

## **SORCE-SIM TAV Version 02 Release Notes (2.0, 06/15/21)**

This data product uses the temporal overlap of the Solar Radiation and Climate Experiment (SORCE) and Total and Spectral Solar Irradiance Sensor (TSIS1) Spectral Irradiance Monitor (SIM) instruments to create an alternate SORCE-SIM irradiance calibration, known as the **TSIS1 Adjusted Values (TAV)**. This is **TAV** version 2.0 (V02.0), using the SORCE-SIM V27 and TSIS-SIM V06 data releases.

This re-calibration is based solely upon the temporal overlap of TSIS1 and SORCE-SIM, without any additional corrections for instrument degradations. As such, the irradiance values at the end of the SORCE-SIM mission are guaranteed to agree with TSIS1-SIM, 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 V02 of the **SORCE-SIM to TSIS-SIM Irradiance Calibration Ratio (STICR)**, which is contained in a separate data product. The DOI for V02 of the **STICR** is <https://doi.org/10.25810/22v9-9s08>.

**TAV** V02.0 differs from V01.1 in that V06 of TSIS1-SIM is now used in creating the V02.0 of **STICR**. The DOI for V02 of the **TAV** data product is <https://doi.org/10.5067/8E8EG9HHVDZS>.

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/](https://disc.gsfc.nasa.gov/datasets/SOR3SIMD_TAV/summary/)).

The **TAV** V02 data product is also available as an IDL<sup>1</sup> 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](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** V02.0 data can be found at <https://doi.org/10.25810/22v9-9s08>.<sup>2</sup> TSIS1-SIM data and release notes can be obtained from <http://lasp.colorado.edu/home/tsis/data/>.

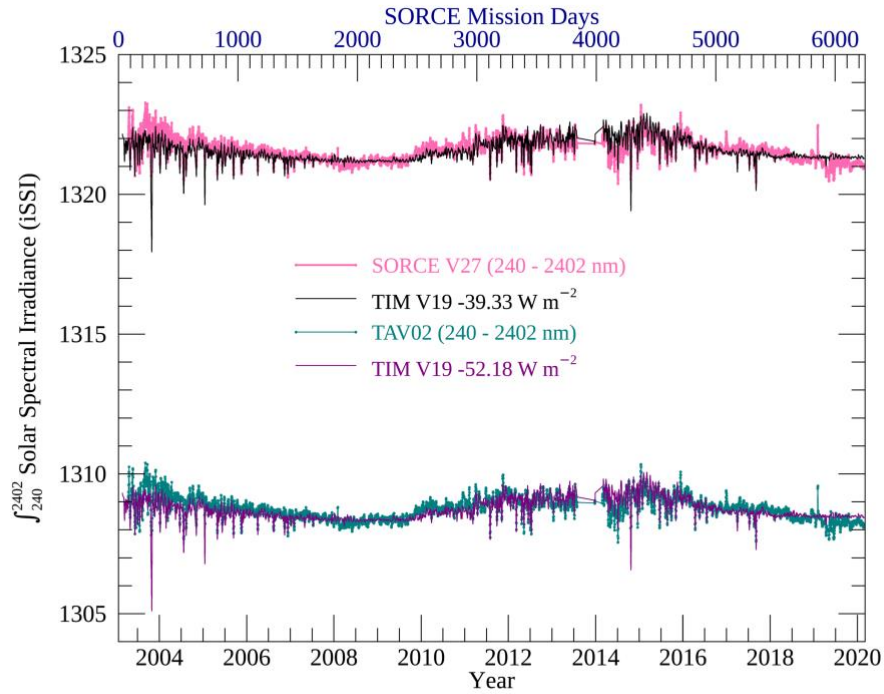
A NetCDF version of the **TAV** V02.0 data product is available from the SORCE website and from the LASP LISIRD website (<http://lasp.colorado.edu/lisird/sorce/>).

The impact of the **TAV** V02.0 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** V02.0 from 240–2402 nm. A publication 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.

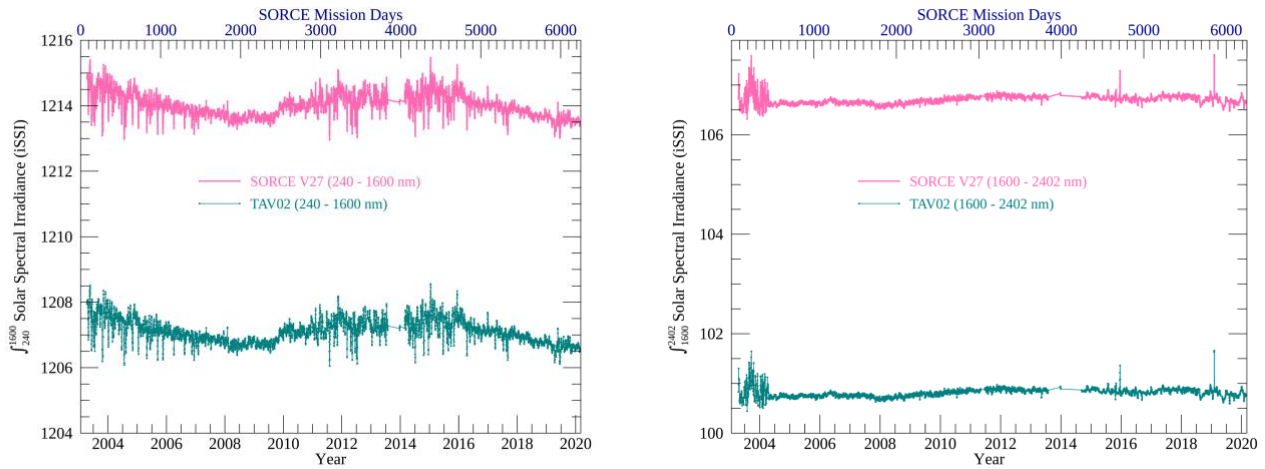
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<sup>1</sup> **Interactive Data Language**: <https://www.13harrisgeospatial.com/Software-Technology/IDL>

<sup>2</sup> **STICR** data and notes are housed at CU Scholar – a collaborative service of the University of Colorado Libraries.



**Figure 1:** Before applying the TAV adjustment, the integrated Solar Spectral Irradiance (iSSI) of SORCE-SIM V27 (from 240–2402 nm) showed an offset of  $-39.333 \text{ W m}^{-2}$  versus SORCE-TIM V19 (SIM does not capture the full Solar spectrum). After the TAV V01 recalibration, this difference (SORCE-TIM V19 –TAV V01) was  $-51.88 \text{ W m}^{-2}$ . For TAV V02, this difference is only marginally different at  $-52.176 \text{ W m}^{-2}$ , a difference from SORCE-SIM V27 of  $-12.843 \text{ W m}^{-2}$  (the TSIS V05 vs V06 iSSI shows a difference of  $\sim 0.3 \text{ W m}^{-2}$ ). Bottom axis gives calendar year, while the top axis gives SORCE Mission Day (SD).



**Figure 2:** The SORCE-SIM V27 and TAV V02 iSSI difference of  $-12.843 \text{ W m}^{-2}$  is approximately split between the SORCE-SIM diodes (240–1600 nm; left panel,  $-6.926 \text{ W m}^{-2}$ ) and the ESR (1600–2402 nm; right panel,  $-5.917 \text{ W m}^{-2}$ ). The SORCE-SIM V27 iSSI is shown in magenta, while TAV V02 is shown in green. The early mission ESR noise at SD < 453 (04/21/2004) was due to an instability in the ESR wavelength drive.

## 1) OVERVIEW:

The **SORCE-SIM** spacecraft was turned off on Feb 25, 2020, this was the 6241<sup>st</sup> **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 **SORCE-SIM** to **TSIS-SIM** Irradiance Calibration Ratio (**STICR**), which uses data over the entire **SORCE-TSIS** overlap time period. Please see the **STICR** V2.0 release notes (<https://doi.org/10.25810/22v9-9s08>) for further details on how this ratio was constructed.

### Data Sources:

**SORCE-SIM** V27 and **TSIS-SIM** V06 data were downloaded (in IDL SAVE file format) from the **LASP** websites on 06/01/2021 from the following websites/files for creating the **TAV** V02.0 and **STICR** V02.0 data products.

**SORCE-SIM** V27: [http://lasp.colorado.edu/data/sorce/ssi\\_data/sim/sav/sorce\\_sim\\_latest.sav.zip](http://lasp.colorado.edu/data/sorce/ssi_data/sim/sav/sorce_sim_latest.sav.zip)

**TSIS-SIM** V06: [http://lasp.colorado.edu/data/tsis/ssi\\_data/tsis\\_ssi\\_L3\\_c24h\\_latest.sav](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-SIM** Adjusted Values (**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.

## 2) TAV ASCII FILE:

The **TSIS-1** Adjusted Values (**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** ( $\sigma_{TAV}$ ) 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 ( $\sigma_{SORCE}$ ) and **TAVR\_UNC** for **TAV\_RATIO** from **STICR** V02.0, are  $1\sigma$  values. Specifically, the  $\sigma_{TAV}$  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** (V02.0) data product (<https://doi.org/10.25810/22v9-9s08>) contains the calibration ratio, and all ancillary data needed to understand the calibration ratio.

The TAV ASCII file, `source_sim_L3_tav_c24h_0240nm_2402nm_20030414_20200225.txt`, contains 9 columns with the FORTRAN/IDL format of '(2f10.1,2f8.2,2i3.2,e13.6,e11.4,f8.1)'. The column names, data types, Format Codes, Units, and Descriptions are given in Table 1. This is the exact format of the SORCE-SIM ASCII V27 data release.

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

Column Number	Column Name	Data Type	Format Code	Units	Description
1	<code>nominal_date_yyyymmdd</code>	R8	F10.1	YYYYMMDD.DDD	Nominal Data Time
2	<code>nominal_date_jdn</code>	R8	F10.1	JD	Nominal Data Time, Julian Day Number
3	<code>min_wavelength</code>	R4	F8.2	nm	Standard wavelength of the measurement
4	<code>max_wavelength</code>	R4	F8.2	nm	Standard wavelength of the measurement
5	<code>instrument_mode_id</code>	I2	I3	integer	Instrument Mode 43(UV), 41(VIS), 44(IR), or 31(ESR)
6	<code>data_version</code>	I2	I3	integer	SORCE-SIM Data Release version (27 for this release)
7	<code>irradiance</code>	R8	E13.6	W/m <sup>2</sup> /nm	Solar Spectral Irradiance
8	<code>irradiance_uncertainty</code>	R4	E11.4	W/m <sup>2</sup> /nm	Irradiance Uncertainty, 1 sigma
9	<code>quality</code>	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/>)

### 3) TAV IDL SAVE FILE:

The IDL SAVE file (**source\_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,'source_sim_L3_tav_c24h_0240nm_2402nm_20030414_20200225.sav',/verbose
% RESTORE: Description: SORCE-SIM TSIS1-SIM Adjusted Values (TAV) Version V02.0. Uses SORCE-SIM V27 and TSIS1-SIM V06 data releases. TAV
V02.0 DOI = https://doi.org/10.5067/8E8EG9HHVDZS, release notes at http://lasp.colorado.edu/home/sorce/data . Contact:
Steven.Penton@lasp.colorado.edu.
```

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[67]
```

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

#### Background on the SORCE-SIM TSIS1-SIM Adjusted Values (TAV) Irradiances (SOR3SIMD\_TAV) : V02.0

*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, known as the TSIS1 Adjusted Values (TAV). This is TAV version 02 (V02), using the SORCE-SIM V27 and TSIS1-SIM V06 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 V02.0 data product, release notes, and further details can be found at: <https://doi.org/10.25810/22v9-9s08> .*

*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 V02.0 differs from V01.1 in that the TSIS1-SIM data release V06 is used (instead of V05). As with TAV V01.1, irradiancies used, and those reported in the TAV data products, are double-precision (E13.6 format) to prevent rounding errors. The new format ensures that TAV irradiance rounding errors 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 V02.0 release notes can be found at : <https://lasp.colorado.edu/home/sorce/instruments/sim/sorce-sim-data-products-release-notes>*

*SORCE-SIM V27, TAV V02.0, 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](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: TSIS1-SIM Adjusted Values (TAV), Greenbelt, MD, USA, Goddard Earth Sciences Data and Information Services Center (GES DISC), <https://doi.org/10.5067/8E8EG9HHVDZS>*

*For more information on the SORCE or TSIS1 SIM 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_yyyyymmdd, 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) *COMPARISON OF TAV V02.0 AND V01.1:*

The difference between **TAV V02.0** and **V01.1** is best examined by comparing the **STICR** ratios used to create the data products.

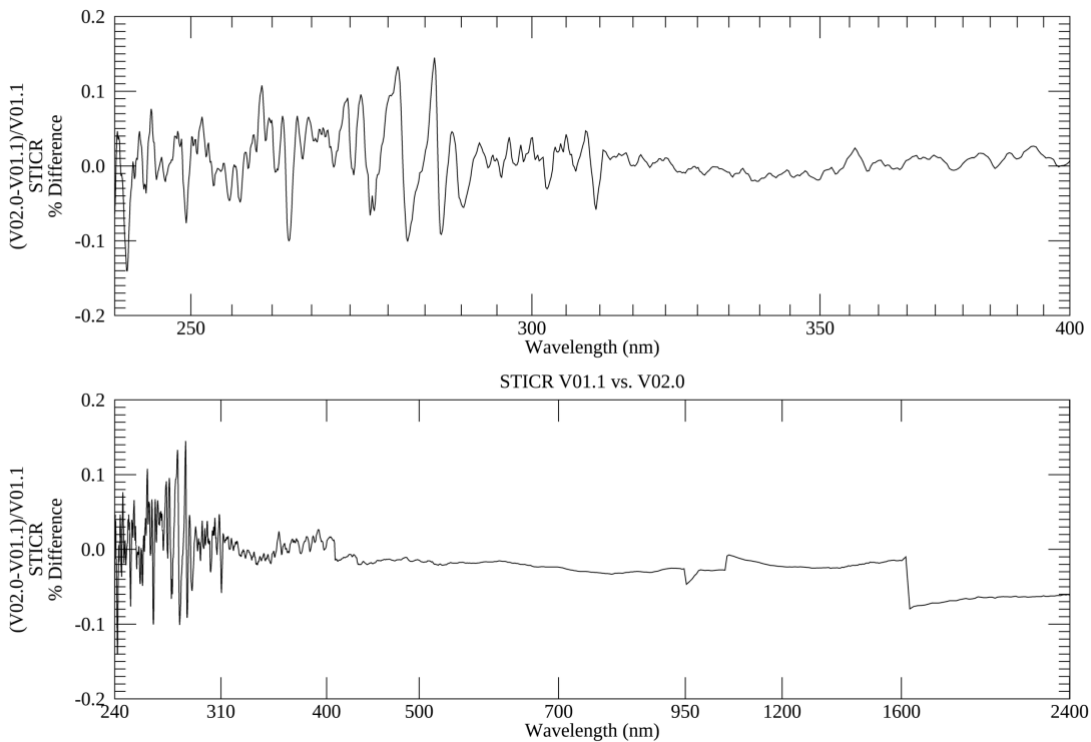


Figure 3: **STICR** V02.0 compared to V01.1. The only change to the **SORCE** data between these versions was the switch to double-precision, while **TSIS1-SIM** data changed from V05 to V06. Differences between **STICR** V02.0 and V01.1 are due to calibration improvements in **TSIS1-SIM** V06. These include a new diode wavelength alignment algorithm and new diode temperature response corrections.

## 5) REVISION HISTORY:

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

1.1: 04/01/2021 – S. 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.*

2.0: 06/02/2021 – S. Penton – *TAV V02.0 uses TSIS1-SIM data release V06 and STICR V02.0*

## 6) ACKNOWLEDGMENTS:

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