Exploring New Instrument deGradation Models and Analysis ENIGMA

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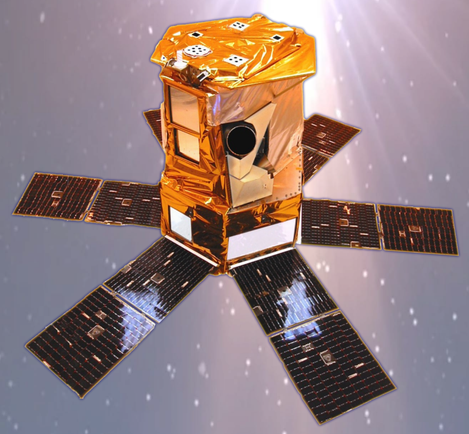
ABSTRACT

The Solar Radiation and Climate Experiment measured Total Solar Irradiance (TSI) and Solar Spectral Irradiance (SSI) from 2003 to 2020. The Solar Irradiance Monitor (SIM) instrument measured daily SSI from 200nm to 2400 nm. The current SORCE-SIM instrument degradation correction uses a measurement equation derived from accessible telemetry, the known instrument refraction geometry, inter-detector comparisons, and inter-spectrometer comparisons. While the current degradation model captures much of the long-term trending, some of the parameters were adjusted without well-defined physical interpretations.

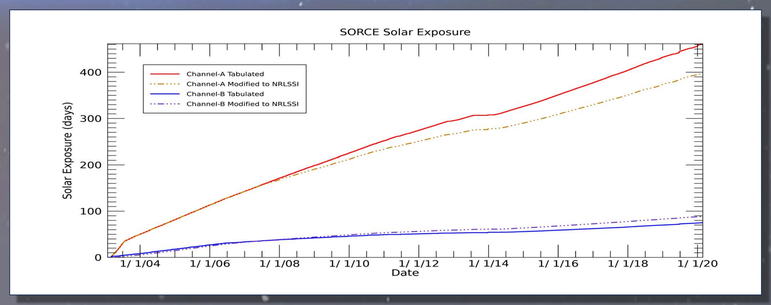
We're reporting on work to Explore New Instrument degradation Models and Algorithms (ENIGMA) to address issues with the current model and with the derived corrected irradiances. The development of an enhanced SORCE-SIM measurement equation will permit the evaluation, and potential inclusion, of degradation mechanisms not captured in the present model.

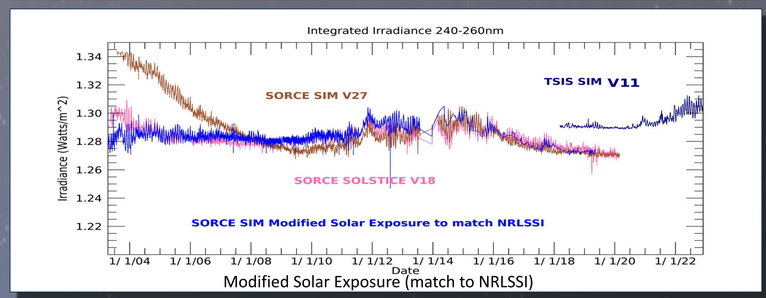
We present an initial updated degradation model which improves our ability to construct a composite irradiance time series in combination with TSIS-SIM, whose measurements overlap with SORCE for 2 years and has well-defined uncertainties. Combining the two datasets, will allow the construction of a consistent composite irradiance time series from 2003-2023.



Possible sources of degradation currently not accounted for in the SIM measurement equation:

- ***Time Varying Kappa***
- ***Mis-identified solar exposure times***
- ***Efficiency of the Hard Radiation Trap (blocking filter)***
- ***Reduction in the Amount of Outgassing Material with time***
- ***Wavelength independent time-varying degradation function***
- ***Replacing Empirical Irradiance Jump Corrections with shift in optical system***





With the initial ***Time-varying Kappa***, we can calculate the amount of solar exposure required for each channel to match the NRLSSI2 proxy model data. In this way, we are forcing the corrected irradiances from Channel A and B to match NRLSSI2.

Current prism degradation model as a function of time (t), wavelength (w) for Channels A and B:

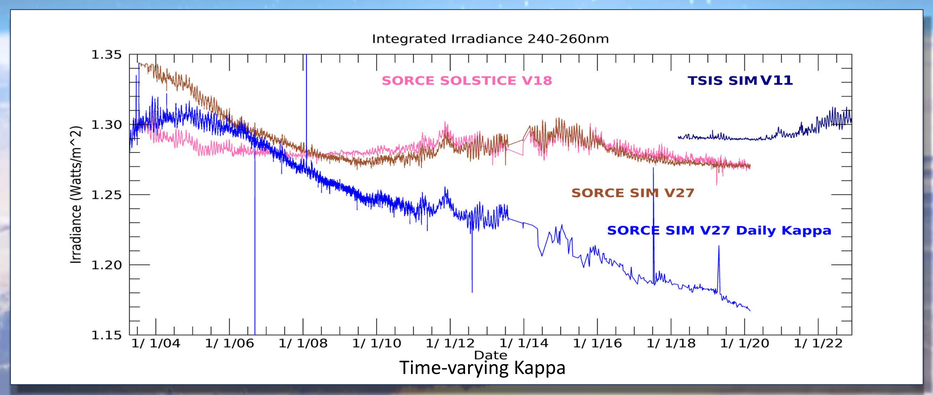
Corrected_Irrad(t,w) = Uncorr_Irrad(t,w) / PrismDeg(t,w)

PrismDeg = (1d – afact(w))*exp(-κ(t,w)*SolarExp(t)) + afact*exp(-κ(t,w)*SolarExp(t))/2d)

At time t_i for Channel A and Channel B:

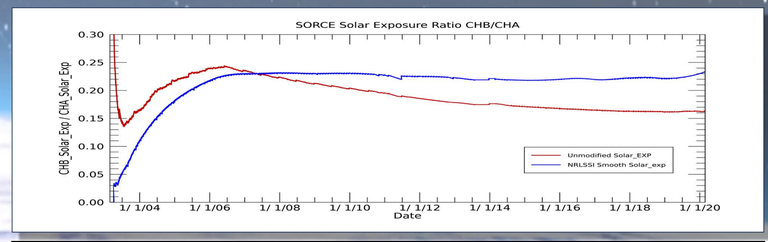
Corrected_A(t_i,w_j) = Corrected_B(t_i,w_j)

With known afact(w_j), SolarExp_A(t_i), SolarExp_B(t), Uncorr_A and Uncorr_B the corresponding common κ(t_i,w_j) is evaluated.

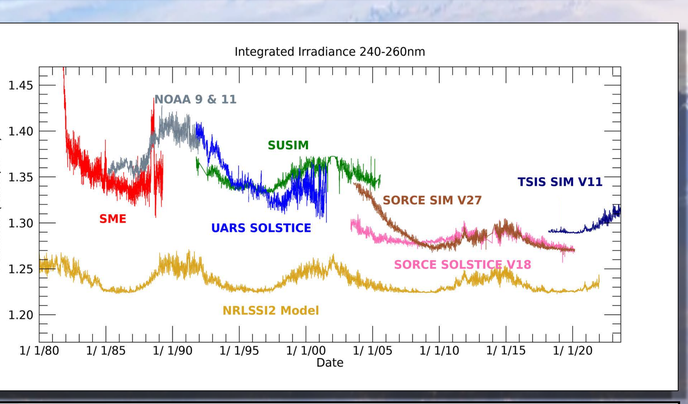


A new common ***Kappa*** can be calculated every time measurements from Channels A and B are taken at the same time, with the know solar exposure record, resulting in a ***Time-varying Kappa***.

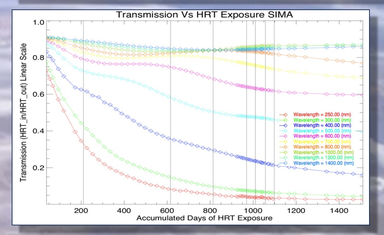
- We are consistently under-correcting for degradation
- Perfect (forced) agreement between CHA and CHB

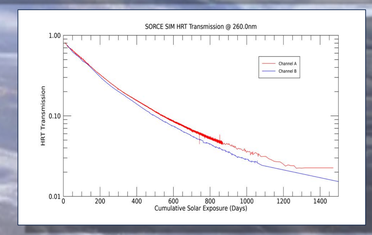


The Solar Exposure record, and specifically the ratio of exposure of Channel-B and Channel-A, is critical in determining the rate of degradation. It turns out a slight modification provides significant changes to our estimate of the degradation rate while increasing the actual exposures and keeping the ratio constant results in the same corrected irradiances.



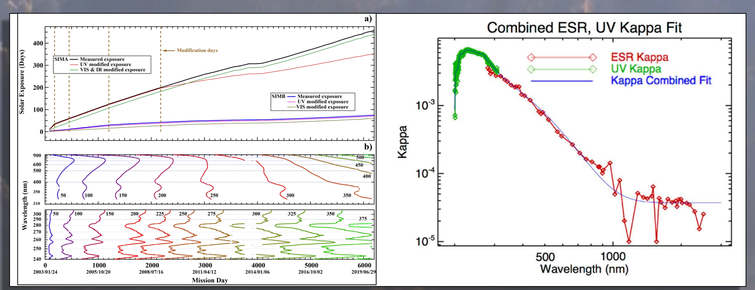
The integrated spectral irradiance for seven independent instruments with as-published absolute calibration and degradation corrections. SME version 1, NOAA 9 & 11 version 8, SUSIM version 22, UARS-SOLSTICE version 18, SORCE SOLSTICE version 18, SORCE-SIM version 27, TSIS-SIM version 6. This illustrates the challenges associated with constructing a long-term record of SSI variability.



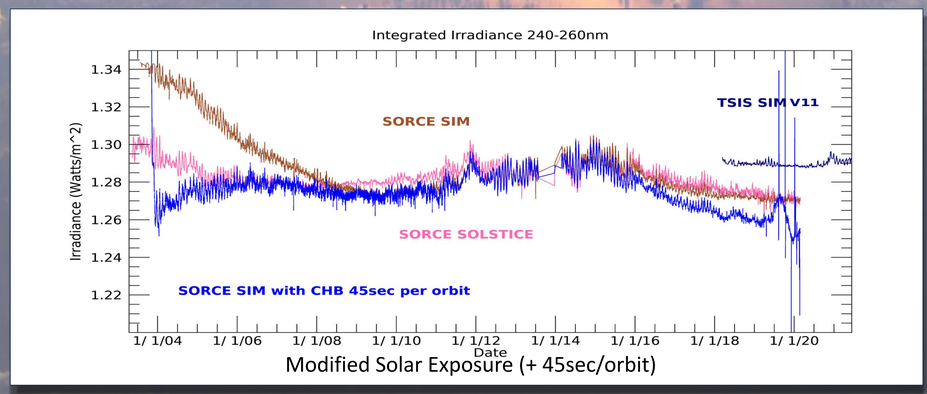


The Hard Radiation Trap (HRT) for Channel-A and Channel-B were used extensively during the first part of the mission to block the potentially harmful solar radiation from reaching the surface of the prisms. Because consecutive scans were obtained with and without the HRT, we have a direct measurement of the HRT degradation at all wavelengths.

We see a clear étalon effect at certain wavelengths that will need to be folded in our degradation model. Also, the rate of degradation as a function of exposure time is different for each channel, contrary to our initial assumption.



*Original degradation model uses a single degradation factor (**Kappa**) as a function of wavelength for the whole mission with a modified solar exposure record, different for each detector. A **time-varying function** is evaluated based on comparison of changes in irradiances in CHA and CHB as a **function of wavelength**.*



There might be some un-accounted for solar exposure. As a test, we arbitrarily added 45 seconds of solar exposure on Channel B for each orbit and recalculated a Time-varying Kappa. The new corrected Irradiances align much better with SOLSTICE.

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