# Parker Solar Probe In-Situ Data at the SPDF Archives

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**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, will be preserving and distributing the data from Parker Solar Probe. 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 has been working with the Parker Solar Probe mission in preparation for archiving and serving its in-situ data starting 2019 Nov 12, and also has arrangements to serve in-situ data from Solar Orbiter when those data become public. SPDF will facilitate scientific analysis of multi-instrument and multi-mission datasets to enhance the science return of Parker Solar Probe mission. 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 Helios, MMS, Van Allen Probes, THEMIS/ARTEMIS, GOLD, ACE, Cluster, Geotail, Polar, 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. 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.

# Parker Solar Probe In-Situ Data at the SPDF Archives

AGU Fall Meeting 2019
**Poster: SH21C-3330**

**R. Candey[1], D. Bilitza[2], R. Chimiak[3], J. Cooper[1], L. Garcia[4], C. Gladney[5], B. Harris[3], L. Jian[1], R. Johnson[5], T. Kovalick[5], N. Lal[1], H. Leckner[5], M. Liu[5], R. McGuire[1], N. Papitashvili[5], U. Rao[5], A. Roberts[1], R. Yurow[5]**

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## Space Physics Data Facility (SPDF)
## NASA Heliophysics Active Final Archive for non-solar data

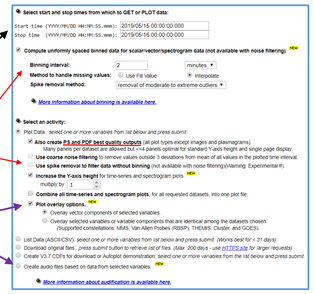
- SPDF is the active and final archive of **in-situ data** from NASA heliophysics missions, including collaboration missions with other US and foreign agencies
- We also archive other data **relevant to NASA heliophysics science objectives**
  - Related data from planetary missions (e.g., MESSENGER, 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) https://cdf.gsfc.nasa.gov
  - Heliophysics Data Portal https://heliophysicsdata.gsfc.nasa.gov

## CDAWeb Data Explorer

Defaults to the last available day of the selected data

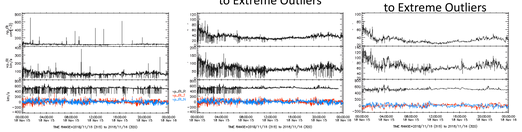
Ways to remove spikes

Other Options: overlay plotting, audification, making animations

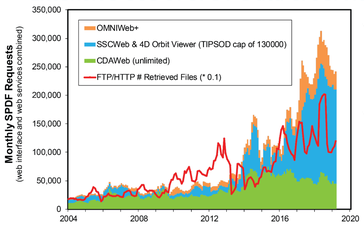



## Comparison Plots of PSP_SWP_SPC_L3I

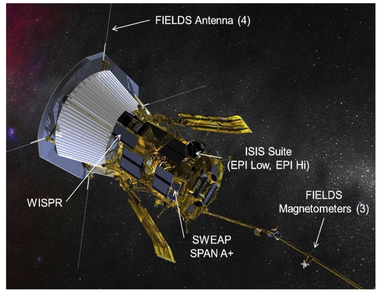
Original Data | Removal of Moderate to Extreme Outliers | Using 2-min Bins and then Removing Moderate to Extreme Outliers



## Extensive Use of SPDF Data & Services




- ✓SPDF data and services enable global-scale, multi-mission heliophysics science
- ✓~30% of papers in AGU's JGR Space Physics acknowledged SPDF services and/or data in recent years

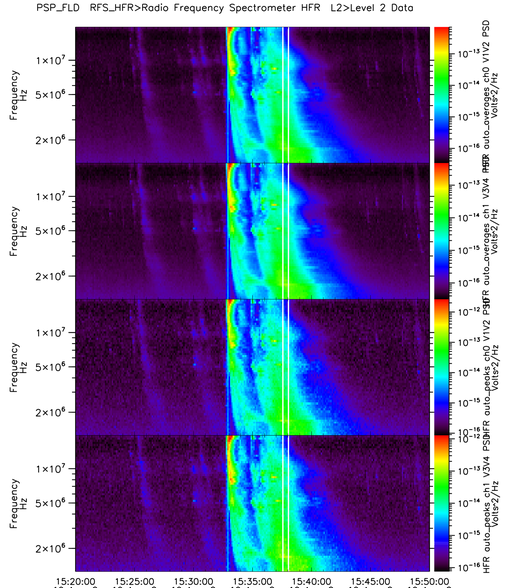


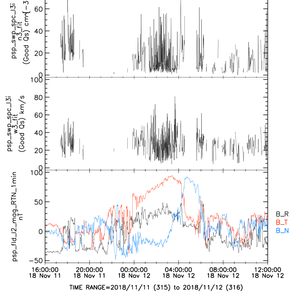

## SWEAP Data sets

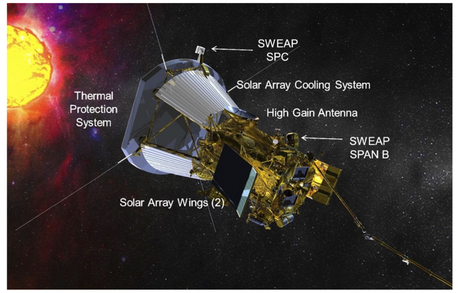
| | | | |
|---|---|---|---|
| **SPC (Solar Probe Cup)** | | psp_swp_spc_l2i | ion charge flux distribution as a function of the energy-per-charge carrier with mode flag, and its quick look plots |
| | | psp_swp_spc_l3i | ion properties derived from moments and fits with quality flag |
| SPI (Solar Probe Analyzer **Ion** instrument) | spi_sf00 | psp_swp_spi_sf00_L2_8Dx32Ex8A | differential proton energy flux at each measured deflector step, energy, and anode for SPAN-Ion |
| | spi_sf00 | psp_swp_spi_**sf00**_L3_mom_INST | partial moments of the proton (0a for alpha) distribution function in the instrument frame of reference |
| | spi_sf0a | psp_swp_spi_**sf0a**_L3_mom_INST | |
| SPE (Solar Probe Analyzer **Electron** instrument) | spa_sf0 | psp_swp_spa_sf0_L2_16Ax8Dx32E | differential electron energy flux from SPAN-A |
| | spa_sf1 | psp_swp_spa_sf1_L2_32E | |
| | spb_sf0 | psp_swp_spb_sf0_L2_16Ax8Dx32E | differential electron energy flux from SPAN-B |
| | spb_sf1 | psp_swp_spb_sf1_L2_32E | |

## FIELDS Data sets

| | | |
|---|---|---|
| MAG (Fluxgate Magnetometer) | mag_RTN | psp_fld_l2_mag_RTN, 1_min, 4_Sa_per_Cyc |
| | mag_SC | psp_fld_l2_mag_SC, 1_min, 4_Sa_per_Cyc |
| RFS (Radio Frequency Spectrometer) | rfs_hfr | psp_fld_l2_rfs_hfr (high frequency receiver) |
| | rfs_lfr | psp_fld_l2_rfs_lfr (low frequency receiver) |
| DFB (Digital Fields Board) | dfb_ac_bpf (bandpass filter) | psp_fld_l2_dfb_ac_bpf_dV34hg |
| | | psp_fld_l2_dfb_ac_bpf_SCMulfhg, SCMumfhg |
| | dfb_ac_spec (spectral data) | psp_fld_l2_dfb_ac_spec_dV12hg, dV34hg, V5hg |
| | | psp_fld_l2_dfb_ac_spec_SCMdlfhg, SCMelfhg, SCMflfhg, SCMmf (d, e, f are 3 axises) |
| | dfb_dc_bpf | psp_fld_l2_dfb_dc_bpf_dV34hg |
| | | psp_fld_l2_dfb_dc_bpf_SCMulfhg |
| | dfb_dc_spec | psp_fld_l2_dfb_dc_spec_dV12hg |
| | | psp_fld_l2_dfb_dc_spec_SCMdlfhg, SCMelfhg, SCMflfhg |
| | dfb_wf_dvdc | psp_fld_l2_dfb_wf_dvdc (differential voltage waveform) |
| | dfb_wf_scm | psp_fld_l2_dfb_wf_scm |
| | dfb_wf_vdc | psp_fld_l2_dfb_wf_vdc (single ended voltage waveform) |
| F2 (FIELDS2 Time Domain Sampler) | | psp_fld_l2_f2_100bps |




## IS⊙IS Data sets

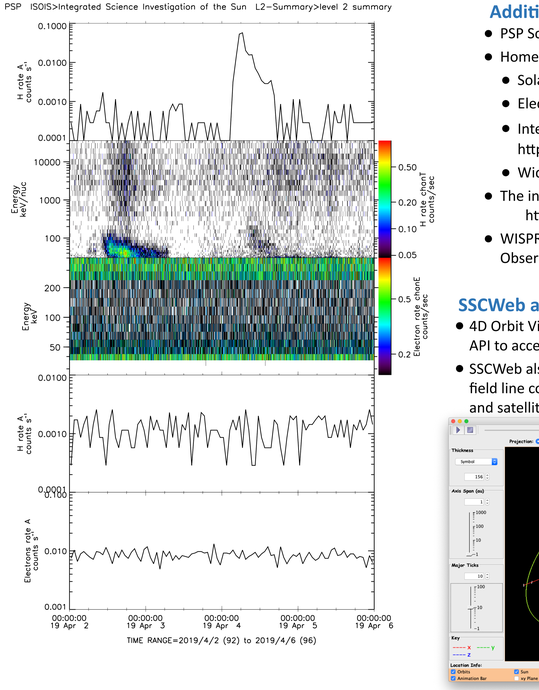
| | | |
|---|---|---|
| EPI-Hi | HET | psp_isois-epihi_l2-het-rates10, rates60, rates300, rates3600 |
| | LET1 | psp_isois-epihi_l2-let1-rates10, rates60, rates300, rates3600 |
| | LET2 | psp_isois-epihi_l2-let2-rates10, rates60, rates300, rates3600 |
| | Selected Summary | psp_isois-epihi_l2-second-rates |
| EPI-Lo | | psp_isois-epilo_l2-ic |
| | | psp_isois-epilo_l2-pe |
| Merged | | psp_isois_l2-summary |

Rates10 is 10-s cadence. Only rates3600 data are the main cruise phase product and they have the largest number of variables. Other data are encounter-only products

count rates of energetic protons and electrons, 10 "data" variables

particle energy

count rates of energetic protons and electrons, 5 "data" variables




## SPDF fully supports the Parker Solar Probe mission with multiple services and access methods

- Direct file downloads via FTPS and HTTPS https://spdf.gsfc.nasa.gov/pub/data/psp/
- Orbit and ground track displays/queries via SSCWeb and 4D Orbit Viewer, along with all other supported heliophysics missions
- CDAWeb services:
  - Plots and listings (ASCII, CSV, JSON)
  - Supersets or subsets by time & selected variables
  - Time-binning of data where appropriate
  - 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
- CDAWeb REST example (CDF fastest but other formats also: text, csv, json, png, gif, ps, pdf, nc, audio)

  For instance, to get a CDF file containing the psp_fld_l2_mag_RTN data from the PSP_FLD_L2_MAG_RTN dataset for a time range:

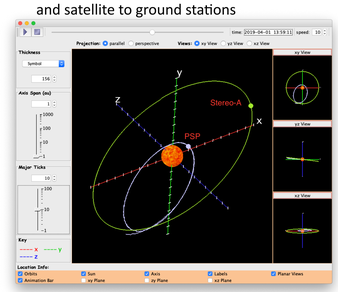
  https://cdaweb.gsfc.nasa.gov/WS/cdasr/1/dataviews/sp_phys/datasets/PSP_FLD_L2_MAG_RTN/data/20190307T100000Z,20190317T230000Z/psp_fld_l2_mag_RTN?format=cdf
- SPDF complement the services of the PSP Science Gateway and instrument teams
- SPDF auto-ingest scripts check PSP an all supported mission data 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 PSP datasets, to add entries to the **Heliophysics Data Portal,** https://heliophysicsdata.gsfc.nasa.gov

## Additional Public Access to PSP Data

- PSP Science Gateway https://sppgway.jhuapl.edu/
- Homepages of instrument teams, with links to public data and user's guides
  - Solar Wind Electrons Alphas and Protons (SWEAP) http://sweap.cfa.harvard.edu
  - Electromagnetic Fields Investigation (FIELDS) http://fields.ssl.berkeley.edu
  - Integrated Science Investigation of the Sun (IS⊙IS) https://spacephysics.princeton.edu/missions-instruments/isois
  - Wide-field Imager for Solar Probe (WISPR) https://wispr.nrl.navy.mil
- The in-situ data at Levels 2-3 and ephemeris data are archived at SPDF https://spdf.gsfc.nasa.gov/pub/data/psp/ (63 GB, 53 datasets)
- WISPR data at Solar Data Analysis Center (SDAC) are searchable and retrievable via Virtual Solar Observatory (VSO, virtualsolar.org) clients: SunPy: Fido, Solarsoft/IDL: vso_search.pro, vso_get.pro

## SSCWeb and the 4-D Orbit Viewer

- 4D Orbit Viewer uses SSCWeb webservices API to access the spacecraft database
- SSCWeb also computes radial and magnetic field line conjunctions between satellites and satellite to ground stations




## 132 Missions Supported by SPDF

https://spdf.gsfc.nasa.gov/data_orbits.html
[*Only orbit data available] Total: ~10,000 datasets, ~300 TB data
Monthly data ingestion rate: ~0.6 million data files, ~13.7 TB data

SOURCE SPACECRAFT:

| | | |
|---|---|---|
| ACE | GOES | Pioneer |
| Active* | GOLD | Pioneer 10 |
| Aeros | GMS 3 | Pioneer 11 |
| AIM | GRACE* | Pioneer Venus |
| Akebono* | Granat | Polar |
| Alouette1 | Hawkeye | Prognoz |
| Alouette2 | Helios | Reimei |
| AMPTE | Hinode | Rosetta* |
| APEX-MAIN* | Hinotori | RHESSI |
| Apollo | IMAGE | ROCSAT-1 |
| Aqua | IMP 7 | SAMPEX |
| Ariel-4 | IMP 8 | Sakigake* |
| Arase (ERG) | IMP_early | San Marco |
| ARCAD | Interball | SCATHA* |
| ARTEMIS | ISEE | SDO |
| ASTRO II* | ISEE 3-ICE | SMILE |
| AE | ISIS | SNOE |
| Aura | ISS | SOHO |
| Aurora2 | Jason 2 | SORCE |
| BARREL | Juno | Spartan-A |
| CALIPSO | Kaguya | Spitzer |
| Cassini* | LANL | Sputnik 1 |
| Cassiope | LRO | STEREO |
| Cluster | LUNA | Suisei |
| Cosmos 900 | Magsat | Swarm |
| C/NOFS | MAP | Tethers |
| CRRES | Mariner 10 | THEMIS |
| CSSWE | Mars | TIMED |
| Dawn* | MAVEN | TRACE |
| DEMETER* | MESSENGER | TWINS |
| DMSP | Microlab 1 | UARS* |
| Double Star* | Mir* | Ulysses |
| DSCOVR | MMS | Van Allen Probes |
| DE | MRO | Vega |
| Equator-S | MSL | Venera |
| Explorer | MSX* | Viking |
| FAST | Munin | Voyager |
| FIREBIRD* | New Horizons | Voyager 1 |
| Fuji* | NOAA* | Voyager 2 |
| Galileo* | Oersted | Wind |
| GCOM W1 | OGO | XMM-Newton |
| Genesis | Ohzora | Yohkoh* |
| Geotail | PARASOL | Zond |
| Giotto* | Parker Solar Probe | |
| | Phobos | |

# Space Physics Data Facility (https://spdf.gsfc.nasa.gov)