

SORCE-SIM STICR Version 1.1 Release Notes (v1.1, 03/04/21)

This is version 1.1 (V01.1) of the [SORCE-SIM](#) to [TSIS-SIM](#) Irradiance Calibration Ratio (**STICR**). This data product uses the temporal overlap of the Solar Radiation and Climate Experiment (SORCE) and the Total and Spectral Solar Irradiance Sensor (TSIS-1) Spectral Irradiance Monitor (SIM) instruments to create an alternate SORCE-SIM irradiance calibration.

The **STICR** is the mean TSIS-SIM/SORCE-SIM irradiance ratio during the temporal overlap between the two missions (on the L3 SORCE-SIM wavelength scale). The **STICR**, SORCE and TSIS-1 mean spectra, plus all ancillary data needed to understand how this ratio was determined are contained in this data product. **STICR** (V01.1) was used to create V01 of the **SORCE-SIM TSIS-1 Adjusted Values (TAV)** irradiance data product (<https://doi.org/10.5067/85A69JPBFAJC>).

In simple terms, SORCE-SIM (irradiance) * **STICR** = SORCE-SIM **TAV**.(irradiance).

STICR V01.1 and **TAV** V01 use TSIS-SIM V05 and SORCE-SIM V27 publicly available data releases. The **STICR** data products are housed at CU Scholar – a collaborative service of the University of Colorado Libraries, and are available in ASCII and IDL¹ SAVE file format at <https://doi.org/10.25810/n6y0-tf68> .

The **TAV** V01 data product appears in ASCII format² in two locations:

- 1) LASP SORCE website (see: <http://lasp.colorado.edu/home/sorce/data/>), and
- 2) NASA DAAC (see: https://disc.gsfc.nasa.gov/datasets/SOR3SIMD_TAV_001/summary/).

A NetCDF version of **TAV** V01 is available at <https://lasp.colorado.edu/lisird/>. An IDL file reader (http://lasp.colorado.edu/data/sorce/file_readers/read_lasp_ascii_file.pro) is available which will read the ASCII files and return an array of structures whose field names and types are defined in Section 2. The **STICR** IDL SAVE file contains all the information in the ASCII file, plus additional information such as the specific days during the SORCE and TSIS temporal overlap which were used in the determination of the **STICR**. The IDL SAVE file is described in Section 3.

Version V01.1 of **STICR** differs from V01.0 in that the TSIS ground calibration error estimate has been removed from the **TSIS_UNC** column and placed into the **TSIS_CAL_ERR** column. This provides a better representation of the actual uncertainty of TSIS-SIM, in **TSIS_UNC**, as it represents only the observed on-orbit performance. This change does not affect **TAV** V01, or actual **STICR**.

Further details on the creation of the **STICR** ratio, shown in Figure 1, and its use in the creation of the **TAV** dataset are being prepared for an upcoming publication (*Earth and Space Science 2021, in prep.*).

¹ **Interactive Data Language**: <https://www.l3harrisgeospatial.com/Software-Technology/IDL>

² The LASP SORCE website also hosts the **TAV** data in IDL SAVE file and NetCDF formats.

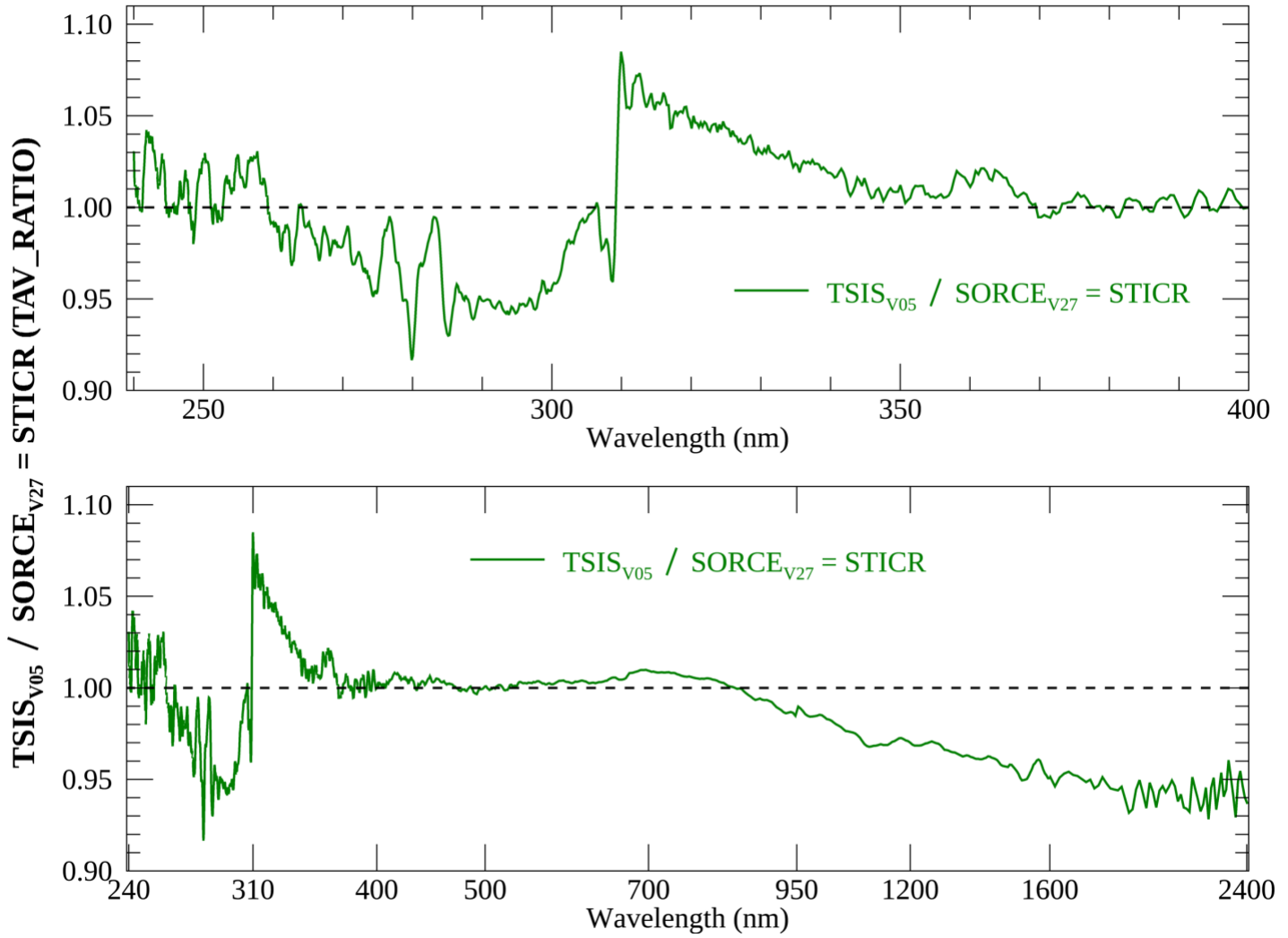


Figure 1: SORCE-SIM to TSIS-SIM Irradiance Calibration Ratio (STICR = TSISV05 / SORCEV27). The upper panel is on a linear scale to highlight the UV, while the bottom panel is on a log wavelength scale.

1) OVERVIEW:

The [SORCE](#) spacecraft was turned off on Feb 25, 202, the 6242nd SORCE mission Day (SD6241). The first mission day (SD0) was January 24, 2003 (01/24/2003). The first TSIS-1 mission day (TD0) was 12/14/2017, however data before TD100 (03/24/2018) is considered commissioning data. The TSIS-1 and SORCE temporal overlap was 804 days starting at TD100 leaves 704 days of overlap (03/24/2018-02/25/2020 = SD5538-6241 = TD100-803).

For **STICR**, we only use include days when both SORCE and TSIS-1 have useable observations. This criterium is based upon SORCE and TSIS-1 mission day integer boundaries, which are midnight-to-midnight UTC days. Before filtering due to various issues, listed below, this amounts to 579 days with common observations.

Data Sources: SORCE-SIM and TSIS-SIM data were downloaded (in IDL SAVE file format) from the LASP websites on 01/09/2021 from the following websites/files.

SORCE V27: http://lasp.colorado.edu/data/sorce/ssi_data/sim/sav/sorce_sim_latest.sav.zip

TSIS-1 V05: http://lasp.colorado.edu/data/tsis/ssi_data/tsis_ssi_L3_c24h_latest.sav

Wavelength Bandpass and Scale :

The wavelength scale for this calibration is the SORCE-SIM nominal L3 wavelength scale. The SORCE-SIM wavelength range (240.02—2412.34 nm) is different than the TSIS-SIM bandpass (200.01—2399.01 nm). We provide **TSIS-1 Adjusted Values (TAV)** for the overlap region of 240.01—2401.40 nm. In the 240.0-2401.4 nm bandpass, SORCE-SIM has 1234 wavelength bins, while TSIS-1 has 1511 elements. After data filling, the TSIS-1 data is interpolated onto the SORCE-SIM wavelength grid using a four-point Lagrange interpolation.

SORCE-SIM Data Preparation:

- 1) The SORCE V27 data was examined to locate the first full scan. This occurs on 03/27/2018 = SD5541 = TD103 . The spectrum from this day was used as the nominal SORCE wavelength scale. This spectrum contains 1235 spectral elements in the 240.01—2401.40 nm bandpass.
- 2) SORCE Irradiance values are filtered to be in the range of $0.01 < \text{Irradiance} < 3.0 \text{ W/m}^2/\text{nm}$ to exclude erroneous values, any NaNs are also filtered in this step.
- 3) If the day has more than 200 out of 1235 irradiance values missing, it is excluded. For our data sample, this resulted in 16 days being removed from our sample.
- 4) Missing irradiance values are filled by locating the nearest (in time) measurement at this wavelength. That days' irradiance, uncertainty and data flags were copied to the missing day and wavelength.

TSIS-SIM Data Preparation: TSIS-SIM data is converted to the SORCE-SIM wavelength scale by:

- 1) TSIS-1 data was examined to locate the first full scan. This occurs on 03/30/2018 = TD106 = SD5544. The spectrum from this data was used as the nominal TSIS wavelength scale and irradiance reference. This spectrum contains 1511 spectral elements in the 240.01—2401.40 nm bandpass.
- 2) TSIS-1 Irradiance values are filtered to be in the range of $0.01 < \text{Irradiance} < 3.0 \text{ W/m}^2/\text{nm}$ to exclude erroneous values, any NaNs are also filtered in this step.
- 3) If the day has more than 200 out of 1511 irradiance values missing, it is excluded. Nine (9) additional days were excluded from our sample due to missing TSIS-1 data, leaving a final sample of 554 days with valid SORCE and TSIS data.
- 4) Missing irradiance values are filled by locating the nearest (in time) measurement at this wavelength. That days' irradiance, uncertainty and data flags are copied to the missing day and wavelength.
- 5) TSIS-1 data is interpolated to the SORCE-SIM wavelength scale using a four-point Lagrange interpolation.

1) STICR ASCII FILE:

The **STICR** ASCII data product contains the calibration ratio, and ancillary data needed to understand the calibration ratio. The ASCII file contains 19 columns and is indexed to the nominal **SORCE L3** wavelength scale, with the exception that the longest **SORCE** wavelength (2412.34 nm) has been omitted as the **TSIS-SIM** does not measure this wavelength.

In this description, **BOLD** will be used to highlight actual column or file names, or to indicate abbreviations associated with the data column names. The “s” subscript is used to indicate an individual daily spectrum or irradiance measurement at a particular wavelength.

The **STICR** ASCII file is named **source_sim_L3_tav_cal_v01.1.txt** contains 20 columns in the FORTRAN/IDL format of '(F8.2,I4,4E11.4,I3,5E11.4,I3,4E11.4,I3,E11.4,E12.4)'. The columns names, data type, FORTRAN/IDL Format Codes and units are given in Table 1.

Table 1: STICR Column Name, Data Type, Format Code, Units, and Description

Column Number	Column Name	Data Type	Format Code	Units	Description
1	SORCE_WAVE	R4	f8.2	nm	SORCE nominal L3 wavelength scale
2	NSPEC_USED	I2	i4	integer	Number of Spectra used at SORCE_WAVE
3	SORCE_IRR	R4	e11.4	$W m^{-2} nm^{-1}$	Mean SORCE Irradiance (During Overlap)
4	SORCE_STD	R4	e11.4	$W m^{-2} nm^{-1}$	SORCE Irradiance Standard Deviation
5	SORCE_SEM	R4	e11.4	$W m^{-2} nm^{-1}$	SORCE Irradiance Standard Error of the Mean
6	SORCE_UNC	R4	e11.4	$W m^{-2} nm^{-1}$	SORCE Irradiance Uncertainty
7	SORCE_VER	I2	i3	version	SORCE Data Version (27 in this Release)
8	TSIS_IRR	R4	e11.4	$W m^{-2} nm^{-1}$	Mean TSIS-1 Irradiance (During Overlap)
9	TSIS_STD	R4	e11.4	$W m^{-2} nm^{-1}$	TSIS-1 Irradiance Standard Deviation
10	TSIS_SEM	R4	e11.4	$W m^{-2} nm^{-1}$	TSIS-1 Irradiance Standard Error of the Mean
11	TSIS_UNC	R4	e11.4	$W m^{-2} nm^{-1}$	TSIS-1 Irradiance Uncertainty
12	CAL_ERR	R4	e11.4	$W m^{-2} nm^{-1}$	TSIS-1 Irradiance Ground Calibration Error Estimate
13	TSIS_VER	I2	i3	version	TSIS-1 Data Version (05 in this release)
14	TAV_RATIO	R4	e11.4	unitless	TSIS_IRR / SORCE_IRR (STICR)
15	TAVR_STD	R4	e11.4	unitless	TAV_RATIO (TAVR) Standard Deviation
16	TAVR_SEM	R4	e11.4	unitless	TAV_RATIO (TAVR) Standard Error of the Mean
17	TAVR_UNC	R4	e11.4	unitless	TAV_RATIO (TAVR) Uncertainty
18	TAVR_VER	I2	i3	version	TAV_RATIO (TAVR) Version (01 in this release)
19	TAVR_CV2	R4	e11.4	$(W m^{-2} nm^{-1})^2$	TAV_RATIO (TAVR) Co-Variance ²
20	TAVR_PHI	R4	e12.4	unitless	TAV_RATIO (TAVR) Autocorrelation (PHI)

STICR ASCII FILE Column Descriptions:

- 1) **SORCE_WAVE:** The SORCE wavelength in nm. This column contains the exact same wavelengths as the nominal SORCE data release, with the exception that the longest wavelength data point (2412.34 nm) has been omitted as TSIS-1 does not cover this wavelength. All other columns are indexed with regards to this column.
- 2) **NSPEC_USED:** To be included in our dataset, both TSIS-1 and SORCE are allowed to be missing as many as 200 wavelengths in an individual scan. As a result, not all days contain data from each instrument. **NSPEC_USED** gives the **N**umber of daily **SPEC**tra **USED**, which can be different for each wavelength. To be counted, both TSIS and SORCE data were available at the wavelength given in the **SORCE_WAVE** column.

- 3) **SORCE_IRR:** Mean SORCE **IRR**adiance (in $W m^{-2} nm^{-1}$) at the wavelength given in the **SORCE_WAVE** column. This value uses a 5σ resistant mean, after which **NSPEC_USED** SORCE irradiances averaged at this wavelength (see additional discussion in the **TAV_RATIO** column description).

$$SORCE_IRR(\lambda) = \frac{1}{NSPEC_USED(\lambda)} \sum_{s=0}^{NSPEC_USED(\lambda)-1} IRR(\lambda)_s$$

- 4) **SORCE_STD:** The **ST**andard **D**eviation (in $W m^{-2} nm^{-1}$) of all values used in calculating **SORCE_IRR**. This is the traditional square root of the variance, and is defined as :

$$SORCE_STD(\lambda) = \sqrt{\frac{\sum_{s=0}^{NSPEC_USED(\lambda)-1} (IRR(\lambda)_s - SORCE_IRR(\lambda))^2}{NSPEC_USED(\lambda) - 1}}$$

- 5) **SORCE_SEM:** The **ST**andard **E**rror of the **M**ean irradiance (**SORCE_IRR**) in $W m^{-2} nm^{-1}$. This is simply the standard deviation (**SORCE_STD**) divided by the square root of the number of values used (**NSPEC_USED**).

$$SORCE_SEM(\lambda) = \frac{SORCE_STD(\lambda)}{\sqrt{NSPEC_USED(\lambda)}}$$

- 6) **SORCE_UNC:** The **UN**Certainty of **SORCE_IRR** (in $W m^{-2} nm^{-1}$) using standard error propagation using the SORCE-SIM published uncertainties (**SORCE_UNC_PUB**(λ)).

$$SORCE_UNC(\lambda) = \sqrt{\frac{\sum_{s=0}^{NSPEC_USED-1} SORCE_UNC_PUB(\lambda)_s^2}{NSPEC_USED(\lambda)}}$$

- 7) **SORCE_VER:** The **VER**sion number for the SORCE-SIM data used. For all values in this release, the SORCE-SIM version is 27 (V27).
- 8) **TSIS_IRR:** Mean TSIS-1 **IRR**adiance at the wavelength given in the **SORCE_WAVE** column (in $W m^{-2} nm^{-1}$). This value is the 5σ resistant mean of all **NSPEC_USED** TSIS-1 irradiances at this wavelength. This is calculated in an identical method as **SORCE_IRR**, but see further discussion in the **TAV_RATIO** column description.
- 9) **TSIS_STD:** The **ST**andard **D**eviation of all values used in calculating **TSIS_IRR** (in $W m^{-2} nm^{-1}$). This is calculated in the same fashion as **SORCE_STD**.

10) **TSIS_SEM**: The **Standard Error of the Mean irradiance (TSIS_IRR)** in $W m^{-2} nm^{-1}$. This is calculated in the same fashion as **TSIS_SEM**.

11) **TSIS_UNC**: The **UNCertainty of TSIS_IRR** (in $W m^{-2} nm^{-1}$) using standard error propagation using the TSIS-SIM published uncertainties (*TSIS_UNC_PUB*). While **SORCE** publishes a single uncertainty estimate, TSIS-1 publishes three independent values:

Instrument Uncertainty (IU): a pre-launch measure of instrument 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.

Measurement Precision (MP): a measure of the on-orbit variance in the scan-to-scan repeatability in the observed spectral irradiances. This value is an upper limit of measurement precision.

Measurement Uncertainty (MU): a metric of the overall on-orbit uncertainty. It has contributions from instrument uncertainty, uncertainty due to post-processing of data (including the correction of instrument degradation), and uncertainty due to differences between observed irradiances for the 3 separate TSIS-SIM channels.

We define the TSIS-SIM published uncertainties (*TSIS_UNC_PUB*) as the **Measurement Precision** and **Measurement Uncertainty** added in quadrature. The **Instrument Uncertainty** is published in the **TSIS_CAL_ERR** column. **TSIS_UNC** is calculated in a similar fashion as **SORCE_UNC** using these uncertainties.

$$TSIS_UNC(\lambda) = \sqrt{\frac{\sum_{s=0}^{NSPEC_USED(\lambda)-1} TSIS_UNC_PUB(\lambda)_s^2}{NSPEC_USED(\lambda)}}$$

$$\text{where, } TSIS_UNC_PUB(\lambda)_s = \sqrt{MP(\lambda)_s^2 + MU(\lambda)_s^2}$$

12) **TSIS_CAL_ERR**: The TSIS-1 ground calibration error estimate (**Instrument Uncertainty, IU**) for TSIS-1 irradiance ($W m^{-2} nm^{-1}$). This error estimate is not included in **TSIS_UNC**, ensuring that **SORCE_UNC** and **TSIS_UNC** both reflect the actual uncertainties associated with the on-orbit measurements. **SORCE** does not have an equivalent measurement.

13) **TSIS_VER**: The **VER**sion number for the TSIS-SIM data used. For all values in this release, the TSIS-SIM version is 05 (V05).

14) **TAV_RATIO**: The **TSIS-1 Adjusted Values correction RATIO** (as referred to as the **SORCE-SIM to TSIS-SIM Irradiance Calibration Ratio, STICR**). This value is the simple division of the **SORCE_IRR** column by the **TSIS_IRR** column at each wavelength.

$$TAV_RATIO(\lambda) = \frac{TSIS_IRR(\lambda)}{SORCE_IRR(\lambda)}$$

The **TAV_RATIO (TAVR)** is used to define the outliers not used during the irradiance determinations in **SORCE_IRR** and **TSIS_IRR**. At each wavelength, a 5σ resistant mean is determined using **TAV_RATIO = TSIS_IRR / SORCE_IRR**. Irradiance measurements not

used in calculating the 5σ resistant mean for **TAV_RATIO** are also excluded when calculating **TSIS_IRR** and **SORCE_IRR**. This preserves near-simultaneous mutual excursions of TSIS and SORCE irradiances that are observing actual solar activity, which could be removed if the outlier determination was performed on the irradiances and not the ratio.

15) TAVR_STD: The **TAV_RATIO** (**TAVR**) **STANDARD** **DEVIATION** at each wavelength. This is calculated in the same fashion as **SORCE_STD** and **TSIS_STD**.

16) TAVR_SEM: The **Standard Error of the Mean TAVR** (**TAV_RATIO**). This is calculated in the same fashion as **SORCE_SEM** and **TSIS_SEM**.

17) TAVR_UNC: The **TAV_RATIO UNCertainty** is determined using standard error propagation for a ratio using the previously derived **SORCE_UNC** and **TSIS_UNC** values at each wavelength, a co-variance term (**TAVR_CV2**), described later as column 18, plus a modification using the **SORCE_IRR – TSIS_IRR** autocorrelation (**TAVR_PHI**), described in column 19 and in Weatherhead, *et al.*, 1998.

$$\frac{TAVR_ERR(\lambda)}{TAV_RATIO(\lambda)} = \sqrt{\left(\frac{SORCE_UNC(\lambda)}{SORCE_IRR(\lambda)}\right)^2 + \left(\frac{TSIS_UNC(\lambda)}{TSIS_IRR(\lambda)}\right)^2 - \frac{2 \times TAVR_CV2(\lambda)}{TSIS_IRR(\lambda) \times SORCE_IRR(\lambda)}}$$

$$TAVR_UNC(\lambda) = \frac{TAVR_ERR(\lambda)}{\sqrt{NSPEC_USED(\lambda)}} \sqrt{\frac{1+TAVR_PHI(\lambda)}{1-TAVR_PHI(\lambda)}}$$

18) TAVR_VER: The **VERSION** number for the **TAV_RATIO**. For all values in this release, the TAVR version is 1.1 (V01.1).

19) TAVR_CV2: The **TAV_RATIO Co-Variance²** is the covariance² term in the **TAVR_UNC** and is defined as:

$$TAV_CV2(\lambda) = \frac{\sum_{s=0}^{N-1} abs\left(\left(TSIS(\lambda)_s - TSIS_IRR(\lambda)\right)\left(SORCE(\lambda)_s - SORCE_IRR(\lambda)\right)\right)}{NSPEC_USED(\lambda)},$$

$$where, N = NSPEC_USED(\lambda),$$

20) TAVR_PHI: The **TAV_RATIO** auto-correlation parameter (**PHI**) was created using 47 consecutive 15-day bins (b) over the SORCE – TSIS overlap. During each 15-day period, a TSIS/SORCE BIN_{ratio} was calculated in identical fashion to **TAV_RATIO**.

$$TAVR_PHI(\lambda) = autocorrelation\ function = \frac{\sum_{b=0}^{N-L-1} (x_b - \bar{x})(x_{b+L} - \bar{x})}{\sum_{b=0}^{N-1} (x_b - \bar{x})^2}$$

where, $x = BIN_{ratio}$, $\bar{x} = TAV_RATIO$, $N = 47$ bins, and $L = 1$ (15-day bin).

2) STICR IDL SAVE FILE:

The IDL **STICR** SAVE file (**source_sim_L3_tav_cal_v01.1.sav**) contains the one string array and one IDL data structure. The string array, **DOC_STICR**, is similar to the text in ASCII file header.

```
IDL> restore,'source_sim_L3_tav_cal_v01.1.sav',/verbose
% RESTORE: Description: V01.1 of SORCE-SIM to TSIS1-SIM Irradiance Calibration Ratio
File (STICR). Uses SORCE-SIM V27 and TSIS1-SIM V05 data releases. Data and
release notes archived at https://doi.org/10.25810/n6y0-tf68 Contact: Steven.Penton@colorado.edu..
% RESTORE: Restored variable: DOC_STICR.
% RESTORE: Restored variable: STICR.
```

The data structure contains all 20 columns described in the ASCII file section, plus additional information that is not easily represented in the ASCII file. The **DOC_STICR** string array contains the majority of text from the header of the ASCII file.

```
IDL> help,DOC_STICR DOC_STICR STRING = Array[71]
IDL> for i=0,n_elements(DOC_STICR)-1 do print,DOC_STICR[i]
```

Background on the SORCE-SIM to TSIS-SIM Irradiance Calibration Ratio (STICR)

This data product uses the temporal overlap of the Solar Radiation and Climate Experiment (SORCE) and the Total and Spectral Solar Irradiance Sensor (TSIS-1) Spectral Irradiance Monitor (SIM) instruments to create an alternate SORCE-SIM irradiance calibration.

This is version 01.1 (V01.1) the SORCE-SIM to TSIS-SIM Irradiance Calibration Ratio (STICR) data product, which is used to create the TSIS Adjusted Values (TAV) contained in a separate data product. This version uses the SORCE-SIM V27 and TSIS-SIM V05 data releases. V01.1 differs from V1.0 in that the TSIS ground calibration error estimate has been removed from the TSIS_UNC column and placed into the TSIS_CAL_ERR column. This provides a better representation of the uncertainty of TSIS-SIM, in TSIS_UNC, as it represents only the observed on-orbit performance. This change does not affect TAV V01, or STICR.

STICR is the mean TSIS-SIM/SORCE-SIM irradiance ratio on the SORCE-SIM wavelength scale using irradiance measurements taken during the temporal overlap of the two instruments. This wavelength scale varies in spectral resolution from 1-34 nm over the spectral range. Irradiances are reported at a mean solar distance of 1 AU and zero relative line-of-sight velocity with respect to the Sun.

The SORCE-SIM to TSIS-SIM Irradiance Calibration Ratio (STICR) details are tabulated in IDL data structures with each row giving the wavelength, number of spectra combined at this wavelength, SORCE mean spectral irradiance, its 1-sigma standard deviation of the mean (STD), standard error of the mean (SEM), uncertainty (UNC), data release version, TSIS-SIM mean spectral irradiance, its 1-sigma STD, SEM, UNC, CAL_ERR, data release version, the STICR (TSIS1/SORCE), its 1-sigma STD, SEM, UNC, co-variance squared (CV2), and auto-correlation (PHI). The TAV auto-correlation (PHI) was constructed using 15-day bins evenly spaced over the overlap region. See the V01.1 STICR release notes for complete details.

The STICR V01.1 data product, release notes and further details can be found at <https://doi.org/10.25810/n6y0-tf68>

SORCE-SIM V27 and TAV 01 release notes can be found at : <https://lasp.colorado.edu/home/sorce/instruments/sim/sorce-sim-data-products-release-notes> .

SORCE-SIM V27, TAV 01, and other SORCE data can be found at <http://lasp.colorado.edu/home/sorce/data> . TSIS-SIM data and release notes can be obtained from <https://lasp.colorado.edu/home/tsis/data/> .

An IDL file reader (http://lasp.colorado.edu/data/sorce/file_readers/read_lasp_ascii_file.pro) is available which will read this file and return an array of structures whose field names and types are taken from the "DATA DEFINITIONS" section.

Jerald Harder et al. (2021), SORCE-SIM to TSIS-1 SIM Irradiance Calibration Ratio (STICR), Boulder, CO, USA, CU Scholar, <https://doi.org/10.25810/n6y0-tf68>

For more information on the SORCE or TSIS instruments and data products, see: <http://lasp.colorado.edu/home/sorce/> or <http://lasp.colorado.edu/home/tsis/> .

```
***DATA DEFINITIONS***, number = 20 (name, type, format)
SORCE_WAVE, R4, f8.2 (nm)
NSPEC_USED, I2, i4 (integer)
SORCE_IRR, R4, e11.4 (W/m^2/nm)
SORCE_STD, R4, e11.4 (W/m^2/nm)
SORCE_SEM, R4, e11.4 (W/m^2/nm)
SORCE_UNC, R4, e11.4 (W/m^2/nm)
SORCE_VER, I2, i3 (version)
TSIS_IRR, R4, e11.4 (W/m^2/nm)
TSIS_STD, R4, e11.4 (W/m^2/nm)
TSIS_SEM, R4, e11.4 (W/m^2/nm)
TSIS_UNC, R4, e11.4 (W/m^2/nm)
TSIS_CAL_ERR, R4, e11.4 (W/m^2/nm)
TSIS_VER, I2, i3 (version)
TAV_RATIO, R4, e11.4 (unitless)
TAVR_STD, R4, e11.4 (unitless)
TAVR_SEM, R4, e11.4 (unitless)
TAVR_UNC, R4, e11.4 (unitless)
TAVR_VER, I2, i3 (version)
TAVR_CV2, R4, e11.4 (W/m^2/nm)^2
TAVR_PHI, R4, e12.4 (unitless)
***END DATA DEFINITIONS*** ***/END DATA DEFINITIONS***
```


The format of the **STICR** data structure is :

```
IDL> help,STICR,/str
** Structure <18ca008>, 9 tags, length=23179840, data length=23179812, refs=1:
SORCE_WAVE DOUBLE Array[1234]
NSPEC_USED UINT Array[1234]
SORCE STRUCT -> <Anonymous> Array[1]
TSIS STRUCT -> <Anonymous> Array[1]
TAV_RATIO DOUBLE Array[1234]
TAVR STRUCT -> <Anonymous> Array[1]
AUTOCORR STRUCT -> <Anonymous> Array[1]
DATA STRUCT -> <Anonymous> Array[1]
VERSION FLOAT
COMMENTS STRING Array[5]
```

The format of the **SORCE** and **TSIS** data structures are almost identical and match as closely as possible as the ASCII file. The difference from the ASCII file is that instead of **SORCE_IRR**, the corresponding data in the IDL SAVE file is given by **SORCE.IRR**. The **TSIS** data structure includes the **CAL_ERR** array, while **SORCE** does not, since it does not have a complete ground calibration.

```
IDL>help,STICR.SORCE,STICR.TSIS,/str
** Structure <f500f88>, 5 tags, length=39496, data length=39490, refs=2:
IRR DOUBLE Array[1234]
STD DOUBLE Array[1234]
SEM DOUBLE Array[1234]
UNC DOUBLE Array[1234]
VER INT 27
** Structure <f501298>, 5 tags, length=39496, data length=39490, refs=2:
IRR DOUBLE Array[1234]
STD DOUBLE Array[1234]
SEM DOUBLE Array[1234]
UNC DOUBLE Array[1234]
CAL_ERR DOUBLE Array[1234]
VER INT 5
```

The **TAV_RATIO** data (**STICR**) is given at the top level of the structure, while all **TAVR_XXX** variables in the ASCII file are given as **TAVR.XXX** in the IDL data structure.

```
IDL>help,STICR.TAV_RATIO
<Expression> DOUBLE = Array[1234]
```

```
IDL>help,STICR.TAVR,/str
** Structure <f5015a8>, 6 tags, length=49368, data length=49362, refs=2:
STD DOUBLE Array[1234]
SEM DOUBLE Array[1234]
UNC DOUBLE Array[1234]
VER FLOAT 1.1
CV2 DOUBLE Array[1234]
PHI DOUBLE Array[1234]
```

This above describes data in the IDL SAVE file that is also in the ASCII file, the following data is **ONLY** provided in the IDL SAVE file. The additional information is contained in a structure describing the auto-correlation needed to determine the **TAVR_UNC**, and the actual **TSIS** and **SORCE** irradiance values used in this **TAV_RATIO** creation.

The autocorrelation data is given in the **STICR.AUTOCORR** data structure, shown below. This gives the number of days per autocorrelation bin (**NDAYS_PER_ACORR_BIN**), the **BIN_RATIOS** as described in the **TAVR_PHI** column description in the ASCII file section, and the start (**START_JD**) and end (**END_JD**) Julian dates of the bins.

```
IDL> help,STICR.AUTOCORR,/str
** Structure <f501ce8>, 4 tags, length=464744, data length=464738, refs=2:
NDAYS_PER_ACORR_BIN INT 15
BIN_RATIO DOUBLE Array[47, 1234]
START_JD DOUBLE Array[47]
END_JD DOUBLE Array[47]
```

The **SORCE** and **TSIS** data used in creating the **TAV_RATIO** are given in the **STICR.DATA** structure, shown below. The data structure gives the Julian Day (**JD**) of the days of **SORCE** and **TSIS** daily spectra used in this project. The **STICR.DATA.SORCE_IRRAD** and **SORCE_IRRAD_UNC** arrays contain the **SORCE** irradiance and uncertainty values as published in the **SORCE-SIM V27** data release for **ALL** days used in this project. Likewise, the **STICR.DATA.TSIS_IRRAD** and **TSIS_IRRAD_UNC** are the corresponding **TSIS** values, with the noted exception that the **TSIS_IRRAD_UNC** values are 2 of the 3 **TSIS** published uncertainties added in quadrature as described in the **TSIS_UNC** section of the **ASCII** file description. The specific irradiance and uncertainty values that are used in the creation of all columns in the **ASCII** files is given by the **STICR.DATA.USED_IN_STICR** array. A 1 (**TRUE**) indicates that the value was used, while a 0 (**FALSE**) indicates that these values did not pass the outlier resistant mean procedure described in the **TAV_RATIO** section of the **ASCII** file description. The sigma used for this filtering is given by **STICR.DATA.SIGMA_FOR_RESISTANT_MEAN** . A comment explaining this is included as **STICR.DATA.COMMENT** .

```
IDL>help,STICR.DATA,/str
** Structure <18bba08>, 8 tags, length=22564440, data length=22564440, refs=2:
JD DOUBLE Array[554]
SORCE_IRRAD DOUBLE Array[554, 1234]
SORCE_IRRAD_UNC DOUBLE Array[554, 1234]
TSIS_IRRAD DOUBLE Array[554, 1234]
TSIS_IRRAD_UNC DOUBLE Array[554, 1234]
SIGMA_FOR_RESISTANT_MEAN
FLOAT 5.00000
USED_IN_STICR BYTE Array[554, 1234]
COMMENT STRING 'An N-sigma resistant mean was used to filter data. Filtered irradiances are marked by a 0 in the used_in_STICR array. The number (N) of sigma used is given by sigma_for_resistant_mean.'
```

Finally, a string array of comments explaining the different acronyms is included as **STICR.COMMENTS**.

```
IDL> help,STICR.COMMENTS,/str
<Expression> STRING = Array[6]
```

```
IDL>for i=0,n_elements(STICR.COMMENTS)-1 do print,STICR.COMMENTS[i]
```

```
TAV_RATIO = SORCE-SIM to TSIS-SIM Irradiance Calibration Ratio (STICR = TSIS1/SORCE)
STD = STandard Deviation of the mean = sqrt(variance)
SEM = Standard Error of the Mean = STD/sqrt(n)
UNC = UNCertainty, propagated using published irradiance uncertainties
CAL_ERR = Ground CALibration ERRor estimate (TSIS only)
```

3) REVISION HISTORY:

1.0: 01/20/2021 – Steven Penton, James Mothersbaugh, Stéphane Béland, and Jerald Harder - *Initial Release*

1.1: 02/26/2021 – Steven Penton and Jerald Harder- *Moved CAL_ERR out of TSIS_UNC into new column*

4) REFERENCES:

Weatherhead, E. C., G. C. Reinsl, G. C. Tiao, X. Meng, D. Choi, W. Cheang, T. Keller, J. DeLuisi, D. J. Wuebbles, J. B. Kerr, A. J. Miller, S. J. Oltmans, and J. E. Frederick, 1998: Factors affecting the detection of trends: Statistical considerations and applications to environmental data. *Journal of Geophysical Research*, 103, 17149-17161.

5)ACKNOWLEDGEMENTS:

The STICR team would like to thank Joel Tibbetts and Peter Breslin for their significant contributions during their summer REU internships at LASP.