Data Infrastructure Supporting the Heliophysics Research

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Outline

- **Introduction**
  - Access to solar data
  - Introduction of SPDF
    - Science enabling services: CDAWeb, SSCWeb, COHOWeb+OMNIWeb
- **Data from new PSP + active missions which are related to outer heliospheric research**
  - PSP, IBEX, New Horizons, Voyager 1/2
- **Heliophysics data environment**
  - Heliophysics data portal
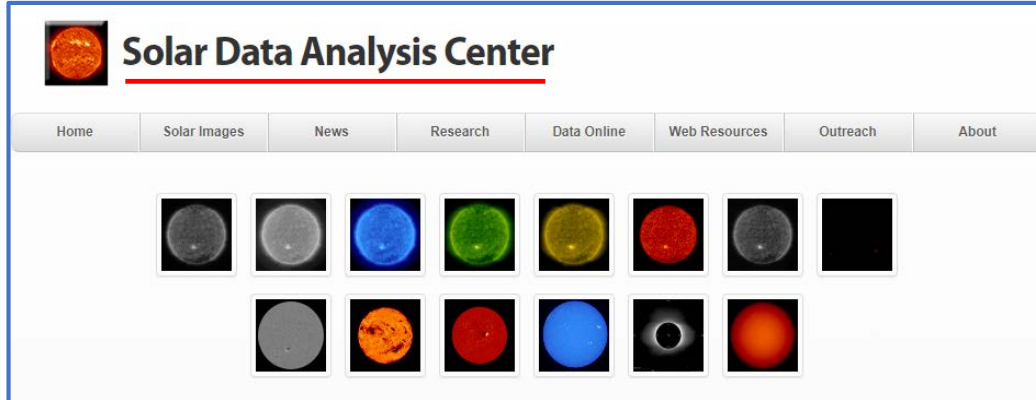 - SPASE metadata
- **Summary**

Introduction

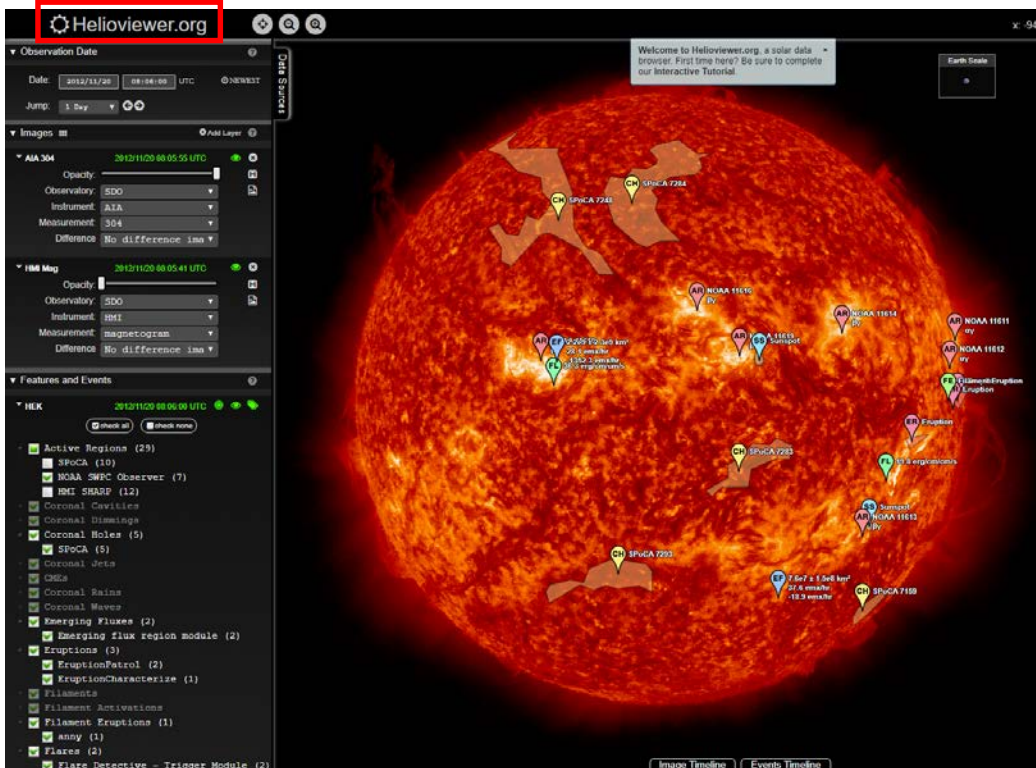Two active and final heliophysics archives for NASA

- Solar Data Analysis Center (SDAC): Remote sensing data of the Sun
- **Space Physics Data Facility (SPDF)**: Data (mostly in situ) of the solar wind, geospace, and outer heliosphere
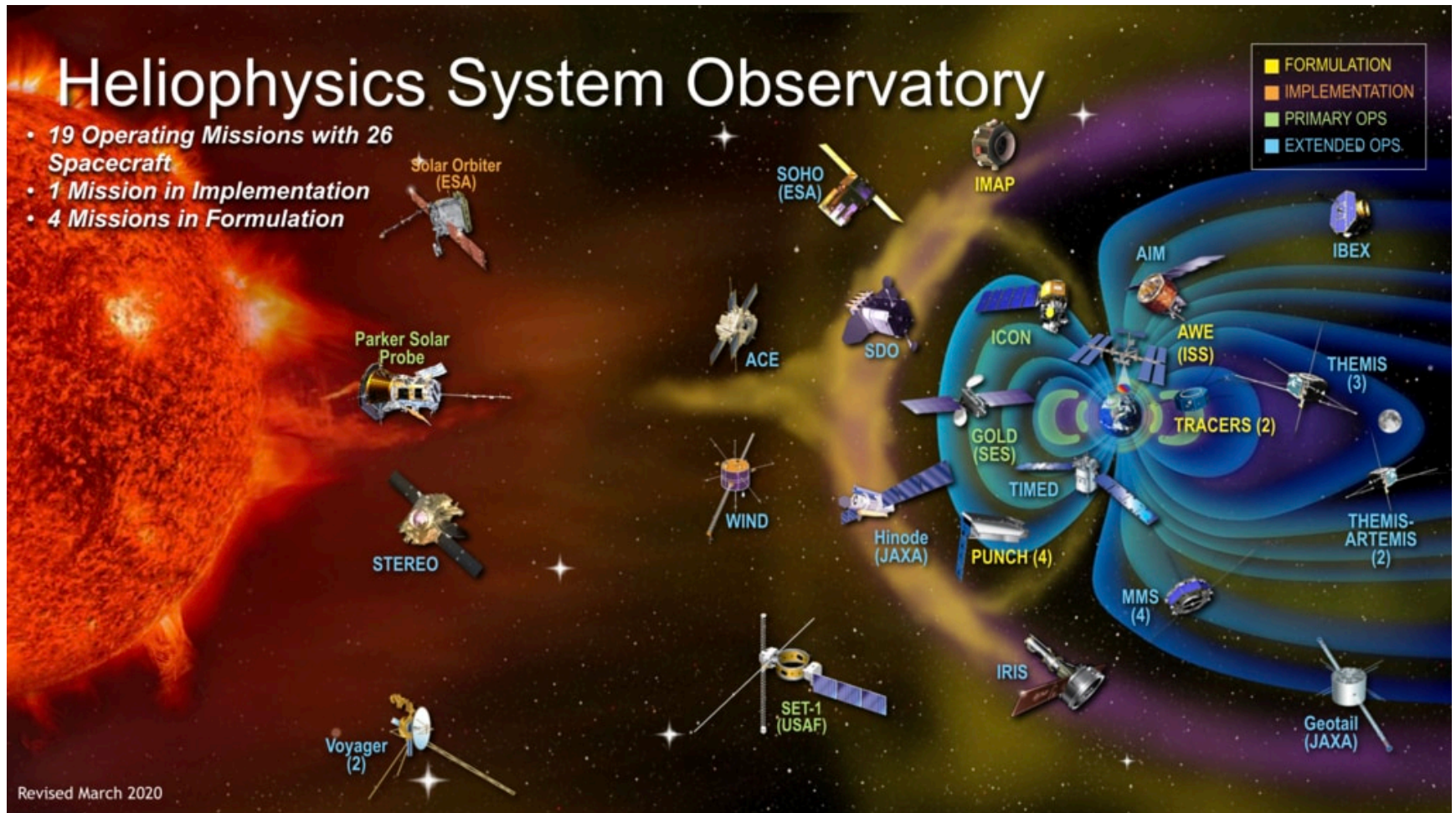
Access to Solar Data

- Solar data are generally from remote sensing and the standard format is **FITS** (Flexible Image Transport System)

- One can search and download the data via web interfaces or SolarSoft

Introduction of SPDF

❖ Scope of the data archived and served at SPDF

- Science data of the solar wind, geospace, and outer heliosphere from NASA heliophysics missions, including collaboration mission with other U.S. and/or foreign agencies
- 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, USGS, or other agencies/programs

❖ SPDF supports 130+ missions or projects (only orbit data for some of them)

❖ The data standard is **CDF** (Common Data Format) or **netCDF4-Classic**

❖ Overall there are ~10,000 data sets and ~300 TB data archived

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

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

GODDARD SPACE FLIGHT CENTER
Space Physics Data Facility

+ Goddard Home
+ NASA Home

Space Physics Data Facility

+ ABOUT	+ DATA & ORBITS	+ ModelWeb at CCMC	+ SCIENCE ENABLED	+ AND MORE

NASA's Space Physics Data Facility (SPDF)

The SPDF is a project of the Heliophysics Science Division (HSD) at NASA's Goddard Space Flight Center. SPDF consists of web-based services for survey and high resolution data and trajectories. The Facility supports data from most NASA Heliophysics missions to promote correlative and collaborative research across discipline and mission boundaries. Read More here.

Data Access & Orbit Services

+ Heliophysics Data Portal (formerly VSPO)
+ Gateway to Services
+ CDAWeb
+ 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
+ 4D Orbit Viewer
+ GIFWalk data and orbit plots
+ Alternative Data Access Methods
+ More information on Data Access for New Users

Access Models

News & Announcements

NOTICE: February 10, 2020: Parker Solar Probe (PSP) data now includes the 3rd orbit about the Sun. The data is available in the archive and CDAWeb.

NOTICE: January, 2020: GOLD L1C and L1D data are being released more regularly now, beyond 11/30/2019. This includes Channel A and B data, except for Channel B data for the period 12/15/2018-3/15/2019 which are currently only available by special request from the GOLD website. The Level-2 data for O2DEN, beyond 8/13/2019, is also being released. The GOLD Global-scale Observations of the Limb and Disk Release Notes and data, Revision 3.1 (Dec 8, 2019), are available at the SPDF archive.

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

+ Overview of SPDF Data

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

Heliophysics Virtual Observatories

+ NASA's Heliophysics Data
  Environment
+ Heliophysics Data Portal
  (formerly VSPO)
+ SPASE Data Model
  and Dictionary
+ VEPO - Virtual Energetic
  Particle Observatory
+ VHO - Virtual Heliospheric
  Observatory
+ ViRBO - Virtual Radiation Belt
  Observatory
+ VITMO - Virtual ITM
  Observatory
+ VMO - Virtual Magnetospheric
  Observatory
+ VMR - Virtual Model
  Repository
+ VSO - Virtual Solar
  Observatory
+ VWO - Virtual Wave
  Observatory

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 3.7.1 Released

Common Data Format (CDF) Version 3.7.1 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.

Move from HTTP to HTTPS

Revised Definition of the Sunspot Number Index

Relocation of Directories and Files Served by FTP by SPDF and NSSDC

Let's Not Lose Our Data

Changed Responsibilities in Archiving NASA Heliophysics Data

All News

Email list for SPDF Announcements

Please sign up for an email list of announcements related to SPDF software and services (changes, upgrades, outages). Postings to gsfc-spdf_announcements@lists.nasa.gov will be very infrequent but are especially useful to regular users of our

Submission Guidelines and Procedures
+ Creating SPASE Data
  Descriptions
+ HPDE Data File Internal
  Metadata (previously ISTP)
  Guidelines
+ Recommended file and data
  collection naming practices
+ Heliophysics URI Template
  Standard **(non-NASA)**
+ New mission data
  requirements

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
+ Other NASA Archives

1. Coordinated Data Analysis Web (CDAWeb)

https://cdaweb.gsfc.nasa.gov/

70 Missions/Sources ➡

- Enable multi-mission, multi-instrument science
- Present dataset view rather than individual data files
- Plot, list, and correlate data
- Download full or a subset of data in CDF or ASCII format

Additional Services
+ CDAWeb Inside IDL
+ Overview of Alternative Data Access Methods
+ Autoplot.org (non-NASA) interface to public CDAWeb database
+ Pre-generated Data and Orbit plots via SPDFs GIFWALK

Additional Resources
+ Usage Statistics
+ Space Physics Use of CDF
+ Data Inventory Graph
+ SPDF Home Page

- **Select zero OR more Sources**
  (default = All Sources if >=1 Instrument Type is selected)

  - ACE
  - AMPTE
  - ARTEMIS
  - Alouette
  - Apollo
  - Arase (ERG)
  - BARREL
  - BEPICOLOMBO
  - CNOFS
  - CRRES
  - Cassini
  - Cluster
  - Cubesats
  - DE
  - DMSP
  - DSCOVR
  - Dawn
  - ELFIN
  - Equator-S
  - FAST
  - GOES
  - GPS
  - Galileo
  - Genesis
  - Geotail
  - Giotto
  - Hawkeye
  - Helios

- **Select zero OR more Instrument Types**
  (default = All Instrument Types if >=1 Source is selected)

  - Activity Indices
  - Electric Fields (space)
  - Electron Precipitation Bremsstrahlung
  - Electrostatic Analyzer Particle Detector
  - Engineering
  - Ephemeris in RTN
  - Ephemeris/Attitude/Ancillary
  - Gamma and X-Rays
  - Housekeeping
  - Imager (space)
  - Imaging and Remote Sensing (ITM/Earth)
  - Imaging and Remote Sensing (Magnetosphere/Earth)
  - Imaging and Remote Sensing (Sun)
  - Magnetic Fields (Balloon)
  - Magnetic Fields (space)
  - Particles (space)
  - Plasma and Solar Wind
  - Pressure gauge (space)
  - Radio and Plasma Waves (space)
  - Spacecraft Potential Control
  - Ground-Based HF-Radars
  - Ground-Based Imagers
  - Ground-Based Magnetometers, Riometers, Sounders
  - Ground-Based VLF/ELF/ULF, Photometers

CDAWeb Data Explorer

Automatically set by the last available day of the selected data

Options:
bin averaging,
noise filtering,
spike removal,
overlay plotting,
audification,
animation

Select start and stop times from which to GET or PLOT data:

Start time (YYYY/MM/DD HH:MM:SS.mmm): `2019/12/16 00:00:00.000`

Stop time (YYYY/MM/DD HH:MM:SS.mmm): `2019/12/17 00:00:00.000`

☐ **Compute uniformly spaced binned data for scalar/vector/spectrogram data (not available with noise filtering)** NEW

Select an activity:

◉ Plot Data : *select one or more variables from list below and press submit.*

    ☐ Also create PS and PDF **best quality outputs** (all plot types except images and plasmagrams).
          Many panels per dataset are allowed but <=4 panels optimal for standard Y-axis height and single page display.

    ☐ **Use coarse noise filtering** to remove values outside 3 deviations from mean of all values in the plotted time interval.
    ☑ **Use spike removal to filter data without binning** (not available with noise filtering)(Warning: Experimental !!).
        Spike removal method: `removal of extreme outliers only ▼`
    ☑ **Increase the Y-axis height** for time-series and spectrogram plots. NEW
        multiply by: `1 ▲▼`
    ☐ **Combine all time-series and spectrogram plots**, for all requested datasets, into one plot file.
    ☑ **Plot overlay options.** NEW
        ◉ Overlay vector components of selected variables.
        ○ Overlay selected variables or variable components that are identical among the datasets chosen
            (Supported constellations: MMS, Van Allen Probes (RBSP), THEMIS, Cluster, and GOES).

○ List Data (ASCII/CSV): *select one or more variables from list below and press submit. (Works best for < 31 days)*
○ Download original files : *press submit button to retrieve list of files. (Max. 200 days - use* HTTPS site *for larger requests)*
○ Create V3.7 CDFs for download or Autoplot demonstration: *select one or more variables from the list below and press submit.*
○ Create audio files based on data from selected variables.
        More information about audification is avaialable here.

Note: CDF patch required for reading Version 3.7 CDFs in IDL or MATLAB.
Get CDFX - IDL GUI plotting/listing toolkit software. To be used with either the daily or "created" CDF files available above.

NEW **Pressing the "Submit" button will spawn a new window/tab in order to support the new "Previous" and "Next" functions.**
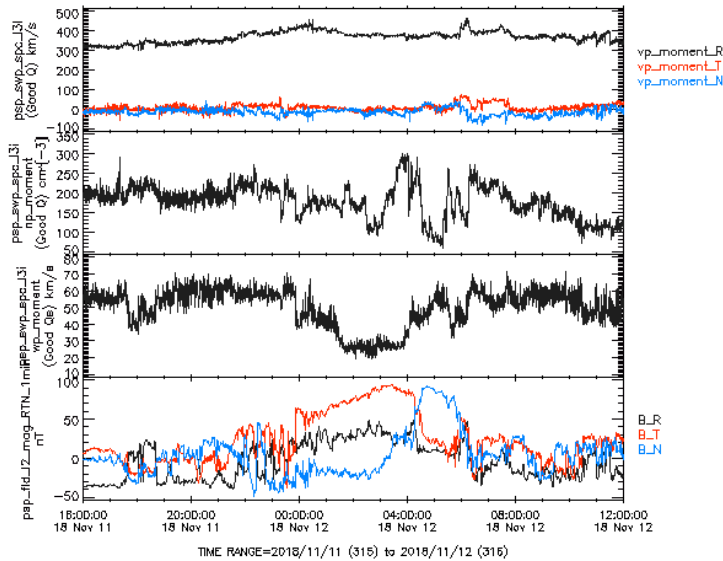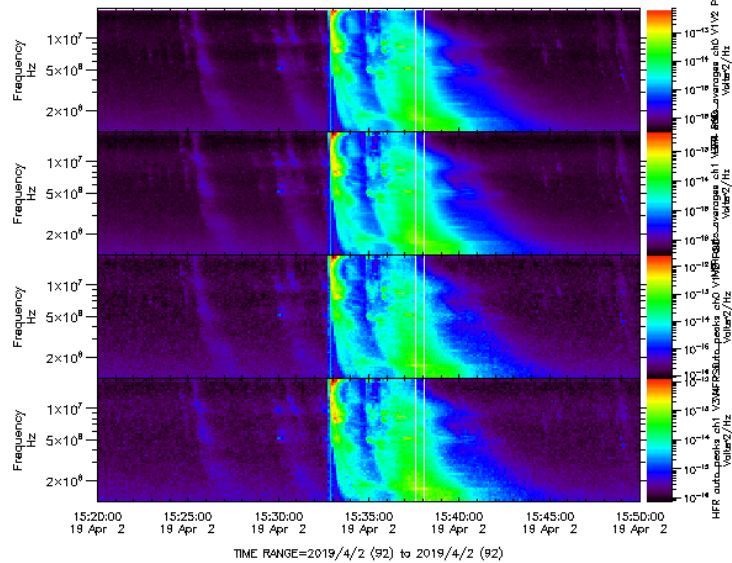
`Submit` `Reset`

Parameter Display Options in CDAWeb

PSP Data
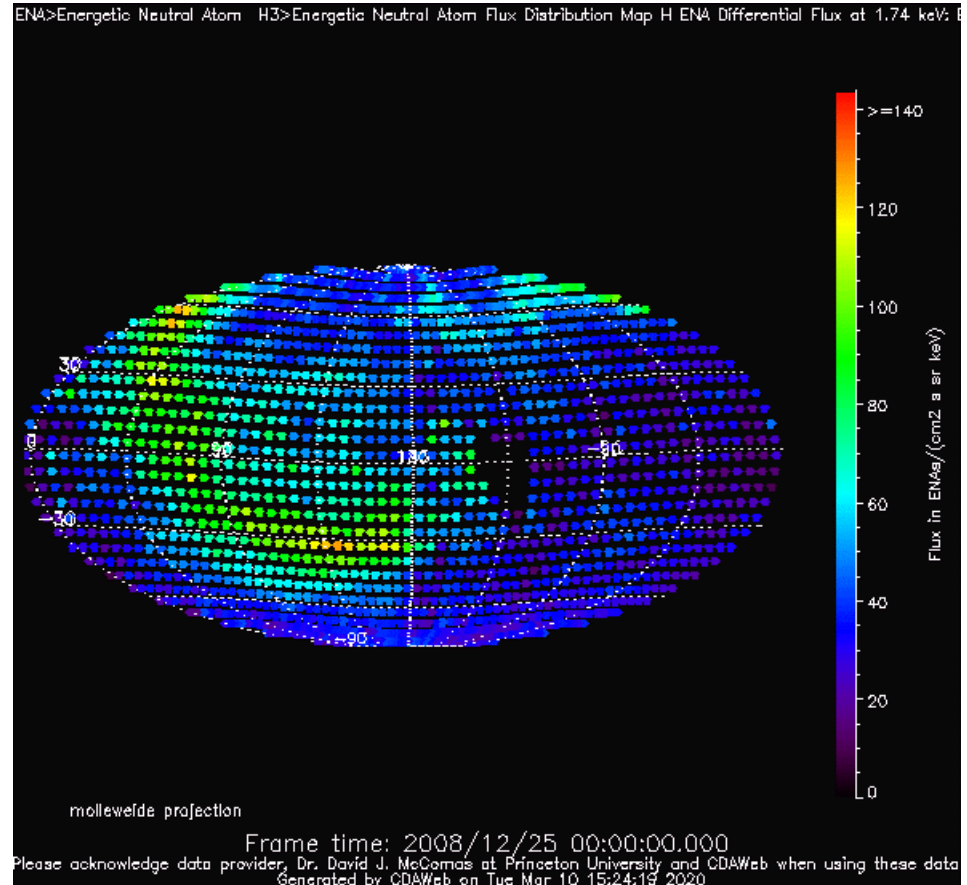
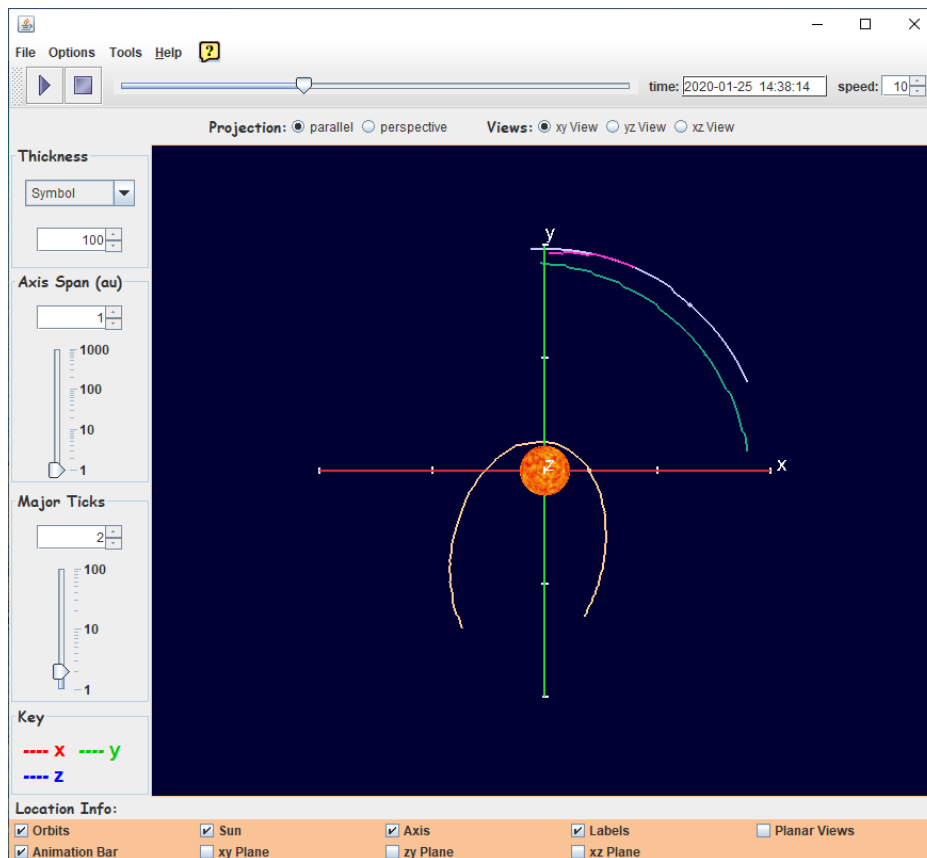IBEX-Hi OMNI-Directional 6-month-average West Ecliptic Maps: H ENA Differential Flux in Channel 4 (1.36-2.50 keV H)

10

2. 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

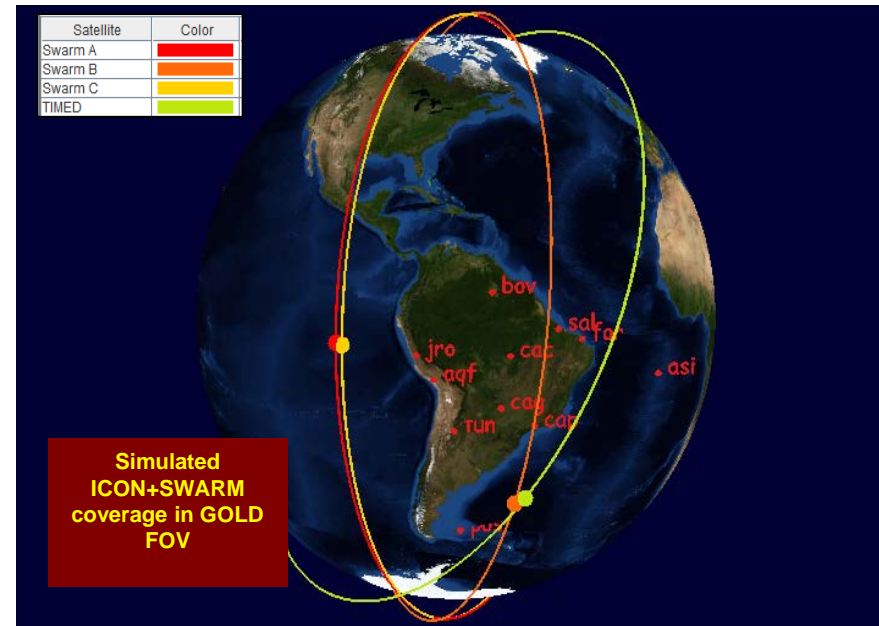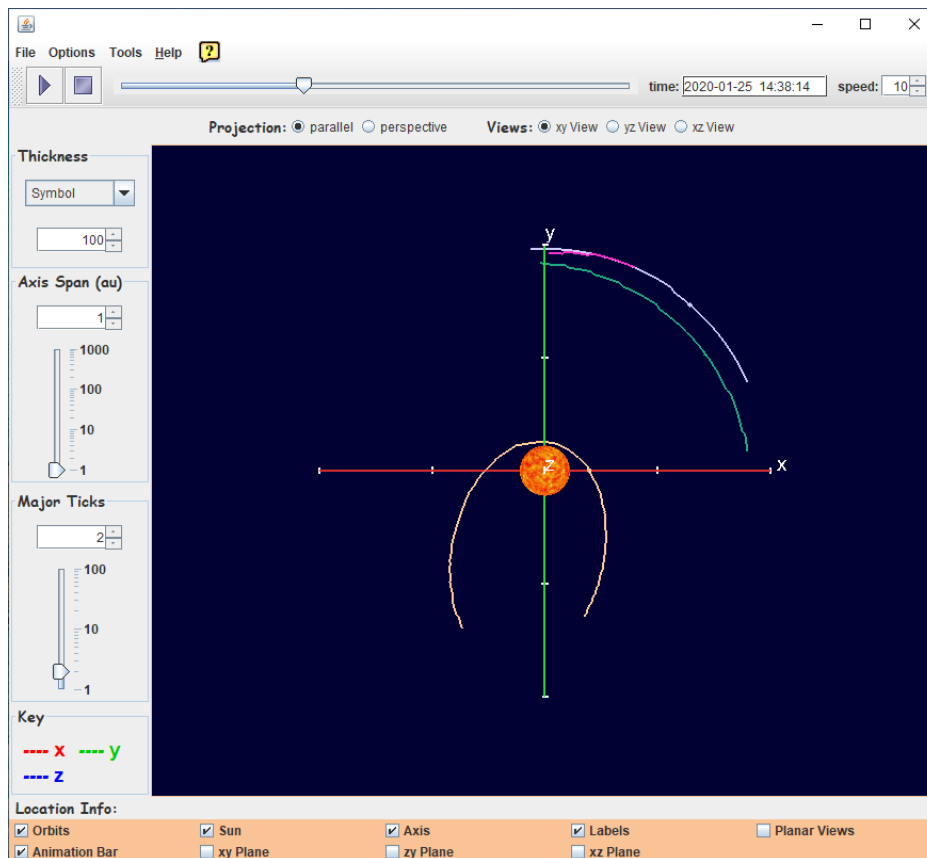o Query for satellite-satellite and satellite-ground station conjunction

2. Satellite Situation Center (SSCWeb)

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

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Simulated ICON+SWARM coverage in GOLD FOV

3. COHOWeb & OMNIWeb

https://cohoweb.gsfc.nasa.gov/coho/

https://omniweb.gsfc.nasa.gov/

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Space Physics Data Facility

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SEARCH NASA [_____] + GO

| + SPDF HOME | + DATA & ORBITS | + VHO at Goddard | + SCIENCE ENABLED | + AND MORE |

COHOWeb
SPDF•Goddard Space Flight Center

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+ ABOUT
+ NEWS
+ FEEDBACK

Deep space hourly and daily merged magnetic field, plasma, proton fluxes* and ephemerides data

PATHWAYS BY FUNCTIONALITY

Spacecraft *H fluxes included	Graphical browse and listing	Listing,Plot with filtering	Distribution functions, medians, avgs, std devs	Scatter plot, linear regr. fits	FTP access to hourly data	FTP access to high res. data
*Helios1	✔	✔	✔	✔	✔	✔
*Helios2	✔	✔	✔	✔	✔	✔
New Horizons	✔		✔	✔	✔	
*OMNI_M	✔	✔	✔	✔	✔	
Parker Solar Probe	✔	✔	✔	✔	✔	✔
*Pioneer10	✔	✔	✔	✔	✔	✔
*Pioneer11	✔	✔	✔	✔	✔	✔
Pioneer Venus	✔	✔	✔	✔	✔	✔
*Stereo-A	✔	✔	✔	✔	✔	✔
*Stereo-B	✔	✔	✔	✔	✔	✔
*Ulysses	✔	✔	✔	✔	✔	✔
*Voyager1	✔	✔	✔	✔	✔	✔
*Voyager2	✔	✔	✔	✔	✔	✔
Mariner2	✔					
Pioneer6	✔					
Pioneer7	✔					

See also: Heliocentric Ephemerides for Selected Spacecraft (Helioweb)

- **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 various locations of heliosphere, especially useful for planetary studies and heliospheric model validation

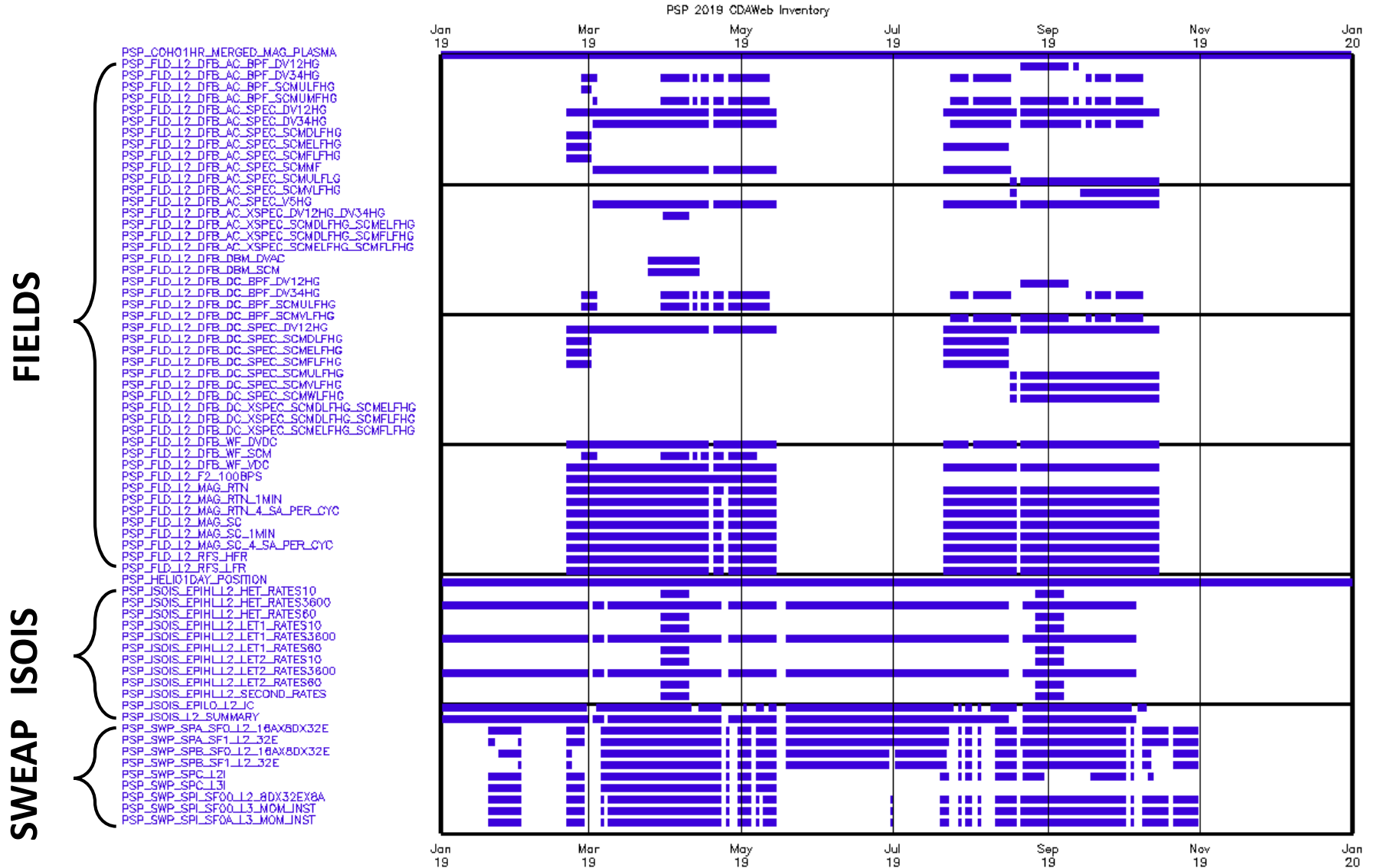- Interface for plotting, filtering, and downloading the data

New PSP + Active Missions Which Are Related to Outer Heliospheric Research
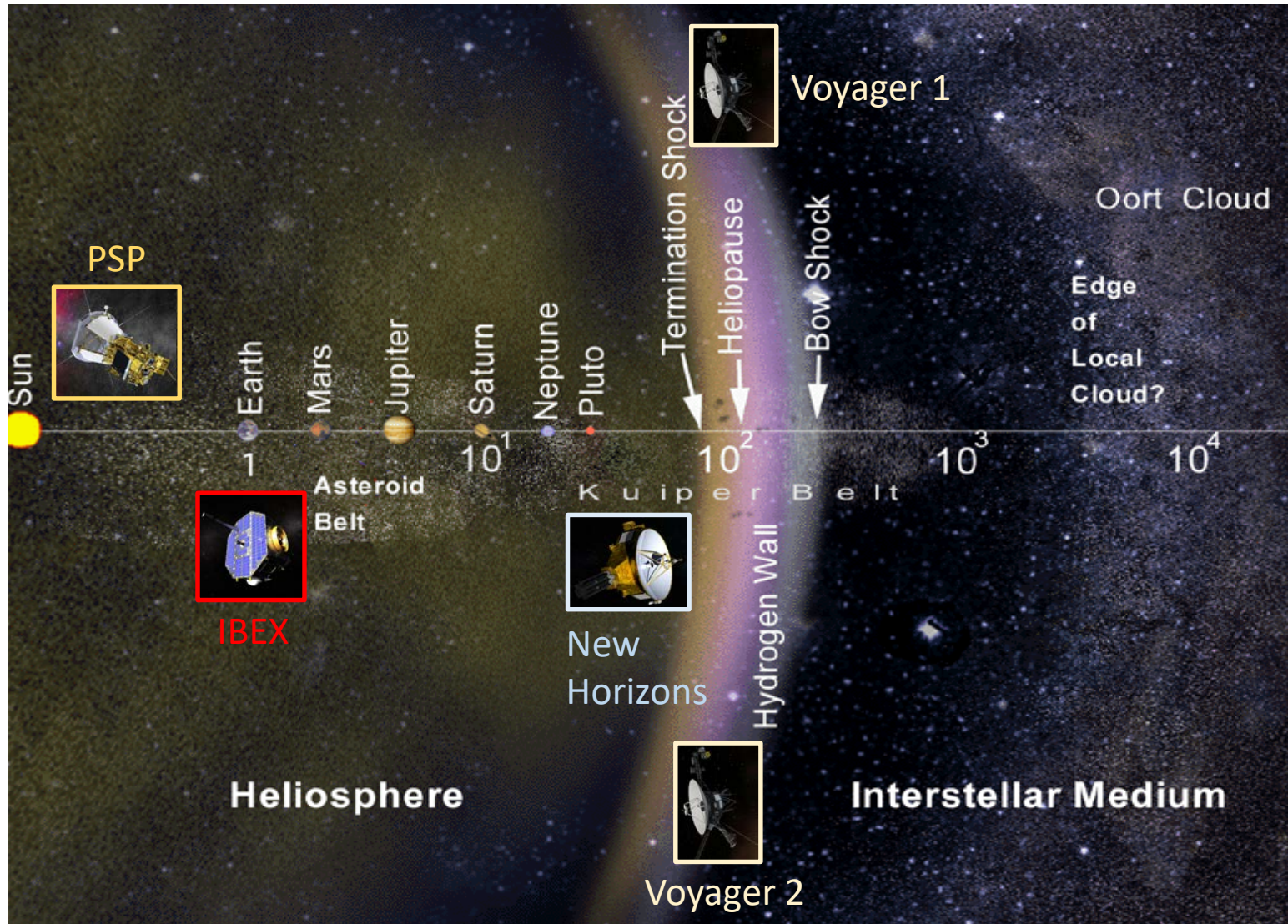
PSP Data

❑ PSP Science Gateway https://sppgway.jhuapl.edu/ with *links to homepages of four instrument teams*

❑ The WISPR (Wide-Field Imager for Parker Solar Probe) data are copied to SDAC, and are searchable and downloadable via Virtual Solar Observatory (VSO, virtualsolar.org) clients

> Solarsoft/IDL: vso_search.pro, vso_get.pro   SunPy: Fido

❑ The in situ data at Levels 2-3 and ephemeris data are archived at SPDF https://spdf.gsfc.nasa.gov/pub/data/psp/ (174 GB, 72 datasets)

- SWEAP (Solar Wind Electrons Alphas and Protons)
  - SPC (Solar Probe Cup)
  - SPAN (Solar Probe Analyzers): ions (SPI), electrons (SPA, SPB) data
- ISOIS (Integrated Science Investigation of the Sun)
  - EPI-Hi, EPI-Lo
- FIELDS
  - MAG: full cadence
  - Radio Frequency Spectrometer (RFS)
  - Digital Filter Board (DFB): bandpass filter, spectra, cross spectra of AC and DC, waveform

Inventory Plot of PSP Data in 2019

PSP 2019 CDAWeb Inventory

FIELDS

ISOIS

SWEAP

TIME RANGE=2019/1/1 to 2020/1/1

Generated by CDAWeb on Mon Mar 9 13:48:32 2020

IBEX Data

- Publically available at
  http://ibex.swri.edu/researchers/publicdata.shtml#pd

- The data above is mirrored at
  https://spdf.gsfc.nasa.gov/pub/data/ibex/

- Most Release 10 and some Release 13 data are converted to CDF and available at CDAWeb

- More data (including from other releases) are under test at
  https://cdaweb.gsfc.nasa.gov/sp_test3017/

IBEX Public CDAWeb Inventory

IBEX_H3_ENA_HI_R10_CG_NOSP_ANTIRAM_1YR
IBEX_H3_ENA_HI_R10_CG_NOSP_OMNI_6MO
IBEX_H3_ENA_HI_R10_CG_NOSP_RAM_1YR
IBEX_H3_ENA_HI_R10_CG_SP_ANTIRAM_1YR
IBEX_H3_ENA_HI_R10_CG_SP_OMNI_6MO
IBEX_H3_ENA_HI_R10_CG_SP_RAM_1YR
IBEX_H3_ENA_HI_R10_NOCG_NOSP_ANTIRAM_1YR
IBEX_H3_ENA_HI_R10_NOCG_NOSP_OMNI_6MO
IBEX_H3_ENA_HI_R10_NOCG_NOSP_RAM_1YR
IBEX_H3_ENA_HI_R10_NOCG_SP_ANTIRAM_1YR
IBEX_H3_ENA_HI_R10_NOCG_SP_OMNI_6MO
IBEX_H3_ENA_HI_R10_NOCG_SP_RAM_1YR
IBEX_H3_ENA_HI_R13_CG_NOSP_RAM_1YR

TIME RANGE=2008/12/25 to 2017/12/26

Generated by CDAWeb on Mon Mar 9 13:15:15 2020

New Horizons Data at SPDF

❑ Primary archive is at the **Planetary Data System**

❑ Data at CDAWeb

- SWAP (Solar Wind Around Pluto)
  - NEW_HORIZONS_SWAP_VALIDSUM: 2008/10/10 – 2018/10/31
    - Solar wind proton density, speed, temperature, dynamic pressure, and thermal pressure
  - NEW_HORIZONS_SWAP_PICKUP-IONS: 2008/11/16 – 2017/03/31
    - Pickup ion density, temperature, pressure
  - NEW_HORIZONS_SWAP_PICKUP-IONS-HISTOGRAM: 2008/10/31 – 2017/03/31
    - Histogram count rate in eV/q and uncertainties of the count rates
  - NEW_HORIZONS_HELIO1DAY_POSITION: 2006/01/20 – 2030/12/31

❑ Other data at SPDF (**other format**)

- PEPSSI (Pluto Energetic Particle Spectrometer Science Investigation)
  - Calibrated flux in the cruise phase 2007 – 2015

# Voyager Data *Related to Outer Heliosphere and VLISM* at SPDF

❑ At CDAWeb
- Voyager 1 and 2 (same for V2)
  - VG1_PWS_LR: 1977/09/05 – 2020/02/25
    - Low rate plasma waves instrument
  - VOYAGER1_48S_MAG-VIM: 2009/01/01 – 2018/12/31
  - VOYAGER1_COHO1HR_MERGED_MAG_PLASMA: 1977/01/01 – 2018/12/31
    - Hourly mag, plasma, proton fluxes, and ephemeris data
  - VOYAGER1_HELIO1DAY_POSITION: 1977/09/06 – 2030/12/31
- Only for Voyager 1
  - VOYAGER1_CRS_DAILY_FLUX: 1977/09/08 – 2016/12/13

❑ Many Other Data at SPDF (**other format**)
- V2 hourly and daily plasma data up to 2018
- LECP (Low Energy Charged Particle) hourly and daily ion and proton fluxes up to 2019 (V1) and 2020 (V2)
- CRS (Cosmic Ray) 15-min, 6-h, daily data up to 2019

Heliophysics Data Environment (HPDE)
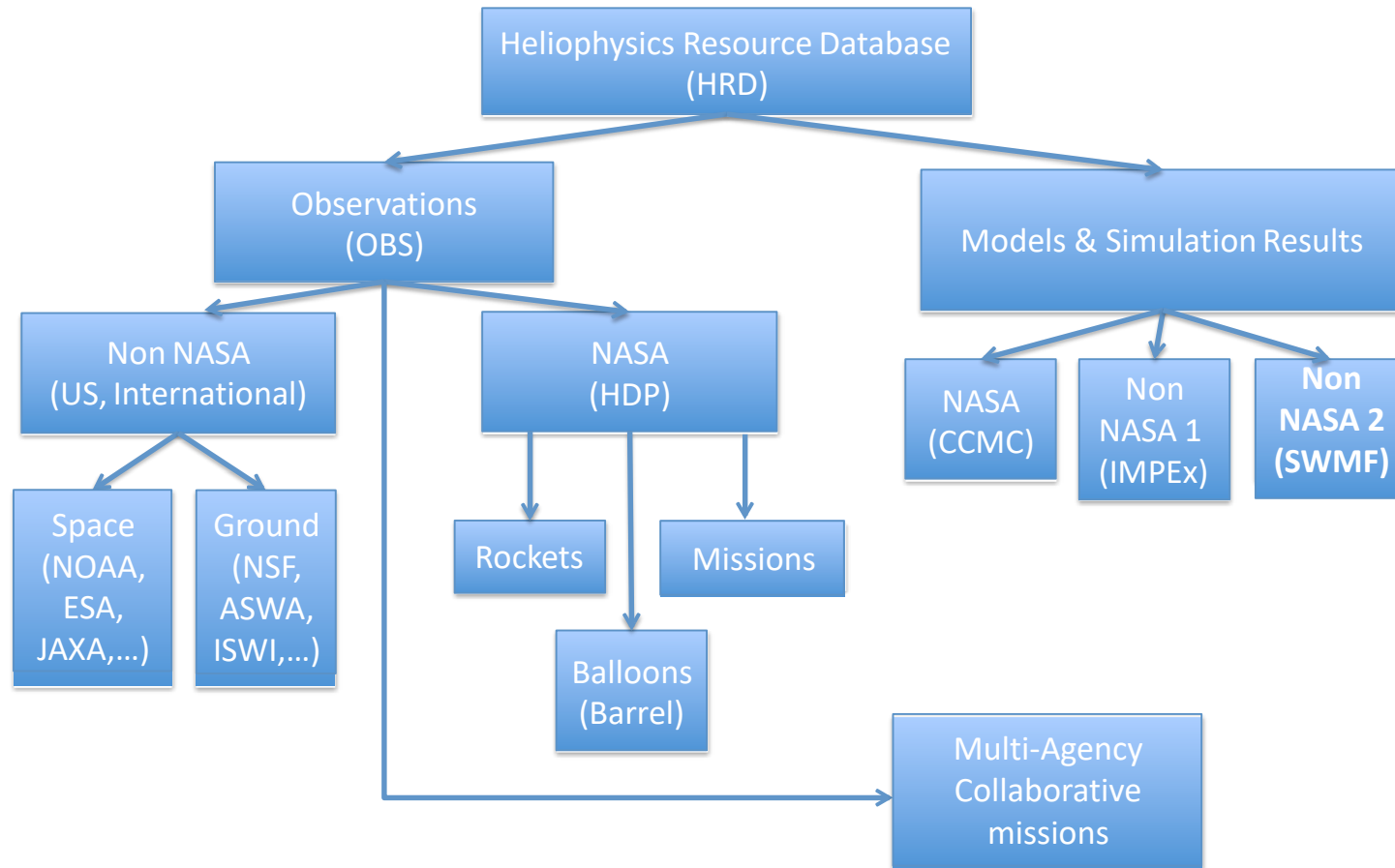
- ❖ NASA Heliophysics Science Data Management Policy at https://hpde.gsfc.nasa.gov/ provides general guidance for Project Data Management and Mission Archive Plans
- ❖ Based on 2020 ROSES solicitations, new and significant data products from NASA research grants will be asked to put in long-term archives

Heliophysics Data Portal (HDP)

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Space Physics Data Facility

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Heliophysics Data Portal "Find it. Browse it. Get it."

SPASE inside

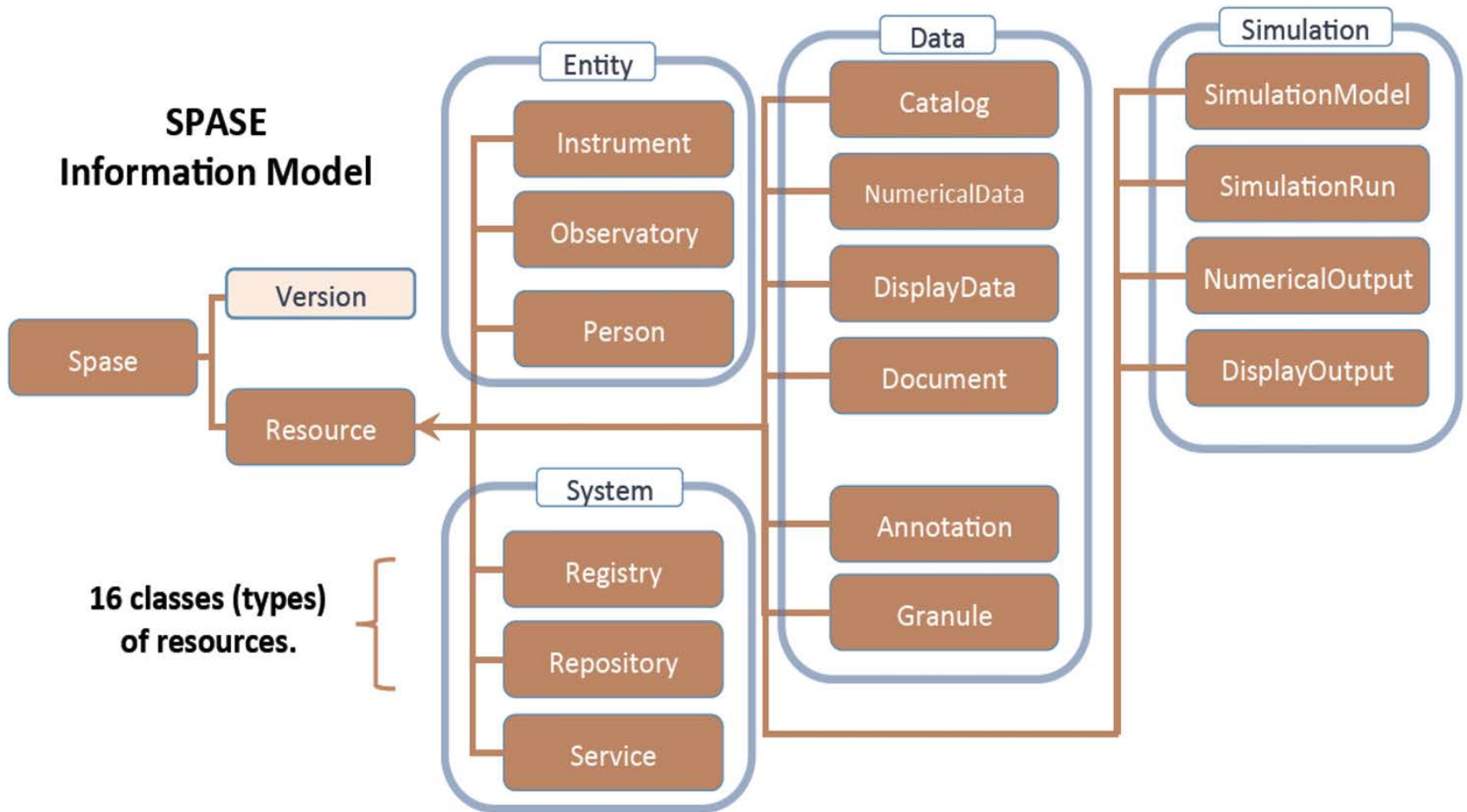| Help | Geo Orbits | Helio Orbits | SPASE Registry | ADS Abstracts | Feedback |

Text Restriction

[ ] Add

Current Product Restrictions

No restrictions are currently set.

Showing 1 - 20 of 2691 Results | View Current List | Sort by Observatory ▼

Time Span Restriction (i)

YYYY-MM-dd or YYYY-DDD

from: [ ]

to: [ ] Add

Element Restriction (i)

Resource type (i)
Measurement type (i)
Observatory Group (i)
Observatory (i)
Instrument (i)
Observed region (i)
Spectral range (i)
Cadence (i)
Repository Name (i)
Access rights (i)
Format (i)

#	Products (& SPASE descriptions)	Access Links	
1	ACE 27-day Survey Plots	· Polar-Wind-Geotail 'gif-walk' site	Get Images/Plots
2	ACE Cosmic Ray Isotope Spectrometer (CRIS) 1-Hour Level 2 Data	· FTP access to files at SPDF · HTTP access to files at SPDF · CDAWeb · ACE Science Center FTP area · ACE Science Center · ACE Cosmic Ray Isotope Spectrometer (CRIS) Level 2 data Home Page	Get Data/Plots
3	ACE Cosmic Ray Isotope Spectrometer (CRIS) Daily Level 2 Data	· FTP access to files at SPDF · HTTP access to files at SPDF · CDAWeb · ACE Science Center ftp area · ACE Science Center · ACE Cosmic Ray Isotope Spectrometer (CRIS) Level 2 data Home Page	Get Data/Plots
4	ACE Daily Survey Plots	· Polar-Wind-Geotail 'gif-walk' site	Get Images/Plots

- HDP includes remote-sensing and in-situ data as well as some CCMC products
- Data authorities are defined in Space Physics Archive Search and Extract (**SPASE**) to track data provenance
- SPASE metadata is used by **HDP,** and enables the search by VxOs and other data services

SPASE Metadata

SPASE Information Model

16 classes (types) of resources.

Details at: http://spase-group.org/data/

Web-Based SPASE Document Editor

- It will generate (a) SPASE description document, (b) Resource ID.
- The **DOI** (Digital Object Identifier) will enable long-term preservation of landing page describing datasets or a collection of datasets

Summary

➢ As critical elements of **Heliophysics Data Environment**, SDAC and SPDF archive and serve observational data relevant to NASA heliophysics science objectives in order to promote correlative and collaborative research across discipline and mission boundaries

➢ The data from the active missions related to the outer heliospheric research and from the new PSP mission have been archived at SPDF, with more to come

➢ SPDF provides three main science-enabling services: CDAWeb, SSCWeb, and COHOWeb

➢ SPDF tracks the usage of archived data and assists mission senior reviews

➢ The **Heliophysics Data Portal** based on SPASE metadata has been built to connect the observational and simulation data