SOLAR-1 STIS Data Release, Provisional Maturity
June 29, 2026

Read-Me for Data Users

Maturity Status

The Space weather Observations at L1 to Advance Readiness – 1 (SOLAR-1, formerly SWFO-L1) Product Validation Review (PVR) for the SupraThermal Ion Sensor (STIS) Provisional maturity was held on May 27, 2026. The review panel concluded that the STIS data products had reached Provisional maturity. As a result, STIS data files may be made available to the public.

Instrument Description

STIS was developed by the University of California, Berkeley team led by Dr. Davin Larson. Its heritage includes MAVEN/SEP, THEMIS/SST, and Wind/3DP/SST. The instrument comprises two solid state telescopes (SSTs):

- The Open telescope (detectors O-D1, O-D2, and O-D3) measures primarily ions thanks to a sweep magnet which repels incoming <300-keV electrons.
- The Foil telescope (F-D1, F-D2, F-D3) is primarily sensitive to electrons thanks to a thin polyamide foil which stops incoming <300-keV ions.

The required dynamic range for the flux drives the division of the front detector into two pixels (O-D1 and O-D3 for the ions, F-D1 and F-D3 for the electrons) whose areas differ by a factor of 100.

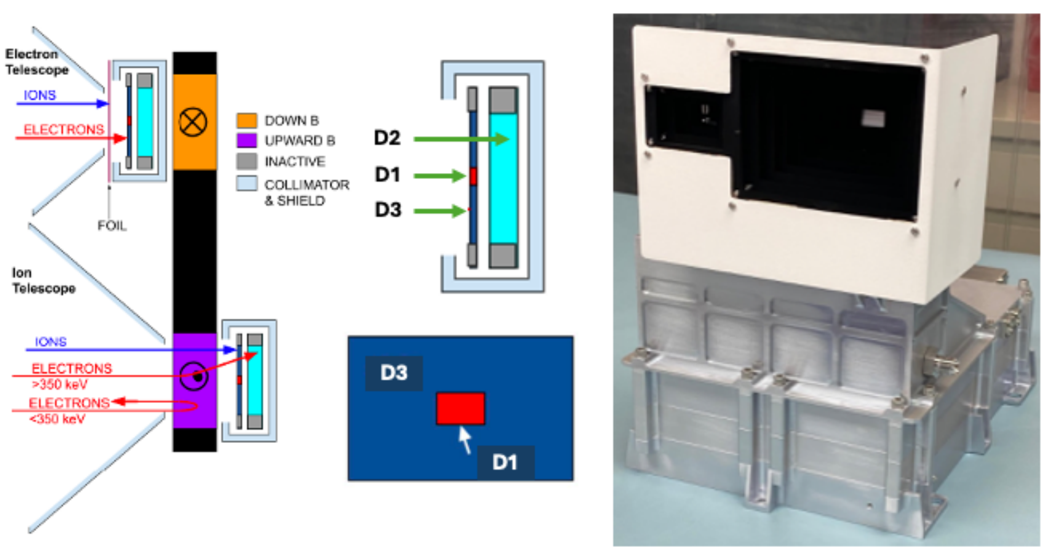

Fig. 1. Left: schematic view of the two telescopes. Center: schematic diagrams of the detectors in each telescope. Right: photograph of STIS at delivery.

Electrons >300 keV and ions >6 MeV pass through the front detectors and deposit their energy in the rear detectors of the telescopes (O-D2, F-D2).

There are 14 event types created from different logical combinations (coincidences) of pulse-height detections by the individual detectors. With 48 energy bins per event type, a histogram of 672 energy bins (48 x 14) is reported in each science packet. The 14 event types are listed in Table 1.

Event Type	Detector Coincidence Logic
O1	O-D1•~O-D2•~O-D3
F1	F-D1•~F-D2•~F-D3
O2	~O-D1•O-D2•~O-D3
F2	~F-D1•F-D2•~F-D3
O12	O-D1•O-D2•~O-D3
F12	F-D1•F-D2•~F-D3
O3	~O-D1•~O-D2•O-D3
F3	~F-D1•~F-D2•F-D3
O13	O-D1•~O-D2•O-D3
F13	F-D1•~F-D2•F-D3
O23	~O-D1•O-D2•O-D3
F23	~F-D1•F-D2•F-D3
O123	O-D1•O-D2•O-D3
F123	F-D1•F-D2•F-D3

Table 1. STIS event types.

Data products, format, and validation process

The STIS data products are based on Level 0 packet data and include:

- Level 0a (generated by SWPC): raw binary CCSDS packets (STIS science (sci), noise (nse), housekeeping (hk)); relevant spacecraft housekeeping packets (cadence: 2 s)
- Level 0b (SWPC): STIS sci, nse, hk, and relevant spacecraft hk, lightly processed (e.g., counts are decompressed, temperatures are calibrated) (2 s)
- Level 1a (NCEI, SWPC): count rates, noise statistics, data quality flags (DQFs) (2 s)
- Level 1b (NCEI, SWPC): dead-time-corrected and calibrated differential directional fluxes, STIS-native energy resolution, DQFs (2 s)
- Level 2 (NCEI, SWPC): fluxes combined into ACE/EPAM-like energy bands for continuity in SWPC Space Weather Forecast Office use, DQFs (2 s)

- Level 3 (SWPC): time-averaged L2 fluxes (EPAM-like resolution), DQFs (1 min), for use by Space Weather Forecast Office
- Level 3 (NCEI): time-averaged L1b fluxes (native resolution), DQFs (1 min), for retrospective scientific use

The flux and energy units are different between the retrospective (sci) files, produced by NCEI, and the operational (oe) files, produced by SWPC. In the oe files, the energies and the fluxes are in MeV and in particles/cm^2-s-sr-MeV, respectively, for continuity with the ACE/EPAM data used by SWPC for geomagnetic storm forecasts. In the sci files, the energies and fluxes are in keV and in particles/cm^2-s-sr-keV, respectively, which are better suited for scientific use of fluxes in the STIS energy range.

The actual incident-energy ranges are 40-6000 keV for the ions and 25-300 keV for the electrons. Data with energies outside these ranges should not be used without consulting with NOAA. The bin center energies are contained in the L1b and L3 data files containing instrument-native energy-resolution fluxes. There are 33 ion energy bins with centers between 40 and 6000 keV and 16 electron energy bins with centers between 25 and 300 keV (see table below for the native energy resolution). In the L2 and L3 files that approximate the EPAM energy bands, the edge energies of the broader bands created by combining multiple STIS L1b energy bins are included.

O3 ion energies (keV)		O3 ion energies (keV)		F3 electron energies (keV)	
center	width	center	width	center	width
27.4	2.5	261.3	40.5	26.4	3.2
29.9	2.4	310.0	56.8	30.1	3.7
32.3	2.9	375.0	65.1	33.8	3.8
35.8	4.0	440.1	65.2	37.7	4.8
40.3	4.5	505.3	81.5	43.5	6.9
44.8	4.4	603.2	114.3	51.4	7.9
49.2	5.4	733.9	130.7	59.4	8.0
55.7	7.4	864.7	130.9	67.4	10.1
64.1	8.4	995.6	163.7	79.5	14.1
72.4	8.2	1192.0	229.3	95.7	16.2
80.5	10.1	1454.2	262.2	111.9	16.3
92.6	14.1	1716.5	262.4	128.2	20.4
108.7	16.0	1978.9	328.1	152.7	28.6
124.6	16.0	2372.7	459.5	185.4	32.7
140.6	20.0	2898.0	525.3	218.2	32.8
164.6	28.1	3423.4	525.4	251.0	41.0
196.7	32.2	3948.8	656.9		
229.0	32.3	4737.1	919.8		
		5788.3	1051.2		

Table 2. STIS native-resolution energy-bin centers and widths.

All products are in the netCDF format.

The SOLAR-1 STIS Provisional-maturity data products are currently undergoing further testing, calibration, and validation. The products have been validated through comparisons with the Electron, Proton, and Alpha ‘Monitor (EPAM) instrument on the Advanced Composition Explorer (ACE) spacecraft, and the Solar and Galactic Proton Sensor (SGPS) instrument onboard the Geostationary Operational Environmental Satellite (GOES) 18 and 19 spacecraft. NCEI continues to work with the SWPC forecast office and the University of California, Berkeley to improve the STIS products. Further changes in ground processing algorithms (GPAs) and calibration tables may take place.

The near-real-time data products are processed at NOAA’s National Weather Service (NWS) Space Weather Prediction Center (SWPC). The retrospective, or scientific, data products are processed at NOAA’s National Centers for Environmental Information (NCEI). Users who do not require low-latency observations are encouraged to use the retrospective data which are the more scientifically authoritative data.

Data Quality Flags

Each file contains an array (function of time) of 64-bit words called ‘quality_flags’, each bit of which represents a data quality flag (DQF). The first bit indicates whether the data arrived in real time or played back from the satellite data recorder. Bits 1-31 are set aside for DQFs calculated from instrument data. Examples include whether decimation is occurring at high count rates, whether temperatures are excessively high or low, and whether electron contamination of the ion fluxes may be significant. Bits 32-63 are set aside for DQFs calculated from spacecraft housekeeping data. Examples include whether the reaction wheel speed magnitude exceeds 2000 rpm, whether the instrument is off-pointed from its nominal orientation, and whether the Sun is in the field-of-view. Details may be found in the ‘comments’ field of ‘quality_flags’. Only a subset of the bits is used at this time.

Issues

Known issues include the following, and several are currently being worked:

1. The STIS ion backgrounds have been characterized using daily minima of hourly full energy resolution fluxes. The histograms of such daily minima as a function of flux, for a 3-month period, indicate that the daily minima fluxes are progressively concentrated to the minimum flux present as the channel energy increases. Above ~1 MeV the daily minima are largely accumulated at the lower flux end of the histogram, indicating the presence of background fluxes, which are likely due to Galactic Cosmic Ray (GCR) fluxes. The characterization of the STIS backgrounds is ongoing, and the possible connection to GCRs will be investigated.
2. In certain narrow bands of spacecraft reaction wheel (RW) speeds, a physical resonance adds noise to measurements from some of the STIS detectors, in particular the small open (ion) detector. The worst resonances are at RW speed magnitudes > 2000 rpm, so

the RW speeds have been kept below this level since October 2025. However, there are significant resonances at lower speeds that affect the small ion detector at energies below 40 keV. This noise is bimodal, indicating a quasi-sinusoidal driver. A new flagging method is being developed to take into account the RW resonances at lower speeds. Work is ongoing to implement this new flagging technique, and to modify the GPA to mask fluxes affected by RW noise. In the meantime, users should be aware that spikes at these low ion energies may be due to RW noise.

3. Cross-species contamination is expected under certain conditions. An existing DQF identifies periods of likely contamination of the ion fluxes by electrons. The development of a DQF identifying periods of contamination of the electron fluxes by protons is also underway. The presence of electron contamination of the ion fluxes, and vice versa, has been verified using GEANT model simulations. The electron fluxes are more susceptible to contamination when >300 keV ion fluxes are elevated. In addition to flagging suspect data, work on mitigating these effects is ongoing.
4. Comparison with the legacy ACE/EPAM suprathermal ion and electron data used by SWPC is ongoing. Results indicate that the EPAM ion fluxes are low compared to STIS ion fluxes. This may be due to the growth of a dead layer in the front EPAM ion detector over time due to radiation damage by protons. Such dead layer growth is present in other older low-energy-ion solid state telescopes flown by NOAA. Effectively, this raises the energies that are being detected by the EPAM ion channels. In contrast, initial comparisons indicate that the EPAM electron detector is much less degraded in this way. However, the background levels in the lowest-energy EPAM ion and electron channels are highly elevated, as a result of an order-of-magnitude secular increase in thermal backgrounds over the 28-year mission life. This reduces the flux range over which the lowest-energy EPAM channels can be compared with STIS.
5. The STIS ion fluxes have been compared with GOES/SGPS proton fluxes in the overlap energy range (1-6 MeV). During periods of high solar wind dynamic pressure or enhanced SYM-H geomagnetic index (geomagnetic storm conditions), comparisons with geostationary satellite data in the above energy range are possible. Under such conditions, the geomagnetic shielding that prevents high energy solar protons from entering the magnetosphere is suppressed, allowing easier access of high-energy protons to geosynchronous orbit. Comparisons show that STIS fluxes are about a factor of 2 higher than the GOES fluxes, owing perhaps to calibration differences between the two data sets. More data during geomagnetically disturbed conditions are needed to fully evaluate this difference, and to determine its source.

For More Information

NOAA NCEI contact information on the SOLAR-1 STIS data:
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