Laboratory for Atmospheric and Space Physics
University of Colorado **Boulder**

TSIS-1 SIM V13 Level 3 Data Product Release Notes (V2)

Sept 3, 2025

Summary

NASA's Total and Spectral Solar Irradiance Sensor-1 (TSIS-1) built by the Laboratory for Atmospheric and Space Physics (LASP) operates on the International Space Station (ISS). TSIS-1 obtains absolute measurements of the total solar irradiance (TSI) and spectral solar irradiance (SSI). TSI and SSI are essential for scientific models of climate change and solar variability. TSIS-1 has two science instruments, the Total Irradiance Monitor (TIM) and the Spectral Irradiance Monitor (SIM).

This document describes Version 13 (V13) of the TSIS-1 SIM Level 3 (L3) data release. This document summarizes data processing and calibration changes that affect SIM L3 data and is not a complete list of changes affecting lower-level data products. Details of SIM L3 temporal and spectral data coverage can be found in § 2. When referring to L3 data product columns (variables), references are in ALL_CAPS.

V13 is the first TSIS-1 SIM L3 data release since the SIM Digital Signal Processor (DSP) anomaly on September 4, 2023. Upon recovery from the DSP-anomaly, the SIM Electronic Substitution Radiometers (ESRs) began reporting anomalous irradiances at some wavelengths.

UPDATE: Routine science data production was temporarily paused in June 2025 to improve the handling of wavelength alignment in SIM V13 products. After the V13 release, the thermal pointing system (TPS) exhibited more frequent pointing excursions near zero crossings, which reduced the algorithm's ability to accurately determine spectral wavelength alignment—most noticeably in the 800-–950 nm range and some shorter wavelengths near 400 nm.

To enhance data quality, an algorithm parameter was tuned to use a wider time range, allowing more valid data to be incorporated and resulting in improved wavelength alignment and irradiance accuracy. Processing resumed in September 2025, and all V13 products have been reprocessed back to late 2023, replacing previous releases.

Users who downloaded SIM V13 data before September 3, 2025, are strongly encouraged to download and use the updated dataset.

SIM L3 data is released on 12-hour and 24-hour cadences. The DOIs for V13 are:

- 12-hour: https://doi.org/10.5067/TSIS/SIM/DATA325
- 24-hour: https://doi.org/10.5067/TSIS/SIM/DATA326

TSIS-1 SIM V13 L3 data appears in three locations in the specified formats:

1. the LASP LISIRD website (ASCII, CSV, and NetCDF)
   - 12-hour: https://lasp.colorado.edu/lisird/data/tsis_ssi_12hr
   - 24-hour: https://lasp.colorado.edu/lisird/data/tsis_ssi_24hr
2. the LASP TSIS website (ASCII, IDL SAV file, and NetCDF)
   - https://lasp.colorado.edu/home/tsis/data
3. the NASA DAAC (ASCII)
   - https://disc.gsfc.nasa.gov/datasets

Table of Contents

1) Summary of TSIS-1 SIM V13 Activities and Changes From V12

During the TSIS-1 prime mission (March 2018-March 2023), TSIS-1 SIM L3 data releases occurred every 6 months, approximately two months after the semi-annual Channel-C scan activities that occur when the Earth is near its' 1 AU distance from the Sun. TSIS-1 is now in the extended mission phase and L3 data releases now occur only when needed to maintain the achievement of science requirements.

V13 addresses issues due to anomalies with the TSIS-1 SIM Digital Signal Processor (DSP) and Electrical Substitution Radiometers (ESR) in September/October 2024. As described in § 7.2, the TSIS-1 SIM DSP stopped responding to ground commands on September 4, 2023. DSP command and control was restored on October 21, 2023. Post DSP-anomaly checkout showed changes in ESR responsivity in certain configurations and wavelength ranges. Data in the affected wavelength regions was taken, but not published in V12 (see the V12 release notes). The TSIS-1 SIM V13 L3 data release addresses these changes in ESR performance, and, necessarily, changes to all V12 degradation corrections that relied upon ESR data for irradiance calibration.

The exact relationship between the DSP and ESR anomalies is unclear as telemetry from the ESRs did not exhibit anomalous behavior until after SIM was power cycled on October 21, 2023. After the ESR-anomaly, the SIM ESRs are showing wavelength and channel-pairing dependent SSI inaccuracies at some wavelengths. For some channel pairings, the change is a static (jump) offset, while for others there is some time dependency (see §7.2).

TSIS-1 SIM ESRs are directly used for all reported SSIs longer than 1620 nm, and, before V13, were used as the irradiance reference for the diode data between 408 and 1620 nm. V13 addresses the ESR anomaly in two important ways: 1) ESR data after the anomaly is no longer used to correct diode degradation between 408 – 1620 nm and a diode degradation model is used instead, and 2) after September 4, 2023 all SSIs longer than 1620 nm have been corrected by a wavelength-dependent spectral correction to the measured ESR irradiances (see §1 and §3.2.1). As a result of the DSP-anomaly, the Channel-C scans scheduled for October 2023 were not performed, however, Channel-C scans were successfully performed in April 2024 and October 2024. Degradation correction updates in V13 include updated Channel-C diode data from the April 2023, April 2024, and October 2024 calibration campaigns; which were not in V12.

As described in detail in § 3, the changes to TSIS-1 SIM data processing since the V12 TSIS-1 SIM L3 data release include:

- Updated degradation correction models
  - Corrected minor bug in Channel-C UV degradation corrections
  - Enhanced prism degradation corrections incorporating new Channel-C scans
  - Implemented a diode degradation correction model for the VIS and IR degradation corrections that previously relied upon the ESR to correct for diode degradation
- Implemented spectral corrections and data quality flags for post-DSP-anomaly ESR data
  - Applied wavelength-dependent spectral corrections to all post-DSP-anomaly ESR L3 data
  - Added an L3 data quality flag (DQF) to indicate ESR data that has had the DSP-anomaly spectral corrections applied (ESR_DSP_ANOMALY_CORRECTED)
- Updated MEASUREMENT_PRECISION uncertainties to be reported on a per-wavelength basis
- Added additional temporal padding to pointing excursions to preserve data quality
- Removed non-standard calibration scans in degradation corrections and in determining MEASUREMENT_PRECISION, as they are susceptible to wavelength misalignment

2) TSIS-1 SIM V13 Temporal and Spectral Coverage

Table 1 gives the available time and spectral range for TSIS-1 SIM L3 V13 dataset. Nominally, L3 irradiances have a latency of ∼25 days to allow for processing and the application of instrument degradation corrections. Data latency is driven by the cadence of Channel-B observations, which are used in the degradation correction model. This delay may be extended due to scheduling constraints such as ISS operations or periods of high beta angles.

TSIS-1 SIM V13 contains a spectral correction for an anomaly of the Electrical Substitution Radiometers (ESRs) as discussed in § 1 and § 7.2. The V13 spectral corrections are static, wavelength-dependent, corrections and do not correct for a period of time from November 2024 to March 2025 when the ESRs were unstable in certain configurations at some wavelengths (1620 – 1800 nm). Table 1 indicates these times and the spectral ranges that are not corrected in V13.

Table 1: Time and spectral range of the TSIS-1 SIM V13 dataset

Time Range	**Wavelength Range (nm)**
March 14, 2018 – December 4, 2023	200 – 2400
December 5, 2023 – December 31, 2023	200 – 1620, 1800 – 2400
January 1, 2024 – January 30, 2024†	200 – 1620, 1700 – 2400
January 31, 2024 – February 29, 2024†	200 – 1620, 1650 – 2400
March 1, 2024 – present	200 – 2400

† During these time periods ESRA was the primary ESR channel and ESRC was the reference channel (ESRA_C). ESRA_B data was also taken during this period, but at an infrequent cadence, and is included in V13.

Temporal gaps are common in the TSIS-1 SIM data record due to ISS operational activities (e.g., orbit boost), anomalies (e.g., power outages), and obstructions at extreme beta angles. ISS obstructions can result in partial or complete loss of SIM spectra for a given day. Early in the mission, spectral gaps also occurred due to instrument planning and operations errors. Figure 1 shows the V13 L3 TSIS-1 SIM 24-hour data acquisition record as of the publication date of this document. Nominal data are shown in **green**, data quality flag (QUALITY=0), **red** shows missing data (QUALITY=1), and **blue** shows data backfilled from the previous day (QUALITY=2). Backfilling is never done when temporal gaps exceed 1 day. **Lime green** data were affected by the ESR anomaly, but have been corrected in V13 (QUALITY=32, see § 3.2.1). **Dark green** data were acquired during the High-rate Fine Sun Sensor-B (HFSS-B(OFF)) pointing period (QUALITY=512, see § 6), and **purple** data are both backfilled and during the HFSS-B(OFF) period (QUALITY=514). Data during the HFSS-B(OFF) pointing period have a wavelength-dependent spectral correction applied, maintaining their usability as quality SSI observations, but carrying a slightly higher uncertainty as captured in the ADDITIONAL_UNCERTAINTY column (see § 5 and § 7.1).

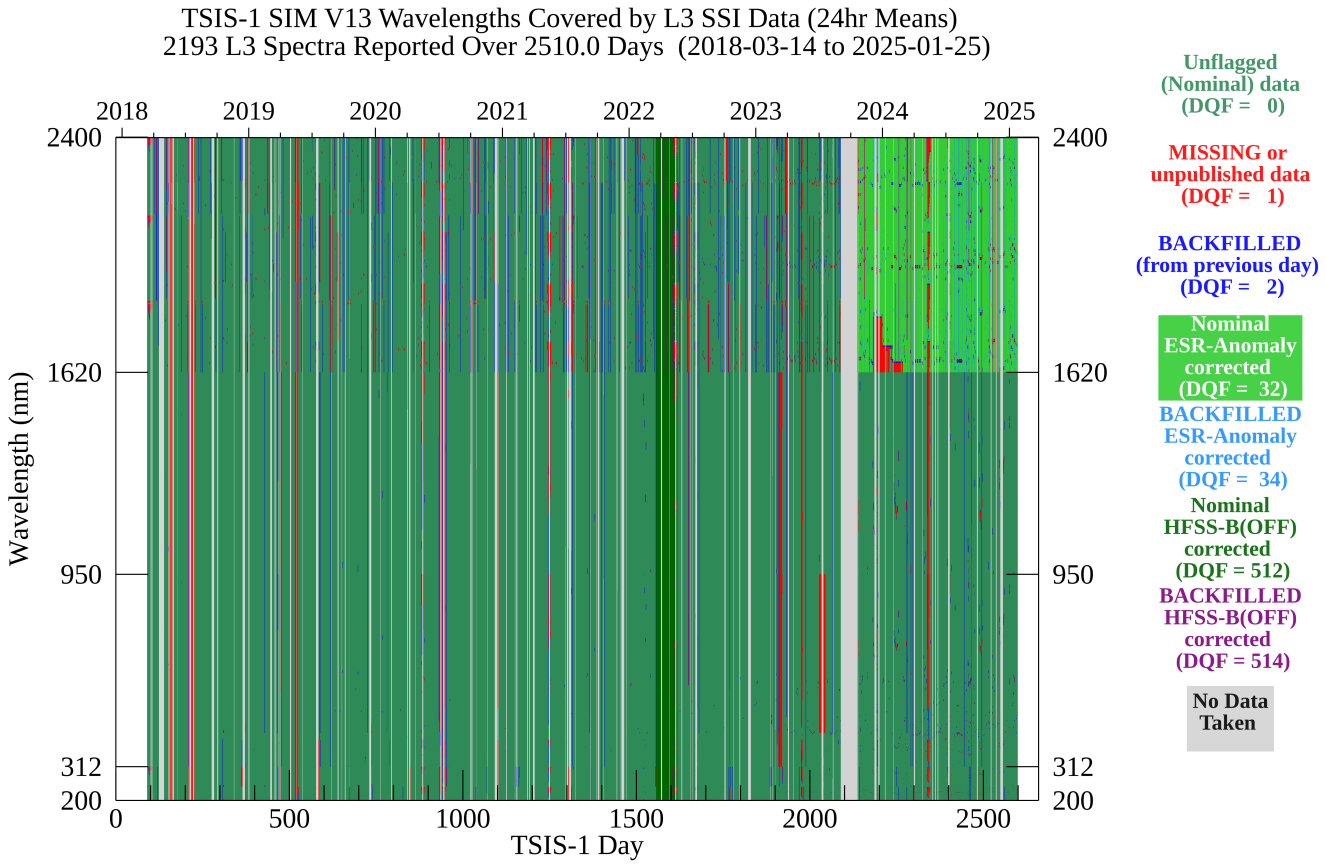

Figure 1: V13 TSIS-1 SIM L3 data acquisition record. As January 25, 2025, data are available on 87% of days since the beginning of nominal operations on March 14, 2018. Note both the **ESR_ANOMALY_CORRECTED** (1620 – 2400 nm) and the "stair-stepped" MISSING L3 ESR data (1620 – 1800 nm) after October 21, 2023 are associated with the ESR anomaly discussed in § 7.2.

3) Details of TSIS-1 SIM V13 Changes

3.1 Updated Degradation Correction Models

Shortward of 408 nm, the V13 degradation corrections are similar to those of V12. Longward of 408 nm, new algorithms and methods are required due to the changes in the ESR performance after the DSP-Anomaly (September 4, 2023).

V13 includes the following degradation correction changes from V12:

1. $\lambda <$ **312 nm:**
   - The degradation method for this waveband has not changed, however, the order of the polynomial used to model the UVB-to-UVA correction has been increased from 5 to 7.
   - A minor update has been applied to the Channel-C degradation corrections to fix a bug that prevented this correction from being applied to UV wavelengths from 200 – 201.7 nm.
2. **312 nm** $< \lambda <$ **408 nm:**
   - The degradation method for this waveband has not changed, however, the order of the polynomial used to model the VISB-to-VISA correction has been increased from 5 to 7.
3. **408 nm** $< \lambda <$ **1582 nm:**
   - V12 corrections used measurements from the ESRs to correct for time-dependent changes in the responsivity of the VIS and IR photodiodes. For V13, this diode degradation is modeled at each wavelength using a two-term exponential fit of the ratio between the VIS or IR photodiode measurements and the ESR measurements from the start of the mission until the DSP anomaly in September 4, 2023. After this date, the fit is extrapolated forward in time since the ESR data is unreliable after the DSP-anomaly.
   - The order of the polynomial used for 408 – 740 nm has been increased from 5 to 7.
   - The linear fit used for 950 – 1582 nm has been changed to a 5th-order polynomial to better capture the prism degradation due to the increased solar activity.
4. **1582 nm** $< \lambda <$ **1620 nm:**
   - Due to current limitations in applying the diode degradation correction from 1580 – 1620 nm, the degradation correction method for this wavelength region remains unchanged from V12. The IRC-to-ESRC ratio is linearly extrapolated forward from the Channel-C scan in April 2023 to maintain the absolute calibration to the pre-anomaly ESR measurements.
5. **1620 nm** $< \lambda <$ **1845 nm:**
   - The degradation method for this waveband has not changed since V12, however, ESR data taken after the DSP-anomaly is corrected with wavelength-dependent corrections, as described in § 3.2.1.

3.2 Irradiance Corrections for post-DSP-Anomaly ESR Data

With the V13 SIM data release, wavelength-dependent irradiance corrections were introduced to account for the anomalous ESR-measured irradiances caused by the ESR DSP anomaly event, which is described in detail in § 7.2. These irradiance corrections contribute additional uncertainty to the L3 irradiance values where they are applied and this additional uncertainty is reported, along with any other potential sources of additional uncertainty, in the ADDITIONAL_UNCERTAINTY column of the L3 TSIS-1 SIM data products (see § 5 for more details regarding the ADDITIONAL_UNCERTAINTY data column).

Although most[1] of the ESR-measured irradiances affected by the ESR anomaly have been corrected and included in V13, some of these irradiance values have not been corrected and these irradiances have not been included in V13 (see Table 1). The analysis is ongoing to investigate corrections for these ESR DSP anomaly-affected irradiances and these irradiance measurements may be included in a future SIM data release.

[1]Greater than 98% of the ESR data from the DSP-anomaly (September 4, 2023) through January 2025, and all data after January 2025, receive the ESR spectral correction.

3.2.1 Wavelength-dependent ESR Irradiance Corrections and Uncertainties

The ESRs operate in a paired configuration where the primary channel ESR is paired with a reference ESR. The nominal pairing pre-DSP-anomaly was ESRA as primary, paired with ESRB as the reference (ESRA_B). After recovery from the DSP-anomaly, wavelength-dependent changes in irradiance as large as 0.7% were noticed on ESRA_B in the region where the ESR is used for generating L3 data (1620 – 2400 nm). Initial measurements taken with the alternate pairing, ESRA_C, showed irradiances that were initially indistinguishable from pre-DSP-anomaly irradiances to within noise levels. Therefore, in December 2023, daily ESR measurements were switched to ESRA_C to continue releasing V12 data. Over the following two months, wavelength- and time-dependent trending was noticed on ESRA_C for wavelengths from 1620 – 1800 nm, and these wavelengths were not published in V12. This trend stopped and irradiances became stable at all wavelengths after March 1, 2024. Due to this trending and the inherent noise levels of the ESR, some ESR data from 1620 – 1800 nm between December 2023 and March 2024 is not included in V13 (see Table 1). All other ESR data for wavelengths longer than 1620 nm after September 4, 2023 have been corrected by the method described below.

The wavelength-dependent changes in the ESR post-DSP-anomaly are corrected in V13 using ratios of pre- and post-DSP-anomaly data. At each wavelength, irradiance values were averaged for the pre- and post-DSP-anomaly data to create average pre- and post-anomaly spectra. See Table 2 for details of the time ranges used for each pairing. The ratio of these spectra determine the ESR spectral correction (see Figures 2, 3, & 4). As indicated in Table 2, time periods one year apart were chosen to minimize the influence of annual (seasonal) variations. These corrections assume negligible solar variability between the pre- and post-DSP-anomaly periods. The statistical accuracy of these corrections, and uncertainties associated with the solar variability assumption, are presented in § 3.2.2. **Lime green** data in Figure 1 have received this spectral correction.

Table 2: Date Ranges and ESR Pairings used to generate ESR SSI Corrections

Corrected ESR Pairing	**Start Date**	**End Date**	**Reference ESR Pairing**	**Start Date**	**End Date**
ESRA_B	Oct 15, 2023	Dec 5, 2023	ESRA_B	Oct 15, 2022	Dec 5, 2022
ESRA_C	Mar 1, 2024	Sep 1, 2024	ESRA_B	Mar 1, 2023	Sep 1, 2023
ESRB_A	Mar 1, 2024	Sep 1, 2024	ESRB_A	Mar 1, 2023	Sep 1, 2023

3.2.2 Wavelength-dependent ESR Irradiance Correction Uncertainties

There are two basic components to the uncertainties of the V13 ESR irradiance corrections:

- Statistical Uncertainty : The measurement uncertainty of the pre- and post-DSP-anomaly spectra indicated in Table 2.
- Systematic Uncertainty : The uncertainty in the assumption that the solar spectral irradiance, SSI(λ), did not vary between the pre- and post-DSP-anomaly time periods.

The pre- and post-DSP-anomaly spectra are independently averaged at each wavelength. The standard error of the mean (SEM) is the statistical uncertainty at each wavelength as given by Equation 1:

$$SEM(\lambda) = \sqrt{\frac{\sigma_\lambda^2}{N_\lambda}} \tag{1}$$

where σ_λ is the standard deviation at each wavelength for either the pre- or post-DSP-anomaly time period and N_λ is the number of SSI measurements combined at this wavelength(λ).

The ESR corrections are defined as the ratio of the pre- and post-DSP-anomaly spectra (SSI_{pre} and SSI_{post}). Using the SEMs of Equation 1, the statistical uncertainty (σ_{stat}) at each wavelength of the corrections is given by Equation 2:

$$\sigma_{stat}(\lambda) = \sqrt{(\frac{SEM_{pre}(\lambda)}{SSI_{pre}(\lambda)})^2 + (\frac{SEM_{post}(\lambda)}{SSI_{post}(\lambda)})^2} \ . \tag{2}$$

NNLSSI[2] models are used to test the assumption of negligible solar variability between the pre- and post-DSP-anomaly time periods. The models predict a maximum SSI change of 80 ± 125 parts-per-million (PPM) between any pre- and post-DSP-anomaly period. The uncertainties of the NNLSSI models are taken to represent the systematic uncertainty, $\sigma_{NNLSSI}(\lambda)$, of the ESR spectral corrections. The total uncertainty of the ESR spectral corrections, $\sigma_{total}(\lambda)$, is taken to be these two quantities added in quadrature:

$$\sigma_{total}(\lambda) = \sqrt{\sigma_{stat}(\lambda)^2 + \sigma_{NNLSSI}(\lambda)^2} \ . \tag{3}$$

The ESR spectral correction uncertainties, $\sigma_{total}(\lambda)$, are reported in the V13 L3 data products in the ADDITIONAL_UNCERTAINTY column, and can be identified by the presence of the QUALITY=32 DQF (ESR_DSP_ANOMALY_CORRECTED).

The ESR spectral corrections and uncertainties are shown in Figures 2, 3, & 4 for the ESRA_C, ESRA_B, and ESRB_A corrections, respectively.

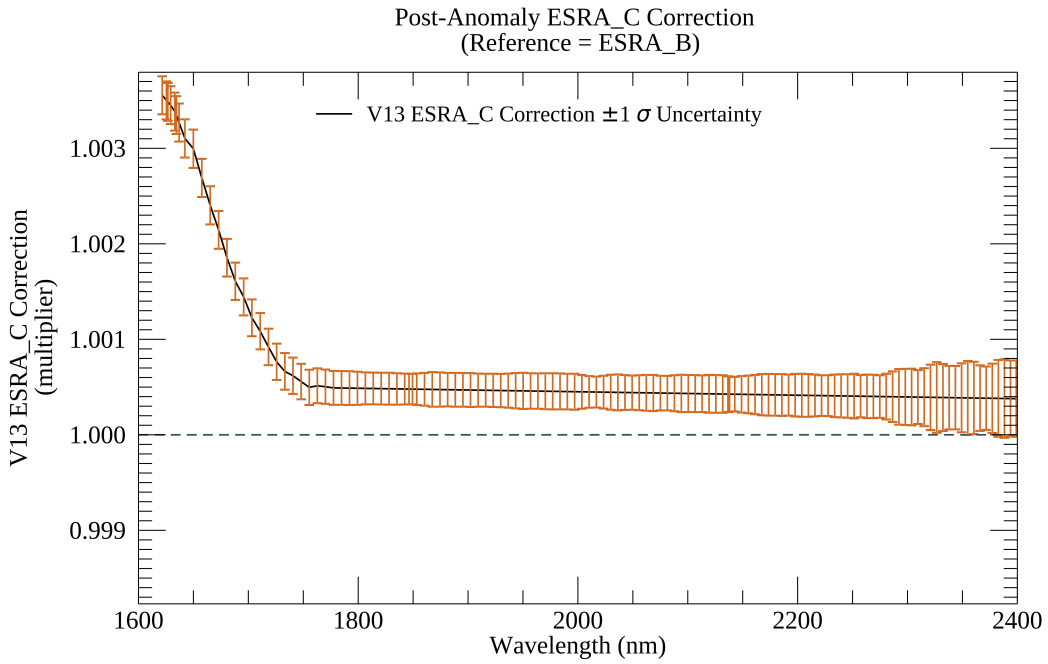

Figure 2: Spectral correction and ADDITIONAL_UNCERTAINTY applied to all V13 ESRA_C data after October 21, 2023.

[2]NOAA Climate Data Record (CDR) of NASA NOAA LASP Spectral Solar Irradiance (NNLSSI). Coddington, Lean, Lindholm, Pilewskie. (2024). https://doi.org/10.25921/esjz-1w61.

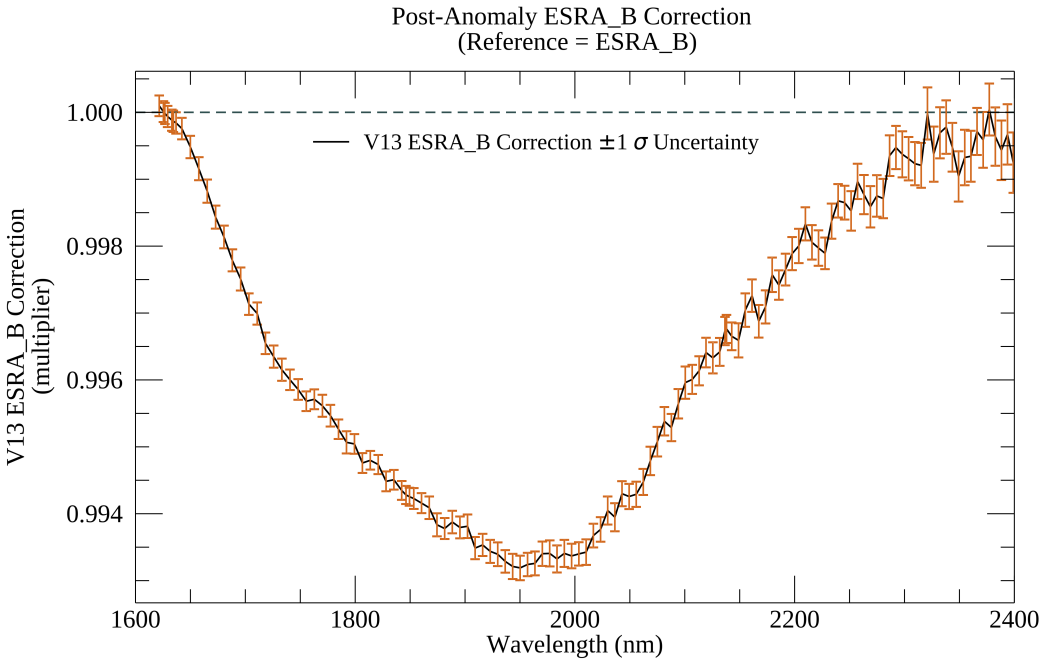

Figure 3: Spectral correction and ADDITIONAL_UNCERTAINTY applied to all V13 ESRA_B data after October 21, 2023.

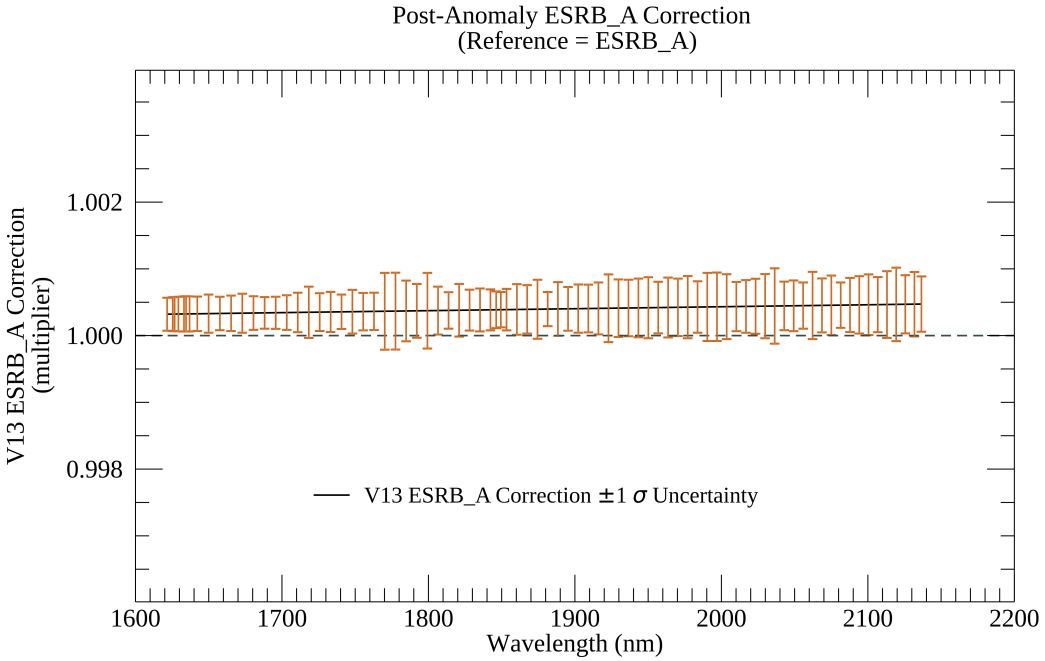

Figure 4: Spectral correction and ADDITIONAL_UNCERTAINTY applied to all V13 ESRB_A data after October 21, 2023. The ESRB_A correction is used in the degradation correction of ESRA data from 1620 – 1845 nm.

3.2.3 New ESR_DSP_ANOMALY_CORRECTED DQF

The ESR_DSP_ANOMALY_CORRECTED (QUALITY=32) data quality flag (DQF) has been added to the L3 data product's QUALITY column. The presence of this DQF indicates that an ESR datum has been corrected to account for the effects of the SIM instrument's DSP anomaly (September 2023). The details of these ESR DSP-anomaly spectral corrections are described in § 3.2.1.

3.3 Updated MEASUREMENT_PRECISION Uncertainty Calculations

Before V13, MEASUREMENT_PRECISION – the intrinsic uncertainty assigned to a single SIM SSI measurement – was determined from the on-orbit scan-to-scan variability during the Solar Cycle 24 and 25 minimum using wavelength-averaged SSIs. For V13 and beyond, MEASUREMENT_PRECISION is determined on a per-wavelength basis without averaging as this more accurately represents the uncertainty of a single SSI measurement. As a result, MEASUREMENT_PRECISIONs reported in V13 contain more small-scale (wavelength) variability and are larger in magnitude than V12. The wavelength-dependent MEASUREMENT_PRECISION for V12 and V13 are shown in Figure 5. Additionally, non-standard calibration scans are no longer used when calculating the MEASUREMENT_PRECISION, as these scans are susceptible to wavelength misalignment.

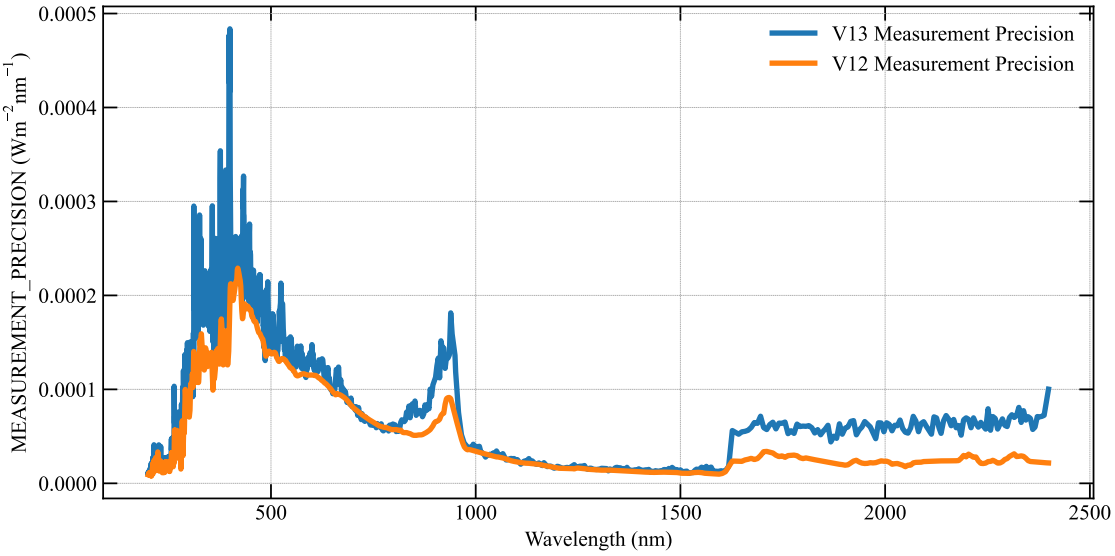

Figure 5: Comparison of V12 (**blue**) and V13 (**orange**) MEASUREMENT_PRECISION. For V12 SIM data and earlier, MEASUREMENT_PRECISION was determined from the on-orbit scan-to-scan variability during the Solar Cycle 24 and 25 minimum using wavelength-averaged SSIs. For V13 and beyond, MEASUREMENT_PRECISION is determined on a per-wavelength basis without averaging, which more accurately represents the uncertainty of a single SSI measurement. As a result, MEASUREMENT_PRECISIONs reported in V13 contain more small-scale (wavelength) variability and are larger in magnitude than V12 for most wavelengths.

3.4 Increased Temporal Padding for Pointing Excursions

The application of the off-nominal pointing filtering has been updated to filter data before and after an off-pointing event. In all previous versions, data was filtered when pointing deviations were greater than 60 arcseconds in the dispersion or cross-dispersion direction, defining an off-nominal pointing event. In V13, the data collected up to 5 seconds before and up to 5 seconds after an off-nominal pointing event are now filtered to ensure that data is filtered when pointing is changing rapidly. This change increased the amount of data excluded due to bad pointing from 0.4% in V12 to 0.6% in V13.

4) Comparison of TSIS-1 SIM V13 Integrated SSI to TSIS-1 TIM V04 TSI

Figure 6 compares the Total Solar Irradiance (TSI) measurements from the V04 data release of TSIS-1 TIM[3] with a TSI estimate (spectrally-integrated SSI, iSSI) derived from the V13 TSIS-1 SIM L3 data release. The SIM iSSI was generated by integrating the daily L3 spectrum from 200 – 2400 nm and adding an offset to account for wavelength regions not measured by SIM. Only complete SIM L3 spectra with no missing or backfilled values are used in Figure 6.

Figure 6 highlights the quality of the long-term SIM corrections by comparing the V13 iSSI against the TSIS-1 TIM TSI V04, which has a reported stability correction uncertainty of ∼10 PPM per year. This plot should not be used to evaluate the TSIS-1 SIM absolute calibrations, as the offset (+52.1711 W m^{-2}) was chosen to match TIM as closely as possible over the mission. However, this value is close to the theoretically expected value of ∼4% of the TSI that falls outside of the SIM instrument's spectral range.

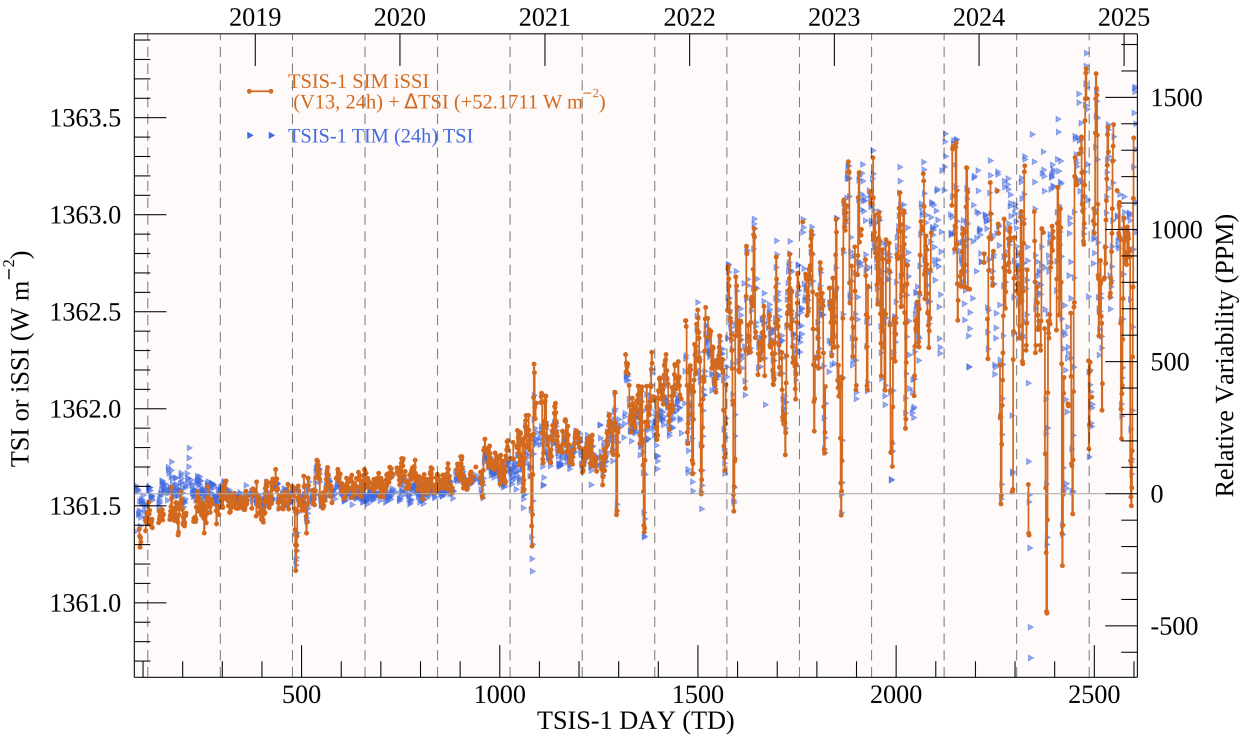

Figure 6: Comparison of TSIS-1 TIM V04 (**blue**) Total Solar Irradiance (TSI) to the spectrally-integrated Solar Spectral Irradiance (iSSI) from the TSIS-1 SIM V13 data release (**orange**). An offset of +52.1711 W m^{-2} has been added to the iSSI to account for wavelength regions not measured by SIM. Vertical lines indicate the planned semi-annual Channel-C scan dates.

[3]See https://lasp.colorado.edu/home/tsis/data/tsi-data/

5) Definition of Uncertainties

Four types of uncertainties are reported in the V13 TSIS-1 SIM L3 data release, these are:

INSTRUMENT_UNCERTAINTY (W m^{-2} nm^{-1}) is a pre-launch measure of instrument spectral irradiance uncertainty with contributions from component, and unit-level, instrument laboratory characterizations, and calibrations with the final end-to-end full spectrum validation of the measured irradiances against a NIST-traceable cryogenic radiometer performed in LASP's Spectral Radiometer Facility. Reported uncertainties represent an upper limit to the irradiance accuracy for each wavelength.

MEASUREMENT_PRECISION (W m^{-2} nm^{-1}) is a wavelength-dependent measure of the on-orbit variance in the scan-to-scan repeatability of the observed spectral irradiances during solar minimum. With the change to reporting the SEM instead of the average, MEASUREMENT_PRECISION is time and wavelength-dependent in TSIS-1 SIM L3 data releases starting with V12.

MEASUREMENT_STABILITY (W m^{-2} nm^{-1}) is a relative metric of the on-orbit degradation correction uncertainties. It has contributions from uncertainties due to the post-processing of data (including instrument degradation correction) and differences between the observed irradiances of the three separate SIM channels. Measurement stability is given as 0.0 at wavelengths $>$ 1845 nm, where the degradation corrections are currently not calculated, and for all data that arrives after the last bi-annual Channel-C calibration scans. The bi-annual Channel-C scans trigger a new data release version, so generally, there will be at least six months of measurement stability values that are 0.0 until they are determined during the creation of the next data release.

ADDITIONAL_UNCERTAINTY (W m^{-2} nm^{-1}) is a composite irradiance uncertainty pertaining to anomalous periods and the associated corrections in the data record, as indicated by the QUALITY data column. This uncertainty is applied to data where, due to atypical circumstances, the data have a higher uncertainty than nominal measurements.

5.1 Notes on Uncertainties

- Beginning with the V08 release, MEASUREMENT_PRECISION is no longer a term in the MEASUREMENT_STABILITY uncertainty.
- V10 extended the prism degradation corrections longward of 1050 nm to 1845 nm. MEASUREMENT_STABILITY uncertainties in this bandpass now include degradation uncertainty estimates.
- Before V12, ADDITIONAL_UNCERTAINTY, MEASUREMENT_PRECISION, and MEASUREMENT_STABILITY were averaged if more than one exposure was available during the data period (12- or 24-hour). These values are now reported as Standard Error of the Mean (SEM) values.
- Before V13, MEASUREMENT_PRECISION was reported based upon averages over wavebands that varied across the SIM spectrum. Starting with V13, MEASUREMENT_PRECISION is correctly reported on a per-wavelength basis. Averaging over wavebands artificially reduces statistical fluctuations present in SIM SSI measurements (see § 3.3).
- As of V13, the only types of ADDITIONAL_UNCERTAINTY are related to the HFSS-B(OFF) pointing anomaly of March through May 2022 (QUALITY=512) and the ongoing ESR anomaly that began in October 2023 (QUALITY=32). Channel- and wavelength-specific spectral corrections are needed during these periods (see § 3.2.1).

For deriving TSIS-1 SIM absolute irradiance uncertainties, it is recommended that V13 users add in quadrature all four uncertainty values. For a relative irradiance uncertainty, reflecting the uncertainty in the irradiances between two time periods, use MEASUREMENT_PRECISION, MEASUREMENT_STABILITY, and ADDITIONAL_UNCERTAINTY added in quadrature.

6) Data Quality Flags (DQFs)

Each TSIS-1 SIM L3 spectral irradiance measurement includes an associated bit-wise integer data quality flag (DQF) in the QUALITY data product column. A QUALITY value of 0 indicates nominal data that has no associated DQFs. If a spectral irradiance measurement has multiple DQF flags set, the values of each flag are summed to create the final QUALITY value. For example, a QUALITY value of 514 indicates backfilled data that was obtained during the HFSS-B(OFF) pointing anomaly, and a QUALITY value of 34 indicates backfilled ESR data that has had a wavelength-dependent correction applied.

Table 3 shows the TSIS-1 SIM L3 DQFs (as discussed in § 3.2.3, V13 introduces the ESR_DSP_ANOMALY_CORRECTED).

Table 3: TSIS-1 SIM L3 data quality flags (DQFs). Note that a QUALITY value of 0 (zero) indicates that no DQF is associated with a particular spectral irradiance measurement and that data should be considered nominal.

Quality Flag Value	Quality Flag Name	Description
1	MISSING_VALUE_FLAG	Indicates missing data items.
2	FILL_VALUE_FLAG	Indicates data items that have been backfilled from previous measurements within one day.
32	ESR_DSP_ANOMALY_CORRECTED	Indicates irradiance measurements for which a wavelength-dependent correction was applied to account for ESR performance changes for data obtained after the TSIS-1 SIM DSP anomaly on September 4, 2023.
512	BAD_HFSSB_POINTING	Indicates irradiance measurements for which a wavelength-dependent correction was applied to account for the HFSS-B(OFF) pointing anomaly that affected data obtained from March 19th to May 19th 2022. See § 7.1 for more information.

7) Notable Events

7.1 Spectral Corrections and Uncertainties During HFSS-B(OFF) Pointing

As discussed in detail in the V08 and V09 L3 release notes[4], during two months from March 19 – May 19, 2022, TSIS-1 SIM observations were offset in pointing by ∼1 arcmin due to surface contamination of the HFSS-B (High-rate Fine Sun Sensor-B). In this document, this is referred to as the HFSS-B(OFF) pointing period. On May 19, 2022, pointing was switched to the redundant sun sensor, HFSS-A, unaffected by surface contamination.

An on-orbit calibration campaign to derive channel- and wavelength-dependent spectral correction factors for Channel-A & -B during the HFSS-B(OFF) pointing period was undertaken in June 2022. To limit solar exposure, especially at off-1AU locations, Channel-C calibration scans were not included. This campaign consisted of two sets of calibration observations, taken two weeks apart. In each set of calibration observations, irradiance data were alternately acquired for each detector and channel combination using the contaminated HFSS-B(OFF) and the uncontaminated HFSS-A. To reduce the impact of a changing Sun, every effort was made to minimize the time between identical scans taken with different pointing (sun sensors).

These spectral pointing corrections, applied in V08 and later data releases, bring irradiance data during the HFSS-B(OFF) period in line with nominal measurements, albeit with slightly higher uncertainty. This added uncertainty reflects the uncertainty in the off-pointing corrections, given the solar variability in the observed irradiances during the special calibration experiments. These uncertainties are reported in the column labeled ADDITIONAL_UNCERTAINTY in all V13 L3 data products.

7.2 DSP and ESR Anomalies of September 2023

On September 4, 2023, the SIM Digital Signal Processor (DSP) stopped responding to ground commands. DSP command and control was restored on October 21, 2023. However, the post-anomaly checkout showed anomalous irradiance measurements with the electric substitution radiometers (ESRs) in certain configurations.

A spectral correction for the majority of the anomalous ESR data has been developed for this release, which has filled most of the data gaps that resulted from the ESR-anomaly. In V13, the V12 ESR data gaps that were present after October 2023 between 1620 – 1800 nm have been mostly filled-in with the new spectral corrections. **Lime green** in Figure 1 represents data which are flagged with the new (QUALITY=32) L3 ESR_DSP_ANOMALY_CORRECTED data quality flag (DQF).

[4]TSIS-1 SIM Release note can be found at https://lasp.colorado.edu/tsis/data/ssi-data/sim-ssi-release-notes/.

8) Additional Notes

- TSIS-1 SIM L3 data products use average irradiances when more than one exposure is available for a given wavelength over the data product period (12- or 24-hour). Beginning with V12, on-orbit uncertainty values reflect this averaging by reporting the standard error of the mean (SEM) for MEASUREMENT_PRECISION, MEASUREMENT_STABILITY, and ADDITIONAL_UNCERTAINTY, whereas previous versions reported the average uncertainties.

- As a result of the SEM uncertainty change described above, the file format of the TSIS-1 SIM L3 NetCDF files was changed on August 22, 2024. The MEASUREMENT_PRECISION variable changed from wavelength-dependent to wavelength and time-dependent.

- SIM line spread function (LSF) details are available on the LASP TSIS-1 website: https://lasp.colorado.edu/home/tsis/data/ssi-data/.

- An IDL (Interactive Data Language) reader for the ASCII formatted data is available at: https://lasp.colorado.edu/data/tsis/file_readers/read_lasp_ascii_file.pro.

- Known data issues that are under ongoing investigation include:

  - Annual oscillations: There are annual oscillations in the SSI time series of some wavelengths, particularly for wavelengths between ∼740 nm and 950 nm. The annual oscillations for wavelengths longer than ∼950 nm were reduced by up to ∼50% in V12.

  - Residual temperature dependencies: The diode and ESR temperature corrections are less accurate during excursions from nominal operating temperatures. This is particularly true near the edges of the detector bandpasses.

  - Some ESR data between 1620 – 1800 nm and December 4, 2023 – February 29, 2024 are excluded from the V13 release due to the ESR-anomaly (see § 7.2, § 3.2.1, & § 2).

- Previous TSIS-1 SIM L3 data releases are archived on CU-Scholar.

- Note for Python users using the NetCDF files:
  - The **xarray** package (2022.3.0) does not properly decode Julian dates (JD) into datetimes. Users should include the '**decode_times=False** in the **xarray.open_dataset** call to keep times in JD.

  - When using **NetCDF4.num2date** (1.5.8) or **cftime.num2date** (1.6.0) to convert the time column, users should provide the flag **has_zero_year=True** to properly convert JD to datetimes.

9) V13 Release Notes Revision History

Revision Version	Contributors	Version Notes
1.0	Stéphane Béland, Michael Chambliss, Luke Charbonneau, Odele Coddington, Caitlin Kessler, Matthew Maclay, Lizzie McMaster, Courtney Peck, Steven Penton, Erik Richard	Initial Release February 6, 2025