SORCE-SIM TAV Version 01 Release Notes (v1.1, 04/01/21)

This data product uses the temporal overlap of the Solar Radiation and Climate Experiment (SORCE) and Total and Spectral Solar Irradiance Sensor (TSIS-1) Spectral Irradiance Monitor (SIM) instruments to create an alternate SORCE-SIM irradiance calibration, known as the **TSIS A**djusted **V**alues (**TAV**). This is **TAV** version 1.1 (V01.1), using the SORCE-SIM V27 and TSIS-SIM V05 data releases.

This re-calibration is based solely upon the temporal overlap of TSIS-1 and SORCE, without any additional corrections for instrument degradations. As such, the irradiance values at the end of the SORCE mission are guaranteed to agree with TSIS-1, but this may not be true for earlier in the SORCE mission due to uncorrected SORCE degradation or instrumental issues.

The **TAV** re-calibration is achieved by multiplying the SORCE-SIM V27 irradiances by V01 of the **S**ORCE-SIM to **T**SIS-SIM **I**rradiance **C**alibration **R**atio (**STICR**), which is contained in a separate data product. The DOI for V01 of the **STICR** is https://doi.org/10.25810/n6y0-tf68, the DOI for V01 of the **T**SIS-1**A**djusted **V**alues (**TAV**) data product is https://doi.org/10.5067/85A69JPBFAJC.

TAV V01.1 differs from V01 in that the irradiancies used, and those reported in the **TAV** data products, have been changed from the E11.4 to E13.6 format to prevent rounding errors. This change also requires that irradiance values are now declared as double-precision (R8) in the header and IDL SAVE file. The new format ensures that rounding errors for both V27 SIM and V01.1 of **TAV** are less than 0.5 parts per million (PPM). A similar change was also made to the V01 **STICR** to ensure double precision is maintained during the **TAV** creation process.

The NASA DAAC short-name for the **TAV** ASCII data product is **SOR3SIMD_TAV**, and this data product appears in ASCII format 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/summary/).

The **TAV** V01 data product is also available as an IDL[1] SAVE file from the LASP website (https://lasp.colorado.edu/home/sorce/data/).

An IDL file reader (http://lasp.colorado.edu/data/sorce/file_readers/read_lasp_ascii_file.pro) is available which will read the **TAV** ASCII file and return an array of structures whose field names and types are defined in Section 2. A **TAV** IDL SAVE file is available on the LASP SORCE website which contains all the information in the ASCII file. The IDL SAVE file is described in Section 3.

Further details on the SORCE-SIM V27 can be found by locating the release notes on the LASP website at http://lasp.colorado.edu/home/sorce/data/. Further details, release notes and **STICR** data can be found at is https://doi.org/10.25810/n6y0-tf68.[2] TSIS-1 data and release notes can be obtained from http://lasp.colorado.edu/home/tsis/data/.

A NetCDF version of the **TAV** V01.1 data product is available from the SORCE website and from the LASP LISIRD website (http://lasp.colorado.edu/lisird/sorce/).

The impact of the **TAV** irradiance re-calibration is shown in Figures 1 and 2 through a comparison of the total Solar irradiance (TSI), as measured by SORCE-TIM (data release V19) versus the integrated Solar Spectral Irradiance (iSSI) of SORCE-SIM V27 and **TAV** V01 from 240–2402 nm. A publication

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

[2] **STICR** data and notes are housed at CU Scholar – a collaborative service of the University of Colorado Libraries.

outlining some of the scientific impacts of the **TAV** recalibration are being prepared for an upcoming publication (*Earth and Space Science, 2021, in prep.*) As this publication matures, details relevant to the use of this data set will be introduced in updates to this document.
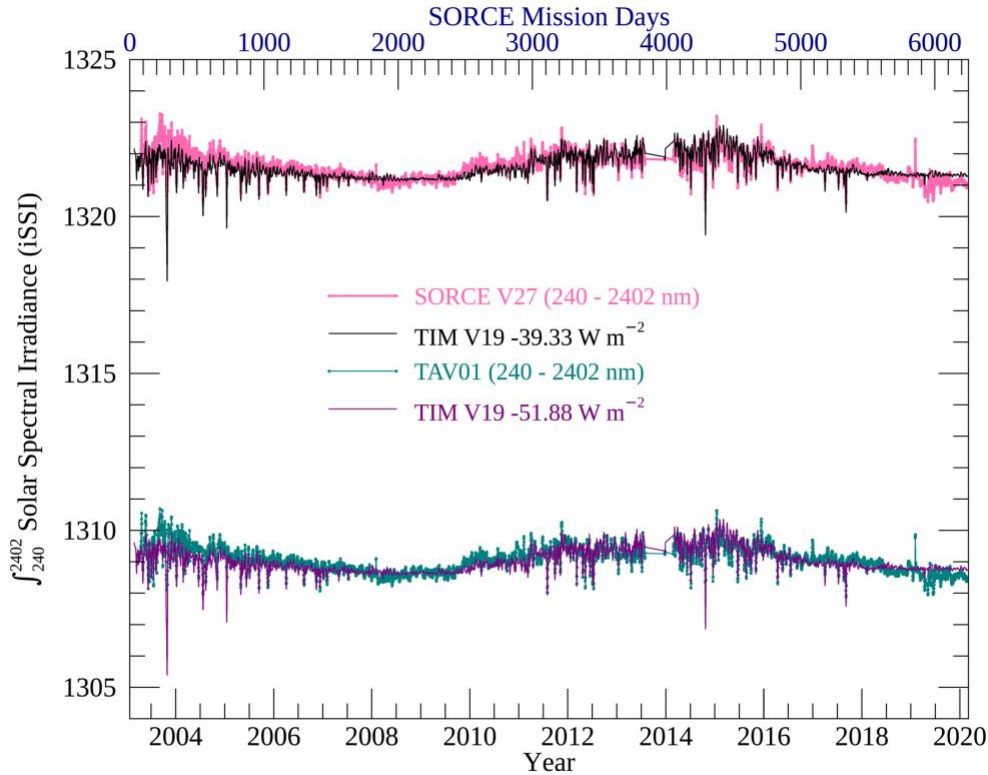

Figure 1: Before apply the **TAV** adjustment, the integrated Solar Spectral Irradiance (iSSI) of SORCE-SIM V27 (from 240–2402 nm) showed an offset of -39.33 W m^2 versus SORCE-TIM V19. After the **TAV** recalibration, this difference is -51.88 W m^2, a difference of -12.55 W m^2. Calendar year is given on the bottom axis, SORCE Mission Day (SD) is given on the top axis.
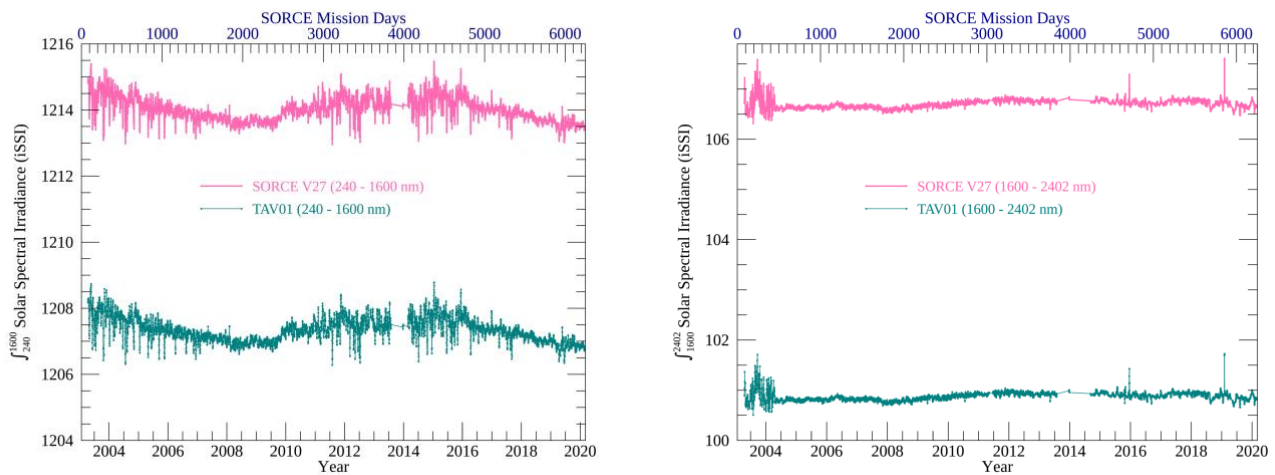

Figure 2: The TIM-TSI and **TAV**-iSSI difference of -12.55 W m^2 is approximately split between the SORCE-SIM diodes (240–1600 nm; left panel, -6.70 W m^2) and ESR (1600–2402 nm; right panel, -5.85 W m^2). The SORCE-SIM V27 iSSI is shown in magenta, while **TAV** V01is shown in green.

The SORCE-SIM spacecraft was turned off on Feb 25, 2020, this was the 6241st 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 overlap region between TSIS-1 and SORCE for this project is 804 days, but starting at TD100 leaves 704 days (03/24/2018-02/25/2020 = SD5538-6241 = TD100-803).

The **TAV** re-calibration uses the **S**ORCE-SIM to **T**SIS-SIM **I**rradiance **C**alibration **R**atio (**STICR**), which uses data over the entire SORCE-TSIS overlap time period. Please see the STICR release notes (https://doi.org/10.25810/n6y0-tf68) for further details on how this ratio was constructed.

Data Sources:
SORCE-SIM V27 and TSIS-SIM V05 data were downloaded (in IDL SAVE file format) from the LASP websites on 01/09/2021 from the following websites/files for creating the **TAV** V01 and **STICR** V01 data products.
SORCE-SIM V27: http://lasp.colorado.edu/data/sorce/ssi_data/sim/sav/sorce_sim_latest.sav.zip
TSIS-SIM 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, with one minor exception. 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 A**djusted **V**alues (**TAV**) for the 240.02–2401.40 nm bandpass. This is the SORCE-SIM L3 wavelength scale, with the longest wavelength, 2412.34 nm, omitted due to the lack of TSIS-1 data at this wavelength.

The **TSIS-1 A**djusted **V**alues (**TAV**) SORCE-SIM ASCII irradiance record is in the same format as the standard SORCE-SIM data record, with the exception that the **IRRADIANCE** and **IRRADIANCE_UNCERTIANTY** columns have been modified as described in this section.

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 **TAV IRRADIANCE** ($TAV_{irradiance}$) data column is the SORCE-SIM V27 **IRRADIANCE** column multiplied by the **TAV_RATIO** column of the **STICR** data product. This calibration forces the mean $TAV_{irradiance}$ during the temporal overlap region (03/24/2018-02/25/2020) to be that measured by TSIS-SIM. No attempt is made to correct for residual degradation trends in either SORCE-SIM or TSIS-SIM data.

The **TAV IRRADIANCE_UNCERTAINTY** (σ_{TAV}) uses standard error propagations appropriate for the multiplication of the SORCE-SIM V27 **IRRADIANCE** ($SORCE_{irradiance}$) by the **TAV_RATIO.** The uncertainties reported, and used, the **IRRADIANCE_UNCERTAINTY** column from SORCE-SIM V27 (σ_{SORCE}) and **TAVR_UNC** for **TAV_RATIO** from **STICR** V01.1, are 1σ values. Specifically, the σ_{TAV} is given by:

$$\sigma_{TAV}(\lambda) = TAV_{irradiance}(\lambda)\sqrt{\left(\frac{TAVR\_UNC(\lambda)}{TAV\_RATIO(\lambda)}\right)^2 + \left(\frac{\sigma_{SORCE}(\lambda)}{SORCE_{irradiance}(\lambda)}\right)^2}$$

The details of the TSIS-SIM irradiance calibration are contained in an independent data product referred to as the SORCE-to-TSIS Irradiance Calibration Ratio (**STICR**). The **STICR** (V01.1) data product (https://doi.org/10.25810/n6y0-tf68) contains the calibration ratio, and all ancillary data needed to understand the calibration ratio.

The **TAV** ASCII file, **sorce_sim_L3_tav_c24h_0240nm_2402nm_20030414_20200225.txt**, contains 9 columns with the FORTRAN/IDL format of '(2f10.1,2f8.2,2i3,e13.6,e11.4,f8.1)'. The columns names, data types, Format Codes, Units, and Descriptions are given in Table 1.

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

Column Number	Column Name	Data Type	Format Code	Units	Description
1	nominal_date_yyyymmdd	R8	F10.1	YYYYMMDD.DDD	Nominal Data Time
2	nominal_date_jdn	R8	F10.1	JD	Nominal Data Time, Julian Day Number
3	min_wavelength	R4	F8.2	nm	Standard wavelength of the measurement
4	max_wavelength	R4	F8.2	nm	Standard wavelength of the measurement
5	instrument_mode_id	I2	I3	integer	Instrument Mode 43(UV), 41(VIS), 44(IR), 31(ESR)
6	data_version	I2	I3	integer	Data Release version (1 for this release)
7	irradiance	R8	E13.6	W/m^2/nm	Solar Spectral Irradiance
8	irradiance _uncertainty	R4	E11.4	W/m^2/nm	Irradiance Uncertainty,1 sigma
9	quality	R4	F8.1	bitwise DQF	Data Quality Flags (DQF), Described in Table 2 of the SORCE-SIM V27 Release Notes*

* See the SORCE-SIM V27 release notes for a full description of the DQFs
(https://lasp.colorado.edu/home/sorce/instruments/sim/sorce-sim-data-products-release-notes/

The IDL SAVE file (**sorce_sim_L3_tav_c24h_0240nm_2402nm_20030414_20200225.sav**) contains a string array and an IDL data structure. The string array, **DOC_TAV**, is similar to the ASCII file text.

```
IDL> restore,'sorce_sim_L3_tav_c24h_0240nm_2402nm_20030414_20200225.sav',/verbose
% RESTORE: Description: SORCE-SIM TSIS1-SIM Adjusted Values (TAV). Uses SORCE-SIM V27 and
           TSIS1-SIM V05 data releases. TAV V01.1 DOI = https://doi.org/10.5067/85A69JPBFAJC, release
           notes at http://lasp.colorado.edu/home/sorce/data . Contact: Steven.Penton@colorado.edu.
% RESTORE: Restored variable: DOC_TAV.
% RESTORE: Restored variable: TAV.
```

The data structure contains all 9 columns described in the ASCII file section, plus additional information that is not easily represented in the ASCII file. The **DOC_TAV** string array contains the majority of text from the header of the ASCII file.

```
IDL> help,DOC_TAV   DOC_TAV     STRING   = Array[66]
IDL> for i=0,n_elements(DOC_TAV)-1 do print,DOC_TAV[i]
```

Background on the SORCE-SIM TSIS-1 Adjusted Values (TAV) Irradiances (SOR3SIMD_TAV)

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, known as the TSIS1 Adjusted Values (TAV). This is TAV version 01 (V01), using the SORCE-SIM V27 and TSIS-SIM V05 data releases.

The SORCE-SIM Solar Spectral Irradiance (SSI) data products are provided on a fixed wavelength scale which varies in spectral resolution from 1-34 nm over the entire 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 TAV data is on the SORCE-SIM wavelength scale, with the exception that the longest TAV wavelength is 2401.4 nm.

The SORCE-SIM to TSIS-SIM Irradiance Calibration Ratio (STICR) is used to re-calibrate the SORCE-SIM irradiance measurements into the TSIS Adjusted Values (TAV) data product. The STICR V01 data product, release notes and further details can be found at : https://doi.org/10.25810/n6y0-tf68 .

The TAV spectral irradiances are tabulated in data structures with each entry giving the nominal date, the measurement wavelength (repeated in both min_wavelength and max_wavelength), the SORCE-SIM instrument MODE, the TAV data VERSION, the spectral IRRADIANCE, its 1-sigma IRRADIANCE_UNCERTAINTY, and the DATA_QUALITY flag. Each field (column) is defined and described in the "DATA DEFINITIONS".

TAV V01.1 differs from V01 in that the irradiancies used, and those reported in the TAV data products, have been changed from the E11.4 to E13.6 format to prevent rounding errors. The new format ensures that rounding errors for both V27 SIM and V01.1 of TAV are less than 0.5 parts per million (PPM).

Identically to SORCE-SIM V27 data, TAV MISSING data have values of 0.0000e+00 for both IRRADIANCE and IRRADIANCE UNCERTAINTY. UV data before mission day 800 (yyyymmdd = 20050403) in the 306-310 nm bandpass are treated as MISSING due to potential saturation. TAV data QUALITY reported in this file are also identical to those in the SORCE-SIM V27 data product.

TAV IRRADIANCE_UNCERTAINTY is a combination of the SORCE-SIM V27 reported uncertainties and the SORCE-SIM to TSIS-SIM Irradiance Calibration Ratio (STICR) reported uncertainties. Uncertainties are combined as $(TAV\_UNC/TAV)^2 = (SIM\_UNC/SIM)^2 + (STICR\_UNC/STICR)^2$.

See the SORCE-SIM V27, STICR, and TAV release notes for justification and further details. SORCE-SIM V27 and TAV V01.1 release notes can be found at : https://lasp.colorado.edu/home/sorce/instruments/sim/sorce-sim-data-products-release-notes

SORCE-SIM V27, TAV V01.1, and other SORCE data can be found at http://lasp.colorado.edu/home/sorce/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 Level 3b Solar Spectral Irradiance: TSIS-1 Adjusted Values (TAV), Greenbelt, MD, USA, Goddard Earth Sciences Data and Information Services Center (GES DISC), https://doi.org/10.5067/85A69JPBFAJC

For more information on the SORCE or TSIS-1 instruments and data products, see: http://lasp.colorado.edu/home/sorce/ or http://lasp.colorado.edu/home/tsis/ .

DATA DEFINITIONS, number = 9 (name, type, format)
nominal_date_yyyymmdd, R8, f10.1
nominal_date_jdn, R8, f10.1
min_wavelength, R4, f8.2 (nm)
max_wavelength, R4, f8.2 (nm)
instrument_mode_id, I2, i3 (mode)
data_version, I2, i3 (version)
irradiance, R8, e13.6 (W/m^2/nm)
irradiance_uncertainty, R4, e11.4 (W/m^2/nm)
quality, R4, f8.1 (see release notes for description)
END DATA DEFINITIONS

The format of the **TAV** data structure is identical to the SORCE-SIM V27 data structure and is a single 7137435 element structure :

```
IDL> help,TAV
        TAV         STRUCT    = -> <Anonymous> Array[7137435]

IDL> help,TAV,/str
        ** Structure <200f7c8>, 9 tags, length=48, data length=44, refs=1:
        NOMINAL_DATE_YYYYMMDD        DOUBLE      20030414.
        NOMINAL_DATE_JDN             DOUBLE      2452744.0
        MIN_WAVELENGTH               FLOAT       240.020
        MAX_WAVELENGTH               FLOAT       240.020
        INSTRUMENT_MODE_ID    INT      43
        DATA_VERSION          INT      27
        IRRADIANCE                   DOUBLE      0.042578066
        IRRADIANCE_UNCERTAINTY       FLOAT    0.000411357
        QUALITY               FLOAT      64.0000
```

4) REVISION HISTORY:

1.0: 01/20/2021 – Steven Penton, James Mothersbaugh, Stéphane Béland, and Jerald Harder - *Initial Release*
1.1: 04/01/2021 – Steven Penton –*Changed irradiance format from E11.4 to E13.6 to prevent rounding errors, and noted float to double-precision change for 'irradiance' in .sav file. Noted that similar change was made to the STICR. Added acknowledgment segment.*

5) ACKNOWLEDGMENTS: