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An integrated analysis platform powered by fitacf CDF and the THEMIS tool developed by *ERG*-Science Center (*ERG*-SC)

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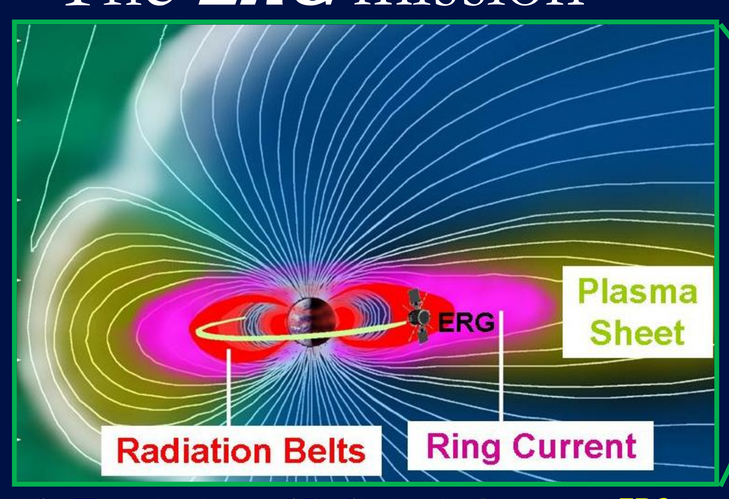
Abstract

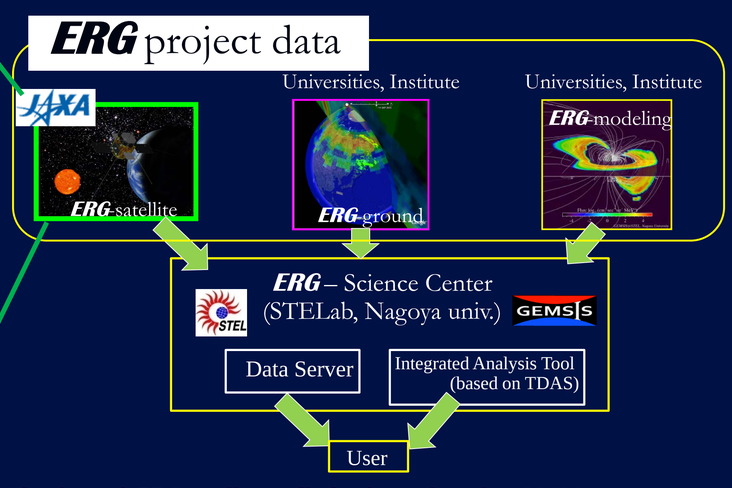
The Energization and Radiation in Geospace (ERG) mission seeks to exploring dynamics of the radiation belt in the Earth's inner magnetosphere with a space-borne probe (ERG satellite) in coordination with the related ground observations and simulations/modeling studies. For this mission, the ERG-Science Center (ERG-SC) will provide a useful data analysis platform based on the THEMIS Data Analysis software Suite (TDAS) which has been widely used by researchers and thus had a great success in producing many conjunction studies with the THEMIS spacecraft and ground data. To import SD data to this highly useful platform, ERG-SC developed the CDF design suitable for SD fitacf data and actually has applied it for SD data obtained by Japanese groups. We have also been developing IDL procedures to load the SD data in CDF and to generate various kinds of plots, not only R-T-I-type plots but also 2-D map plots with other data, such as all-sky images of THEMIS-GBO and orbital footprints of various satellites. So far we have completed the CDF conversion of Japanese SD radar data (HOK, KSR, SYE, SYS), which have already been made available to the Japanese community. ERG-SC is going to release to the international community the generated CDF files with the associated IDL procedures for use in TDAS during this year (2011). We are ready and quite positive to collaborate with the other radar groups to get more data involved in this data analysis platform. Hopefully the CDF-TDAS scheme by ERG-SC will make SD data more easily accessible and analyzable for researchers and thereby facilitate collaborative studies with other data in the upcoming era of the great exploration for the inner magnetosphere, carried out by the ERG(Japan)-ORBITALS(Canada)-RBSP(U.S.A.)-THEMIS(U.S.A.) fleet.

The *ERG* mission



The **Energization and Radiation in Geospace (*ERG*)** is Japanese satellite mission (launch planned in JpFY2014-2015) and its primary goal is to understand the energization and transport processes of the radiation belt particles in the Earth's inner magnetosphere (IM).

Framework of *ERG*-SC



- The data of *ERG*-satellite will also be archived in JAXA.
- The *ERG*-science center (*ERG*-SC) at STE lab will archive CDF/HDF files of all kind of the project data and develop the integrated analysis tools based on the THEMIS Data Analysis Software (TDAS).

Purpose:
To facilitate integrated analysis using both satellite and ground data including SD for the upcoming IM exploration era.

What *ERG*-SC does:
- Archive Japanese SD data in the Common Data Format (CDF).
- Make the data available basically under an open data policy as long as users observe the rules of the road provided by the PIs, in the same manner as satellite data.
- Develop plug-in software libraries to incorporate ERG-SC-related ground data, such as Japanese geomag. data and SD data, into TDAS.

ERG-SC activity (2009-present)
- 210MM and NIPR geomag. CDF were made available through internet and the plug-in libraries have been released as a part of TDAS (Mar, 2011).
- CDF conversion of Japanese SD (HOK, KSR, SYE, and SYS) fitacf data has been **completed** and SD data have been made available to Japanese STP researchers with IDL libraries to load/plot them (May, 2011).

See below about details!!

Summary

The common time fitacf data of Japanese SD radars in CDF and the related IDL libraries have been made available to Japanese STP community. We hope to open them also to the international community in near future to maximize scientific outputs and thereby make us ready to go integrated studies with SD data and IM satellite data toward the upcoming ERG-RBSP-ORBITALS-THEMIS constellation era.

More to come in CDF with TDAS plug-in in future:
- STEL induction magnetometer data (Japan, Canada, Russia)
- EISCAT radar data (in Northern Scandinavia and Svalbird)
- VLF radar data of Syowa (Japanese observtory in Antarctica)
- Riometer data provided by NIPR
- Induction magnetometer data of Syowa and Iceland by NIPR

Outline of the CDF design for SD fitacf data by *ERG*-SC

- Only common time (CT) data are stored.
- Stored beam by beam, as in the original fitacf files.
- The metadata part consists of the NASA/SPDF-standard ones, and those newly defined by *ERG*-SC (those in the list below hatched in blue).
- The rules of the road (data policy) is stored in each data file and displayed to users every time data are loaded using ERG-SC IDL libraries.
- The position (lat, lon) of each range gate is given as a fixed table (data variable "position_tbl_?" in the variable list shown below) which has been calculated on the CDF conversion. We add to the attributes the version of the rpos library (e.g., "librpos 1.04") so that data users can know which version of the library was used to derive the position table stored in CDF.

Global attribute list (metadata part)

Attribute Name	Attribute value (example)
Project	"SD>Super Dual Auroral Radar Network"
Discipline	"Space Physics>Magnetospheric Science"
Source_name	"SD>Super Dual Auroral Radar Network"
Data_type	"fitacf_l2>Fitacf level 2 data"
Descriptor	"HOK>SuperDARN Hokkaido HF radar"
Data_version	"1"
TITLE	"SuperDARN Hokkaido HF radar Fitacf data"
TEXT	""
Generated_by	"Solar-Terrestrial Environment Laboratory, Nagoya University"
Generation_date	"20090924"
MODS	"Created 10/2009"
ADID_ref	""
Logical_file_id	"SD_FITACF_L2_"
Logical_source	"SD_FITACF_L2_"
Logical_source_description	"SuperDARN Fitacf Level 2 data for the Hokkaido radar"
PI_name	"Nozomu Nishitani"
PI_affiliation	"Solar-Terrestrial Environment Laboratory, Nagoya University"
Mission_group	"SuperDARN"
Instrument_type	"Ground-Based HF-Radars"
TEXT_supplement	""
Rules_of_use	"Data distributed with this CDF file can be used freely for scientific research. Please note that the data are not fully calibrated and may still contain glitches and errors which could yield scientifically wrong or misleading results. We strongly recommend working directly or checking with the PI (Nozomu Nishitani, STEL, Nagoya Univ., E-mail: nisitani@stelab.nagoya-u.ac.jp) and/or researchers of the other SuperDARN PI groups regarding data accuracy and interpretation. Data users must contact the PI before any form of presentation/publication including any fraction or the entire part of data. (… followed by the acknowledgement statements ..)
LINK_TEXT	"For more information, see"
LINK_TITLE	"SuperDARN Hokkaido Radar, Nagoya University"
HTTP_LINK	"http://center.stelab.nagoya-u.ac.jp/hokkaido/"
Time_resolution	"3s"
Data_start_time	"2010-04-20/00:00:00"
Data_end_time	"2010-04-20/23:59:59"
RST_version	"2.10"
fiacf_version	"fitacf 2.00"
rposlib_version	"librpos 1.04"
calibration_history	"10/2009: Initial quality check passed"
Known_problems	""
radar_position	"+43.53N +143.61E (geographic coordinates)"
operation_start	"2006-11-10"
operation_end	""

Suffix "_0" in the data variable names means that they were obtained by the 75 range gate measurement. Suffix "_1" is given for those of the 110 range gate measurement, and "_2" or greater would be given for data of larger range gate modes. If measurements of two different range gates coexist in one day, then two sets of data variables (hatched in violet) are stored in a CDF file.

The rules of the road (data policy) is stored in attribute "Rules_of_use". This statement is displayed to users every time data are loaded.

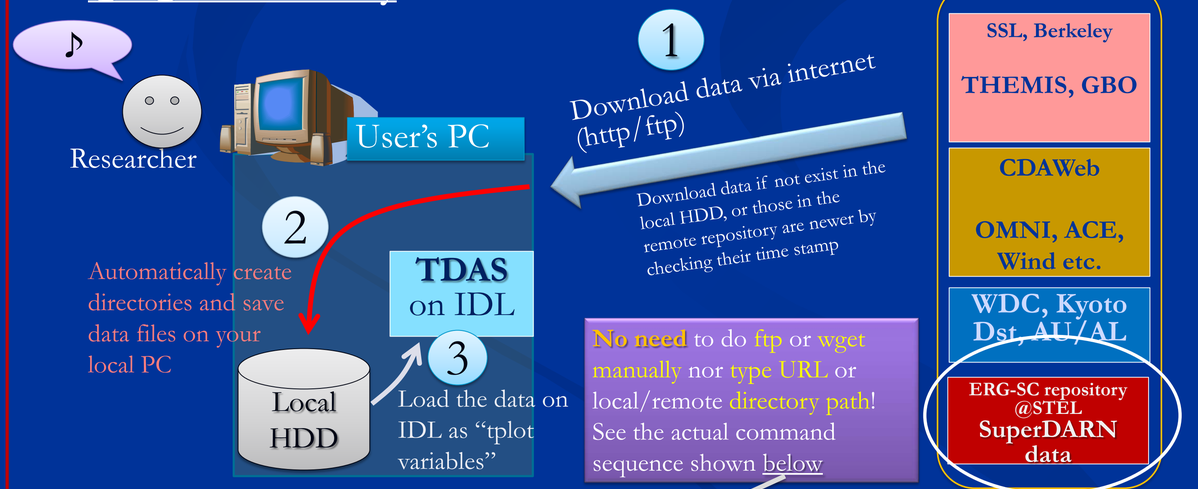
Attribute "calibration_history" holds the list of calibration processes made for data in a CDF file.

Data variable list

Data variable name	Description
hdw_station_id	Hardware station id
hdw_year	Hardware year
hdw_yr_sec	Hardware year sec
hdw_lat	Hardware latitude
hdw_lon	Hardware longitude
hdw_altitude	Hardware altitude
hdw_boresite	Hardware boresite
hdw_bm_sep	Hardware beam sep
hdw_vdir	Hardware vdir
hdw_atten	Hardware atten
hdw_tdiff	Hardware tdiff
hdw_phidiff	Hardware phidiff
hdw_interfer_pos	Hardware interfer position
hdw_rec_rise	Hardware rec rise
rgate_no_0	Range gate number
position_tbl_0	position table in GEO
Epoch_0	Beam time
cpid_0	Control Program ID
int_time_0	Beam integration time
azim_no_0	Azimuth number of beam
pwr_0	Backscatter power
pwr_err_0	Error of backscatter power
spec_width_0	Spectral width
spec_width_err_0	Error of spectral width
vlos_0	Light-of-sight Doppler velocity
vlos_err_0	Error of light-of-sight Doppler velocity
elev_angle_0	Elevation angle
elev_angle_err_0	Error of elevation angle
phi0_0	phi-zero
phi0_err_0	Error of phi0
echo_flag_0	Echo flag (ionospheric echo or ground scatter)
quality_flag_0	Data quality (0: ok, 1: caution, >2: bad)
quality_flag_info_0	Detailed information of quality check (1st bit ON: echo power < 3dB, 2nd bit ON: spec_width > 100m/s, the other bits are reserved for future use)
scanno_0	Scan number
scanstartflag_0	Scan start flag (1 if the current beam is the start of a new scan)
lagfr_0	Lag time of first range
smsep_0	Sampling separation in microsec
nrang_max_0	Maximum number of range gate
tfreq_0	Transmission frequency
noise_0	Noise level
num_ave_0	How many times pulse sequences are integrated to get raw spectra
txpl_0	Pulse length of transmission

How TDAS download and load data

Just type one load command, then you can do all through ①~③ automatically!!



No need to do ftp or wget manually nor type URL or local/remote directory path! See the actual command sequence shown below

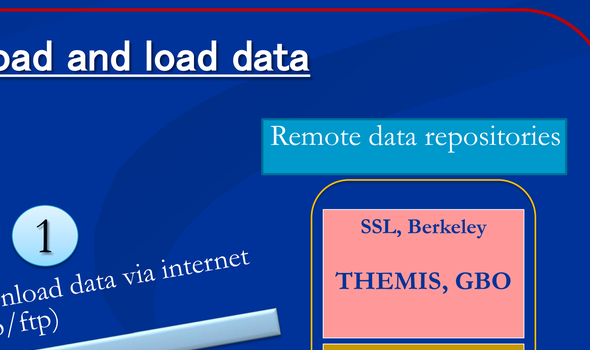
Sample commands of TDAS

```
IDL> timespan, '2007-07-26/16:00', 3, /hour
IDL> erg_load_sdfit, site='hok', /get_sup
IDL> erg_load_sdfit, site='ksr', /get_sup
       ; Load data for 2 SD radars (HOK,KSR)

    ;Draw a range-time plot by tplot
IDL> tplot, [ 'sd_hok_vlos_1', $
              'sd_ksr_vlos_0'    ]



IDL> window, 1 & erase
IDL> timespan, '2008-04-03'
IDL> thm_asi_create_mosaic,'2008-04-03/11:51:00'
IDL> overlay_polar_sdfit, $
          'sd_hok_vlos_1',/geo_plot
IDL> overlay_map_themis_ifoot, '20080403', $
          ['e','0800','1600'], /geo_plot
  ; Draw a THEMIS-ASI mosaic plot, superposed
  ; by the HOK fan plot for the same time and
  ; the footprint of THEMIS probe-E for 8-16 UT
  ; (All are plotted on the geographical map)
```



A set of load/visualization commands shown above have been released by *ERG*-SC for the science community with the CDF data repository. (Currently can be accessed only from inside of Japan)

Graphic objects drawn by overlay_polar_???, overlay_map_??? can be superposed on any map defined by "map_set" (IDL standard command to define grids for 2-D map plotting)