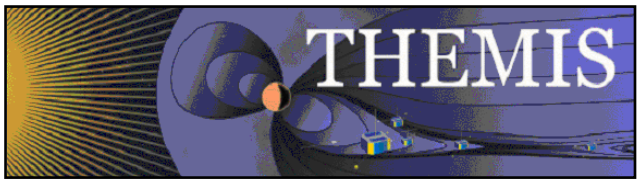


THEMIS
Science Data Analysis
Software User's Guide

THM-SOC-120
June 2009

Jim McTiernan, THEMIS Science Software Engineer

Jim Lewis, THEMIS Science Software Engineer

Pat Cruce, THEMIS Science Software Engineer

Brian Kerr, THEMIS Science Software Engineer

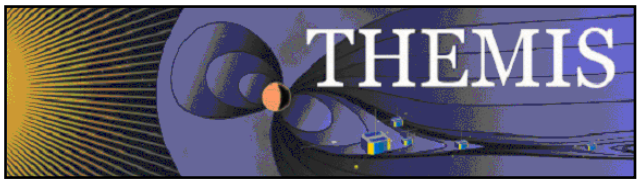
Michael Feuerstein, THEMIS Science Software Engineer

Cindy Goethel, THEMIS Science Software Engineer

Timothy Quinn, THEMIS Science Operations

David A. King, THEMIS Science Software Manager

Vassilis Angelopoulos, THEMIS Principal Investigator



Document Revision Record

Rev.	Date	Description of Change	Revised By
01	08/06/2007	v2.01 Incremental Changes	D. King
02	11/06/2007	v3.00 Release Changes	D. King / J. McTiernan / Andreas Keiling
03	11/19/2007	Replace Data Variable Description Tables	D. King / Andreas Keiling
04	05/2008	v4.00 Release Changes	Software Team
05	04/2009	V5.00 Release Changes	Software Team
06	06/2009	V5.1 Release Changes	Software Team

Distribution List

Name	Email
Dr. Davin Larson, UCB	davin@ssl.berkeley.edu
Dr. Tai Phan, U.C. Berkeley	phan@ssl.berkeley.edu
Dr. Forrest Mozer, UCB	fmozer@ssl.berkeley.edu
Dr. Robert Ergun, LASP	ree@fast.colorado.edu
Dr. Robert Lin, UCB	rlin@ssl.berkeley.edu
Dr. Chris Cully, LASP	cully@colorado.edu
Dr. John Bonnell, UCB	jbonnell@ssl.berkeley.edu
Dr. Charles Carlson, UCB	cwc@ssl.berkeley.edu
Dr. Krishan Khurana, UCLA	kkhurana@igpp.ucla.edu
Dr. Uli Auster, TUBS, Austria	uli.auster@tu-braunschweig.de
Dr. Alain Roux, CETP, France	Alain.roux@cetp.ipsl.fr
Dr. Jim McFadden, UCB	mcfadden@ssl.berkeley.edu
Dr. Manfred Bester, UCB	manfred@ssl.berkeley.edu
Dr. Steven Mende, UCB	mende@ssl.berkeley.edu
Dr. Harald Frey, UCB	hfrey@ssl.berkeley.edu
Dr. Karl-Heinz Glassmeier, TUBS, Germany	kh.glassmeier@tu-braunschweig.de
Dr. David Sibeck, NASA GSFC	david.g.sibeck@nasa.gov

TBD List

Identifier	Description

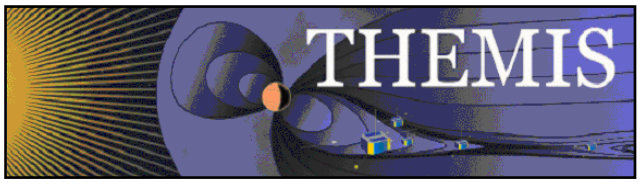


Table of Contents

DOCUMENT REVISION RECORD

DISTRIBUTION LIST

TBD LIST

1. INTRODUCTION
    1.1 Purpose and Scope
    1.2 Applicable Documents

2. THEMIS WEB DATAAND SOFTWARE INTERFACE
    2.1 THEMIS Web Site - Home Page
    2.2 THEMIS Data Web Pages
    2.3 THEMIS Software Web Page
    2.4 THEMIS Software - For Developers Web Page
    2.5 THEMIS Contact Us Web Page

3. THEMIS SCIENCE SUPPORT HELP SYSTEM
    3.1 THEMIS Science Support Help Process
    3.2 THEMIS Science Support Help Form
    3.3 THEMIS Science Support Help Form - GUI Text Form
    3.4 Help Form Location - GUI Message Window
    3.5 Saved History Location - GUI Message Window

4. THEMIS DATA
    4.1 THEMIS Data Overview
    4.2 THEMIS Data Quantity Summary

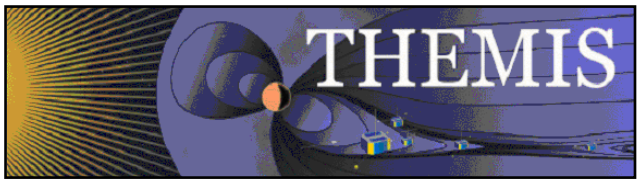
5. THEMIS DATA ANALYSIS SOFTWARE
    5.1 System Requirements
    5.2 Known Limitations
    5.3 Installation and Configuration
        5.3.1 IDL Path Setup
            5.3.1.1 IDL PATH Setup on Windows (and IDLDE on UNIX, Linux and Mac)
            5.3.1.2 IDL PATH Setup for IDL Command Line (UNIX, Linux or Mac OS X)
        5.3.2 Data Directory Set-up
    5.4 How to Get Started
        5.4.1 Crib Sheets in idl/themis/examples
        5.4.2 IDL Documentation for TDAS

5.5 Software Functions
5.5.1 Loading THEMIS Data
5.5.2 General Conventions: variable name construction and reference
5.5.3 Plotting the Data
5.5.3.1 Plotting with Tplot
5.5.3.2 Plotting with Plotxy
5.5.3.3 Plotting with Plotxyz
5.5.3.4 Plotting Angular Spectra
5.5.3.5 Removing SST Contaimination
5.5.3.6 Overlaying Spectrograms
5..5.4 Calibrations and Beyond
5.5.5 Geophysical Coordinate Transformations
5.5.6 Analystical Coordinate Transformations
5.6.1.1 Field Aligned Coordinate Transformations
5.6.1.2 Minimum Variance Transformations
5.5.7 Tsyganenko Model
5.5.7.1 Introduction
5.5.7.2 Installation
5.5.7.3 Model Routines
5.5.7.4 Trace Routines
5.5.8 Mini Language
5.5.9 Data Export
5.5.10 Configuring Local Data Cacheand Remote Access Behaviour
5.5.10.1 Configuration at Startup
5.5.10.2 On-the-fly Configuration
5.5.10.3 Note for users who connect using aweb proxy server
5.5.11 Managing your Data Cache
5.5.12 Define the root_data_dir for other ancilliary (non-THEMIS) data
5.6 Software Organization

6. GRAPHICAL USER INTERFACE (GUI)
6.1 Main Window Overview
6.1.1 Pull Down Menus
6.1.2 Toolbar Icons
6.1.3 Graph Area
6.1.4 Status Bar
6.1.5 Buttons
6.1.6 Windows
6.1.7 Pages
6.1.8 Panels
6.1.9 Color Palette
6.1.10 Data Tree
6.2 Mouse and Keyboard Events
6.2.1 Tracking
6.2.2 Legend
6.2.3 Mouse Clicks
6.2.4 Keyboard Events
6.2.5 Markers
6.2.6 Data Zoom

6.2.7 Page Zoom
6.3 File Menu
6.3.1 Open THEMIS Document
6.3.2 Save THEMIS Document
6.3.3 Save AS
6.3.4 Close Page
6.3.5 Load THEMIS Data
6.3.6 Save Data As
6.3.7 Manage Data and Import/Export TPlot
6.3.8 Export Image to File
6.3.9 Print
6.3.10 Print Setup
6.3.11 Properties
6.3.12 Generate THEMIS Overview Plot
6.3.13 Exit
6.4 Edit Menu
6.4.1 Copy
6.4.2 Delete Marker
6.4.3 Subset
6.5 View Menu
6.5.1 Refresh
6.5.2 Scroll Forward/Backward
6.5.3 Expand/Reduce
6.5.4 History Window
6.5.5 Legend
6.5.6 Status Bar
6.6 Graph Menu
6.6.1 Panel Tracking
6.6.2 Track One Panel
6.6.3 Track All
6.6.4 Show Vertical Tracking
6.6.5 Plot/Layout Options
6.6.5.1 Line Options
6.6.6 Page Options
6.6.7 Panel Options
6.6.8 X/Y Axis Options
6.6.9 Z Axis Options
6.6.10 Variable Options
6.7 Analysis Menu
6.7.1 Calculate
6.7.2 Nudge
6.7.3 Data Processing
6.7.3.1 Subtract Average
6.7.3.2 Subtract Median
6.7.3.3 Smooth Data
6.7.3.4 High Pass Filter
6.7.3.5 Block Average
6.7.3.6 Clip

6.7.3.7 Deflag
6.7.3.8 Degap
6.7.3.9 Clean Spikes
6.7.3.10 Time Derivative
6.7.3.11 Wavelet Transform
6.7.3.12 Dpwrspec
6.7.3.13 Coordinate Transform
6.7.3.14 Particle Spectra
6.8 Page Menu
6.8.1 New
6.8.2 Close
6.8.3 Pages
6.9 Help Menu
6.9.1 Help Window
6.9.2 Help Request Form
6.10 TPlot
6.10.1 Import/Export
6.10.2 tplot_gui
6.11 Platform Depencies
6.11.1 Linux



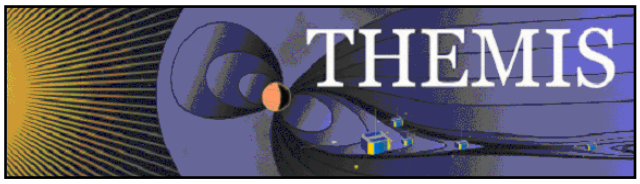
1. Introduction

1.1 Purpose and Scope.

The purpose of this document is to present to the worldwide scientific community what tools are available for viewing, downloading, processing, calibrating and plotting THEMIS data and how to use these tools.

1.2 Applicable Documents.

1.	THM_SYS_012_PDMP	THEMIS Project Data Management Plan
2.	THM_SOC_101_TIME	THEMIS TIME Definition
3.	THM_SOC_103_HKP_VARNAMES	THEMIS Housekeeping L1 Variable Name Def's
4.	THM_SOC_105_FIELDS_VARNAMES	THEMIS Fields Variable Names Definitions
5.	THM_SOC_108_GMAG_L1_VARNAMES	THEMIS GMAG Variable Name Definitions
6.	THM_SOC_110_COORDINATES	THEMIS Coordinate Systems Definitions
7.	THM_SOC_111_SUNSENSPROC	THEMIS SUN SENSOR Science Processing
8.	THM_SOC_112_ATTPAIPROC	THEMIS Science ATT & Inertia Determ.
9.	THM_SOC_113_FGM_CALPROC	THEMIS FGM CAL File and Processing
10.	THM_SOC_114_SCM_CALPROC	THEMIS SCM CAL File and Processing
11.	THM_SOC_115_EFI_CALPROC	THEMIS EFI CAL File and Processing
12.	THM_SOC_116_ESA_CALPROC	THEMIS ESA CAL File and Processing
13.	THM_SOC_117_SST_CALPROC	THEMIS SST CAL File and Processing
14.	SAI-SPEC_1079A (Oct. 26, 2005)	THEMIS Coordinate Systems
15.	SAI-RPR-0722a (September, 2006)	Probe Alignment Report (MSSS data, p18)
16.	pturin e-mail on Faro alignment results (9/28/06)	FGM, SCM mag alignments
17.	THM-MB-005-Magnetometer clocking r7.pdf	MAG clocking angles



2. THEMIS Web Page Interface

2.1 THEMIS Web Site - Home Page

The THEMIS Home Web Page can be displayed by using the following URL: http://themis.ssl.berkeley.edu/.
Across the top portion of this web page are a series of drop down menus (Home, The Mission, Data, Software, Publications, News & Events, Contact Us and For the Public). In this document we will be discussing only the Data, Software and Contact Us Web Pages.

The THEMIS Data Drop Down Menu allows you to select the following options: *Overview, Usage Rules, Summary Plots, Data Retrieval, Data Descriptions, Event List and Data Processing Status*. These options will be discussed in more detail in Section 2.2.

The THEMIS Software Drop Down Menu allows you to Select the following options: *Software, Developers* and *Documentation*. These options will be discussed in more detail in Section 2.3.

The THEMIS Contact Us will automatically link you to a web page that will allow you to send emails to the THEMIS PI or THEMIS Instrument Scientists or send a Help Request to the THEMIS Science Support Team with Comments, Observations, Problems or Questions concerning data, a document, download, GUI, Plot, Software, Web Interface or any other issue not listed.
This Help Request option will be discussed in more detail in Section 2.4.

Please note: Differences between the screen displays presented in this document and what you may see online are due to Web Page Upgrades not yet reflected in this document. The screen displays incorporated into this document are to give the reader a sense of the functionality of the Web Interface to THEMIS Science Software.

Please see copy of the Themis Home Web Page on the Next Page.

THEMIS Web Site - Home Page

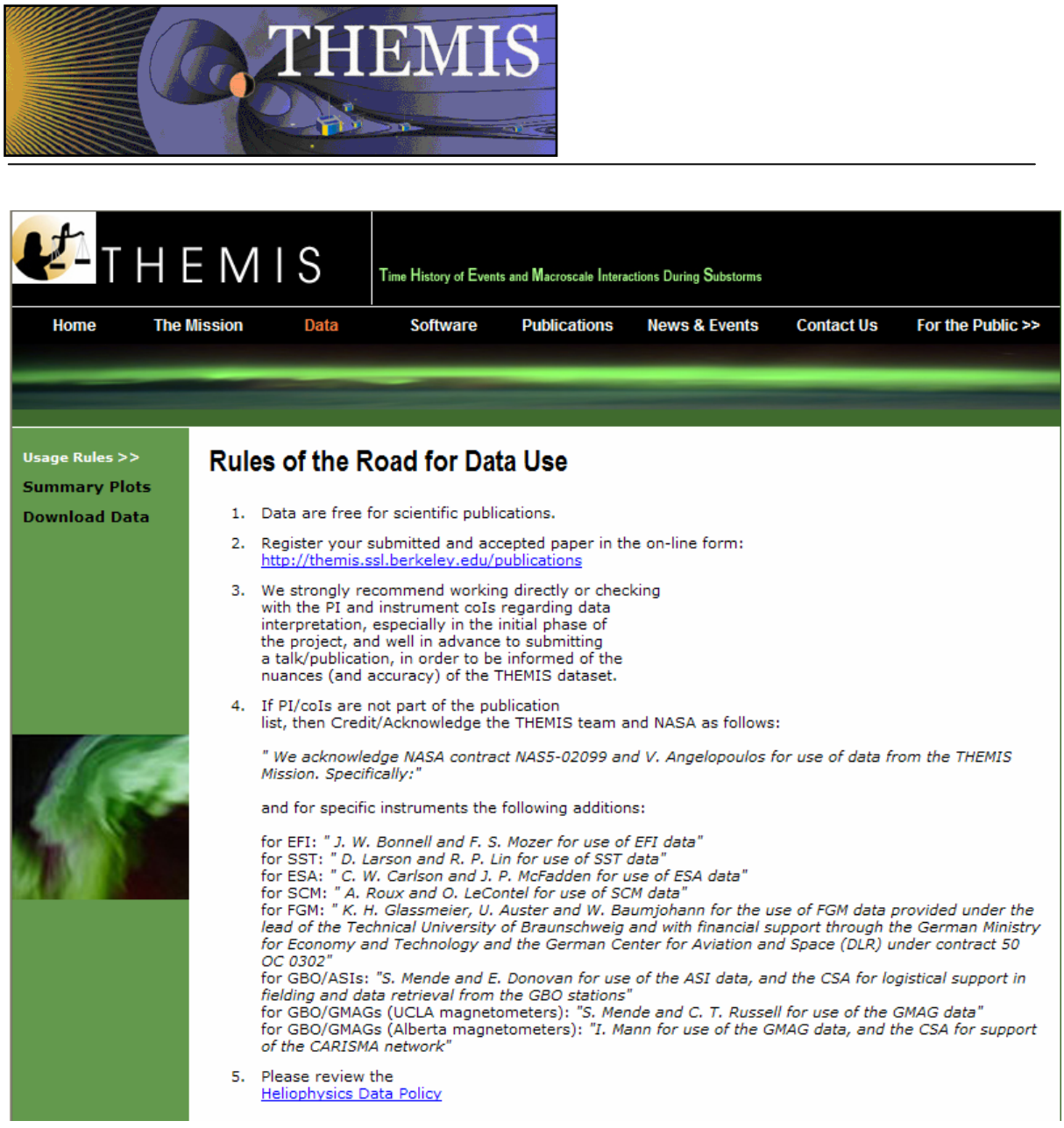
2.2 THEMIS Data Web Pages

The THEMIS Data Drop Down Menu has seven Options.

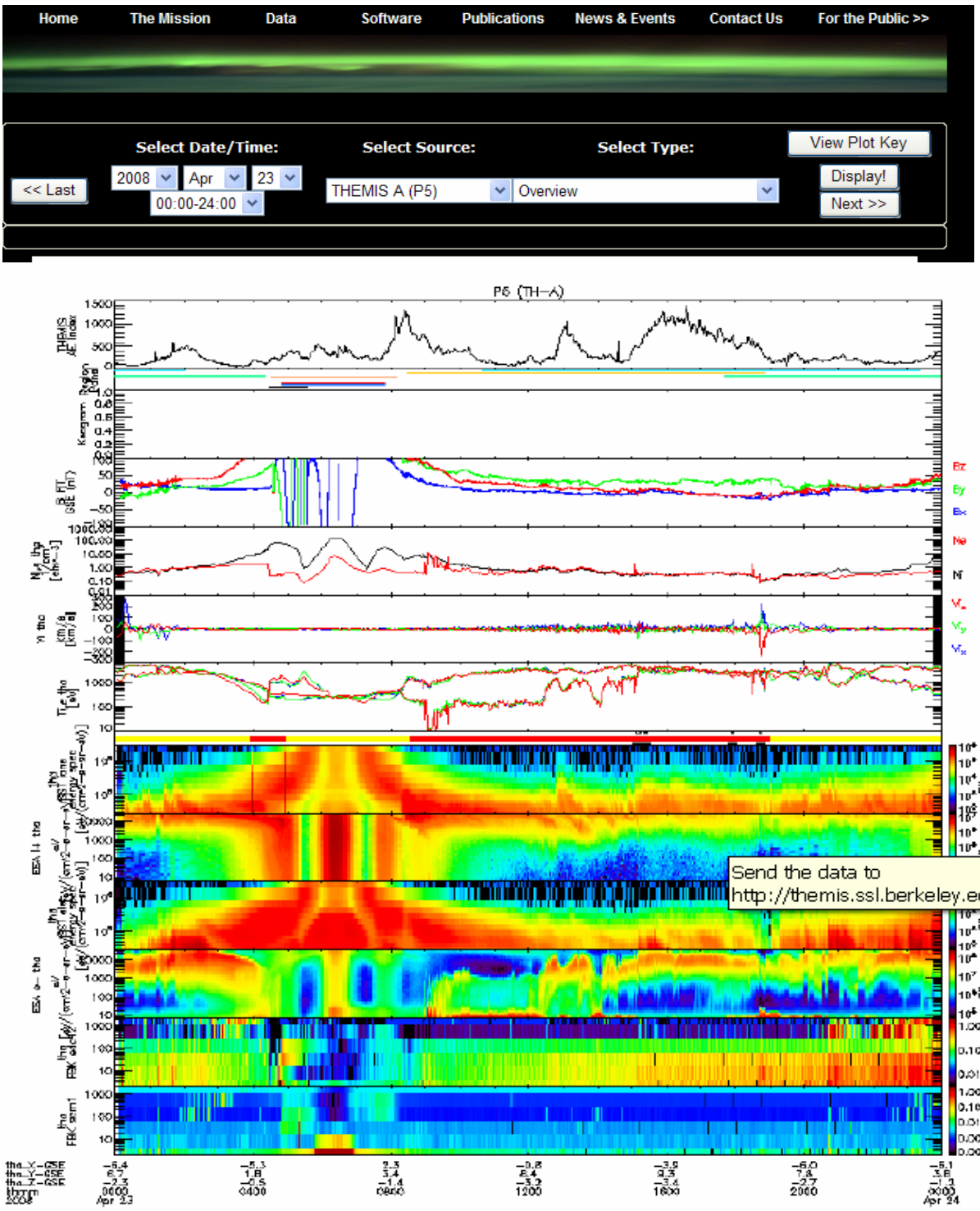
- *Overview* - A Data Overview and convenient location to Instruments, Orbits, Data Descriptions and more.
- *Usage Rules* - displays the Rules for using the THEMIS Data website (Rules of the Road).
- *Summary Plots* which will allow you to look at Summary Plots of one Probe, Multiple Probes, Ground Magnetometer, All Sky Imager or Orbits Data. *Download Data* to Download THEMIS Data.
- *Data Retrieval* - Menu of the following options:
  Data Files All -ftp site of all themis data directories and data files
  Data Files By Platform - allows selection to either a probe, gmag or flatsat data files
  Data Files By Group - allows selection by Probe and Instrument
- *Data Descriptions* - which will lead you to the documentation ftp site where the 'Science Data Variable Descriptions' document can be found.
- *Event List* which will display the Events ftp site.

Please note: If using THEMIS Science Software Data Analysis Tools there is no need to use the Data Retrieval - Data Files By Group Option. Please see screen displays below for all options.

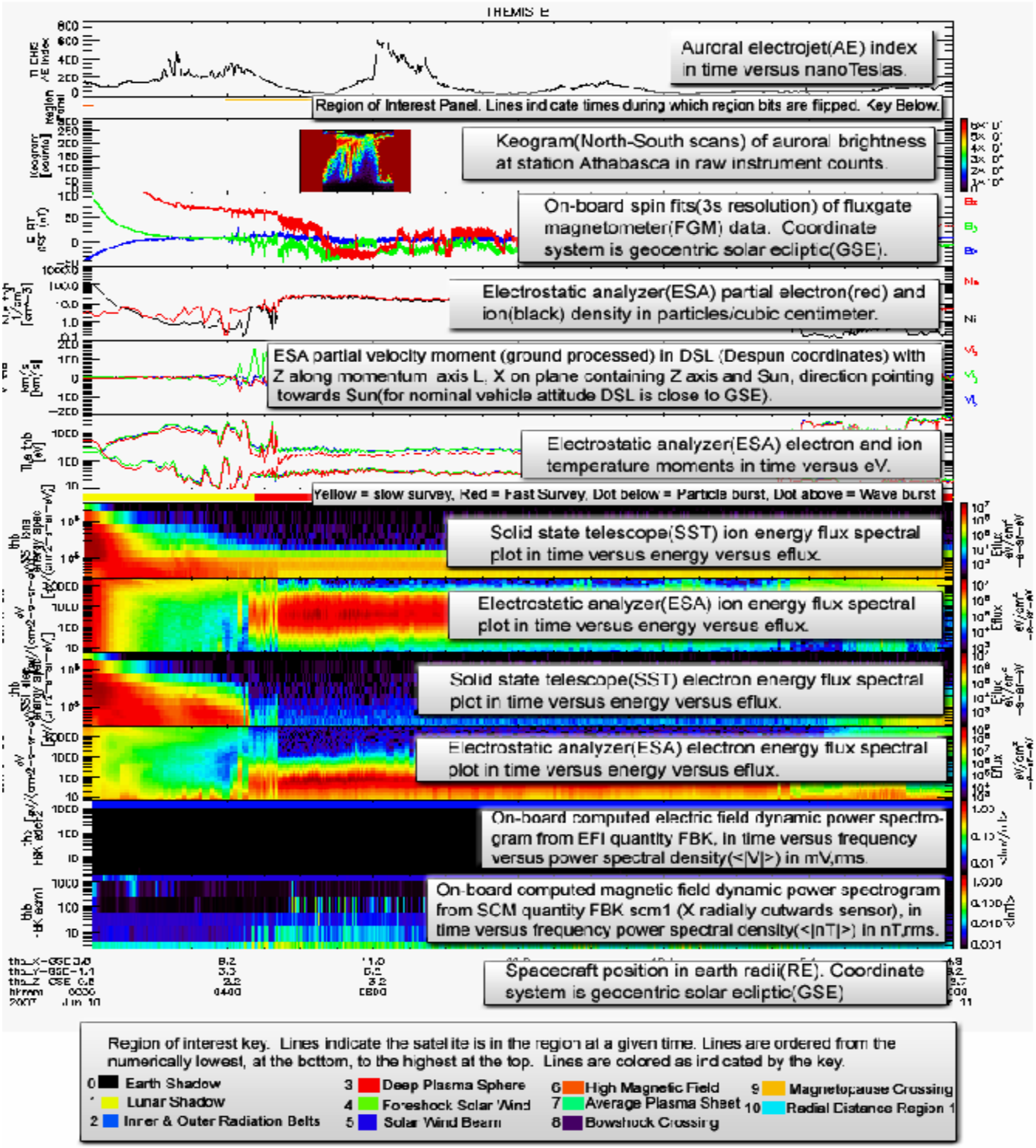
THEMIS Data Dropdown Menu



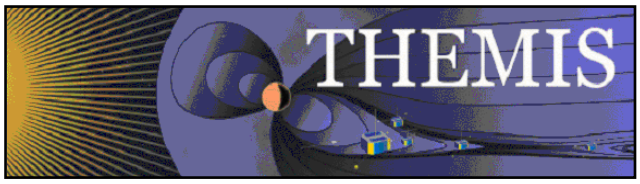
THEMIS Data Usage Rules Web Page



THEMIS Data Summary Plot Web Page



THEMIS Summary Web Page - View Plot Key Button

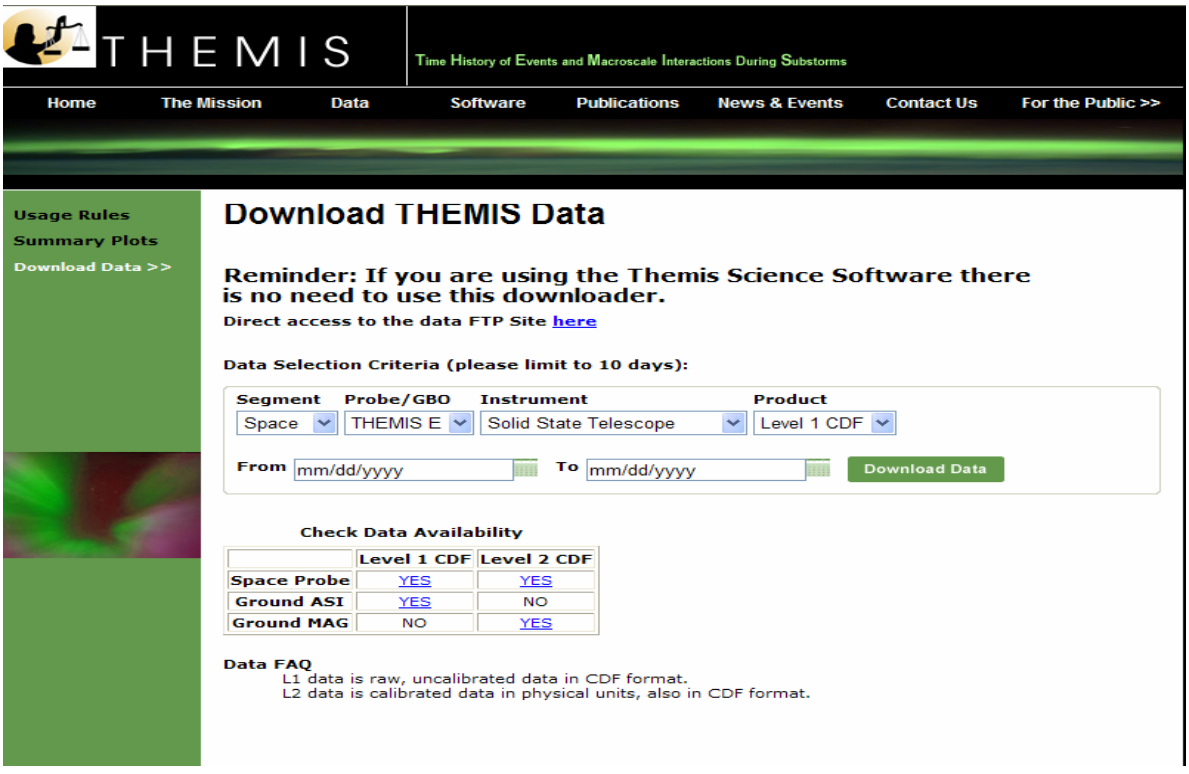


Index of /data/themis

Name	Last modified	Size	Description
Parent Directory		-	
FAST_Images/	04-Feb-2009 12:04	-	
LZP/	03-May-2007 09:53	-	
backup_apr16/	16-Apr-2008 16:36	-	
bad_files	21-Mar-2008 17:29	48K	
bfds/	26-Mar-2007 11:27	-	
cronwatch/	10-Jul-2008 10:18	-	
despike_preserve/	08-Jul-2008 15:11	-	
ephem/	16-Jul-2008 17:16	-	
events/	27-Jan-2009 22:08	-	
idl_ctables/	30-Jul-2007 23:27	-	
incoming/	21-Nov-2008 15:30	-	
index.html.091508	08-Aug-2008 16:27	1.3K	
int_rebuild_7feb07/	03-Feb-2007 05:35	-	
l0/	03-Apr-2008 16:54	-	
l1_reprocess_backup_20081020/	20-Oct-2008 20:26	-	
l2_offline/	25-Apr-2008 12:16	-	
moc/	09-Apr-2007 16:59	-	
nios/	05-Mar-2007 10:55	-	
old_production/	09-Jun-2008 10:39	-	
overplots/	31-Dec-2008 23:43	-	
process_logs/	04-Feb-2009 13:38	-	
qa/	16-Jul-2008 11:55	-	

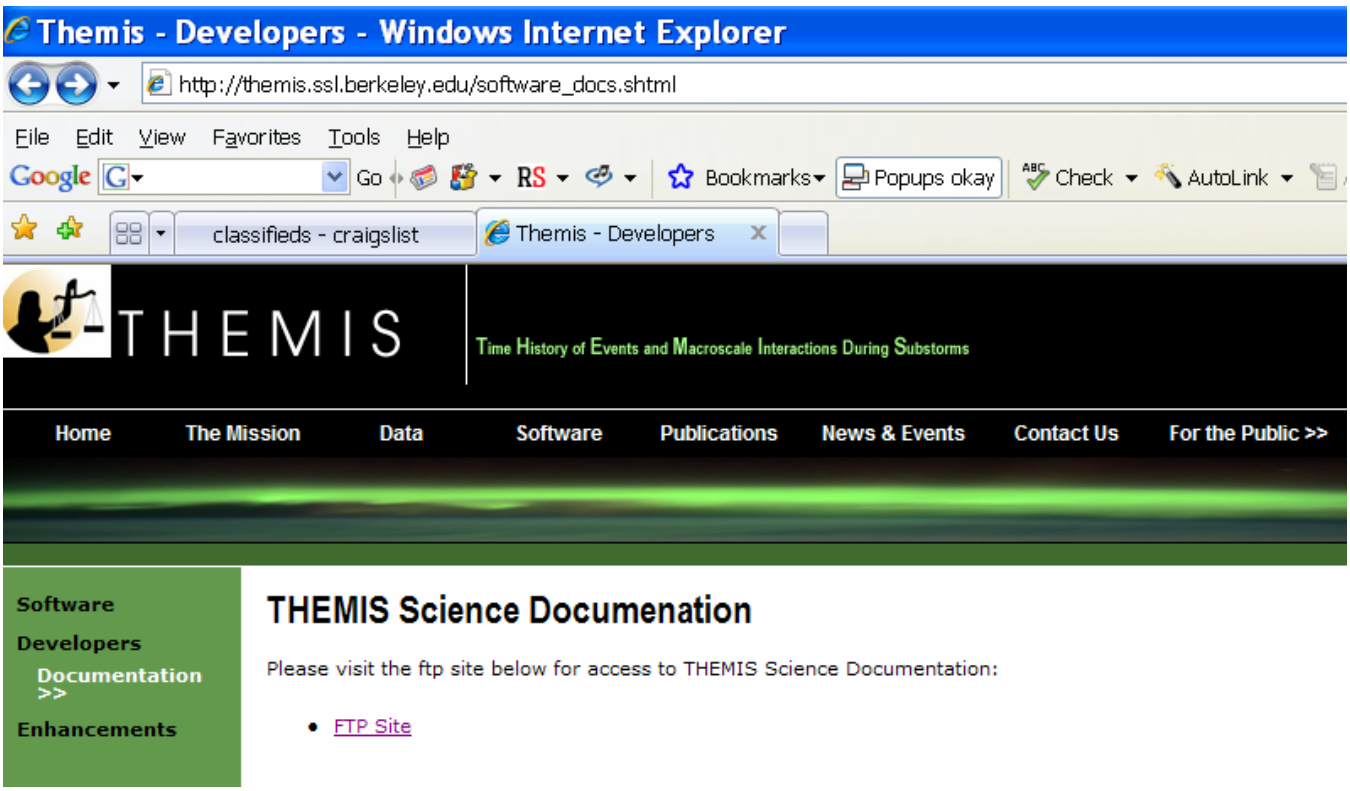
THEMIS Data Retrieval - ALL

THEMIS Data Retrieval - By Platform

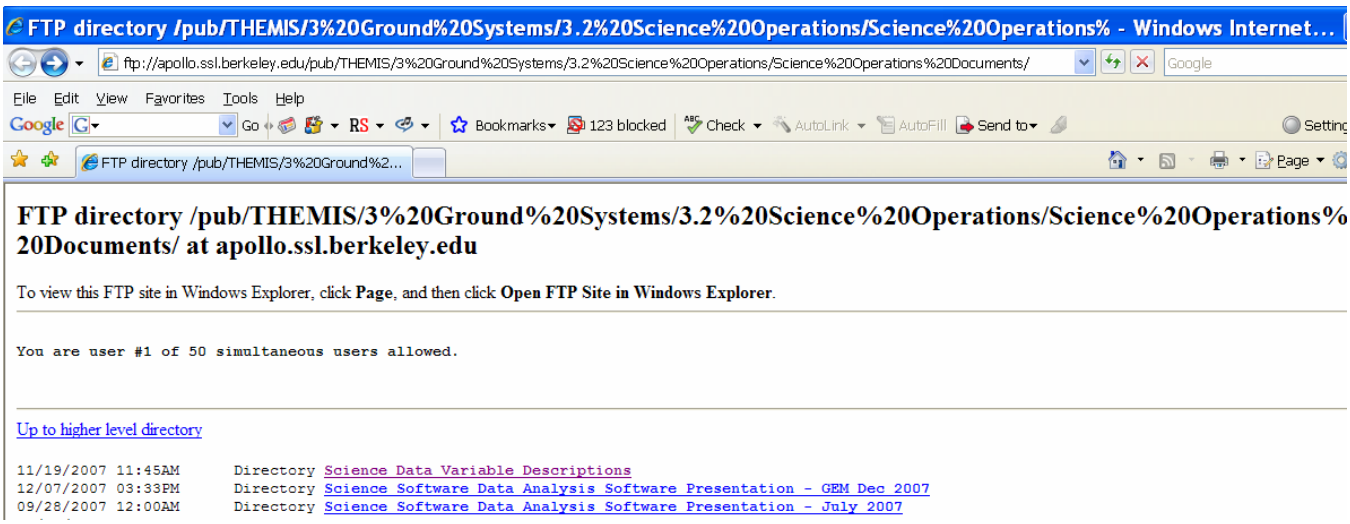


THEMIS Data Retrieval - By Group

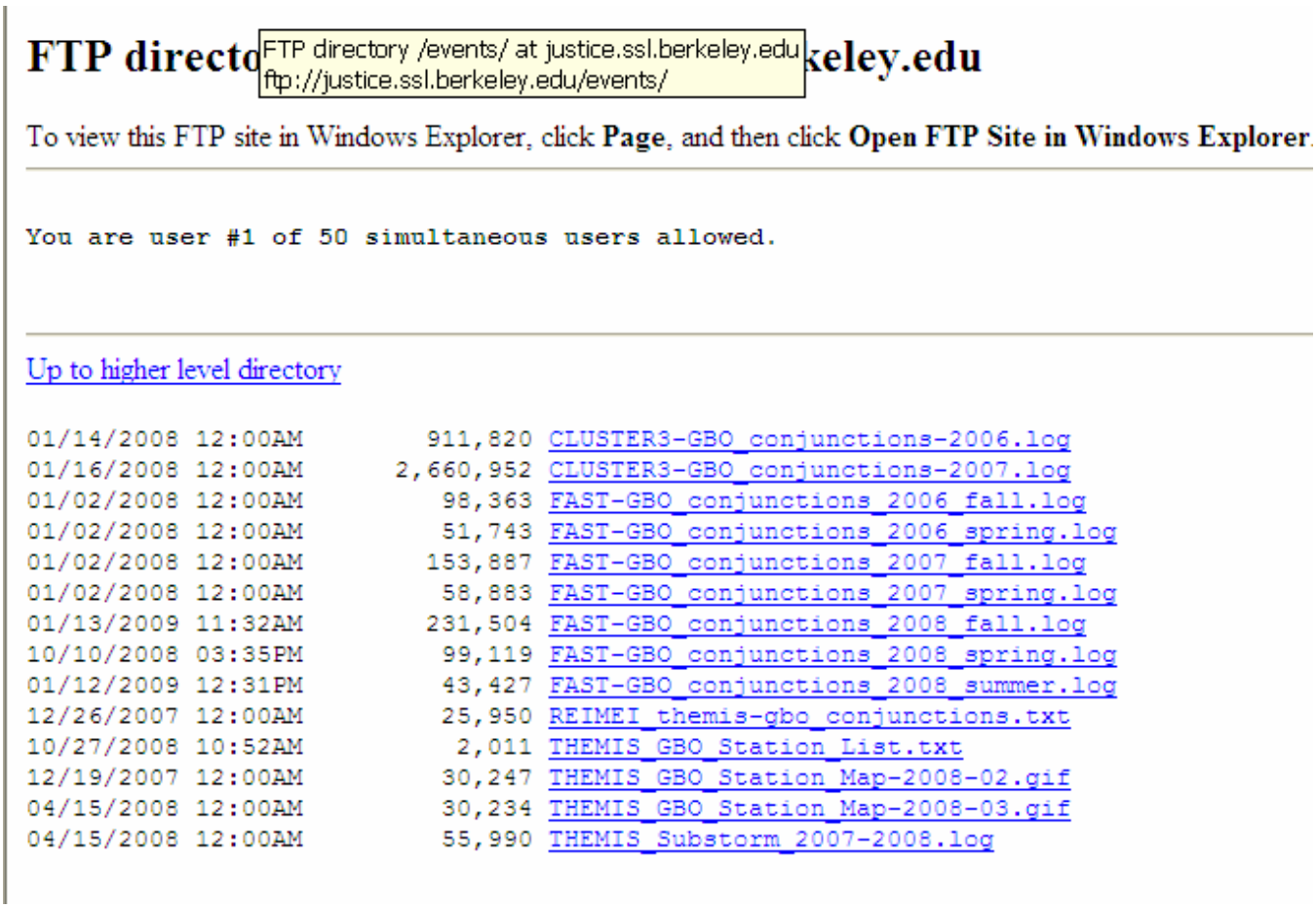
Selecting Data Descriptions will display this web page and then click on ftp



Will display a list of documents on the ftp site - Click on Science_Data_Variable_Descriptions and then choose the .xls or .pdf version



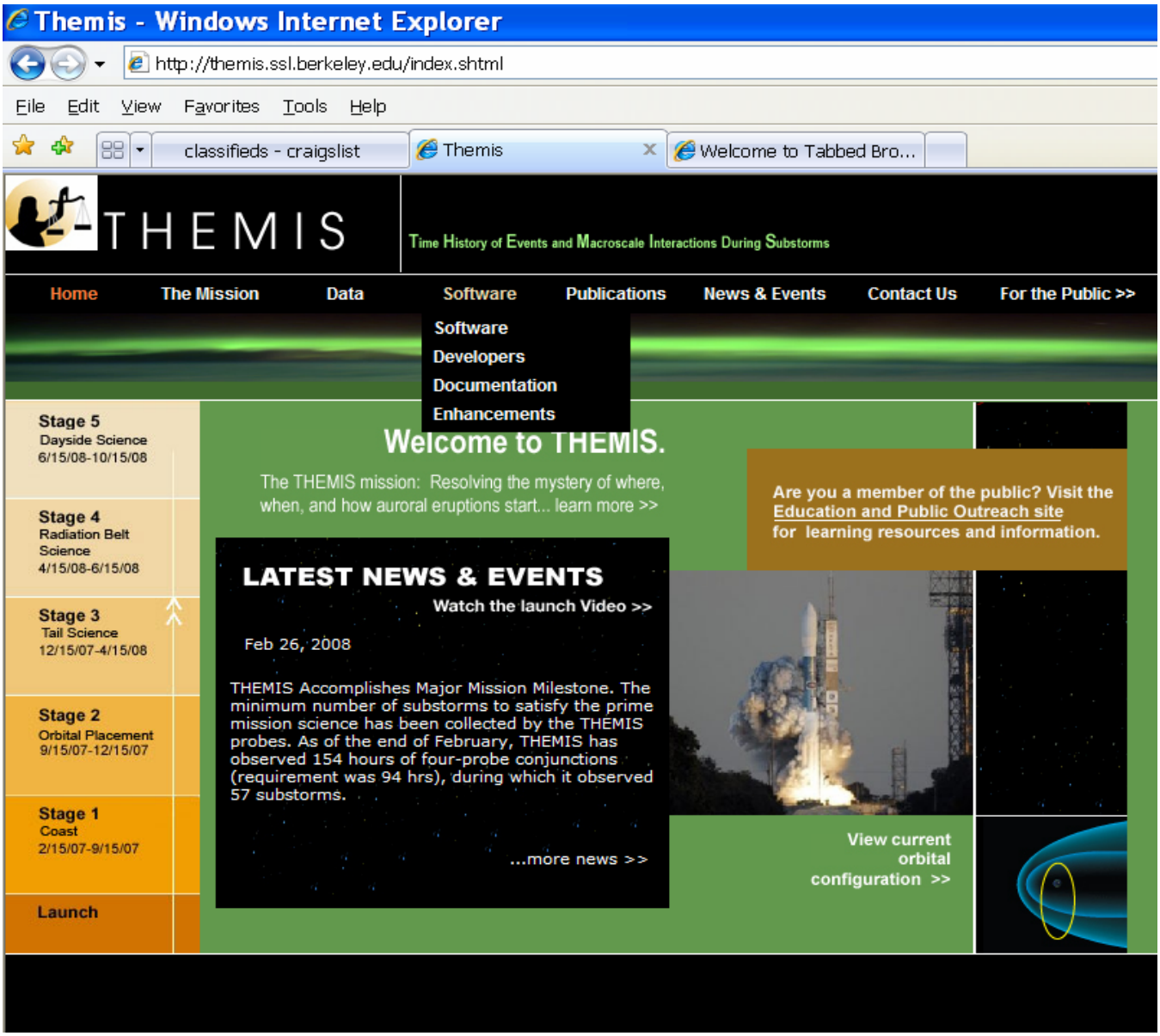
When you select the Event List on the data dropdown menu the following ftp site and related files are found.



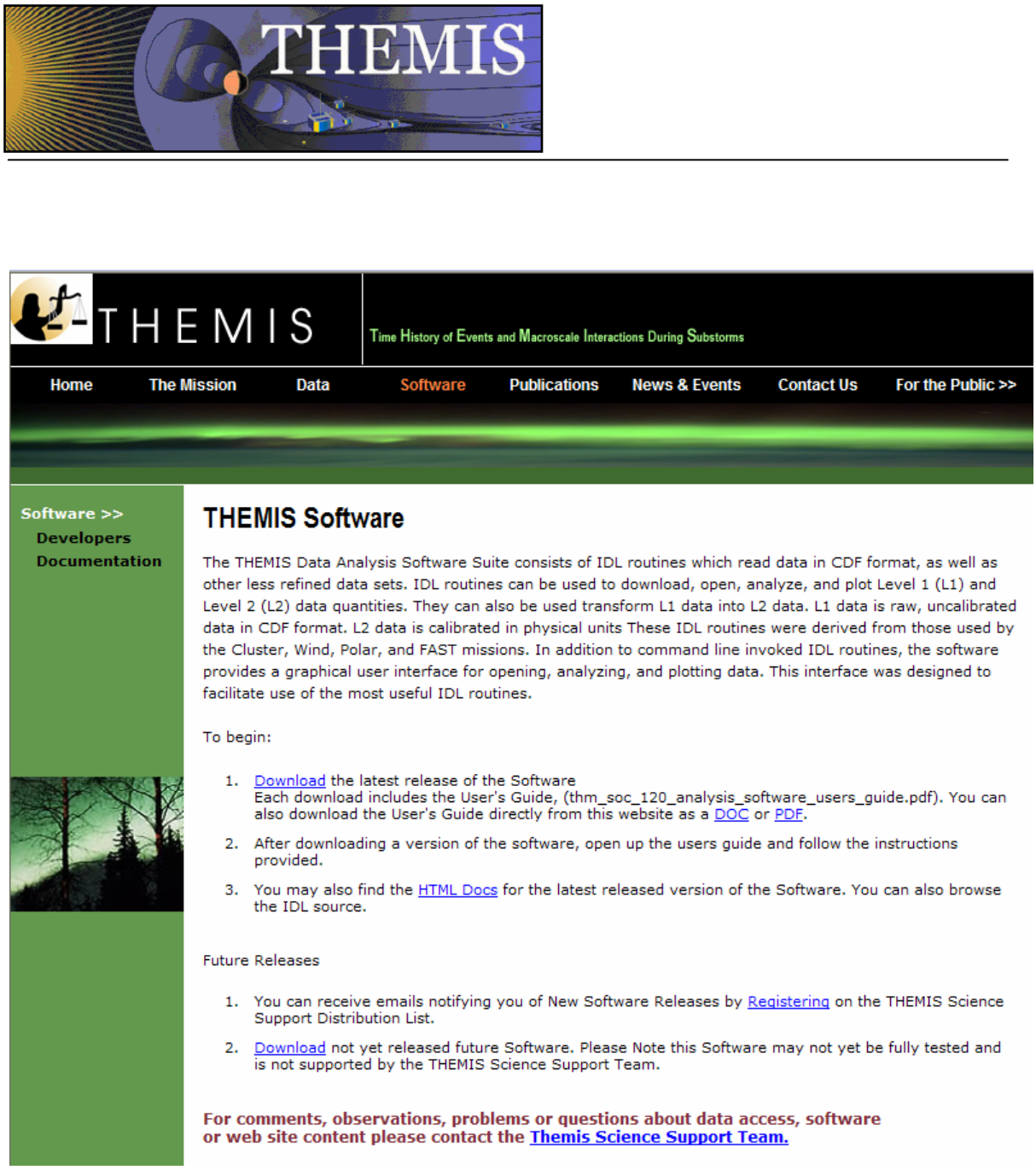
THEMIS Event List - ftp site

2.3 THEMIS Science Software Web Page

The THEMIS Science Software Drop Down Menu has three options. *Software* which displays a web page for downloading the latest release of the THEMIS Science Software Data Analysis Tools, Documentation, Registering to be notified of Future Releases of the Software, Download not yet released Software and Contacting the THEMIS Science Support Team with Help Requests. *Developers*, options to read about how to develop and contribute Software to THEMIS Science Software. *Documentation* which provides a link to the THEMIS Science Software Documentation ftp site. Enhancements, which will display the latest Accomplishments and Enhancements (A&E). The previous month's A&E is available as well.
Please note: If you download the not yet released Software, this Software may not have been tested (you are on your own). Please see screen displays below.

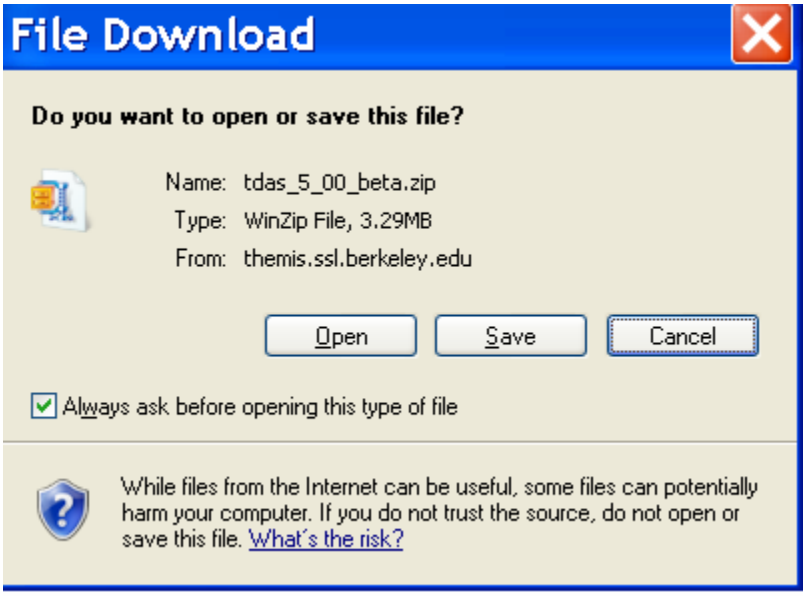


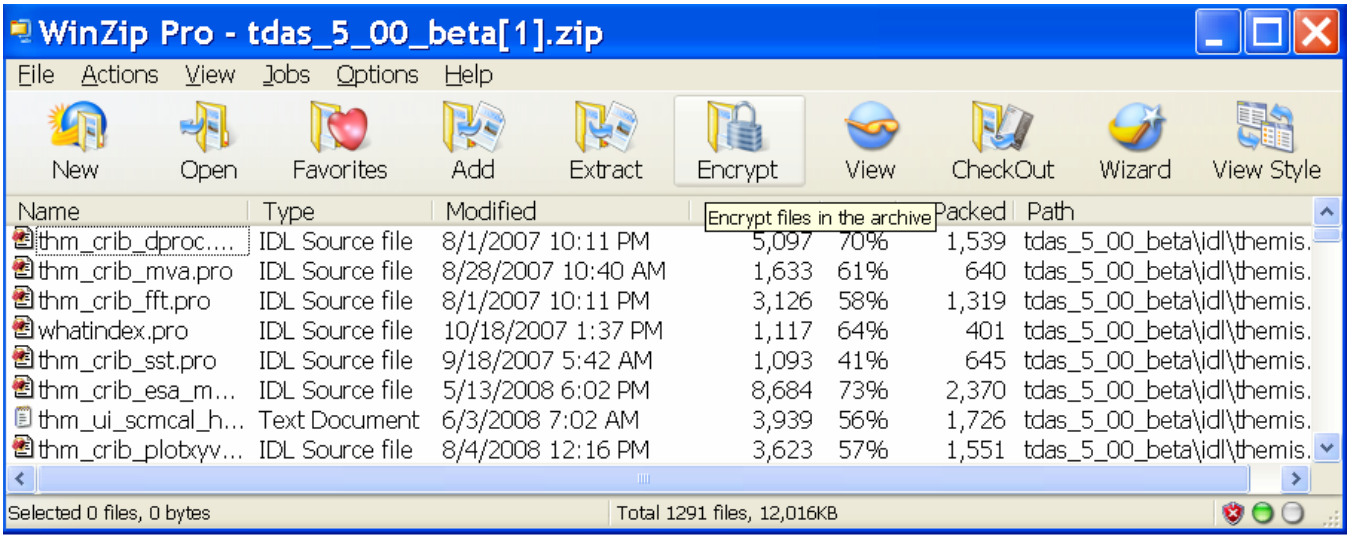
THEMIS Science Software Drop Down Menu



THEMIS Science Software Web Page

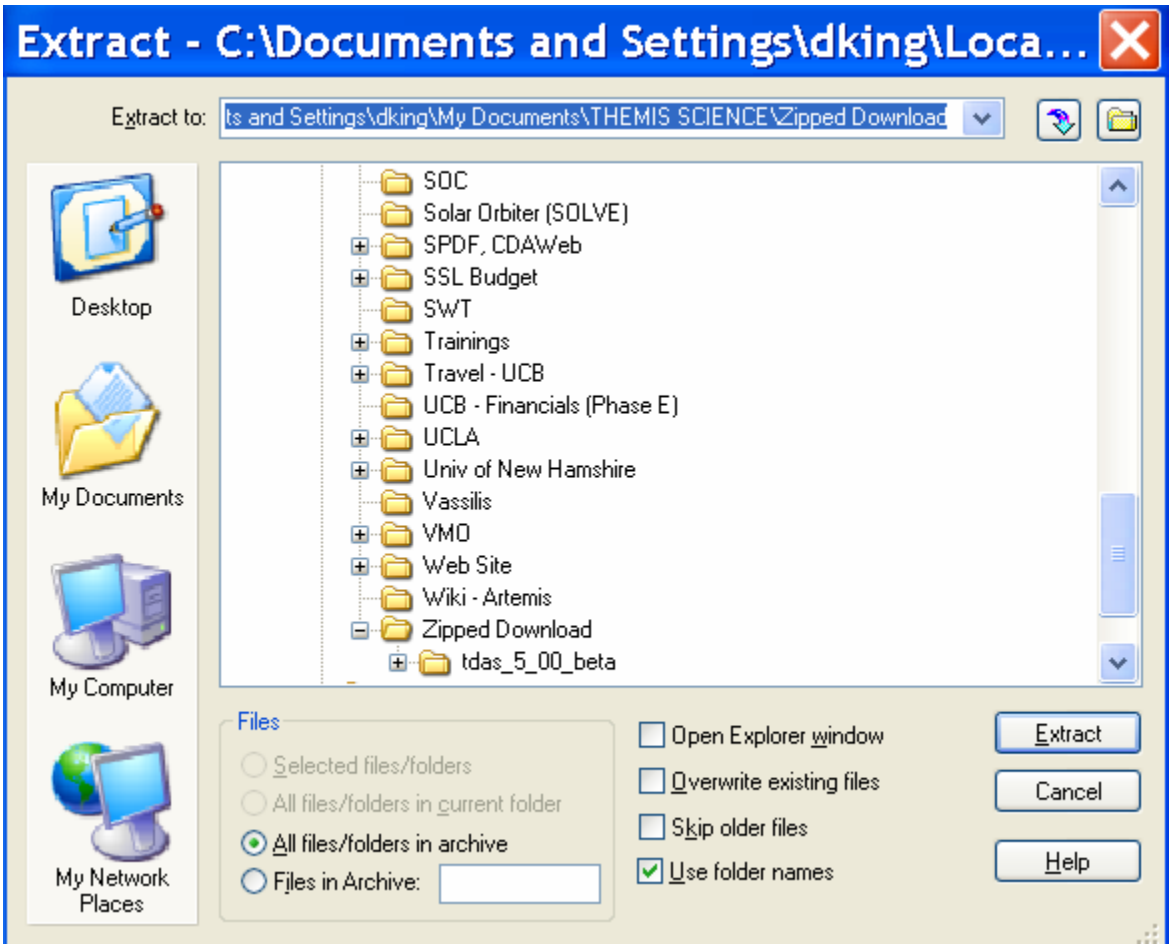
When you click on Download the latest release on a Windows machine A File Download dialogue box will be displayed. Click on 'Open' and the WinZip box will appear. Select the Extract icon to download the unzipped versions of the THEMIS Science Software to your computer. Notice the Extract display will ask you where to put the downloaded files. Please see Screen displays on th this and the next page.



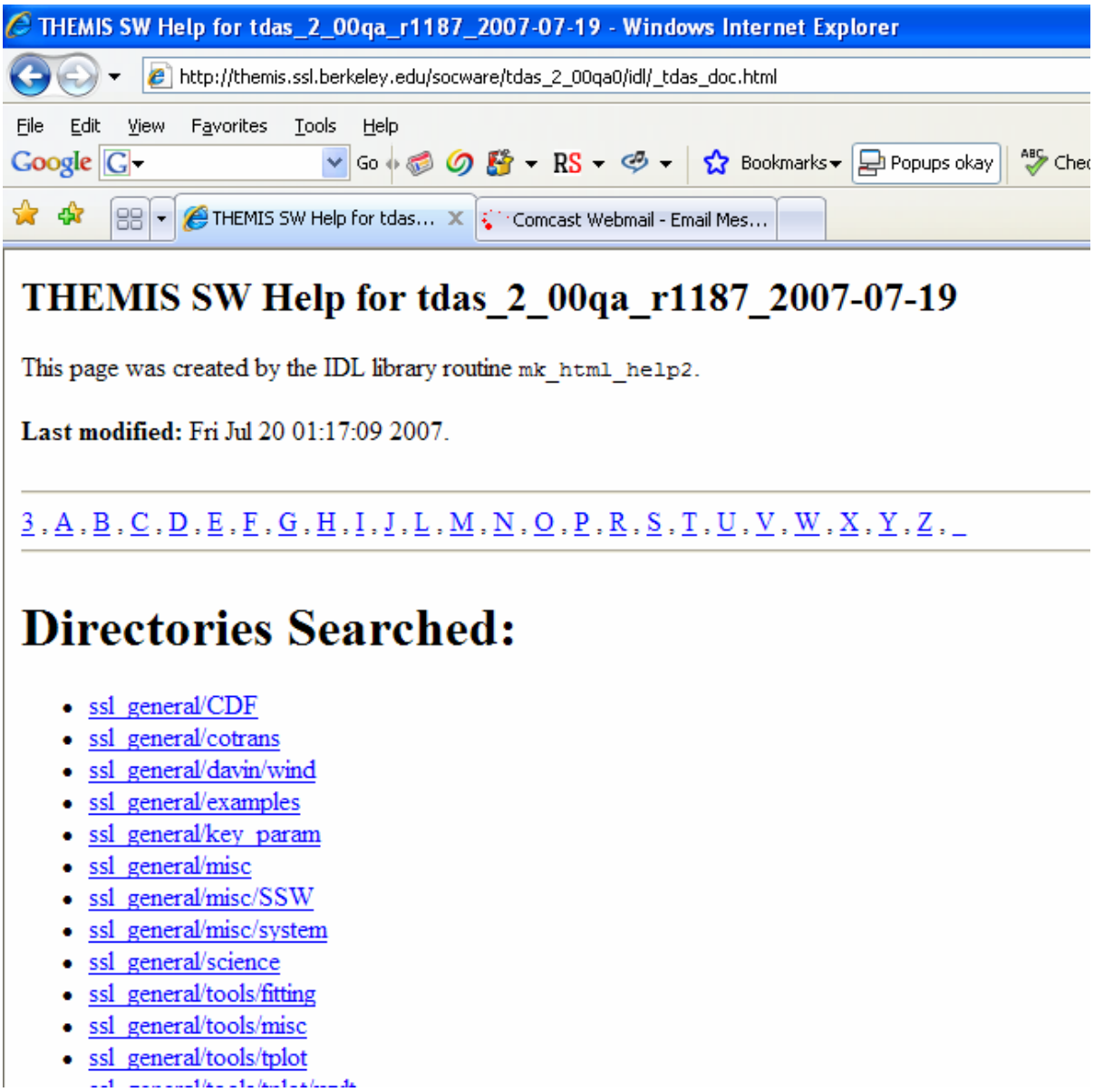


THEMIS Science Software - Download Software

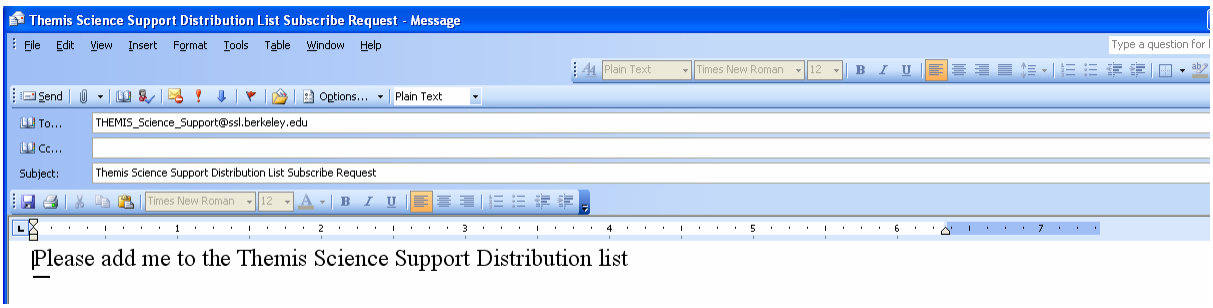
Recommendation is put the Software where you can easily find it as you will need to set the IDL path.



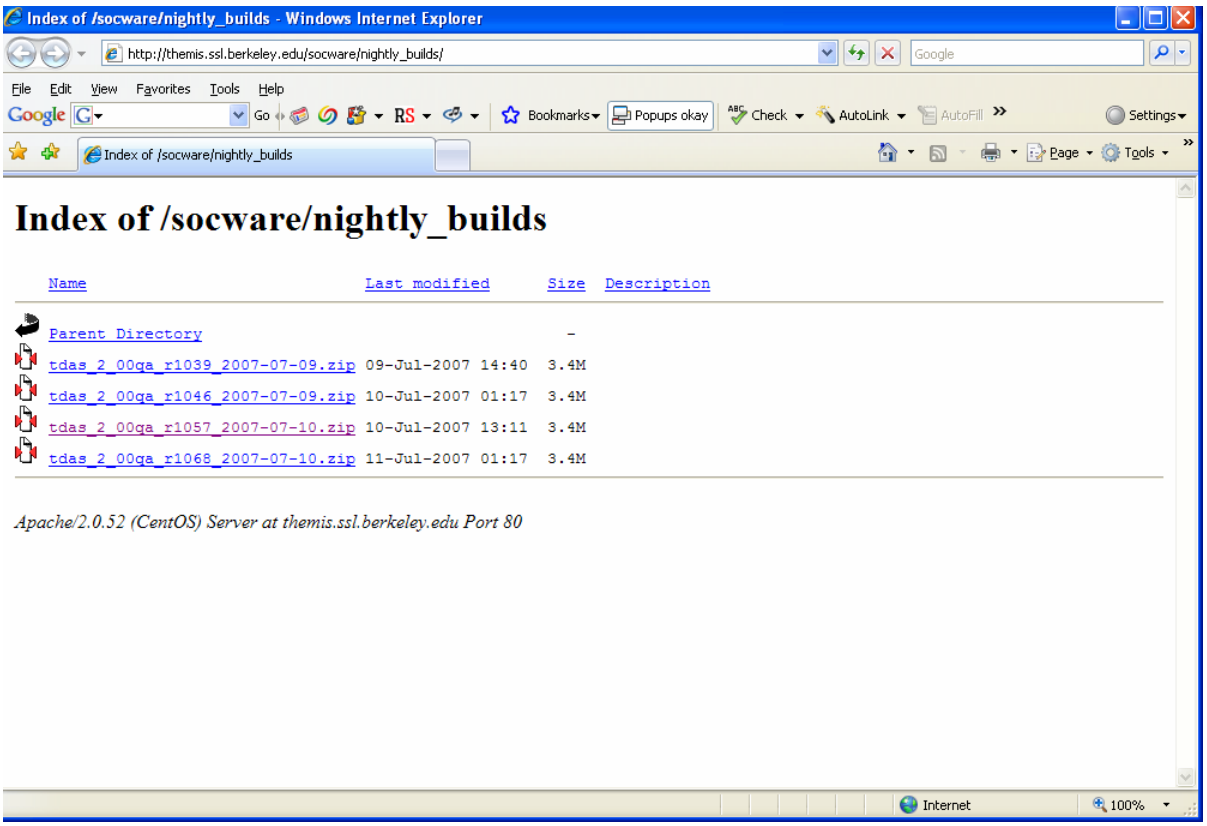
THEMIS Science Software - Download Software



THEMIS Science Software - HTML Docs



THEMIS Science Software - Registration for Notification



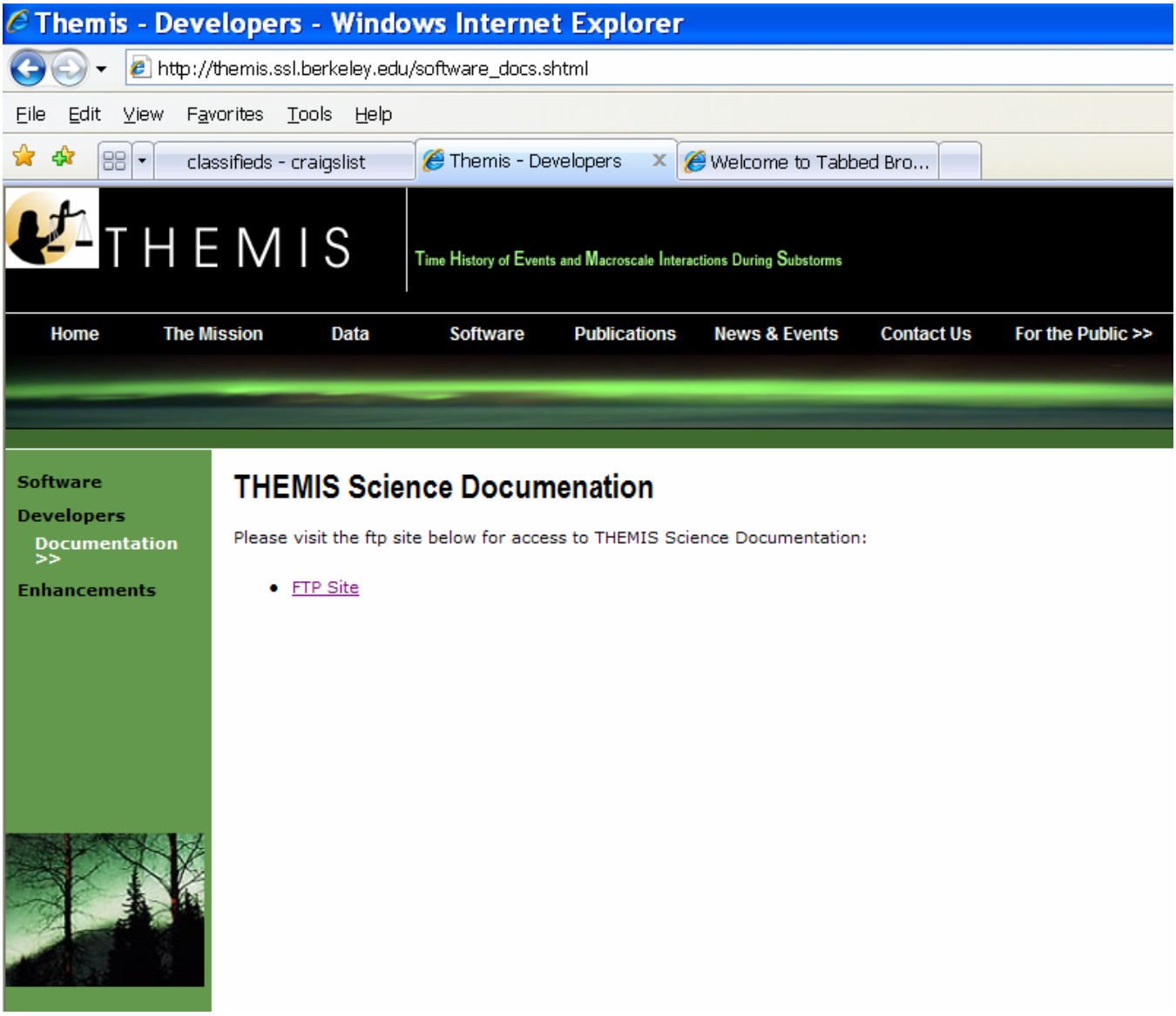
THEMIS Science Software - Download Not Yet Released Software

2.4 THEMIS Science Software - For Developers Web Page

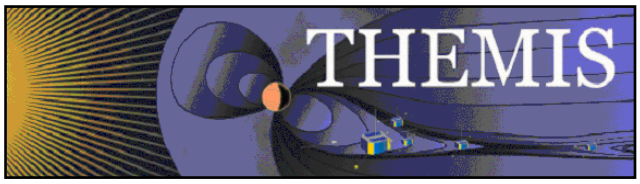
The THEMIS Science Software for Developers Web Page has links to aide software developers how to develop and contribute software to the THEMIS Science Software library. The 'Additional Documentation' option will link you to the ftp site where current THEMIS Science Software documentation can be found.

THEMIS Software - For Developers Web Page

When you click on the Documentation Option on the THEMIS Software Dropdown menu the following web page appear. Click on ftp site and you will be transferred to the THEMIS Document ftp site.



THEMIS Documentation Web Page



ftp://apollo.ssl.berkeley.edu/pub/THEMIS/3%20Ground%20Systems/3.2%20Science%20Operations/Science%20Opera

FTP directory /pub/THEMIS/3%20Ground%20Systems/3.2%20Science%20Ope

To view this FTP site in Windows Explorer, click **Page**, and then click **Open FTP Site in Windows Explorer**.

```
You are user #1 of 50 simultaneous users allowed.
```

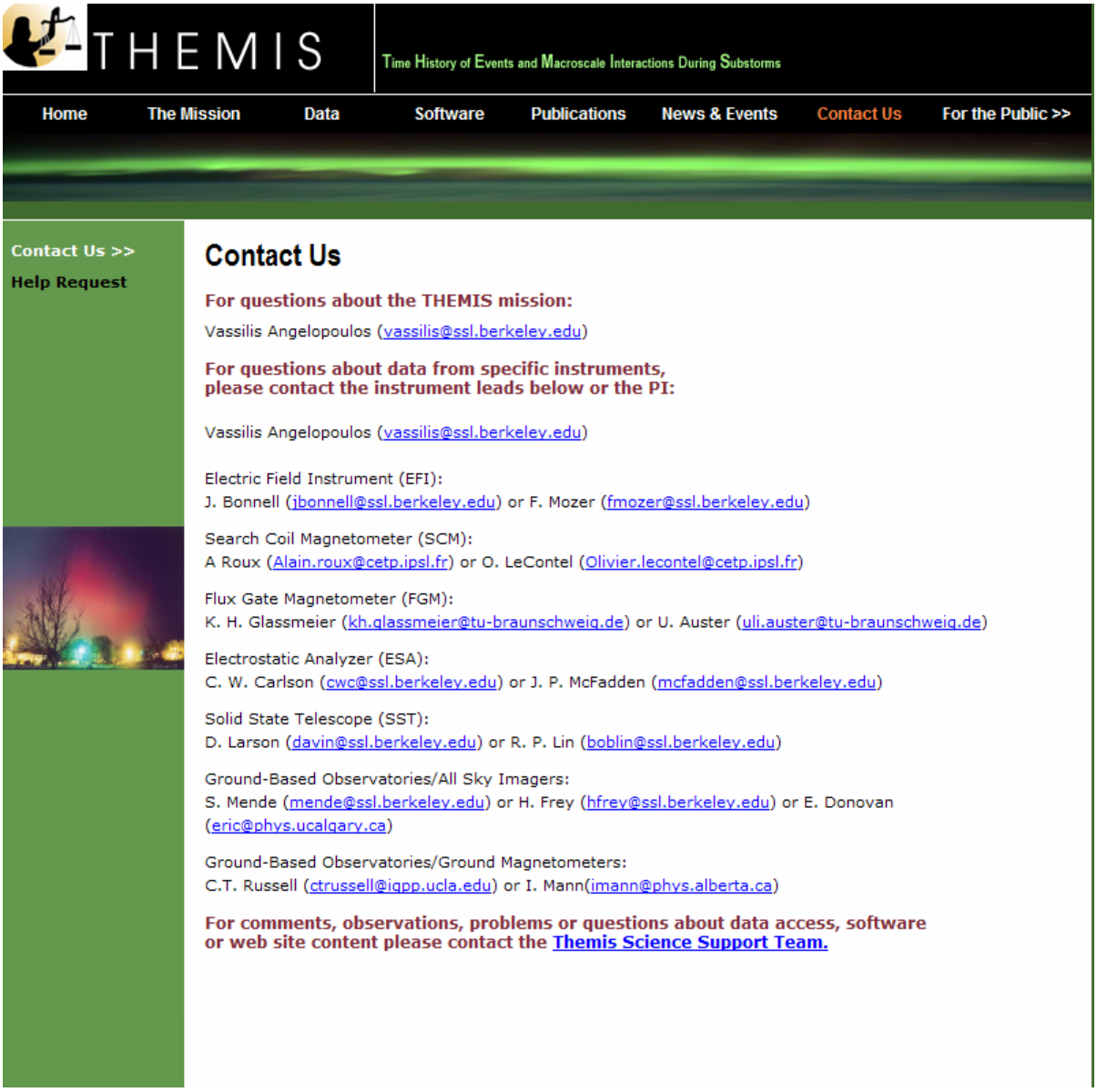
Up to higher level directory

11/19/2007 12:00AM	Directory		Science Data Variable Descriptions
09/28/2007 12:00AM	Directory		Science Software Data Analysis Software Presentation - 200707
12/07/2007 12:00AM	Directory		Science Software Data Analysis Software Presentation - 200712 GEM
06/20/2008 12:00AM	Directory		Science Software Data Analysis Software Presentation - 200806 GEM
09/22/2008 09:16AM	Directory		Science Software Data Analysis Software Presentation - 200809 SWT UNH
12/11/2008 01:12PM	Directory		Science Software Data Analysis Software Presentation - 200812 GEM
05/24/2007 12:00AM	Directory		Software Developers Guide
05/12/2008 12:00AM	Directory		Software Users Guides
06/15/2007 12:00AM	Directory		SpinFits Documents
08/29/2008 03:58PM		4,616	magstations.txt
04/24/2007 12:00AM		147,968	thm_ogs_431m_ephemeris_format_definition.doc
06/15/2007 12:00AM		208,126	thm_ogs_431m_ephemeris_format_definition.pdf
06/15/2007 12:00AM		130,560	thm_soc_101_TIME_20070120.doc
06/15/2007 12:00AM		231,206	thm_soc_101_TIME_20070120.pdf
06/15/2007 12:00AM		130,048	thm_soc_102_STATEFILE_20070420.doc
06/15/2007 12:00AM		231,011	thm_soc_102_STATEFILE_20070420.pdf
06/15/2007 12:00AM		231,936	thm_soc_103_HSK_VARNAMES_20070129.doc
06/15/2007 12:00AM		358,669	thm_soc_103_HSK_VARNAMES_20070129.pdf
06/15/2007 12:00AM		176,128	thm_soc_105_FIELDS_VARNAMES_20060929.doc
06/15/2007 12:00AM		202,932	thm_soc_105_FIELDS_VARNAMES_20060929.pdf
06/15/2007 12:00AM		117,760	thm_soc_106_PARTICLES_VARNAMES_20061102.doc
06/15/2007 12:00AM		151,715	thm_soc_106_PARTICLES_VARNAMES_20061102.pdf
06/15/2007 12:00AM		547,328	thm_soc_108_GMAG_L2_VARNAMES_20060929.doc
06/15/2007 12:00AM		498,732	thm_soc_108_GMAG_L2_VARNAMES_20060929.pdf
06/15/2007 12:00AM		224,256	thm_soc_109_ASI_L1_VARNAMES_20070108.doc
06/15/2007 12:00AM		281,333	thm_soc_109_ASI_L1_VARNAMES_20070108.pdf
06/15/2007 12:00AM		557,568	thm_soc_110_COORDINATES_20060929.doc
06/15/2007 12:00AM		689,082	thm_soc_110_COORDINATES_20060929.pdf
08/08/2007 12:00AM		115,200	thm_soc_111_sun_sensor_science_processing_Preliminary_Document.doc
08/08/2007 12:00AM		57,198	thm_soc_111_sun_sensor_science_processing_Preliminary_Document.pdf
08/02/2007 12:00AM		373,248	thm_soc_112_ATTPROC.doc

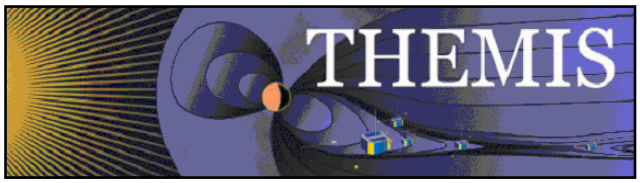
THEMIS Software Drop Down Menu - Documentation ftp site

2.5 THEMIS Contact Us Web Page

The THEMIS Contact Us Web Page lists the contact information for the THEMIS Principal Investigator as well as the Co-Investigators for each THEMIS Instrument. In addition there is an option to send a Help Request to the THEMIS Science Support Coordinator with comments, observations, problems or questions. The Help Request form and process will be explained in more detail in Section 3. Please see the screen display below.



THEMIS Software Contact Us Web Page



3 THEMIS Science Support Help System

3.1 THEMIS Science Support Help Process

The THEMIS Science Support Help Process for users who have Comments, Observations, Problems or Questions concerning data, a document, download, GUI, Plot, Software, Web Interface or any other issue not listed. The Help Process is a bit different for Step 1 if you are using the Web or the GUI Interface.

For the Web to Help Request Form Interface:
From either the Software or Contact Us Web Pages (example on previous page) the user will see the following:
For comments, observations, problems or questions about data access, software or web site content please contact the THEMIS Science Support Team.

If you click on **THEMIS Science Support Team** a Themis Science Support Help Request Form (example in Section 3.2) will be displayed. The user fills out the form and hits 'Submit'. Depending on your computer and email application the processing will be different for the email to be sent. For some computers that is all you need to do and the form is sent automatically. If you have a PC running Windows a box will be display asking you which email Application you use. If you use a desktop email application like Outlook, Outlook Express, select that button, hit OK and the Form will be automatically sent to the Support Coordinator. If you choose either of the two other options (Internet Email or Other) Windows will guide you through a three step process to send your email. Again, if not using windows (e.g. Mac, Linux or Unix) the process maybe different. Yet the main goal is for the Help Request Form to be sent to THEMIS_Science_Support@ssl.berkeley.edu.

For the GUI to the Help Request Form Interface:
By clicking on the “HELP" drop down menu on the GUI Main window or if the THEMIS Science Software GUI detects and error, a Help Request Form will be displayed (example in Section 3.3). Fill out the form and then click on 'Save'. Be sure to save somewhere you can find it. Then if reporting a bug please save and send your history file. Do this by first selecting “History Window” on the “View” drop down menu and then clicking on “Save” at the bottom of the History window. The suggestion is to put your Help Request Form and Saved History file in the same location At this point you can address your email to **THEMIS Science Support Team,** attach your Help Request Form and your History file and send.

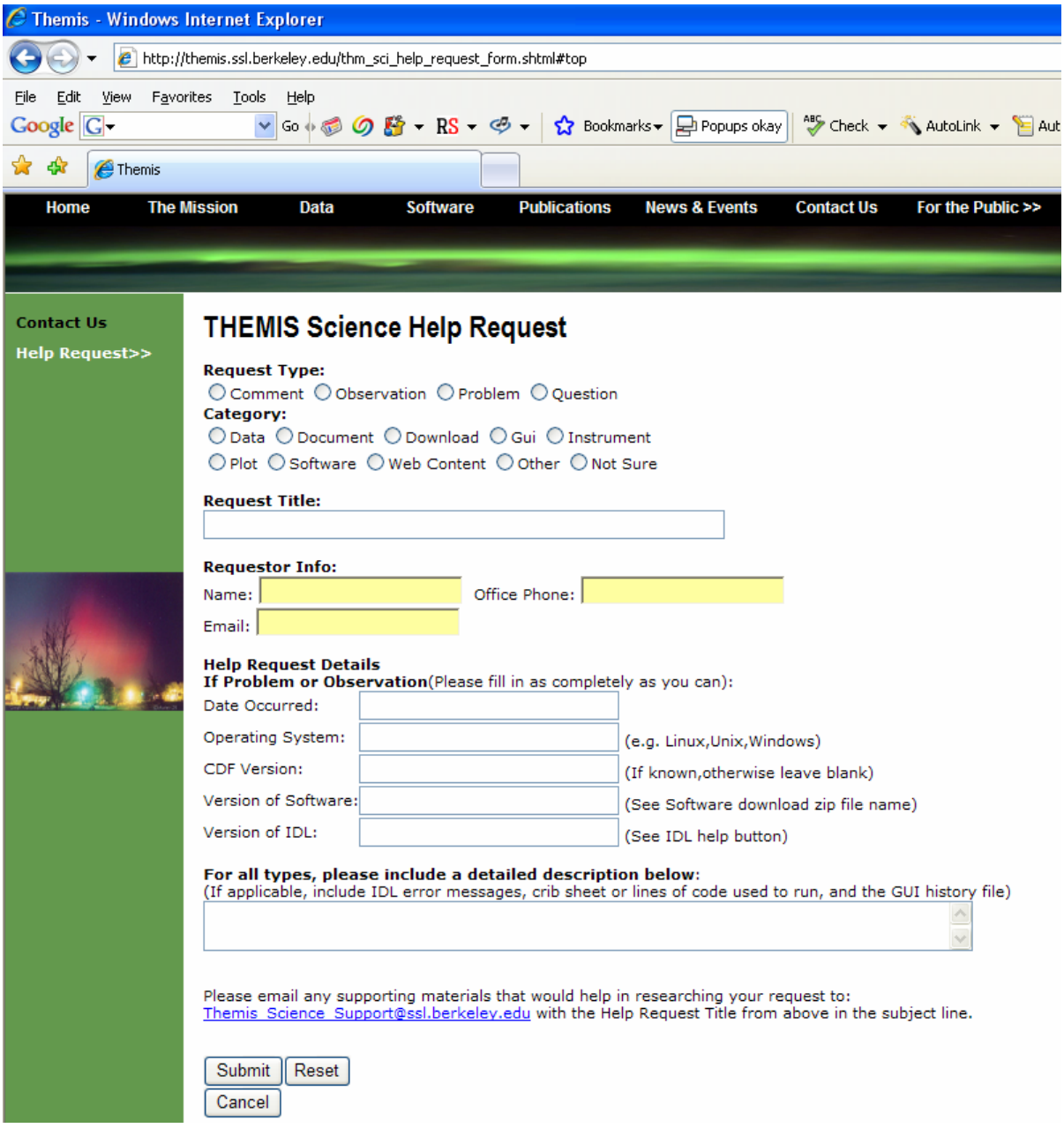
The remaining steps are the same for either the Web or GUI Interface.
Step 2: User sends any additional information (logs, error messages, etc) to THEMIS_Science_Support@ssl.berkeley.edu.

Step 3: The Support Coordinator will log in your help request, send you back an email confirming receipt of your help request with your Help Request Number. The Support Coordinator will also forward your Help Request and any attachments to the person (Actionee) who will investigate and answer your Help Request.

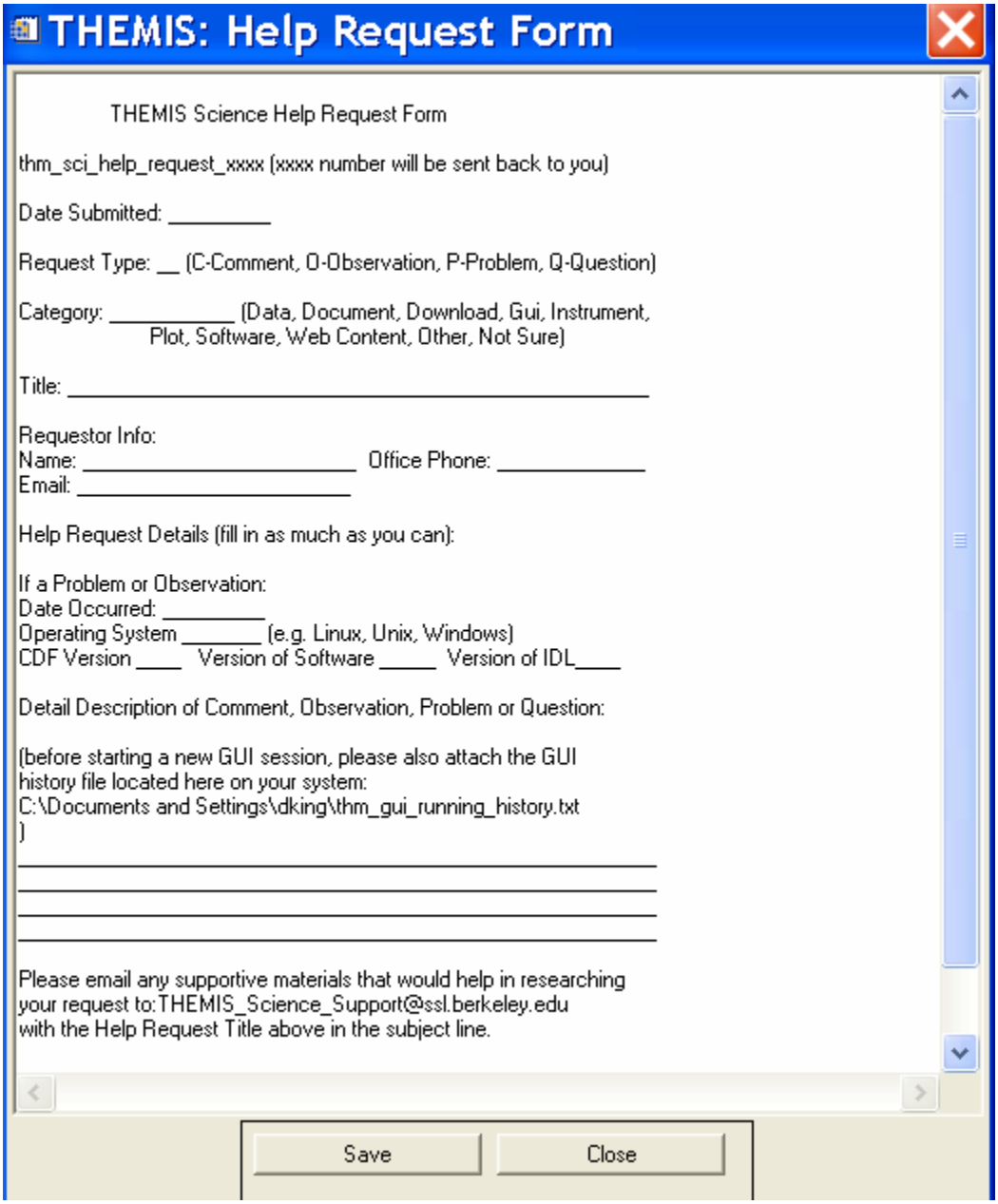
Step 4: The Actionee will contact the User to respond to the comment, observation, problem or question.

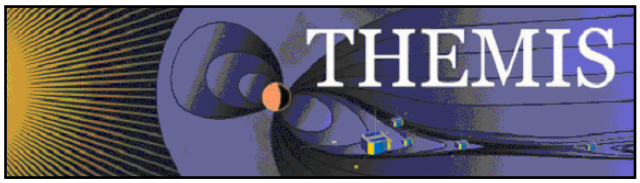
Step 5: Feel free at any time to send an email to the Support Coordinator requesting status of your request.

3.2 THEMIS Science Support Help Form - Web Form



3.3 THEMIS Science Support Help Form





4 THEMIS DATA

This section describes the THEMIS data, as seen by the THEMIS Data Analysis Software.

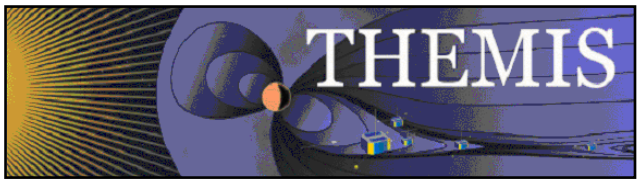
4.1 THEMIS DATA Overview

THEMIS data is available in 3 levels

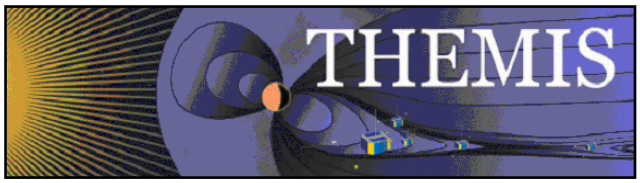
Level 0	telemetry packet format, overlaps removed and formatted into daily files
Level 1	CDF data files, contain raw telemetry data
Level 2	CDF data files, calibrated data

4.2 THEMIS DATA Quantity Summary

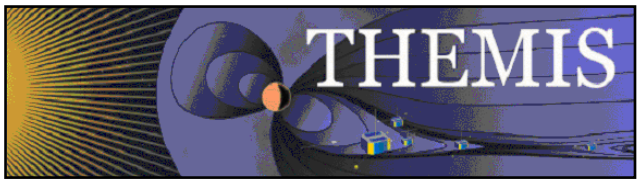
The table on the next few pages summarizes the data types recognized by TDAS. They will include the variable names as they appear on an Instrument's GUI Widget as well as in the GUI Main widget's Active Data window (GUI concepts will be discussed in Section 6). Please note that in the table below the variable names will not include their probe prefix (e.g. tha_ for a probe 'A' variable).



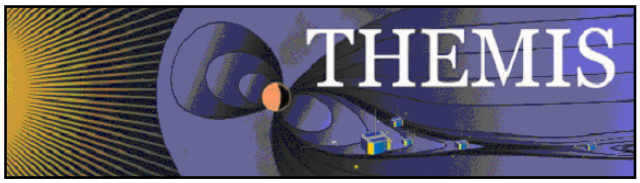
Instrument	Level	Data Name	Description
ASI	L1	asf_????	All-sky imager full resolution images of 256x256 pixels (???? = 4-letter code of ground station)
		ast_????	All-sky imager thumbnail images of 32x32 pixels (???? = 4-letter code of ground station)
ASK	L1	ask_????	All-sky imager keogram images of 256 pixels (???? = 4-letter code of ground station)
ESA	L0 or L2	For ESA: ? = f or r or b	f=full, r=reduced, b=burst
		pei?_density	ion density
		pei?_t3	diagonalized ion temperature
		pei?_en	ion energy spectrogram
		pei?_en_eflux	ion energy flux spectrogram
		pei?_velocity	ion velocity (DSL)
		pei?_velocity_???	ion velocity (???=DSL or GSE or GSM)
		pei?_ptens	ion pressure tensor (DSL)
		peif_mftens	ion momentum flux tensor (DSL)
		pei?_magt3	ion temperatures in B frame
		pei?_avgtemp	trace of diagonalized temperature tensor divided by 3
		pei?_vthermal	ion thermal velocity
		pei?_symm	direction of pressure tensor symmetry (DSL)
		pei?_symm_ang	angle between symmetry direction and B
		pei?_ang	ion angle spectrogram
		pei?_tot	total ion count
		pei?_en_counts	ion count vs. energy
		pei?_mode	ion instrument mode
		pee?_density	electron density
		pee?_t3	diagonalized electron temperature
		pee?_en	electron energy spectrogram
		pee?_en_eflux	electron energy flux spectrogram
		pee?_velocity	electron velocity (DSL)
		pee?_velocity_???	electron velocity (???=DSL or GSE or GSM)
		pee?_ptens	electron pressure tensor (DSL)
		pee?_mftens	electron momentum flux tensor (DSL)
		pee?_magt3	electron temperatures in B frame
		pee?_avgtemp	trace of diagonalized temperature tensor divided by 3
		pee?_vthermal	electron thermal velocity
		pee?_symm	direction of pressure tensor symmetry (DSL)
		pee?_symm_ang	angle between symmetry direction and B
		pee?_ang	electron angle spectrogram
		pee?_tot	total electron count
		pee?_en_counts	electron count vs. energy
		pee?_mode	electron instrument mode



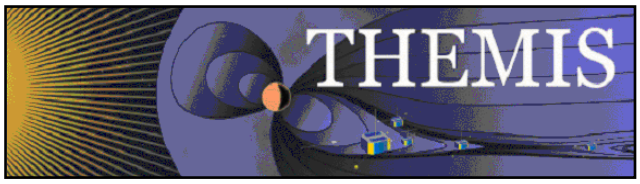
Instrument	Level	Data Name	Description
SST	L1 or L2	For SST: ? = f or r or b	f=full, r=reduced, b=burst
		psi?_#	# = same quantities as for ESA
		pse?_#	# = same quantities as for ESA
MOM (on-board moments)	L1 and L2	peim_density	ESA ion density
		peim_flux	ESA ion flux
		peim_mftens	ESA ion momentum flux tensor
		peim_eflux	ESA ion energy flux
		peim_velocity	ESA ion velocity
		peim_press	ESA ion pressure
		peem_density	ESA electron density
		peem_flux	ESA electron flux
		peem_mftens	ESA electron momentum flux tensor
		peem_eflux	ESA electron energy flux
		peem_velocity	ESA electron velocity
		peem_press	ESA electron pressure
	L1 and L2	psim_#	# = SST quantities (same as for ESA)
		psem_#	# = SST quantities (same as for ESA)
EFI	L1 or L2	eff	E field, fast survey/full orbit, 3D
		efp	E field, particle burst, 3D
		efw	E field, wave burst, 3D
		eff_dot0	E field, fast survey/full orbit, 3D, using E dot B=0
		efp_dot0	E field, particle burst, 3D, using E dot B=0
		efw_dot0	E field, particle burst, 3D, using E dot B=0
		eff_0	E field, fast survey/full orbit, 3D, using Ez=0
		efp_0	E field, particle burst, 3D, using Ez=0
		efw_0	E field, particle burst, 3D, using Ez=0
		efs	On-board spin-fit electric field
		efs_0	On-board spin-fit electric field using Ez=0
		efs_dot0	On-board spin-fit electric field using E dot B=0
		vaf	Voltage, processor A, fast survey/full orbit
		vap	Voltage, processor A, particle burst
		vaw	Voltage, processor A, wave burst
		vbf	Voltage, processor B, fast survey/full orbit
		vbp	Voltage, processor B, particle burst
		vbw	Voltage, processor B, wave burst
		ef?_hed	16-byte packet header for analogous data type; ?=f or p or w
		ef?_raw	raw data for analogous data type; ?=f or p or w
		va?_hed	16-byte packet header for analogous data type; ?=f or p or w
		va?_raw	raw data for analogous data type; ?=f or p or w



Instrument	Level	Data Name	Description
FBK	L1 only	fb1	Filter Bank 1 (E and/or B)
		fb2	Filter Bank 2 (E and/or B)
		fbh	Filter Bank high frequency (100-300kHz)
	L1 and L2	fb_hff	High-frequency filter peak and average values
		fb_eac12	Spectrogram E field AC component, sensors 1&2 (spin plane)
		fb_eac34	Spectrogram E field AC component, sensors 3&4 (spin plane)
		fb_eac56	Spectrogram E field AC component, sensors 5&6 (axial)
		fb_edc12	Spectrogram E field DC component, sensors 1&2 (spin plane)
		fb_edc34	Spectrogram E field DC component, sensors 3&4 (spin plane)
		fb_edc56	Spectrogram E field DC component, sensors 5&6 (axial)
		fb_scm?	Spectrogram SCM? (search coil) ; ?=1,2,3 (three axes)
		fb_v?	Spectrogram floating potential of sensor ?=1,2,3,4,5,6
FFT (on-board)	L1 and L2	ffp_16	FFT power spectrum in particle burst x 16 frequencies
		ffp_16_dbpara	FFT power spectrum for dB (parallel)
		ffp_16_dbperp	FFT power spectrum for dB (perpendicular)
		ffp_16_eac12	FFT power spectrum for AC component E12
		ffp_16_eac34	FFT power spectrum for AC component E34
		ffp_16_eac56	FFT power spectrum for AC component E56
		ffp_16_edc12	FFT power spectrum for DC component E12
		ffp_16_edc34	FFT power spectrum for DC component E34
		ffp_16_edc56	FFT power spectrum for DC component E56
		ffp_16_epara	FFT power spectrum for E (parallel)
		ffp_16_eperp	FFT power spectrum for E (perpendicular)
		ffp_16_scm?	FFT power spectrum for SCM? ; ?=1,2,3 (axes)
		ffp_16_v?	FFT power spectrum for V? ; ?=1,2,3,4,5,6 (sensors)
		ffp_32_#	# = same quantities in particle burst x 32 frequencies
		ffp_64_#	# = same quantities in particle burst x 64 frequencies
		ffw_16_#	# = same quantities in wave burst x 16 frequencies
		ffw_32_#	# = same quantities in wave burst x 32 frequencies
		ffw_64_#	# = same quantities in wave burst x 64 frequencies
FGM	L1 and L2	fgl	B field, low telemetry (low data rate)
		fgh	B field, high telemetry (high data rate)
		fge	engineering data (decimated from FGH)
	L2 only	fgs	B field, spin-resolution magnetic field B in DSL



Instrument	Level	Data Name	Description
FIT	L2 only	efs	On-board spin-fit electric field (EFI) data
(on-board)		efs_0	On-board spin-fit electric field (EFI) using Ez=0
		efs_dot0	On-board spin-fit electric field (EFI) using E dot B=0
		efs_sigma	Variance of onboard spin-plane electric field spin fit
		fgs	On-board spin-fit FGM data
		fgs_sigma	Variance of onboard spin-plane magnetic field spin fit
		fit	SpinFIT file E&B raw data
		fit_bfit	FGM spinfit calibrated data: A,B,C,sig,avg
		fit_efit	EFI spinfit calibrated data: A,B,C,sig,avg
GMAG	L2	mag_????	Ground magnetometer data in DHZ coordinates (???? = 4-letter code of ground station)
SCM	L1 and L2	For SCM: ? = f or p or w	f=fast survey, p=particle burst, w=wave burst
		scf	waveform fast survey (DSL)
		scp	waveform particle burst (DSL)
		scw	waveform wave burst (DSL)
		sc?_misalign	misalignment of Z axis from spin axis
		sc?_dc	X-Y (spin plane) values of the DC field in DSL
		sc?_iano	time discontinuities of data
		sc?_cal	calibrated data (unit depends on selected step)
STATE	L1	state_pos	GEI position, xyz
		state_vel	GEI velocity, xyz
		state_man	Maneuver flag
		state_roi	Regions of interest
		state_spinras	spin axis right ascension, deg
		state_spindec	spin axis declination, deg
		state_spinalpha	Geom to spin axis, Euler alpha, deg
		state_spinbeta	Geom to spin axis, Euler beta, deg
		state_spinper	spin period, sec
		state_spinphase	spin phase, deg



5. THEMIS DATA ANALYSIS SOFTWARE

The THEMIS Data Analysis Software (hereafter referred to as TDAS) is IDL-based. TDAS routines can be used to download, open, analyze and plot L1 or L2 data and process L1 data into L2 data quantities. There are two main ways to use the programs: with the command line interface or with the GUI interface.

Other features include coordinate transformations and utility routines to translate data into other products (e.g., ascii) as necessary.

5.1 System Requirements

The THEMIS Data Analysis Software requires an IDL developer's license for Windows or a UNIX-like operating system, e.g. Solaris, Linux, or Mac OS X. The software has been tested on IDL 6.3, 6.4 and 7.0 but should work on any level of IDL above 6.2. There is a patch to IDL, which is recommended for best handling of the CDF file format that is used by the THEMIS data files. See: http://cdf.gsfc.nasa.gov/html/cdf_patch_for_idl6x_new.html
If you are using IDL 6.2, or if you are using Intel Mac with any version of IDL (up to 6.4), or if you are using IDL 7.0 you must install this patch to read CDF files properly.

Mac OS X notes:

You need X11 to view plots and use the GUI in IDL. You can search for X11 in the Spotlight to see if the X11 application is installed on your system. X11 is available on your Mac installation disks, but may not be installed by default.

There is a known problem, mentioned in the IDL 6.3 release notes, which affects all IDL users running Mac OS 10.4 (Tiger). The tlimit command will lock up IDL because the plot window will not receive any mouse clicks.
Workaround: Change the X11 start-up parameters. Do the following:

1. Open any terminal window (in the X11 application menu bar, you can choose xterm from the applications menu)
2. Enter the following at the shell prompt:
   defaults write com.apple.x11 wm_click_through -bool true
3. Quit X11 (if it is running).

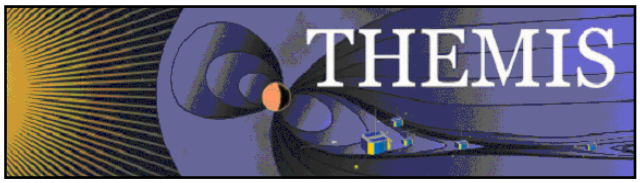
The new default will take effect the next time you start X11, and it will persist from that point (i.e., you will not have to make the change again).

Linux, Ubuntu notes:

There are problems with some versions of ubuntu and IDL graphic objects. If you find that widgets are not realized when opening a new window, you may need to turn visual effects off. This can be done using ubuntu system preferences and setting Visual effects to none.

5.2 Known Limitations

1. Incompatibilities with Solar Software (SSW). There exist some name clashes if both TDAS and SSW are on your IDL_PATH.
2. ASI data: ASF (full resolution ASI data) requires a 64-bit machine to load more than 1 hour's worth of data.
3. "Warning for IDL 7.0 users. A bug has been found with IDL 7.0 and CDFs that cause crashes on any operating system when loading CDF data. All IDL 7.0 users must go to: http://cdf.gsfc.nasa.gov/html/cdf_patch_for_idl6x_new.html and install this patch."
4. The IDL executive command .reset_session does not work for the THEMIS GUI software. Please use the command .full_reset_session to reset IDL sessions..



5.3 Installation and Configuration

Getting started is usually as simple as of downloading the code and setting up your IDL path, according to the instructions, below.

For a new installation:

1. Download and expand the latest TDAS release .zip file. See section 2.3 THEMIS Science Software – Download Software.
2. Create a directory called TDAS into which you will copy the latest software.
3. Move the tdas_x_xx folder into the TDAS directory you created.
4. Configure IDL to search the TDAS directory for IDL programs. See section 5.3.1 IDL PATH setup.

For an upgrade of an existing installation of TDAS, as per the above 4 steps:

1. Remove old tdas_x_xx from the TDAS directory.
2. Download and expand the latest TDAS release .zip file.
3. Copy the new tdas_x_xx directory into the pre-existing TDAS directory.
4. Re-start IDL.

5.3.1 IDL PATH setup

5.3.1.1 IDL PATH Setup on Windows (and IDLDE on UNIX, Linux and Mac)

For Windows or IDLDE on UNIX, you can use the File->Preferences widget to set up the path so IDL can find the THEMIS IDL files.

> UNIX Note: If you use IDLDE on UNIX-like systems, these instructions only work if you do not set the IDL_PATH environment variable before you call IDLDE. If IDLDE does not allow you to set the path by following these instructions, then follow the instructions for UNIX installation, below.

Start IDL (Windows) or IDLDE (UNIX, Linux, Mac).

Go to File->Preferences
Select the 'Path' tab.

If <IDL_DEFAULT> is not present, press 'Insert Standard Libraries'

Press Insert
Browse to find the TDAS directory you created (see section 5.3 Installation and Configuration)
Check the box to indicate "search subdirectories"

5.3.1.2 IDL PATH Setup for IDL Command Line (UNIX, Linux or Mac OS X)

For the command line version of IDL, installation consists of setting up the IDL_PATH environment variable

Simply set the IDL_PATH environment to search all subdirectories of the TDAS directory you created in section 5.3 Installation and Configuration.

for csh or tcsh, place the following in your .cshrc file

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

for bash or sh, place the following in your .bashrc (Linux, Solaris) or .bash_profile (Mac) file:

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

Mac OS X Notes:
You can edit your .bash_profile file using the standard Mac TextEdit program (normally, it's impossible to open 'hidden' files beginning with '.' using TextEdit or the Mac Finder)

In the Terminal, type (or cut-and-paste)
/Applications/TextEdit.app/Contents/MacOS/TextEdit ~/.bash_profile

That will open the .bash_profile file in the standard Mac text editor. The following configurations are recommended to enable you to use IDL from the Terminal.

```
# Configurations to make IDL and TDAS work from the Terminal
export DISPLAY=:0.0
IDL_LOC='/Applications/rsi/idl_6.3'
source ${IDL_LOC}/bin/idl_setup.bash
export IDL_PATH='<IDL_DEFAULT>:/path/to/tdas'
# End configurations for IDL and TDAS
```

Note that IDL_LOC may vary, depending on version of IDL installed. Search for actual location of IDL using Spotlight.

Tip:
You can drag the 'tdas' directory from the Finder into the TextEdit or Terminal window to paste the actual path for /path/to/tdas.

After saving the file, be sure to exit the TextEdit application from the menu bar, so you can get your command line prompt back!

5.3.2 Data Directory Setup

The THEMIS Data Analysis Software requires a local data directory in which THEMIS data files can be cached. The software will attempt to create the local data directory for you at the following default location, depending on your operating system.

OS	LOCAL_DATA_DIR
Windows	C:\data\themis
Solaris, Linux, Mac OS X	~/data/themis

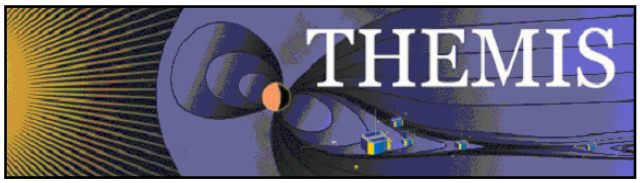
These locations should work as-is for most installations; however, if you don't have administrative privileges to create the data directory in the above locations, you can have your system administrator create it for you, or you can configure the THEMIS Data Analysis Software to use an alternate location. See Remote Data Access and Local Data Cache (Sections 5.5.9 – 5.5.11) for information about configuring an alternate location.

5.4 How to Get Started

Assuming you have the software installed, the best place to start is with a crib sheet. The crib sheets in the idl/themis/examples folder give end-to-end examples of how to load, process and plot the data available for a given instrument.

5.4.1 Crib Sheets in idl/themis/examples

thm_crib_asi	Crib sheet for loading and displaying All Sky Imager and Keogram data.
thm_crib_calc	Crib sheet for the mini-language program 'calc'
thm_crib_cotrans_lmn	Crib sheet for coordinate transform to 'LMN' coordinates



thm_crib_dproc	Crib sheet for testing some common data processing routines
thm_crib_efi	Crib sheet for Electric Fields Instrument waveforms.
thm_crib_esa_da	Crib sheet for analysis of ESA particle distributions
thm_crib_esa_moments	Crib sheet for ground processed ESA moments
thm_crib_esa_read_gmoms	Crib sheet for reading ground-processed ESA moments
thm_crib_esa_slice2d	Crib sheet for creating 2d 'slices' of ESA particle distributions
thm_crib_export	Crib sheet for exporting THEMIS data and/or plots in common data formats.
thm_crib_fac	Crib sheet showing how to transform into field-aligned coordinates
thm_crib_fbk	Crib sheet for Filter Bank.
thm_crib_fft	Crib sheet for on-board Fast Fourier Transform data.
thm_crib_fgm	Crib sheet for Flux Gate Magnetometer
thm_crib_fit	Crib sheet for on-board Fields Spin Fit
thm_crib_gmag	Crib sheet for GMAG, including wavelet demo.
thm_crib_make_ae	Crib sheet for creating geomagnetic AE indices
thm_crib_mom	Crib sheet for on-board particle Moments.
thm_crib_mva	Crib sheet for transformation into minimum variance analysis coordinates
thm_crib_overplot	Crib sheet for creating overview plots
thm_crib_part_getspec	Crib sheet for generating angular particle spectra
thm_crib_plotxy	Crib sheet with for plotxy, which creates 2d plots for 3d quantities
thm_crib_plotxyvec	Crib sheet for plotxyvec, which plots arrow on plotxy, plotxyz images
thm_crib_plotxyz	Crib sheet with for plotxyz, which creates isotropic spectrographic plots
thm_crib_scm	Crib sheet for Search Coil Magnetometer
thm_crib_sst	Crib sheet for Solid State Telescope (SST).
thm_crib_sst_contamination	Crib sheet for SST contamination removal
thm_crib_state	Crib sheet for State data – loading and plotting probe position data
thm_crib_tplot	Crib sheet for using tplot plotting package, using GMAG data as an example.
thm_crib_tplot_overlay	Crib sheet showing how to overlay spectra on other spectra
thm_crib_tplotxy	Crib sheet with for plotxy; creates 2d plots for 3d quantities in tplot variables
thm_crib_trace	Crib to demonstrate use of Tsyganenko trace routines, and means for generating plots of trace routines.
thm_crib_twavpol	Crib for generation of wave polarization from SCM (Search Coil Magnetometer) data
thm_map_examples	Examples for mapping Ground Base Observatories (GBO)

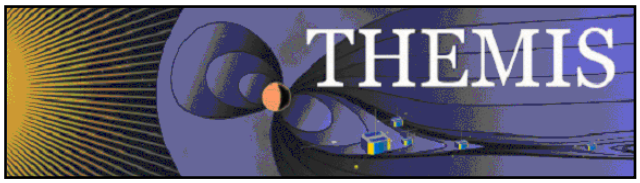
You can run any of the crib sheets by typing
```
.run <thm_crib_xxx>
```

when execution stops at a 'stop' command in the crib sheet, type
```
.c
```
to continue.

Alternatively, you can cut and paste from the crib sheet to the command line.

The crib sheet thm_map_examples is not in the same format as the other crib sheets: it defines some procedures which you can then run for yourself, or use as examples for your own code.

5.4.2 IDL Documentation for TDAS

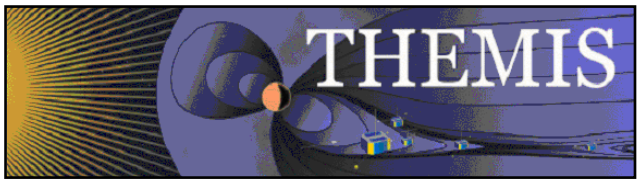


To find more information on any of the TDAS routines used in the crib sheets, use:

- The source code of the crib sheets, which is included in the idl/themis/examples directory of the software distribution.
- HTML help included with the software distribution: point your web browser to idl/_tdas_doc.html at the location where your TDAS software is installed locally.
- IDL XDOC widget. At the IDL prompt, type:
  xdoc
- IDL doc_library procedure. At the IDL prompt, type:
  doc_library, 'command_name'

Sample THEMIS routine documentation:

```
;+
;Procedure: THM_LOAD_GMAG,
; thm_load_gmag, site = site, datatype = datatype, trange = trange, $
;               level = level, verbose = verbose, $
;               subtract_average = subtract_average, $
;               subtract_median = subtract_median, $
;               varname_out = varname_out, $
;               subtracted_values = subtracted_values, $
;               downloadonly = downloadonly, $
;               valid_names = valid_names
;keywords:
;  site  = Observatory name, example, thm_load_gmag, site = 'bmls', the
;          default is 'all', i.e., load all available stations . This
;          can be an array of strings, e.g., ['bmls', 'ccmv'] or a
;          single string delimited by spaces, e.g., 'bmls ccnv'
;  datatype = The type of data to be loaded, for this case, there is only
;          one option, the default value of 'mag', so this is a
;          placeholder should there be more that one data type. 'all'
;          can be passed in also, to get all variables.
;  TRANGE= (Optional) Time range of interest  (2 element array), if
;          this is not set, the default is to prompt the user. Note
;          that if the input time range is not a full day, a full
;          day's data is loaded
;  level = the level of the data, the default is 'l2', or level-2
;          data. A string (e.g., 'l2') or an integer can be used. 'all'
;          can be passed in also, to get all levels.
;  /VERBOSE : set to output some useful info
;  /SUBTRACT_AVERAGE, if set, then the average values are subtracted
;                   from the loaded variables,
;  /SUBTRACT_MEDIAN, if set, then the median values are subtracted
;                   from the loaded variables,
;  varname_out= a string array containing the tplot variable names for
;               the loaded data, useful for the following keyword:
;  subtracted_values = returns N_elements(varname_out) by 3 array
;                    containing the average or median (or 0) values
;                    subtracted from the data.
;  /downloadonly, if set, then only download the data, do not load it
;                into variables.
;  no_download: use only files which are online locally.
;  relpathnames_all: named variable in which to return all files that are
;          required for specified timespan, probe, datatype, and level.
;          If present, no files will be downloaded, and no data will be loaded.
;  /valid_names, if set, then this will return the valid site, datatype
;               and/or level options in named variables, for example,
;
;               thm_load_gmag, site = xxx, /valid_names
; get_support_data = does nothing.  present only for consistency with other
;               load routines
;
;Example:
;   thm_load_gmag, site = 'bmls', trange =
;   ['2007-01-22/00:00:00','2007-01-24/00:00:00']
;
```



```
;Written by: Davin Larson,   Dec 2006
; 22-jan-2007, jmm, jimm@ssl.berkeley.edu rewrote argument list, added
; keywords,
; 1-feb-2007, jmm, added subtract_median, subtracted_value keywords
; 19-mar-2007, jmm, fixed the station list...
; $LastChangedBy: jimm $
; $LastChangedDate: 2007-05-21 19:44:54 -0400 (Mon, 21 May 2007) $
; $LastChangedRevision: 678 $
; $URL: svn+ssh://thmsvn@ambrosia.ssl.berkeley.edu/repos/thmsoc/branches/QA/idl/themis/ground/thm_load_gmag.pro $
;-
```

5.5 Software Functions

This section described the functionality of the THEMIS software. The examples are given using the command line interface, but the concepts are the same for the GUI.

5.5.1 Loading THEMIS Data

The THEMIS software is set up to work with Level 1 THEMIS data by default. Level 1 data is loaded and calibrated creating data quantities which are the same as the Level 2 products. The exceptions are GMAG (ground magnetometer), FGM (Flux-Gate Magnetometer), and FBK (Filter Bank) data, which are input from Level 2 files. In future versions we will change the default to Level 2 when reliable Level 2 files become available for each instrument. With the exception of ESA data, TDAS does not work with Level 0 data, and instead works with the Level 1 in CDF data format.

It is also possible to load raw Level 1 data. Calibration routines are available for those who want to have full access to intermediate outputs, settings of calibration parameters, diagnostic outputs, etc.

The THEMIS software automatically creates a local data cache which mirrors the structure of the THEMIS data archive. The software is written such that the default settings will work for the majority of users. The location of the THEMIS data archive is also found automatically by the software.

To download some data and load it into IDL, specify a timespan and type of data you want to load. If the data does not exist locally on your local_data_dir, it will be downloaded automatically before it is loaded into IDL.

At the IDL prompt, type:

```
timespan, '2006-11-11', 1, /day
```

Then, use one of the thm_load commands, e.g.

```
thm_load_gmag, site='ccnv'
```

List of routines for loading data:

thm_load_asi	Load All-Sky Imager data for any ground station (by keyword) or all available.
thm_load_ask	Load All Sky Keogram data for all observatories.
thm_load_efi	Load efi waveforms
thm_load_esa	Load ElectroStatic Analyzer data (for L2 esa data)
thm_load_esa_pkt	Load Level 0 ESA data
thm_load_fbk	Load Filter Bank data
thm_load_fft	Load on-board Fast Fourier Transform data.
thm_load_fgm	Load fgm waveforms (choice of fgl, fgh…)
thm_load_fit	Load On-Board Fields Spin-Fit data
thm_load_scm	Load Search Coil Magnetometer data.
thm_load_gmag	Load ground magnetometer data for any ground station.

thm_load_hsk	Load housekeeping data – all or one by keyword.
thm_load_mom	Load on-board moments data (only density moment is currently valid)
thm_load_scm	Load SCM waveform.
thm_load_spin	Load THEMIS spin model parameters
thm_load_sst	Load Solid State Telescope data.
thm_load_state	Load Orbit and Attitude data

Standard Load Procedure Keywords:

SITE	string: ground station name, or a list of ground station names, or ‘all’
PROBE	string: probe name, or a list of probe names, or ‘all’. e.g. ‘a b c’
DATATYPE	type of CDF variable for the given instrument.
LEVEL	Level of data file to load: 'l1' or 'l2' default is usually ‘l1’.
TYPE	‘raw’ or ‘calibrated’. applies to ‘l1’ data only. ‘Calibrated’ is the default.
VALID_NAMES	Return valid names for DATATYPE, SITE, PROBE, and LEVEL
VERSION	Version of CDF file to load (useful for STATE data): 'v01', 'v02'
GET_SUPPORT_DATA	Get support data quantities from CDFs well as data quantities, only used for ‘l1’ data.
CDF_DATA	Return a structure containing data and metadata from CDF.

Note that all of these keywords are not present for all of the different load routines. This is true for the ESA, SST and MOM load routines which are under development.

5.5.2 General Conventions: variable name construction and reference

The command line interface of TDAS provides a general interface for referring to a data quantity, based on keywords. The lists in these keywords can be arrays of strings, or scalar strings containing space-separated lists.
PROBE : specifies the probe, or probes of interest: ‘a b c’ or [‘a’, ‘b’, ‘c’]
DATATYPE: specifies the type of data, for a given instrument: corresponds to name in CDF file
SUFFIX: a suffix to the variable name

The data is loaded into variables with the following name:
tha_bbb_suf
where a is the probe designation, bbb is the datatype designation, and _suf is the optional suffix.
For some data, a midfix is added before the datatype: e.g. for all STATE and HSK data a midfix is added before the datatype it in the variable name. e.g.
tha_state_pos
In this example, the datatype is POS, but the state_ midfix had been added before it in the name.

The various thm_load and thm_cal (calibration) routines, as well as thm_cotrans (coordinate transform) accept the above keywords to determine which data to operate upon.

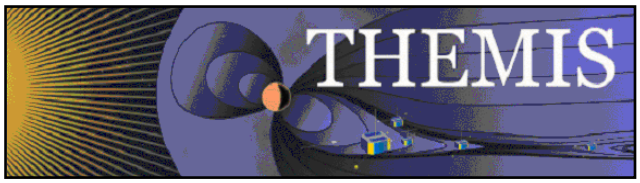
General-purpose routines (e.g. tplot) contained in TDAS can refer to sets of variables using glob-style patterns. For example:

th?_???_raw

refers to data for all probes for all non-state data types, which have the ‘_raw’ suffix.

th[ab]_fg?

refers to FGL, FGH, and FGE for probes A and B.



5.5.3 Plotting the Data

5.5.3.1 Plotting with Tplot

Documentation that explains how to use these routines in detail can be found in the headers at the beginning of the procedure files, in the cribs, or by using the 'doc_library' command. For example: `doc_library,'tplot'`

Plotting routines:

tplot	General purpose time plotting utility for creating plots of lines and spectragrams.
tplot_names	Lists current stored data names that can be plotted with the TPLOT routines.
tplot_options	Sets global options for the tplot routine.
options	Sets options for specified tplot variable(s)
tlimit	Zoom into or out of a tplot.
xlim	Sets x-axis limits for specified tplot variable(s)
ylim	Sets y-axis limits for specified tplot variable(s)
zlim	Sets z-axis limits for specified tplot variable(s)
get_data	Get data out of a tplot variable into a structure containing a time tag array and a data array.
store_data	Store a data array structure into a tplot variable.

Cribs: idl/themis/examples/thm_crib_tplot.pro
idl/ssl_general/tplot/_get_example_dat.pro
idl/ssl_general/tplot/_tplot_example.pro
idl/ssl_general/tplot/_tplot_demo.pro

tplot – use to create a time series plot of user defined quantities.
idl/ssl_general/tplot/tplot.pro

```
tplot, 1                    ; Plot the first quantity (as revealed by calling tplot_names)
tplot, [1,2,3]              ; Plots a stack plot of the first 3 data quantities.
tplot,'amp slp flx2'        ; Plots the named quantities
tplot, 'th?_fgh'            ; Plots a stack plot of High Rate Flux Gate Magnetometer data for all
                            ; available probes.
tplot,'flx1',/ADD_VAR       ; Add the quantity 'flx1' to previous plot.
tplot                       ; Re-plot the last variables.
tplot,var_label=['alt']     ; Put Distance labels at the bottom.
```

tplot_names – use to print a list of acceptable names to plot and to get info on those tplot variables.
idl/ssl_general/tplot/tplot_names.pro

```
tplot_names,'*3dp*'               ; display all names with '3dp' in the name
tplot_names,'ehspec',/verbose     ; print out more info on the data structure in 'ehspec'
tplot_names,/time_range           ; print out the time range for tplot var in memory
```

tplot_options – use to control the plotting of all tplot variables (e.g. the title, margins, etc. of the plot window).
idl/ssl_general/tplot/tplot_options.pro

```
tplot_options,'title','My Data'              ; Set title
tplot_options,'xmargin',[10,10]              ; Set left/right margins to 10 characters
tplot_options,'ymargin',[4,2]                ; Set top/bottom margins to 4/2 lines
tplot_options,'position',[.25,.25,.75,.75]   ; Set plot position (normal coord)
tplot_options,'wshow',1                      ; de-iconify window with each tplot
tplot_options,'version',3                    ; Sets the best time ticks possible
tplot_options,'window',0                     ; Makes tplot always use window 0
tplot_options,/help                          ; Display current options
tplot_options,get_options=opt                ; get option structure in the variable opt.
tplot_options,'ygap',0.0                     ; eliminate the vertical spacing between panels
```

options – use to control the plotting of one or more tplot panels. This procedure can be used to set all IDL plotting keyword parameters (i.e. psym, color, linestyle, etc) as well as some keywords that are specific to tplot (i.e. panel_size, labels, etc.)

idl/ssl_general/tplot/options.pro

```
options, 'tvar_name(s)','panel_size',1.5 ; Change the relative panel width
options, 'tvar_name(s)','labflag',-1     ; Set evenly spaced labels
options, 'tvar_name(s)','labflag',0      ; No labels
options, 'tvar_name(s)','spec',1         ; set option to produce a spectrum plot
options, 'tvar_name(s)','y_no_interp',1  ; prevent y-axis interpolation
options, 'tvar_name(s)','y_no_interp',0  ; allow y-axis interpolation
options, 'tvar_name(s)','ystyle',1       ; force exact y-axis limits
options, 'tvar_name(s)','ystyle',0       ; return to autoranging
options, 'tvar_name(s)','spec',0         ; change to multi-line plot
```

tlimit – defines time range for tplot.
idl/ssl_general/tplot/tlimit.pro

```
tlimit                      ; Use the cursor to set time range
tlimit,'12:30','14:30'
tlimit, 12.5, 14.5
tlimit,t,t+3600             ; t must be set previously
tlimit,/FULL                ; zooms to full time range available
tlimit,/LAST                ; previous limits
```

xlim, ylim, zlim – To set plotting limits for plotting routines. zlim typically applies to spectragrams.
idl/ssl_general/tplot/xlim.pro
idl/ssl_general/tplot/ylim.pro
idl/ssl_general/tplot/zlim.pro

```
xlim                        ; Set "TPLOT" limits using the cursor.
ylim,'Ne',.01,100,1         ; Change limits of the "TPLOT" variable 'Ne'.
zlim,'ehspec',1e-2,1e6,1    ; Change color limits of the "TPLOT" variable 'ehspec'.
xlim,lim,-20,100            ; create a variable called lim that can be passed to a
                            ; plotting routine such as "SPEC3D".
```

tplot variables can be stored in files using tplot_save and loaded using tplot_restore. You can also retrieve data from tplot variables and manipulate it in IDL. For example, if you run thm_part_getspec, specifying the /energy keyword, you can get the values corresponding to the center of each energy channel from the 'th*_en_eflux*' tplot variables that are created by using get_data:

```
get_data, 'thc_pser_en_eflux', x, y, z
print, z[0,*]
```

You can find these codes at idl/ssl_general/tplot/get_data.pro and idl/ssl_general/tplot/store_data.pro

5.5.3.2 Plotting with Plotxy

Plotxy and plotxyz are routines that are designed to plot two dimensional projections of three dimensional vector data or cuts across a three dimensional space. The ratio of lengths of the axes will be maintained so that relationships between the axes will not be distorted. Another way to say this is that they generate isotropic line plots. Any possible projection can be specified by naming the two axes of the data that identify a plane or by providing a matrix whose columns define a generic plane. The plot will contain a projection of the data within the plane defined by the span of the axes or the span of the two columns of the matrix. Plotxy is used to plot array data and tplotxy is used to plot tplot variables. These routines are useful for plotting spacecraft position data and traces of magnetic field lines. Plots that are generated by plotxy and plotxyz can be arranged in the same window together but there is no option that allows the placement of plotxy and tplot plots in the same window. Plotxy takes an array of vectors as an input. Tplotxy takes the name or names of tplot variables to be plotted as an input.

Documentation that explains how to use these routines in detail can be found in the headers at the beginning of the procedure files, in the cribs, or by using the 'doc_library' command. For example: `doc_library,'plotxy'` The plots generated by these routines can be exported in the same ways that tplot plots can be exported.

The routines can be found at:
idl/ssl_general/tplot/plotxy.pro
idl/ssl_general/tplot/tplotxy.pro

Cribs for the routines can be found at:
idl/themis/examples/thm_crib_plotxy.pro
idl/themis/examples/thm_crib_tplotxy.pro

The example below demonstrates how to plot the orbit of THEMIS C.

```
;this sets the time range and loads the position data
timespan,'2008-04-02'
thm_load_state,probe='c d',coord='gse'

;set up a window for the plots
window,xsize=600,ysize=300

;convert data from km to earth radii
tkm2re,'th?_state_pos',/replace

;this will set up a two plot panel one will contain the x vs y plot of the spacecraft orbit
;the other will contain the  x vs z  plot of the spacecraft orbit.  The x axis will run from right to
left on the second plot.

tplotxy,'thc_state_pos thd_state_pos',multi='2 1',colors=[2,4]
tplotxy,'thc_state_pos thd_state_pos',versus='xrz',/add,colors=[2,4]
```

5.5.3.3 Plotting with Plotxyz

Plotxyz is a routine that is designed to plot isotropic or non-timeseries spectrograms. Generally, plotxyz is used in conjunction with bin2d to generate a two dimensional array that contains values that are a function of two other variables. For example, plotxyz can be used to generate a spectrogram of pressure vs. x-y position. Many of the options for plotxyz and plotxy are the same, but there is no version plotxyz that works directly with tplot variables. Plotxyz and plotxy plots can be arranged in the same window together, but there is no option that allows the arrangement of plotxyz plots in the same window as tplot plots. Plotxyz requires three inputs, and accepts many different options keywords. The first input is an M element one dimensional array that contains the values of the x axis. The second input is an N element one dimensional array that contains the values of the y axis. The third input contains an MxN element two dimensional array that stores the z value of each combination of x and y.

Documentation that explains how to use these routines in detail can be found in the headers at the beginning of the procedure files, in the cribs, or by using the 'doc_library' command. For example: `doc_library,'plotxyz'` The plots generated by this routine can be exported in the same ways that tplot plots can be exported.

The routines can be found at:
idl/ssl_general/tplot/plotxyz.pro
idl/ssl_general/misc/bin2d.pro

The crib for the routines can be found at:
idl/themis/examples/thm_crib_plotxyz.pro

The example below shows how to generate a spectrogram of density versus position using plotxyz.

```
;load the data and convert to RE
timespan,'2008-02-14'

thm_load_state,probe='a',coord='gsm'
thm_load_mom,probe='a'

tKm2Re,'tha_state_pos',/replace
get_data,'tha_state_pos',data=d_pos
```

```
get_data,'tha_peim_density',data=d_den

;interpolate the data onto the same time grid
den = interpol(d_den.y,d_den.x,d_pos.x)

;bin the data using bin2d
;the '$' in the command below shows IDL that this is a single command that is printed on two lines.
;if you want you can remove the '$' and print the next two lines on a single line in IDL
bin2d,d_pos.y[*,0],d_pos.y[*,1],den,binum=20,averages=averages,$
xcenters=x_centers,ycenters=y_centers,flagnodata=!values.d_nan

;plot the spectrogram
plotxyz,x_centers,y_centers,averages,xtitle='X [RE GSM]',ytitle='Y [RE GSM]',/grid
```

5.5.3.4 Plotting Angular Spectra

Use `thm_part_getspec.pro` to produce angular and/or energy spectra of Themis particle data (SST/ESA) as a function of time. In addition to specifying the time range of interest, the user can also choose to calculate spectra for one or more probes and data types. Only a single type of angular spectra (i.e. phi, theta, pitch angle, gyrophase) may be created by a single execution of the code. However, energy spectra may be created concurrently with angular spectra. Regardless of the type of spectra to be calculated, the ranges of phi, theta, pitch angle, gyrophase, and energy used to calculate the spectra can be set by the user. Phi, theta, and energy ranges affect energy and phi/theta angular spectra. Phi, theta, pitch angle, gyrophase and energy ranges affect pitch angle/gyrophase spectra. The code also has the ability to normalize the flux for each time sample in a spectra plot to values between 0 and 1. By default, tplot variables containing angular spectra have tplot names containing "an_eflux" followed by the angular spectra type (e.g. phi, theta, pa, gyro), and energy spectra tplot names end with "en_eflux". Typing `doc_library, 'thm_part_getspec'` at the command prompt will return a list of detailed keyword usage information. See `themis/examples/thm_crib_part_getspec.pro` for an in-depth description of the code and examples of how to generate different types of plots. Below is a simple example that will calculate iSST phi angular spectra for two probes, and automatically generate a plot using the `/autoplot` keyword.

```
thm_part_getspec, probe=['a','e'], trange=['07-03-23/10:30','07-03-23/12'], $
                  phi=[0,360], theta=[-90,90], data_type=['psif'], angle='phi', /autoplot
```

5.5.3.5 Removing SST Contamination

Sun contamination, electronic noise, and the on-board mask can be removed by passing various arguments to thm_part_getspec and thm_part_moments. These operations may only be performed on ground data(not for on-board moments) and they only work on full or burst distribution data. A crib describing the operations in detail can be found at: `themis/examples/thm_crib_sst_contamination.pro`

`thm_part_getspec` can be used to generate angular plots with contamination removed.
`thm_part_moments` can be used to generate moments(en_eflux,denstity,etc..) with contamination removed.

Both routines use the same set of arguments to remove contamination. Contamination is usually easier to see in angular plots and data at different times may require slightly different settings to effectively remove the contamination, so it is often useful to generate angular plots with thm_part_getspec to test that the contamination is being removed effectively before generating moments. A basic description of the techniques used to remove the types of contamination is below:

Sun Contamination:
The routine fills in all the data that is more than some statistical limit from the data. The statistic that is used, the limit, and the method of filling can be set by the user. Linear interpolation along phi has been found to be an effective method for filling and the standard deviation from the median is effective at identifying contamination. A limit of 2.0 is the default. If the contamination isn't being removed, lowering the limit or changing the methods used can sometimes be helpful.

On-Board-Masking:
The on-board mask is identified by finding the phi bin that has a 0 value for a given percentage of the time interval. Generally a value of 100% or 99% is very effective. 99% is often better because in some data sets that mask will not always be 0, due to errors in transmission. The phi is then filled in using the user specified fill method. Linear interpolation across phi generally works quite well.

Electronic Noise:
Electronic noise is removed via a 2-step process. First the user generates an angular plot of the contaminated data of interest. They then use `edit3dbins` to examine the relative values of the contaminated bins during at a time when flux is nearest to 0 in all angles. They select the bins that look contaminated during this time and pass the list of contaminated bins into `thm_part_getspec` or `thm_part_moments` along with the time interval of the low flux region. The routines then subtract the values of selected bins during the low flux interval from those bins over the entire interval.

5.5.3.6 Overlaying Spectrograms Using Tplot Pseudovariables

Pseudovariables are a little known tplot feature that allows one or more tplot variables to be stored in a single tplot variable using the store_data command. For example,

```
store_data, 'pseudo_var', data=['tplot_var1','tplot_var2']
```

allows the user to plot the tplot variables tplot_var1 and tplot_var2 together in the same panel with the command:

```
tplot, 'pseudo_var'
```

One application of this feature is the merging of multiple spectrograms into a single plot. For example, one can combine full and burst mode spectrograms into a single plot by overlaying the burst mode data on top of the full mode data. Below is an example using ESA full and burst ion energy spectra:

```
thm_part_getspec, probe=['a'], trange=['07-03-23/10:30','07-03-23/12:40'], $
                  theta=[-90,90], phi=[0,360], data_type=['peif','peib'], $
                  /energy, datagap=400
```

The datagap keyword is very important in this case. It should be set to a number of seconds that is less than the time gap between burst data segments, but greater than the sample interval of the underlying full mode data. This is necessary to prevent tplot from interpolating between the burst mode segments, thus allowing the underlying full mode data to be seen between the burst mode data segments.

Now create a pseudovariable that stores the full and burst data in one tplot variable:

```
store_data, 'tha_comb', data=['tha_peif_en_eflux','tha_peib_en_eflux']
```

The next step is to set the y-axis and z-axis limits of the pseudovariable. This ensures that the full and burst mode data will have the same color and vertical scale.

```
ylim,'tha_comb',5,23000 ; set y-axis limits
zlim,'tha_comb',10,3e6 ; set all spectra to same color scale
```

5.5.4 Calibrations and Beyond

Refer to the crib sheet for each instrument for usage of the calibration routines. The interface to the various calibration routines has not yet been standardized.

Calibration: from L1 data to physical quantities

thm_cal_efi	Calibrates Electric Fields Instrument
thm_cal_fbk	Calibrates Filter Bank
thm_cal_fft	Calibrates FFT data
thm_cal_fgm	Calibrates Flux gate magnetometer
thm_cal_fit	Calibrates spin fit data..
thm_cal_mom	Calibrates all (ESA and SST) on-board moment data
thm_cal_scm	Calibrates SCM data

For working with SST or ESA data and creating ground-processed moments, see the crib sheets.

5.5.5 Geophysical Coordinate Transformations

thm_cotrans can be used to transform a THEMIS vector data quantity stored in a tplot variable to any of the following coordinate systems:

Abbreviation	Description
SPG	Spinning Probe Geometric
SSL	Spinning SunSensor L-vectorZ
DSL	Despun SunSensor L-vectorZ
GEI	Geocentric Equatorial Inertal
GSE	Geocentric Solar Ecliptic
GSM	Geocentric Solar Magnetospheric
SM	Solar Magnetic

For details and diagrams, see THM_SOC_110_COORDINATES.

The default output of thm_load routines is DSL. The thm_load routines set metadata in the tplot variable, which indicates the coordinate system of the data. Thm_cotrans is aware of this metadata, so it is not necessary to specify an input coordinate system when calling thm_cotrans.
thm_cotrans usage:

;Procedure: thm_cotrans
;Purpose: Transform between various THEMIS and geophysical coordinate systems
;keywords:

```
;  probe = Probe name. The default is 'all', i.e., transform data for all
;         available probes.
;         This can be an array of strings, e.g., ['a', 'b'] or a
;         single string delimited by spaces, e.g., 'a b'
;  datatype = The type of data to be transformed, can take any of the values
;         allowed for datatype for the various thm_load routines. You
;         can use wildcards like ? and [lh].
;         'all' is not accepted. You can use '*', but you may get unexpected
;         results if you are using suffixes.
;  in_coord = 'spg', 'ssl', 'dsl', 'gse', 'gsm', or 'gei'
;         coordinate system of input.
;         This keyword is optional if the coord_sys attribute
;         is present for the tplot variable, and if present, it must match
;         the value of that attribute.  See cotrans_set_coord, cotrans_get_coord
;  out_coord = 'spg', 'ssl', 'dsl', 'gse', 'gsm', or 'gei'
;          coordinate system of output.
;  in_suffix = optional suffix needed to generate the input data quantity name:
;          'th'+probe+'_'datatype+in_suffix
;  out_suffix = optional suffix to add to output data quantity name.  If
;          in_suffix is present, then in_suffix will be replaced by out_suffix
;          in the output data quantity name.
; valid_names:return valid coordinate system names in named variables supplied to
;         in_coord and/or out_coord keywords.
;Optional Input Parameters:
; in_name  Name(s) of input tplot variable(s) (or glob pattern) (space-separated string list or array of strings.)
; out_name Name(s) of output tplot variable(s).  glob patterns not accepted.
;         Number of output names must match number of input names (after glob
;         expansion of input names).  (single string, or array of strings.)
;
; Example:
; thm_cotrans, probe='a', datatype='fgl', out_coord='gsm', out_suffix='_gsm'
Several examples of thm_cotrans usage can be found in thm_crib_fgm.pro.
A low-level coordinate transformation routine is available if working with simple arrays rather than tplot variables is desired.
```

cotrans	Transform between geophysical coordinate systems GSE, GEI, and GSM.

5.5.6 Analytical Coordinate Transformations

5.5.6.1 Field Aligned Coordinate Transformations

The TDAS distribution allows transformation of three dimensional vectors into magnetic field aligned coordinate systems.

In order to rotate a vector into a field aligned coordinate system, a coordinate transformation matrix must first be generated using `/themis/state/thm_fac_matrix_make.pro`. This routine allows the generation of transformations for several different varieties of coordinate system. The primary input to `thm_fac_matrix_make` is a tplot variable containing the magnetic field vector, which is typically generated by calling `thm_load_fgm.pro`. Depending on the type of coordinate system variant requested, a tplot variable containing the position vector array (generated by calling `thm_load_state.pro`) may also need to be supplied via the `pos_var_name` keyword. The Z axis of the resulting coordinate system (transformation) will always be in the direction of B field vector. The `other_dim` keyword determines the requested variant of the transformation by specifying the second axis for the field aligned coordinate system. The third dimension will always be the cross product of this Z axis and the `other_dim` axis. Type `doc_library, 'thm_fac_matrix_make'` at the command prompt to see a description of the different `other_dim` options or look at the header at the top of the procedure file.

One caveat is that the magnetic field tplot variable must be in gse, gsm, or dsl coordinates, depending on what transformation has been selected. Another caveat is that the position tplot variable must be in gei coordinates, the default coordinate system of `thm_load_state`. Also note that the resulting transformation matrices will only correctly transform data from the coordinate system of the input variable to the field aligned coordinate system. So if mag_var_name is in DSL coordinates then you should only use the output matrices to transform other data in DSL coordinates.

Once the transformation matrix has been generated, the vector can be rotated by calling `/ssl_general/cotrans/special/tvector_rotate.pro` with the transformation matrix as the first argument, and the tplot variable containing the vector to be rotated into the field aligned coordinate system as the second argument. Below is an example:

```
timespan, '2007-03-23'
thm_load_state,probe='c', /get_support_data
thm_load_fgm,probe = 'c', coord = 'dsl'
  ;smooth the Bfield data appropriately
tsmooth2, 'thc_fgs_dsl', 601, newname = 'thc_fgs_dsl_sm601'
  ;make transformation matrix
thm_fac_matrix_make, 'thc_fgs_dsl_sm601', other_dim='xgse', newname = 'thc_fgs_dsl_sm601_fac_mat'
  ;transform Bfield vector (or any other) vector into field aligned coordinates
tvector_rotate, 'thc_fgs_dsl_sm601_fac_mat', 'thc_fgs_dsl', newname = 'thc_fgs_facx'
```

See `themis/examples/thm_crib_fac.pro` for more examples of how to rotate vectors into field aligned coordinates.

5.5.6.2 Minimum Variance Transformations

The TDAS distribution allows transformation of three dimensional vectors into a minimum variance coordinate system defined by an interval or intervals from time series vectors.

This transformation is performed in two steps. First, transformation matrices must be generated from some input time series vector data. Second, the transformation matrices must be used to transform time series vector data. These input data must be stored in tplot variables.

The minimum variance coordinate system is defined by generating the covariance matrix for an interval of data. This matrix is then diagonalized to identify the eigenvalues and eigenvectors of the covariance matrix. The eigenvector with the smallest eigenvalue will be the direction of the z component of the new coordinate system. The eigenvector with the largest eigenvalue will be the direction of the x component of the new coordinate system. The third eigenvector will be the y direction of the coordinate system.

The user should note that the resulting transformation matrices will only correctly transform data from the coordinate system of the input variable to the minimum variance coordinate system. So if the data used to define the coordinate system are in gse coordinates then you should only use the output matrices to transform other data that are in gse coordinates.

The routine to generate the matrices can be found at:
`idl/ssl_general/cotrans/special/minvar/minvar_matrix_make.pro`
The routine to perform rotations using the minimum variance matrices can be found at:
`idl/ssl_general/cotrans/special/tvector_rotate.pro`
The cribs for these routines can be found at:
`idl/ssl_general/cotrans/special/minvar/mva_crib.pro`
`idl/themis/examples/thm_crib_mva.pro`

Additional documentation can be found in the headers at the top of the procedure files listed above or by typing 'doc_library' from the idl command prompt. For example: doc_library,'minvar_matrix_make' will show the documentation for 'minvar_matrix_make'.

The example below will use fluxgate magnetometer data to generate a minimum variance coordinate system and transform that data into the minimum variance coordinate system.

```
;this sets the time interval from which data should be loaded
timespan,'2007-07-10/08:10:00',22,/minute
;this loads the data
thm_load_fgm,probe='c',coord='gse'

;this generates the transformation matrices
minvar_matrix_make,'thc_fgs_gse',tstart='2007-07-10/07:54:00',tstop='2007-07-10/07:56:30'

;this transforms the data
tvector_rotate,'thc_fgs_gse_mva_mat','thc_fgs_gse',newname='mva_data_day'

;this sets the axis labels
options,'mva_data_day',labels=['maxvar','midvar','minvar']

options,'mva_data_day',labflag=1

;this plots the original data and the transformed data
tplot,'thc_fgs_gse mva_data_day'
```

5.5.7 Tsyganenko Model

5.5.7.1 Introduction

Version 4.0 of TDAS allows access to the Tsyganenko Fortran routines via a DLM interface written by Haje Korth. Wrapper code has been provided in IDL to make use of the Tsyganenko model from IDL quick and easy, even for a user that is not familiar with the models. Support has been provided for routines that provide the model B field at a user specified set of locations and for tracing field lines from a position to the ionosphere or the equator. Routines are also available to ease the generation of model parameters from solar wind data. The supported models are the t89,t96,t01 and t04s models.

5.5.7.2 Installation

To run the Tsyganenko routines you will need to install Haje Korth's IDL GEOPACK wrapper for Tsyganenko's original Fortran code. The current version of the IDL GEOPACK can be found at the THEMIS website at the following URL: http://themis.ssl.berkeley.edu/idl_geopack_all_67.zip . Please download this file and unzip it. You then need to place two files in your idl dlm directory. If you do not know what your dlm directory is you can type 'print,!DLM_PATH
' from within idl. The first file is called 'idl_geopack.dlm'. The second file will have a different name depending on your operating system. For windows it will be called 'idl_geopack.dll
'. On most other OS's it will be called 'idl_geopack.so'. This file will be found in a subdirectory of idl_geopack_all_67.zip that is named for your operating system. After you copy these files two files into your idl dlm directory , all you need to do is restart idl. If you want to test that the installation worked type 'print,igp_test()'. If this prints out '1', it worked.

These installation instructions can also be found in the software distribution itself in
idl/external/IDL_GEOPACK/README.txt

5.5.7.3 Model Routines

Routines to generate the model field vectors for time series of position vectors can be found in the idl/external/IDL_GEOPACK directory and its subdirectories. These routines take either tplot variables or arrays of times and positions as arguments. They will produce the model magnetic field. Extensive documentation and examples can be found in the cribs and in the headers at the tops of the files.

One caveat is that you should remember to set the period keyword equal to a number of seconds equal to the cadence of your data to prevent the result vectors from sawtoothing when the geomagnetic dipole is recalculated. If your position data is all at a single time do not worry about the period argument.

The cribs for the routines are:
idl/external/IDL_GEOPACK/t89/tt89_crib.pro
idl/external/IDL_GEOPACK/t96/tt96_crib.pro

idl/external/IDL_GEOPACK/t01/tt01_crib.pro
idl/external/IDL_GEOPACK/t04s/tt04s_crib.pro

The tplot based routines are:
idl/external/IDL_GEOPACK/t89/tt89.pro
idl/external/IDL_GEOPACK/t96/tt96.pro
idl/external/IDL_GEOPACK/t01/tt01.pro
idl/external/IDL_GEOPACK/t04s/tt04s.pro

The array based routines are:
idl/external/IDL_GEOPACK/t89/t89.pro
idl/external/IDL_GEOPACK/t96/t96.pro
idl/external/IDL_GEOPACK/t01/t01.pro
idl/external/IDL_GEOPACK/t04s/t04s.pro

The routine that generates model parameters from solar wind data for the t96,t01, and t04s models is:
idl/external/IDL_GEOPACK/get_tsy_params.pro

Here is a simple example:

```
timespan,'2007-03-23'
thm_load_state,probe='b',coord='gsm'
tt89,'thb_state_pos',kp=2,period=60
tplot,'thb_state_pos_bt89'
```

5.5.7.4 Trace Routines

Routines to trace field lines from specified positions can be found in the idl/external/IDL_GEOPACK/trace/ directory. The routines will use numerical techniques for solving differential equations to trace the magnetic field lines from a set of specified positions to either the equator or the ionosphere. These routines take as arguments either tplot variables storing three dimensional position data or arrays of vectors and times. They will produce footprints of the field lines on the ionosphere or equator. Full traces of the entire field lines can be returned if requested as well. Plotting of traces can often best be performed with the plotxy or tplotxy plotting routines. The trace routines can trace using any of the four supported Tsyganenko models. The trace routines work equally well if all positions use the same time and are often used to look at field lines traced from several positions at a single instant. More extensive documentation and examples can be found in the headers at the top of files and in the crib.

These routines come with two caveats:
1. As with the model routines, if your data is not all at a single time the period keyword should be set to the cadence of your data to prevent inaccuracies from geomagnetic dipole recalculations.
2. Solving differential equations can take a long time, so please be patient. Sometimes the field lines will continue away from the earth an infinite distance or even fall into an infinite loop condition due to the insolubility of the system. The latter case only occurs rarely. To avoid the former case the R0 and RLIM parameters can be used to set maximum and minimum distance cutoffs at which to stop tracing.

An extensive crib for these routines can be found at:
idl/external/IDL_GEOPACK/trace/ttrace_crib.pro

The tplot based routines can be found at:
idl/external/IDL_GEOPACK/trace/ttrace2equator.pro
idl/external/IDL_GEOPACK/trace/ ttrace2iono.pro

The array based routines can be found at:

idl/external/IDL_GEOPACK/trace/trace2equator.pro
idl/external/IDL_GEOPACK/trace/trace2iono.pro

The trace routines can also use the get_tsy_params routine to generate model parameters. It is at:
idl/external/IDL_GEOPACK/get_tsy_params.pro

```
Here is a simple example:
timespan,'2007-03-23'

thm_load_state,probe='b',coord='gsm'

ttrace2iono,'thb_state_pos',external_model='t89',par=2.0D,/km
,period=60
tplotxy,'thb_state_pos_foot'
```

5.5.8 Mini Language

A simple scripting language for working with tplot variables has been provided in a form that is usable at the command line and from within the THEMIS GUI. At the command line you can access this language using the 'calc' command. From within the GUI you can access this language by selecting “Analysis->Calculate...” from the main GUI window.

Here is an example of a mini language call from the command line:
`calc,'”tha_state_pos_avg” = mean(“tha_state_pos”,2)'`

In the GUI this statement would simply be:

`”tha_state_pos_avg” = mean(“tha_state_pos”,2)`

In both cases the command takes the average of each x,y,z triplet and stores the output in a new tplot variable that has dimensions time by 1 rather than time by 3(x,y,z). Inside the gui the outer set of single quotation marks is not required.

Examples of command line usage can be found in the file:
`themis/examples/thm_crib_calc.pro`

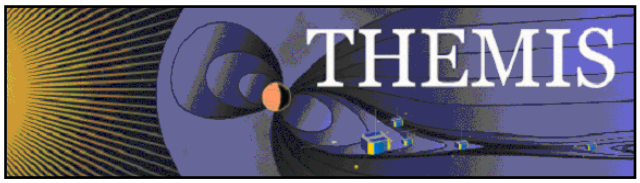
In all subsequent examples, the 'calc' command will be omitted for brevity.

Data Types:

There are three basic data types in the mini language:
1. Numerical constants.
These are terms like:
`1,1B,1.2,-2.3e-4`
The mini language accepts numerical constants of any type that IDL accepts with the exception of complex numbers

2. Normal variables
These are terms like:
`a,b,hello, world`
These can be read out of the current IDL session or defined by a mini-language statement. Their only major restriction is that when they are used in the GUI they are only in scope for the duration of a mini-language program.

3. Tplot/Gui variables.
These are terms like:
`“tha_state_pos”, “thb_fgs_dsl”,”thc_peif_en_eflux”`



These are settings, time, and data bound together into a single name. Most of the data in the GUI and from Themis will be represented in this form. To differentiate these variables from normal variables, they are always denoted with quotes(“ “). When tplot/gui variables are used in expressions their times and other settings are carried along into the output if the output is also a tplot/gui type.

Operations between Normal Variables and Tplot/GUI variables, are required to have matching numbers of elements and matching dimensions to work.

Syntax:

Statements in the mini language have one of two basic forms.

1. Basic Assignments:
These are statements like:

```
a = 6374.4
“thb_state_pos_re” = “tha_state_pos” / a
state_var = “tha_state_pos”
```

The left hand side can be a normal variable or a tplot/gui variable. The right hand side can contain and combination of numerical constants, normal variables, tplot/gui variables, operators, and functions.

2. Compound Assignment/Operations:
These are statements like:

```
“tha_state_pos” /= 6374.4
```

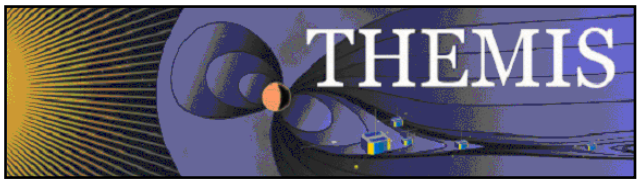
These have the same form as basic assignments but allow the user to write statements in a more concise form.(the statement above is equivalent to:

```
 “tha_state_pos” = “tha_state_pos” / 6374.4
```

Operators:

Operators can be used to combine any of the data types on the right hand of the equation. The only practical limitation on the number of operators and data types that can be combined in a single expression is the amount of available memory. These operators follow the same operator precedence as IDL. Like many languages, the operator precedence can be overridden using parentheses. The allowable operators are:

```
~  : logical negation (c = ~a)
++ : increment (c = a++) or (c = ++a)
-- : decrement (c = a--) or (c = --a)
-  : subtraction (ex: c = b-a)
+  : addition (ex: c = b+a)
*  : multiplication (ex: c = b*a)
/  : division (ex: c = b/a)
^  : exponentiation ( ex: c = b^a)
<  : array less-than (ex: c = b < a)
>  : array greater-than ( ex: c = b > a)
&& : logical conjunction ( ex: c = a && b)
|| : logical disjunction ( ex: c = a || b)
#  : row-major matrix multiplication ( ex: c = a # b)
## : column-major(traditional) matrix multiplication ( ex: c = a ## b)
mod : modulus operator (ex: c = a mod b)
and : binary conjunction (ex: c = a and b)
eq  : logical equivalence (ex: c = a eq b)
ge : logical greater-than-or-equal-to (ex: c = a ge b)
```



```
gt : logical greater-than (ex: c = a gt b)
le : logical less-than-or-equal-to (ex: c = a le b)
lt : logical less-than (ex: c = a lt b)
or : binary disjunction ( ex: c = a or b)
xor : binary xor (ex: c = a xor b)
() : precedence override ( ex: d = (a + b) * c)
```

Note that any of these operators can be combined with an '=' to create a compound operator/assignment statement in the mini language.

Also users on the command line can obtain a list of the available operators using the following statement:

```
calc,operator_list=op
print,op
```

Functions:

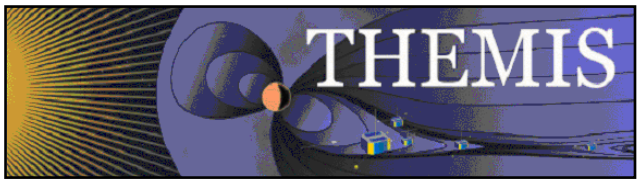
The mini language supports a variety of different functions, but it does not maintain the function/procedure distinction that IDL does. All routines must be function calls. All routines are built in. There are no user-defined function calls. All functions have one required argument which can be an element of any data type. Some routines also accept a second optional argument. The optional argument is always a number. Functions and operations can be combined together in the same ways that a normal programming language would combine them. Example:

```
“tha_state_pos_log” = log(“tha_state_pos”+10) / 6374.4
```

The list of available functions follows:

```
log(x[,base]) : By default, returns a base 10 logarithm on the input.
                If [,base] is provided, this function will perform the logarithm
                using the provided base. Example:
                “tha_peif_en_eflux_log” = log(“tha_peif_en_eflux_log”,2)

ln(x)         : Returns a natural logarithm of the input.
exp(x[,base]) : By default returns e^x, where e is the natural base.  If [,base]
                is provided, it will return base^x.
sqrt(x)       : Returns the square root of the input.
abs(x)        : Returns the absolute value of the input.
sin(x)        : Returns the sine of the input.
arcsin(x)     : Returns the inverse sine of the input.
sinh(x)       : Returns the hyperbolic sine of the input.
cos(x)        : Returns the cosine of the input.
arccos(x)     : Returns the inverse cosine of the input.
cosh(x)       : Returns the hyperbolic cosine of the input.
tan(x)        : Returns the tangent of the input.
arctan(x)     : Returns the inverse tangent of the input.
tanh(x)       : Returns the hyperbolic tangent of the input.
csc(x)        : Returns the cosecant of the input.
arccsc(x)     : Returns the inverse cosecant of the input.
csch(x)       : Returns the hyperbolic cosecant of the input.
sec(x)        : Returns the secant of the input.
arcsec(x)     : Returns the inverse secant of the input.
sech(x)       : Returns the hyperbolic secant of the input.
cot(x)        : Returns the cotangent of the input.
arccot(x)     : Returns the inverse cotangent of the input.
coth(x)       : Returns the hyperbolic cotangent of the input.
```



```
min(x[,dim])  : By default returns the single minimum for the entire input.
                If [,dim] is provided function will perform the minimum across a
                particular dimension of the input.  A one dimensional array will
                be returned. Typically min(x,1) will perform a minimum across
                time. min(x,2) will perform a minimum across x,y,z, etc...
max(x[,dim])  : By default returns the single maximum for the entire input.
                If [,dim] is provided function will perform the maximum across a
                particular dimension of the input.
mean(x[,dim]) : By default returns the single mean for the entire input.
                If [,dim] is provided function will perform the mean across a
                particular dimension of the input.
median(x[,dim]) : By default returns the single median for the entire input.
                If [,dim] is provided function will perform the median across a
                particular dimension of the input.
count(x[,dim]) : By default this function returns the count of the number of
                 elements in the input. If [,dim] is provided this function will
                 count the elements in each particular dimension of the input and
                 return a result with multiple elements.
total(x[,dim]) : By default this function returns the total of the elements in
                 the input. If [,dim] is provided this function will total the
                 elements in each particular dimension of the input and return a
                 result with multiple elements.
```

On the command line, you can use the following command to obtain a list of available functions:

```
calc,function_list=f
print,f
```

Error handling:

When using the GUI any errors will be reported in a popup message and in the status bar at the bottom. On the command line errors are returned through the 'error' keyword. For example:

```
THEMIS> calc,'illegal statement',error=e
THEMIS> help,e,/str
** Structure <89b945c>, 4 tags, length=68, data length=68, refs=1:
   TYPE            STRING    'error'
   NAME            STRING    'User statement syntax error'
   STATE           LONG                 3
   TOKEN           STRUCT    -> <Anonymous> Array[1]
```

The returned statement contains the name of the error type and also returns information about the state of the interpreter that can be useful in helping THEMIS programmers diagnose and fix the error.

5.5.9 Data Export

You can export your data and/or plots to a variety of data formats.
Examples (please read procedure headers for additional options and information):

Export to ASCII files:
This example writes out Flux Gate Magnetometer Slow Survey data for all probes.
The ext keyword is being used to add the time of the data to the filename.
The dir keyword is being used to set the directory to which the files will be written.

```
tplot_ascii, 'th?_fgs', trange=timerange(/current), dir='~/thm/waves', ext='_20070520.txt'
```

Export to PNG:
This example writes a png of the plot displayed by the given tplot command.

```
tplot,'th?_fgs' ;plots the data
makepng, '~/thm/waves' ;make a png  file called  ~/thm/waves.png
```

Export to Postscript:
This example writes a postscript by recreating the previously generated plot.

```
tplot, 'th?_fgs'     ;setup the plot however you want it
popen,'~/thm/waves'  ;start a ps called waves.ps
tplot                ;call with no arguments to replot previous plot
pclose               ;finalize postscript and save it
```

Export to Encapsulated Postscript(EPS):
This example writes an encapsulated postscript by recreating the previously generated plot.

```
tplot, 'th?_fgs'                   ;setup the plot however you want it
popen, '~/thm/waves', /encapsulated ;start an eps called waves.eps
tplot                              ;call with no arguments to replot previous plot
pclose                             ;finalize eps and save it
```

5.5.10 Configuring Local Data Cache and Remote Access Behavior

Data locations may be configured at IDL startup (for example, if you want the data to reside in a non-standard location), or dynamically during an IDL session.

The following table summarizes the controls that can be used, in order of precedence:

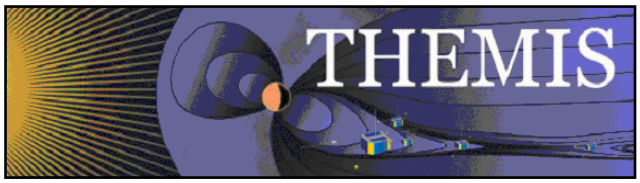
- !THEMIS system variable
- thm_config.txt (editable with and IDL program: thm_ui_config)
- environment variable settings

The following table summarizes the settings available:

!themis structure element	Environment Variable	Description
local_data_dir	THEMIS_DATA_DIR	a writable, local directory in which to cache data files. The default on Unix/Linux/Mac is '/disks/data/themis'. On windows, the default is 'C:\data\themis'
remote_data_dir	THEMIS_REMOTE_DATA_DIR	URL to a data archive where THEMIS data can be found. By default, http://themis.ssl.berkeley.edu/data/themis
no_download	N/A	1: don't access remote_data_dir
no_update	N/A	0: download only if file on server differs or if local file does not exist. 1: download only if local file does not exist. i.e. no clobber.
Verbose	N/A	level of verbosity for themis commands, 0=silent. Values >1 are generally for debugging.

5.5.10.1 Configuration at startup

If you want to change the local_data_dir where data will be stored, run thm_ui_config at the IDL prompt.



Change the setting for Local Data Directory and press 'Save'; this will save the configuration to be used in all future IDL sessions. The configuration is saved in a thm_config.txt file in an OS-specific location. Note that this operation only changes the Local Data Directory for THEMIS data. It does not change the ROOT_DATA_DIR variable defined in section 5.5.11. A more detailed description of the thm_ui_config widget is given in section 6.1.12.

5.5.10.2 On-the-Fly configuration

The local data directory location can be changed on-the-fly by setting the !themis.local_data_dir system variable. For example, when you are on a PC connected to the SSL network, you may choose to use a networked data dir:

```
!themis.local_data_dir = '\\justice\data\themis\'
```

The remote_data_dir structure element can also be updated to a different URL.

If you want the software to use only locally available data, and don't want the software to try to download data, you can set:

```
!themis.no_download = 1
```

Note that you can only set the !themis variable in an IDL session after a thm_ command has already been run, or after explicitly calling thm_init. Using thm_ui_config from the IDL prompt without pressing 'Save' in the widget is an alternate way of setting !themis for the current IDL session.

5.5.10.3 Note for users who connect using a web proxy server

If you are behind a firewall and have to access the net through a Web proxy, set the environment variable 'http_proxy' to point to your proxy server and port, e.g. (for Unix) 'setenv http_proxy=http://web-proxy-server.my_institution.edu:3128' The URL *MUST* begin with "http://".

This can be done in your IDL_startup file, e.g. IDL > setenv, 'http_proxy= http://web-proxy-server.my_institution.edu:3128'

5.5.11 Managing Your Data Cache

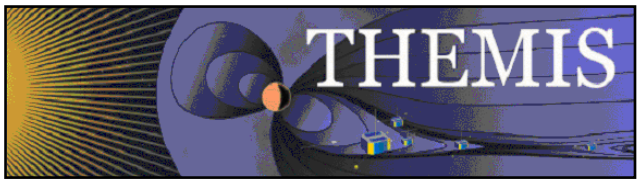
There currently exist two experimental routines for managing your THEMIS data file cache. These routines serve as an example of how you will be able to download all data for a given time range with a single command.

- thm_file_download – can be used to download all types of THEMIS data for a given time span.
- thm_file_cleanup – delete empty directories. This is a function call. It searches the hierarchy and return files matching a given pattern, sorted by access time. This will only delete files if the "delete files" keyword is set.

5.5.12 Define the root_data_dir for ancillary (non-themis) data

To define the root data directory for ancillary (non-themis) data (e.g., wind, ace, goes), which can also be accessed and manipulated by TDAS software, the default can be changed by setting an environment variable "ROOT_DATA_DIR".

For example the following line can be put in the IDL_STARTUP file:
setenv,'ROOT_DATA_DIR=/mydatacache/'
or an equivalent setting made in the shell. The default for ROOT_DATA_DIR is '/disks/data' on Unix/Linux/Mac and 'C:\data' for Windows. It is important to note that the default THEMIS data directory will then be ROOT_DATA_DIR/themis/. This value can be changed using the methods described in section 5.5.9.



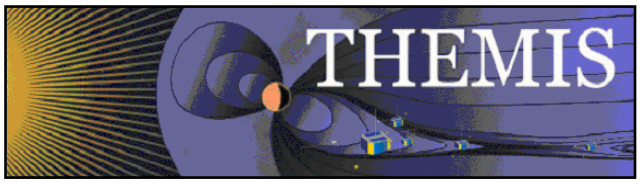
5.6 Software Organization

The themis directory contains THEMIS-specific routines. The general directory (currently named ssl_general) contains routines which are useful for more than one space-science mission for which THEMIS team members are developing code. The external directory contains packages developed and maintained by other groups, but which are required for writing (and running) some of the themis and/or general routines.

The idl directory of the distribution includes the following files and sub-directories.

_tdas_doc.html	Documentation in HTML format, including alphabetical list of all routines.		
themis/	setup_themis	Sample setup script for csh (UNIX)	
	ground/	routines for loading, processing and plotting ground-based data. e.g. thm_load_gmag, thm_gmag_stackplot, imageplot, mosaicplot	
	spacecraft/	fields /	routines for loading, processing and plotting particles data, e.g. thm_proc_fgm
		particles/	routines for loading, processing and plotting particles data, e.g. thm_load_sst, thm_cal_sst
	state/	Routines for reading state and performing coordinate transformations, e.g. thm_load_state, thm_cotrans.	
	examples/	Crib sheets, like thm_crib_ask	
	common/	THEMIS-specific tools useful to multiple data types and instruments, eg thm_gui, thm_file_download, thm_init	
ssl_general/	CDF/	CDF utilities, including cdf2tplot, and other utilities like cdf2tplot, cdf_info, cdf_load_vars (into IDL structure representation of CDF)	
	science/	Routines useful for specific scientific analysis.	
	cotrans/	General coordinate transformation: cotrans, ssl2dsl, dsl2gse	
	tplot/	General time-plotting utilities	
	misc/, tools/	Miscellaneous routines used by tplot and other ssl_general routines.	
	key_param/	Load routines for ACE, KP, WIND, POLAR data, some of these	
	missions/	Load routines for ACE, KP, WIND, POLAR data. Some of these replace older routines in the /key_param directory.	
external/	CDAWeb	CDAWeb are CDF routines distributed by NASA's SPDF.	
	IDL_GEOPACK	Magnetic field modeling, Tsyganenko models	

The _tdas_doc.html file contains a complete listing of all routines in the hierarchy, along with links to complete documentation.



6 Graphical User Interface

The THEMIS Graphical User Interface (GUI) provides a powerful interface to THEMIS science data. It is designed for ease of use in viewing and analyzing data and is set in a familiar windows-like environment. Features include the ability read, load, and view data, create publishing quality plots, access commonly used THEMIS analysis software, and increased user interaction.

The GUI code is bundled together with the THEMIS IDL code distribution; they are downloaded and installed as a single package.

A text-only version of the documentation for the GUI is available within the software distribution at idl/themis/examples/thm_gui.txt.

6.1 Main Window Overview

The main GUI window is shown below in Figure 6.1. This is a snapshot of the window when the GUI is first started. Since no data or THEMIS GUI document has been loaded and no plots created, the main graph area will be blank.

Starting from the top of the window is the windows frame titled. THEMIS: Main Window. It has the standard window features in the frame to minimize, maximize, and close the window.

Below the frame is the main menu bar. Commonly used menus include File, Edit, View, Page, and Help. Specific to the THEMIS application are Graph and Analysis pull down menus.

Next, below the main menu bar is the toolbar. For quick and easy access to the most frequently used functions, the toolbar contains icon buttons the user can click on versus navigating through the pull down menu hierarchy. All icon buttons in the toolbar contain tooltips to provide the user with a brief description of the functionality.

The large central area of the main window contains the graph area and is where plots are displayed. To the right of the graph area is a scroll bar that allows the user to scroll vertically when multiple plots are displayed.

And, finally, at the bottom of the window is a message bar. The message bar updates the user on the state of the GUI, the status of an operation, and provides general information to the user, including warning and/or error messages.

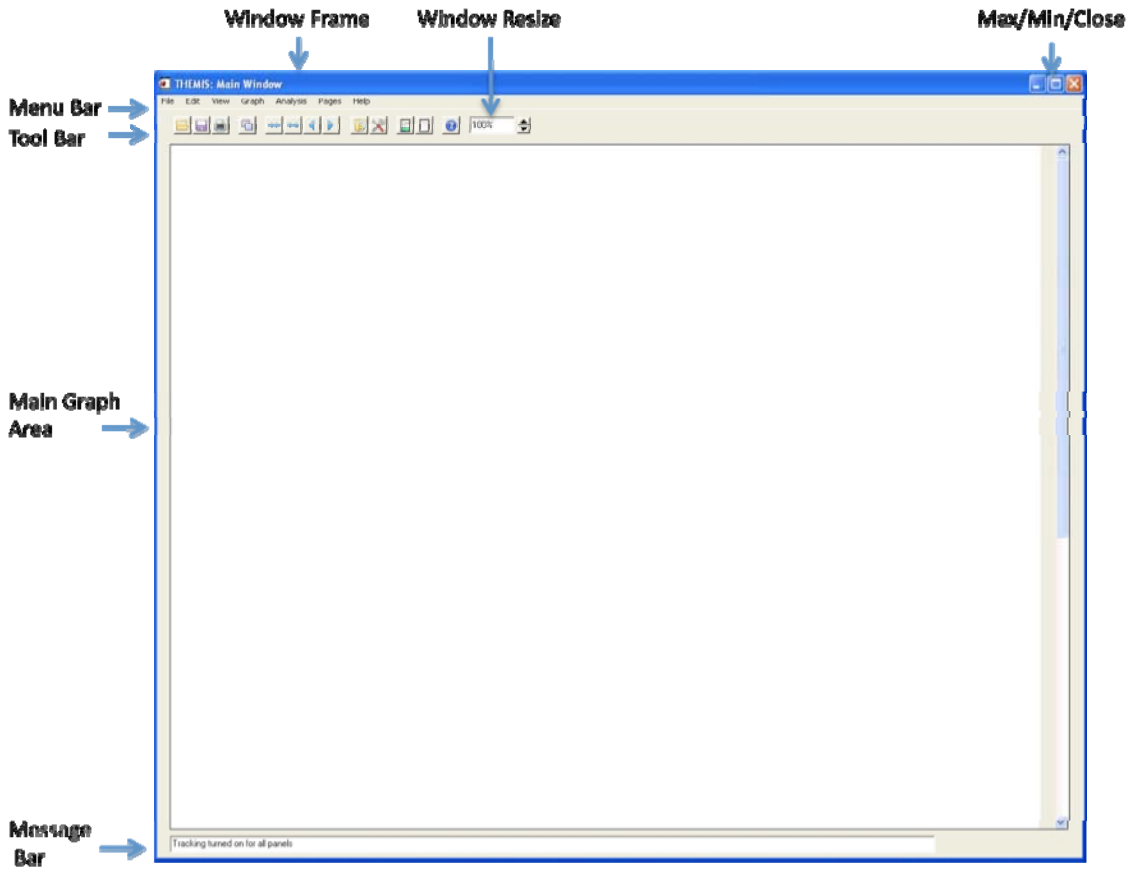


Figure 6.1

6.1.1 Pull Down Menus

Pull down menus use standard features that users are familiar with and including the following:

Sensitive: A menu item may be sensitized or desensitized (grayed out) depending on the state of the GUI and/or the availability of an operation at the time it is requested.

Checked: Check marked menu items are used when an option can be turned on or off. The check mark allows the user to toggle on or off an item.

Sub: In cases where multiple options are available, a sub menu is used to further divide the functionality. Submenus will have a carrot or arrow head indicating there are additional options to select from.

Dynamic: One menu, the Page menu, is not static and changes with the number of pages that have been created.

Pop-Up: In cases where a menu item displays another window, the name of the item will be following by three periods.

Accelerator: Some menus have accelerator keys associated with them. Accelerator keys provide a quick and easy way to invoke functions. When a menu item has an accelerator key, the key combination will be listed next to the name of the menu item.

An example pull down menu is shown below in Figure 6.1.1.

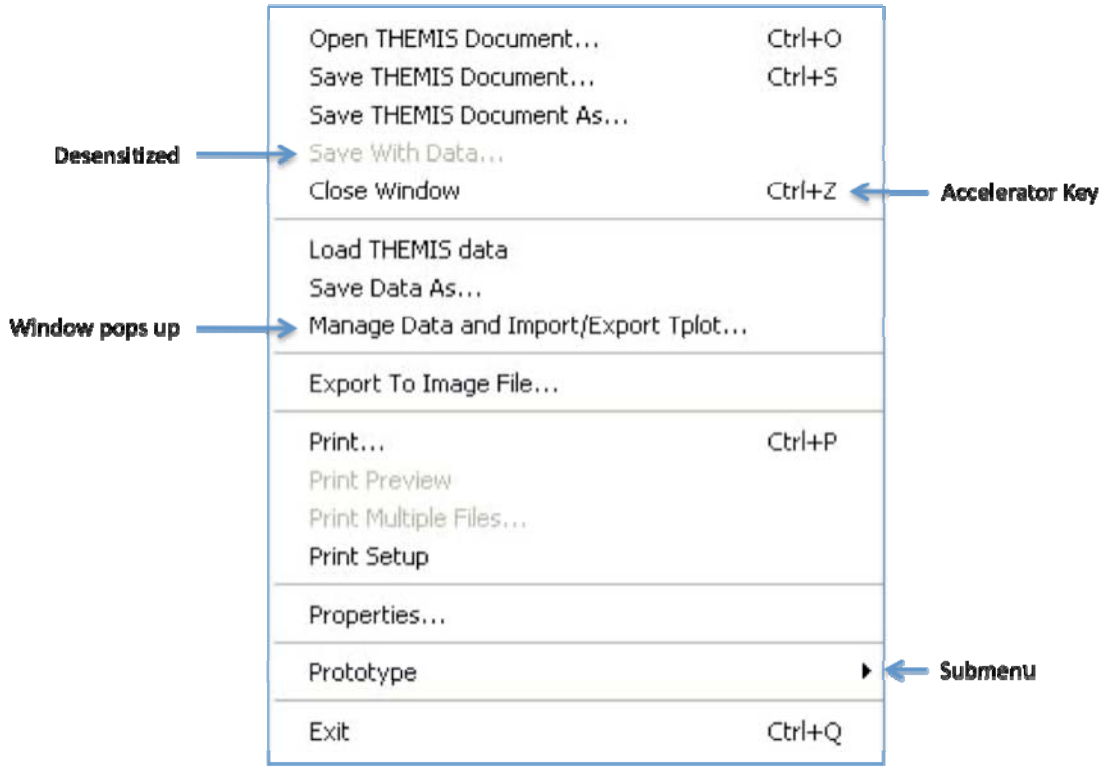


Figure 6.1.1

6.1.2 Toolbar icons

The tool bar provides short cuts to more commonly used functions. The buttons contain familiar icons depicting the operation. In addition, each tool bar button contains a tool tip that is displayed when the cursor hovers over the button. The tool tip displays text describing the function of the button. Buttons are clustered when their functionality is similar. Figure 6.1.2 shows a picture of the tool bar.

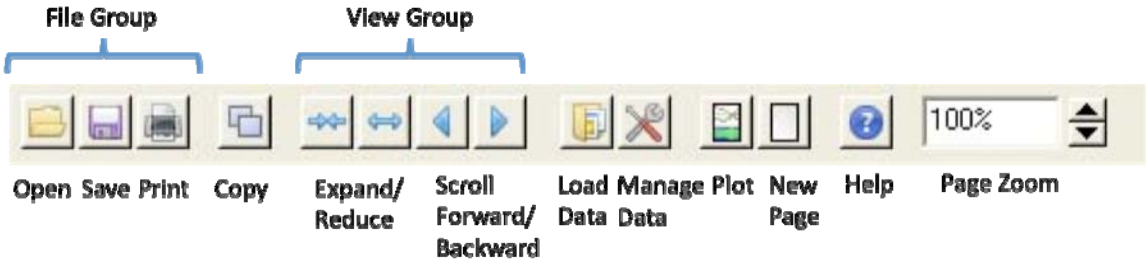


Figure 6.1.2

6.1.3 Graph Area

Shown below, in Figure 6.1.3, is an example of the main graph area with a graph plotted.

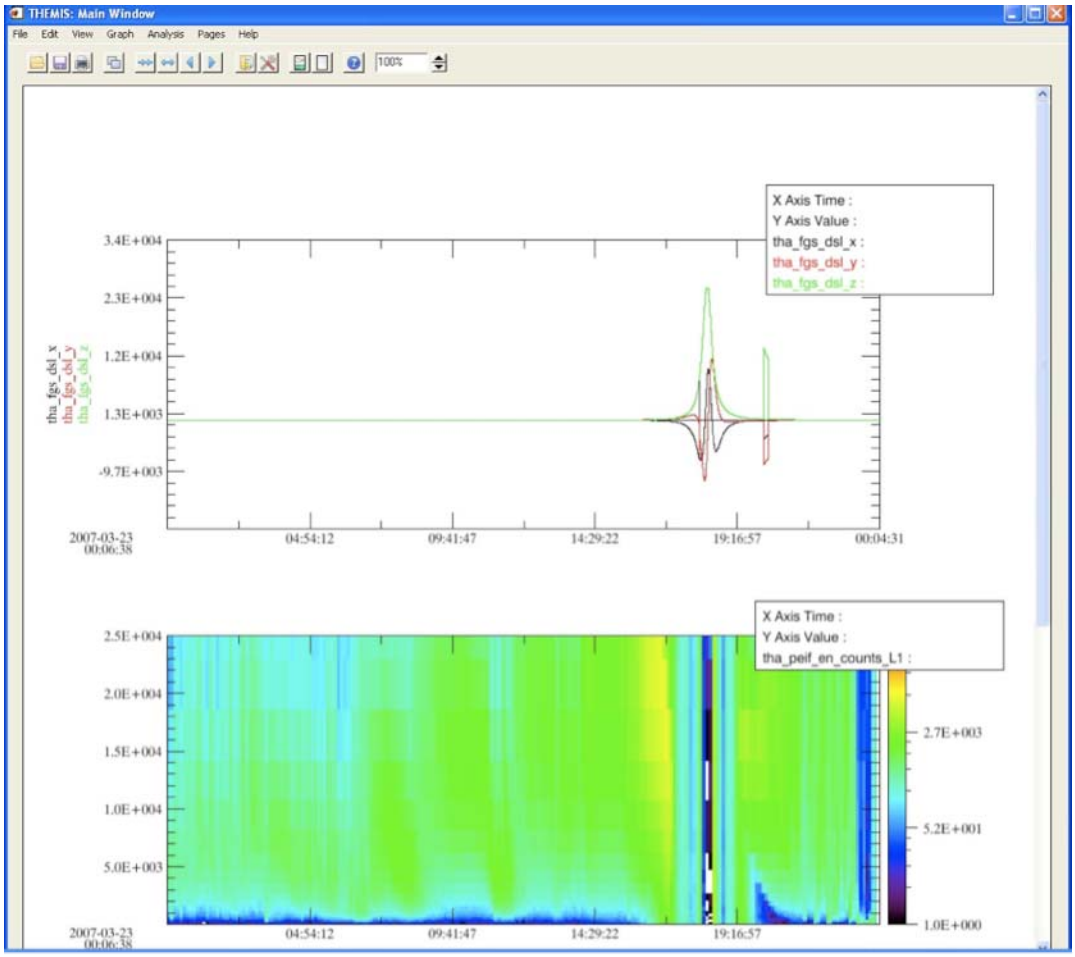


Figure 6.1.3

6.1.4 Status Bar

The status bar is located below the main graph area and displays messages to the user. Messages include status updates, state of the GUI and/or operation, success and failure notices, as well as warning and error information. It is important for the user to remember to check the status bar periodically for messages, particularly if you think something is not correct. Information displayed in this bar may be helpful and provide an answer to your question.

Figure 6.1.4

Please note, when a severe error or incorrect usage occur you will be notified via a pop-up dialog window explaining the error. Additional instructions may be provided.

6.1.5 Buttons

In order to provide a consistent interface throughout the GUI, you will find most windows contain the set of buttons shown in Figure 6.1.5.

Figure 6.1.5

OK: When this button is clicked whatever changes you made since the window was first displayed will be made, committed within the system. The window will be closed and the main graph area will be updated to reflect the changes. Please note that when OK is selected the original settings will be lost.

Apply: The apply button will update the main graph area so that you can view your changes. The window will not be closed and your changes will not be committed.

Cancel: Whenever the cancel button is clicked all changes made since the window was first invoked will be reset to original settings. The window will be closed. The main graph area will be updated to reflect it's original state. You should note that like the OK button, when the cancel button is selected all changes are lost permanently.

6.1.6 Windows

A window within the GUI refers to any windows that is opened when pull down selections are made, a tool bar button is clicked and other user interactions. Windows have frames, titles, and minimize, maximize, and close buttons within the frame. Most windows are also modal. That is, the user must either click the OK or Close button, or the Cancel button 'X' in the window frame before control is returned to the calling or original window.

NOTE: Screen size and system settings vary from machine to machine. During testing, a rare case was found that opened some IDL windows to size zero. The windows included the dialog box pick file and printer setup used in the File pull down menu. This is an error internal to IDL. If a window opens to size zero, you simply need to resize to see the content.

6.1.7 Pages

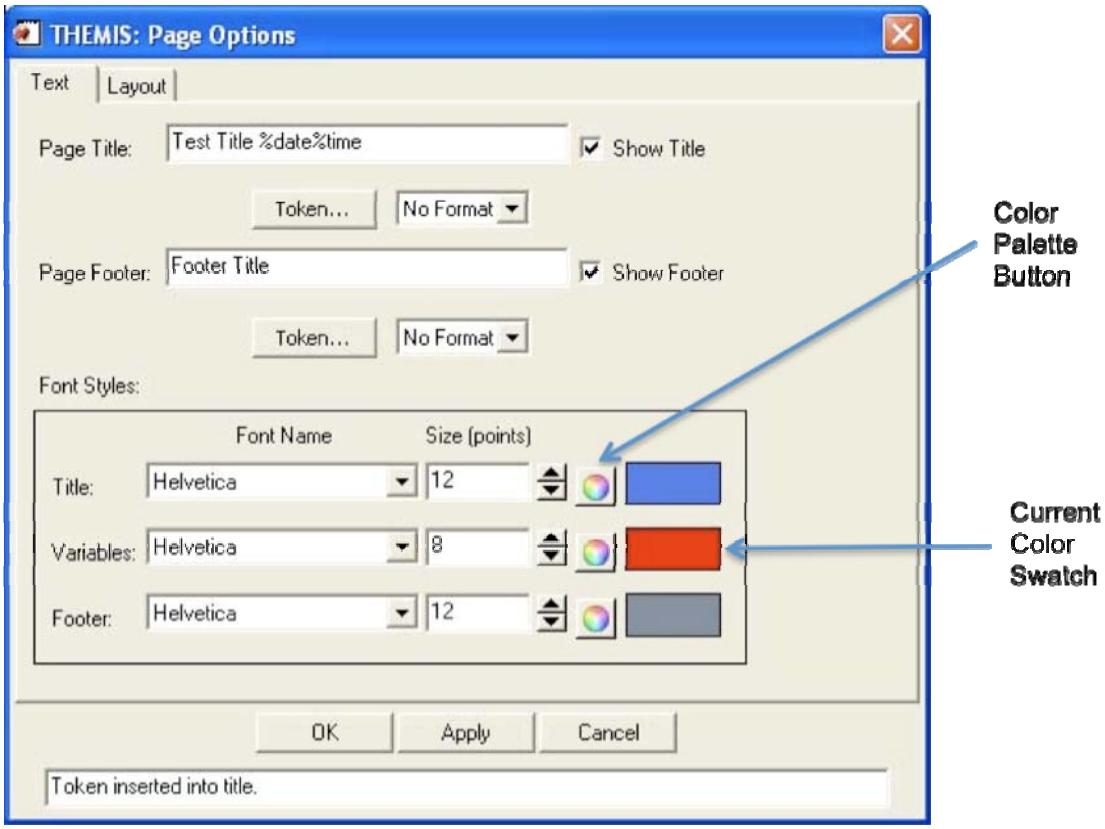
The user can have one or many pages during a session. A page contains one or many panels, titles, background color, etc. The number of pages that have been created can be determined by using the Page pull down menu. The Page pull down menu also provides a way for the user to toggle between pages since only one page can be displayed at a time.

6.1.8 Panels

A panel is a plot or graph on a page. Panels are usually contained within an axis frame and have x and y axes (and z axes for spectral data), traces, ticks, gridlines, and other features. One or many panels can be created per page.

6.1.9 Color Palette

Most of the Graph Options windows allow the user to change the color of labels, traces, background, grid, annotations, and more. Whenever color can be modified, a Color Button (with a color palette icon) and Color Swatch with the current color setting will be available. An example of the Color Button and Current Color Swatch and shown in Figure 6.1.9a.



6.1.9a

When the color button is clicked a Color Palette window is displayed. The user can select a color by clicking on the color tiles or by using the RGB slider bars below the tiles. When a selection has been made the current color swatch in the middle of the window will be updated to reflect the new color. You can choose to accept the color by clicking on the Accept Button or choose not to make any changes by clicking on the Cancel Button. Both the Cancel and Accept buttons will close the color palette window and return to the original or calling window. If the user accepted the color, the current color swatch in the original window will be updated. The color palette window is shown in Figure 6.1.9b.

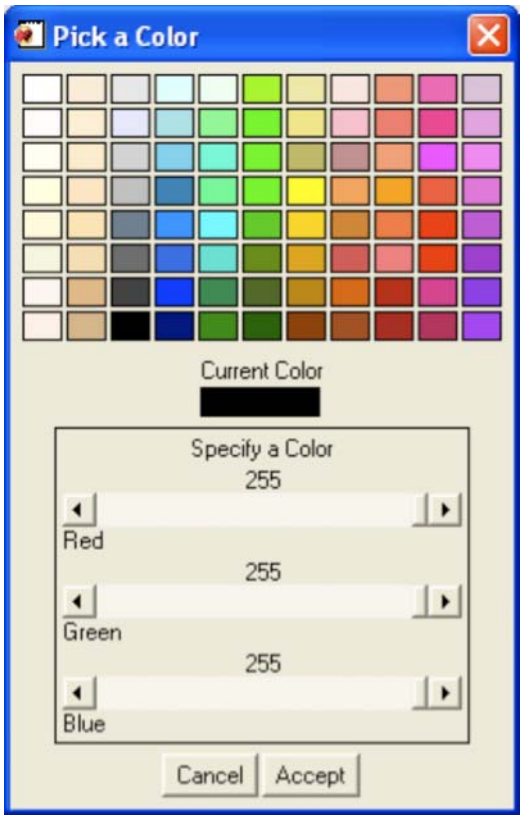


Figure 6.1.9b

The Color Palette window is a modal window and you must either make a selection or cancel the window in order to return control to the calling window.

6.1.10 Data Tree

All data that have been loaded directly into the GUI or imported from tplot variables are displayed in a tree widget. Many of the GUI windows require the user to select data for analysis or plotting and will be displayed in tree format. The tree widget allows the user to expand or collapse the tree by clicking on the '+' (expand) or '-' (collapse) buttons next to the data. The data tree hierarchy is as follows:

Mission
Probe
Instrument
Data Set
Data Components

An example of a data tree is shown below in Figure 6.2.9.

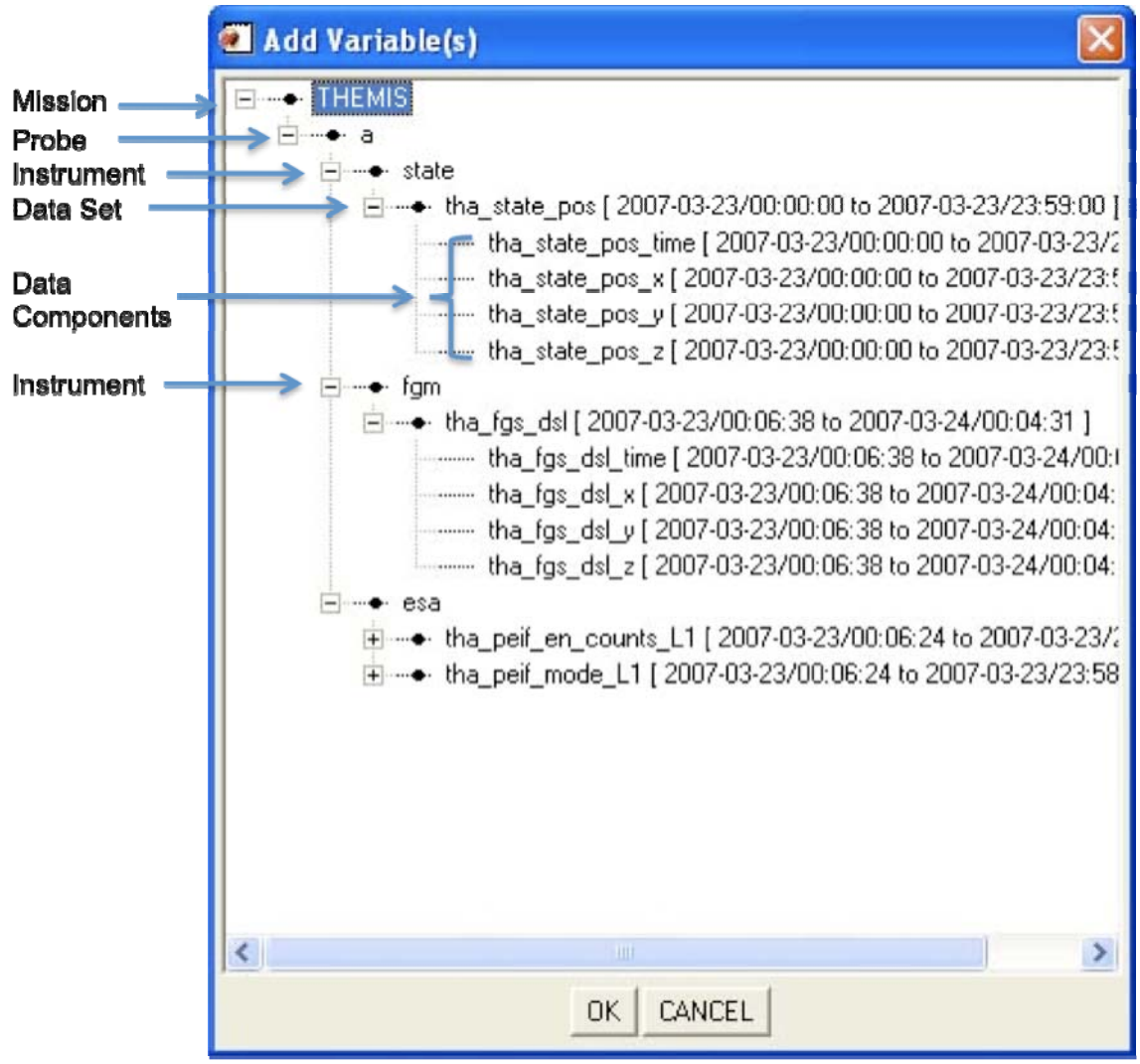


Figure 6.1.10

6.2 Mouse and Keyboard Events

6.2.1 Tracking

When tracking is enabled any movement within the frame of a panel in the draw area will be tracked. Tracking can be toggled on and off from the Graph pull down menu. The user can choose to track one panel or all panels. In addition the user can track vertically, horizontally or both. When the GUI session is first started, tracking of all panels is on by default and tracking both vertically and horizontally. Figure 6.2.1 shows an example of the main graph area when tracking is turned on and tracking all panels.

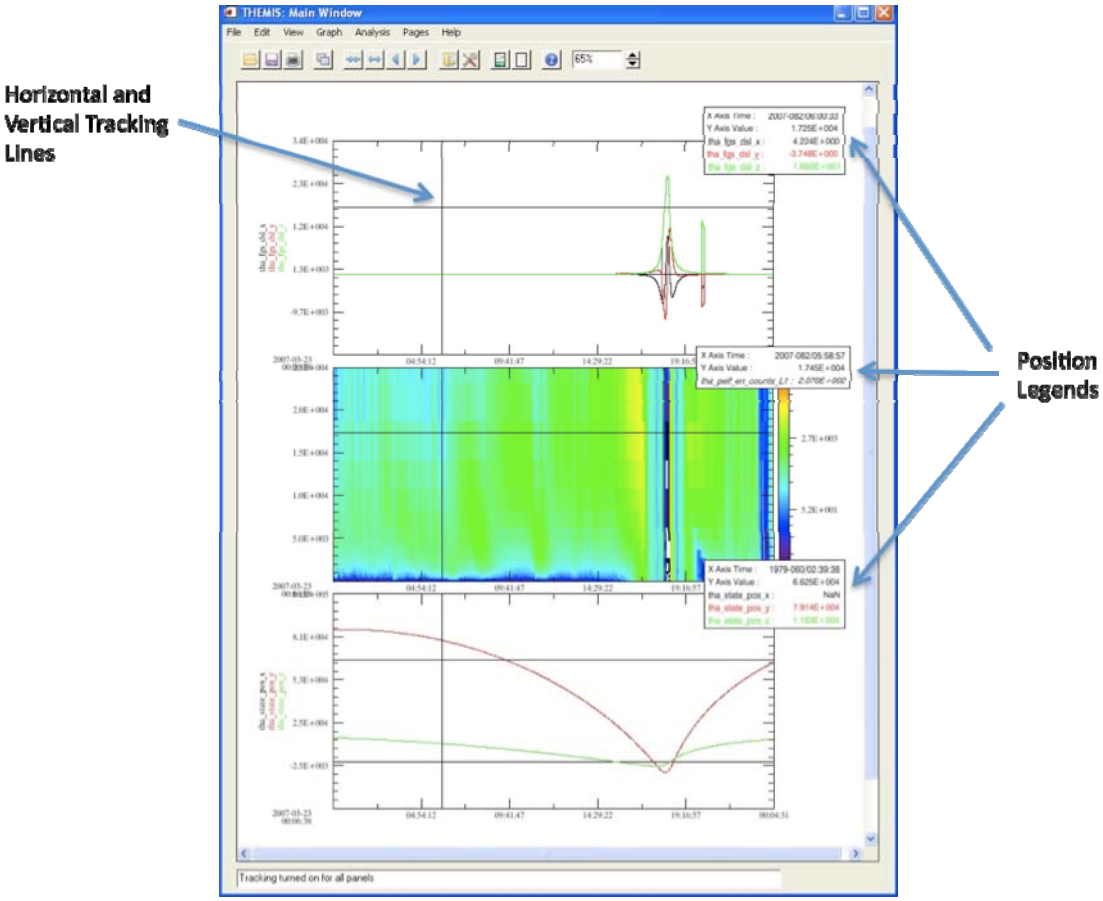


Figure 6.2.1

6.2.2 Legend

When tracking is on a legend will be appear in the upper right corner of each panel that is being tracked. The values of each data point intersecting the vertical tracking line are displayed. See Figure 6.2.1 above. The user can choose to turn the position legend on or off by toggling the Position Legend under the View menu. The legend is on by default. If only one panel is being tracked, then only one panel will have a legend. Please note that if you have the position legend on and choose the print option, the legend will not appear in the plot so that the user can view the entire panel.

6.2.3 Mouse Clicks

The mouse button offers several ways to interact with the GUI and the graph area. Mouse clicks include Single Click (left button), Right Click, Ctrl-Click-Drag, and Click-Drag.

Single Click:
There are two possible events that a single click will generate. One is when marker(s) are present and the user clicks within the highlighted area of a marker, the other is when the user clicks outside of a marker but within the graph area. Markers will be explained shortly in Section 6.2.5. For now, we will describe a single click in the graph area, which brings up a graph options menu window. Which graph options window is displayed depends on where within the graph area the mouse button was depressed.

There are 5 options.

Page: Any area that is outside of a panel, axis, label, or variable display will bring up the Page Options Window. In the event the GUI cannot determine which object was clicked, the Page Options Window will be opened.
Panel: When the user clicks within the frame of any panel, the Panel Options window is displayed
X-Axis: When the user clicks on the X Axis the Axis Options panel is displayed.
Y-Axis: When the user clicks on the X Axis the Axis Options panel is displayed.
Variables: If variables are present the user can click in the variable display area to open the Variable Options window.

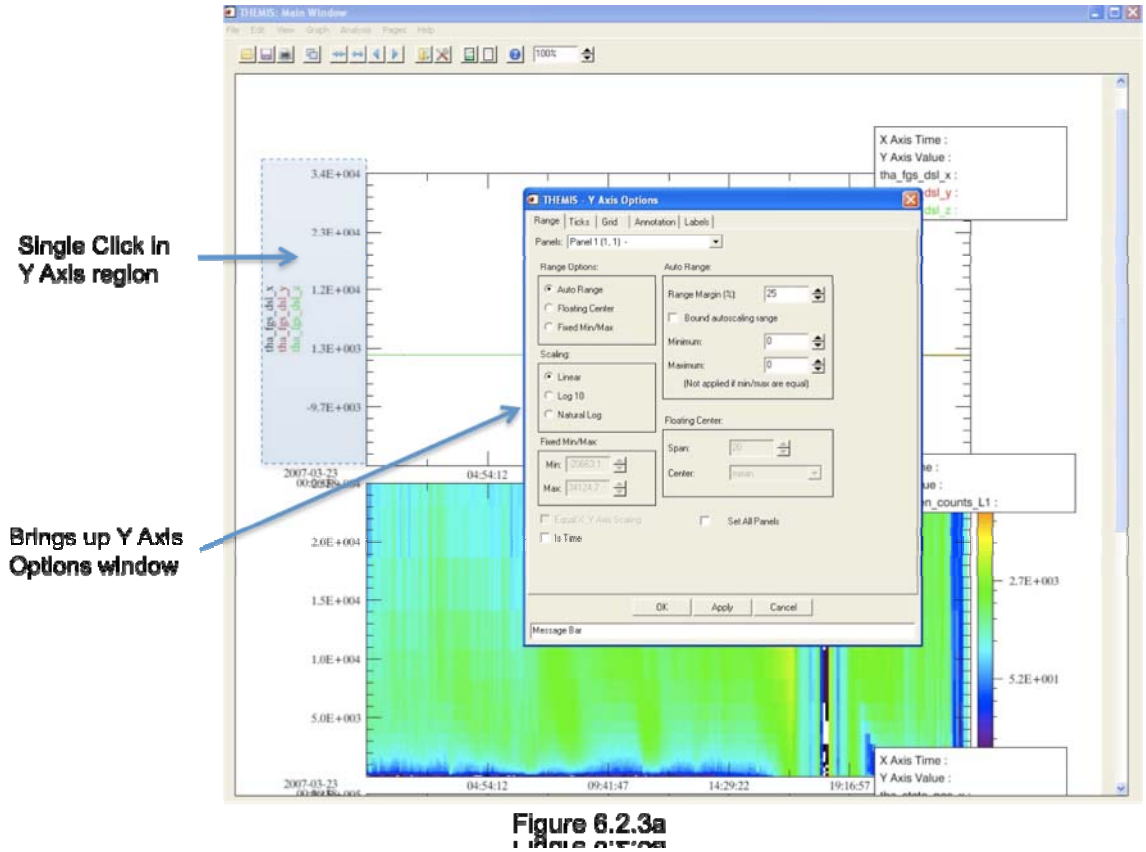


Figure 6.2.3a

Please note that resolution and screen size vary between machines and platforms. If you click close to another option in the draw and do not get the window you wanted, try clicking more in the middle of the area you want.

Right Click:
Clicking the right mouse button will bring up a context menu containing the most commonly used options associated with plotting and data analysis. The context menu contains the following menu items.

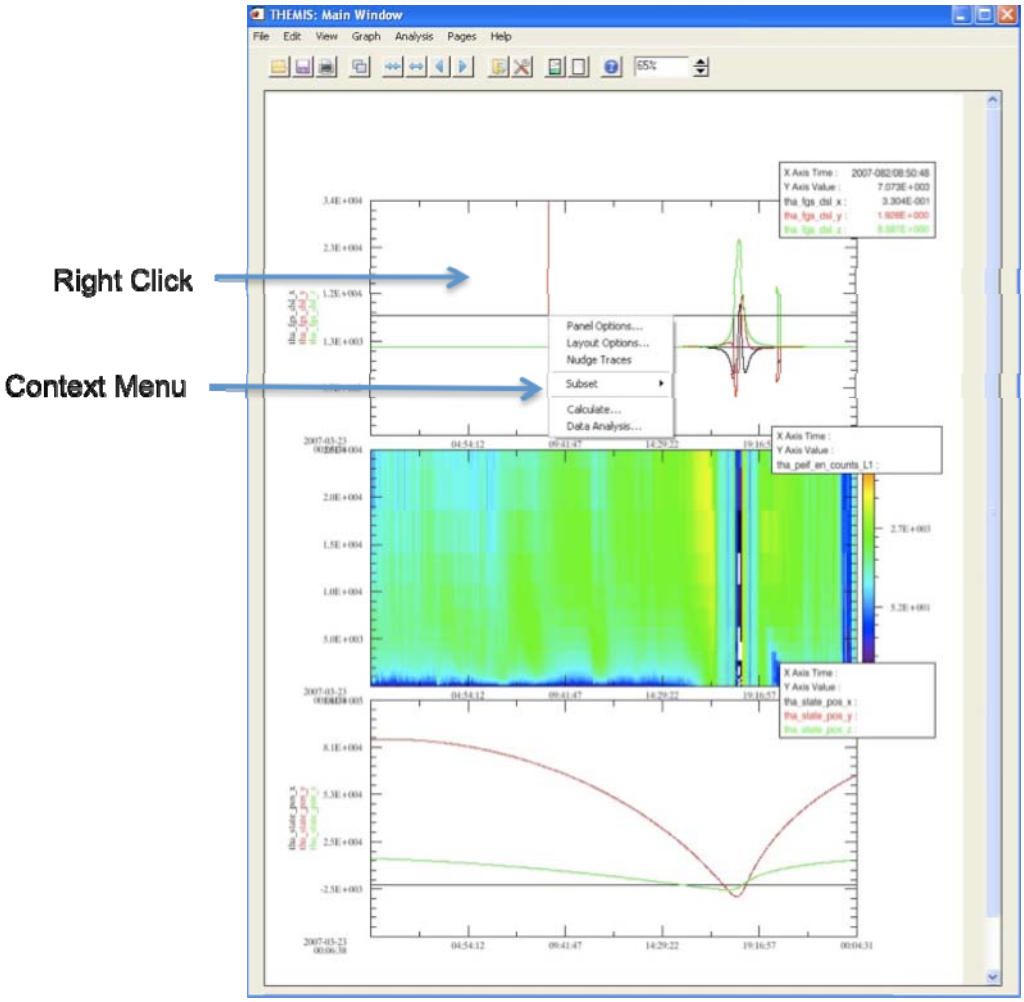


Figure 6.2.3b

6.2.4 Keyboard Events

There are two kinds of keyboard events, scrolling and expanding/reducing.

Scroll: The user can scroll the panels in the active page forward or backward by using the left and right arrow keys. The plot will be moved forward or backward in time by one major tick length.

Reduce/Expand: The panels can also be reduced or expanded by using Ctrl-Backspace of Ctrl-Tab keys. Ctrl-Tab will expand the panels horizontally by two major tick lengths (one major tick length is added to both the left and right sides of the x axis). Similarly, Ctrl-Backspace will reduce the panels displayed by two major tick lengths.

Accelerator Keys: Standard accelerator keys are available for the more frequently used functions. Accelerator keys include

Ctrl-O – Opens an existing THEMIS GUI Document

Ctrl-S – Saves a THEMIS GUI Document
Ctrl-Z – Close page
Ctrl-P – Print page
Ctrl-Q - Quit
Ctrl-R - Refresh
Ctrl-C - Copy

6.2.5 Markers

Marking is a new feature that allows the user to mark or select regions of interest in panels on the active page. If tracking is set for all panels then all panels will be marked. Likewise, if only one panel tracking is set, then only the panel the cursor is in is marked. Marker ranges are selected horizontally or along the x-axis, using the vertical tracking line as the boundary. The y-axis range is preserved.

A Ctrl-Click-Drag operation is used to create a marker. To do this, hold the Ctrl key while depressing the mouse button and dragging the mouse. The user can click the mouse button or the Ctrl key in any order, marking will not start until the Ctrtl key is pressed and cursor movement is detected. Marking ends when the user releases the mouse button. When you are finished, the marked area will be highlighted. If the cursor leaves the draw area, marking will be cancelled. Figure 6.2.5 shows examples of two markers, one created while all panels were being tracked, the other with only one panel tracking.

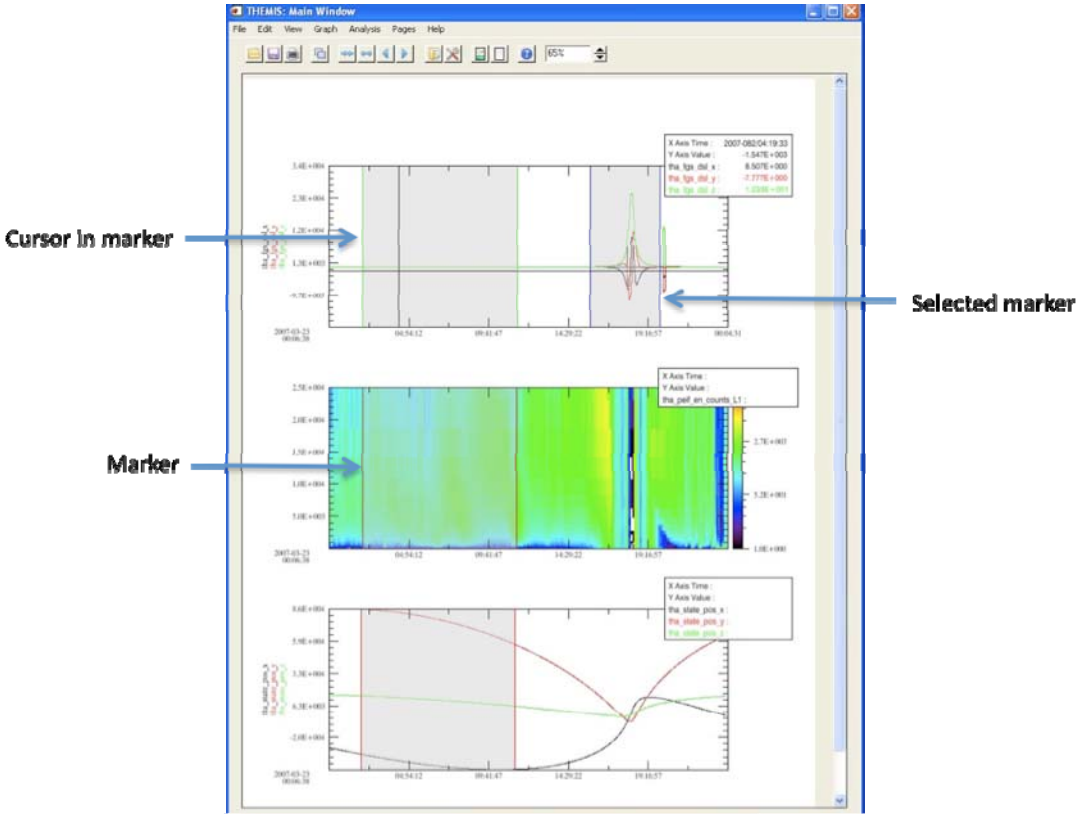


Figure 6.2.5

There are several things worth noting about the marked regions shown in Figure 6.2.5. First, note that all three markers have boundary lines drawn in different colors. The current state of the marker is color coded.

Green: Indicates that the cursor is currently within the marker
Blue: Indicates the user has clicked the mouse button within that marker to make it 'Active' or the currently selected marker. Only one marker can be active at a time.
Red: Represents all other markers (not active or the cursor is not within its area.

When a marker is 'active' (blue boundary lines) there are additional functions you can perform on the marker. You can choose to delete the marker or zoom into the marked area.

To delete a marker select the Delete Marker option under the Edit pull down menu.

To display only the marked area, select the Subset option under the Edit pull down menu. A new page will be created and displayed containing only the marked area. The original page is preserved. You can use the Page pull down menu to see your new page name and to move between pages or back to the original page. Marked areas are preserved and will not be lost when navigating between pages.

6.2.6 Data Zoom

Besides zooming in on marked areas, the user can also click and drag the mouse to zoom into a selected area. While markers preserve the y axis range, the click and drag does not.

To zoom into an area depress the mouse button and drag the cursor. You will note that as you move the cursor and rectangular area is drawn on the panels. A corner of the rectangle is pinned as soon as you press the mouse button and cursor motion is detected. This rectangle is referred to as a rubber band box and can be moved in any direction. If the cursor leaves the draw area the zoom will be canceled. Figure 6.2.6a shows an example of a selected area.

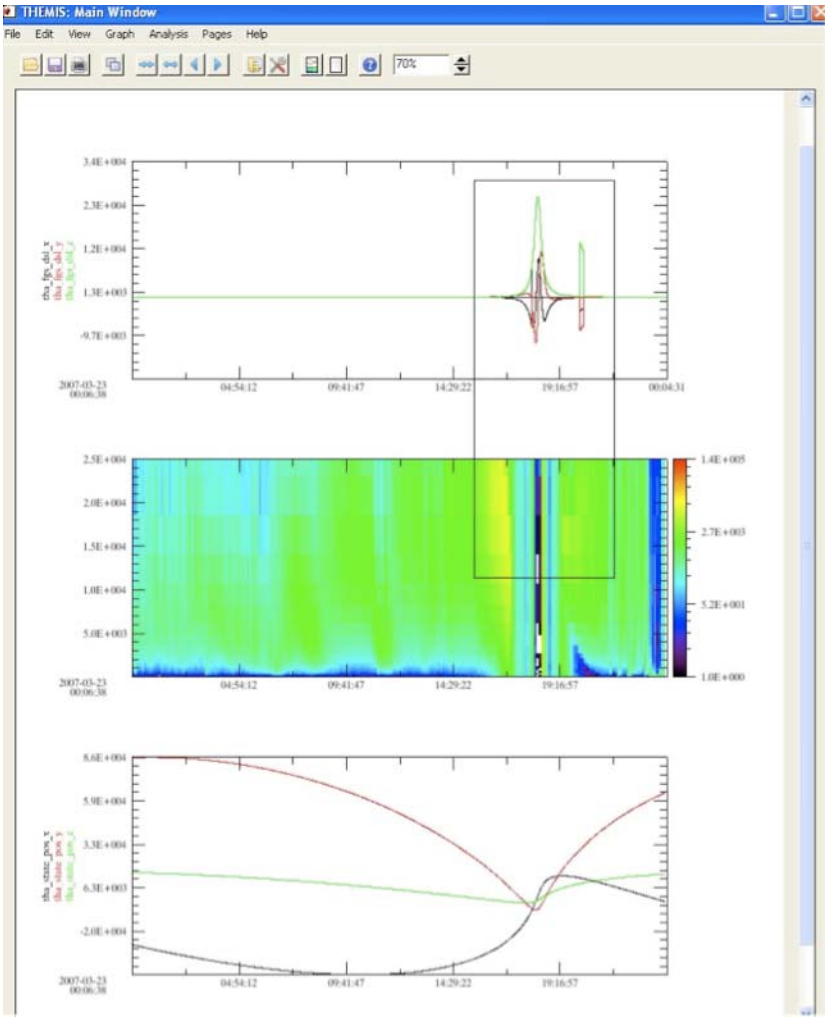


Figure 6.2.6a

Once you are happy with the area you have selected you can release the mouse button. When the mouse button is released a new page will be created and the panel(s) redrawn with the x and y ranges contained in the rectangular area. Panels not contained in the rectangle will not be redrawn. Similar to the Subset Marker option, the original page prior to the zoom operation is preserved. The Page pull down menu on the main GUI allows you to toggle between the two pages. Figure 6.2.6b shows the new page that was zoomed into.

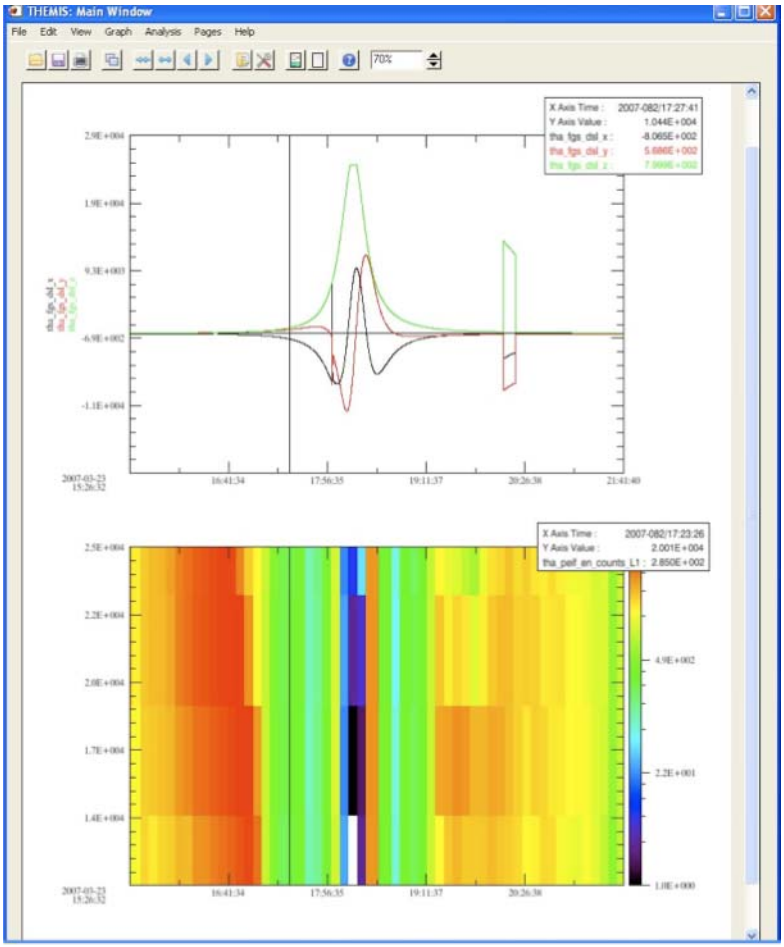


Figure 6.2.6b

6.2.7 Page Zoom In/Out

In addition to zooming into marked regions and/or rectangular areas the user can also choose to modify the page size by using the zoom spinner widget on the toolbar. The zoom spinner allows the user to increase or decrease page size by entering a percent value of the original page size. The user should be aware that when zooming in and out of the page, the main graph area will not change in size, only the page will. You can see this in Figure 6.2.7, which shows an example of decreasing the page size by 50%.

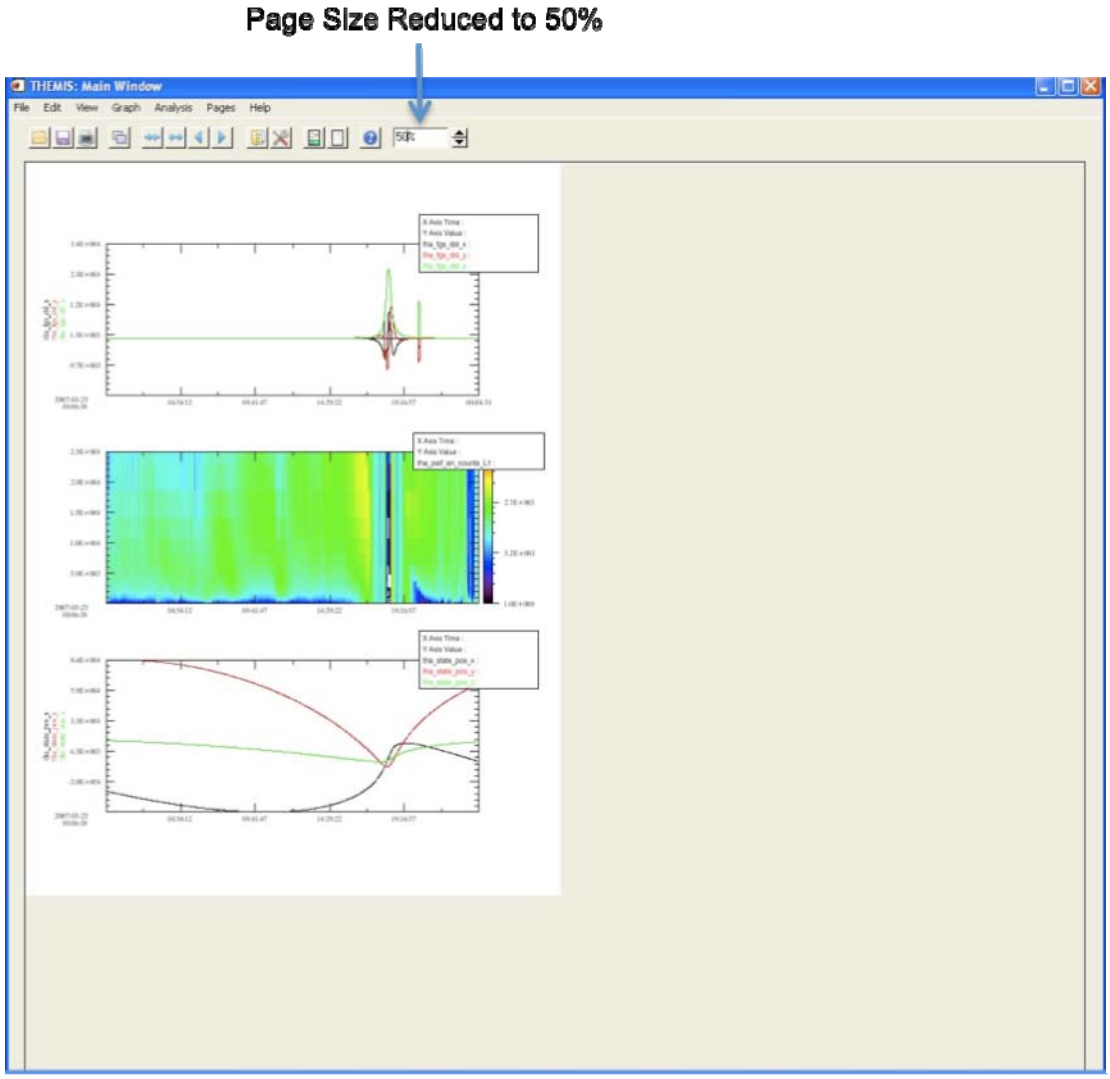


Figure 6.2.7

6.3 File Menu

The file menu contains selections that are related to loading, saving, and managing data, as well as printing and exporting image files. Figure 6.3 shows all options in the File pull down menu.

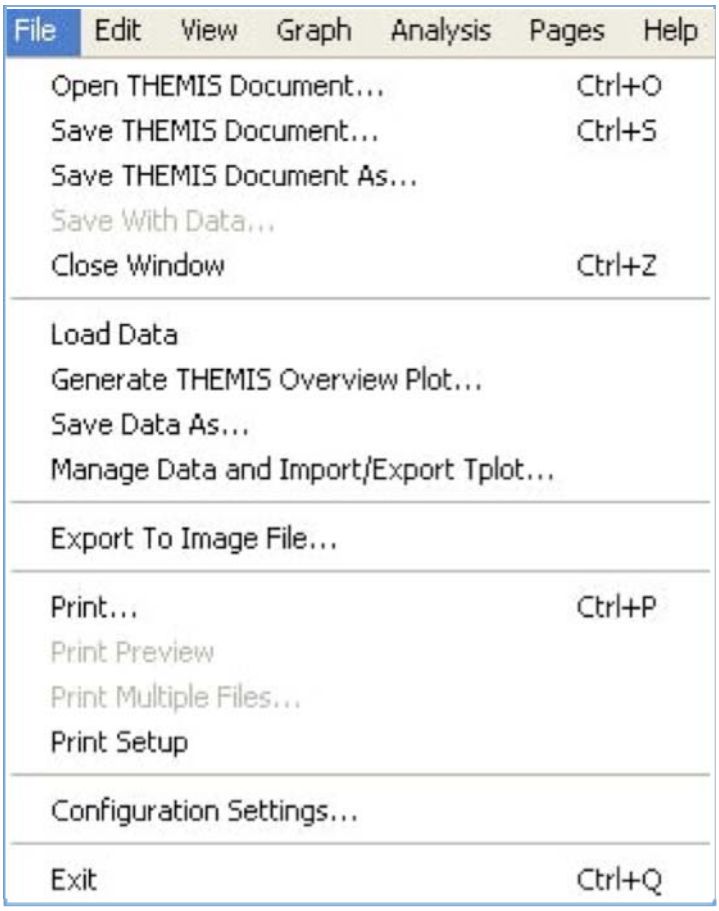


Figure 6.3

6.3.1 Open THEMIS Document

The THEMIS GUI now includes the capability to (partially) save the state of a GUI session to a file we'll refer to as a "THEMIS GUI Document" (with default file extension of TGD). TGD files are plain ASCII text, use XML to represent properties of GUI objects and loaded data, and can be examined with any ASCII file editor. Many web browsers also include support for viewing XML documents (although one may need to change the file extension to XML to get the browser to recognize the format).

As of TDAS release 5.00, any loaded data associated with a GUI session is NOT directly stored in the TGD file; instead, the document contains the information necessary to reconstruct the sequence of calls that were initially used to load the data. There are some pros and cons to this approach that users should be aware of:

1) TGD files are relatively small, and can be easily shared as email attachments. Because they are plain ASCII text, there are no significant file format differences between different platforms, so TGD files are portable between systems.
2) Opening a TGD file may require internet connections to THEMIS data servers in order to download any data files that are not already cached in the user's local file system.
3) Since the TGD file only records the sequence of thm_load_DATATYPE calls, **other manipulations such as coordinate transforms, data processing options, or operations performed outside the GUI will not be reflected**

in the TGD document, and will probably cause problems when such a document is loaded. Calibrations and coordinate transforms specified through the "Load THEMIS Data" dialog should be correctly represented in the TGD file.

4) **Opening a TGD file is a DESTRUCTIVE operation that wipes out the current window configuration and loaded data, replacing it with the contents of the TGD file. We recommend that users save their work before opening a new TGD file, and pay attention to any warning dialogs to avoid nasty surprises.**
5) As of the beta release of the new GUI, no versioning information is stored in the XML file, **so it is very likely that TGD files created under this release may not be readable in later releases**. We hope to guarantee backward compatibility of TGD files once the GUI is out of beta and the internal interfaces have stabilized a bit.

To open a TGD file, select "Open THEMIS Document…" from the File pull-down menu. This will bring up a pop-up dialog warning of the potentially destructive consequences of opening the file; if you're sure you want to proceed, click "OK" to dismiss the warning pop-up.

A file picker dialog will appear. Its appearance and exact functionality will depend on your platform; on Windows XP, this is what it looks like:

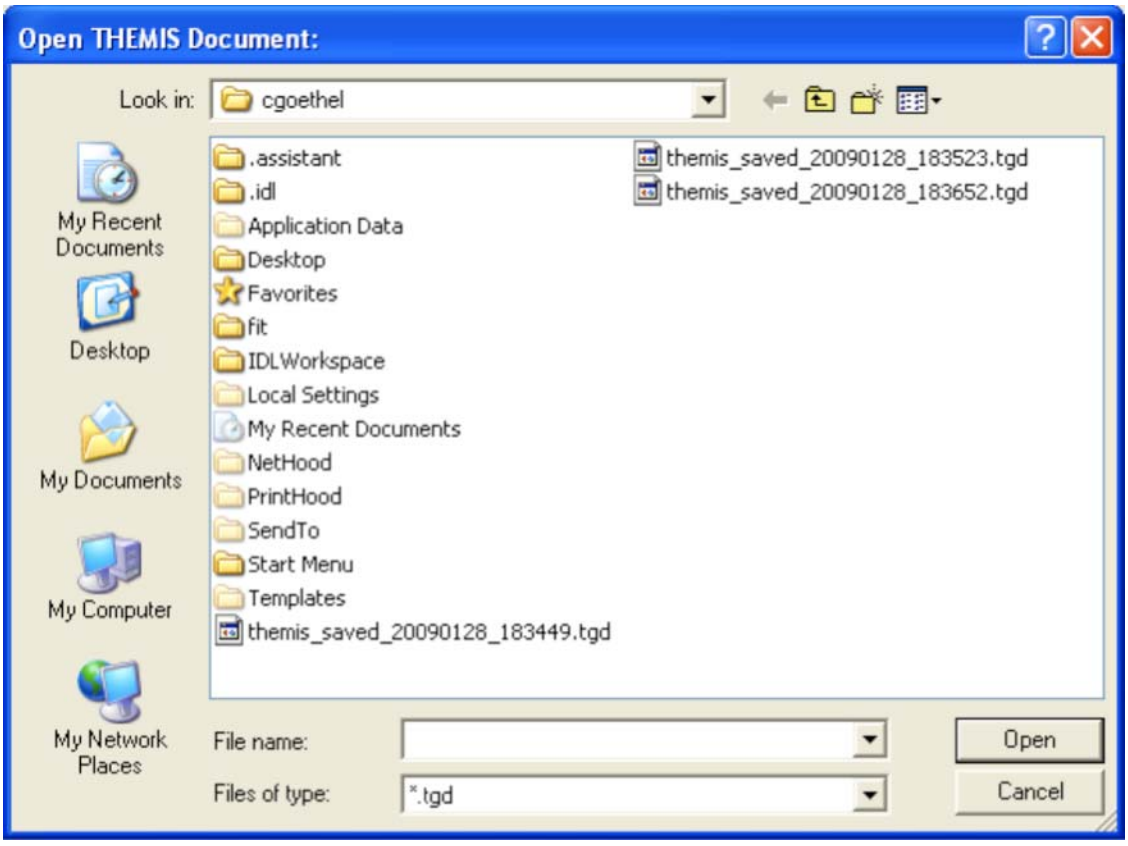


Figure 6.3.1

Navigate to the file you wish to open, and click "Open" (or perhaps "OK", depending on your platform).

This should trigger the process of loading the data specified in the TGD file you just opened; you should see progress messages scrolling by in the IDL command window. It may take several minutes to load all the data, depending on how

complex a document is being loaded; TDAS may also need to open an internet connection to the THEMIS data servers to download any data files not already cached on your local file system.

If all goes well, when the data is finished loading, the main draw window should update and show the plots for the first GUI window specified in the TGD file. Other windows saved in the TGD file should be accessible through the "Window" drop-down menu button. Any errors detected while parsing the XML file or loading the data will be reported by a pop-up error dialog, or a message in the status area at the bottom of the main GUI window.

6.3.2 Save THEMIS Document

Please refer to the caveats in section 6.3.1 regarding what is and is not represented in the THEMIS GUI Document format, particularly regarding coordinate transforms, data processing operations, and operations performed outside of the THEMIS GUI. We recommend a workflow something like this:

18. Use the "Load THEMIS Data" dialog to load the all the data you want to work with
19. Use the "Window" menu and "Graph->Plot/Layout options…" dialog to create some plots
20. Use "Save THEMIS Document" to save the window configuration, plot properties, and loaded data call sequence information, creating a "checkpoint" that can easily be restored later
21. Perform any other manipulations (coordinate transforms, data processing routines, non-GUI operations), and be prepared to repeat them after opening the TGD file at some later time to restore the check pointed GUI configuration.

When you're ready to save your plots and loaded data, click "Save THEMIS Document" under the File pull-down menu. All pages, plot settings, data, and data operations will be saved. If this session has not yet been saved to a TGD file, a platform-specific file-saving dialog will appear. On Windows XP it will look something like this:

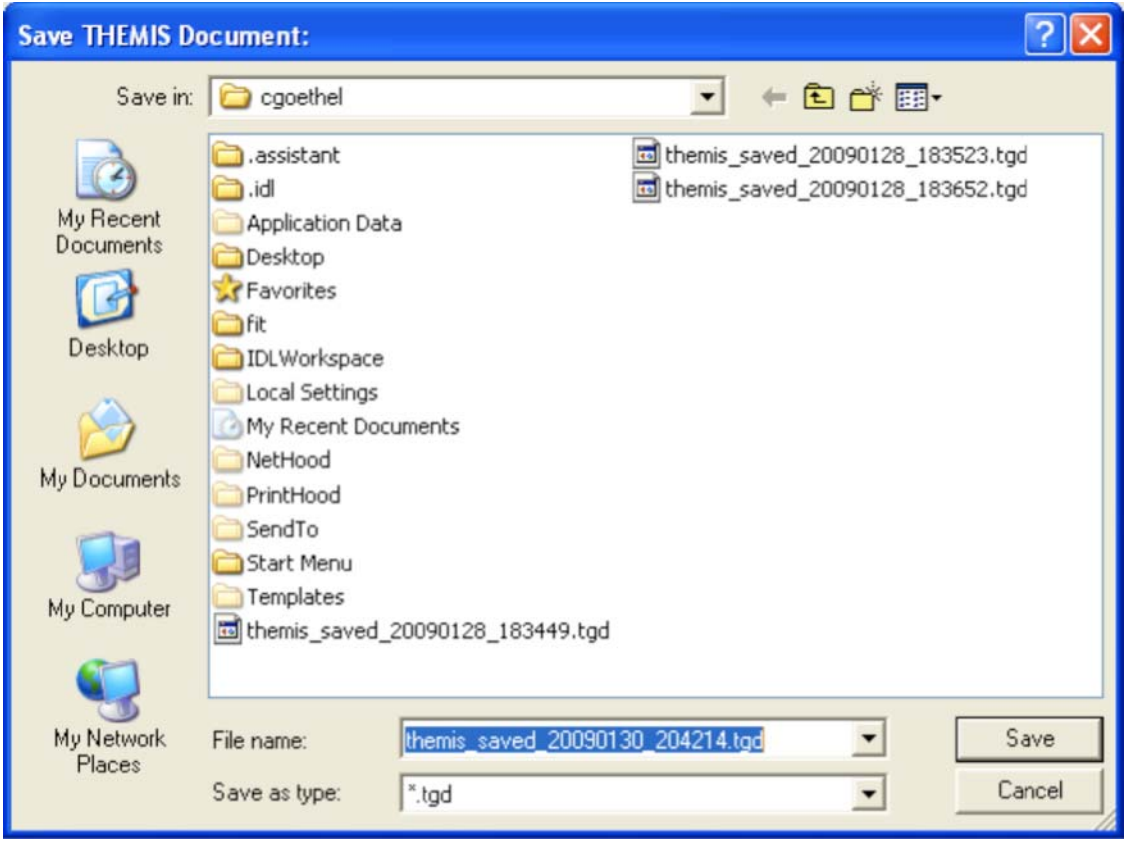


Figure 6.3.2

Navigate to the directory where you'd like to save the file, select a new filename if you don't like the default, and click "Save" (or maybe "OK", depending on your platform).

If "Save THEMIS Document" has already been invoked, or if the current session is the result of loading a TGD file, the file picker dialog will not appear, and the filename from the most recent save or open operation will be used again.

If the file already exists, a pop-up will appear to warn that you're about to overwrite an existing file. If you choose to proceed, the "save document" routine will try to confirm that you have write permission before attempting the save. **However, due to an IDL bug on Windows platforms, the condition "write permission denied" is not properly detected, and will probably crash your entire IDL session if you attempt to save to a file without write permission**. This bug does not appear to affect Unix, Solaris, or Mac users.

If the save attempt fails, an error message should be displayed, either in a pop-up warning dialog, or a message in the status area at the bottom of the main GUI window. If the save succeeds, a success message will appear in the status area.

6.3.3 Save As…

The File->Save As… dialog also saves a TGD file. The only difference between "Save THEMIS Document" and "Save As…" is that "Save As…" always pops up a file picker dialog, allowing one to change the filename associated with the GUI session. "Save THEMIS Document" will reuse the last filename successfully saved to, only displaying a file picker the first time the GUI state is saved.

See the documentation for "Save THEMIS Document" in section 6.3.2 for more information about saving TGD files.

6.3.4 Close Page

The THEMIS GUI allows the user to have multiple pages. If you wish to close a page there are several ways this can be done. The first is using the File pull down menu and selecting the Close option. The currently displayed page, or the ‘active’

page will be closed. Other pages will still be available. The main graph area will redraw the next page up in the list, unless there are no more pages, in which case a blank graph area will be drawn. In addition, the Page pull down menu dynamic options will be updated and renumbered to reflect the change.

Besides the file pull down menu, you can also type Ctrl-Z or select the Close option under the Page pull down menu.

It should be noted that once a page is closed the settings that were associated with that page will be lost, unless you requested Save THEMIS Document under the File pull down menu before you closed the page. The data that was plotted in the page still remain are available for analysis and plotting. Only the plot settings are deleted.

6.3.5 Load Data

The Load Data option, under the File pull down menu, opens a window that allows the user to select specific data sets to be loaded into memory. Four missions are available for loading data and include THEMIS, GOES, WIND, and ACE data. There is also a tab for loading THEMIS particle spectra.

6.3.5.1 THEMIS Data

The left hand side of the window contains the data selection area and the right hand side of the window displays data that has already been loaded

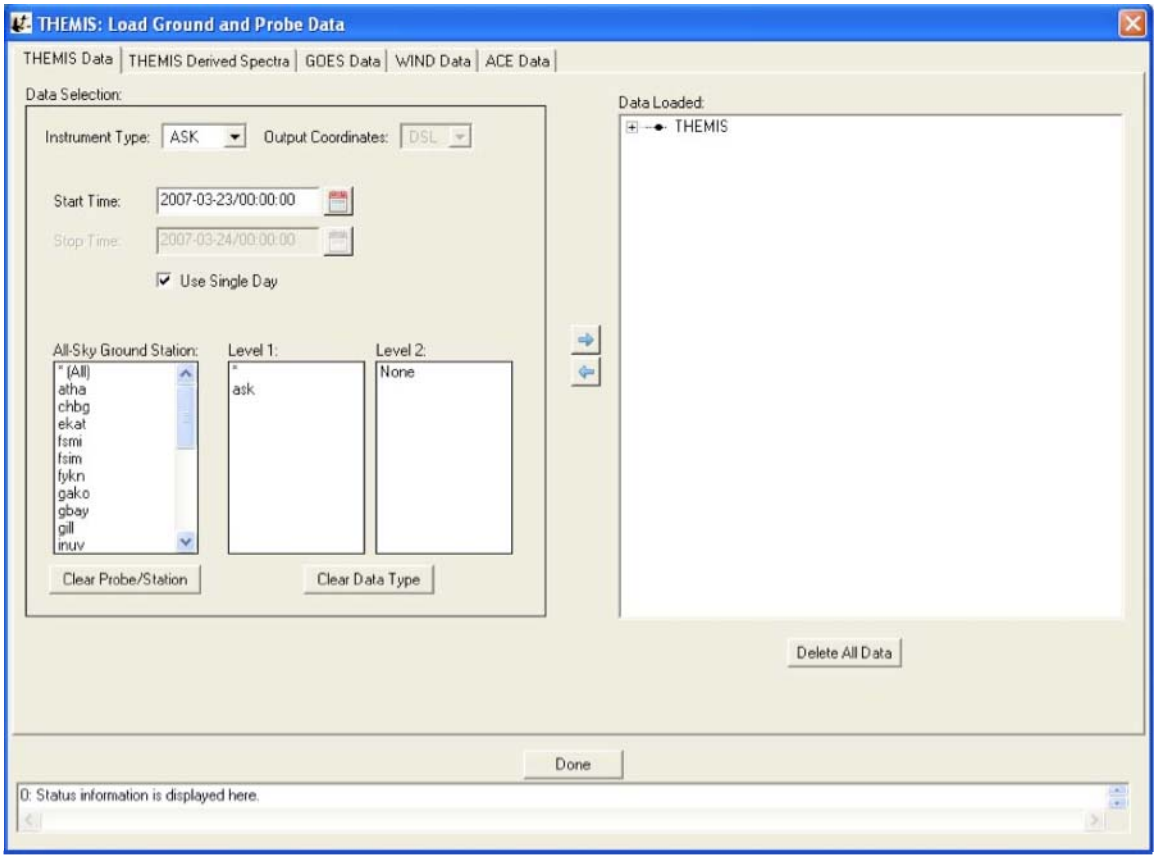


Figure 6.3.5

Data can be removed at any time by making a selection in the data tree and clicking the left arrow button. The data tree will be updated to reflect the deletion. The user can also use the Clear All button below the data tree to delete all data.

At the bottom of the window is a status bar. Messages regarding the load process, data, and/or status of the window will be displayed here.

When you have loaded all the data you want, click the Done button below the data tree.

The THEMIS data has a configuration file that sets global (system) variables and initializes devices.This procedure will define the location of data files and the data server. This procedure is intended to be called from within the "THM_INIT" procedure. This should be the only THEMIS file that requires modification for use in different locations.

There is no need to modify this file if:
- Your computer is an SSL UNIX machine that mounts "/disks/data/" (i.e. ALL Linux and Solaris machines at SSL)
- You use a portable computer that will be caching files on a local hard drive.

Settings in this file will be overridden by settings in the environment. See setup_themis or setup_themis_bash for examples of setting environment variables on UNIX-like systems. The environment can also be set on Windows systems.

Note: GOES data does have a configuration file similar to THEMIS, however, the WIND and ACE data do not. This means that the settings for downloading data are default values and cannot be set. For more see Section 5.3 Installation and Configuration.

6.3.5.2 THEMIS Derived Spectra

By selecting the THEMIS Derived Spectra tab a different window is displayed, This window provides an interface to the TDAS routine “THM_PART_GETSPEC”, which is described in section 5.5.3.4. THM_PART_GETSPEC Operates on Level 1 SST and ESA data only. For each data type, (e.g., peif, peef, psif, psef, etc...) all of the L1 data must be loaded. For ESA data, this is done automatically when a data type is chosen from the Load THEMIS Data widget. For SST you need to click on all L1 variable choices for each given data type when loading. Be sure that all of the appropriate data is loaded. For pitch angle and gyro-velocity distributions, FGS and STATE data for the appropriate probes are also necessary. These will be automatically loaded if they have not been loaded already.

The top window on the left side allows you to choose a suffix for the new variables that are created.
The drop-down menu below this allows you to choose the type of angular particle distribution to create. The choices are “PHI”, in degrees relative to probe-sun direction in spin plane, “THETA”, in degrees relative to spin plane or the azimuth for pitch angle distributions, “PA”, for pitch angle, degrees relative to the magnetic field, and “GYRO”, for gyro-velocity distributions. (See section 5.5.3.4 for details about the various angular choices.)

The set of windows below allows the user to set minimum and maximum values for the different angular ranges, and a start angle for the PHI option. Below these are windows allowing the user to set energy and time ranges. In the energy range box, there is a check box labeled “Return Energy Spectrum”; if this is checked, then the process will create an energy spectrum for the data integrated over the full angular range.

On the right side there is first a check-box labeled “Normalize Spectrum”, if this is checked, then the spectra are normalized. The windows below allow you to change the number of points used to re-grid the angular data for interpolation. The dropdown below this allows you to change the default value for the second axis for conversion to field-aligned coordinates, used for pitch angle and gyro-velocity distributions. The next window allows you to specify the maximum gap in seconds over which data are interpolated.

The options below this are all restricted for use for SST data, if the check-box for SST mask removal is checked, then the value in the box below this will be the proportion of values that need to be zero at a given time for the program to decide that a mask is present. If the box for SST Sun Contamination is checked, then the drop-list menu below can be used to choose the sun pulse cleaning method for contamination removal. The window below this is used for the value of the standard deviation tolerance for sun pulse cleaning, and finally the drop-list menu below this allows you to specify the default method for filling in points that are removed; either "INERPOLATION" or "SPIN_FIT". For a more detailed explanation of the input parameters, please see section 5.5.3.4.

To initiate the process, click the "Apply" button. New variables are created, and appended with the input value for the suffix. For example, if "tha_psif" data is used with the "PHI" option set, the angular spectrum will have the name "tha_psif_an_eflux_phi_part_spec" and if the energy spectrum is calculated then this variable will have the name "tha_psif_en_eflux_part_spec" as shown here.

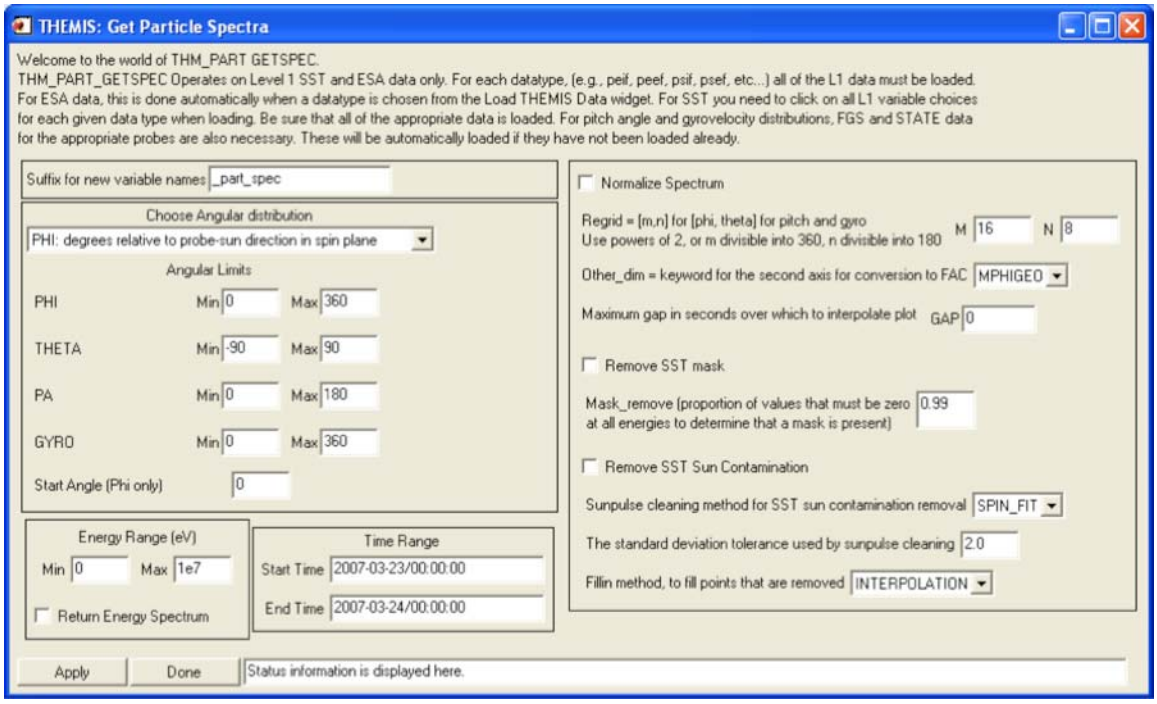


Figure 6.3.5.2

6.3.5.3 GOES Data

Selecting the GOES Data tab displays a window similar in form to the THEMIS Data tab, however, this tabbed windows is specific to down loading GOES data. The user can select a time frame, the probes, and parameter types. Once the user has made their selections, to download and import data into the GUI memory, click on the right arrow key, in between the GOES Data Selection Area and the Data Loaded area. An hourglass will appear while data is being loaded. If the user chooses to delete data, they can select the variable name from the data loaded window and click the left arrow key.

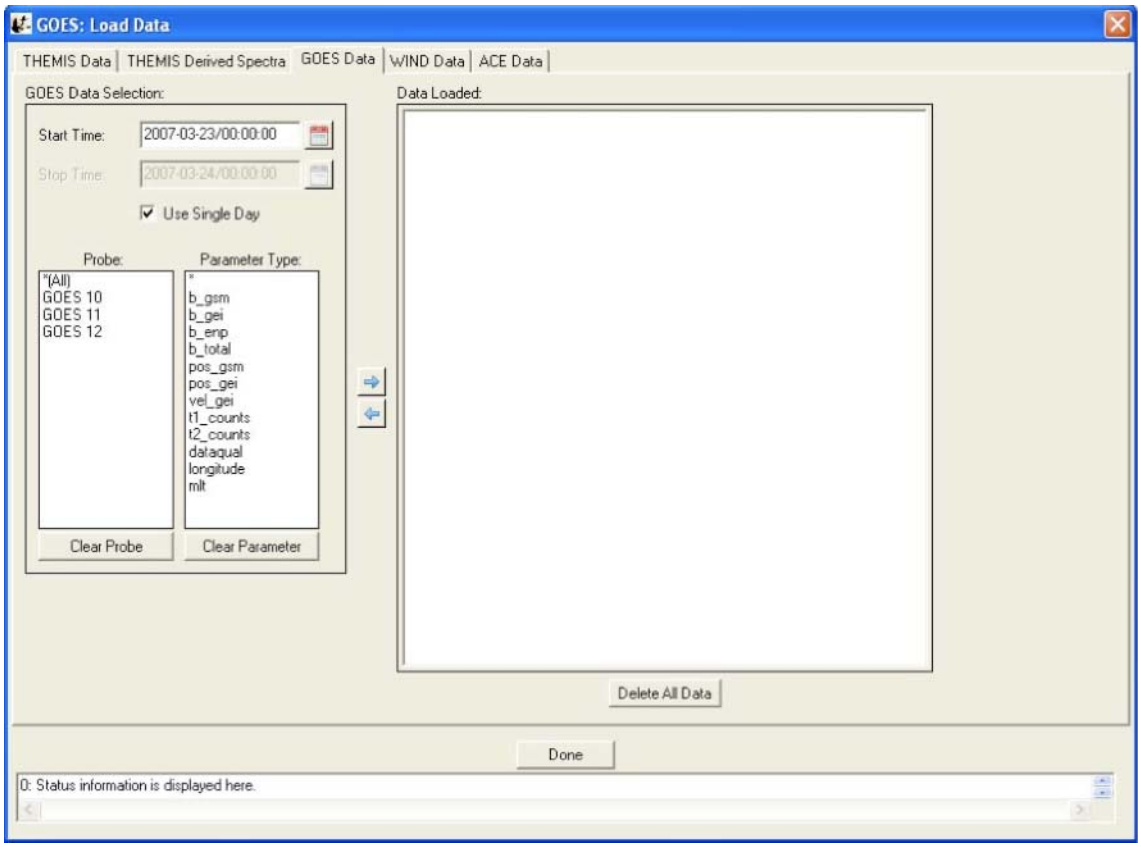


Figure 6.3.5.3

6.3.5.4 WIND Data

Selecting the WIND Data tab displays a window similar in form to the THEMIS Data tab, however, this tabbed windows is specific to down loading WIND data. The user can select a time frame, the instrument type, data type, and parameter types. Once the user has made their selections, to download and import data into the GUI memory, click on the right arrow key, in between the WIND Data Selection Area and the Data Loaded area. An hourglass will appear while data is being loaded. If the user chooses to delete data, they can select the variable name from the data loaded window and click the left arrow key.

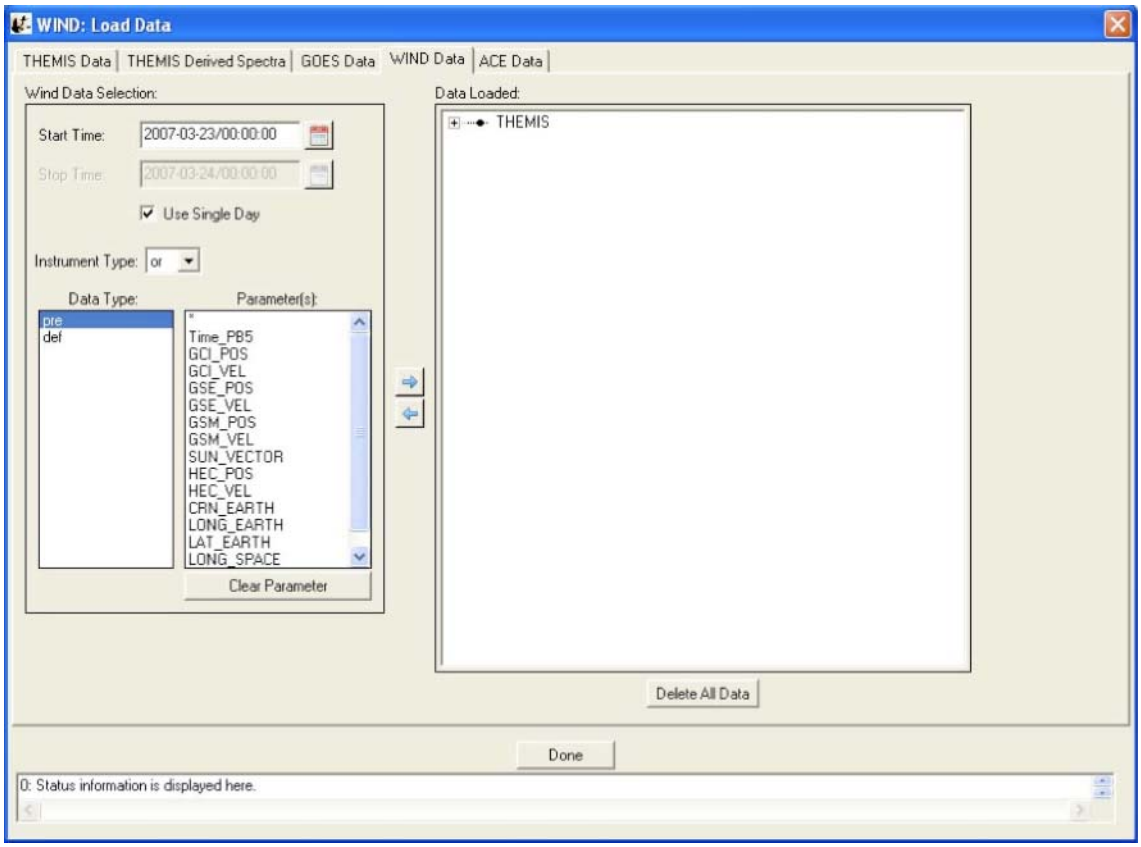


Figure 6.3.5.4

6.3.5.5 ACE Data

Selecting the ACE Data tab displays a window similar in form to the THEMIS Data tab, however, this tabbed windows is specific to down loading ACE data. The user can select a time frame, instrument type, data type, and parameter types. Once the user has made their selections, to download and import data into the GUI memory, click on the right arrow key, in between the ACE Data Selection Area and the Data Loaded area. An hourglass will appear while data is being loaded. If the user chooses to delete data, they can select the variable name from the data loaded window and click the left arrow key.

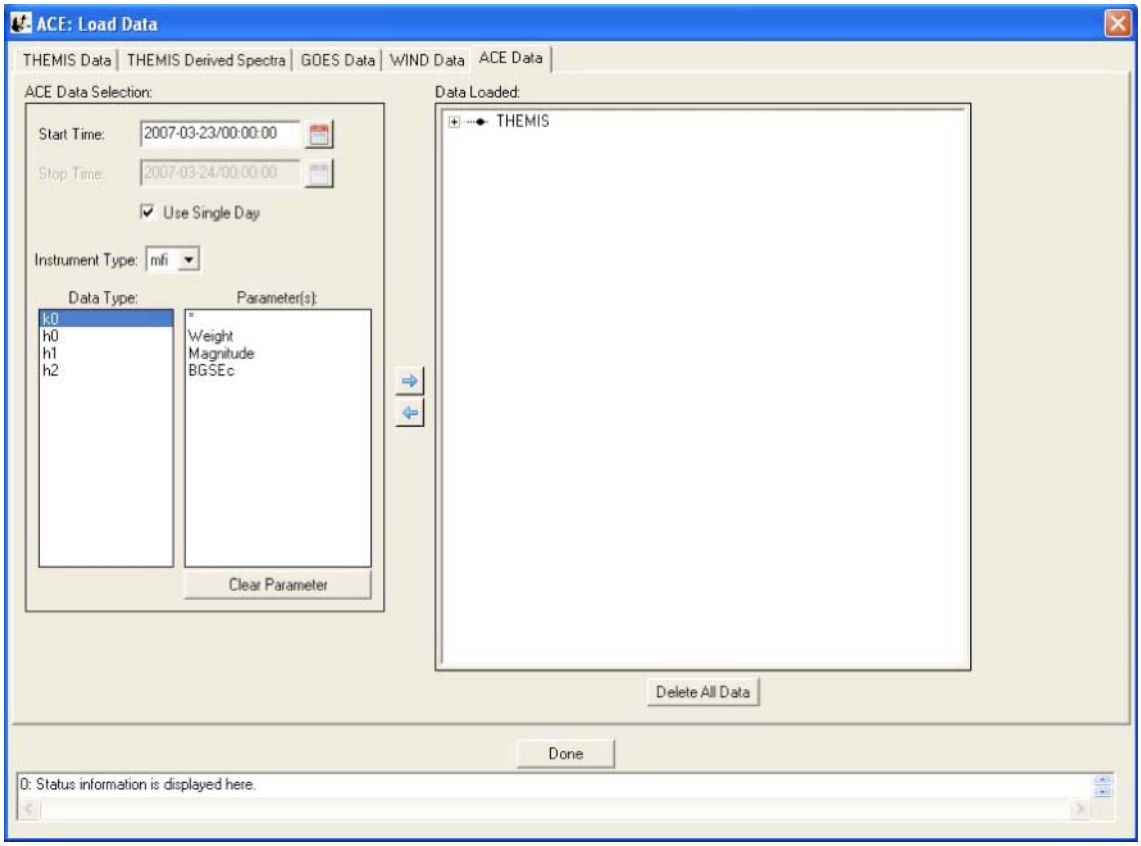


Figure 6.3.5.5

6.3.6 Save Data As…

The "Save Data As…" dialog allows the user to select a set of variables, and save the data as ASCII (with various formatting options) or as a set of files in the UCLA binary "upper flat file" format. Unlike "Save THEMIS Document" or "Save As…", "Save Data As…" does not attempt to save any GUI objects or plotting parameters.

Click "File->Save Data As…" to bring up the dialog. On Windows XP, it will look something like this, assuming some data has already been loaded:

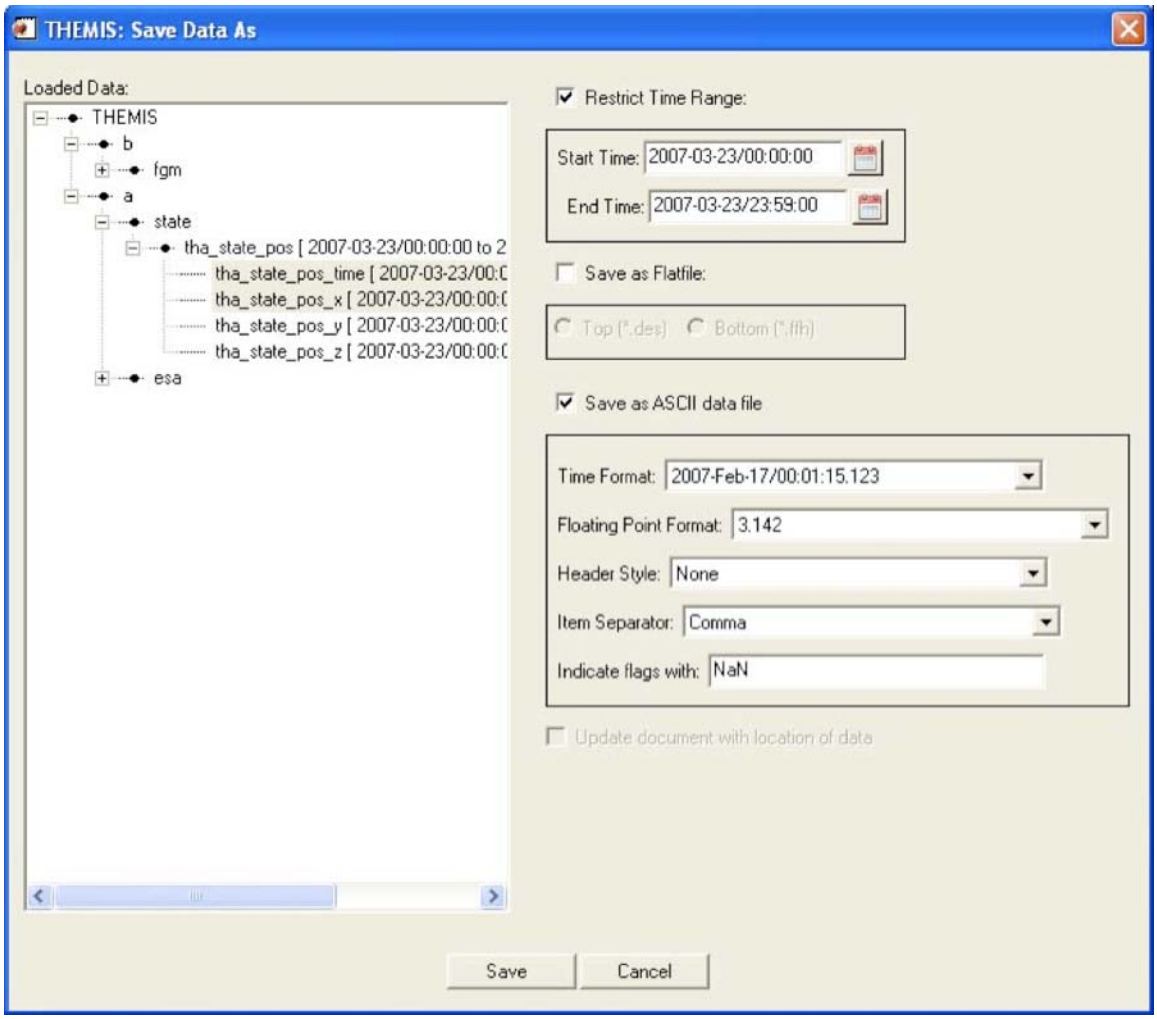


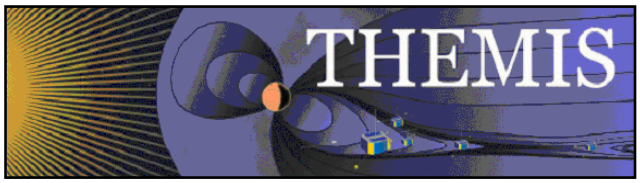
Figure 6.3.6

The left hand "Loaded Data" pane is a "tree widget" representing the data variables currently available. In the above screen shot, many of the nodes are fully expanded. Click any box showing "+" to expand that node, or click a box showing "-" to collapse that node.

To the right of the "Loaded Data" pane are some additional controls. If the "Restrict Time Range" box is checked, only the data with timestamps in the given time range will be saved. For now, the start and end times must be typed into the text box in YYYY-MM-DD/HH:MM:SS format. In a future release, we may add a graphical interface of some sort to specify the time range with mouse clicks and drags.

If the "Save as Flat file" box is checked, the data will be saved in (binary) UCLA flat file format. There are actually two formats available (upper/lower, or top/bottom in this dialog), but for this release, only the upper flat file format is supported. For further information about this format, please consult the UCLA documentation.

If the "Save as ASCII data file" box is checked, the data will be saved as ASCII, one line per record. If this format is selected, there are additional choices for how the ASCII data is formatted. The "Time Format" drop-down menu brings up a



list of different formats for representing timestamps with varying degrees of precision. The "Floating Point Format" drop-down menu specifies the precision and format of floating point quantities that are not internally marked as timestamps.

The "Header Style" drop-down menu offers a few options for including header lines in the ASCII output. If "None" is selected, no header will be produced; for "Field Names Only", a single header line will be included, listing the field names associated with each data column; for "Tecplot", a Tecplot-compatible header will be produced with one line of field names, and another line with a sample count and some other information.

The "Item Separator" drop-down menu allows the user to select whether columns are to be separated by commas, tabs, or spaces. This option also applies to the header, if one is requested.

As an example, if "Header Style" is set to "Field Names Only" and "Item Separator" is set to "Comma", the resulting ASCII file should be readable by Excel or other utilities that understand CSV ("comma separated value") formatted files.

The "Indicate flags with:" text box allows the user to choose what gets printed if an IEEE-754 "NaN", "Inf", or other non-numeric floating point value is encountered during the conversion to ASCII. We suggest keeping the default text "NaN". (The term "flag" is used because in some situations, TDAS inserts NaN values to "flag" missing or invalid data samples.)

"Update document with location of data" is not yet implemented in this release (and perhaps never will be), and should be disregarded for now.

The suggested workflow for this dialog is to first use the tree widget in the "Loaded Data" pane to select some subset of the currently loaded variables, then use the controls on the right hand side to select a file format, an optional time range, and any additional style settings (if ASCII format is selected). Clicking the "Save" button will perform a few checks on the selected data variables, and if the selection is valid, the GUI will pop up a file picker dialog to specify the filename and directory to save.

Caveats:

This dialog does not permit saving arbitrary collections of variables. Owing to the record-oriented structure of these file formats, all selected variables must contain the same number of samples. For UCLA upper flat file format, the only valid data types are 4-byte integers, and 4- and 8-byte floating-point values. THEMIS data represented as bytes or 16-bit integers (for example, ASK) cannot be saved as UCLA upper flat files. These restrictions are enforced at the very end of the workflow, when the user clicks "Save". The first variable name with an incompatible sample count or data type will be mentioned in the error message; try removing that variable from the selection, and repeat the process until a valid ensemble of variables remains.

ASCII files generated from large data sets (e.g. several hours of ASK keogram data) are potentially enormous, and may appear to lock up IDL for a long time while the file is being written. Even modest ASCII data sets may require several minutes to be saved. These operations are somewhat inefficient; due to the need for column-by-column checking, formatting, and output of data fields, such operations are difficult to put into vector formats in IDL without incurring a severe penalty in memory consumption.

6.3.7 Manage Data and Import/Export Tplot

The Manage Data Window allows you to import TPLOT variables into the GUI, export TPLOT variables from the GUI, delete GUI variables, and view/edit the meta-data associated with various GUI variables.

To import TPLOT variables you can select one or many (ctrl/shift-click) tplot variables in the left TPLOT Data area, then press the right arrow button to move data into the GUI. The data will then be moved into the GUI and attempt to detect the

variable meta-data that includes name, mission, observatory, instrument, units, and coordinate system. Figure 6.3.7a shows the Manage Data window.

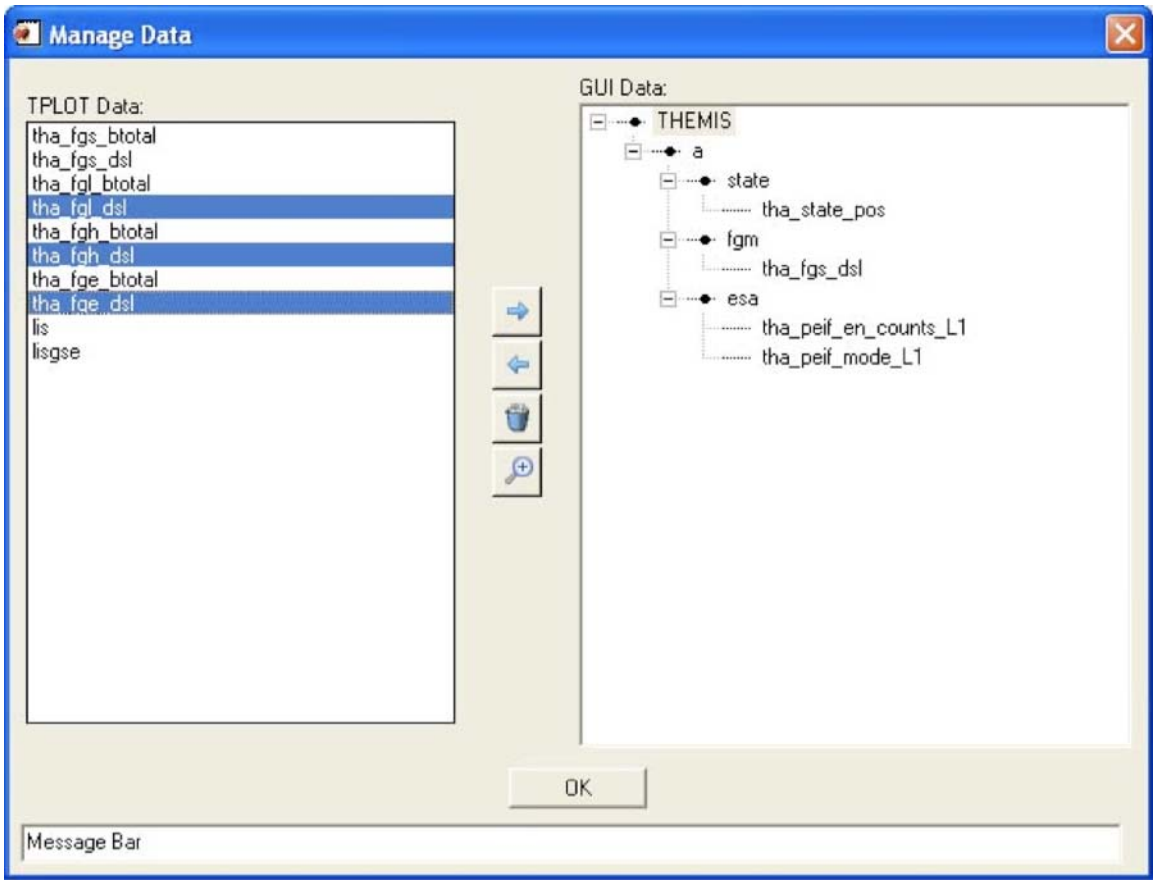


Figure 6.3.7a

When the right arrow is clicked to import tplot data, the Verify Data Window will be displayed allowing you to verify that this data was correctly detected. Click the OK button if it is or 'Cancel' if you change your mind about importing. After you press 'OK' on the Verify Data panel, the data will be loaded. Figure 6.3.7b shows the Verify Data window.

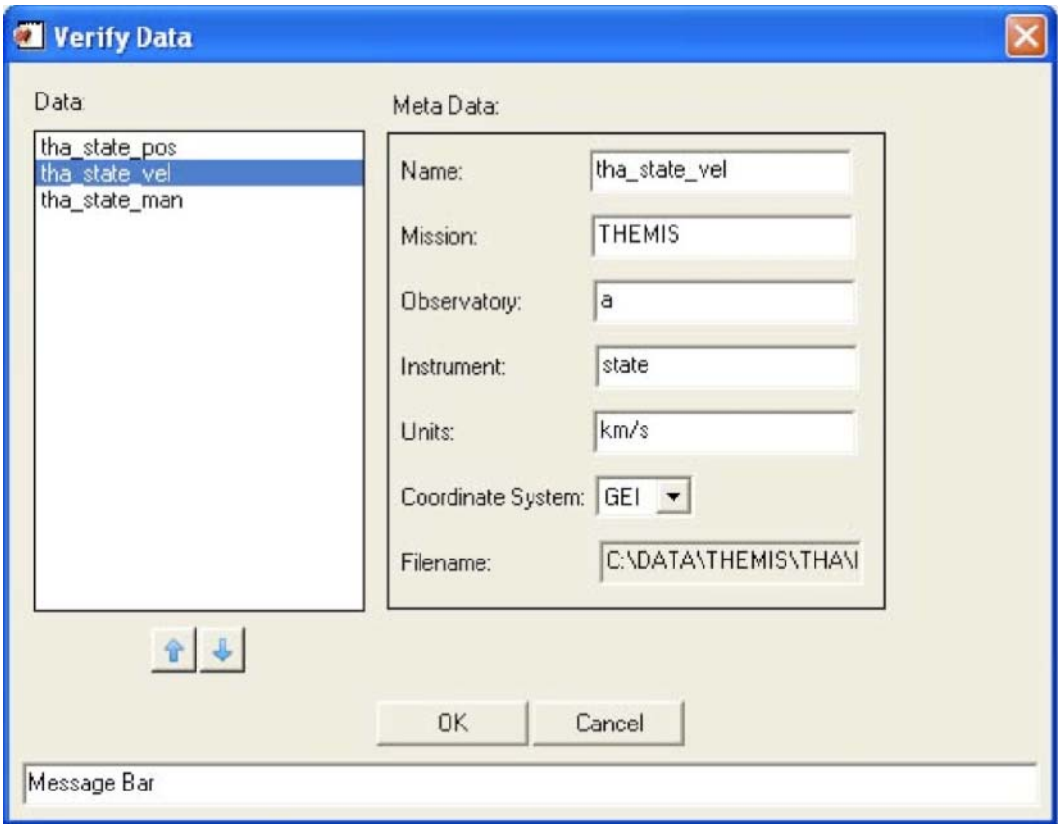


Figure 6.3.7b

To export GUI variables to TPLOT, select the GUI quantities that you would like to export from the tree at the right and select the left arrow button to export them.

To delete GUI variables, select the GUI quantities that you would like to delete from the tree at the right, then select the trash can button to delete them.

To examine the meta-data (name, mission, observatory, instrument, units, coordinate system, and file name) associated with particular GUI variables. Select the variable to be examined in the tree at the right and select the magnifying glass button to examine the meta-data. A menu like the verify menu will pop-up and you can view or edit the meta-data for the selected quantities.

6.3.8 Export Image To File…

The Export to Image Menu allows you to generate an image file of your currently active page. The THEMIS GUI supports the following file types: Portable Network Graphics (.png), Encapsulated Postscript (.eps), Windows Meta-File (.emf, Windows Only), Windows Bitmap (.bmp), Graphics Interchange Format (.gif), Joint Photographic Experts Format/JPEG (.jpg), JPEG 2000 (.jp2), Apple PICT format (.pic), Portable Picture Map (.ppm), Sun Raster Format (.srf) .

The EPS export uses the routine ssl_general/misc/fancompress.pro to decrease the size of line plots when exported to EPS. EPS files without compression can be tens or even hundreds of MB large. Fan Compression should generally keep the EPS

size down to less than 1 MB. Fan Compression removes redundant data points using an IDL implementation of the algorithm described in the paper: Fowell, Richard A. and McNeil, David D. , “Faster Plots by Fan Data-Compression,” IEEE Computer Graphics & Applications, Vol. 9, No. 2,Mar. 1989, pp. 58-66.

EPS files created by the gui with large line resolution percentages may
take a long time to read in postscript readers.
The directory to which you will output is listed at the top. The 'Arrow' button will allow you to move up one directory. You can also edit the directory by typing directly into the directory field, or selecting the desired directory from the directory list below.

The file name for output is listed in the text box at the bottom. Change the output format by selecting a different type from the 'Save As' dropdown menu at the bottom. The 'Options' button will show the graphics output options for the selected file type. These options will change depending on the file type. They involve things like the size and resolution of the output file.

When you are ready to actually save the file, select the 'Save' button, and the requested file will be saved to the selected directory. If you change your mind select the 'Cancel' button or the 'X' in the corner. Figure 6.3.8 shows the Save Image window.

Figure 6.3.8

NOTES:

- .EPS and .EMF both support vector output, which is needed if you want to resize without pixelation or load the file into Illustrator to select individual labels and ticks for editing. To turn on vector output for either of these format types, press the 'Options' button and select 'Vector'.
- Setting line plot resolution at or past 70% can make the file unreadable due to the size of the file.

6.3.9 Print

When the Print option is selected under the File pull down menu an IDL print dialog window will be displayed. The default print device will be displayed and you can choose the number of copies you would like printed out. If you do not wish to use

the default printer listed, please see Section 6.3.11, Printer Setup, which allows you to select from all printers that are recognized by your system. In addition, the Printer Setup window allows the user to control additional print parameters.

Please note that printing on Linux only works in black and white. Figure 6.3.9 shows an example of the print dialog window.

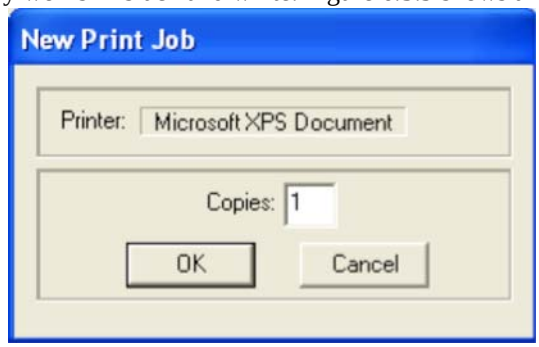


Figure 6.3.9

6.3.10 Print Setup

The Printer Setup option available under the File pull down menu allows the user to set up print parameters, select print devices, and print. The Print Setup option displays the standard IDL print dialog window. All print devices that your system can detect are listed in the Select Printer box. In addition, you can control the number of copies, page range, collating details, and preferences associated with the print device you selected. For detailed information about this dialog box and the preferences you can set, please refer to the IDL User's Guide. Figure 6.3.10 shows the Print Setup window.

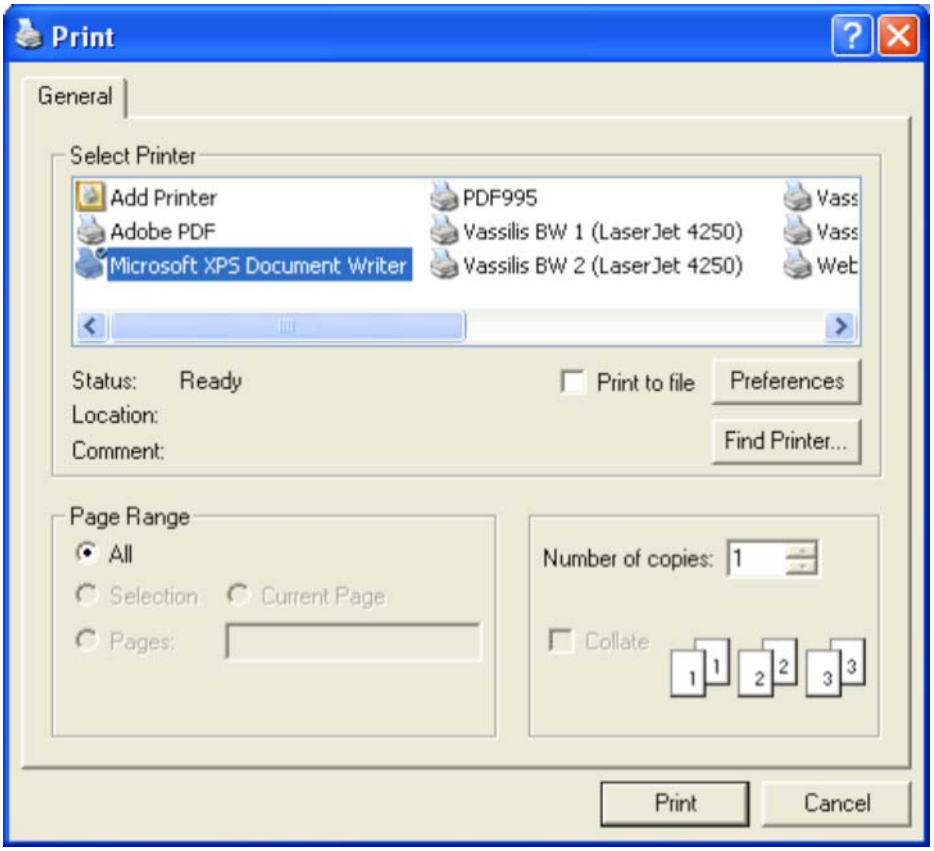


Figure 6.3.10

6.3.11 Configuration Settings…

This button pops up a window that allows access to the system variables that control the automatic downloading process. You can type in values for the different options in the window. Note that you should not need to do this very often.

The top window gives the local data directory. THEMIS data that are downloaded are written to this directory. The default value for users who are logged on to an ssl.berkeley.edu machine is "/disks/data/themis/". For windows users, the default value is "C:\data\themis\". It can be set to any directory for which the user has write permission.

The second text box shows the remote data directory. The default is http://themis.ssl.berkeley.edu/data/themis/

Next is the flag for automatic downloads; set this to 0 for automatic downloads, 1 for no automatic downloads. (This should be set to 1 for local SSL users, or anybody who has the entire database stored locally).

Next is the flag for file updates, if set to zero this will update files in local data directories if there is a file in the remote data directory which has the same name, but is new. When this flag is set to 1, this is not done. Next is the download only flag; Set this to 0 to download and load data, set to 1 to only download data, and not load.

The graphics mode allows you to select whether the graphics rendered are done with hardware or software. Rendering of graphics varies based on your system and platform. If your graphics are slow to display, you might want to switch your graphics mode. By default the GUI initializes to hardware. Whenever you click the save button, the configurations you selected will then be used as default values the next time you run the GUI.

The verbose flag controls the number of messages that will be displayed. Set this to a number from 0 to 10. The higher the number, the more messages you get during processing. The Configuration Settings window is show below in Figure 6.3.11

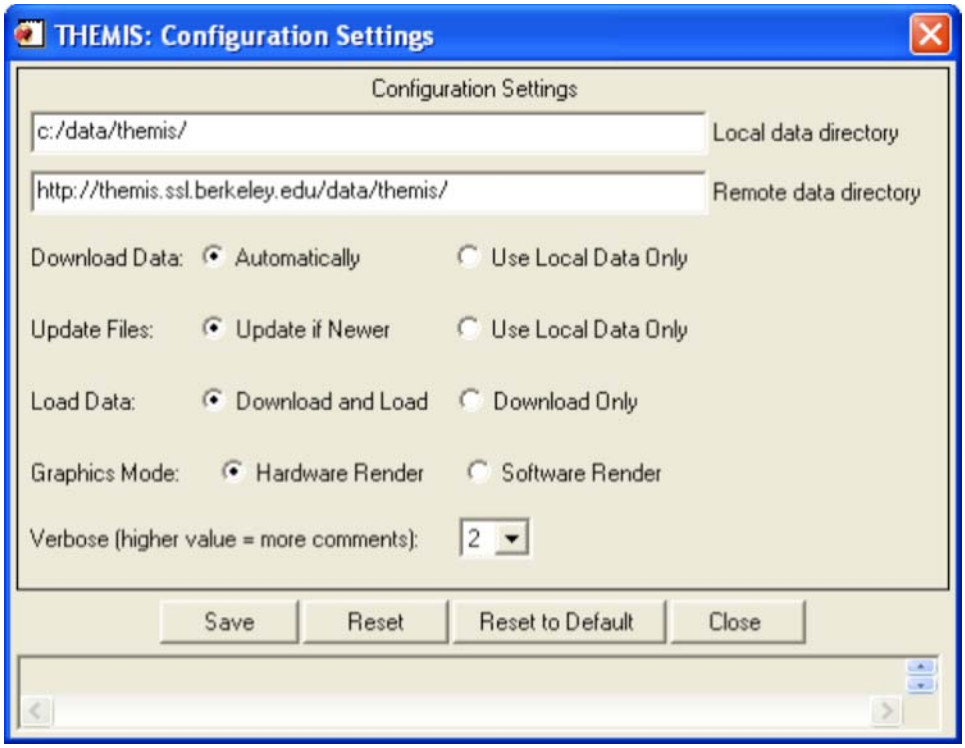


Figure 6.3.11

RESET - If you press this button, configuration settings are returned to their original state prior to opening this window.

RESET TO DEFAULT - If you press this button, the configuration is returned to the default state in THM_CONFIG.pro, and any saved configuration file is deleted. This means that if you want to go back to a configuration that you have saved previously, you need to reset the values and then save the configuration. Alternatively, you can locate the previously saved file and copy it to the appropriate location in the APP_USER_DIR shown below.

SAVE - If this button is pressed, then the current configuration is saved in a file. This file ends up in a directory created by the IDL APP_USER_DIR routine, on a windows system the path looks like this: "C:\usernme\.idl\themis\thm_config-4-win32\thm_config.txt". On a linux machine, it looks like: "$HOME/.idl/themis/thm_config-4-linux/thm_config.txt"

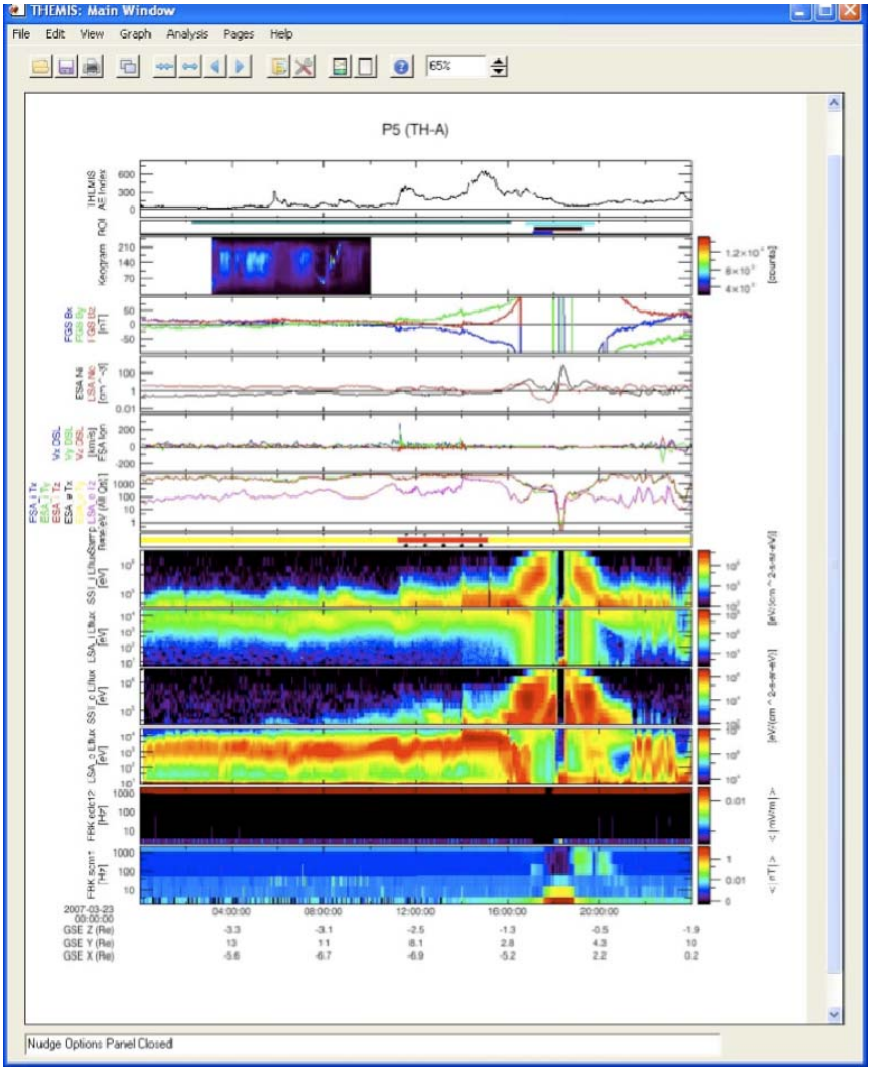
Important: Once you have saved this file, it will always be read when you run any THEMIS routines -- you should only need to do this once for each operating system that you are using.

Whenever you save a new file, the old file is copied to a file tagged with the current date and time, for retrieval in case of disaster.

6.3.12 Overview Plot

The Generate THEMIS Overview Plot menu option will create mission overview plots of all instruments. When this option is selected a window will be opened that allows the user to specify which probe (a-e) and time range are used to create the plots. Since a significant amount of data is required to generate these plots, it might take several minutes to load all the necessary data. The user should also be aware that ESA data in the common block will be deleted. If you plan on using Getspec options you will need to reload not only ESA data, but also SST. Figure 6.3.12.a shows the overview plot window and figure 6.3.12.b contains the overview plot.

6.3.12.a



6.3.12.b

6.3.13 Exit

The Exit option under the File pull down menu will terminate the THEMIS GUI session. All windows will be closed and control returned to the command line.

6.4 Edit Menu

The Edit menu contains options that allow the user to copy images or pages and delete or zoom into marked areas. Figure 6.4 shows the Edit pull down menu selections.

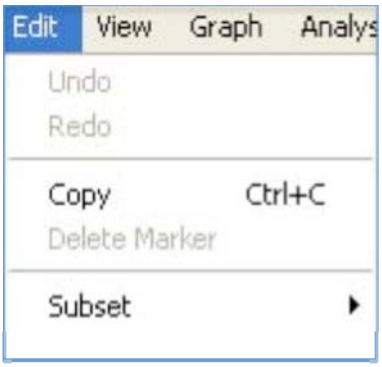


Figure 6.4

6.4.1 Copy

The Copy option in the Edit pull down menu will place a copy of the current or 'active' page on the clipboard. You may also use the accelerator key sequence Ctrl-C to copy the current page. Once the image has been placed on the clipboard, the user may paste it into any program, such as a Word document.

6.4.2 Delete Marker

If markers exist and one has been selected, the Delete Marker option under the Edit pull down menu will remove the marker and redraw the page without the marker. Recall that when a marker is selected, the vertical lines bounding the marked area are drawn in blue. If no markers exist, or none have been selected the procedure will do nothing and you can continue with other GUI operations.

6.4.3 Subset

The Subset option will create a new page based on the 'active' window or the selected marker. This menu item contains two submenus, Page and Marker.

The first item, Page, makes a copy of the 'active' page and pastes that copy into a new page. The original page is preserved. You can use the Page pull down menu to toggle back and forth between pages.

The second item, Marker, zooms in to the selected marker. Like with Subset Page, the Subset marker option will create a new page, this time containing only the x range that is contained within the marker boundary. The original page is preserved.

6.5 View Menu

The View menu contains items that modify the look of the main GUI window and/or the page and panels displayed in the main graph area.

Figure 6.5

6.5.1 Refresh

You can use the Refresh option in the View pull down menu at any time to redraw the ‘active’ page. The Refresh option also has an accelerator key, Ctrl-R.

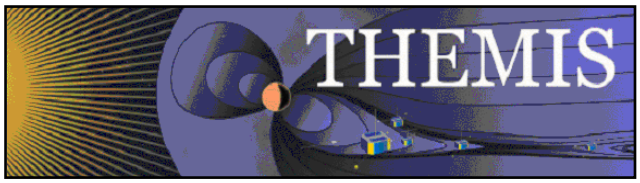
6.5.2 Scroll Forward/Backward

Scrolling can be invoked in three ways, using the Scroll Forward or Scroll Backward option in the View pull down menu, using the left and right arrow keys, or by using the scroll icons in the toolbar. A scroll request will move the x-axis forward or backward by the range of a major tick. This operation will be done for all panels in the ‘active’ page.

6.5.3 Expand/Reduce

Similar to scrolling the Scrolling forward can be invoked in three ways, using the Scroll Forward or Scroll Backward option in the View pull down menu, using the left and right arrow keys, or by using the scroll icons in the toolbar. A scroll request will move the x-axis forward or backward by the range of a major tick.

6.5.4 History Window



The history window is a list of the steps, operations, and plots that have been executed during the course of your session, as well as warning and error messages. Just below the history window are buttons that allow the user to save the history in a file, and clear the history. The "Save" button will save the history in an IDL source file. When you click here, a file selection window pops up, allowing you to choose the filename and path for the file. The default file is "thm_gui_history_yyyymmddss.pro" and is located in your local working directory. The time stamp on the default file name is the local system time. The "Close" button close the history window. History window messages are not lost when the window is closed. History messages are recorded at all times while the THEMIS GUI is running, regardless of whether the window is displayed or not.

Since the history information includes error message, it will be used as a debugging tool. When an unexpected error is encountered during your session, you will be notified with a message and the Error Report Form will be displayed. When the Save button is clicked in the Error Report window both the Error Report Form and the History file when the Save button is clicked in the History window only the history file is saved. In addition to history messages, IDL journal messages will also be appended to the file.

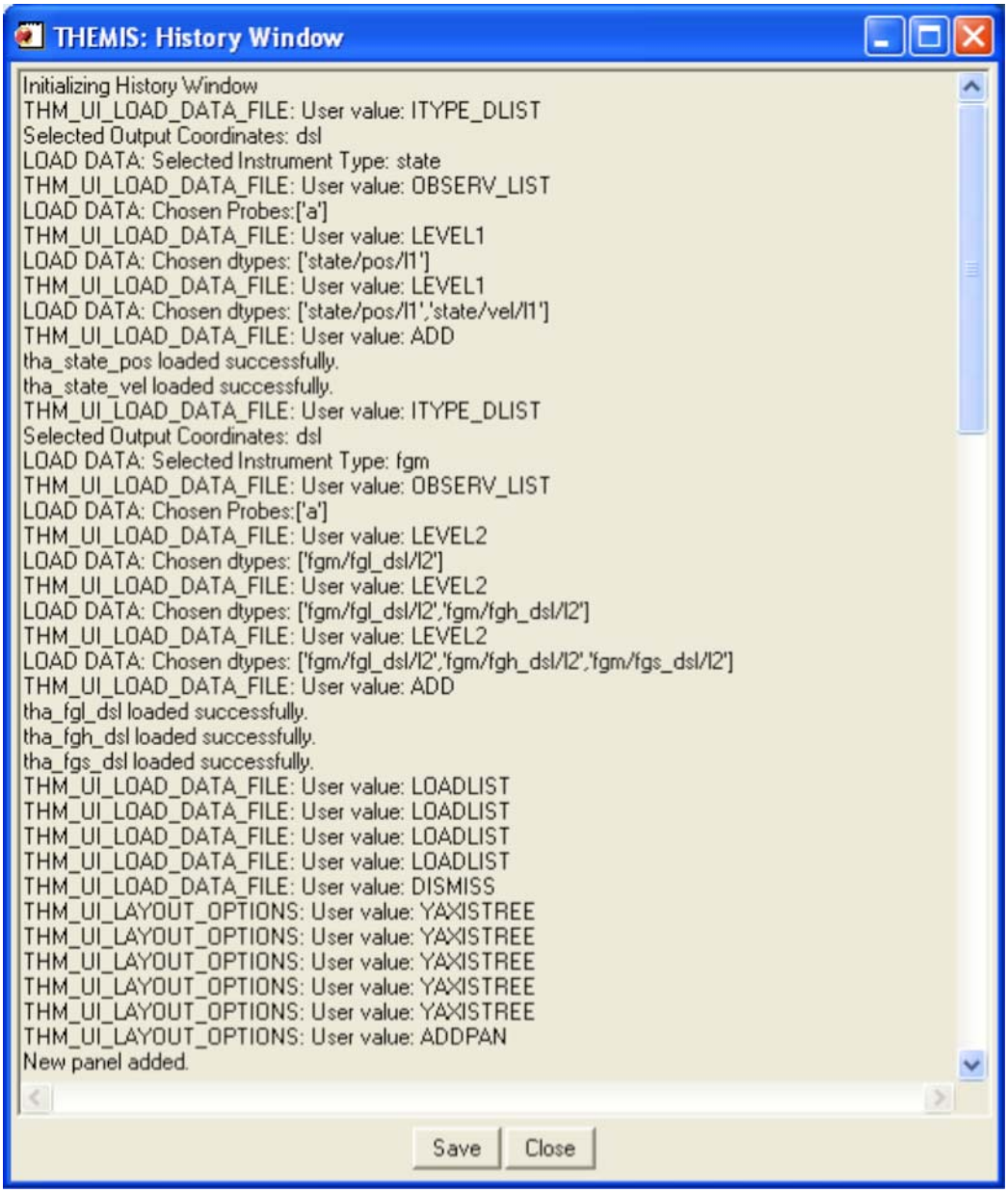


Figure 6.5.4

6.5.5 Position Legend

The Position Legend is the box in the upper right hand corner of each panel displayed in the ‘active’ page. The legend box displays a value for each variable within the panel. The value displayed is the value at the point where the vertical tracking line intersects the data line, in other words the x value of the data at the x position of the cursor. Whenever the cursor is moved the values in the legend box will be updated. Note that along with the y-axis labels, the legend labels and values are color-coded and synchronized with the color of the line within the plot. Figure 6.5.5a below shows an example of the legend box.

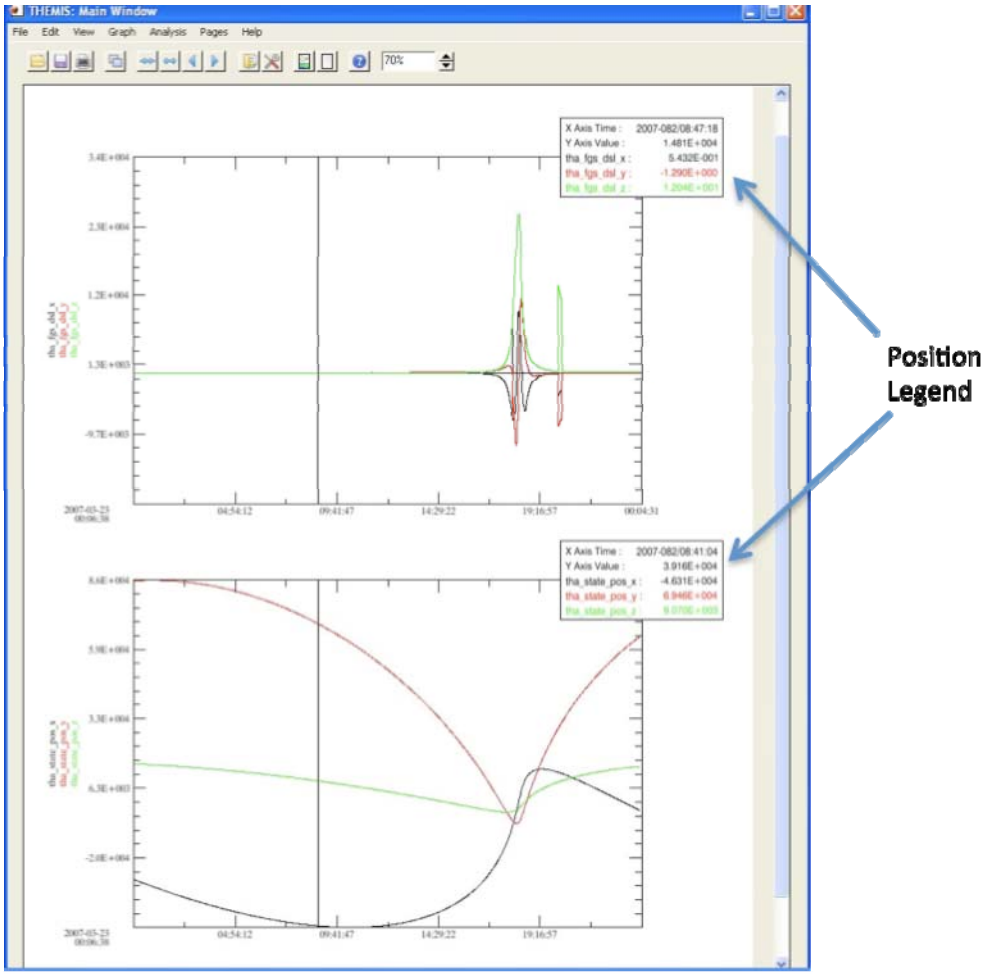


Figure 6.5.5a

The legend box is only on when tracking is enabled. If tracking is enabled and the user can chooses not to display the legend box, they can turn the legend on and off by toggling the Position Legend option selection in the View pull down menu. The Position Legend is a checked marked menu item, when a check mark appears to the left of the menu name the position legend will be shown, no check mark indicates that the legend is off. Figure 6.5.5b below shows an example of a page with the position legend turned off.

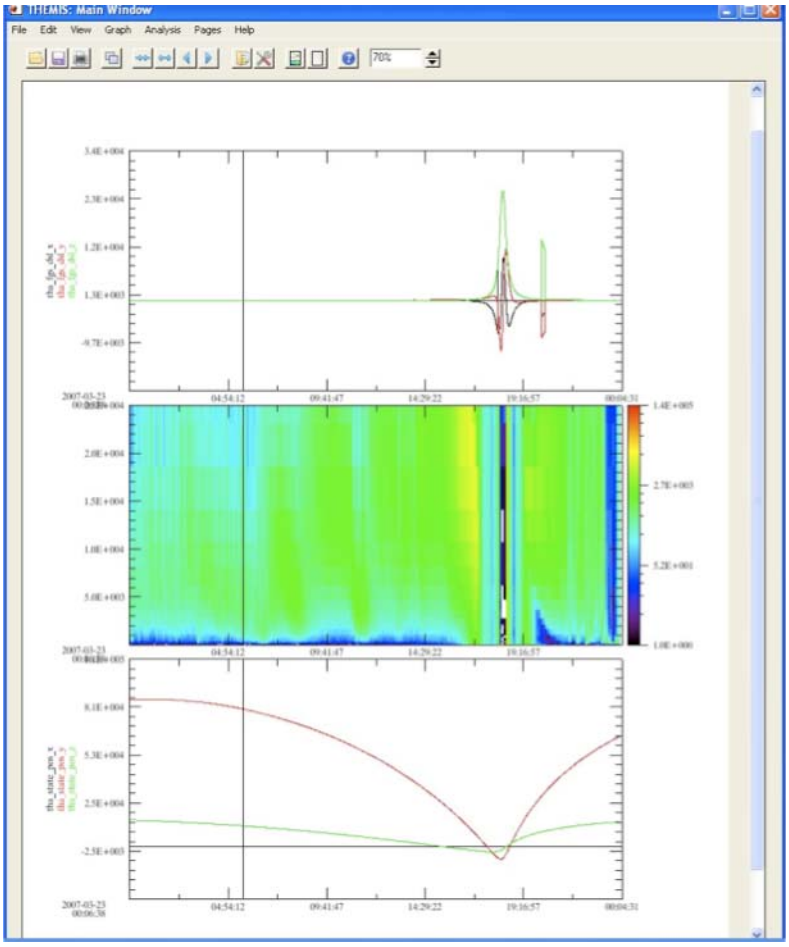


Figure 6.5.5b

It is worth noting that when a page is sent to a print device, the legend will not appear in the hard copy so that the area covered by the legend box can be seen.

6.5.6 Status Bar

At the bottom of the main GUI window is a status bar. The status bar displays text messages that provide information regarding the state of the GUI, the status of an operation, and other updates that are of interest to the user. If, during the course of your session, you have an unexpected result, it is worth checking the status bar. Most messages sent to the message bar are also recorded in the History message buffer. In the event that an expected error occurs due to incorrect usage of the GUI or request of an operation not allowed at that time you will be informed with an IDL dialog box. The dialog is popped up and you will need to either acknowledge the message or respond with a yes or no.

6.6 Graph Menu

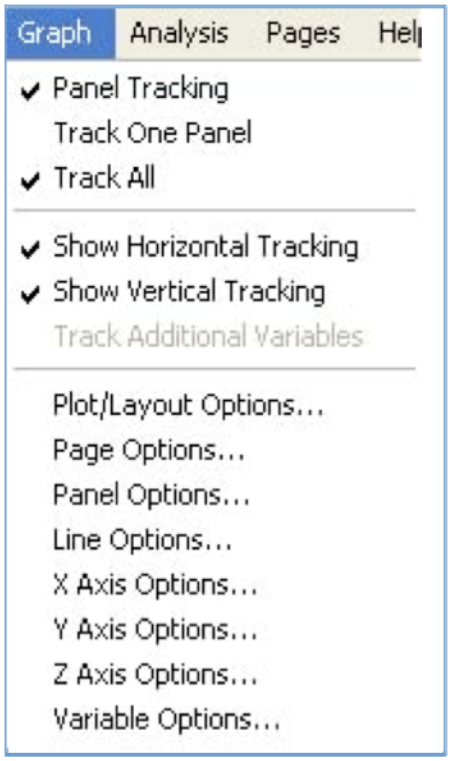


Figure 6.6

6.6.1 Panel Tracking

Tracking can be toggled on or off by selecting the Panel Tracking option under the Graph menu. When tracking is on, you will see a vertical bar tracking any cursor movement that occurs inside the frame of a panel. This option is a checked menu item. When a check mark is displayed before the menu item name, Panel Tracking, then you will see the vertical line. When no check mark is present tracking is turned off. By turning off tracking, you also turn off the position legend box in the upper right corners of the panels. This menu item will also turn off the Track One Panel and Track All options.

6.6.2 Track One Panel

The user can choose to turn the vertical tracking line to track only one panel at a time versus all panels. When this mode is selected the vertical tracking bar will track only the panel that the cursor is in. Similarly, if the position legend is on, only the legend box of the panel the cursor is in will be updated. This is a checked menu item and is on when the check mark is present and off when not. When tracking is in one panel mode, the track all option will automatically be turned off and the menu item will be unchecked. The Track One/Track All menu pairs are mutually exclusive so when one mode is on, the other will be turned off.

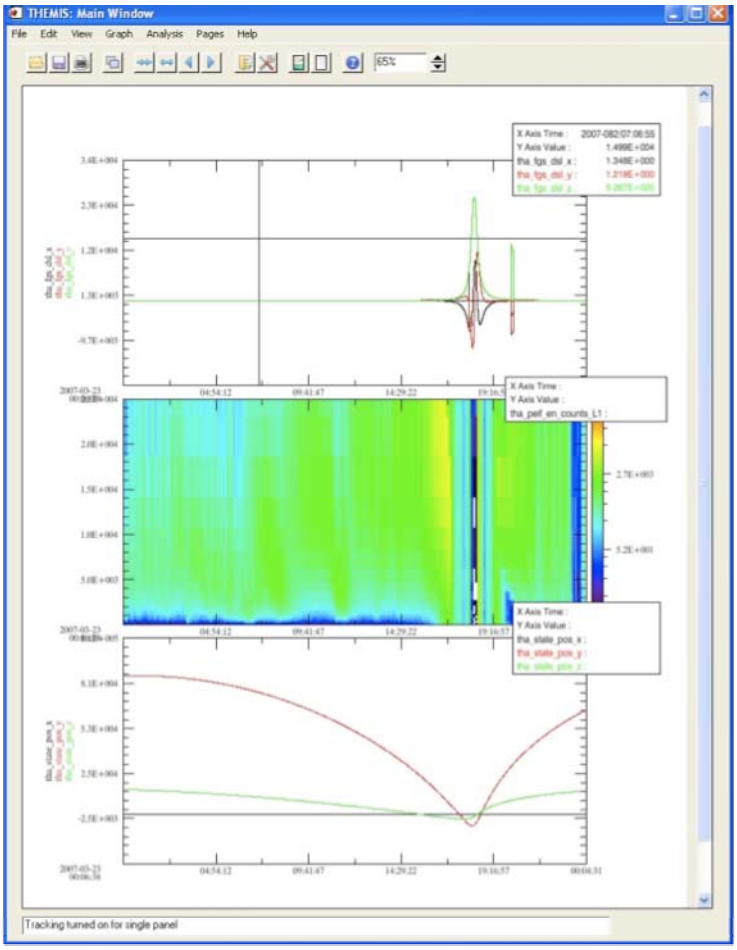


Figure 6.6.2

6.6.3 Track All

When in track all mode, the vertical line will track the cursor movement in all panels in the 'active' page. See section 6.6.2 Track One Panel to see how the two menu items are paired.

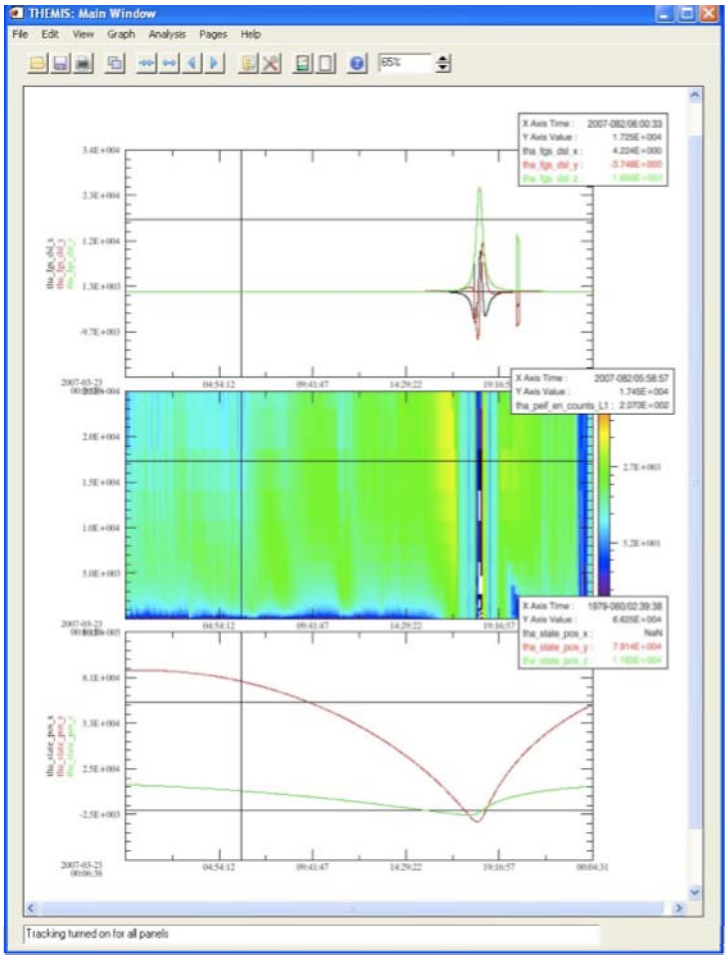


Figure 6.6.3

6.6.4 Vertical Tracking

Currently the tracking line is only displayed vertically. This menu item will be turned on whenever tracking is on, and off when tracking is off. This is regardless of whether tracking one panel or all panels. Future versions may implement horizontal tracking as well.

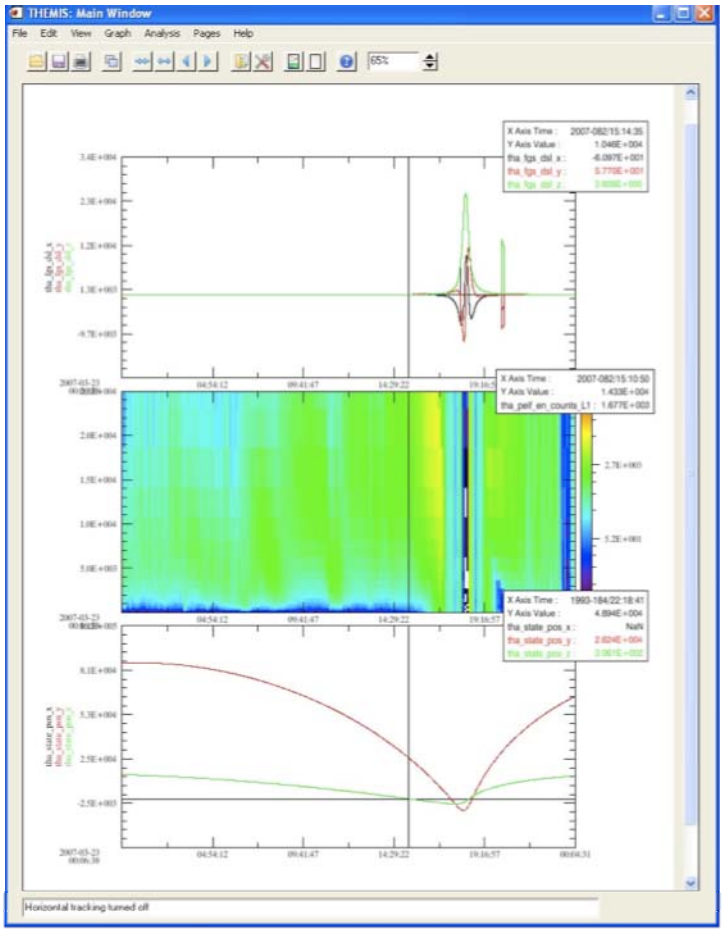


Figure 6.6.4

6.6.5 Horizontal Tracking

Currently the tracking line is only displayed vertically. This menu item will be turned on whenever tracking is on, and off when tracking is off. This is regardless of whether tracking one panel or all panels. Future versions may implement horizontal tracking as well.

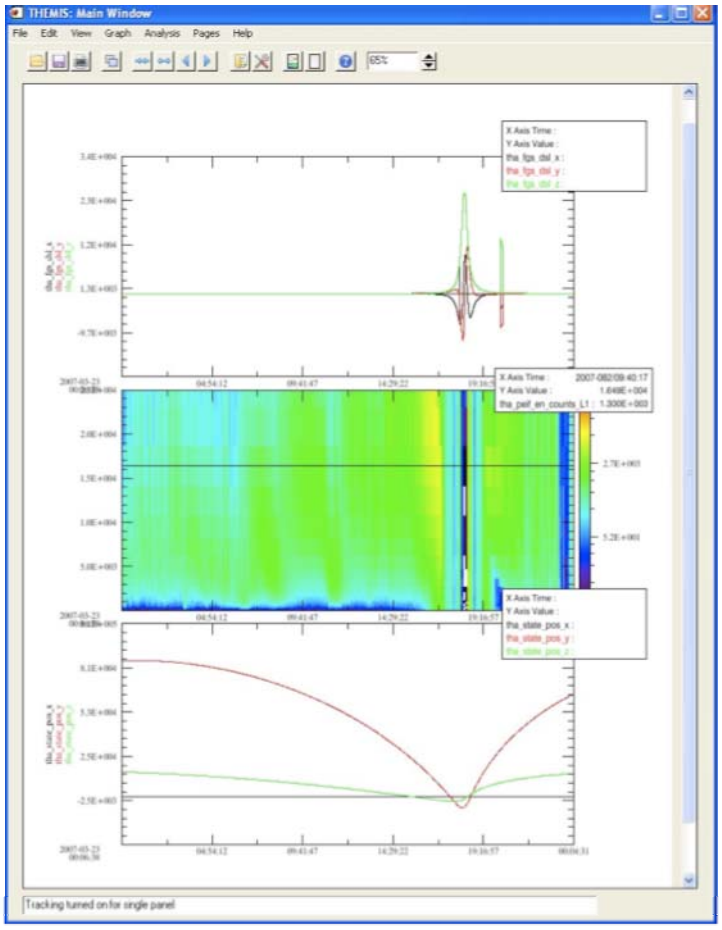


Figure 6.6.5

6.6.6 Plot/Layout Options

The Plot/Layout Options window allows the user to create panels and select data values for display on those panels. Panels can be added, deleted, and reordered. In addition, settings associated with panels and traces can be modified.

The left hand side of the window is used for selecting data for display on the X and Y-axes. The right hand side of the window is for manipulating panels. If no data has been loaded or panels created both these text areas will be blank. The Variable section at the bottom of the window allows the user to select variables for display below axes.

There are two modes for selecting data for display, Linear and Spectral. The default mode is Linear. When in linear mode the user can choose to select both X and Y data for display, or select only Y data, allowing the X-axis to default to time. When the window is initialized it will default to Y only data selection. The Show X Data check box located in the upper left hand corner of the window provide a way to toggle between the two modes. When X data is shown, both X and Y-axes data trees will be decomposed into individual components. When the Show X Data is not checked, the Y-axis data tree will expand to show only data sets. Figures 6.6.5a and 6.6.5b show examples of both.

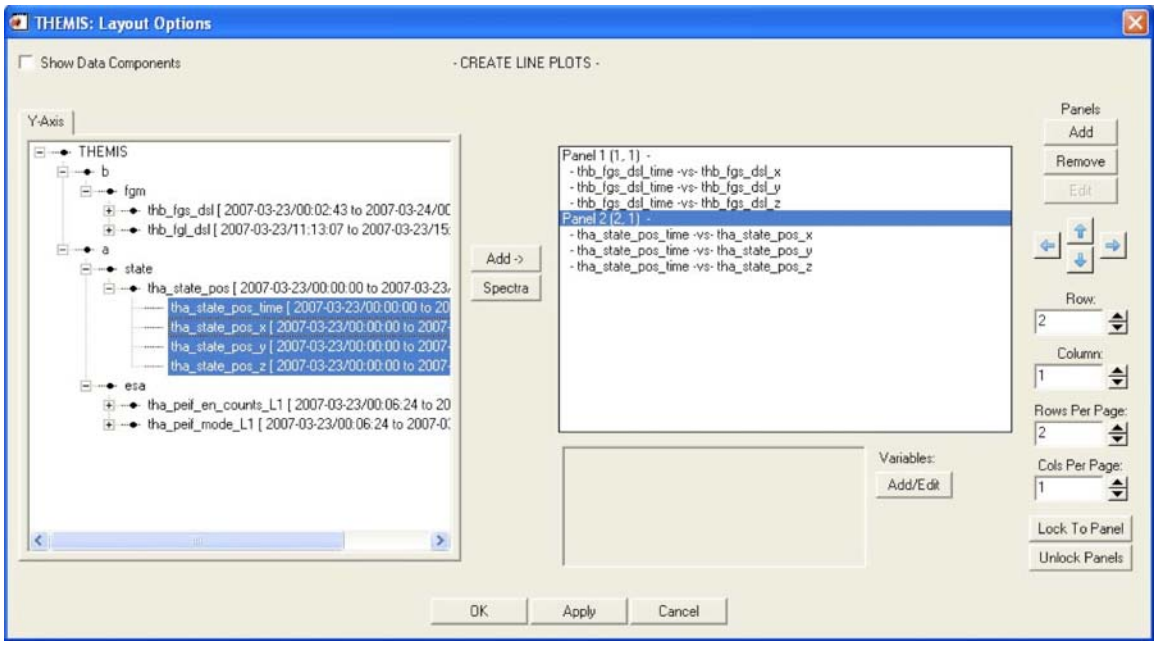


Figure 6.6.6a

Once data is selected the user can click on the 'Add->' button to add it to a panel. For the first addition, if no panels exist, one will be created automatically and named, Panel 1(1,1). This is not true for subsequent additions. If you want to display data on a different panel, you must first click the 'Add' button on the far right hand side of the window otherwise the data will be placed on the most recently selected panel.

As new panels are added the panel number will increase sequentially, regardless of whether earlier panels were deleted or reordered. The row and column numbers are displayed in parenthesis next to the panel number. It is important to note that Panel numbers do not change, however, row and column values can

The user can choose to delete a panel or trace by selecting (or highlighting) the item in the panel text box and clicking delete. Further, the user can modify panel or trace settings by selecting the item and clicking the Edit button. See Sections 6.6.5.1 and 6.6.5.2 for additional details.

The Up and Down arrow buttons provide a way to reorder panel rows or trace location on the panel. The left and right arrow buttons move panels by column. Panels can be overlaid, in other words, they can have the same row and column number. The user needs to be aware of this feature when reordering so that care can be taken to ensure the correct layout is created.

The row and column number of a panel can be changed using the Row and Column spinner widgets below the arrow buttons. The total number of rows and columns per page can also be modified. Please note that the total number of page rows and/or columns cannot be set to a value less than the largest row and/or column value (e.g. Panel 4(5, 2) – Panel 4 is displayed in row 5, the user cannot change the total rows to any value smaller than 5, likewise, in this example, total page columns must be greater than or equal to 2).

A new feature is available that allows you to lock the x-axis to a selected panel. To do this, select the panel you wish to lock to and click the Lock to Panel button in the bottom right corner of the window. The panel that all others are locked to will have an '(L)' preceding the panel name. When locked the x-axis annotations are only displayed on the last or bottom panel.

The default mode for this window is that the x-axis is time and the y-axis data. The user can choose to show all data components by clicking the Show Data Components check box at the top of the window. When checked, a new tab for the X-axis data will be displayed. In this mode the user can specifically select any x and y data values that have been loaded. You

must remember to return to the Y-axis tab and make a selection before clicking the Add button. Figure 6.6.6.b shows the Layout Options window in the Show Data Components mode.

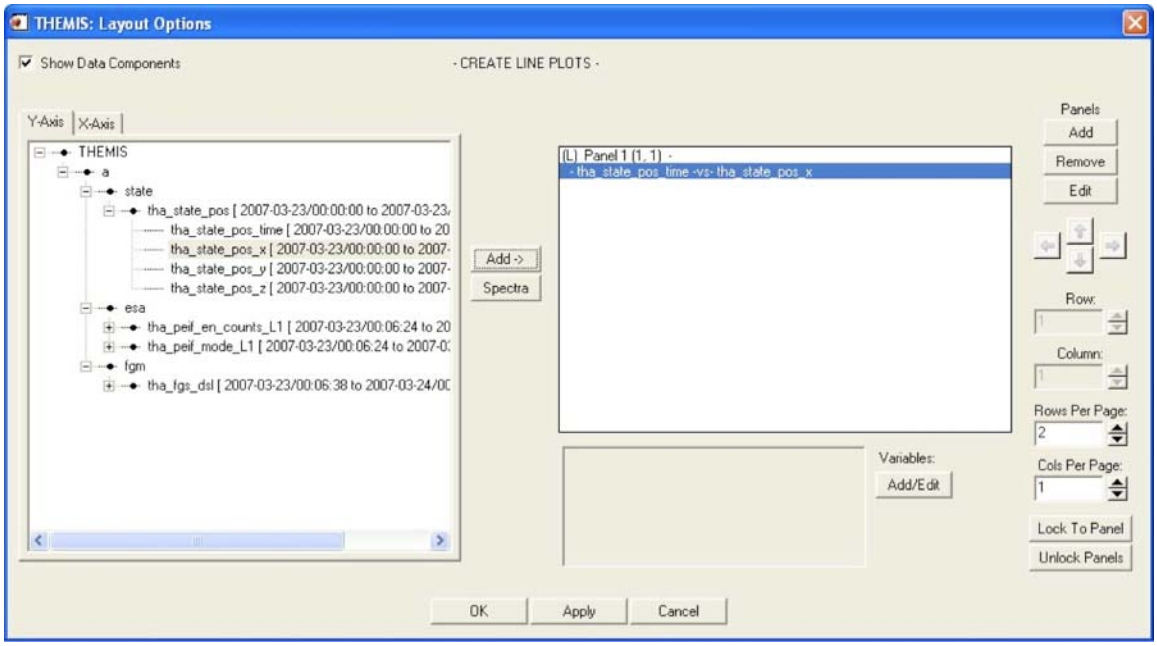


Figure 6.6.6b

To plot spectral data the user must switch from linear mode to spectral by clicking the Spectral button. The window will be displayed with a Z Axis tab for data selection. All other operations remain the same as described for linear data. The user can toggle back to the linear layout options window by clicking the Linear button. If linear data is selected while in spectral mode or spectral data selected while in linear mode the data may not be added to the panel, or if added the results might not be as expected.

At any time the user can click the Apply button to view the panel layout, the OK button to commit the layout, and close the window, or Cancel to undo changes and close the window.

At the bottom of the Layout Panel is a variable section. The text box will display any variables that have been chosen for display below the x-axis. The user can also click the Add button to bring up the Variable Options window. See section 6.6.10 for details on creating variables for display.

6.6.6.1 Line Options

When a trace (or line) is highlighted in the panel window and the Edit button clicked the Line Options window will be opened. The Line Options window allows the user to modify any settings that are associated with plotting the line. The Edit button is for traces only and will not open if a panel is selected.

Line Options can also be opened from the Graph pull down menu.

At the top of the window the user can change the panel and x and y-axes, the window will default to whatever the user selected in the Plot/Layout Options window. Once a trace is selected each widget will be updated to show the current settings for that trace. Line and symbol settings, as well as symbol frequency can be modified on this window. Figure 6.6.5.1 shows the Line Options window.

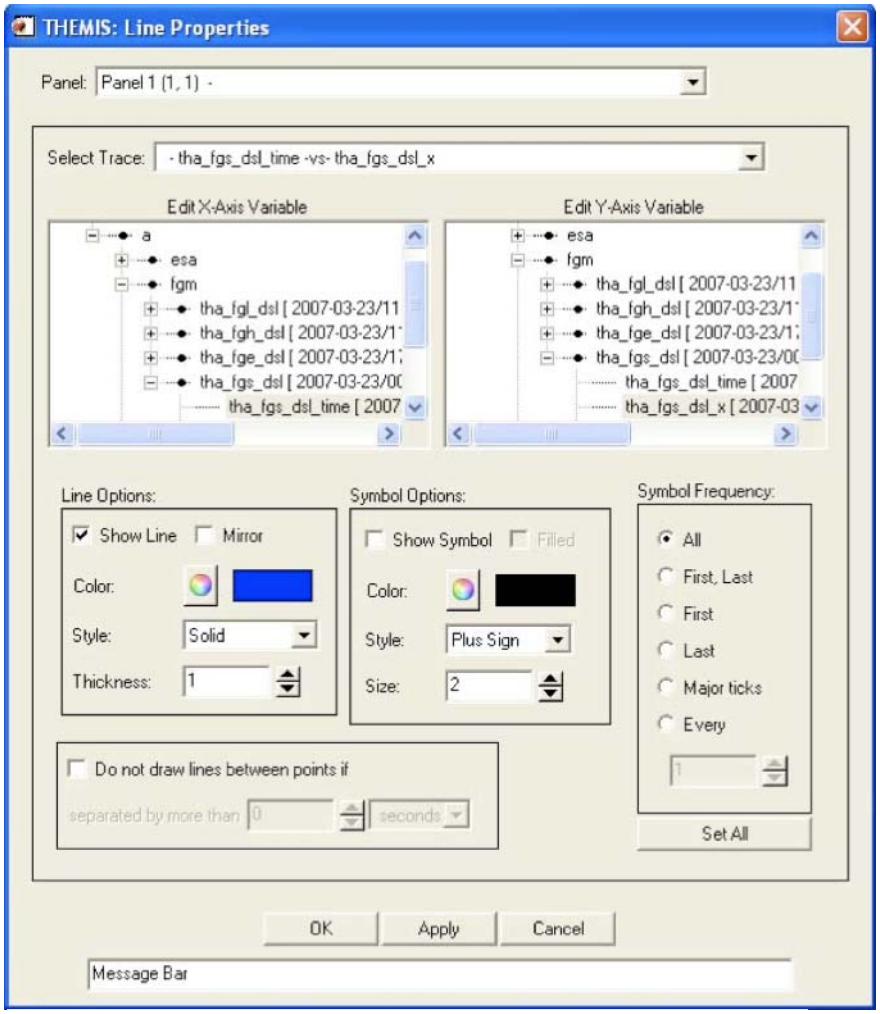


Figure 6.6.6.1

Line Modifications

Show: The show check box determines whether the line is displayed or not. A check indicates the line will be drawn.

Mirror: The mirror check box will draw a horizontal line at zero and reflect the trace below.

Color: The color button will open the color palette allowing the user to select a different color. When a new color has been accepted the current color swatch next to the button will be updated to reflect the change. If the Apply or OK buttons are clicked the trace will be drawn in the new color.

Style: The line style drop list contains all the line styles that IDL allows (e.g. dashed, dotted, etc..).

Thickness: The thickness spinner widget lets the user change to size of the line.

Symbol Modifications

Show: The show check box will determine whether the symbol is displayed in the plot, or not. A checked box indicates the symbol will be drawn.

Fill: Fill has not yet been implemented, however, when checked the symbol will be filled in with the selected color.

Style: The symbol style drop list lets the user choose any of the symbols that IDL allows.

Color: The color button will open the color palette allowing the user to select a different color. When a new color has been accepted the current color swatch next to the button will be updated to reflect the change. If the Apply or OK buttons are clicked the symbol will be drawn in the new color.

Size: The size spinner allows the user to increase or decrease the display size of the symbol.

Symbol frequency has five options for determining when a symbol is drawn and include: First Point, First and Last Point, Last Point, Major Ticks, or Every x points. If the Every x points button is clicked a numeric value can be specified in the spinner widget (e.g. a value of 20 will plot a symbol every 20th point).

As with all graph options windows, the user can click the OK, Apply, or Cancel at any time.

6.6.7 Page Options

The Page Options window controls settings global to the current page. To open this window Select Page Options in the Graph pull down menu.

The Text tab (shown below in Figure 6.6.7a) lets the user choose the settings for size, font, and color of the title, variables, and footer. The 'Token…' buttons let the user insert a time stamp with a variety of formats into the title/footer (note that the GUI inserts the token at the current location of the cursor). The 'Format…' buttons change boldface and italic settings. The Font Style frame controls font, font size, and font color (a color dialog box opens – see Figure) for both title and footer. Use the Show check boxes to hide or show the title and footer.

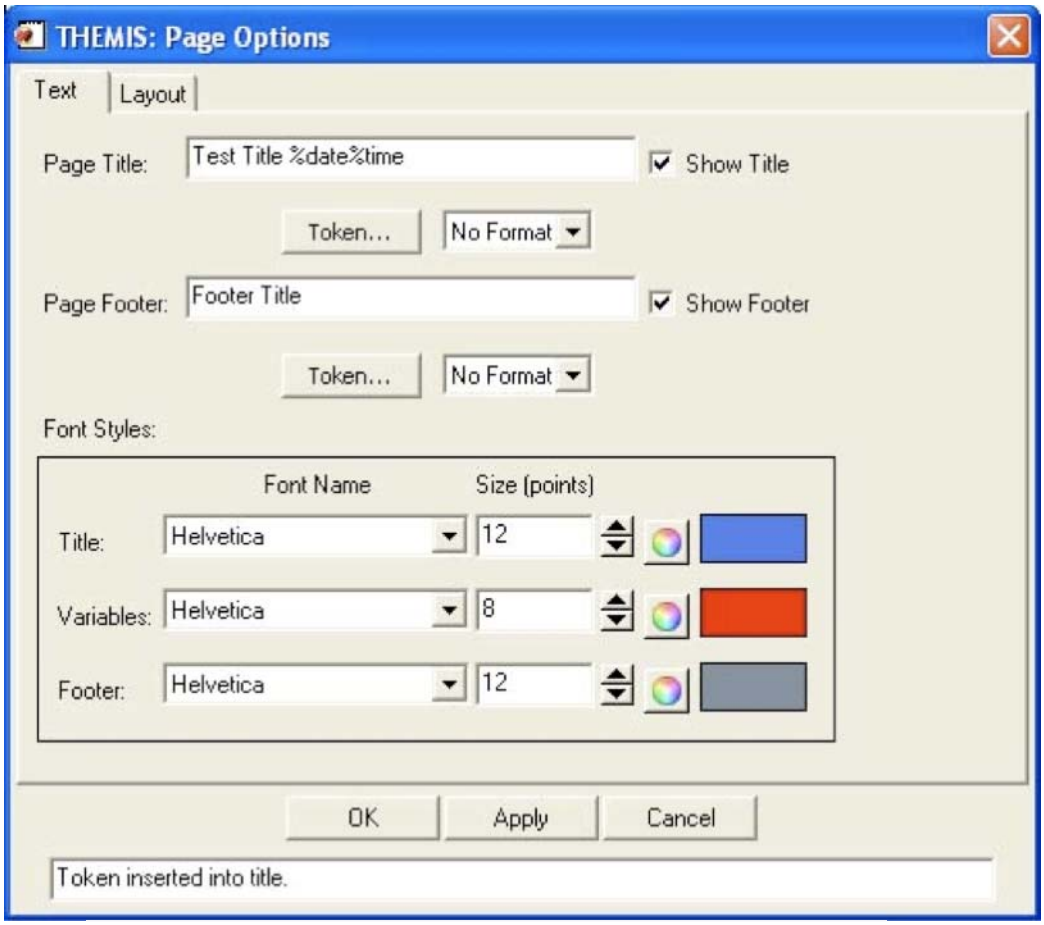


Figure 6.6.7a

Figure 6.6.7b shows the token options that are available.

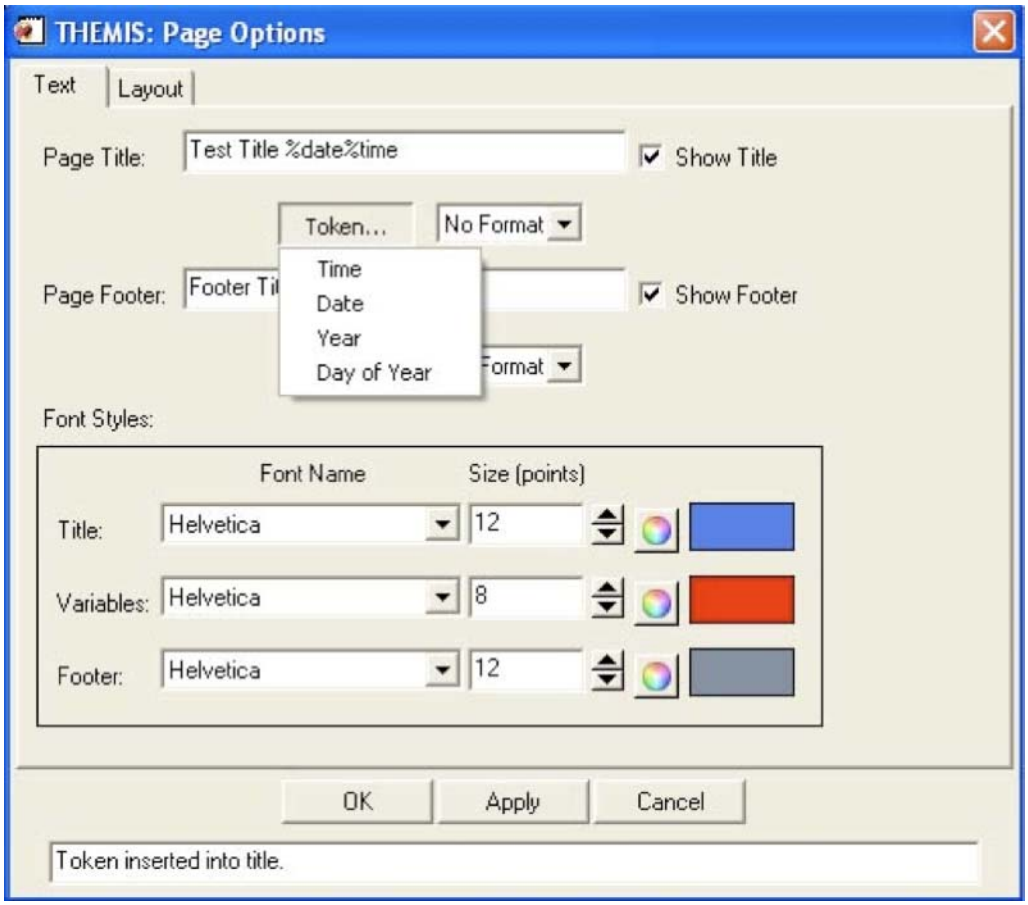


Figure 6.6.7b

The Layout tab (shown below in Figure 6.6.7.c) has four active frames: Panel Arrangement, Margins, Canvas Size, and Background. Panel Arrangement: The horizontal and vertical panel spacing sets the horizontal and vertical distance between columns and rows (respectively) of the panels. Margins: The top, left, right, and bottom margins set the distance (in inches) from the corresponding edge of the canvas to the nearest panel. The margins must be at least 0.1 inches. Canvas size: The dimensions of the page in inches.

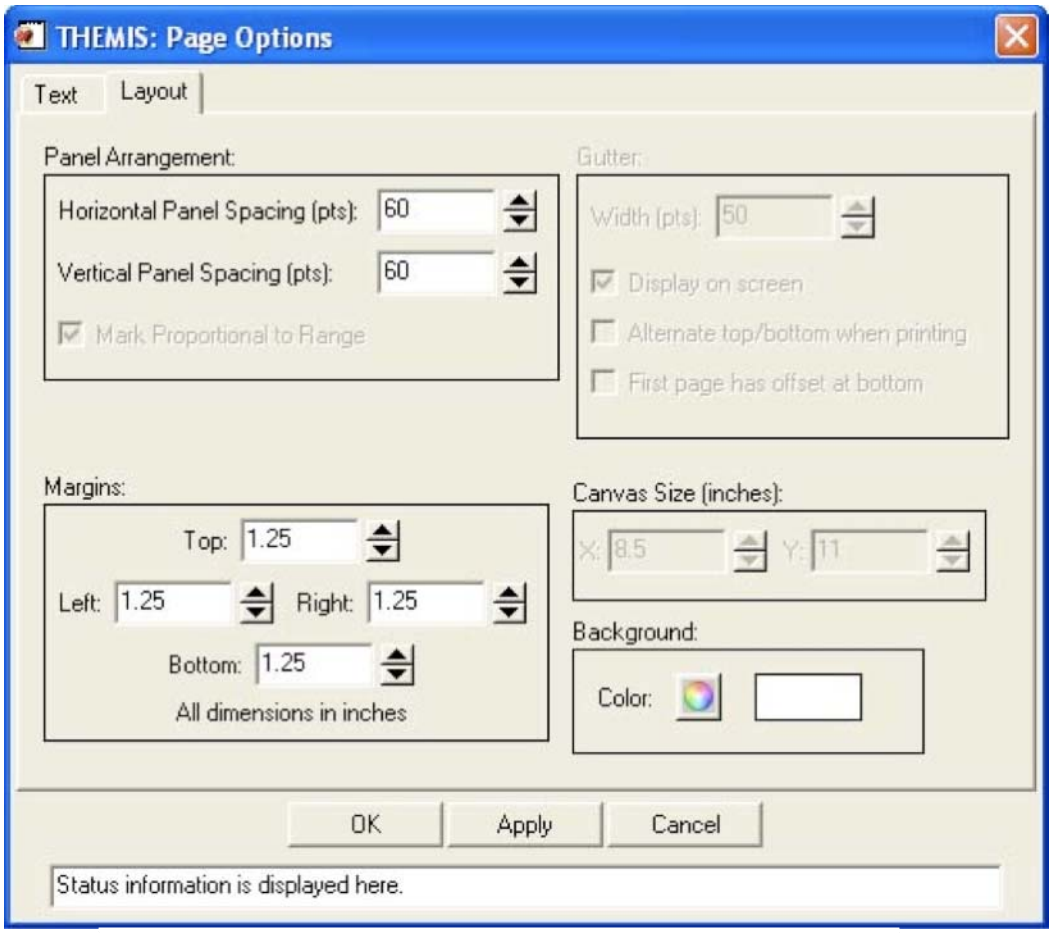


Figure 6.6.7c

6.6.8 Panel Options

The Panel Options window allows the user to modify the layout, spacing, and color of the panel.

There are four ways in which the row and column configuration can be modified. The row and column spinner widgets allow the user to specify the row/column they want the selected panel to be drawn on. The row and column span determine how many rows or columns the user wishes the panel to for.

Properties associated with the panel frame, color, and thickness as well as back ground color can also be controlled here. If you wish to apply your modifications to all panels on the current page you can check the Set All Panels box. At any time the OK, Apply, or Cancel button can be clicked to commit, view, or undo the changes. Figure 6.6.8 shows the Panel Options window Trace tab.

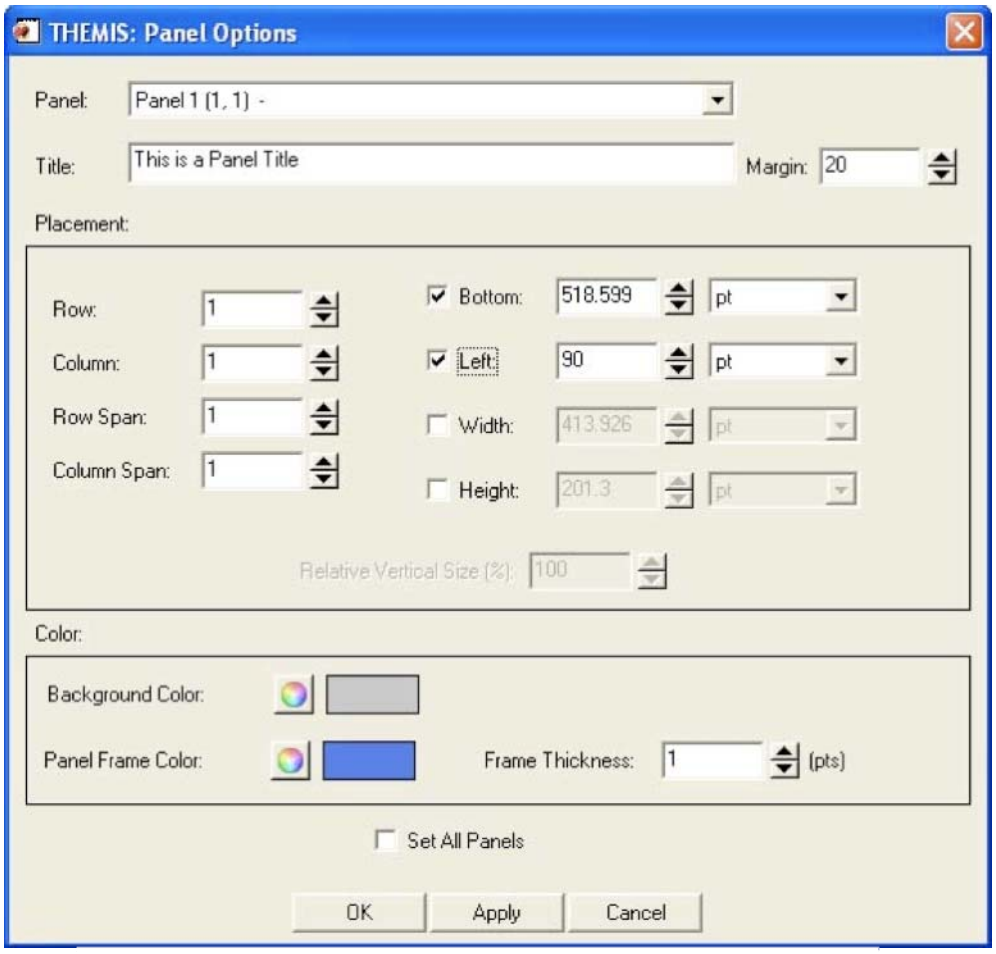


Figure 6.6.8

6.6.9 X/Y Axis Options

The X-Axis Options window controls the x-axis settings for the selected panel (use the panel drop down menu at the top of the window to change the selection). To get X-Axis Options, select it from the Graph pull down menu. Accepting and canceling changes: Clicking OK accepts the changes and refreshes the page. Clicking Apply accepts the changes provisionally and refreshes the page. Clicking Cancel rejects any changes and refreshes the page. Dismissing the window via the operating system ('X' button) has the same effect as clicking Cancel.

The Range tab sets how the GUI determines the displayed range and gives a special option for when the axis displays time. If the axis is time, then the 'Is Time' check box should be set. When the axis is time, then only the fixed Min/Max frame, and the Set All Panels button are active. *(**A note about Set All Panels:** This button works individually for each tab. Any operations done on a given tab **after** setting the button will propagate to all panels. Behavior with Locked X-Axes on the X-Axis only: When Locked X-Axes in Plot/Layout Options is checked [the default], the GUI will check Set All Panels for the Range, Ticks, and Grid tabs, while unchecking Set All Panels for the Annotation and Labels tabs. We recommend that the user keeps these settings for the Annotation and Labels tabs when axes are locked.)* When the axis is time, the GUI represents the Min/Max range in date/time format. When the data is not time (uncheck Is Time), the Range and Scaling

sections become active. The Range Options buttons now make active (only one at a time) the following frames: Auto Range, Floating Center, and Fixed Min/Max.

Auto Range: The range margin sets a margin between the plotted data and the plot box edge (above and below) as a percentage of the maximum minus the minimum of the displayed data. The bound auto-scaling range puts absolute limits on how big the range can get; auto-ranges fully within the bounds are unaffected.

Floating Center: The GUI determines the center as a mean, or median of the data (the approximate mean/median options currently function identically to the mean/median options.). If the axis uses linear scaling then floating range is calculated using the following equations. Minimum Range = center – span, Maximum Range = center + span. If the axis uses logarithmic scaling then the floating range is calculated using the following equations: Minimum Range = base ^ (log(center) – span), Maximum Range = base ^ (log(center) + span). In other words, the span of the floating center on a logarithmic plot is the number of orders of magnitude above and below the center that should be included in the plot.
In the equation above 'base' is either e or 10, and 'log' is either the natural logarithm or the base 10 logarithm, depending upon the type of log scaling that is used.

If the axis is Fixed Min/Max: The user determines an absolute range.

Scaling: The user can select linear, logarithmic base 10, or natural logarithmic scaling. Figure 6.6.9a shows the Range Tab of the X/Y Axis Options window.

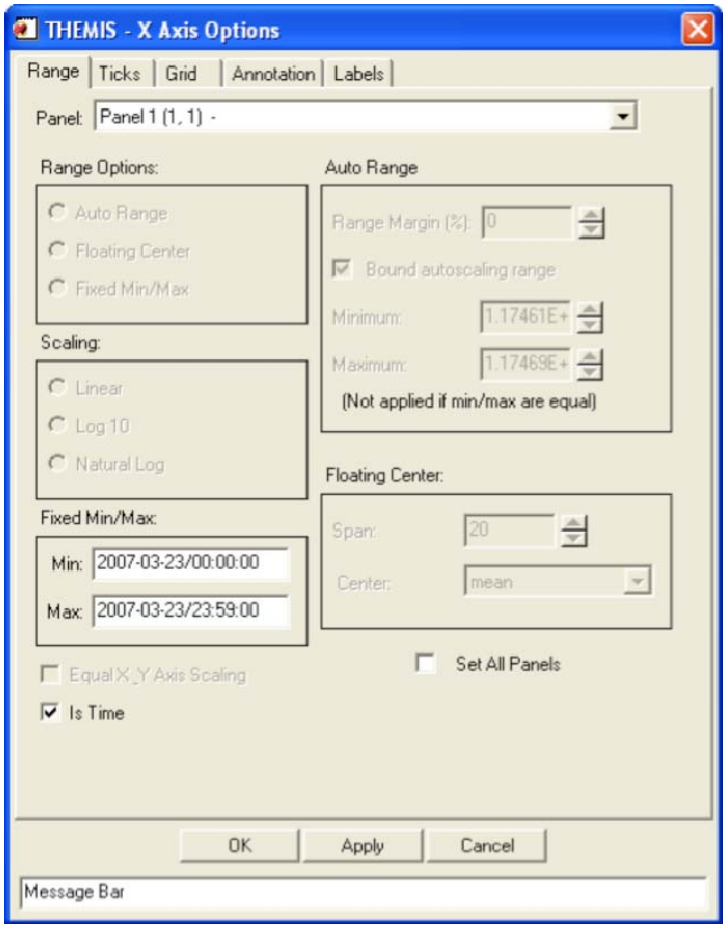


Figure 6.6.9a

The Ticks tab sets where and how to draw the axis ticks, and contains two frames for Placement and Length The user can choose to manipulate ticks by number, or by interval. When the 'Major Ticks by Number' radio button is on, the user can modify the number of ticks in the spinner. . By default, the GUI determines ticks automatically, however, the user can toggle this feature on or off. Please note that when Aesthetic Ticks are on, the # of minor ticks will have no effect. Alternately, the user can elect to manipulate ticks by interval. When the 'Major Ticks by Interval' button is on, the user can enter the number, the units, and/or the specific time at which to align ticks. If the axis is time, 'Units' sets the tick frequency in common time units, otherwise the units widget is not active. The 'Draw Ticks' drop list provides for different tick style's and includes drawing the tick inside the panel frame, outside the panel frame, or both. The Placement frame has right and left buttons that switch ticks on/off for the right and left y-axes of the plot box. The Length frame controls the lengths of the major and minor axes. Figure 6.6.8b shows the Ticks Tab of the X/Y Axis Options window.

Tick options will be measured in orders of magnitude of data units if the axis is logarithmically scaled and data units if the axis is linearly scaled.

Here are some examples that explain how these options work:

1. If the axis has linear scaling, the minimum range of the axis is 50, the maximum range of the axis is 100, the 'Major Tick Every' is 10, major ticks will be placed at 55, 65,75,85, and 95.
2. If the range of the axis is from 10^1 to 10^6, the axis has base 10 logarithmic scaling and 'Major Tick Every' = 2. Then major ticks will be placed at 10^2,10^4 and 10^6.

NOTE: When auto-ticks are chosen the number of ticks is an upper bound. The actual number of ticks will be determined based on the range of the data.

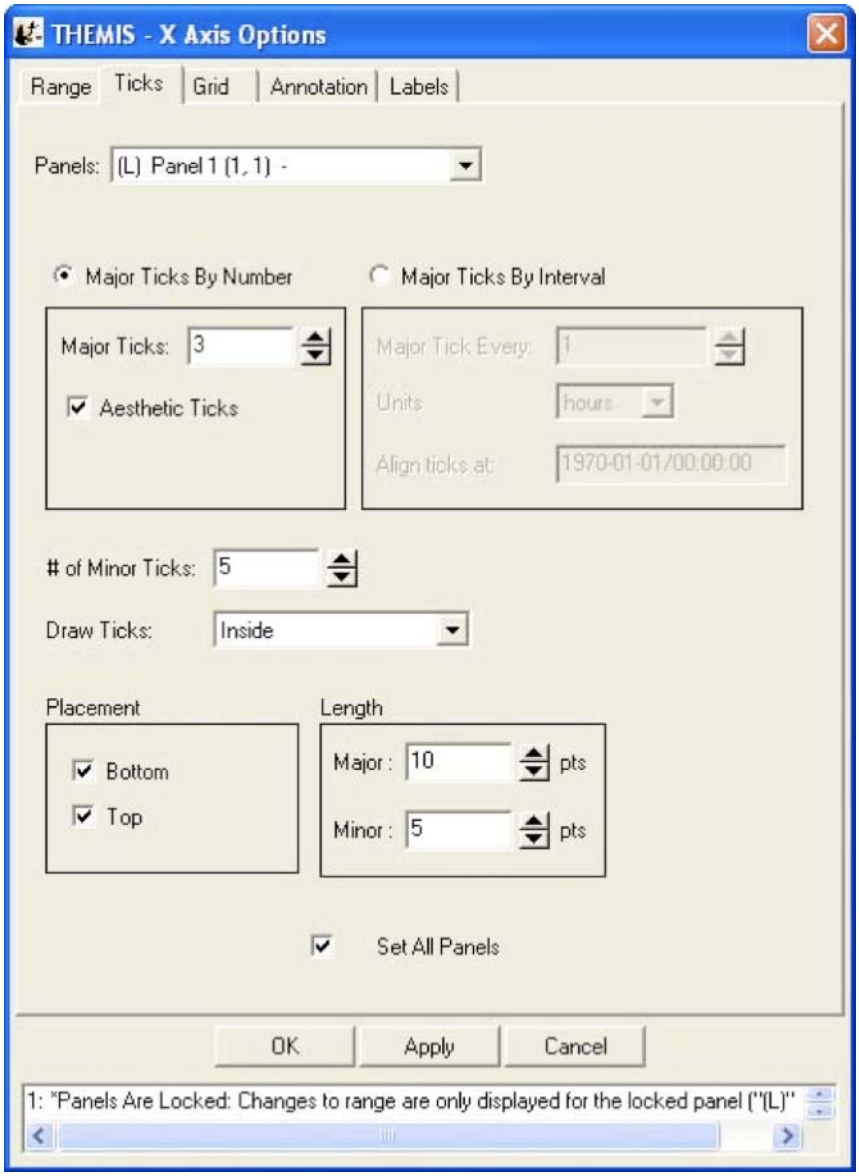


Figure 6.6.9b

The Grid tab has a setting for the Panel Frame Thickness (which includes the tick thickness), and two frames to implement Major and Minor Grids (color, thickness, and style). Figure 6.6.9c shows the Grid Tab.

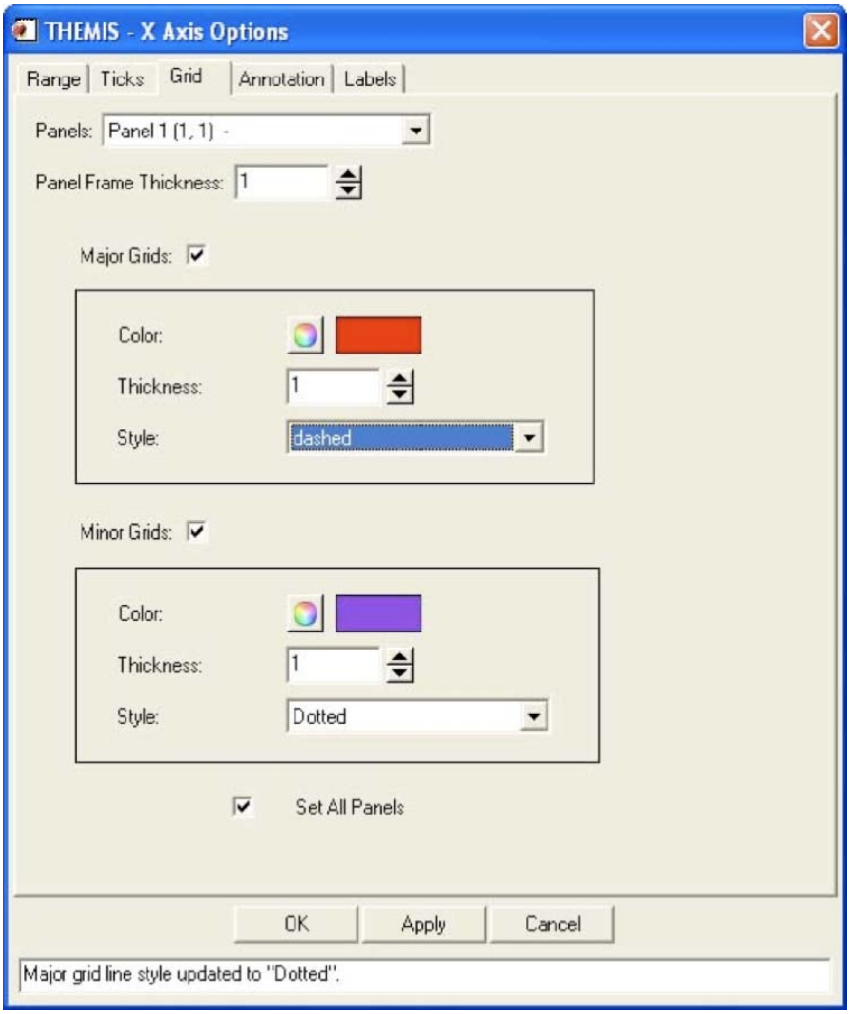


Figure 6.6.9c

The Annotation tab allows control over annotation settings for the major ticks. This tab can also draw a single line at axis zero (checkbox). (Note that the line appears at axis 1 for logarithmic scaling.) The annotation format dropdown has a variety of format options and the GUI provides time formats when the axis is time. The user can also choose to annotate the first and/or the last tick ('Annotate first'/'Annotate last'). (Note that the first/last tick often coincides with the edges of the plot box.) Annotation options for numerical data include auto formatting, decimal notation, and scientific. The default is auto-format. Check 'Show Date' to show the date (in the lower left corner of the panel region) and control its format. Check 'Annotate Along Axis' to control the placement (top or bottom x-axis), frequency, orientation, font, font size, and color of the x-axis annotations. Figure 6.6.9.d shows the X Axis options annotation tab.

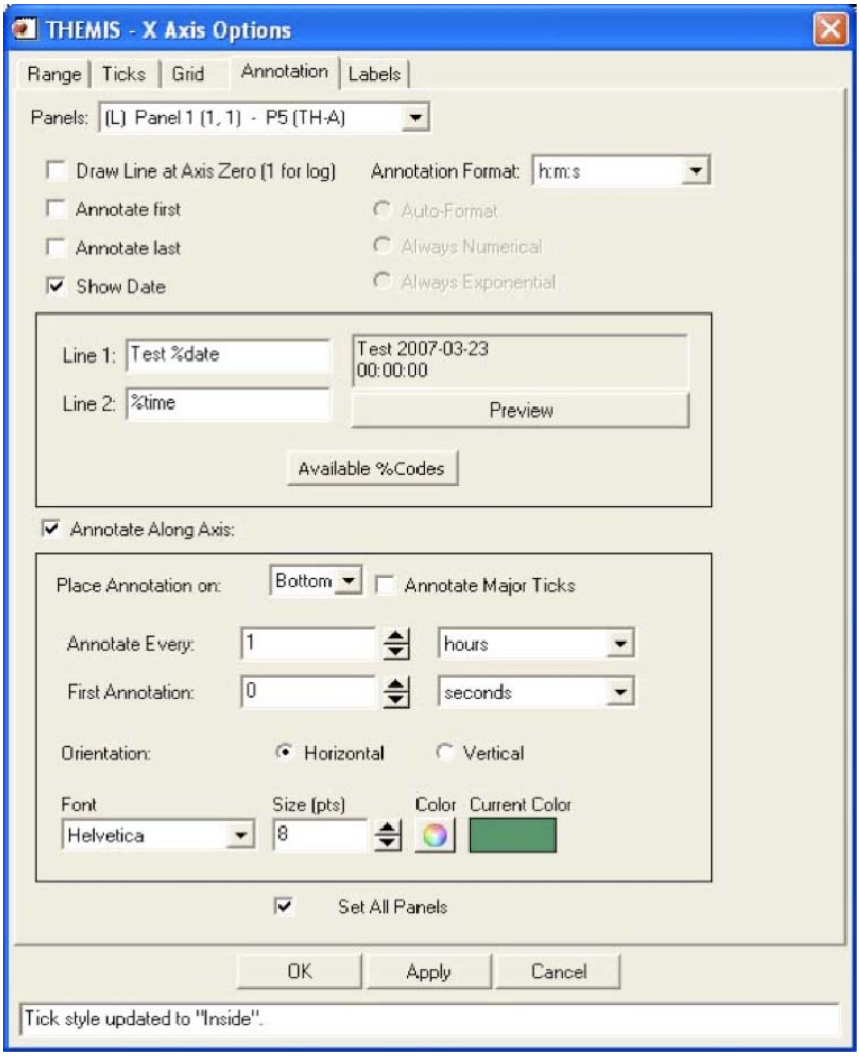


Figure 6.6.9d

Other annotation options include where to place the annotations, orientation, font type, size and color. Annotation precision, by default, will be calculated automatically. The user can specify numerical or exponential format by clicking in the radio buttons directly below the annotation Figure 6.6.9.d1 below shows the list of codes that are available for adding to text lines 1 and 2.

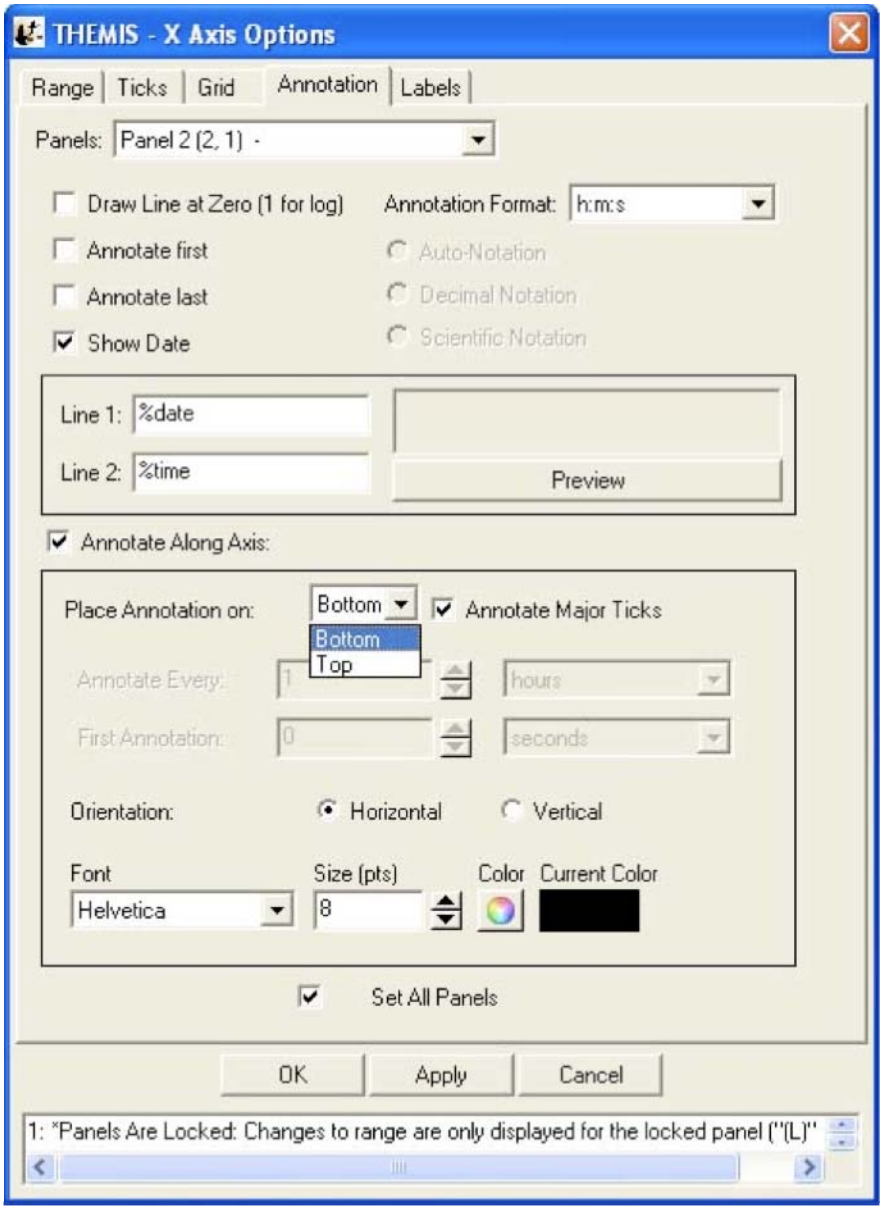


Figure 6.6.9d1

The Labels tab controls whether the labels are shown and/or stacked. Check both 'Show Labels' and 'Show Label' to display a label. The Style frame sets orientation and margin (globally to the given axis and panel), and font, format, font size, and color (for individual labels). The Labels Tab on the X/Y Axis Options window is shown below in Figure 6.6.9e

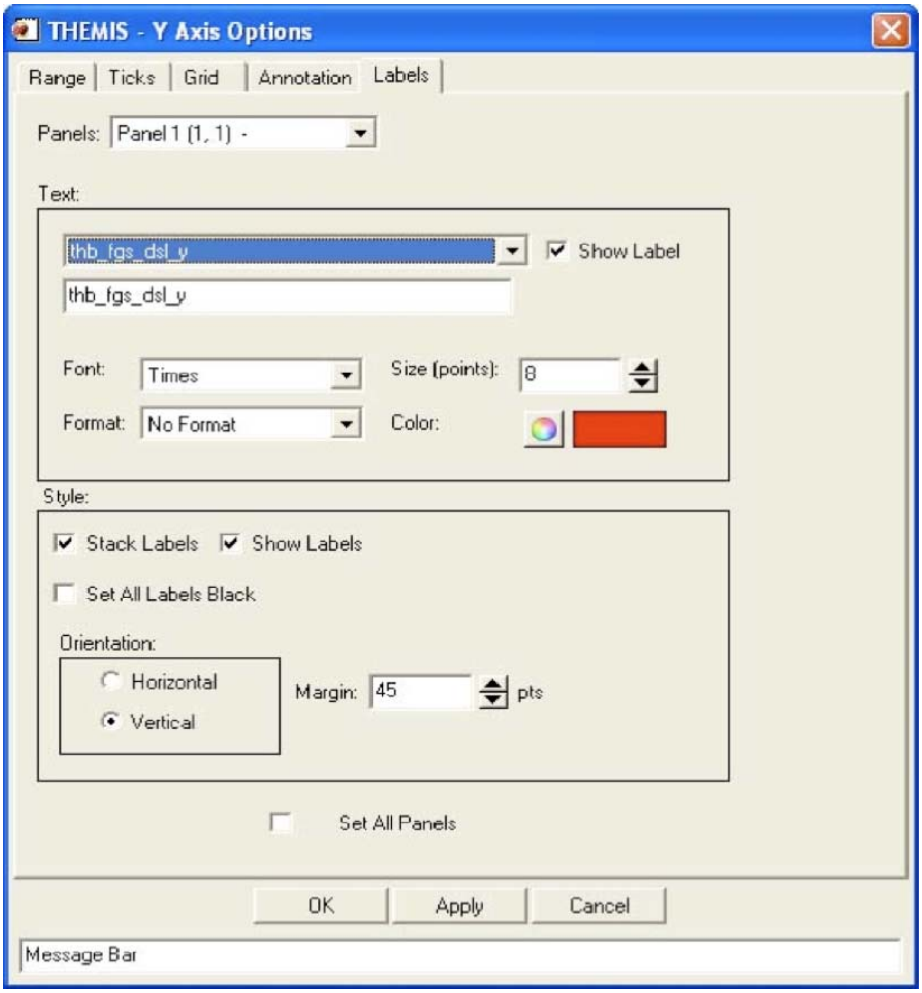


Figure 6.6.9e

The Y-Axis Options window has an additional feature that the X-Axis Options does not. The user can choose to set all Labels to black. By default the line color and label color are synced on the y axis, the Set All Labels Black allows the user to override the default colors. This can be useful in printing publication plots.

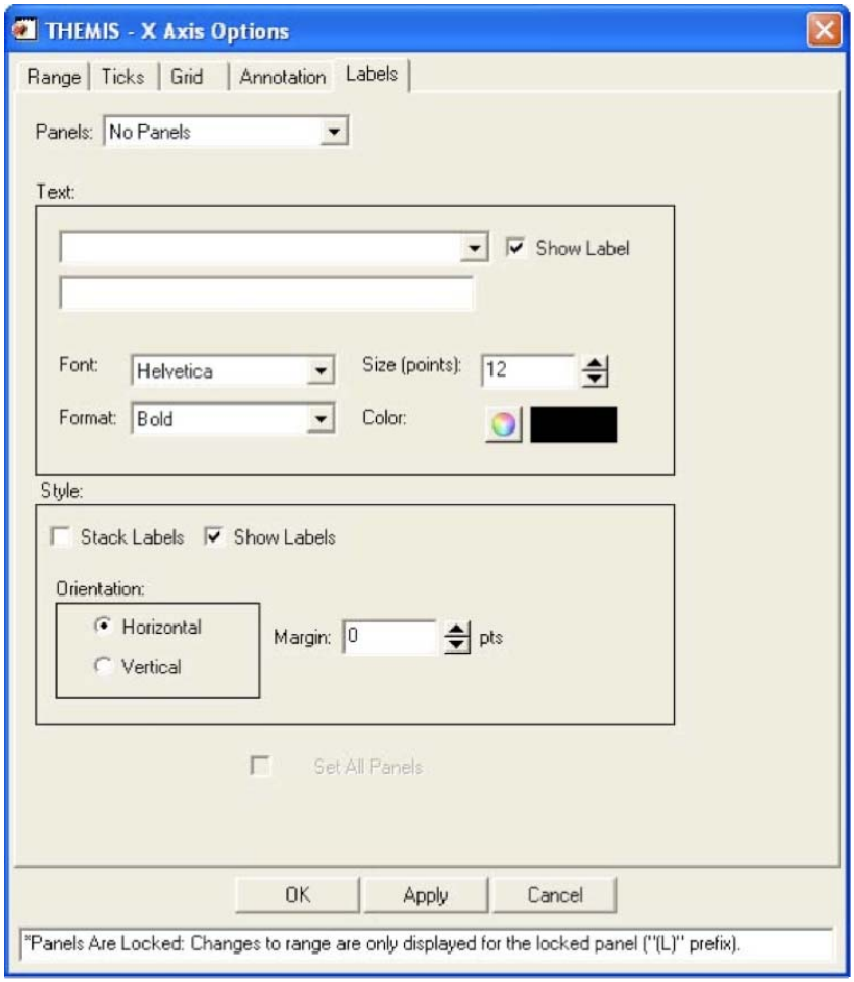


Figure 6.6.8f

6.6.10 Z Axis Options

The THEMIS GUI allows graphing of three-dimensional spectral quantities from the spacecraft as well as ground-based keograms. See the Section 6.6.5 Plot/Layout Options for details on graphing spectra. The second panel in Figure 6.6.10a shows an example of spectral data.

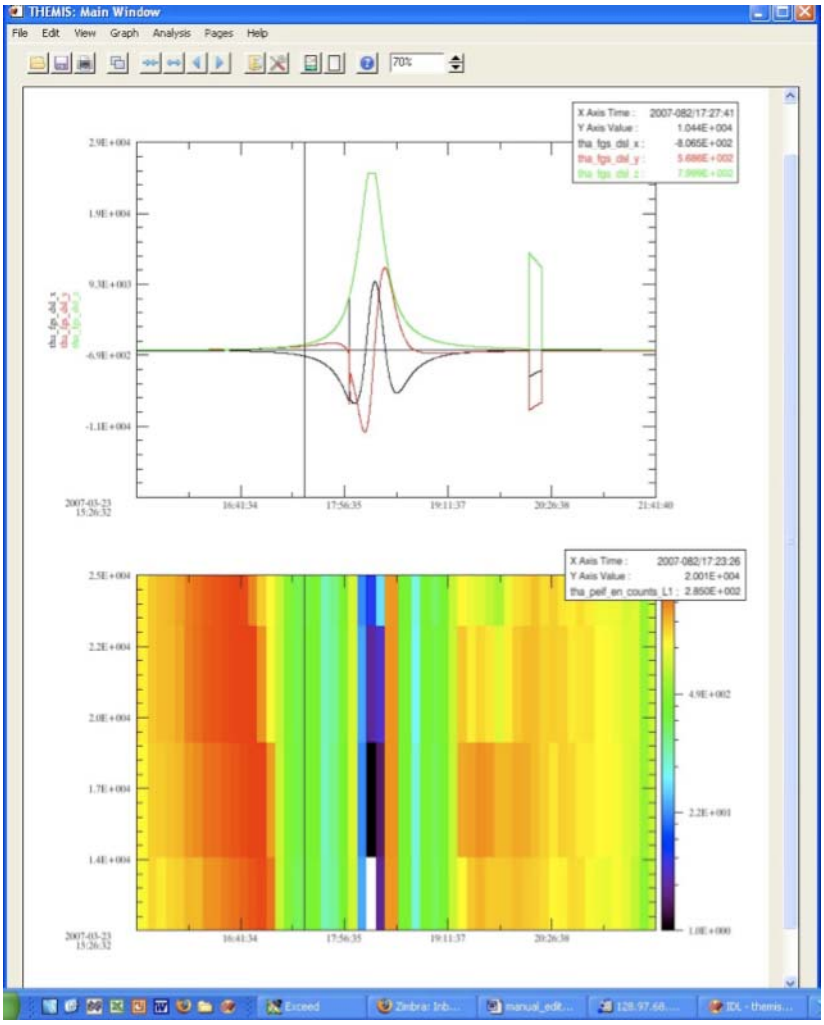


Figure 6.6.10a

Once spectral plots are created their extra display features and parameters can be edited in the Z Axis Options found under the Graph pull down menu in the main window. Options for the X and Y-axes are still functional and can also be found under the Graph pull down menu.

Settings:

The Settings tab (figure 6.6.10b) contains display and annotation options. The Panels drop list contains all plots in the active page that have z-axes.

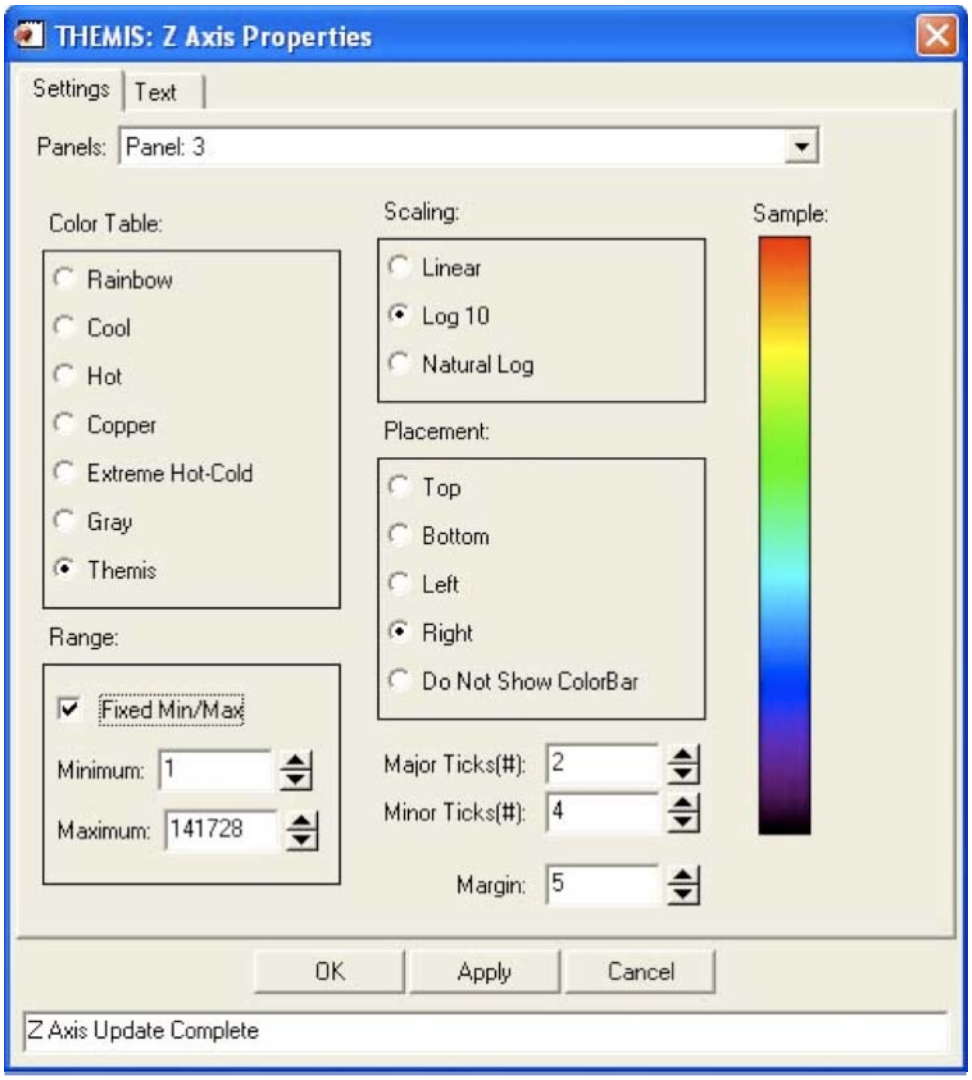


Figure 6.6.10b

Color Table: The color table section allows the user to change the color scheme being mapped to z-axis values on the active panel. A preview of the current selection can be seen on the right. The color bar represents numerical values in decreasing order from top to bottom. Colors are mapped to numerical values according to the chosen Scaling.

Scaling: Determines how the selected Color Table is mapped to z-axis values. Values within the range are assigned linearly by default but can be assigned according to a base-ten or natural logarithmic scale.

Placement: Sets the position of the Color Bar (see fig. 6.6.10a). The Color Bar displays the color scheme of the associated panel plus numeric annotations for scaling.

Number Ticks: The number of "ticks" (i.e. scaling annotations) that are displayed along the Color Bar. Ticks will only be displayed if the Color Bar is present.

Margin: The distance, in number of pixels, between the plot area and the Color Bar.

Range: The z-axis range is automatically calculated by default and the color table is mapped with the selected scaling. Checking the Fixed Min/Max box allows the user to specify the maximum and minimum values for the plot. Values above or below the limits are respectively assigned the color corresponding to the maximum or minimum value.

Text:

The text tab (figure 6.6.10c) contains options for formatting z-axis annotations and adding/formatting z-axis labels. The Panels drop list contains all plots in the active page that have z-axes.

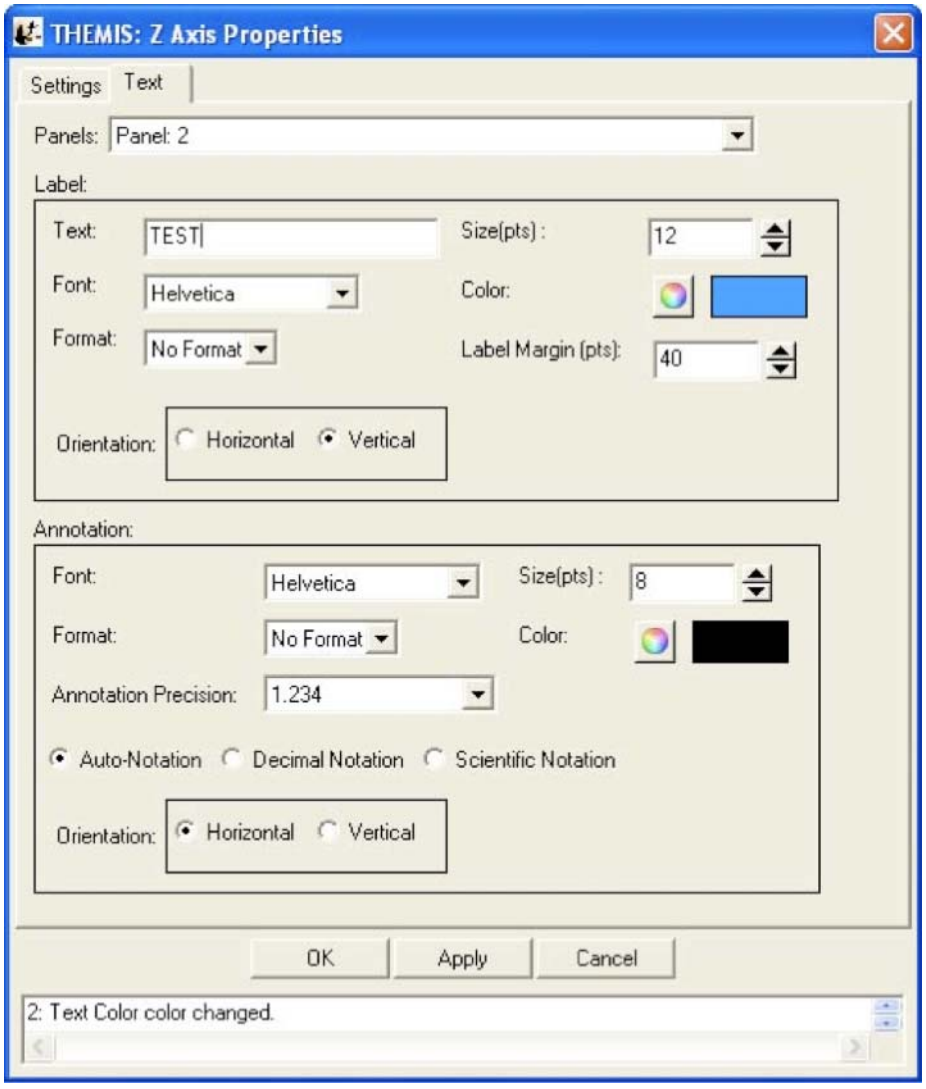


Figure 6.6.10c

Label

Text: Enter text here to create a label for the Color Bar.

Font: Select the font for the text entered into the Text box to be displayed in.

Format: Select formatting options for Label text such as bold and italic.

Size: The font size for the Label text.

Color: The color button will open the color palette for selecting the color of the Label text.

Label Margin: The label margin spinner sets the size of the margin before the Label. Margin values are in points.

Orientation: Labels can be drawn horizontally or vertically.

Annotation

The annotation section allows the user to set the same parameters as Labels with the exception of entering text and setting annotation margins. Annotation precision, by default, will be calculated automatically. The user can specify numerical or exponential format by clicking in the radio buttons directly below the annotation

6.6.11 Variable Options

The Variable Options window (see Figure 6.6.11a below) lets the user add variables beneath the selected panel. To get Variable Options, select it from the Graph pull down menu. Accepting and canceling changes: Clicking OK accepts the changes and refreshes the page. Clicking Cancel rejects any changes. Dismissing the window via the operating system ('X' button) has the same effect as clicking Cancel. An Apply button to accept changes provisionally will be available in a later release. Figure 6.6.11a shows an example of the Variable Options window.

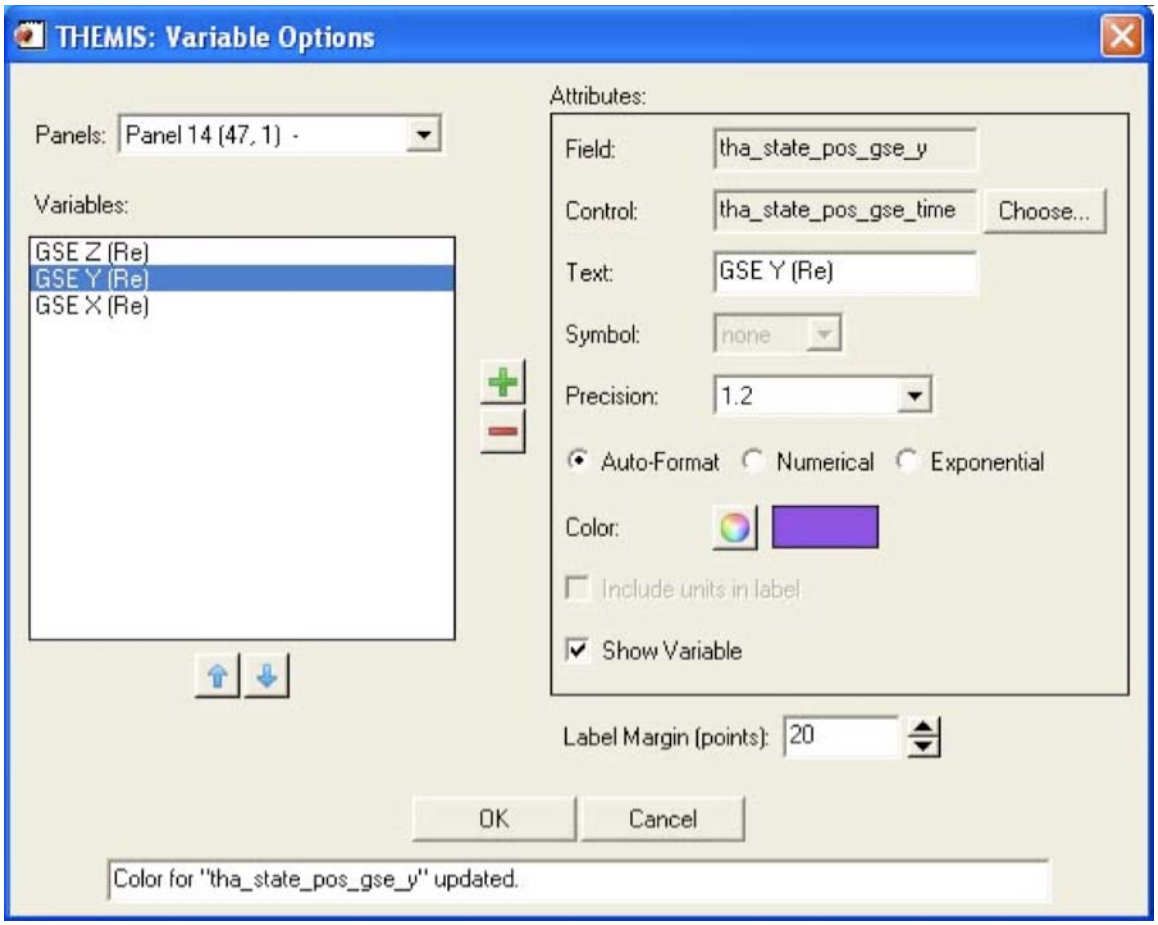


Figure 6.6.11a

The Attributes frame: The Field attribute shows the proper data name of the variable and never changes. The Control attribute shows which data name represents the abscissa for the variable. By default, the GUI sets the control to the time data for the Field. The Text attribute changes the name of the variable as displayed in the Variables frame on the left and on the plotted panel. The Precision attribute sets the format of the variable annotations (time formats for time variables, floating formats for numeric variables). Precision, by default, is calculated automatically, however, the user can choose to override the default settings by selecting either the numerical or exponential radio buttons. The color attributes set the color of the selected variable. The 'Include units in label' check box currently has no effect. Use the 'Show Variable' check box to show or hide a variable on the plot. Status information on the window operations appears in the status bar at the bottom of the window.

To add variables, click the add button ('+'). The 'Add Variable(s)' dialog appears with a tree view of the loaded data. Select individual data products, or entire branches. Shift-click or ctrl-click to select ranges or elements. Click OK to accept the selections, or Cancel to start over. Any selections now appear in the Variables frame on the left. Click OK to accept and have these variables appear below the current panel, or Cancel to exit Variable Options with no changes. The user may also select a variable (click on it) to change its attributes (see the Attributes frame on the right), to delete it ('-' button), or to change its position in the list (up and down arrows). The Label Margin (below Attributes) changes the margin between all variables (for the selected panel) and the left y-axis of the plot box, and also changes the margin between the variable legend and the right y-axis of the plot box. An example of the Add Variable window is shown below in Figure 6.6.11b.

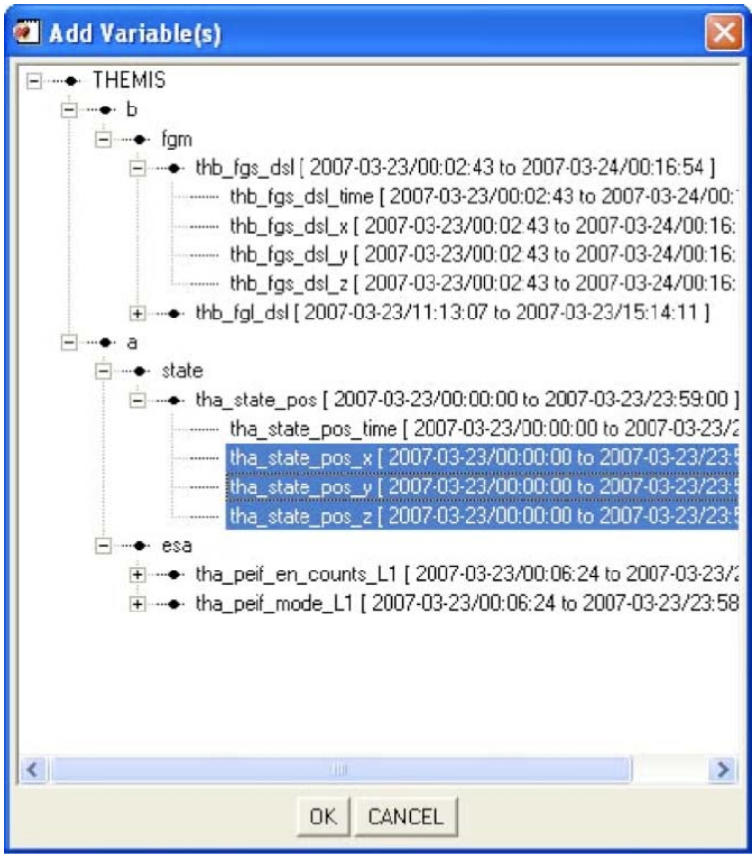


Figure 6.6.11b

A note on locking axes: The GUI hides all variables except those on the last panel when 'Lock X-Axes' is checked (see Plot/Layout Options on the Graph pull down menu). ***This behavior may be modified in later versions.***

6.7 Analysis Menu

The Analysis pull down menu contains selections that allow you to perform various functions on data. Figure 6.7 shows the Analysis Menu options.

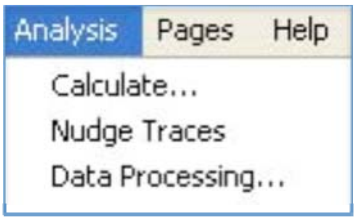


Figure 6.7

6.7.1 Calculate

The Calculate Window allows you to access a built in language that will perform simple vector operations on GUI data. The Syntax of the language itself is described in section 5 of the manual. Commands for the language can be typed into the text box on the left. Each line will be treated as a separate line. If you want to insert a particular data quantity, just select the quantity from the menu at the right and the quantity will be added to the program text box. You can also insert variables that store the values of numerical constants by selecting them from the drop list in the lower right corner of the window. On the far right side of the window, are drop lists containing common ideal functions and operators. By clicking on an item in the drop list, the function or operator will be inserted into the text box at the last position of the cursor.

Rather than typing your commands in the GUI you can also type a GUI program in a plain text file and load it into the GUI by selecting the 'Open' button at the bottom. If you want to save the program that you currently have in the text box, select the 'Save' button at the bottom of the window.

When you are ready to run the program, select the 'Run' button at the bottom and the Calculate program will be executed. Any quantities that are created will be automatically loaded into the GUI, but if they are much different from the quantities that they came from you may want to double check their meta-data in the manage data menu.

To exit this window, click on the 'X' in the upper right hand corner of the window or the 'OK' button at the bottom of the window. The Calculate window is shown in Figure 6.7.1.

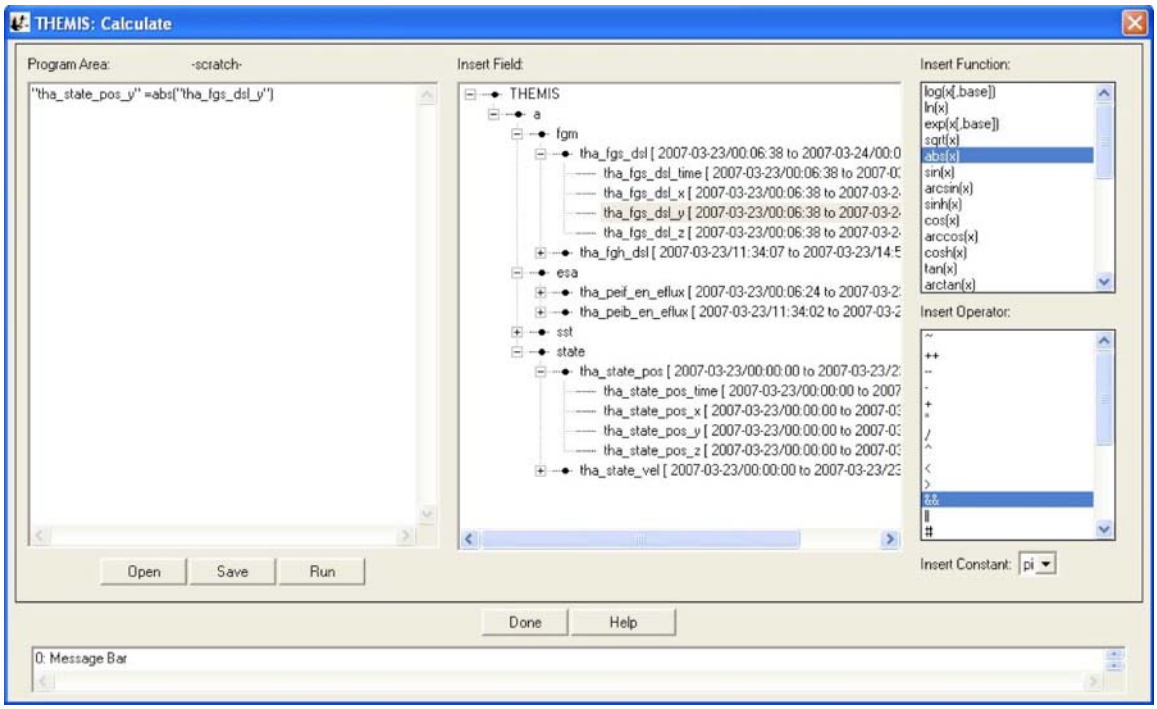


Figure 6.7.1

6.7.2 Nudge

The Nudge Traces option allows the user to "nudge" a trace on a line plot. "Nudging" simply shifts the given trace by a specified amount of time. To activate, select "Nudge Traces" from the "Analysis" pull-down menu on the Main GUI. Note that you need to have created a page and panel and plotted some data before anything will happen when you make this selection. If there has been data plotted, then a window will pop up, allowing you to select the panel, and trace that will be nudged. An example of this window is shown below. There are two drop-down menus that allow you to select the panel and trace that will be nudged. For the current selection, panel 1 is selected, and the trace "tha_state_pos_x" is selected. The units (time units or records) are selected on the right side of the panel; in the example the shift will be given in hours. The number of hours (or minutes, or seconds, etc…) can be selected in the window below the trace selection window. Note that you can type a value into this window as well as use the arrows on the side to scroll values.

When the "Apply" button is clicked, the trace is shifted. This is accomplished by creation of a new variable. The amount of the shift is recorded in the variable name to avoid confusion, to allow for easy recovery of the original values, and to allow a nudged variable to be plotted along with the original. In this example, the new variable name is "tha_state_pos_x_3_hr" and is shown on the panel where the nudged trace is plotted.

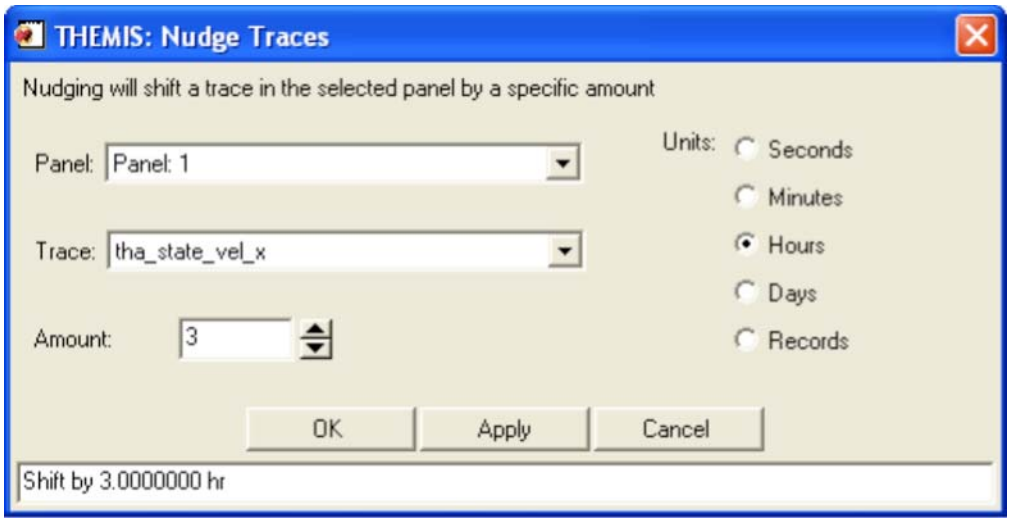


Figure 6.7.2

Warning: Note that traces are shifted one at a time. If you are attempting to nudge a spectrogram (e.g, THEMIS ESA or SST flux spectrograms, or ASK All Sky Keograms) then you may get unpredictable results when the plot shows up.

6.7.3 Data Processing

When you click on "Data Processing…" on the Analysis pull-down menu on the Main GUI, a window pops up that allows you certain data processing tasks.

This window is shown below. On the left side is a window that shows the data that has been loaded. You can click on each variable in this window, and set it to "active" by clicking on the right arrow button in between windows. This process works both ways; you can set data to "inactive" by clicking on it in the right-hand window and clicking the left arrow button in the middle. You also have the option to clear the active data by clicking the "Clear Active" button. Data processing tasks are only possible when there is "active" data.

In this window, the "active" data set is "tha_fgh". Any data processing task will affect these data only. Note that it is not possible to select individual traces for data processing; the full variable is processed.

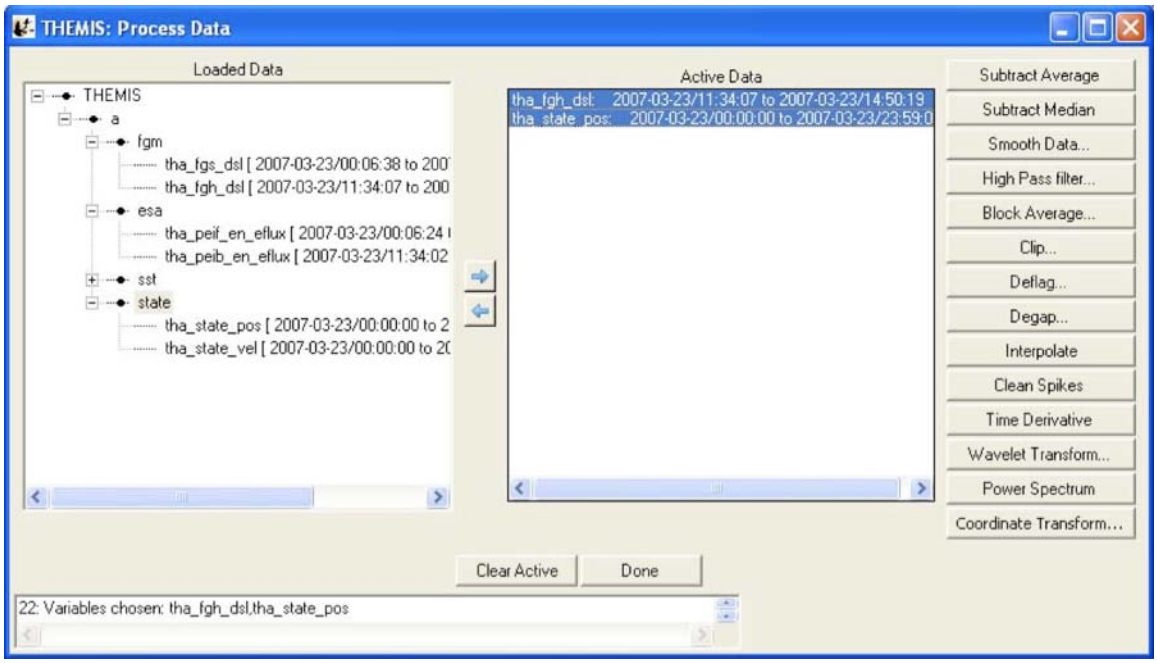


Figure 6.7.3

A data processing task will change the active data set to be the data that has been just been created, so once a task is finished this variable will show up in the right-hand window, and also it will be added to the loaded data tree on the left. Clicking the “Done” button closes the window.

6.7.3.1 Subtract Average

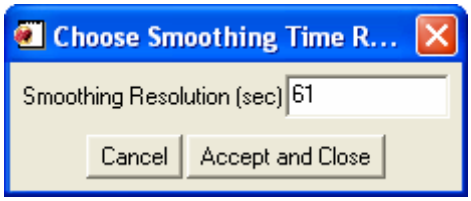
For each active data set, the average value is subtracted. new variables are created, the new names have the syntax: new_var = old_var+"-d", and the new variables become the active data sets`. Note the change in both windows in the figure below, the new variable has been added and set to active.

6.7.3.2 Subtract Median

For each active data set, the median value is subtracted. new variables are created, the new names have the syntax: new_var = old_var+"-m", and the new variables become the active data sets.

6.7.3.3 Smooth Data

This process performs boxcar smoothing of the data. A widget will pop up, asking for the size of the time interval to smooth over. Choose a value, and click on "Accept and Close". The default is 61 seconds. New variables will be created, with "_sm_dt" appended to the old variable names, where dt is the smoothing resolution. Click “Cancel” to cancel the operation.

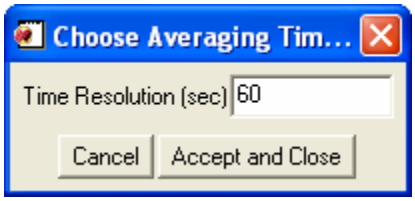


6.7.3.4 High Pass Filter

Click this button to apply a high-pass filter to the data; a window will pop up asking for the time resolution for the smoothed data that will be subtracted from the original data to apply the filter.

6.7.3.5 Block Average

Click this button to average that data over time; a window will pop up, asking for the time resolution. The default time resolution is 60 seconds. New variables will be created, with "_av_dt" appended to the old variable names, where "dt" is the time resolution. Click “Cancel” to cancel the operation.

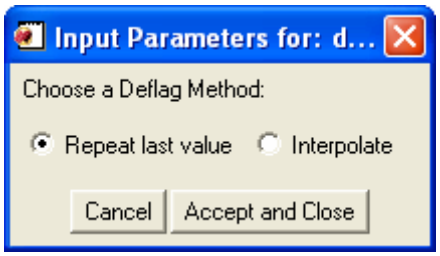


6.7.3.5 Clip

Clips data above and below a set maximum and minimum, a widget pops up which allows these values to be set. Then data outside the range is set to NaN. New variables will be created, with "_clip" appended to the old variable names. Click “Cancel” to cancel the operation.

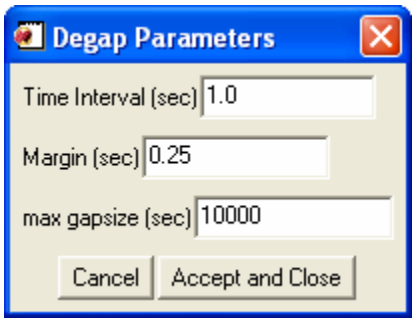
6.7.3.6 Deflag

Interpolates or repeats the most recent valid data value over gaps in the data (gaps are denoted by NaNs, and can be created by the clipping process; a “deflag” often happens after NaN values are inserted by a “clip” operation). A window pops up which is used to set the method, there are two choices: "repeat" will repeat the last good value over the gap; "linear" will interpolate over gaps. New variables will be created, with "_deflag" appended to the old variable names. Click “Cancel” to cancel the operation.



6.7.3.7 Degap

The degap procedure locates gaps in data, and fills them in with 'NaN' values, so that the plotting process displays the data gaps correctly (Otherwise it simply draws a line across the gap). It figures out where to add data points by checking which time differences are greater than or equal to an input time interval, plus a margin, and inserts equally spaced 'NaN' data points at time intervals with spacing determined by the size of the data gap divided by the number of points that fit with minimum cumulative error. Click “Cancel” to cancel the operation.



6.7.3.8 Clean Spikes

This process removes large single point spikes from messy data. New variables are created, with "_dspk" appended to the old variables.

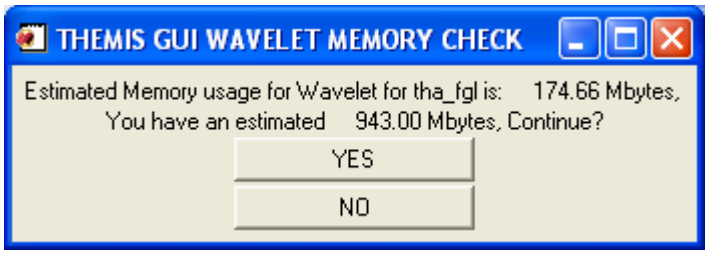
6.7.3.9 Time Derivative

This process takes the time derivative of the active data sets. New variables are created, with "_d" appended to the original variable names.

6.7.3.10 Wavelet Transform

The data is split into components, and a basic wavelet transform is performed on each component, with "_wv" appended to the old variable names. (Note that this is designed for data that are either electric or magnetic field data type. Applying this to other data (e.g., spectrograms) will cause non-intuitive results.)

Since this process can be very memory-intensive, the user is first asked to specify a time range. A window allows the user to input start and end times.



Note the values shown here are rough estimates of the available memory and estimated memory usage. If they are close, then it is advisable to click the “NO” button. The process will continue if the “YES” button is pushed. Typical machines have 1 to 2 G-bytes of memory as of this writing (Feb-2009), but if there has been data loaded the available memory may be less. For Window PCs IDL may be limited to 2 GB or less.

6.7.3.12 Power Spectrum

When the Power Spectra button is clicked a new window will be opened containing power spectral parameters that the user can manipulate. The user can choose between dynamic or time power spectra, and select window size and shift, time range and how the data is to be binned. The data is split into components, and a power spectrum is obtained from each component. Appended to the original variable names are "_dpwrspc " or "_tpwrspc" depending on the type of power spectra the user selected. Note that this is designed for data that are either electric or magnetic field data type. Applying this to other data (e.g., spectrograms) will cause non-intuitive results.

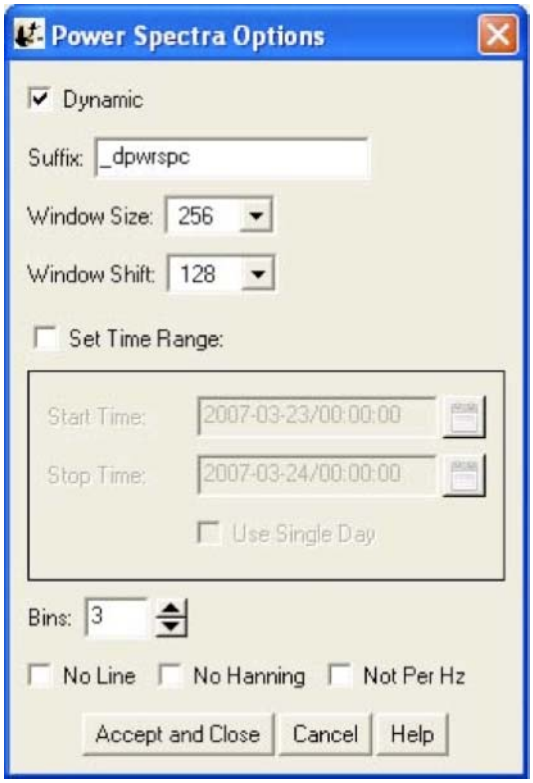


Figure 6.7.3.12

6.7.3.13 Coordinate Transform

When the "Coordinate Transform" button is clicked, a dropdown menu appears with different choices for coordinate transforms. Each possible output coordinate system has a button. The possibilities are: "SPG" (Spacecraft Probe Coordinates), "SSL" (Spinning Spacecraft Coordinates), "DSL" (Despun Spacecraft Coordinates), "GSE" (Geocentric Solar Ecliptic), "GSM" (Geocentric Solar Magnetospheric), "GEI" (Geocentric Earth Inertial), and “SM” (Solar Magnetic).

Only the active data sets are transformed. The input coordinate systems for the active data sets are automatically obtained. Data with "Unknown" coordinates and ground-based data will not be transformed. Note that state data for the appropriate THEMIS probe is necessary for the coordinate transform to occur. If it is not present, then a pop-up will alert the user, and give the option to load the state data.

Click on the "Transform" button to perform the transformation. Warnings and error messages will appear in the text window at the bottom, and also in the progress window on the main widget. Click on the "Close" button to dismiss the popup.

6.7.3.14 Interpolate

Selecting the interpolate button opens a window containing interpolation options. This function uses the standard IDL interpolate routines. Besides manipulating the interpolation parameters the user can also limit the time range and specify the suffix for the new variable name. Clicking the OK button run the interpolate function on any variables that are in the Active Data area on the Data Processing window.

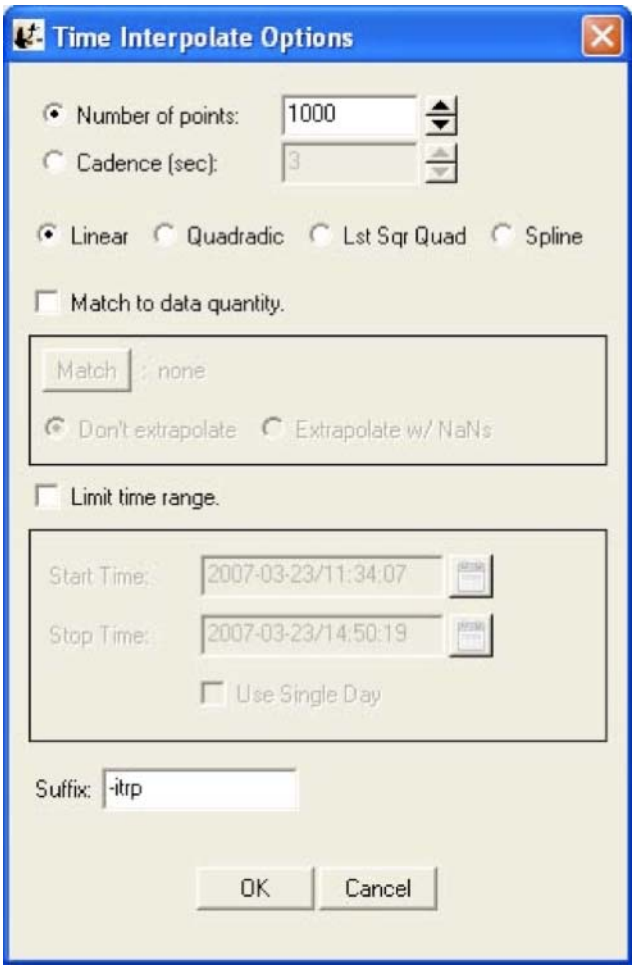


Figure 6.7.3.14

6.8 Page Menu

The Page pull down menu contains options to open, close and toggle between pages. The Page menu options are shown below in Figure 6.8.

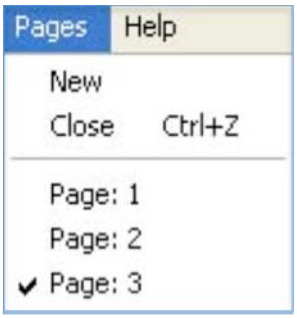


Figure 6.8

6.8.1 New

The New option under the Page pull down menu will open a new page. The new page will be blank since no data or panels have been selected. Figure 6.8.1 shows an example of a new page. In addition, the new page will be added to the Page pull down menus. To create new panels on this page select the Plot icon button on the tool bar or the Plot/Layout option under the Graph menu.

6.8.2 Close

The THEMIS GUI allows the user to have multiple pages. If you wish to close a page there are several ways this can be done. The first is using the Page pull down menu and selecting the Close option. The currently displayed page, or the 'active' page will be closed. Other pages will still be available. The main graph area will redraw the first page in the list, unless there are no more pages, in which case a blank graph area will be drawn. In addition, the Page pull down menu dynamic options will be updated and renumbered to reflect the change.

Besides the file pull down menu, you can also type Ctrl-Z or select the Close option under the File pull down menu.

It should be noted that once a page is closed the settings that were associated with that page will be lost, unless you requested Save THEMIS Document under the File pull down menu before you closed the page. The data that was plotted in the page still remain are available for analysis and plotting. Only the plot settings are deleted.

6.8.3 Pages

The lower portion of the Pages pull down menu contains dynamic menu items and is dependent on the number of pages that have been created. Figure 6.8 above, shows an example of the pull down menu with three pages. Each of the dynamic menu items are checked menus. Only one page can be checked or displayed at a time, since only one page can be displayed at a time. The user can toggle between pages by simply clicking the page they wish to view. When new pages are created a new menu items is added to the list. Likewise, when pages are closed, the menu items are renumbered to reflect the new page count. If all pages have been closed, the last page (page one) will be cleared, however it will remain as a blank page. Similarly, when the GUI is initialized there a blank page is already created.

6.9 Help Menu

The user can view a text version of this document or create a help request form. Figure 6.9 shows the Help pull down menu options.

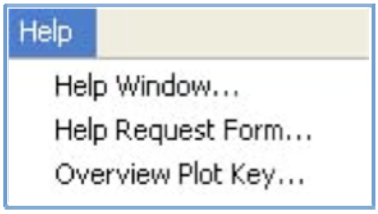


Figure 6.9

6.9.1 Help Window

Clicking on the Help menu and selecting Help Window… will open a dialog box that will provide you with the URL for the online User's Guide document. Figure 6.9.1 shows the help dialog window.

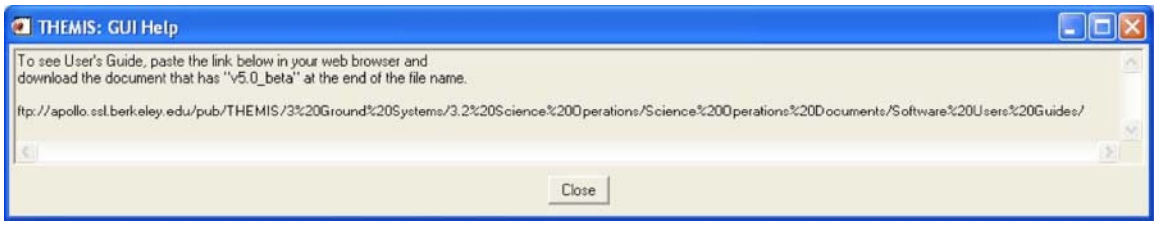


Figure 6.9.1

6.9.2 Help Request Form

When this button is clicked, a text window pops up displaying the THEMIS Science Help Request Form. This allows the user to input information about the error which has occurred. There is a save button, which saves the help request form in a file. In addition to the request form a History file will be save containing History window and journaling messages. You will be informed where both files are located. Both files should be emailed to THEMIS_Science_Support@ssl.berkeley.edu. Click the Close button to dismiss this widget.

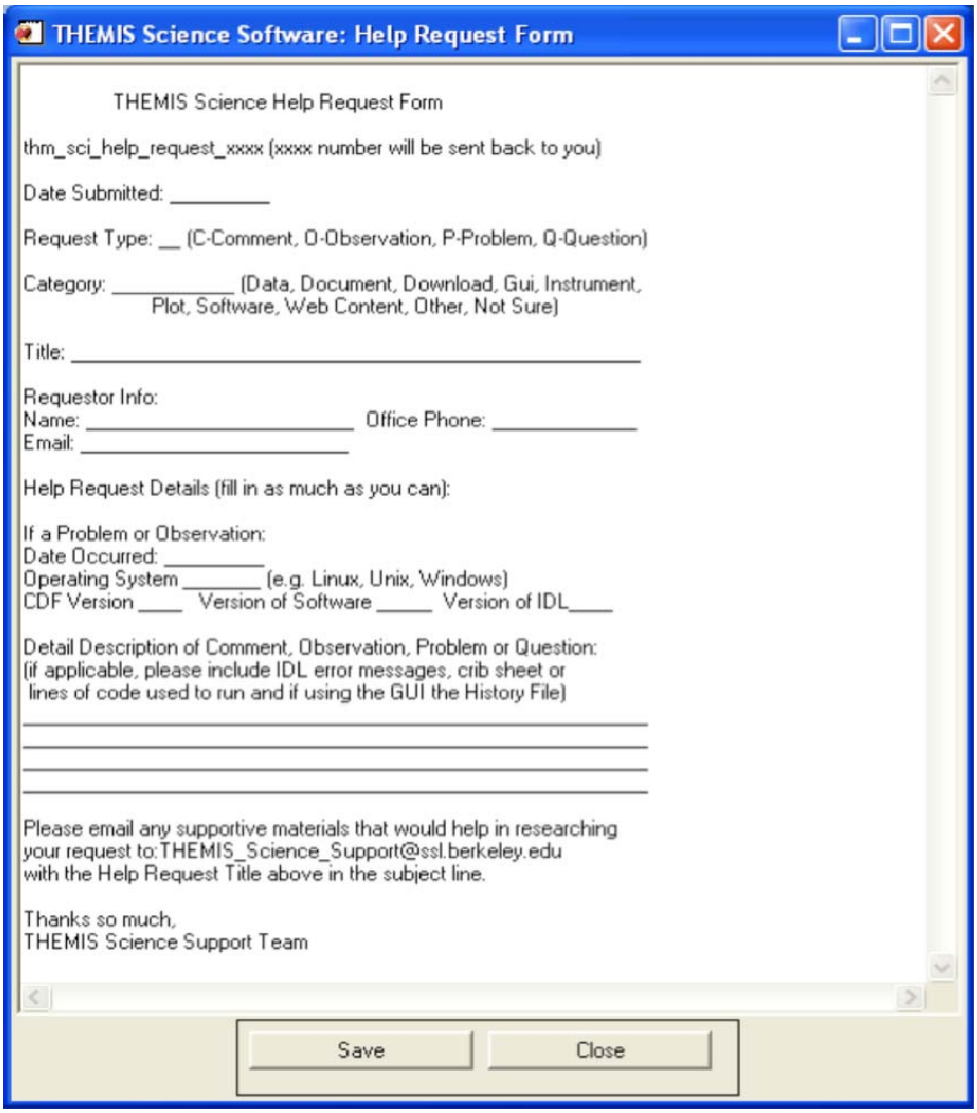


Figure 6.9.2

6.9.3 Overview Plot Key…

When the Overview Plot Key menu item is selected a window will open with an example of the overview plots. Each panel contains a legend or key describing the data that is plotted. This is a sample window only and does not contain current data. It sole purpose is to define for the user the data that is drawn in the overview window.

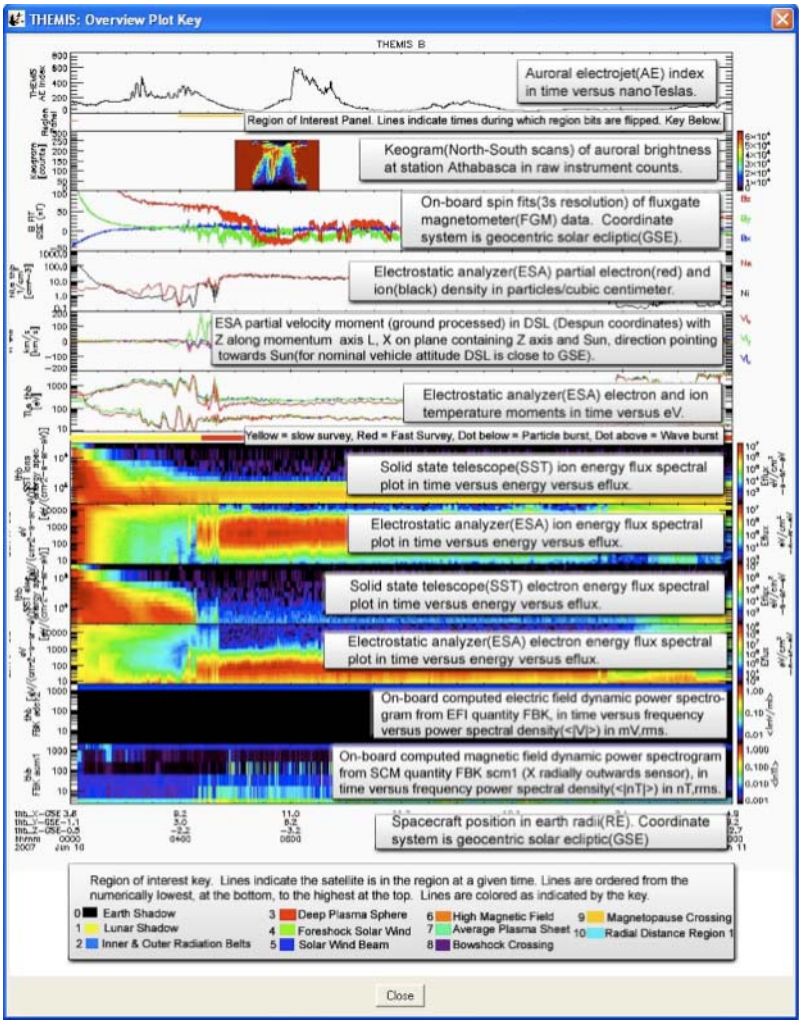


Figure 6.9.3

6.10 TPLOT

6.10.1 Import / Export

The GUI maintains an internal representation of the data for its own use. Data loaded into the GUI directly use the thm_load_data routines available in the software distribution. Tplot variables created at the command line can be imported into the GUI for internal use, or exported from the GUI for command line use. The Load THEMIS Data and Manage Data Import/Export Tplot items under the File pull down menu provide options to manage the data. See Sections 6.3.5 and 6.3.7 for further details.

6.10.2 tplot_gui

In addition to importing and exporting tplot variables the user can also plot variables from the command line for display within the GUI. Tplot_gui works in the same way that tplot works, however, tplot_gui will display the plot on a new page in the GUI graph area. Tplot used in the original way will display the plot in a new window that is external to the GUI. For example, at the IDL command line you can type the following:

IDL> tplot_gui, 'tha_fgl_dsl'

Before drawing the plot, the Verify Data panel will be opened. In order for the GUI to use tplot data it requires the variable be imported. The Verify Data panel simply allows you to check the validity of the tplot meta data. See Section 6.3.7 for details on managing, importing, and exporting data. Figure 6.10.2a shows an example of the Verify Data window.

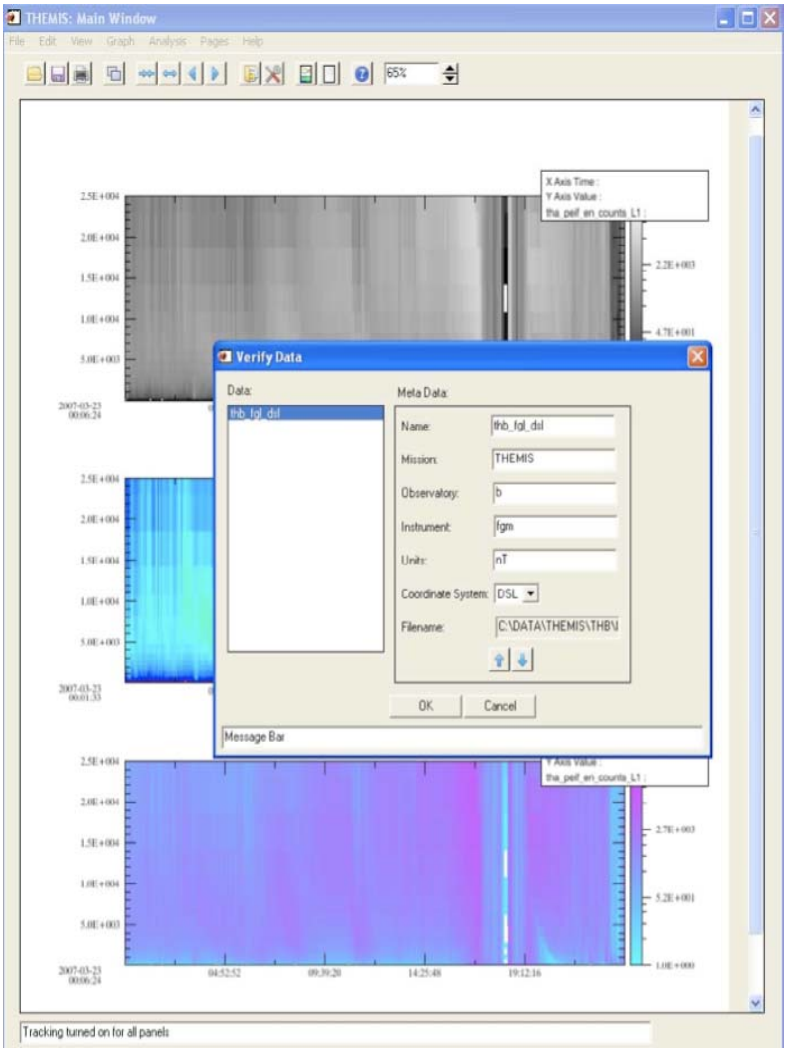


Figure 6.10.2a

Once you accept the meta-data values and click the OK button a new page and plot will be created. Figure 6.10.2b shows the new plot.

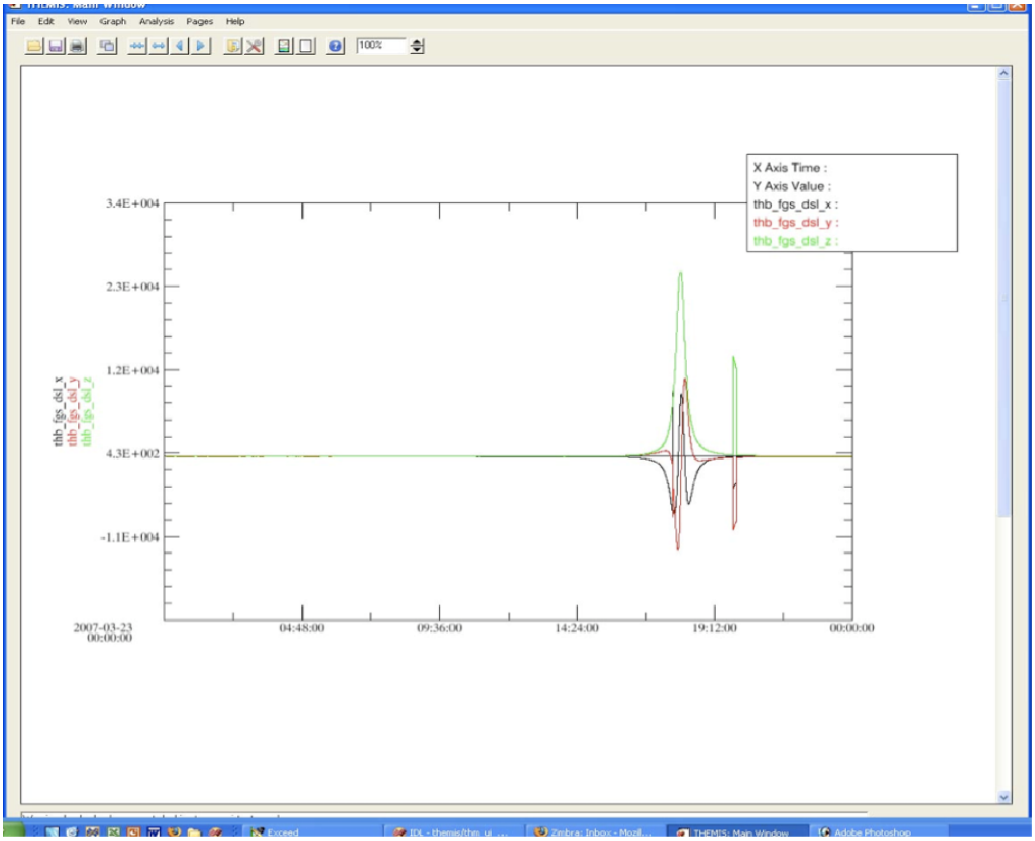


Figure 6.10.2b

Because the default plot mode of the GUI is linear, spectral data will be drawn in linear mode. You can switch to spectral mode by using the Plot/Layout Options under the Graph pull down menu, or by clicking the graph icon button on the toolbar.

No changes have been made to the tplot procedure and it functions as it always has. An example of the IDL command line and resulting plot are show below in Figure 6.10.2c

IDL> tplot, 'tha_gfl_dsl'

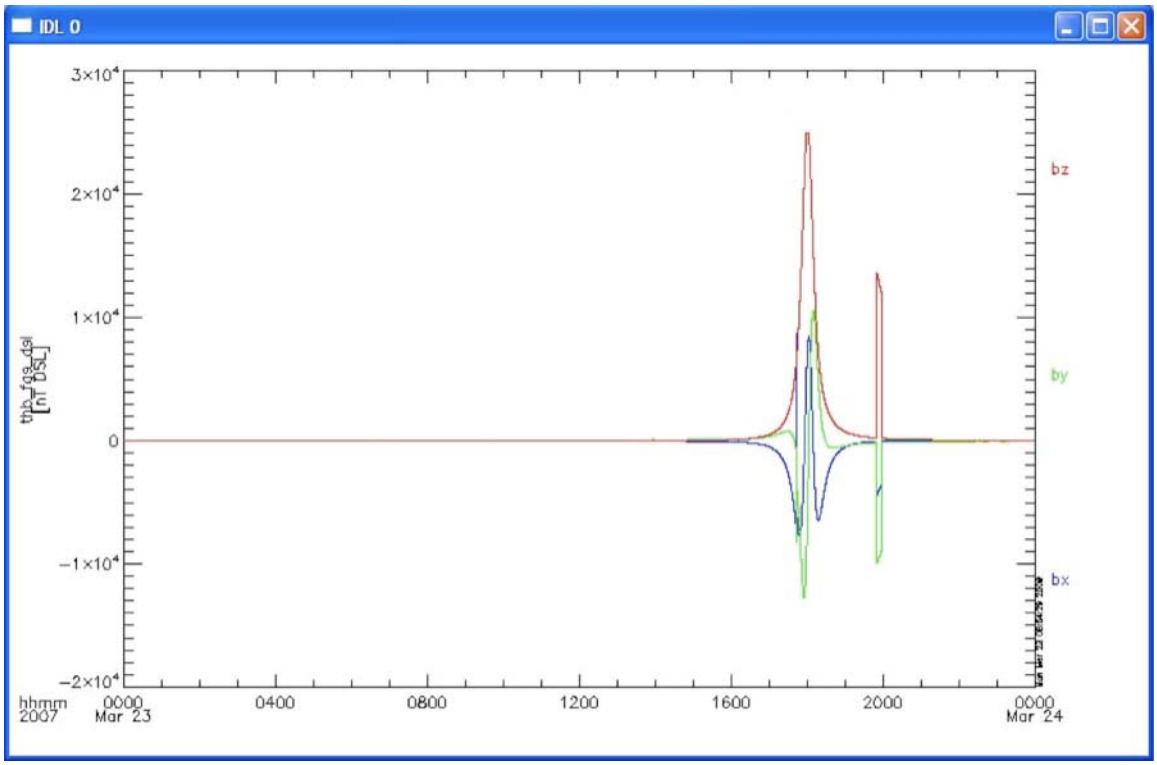


Figure 6.10.2c

6.11 Platform Dependencies

6.11.1 Linux

Printing only works in black and white.