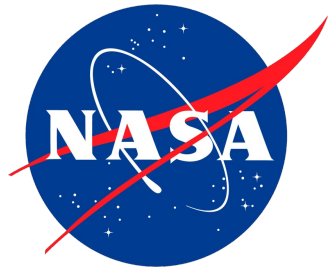
International Solar-Terrestrial Physics (ISTP) metadata guidelines and their use at the Space Physics Data Facility (SPDF)

Eric Grimes on behalf of the SPDF team

NASA GSFC/ADNET Systems

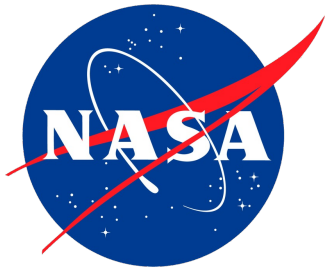
https://spdf.gsfc.nasa.gov

Overview



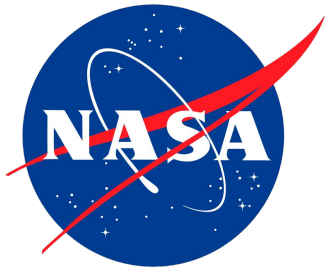
- Brief introduction to the SPDF
- Brief introduction to the ISTP guidelines
- Tools for specifying ISTP metadata in CDF files (SKTEditor, and .SKT files)
- Examples showing how CDAWeb uses the ISTP metadata to provide access to a large number of datasets

Introduction to the SPDF



- Active archive of **in-situ** data from NASA heliophysics missions, and collaborative missions with other US and foreign agencies relevant to NASA **heliophysics science objectives** (planetary, NOAA, DoD, and ground-based magnetometers, aurora cameras, radars, etc.), from the Sun to the local interstellar medium, including planetary magnetosphere, ionosphere, thermosphere, and mesosphere
- SPDF provides three main science-enabling services besides archiving data
  - CDAWeb (Coordinated Data Analysis Web): browse, correlate, and display
  - SSCWeb (Satellite Situation Center): orbit/ground track displays and queries
  - OMNIWeb and COHOWeb for solar wind plasma, fields, and energetic particles

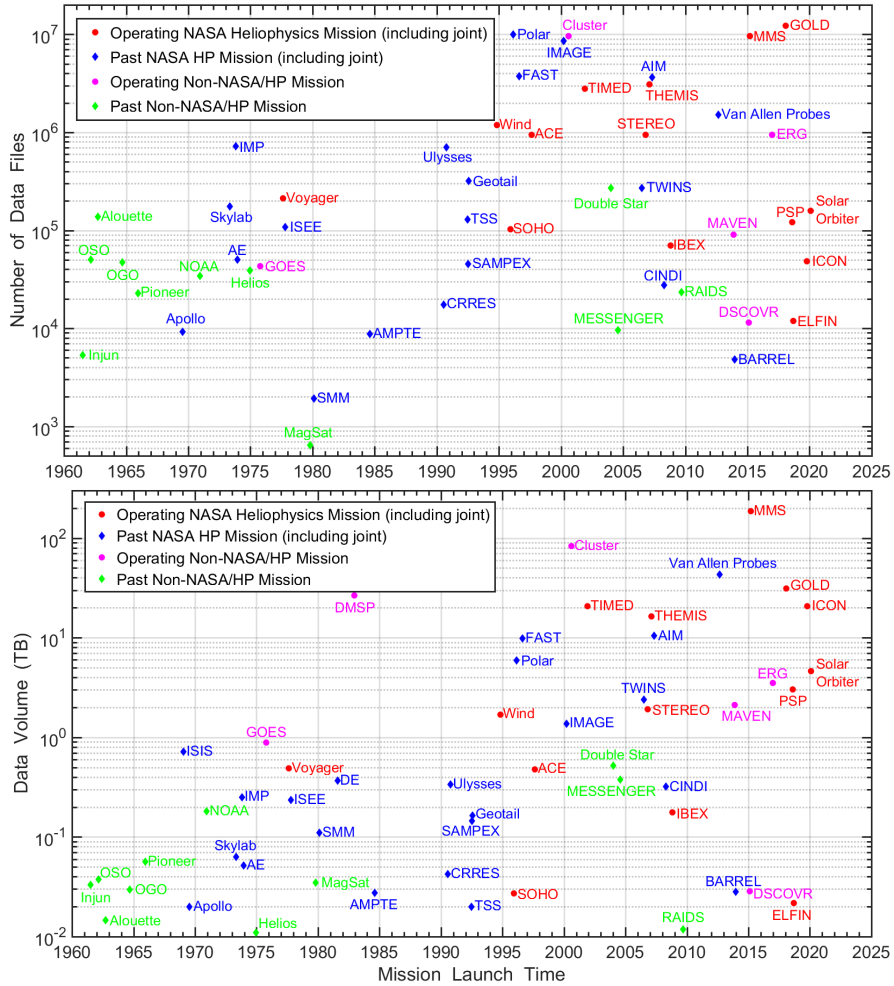
Introduction to the SPDF



- SPDF enables multi-instrument, multi-mission heliophysics science
  - Specific mission/instrument data in context of other missions/data
  - Specific mission/instrument data as enriching context for other data
- SPDF also builds critical infrastructures for the **heliophysics data environment**:
  - Common Data Format (CDF) self-describing science file format:
    - https://cdf.gsfc.nasa.gov
  - Heliophysics Data Portal https://heliophysicsdata.gsfc.nasa.gov discipline-wide data inventory and access service
  - ISTP Metadata Guidelines:
    - https://github.com/IHDE-Alliance/ISTP_metadata

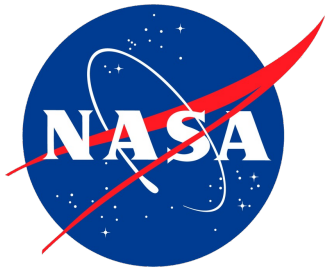
Introduction to the SPDF

- Data (~550 TB) from >130 missions
- Number of datasets: ~8,000-10,000
- Number of files
  - ~100 million files total
  - ~16 million CDF files in CDAWeb
  - ~15 million pre-generated plots (gif, png, jpeg)
- Amount of traffic / data volume (March 2024)
  - ~10,000,000 monthly requests
  - ~17 TB transferred



Note: only 53 missions/projects with more than 10GB of data are plotted

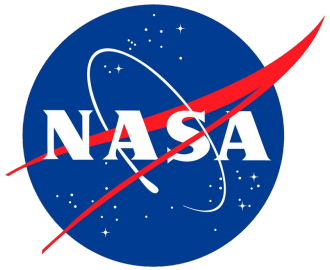
ISTP Guidelines



- ISTP/IACG Guidelines (mid 1990s) and subsequent extensions by SPDF define implementation standards for CDFs and NetCDFs
  - Include general file naming conventions
  - Data is time-ordered and time-identified; times vary by record
    - Set of required and suggested metadata
  - Global attributes provide overall context of the dataset
  - Variable attributes can point to other variables by name
    - Attributes thus carry information about relationships among variables
    - Variables can carry metadata (e.g., labels for dimensional variables)
  - Missions add their own metadata requirements
- **ISTP metadata is independent of CDF and easily used in other self-describing science formats like CEFs, netCDFs and HDFs, and probably FITS and ASDF**

https://github.com/IHDE-Alliance/ISTP_metadata

ISTP Guidelines



- Global attributes required:
  - **Project**: identifies the name of the project and indicates ownership
  - **Source_name**: identifies the mission or investigation that contains the sensors
  - **Descriptor**: the name of the instrument or sensor that collected the data
  - **Data_type**: identifies the data type of the dataset
  - **Logical_file_id**: the name of the CDF file using the ISTP naming convention (source_name/descriptor/data_type/date/data_version)
  - **PI_name**: name of the principal investigator (PI)
  - **PI_affiliation**: affiliation of the PI
  - **Discipline**: describes the science discipline and subdiscipline
  - **Mission_group**: single value that is used to facilitate making choices of source through CDAWeb.
  - **Instrument_type**: type of instrument (e.g., “Magnetic Fields (space)” or “Electric Fields (space)”)
  - **Data_version**: the version of the data file; this gets incremented when a particular file is reproduced
  - **Logical_source**: Includes the Source_name, Data_type and Descriptor information (e.g., mms1_aspoc_srvy_l2)
  - **Logical_source_description**: short dataset description
  - **TEXT**: description of the experiment

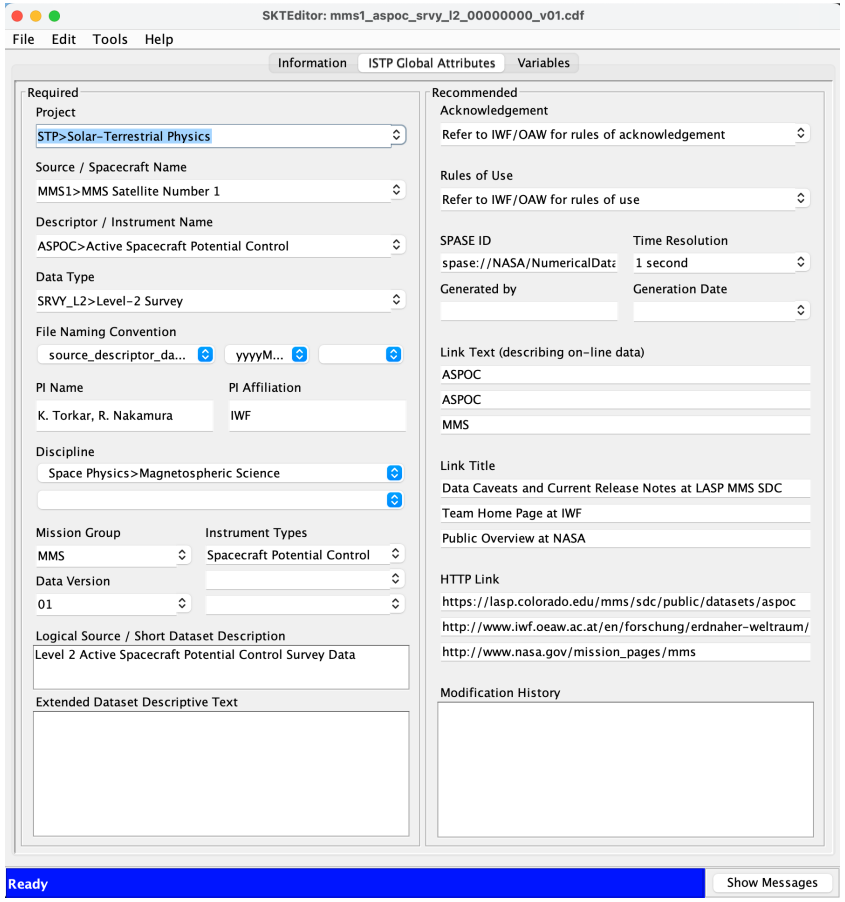
https://github.com/IHDE-Alliance/ISTP_metadata/blob/main/v1.0.0/02_metadata-global-attributes.md

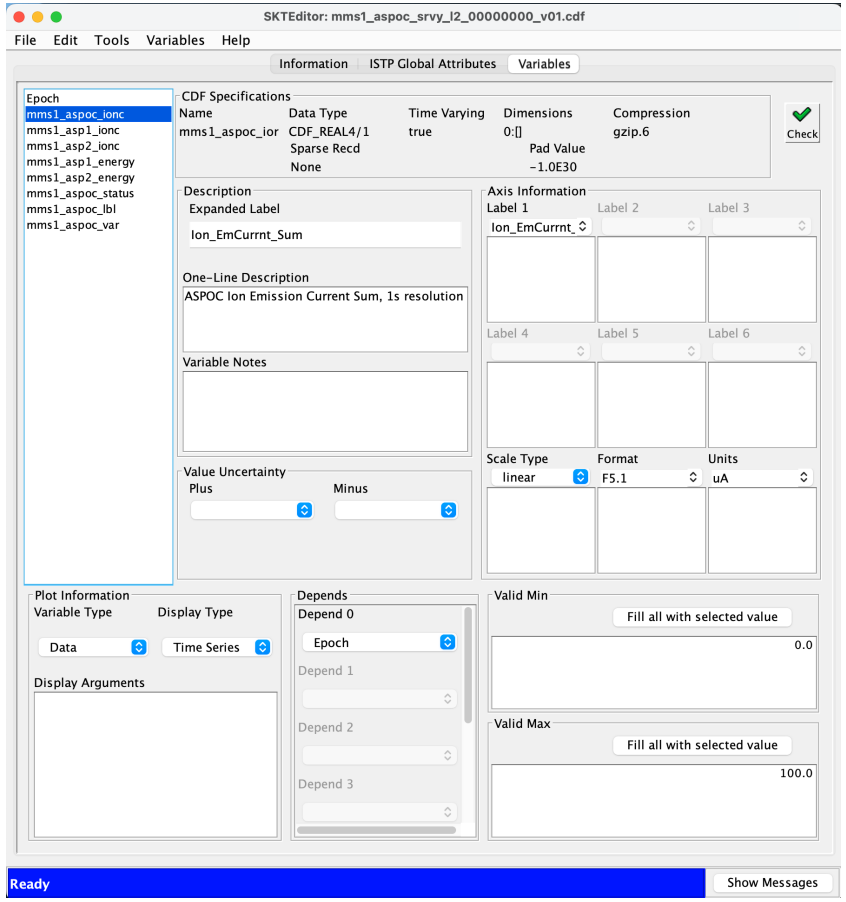
ISTP Guidelines

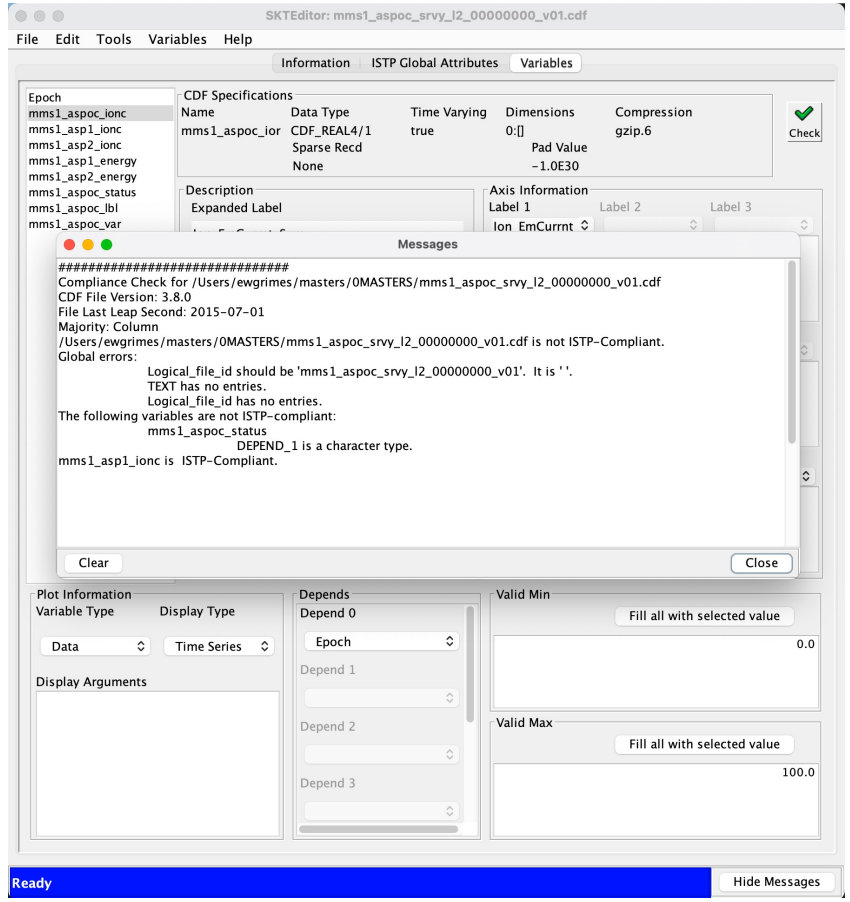
- Variable attributes required for automated processing:
  - **CATDESC**: variable description
  - **DEPEND_0**: points to time variables
  - **DEPEND_1, 2, 3**: point to variables that describe other dimensions
  - **FIELDNAM**: short variable name for plots
  - **FILLVAL**: values indicating missing or bad data
  - **LABLAXIS/LABL_PTR_#:** axis and column titles
  - **UNITS/UNIT_PTR**: units
  - **VALIDMIN/VALDMAX**: valid data range
  - **VAR_TYPE**: describes the variable type (“data”, “support_data”, etc)

https://github.com/IHDE-Alliance/ISTP_metadata/blob/main/v1.0.0/04_metadata-variable-attributes.md

SKTEditor (Java)

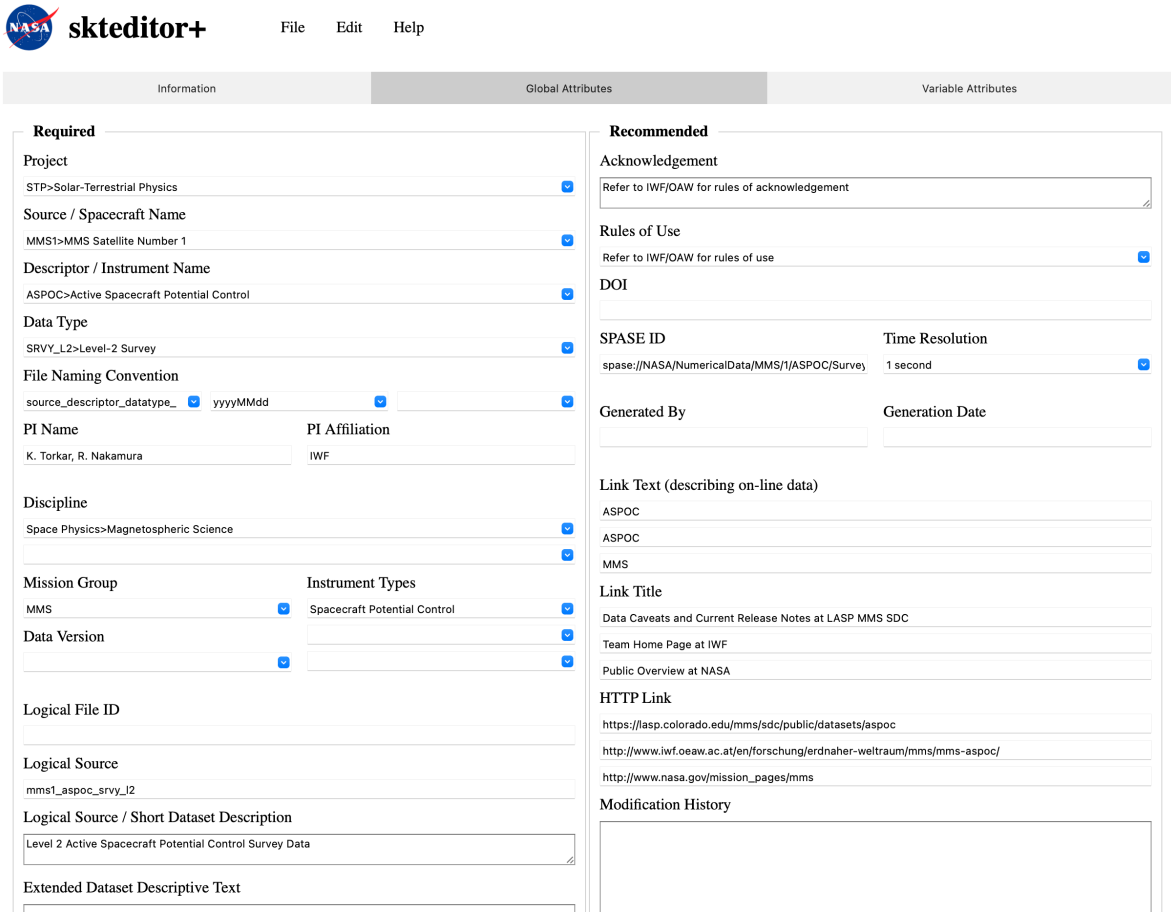


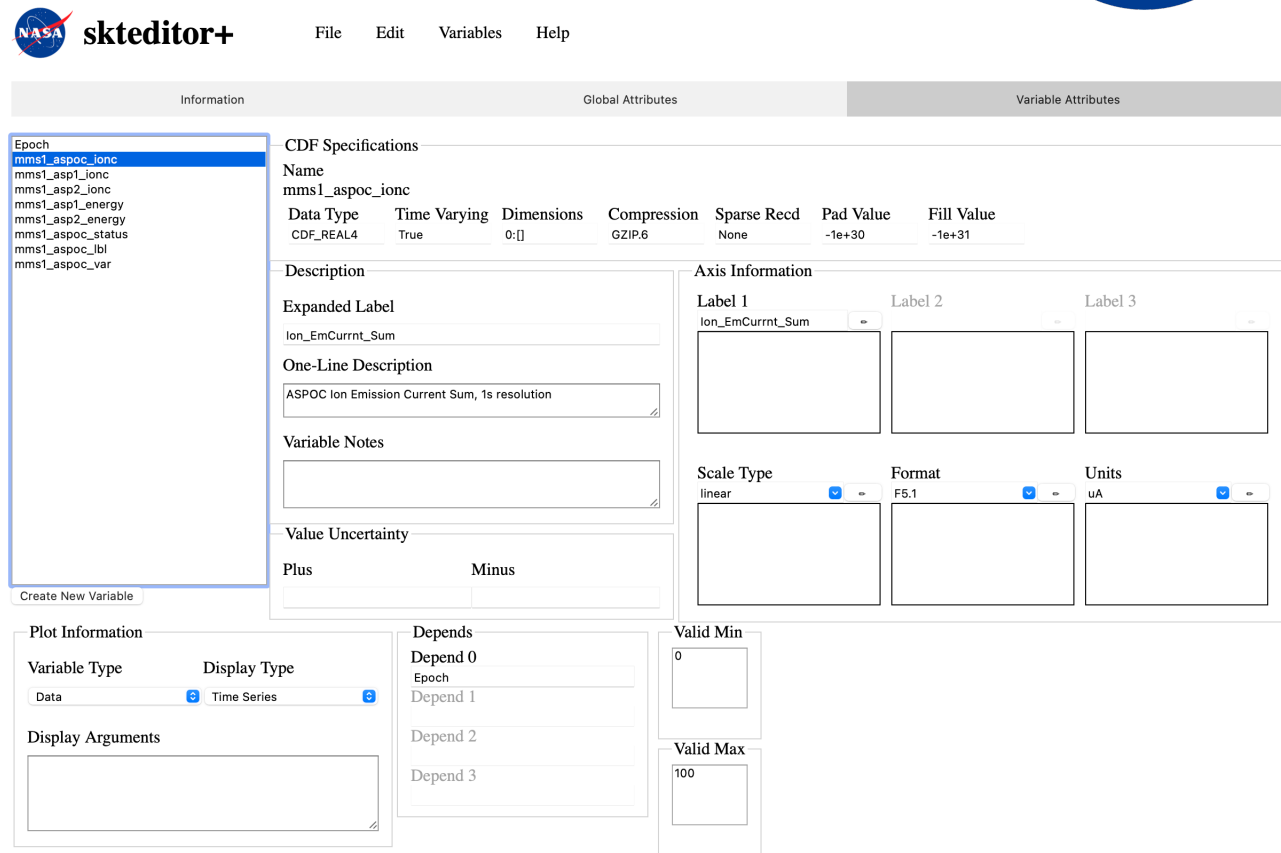




https://spdf.gsfc.nasa.gov/skteditor/

SKTEditor (JavaScript)



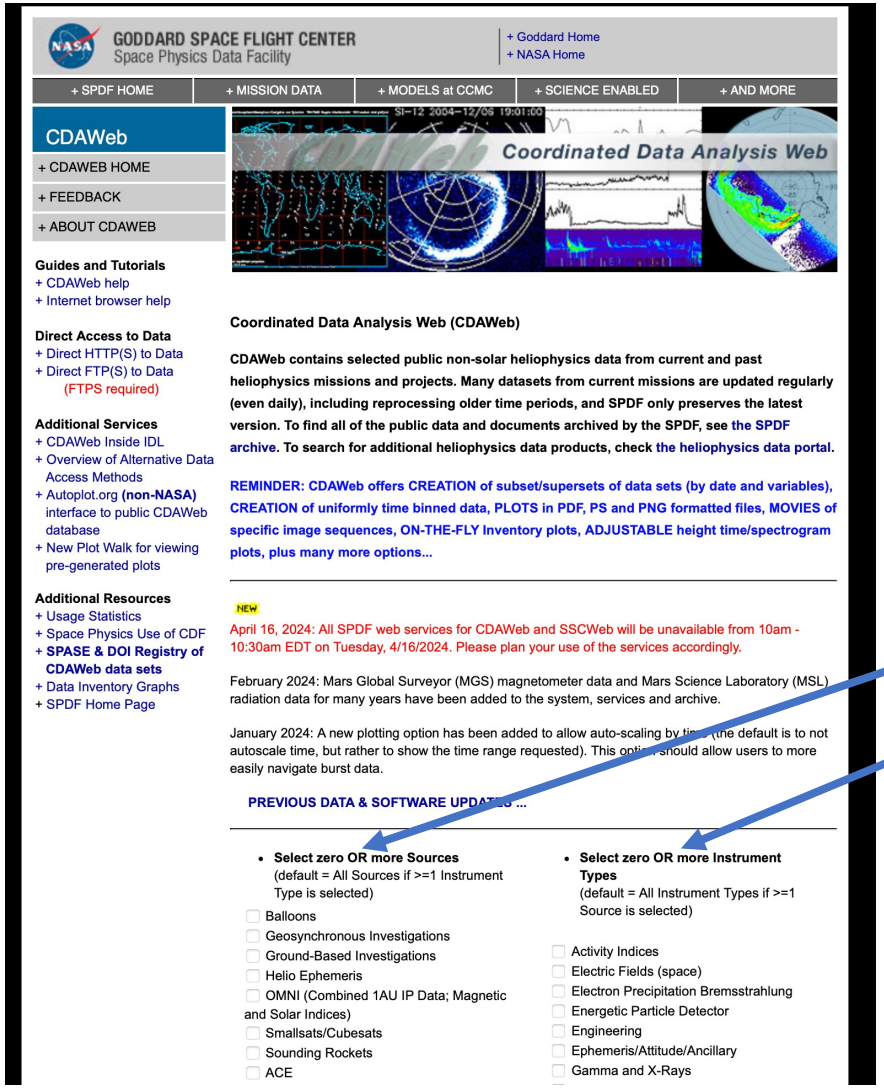


Skeleton Tables

- Skeleton tables are ASCII files that describe a CDF file
- You can create one from a CDF (with or without data) using our SkeletonTable program
- You can create a CDF from a skeleton table using our SkeletonCDF program
- The SkeletonTable and SkeletonCDF programs can be found at:
  - https://cdf.gsfc.nasa.gov
- Examples can be found at:
  - https://spdf.gsfc.nasa.gov/pub/software/cdawlib/0SKELTABLES

```
! Skeleton table for the "mms1_aspoc_srvy_l2_00000000_v01.cdf" CDF.
! Generated: Tuesday, 26-Sep-2023 16:07:53
! CDF created/modified by CDF V3.8.0
! Skeleton table created by CDF V3.8.1_0

#header

                    CDF NAME: mms1_aspoc_srvy_l2_00000000_v01.cdf
                DATA ENCODING: NETWORK
                    MAJORITY: COLUMN
                      FORMAT: SINGLE

! Variables  G.Attributes  V.Attributes  Records  Dims  Sizes
! ---------  ------------  ------------  -------  ----  -----
    0/9          29            29         0/z      0
! CDF_COMPRESSION: None
! (Valid compression: None, GZIP.1-9, RLE.0, HUFF.0, AHUFF.0)
! CDF_CHECKSUM: MD5
! (Valid checksum: None, MD5)
! CDF_LEAPSECONDLASTUPDATED: 20150701


#GLOBALattributes

! Attribute         Entry       Data
! Name              Number      Type        Value
! ---------         ------      ----        -----

  "Project"             1:    CDF_CHAR     { "STP>Solar-Terrestrial " -
                                             "Physics" } .

  "Discipline"          1:    CDF_CHAR     { "Space " -
                                             "Physics>Magnetospheric " -
                                             "Science" } .

  "Source_name"         1:    CDF_CHAR     { "MMS1>MMS Satellite Number 1" } .

  "Data_type"           1:    CDF_CHAR     { "SRVY_L2>Level-2 Survey" } .

  "Descriptor"          1:    CDF_CHAR     { "ASPOC>Active Spacecraft " -
                                             "Potential Control" } .

  "Data_version"        1:    CDF_CHAR     { " " } .

  "Generated_by"        1:    CDF_CHAR     { " " } .

  "Generation_date"     1:    CDF_CHAR     { " " } .

  "TITLE"               1:    CDF_CHAR     { "MMS ASPOC Beam Parameters" } .

  "TEXT"                1:    CDF_CHAR     { " " } .

  "MODS"                1:    CDF_CHAR     { " " } .

  "Logical_file_id"     1:    CDF_CHAR     { " " } .

  "Logical_source"      1:    CDF_CHAR     { "mms1_aspoc_srvy_l2" } .
```

CDAWeb


GODDARD SPACE FLIGHT CENTER
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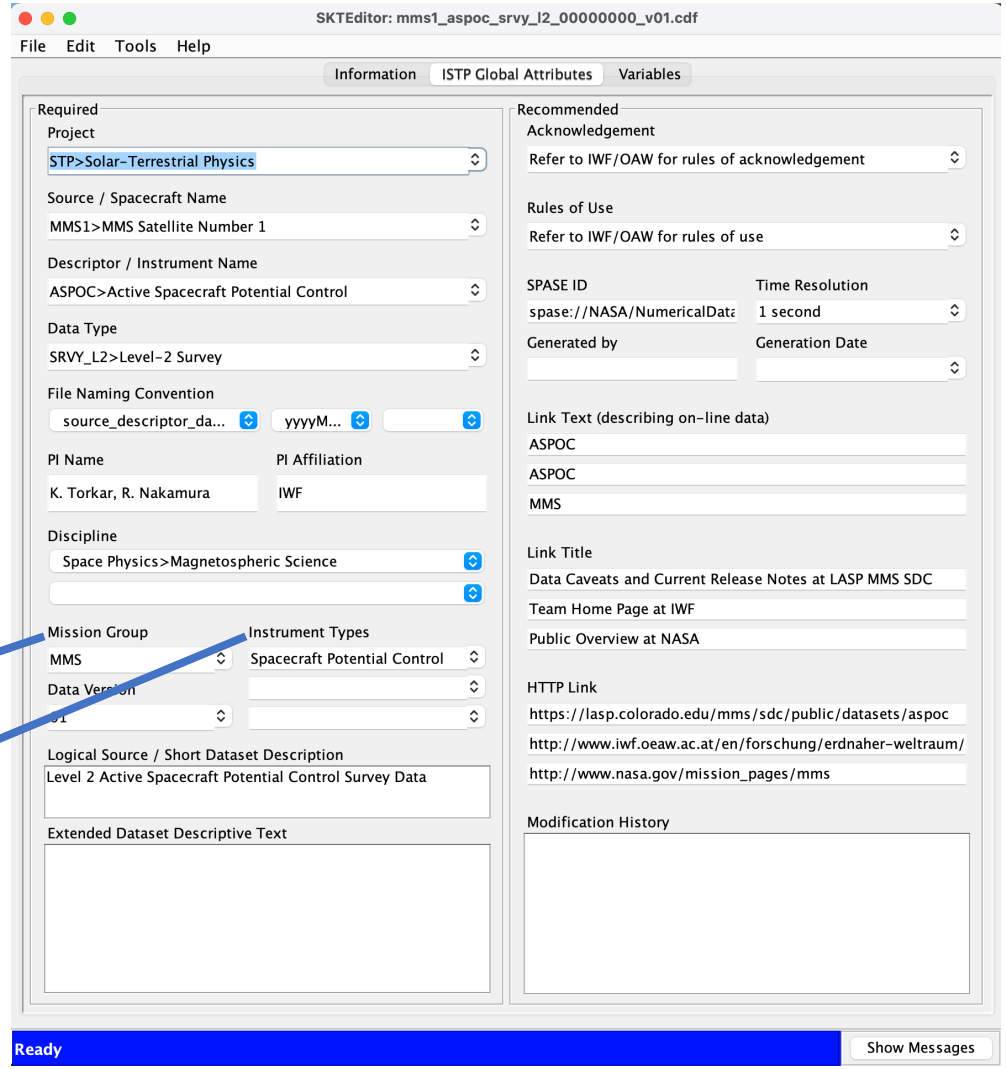
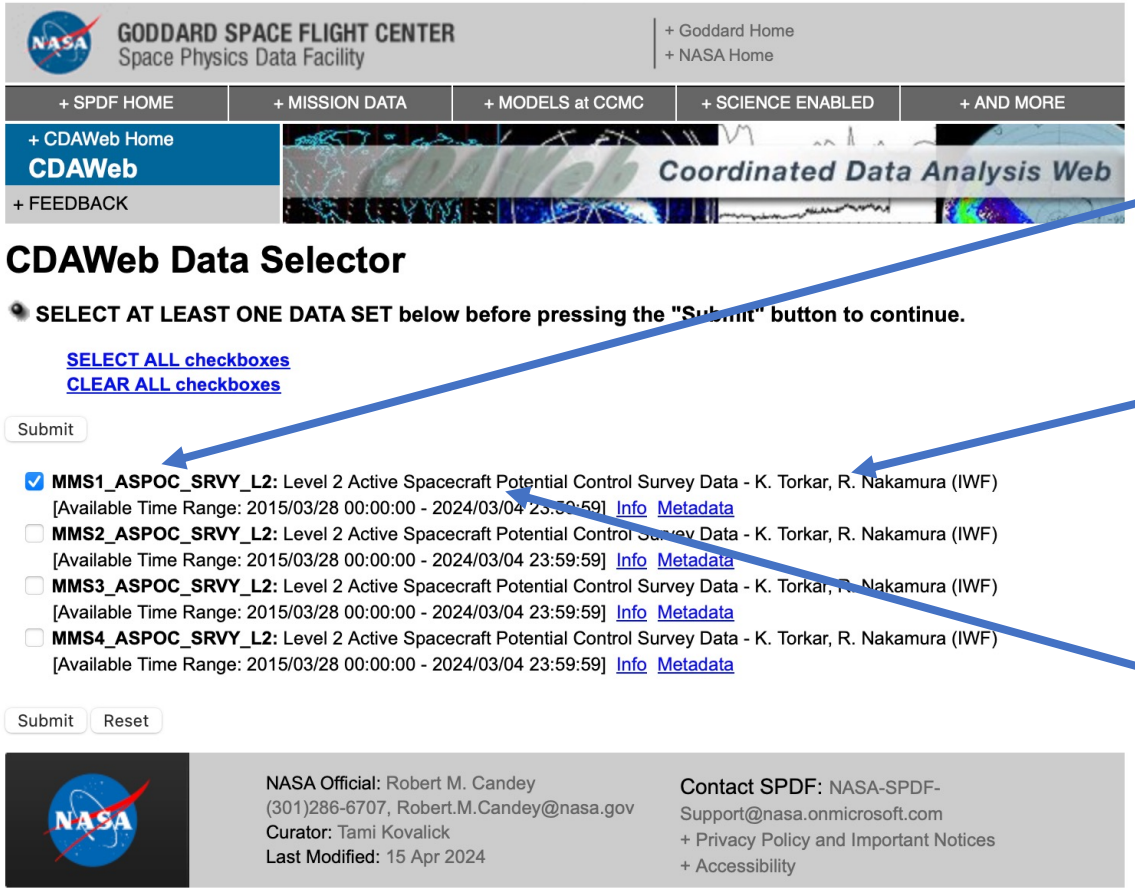
+ NASA Home
+ SPDF HOME
+ MISSION DATA
+ MODELS at CCMC
+ SCIENCE ENABLED
+ AND MORE
CDAWeb
+ CDAWEB HOME
+ FEEDBACK
+ ABOUT CDAWEB
Guides and Tutorials
+ CDAWeb help
+ Internet browser help
Direct Access to Data
+ Direct HTTP(S) to Data
+ Direct FTP(S) to Data
(FTPS required)
Additional Services
+ CDAWeb Inside IDL
+ Overview of Alternative Data Access Methods
+ Autoplot.org (non-NASA) interface to public CDAWeb database
+ New Plot Walk for viewing pre-generated plots
Additional Resources
+ Usage Statistics
+ Space Physics Use of CDF
+ SPASE & DOI Registry of CDAWeb data sets
+ Data Inventory Graphs
+ SPDF Home Page
Coordinated Data Analysis Web
Coordinated Data Analysis Web (CDAWeb)
CDAWeb contains selected public non-solar heliophysics data from current and past heliophysics missions and projects. Many datasets from current missions are updated regularly (even daily), including reprocessing older time periods, and SPDF only preserves the latest version. To find all of the public data and documents archived by the SPDF, see the SPDF archive. To search for additional heliophysics data products, check the heliophysics data portal.
REMINDER: CDAWeb offers CREATION of subset/supersets of data sets (by date and variables), CREATION of uniformly time binned data, PLOTS in PDF, PS and PNG formatted files, MOVIES of specific image sequences, ON-THE-FLY Inventory plots, ADJUSTABLE height time/spectrogram plots, plus many more options...
NEW
April 16, 2024: All SPDF web services for CDAWeb and SSCWeb will be unavailable from 10am - 10:30am EDT on Tuesday, 4/16/2024. Please plan your use of the services accordingly.
February 2024: Mars Global Surveyor (MGS) magnetometer data and Mars Science Laboratory (MSL) radiation data for many years have been added to the system, services and archive.
January 2024: A new plotting option has been added to allow auto-scaling by time (the default is to not autoscale time, but rather to show the time range requested). This option should allow users to more easily navigate burst data.
PREVIOUS DATA & SOFTWARE UPDATES ...
Select zero OR more Sources
(default = All Sources if >=1 Instrument Type is selected)
Balloons
Geosynchronous Investigations
Ground-Based Investigations
Helio Ephemeris
OMNI (Combined 1AU IP Data; Magnetic and Solar Indices)
Smallsats/Cubesats
Sounding Rockets
ACE
Select zero OR more Instrument Types
(default = All Instrument Types if >=1 Source is selected)
Activity Indices
Electric Fields (space)
Electron Precipitation Bremsstrahlung
Energetic Particle Detector
Engineering
Ephemeris/Attitude/Ancillary
Gamma and X-Rays


SKTEditor: mms1_aspoc_srvy_l2_00000000_v01.cdf
File Edit Tools Help
Information
ISTP Global Attributes
Variables
Required
Project
STP>Solar-Terrestrial Physics
Source / Spacecraft Name
MMS1>MMS Satellite Number 1
Descriptor / Instrument Name
ASPOC>Active Spacecraft Potential Control
Data Type
SRVY_L2>Level-2 Survey
File Naming Convention
source_descriptor_da...
yyyyM...
PI Name
K. Torkar, R. Nakamura
PI Affiliation
IWF
Discipline
Space Physics>Magnetospheric Science
Mission Group
MMS
Instrument Types
Spacecraft Potential Control
Logical Source / Short Dataset Description
Level 2 Active Spacecraft Potential Control Survey Data
Extended Dataset Descriptive Text
Recommended
Acknowledgement
Refer to IWF/OAW for rules of acknowledgement
Rules of Use
Refer to IWF/OAW for rules of use
SPASE ID
spase://NASA/NumericalData
Time Resolution
1 second
Generated by
Generation Date
Link Text (describing on-line data)
ASPOC
ASPOC
MMS
Link Title
Data Caveats and Current Release Notes at LASP MMS SDC
Team Home Page at IWF
Public Overview at NASA
HTTP Link
https://lasp.colorado.edu/mms/sdc/public/datasets/aspoc
http://www.iwf.oeaw.ac.at/en/forschung/erdnaher-weltraum/
http://www.nasa.gov/mission_pages/mms
Modification History
Ready
Show Messages

CDAWeb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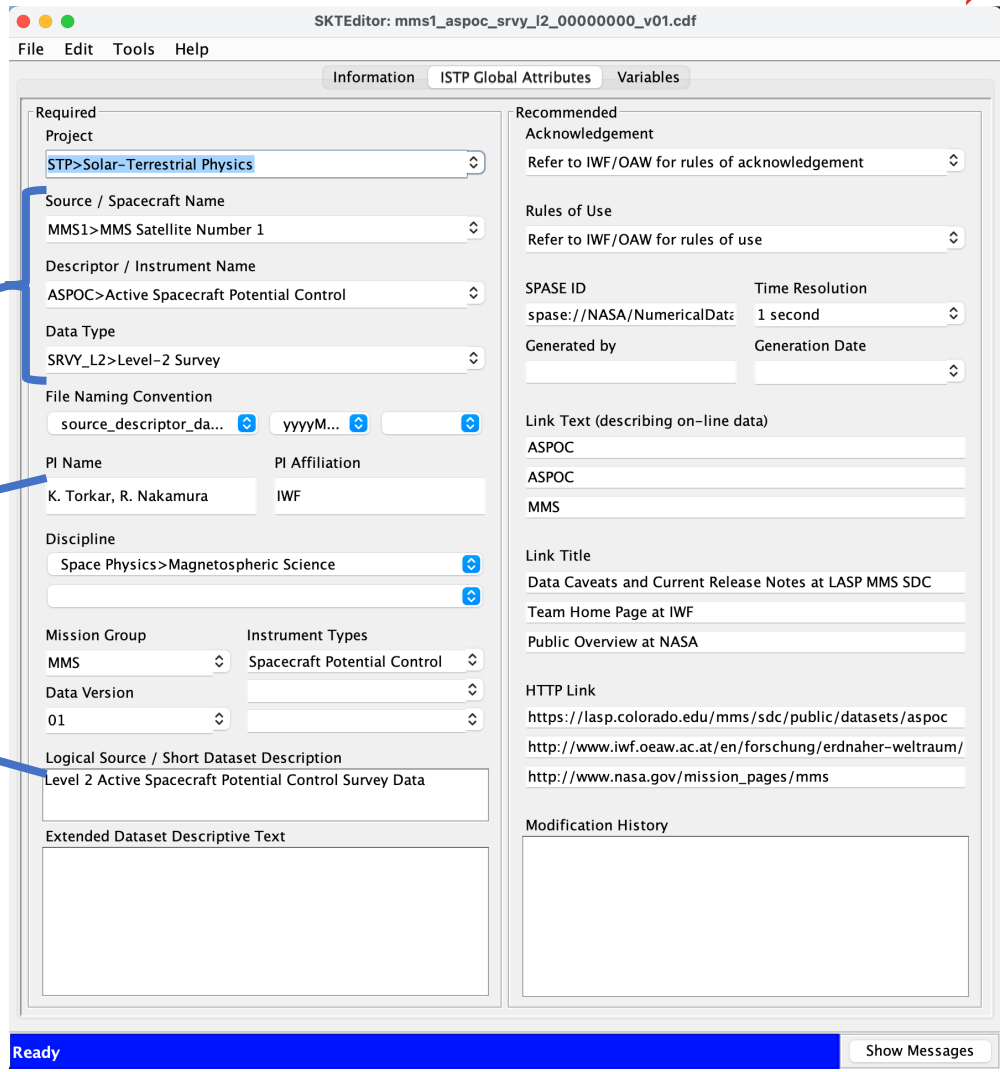
+ Goddard Home
+ NASA Home
+ SPDF HOME
+ MISSION DATA
+ MODELS at CCMC
+ SCIENCE ENABLED
+ AND MORE
+ CDAWeb Home
CDAWeb
+ FEEDBACK
Coordinated Data Analysis Web
CDAWeb Data Selector
SELECT AT LEAST ONE DATA SET below before pressing the "Submit" button to continue.
SELECT ALL checkboxes
CLEAR ALL checkboxes
Submit
MMS1_ASPOC_SRVY_L2: Level 2 Active Spacecraft Potential Control Survey Data - K. Torkar, R. Nakamura (IWF)
[Available Time Range: 2015/03/28 00:00:00 - 2024/03/04 23:59:59] Info Metadata
MMS2_ASPOC_SRVY_L2: Level 2 Active Spacecraft Potential Control Survey Data - K. Torkar, R. Nakamura (IWF)
[Available Time Range: 2015/03/28 00:00:00 - 2024/03/04 23:59:59] Info Metadata
MMS3_ASPOC_SRVY_L2: Level 2 Active Spacecraft Potential Control Survey Data - K. Torkar, R. Nakamura (IWF)
[Available Time Range: 2015/03/28 00:00:00 - 2024/03/04 23:59:59] Info Metadata
MMS4_ASPOC_SRVY_L2: Level 2 Active Spacecraft Potential Control Survey Data - K. Torkar, R. Nakamura (IWF)
[Available Time Range: 2015/03/28 00:00:00 - 2024/03/04 23:59:59] Info Metadata
Submit
Reset
NASA Official: Robert M. Candey
(301)286-6707, Robert.M.Candey@nasa.gov
Curator: Tami Kovalick
Last Modified: 15 Apr 2024
Contact SPDF: NASA-SPDF-Support@nasa.onmicrosoft.com
+ Privacy Policy and Important Notices
+ Accessibility


SKTEditor: mms1_aspoc_srvy_l2_00000000_v01.cdf
File Edit Tools Help
Information ISTP Global Attributes Variables
Required
Project
STP>Solar-Terrestrial Physics
Source / Spacecraft Name
MMS1>MMS Satellite Number 1
Descriptor / Instrument Name
ASPOC>Active Spacecraft Potential Control
Data Type
SRVY_L2>Level-2 Survey
File Naming Convention
source_descriptor_da...
yyyyM...
PI Name
K. Torkar, R. Nakamura
PI Affiliation
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Discipline
Space Physics>Magnetospheric Science
Mission Group
MMS
Instrument Types
Spacecraft Potential Control
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Level 2 Active Spacecraft Potential Control Survey Data
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SPASE ID
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Time Resolution
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Link Text (describing on-line data)
ASPOC
ASPOC
MMS
Link Title
Data Caveats and Current Release Notes at LASP MMS SDC
Team Home Page at IWF
Public Overview at NASA
HTTP Link
https://lasp.colorado.edu/mms/sdc/public/datasets/aspoc
http://www.iwf.oeaw.ac.at/en/forschung/erdnaher-weltraum/
http://www.nasa.gov/mission_pages/mms
Modification History
Ready
Show Messages

CDAWeb

Variable parameters (required for Listing, Creating and Plotting data only)

MMS1_ASPOC_SRVY_L2: Info Metadata

Level 2 Active Spacecraft Potential Control Survey Data - K. Torkar, R. Nakamura (IWF)

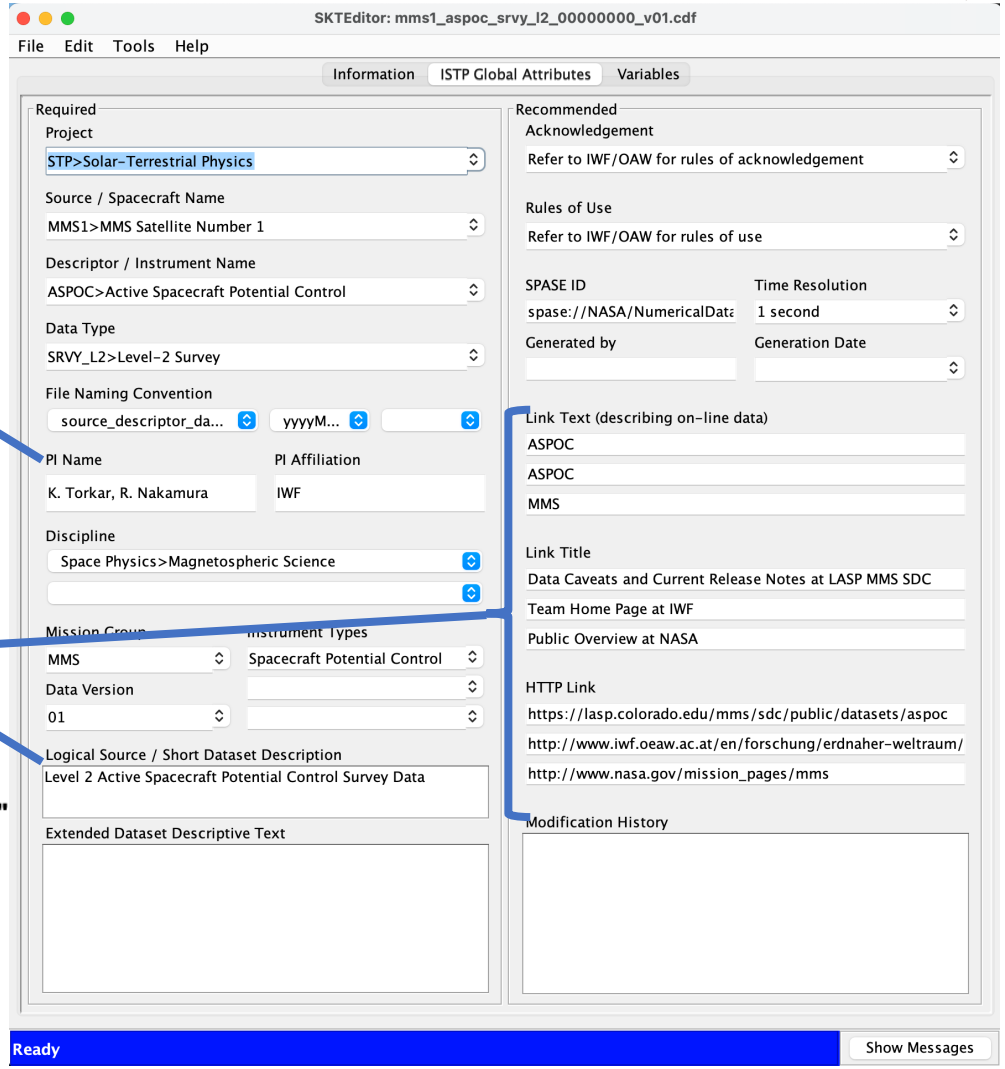
Available dates: 2015/03/28 00:00:00 - 2024/03/04 23:59:59
(Continuous coverage not guaranteed - check the inventory graph for coverage)

- ☐ ASPOC Ion Emission Current Sum, 1s resolution
- ☐ ASPOC Unit 1 Ion Emission Current, 1s resolution
- ☐ ASPOC Unit 2 Ion Emission Current, 1s resolution
- ☐ ASPOC Unit 1 Emitted Beam Energy, 1s resolution
- ☐ ASPOC Unit 2 Emitted Beam Energy, 1s resolution
- ☐ ASPOC Data Quality and Instrument Status, 1s resolution

[ASPOC Data Caveats and Current Release Notes at LASP MMS SDC]
[ASPOC Team Home Page at IWF]
[MMS Public Overview at NASA]
[MMS Misson Page at NASA GSFC]
[MMS/SMART Investigation Overview at SwRI]

Pressing the "Submit" button will spawn a new window/tab in order to support the new "Previous"

Submit Reset



Note: the current SKTEditor interface is limited to 3 links, but more can be specified by clicking “Tools” -> “Attribute Editor” or by editing the skeleton table

CDAWeb

Variable parameters (required for Listing, Creating and Plotting data only)

MMS1_ASPOC_SRVY_L2: Info Metadata

Level 2 Active Spacecraft Potential Control Survey Data - K. Torkar, R. Nakamura (IWF)

Available dates: 2015/03/28 00:00:00 - 2024/03/04 23:59:59
(Continuous coverage not guaranteed - check the inventory graph for coverage)

- [ ] ASPOC Ion Emission Current Sum, 1s resolution
- [ ] ASPOC Unit 1 Ion Emission Current, 1s resolution
- [ ] ASPOC Unit 2 Ion Emission Current, 1s resolution
- [ ] ASPOC Unit 1 Emitted Beam Energy, 1s resolution
- [ ] ASPOC Unit 2 Emitted Beam Energy, 1s resolution
- [ ] ASPOC Data Quality and Instrument Status, 1s resolution

[ASPOC Data Caveats and Current Release Notes at LASP MMS SDC]
[ASPOC Team Home Page at IWF]
[MMS Public Overview at NASA]
[MMS Misson Page at NASA GSFC]
[MMS/SMART Investigation Overview at SwRI]

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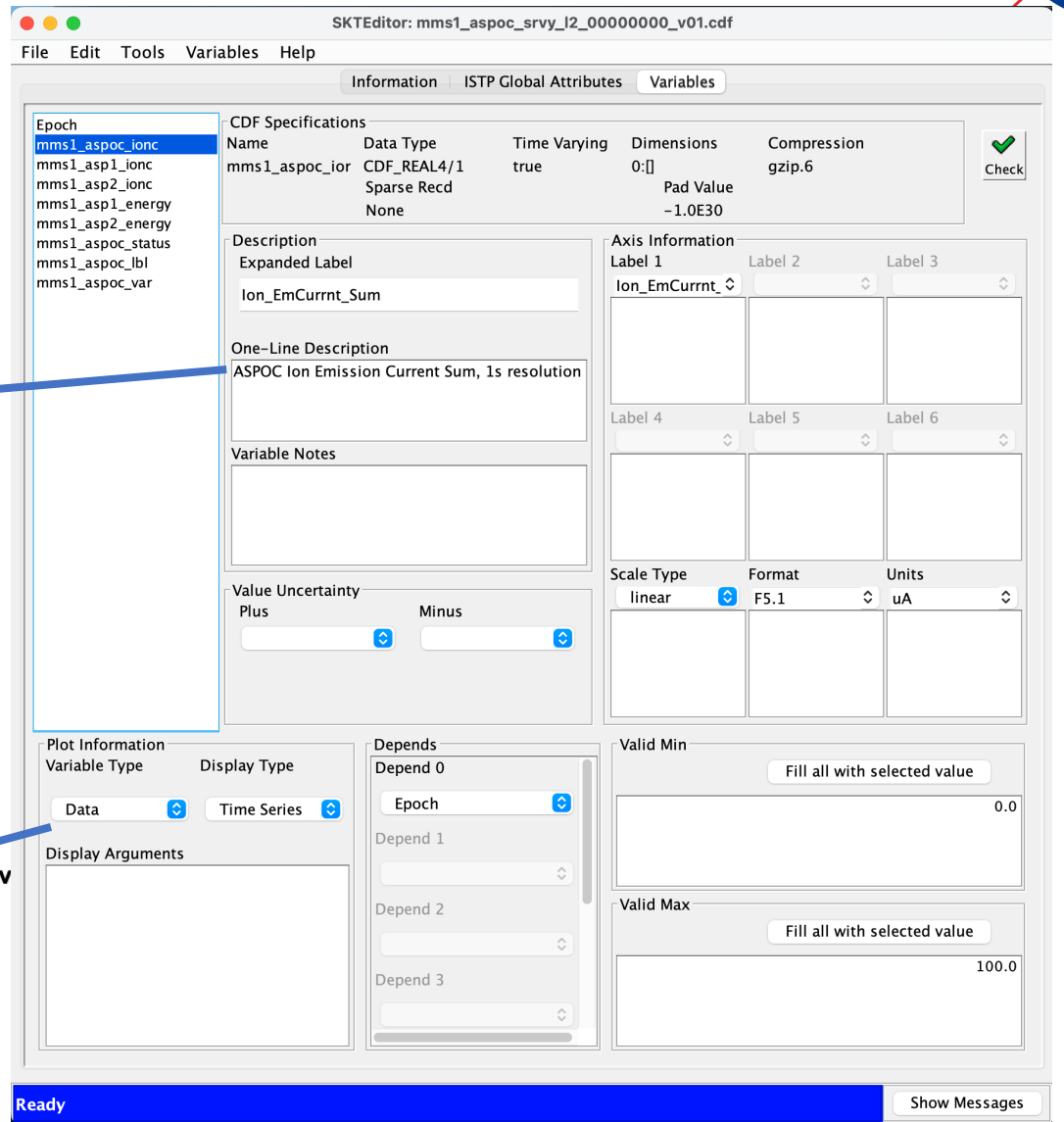
Submit Reset



Note: support data (e.g., the Epoch and label variables) aren't shown in the CDAWeb interface

CDAWeb

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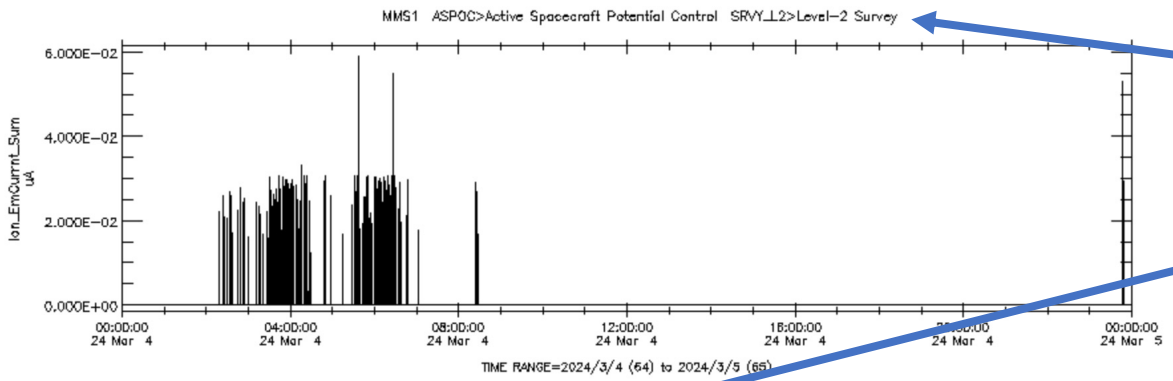
+ SPDF HOME | + MISSION DATA | + MODELS at CCMC | + SCIENCE ENABLED | + AND MORE

+ CDAWeb Home
CDAWeb
+ FEEDBACK

Coordinated Data Analysis Web

MMS1_ASPOC_SRVY_L2



Please acknowledge PI, K. Torkar, R. Nakamura at IWF and CDAWeb when using these data.
Generated by CDAWeb on Mon Apr 15 11:30:38 2024

<< Previous time range | Next time range >>
>> Zoom IN time range << | << Zoom OUT time range >>
< Pan left | Pan right >

Current Requested Time Range:
2024/03/04 00:00:00.000 to 2024/03/05 00:00:00.000
1 day(s) 0 hours 0 minutes 0 seconds

Return to: CDAWeb Data Explorer

notes and caveats

NASA Official: Robert M. Candey
(301)286-6707, Robert.M.Candey@nasa.gov
Curator: Tami Kovalick
Last Modified: 15 Apr 2024

Contact SPDF: NASA-SPDF-Support@nasa.onmicrosoft.com
+ Privacy Policy and Important Notices
+ Accessibility

SKTEditor: mms1_aspoc_srvy_l2_00000000_v01.cdf

File Edit Tools Help

Information | ISTP Global Attributes | Variables

Required

Project: STP>Solar-Terrestrial Physics

Source / Spacecraft Name: MMS1>MMS Satellite Number 1

Descriptor / Instrument Name: ASPOC>Active Spacecraft Potential Control

Data Type: SRVY_L2>Level-2 Survey

File Naming Convention: source_descriptor_da... | yyyyM...

PI Name: K. Torkar, R. Nakamura

PI Affiliation: IWF

Discipline: Space Physics>Magnetospheric Science

Mission Group: MMS

Instrument Types: Spacecraft Potential Control

Data Version: 01

Logical Source / Short Dataset Description: Level 2 Active Spacecraft Potential Control Survey Data

Extended Dataset Descriptive Text:

Recommended

Acknowledgement: Refer to IWF/OAW for rules of acknowledgement

Rules of Use: Refer to IWF/OAW for rules of use

SPASE ID: spase://NASA/NumericalDat

Time Resolution: 1 second

Generated by:

Generation Date:

Link Text (describing on-line data): ASPOC | ASPOC | MMS

Link Title: Data Caveats and Current Release Notes at LASP MMS SDC | Team Home Page at IWF | Public Overview at NASA

HTTP Link: https://lasp.colorado.edu/mms/sdc/public/datasets/aspoc | http://www.iwf.oeaw.ac.at/en/forschung/erdnaher-weltraum/ | http://www.nasa.gov/mission_pages/mms

Modification History:

Ready | Show Messages

CDAWeb

GODDARD SPACE FLIGHT CENTER
Space Physics Data Facility

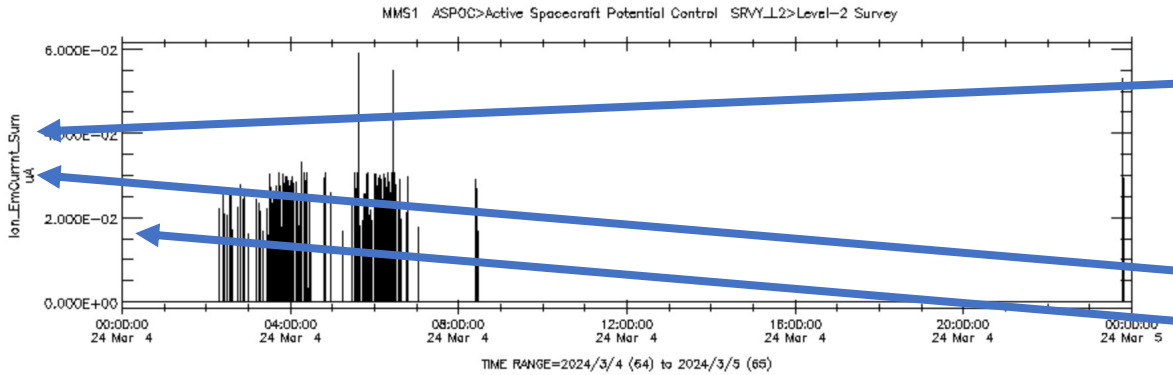
+ Goddard Home
+ NASA Home

+ SPDF HOME | + MISSION DATA | + MODELS at CCMC | + SCIENCE ENABLED | + AND MORE

+ CDAWeb Home
CDAWeb
+ FEEDBACK

Coordinated Data Analysis Web

MMS1_ASPOC_SRVY_L2



Please acknowledge PI, K. Torkar, R. Nakamura at IWF and CDAWeb when using these data.
Generated by CDAWeb on Mon Apr 15 11:30:38 2024

<< Previous time range | Next time range >>
>> Zoom IN time range << | << Zoom OUT time range >>
< Pan left | Pan right >

Current Requested Time Range:
2024/03/04 00:00:00.000 to 2024/03/05 00:00:00.000
1 day(s) 0 hours 0 minutes 0 seconds

Return to: CDAWeb Data Explorer

notes and caveats

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(301)286-6707, Robert.M.Candey@nasa.gov
Curator: Tami Kovalick
Last Modified: 15 Apr 2024

Contact SPDF: NASA-SPDF-Support@nasa.onmicrosoft.com
+ Privacy Policy and Important Notices
+ Accessibility

SKTEditor: mms1_aspoc_srvy_l2_00000000_v01.cdf

File Edit Tools Variables Help

Information | ISTP Global Attributes | Variables

Epoch
mms1_aspoc_ionc
mms1_asp1_ionc
mms1_asp2_ionc
mms1_asp1_energy
mms1_asp2_energy
mms1_aspoc_status
mms1_aspoc_lbl
mms1_aspoc_var

CDF Specifications

Name	Data Type	Time Varying	Dimensions	Compression
mms1_aspoc_ior	CDF_REAL4/1	true	0:[]	gzip.6
	Sparse Recd		Pad Value	
	None		-1.0E30	

Check

Description
Expanded Label
One-Line Description: ASPOC Ion Emission Current Sum, 1s resolution
Variable Notes

Axis Information
Label 1: Ion_EmCurrnt_
Label 2 | Label 3 | Label 4 | Label 5 | Label 6

Value Uncertainty
Plus | Minus

Scale Type: linear | Format: F5.1 | Units: uA

Plot Information
Variable Type: Data | Display Type: Time Series
Display Arguments

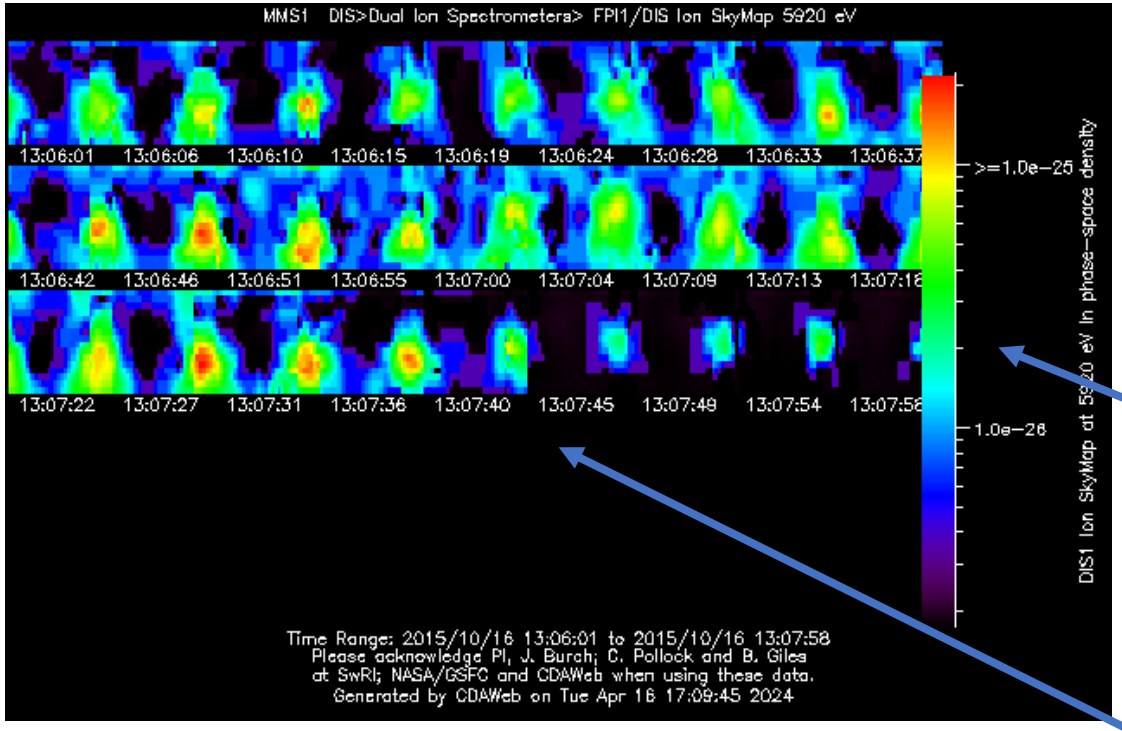
Depends
Depend 0: Epoch
Depend 1 | Depend 2 | Depend 3

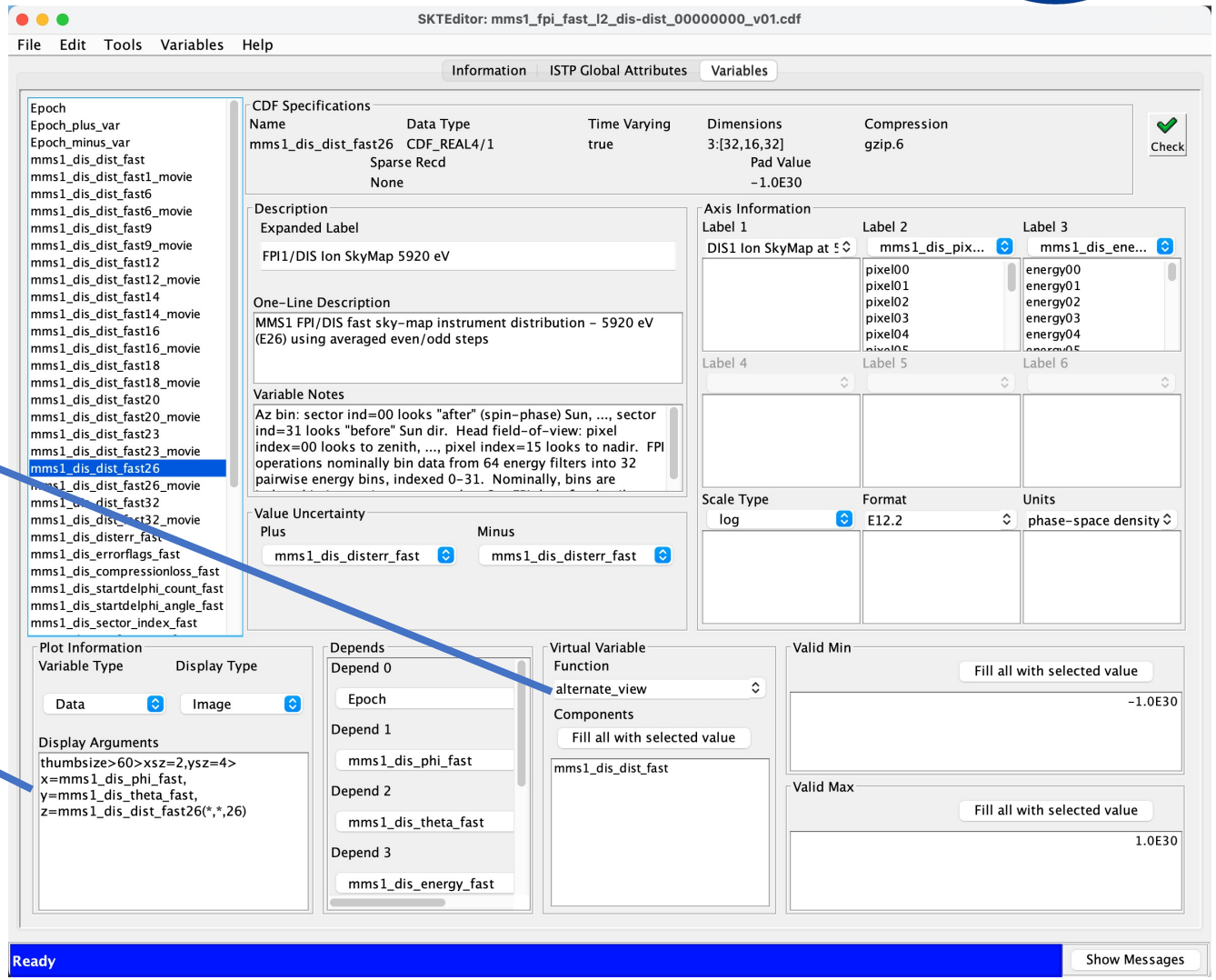
Valid Min
Fill all with selected value
0.0

Valid Max
Fill all with selected value
100.0

Ready | Show Messages

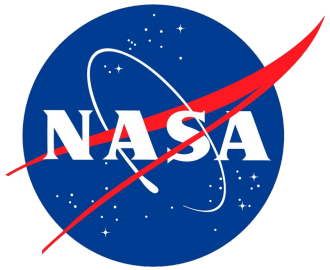
CDAWeb





Note: plotting of multi-dimensional variables are enabled by the SPDF team adding virtual variables. Please make higher level products, so we don't have to do this!

Thank you!



- We have many more examples at:
  - https://spdf.gsfc.nasa.gov/istp_guide/variables.html
- Please contribute to the metadata standards:
  - https://github.com/IHDE-Alliance/ISTP_metadata