The reference solar spectrum of the Solar Irradiance Climate Data Record

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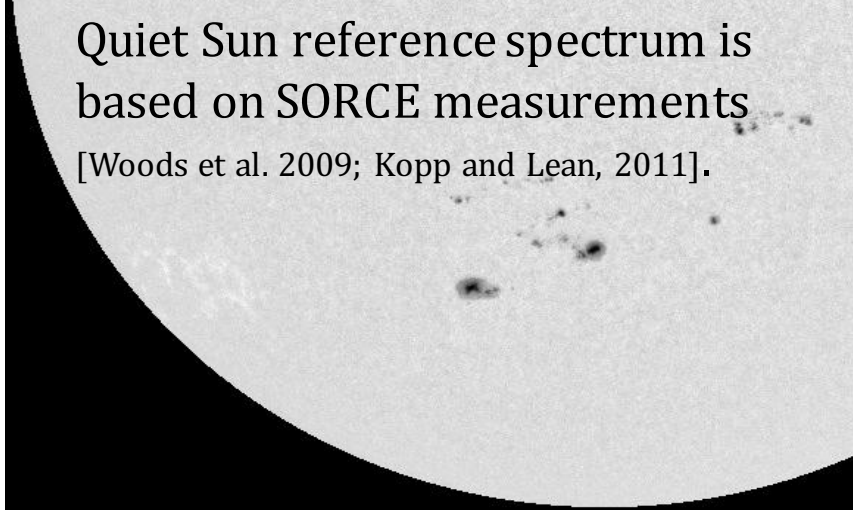
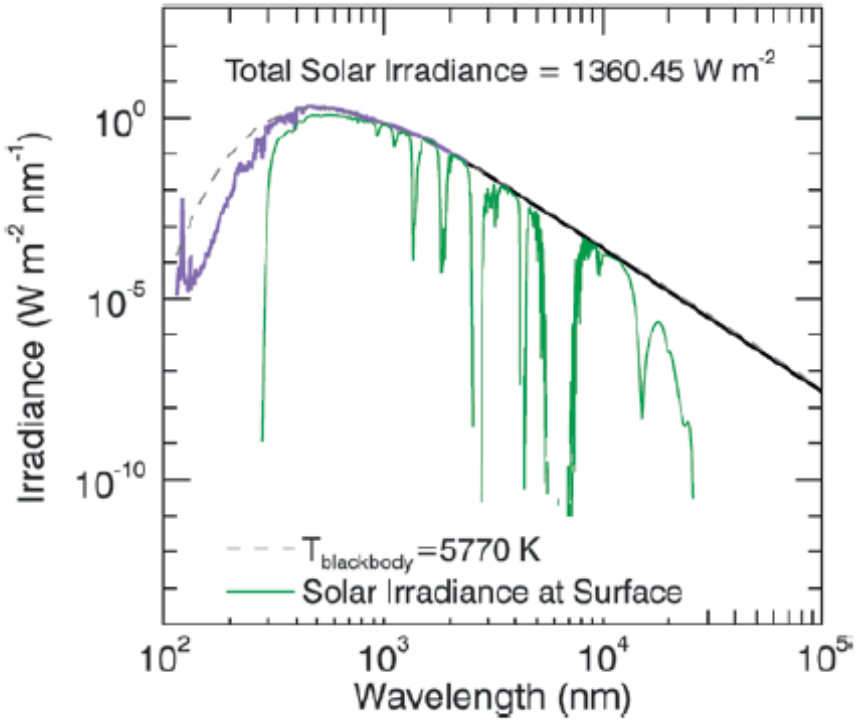
The updated NRLTSI2 and NRLSSI2 solar variability models form the Solar Irradiance Climate Data Record [*Lean et al.*, 2000; *Coddington et al.*, 2016].

- *Model formulation*. The magnitude of the irradiance changes from Quiet Sun conditions are determined from multiple linear regression analysis of observations and proxy records of magnetic variability.
- *Quiet Sun reference spectrum*. The NRLSSI2 reference spectrum is based on SORCE measurements [*Woods et al.*, 2009].
  - 99,884 spectral bins of 1-nm spectral resolution spanning 115 nm through 100,000 nm.
- The integral of NRLSSI2 reference spectrum is 1360.45 W m-2 [*Kopp and Lean*, 2011].





From Coddington et al., 2016, BAMS, vol. 97(7).

Summary of Data Sets used in the Solar Irradiance CDR reference spectrum

- **λ< 300 nm**: LASP WHI spectrum [Woods et al. 2009] (http://lasp.colorado.edu/lisird/whi_ref_spectra/)

- **λ from 300 nm – 1000 nm**: SOLSPEC (ATLAS-1 mission) high resolution observations [Thuillier et al., 1998] constrained in magnitude to match the overall irradiances of the LASP WHI spectrum. (solspec_uvvi_v9_b_reference_spectrum.txt)

- **λ from 1000 nm – 2400 nm**: SORCE SIM observations as incorporated in LASP WHI spectrum.

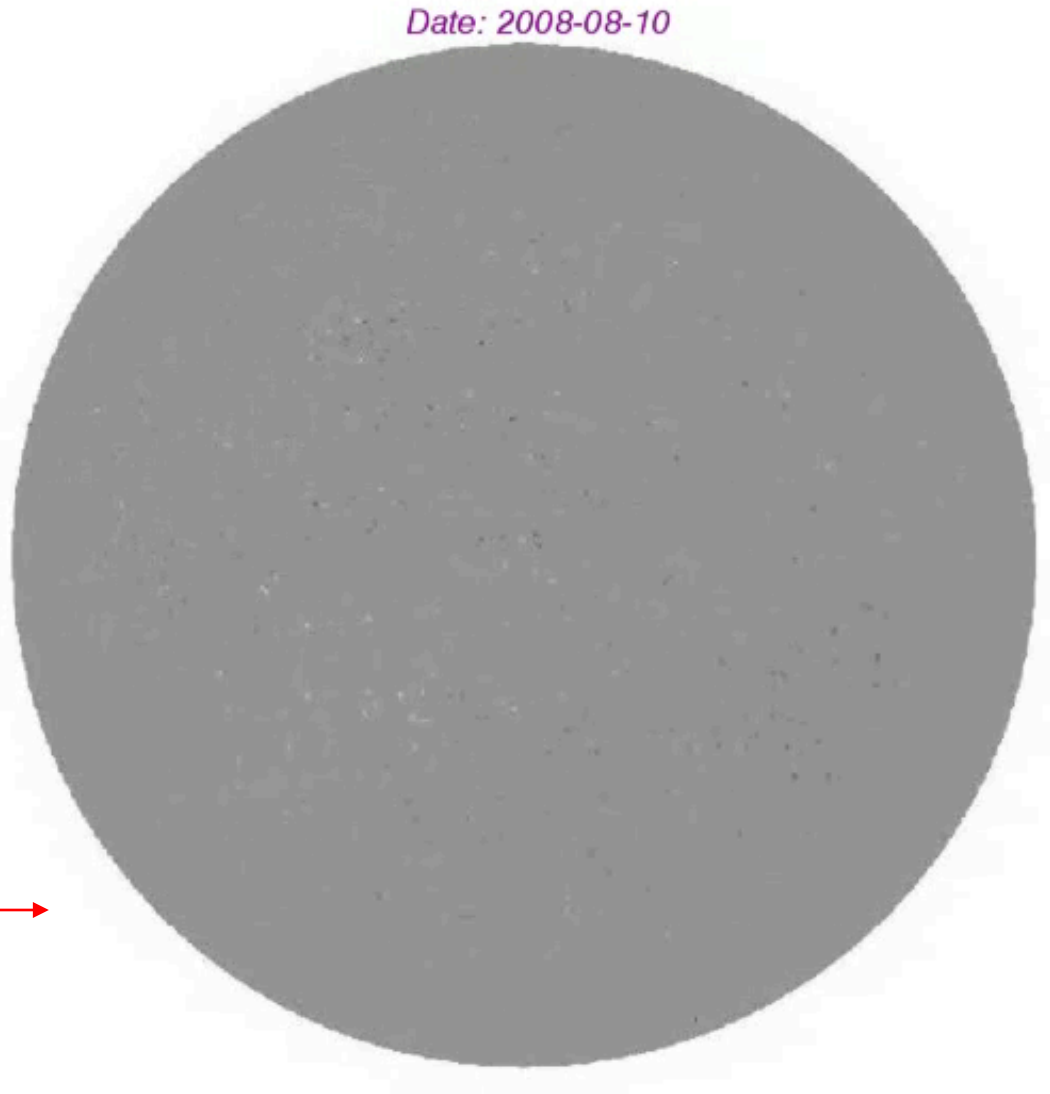
- **λ > 2400 nm**: Kurucz (1991) theoretical spectrum.

- In a final step, the integral of the spectrum is normalized to the adopted quiet sun TSI of 1360.45 Wm-2 (from SORCE TIM observations).

LASP Whole Heliosphere Inteveral: Quiet Sun Campaign (Aug 10-16, 2008) [Woods et al., 2009]

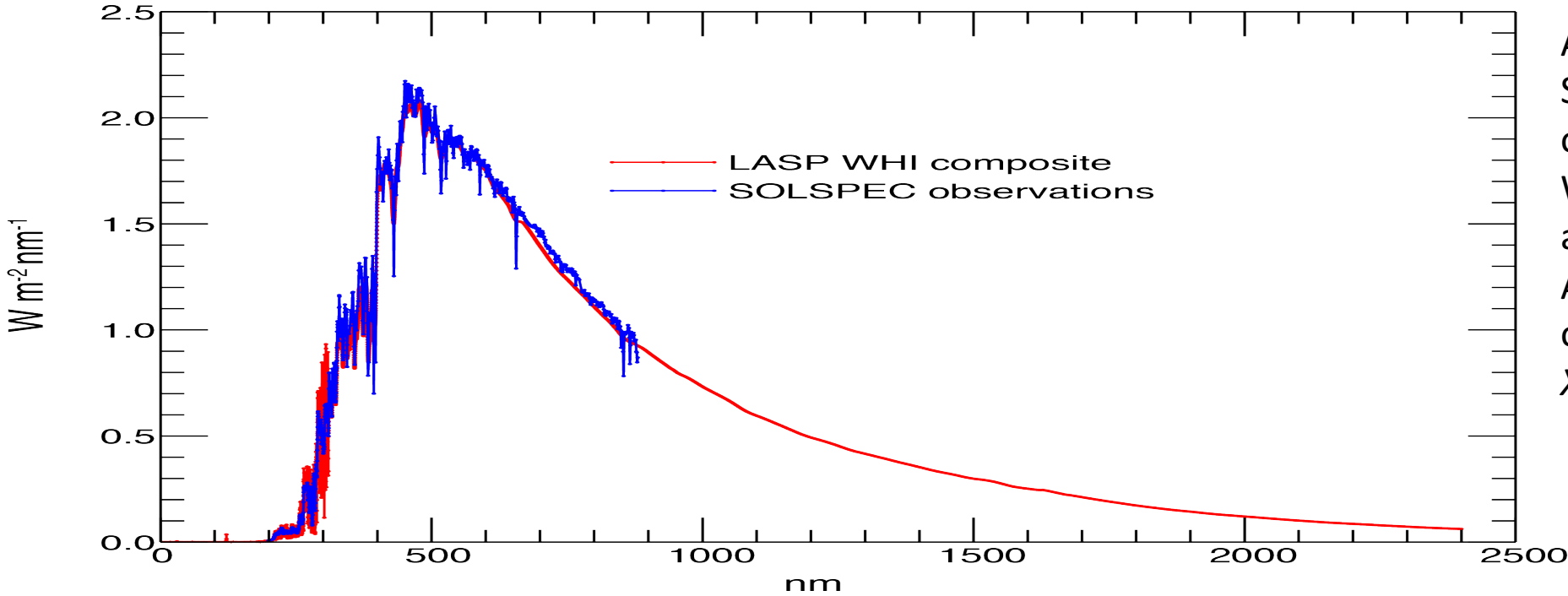
- Measurements during a time period when the solar disk was free of spots and faculae.
  - USAF SOON stations = "0" sunspots
  - Gyula (Hungary) Observing station = "0" sunspots
  - Bremen Composite Mg II index: 0.1504-.1508
  - Adopted Mg Quiet value = 0.1502

How quiet was the Sun during the "Quiet Sun Campaign"?

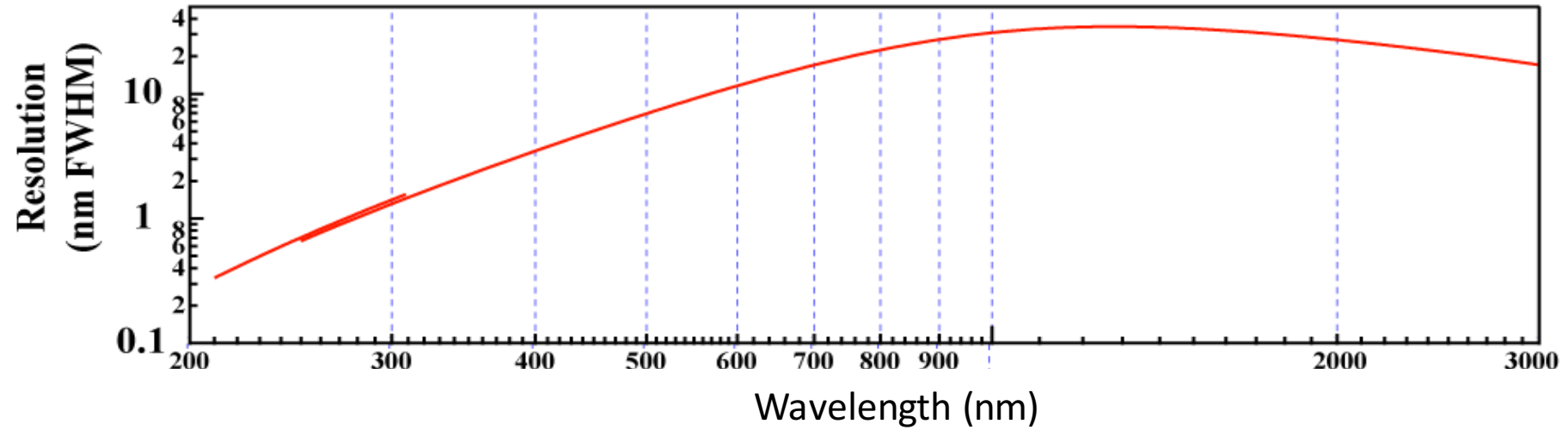


Data courtesy of Michelson Doppler Imager (MDI) on the board of Solar and Heliospheric Observatory (SOHO)

Observations used in the NRLSSI2 reference spectrum.

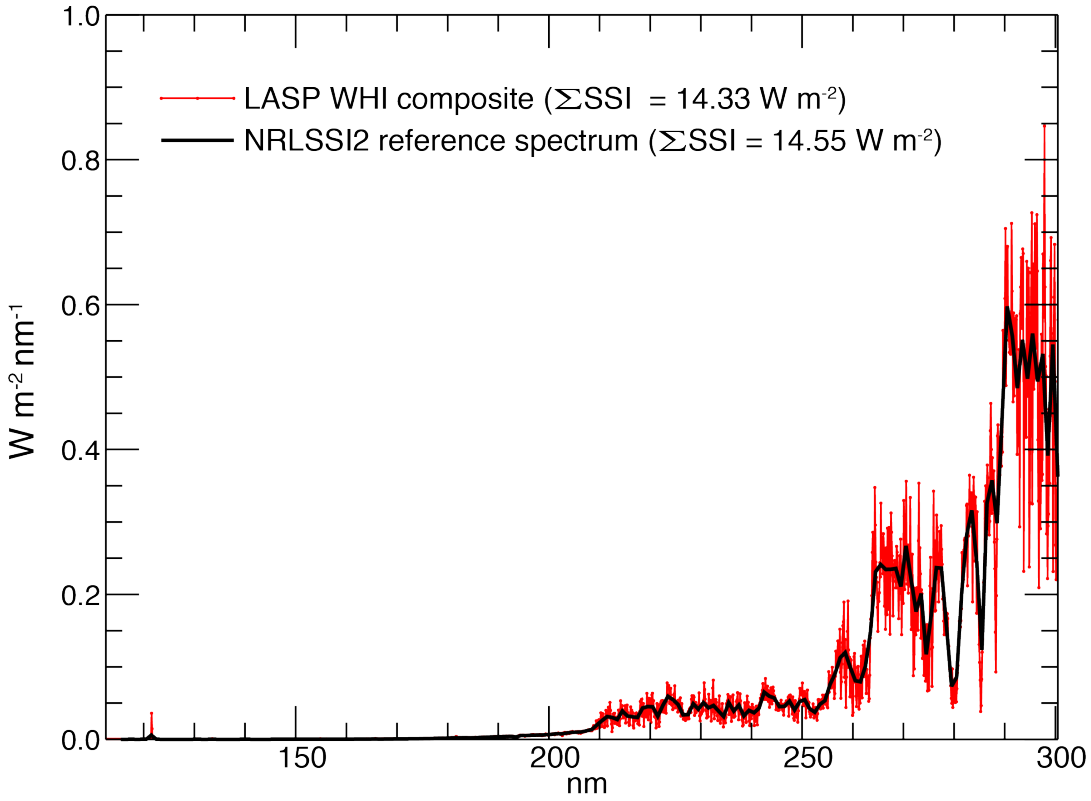


A comparison of SORCE observations from WHI campaign and SOLSPEC Atlas-1 observations.
X-axis is linear.

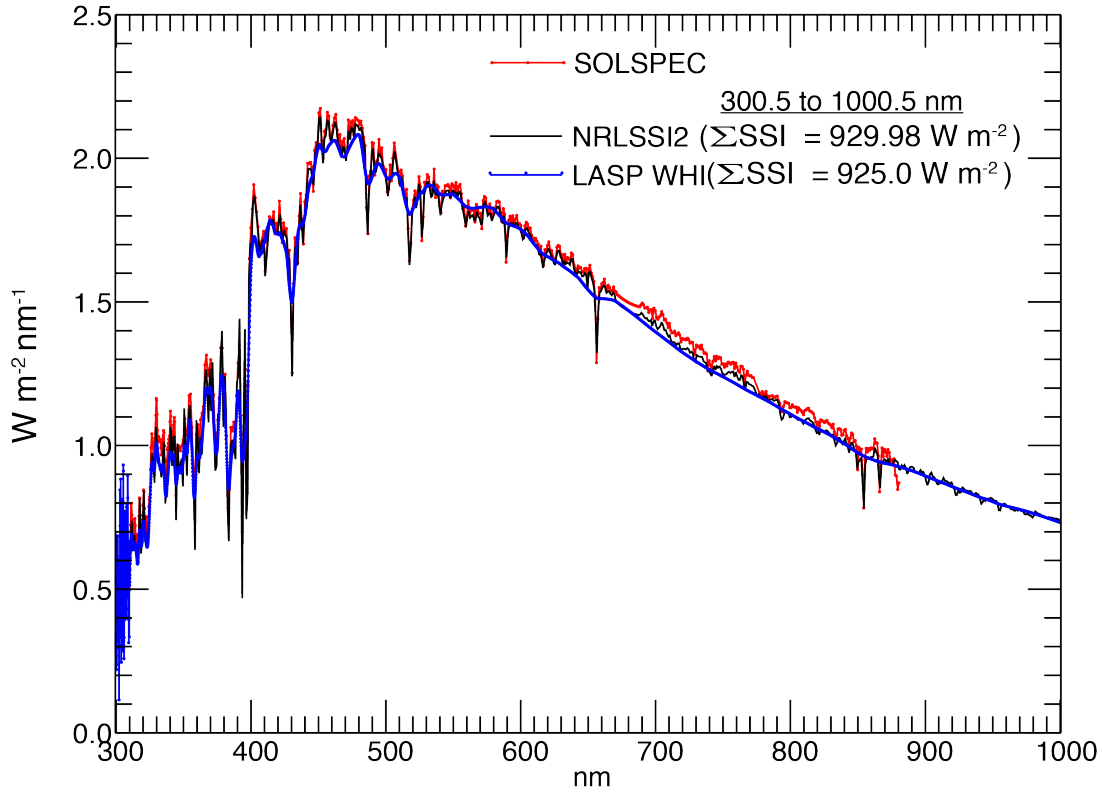


SIM has variable spectral resolution because of the prism (dispersive element).
X-axis is log-scale.

Observations used in the NRLSSI2 reference spectrum: UV and VIS Component

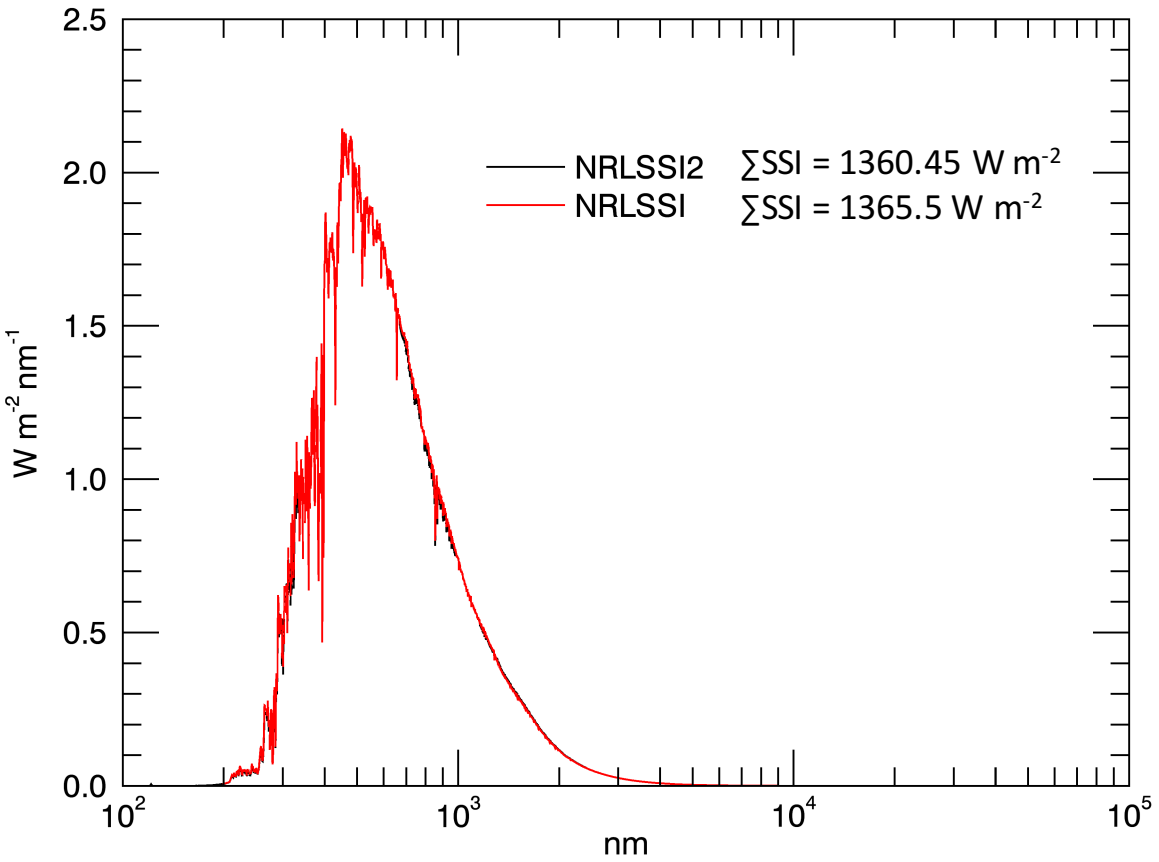


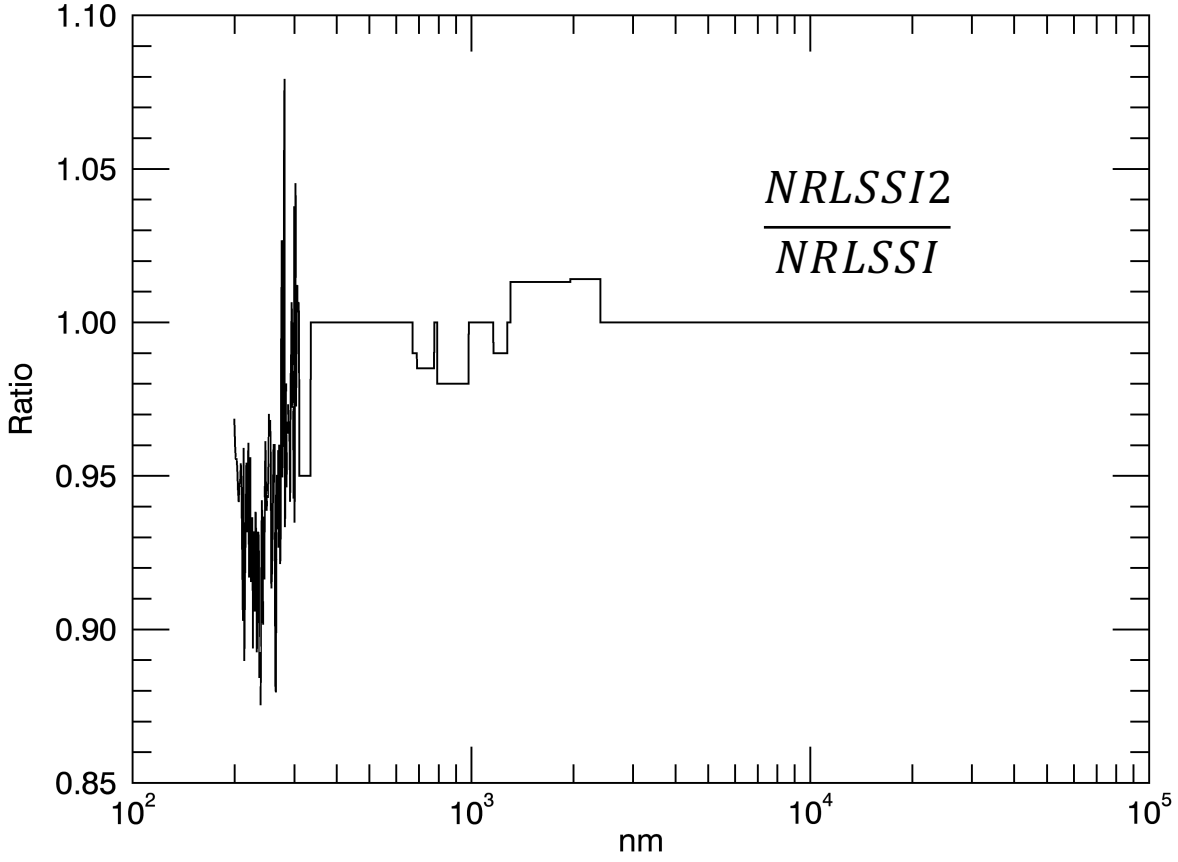
λ< 300 nm: Solar Irradiance CDR reference spectrum is the LASP WHI spectrum at 1-nm resolution.



λ from 300 nm – 1000 nm: SOLSPEC (ATLAS-1 mission) high resolution observations constrained in magnitude to match the overall irradiances of the LASP WHI spectrum.

Comparison of reference spectra from the original NRLSSI model and NRLSSI2





Original NRLSSI reference spectrum: An average of SOLSTICE observations during the UARS era (between 120 and 400 nm) and SOLSPEC (ATLAS-1) observations between 401-874 nm. Kurucz (1991) model was used for wavelengths > 874 nm.

Product	Type	No. of wavelength bins	Time range, update cadence
TSI composite	Observational composite	—	1978–2014, periodic
TSI (daily and monthly avg)	NRLTSI2 model output	—	1882–2014, quarterly
TSI (yearly avg)	NRLTSI2 model output	—	1610–2014, yearly
SSI (daily and monthly avg)	NRLSSI2 model output	3,785 (variable width)	1882–2014, quarterly
SSI (yearly avg)	NRLSSI2 model output	3,785 (variable width)	1610–2014, yearly
SSI reference spectra	NRLSSI2 model output	Measurements → 99,884 (1-nm width) Model output	Quiet sun; Low, moderate, and high solar activity; Maunder Minimum
Facular brightening and sunspot darkening indices	NRLTSI2/NRLSSI2 model input	—	1882–2014, quarterly

We also provide model data (at 1-nm spectral resolution) for various solar activity levels. Are these of use for your efforts?

Data Access

NOAA CDR Program: https://www.ncdc.noaa.gov/cdr

ftp://data.ncdc.noaa.gov/cdr/solar-irradiance/ssi/ancillary-data/tsi-ssi_v02r00_reference-spectra_c20151019.txt

Measurement Requirements for a climate data record of TSI and SSI

Table 1. Measurement requirements established for the TSIS TIM and SIM instruments that are driven by the need to understand Earth's climate response to solar variability, for separating natural from anthropogenic climate forcing effects, and for the monitoring and interpretation of the variability in wavelength-dependent processes induced by changes in Earth's surface and atmosphere.

Parameter	TSI CDR requirement	SSI CDR requirement
Absolute accuracy	0.01%	0.2%
Stability	0.001% yr^{-1}	0.05% yr^{-1} (λ < 400 nm) 0.01% yr^{-1} (λ > 400 nm)
Relative precision	0.001%	0.01%

The Total and Spectral Solar Irradiance Sensor (TSIS) TIM and SIM instruments are expected to meet these requirements.
TSIS launch date ~ November 1, 2017.

From Coddington et al., 2016, BAMS, vol. 97(7).