

Science Software – v5.21 Training

GEM – San Francisco, CA

December, 2010



Agenda



12:00	Introduction	C. Russell
12:05	Science Data Status Report	C. Russell
12:10	THEMIS Web Site	C. Russell
12:15	THEMIS Data Analysis Software	C. Russell
12:30	Coordinate Transforms	P. Cruce
12:35	Plotting	P. Cruce
12:45	Mini-Language	P. Cruce
1:00	THEMIS Graphical User Interface (GUI)	C. Russell/ P. Cruce
1:40	THEMIS Ground Based Observatories (GBO)	P. Cruce
1:50	SPDF – CDAWeb	P. Cruce

[ftp://apollo.ssl.berkeley.edu/pub/THEMIS /3 Ground Systems /3.2 Science Operations/
Science Operations Documents/](ftp://apollo.ssl.berkeley.edu/pub/THEMIS/3%20Ground%20Systems/3.2%20Science%20Operations/Science%20Operations%20Documents/)

THEMIS Data Analysis Software

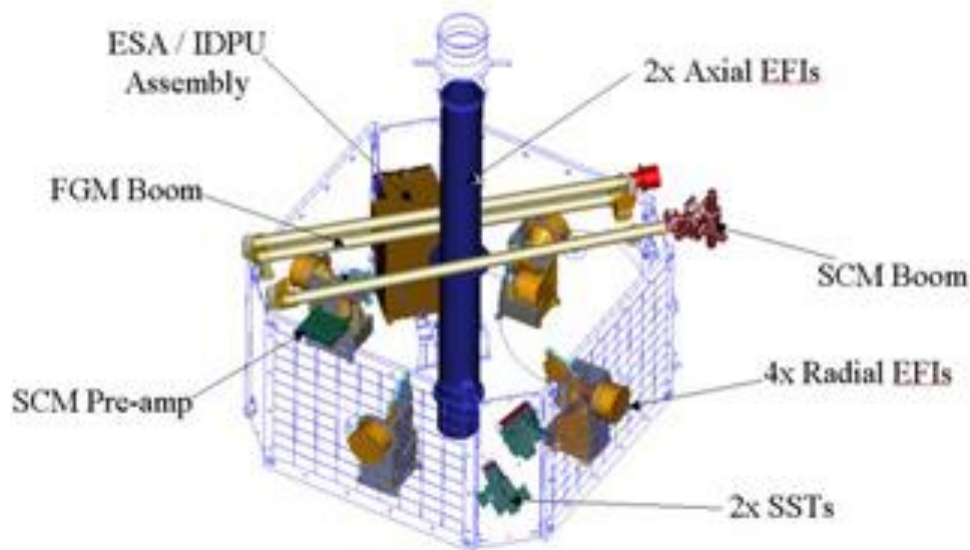
Organization	Contributors
UC Berkeley	D Larson, H Frey, J Bonnell, J McFadden, A Keiling J McTiernan, J Lewis
UCLA	V Angelopoulos, P Cruce, C Russell, H Leinweber, A Flores, K Ramer, B Kerr, M Feuerstein
SP Systems	K Bromund
APL	H Korth
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MPE	E Georgescu
TUBS	U Auster, F Plaschke
CETP	P Robert, O LeContel
Calgary	B Jackel, E Donovan

FIELDS INSTRUMENTS:

EFI - Electric Field Instruments
FGM - Flux Gate Magnetometer
SCM - Search Coil Magnetometers

PARTICLE INSTRUMENTS:

ESA - Electrostatic Analyzer
SST - Solid State Telescope



GROUND BASED:

ASI – All-Sky Imager Array

GMAG – Magnetometer Array

PROCESSED DATA:

FBK – Filter Bank

FIT – Onboard Spin-Fit

FFT – Fast Fourier Transform

MOM – Onboard Moments

STATE – Spacecraft state vectors





- The software operates on Level 1 and Level 2 data.
- Data Level Definitions:
 - Level 0 Data –
 - Raw files (*.pkt) one per APID.
 - Only used for loading ESA data.
 - Level 1 Data -
 - CDF (Common Data Files) files (*.cdf)
 - Files contain raw, un-calibrated data. i.e. counts, DAC units.
 - Requires TDAS software to interpret. Calibration is done by default when Level 1 data is input.
 - Level 2 Data -
 - CDF files – contain physical quantities – TDAS software is not needed for interpretation.
 - Files available for ESA, FBK, FIT, FFT, FGM, MOM, SST – can be downloaded from SPDF.



V5.21 Science Software/Data Status Report

- **General** Loads, introduces and calibrates all L1 quantities, all instruments
Loads calibrated L2 quantities
- **STATE** L1 STATE available since launch, V03 STATE (improved attitude and spin phase corrections)
- **FGM** L1, L2 data available since early March 2007
- **FIT / FFT / FBK** - L1, L2 data available since early March 2007
- **SCM** L1 data available since early March 2007
L2 frequency spectrograms (FBK) available now
L2 SCM available since May 2010
- **EFI** All L1 data available from TH-C since May 2007, TH-D,E since Jun 7
L2 EFI expected Winter 2010
- **ESA** No L1 data, only L0 data – however, read-in is transparent to user
All data available since ESA turn-on, i.e., mid-March
L2 omnidirectional energy spectrograms, ground moments available now.
- **MOM** On-board moments available from August 2007 on. L2 moments (from ESA only) available.
- **SST** L1 data available since SST turn-on, mid-March
L2 omnidirectional energy spectrograms available now
- **ASI** L1 thumbnail images from 21 stations available.
L1 full-resolution images available up to April 2009,
Mosaics, movies for full mission
- **GMAG** L2 CDF files with ground magnetometer data from 50 stations. That includes one from Greenland, 7 from Augsburg College, 11 from the University of Alaska, one from University of Athabasca, 6 from the University of Alberta, and 24 THEMIS EPO/GBO sites. Adding 3 new sites from University of Athabasca and 25 new sites from Norway, Greenland, and Denmark by Oct 2010.
- **Other Missions**
 - **GOES** – High-resolution (0.5s) magnetometer data from GOES 10, 11 and 12 satellites from September 2007–December 2008 for each satellite.
 - **ACE** - The ACE data consists of magnetometer values in GSM coordinates with one minute averages and Solar Wind Electron Proton Alpha Monitor data



- TDAS Version 5.21 was released Spring 2010.
- TDAS Version 6.0 is to be released Spring 2011.

Command Line Interface

- Enhanced spinmodel_get_info
- On-Board moments calibrations enhanced
- New software to allow calibration of SST full/burst distribution data using text files
- New beta version of 2-D slices (for GUI too)
- New processing tools for VC → L0 and L0 → L1

- **Graphical User Interface**

- Tplot_gui was modified to support x/y/zstacklabels
- Raw data check box added to the load data panel

- **Science Data**

- L2 ESA, FGM, FIT, SCM, MOM data reprocessed with solar wind mode flags.
- Level 1 STATE, SST and MOM data reprocessed with enhanced spin model and solar wind flags.
- New FGM calibrations and formats for time variables
- TH-B and TH-C L0 and L1 data reprocessed



THEMIS Main Web Page



<http://themis.ssl.berkeley.edu>



THEMIS Software Web Page



THEMIS
Time History of Events and Macroscale Interactions During Substorms

Home The Mission Data **Software** Publications News & Events Contact Us For the Public >>

Software >>
Documentation
Enhancements
Developers

THEMIS Software

The THEMIS Data Analysis Software Suite consists of IDL routines which read data in CDF format, as well as other less refined data sets. IDL routines can be used to download, open, analyze, and plot Level 1 (L1) and Level 2 (L2) data quantities. They can also be used transform L1 data into L2 data. L1 data is raw, uncalibrated data in CDF format. L2 data is calibrated in physical units. These IDL routines were derived from those used by the Cluster, Wind, Polar, and FAST missions. In addition to command line invoked IDL routines, the software provides a graphical user interface for opening, analyzing, and plotting data. This interface was designed to facilitate use of the most useful IDL routines.

To begin:

1. [Download](#) the latest release of the Software
You can download the Quick Reference Guide directly from this website as a [DOC](#) or [PDF](#).
You can download the User's Guide directly from this website as a [DOC](#) or [PDF](#).
2. After downloading a version of the software and the user's guide, open up the users guide and follow the instructions provided.
3. You may also find the [HTML Docs](#) for the latest released version of the Software. You can also browse the IDL source.

Future Releases:

1. You can receive emails notifying you of New Software Releases by [Registering](#) on the THEMIS Science Support Distribution List.
2. [Download](#) not yet released future Software. Please Note this Software may not yet be fully tested and is not supported by the THEMIS Science Support Team.

IDL Geopack DLM:

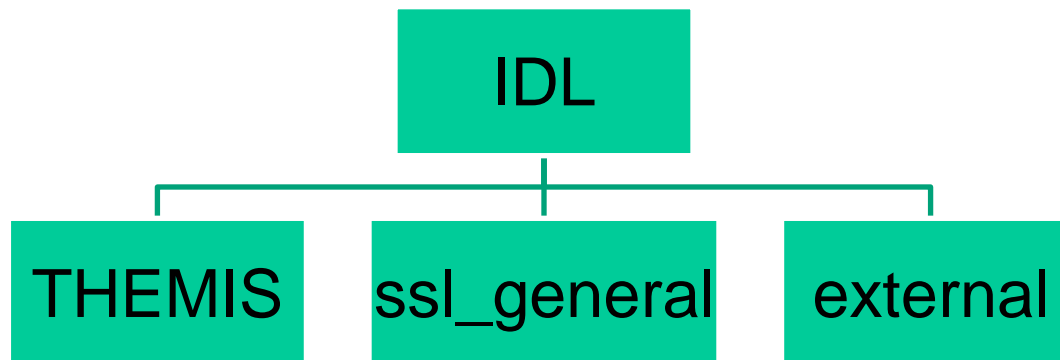
To use the Tsyganenko Model extensions to the THEMIS software you need to [Download](#) and install the interface between Tsyganenko's Fortran code and IDL. This interface was developed and provided for THEMIS as a courtesy by Haje Korth. Installation instructions can be found [here](#).

For comments, observations, problems or questions about data access, software or web site content please contact the [Themis Science Support Team](#).

THEMIS_Science_Support@ssl.berkeley.edu



- THEMIS Data Analysis Software (TDAS) Objectives
 - Powerful, Flexible Command Line Interface
 - GUI provides easy access to data, analysis tools, and graphics
- IDL based (library of routines –but no main program!).
- Code is available to everyone
- It is not required to analyze level 2 data.
- Functionally separates the tasks into:
 - Reading
 - Manipulating
 - Plotting
- Platform independent. Works on:
 - Solaris
 - Linux
 - Windows, Vista
 - Mac OS X

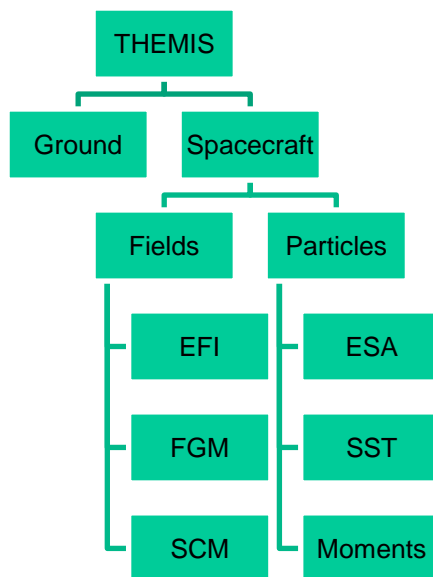


- **THEMIS (idl/themis/)** – routines specific to THEMIS
- **ssl_general (idl/ssl_general/)** – general routines
- **external (idl/external/)** – external libraries



THEMIS Specific Routines (idl/themis/)

- Instrument specific routine organization
 - Load Data
 - Calibrate Data
 - Coordinate Transformations
 - Crib Sheet Examples





General routines (idl/ssl_general)

- Library of generic routines useful for building mission-specific load routines
 - CDF reading/writing routines
 - File retrieval routines
 - Miscellaneous routines
- Plotting routines
 - Uses “tplot variables”: strings that associate data together with metadata and plotting parameters.
 - Routines to manipulate/plot tplot variables
- Data Export routines
- Data Processing routines



External Libraries (idl/external)

- CDAWlib – from NASA SPDF, reads/plots CDF data
- IDL_GEOPACK – Magnetic field modelling kit



- Windows, Solaris, LINUX, PPC Mac or Intel Mac.
- IDL 6.2 or higher required
- IDL Patch Recommended
 - Required for IDL 6.2, (Strongly recommended for IDL 6.4 and up)
 - http://cdf.gsfc.nasa.gov/html/cdf_patch_for_idl6x_new.html
- For Mac, system configurations are required to run IDL
 - Required for Intel Mac, regardless of IDL version
 - X11 – may need to be installed.
 - Mouse click-through
 - one-time X11 configuration necessary for proper operation
- See THEMIS User's Guide for full information, available at: <ftp://apollo.ssl.berkeley.edu/pub/THEMIS/>

- **Installation**

- Download and expand the latest TDAS release .zip file. The latest version is 5.21.

http://themis.ssl.berkeley.edu/socware/tdas_5_21/tdas_5_21.zip

- **Set up the IDL path**

- Windows and IDLDE on any platform: File->Preferences
- UNIX-like systems (Mac OS X, Linux, Solaris)

In `.cshrc`:

```
setenv IDL_PATH '<IDL_DEFAULT>:+/path/to/tdas'  
-Or-
```

In `.bashrc` or `.bash_profile`:

```
export IDL_PATH='<IDL_DEFAULT>:+/path/to/tdas'
```

- **Set path to Data Directory**

- Data directory will be created automatically at
 - `C:/data/themis` (Windows)
 - `~/data/themis` (UNIX/LINUX/Max OS X)
- Run `thm_ui_config` from command line or THEMIS GUI if you need to change this.



- Data Directory structure is large!
 - ~3GB/day for all probes (L1 data)
- Directory hierarchy keeps directory size manageable
 - Software performs automatic file retrieval.
 - Software maintains directory hierarchy.
- Behaviour of Automatic File Retrieval is configurable
 - ‘No Download’ mode for stand-alone operation.
 - ‘No Update’ mode to preserve local modifications.
 - Root directory determined automatically, is configurable.
 - Available configuration methods:
 - thm_ui_config IDL widget
 - Button on THEMIS GUI widget
 - Environment variables



Usage Conventions:

- **Use IDL keywords to determine functionality**
 - Data Levels - Calibrated Level 1 data is the default (Except for SST and ESA data, which are handled differently).
 - Data type and Probe keywords determine which data is loaded and/or created through the calibration process
 - Get_Support_Data keyword needed in thm_load_state to load data needed by thm_cal* and thm_cotrans routines
 - To load uncalibrated data, set type = 'raw' (For all but SST, ESA)
- **IDL Command Line Examples:**
 - timespan,'2007-07-07',1 ;choose a time range
 - thm_load_state, probe = 'a', /get_support_data
 - thm_load_fgm, probe='a', coord='gsm', datatype='fgl', level=1



Probe specification. Example: tha

- a – can be one of [a-e] specifies probe

Particle data. Example: tha_peif

- p – particles
- e – ESA, s – SST
- i – ions, e – electrons
- f – full, r – reduced, m – moments, b – burst

FGM data. Example: tha_fgl

- l – low telemetry rate, h – high telemetry rate, e – engineering decimated high rate, s – spin fit.

Electric Fields and SCM. Example: tha_efs

- ef - efi, sc – scm, fb – fbk, ff – fft
- s – spin fit, f – full orbit or fast survey, p – particle burst, w – waves burst.

Wildcards are accepted in names when plotting and data processing:

- th?_fg?
- th[ab]_fg[lh]
- th?_state*

Load Routine Summary

Name	Description	Level 0	Level 1		Level 2
			Raw	Calibrated	
thm_load_asi	All-Sky Imager		*	(-)	
thm_load_ask	All-Sky Keogram		*	(-)	
thm_load_efi	Electric Fields Instrument Waveforms		*	*	
thm_load_esa	ElectroStatic Analyzer				*
thm_load_esa_pkt	ElectroStatic Analyzer	*			
thm_load_fbk	Fields Filter Bank		*	*	*
thm_load_fft	On-Board Fields Fast Fourier Transform		*	*	*
thm_load_fgm	Flux Gate Magnetometer Waveforms		*	*	*
thm_load_fit	On-Board Fields Spin-Fit		*	*	*
thm_load_gmag	Ground Magnetometer				*
thm_load_hsk	Housekeeping		*	*	
thm_load_mom	On-Board Particle Moments		*	*	*
thm_load_scm	Search Coil Magnetometer Waveforms		*	*	*
thm_load_sst	Solid State Telescope		*	(-)	*
thm_load_state	Orbit and Attitude		V3		
thm_load_pseudoae	THEMIS gmag Derived AE-Index			*	
thm_load_slp	Solar Lunar Position, Attitude, Velocity				*
thm_load_scmode	Spacecraft Mode			*	
thm_load_trg	Spacecraft Trigger		*		
thm_load_bau	BAU Housekeeping		*	*	

Notes:

(-) data reduction and analysis routines available: see crib sheet



Crib Sheets for Loading, Processing and Plotting

thm_crib_asi

thm_crib_dproc

thm_crib_efi

thm_crib_esa_da

thm_crib_esa_moments

thm_crib_export

thm_crib_fac

thm_crib_fbk

thm_crib_fft

thm_crib_fgm

thm_crib_fit

thm_crib_gmag

thm_crib_mom

thm_crib_mva

thm_crib_overplot

thm_crib_part_getspec

thm_crib_scm

thm_crib_sst

thm_crib_state

thm_crib_tplot

thm_crib_tplotxy

thm_crib_twavpol

thm_crib_part_slice2d

thm_map_examples

IDL>.run thm_crib_asi

or cut and paste, or copy and modify



- **thm_cotrans**
 - transforms to/from any of the following coordinate systems
 - updates metadata in output.
 - knows coordinate system of input from metadata
- **Currently Supported Geophysical Coordinate Systems**
 - SPG Spinning Probe Geometric
 - SSL Spinning SunSensor L-vectorZ
 - DSL Despun SunSensor L-vectorZ
 - GEI Geocentric Equatorial Inertial
 - GSE Geocentric Solar Ecliptic
 - GSM Geocentric Solar Magnetospheric
 - SM Solar Magnetic
 - GEO Geographic Coordinate System
 - SSE Selenocentric Coordinate System
- **Example (previously loaded FGM and STATE data)**
 - `thm_cotrans, 'th?_fg?', out_coord='geo', out_suffix = 'geo'`



- Plotting

- tplot
- tplotxy
- plotxy
- plotxyz
- tplot_names
- tlimit
- get_data
- store_data

Example:

```
tt89,'thc_state_pos',newname='model_field'  
fac_matrix_make,'model_field' ,other_dim=  
'xgse', newname = 'fac_mat'  
tvector_rotate, 'fac_mat', 'thc_peir_velocity',  
newname = 'ion_velocity_model_fa'
```

Analytic Coordinate Transformations

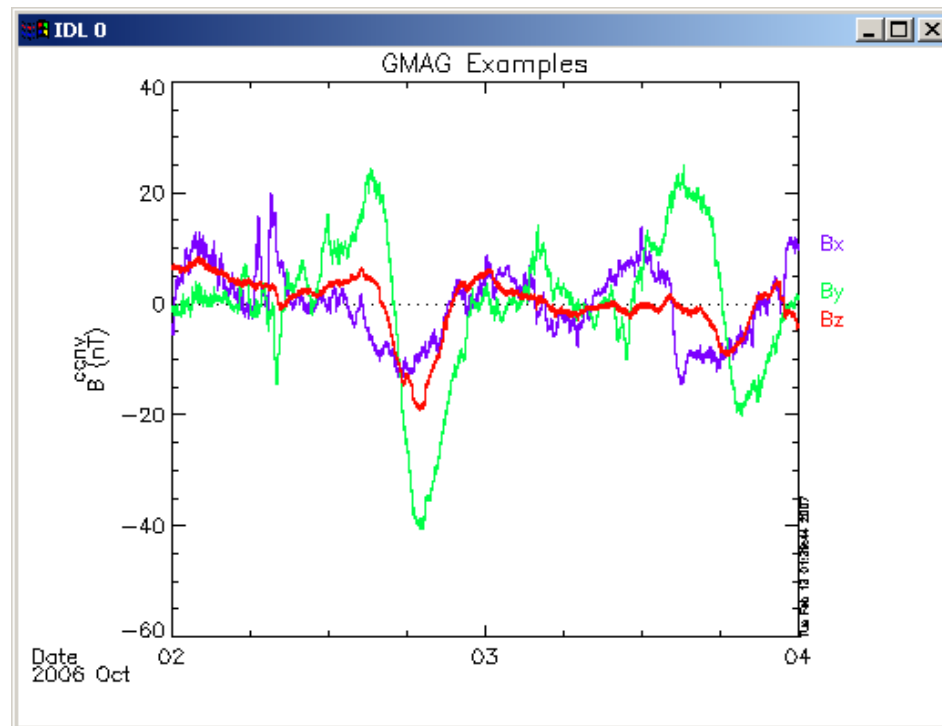
- tvector_rotate
- fac_matrix_make
- thm_fac_matrix_make
- minvar_matrix_make
- enp_matrix_make
- rxy_matrix_make
- sse_matrix_make
- gsm2lmn

Tsyganenko Model

- (t)trace2iono
- (t)trace2equator
- (t)t89
- (t)t96
- (t)t01
- (t)t04s



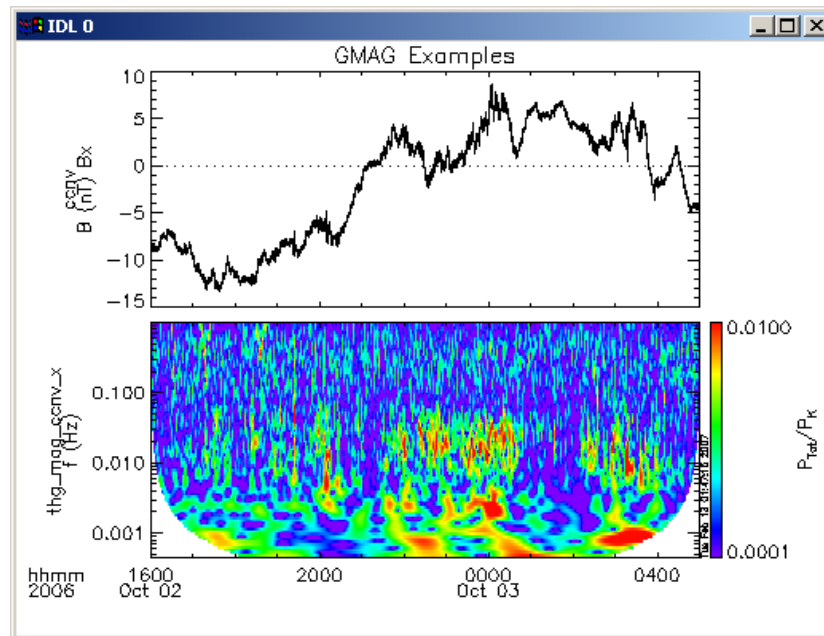
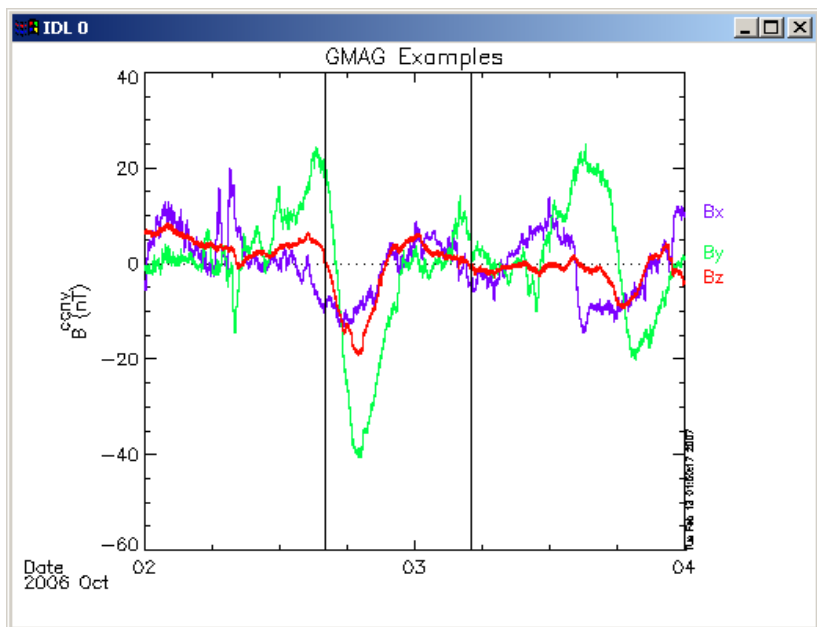
- To load data:
 - » `timespan,'6-10-2',2,/days`
 - » `thm_load_gmag,site='ccnv',$/subtract_average`
- To plot data:
 - » `options,'thg_mag_ccnv',$/labels=['Bx','By','Bz']`
 - » `tplot_options,'title',$/'GMAG Examples'`
 - » `tplot,'thg_mag_ccnv'`

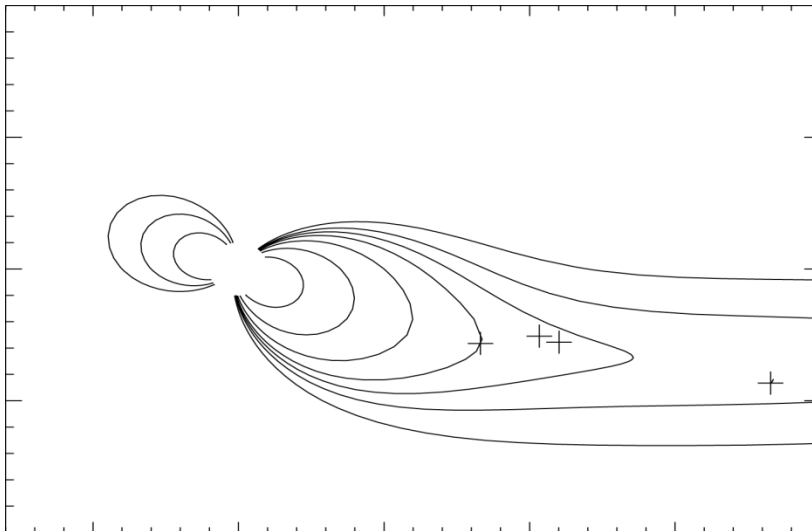




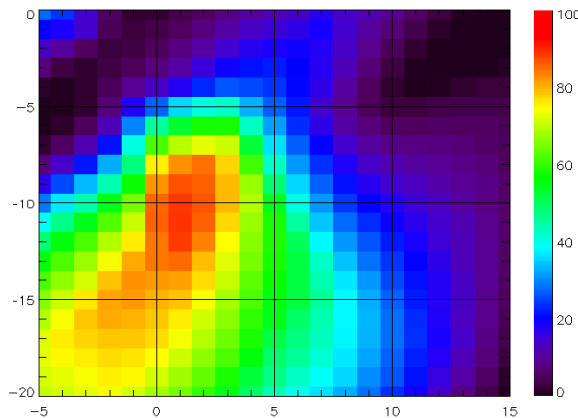
- Wavelet transform on an interval of interest
 - Define and display the interval
 - » `Tr = ['2006-10-2/16:00','2006-10-3/05']`
 - » `timebar, tr`

- Split the 3-vector into components:
 - » `split_vec, 'thg_mag_ccnv'`
- Compute transform of one component
 - » `wav_data, 'thg_mag_ccnv_x', /kol $, trange=tr, maxpoints=241*3600*2`
- Set color limits (log scale)
 - » `zlim, '*pow', .0001, .01, 1`
- Plot it.
 - » `tplot, '*ccnv_x*', trange=tr`

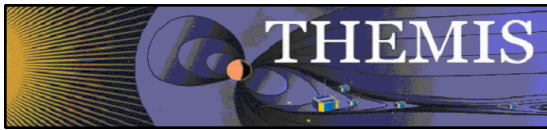




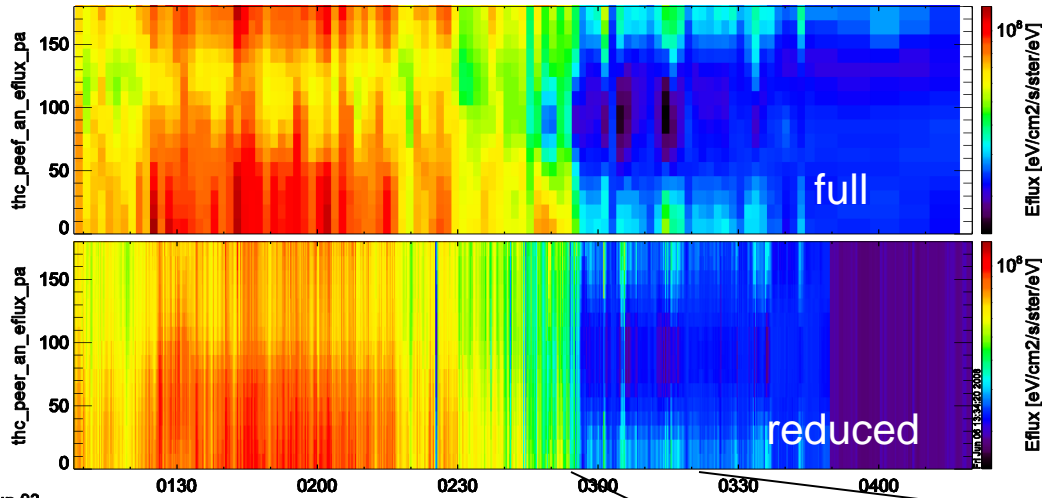
tplotxy can be used to plot isotropic position plots. Like plots of magnetic field models and spacecraft position



Plotxyz can be used to plot 3 dimensional isotropic data, with any axis. (Not restricted to time-series.)



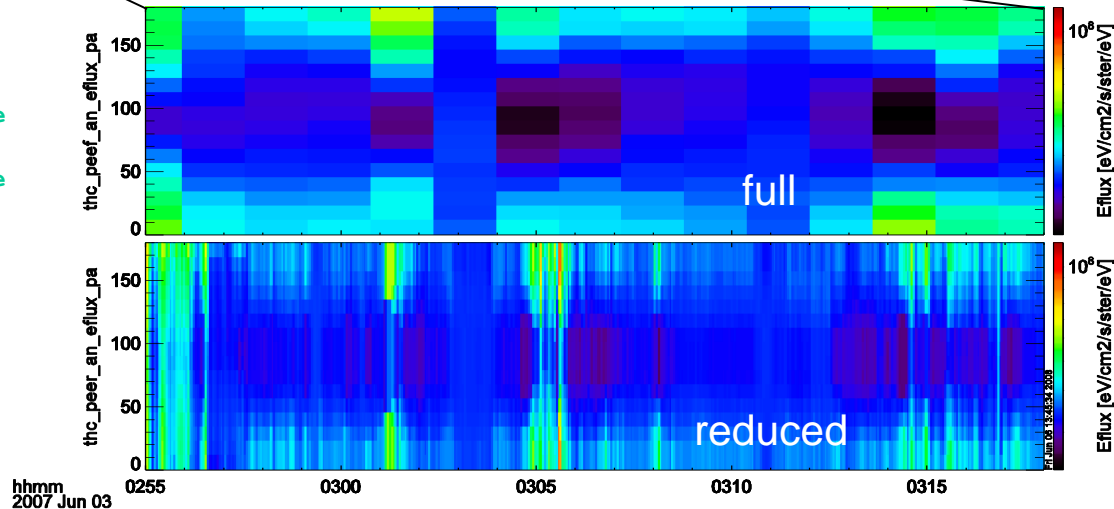
Plotting Angular Spectra



Pitch angle spectra for full and reduced mode electron ESA data. Plotted using tplot.

hhmm
2007 Jun 03

```
thm_part_getspec, $  
probe=['c'], $ ;select probe  
trange=['07-06-03/01:08', $ ;select timerange  
        '07-06-03/04:20'], $  
data_type=['peef','peer'], $ ;select data type  
angle='pa', $ ;select pitch angle spectra  
regrid=[32,16] ;set resolution of pitch/gyro  
spectra
```



hhmm
2007 Jun 03

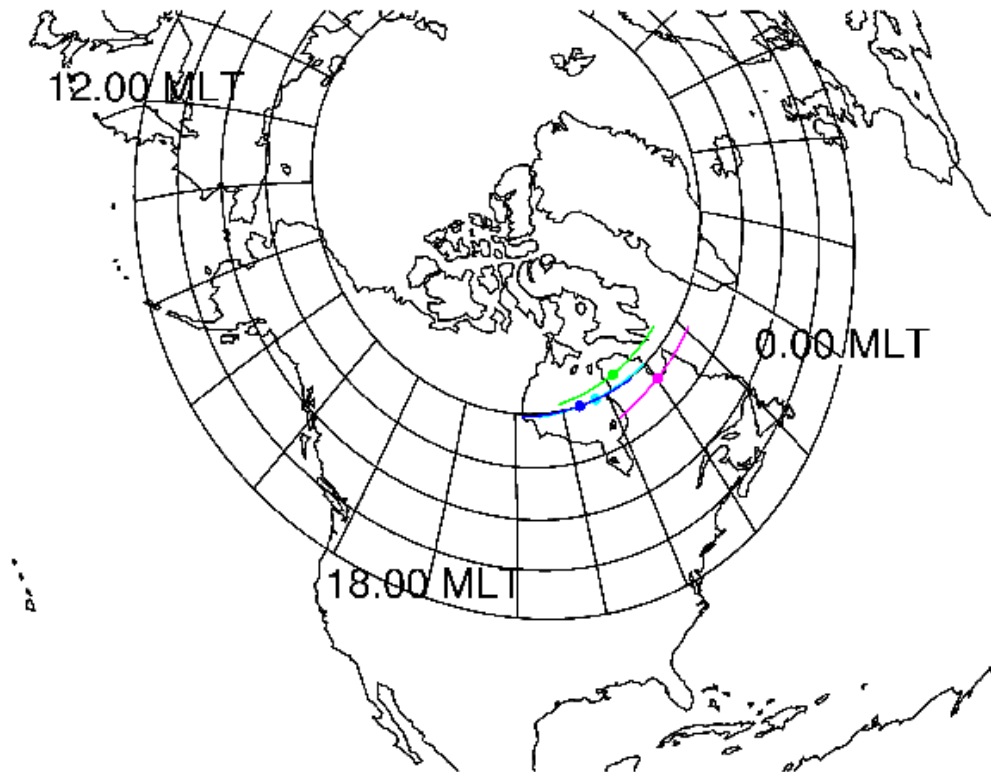


Trace / Orbit Plots

- New routines have been added to perform different 2d projections of 3d data. This particularly useful for plotting orbits and field lines.
- A Tsyganenko interface has been added to TDAS that allows us to calculate model field lines for T89,T96,T01,&T04 models. Field lines can also be Traced.
- Examples of these routines can be found in `themis/examples/thm_crib_trace.pro`, `themis/examples/thm_crib_plotxy.pro` and `themis/examples/thm_crib_tplotxy`
- The graphics in the next slide were generated with `thm_crib_trace.pro`
Example: `.run thm_crib_trace.pro`
- A routine was added to plot an arbitrarily sized and spaced AACGM coordinate grid on a world map.
- NEW (09/02/2010): IDL GEOPACK v7.3 released and includes updated IGRF coefficients valid through 2015 with extrapolation to 2020.
http://dysprosium.jhuapl.edu/idl_geopack/

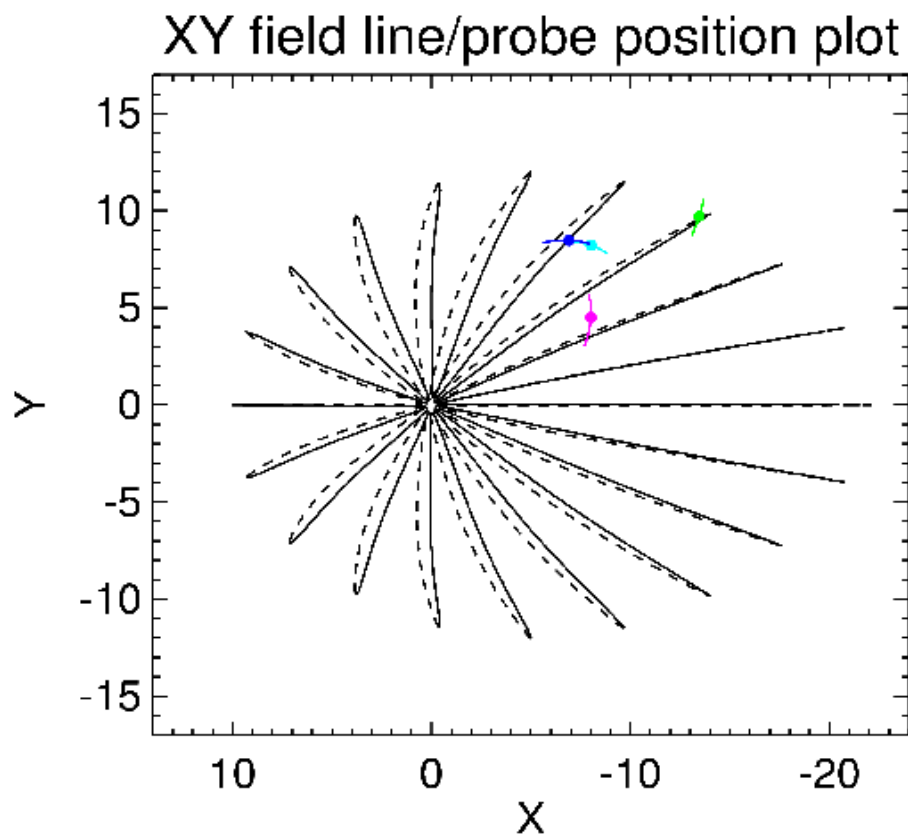


Trace/Orbit Plots - AACGM/Iono Trace Plot



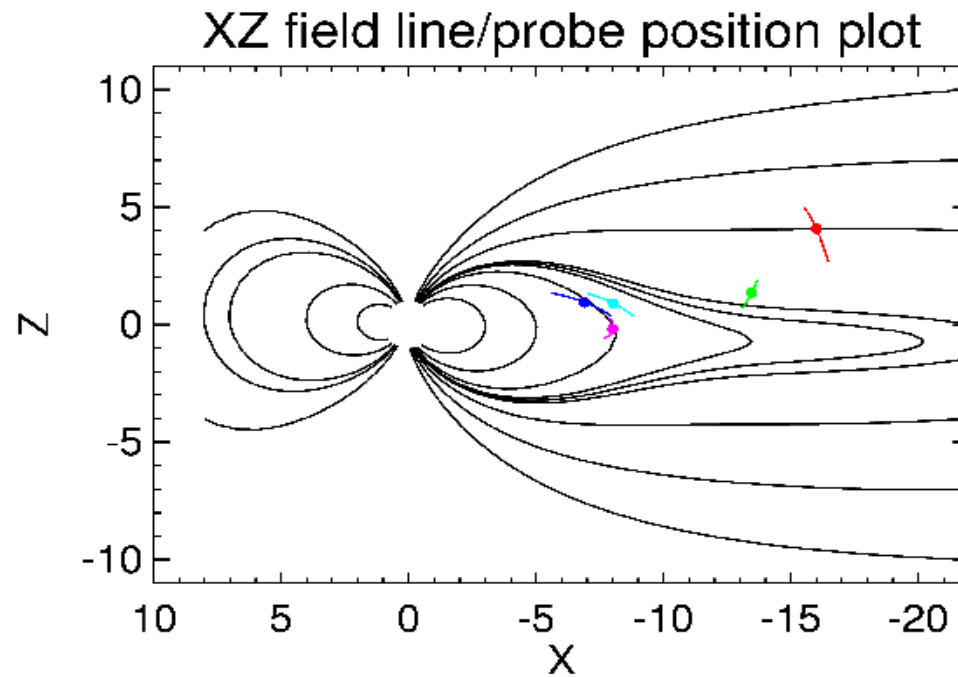


Trace / Orbit Plots – XY Plot





Trace / Orbit Plots – XZ Plot



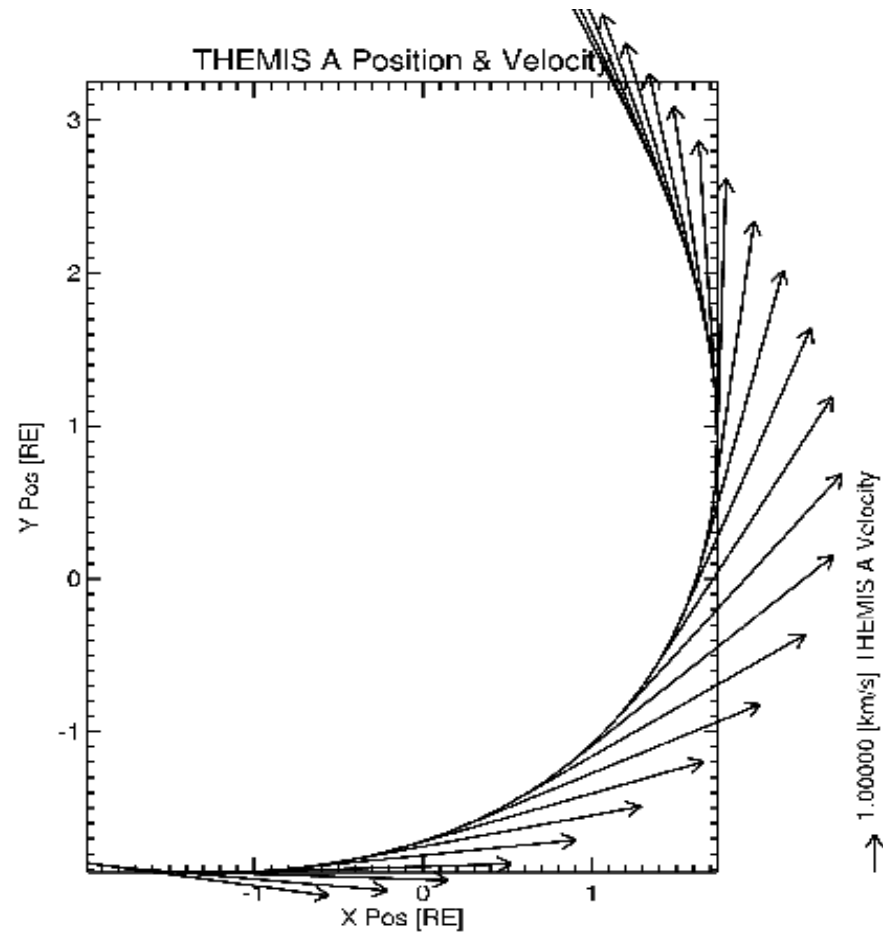


THEMIS – Mini Language

- Simple scripting language has been written in IDL.
- This language allows access to some data analysis functionality in the IDL virtual machine and eases manipulations of time series data.(tplot)
- This language allows composition of statements and functions with order of operations to give significant flexibility in statement construction.
- Examples:
 - 1: Position to RE: `calc,"tha_pos_re" = "tha_state_pos"/6374.4'`
 - 2: Natural log of total esa density:
`calc,"tha_density_log" = ln("tha_peir_density"+"tha_peer_density")`
 - 3: Store tplot data in non-tplot idl variable: `calc,'var_data = "tha_efs"`
 - 4: Average Magnetic Pressure:
`calc,'Pb_avg = mean(0.01*total("tha_fgs_dsl"^2,2)/25.132741)'`

Additional examples can be found in `themis/examples/thm_crib_calc.pro`

Plotxyvec – Position/Velocity Plot

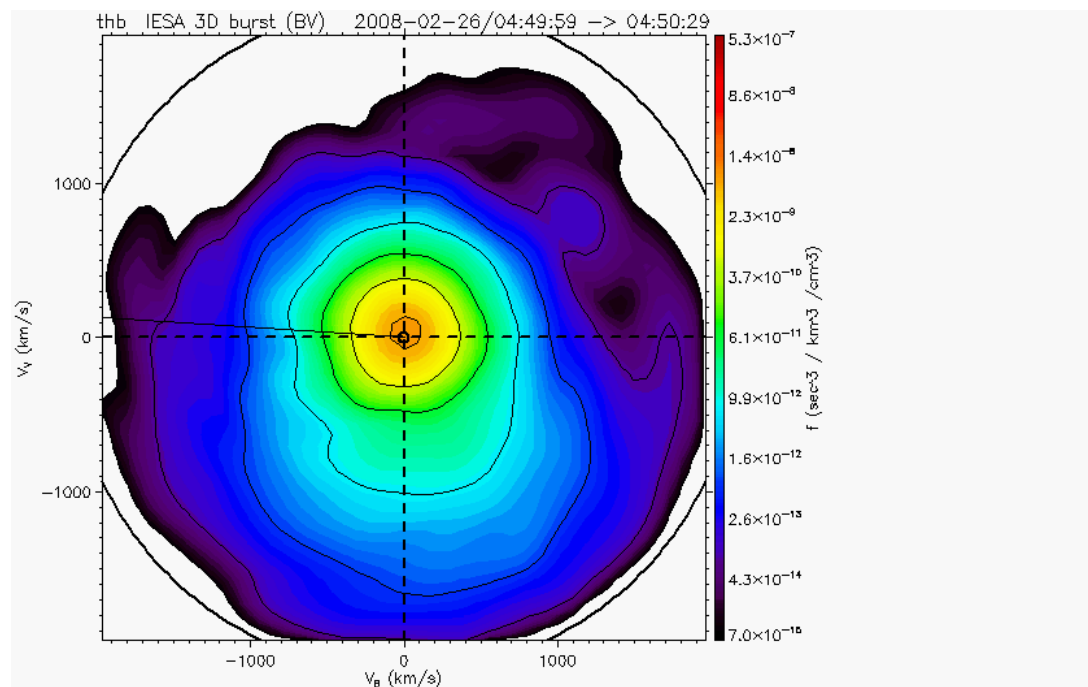
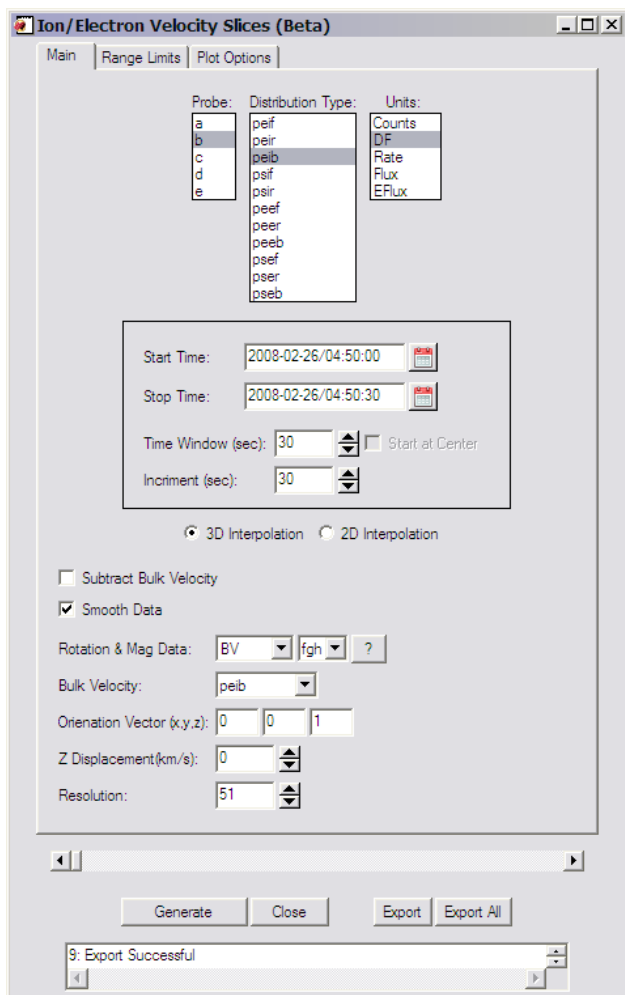


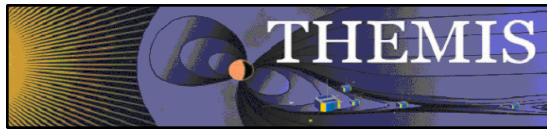


Ion Electron Velocity Slices(Beta)



Beta support for Slices of 3d particle Velocity distributions are supported in the bleeding edge. Code can be started by typing: thm_ui_slice2d or can be accessed from the GUI by selecting Analysis->Velocity Slices

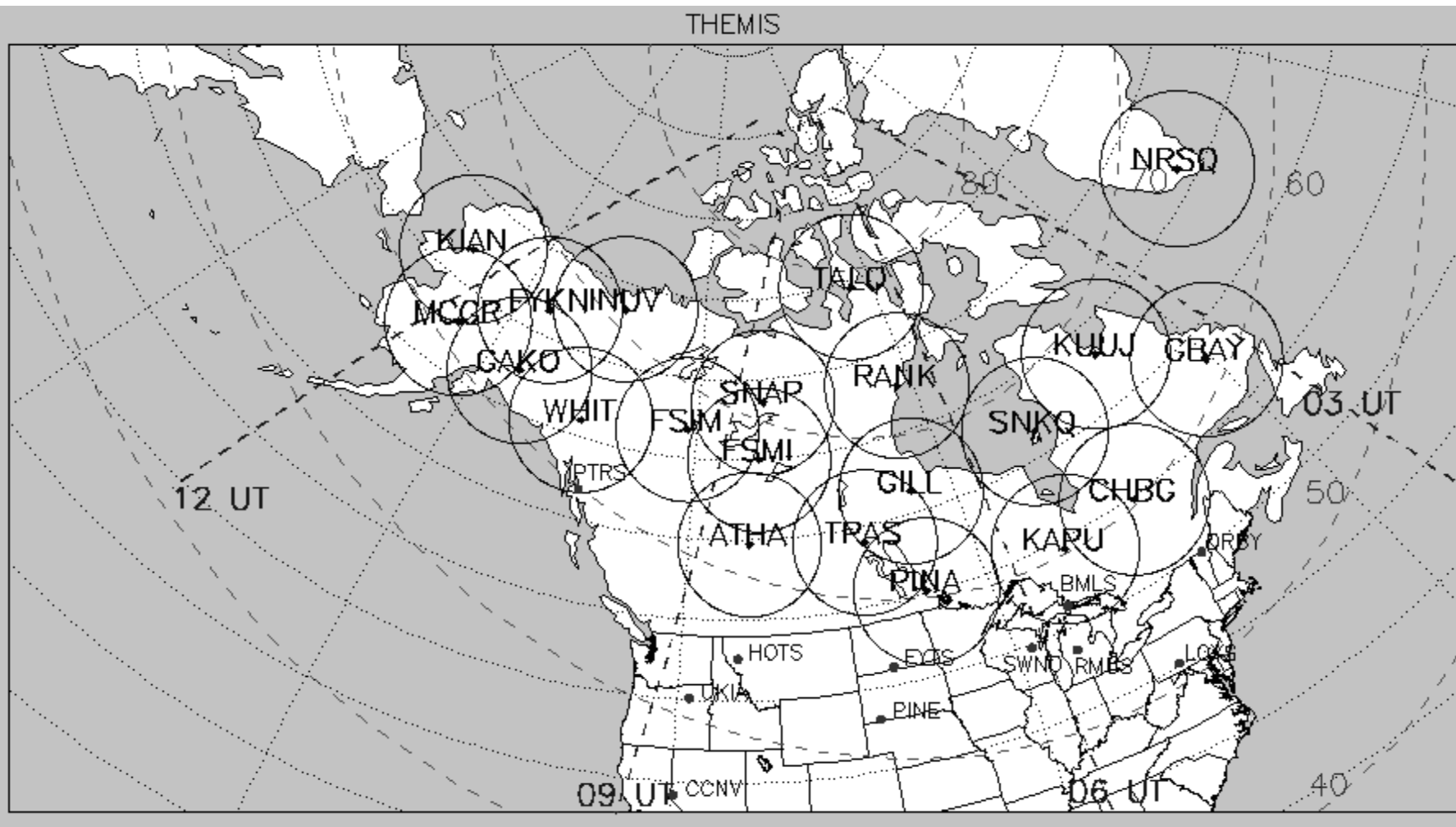




THEMIS Data Analysis Software Graphical User Interface



THEMIS software for GBO all-sky imager
Thm_crib_asi.pro
Harald U. Frey
(updated October 2010)

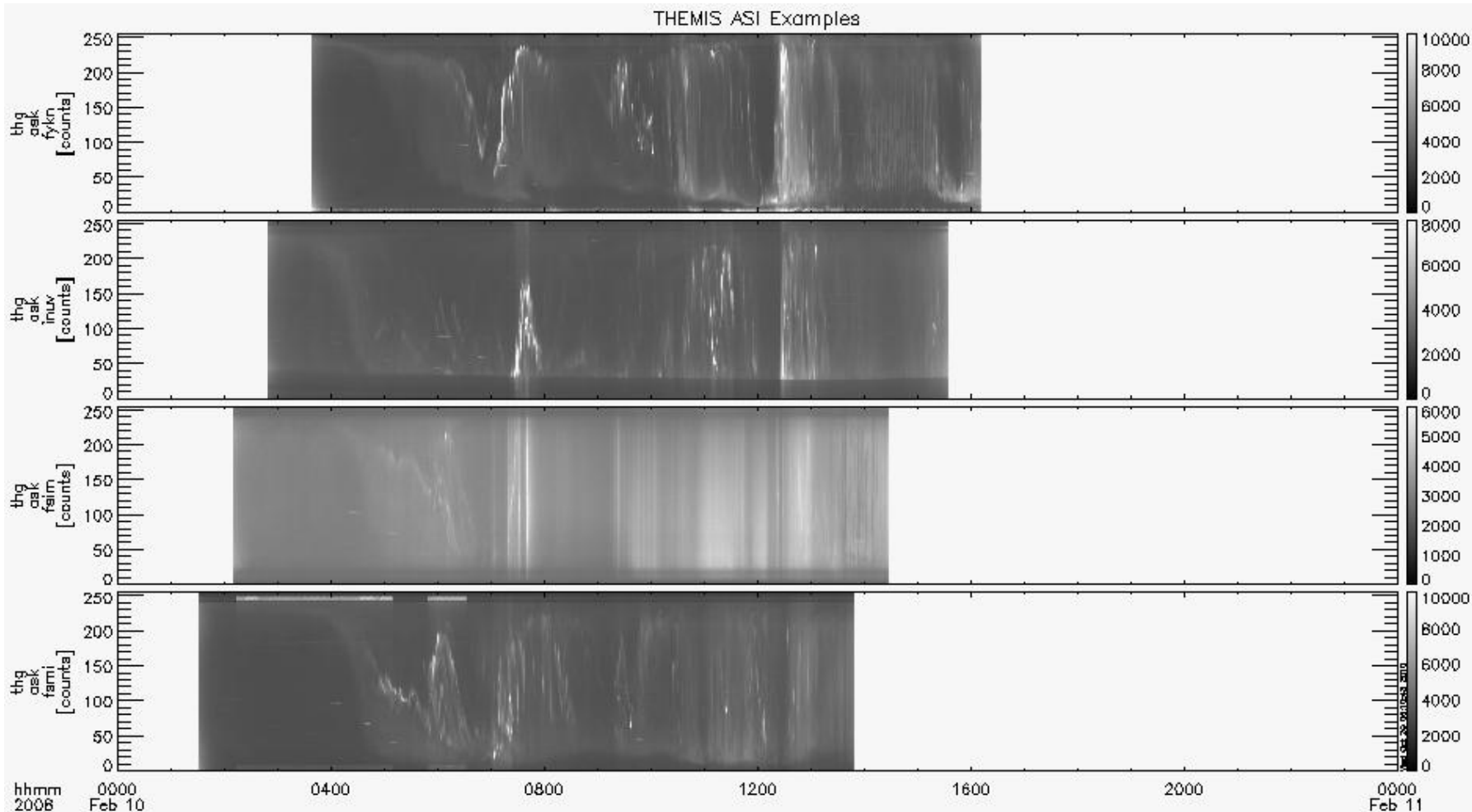


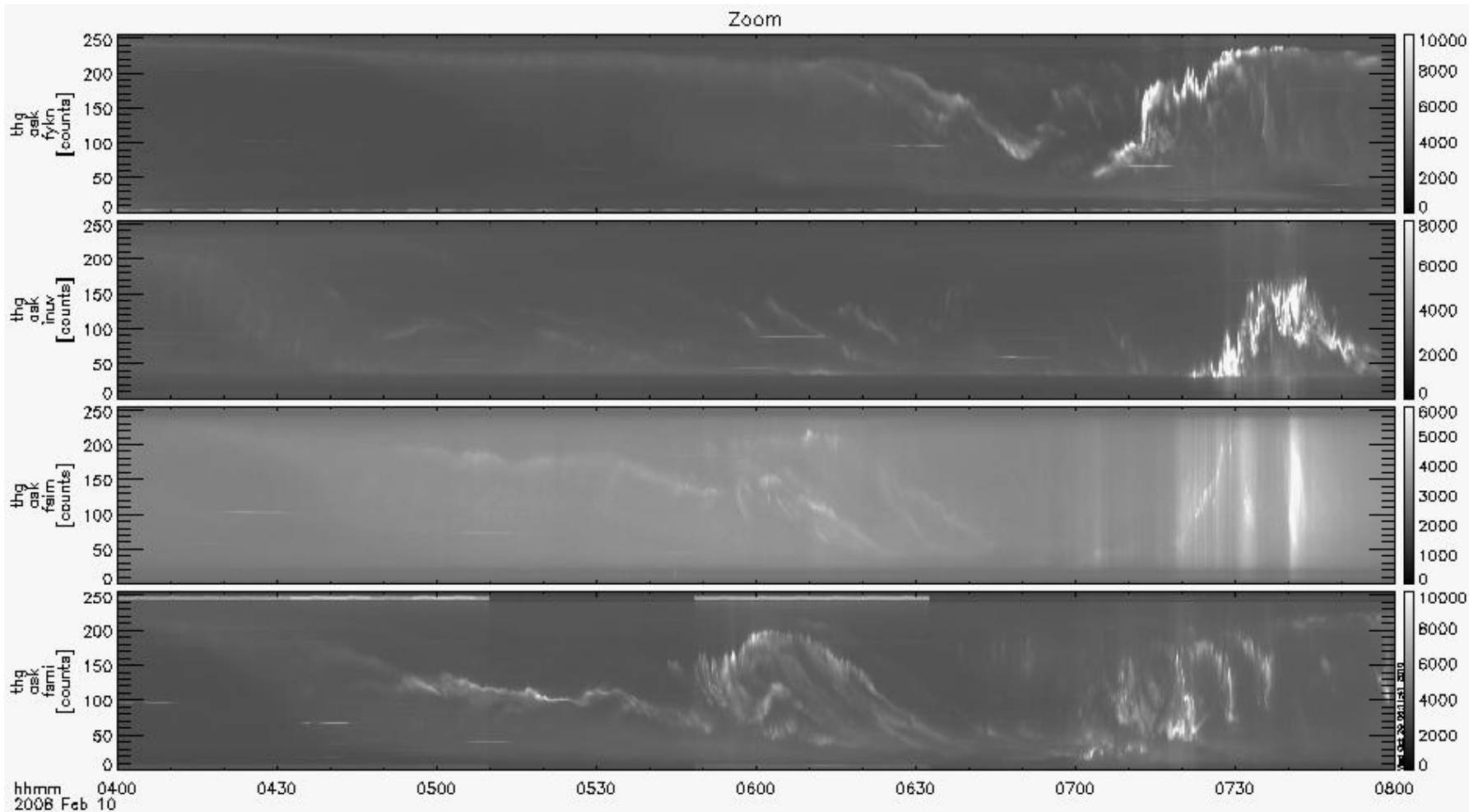


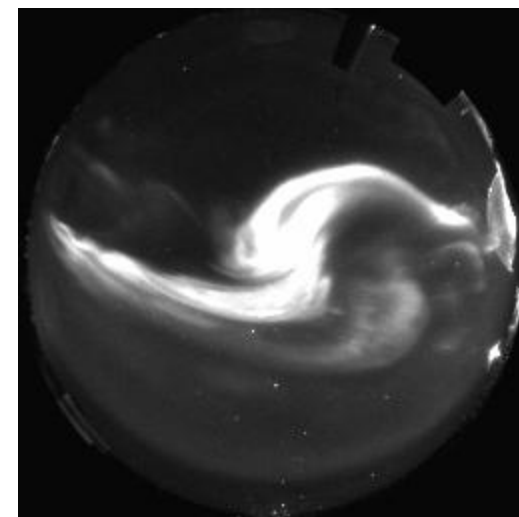
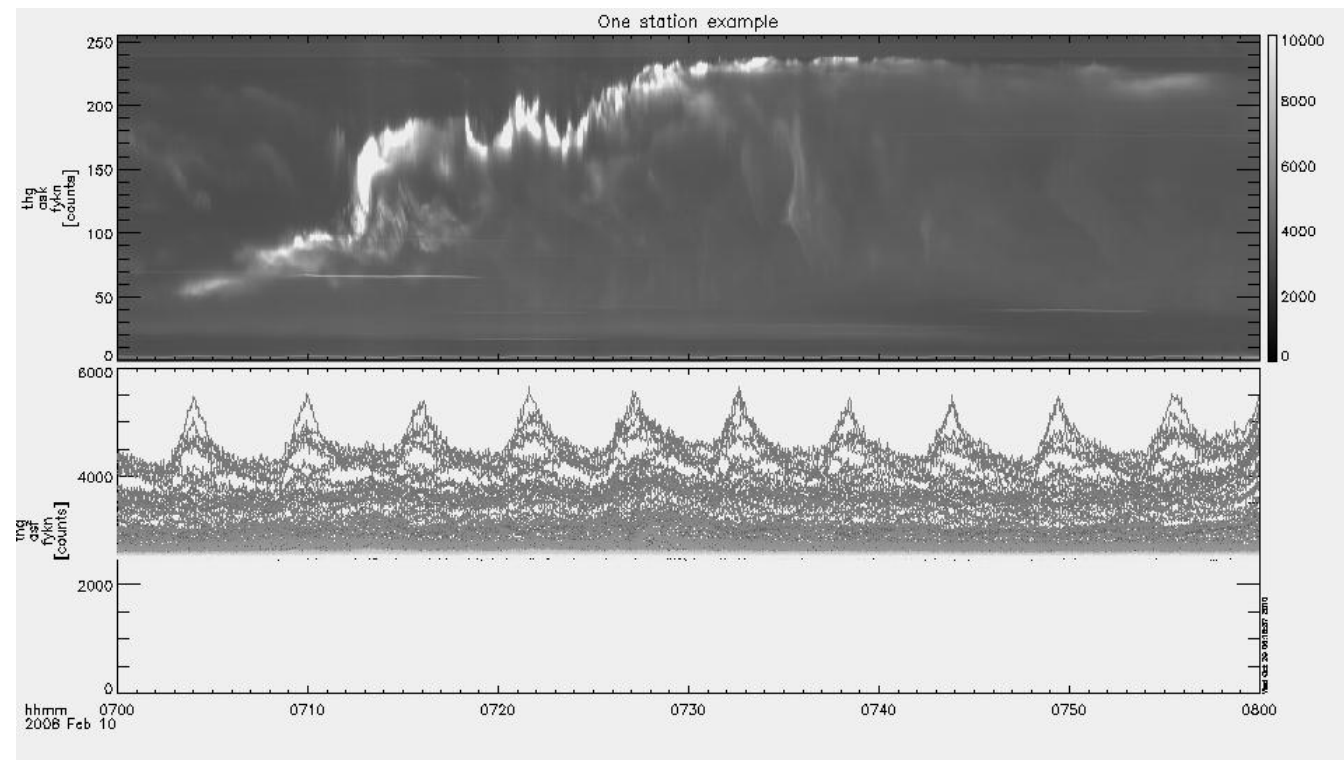
1. Keograms along local magnetic meridian
 - Delivered daily jpeg-compressed
 - Reprocessed $\frac{1}{2}$ year later with full resolution images
2. Geomagnetically mapped thumbnail images
 - Delivered daily using square-root intensity compression
 - 1024 pixels within $\pm 8^\circ$ magnetic Latitude and $\sim \pm 12^\circ$ Longitude
 - 3 seconds temporal resolution
3. Full resolution images
 - 256x256 pixels covering about 600 km radius around station
 - Delivered about $\frac{1}{2}$ year later
 - 3 seconds temporal resolution
 - Full 16 bit intensity scale



Daily overview of selected keograms

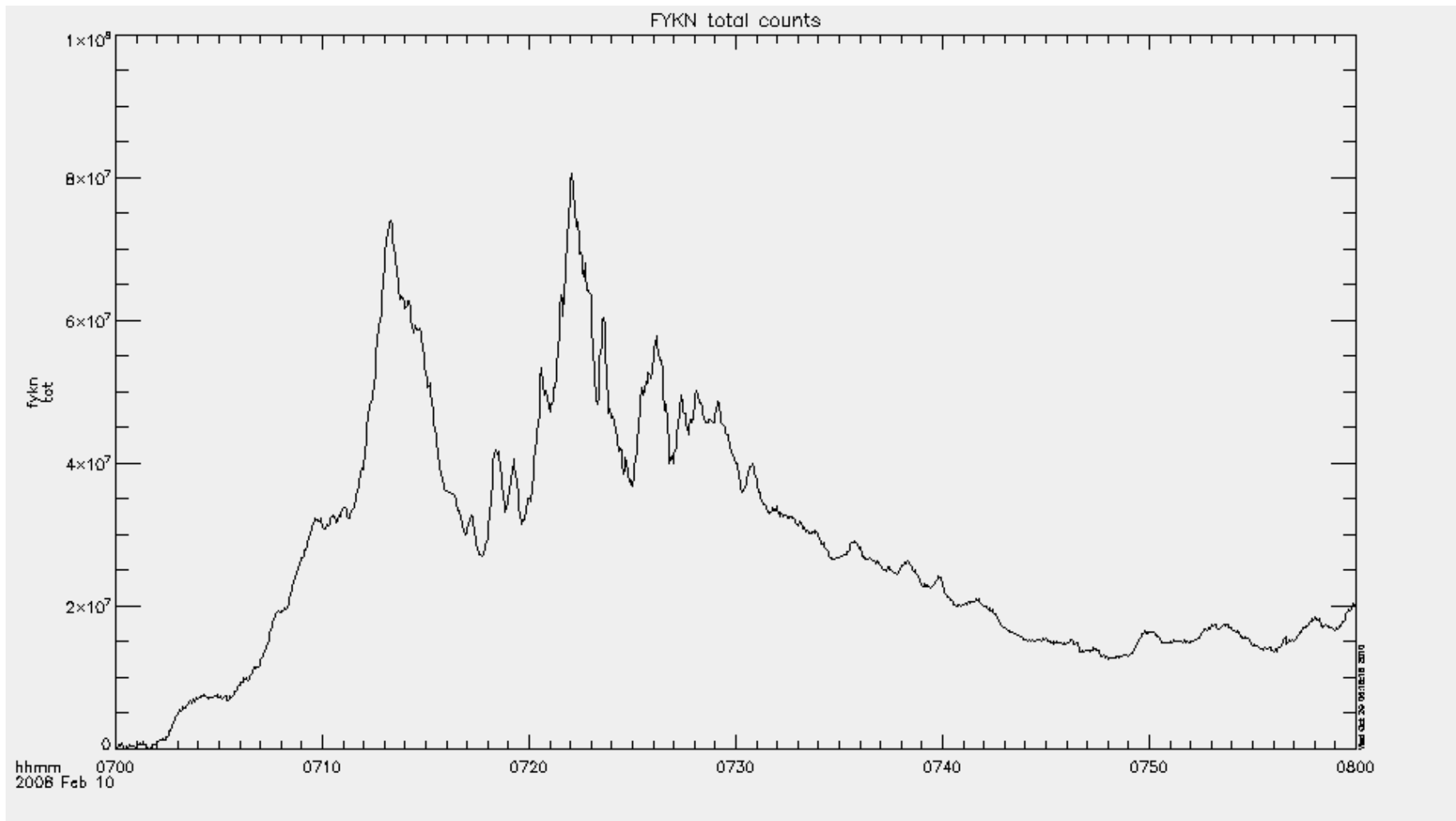


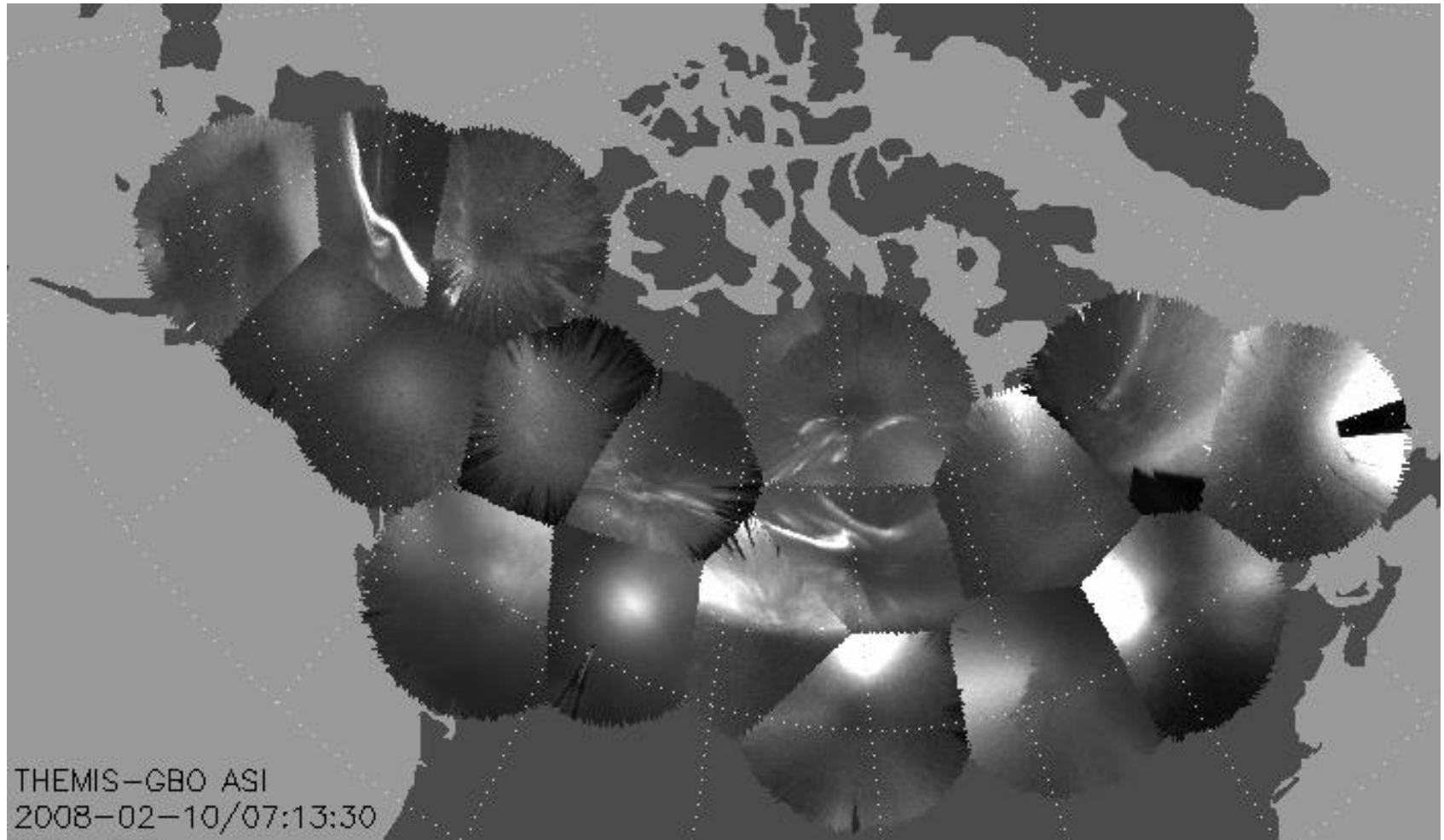


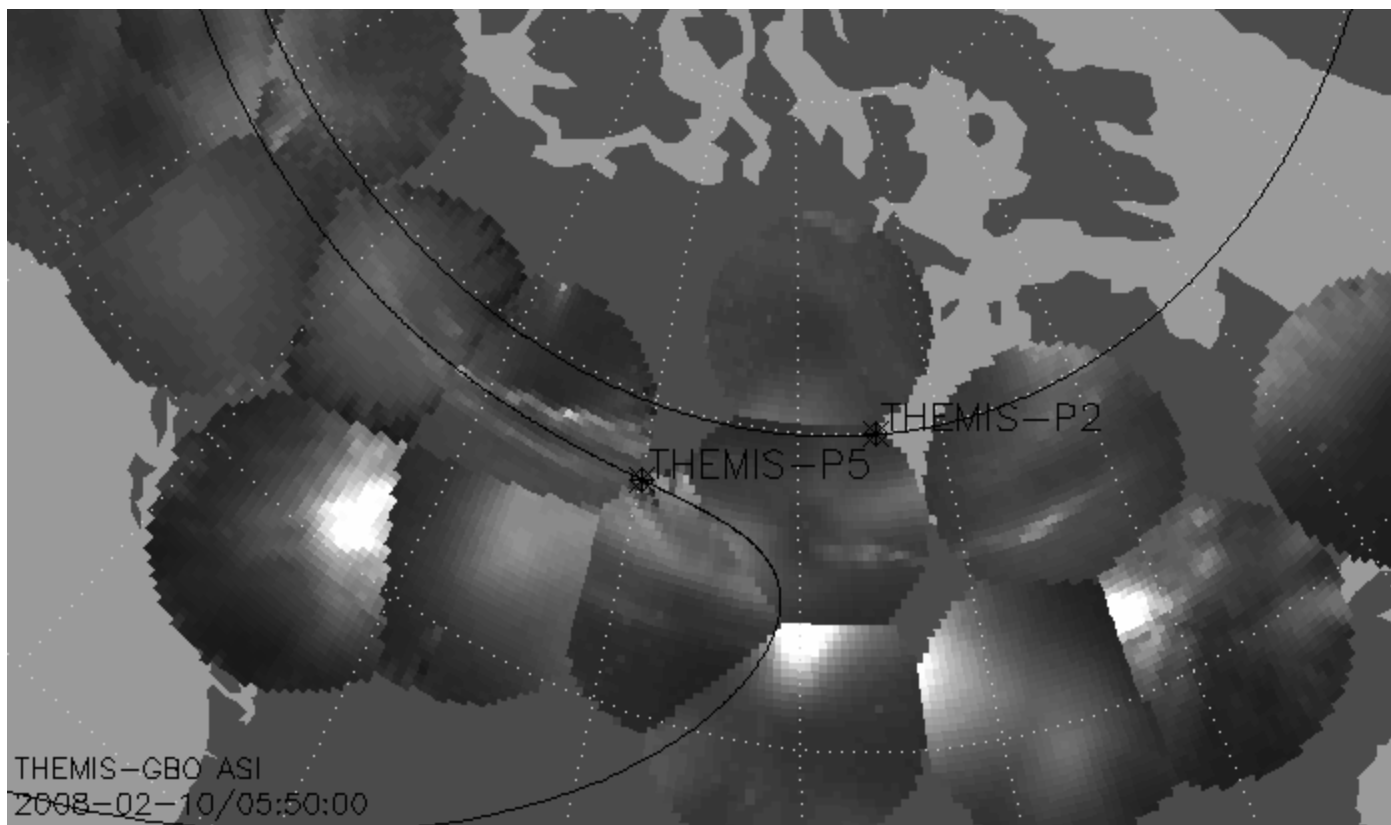




Total number of counts in images to see major increase (substorm onset)



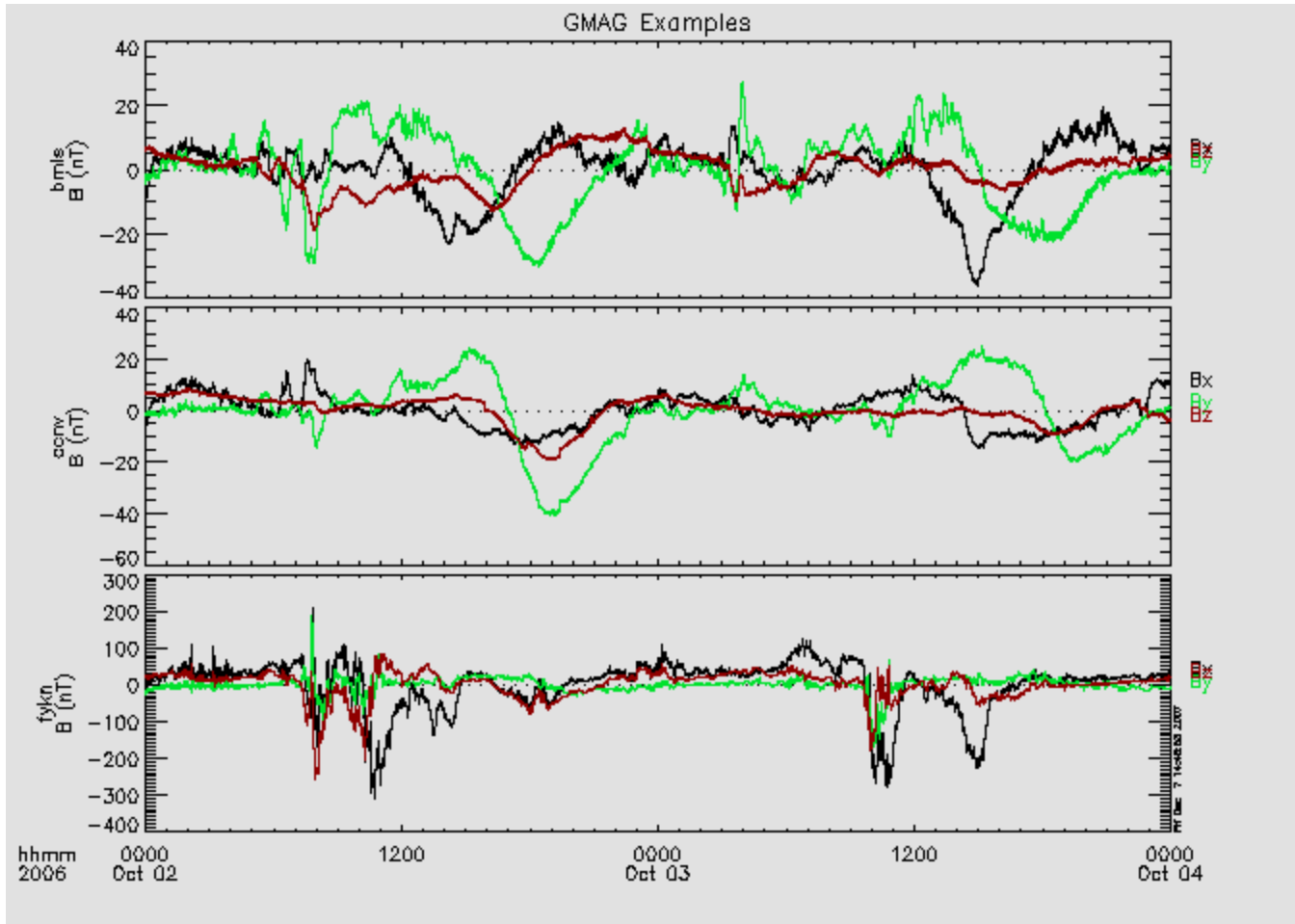




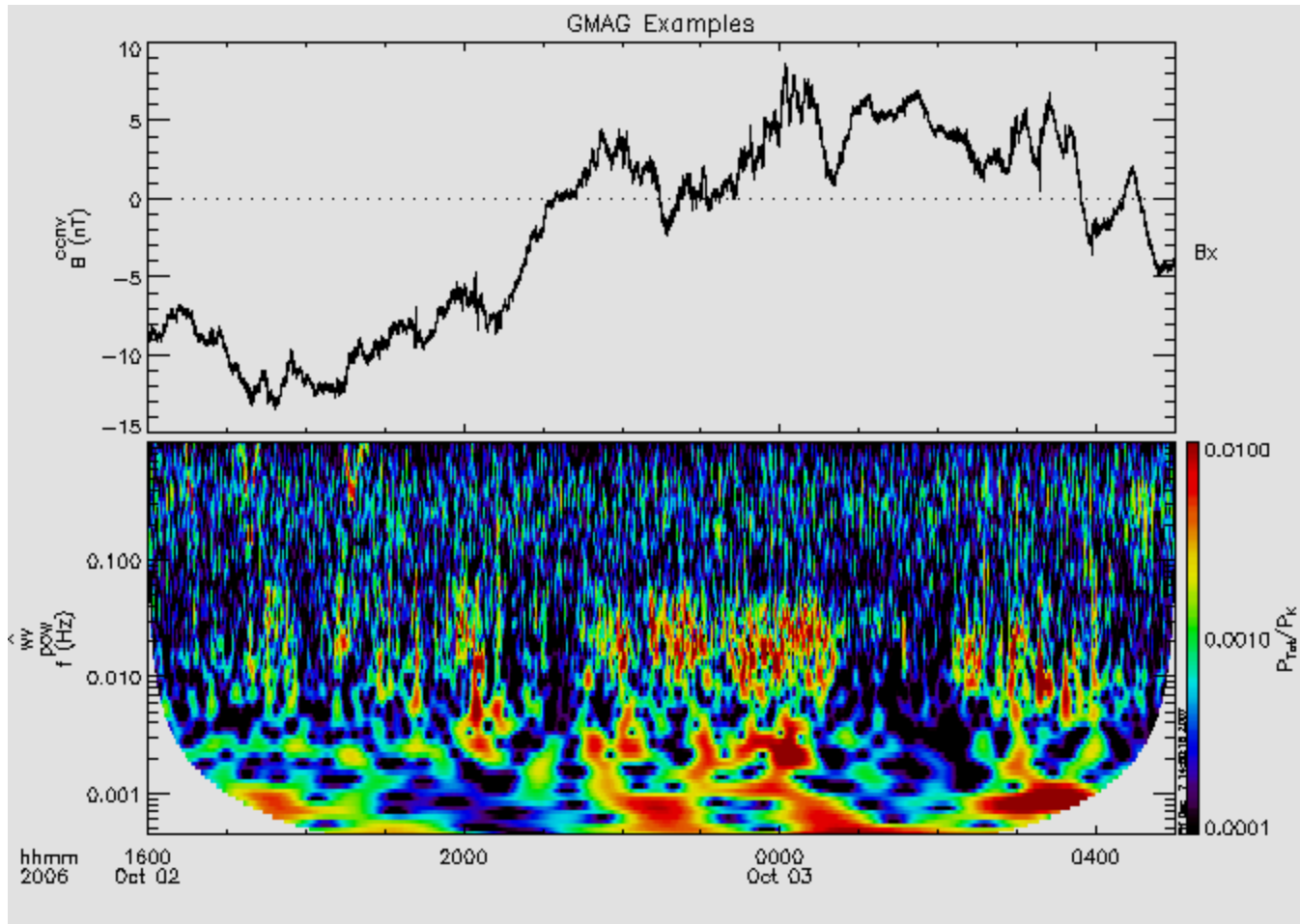
Black line marks footprint of THEMIS-P2 and P5 during whole night
Asterisk marks location at time of mosaic

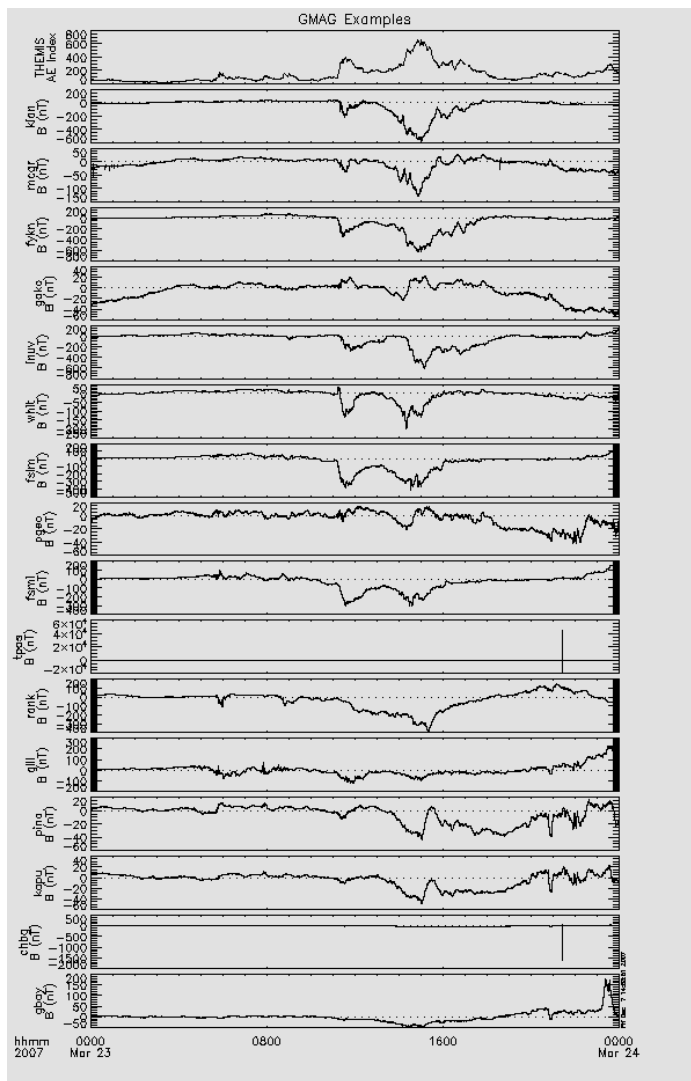
Ground magnetometer Examples

Thm_crib_gmag.pro



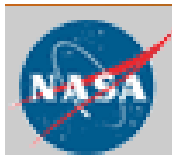
GMAG Data With Average Subtracted







Data and Orbits at SPDF



Space Physics Data Facility





CDF:

CDF V3.3.0 is in its final testing phase. It adds file validation and sanity checks while accessing CDF files. This addresses potential security vulnerabilities, e.g. data overflow in applications caused by compromised files. Additional functionality and performance improvements were made in the IDL and MATLAB library support. .

CDAWeb THEMIS Data:

May 7, 2009: THEMIS FGM dataset files being reprocessed at Berkeley and re-ingested into CDAWeb

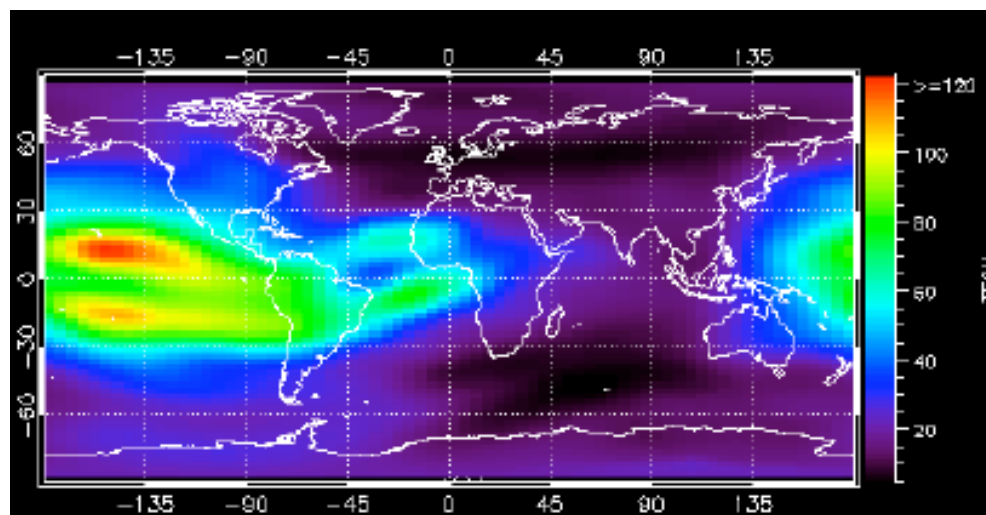
Sep 2008 - Jun 2009: Magnetometer data added from several additional ground stations for a total of now 44 stations from the GBO (31), GEONS (11), and GIMA (2) networks (most recent NAIN, CDRT and NRSQ).

CDAWeb THEMIS-related Data:

Eight new geomagnetic activity index variables added to the OMNI 1min and 5min datasets: AE, AL, AU, SYM/D, SYM/H, ASY/D, ASY/H, PC ; already available in OMNI-1hour: daily Rz and F10.7 , 3-hour Kp and ap, 1-hour Dst, AE, AL, AU, and PC

New on CDAWeb - Global images and movies of Total Electron Content (TEC) deduced from Global Positioning Satellites (GPS_TEC2HR_IGS) (1998 through present). Excellent data set for monitoring the global ionospheric response to magnetic storms.

Global GPS-TEC image showing the typical Equatorial Anomaly signature with crests on both sides of the magnetic equator.



Level-2 Data from all 5 Satellites for FGM, ESA, SST, FBK, FFT, & FIT data quantities.

Ground Magnetometer Data from 44 stations (31 GBO, 11 GEONS, 2 GIMA)

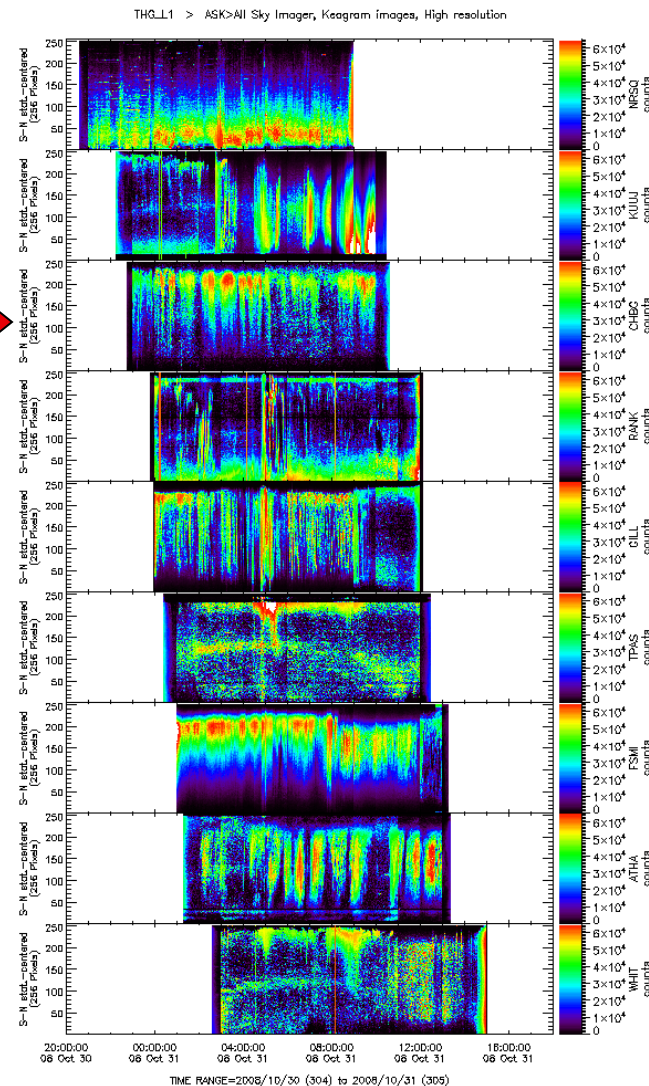
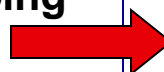
Keograms from 23 All-Sky-Imagers (ASI) going back to 2005.

All data updated daily (auto-ingest) from THEMIS data site.

GIF-Walk: pre-generated Magnetopause Crossing Survey plots (David Sibeck, NASA GSFC)

http://cdaweb.gsfc.nasa.gov/cgi-bin/gif_walk

State files with definitive orbits (bi-weekly updates) in all coordinate systems used in SSC and incl. magnetic traces. Very popular data set.



Common Data Format- CDF

CDF Version 3.2.2 release, fixes memory leak and Read Only mode problems, and includes some changes for the tool programs.

CDF Patch for Matlab

CDF Patch for IDL 6+ (strongly recommended)

CDF Java Network Launching Protocol latest development