

# Heliophysics System Observatory





# NASA Heliophysics Data Resources

Exploring HDRL, SDAC, SPDF, HelioCloud, & Open Science

Heliophysics Summer School 2025

C. Alex Young

NASA Goddard Space Flight Center

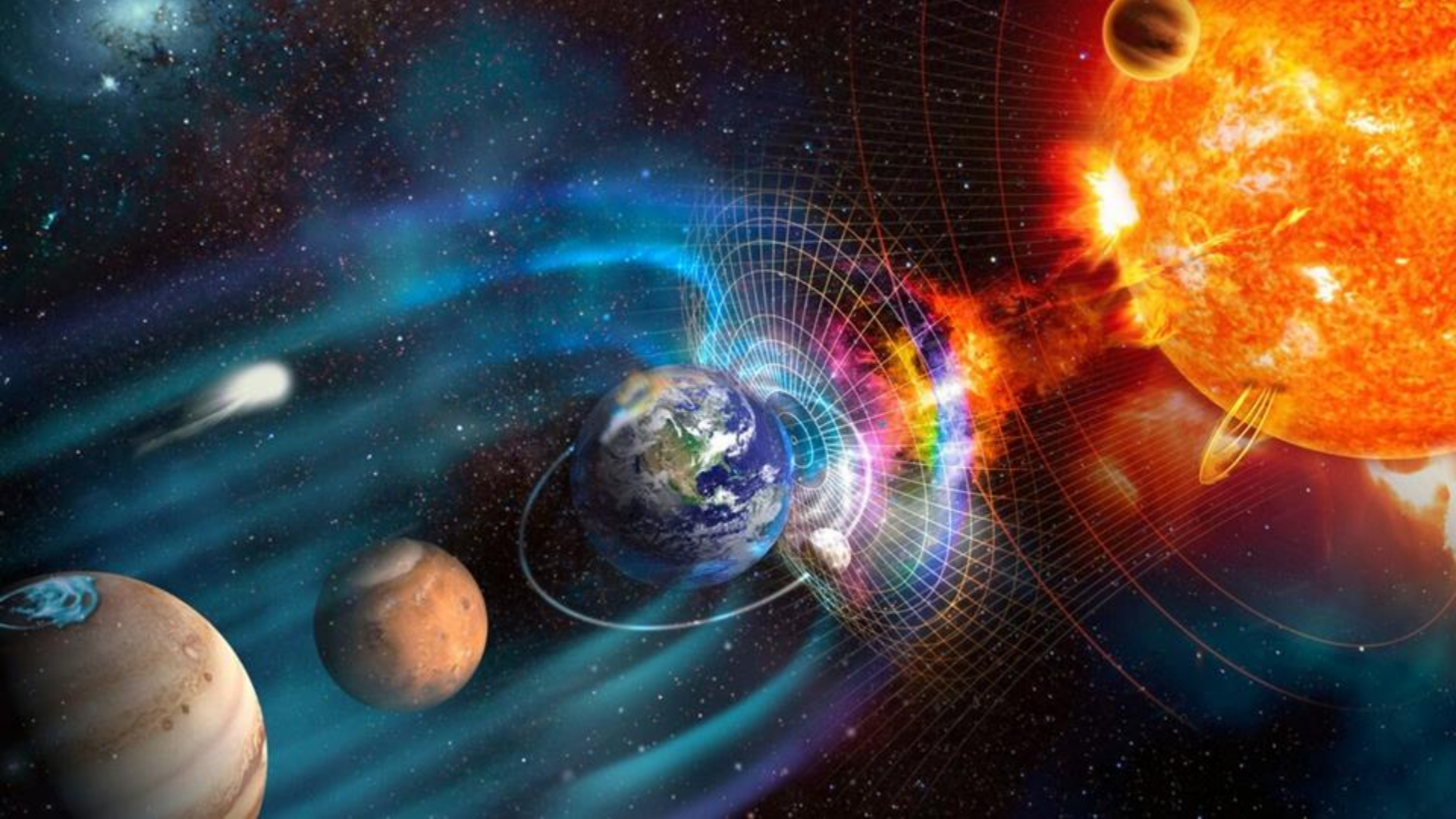
Heliophysics Science Division

Associate Director for Science Communication

# Benefits

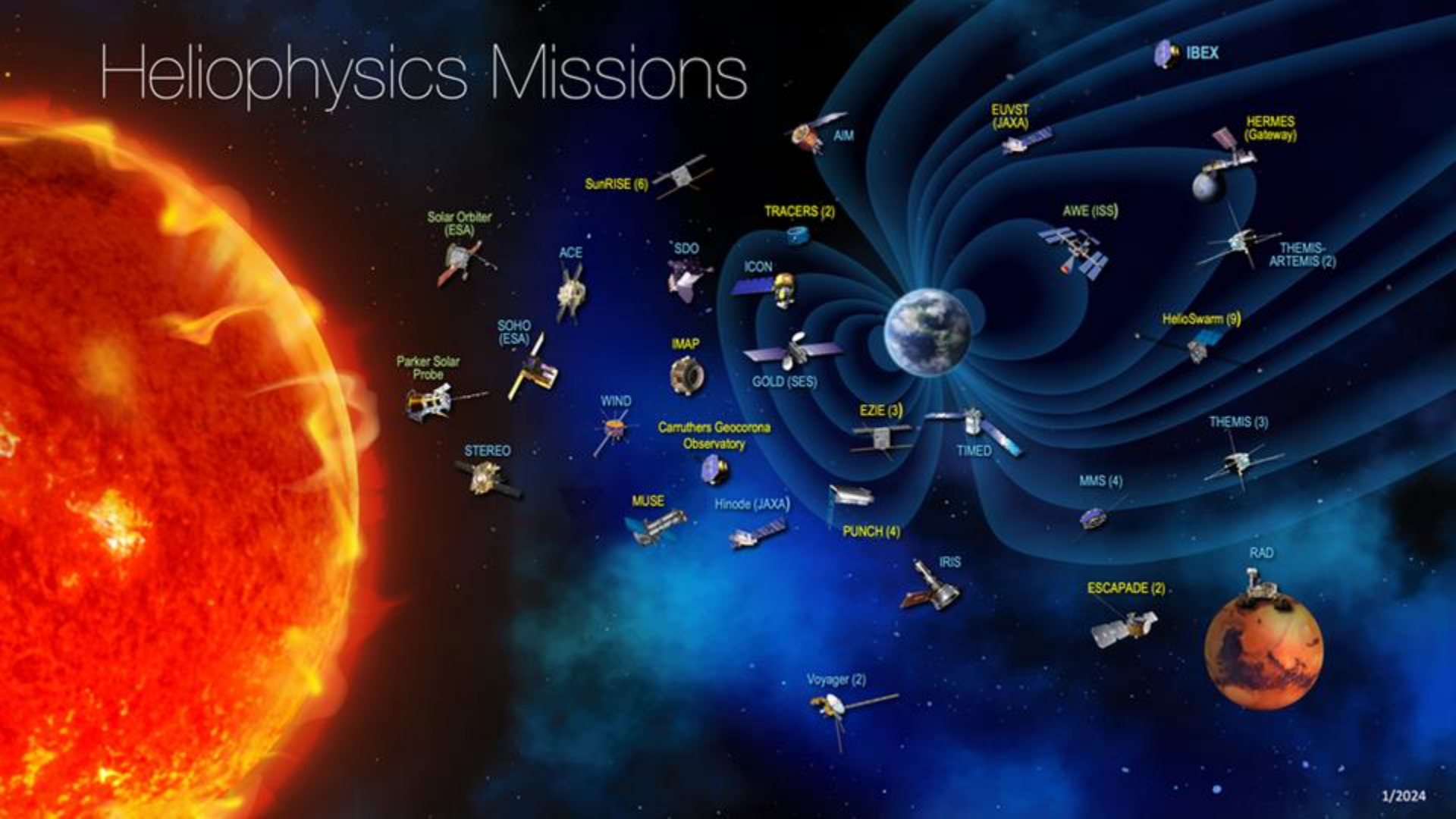
**Enable you to do your science by making data and computing resources available.**

**Help you find the knowledge and connections to facilitate research and collaborations.**





# Heliophysics Missions

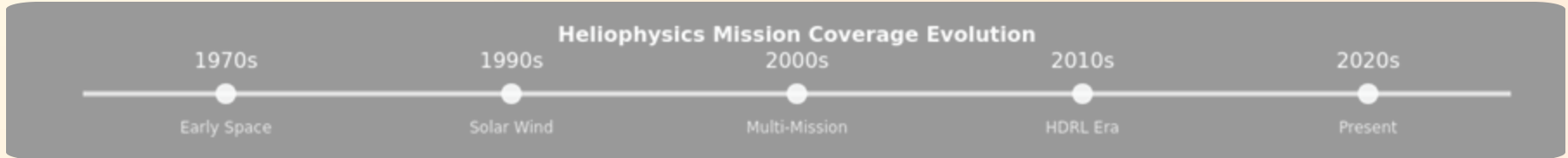


# Features

# Legacy Coverage

## 65+ Years of Space Missions

Comprehensive data coverage in heliophysics



### Solar Missions

- SOHO: LASCO, EIT, SUMER, VIRGO
- SDO: AIA, HMI
- STEREO: Dual perspective



### Wind & Magnetospheric

- ACE: Solar Wind Ionosphere
- Cluster: Magnetic Field
- THEMIS: Aurora borealis



### Legacy & Historical

- SMM, Yohkoh, TRACE
- Helios, Ulysses
- Legacy data: 1970s to present



### Data Coverage Impact



Multi-decade observations



Comprehensive spatial coverage



Detailed temporal resolution

# Why HDRL Matters

The scale and impact of heliophysics data infrastructure



## Massive Scale

**2.5 PB**

Data across 300 million files



## Legacy Coverage

**65+**

Years of space missions



## Open Science Impact

Real-time space weather forecasting

NOAA & NASA mission support

National security systems

International research collaboration

### Time-Centric

Search by time intervals

### Mission-Centric

Cross-mission analysis

### Event-Centric

Solar event correlation

### SPASE Metadata

Standardized discovery

*"Enabling reproducible, collaborative heliophysics research at global scale"*



# Research Applications

HDRL enables diverse research applications across the heliophysics ecosystem:



## Analysis Tools

- SolarSoft (IDL): Legacy instrument packages
- SunPy (Python): Modern analysis framework



## Cloud Platforms

- HelioCloud: Cloud-native research infrastructure
- 600+ TB: Scalable analysis environment



## Visualization Tools

- 4-D Orbit Viewer: Interactive 3D + Time visualization
- Web-based Solar: Browser visualization



## Web Interfaces

- CDAWeb: Browser-based access to Level-2 datasets
- OMNIWeb: Solar wind data visualization



## Python Ecosystem

- SunPy: Solar physics analysis
- PySPEDAS: Multi-mission data analysis



## Data Standards

- CDF Format: Self-describing data format
- SPASE Model: Standardized metadata

# Python Ecosystem for Space Physics

Python has become the de facto programming language for heliophysics data analysis, providing powerful tools for data processing and visualization.



## SunPy

Core package for solar physics data analysis



Map Objects: 2D spatial solar observations



TimeSeries: 1D temporal measurements



Astropy: Full ecosystem integration



## PySPEDAS

Multi-mission analysis framework



30+ Missions: MMS, THEMIS, PSP, etc.



tplot Model: Multi-panel time series plots



Unified Loading: Consistent data interface



## PyHC

Community resources for Python training



Summer School: 5-day intensive training



Core Packages: Kamodo, PlasmaPy, pysat, SpacePy



Open Access: Free attendance + NSF travel support

## Additional Resources:



Hands-on Jupyter Notebooks



Comprehensive Documentation



Community Support Forums

# Advanced Modeling & Analysis Platforms

HDRL provides advanced platforms that enable sophisticated analysis and modeling of heliophysics data



## HelioCloud Advanced



### AI/ML Integration

Frontier Development Lab for machine learning on heliophysics data



### Anomaly Detection

Pattern recognition algorithms to identify unusual solar events



### Citizen Science

Public engagement projects enabling community participation



### Scalable Compute

GPU clusters for deep learning and high-performance computing



## Kamodo Framework



### NASA CCMC

Model-agnostic framework for multi-physics modeling



### Global Models

Support for TIE-GCM, SWMF, OpenGGCM and other global models



### Run-on-Request

Interactive model execution with parameter customization



### Format-Agnostic

Universal data readers supporting multiple formats



# What challenges do you face accessing heliophysics data?



## HDRL Ecosystem

- ✧ NASA's federated "system-of-systems"
- ✧ Three cooperating pillars: SDAC, SPDF, HP Consortium
- ✧ Unified access with standardized formats
- ✧ RESTful/HAPI interfaces for automation



Comprehensive Data Registry & Analysis Tools



Think about your current data workflow challenges as we explore solutions together

## Open Science Discussion

### ✓ Findable

- ✓ SPASE metadata with persistent DOIs
- ✓ Comprehensive registries
- ✓ Time/mission/event-based discovery

### ✓ Interoperable

- ✓ Standard formats (CDF, FITS, netCDF)
- ✓ Unified metadata schemas (FITS, SOLARNET, ISTP)
- ✓ HAPI protocol compliance

### ✓ Accessible

- ✓ Multiple access methods (web, API, bulk)
- ✓ Clear licensing and documentation
- ✓ Zero-embargo by end-2025

### ✓ Reusable

- ✓ Open-source analysis tools
- ✓ Documented workflows
- ✓ Version control & reproducibility

### 👤 Community Experiences

- 🗨️ What open repositories have you used? What worked well?

### ⚠️ Common Challenges

- ⚠️ Data discovery, format inconsistencies, documentation gaps



# How HDRL addresses Open Science barriers

## Common Challenges

### **Data Fragmentation**

Scattered across multiple repositories with different access methods

### **Format Inconsistencies**

Varying data formats requiring specialized tools and knowledge

### **Metadata Gaps**

Insufficient documentation for data discovery and interpretation

## HDRL Solutions

### **Federated Access**

Single entry point to 2.5 PB across all major heliophysics archives

### **Standardized Formats**

CDF, FITS, netCDF with ISTP compliance and unified interfaces

### **Rich Metadata**

SPASE model with DOI citations and comprehensive documentation



## NASA Policy Alignment



**SPD-41a Compliance:** Public data at publication



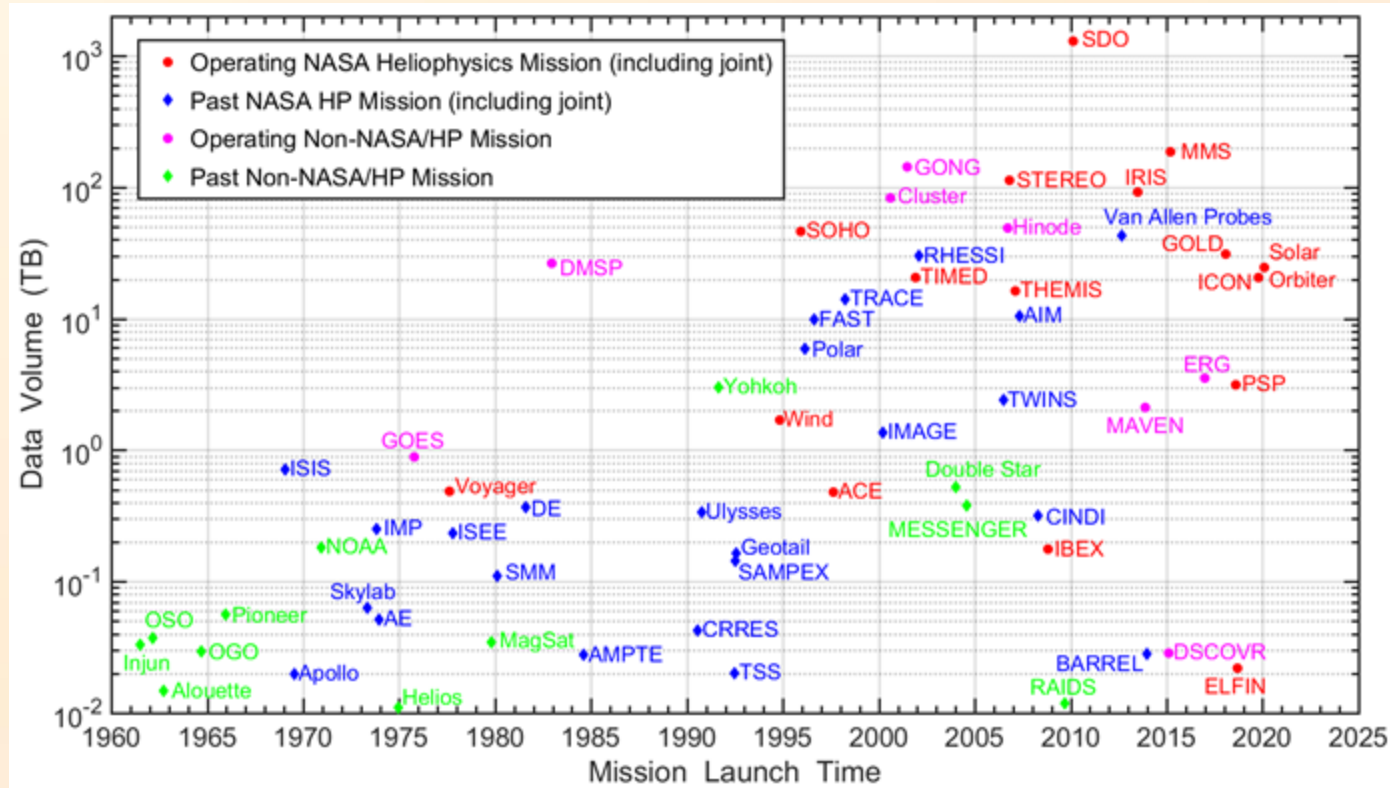
**Open Source:** Public repositories & collaboration



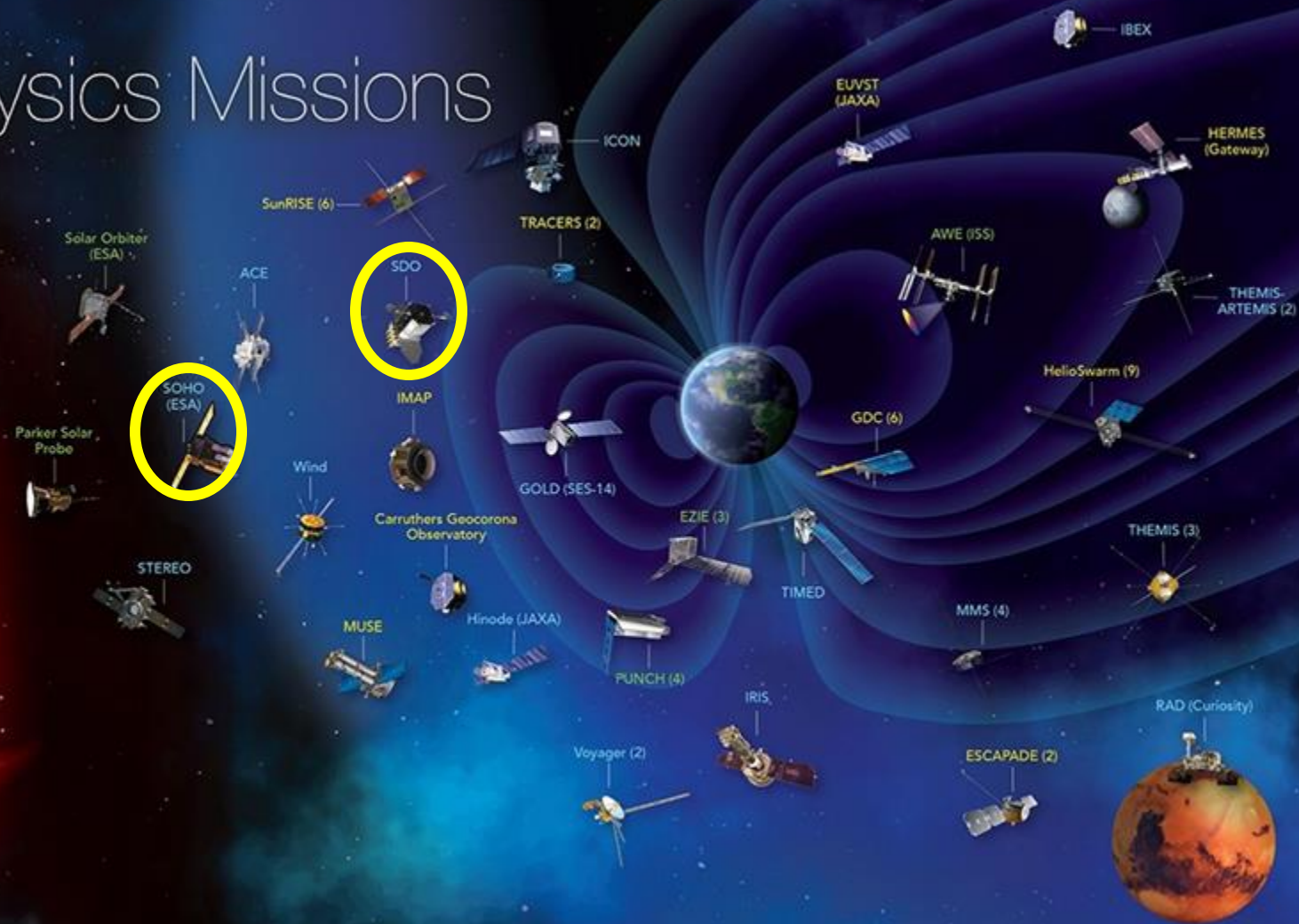
**International:** COSPAR HAPI & schema.org standards

## Mission Data Archived at HDRL

100+ missions over 65 years, covering from the Sun to the local interstellar medium  
~300 million files, 8000+ datasets, 600+ instruments



# Heliophysics Missions



Hands-On with SDAC

# Solar Data Analysis Center

NASA's Primary Solar Physics Archive



## Mission Coverage

- ✳ **SOHO:** LASCO, EIT, SUMER, VIRGO
- ⚙ **SDO:** AIA, HMI comprehensive datasets
- 🔭 **STEREO:** Dual perspective observations
- 📡 **Legacy:** SMM, Yohkoh, TRACE, Hinode



## Analysis Tools

- 🔑 **SolarSoft (IDL):** Legacy instrument packages
- 🐍 **SunPy (Python):** Modern analysis framework
- 🌐 **Helioviewer:** Browser-based access and API

## Virtual Solar Observatory



Web browser interface and software API



**EUV Images**

171, 195, 284, 304 Å



**Coronagraph**

LASCO C2/C3



**Spectroscopy**

SUMER spectra



**Irradiance**

VIRGO time series

## Web-Based Solar Visualization & RESTful API

Platform Features: RESTful API v2

### Web-Based Interface

No installation required

### Image Retrieval

JPEG 2000 format

### Open Source

ESA & NASA funded

### Movie Generation

Time sequences

### Multi-Mission Support

SDO, SOHO, etc.

### Screenshot API

Easy sharing

### Real-Time Access

Latest observations

### Event Queries

HEK integration

# Helioviewer



Example API Call:

```
https://api.helioviewer.org/v2/getJP2Image/?date=2024-01-01T00%3A00%3A00&instrument=SDO/AIA&wavelength=171&size=512
```

The RESTful API allows users to access solar images from different missions and tools, making it possible to create custom visualizations and automate data processing.



# Heliophysics Missions



# Heliophysics Missions

This infographic illustrates various space missions dedicated to studying the Sun and the solar wind. The Sun is depicted on the left, with solar wind represented by blue and purple waves emanating from it. Missions are shown at different distances from the Sun, with Earth and Mars also indicated. Two missions, TRACERS and EZIE, are highlighted with yellow circles.

Missions shown include:

- Solar Orbiter (ESA)
- Parker Solar Probe
- STEREO
- SOHO (ESA)
- ACE
- Wind
- MUSE
- SunRISE (6)
- IMAP
- Carruthers Geocorona Observatory
- Hinode (JAXA)
- Voyager (2)
- IRIS
- ESCAPADE (2)
- RAD (Curiosity)
- THEMIS (3)
- MMS (4)
- THEMIS-ARTEMIS (2)
- HERMES (Gateway)
- IBEX
- EUVST (JAXA)
- AWE (ISS)
- GDC (6)
- HELIO Swarm (9)
- TIMED
- PUNCH (4)
- GOLD (SES-14)
- CON
- TRACERS
- EZIE (3)






Hands-On with SPDF

# Space Physics Data Facility

Four Integrated Services for Heliophysics Research




## CDAWeb

-  **Web Browser:** Level-2 heliophysics datasets
-  **Customizable:** Time, variables, spacecraft subsetting
-  **Visualization:** Plots, movies, spectrograms






## SSCWeb

-  **Spacecraft Orbits:** 3D trajectory database
-  **4-D Viewer:** Interactive 3D+time visualization
-  **Advanced Queries:** Magnetospheric regions



## OMNIWeb

-  **Near-Earth:** Cross-normalized solar wind data
-  **Multi-Resolution:** 1-hour, 1-minute, 5-minute bins
-  **Long-term:** 1963 to present coverage



## CDF Tools

-  **Self-describing:** Platform-independent format
-  **Complete Toolset:** Libraries, editors, utilities
-  **Multi-language:** IDL, C, Fortran, Java, Python



A

CDAWeb + OMNIWeb  
Data browsing & time series analysis



B

SSCWeb + 4-D Orbit Viewer Trajectory  
visualization & conjunctions



# Linking SPDF Services with Missions

[https://spdf.gsfc.nasa.gov/data\\_orbits.html](https://spdf.gsfc.nasa.gov/data_orbits.html) (Partial Screenshot Below)

Click an **SPDF service name** to check mark (✓) the spacecraft whose data are available.

Click a **spacecraft name** to check mark (✓) the SPDF services with its data.

See [Info for New Users](#) for more information about these data services.

160+ missions

Go to Service's Home Page		Show Source Info	Orbit/Trajectory Data Only			
<b>DATA SERVICES:</b>		<b>SOURCE SPACECRAFT:</b>	DE	Jupiter	RHESSI	<b>OTHER DATA SOURCES:</b>
<a href="#">CDWeb</a>		ACE	ELFIN	Kepler	SAMPEX	
High-resolution, current space physics data with graphics and listings from many missions.		Active*	Endurance	KPLO (Danuri)	Sakigake*	Planet & Comet Positions
<a href="#">OMNIWeb Plus</a>		Aditya-L1	Equator-S	Lagrange Point 1 (L1)	San Marco	Ground-based
Hourly-averaged solar wind magnetic field and plasma, etc.		Aerocube	Explorer	Landsat	Saturn	Activity Indices
<a href="#">PlotWalk</a>		Aeros	FAST	LANL	SCATHA*	
Browse pregenerated data and orbit plots		AJM	FIREBIRD*	LRO	SDO	
<a href="#">SPDF FTPS Site</a>		Akebono*	Formosat	LUNA	SET-1/DSX	
<a href="#">Read FTP to FTPS information.</a>		Alouette1	Freja*	Magsat	SMILE	
<a href="#">SPDF HTTPS Site</a>		Alouette2	Galileo*	MAP	SNOE	
		AMPTE	Gateway*	Mariner 10	SOHO	
		APEX-MAIN*	GCOM W1	Mars	Solar Orbiter	
		Apollo	Genesis	MAVEN	SORCE	
		Aqua	Geotail	MESSENGER	Spartan-A	
		Ariel-4	Giotto*	MGS	Spitzer	
		Arase (ERG)	GOCE	Microlab 1	SPORT	
		ARCAD	GOES18	Mir*	Sputnik 1	
		ARTEMIS	GOES19	MMS	STEREO	
		ASTRID II*	GOLD	MRO	Suisei	
		AE	GPS	MSL	Swarm	
		Aura	GMS 3	MSX*	Tatiana	
		Aureol2	GRACE*	Munin	THEMIS	
		AWE	Granat	Neptune	TIMED	
		BARREL	Hawkeye	New Horizons	TRACE	
		BepiColombo	Helios	NOAA*	TSS-1R	
		BioSentinel	Hinode	Oersted	TWINS	
		CALIPSO	Hinotori	OGO	UARS*	
		Cassini*	IBEX	Ohzora	Ulysses	
		Cassiope	ICE	OSIRIS-REx (-APEX)	Uranus	
		Cirbe	ICON	PARASOL	Van Allen Probes	
		Cluster	IMAGE	Parker Solar Probe	Vega	

60+ Missions or Mission Groups →

## Coordinated Data Analysis Web (CDAWeb)

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

- **Special data source groups:** balloons, ground-based investigations, cubesats, sounding rockets, etc.
- **Enable Systems Science:** cross-mission, multi-instrument science
- Present dataset view rather than individual files
- 70% of 2744 datasets in CDAWeb have SPASE records; 57% have DOIs

• Select zero OR more Sources  
(default = All Sources if  $\geq 1$  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
- ☐ AIM
- ☐ AMPTE
- ☐ ARTEMIS
- ☐ Alouette
- ☐ Apollo
- ☐ Arase (ERG)
- ☐ CNOFS
- ☐ CRRES
- ☐ Cassini
- ☐ Cluster
- ☐ DMSP
- ☐ DSCOVR

• Select zero OR more Instrument Types  
(default = All Instrument Types if  $\geq 1$  Source is selected)

- ☐ Activity Indices
- ☐ Electric Fields (space)
- ☐ Electron Precipitation Bremsstrahlung
- ☐ Energetic Particle Detector
- ☐ Engineering
- ☐ Ephemeris/Attitude/Ancillary
- ☐ Gamma and X-Rays
- ☐ Ground-Based HF-Radars
- ☐ Ground-Based Imagers
- ☐ Ground-Based Magnetometers, Riometers, Sounders
- ☐ Ground-Based VLF/ELF/ULF, Photometers
- ☐ Housekeeping
- ☐ 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
- ☐ UV Imaging Spectrograph (Space)

- ☐ **AEROCUBE-6-B\_DOSIMETER\_L2:** Aerocube 6/Dosimeter Level 2 - J. B. Blake (The Aerospace Corporation)  
[Available Time Range: 2014/06/21 14:49:56 - 2017/06/30 15:24:08] [Info](#) [Metadata](#)
- ☐ **CSSWE\_REPTILE\_6SEC-COUNTS-L1:** CSSWE REPTile level1 6sec Counts and Position - Xinlin Li (University of Colorado at Boulder)  
[Available Time Range: 2012/09/14 00:28:03 - 2014/08/20 20:27:56] [Info](#) [Metadata](#)
- ☐ **CSSWE\_REPTILE\_6SEC-FLUX-L2:** CSSWE REPTile level2 6sec flux and Position - Xinlin Li (University of Colorado at Boulder)  
[Available Time Range: 2012/09/14 00:28:03 - 2014/08/20 20:27:56] [Info](#) [Metadata](#)
- ☐ **ELA\_L1\_STATE\_PRED:** ELFIN-A state file, contains predictive position, velocity, and attitude - V. Angelopoulos (UCLA, IGPP/EPSS)  
[Available Time Range: 2018/09/17 00:00:00 - 2022/09/17 23:59:59] [Info](#) [Metadata](#)



# CDAWeb Data Explorer

- Time interval is automatically set by the last available day of the selected dataset(s)
- Remove spikes or filter coarse noise
- **Plot data availability**
- Adjust X and Y lengths for plotting
- **Auto scale time axis for finding discrete bursts or events**
- Overlay vector components of selected variables, or selected variables that are identical among multiple datasets
- Output a subset or a superset of datasets in CDF, ASCII/CSV, JSON
- Create **audio** and **movie** files for selected variables

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

Start time (YYYY/MM/DD HH:MM:SS.mmm): 2022/09/17 00:00:00.000

Stop time (YYYY/MM/DD HH:MM:SS.mmm): 2022/09/18 00:00:00.000

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

☐ Use spike removal to filter data without binning (not available with noise filtering)(Warning: Experimental !!).

Select an activity:

☐ Data Availability Chart : Generate a chart showing when data is available for the selected data set(s) and time range (Select > 1day).

☒ 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.

☐ Change the X-axis width for time-series and spectrogram PNG plots (NEW default=3). NEW

☐ Change the Y-axis height for time-series and spectrogram plots (NEW default=2). NEW

☐ Autoscale time axis (useful for finding discrete bursts/events). NEW

☐ Combine all time-series and spectrogram plots, for all requested datasets, into one plot file.

☒ Plot overlay options.

☒ 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://cdaweb.gsfc.nasa.gov/> for larger requests)

☐ Create V3.9 CDFs for download: select one or more variables from the list below and press submit. NEW

☐ Create audio files based on data from selected variables. [More information about audification.](#)

Note: CDF patch required for reading Version 3.9 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.

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

# Each supported dataset also provides links to IDL and Python code examples for downloading and working with the data files independently (outside of the CDAWeb system)

## CDAS Web Service Client Code Examples

The following web service client code examples demonstrates how to access data from the [AEROCLUE-6-B DOSIMETER 1.2](#) dataset from particular programming environments.

### Jupyter Notebook on Binder

The following link launches a Python Jupyter Notebook that demonstrates using the cdasws library to access [AEROCLUE-6-B DOSIMETER 1.2](#) data in a Jupyter Notebook. It is merely an example and does not show all the capabilities of the library. You should edit the code to suit your needs.

[Launch](#) [Binder](#)

### cdasws Python Library

The following code demonstrates using the cdasws library to access [AEROCLUE-6-B DOSIMETER 1.2](#) data in a Jupyter Notebook. It is merely an example and does not show all the capabilities of the library. You should edit the code to suit your needs.

```
# Install these prerequisites once before executing the example code:
# Option 1.
# Install CDF from https://cdf.gsfc.nasa.gov/
# pip install -U spacepy
# pip install -U cdasws
# Option 2.
# pip install -U xarray
# pip install -U cdflib
# pip install -U cdasws

from cdasws import CdasWs
cdas = CdasWs()

# Edit the following vars, time variables, and printing to suit your
environment
# (spacepy or cdflib) and needs.
vars =
['alt', 'lat', 'lon', 'XYZ_0EO', 'dos11', 'dos1m', 'dos1rate', 'dos21', 'dos2m',
```

### cdasws IDL Library

The following code demonstrates using the cdasws library to access [AEROCLUE-6-B DOSIMETER 1.2](#) data in IDL. It is merely an example and does not show all the capabilities of the library. You should edit the code to suit your needs.

```
compile_opt idl2
savFilename = filepath('spdfcdas.sav', /tmp)
OURL = obj_new('IDLnetURL')
; For IDL installations with old root certificates
OURL->setProperty, SSL_VERIFY_PEER=0
savFilename = OURL->get(filename=savFilename,
url='https://cdasweb.gsfc.nasa.gov/WebServices/REST/spdfcdas.sav')
restore, savFilename

; Edit the following vars and time variables to suit your needs.
vars =
['alt', 'lat', 'lon', 'XYZ_0EO', 'dos11', 'dos1m', 'dos1rate', 'dos21', 'dos2m', 'dos2rat
e', 'dos31', 'dos3m', 'dos3rate', 'flag', 'Sample_Rate', 'Lm_10RF', 'Bmag_10RF', 'MLT_10
RF', 'InvLat_10RF', 'Lm_OPQ', 'Bmag_OPQ', 'MLT_OPQ', 'InvLat_OPQ', 'Loss_Cone_Type', 'B
xyz_0EO', 'Seq', 'I', 'K', 'K_2', 'Lstar', 'Lstar_2', 'Mmin', 'Mmin_2', 'Loss_Cone_Near',
'Loss_Cone_Far', 'B100N', 'LAT100N', 'LON100N', 'B100S', 'LAT100S', 'LON100S', 'Alpha',
'Alpha_X', 'Alpha_Y', 'Alpha_Eq', 'Beta', 'Beta_X', 'Beta_Y', 'Phi_B', 'OmegaXYZ_0EO', '
B_spin', 'Spin_Sun', 'Dist_In_Track', 'Lag_In_Track', 'Dist_Cross_Track_Moris', 'Dist
_Cross_Track_Wert', 'Dist_Total', 'alt_10Hz', 'lat_10Hz', 'lon_10Hz', 'dos11_10Hz', 'd
os1m_10Hz', 'dos1rate_10Hz', 'dos21_10Hz', 'dos2m_10Hz', 'dos2rate_10Hz', 'dos31_10Hz',
'dos3m_10Hz', 'dos3rate_10Hz', 'flag_10Hz', 'Subcom_10Hz', 'Lm_OPQ_10Hz', 'Bmag_OPQ
_10Hz', 'MLT_OPQ_10Hz', 'InvLat_OPQ_10Hz', 'Loss_Cone_Type_10Hz', 'K_2_10Hz', 'Lstar_
2_10Hz', 'Mmin_2_10Hz', 'Alpha_10Hz', 'Beta_10Hz', 'Dist_In_Track_10Hz', 'Lag_In_Trac
```

[Copy code to clipboard](#) [Download code](#)

More information about using this library is available from the following:

- IDL library description [cdasws](#)
- Jupyter IDL [notebook examples](#)
- Application Programming Interface description [API](#)

**Alternative data access methods** [https://cdasweb.gsfc.nasa.gov/alternative\\_access\\_methods.html](https://cdasweb.gsfc.nasa.gov/alternative_access_methods.html)

# 4-D Orbit Viewer (160+ Spacecraft)

<https://sscweb.gsfc.nasa.gov/4dorbit/>

The screenshot displays the 4-D Orbit Viewer interface. At the top, a toolbar contains icons for menu, download, image, settings, zoom, bookmark, and help. The title "4D Orbit Viewer" and the NASA logo are in the top right, along with an "SPDF" button. On the left, a list of celestial bodies is shown with their respective icons: Earth (⊕), Moon (☾), Sun (☉), Mercury (♿), Venus (♀), Mars (♂), and Lagrange Point 1 (L<sup>1</sup>). The central view shows a 3D model of Earth with a red diamond at its center, representing the Sun. Three coordinate axes are visible: a vertical blue axis pointing up, a horizontal green axis pointing right, and a diagonal blue axis pointing down. The word "Earth" is labeled at the top and bottom of the vertical axis. On the right side, there are several icons for camera controls: a button with "B" and a camera icon, a button with "M" and a camera icon, a button with "YZ" and a camera icon, a button with "XZ" and a camera icon, a button with "XY" and a camera icon, a button with a grid icon, and a button with a grid icon. At the bottom, there is a playback control bar with a "Start" button, a play button, a "Loop" toggle switch, a help button, and a "Speed: 1 x" button. A timeline at the bottom shows the date "2024 Oct 13 00:00:00" on the left, "2024 Oct 13 00:00:00" in the center, and "2024 Oct 14 00:00:00" on the right, with a small "26" next to the final date.

4D Orbit Viewer

SPDF

⊕ Earth

☾ Moon

☉ Sun

♿ Mercury

♀ Venus

♂ Mars

L<sup>1</sup> Lagrange Point 1

Earth

Earth

Start

Loop

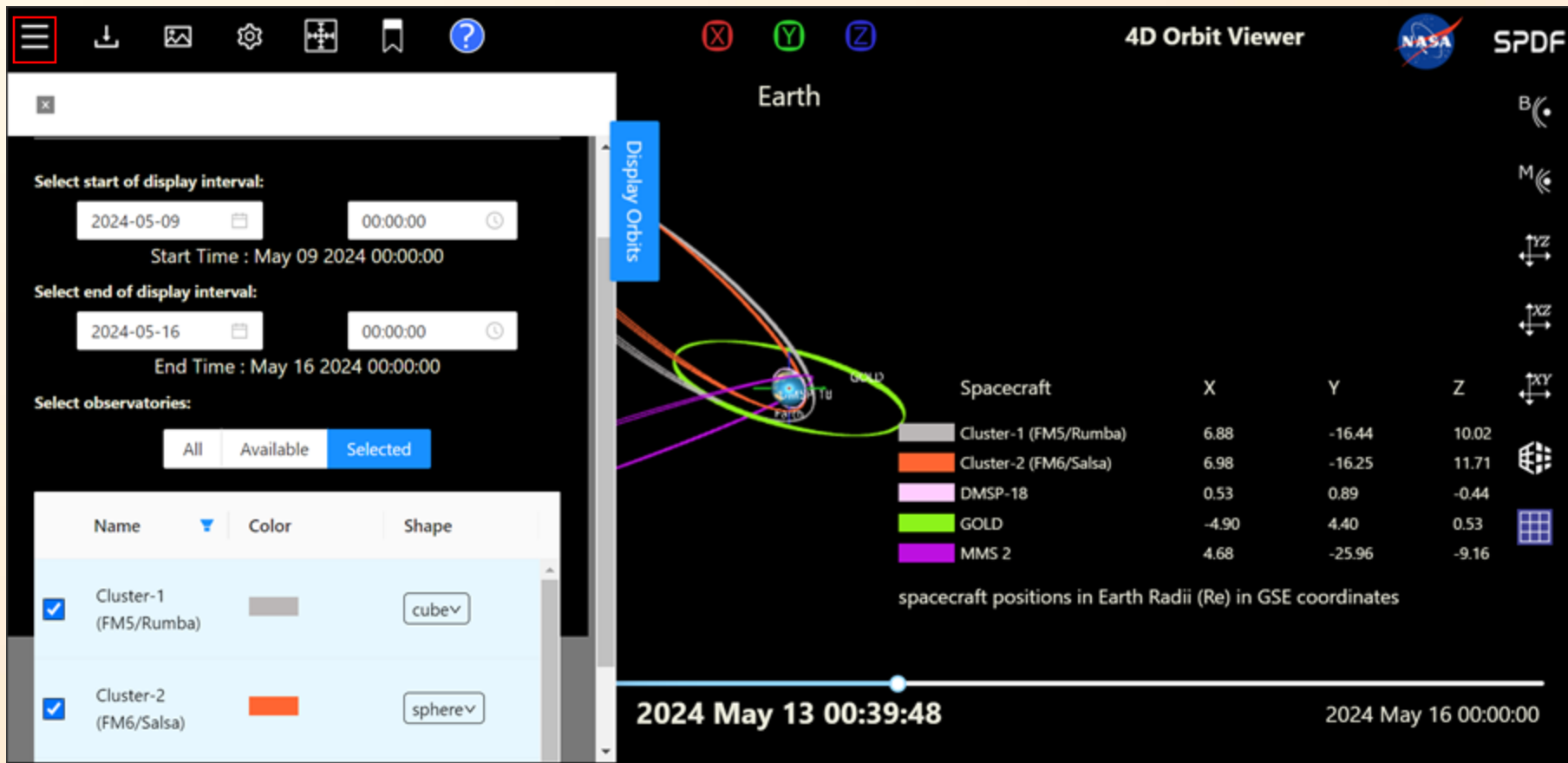
Speed: 1 x

2024 Oct 13 00:00:00

2024 Oct 13 00:00:00

2024 Oct 14 00:00:00<sup>26</sup>

# 4-D Orbit Viewer: Time and Spacecraft Selection



# NSF-Supported Geospace Data Infrastructure

**Tai-Yin Huang**  
**Program Director**  
**Geospace, AGS Division**  
**Geosciences Directorate, NSF**



**August 15, 2025**  
**Heliophysics Summer School**



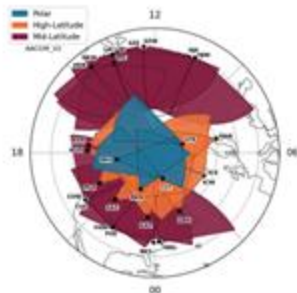


# AGS-Supported Data Infrastructure

**Madrigal:** manages and serves archival and real-time data from a wide range of instruments such as radars, ionosondes, Fabry-Perots, satellite instruments, DMSP, Michelson Interferometers, Lidars, imagers, magnetometers, radiometers, photometers, riometers, VLF, and modelled data. [Madrigal database at Millstone](#)

**SuperDARN:** provides access to SuperDARN data (line-of-sight velocity, spectral width, power of backscattered signal, and thermospheric neutral wind) in platform-independent netCDF files and data visualizer. [VT SuperDARN](#) and [Superdarn](#)

**AMISR (Advanced Modular Incoherent Scattered Radar):** provides electron temperatures, plasma line, ion-neutral collision frequency. [AMISR](#)



# AGS-Supported Data Infrastructure



**SuperMAG:** provides easy access to validated ground magnetic field perturbations in the same coordinate system, identical time resolution and with a common baseline removal approach. Global magnetic field observations and products made possible by the contributors.

[SuperMAG](#)



**AMPERE (Active Magnetosphere and Planetary Electrodynamics Response Experiment):** provides AMPERE magnetic perturbation data and data products derived from the Iridium constellation

[AMPERE](#)



# AGS-Supported Data Infrastructure



**LISN (Low Latitude Ionospheric Sensor Network):** provides GPS, magnetometer, and ionosonde data. [LISN](#)



**Community Coordinated Modeling Center (with NASA):** provides access to modern space research models; tests and evaluates models; supports Space Weather forecasters; supports space science. [Home](#) | [CCMC](#)



**COMMUNITY  
COORDINATED  
MODELING  
CENTER**



**MANGO (Midlatitude Allsky-imaging Network for Geospace Observations):** A network of all-sky cameras and FPIs to observe wave activity in the thermosphere). [MANGO Network](#)



# AGS-Supported Data Infrastructure

The US NSF National Center for Atmospheric Research  
(NSF NCAR)



**Geoscience Data  
Exchange (GDEX):**  
public data repository.

**Information Systems Lab  
(CISL):** provides  
supercomputing, analysis  
and visualization  
resources, stores,  
develops, and curates data

**High Altitude  
Observatory (HAO):**  
provides data (MLSO and  
PFI) and models.

**(CDG):** provides long-term  
stewardship for data  
assets related to geo-  
and helio-science model  
output that are generated  
as a result of NCAR

To search and discover datasets across all of NCAR's data repositories, use: <https://data.ucar.edu/>.  
To submit a request to deposit data at NCAR, do so through: <https://submit-data.ucar.edu>.









# NSF-Supported Data Infrastructure



[Data Access - NSO - National Solar Observatory](#)

-  [Dkist data, DKIST Data Center Archive](#)
-  [NISP \*\*SOLIS\*\* \(Synoptic Optical Long-term Investigations of the Sun\), NSO/NISP: SOLIS Data Information](#)
-  [NISP \*\*GONG\*\* \(Global Oscillation Network Group\), NSO/GONG: Data Access](#)
-  [Historical Archive, \[Historical Archive - NSO - National Solar Observatory\]\(#\)](#)
-  [VSO data, \[Virtual Solar Observatory\]\(#\)](#)



# Examples

What can you do with these resources?

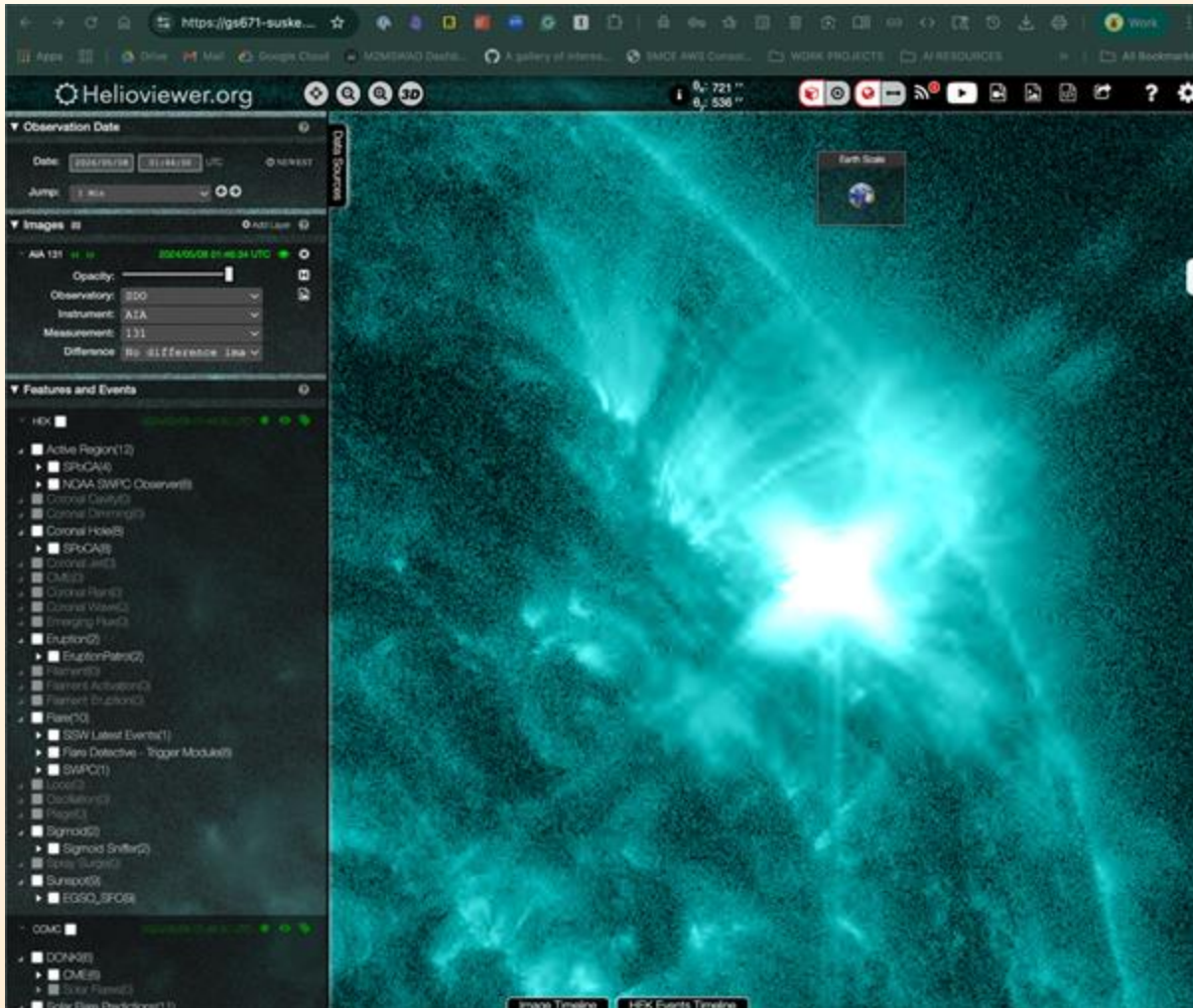
**Try it for yourself.**



# Helioviewer

SDO and SOHO data visualized easily without  
processing yourself

[Helioviewer](#)



The **Helioviewer Project** is an open platform for exploring solar and heliospheric imagery -

via the **Helioviewer.org** web app, the **JHelioviewer** desktop viewer, and **public APIs** -

letting you browse **near-real-time** and **historical data**, **overlay events**, and generate **screenshots** and **movies**.

# CDAWeb

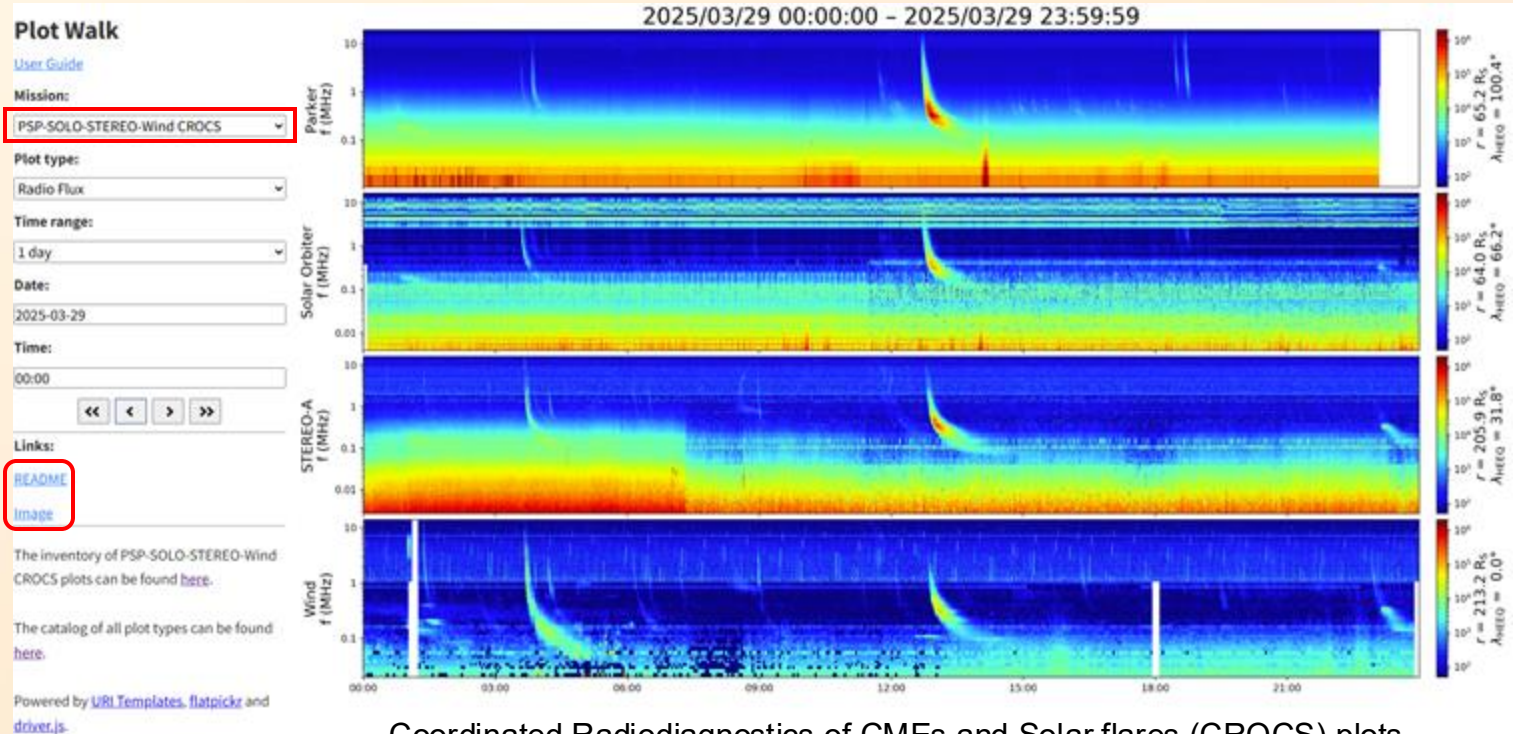
Coordinated Data Analysis Web

Non-solar heliophysics data from current and past heliophysics  
missions and projects

# Plot Walk for Pre-Generated Plots

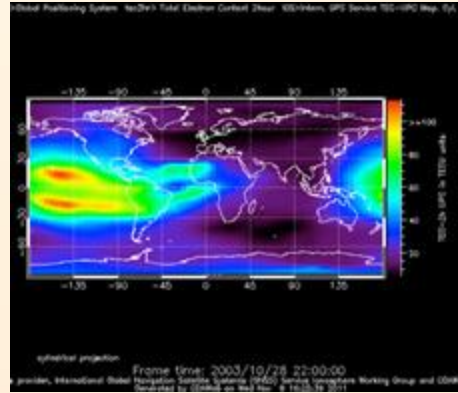
[https://spdf.gsfc.nasa.gov/plot\\_walk/](https://spdf.gsfc.nasa.gov/plot_walk/)

Summary or quick-look plots from 20+ missions (12.5 million plots)



Coordinated Radiodiagnostics of CMEs and Solar flares (CROCS) plots using radio data from PSP, Solar Orbiter, STEREO A, and Wind missions

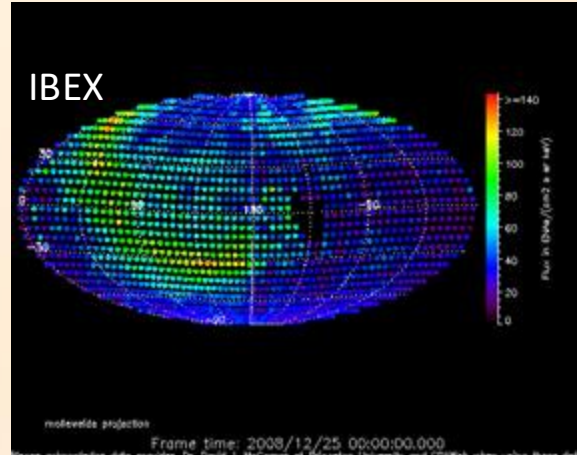
## GPS International GNSS Service Total Electron Content



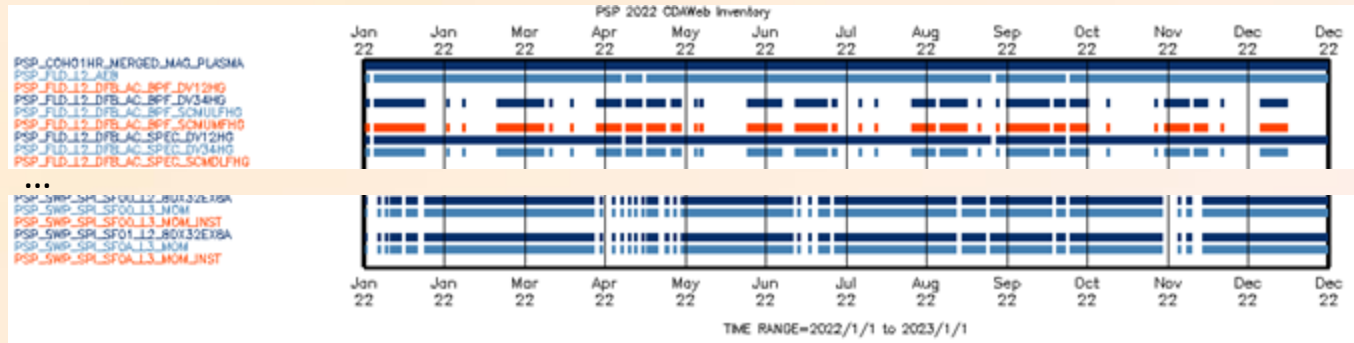
Example  
Parameter  
Displays  
in CDAWeb



More at <https://cdaweb.gsfc.nasa.gov/about.html>



Inventory  
Plot for  
Mission  
Datasets



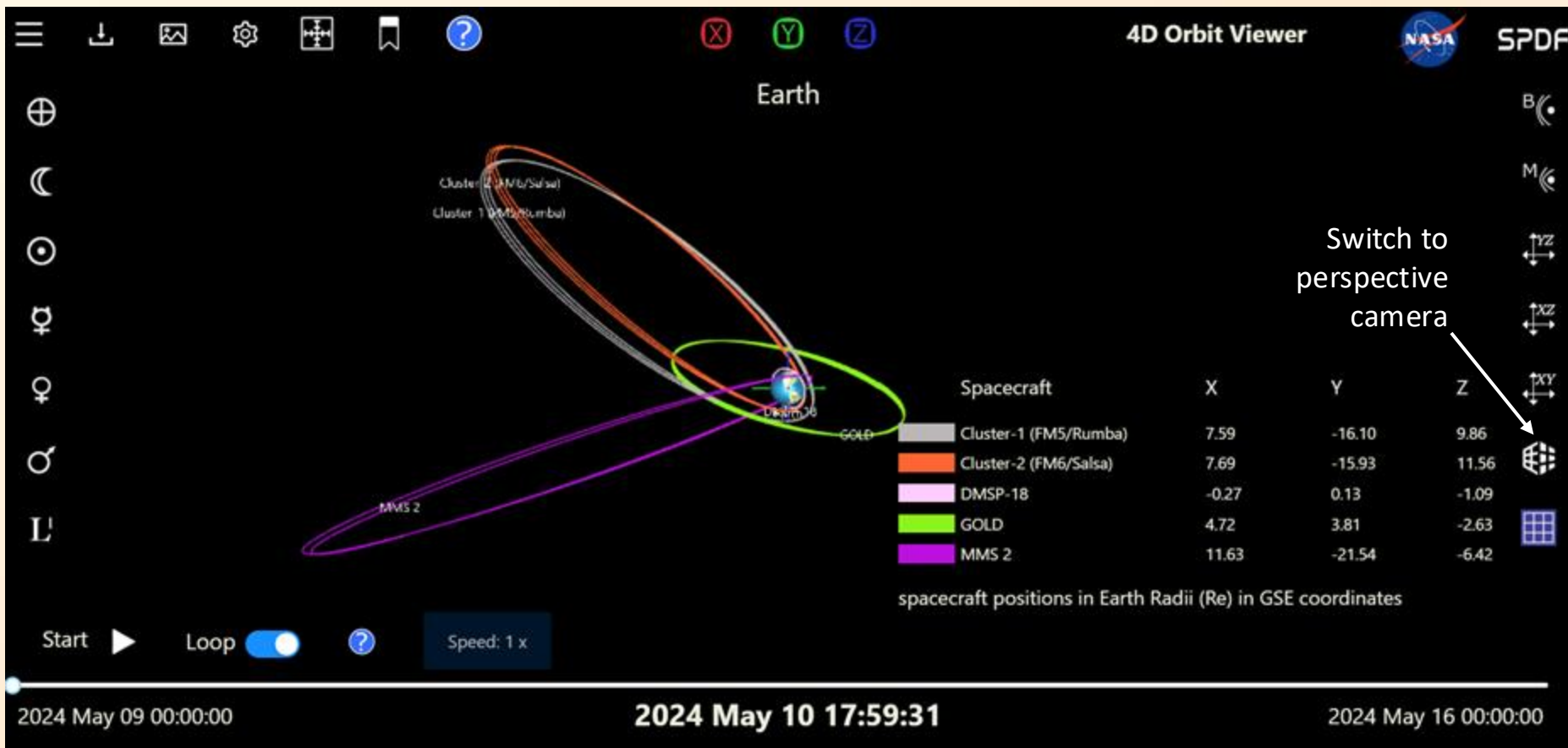
[https://cdaweb.gsfc.nasa.gov/sc\\_inventory\\_plots/](https://cdaweb.gsfc.nasa.gov/sc_inventory_plots/)

# 4-D Orbitviewer

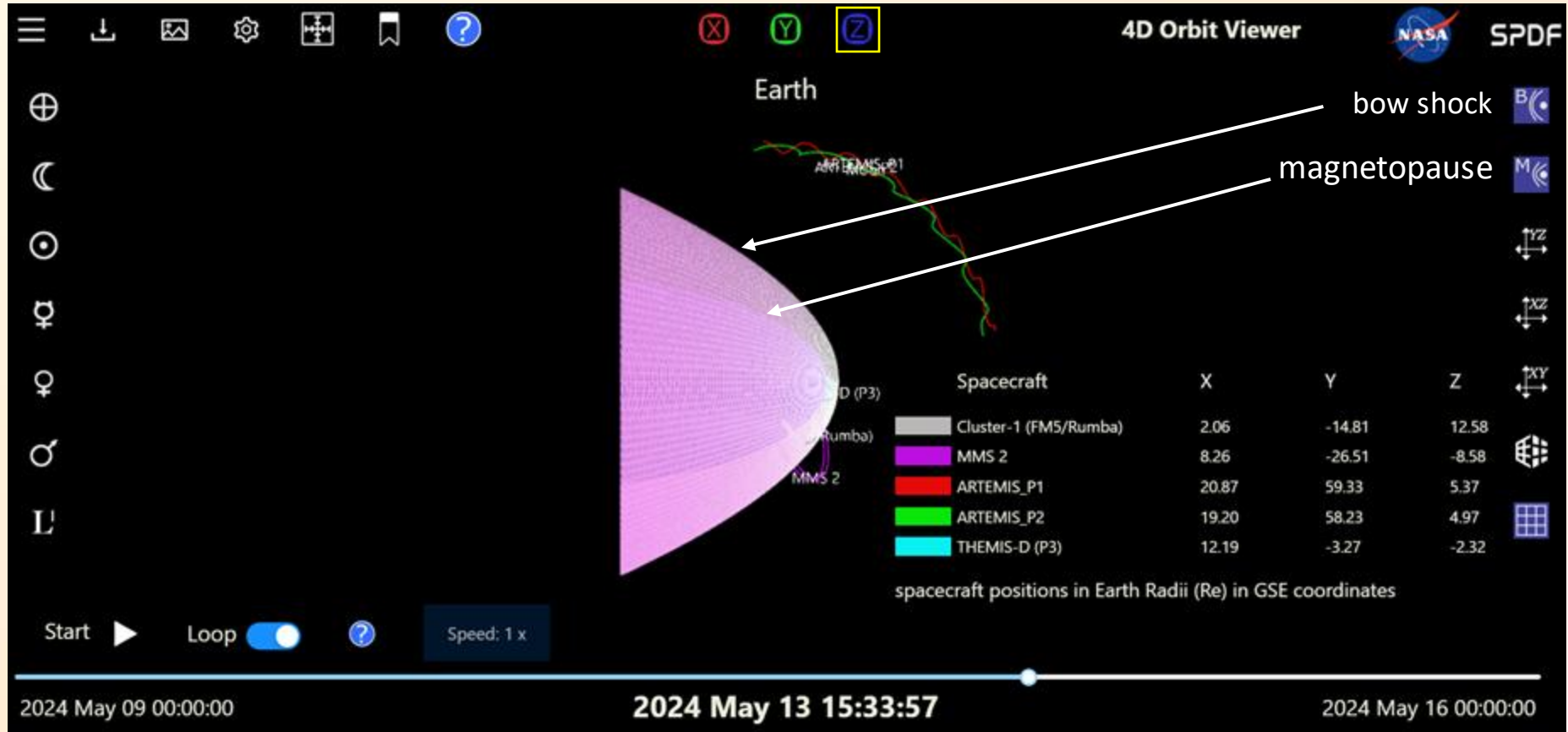
Provides an interactive 4-D animation of spacecraft orbits over time



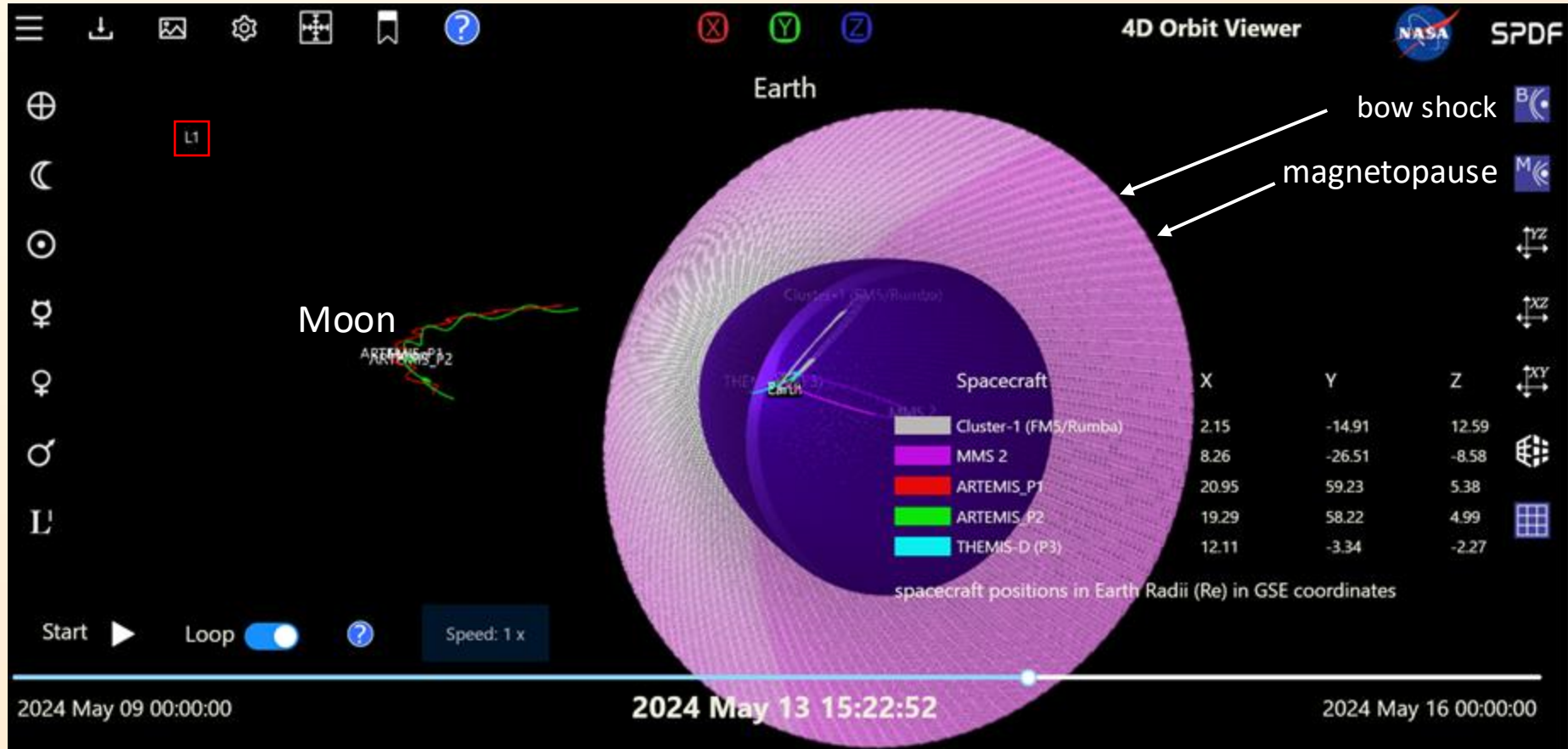
# 4-D Orbit Viewer: Different Perspectives



# 4-D Orbit Viewer: Bow Shock and Magnetopause



# 4-D Orbit Viewer: Rotation of Coordinates

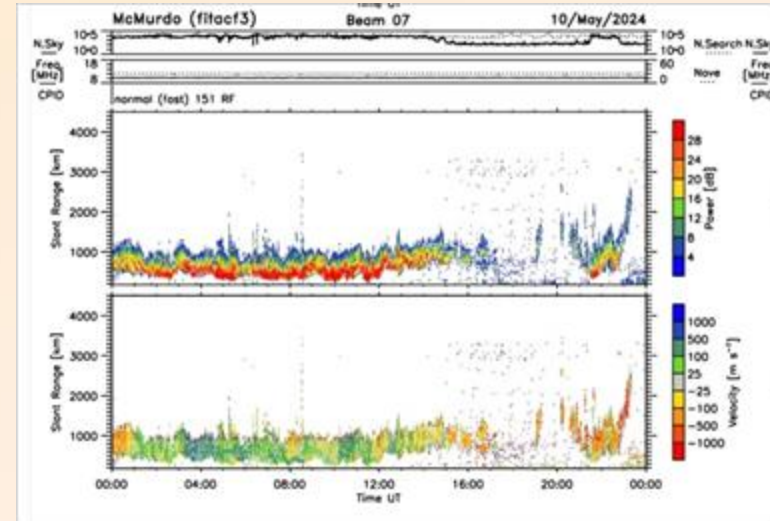


# VT SuperDARN

Virginia **T**ech Super **D**ual **A**uroral **R**adar **N**etwork

**VT SuperDARN** is the **Virginia Tech** research group within the international **Super Dual Auroral Radar Network** (SuperDARN)

The SuperDARN is a global array of high-frequency (HF) radars that continuously observe the ionosphere to map plasma convection and other geospace dynamics, which are crucial for space-weather research and operations.



[VT SuperDARN](#)

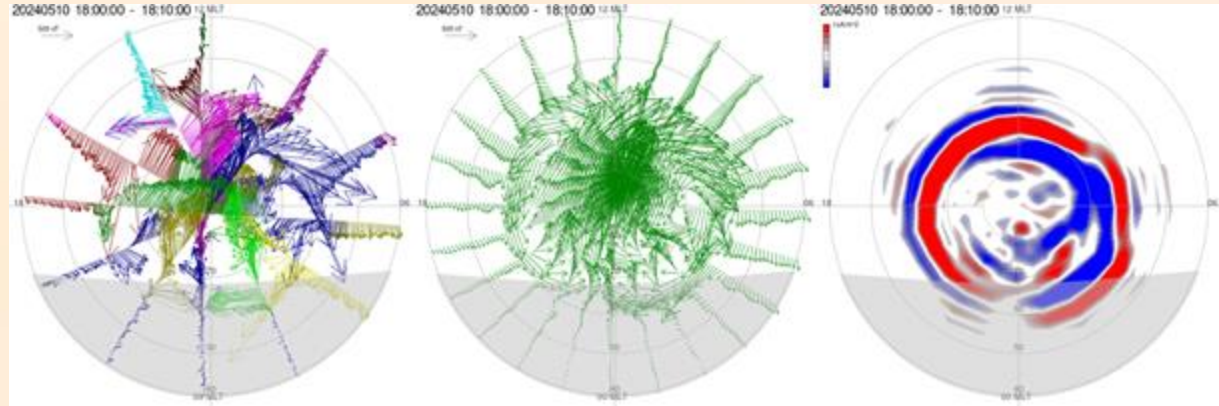
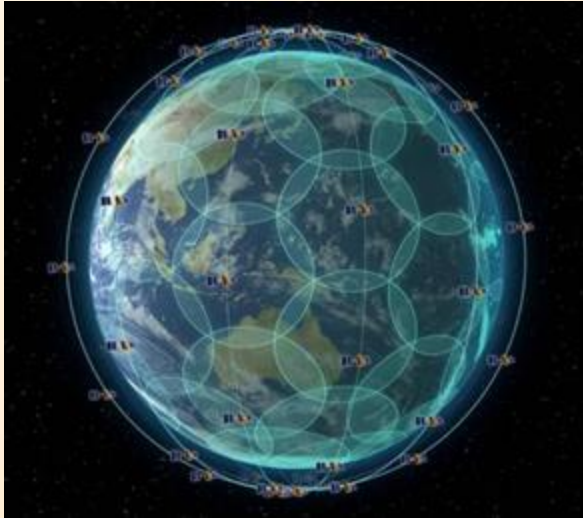
# AMPERE

**A**ctive **M**agnetosphere and **P**lanetary **E**lectrodynamics **R**esponse **E**xperiment



**AMPERE (Active Magnetosphere and Planetary Electrodynamics Response Experiment)** is a space-weather observing system run by Johns Hopkins Applied Physics Lab (with NSF, Iridium, and Boeing)

It uses the Iridium communications satellites' onboard engineering magnetometers to continuously map field-aligned (Birkeland) currents and large-scale ionospheric electrodynamics.



AMPERE JHUAPL

# Thank you!!

What can we do to help you do your science?

What data and what tools do you need?

NASA: [C. Alex Young - c.alex.young@nasa.gov](mailto:c.alex.young@nasa.gov)

NSF: [Tai-Yin Huang - thuang@nsf.gov](mailto:thuang@nsf.gov)