SPEDAS (Space Physics Environment Data Analysis Software): Flexibility and Interoperability for Heliophysics Data Analysis

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SPEDAS downloads, documentation, and email list:
spedas.org

Jim Lewis
Space Sciences Lab, University of California, Berkeley
jwl@ssl.berkeley.edu

Agenda

Introduction to SPEDAS, Key Features

Leveraging Standard File Formats and Metadata Conventions

Interoperability with Other Tools, Data Sources

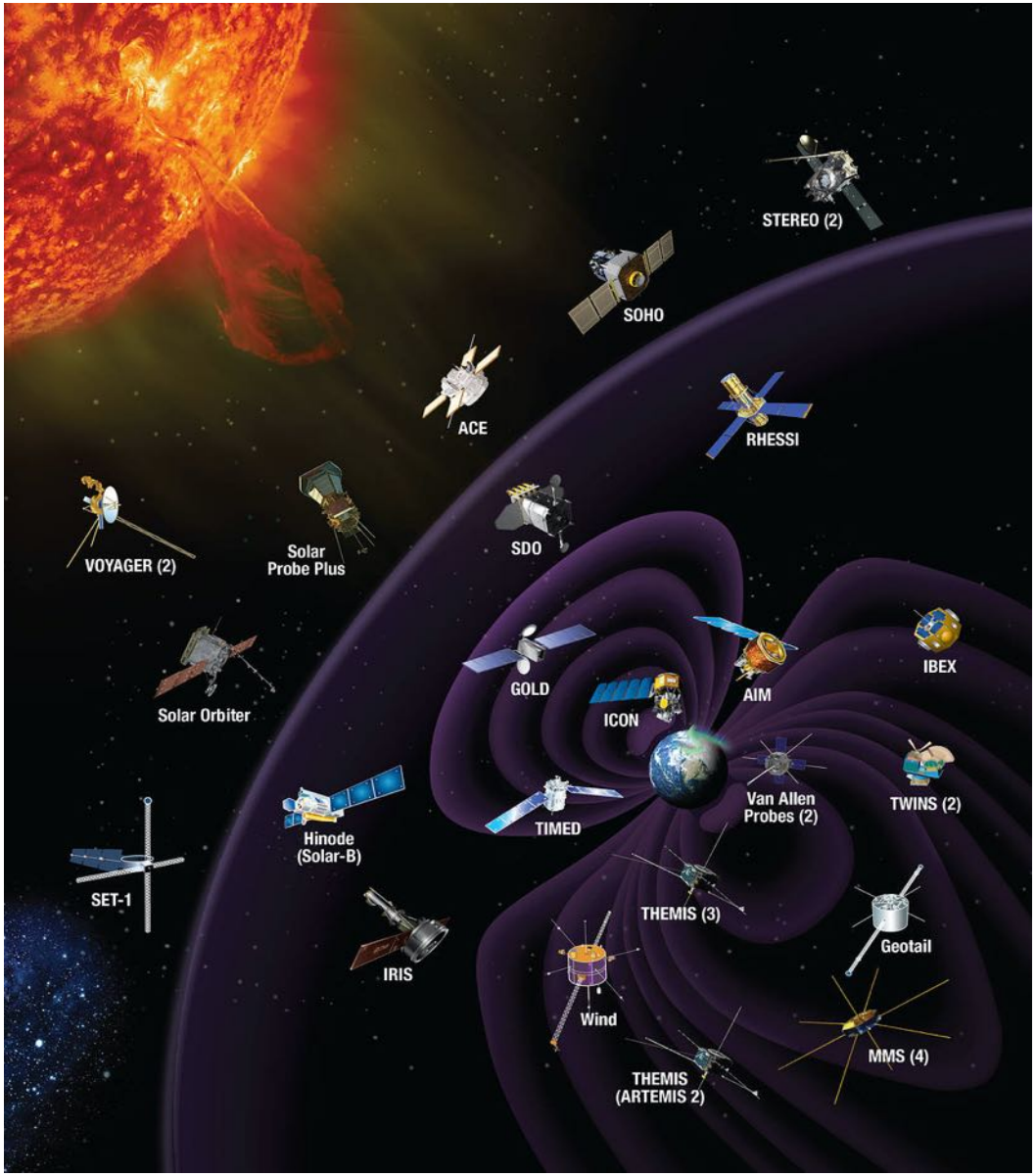
PySPEDAS, Python Heliophysics Community

Q&A, discussion

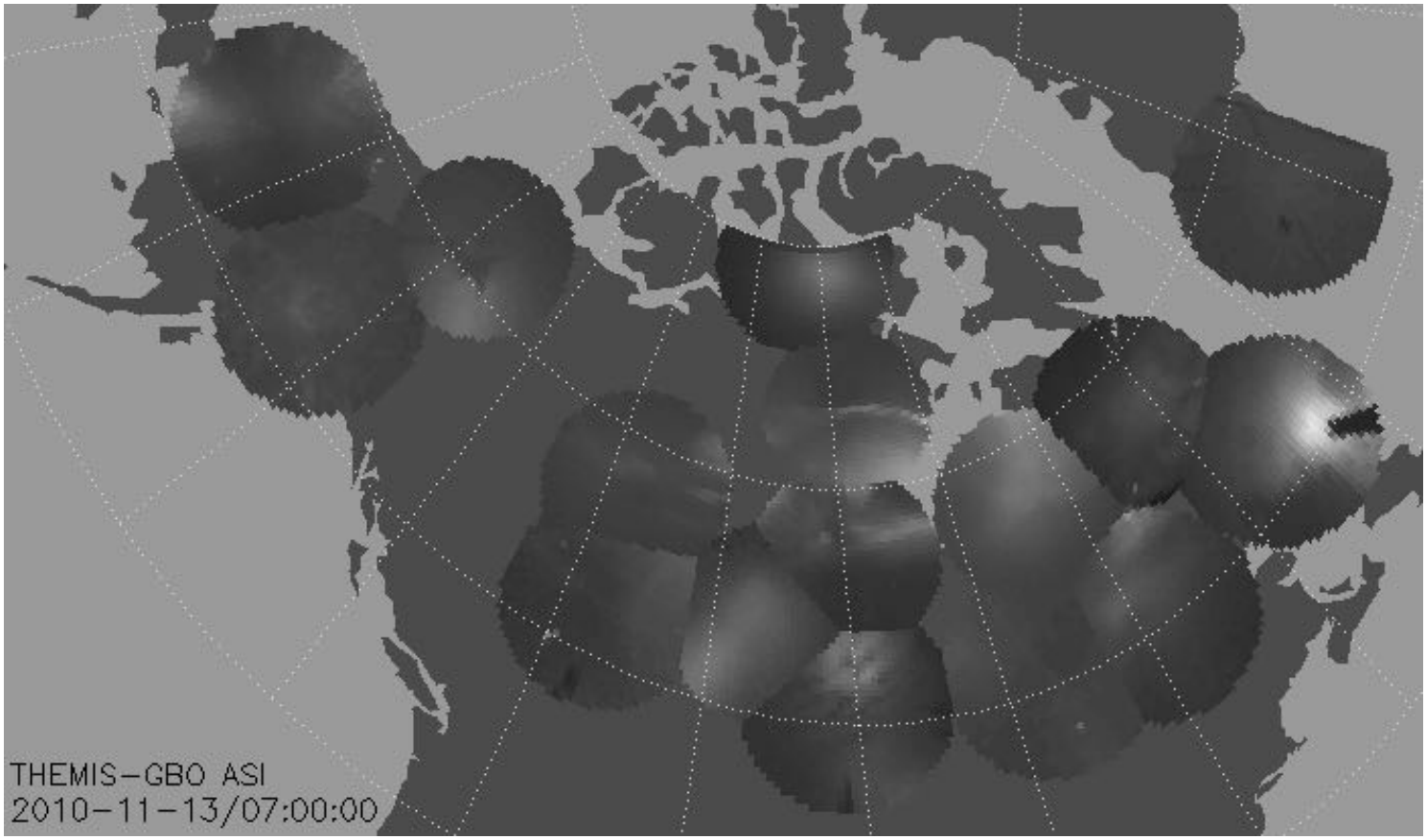
Key SPEDAS Features

- Load data from multiple sources, in multiple file formats, into a common environment
- Interactively locate and download data using NASA's CDAWeb service, and the Heliophysics Application Program Interface (HAPI)
- Rich set of analysis tools for working with magnetic and electric field instruments and particle detectors
- Plotting tools: time series line plots and spectrograms, multi-panel summary plots, orbit plots, map plots, 3-d particle data visualizations
- Magnetic field modeling tools
- Export plots as Postscript for publication
- Export results of analysis to CDF (Common Data Format) files for use in other tools
- Exchange data between SPEDAS and Autoplot
- Command Line Interface (CLI) and Graphical User Interface (GUI)

Heliophysics System Observatory Spacecraft



THEMIS All-Sky Imagers Mosaic Map



Ground Magnetometer Stations

Sample SPEDAS work flow

- Load THEMIS satellite positions and fluxgate magnetometer data for a time range of interest

- Load solar wind parameters from the OMNIWeb data repository

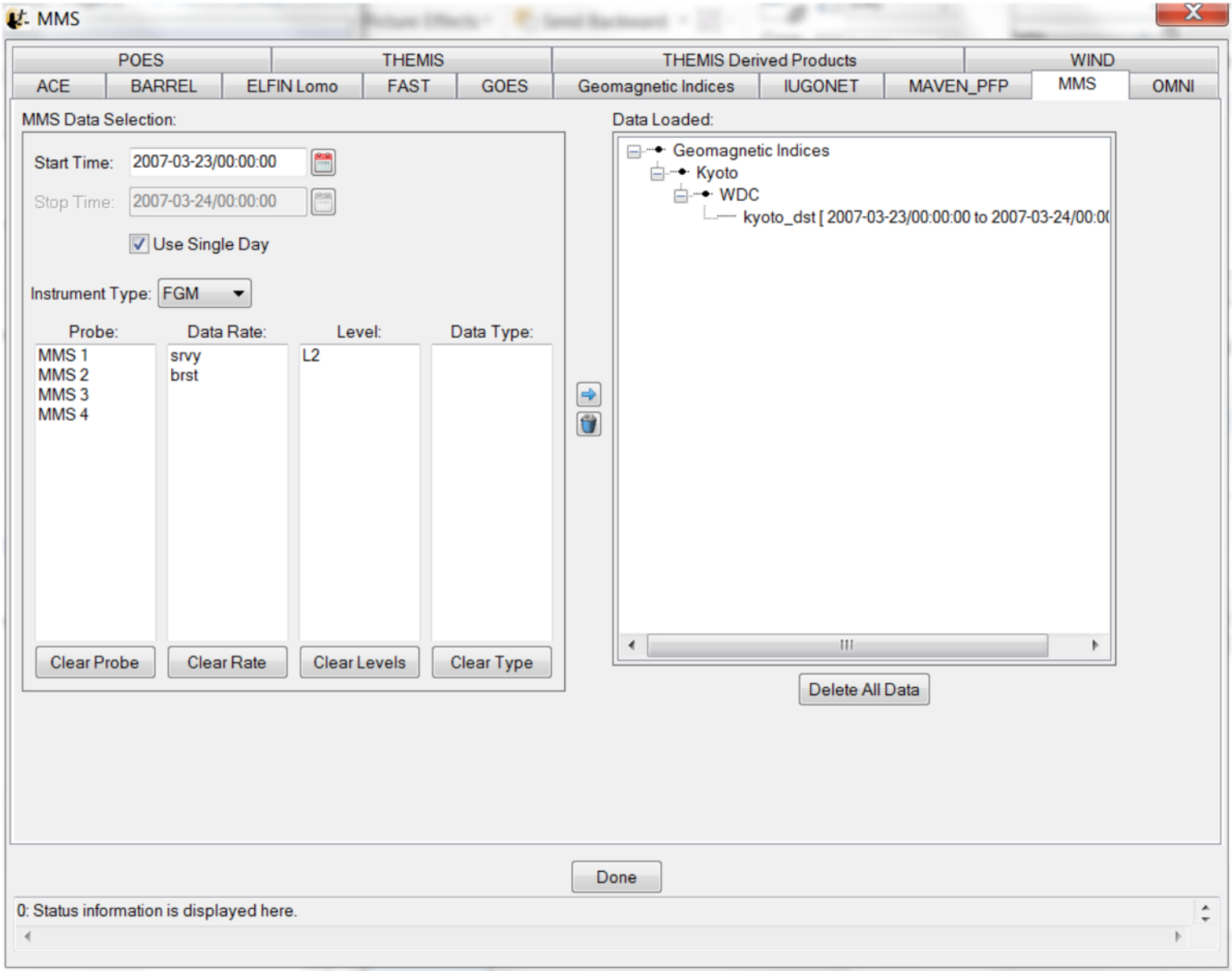
- Load geomagnetic indices from the Kyoto data repository

- Use the solar wind parameters, geomagnetic indices, and times/locations as inputs to a magnetic field model, to generate expected field values at the THEMIS times and positions

- Plot and compare the THEMIS observed fields to the modeled fields

- Each of these steps could be accomplished with just a few lines of IDL code.

Load Data panel (MMS plugin tab)

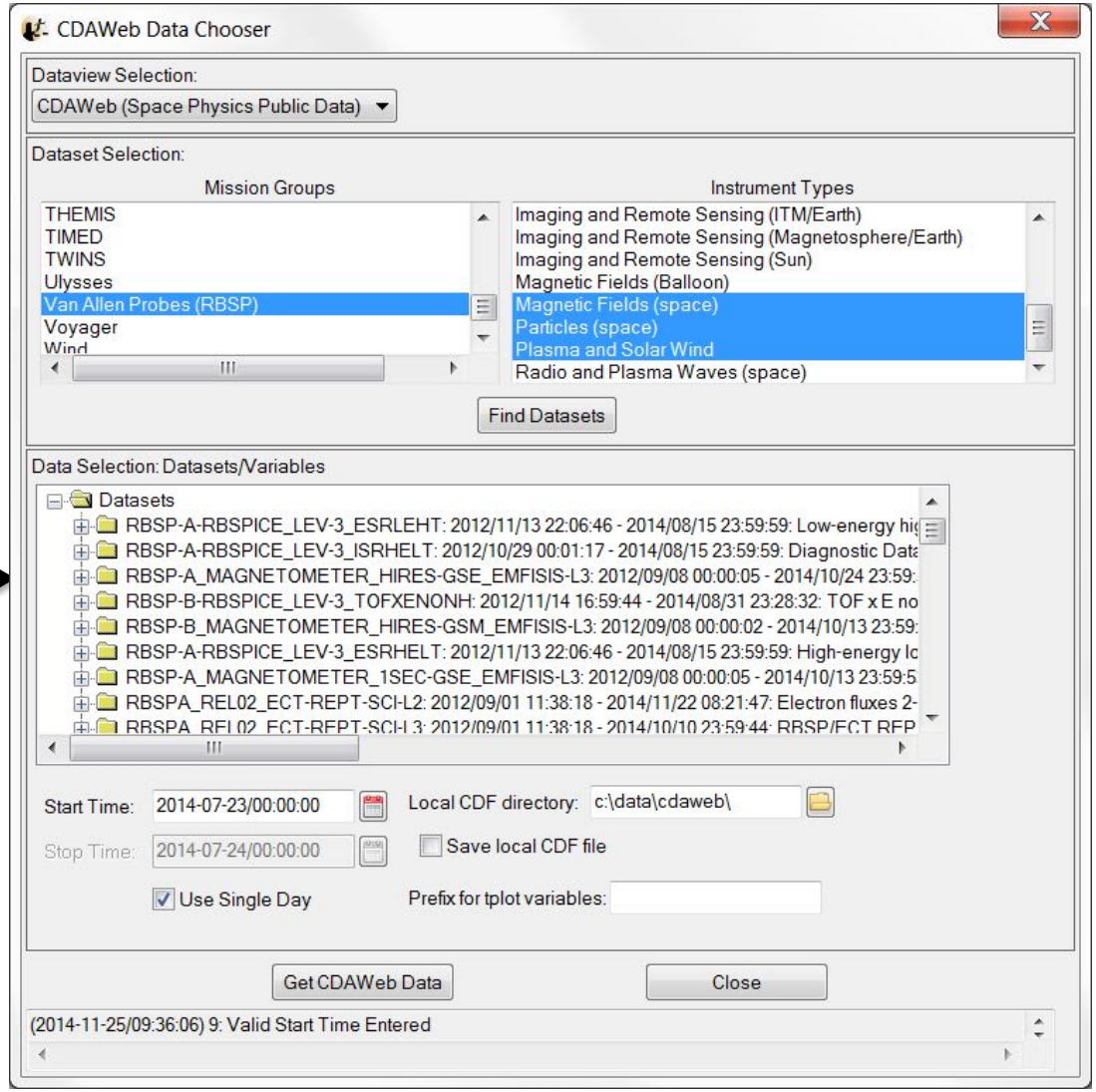


Loading CDAWeb Data

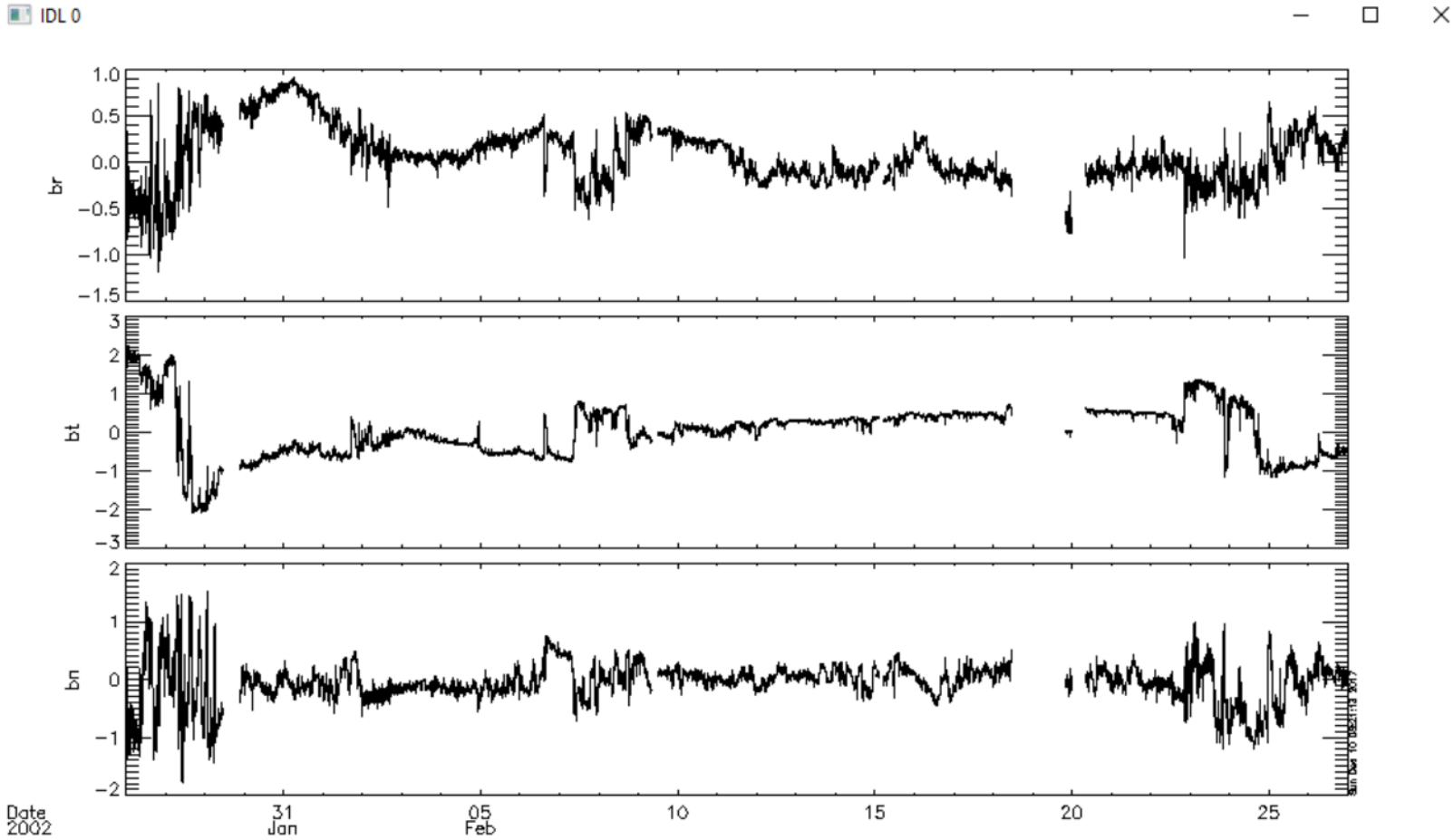
To Load **CDAWeb Data**:

-Select 'Load Data using CDAWeb' under the File menu

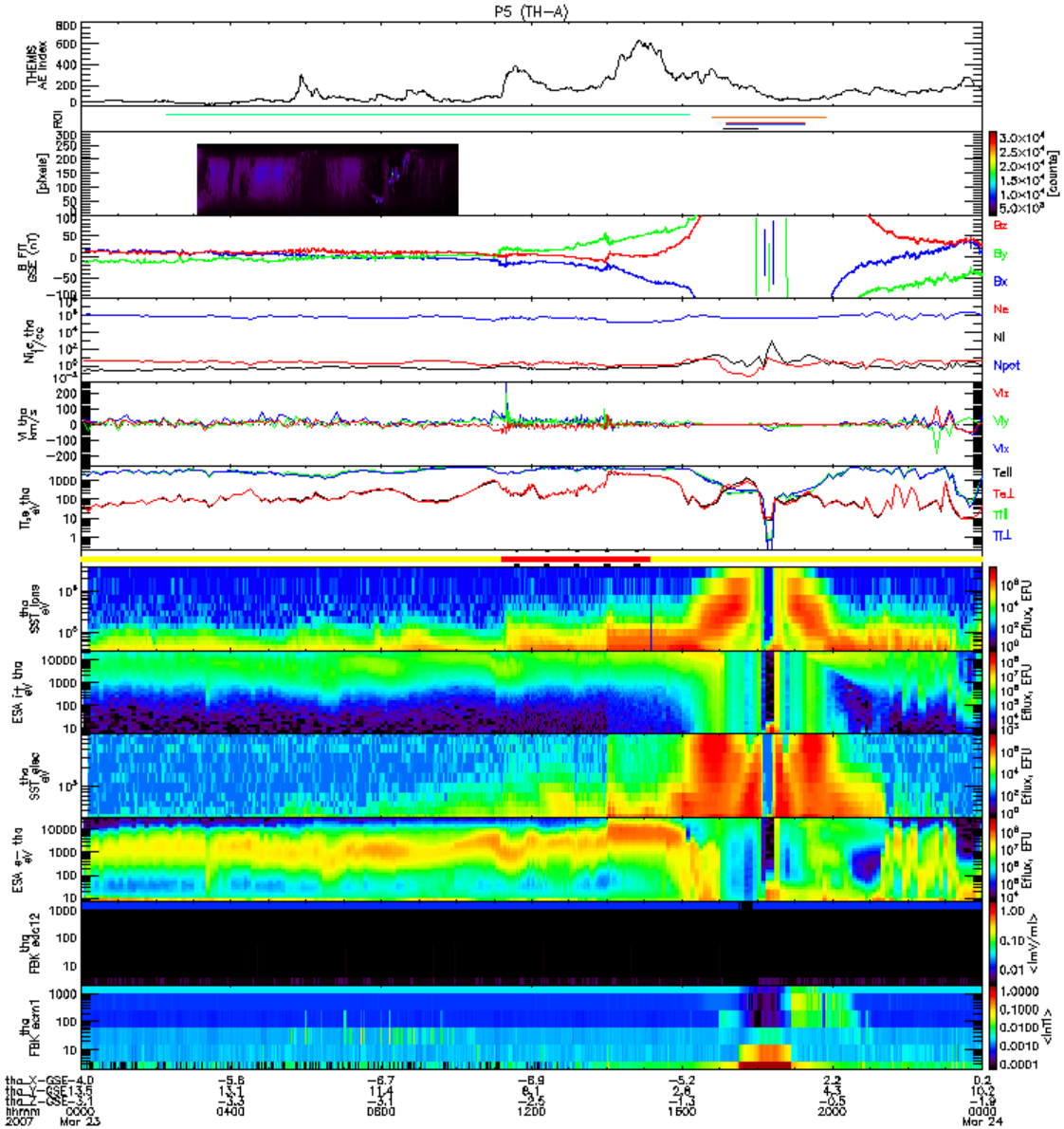
- Select Mission Group (i.e., TWINS, Cluster, RBSP, etc.)
- Select the Instrument Type
- Click 'Find Datasets'
- Select variable or dataset to download
- Click 'Get CDAWeb Data'



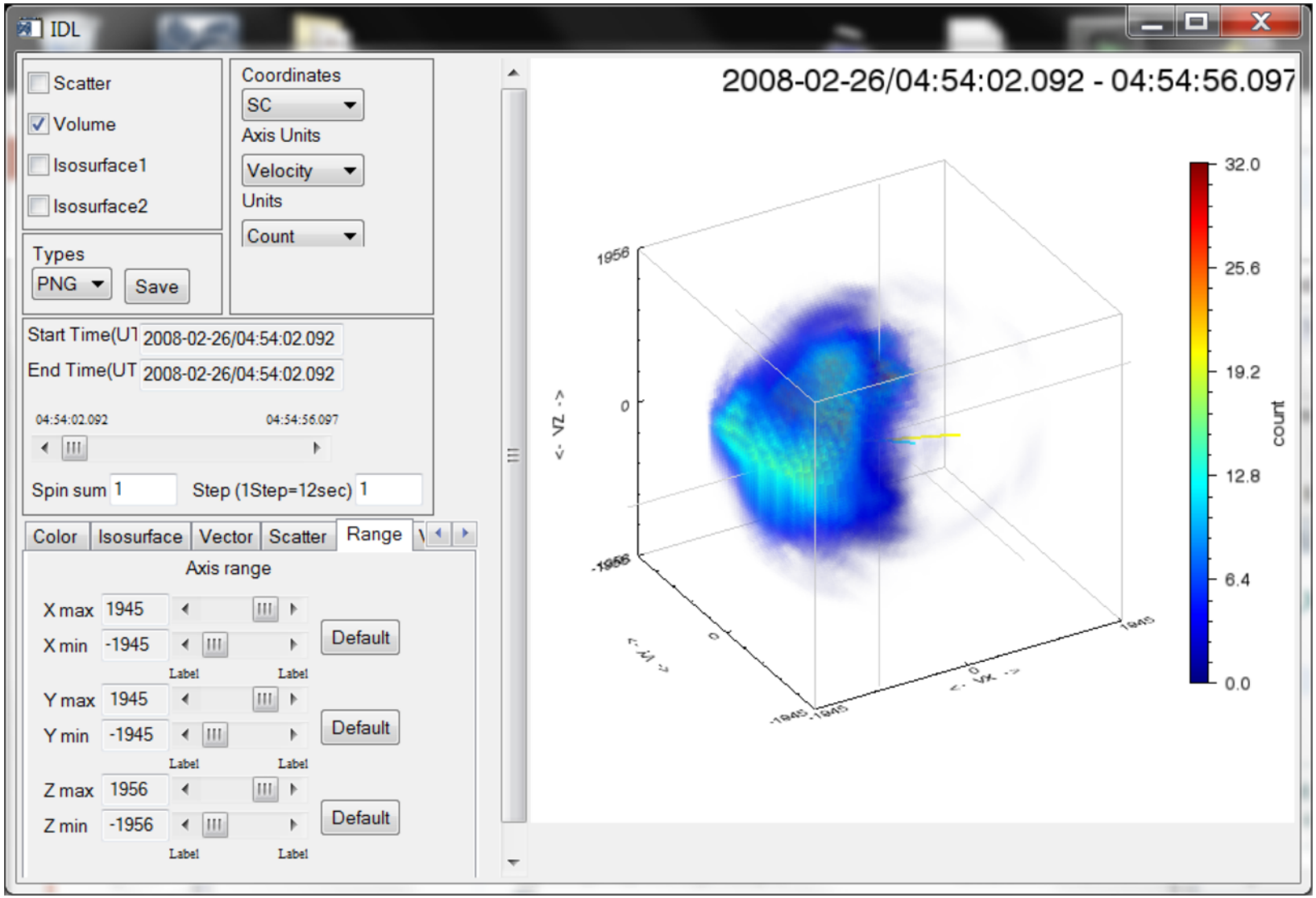
Cassini mag data via Heliophysics API (HAPI), from idl/general/crib_hapi.pro:



THEMIS A Summary Plot



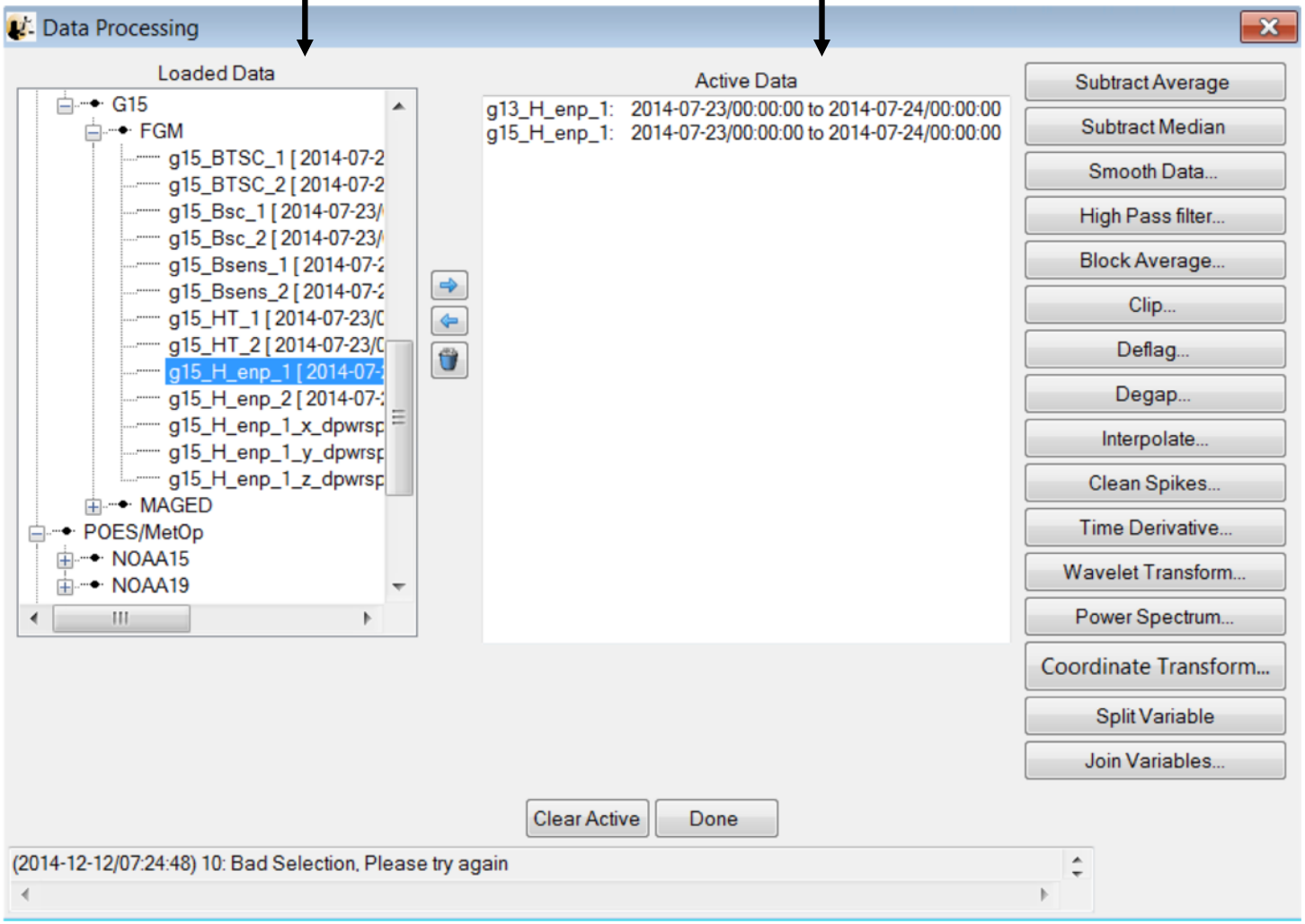
ISEE 3D settings panel (using THEMIS data)



Data Analysis

Available Data

Active Data

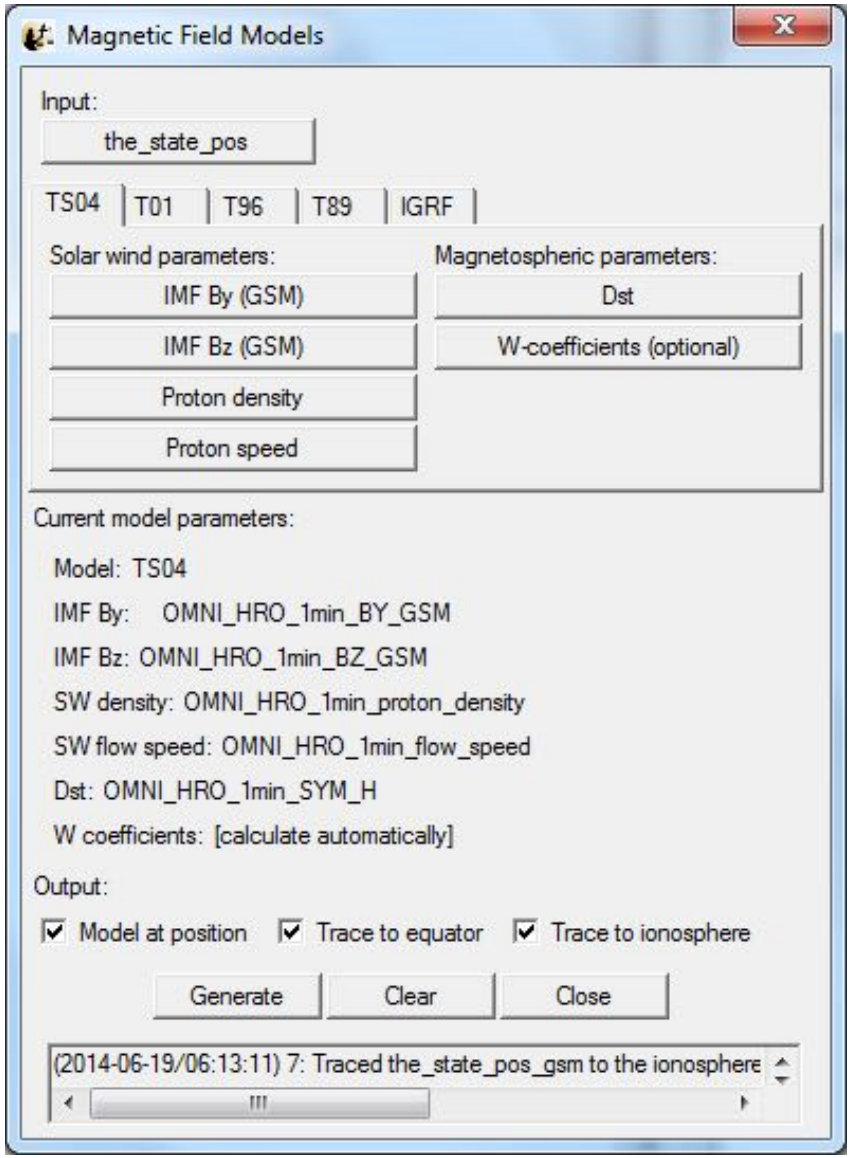


Common Functions

Magnetic Field Models

The GUI is now able to:

- Model the field at the spacecraft position
- Trace field from position to the ionosphere and equator



Key data and metadata concepts

- CDF and ISTP metadata conventions
  - Many data providers have adopted CDF with ISTP metadata standards
  - SPEDAS has generic CDF reading software that can sensibly handle ISTP compliant CDFs, and convert them to TPLOT or GUI variables for further analysis within SPEDAS
  - Several ground magnetometer networks publish data in other formats, which the THEMIS SOC ingests, converts to ISTP-compliant CDFs, and republishes for use with SPEDAS.
- NetCDF
  - The ISTP recommendations are strongly associated with CDF, but the concepts can also be applied to NetCDF files, so they can be loaded with the generic SPEDAS NetCDF reader
- Mission specific metadata extensions are handled via load routines built on the generic SPEDAS tools, translating the additional metadata to TPLOT attributes
- SPEDAS can also create ISTP compliant CDFs from TPLOT variables

Data discovery, working with archives

- SPEDAS offers an interactive GUI for discovering and loading data from CDAWeb
- SPEDAS has command-line tools for loading data via the Heliophysics Application Program Interface (HAPI)
- Tools are under development for data access via the DAS2 protocol
- SPEDAS supports importing and exporting Autoplot data; any data that can be located and accessed with Autoplot is therefore also available for analysis in SPEDAS. The current implementation handles metadata via exchange of ISTP compliant CDF files.
- Metadata representation in non-CDF data formats can be a sticking point when trying to use it in SPEDAS

- IDL licensing fees, and the relative scarcity of skilled IDL developers, can represent significant barriers to adoption of SPEDAS
- SPEDAS major releases are available as free-to-use “Virtual Machine” executables, but do not support command-line usage or compilation of new code.
- The SPEDAS development team is working on PySPEDAS, a set of Python tools implementing many key features of IDL SPEDAS.
- PySPEDAS development is being coordinated with the broader Python Heliophysics community (heliopython.org), to avoid duplication of effort and unnecessary proliferation of standards, and promote reuse of components that already exist in Python form.

- Openness: SPEDAS is free to download. The full version requires an IDL license to run, but we also release a GUI-only version that requires no additional licensing. This has proven to be very popular with students, and researchers who cannot afford the expense of a full IDL development license.
- Standard compliance: SPEDAS is designed to work with the ISTP guidelines for required and optional metadata in CDF files (and similar formats such as NetCDF). Data providers can be confident that if they produce ISTP-compliant data products, SPEDAS will be able to load them.
- Community engagement: The SPEDAS development team tries to be as responsive as possible to bug reports, enhancement and help requests, and other feedback from SPEDAS users. We regularly hold tutorial sessions at the GEM and AGU conferences, and host several webinars a year featuring in-depth demonstrations of SPEDAS tools and capabilities. We maintain a web site, spedas.org, with up-to-date documentation, downloadable software, conference presentations and tutorials, and a mailing list, so that all SPEDAS-related information can be found in the same place.
- Strong quality assurance processes: Each formal release of SPEDAS is put through a rigorous QA process including unit tests, regression tests, and end-to-end tests. We also release nightly “bleeding edge” versions which include the latest features and bug fixes. The SPEDAS team strives to keep these nightly builds stable and reliable, despite the lack of formal QA processes at that level. Users can trust that the nightly builds are suitable for daily use, and having more eyes on the software means that bugs are more quickly reported and fixed.