Science Software – v5.00 Training

GEM Mini-Workshop

December, 2008
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<th>Topic</th>
<th>Presenter</th>
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<td>Introduction</td>
<td>D. King</td>
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<td>01:05</td>
<td>THEMIS Web Site</td>
<td>D. King</td>
</tr>
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<td>01:15</td>
<td>V5.00 Science Software/Data Status Report</td>
<td>J. McTiernan, J. Lewis</td>
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<td>01:25</td>
<td>THEMIS Science Data Analysis Software</td>
<td>J. McTiernan / B. Kerr</td>
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<td>P. Cruce</td>
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<td>C. Goethel</td>
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<td>J. McTiernan</td>
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<td>03:00</td>
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<td>All</td>
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V5.00 Science Software/Data Status Report

• General
  – Loads, introduces and calibrates all L1 quantities, all instruments
  – Loads calibrated L2 quantities

• STATE
  – L1 STATE available since launch, L2 STATE in progress

• FGM
  – L1, L2 data available since early March 2007

• FIT / FFT / FBK
  – L1, L2 data available since early March 2007

• SCM
  – L1 data available since early March 2007
  – L2 frequency spectrograms (FBK) available now

• EFI
  – All L1 data available from TH-C since May 2007, TH-D,E since Jun 7

• ESA
  – No L1 data, only L0 data – however, read-in is transparent to user
  – All data available since ESA turn-on, i.e., mid-March
  – L2 omnidirectional energy spectrograms, ground moments available now

• SST
  – L1 data available since SST turn-on, mid-March
  – L2 omnidirectional energy spectrograms available now

• ASI
  – L1 thumbnail images from 21 stations available. L1 full-resolution images available up to late April 2008,
  – Mosaics, movies for full mission

• GMAG
  – L2 cdf files with ground magnetometer data from 41 stations
## THEMIS Data Analysis Software

<table>
<thead>
<tr>
<th>Organization</th>
<th>Contributors</th>
</tr>
</thead>
<tbody>
<tr>
<td>UC Berkeley</td>
<td>D Larson, H Frey, J Bonnell, J McFadden, A Keiling, J McTiernan, J Lewis</td>
</tr>
<tr>
<td>UCLA</td>
<td>V Angelopoulos, P Cruce, B Kerr, C Goethel, M Feuerstein, K Ramer, H Schwarzl</td>
</tr>
<tr>
<td>SP Systems</td>
<td>K Bromund</td>
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<td>NASA/GSFC</td>
<td>V Kondratovich</td>
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<td>MPE</td>
<td>E Georgescu</td>
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<td>TUBS</td>
<td>U Auster</td>
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<tr>
<td>CETP</td>
<td>P Robert, O LeContel</td>
</tr>
<tr>
<td>Calgary</td>
<td>B Jackel, E Donovan</td>
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</tbody>
</table>
Overview

• Software Objectives
  – Powerful, Flexible Command Line Interface
  – GUI to provide Easy Access to Key Features
• Software Installation
• Data Distribution
• Key Routines, crib sheets.
• Examples
Software Objectives

- Code is available to everyone, but not required to analyze data.
- IDL based (library of routines – but no main program!).
- Separates the tasks of:
  - Reading files.
  - Manipulating data
  - Plotting
- Platform independent. Works on:
  - Solaris
  - Linux
  - Windows
  - Mac OS X
- Self-Documenting
  - Auto-generated html help: idl/_tdas_doc.html
  - IDL> DOC_LIBRARY, ‘routine_name’
THEMIS-specific routines (idl/themis)

- Instrument-specific routines organized according to ground/spacecraft/state, fields/particles, instrument name.
  - Loading data
  - Calibrating data
- Transforming data
- Examples – crib sheets
- GUI – built on top of the command-line routines

General routines (idl/ssl_general)

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

External Libraries (idl/external)

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

Windows, Solaris, LINUX, PPC Mac or Intel Mac.

IDL 6.2 or higher required

IDL Patch Recommended

- Required for IDL 6.2, (Strongly recommended for IDL 6.4 and 7.0)
- Required for Intel Mac, regardless of IDL version

For Mac, system configurations are required to run IDL

- X11 – may need to be installed.
- mouse click-through
  - one-time X11 configuration necessary for proper operation:
    defaults write com.apple.x11 wm_click_through -bool true

See THEMIS User's Guide for full information, available at:
ftp://apollo.ssl.berkeley.edu/pub/THEMIS/
Installing/Configuring TDAS

For a new installation:

• Download and expand the latest TDAS release .zip file. The latest version is 4.01. http://themis.ssl.berkeley.edu/socware/tdas_4_01/tdas_4_01.zip
• Create a directory called TDAS into which you will copy the latest software.
• Move the tdas_4_01 folder into the TDAS directory you created.
• Configure IDL to search the TDAS directory for IDL programs. Details on next slide.

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

• Remove old tdas_x_xx from the TDAS directory.
• Download and expand the latest TDAS release .zip file.
• Copy the new tdas_x_xx directory into the pre-existing TDAS directory.
• Re-start IDL.
Path Setup

Set up the IDL path

• Windows and IDLDE on any platform:
  File->Preferences
  Path Tab
  Press Insert
  Browse to find the TDAS folder you created.
  Check the box preceding the path to 'search subdirectories'

• UNIX-like systems (Mac OS X, Linux, Solaris)
  In .cshrc:
  setenv IDL_PATH ‘<IDL_DEFAULT>:+path/to/tdas’
  -Or-
  In .bashrc or .bash_profile:
  export IDL_PATH='<IDL_DEFAULT>:+path/to/tdas'

Path to Data Directory

• Data directory will be created automatically at
  – C:/data/themis (Windows)
  – ~/data/themis (UNIX/LINUX/Max OS X)
• Run thm_ui_config from command line or THEMIS GUI if you need to change this.
The software operates on Level 1 and Level 2 data.

Data Level Definitions:

Level 0 Data –
- Raw files (*.pkt) one per APID.
- Only used for loading ESA data.

Level 1 Data -
- CDF (Common Data Files) files (*.cdf)
- Files contain raw, uncalibrated data. i.e. counts, DAC units.
- Requires TDAS software to interpret. Calibration is done by default when Level 1 data is input.

Level 2 Data -
- CDF files – contain physical quantities – TDAS software is not needed for interpretation.
- Files available for ESA, FBK, FIT, FGM, MOM*, SST – can be downloaded from SPDF. *(except for MOM)
Data / Directory structure

- Data Directory structure is large!
  - Scores of files per day
  - ~3GB/day for all probes (L1 data)

- Directory hierarchy keeps directory sizes manageable
  - Software performs automatic file retrieval.
  - Software maintains directory hierarchy.

- Behaviour of Automatic File Retrieval is configurable
  - ‘No Download’ mode for stand-alone operation.
  - ‘No Update’ mode to preserve local modifications.
  - Root directory of local copy of hierarchy is determined automatically, but configurable.
  - Available configuration methods:
    - thm/ui/config IDL widget
    - Button on THEMIS GUI widget
    - Environment variables
## Primary Routines

### Load Routine Summary

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>L0</th>
<th>L1</th>
<th>L2</th>
</tr>
</thead>
<tbody>
<tr>
<td>thm_load asi</td>
<td>All-Sky Imager</td>
<td>*</td>
<td>-</td>
<td></td>
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<tr>
<td>thm_load ask</td>
<td>All Sky Keogram</td>
<td>*</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>thm_load.efi</td>
<td>Electric Fields Instrument waveforms</td>
<td>*</td>
<td>(*)</td>
<td></td>
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<tr>
<td>thm_load.esa</td>
<td>ElectroStatic Analyzer</td>
<td>*</td>
<td></td>
<td>(*)</td>
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<tr>
<td>thm_load.esa_pkt</td>
<td>ElectroStatic Analyzer</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>thm_load.fbk</td>
<td>Fields Filter Bank</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>thm_load.fft</td>
<td>On-board Fields Fast Fourier Transform.</td>
<td>*</td>
<td>*</td>
<td></td>
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<tr>
<td>thm_load.fgm</td>
<td>Flux Gate Magnetometer waveforms</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>thm_load.fit</td>
<td>On-Board Fields Spin-Fit</td>
<td>*</td>
<td>*</td>
<td></td>
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<tr>
<td>thm_load.gmag</td>
<td>Ground Magnetometer</td>
<td>*</td>
<td></td>
<td>*</td>
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<td>thm_load.hsk</td>
<td>Housekeeping</td>
<td>*</td>
<td></td>
<td></td>
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<tr>
<td>thm_load.mom</td>
<td>On-board Particle Moments</td>
<td>*</td>
<td>(*)</td>
<td></td>
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<tr>
<td>thm_load.scm</td>
<td>Search Coil Magnetometer waveform</td>
<td>*</td>
<td>(*)</td>
<td></td>
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<tr>
<td>thm_load.sst</td>
<td>Solid State Telescope</td>
<td>*</td>
<td></td>
<td>*</td>
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<tr>
<td>thm_load.state</td>
<td>Orbit and Attitude</td>
<td>v2</td>
<td></td>
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</tr>
</tbody>
</table>

Notes:
- (*) calibration routine available but still under development
- data reduction and analysis routines available: see crib sheet
Usage Conventions:

Use keywords to determine functionality

- **level** - Calibrated Level 1 data is the default (Except for SST and ESA data, which is handled differently).

- **datatype** and **probe** keywords determine which data is loaded and/or created through calibration process

- **/get_support_data** keyword is needed in thm_load_state to load data required by thm_cal* and thm_cotrans routines.

To load uncalibrated data, set type = ‘raw’ (For all but SST, ESA)

Example from IDL Command Line:

```idl
  timespan,'2007-07-07',1 ;choose a time range
  thm_load_state, probe = 'a', /get_support_data
  thm_load_fgm, probe='a', coord='gsm', datatype='fgl', level=1
```
Variable Names

Probe specification. Example: tha
  • a – can be one of [a-e] specifies probe

Particle data. Example: tha_peif
  • p – particles
  • e – ESA, s – SST
  • i – ions, e – electrons
  • f – full, r – reduced, m – moments, b – burst

FGM data. Example: tha_fgl
  • l – low telemetry rate, h – high telemetry rate,
    e – engineering decimated high rate, s – spin fit.

Electric Fields and SCM. Example: tha_efs
  • ef - efi, sc – scm, fb – fbk, ff – fft
  • s – spin fit, f – full orbit or fast survey, p – particle burst,
    w – waves burst.

Wildcards are accepted in names when plotting and data processing:
  • th?_fg?
  • th[ab]_fg[lh]
  • th?_state*
<table>
<thead>
<tr>
<th>Crib Sheets for Loading, Processing and Plotting</th>
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<tbody>
<tr>
<td>thm_crib_asi</td>
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<tr>
<td>thm_crib_dproc</td>
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<td>thm_crib_efi</td>
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<tr>
<td>thm_crib_esa_da</td>
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<td>thm_crib_esa_moments</td>
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<tr>
<td>thm_crib_state</td>
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<tr>
<td>thm_crib_tplot</td>
</tr>
<tr>
<td>thm_crib_tplotxy</td>
</tr>
<tr>
<td>thm_crib_twavpol</td>
</tr>
<tr>
<td>thm_map_examples</td>
</tr>
</tbody>
</table>

IDL> .run thm_crib_asi

or cut and paste, or copy and modify
Coordinate Transformations

- **thm_cotrans**
  - transforms to/from any of the following coordinate systems in a single call
  - updates metadata in output.
  - knows coordinate system of input from metadata

- **Currently Supported Geophysical Coordinate Systems**
  - SPG  Spinning Probe Geometric
  - SSL  Spinning SunSensor L-vectorZ
  - DSL  Despun SunSensor L-vectorZ
  - GEI  Geocentric Equatorial Inertial
  - GSE  Geocentric Solar Ecliptic
  - GSM  Geocentric Solar Magnetospheric
  - SM   Solar Magnetic
  - GEO  Geographic Coordinate System

- **Example (using previously loaded FGM and STATE data)**
  - `thm_cotrans, 'th?_fg?', out_coord='geo', ouf_suffix = 'geo'`
Plotting & Analysis Routines

Plotting

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

Example:
```
tt89,'thc_state_pos',newname='model_field'
fac_matrix_make,'model_field',other_dim='xgse', newname = 'fac_mat'
tvector_rotate, 'fac_mat', 'thc_peir_velocity', newname = 'ion_velocity_model_fa'
```
Command Line Example 1

- To load data:
  » `timespan,'6-10-2',2,/days`
  » `thm_load_gmag,site='ccnv',$/subtract_average`

- To plot data:
  » `options,'thg_mag_ccnv',$/labels=['Bx','By','Bz']`
  » `tplot_options, 'title', $'GMAG Examples'`
  » `tplot, 'thg_mag_ccnv'`
Command Line Example 2

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

- Split the 3-vector into components:
  » split_vec,'thg_mag_ccnv'

- Compute transform of one component
  » wav_data,'thg_mag_ccnv_x','/kol $ \text{trange}=tr \text{,maxpoints}=24\text{l}*3600*2$

- Set color limits (log scale)
  » zlim,'*pow', .0001,.01,1

- Plot it.
  » tplot,'*ccnv_x*',trange=tr
Plotting Examples

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

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

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

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

- New routines have been added to perform different 2d projections of 3d data. This particularly useful for plotting orbits and field lines.

- A Tsyganenko interface has been added to TDAS that allows us to calculate model field lines for T89,T96,T01,&T04 models. Field lines can also be Traced.

- Examples of these routines can be found in themis/examples/thm_crib_trace.pro, themis/examples/thm_crib_plotxy.pro and themis/examples/thm_crib_tplotxy

- The graphics in this slide were generated with thm_crib_trace.pro
  Example: .run thm_crib_trace.pro

- A routine was added to plot an arbitrarily sized and spaced AACGM coordinate grid on a world map.
Trace/Orbit Plots - AACGM/Iono Trace Plot
Trace / Orbit Plots – XY Plot

XY field line/probe position plot

15
10
5
0
-5
-10
-15

10
0
-10
-20

THEMIS Science Software Training
San Francisco, December 14, 2008
Trace / Orbit Plots – XZ Plot

XZ field line/probe position plot
Mini Language

THEMIS – Mini Language

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

Additional examples can be found in themis/examples/thm_crib_calc.pro
THEMIS – Additional New Features

• Solar Wind Code - The solar wind code serves SW data propagated to the bow-shock nose, which can be used, potentially, by various applications (currently, they are used in dynamic magnetopause model). The code takes WIND SWE and MFI data, served by SPDF, and propagates them to the bow-shock nose using OMNI methodology. There is also the option of use of already-propagated OMNI HRO and OMNI-2 data. Recently-appeared opportunity to test directly the propagated data by comparison with THEMIS B data shows a good agreement and potential for improvement.

• Outlier Removal Code - Quadratic trend is determined in a hollow vicinity of each point. The data value is compared with the trend value. If the deviation is statistically improbable, the value is repaired. There are 6 options for repair to chose.

• We have now six new routines which allow downloading/creating all A-indices from Kyoto, the Dst index from Kyoto, and the pseudo A-indices using THEMIS data plus crib sheets for each routine. All routines are fully "automatic", i.e., they don’t require any manual download of data.

• Program developed to read ACE ascii data. Example: idl> noaa_ace_nrt_load

• A new plotting routine (plotxyvec.pro) has been added for plotting arrows on top of plotxy and plotxyz plots. In addition a new routine grad.pro has been developed for calculating the gradient of a scalar field. Examples of usage can be found in themis/examples/thm_crib_plotxyvec.pro
Plotxyvec – Position/Velcity Plot
THEMIS – New GUI Features

- UCLA SPLASH GUI used as a model for the design
- Windows Environment - provides a universal and standard interface
  Pull Down Menu’s  Tool Bar  Accelerator Keys
- Increased User Interaction – added cursor, mouse, and keyboard features
  Click and Drag, Single/Double Clicks, Tab/Backspace, and Right/Left Arrow keys
- Plot Capabilities – multiple pop up windows allow user to control plot settings
  Line/Spectral plots  X/Y Axis and Grid styles  Panel layout  Page setup
- Tracking – vertical and horizontal tracking features cross hairs displayed as cursor moves over plot region, data is displayed and updated as cursor moves
- Markers – users can select regions of interest by Ctrl-Click-Drag
- Variables - user can select any loaded data to be displayed at bottom
- Analysis – additional capabilities include the new mini language, a nudge function, and analysis routines
- Original GUI – all current functionality will be preserved, including data analysis
New THEMIS GUI Availability Dates

• Release with TDAS v5.0 during January 2009
• Webcast Trainings during January 2009
• January 2009 Release for PC – Windows
  Phase II Release for Mac and Linux
• Original GUI will still be available until April 2009
THEMIS software for GBO all-sky imager
Thm_crib_asi.pro
Harald U. Frey
1. Keograms along local magnetic meridian
   • Delivered daily jpeg-compressed
   • Reprocessed ½ year later with full resolution images
2. Geomagnetically mapped thumbnail images
   • Delivered daily square-root intensity compression
   • 1024 pixels within ±8° magnetic Latitude and ~±-12° Longitude
   • 3 seconds temporal resolution
3. Full resolution images
   • 256x256 pixels covering about 600 km radius around station
   • Delivered about ½ year later
   • 3 seconds temporal resolution
   • Full 16 bit intensity scale
Daily overview of available keograms
Zoom into interesting time
Watch “movie” of single station
Mosaic of whole GBO array from full resolution images
Mosaic with S/C footprint
From thumbnail images

Black line marks footprint of THEMIS-P2 during whole night
Asterisk marks location at time of mosaic
Ground magnetometer Examples
Thm_crib_gmag.pro
Three station example
Wavelet transform example
Pseudo-AE of network
Data and Orbits

at SPDF

Space Physics Data Facility
Level-2 Data from all 4 Instruments on all 5
Satellites (GBO, GEONS)
Ground Magnetometer Data from 42 stations
NEW: Keograms from 22 All-Sky-Imagers (ASI)
All data updated daily (auto-ingest) from
THEMIS data site.
GIF-Walk: pre-generated Magneto-pause Crossing Survey plots (David Sibeck, NASA GSFC)
November 25, 2008: All THEMIS L2 FIT files reprocessed to fix data problem - new files available in CDAWeb on November 24, 2008.

November 10, 2008: CDAWeb has been updated to contain all of the newly reprocessed THEMIS ESA, FGM, SST and State files. This new version of the THEMIS L2 ESA files contain data quality variables (which are applied to the marked variables when plotted).

New functionality added to all output pages: Previous/Next buttons produce the next or previous plot, listing or cdf.

Postscript and PDF plotting files now supported for all plot types except images.
CDAWeb - Other Data

Many data products of THEMIS interest:
ACE, Cluster, Geotail, FAST, NOAA, GOES, LANL, Wind …

ITM data to study storm effects in ITM region: TIMED, ROCSAT, GPS (under development)
Orbits for most science satellites, updated regularly and often including predicts.

TIPSOD 4-D orbit viewer

Saved queries for typical THEMIS-related SSCweb runs (1-click access).

http://sscweb.gsfc.nasa.gov
THEMIS Science Software Training

Software - 50

San Francisco, December 14, 2008
Common Data Format- CDF

CDF Version 3.2.2 release, fixes memory leak and ReadOnly mode problems, and includes some changes for the tool programs.
CDF Patch for Matlab
CDF Patch for IDL 6+ (strongly recommended)
CDF's Java Network Launching Protocol latest development

http://cdf.gsfc.nasa.gov