From Aleph to TAV: SORCE/SIM Recalibration Using TSIS

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The Spectral Irradiance Monitor (SIM) onboard the Solar Radiation and Climate Experiment (SORCE) mission has been taking daily Solar Spectral Irradiance (SSI) measurements from a ~900-minute revolution since April 2003. We present a comparison of SORCE/SIM Solar Spectral Irradiance (SSI) measurements to near-simultaneous Total and Spectral Solar Irradiance Sensor (TSIS) observations. TSIS has been taking data from the International Space Station (ISS) since March 14, 2018.

SORCE/SIM’s SSI measurements (240–2400 nm) have a spectral resolution from 0.25 nm (UV) to 33 nm (IR), TSIS uses three photoDIODEs, and an Electrical Substitution Radiometer (ESR) detector. The DIODEs are referred to as the UV (240–310 nm), VIS (310–950 nm), and IR (950–1600 nm) DIODEs.

We selected six distinct 28-day periods of SORCE/SIM/TSIS/V01 overlap (Mar, Jun, Oct, and Nov 2018, and Feb and May 2019). During these periods (all ~Solar minimum), SORCE and TSIS produced near-continuous SSI measurements during times of low Solar variability. These periods were selected to be 28 days each to cover a full Carrington rotation (~27.3 days).

We repeat a similar process, but with the TSIS data release (Harder et al., 2009). This process was given the name “ALEPH” comparison to the best available solar spectrum at the time (due to well-known sensitivity to temperature fluctuations).

Post-processing of publicly available data included:
1) A daily zero-point wavelength alignment of each SORCE/SIM diode bandwidth;
2) A spectral convolution to account for the spectral resolution difference of SORCE to TSIS/SIM.

SORCE/SIM’s absolute irradiance scale was defined by a comparison to the best available solar spectrum at the time (Harder et al., 2009). This process was given the name “ALEPH” correction, as aleph is the first letter in the Hebrew alphabet.

Here, we repeat a similar process, but with the TSIS data release V01. As “TAV” is the last letter in the Hebrew alphabet, we designate our correction as the TAV Adjusted Values (TAV) correction. The TAV correction allows a re-calibration of the entire SORCE/SIM mission, resulting in improved constraints on Solar models. For example, here we examine its impact on the Solar brightness temperature (Tb), i.e. solving the Planck equation for brightness temperature and temperature based on our corrected SSI measurements.

**SORCE/SIM vs. TSIS/SIM**
- Both utilize Föy prism spectrometers with similar DIODEs, ESRs, and prisms, which cover 240–2400 nm.
- DIODEs are sensitive to space environment, e.g. temperature.
- Prisms degrade with Solar exposure, and dispersion is temperature-dependent.
- The TSIS/SIM had a full ground calibration, while SORCE/SIM did not.
- At the time of our first test window, TSIS/SIM had been active for ~3 months, while SORCE/SIM had been active for ~15 years.

**Time Range Comparison**
R3 and R4 (above) were the most proximate ranges selected. Despite their temporal proximity, drastically different irradiance characteristics were seen at the same wavelength (see SSI Ratio Trends).

**SORCE Wavelength Alignment**
During SORCE/SIM observations, prisms non-repeatability and temperature variations can result in wavelength shifts of the recorded spectra. The pipeline attempts to correct these offsets; however, we perform an additional diode/ESR-dependent zero-point correction by performing a 2-step cross-correlation of each spectrum. Maximum shifts (and 1σ offsets) given below.

**Comparison of the six spectral ratios (Ri) calculated the following:**
- Subsequent periods exhibit increasingly divergent TSIS and SORCE ratios for the UV and VIS diodes.
- TSIS/SIM UV and VIS diodes display a trend of decreasing irradiance over our test period, respectively: ~0.5% and ~0.2%.
- We believe the above trends may be partially attributed to instrument degradation in both TSIS and SORCE.
- The ESR (IR) data release has not yet been published.
- We are currently unable to account for the degradation of TSIS/ESR.
- We thus chose R1 as our baseline ratio for final analysis.

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**Conclusions**
- We have developed a procedure to recalibrate the absolute irradiance scale of SORCE/SIM using month-long time regions of TSIS/SIM observations.
- This recalibration changes the absolute irradiance in all channels by up to 5%.
- When viewed in terms of Tb, the recalibration agrees much closer to SOLSPEC than the current calibration, but still shows significant differences.
- Our “TAV” recalibration has been shown to give the same results in both the 2008 and 2018 Solar minima, suggesting that the TAV correction can be used through the SORCE/SIM mission.

**Future work and next steps**
- Re-evaluate TSIS+SORCESSI ratio using TSIS V2.
- The uncorrected trends in TSIS/SIM V01, of up to 0.5% per year, prevent us from evaluating the stability of SAV over time.
- Use TSIS V01 derived TAV to flux calibrate the UV/VIS gap (300–310 nm), as part of SORCE/SIM data release V26.
- Use TSIS V02 derived TAV to flux calibrate all SORCE/SIM data by translating TAV to SORCE mission day 453 (April 21, 2004), as required by the SORCE/SIM pipeline, for the SORCE/SIM V27 data release.