# NASA Space Physics Data Facility (SPDF) Archives and the Heliophysics Data Environment and International Heliophysics Data Environment Alliance

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Space Physics Data Facility (SPDF) <https://spdf.gsfc.nasa.gov>

NASA Heliophysics Active Final Archive for non-solar data

# Introduction to SPDF

- **SPDF** <https://spdf.gsfc.nasa.gov> is the active and final archive of non-solar data from NASA heliophysics missions, including collaboration missions with other US and foreign agencies

- We also archive other data **relevant to NASA heliophysics science objectives**
  - Related data from planetary missions (e.g., MESSENGER, MAVEN, New Horizons)
  - Heliophysics data from some NOAA and DoD satellites (e.g., GOES, DSCOVR)
  - Ground-based magnetometers, aurora cameras, radars, etc., which are funded by NSF or other agencies/programs

- The data covers the space from the Sun to the local interstellar medium, including magnetosphere, ionosphere, thermosphere, and mesosphere (M-ITM) of the Earth and other applicable planets

- 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 Plus: solar wind conditions, especially at the bowshock nose

- 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
  - Ancillary services & software (orbits, data standards, special products)

# SPDF as part of the broader science community

- SPDF is non-solar sister to the NASA **Solar Data Analysis Center (SDAC)** <https://umbra.nascom.nasa.gov/>

- SPDF and SDAC are the NASA archives under the NASA **Heliophysics Data Environment (HPDE)** <https://hpde.gsfc.nasa.gov/>

- SPDF is a member of the **International Heliophysics Data Environment Alliance (IHDEA)** <https://ihdea.net/>

- SPDF provides critical infrastructure tools 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>
  - Heliophysics Data Environment (HPDE) Data File Internal Metadata (previously ISTP) Guidelines

# Over 132 Missions Supported by SPDF

*Only orbit data available

| | | | | | |
|---|---|---|---|---|---|
| ACE | Cassiope | GOES | LUNA | Pioneer | STEREO |
| Active* | Cluster | GOLD | Magsat | Pioneer 10 | Suisei |
| Aeros | Cosmos 900 | GMS 3 | MAP | Pioneer 11 | Swarm |
| AIM | C-NOFS | Granat | Mariner 10 | Pioneer Venus | Tatiana |
| Akebono* | CRRES | Hawkeye | Mars | Polar | THEMIS |
| Alouette1 | CSSWE | Helios | MAVEN | Prognoz | TIMED |
| Alouette2 | Dawn* | Hinode | MESSENGER | Reimei | TRACE |
| AMPTE | DEMETER* | Hinotori | Microlab 1 | Rosetta* | TWINS |
| APEX-MAIN* | DMSP | IMAGE | Mir* | RHESSI | UARS* |
| Apollo | Double Star* | IMP 7 | MMS | ROCSAT-1 | Ulysses |
| Aqua | DSCOVR | IMP 8 | MRO | SAMPEX | Van Allen Probes |
| Ariel-4 | DE | IMP_early | MSL | Sakigake* | Vega |
| Arase (ERG) | Equator-S | Interball | MSX* | San Marco | Venera |
| ARCAD | Explorer | ISEE | Munin | SCATHA* | Viking |
| ARTEMIS | FAST | ISEE 3-ICE | New Horizons | SDO | Voyager |
| ASTRID II* | FIREBIRD* | ISIS | NOAA* | SMILE | Voyager 1 |
| AE | Freja* | ISS | Oersted | SNOE | Voyager 2 |
| Aura | Galileo* | Jason 2 | OGO | SOHO | Wind |
| Aureol2 | GCOM W1 | Juno | Ohzora | SORCE | XMM-Newton |
| BARREL | Genesis | Kepler | PARASOL | Spartan-A | Yohkoh* |
| CALIPSO | Geotail | LANL | Parker Solar Probe | Spitzer | Zond |
| Cassini* | Giotto* | LRO | Phobos | Sputnik 1 | |

Total:  ~10,000 datasets, ~350 TB data

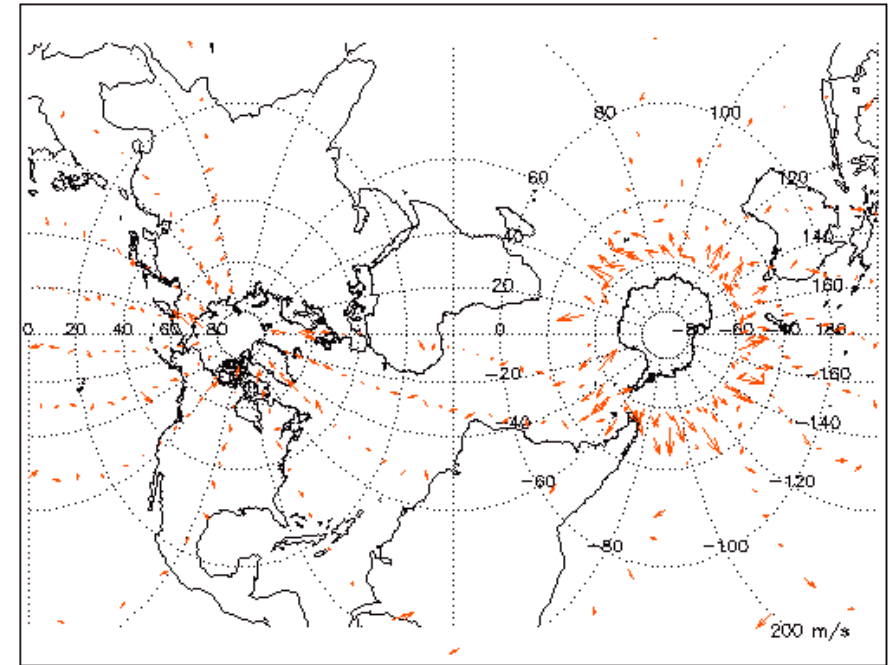Recent average monthly data ingestion rate:  ~0.6 million data files, ~13.7 TB data
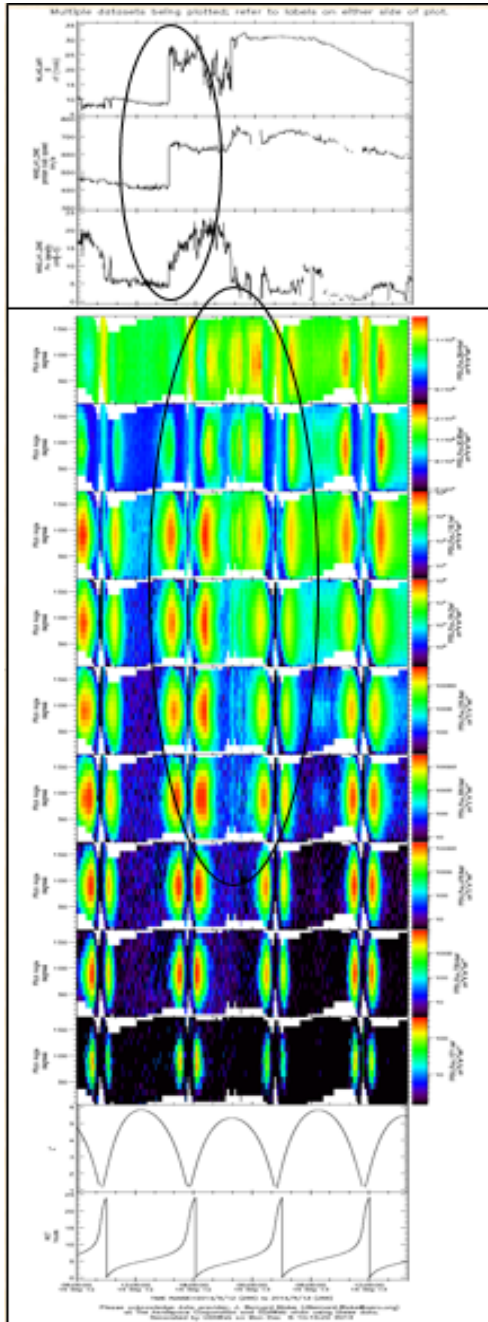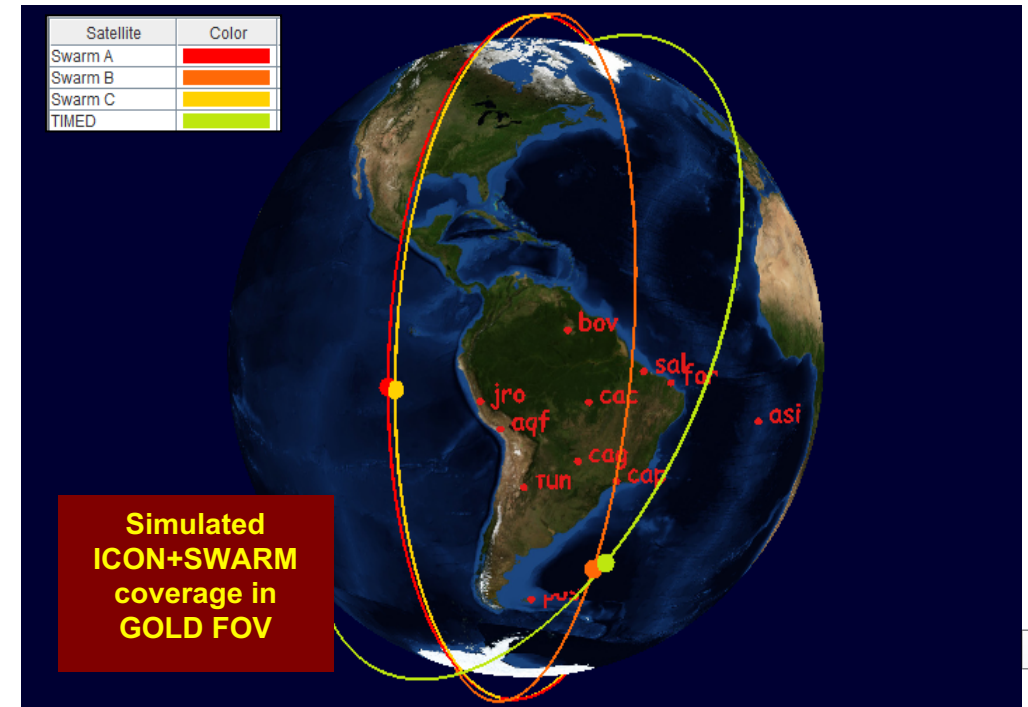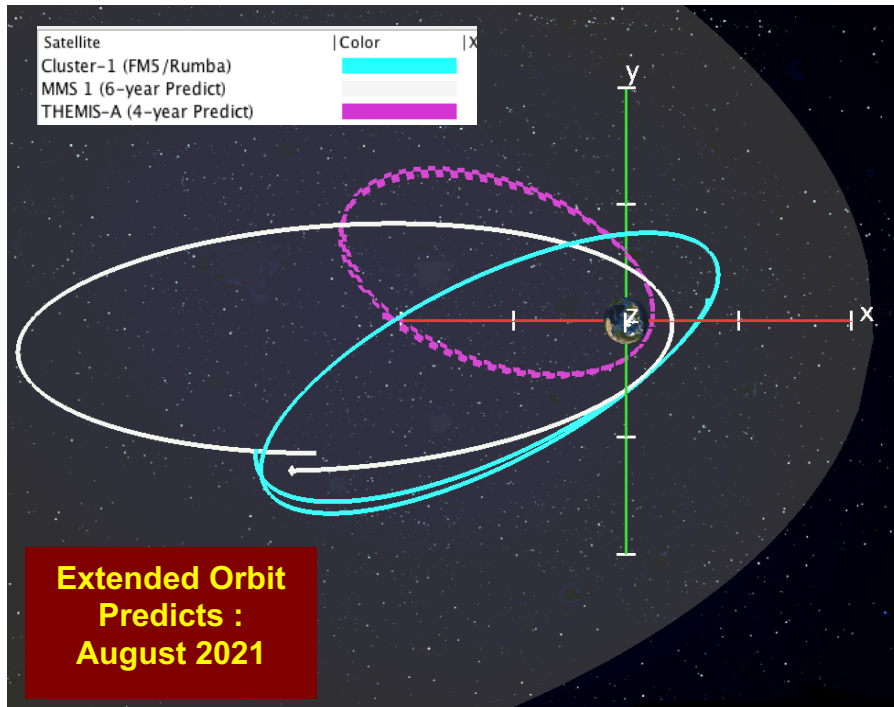
# Parameter Displays in CDAWeb



WIND MFI & SWE
Van Allen Probe A ECT & MagEIS
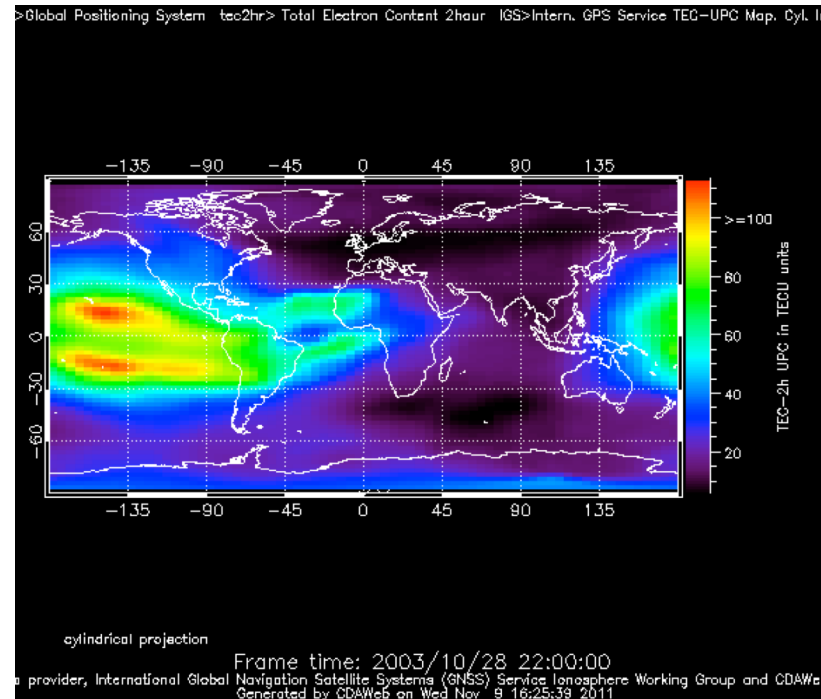


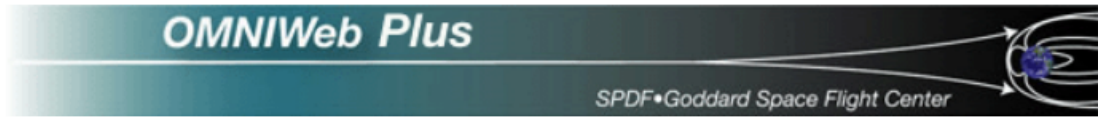GPS International GNSS Service Total Electron Content



TIMED/TIDI Wind Vectors Movie Transverse Mercator Projection

5

# Satellite Situation Center (SSCWeb)

o Include most heliospheric satellites and many ground stations

o Plot and list orbits of multiple s/c in a variety of coordinate systems

o **4D Orbit Viewer:** Interactive 4D animation of orbits

o Query for satellite-satellite and satellite-ground station conjunction



| Satellite | Color | X |
|---|---|---|
| Cluster-1 (FM5/Rumba) | | |
| MMS 1 (6-year Predict) | | |
| THEMIS-A (4-year Predict) | | |

**Extended Orbit Predicts : August 2021**



| Satellite | Color |
|---|---|
| Swarm A | |
| Swarm B | |
| Swarm C | |
| TIMED | |

**Simulated ICON+SWARM coverage in GOLD FOV**

# OMNIWeb Plus

- OMNI Data: Database of solar wind magnetic field and plasma parameters mapped to the nose of the Earth's bow shock

- Based on a large volume of quality-controlled satellite measurements (since Nov. 1963)

- **COHOWeb**: Solar wind field, plasma, and proton fluxes in other locations of heliosphere, especially useful for planetary studies and heliospheric model validation

- Interface for plotting, filtering, and downloading the data

# SPDF data and services are widely used
(see reports at <https://cdaweb.gsfc.nasa.gov/publiclogs/>)



34% of heliophysics papers in AGU journals
acknowledged SPDF services and data
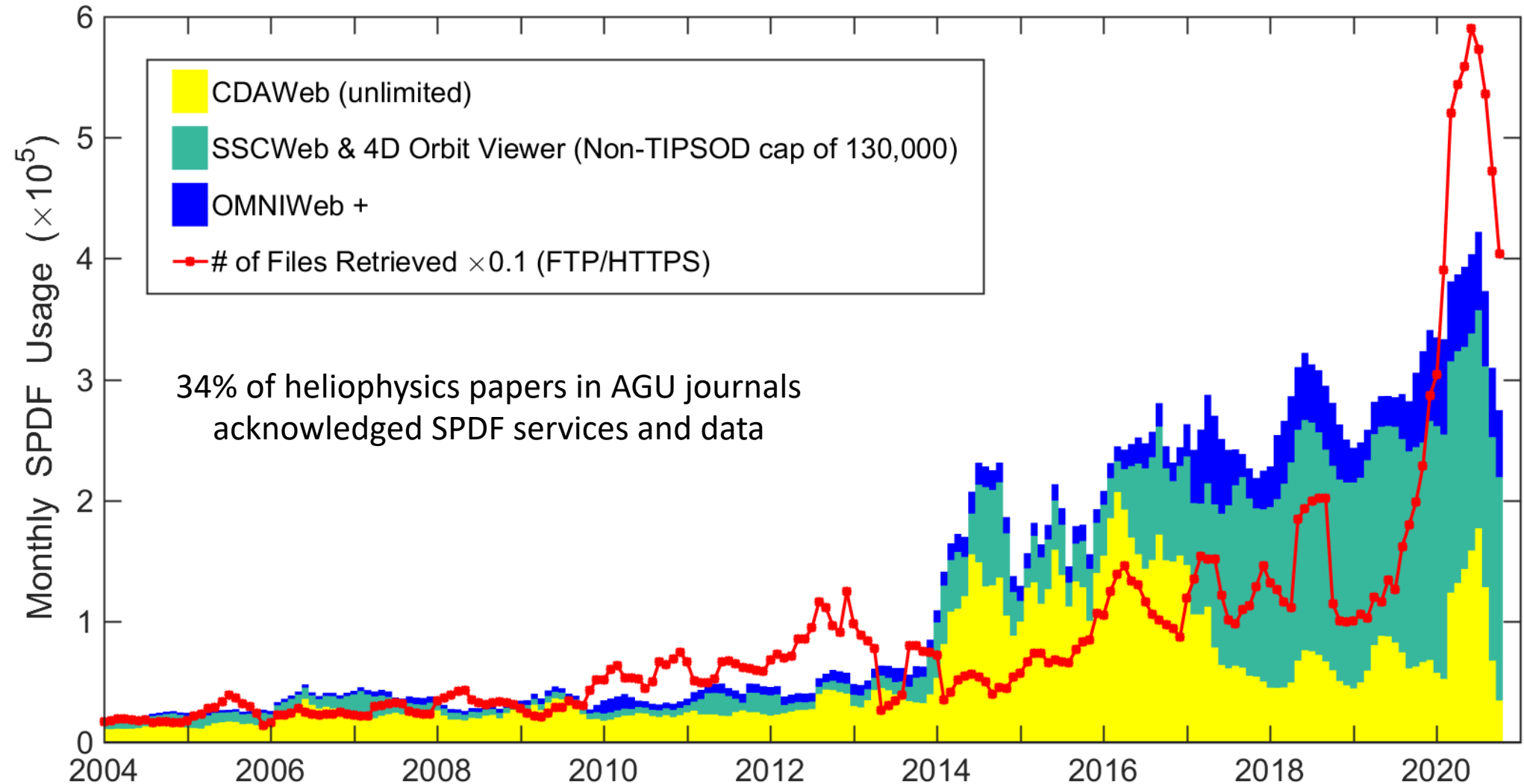
# SPDF activities in past year and near future

- Added Parker Solar Probe (85), AIM, GOLD, IBEX data (40), and Explorer-35

- Working on Solar Orbiter (74) and ICON data, final data from Van Allen Probes, TWINS.

- New mission requirements <https://spdf.gsfc.nasa.gov/guidelines/archive_newdata_reqt.html>

- Exploring changes to become part of NASA's Heliophysics Digital Resource Library, such as additional outreach materials, user support, and support for data in cloud services

- Will add webservices for event lists for burst mode data and science events (CMEs, bow shock crossings, etc.) and support to SSCweb and CDAWeb

- Adding SPASE Resource ID and DOI to CDAWeb metadata and display

- CDAWeb added netCDF support, variable_purpose attribute, IBEX mapped images

- CDF: planning new features and tools, systematize ISTP metadata guidelines, explore cloud support

- Developing alternatives to the Java-based 4D Orbit Viewer and SKTeditor tools

# SPDF provides multiple services and access methods

- Direct file downloads via FTPS and HTTPS <https://spdf.gsfc.nasa.gov/pub/data/>

- Orbit and ground track displays/queries via SSCWeb and 4D Orbit Viewer

- CDAWeb services:
  - Data files, plots and listings with supersets or subsets by time & selected variables, time-binning
  - Web service interfaces (REST, SOAP, IDL, Matlab, Java, Python) <https://cdaweb.gsfc.nasa.gov/WebServices/>
  - New HAPI (Heliophysics API) <https://cdaweb.gsfc.nasa.gov/hapi>
  - Autoplot autoplot.org/help#CDAWeb
  - Other methods such as IDL <https://cdaweb.gsfc.nasa.gov/alternative_access_methods.html>

- SPDF complement the services of the mission and instrument teams

- SPDF auto-ingest scripts check all supported mission data sites daily to retrieve new data files, and CDF files are validated and ingested

- Master CDFs add or improve metadata for use in CDAWeb

- The **SPASE** (Space Physics Archive Search and Extract <http://www.spase-group.org/>) team use the master CDFs to generate SPASE IDs and descriptions for all datasets, to add entries to the **Heliophysics Data Portal** <https://heliophysicsdata.gsfc.nasa.gov>

# Heliophysics Data Portal

The **SPASE** (Space Physics Archive Search and Extract <http://www.spase-group.org/>) team use the master CDFs to generate SPASE IDs and descriptions for all datasets, to add entries to the **Heliophysics Data Portal** <https://heliophysicsdata.gsfc.nasa.gov>

# SPDF Home Page

## Space Physics Data Facility
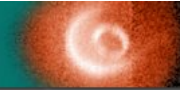
+ ABOUT  + DATA & ORBITS  + ModelWeb at CCMC  + SCIENCE ENABLED  + AND MORE

### NASA's Space Physics Data Facility (SPDF)

Space Physics Data Facility (SPDF) is the NASA active and permanent archive for non-solar heliophysics data (solar data at SDAC), per the NASA Heliophysics Science Data Management Policy. SPDF is a project of the Heliophysics Science Division (HSD) at NASA's Goddard Space Flight Center. SPDF also provides multi-project, cross-disciplinary access to data to enable correlative and collaborative research across discipline and mission boundaries with present and past missions. SPDF maintains the SSCweb database of spacecraft orbits, the OMNIweb cross-normalized database, and the Common Data Format (CDF) self-describing science data format and associated software.

**Data Access & Orbit Services**

+ Heliophysics Data (search) Portal
+ Gateway to SPDF Services
+ CDAWeb (data browser)
+ CDAWeb Inside IDL
+ OMNIWeb Plus
   (now including COHOWeb, ATMOWeb, FTP Browser, HelioWeb and CGM)
+ Direct HTTP(S) to Data
+ Direct FTP(S) to Data
   (FTPS required)
+ SSCWeb (orbit search)
+ 4D Orbit Viewer
+ GIFWalk data and orbit plots
+ Alternative Data Access Methods
+ SDAC VSO - Virtual Solar Observatory
+ SDAC - Solar Data Analysis Center
+ More information on Data Access for New Users

**Access Models**

+ Community Coordinated Modeling Ctr. (CCMC)
+ ModelWeb at CCMC

**Heliophysics Virtual Observatories**

+ VEPO - Virtual Energetic Particle Observatory
+ VWO - Virtual Wave Observatory

**General**

+ NASA's Heliophysics Data Environment
+ SPASE Data Model and Dictionary
+ IHDEA - International Heliophysics Data Environment Alliance
+ Heliophysics Education and Public Outreach
+ Science Visualization Studio

### News & Announcements

**NOTICE: November 18, 2020: The Parker Solar Probe (PSP) data has been extended through August 2020, for most data sets, and includes encounter 5 and the remainder of orbit 5. The new data files were added to the CDAWeb system and to the SPDF PSP archive.**

**NOTICE: November 11, 2020: The insitu and ephemeris data from the Solar Orbiter mission are available at the SPDF Solar Orbiter archive. The Level 2 and above of science data as well as the low latency data are served at CDAWeb. All the data are mirrored from the ESA Solar Orbiter Archive.**

**NOTICE: July 2020: SPDF WEB ADDRESS CHANGES: Alternate names for the web addresses for various SPDF web sites have been deprecated and redirected to the standard name. For instance, please change any use of spdf.sci.gsfc.nasa.gov to https://spdf.gsfc.nasa.gov/ and cdaweb.sci.gsfc.nasa.gov to https://cdaweb.gsfc.nasa.gov/.**

NOTICE: The MMS Level 2 data products are available via SPDF HTTPS and all data sets are available in CDAWeb. The range of publicly available MMS data will continue to be updated weekly.

#### New CDF Version 3.8.0 Released

Common Data Format (CDF) Version 3.8.0 is now available. Updates for Perl, IDL, Matlab, and Java interfaces and the SKTeditor CDF editor are available. For further details and changes, see the CDF release notes.

#### Previous Parker Solar Probe (PSP) Data updates

#### Let's Not Lose Our Data

**SPDF Web Service APIs**

+ CDAWeb
+ SSCWeb
+ Heliophysics API (HAPI)

**Software**

+ CDF (Common Data Format)
+ Space Physics use of CDF
+ CDF/netCDF/FITS/ HDF/XML /ASCII Format Translations
+ CDF SKTEditor
+ MakeCDF
+ CDAWlib /CDFX (IDL)
+ ViSBARD (visualization)

**Submit New Data to the Archive**

+ New mission data requirements
+ Overview of SPDF Data Submission Guidelines and Procedures
+ Registering Data Products with SPASE metadata descriptions
+ HPDE Data File Internal Metadata (previously ISTP) Guidelines
+ Recommended file and data collection naming practices
+ Heliophysics URI Template Standard

**Additional Databases**

+ LunaSOX - Lunar Solar Origins Exploration
+ Multi-satellite Bow Shock Database
+ Multi-satellite Magnetopause Crossing Database

**Links**

+ SPDF Feedback/Support
+ Heliospheric Physics Laboratory (672)
+ Heliophysics Science Division (670)
+ NSSDCA - National Space Science Data Coordinated Archive

# Abstract

The Space Physics Data Facility (SPDF https://spdf.gsfc.nasa.gov) and Solar Data Analysis Center (SDAC https://umbra.nascom.nasa.gov/), as the NASA Heliophysics active final archives, are chartered to preserve and distribute heliophysics data from NASA missions and relevant other data.

Working in cooperation with current operating missions and the heliophysics community, SPDF ingests, preserves and serves a wide range of past and current public science-quality data from the ionosphere into the furthest reach of deep-space exploration. SPDF facilitates scientific analysis of multi-instrument and multi-mission datasets to enhance the science return of multiple missions by making them available in a common way with standardized formats, metadata and web services.

SPDF develops and maintains the Common Data Format (CDF) and the associated Heliophysics Data Environment (HPDE) Data File Internal Metadata (previously ISTP) Guidelines.

SPDF services include CDAWeb, which supports both survey and burst mode data with graphics, listings and data superset/subset functions. All public data held by SPDF are also available for direct file download by HTTPS or FTPS links.

SPDF is currently receiving and serving from missions including Parker Solar Probe, Helios, MMS, Van Allen Probes, THEMIS/ARTEMIS, GOLD, ACE, Cluster, Geotail, Polar, Wind and many others, and more than 120 Ground-Based investigations. SPDF recently added support for ARASE/ERG and MAVEN as supplementary access at the requests of those missions.

SPDF also operates the multi-mission orbit displays and query services of SSCWeb and the Java-based 4D Orbit Viewer, as well as the Heliophysics Data Portal (HDP) discipline-wide data inventory and access service, and the OMNIweb near-Earth solar wind plasma and magnetic field database.

SPDF is a member of the International Heliophysics Data Environment Alliance (IHDEA https://ihdea.net/). IHDEA seeks to create an open heliophysics data environment to more effectively exchange and access diverse and complex heliophysics data products from space and ground-based instruments and models, through coordinated development and use of heliophysics standards for data, metadata, and services.