SORCE-SIM STICR Version 2.0 Release Notes (v2.0, 06/15/21)

This is version 2.0 (V02.0) of the SORCE-SIM to TSIS-SIM **I**rradiance **C**alibration **R**atio (**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** (V02.0) was used to create V02.0 of the SORCE-SIM **T**SIS-1 **A**djusted **V**alues (**TAV**) irradiance data product.

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

STICR V02 and **TAV** V02 use TSIS-SIM V06 and SORCE-SIM V27 publicly available data releases. The **STICR** V2.0 data products are housed at CU Scholar – a collaborative service of the University of Colorado Libraries, and are available in ASCII and IDL[1] SAVfile format at https://doi.org/10.25810/22v9-9s08 .

The **TAV** V02 data product (https://doi.org/10.5067/8E8EG9HHVDZS) appears in ASCII format[2] 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_002/summary/).

A NetCDF version of **TAV** V02 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 SAVfile 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 SAVfile is described in Section 3.

Version V02.0 of **STICR** differs from V01.1 in not only the new TSIS-1 SIM data release version, but also all irradiance and ratio values and uncertainties are generated and reported using double-precision. As with V01.1 of **STICR**, TSIS-1 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 TSIS1-SIM, in **TSIS_UNC**, as it represents only the observed on-orbit performance. Also new in **STICR** V02 is the inclusion of the **STICR.AUTOCORR** structure of the IDL SAVfile to document the number of spectra used for each autocorrelation bin for each wavelength.

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.*).

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[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.
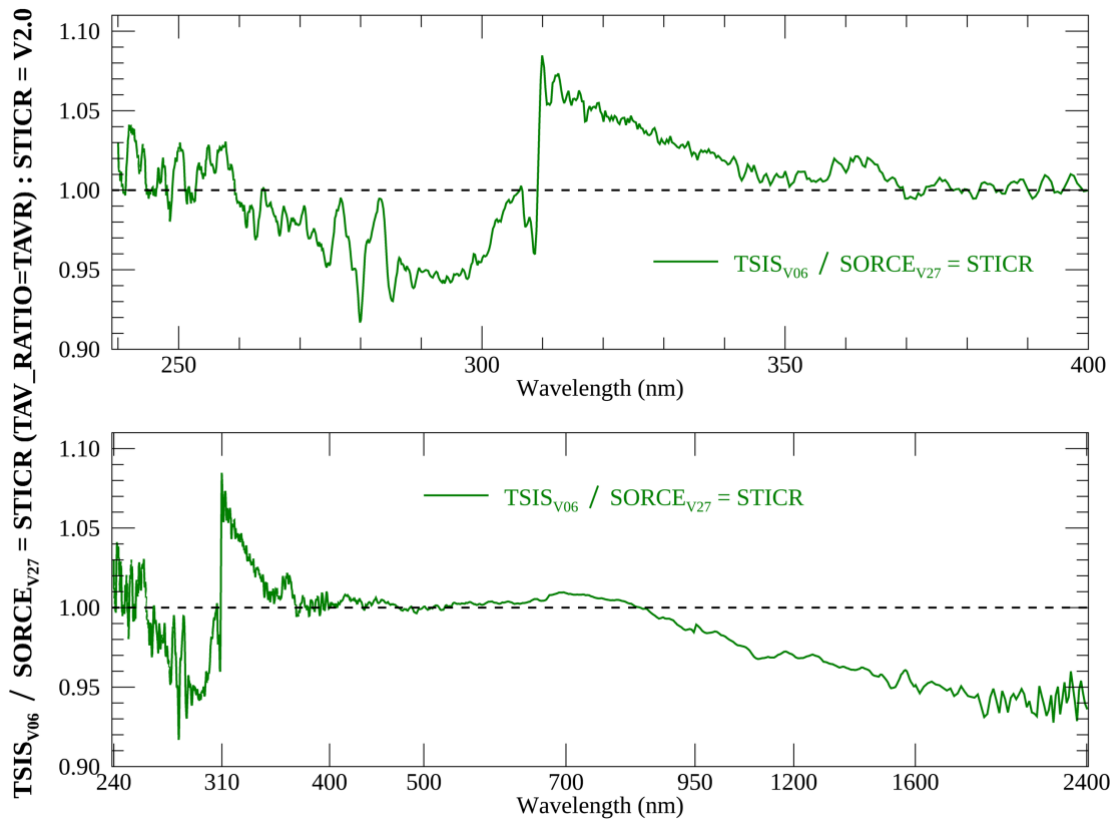
Figure 1: **S**ORCE-SIM to **TSIS**-SIM **I**rradiance **C**alibration **R**atio (**STICR** = TSIS V06 / SORCE V27). Upper panel is a linear scale to highlight the UV, while the bottom panel is on a log wavelength scale.
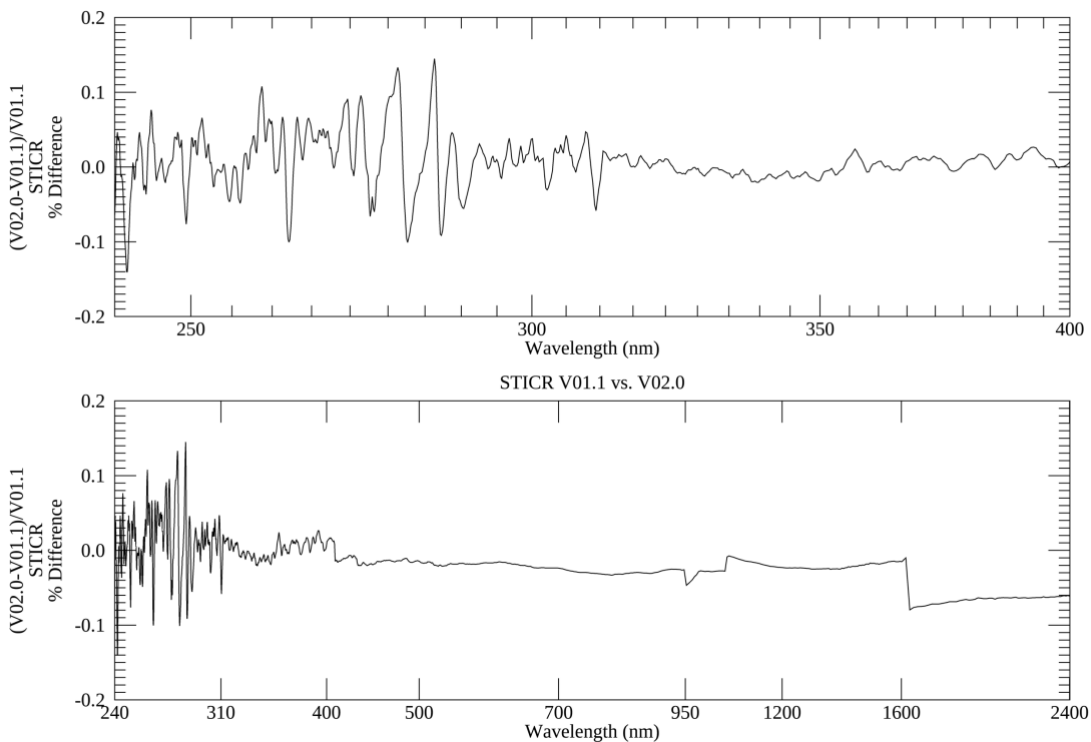

Figure 2: STICR V02.0 compared to V01.1. The only change to the SORCE data between these versions was the switch to double-precision, while TSIS data changed from V05 to V06. Differences between **STICR** V02.0 and V01.1 are due to calibration improvements in TSIS V06. These include a new diode wavelength alignment algorithm and new diode temperature response corrections.

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 SAVfile format) from the LASP websites on 06/08/2021 from the following websites/files.
      SORCE V27: http://lasp.colorado.edu/data/sorce/ssi_data/sim/sav/sorce_sim_latest.sav.zip
      TSIS-1 V06: 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 **T**SIS1-SIM **A**djusted **V**alues (**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 $0.01 <$ Irradiance < 3.0 W/m^2/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 $0.01 <$ Irradiance < 3.0 W/m^2/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.

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 **sorce_sim_L3_tav_cal_v02.0.txt** contains 20 columns in the FORTRAN/IDL format of '(F8.2,I4,E13.6,3E11.4,I3,E13.6,4E11.4,I3,E13.6,3E11.4,F5.1,E11.4,E12.4)'. For **STICR** V02, SORCE-SIM mean irradiance (**SORCE_IRR**), TSIS1-SIM mean irradiance (**TSIS_IRR**), and the **STICR** ratio (**TAV_RATIO**) columns were changed from single-precision (R4) to double precision (R8). This is consistent with the change in the SORCE-SIM V27 data release. Also, the format of the **TAVR_VER** column (**TAV_RATIO** version) was changed from I3 to F5.1 to allow subversions. Columns names, data types, 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	R8	e13.6	$W\,m^{-2}\,nm^{-1}$	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	R8	e13.6	$W\,m^{-2}\,nm^{-1}$	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 (06 in this release)
14	TAV_RATIO	R8	e13.6	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	R4	F5.1	version	**TAV_RATIO** (TAVR) Version (2.0 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 **S**tandard **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 **UNC**ertainty of **SORCE_IRR** (in $W\ m^{-2}\ nm^{-1}$) using standard error propagation using the SORCE-SIM published uncertainties ($SORCE\_UNC\_PUB(\lambda)$).

$$SORCE\_UNC(\lambda) = \sqrt{\frac{\sum_{s=0}^{NSPEC\_USED-1} SORCE\_UNC\_PUB(\lambda)_s^2}{NSPEC\_USED(\lambda)}}$$

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 **S**tandard **E**rror of the **M**ean irradiance (**TSIS_IRR**) in $W\ m^{-2}\ nm^{-1}$. This is calculated in the same fashion as **TSIS_SEM**.

11) **TSIS_UNC**: The **UNC**ertainty 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.

$$TSIS\_UNC(\lambda) = \sqrt{\frac{\sum_{s=0}^{NSPEC\_USED(\lambda)-1} TSIS\_UNC\_PUB(\lambda)_s{}^2}{NSPEC\_USED(\lambda)}}$$

$$where, TSIS\_UNC\_PUB(\lambda)_s = \sqrt{MP(\lambda)_s^2 + MU(\lambda)_s^2}$$

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 06 (V06).

14) **TAV_RATIO**: The **TSIS-1 A**djusted **V**alues correction **RATIO** (as referred to as the **S**ORCE-SIM to **TSIS-**SIM **I**rradiance **C**alibration **R**atio, **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_R**ATIO (**TAVR**) **ST**andard **D**eviation at each wavelength. This is calculated in the same fashion as **SORCE_STD** and **TSIS_STD.**

16) **TAVR_SEM**: The **S**tandard **E**rror of the **M**ean **TAVR** (**TAV_RATIO**). This is calculated in the same fashion as **SORCE_SEM** and **TSIS_SEM.**

17) **TAVR_UNC**: The **TAV_R**ATIO **UNC**ertainty 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.

$$\frac{TAVR\_ERR(\lambda)}{\textbf{TAV\_RATIO}(\lambda)} = \sqrt{(\frac{\textbf{SORCE\_UNC}(\lambda)}{\textbf{SORCE\_IRR}(\lambda)})^2 + (\frac{\textbf{TSIS\_UNC}(\lambda)}{\textbf{TSIS\_IRR}(\lambda)})^2 - \frac{2 \times \textbf{TAVR\_CV2}(\lambda)}{\textbf{TSIS\_IRR}(\lambda) \times \textbf{SORCE\_IRR}(\lambda)}}$$

$$\textbf{TAVR\_UNC}(\lambda) = \frac{TAVR\_ERR(\lambda)}{\sqrt{\textbf{NSPEC\_USED}(\lambda)}} \sqrt{\frac{1+\textbf{TAVR\_PHI}(\lambda)}{1-\textbf{TAVR\_PHI}(\lambda)}}$$

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

19) **TAVR_CV2**: The **TAV_R**ATIO **C**o-**V**ariance^2 is the covariance^2 term in the **TAVR_UNC** and is defined as:

$$\textbf{TAV\_CV2}(\lambda) = \frac{\sum_{s=0}^{N-1} abs\left((TSIS(\lambda)_s - \textbf{TSIS\_IRR}(\lambda))(SORCE(\lambda)_s - \textbf{SORCE\_IRR}(\lambda))\right)}{\textbf{NSPEC\_USED}(\lambda)}$$

$$where, N = \textbf{NSPEC\_USED}(\lambda)$$

20) **TAVR_PHI**: The **TAV_R**ATIO auto-correlation parameter (**PHI**) was created using 47 consecutive 15-day bins (b) over the SORCE – TSIS1 overlap. During each 15-day period, a TSIS/SORCE BIN_{ratio} was calculated in identical fashion to **TAV_RATIO**.

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

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

The IDL **STICR** SAVfile (**sorce_sim_L3_tav_cal_v02.0.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,'sorce_sim_L3_tav_cal_v02.0.sav',/verbose
% RESTORE: Description: V02.0 of SORCE-SIM to TSIS1-SIM Irradiance Calibration Ratio File (STICR). Uses SORCE-SIM V27.0 and TSIS1-SIM V006.0 data
releases. STICR data and release notes archived at https://doi.org/10.25810/22v9-9s08 Contact: Steven.Penton@lasp.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[74]
IDL> for i=0,n_elements(DOC_STICR)-1 do print,DOC_STICR[i]
```

Background on the SORCE-SIM to TSIS1-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 (TSIS1) Spectral Irradiance Monitor (SIM) instruments to create an alternate SORCE-SIM irradiance calibration.

This is version 02.0 (V02.0) the SORCE-SIM to TSIS1-SIM Irradiance Calibration Ratio (STICR) data product, which is used to create the TSIS1 Adjusted Values (TAV) contained in a separate data product. This version uses the SORCE-SIM V27 and TSIS1-SIM V06 data releases. STICR V02.0 differs from V01.1 in that the format for the SORCE_IRR, TSIS_IRR, and TAV_RATIO columns has changed from E11.4 to E13.6 to mitigate rounding errors, and the TAVR_VER (TAV_RATIO version number) column was changed from an I3 to an F5.1 to allow subversions. STICR V02.0 differs from V01.0 in that the TSIS1 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 TSIS1-SIM, in TSIS_UNC, as it represents only the observed on-orbit performance. STICR V02.0 was used to create V02.0 of the TAV data product. STICR is the mean TSIS1-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 TSIS1-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, TSIS1-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 V02.0 STICR release notes for complete details. The STICR V02.0 data product, release notes and further details can be found at https://doi.org/10.25810/22v9-9s08 .

SORCE-SIM V27 and TAV V02 release notes can be found at : https://lasp.colorado.edu/home/sorce/instruments/sim/sorce-sim-data-products-release-notes . The TAV V02 data product can be found at https://doi.org/10.5067/8E8EG9HHVDZS .

SORCE-SIM V27, TAV V02, and other SORCE data can be found at http://lasp.colorado.edu/home/sorce/data. TSIS1-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 TSIS1-SIM Irradiance Calibration Ratio (STICR), Boulder, CO, USA, CU Scholar, https://doi.org/10.25810/22v9-9s08 .

For more information on the SORCE or TSIS1 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, R8, e13.6 (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, R8, e13.6 (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, R8, e13.6 (unitless)
 TAVR_STD, R4, e11.4 (unitless)
 TAVR_SEM, R4, e11.4 (unitless)
 TAVR_UNC, R4, e11.4 (unitless)
 TAVR_VER, R4, f5.1 (version)
 TAVR_CV2, R4, e11.4 (W/m^2/nm)^2
 TAVR_PHI, R4, e12.4 (unitless)
 ***END DATA DEFINITIONS***
```

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

```
IDL> help,STICR,/str
        ** Structure <4077608>, 11 tags, length=23247736, data length=23247704, refs=2:
            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     2.00000
            SVERSION     STRING   'V02.0'
            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 SAVfile 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 <70004108>, 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 <70004418>, 6 tags, length=49368, data length=49362, 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       6
```

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 2.0
        CV2 DOUBLE Array[1234]
        PHI DOUBLE Array[1234]
```

This above describes data in the IDL SAVfile that is also in the ASCII file, the following data is **ONLY** provided in the IDL SAVfile. 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 in 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. The **NUSED_PER_ABIN** column was added in V02 to document the number of spectra used for each autocorrelation bin for each wavelength.

```
IDL> help,STICR.AUTOCORR,/str
        ** Structure <70004b78>, 5 tags, length=522744, data length=522736, refs=2:
```

```
                NDAYS_PER_ACORR_BIN  INT         15
                BIN_RATIO        DOUBLE   Array[47, 1234]
                START_JD         DOUBLE   Array[47]
                END_JD           DOUBLE   Array[47]
                NUSED_PER_ABIN      BYTE    Array[47, 1234]
```

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 <4043408>, 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 – S. Penton and J. Harder- *Moved CAL_ERR out of TSIS_UNC into new column*
2.0: 06/01/2021 – S. Penton - *Changed text output to double-precision, now using TSIS1-SIM version V06.*
                    Added **NUSED_PER_ABIN** *to the STICR.AUTOCORR data structure.*

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: