GeoData:A Generalized Data Analysis Software Suite
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Introduction

Many researchers in aeronomy and space physics work with data sets from many different types of sensors: radars, all sky cameras etc. Often though, researchers develop different sets of software for each of their sensors to analyze the data. These codebases often have a lot of functionality overlap which yields a large amount of seemingly unnecessary recoding. Another complication is also added data from different sensors need to be combined which requires time and spatial registration of the data.

We have developed a software codebase with the goal to answer the difficulty associated with analyzing data from multiple sensors. We have created a standard format which sensor data can be read into, at which point the user has access to a library of different plotting, interpolation and analysis functions. This code base is composed in both MATLAB and Python housed in repositories that have the same functionality. There are also generalized outputs for data so it can be moved from language to language if multiple users are working together and use the different languages.

It is our hope that this will help increase productivity of the various research communities that may use this. We also hope to find more collaborators to help develop this software suite further in order to add more functionality.

What Is GeoData?

GeoData is a advanced programing interface (API) specialized for plotting and analyzing data from geophysical sensors such as incoherent scatter radars, all sky cameras etc. The main goal is to be able to reduce the time researchers need to code in order to turn data from a sensor to plots and data products that can be easily be analyzed. This is illustrated below where Sonndalstrom data downloaded through Madgrigal then plotted with only a few commands.

Capabilities and Example

The API is built so the user can work with a numbers of different sensors to analyze and plot data. Currently the API has a large number of capabilities and supports a large number of different coordinate systems. Some of which are listed below:

- Multi-Dimensional Interpolation
- Linear
- Nearest neighbor
- Cubic
- Natural Neighbor (currently MATLAB only)
- 3-D slice functions
- 2-D slice functions
- Range vs Time plots
- Contour plotting
- Supported Coordinate Systems
- WGS
- ECEF
- ENU
- Local Spherical
- Additional Capabilities
- Time registration
- Automatic label generation

The example below showing many of the capabilities is derived from a 2012 RISR experiment used to look for polar cap patches similar to what is seen in (Dahlgren, 2012).

Figure 1: Electron density data from Sonndalstrom during a poleward boundary intensification.

The figure also demonstrates the utility of this software for reproducible research. The specific example was taken from an experiment used to show the response of the ionosphere to an auroral poleward boundary intensification (Semeter, 2005). With this API the user can quickly recreate similar figures from past publications. The user can then build on the results from other researchers.

Another aspect of this software that is beneficial is that it creates a standard data structure so new custom plot types can be created such as the one below.

Figure 2: Electron density spatially averaged over the PFISR (Poker-Flat Incoherent Scatter Radar) beam width varying with altitude and time. The figure shows a low altitude ionization, caused by electrons of energy greater than 10 keV during the expansion phase of a substorm starting at 11:46 UT.

References

The software is available through GitHub at the following addresses:
- MATLAB Version: https://github.com/jswoboda/GeoDataMATLAB
- Python Version: https://github.com/jswoboda/GeoDataPython

Literature References:
J. Semeter, et. al., JGR, 2005.

Future Work

We intend to continue to develop this tool set and add more functionality. The future tasks with in our own group include but are not restricted to the following:

- Add magnetic field estimates from IGRF models
- Incorporate other Geophysical modeling tools such as MSIS
- Develop plotting routines to work with vector value data
- Create an automated way to make movies form sensor data

We are also looking for collaborators from outside our group and we would like to extend this API to other sensors such as:

- SuperDARN and other coherent radar systems
- Satellite systems and data sets, such as SWARM and AMPERE

Lastly we are also looking to extend this to a possible web-based where through a browser one could create plots from a number of different sensors.

Conclusion

We have developed a set of tools to the community to do data analysis from a multitude of different sensors. This can be used a standard tool kit for a number of different users in the space physics and aeronomy community to do common tasks. It is our hope that this will help speed up the process of doing scientific research and promote more reproducibility in the field. With more and more large data sets coming to the field this tool set could be one of the keys that will unlock their full value to the scientific community.