***Geoinformatics Project, 2021***

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| **GNSS (GPS) DATA PROCESSING**    **GROUP MEMBERS** | | |
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**Abstract**

The Clock, Ephemeris, Integrity (CEI) data set of a GNSS Satellite contain the essential parameters to use the satellite’s broadcast signals for positioning purposes. By reading the navigation message file of a GPS, a user can determine the approximate position and velocity of a satellite and correct for the propagation delay of the signal due to ionospheric effects.

The GNSS Data Processing Software (GDPS) has been developed, using Python, for determining the position, velocity and ephemerides of a satellite by reading its navigation message. By using the ionospheric error correction parameters in the file, GDPS determine the variation of the ionospheric effect on different positions of the Earth. A Graphical User Interface has been developed to enable a user access GDPS.

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**Introduction**

GNSS Point positioning involves measurement of the signals emitted by a satellite for the determination of the position of a receiver on the surface of the Earth. The emitted signal contains information about the clock, ephemerides and integrity of the satellite. The signal propagation through the atmosphere is delayed by the presence of free electrons in the ionosphere (about 100 and 1000 km altitude) and the water vapour content of the troposphere. These delays affect the precision in the estimated position of a receiver. By reading the navigation message file, a user can determine the approximate position and velocity of a satellite and correct for the propagation delay of the signal due to ionospheric effects.

GDPS is a program for determining the position, velocity and ephemerides of a satellite by reading its navigation message. By using the ionospheric error correction parameters in the file, GDPS determine the variation of the ionospheric effect on different positions of the Earth. A simple Graphical User Interface has been developed to enable a user access GDPS. The algorithms implemented in the software are as defined in the IS-GPS-200L (Sections 20.3.3.4.3 and 20.3.3.5.2.5 for ephemeris determination and Ionospheric Model respectively).

**Objectives**

The objectives of the exercise has been to develop a software that

* computes the time varying position of the phase center of a satellite’s antenna
* computes the velocity of a satellite
* produces maps of the ephemerides of a satellite
* produces a map showing time varying effects of the ionosphere on the propagated signal
* produces a Graphical User Interface for accessing the software

**Main features**

GDPS has two main modules:

* Satellite orbit: this module tracks the position and velocity of a satellite vehicle over time. It allows to visualize the ground tracks of any chosen satellite vehicle over the surface of the earth, and to show the variation of azimuth and elevation that it would have with respect to an arbitrary position inserted by the user.
* Ionospheric error correction: This module shows the time varying effects of ionospheric delay on a GPS satellite emitted signal. It allows visualizing the ionospheric delay with respect to time across varying positions of the earth, elevation and azimuth of a GPS receiver with respect to satellite.

Prerequisites

1. Libraries

To run the GDPS program, the user is required to install the following packages

* Matplotlib ( 3.2.0 )
* Cartopy ( 0.18.0 )
* Astroplan ( 0.8 )
* wx ( 4.1.1 )
* Geopandas ( 0.9.0 )
* Numpy ( 1.18.1 )

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**DEFINED LIBRARIES**

The main libraires are being used in the Main.py file are

* IonosphericCorrectionSF.py
* sat\_orbit.py
* read\_rinex.py which contains the methods
  + readIonosphericParamters( )
  + read\_nav( )
  + getSatellitePRN ( )
* Cart2geod.py
* RotationParam.py
* Rotation.py

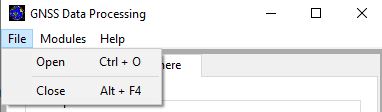
Other olibraries defined but not used include

* ClockCorrection.py
* Deg2rad.py
* Ecef2eci.py
* Geod2cart.py
* GeometricRange.py
* GPStime.py
* IonosphericCorrectionDF.py
* L1\_L2Corection.py
* PseudoRangeIonoCorrection.py
* Rad2deg.py
* RelativisticEffects.py
* SaastamoinenModel.py

**How to install the software**

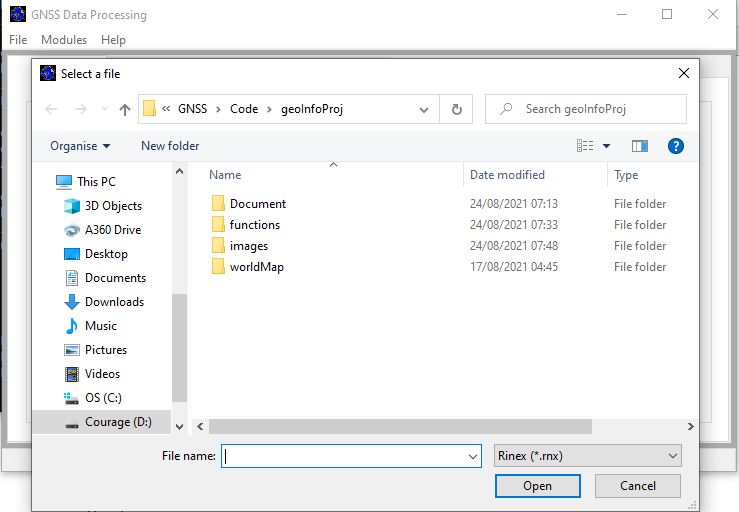
**Menu Items**

* The File menu contains the items Open and Close.

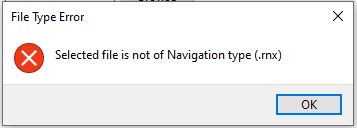




The Open menu item is needed to open a GPS Navigation message file (.rnx) before the main functionalities can be accessed (Figure ………..).



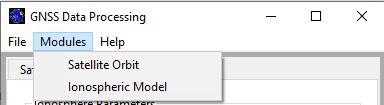
When the file is not of the type ‘.rnx’, an error message is printed to the user as shown in Figure ……….. defining the error and by closing the dialog, the user can select the required file type.



The Close menu item exits the main window of the GUI.

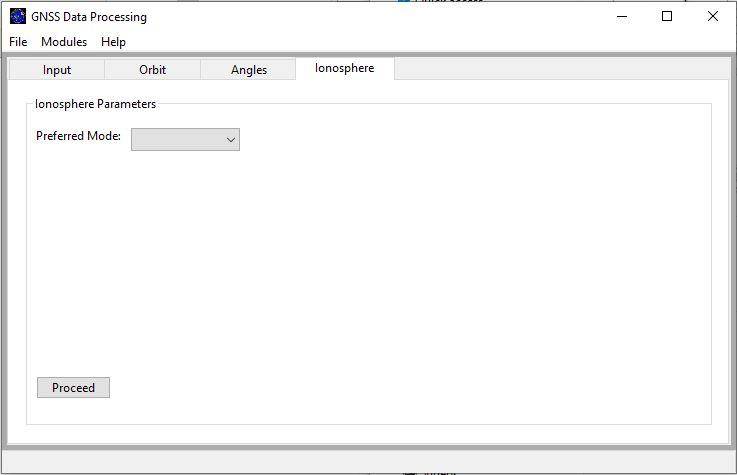
* Modules

The Modules menu shows the main functionalities (Satellite Orbit and Ionospheric Model) for the software.

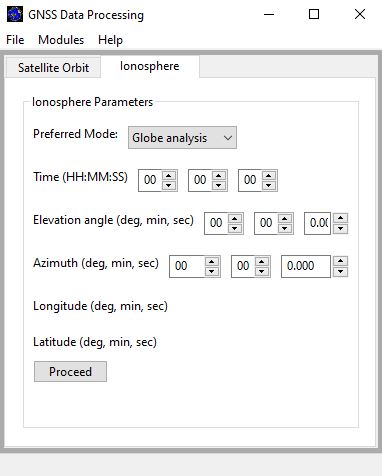


The Satellite Orbit item gives navigation to the Orbit panel.

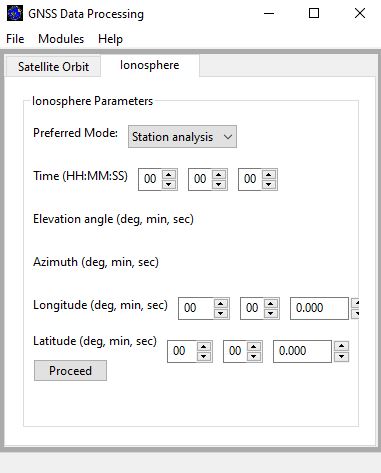
The Ionospheric Model navigates to the Ionosphere panel where the paramters needed for performing the Ionosphere computation are needed. On this panel (Figure ………………..), the user selects the preferred model (Station analysis or Globe analysis).



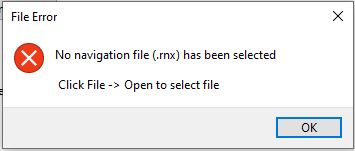
By selecting the Globe aanalysis, the panel is updated, exposing the buttons for inserting the paramters (time, elevation and azimuth), Figure …………………. The default values in the buttons are zeros and the user can change the values. Also, only numerical values can be entered in each button. By clicking on the ‘Proceed’ button, an Ionospheric Error map is produced showing the variations in the ionospheric effects on the globe.



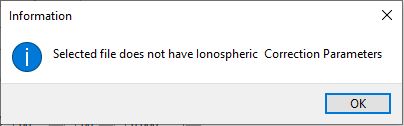
By selecting the station analysis, the panel is also updated (Figure ………..), exposing the buttons for inserting the parameters (time, longitude and latitude) required for the model. Also, the default values in the buttons are zeros and the user can change the values. By clicking on the ‘Proceed’ button, an Ionospheric Error map is produced showing the variations in the ionospheric effects on the globe.



In both instances of Global and station analysis, when a GPS Navigation message file has not been selected, the user is informed of the unavailability of the Rinex file (Figure ……………..) and given a guide to select the file.

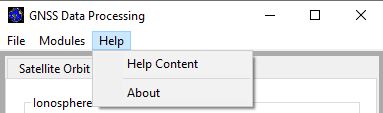


Also, when a file is selected and there are no ionospheric error correction parameters in the file (Figure ……………..), the user is also informed of such and can select another file.



* Help

The Help menu (Figure …..) shows the Help Content and About items.



The Help Content gives a brief description on how to use the software as well as an introduction to the models used in the software.

The About menu item shows the About page (Figure ….) which gives a brief description to the about the project.



For easy access, shortcuts have been created for access shown in the table below

|  |  |
| --- | --- |
| **KEY SHORT CUTS** | **DEFINITION** |
| Ctrl + O | Open |
| Alt + F4 | Close |
| Ctrl + K | Orbit panel |
| Ctrl + I | Ionosphere panel |
| F1 | Help contents |

**Data Processing**

Figure …………….. shows a sample output map for a global and station ionospheric error analysis respectivley. With regions of higher ionospheric error at the time shaded red and regions of lower ionospheric effects shaded blue.

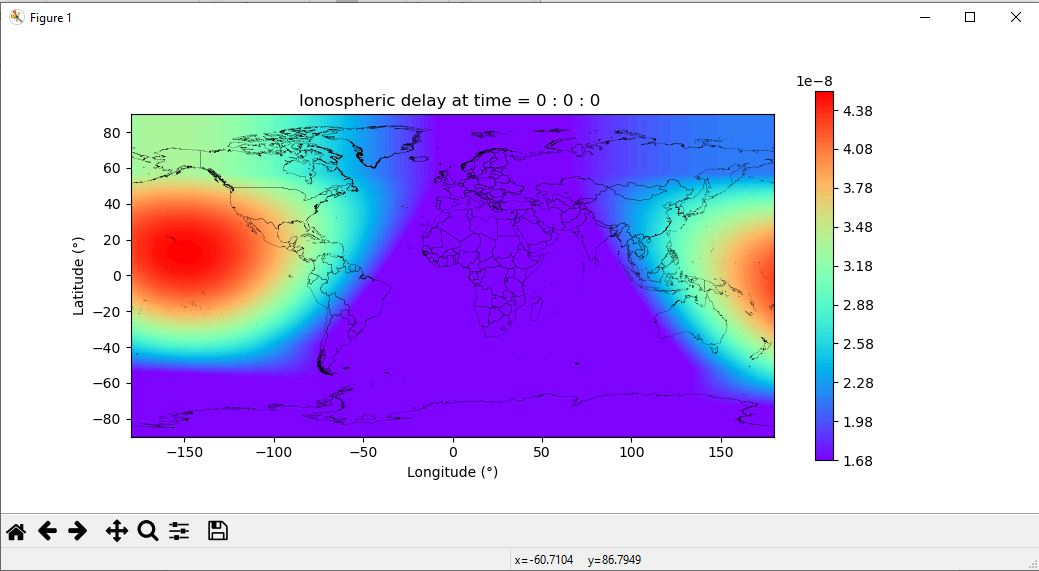
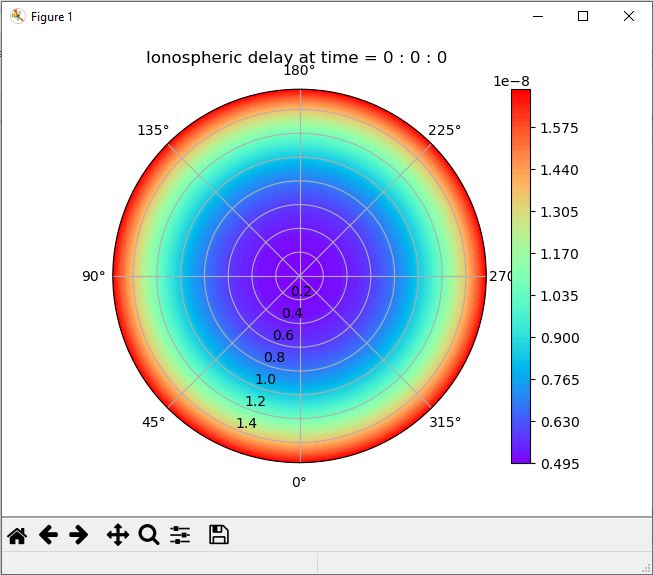


Figure ………………………. Shows a sample output map of the varation of ionospheric error for varying elevation and azimuth. From the graph, it is more clear that the ionospheric error is higher for lower elevation of the station with respect to the satellite vehichle.



**/// Update the readme on libraries to install to use the program**