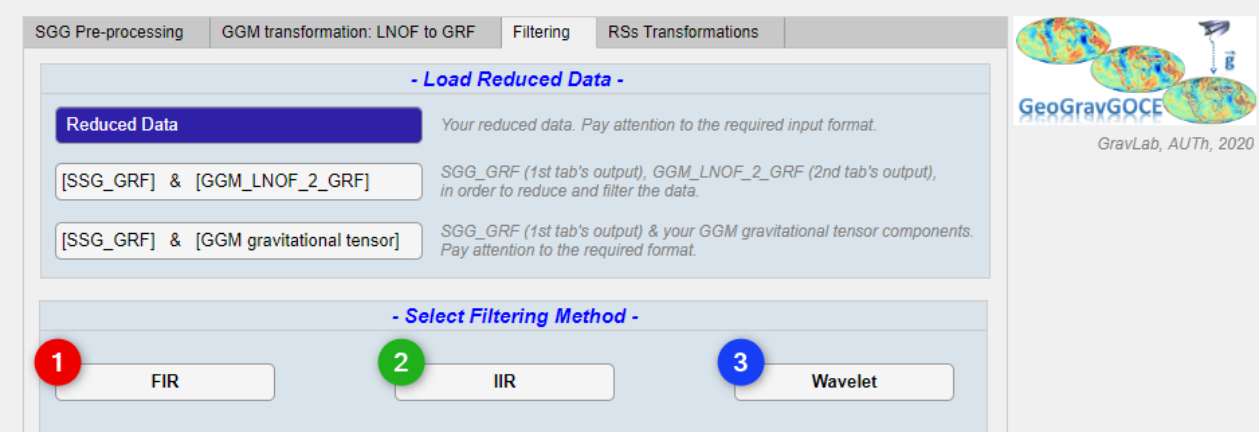


Figure 13: The activated filtering Choices: (1) FIR, (2) IIR and (3) Wavelet

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FIR choice

- **FIR pushbutton:**

In the dialog box, input the N^{th} filter order (N=1500 is recommended it).

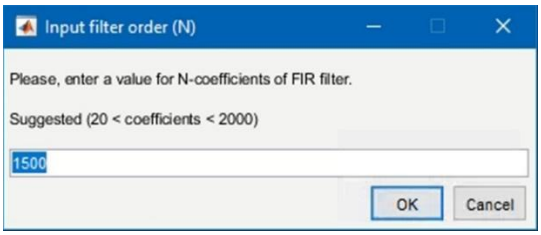

Figure 14: Dialog box of the FIR pushbutton.

Once the filtering is over, green lamps will light, and the outputs (Vij_FIR.mat and Vij_FIR_Report.txt) will automatically be saved in the FIR folder.

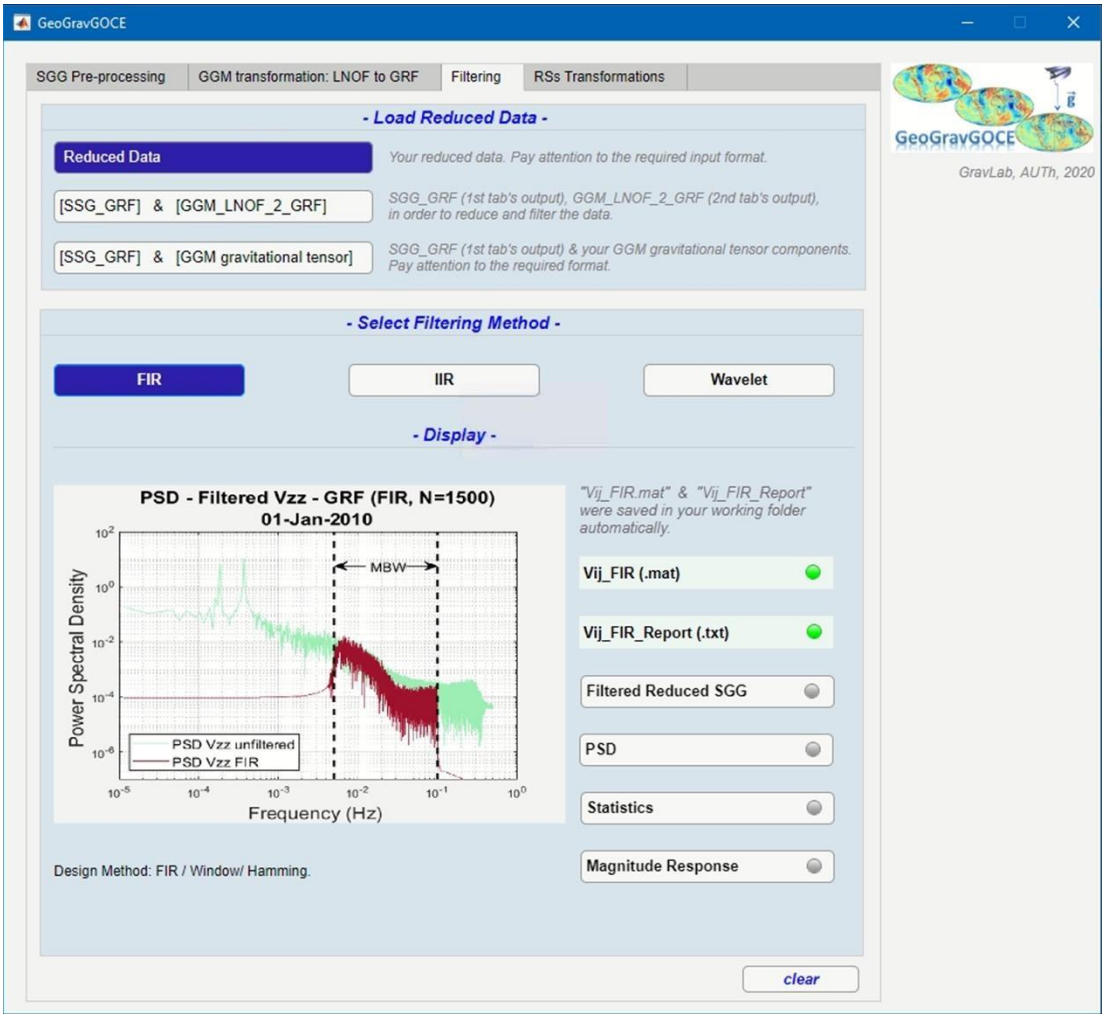

Figure 15: The main window of the FIR pushbutton.

- **Filtered Reduced SGG pushbutton:**

This button creates figures of the FIR filtered GGs ($Vxx, Vyy, Vzz, Vxy, Vxz, Vyz$). When the creation of the graphs is over, the green lamp will light, and the figures will automatically be saved in the FIR/FIR Filtered Vij GRF folder. The output of this pushbutton is presented in Figure 16.

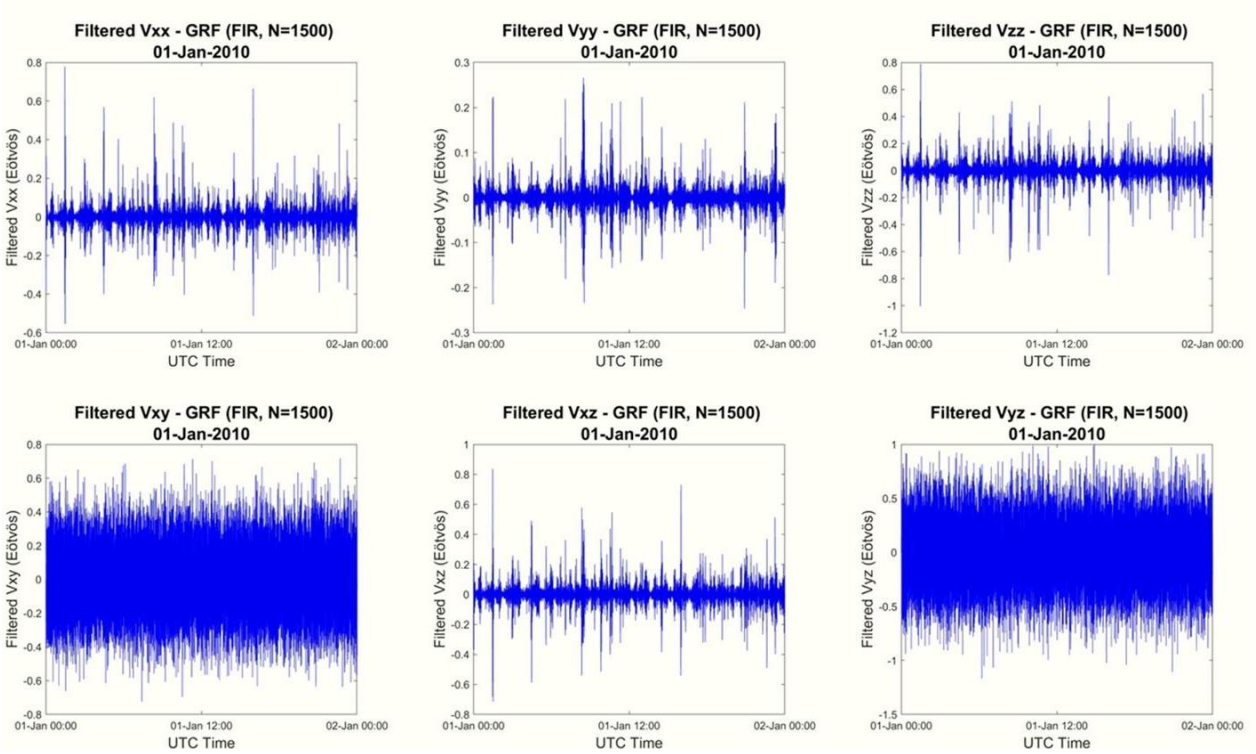

Figure 16: The FIR filtered Vij in GRF, (unit: Eötvös).

- **PSD pushbutton:**

This button creates figures with the Power Spectral Densities (PSDs) of the filtered and the unfiltered reduced GOCE signals. The figures represent the strength of the signals and the spectral characteristics of the GOCE gravity gradients in the frequency domain. When the creation of the graphs is over, the green lamp will light, and the figures will automatically be saved in the FIR/PSD FIR filtered Vij GRF folder. The output of this pushbutton is presented in Figure 17.

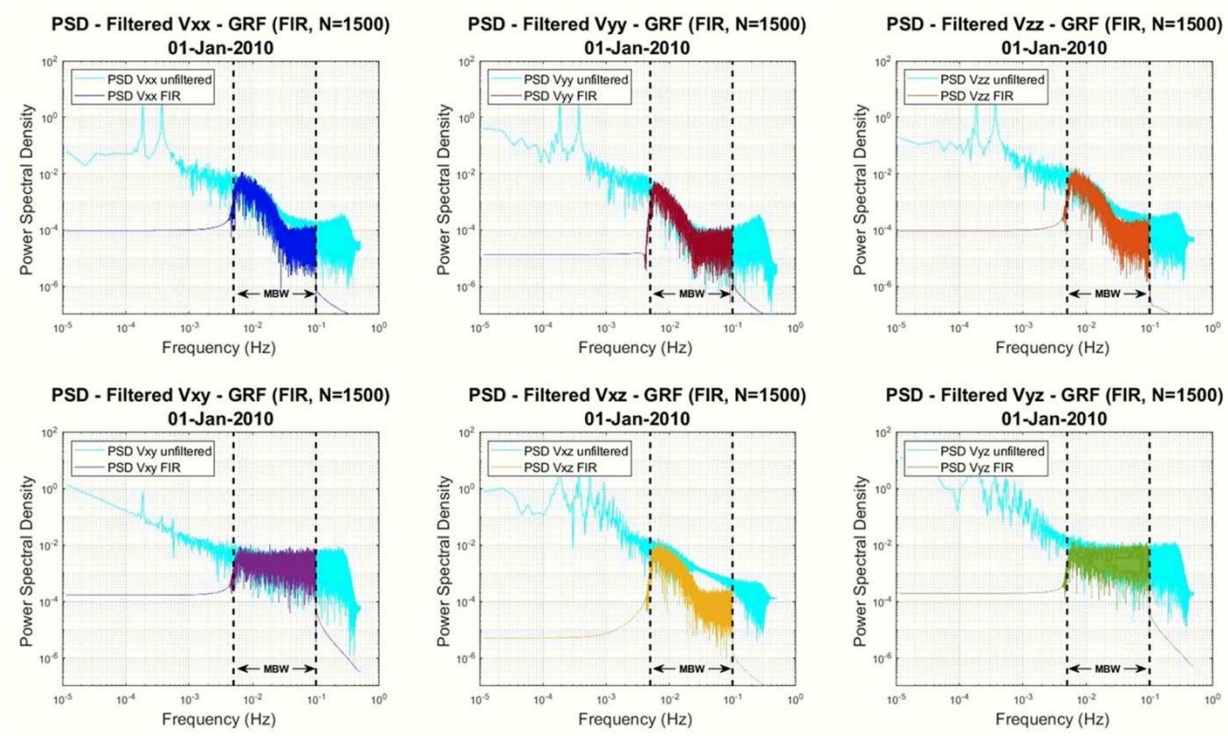

Figure 17: The PSDs of the FIR filtered Vij in GRF.

- **Statistics pushbutton:**

This button computes the statistical values of the FIR filtered data. When the statistical computation is over, the green lamp will light, and the outputs (stats_filtered_Vij_GRF.mat and stats_filtered_Vij_GRF _Report.txt) will automatically be saved in the FIR/Statistics_filtered_Vij_GRF folder. The stats_filtered_Vij_GRF.mat contains the statistics of the filtered GGs (Eötvös) in the GRF, and its dimensions are [Nx6] cells, where: N (rows) depict the number of the processed files, and the six (columns) present the six filtered gravity gradients ($V_{xx}, V_{yy}, V_{zz}, V_{xy}, V_{xz}, V_{yz}$). Each interior cell includes the minimum (min), the maximum (max), the mean (mean), the standard deviation (std), and the root mean square (rms) value of the GGs.

- **Magnitude Response pushbutton:**

This button displays the user's N^{th}-order filter's magnitude response via Matlab's interactive Filter Visualization Tool. The tool enables the user to display the magnitude, the phase response, the group delay, the impulse response, the step response, the pole-zero plot, and the coefficients of the filter. The interactive output of this pushbutton is presented in Figure 18.

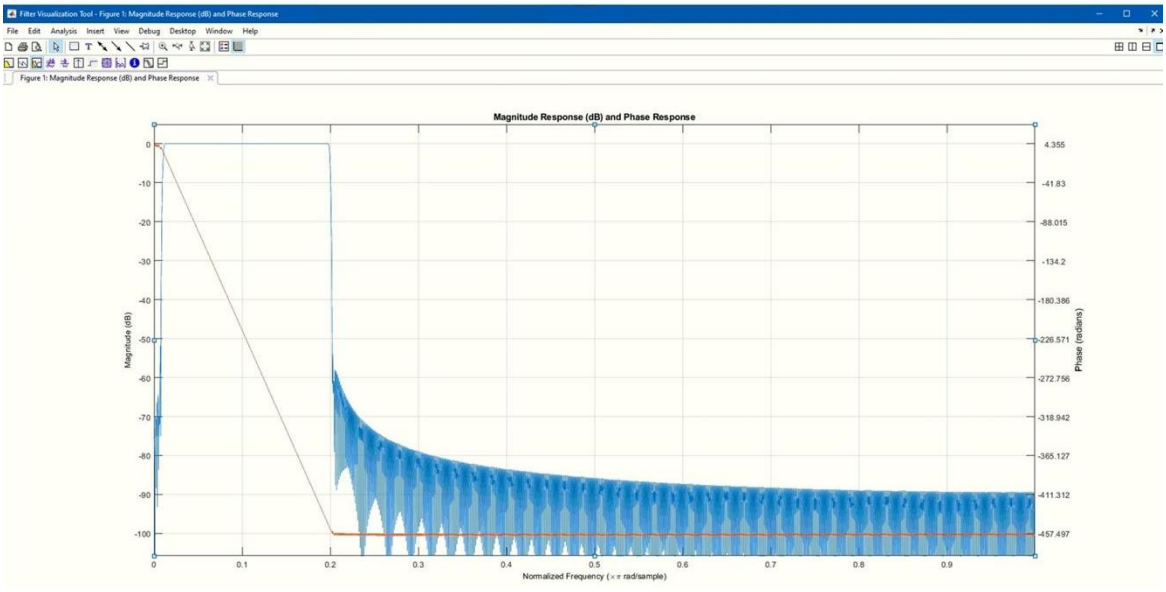

Figure 18: Magnitude and Phase response of the N-order filter.

IIR choice

- **IIR pushbutton:**

In the dialog box, input the N^{th} filter order (N=5 is recommended it).

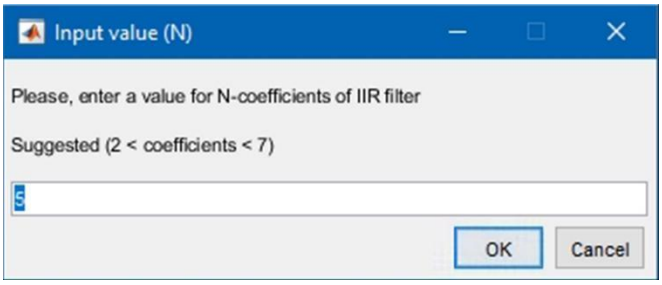

Figure 19: Dialog box of the IIR pushbutton.

Once the filtering process is over, green lamps will light, and the outputs (Vij_IIR.mat and Vij_IIR_Report.txt) will automatically be saved in the IIR folder.

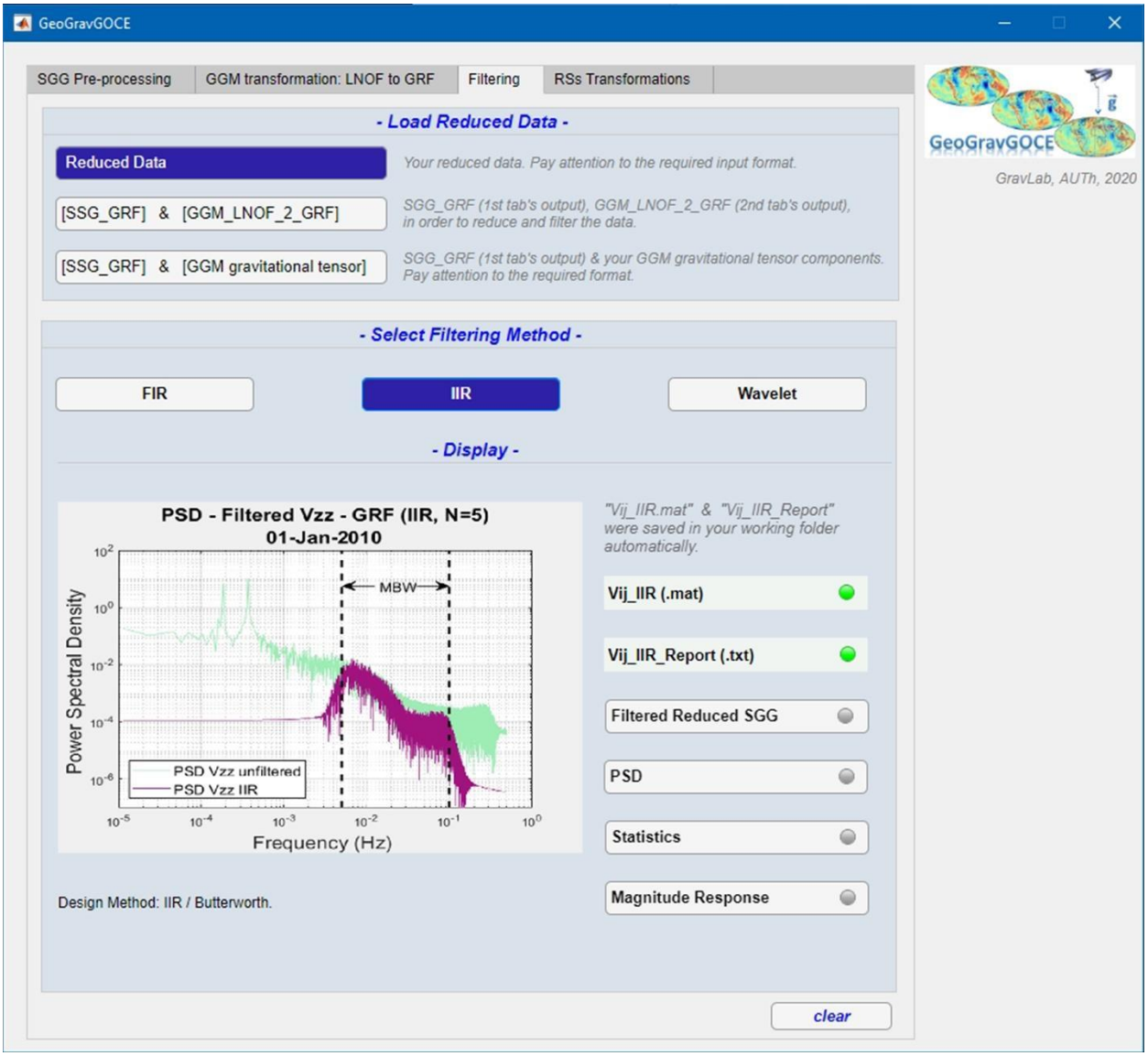

Figure 20: The main window of the IIR pushbutton.

- **Statistics pushbutton:**

This button computes the statistical values of the IIR filtered data. When the statistical computation is over, the green lamp will light, and the outputs (stats_filtered_Vij_GRF.mat and stats_filtered_Vij_GRF _Report.txt) will automatically be saved in the IIR/Statistics_filtered_Vij_GRF folder. The stats_filtered_Vij_GRF.mat contains the statistics of the filtered GGs (Eötvös) in the GRF, and its dimensions are [Nx6] cells, where: N (rows) depict the number of the processed files, and the six (columns) present the six filtered gravity gradients ($V_{xx}, V_{yy}, V_{zz}, V_{xy}, V_{xz}, V_{yz}$). Each interior cell includes the minimum (min), the maximum (max), the mean (mean), the standard deviation (std), and the root mean square (rms) value of the GGs.

- **Filtered Reduced SGG pushbutton:**

This button creates figures of the IIR filtered GGs ($Vxx, Vyy, Vzz, Vxy, Vxz, Vyz$). When the creation of the graphs is over, the green lamp will light, and the figures will automatically be saved in the IIR/IIR Filtered Vij GRF folder. The output of this pushbutton is presented in Figure 21.

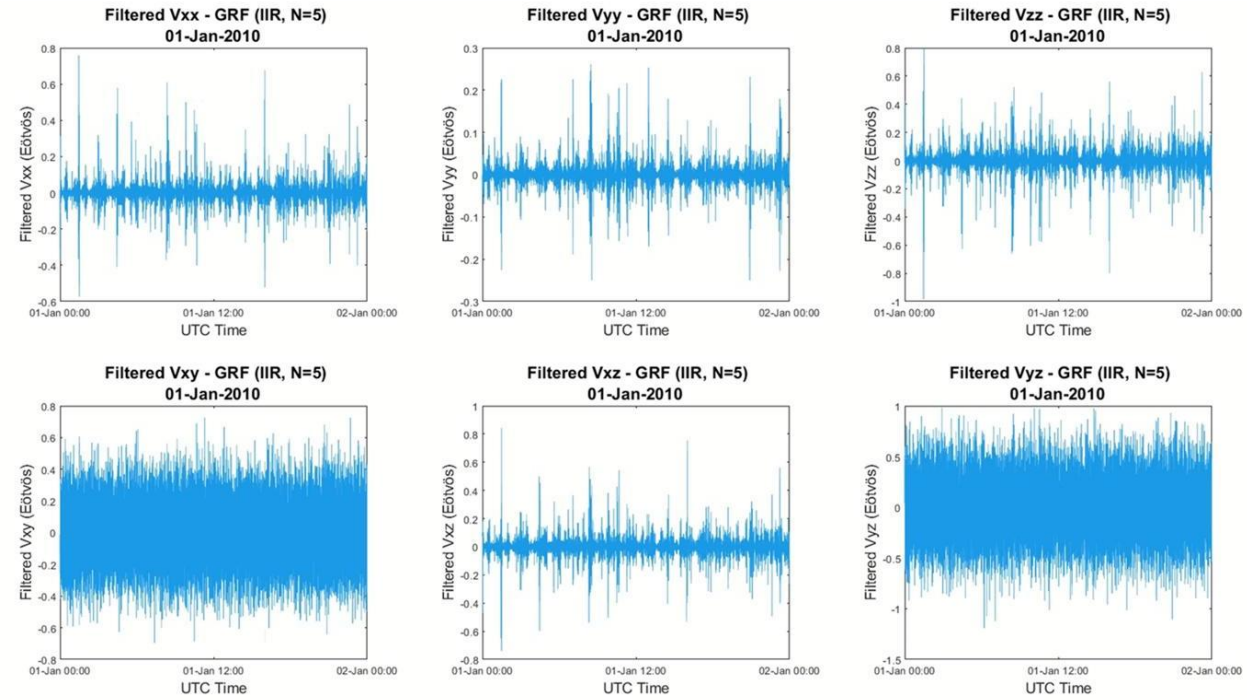

Figure 21: The IIR filtered Vij in GRF, (unit: Eötvös).

- **PSD pushbutton:**

This button creates figures with the Power Spectral Densities (PSDs) of the filtered and the unfiltered reduced GOCE signals. When the creation of the graphs is over, the green lamp will light, and the figures will automatically be saved in the IIR/PSD IIR filtered Vij GRF folder. The output of this pushbutton is presented in Figure 22.

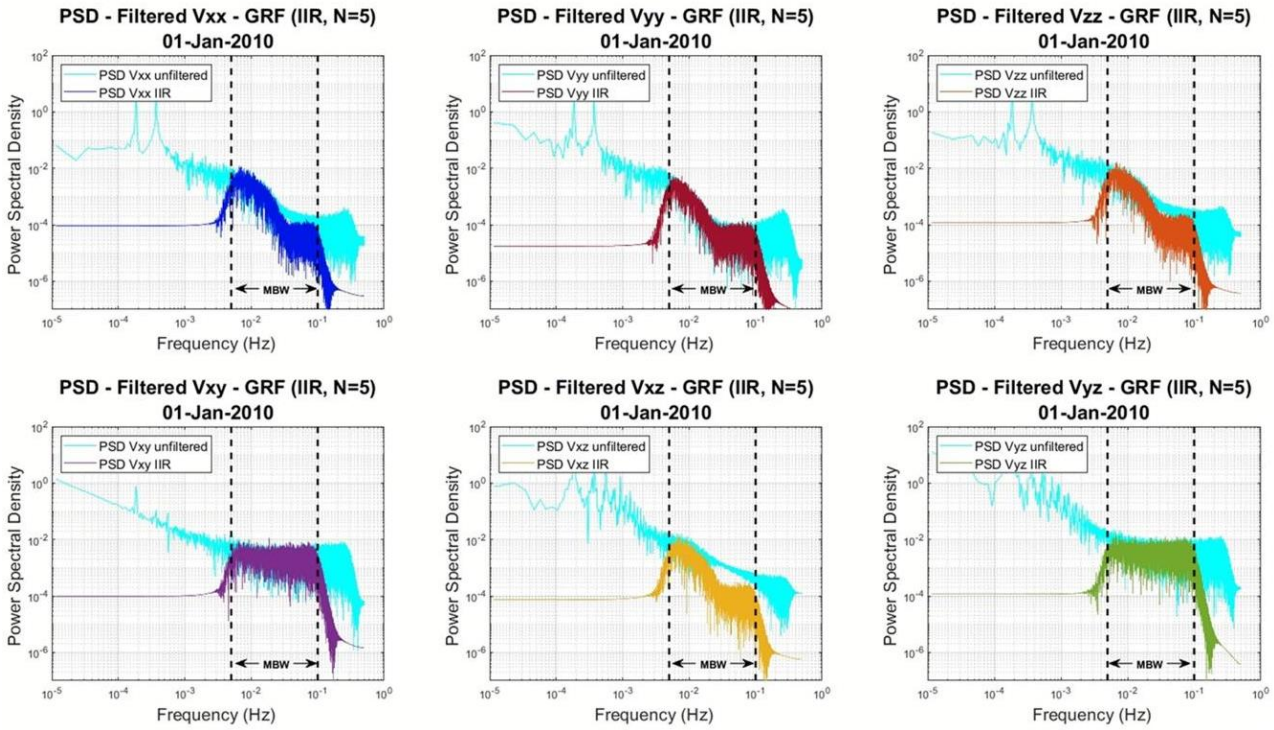

Figure 22: The PSDs of the IIR filtered Vij in GRF.

- **Magnitude Response pushbutton:**

This button displays the user's N^{th}-order filter's magnitude response via Matlab's interactive Filter Visualization Tool. The tool enables the user to display the magnitude, the phase response, the group delay, the impulse response, the step response, the pole-zero plot, and the coefficients of the filter. The interactive output of this pushbutton is presented in Figure 23.

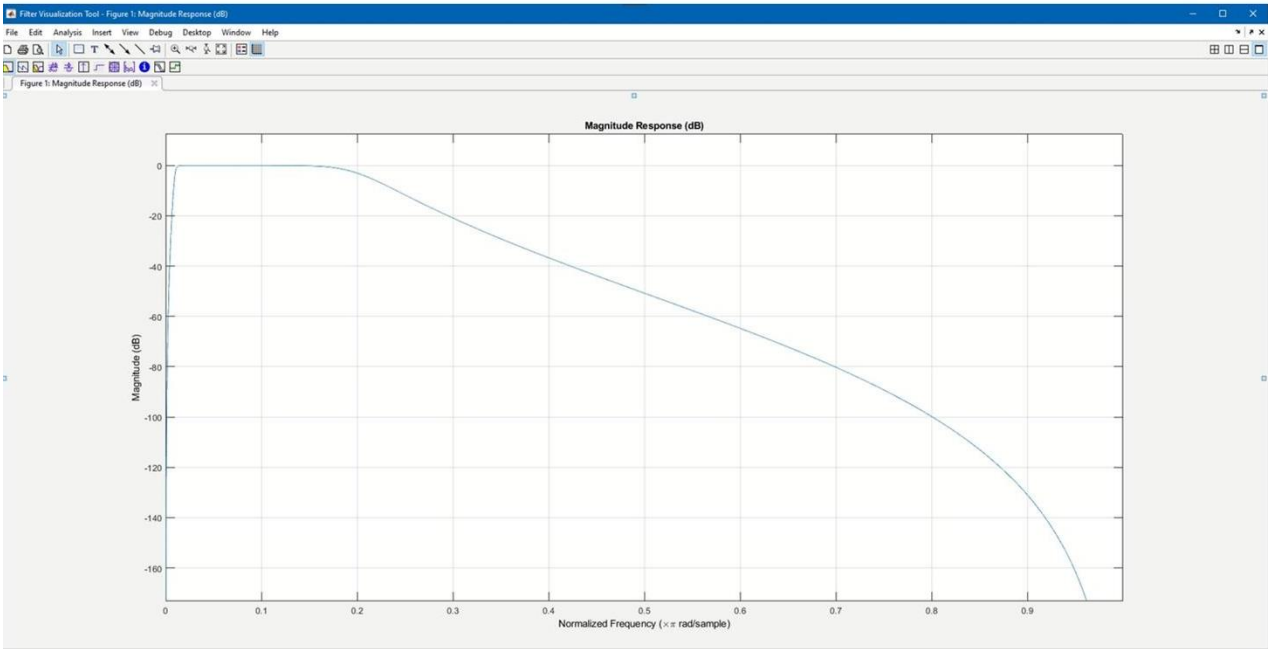

Figure 23: Magnitude response of the N-order filter.

Wavelet choice

- **WL MRA decomposition pushbutton:**

The WL MRA decomposition pushbutton is activated once you select the Wavelet filtering option. Please, press the WL MRA decomposition button and wait until the extraction of the orbits of each day and their decomposition in twelve levels are over. Once the decomposition is over, the green lamp will light, and the outputs will automatically be saved in the Wavelet folder. Note that The WL MRA decomposition button has two different kinds of outcomes. Firstly, the detail coefficients of each level of decomposition and the approximation coefficient of the last level of decomposition, and secondly, the PSDs of the coefficients. The outputs are saved automatically in the Wavelet/WL MRA Decomposition folder. The two outputs of this pushbutton are presented below in Figure 26 and Figure 27.

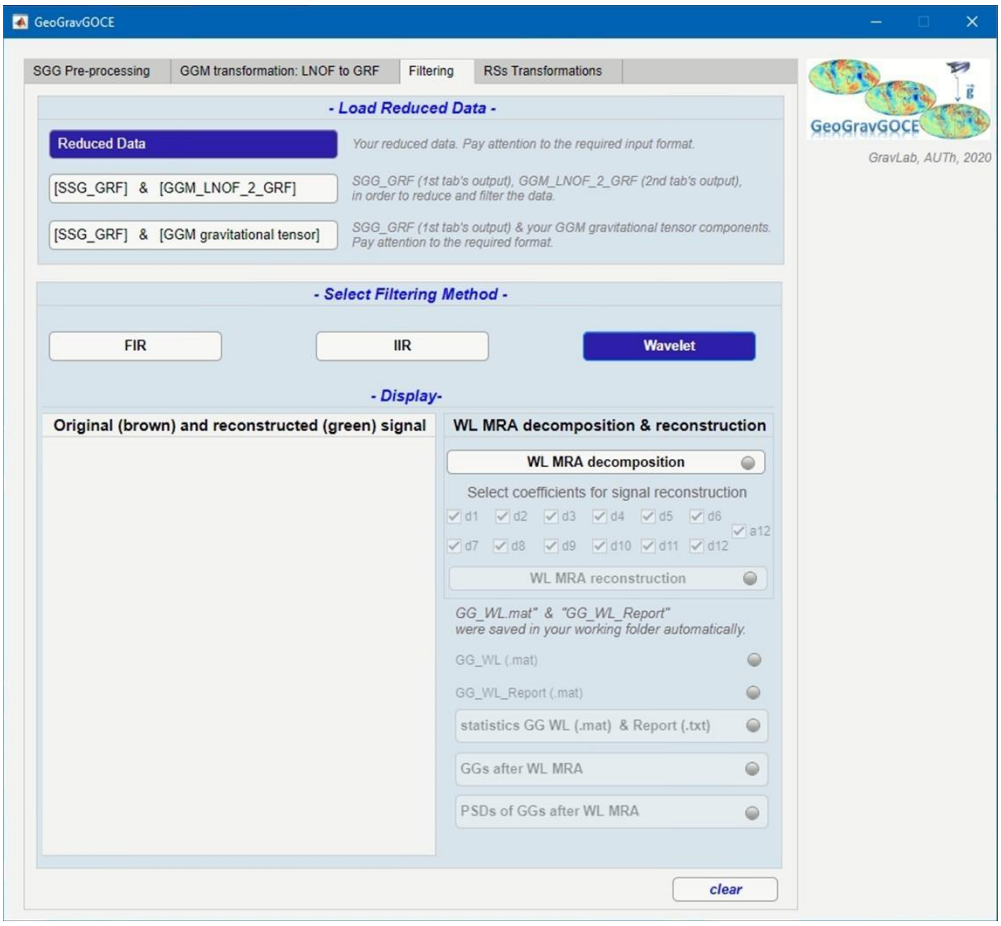

Figure 24: The main window of the Wavelet pushbutton.

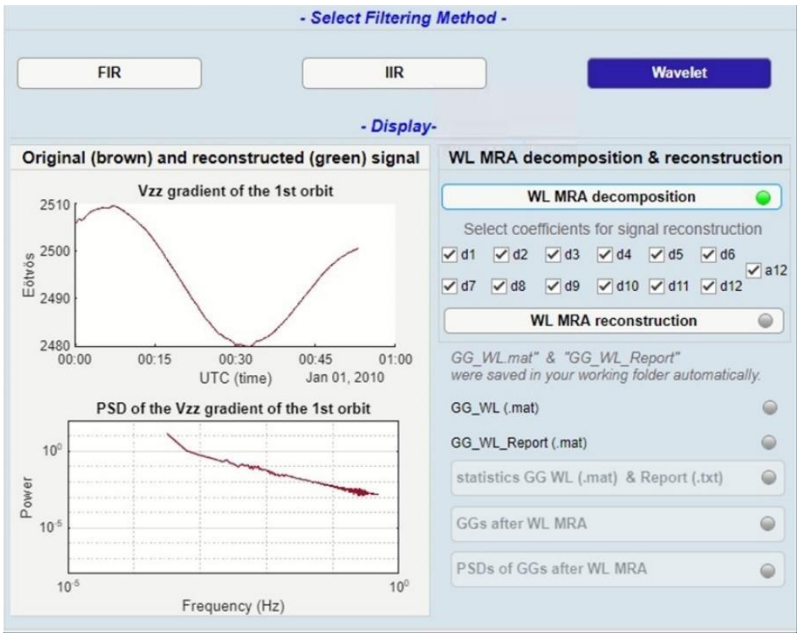

Figure 25: After pressing the WL MRA decomposition pushbutton.

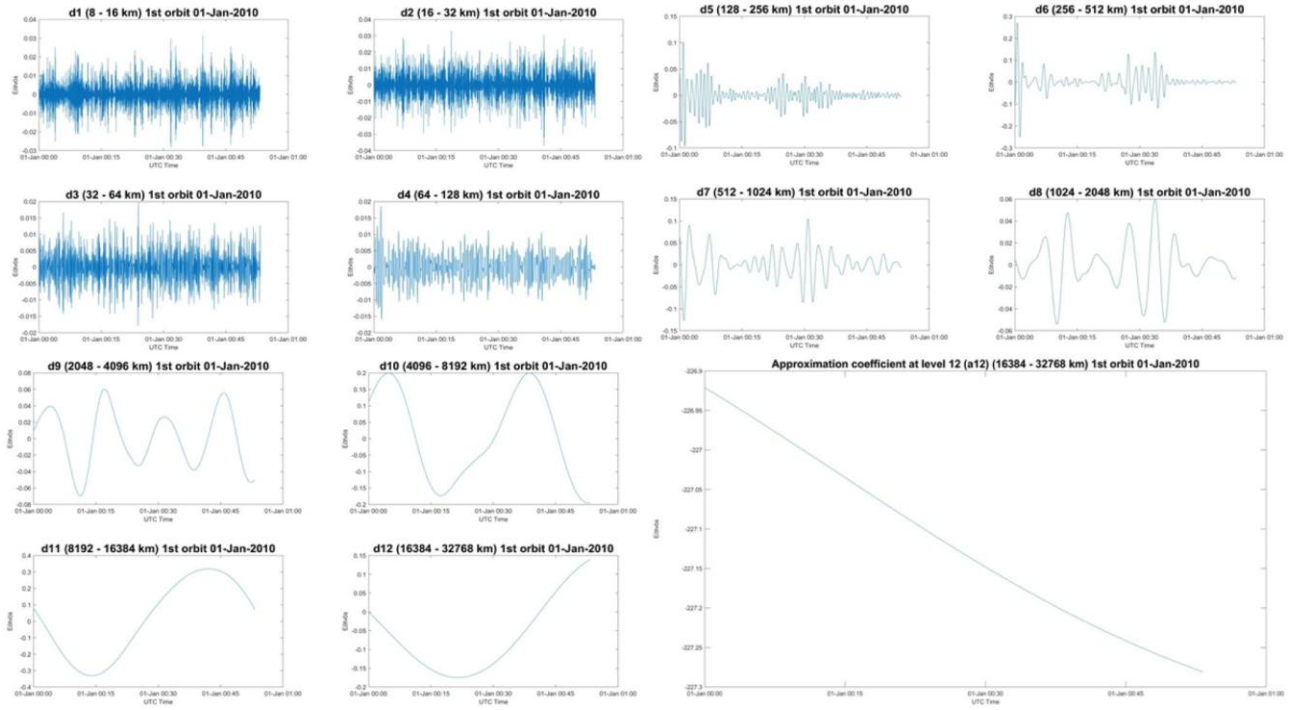

Figure 26: The first output of the Wavelet MRA decomposition button: Detail and approximation coefficients of the first orbit of the first loaded day, (unit: Eötvös).

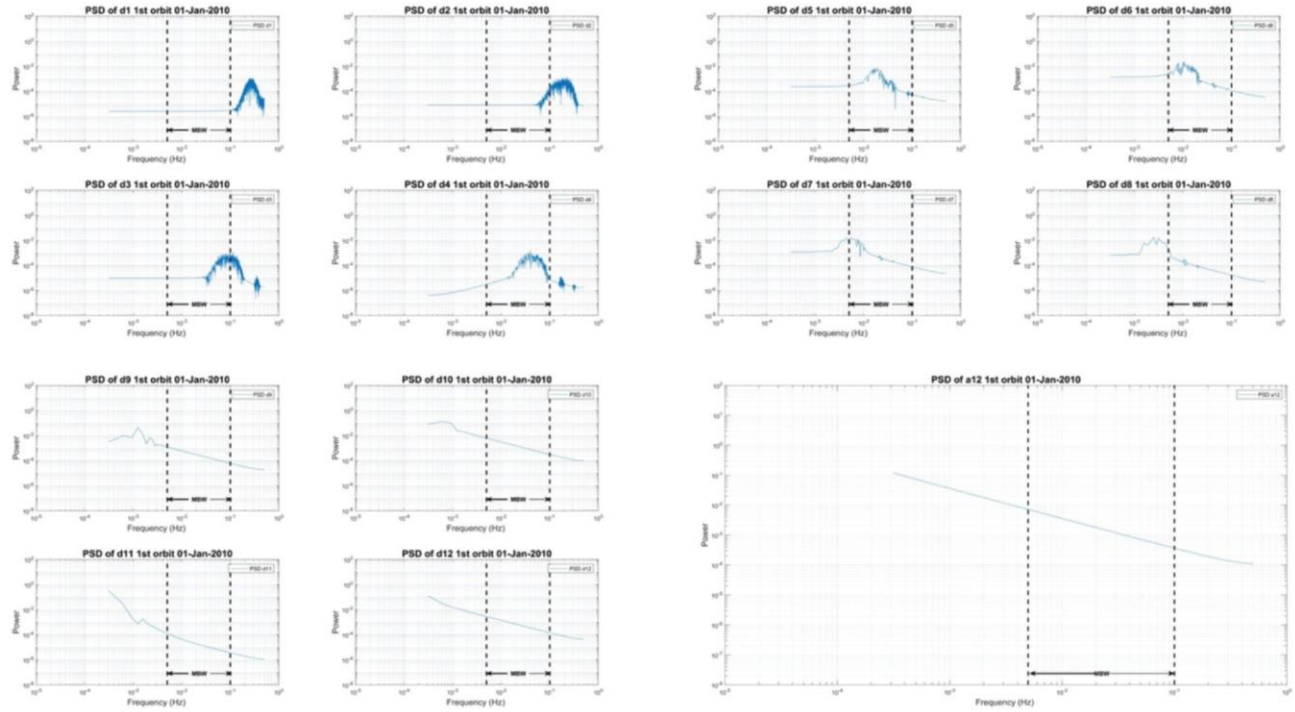

Figure 27: The second output of the Wavelet MRA decomposition button: PSDs of the coefficients of the first orbit of the first loaded day.

- **WL MRA reconstruction pushbutton:**

When the decomposition process is over, thirteen checkboxes are activated, corresponding to the twelve detail coefficients of the levels and the approximation coefficient of the last level. Please check the desired checkboxes and press the WL MRA reconstruction pushbutton. Note that the selection of coefficients can be determined by the outputs of the WL MRA decomposition button.

Once the reconstruction is over, the green lamp will light, and the outputs (GG_WL.mat and GG_WL_Report.txt) will automatically be saved in the Wavelet folder.

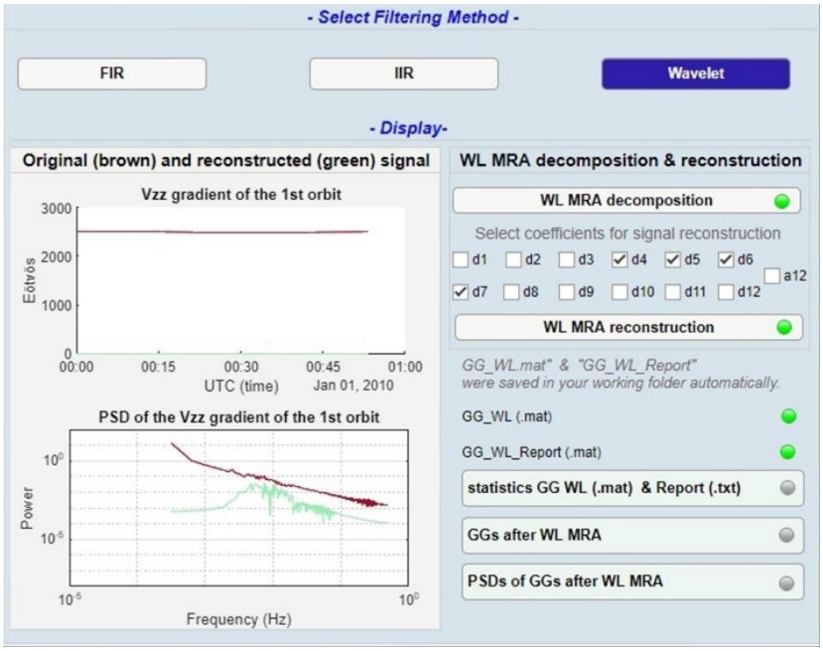

Figure 28: After pressing the WL MRA reconstruction pushbutton.

- **Statistics GG WL(.mat) & Report (.txt) pushbutton:**

This button computes the statistical values of the WL filtered data. When the statistical computation is over, the green lamp will light, and the outputs (stats_GG_WL_MRA_Vij.mat and stats_GG_WL_MRA_Vij_Report.txt) will automatically be saved in the Statistics_GG_WL_MRA folder. The stats_GG_WL_MRA_Vij.mat contains the statistics of the filtered GGs (Eötvös) in the GRF, and its dimensions are [Nx6] cells, where: N (rows) depict the number of the processed files, and the six (columns) present the six filtered gravity gradients ($V_{xx}, V_{yy}, V_{zz}, V_{xy}, V_{xz}, V_{yz}$). Each interior cell includes the minimum (min), the maximum (max), the mean (mean), the standard deviation (std), and the root mean square (rms) value of the GGs.

- **GGs after WL MRA pushbutton:**

This button creates figures of the filtered GGs ($Vxx, Vyy, Vzz, Vxy, Vxz, Vyz$) in daily format. When the creation of the graphs is over, the green lamp will light, and the figures will automatically be saved in the

WL MRA Reconstruction/Gravity Gradients after WL MRA folder. The output of this pushbutton is presented in Figure 29.

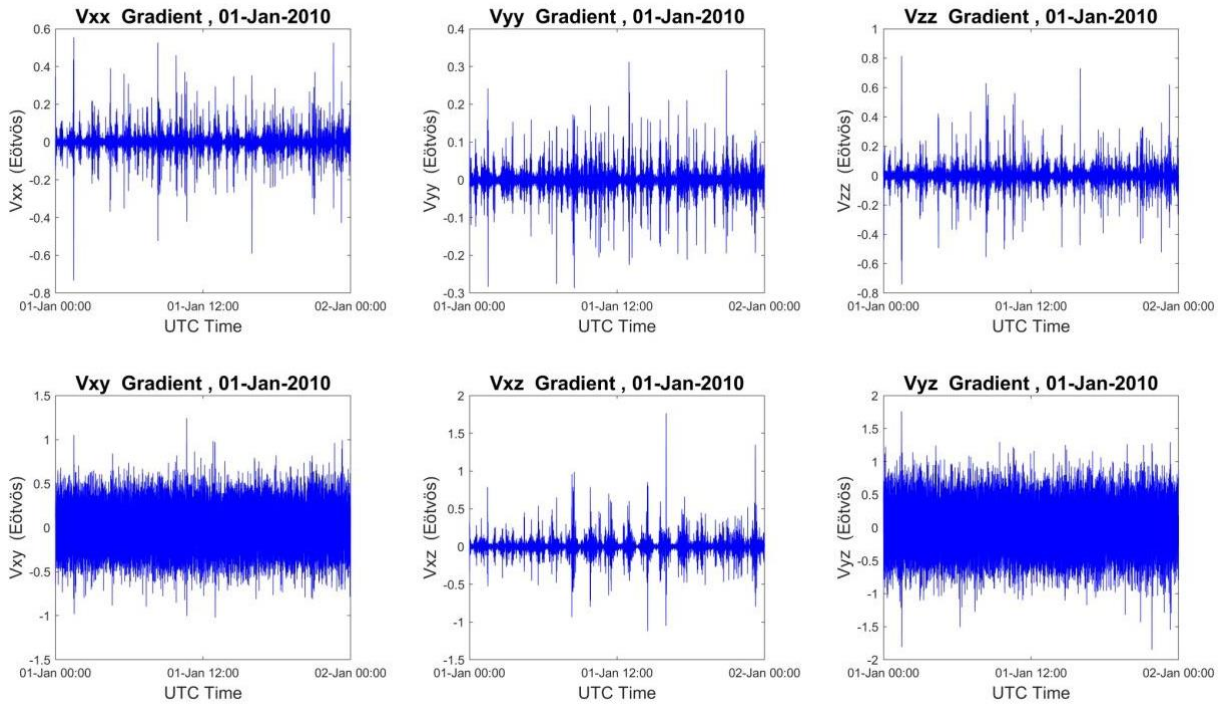

Figure 29: The output of the GGs after WL MRA button: Reconstructed Gravity Gradients for one day of data, (unit: Eötvös).

- **PSDs of GGs after WL MRA pushbutton:**

This button creates figures with the Power Spectral Densities (PSDs) of the filtered and the unfiltered GOCE signals. When the creation of the graphs is over, the green lamp will light, and the figures will automatically be saved in the WL MRA Reconstruction/PSDs after WL MRA folder. The output of this pushbutton is presented in Figure 30.

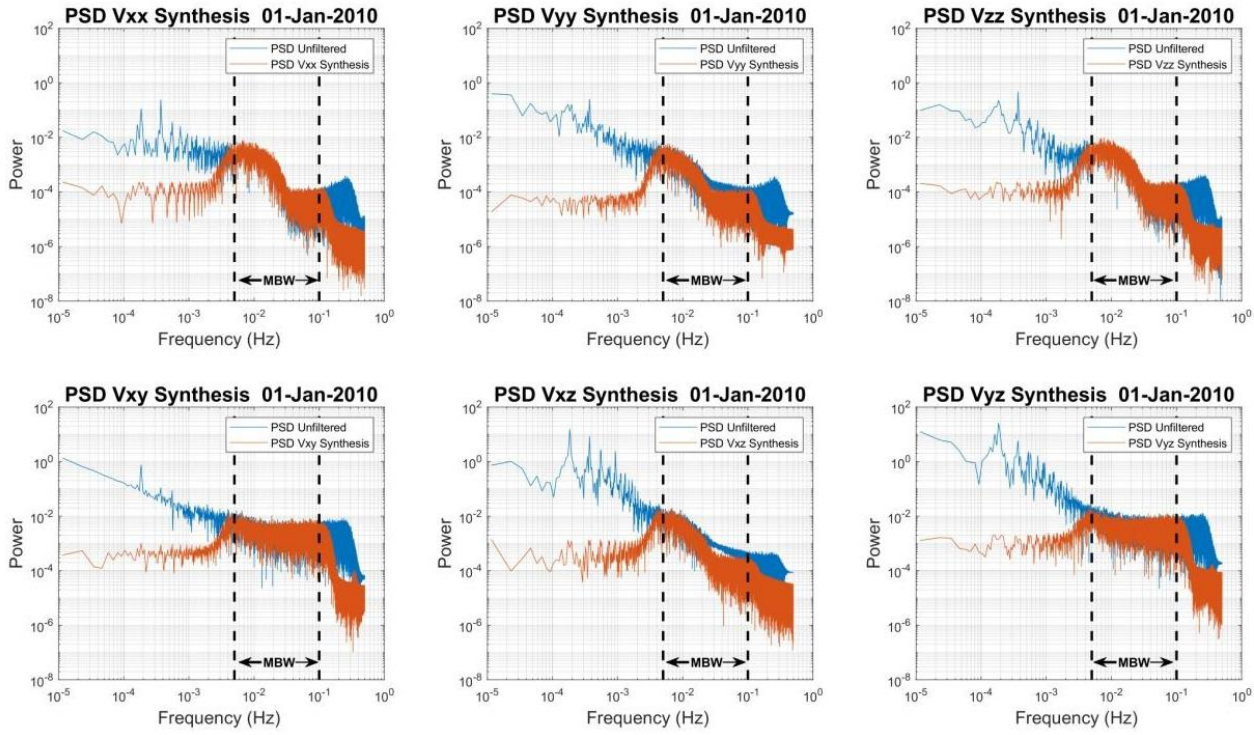

Figure 30: PSDs of GGs after WL MRA button PSDs of the reconstructed Gravity Gradients for one day of data.

4th tab – RSs Transformations

The fourth tab was designed to transform the gravity gradients from the GRF to LNOF and vice versa.

GRF to LNOF

- **Load data for GRF to LNOF transformation pushbutton:**

In this button, you can load the gravity gradients in the GRF in order to transform them in the LNOF. Please pay attention to the input data format (see Readme.txt).

- **Transformation GRF to LNOF pushbutton:**

Press the Transformation GRF to LNOF pushbutton and wait for the processing. Once the transformation is over, the green lamp will light, and the outputs (VLNOF_gradients.mat and VLNOF_gradients_Report.txt) will automatically be saved to the RSs Transformations - to LNOF folder.

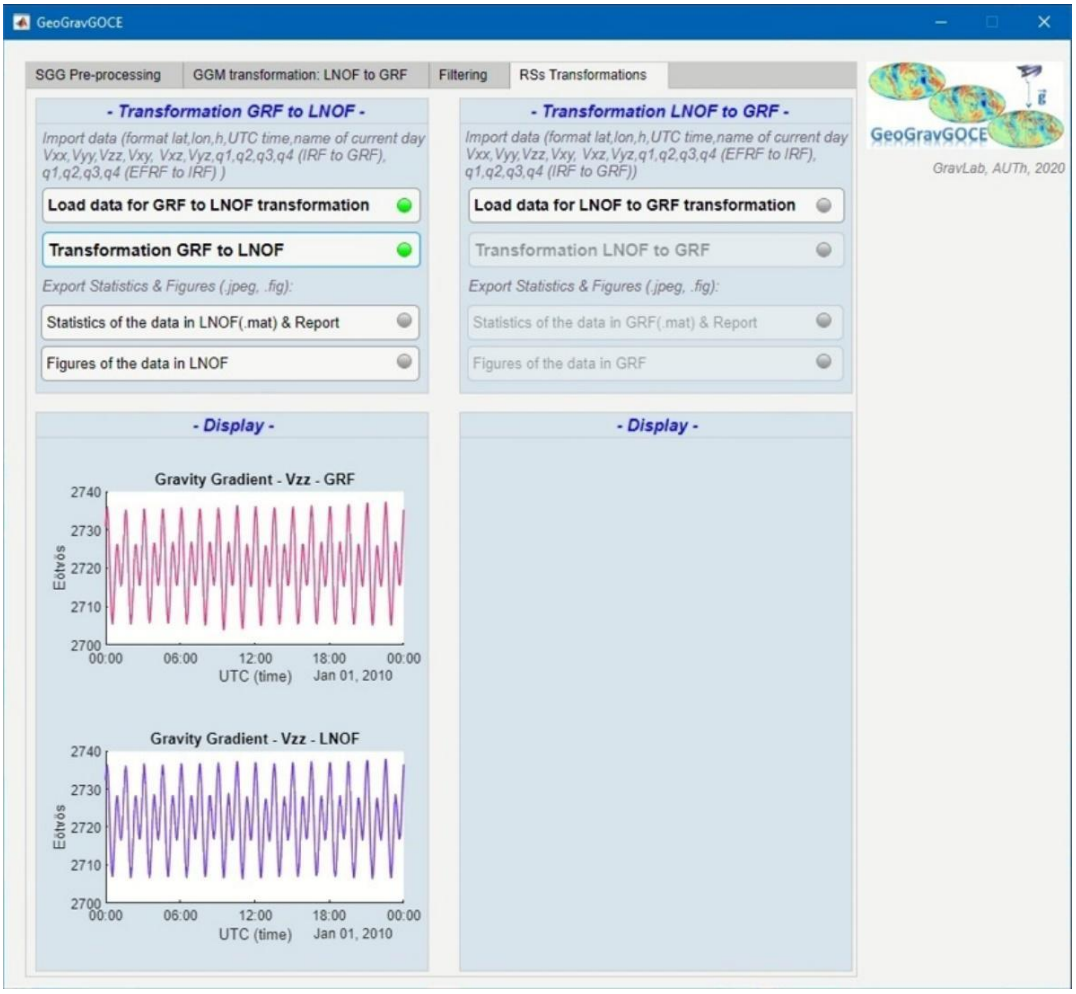

Figure 31: After pressing the Transformation GRF to LNOF pushbutton.

- **Statistics of the data in LNOF (.mat) & Report pushbutton:**

This button computes the statistical values of the transformed data. When the statistical computation is over, the green lamp will light, and the outputs (stats_GGs_transf_LNOF.mat and stats_GGs_transf_LNOF_Report.txt) will automatically be saved in the Statistics_GGs_in_LNOF folder. The stats_GGs_transf_LNOF.mat contains the statistics of the transformed GGs (Eötvös) in the LNOF, and its dimensions are [Nx6] cells, where: N (rows) depict the number of the processed files, and the six (columns) present the six transformed gravity gradients ($V_{xx}, V_{yy}, V_{zz}, V_{xy}, V_{xz}, V_{yz}$). Each interior cell includes the minimum (min), the maximum (max), the mean (mean), the standard deviation (std), and the root mean square (rms) value of the GGs.

- **Figures of the data in LNOF pushbutton:**

This button creates figures of the transformed GGs ($Vxx, Vyy, Vzz, Vxy, Vxz, Vyz$). When the creation of the graphs is over, the green lamp will light, and the figures will automatically be saved in the RSs Transformations - to LNOF folder. The output of this pushbutton is presented in Figure 32.

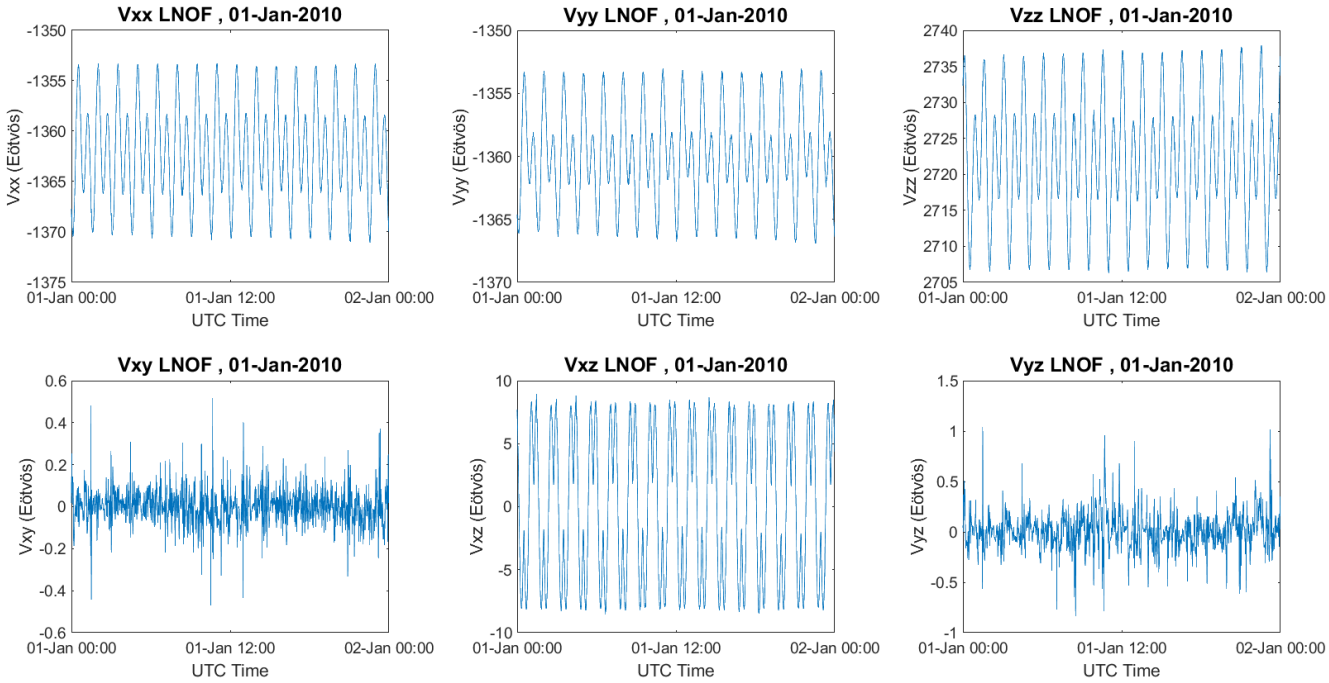

Figure 32: The output of the Figures of the data in LNOF button.

LNOF to GRF

- **Load data for LNOF to GRF transformation pushbutton:**

In this button, you can load the gravity gradients in the LNOF in order to transform them in the GRF. Please pay attention to the input data format (see Readme.txt).

- **Transformation LNOF to GRF pushbutton:**

Please, press the Transformation LNOF to GRF pushbutton and wait for the processing. Once the transformation is over, the green lamp will light, and the outputs (VGRF_gradients.mat and VGRF_gradients_Report.txt) will automatically be saved to the RSs Transformations - to GRF folder.

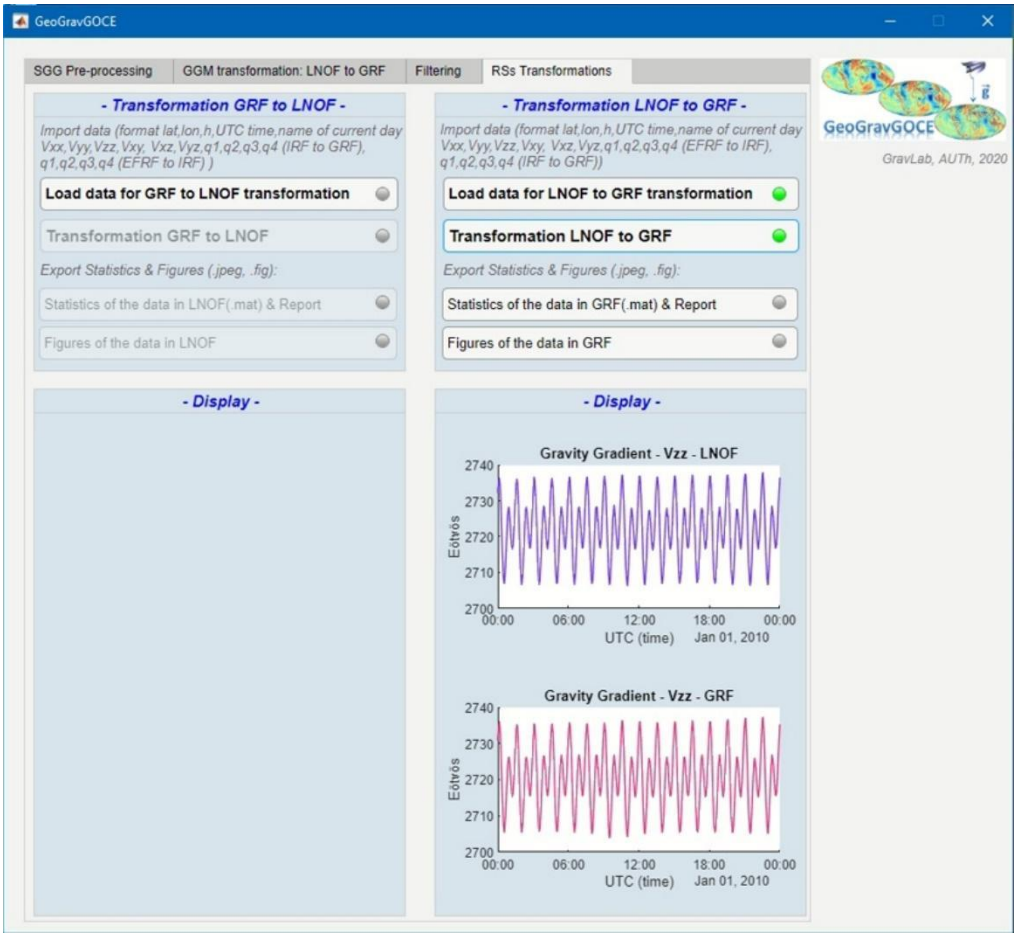

Figure 33: After pressing the Transformation LNOF to GRF pushbutton.

- **Statistics of the data in GRF (.mat) & Report pushbutton:**

This button computes the statistical values of the transformed data. When the statistical computation is over, the green lamp will light, and the outputs (stats_GGs_transf_GRF.mat and stats_GGs_transf_GRF_Report.txt) will automatically be saved in the Statistics_GGs_in_GRF folder. The stats_GGs_transf_GRF.mat contains the statistics of the transformed GGs (Eötvös) in the LNOF, and its dimensions are [Nx6] cells, where: N (rows) depict the number of the processed files, and the six (columns) present the six transformed gravity gradients ($V_{xx}, V_{yy}, V_{zz}, V_{xy}, V_{xz}, V_{yz}$). Each interior cell includes the minimum (min), the maximum (max), the mean (mean), the standard deviation (std), and the root mean square (rms) value of the GGs.

- **Figures of the data in GRF pushbutton:**

This button creates figures of the transformed GGs ($Vxx, Vyy, Vzz, Vxy, Vxz, Vyz$). When the creation of the graphs is over, the green lamp will light, and the figures will automatically be saved in the RSs Transformations - to GRF folder. The output of this pushbutton is presented in Figure 34.

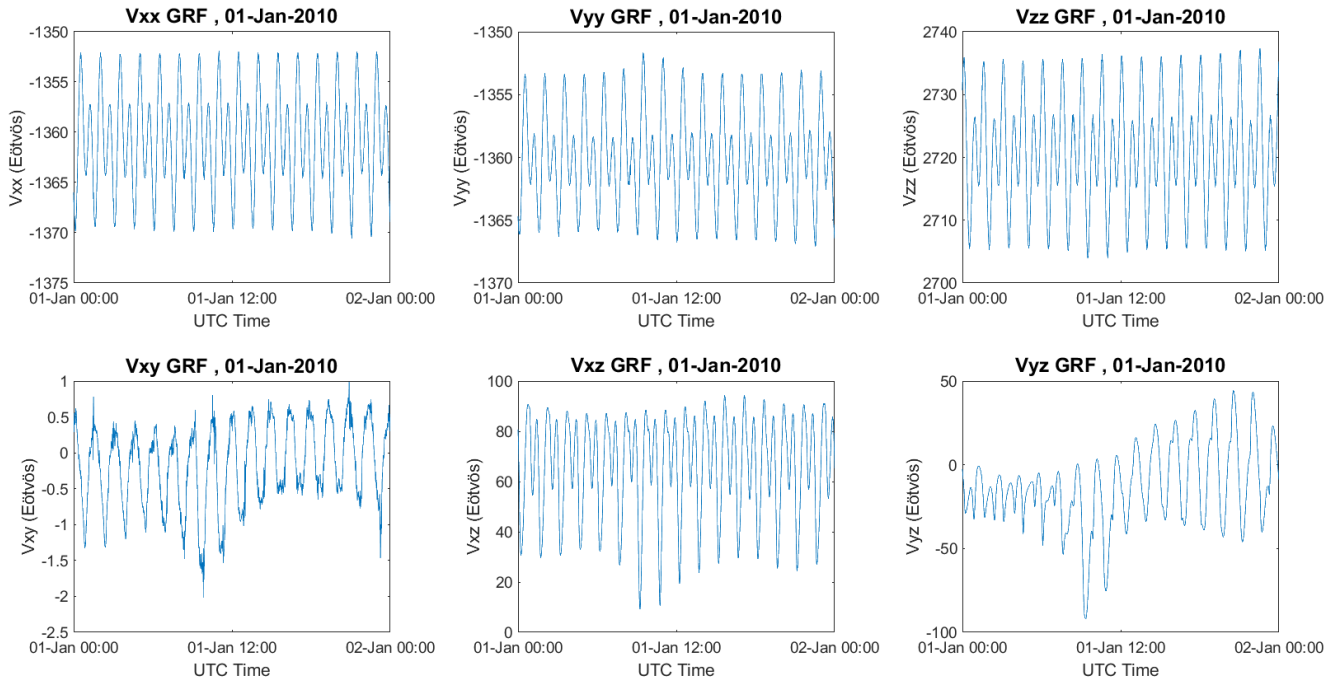

Figure 34: The output of the Figures of the data in GRF button.

- **Clear pushbutton:**

In the first and the third tab, the clear pushbutton is optional for the user and used for refreshing everything (e.g., the workspace variables and the content of the display panels) in the app.

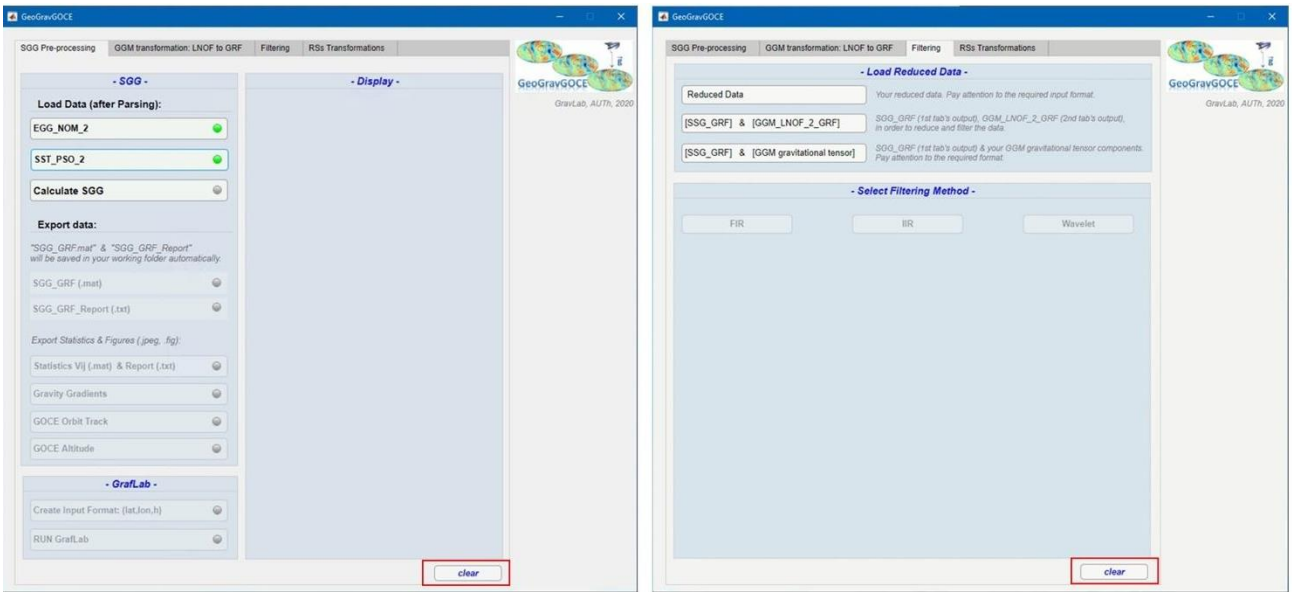

Figure 34: The clear buttons.

 # References

Bucha, Blažej, and Juraj Janák. 2013. 'A MATLAB-Based Graphical User Interface Program for Computing Functionals of the Geopotential up to Ultra-High Degrees and Orders'. *Computers and Geosciences*. doi: 10.1016/j.cageo.2013.03.012.

Pawlowicz, R. 2020. 'M_Map: A Mapping Package for MATLAB, Version 1.4m, [Computer Software], Available Online at Www.Eoas.Ubc.ca/~rich/Map.Html.'