

# Update on Space Physics Data Facility (SPDF) Data Archives and Services

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Fall AGU 2020

2020 Dec. 14

Poster: SH037-0016

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

NASA Heliophysics Active Final Archive for non-solar data

# Abstract

The Space Physics Data Facility (SPDF <https://spdf.gsfc.nasa.gov>), as the non-solar NASA Heliophysics active final archive, works with current operating missions and the heliophysics community to ingest, preserve and serve a wide range of past and current public science-quality data from the mesosphere 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 the many missions. SPDF develops and maintains the Common Data Format (CDF) and the associated ISTP/SPDF metadata 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 from the SPDF home page (<https://spdf.gsfc.nasa.gov>). SPDF is currently receiving and serving from missions including Parker Solar Probe, MMS, Van Allen Probes, THEMIS/ARTEMIS, GOLD, ACE, Cluster, IBEX, Voyager, Geotail, Wind and many others, and >120 Ground-Based investigations. SPDF recently added support for ARASE/ERG and MAVEN as supplementary access at the requests of those missions, and is expecting Solar Orbiter and ICON data. 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 OMNIWeb and COHOWeb for near-Earth and deep-space solar wind plasma, magnetic field, and energetic particle database, respectively.

## Plain-Language Summary:

Working in cooperation with current operating missions and the heliophysics community, Space Physics Data Facility (SPDF <https://spdf.gsfc.nasa.gov>), as one of the NASA Heliophysics active final archives, preserves and distributes in-situ data. SPDF ingests, preserves and serves a wide range of past and current public science-quality data from the mesosphere into the furthest reach of deep-space exploration from a wide variety of heliophysics missions.

# Introduction to SPDF

- SPDF is the active and final archive of **in-situ 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 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 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>>

# Over 132 Missions Supported by SPDF

\* Only orbit data available

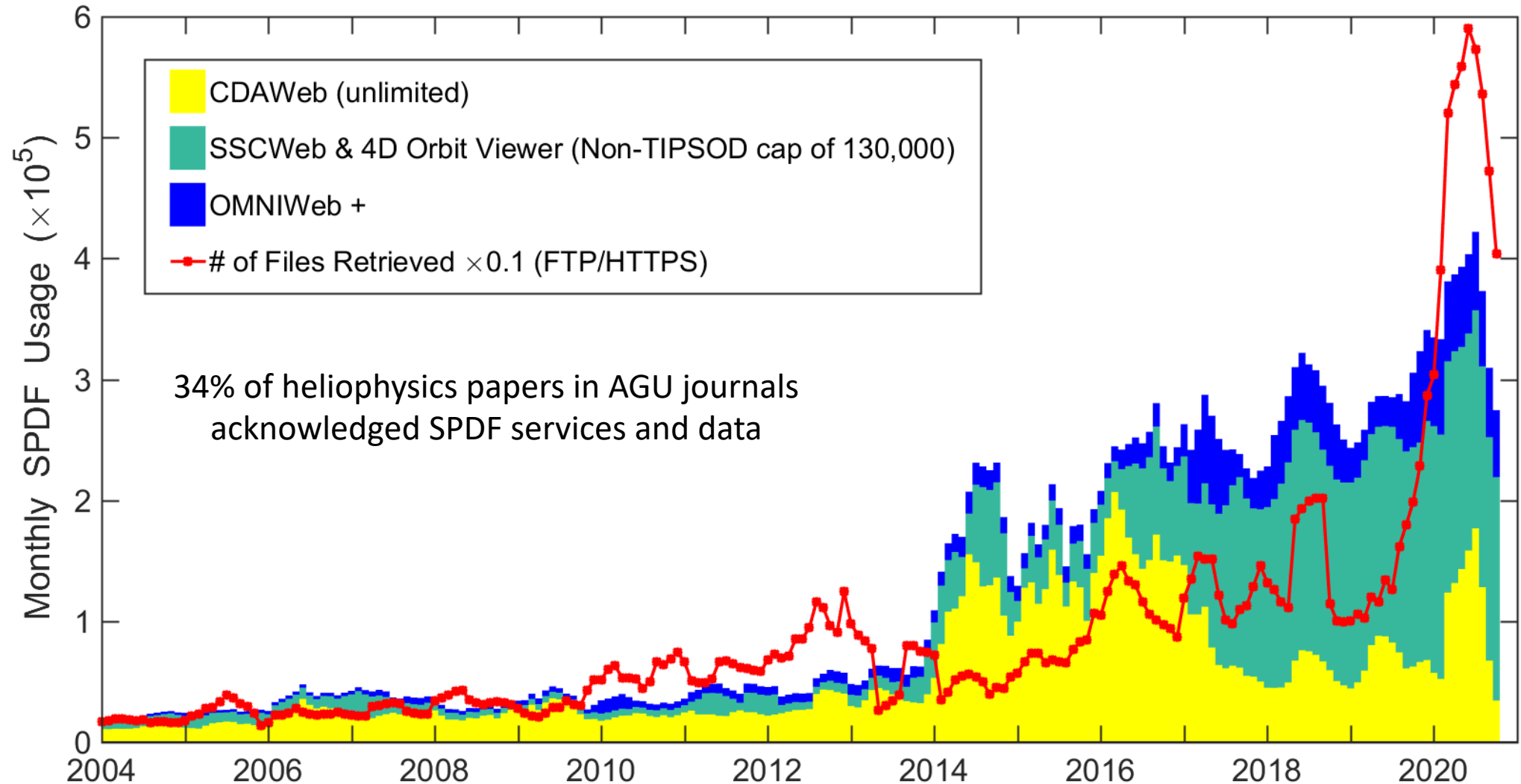
ACE	?	Cassiope	?	GOES	?	LUNA	?	Pioneer	?	STEREO	?
Active*	?	Cluster	?	GOLD	?	Magsat	?	Pioneer 10	?	Suisei	?
Aeros	?	Cosmos 900	?	GMS 3	?	MAP	?	Pioneer 11	?	Swarm	?
AIM	?	C-NOFS	?	Granat	?	Mariner 10	?	Pioneer Venus	?	Tatiana	?
Akebono*	?	CRRES	?	Hawkeye	?	Mars	?	Polar	?	THEMIS	?
Alouette1	?	CSSWE	?	Helios	?	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	?		

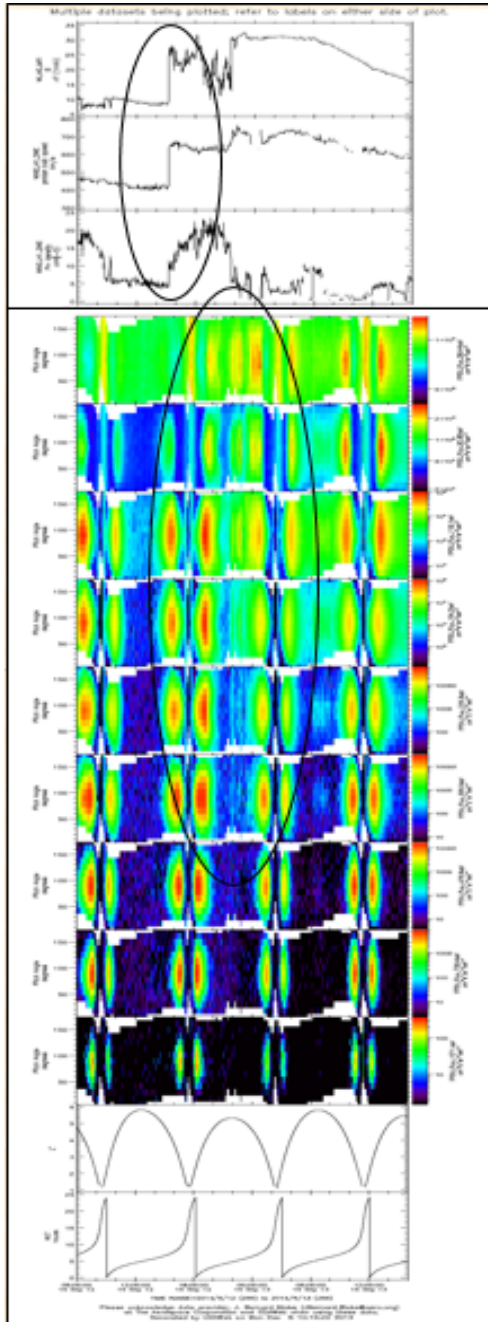
Total: ~10,000 datasets, ~350 TB data

Recent average monthly data ingestion rate: ~0.6 million data files, ~13.7 TB data

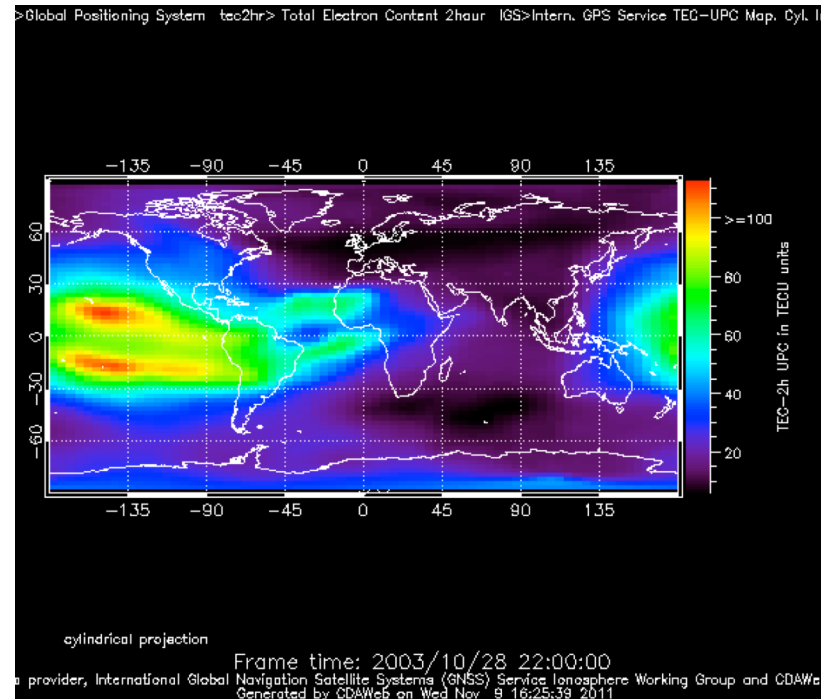
# Extensive use of SPDF Data and Services

(see reports at <<https://cdaweb.gsfc.nasa.gov/publiclogs/>>)

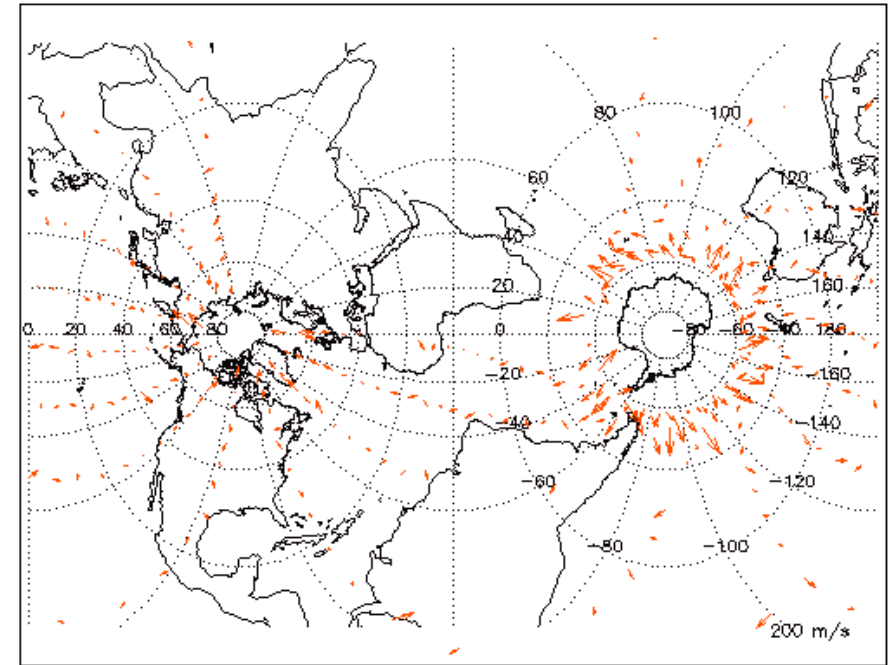




# Parameter Displays in CDAWeb



GPS International GNSS Service Total  
Electron Content

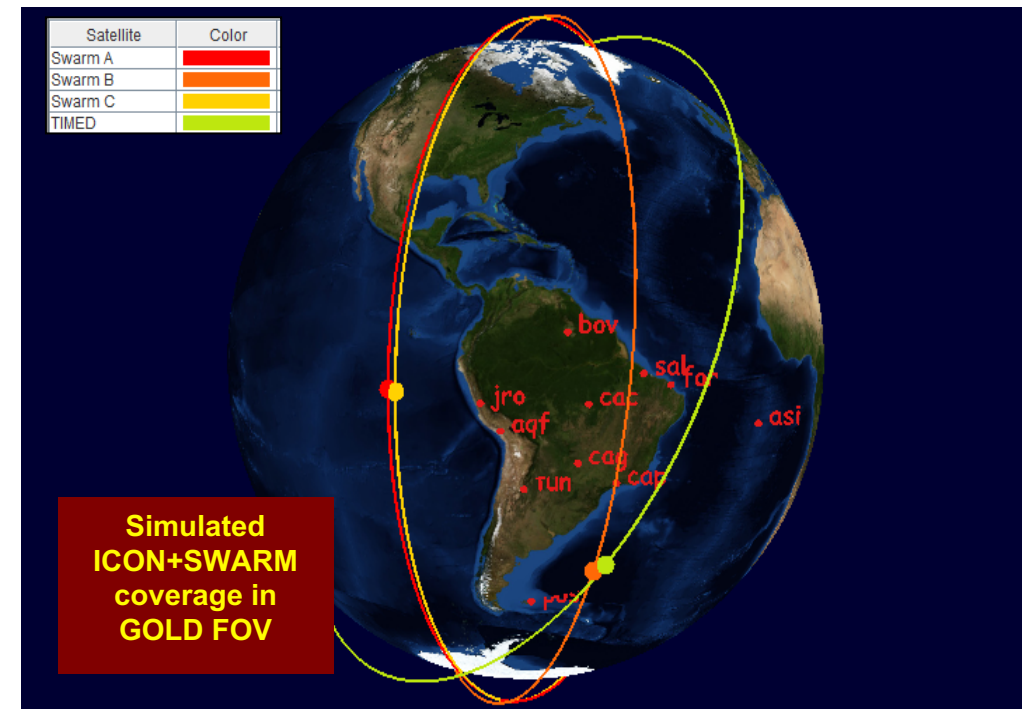
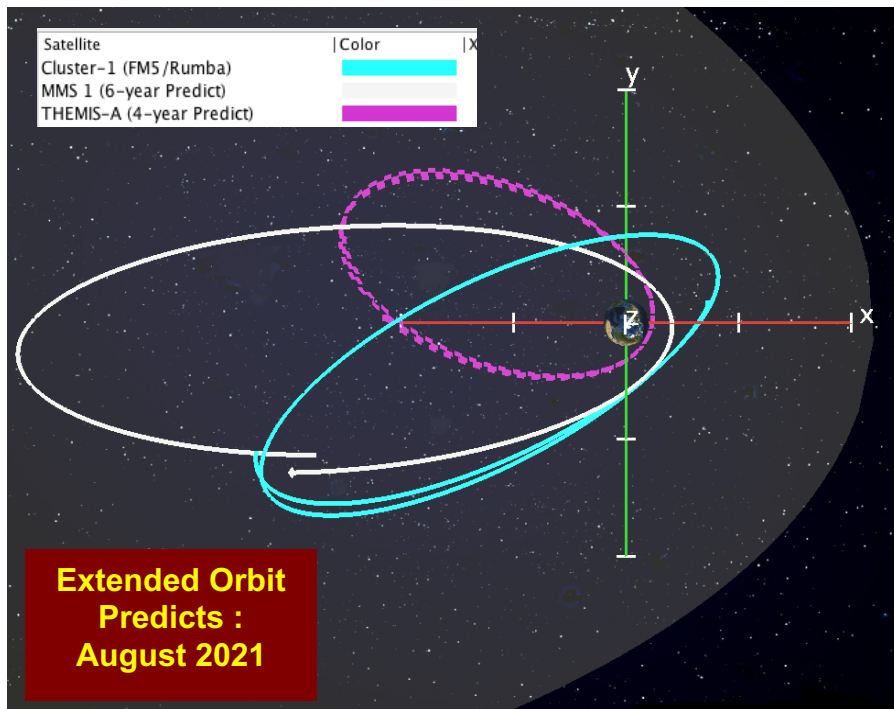


TIMED/TIDI Wind Vectors Movie  
Transverse Mercator Projection

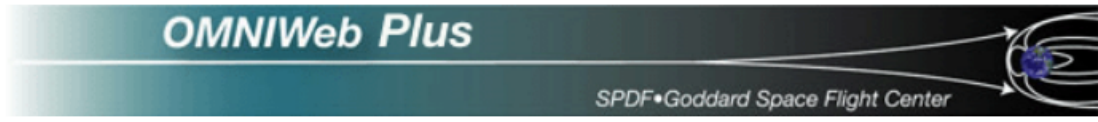


# Satellite Situation Center (SSCWeb)

- Include most heliospheric satellites and many ground stations
- Plot and list orbits of multiple s/c in a variety of coordinate systems
- **4D Orbit Viewer:** Interactive 4D animation of orbits
- Query for satellite-satellite and satellite-ground station conjunction



- OMNIWeb Plus, Home
+ ABOUT THE DATA
+ABOUT THE INTERFACE
+Data from command line
+ SPDF/FTP
+ Citing OMNI data usage
DATA via FTPBrowser
Energetic Particle fluxes
ATMOWeb main page
CGM transformation



Paths to Magnetic field, Plasma, Energetic particle data relevant to heliospheric studies and resident at Goddard's Space Physics Data Facility.

- OMNI data (spacecraft-interspersed, near-Earth solar wind data)
  - Low resolution OMNIWeb (1-hour, 1 and 27 days, 1963 - current)
  - High resolution OMNIWeb (1-min, 5-min, 1981 - current)
- Spacecraft-specific data sets (near 1 AU, including near-Earth)
  - + ACE
  - + Geotail
  - + IMP-8, IMP6&7
  - + Wind
  - + Explorer 33&35, Genesis, ISEE 3, Prognoz, SOHO, GOES
  - + Moon Related Spacecraft
  - + DSCOVR
- Deep space data
  - COHOWeb-formatted hourly solar wind field, plasma and proton fluxes
  - + Pioneer
  - + Ulysses
  - + Voyager
  - + Cassini, Helios, Mariner, STEREO
- Interfaces for comparing multi-source data
  - + Merged Magnetic field and Plasma 1-min
  - + Magnetic field
  - + Plasma
  - Energetic particle fluxes
    - Multi-source spectra of energetic particle fluxes (MSSP)
    - + IMP8/CPME, GOES and ACE/SIS proton fluxes, 1-hour

[Heliocentric Trajectories for Selected Spacecraft, Planets, and Comets](#)

# 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 activities in past year and near future

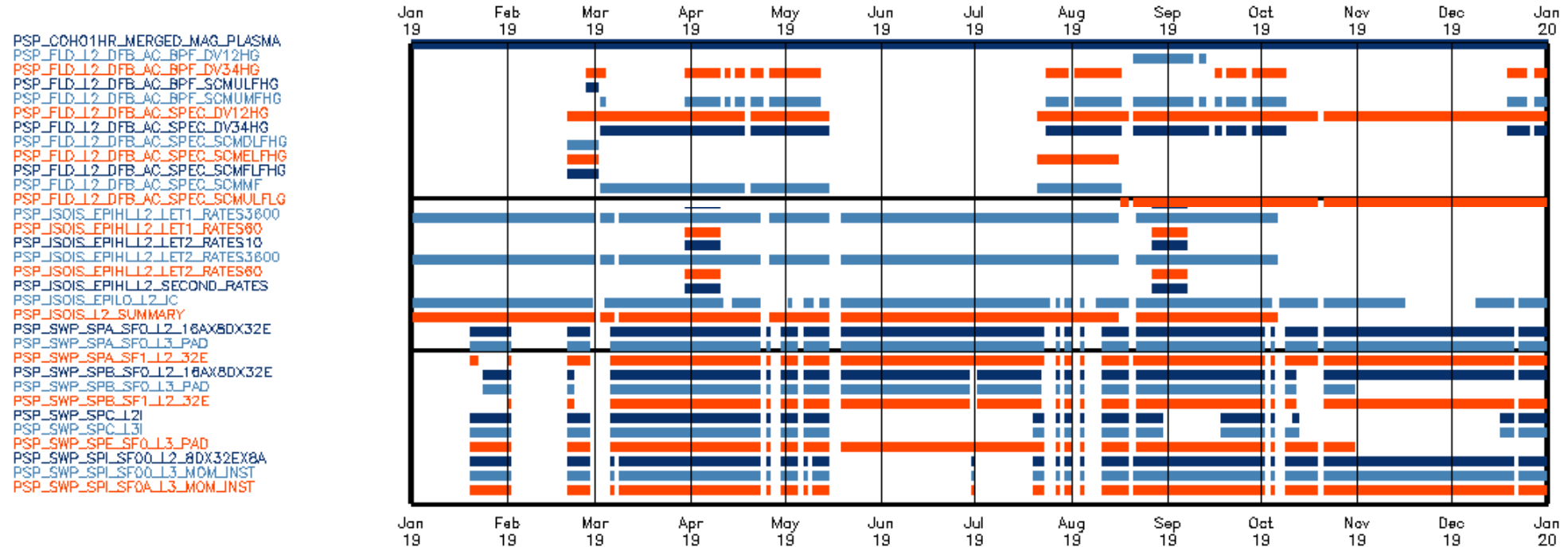
- Added Parker Solar Probe (85), AIM, GOLD, IBEX data (40), and Explorer-35
- Working on Solar Orbiter (74) and ICON data, final data from Van Allen Probes, TWINS.
- New mission requirements <[https://spdf.gsfc.nasa.gov/guidelines/archive\\_newdata\\_reqt.html](https://spdf.gsfc.nasa.gov/guidelines/archive_newdata_reqt.html)>
- 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 webservice 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
- Redirected alternative server names, such as `cdaweb.sci.gsfc.nasa.gov`, and switched FTP to FTPS, so please update your codes and scripts
- CDAWeb added netCDF support, `variable_purpose` attribute, IBEX mapped images
- CDF: planning new features and tools, systematize ISTP metadata guidelines, explore cloud support
- Adding support for end dates in filenames  
`<dataset>_<beginTime>-<endTime>_<varyingInfo>_v<version>.cdf` [hyphen or underscore between times]
- Developing alternatives to the Java-based 4D Orbit Viewer and SKTeditor tools
  - New SKTeditor may also enable the user to define the SPASE metadata at the same time as defining the internal metadata and structure of the CDF/netCDF to be created.
  - Developing prototypes of HTML5/Javascript-based interfaces for the 4D orbit viewer. We plan to expand this project to add interactive data plotting and sonification tied to the orbit display, similar to CDAWeb and perhaps data glyphs along the orbits as well.

# 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](http://autoplot.org/help#CDAWeb)
  - Other methods such as IDL <[https://cdaweb.gsfc.nasa.gov/alternative\\_access\\_methods.html](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>>

# Parker Solar Probe

## Part of 2019 Inventory Plot



- About 75 data sets in CDAWeb for 3 in-situ instrument suites: SWEAP, FIELDS, ISOIS
- Due to different telemetries in encounter phase and cruise phase, there are many data gaps. The inventory plot provided by SPDF helps the users to search for data availability
- SPASE group supported by NASA has made SPASE description for these data sets

# Solar Orbiter

- Solar Orbiter is a joint mission between ESA and NASA, but primarily an ESA mission with Solar Orbiter Archive (SOA) as the primary archive
- NASA mirrors the data at SOA and then SPDF ingests and archives the in-situ data from the mirror
- There are 16 low latency and more than 80 science data sets served at CDAWeb so far
- The SPASE descriptions for all these data sets are being developed

# CDF Status and Recent Development

- Released CDF 3.8.0.1
- Continued CDF support and general development, plus added features
- Use FILLVAL to fill the missing data if it exists, instead of the pad value
- Added options to cdfconvert (remove dimension without DEPEND\_\*, use FILLVAL if exists in place of pad value)
- Use FORMAT attribute for data listing if it exists
- Update zlib package to V2.1.11, for code improvements and bug fixes
- More generalized CDF epoch data encoding and parsing functions, default encoded epoch data now ISO-8601 format
- CDF epoch data conversion to/from Unix time
- String typed variables padded with a single space and followed by NULs
- cdf2skt tool option to choose how to display variable's metadata and data

# CDF Plans

- High-level functions to read variables or whole CDF into a map structure for IDL, Java, Perl and C#
- CDF-JSON converter
- Improve Windows installer, autoconf/make build/install, Mave/Ant/Gradle installs
- Improve documentation, beginner's guides, add to Wikipedia CDF entry
- Standardize ISTP/IACG Metadata Guidelines with version control, etc.
- New SKTeditor in Javascript or Python, perhaps also SPASE metadata creation
- Looking into supporting CDFs in cloud object storage, perhaps Zarr like netCDF is exploring
- Define CDF MIME type and international standard
- Apache 2 license in place of current custom license
- Update CDFML and its corresponding JSON representation with cdf.xsd use more specific datatype (e.g., xs:dateTime, xs:integer, xs:float, etc.) instead of just xs:string



# File naming changes

- Need to add following to the current recommended file naming guidelines <[https://spdf.gsfc.nasa.gov/guidelines/file\\_naming\\_recommendations.html](https://spdf.gsfc.nasa.gov/guidelines/file_naming_recommendations.html)>:
- Add support for end times to the overall pattern:
  - <dataset>\_<beginTime>\_<varyingInfo>\_v<version>.cdf [underscore between sections, hyphens within sections]
  - <dataset>\_<beginTime>-<endTime>\_<varyingInfo>\_v<version>.cdf [hyphen between times]
  - <dataset>\_<beginTime>\_<endTime>\_<varyingInfo>\_v<version>.cdf [underscore between times]
- Formats for the begin/endTime :
  - YYYYMMDD
  - YYYYDOY
  - YYYYMMDDHHMMSS
  - YYYYMMDDTHHMMSS
  - Probably others.
- Version/revision formats (keep only greatest one)
  - Normal/standard: V01
  - Complex RBSP version: v1.1.0-00, e.g. rbsp-a-rbspice\_lev-3\_isrheld\_20161208\_v1.1.9-00.cdf