The New Climate Data Record of Solar Irradiance

Comparisons with Observations and Models over a range of solar activity time scales

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NOAA Climate Data Record (CDR) program

https://www.ncdc.noaa.gov/cdr/atmospheric

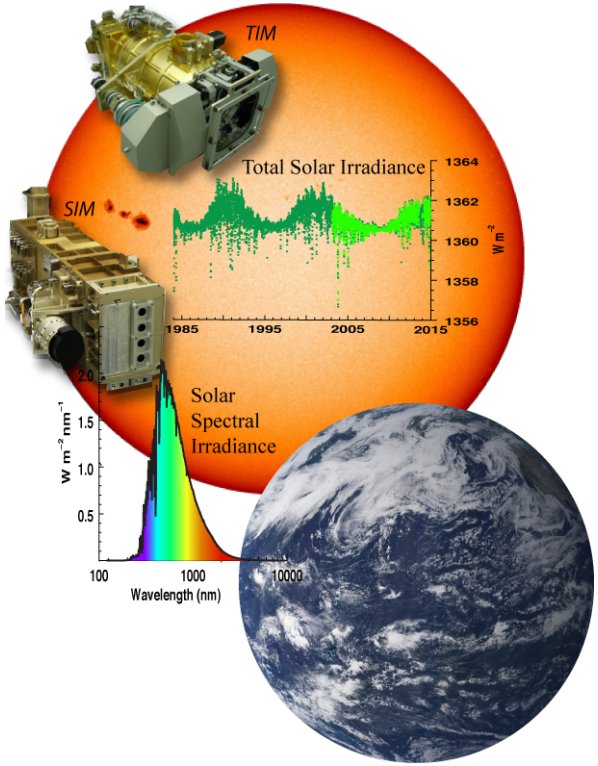
Some of the NOAA Atmospheric Climate Data Records
Solar Irradiance (TSI and SSI)
Outgoing Longwave Radiation
Ocean Heat Fluxes
Ozone
Cloud Properties
Aerosol Optical Thickness

- The Naval Research Laboratory (NRL) solar variability models have previously been used in IPCC assessments for simulations of climate and atmospheric change.
  - A description of the updated NRL models that form the Solar Irradiance CDR *[Coddington et al., 2015, BAMS, Vol 97(7)]*

- The solar forcing dataset for CMIP6 is an average of NRL and SATIRE model outputs *[Matthes et al., 2016, Geosci. Model Dev. Discuss., in review]*

*Our motivation is to present comparisons of NRL & SATIRE to SORCE observations.

Deliverables



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	99,884 (1-nm width)	Quiet sun Low, moderate, and high solar activity Maunder Minimum
Facular brightening and sunspot darkening indices	NRLTSI2/NRLSSI2 model input	—	1882–2014, quarterly

Documentation	Climate-Algorithm Theoretical Basis Document
Stewardship	i. Yearly Quality Assurance Reports & replacement of preliminary data with final data ii. Model Input Time Series

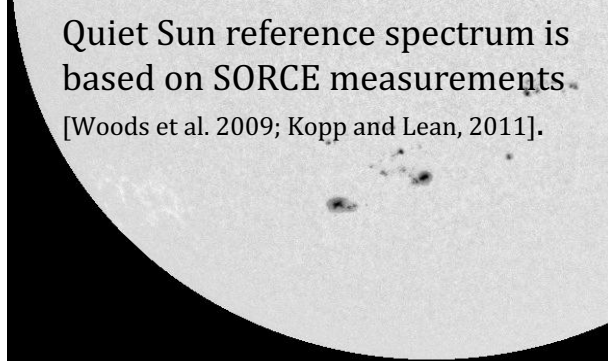
Data Access

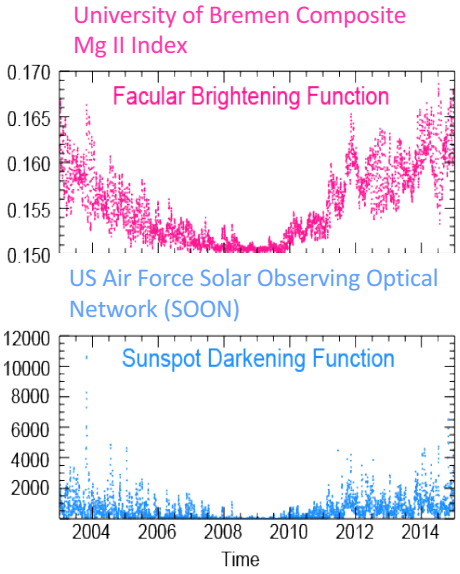
CDR Program: https://www.ncdc.noaa.gov/cdr

LASP LISIRD: http://lasp.colorado.edu/lisird3/data/nrl2_files

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.





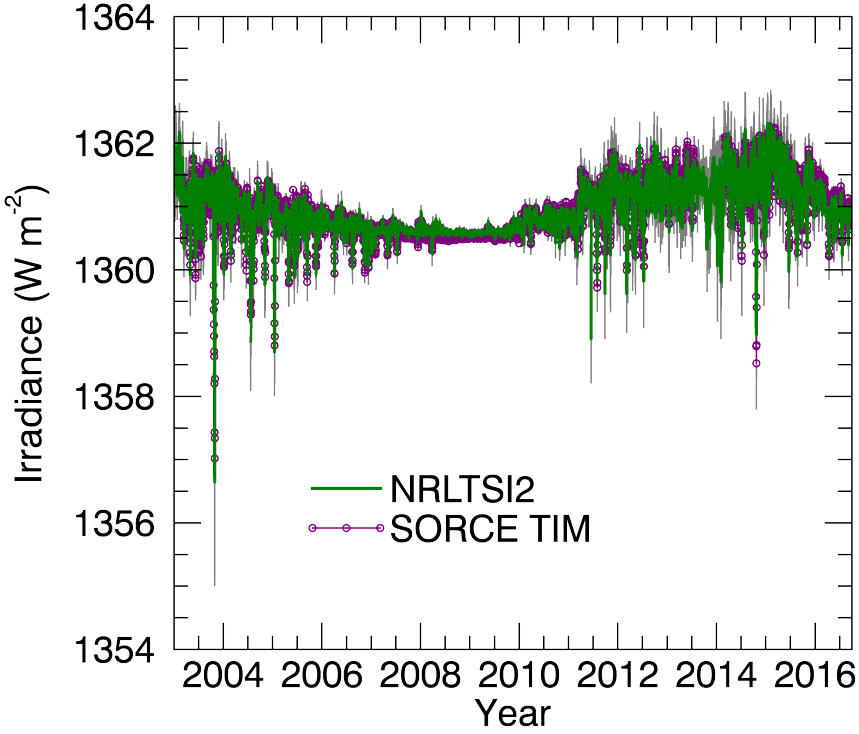
*For NRL2, SORCE SSI data are *detrended* prior to regression analysis because the observed solar cycle variability conflicts with theory and models [Lean and Deland, 2012; Yeo et al, 2014].

What's new for v02r01? (to be released early 2017).

1. **Improved representation of sunspot darkening index.**
   - **Goal: reduce std. dev of residual differences w.r.t. observations**
2. **Addressing sensitivities in modeled irradiance due to proxy input records.**
   - **Goal: Improve representation of estimated irradiances.**
   - **Impact: Affects relative weighting of sunspots and faculae prior to 1980.**
3. **Addressing impact of revised sunspot number on historical irradiance.**
   - **Goal: Provide 2, independent historical (1610-1882) irradiance time series based on Hoyt and Schatten [1998] and updated SILSO sunspot number records [Clette et al. 2015].**
4. **Improve the Observational TSI CDR composite with additional data.**
   - **Goal: Include RMIB composite, in addition to ACRIM and PMOD composites.**

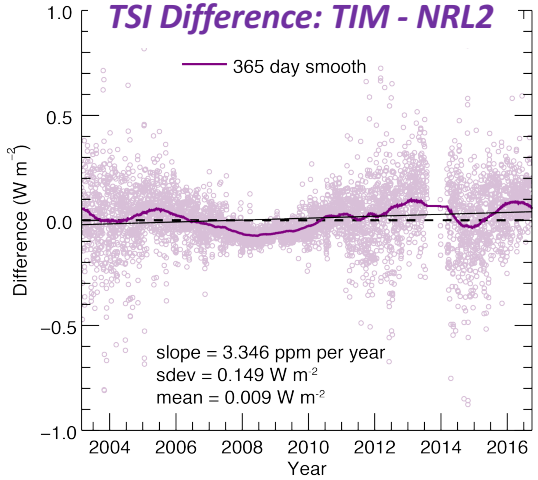
*NRLTSI and NRLSSI data shown today are v02r01.

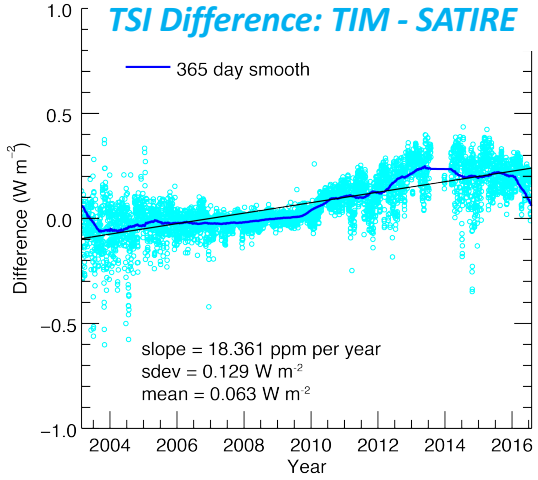
SORCE Era: TSI Comparisons



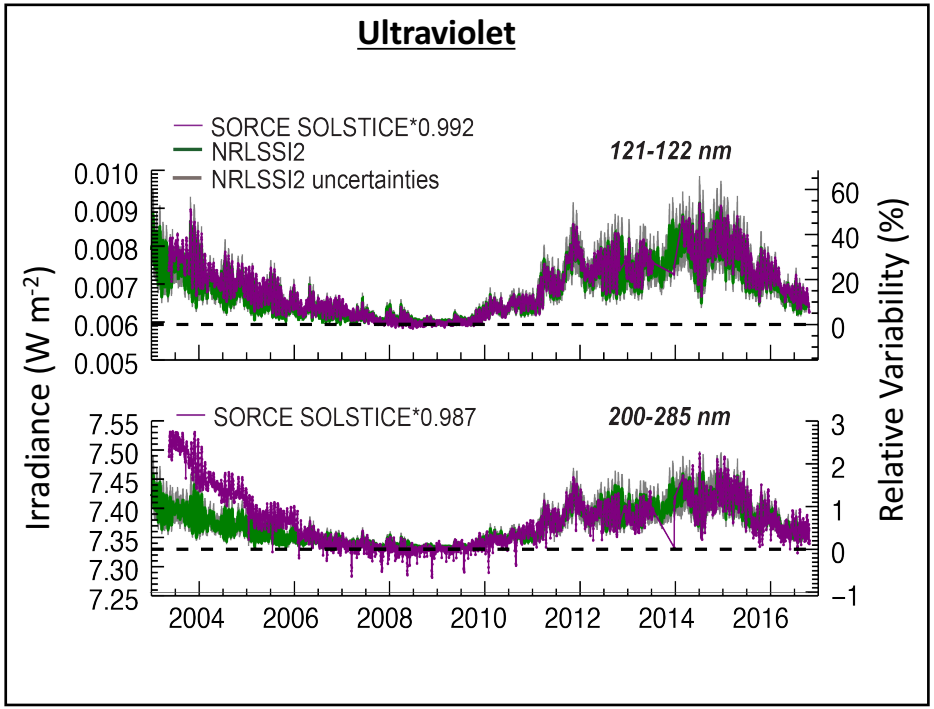
13+ years of SORCE TIM observations

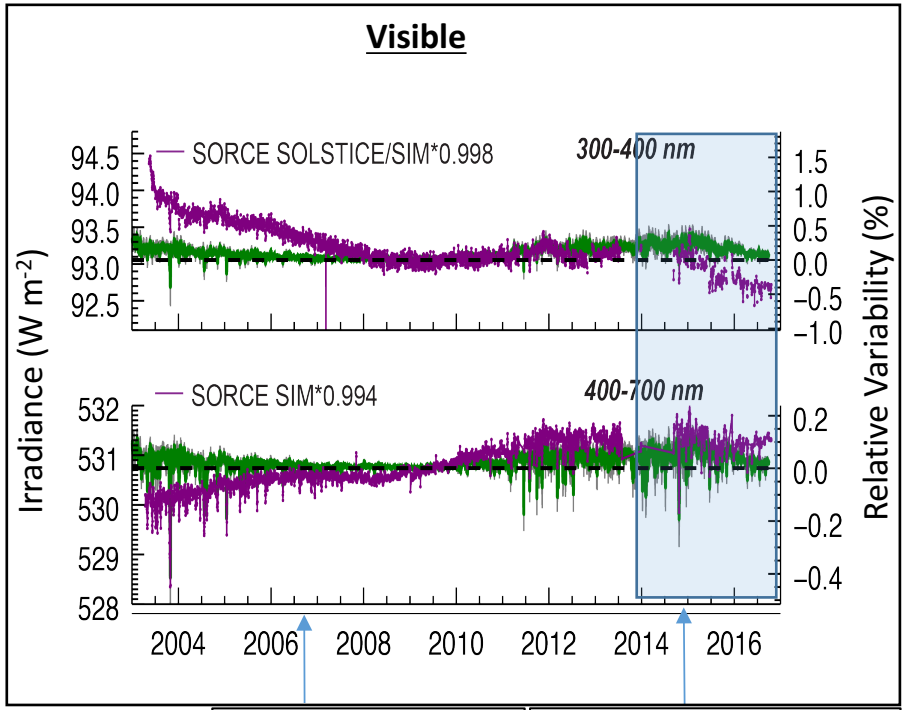
SORCE TIM accuracy= 350 ppm; stability = 10 ppm / year





SORCE Era: SSI Comparisons



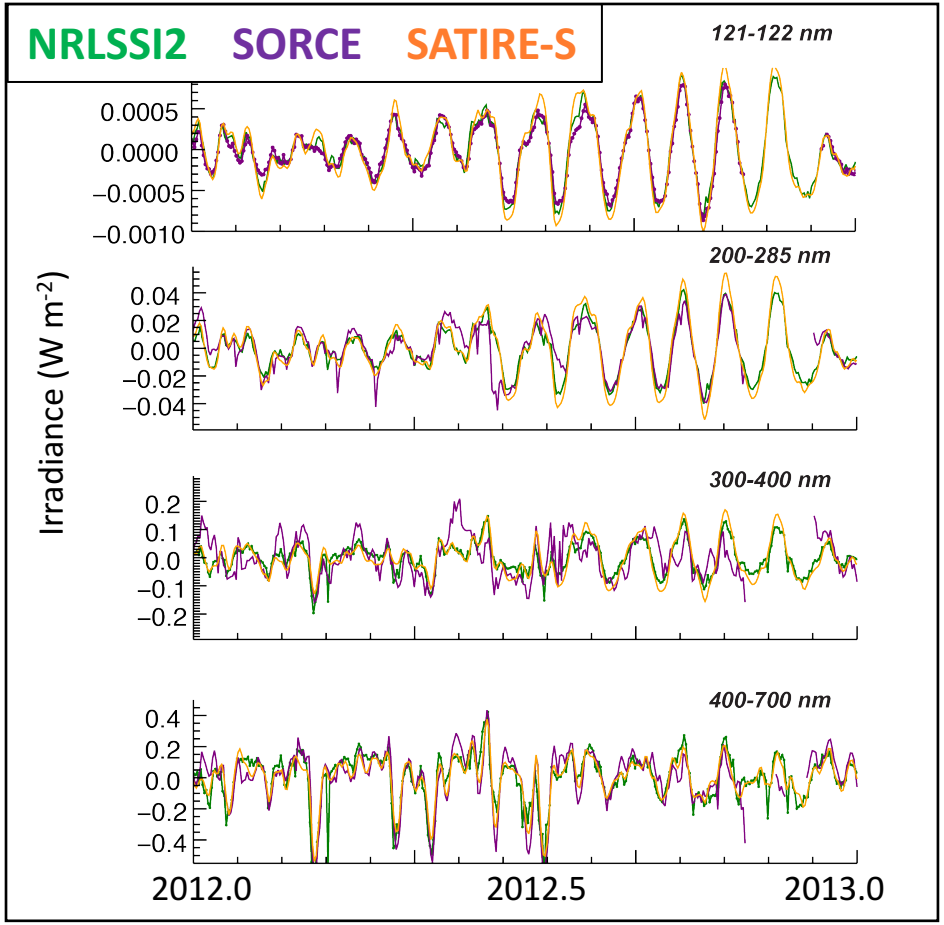


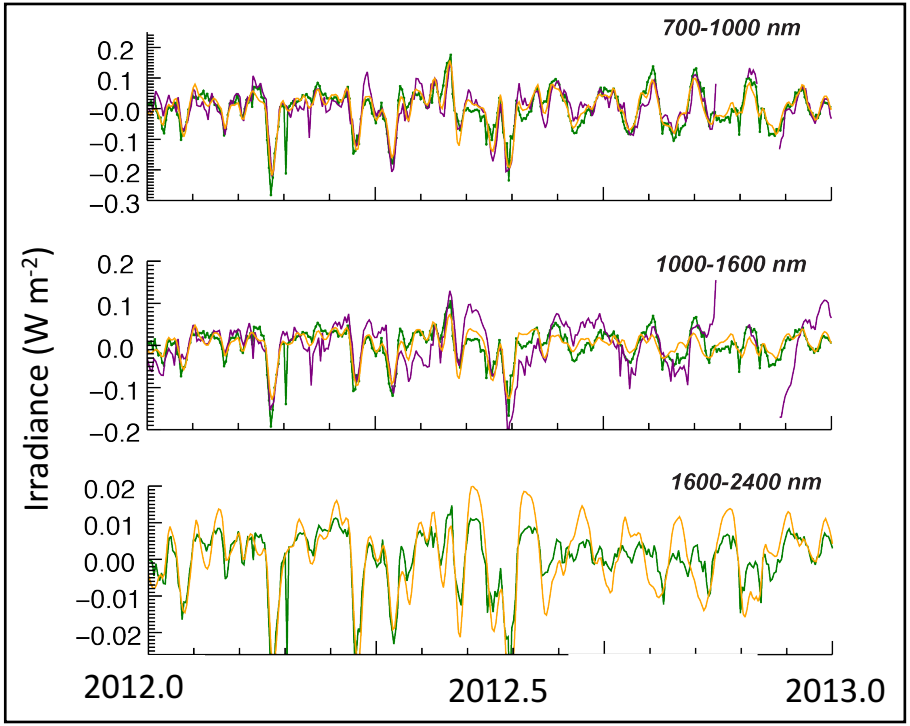
TSIS SIM designed for long-term spectral irradiance measurements and improved model validation.

Ex. SIM operations change

S/C operations change "Day-only" Operations (DO-OP)

SORCE Era: Solar Rotation SSI Comparisons (2012)

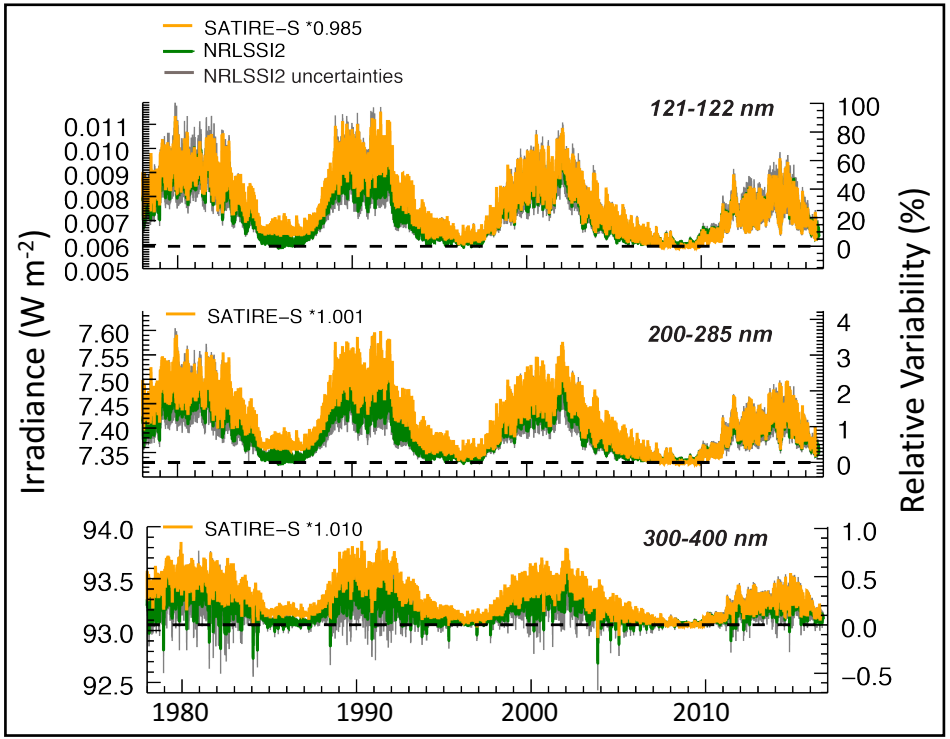


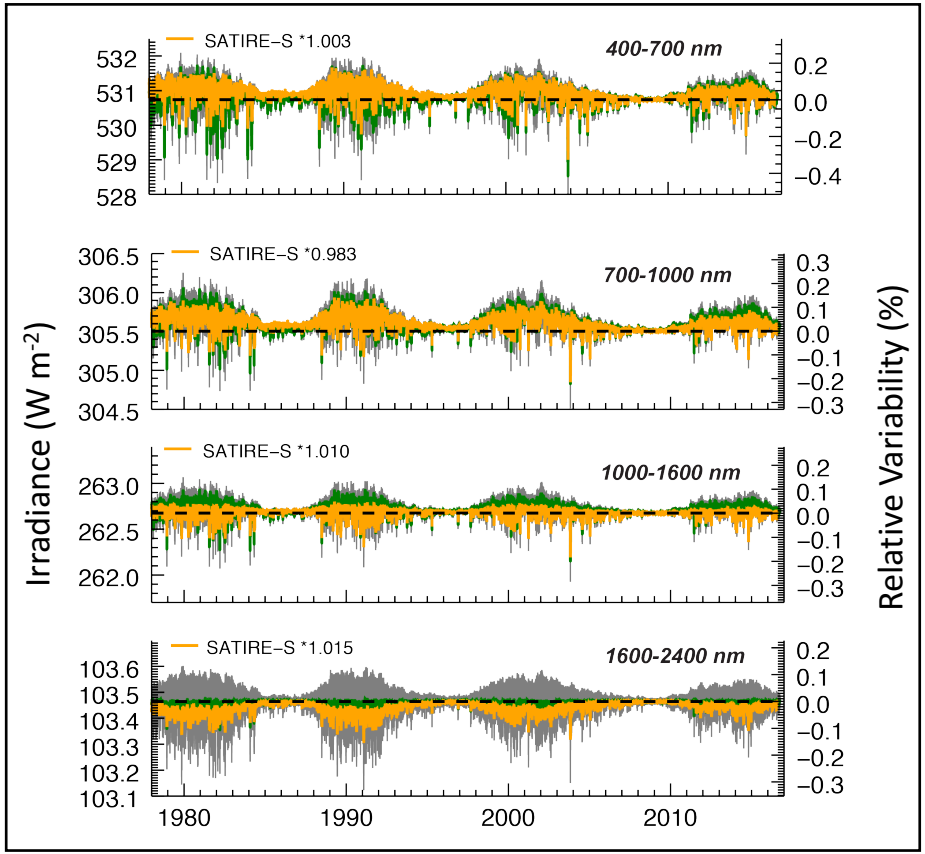


Observations and models have all been detrended by removing an 81-day running mean.

*At UV wavelengths, SATIRE solar variability exceeds that of SORCE SOLSTICE and NRLSSI2.

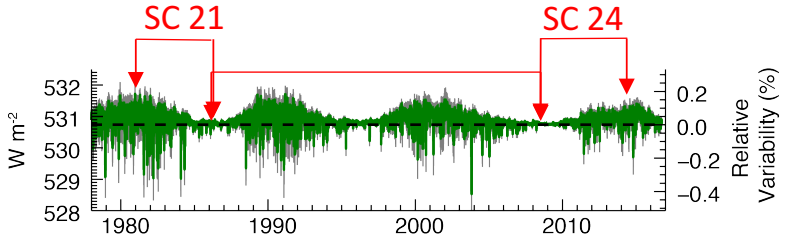
Satellite Era (1978-2016): SSI Comparisons



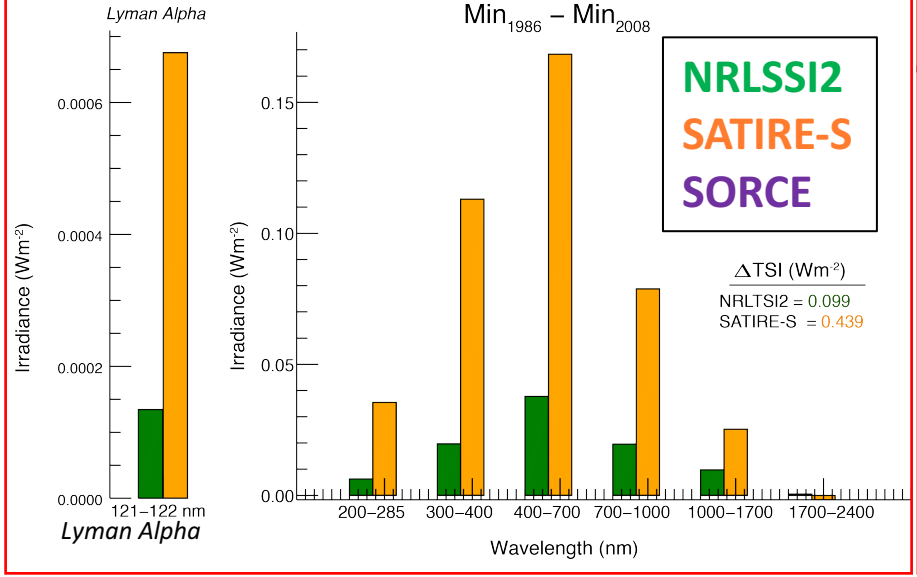


**SATIRE model normalized to match NRLSSI2 on 1 Jan 2009*

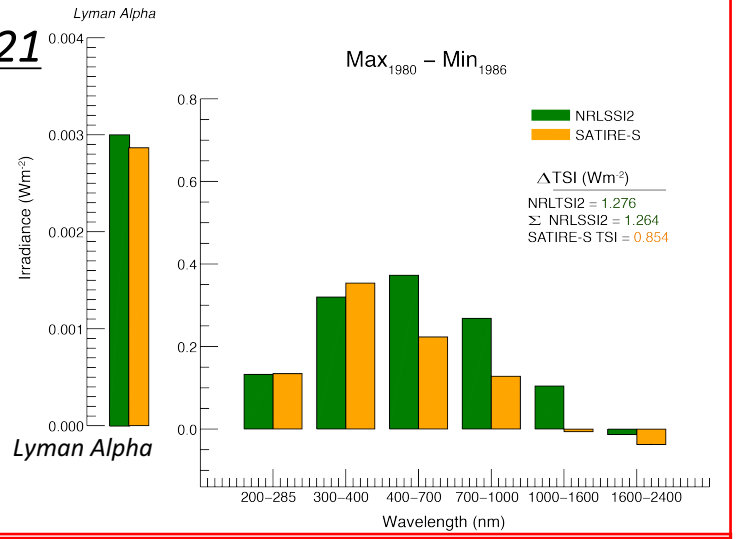
Energy Change



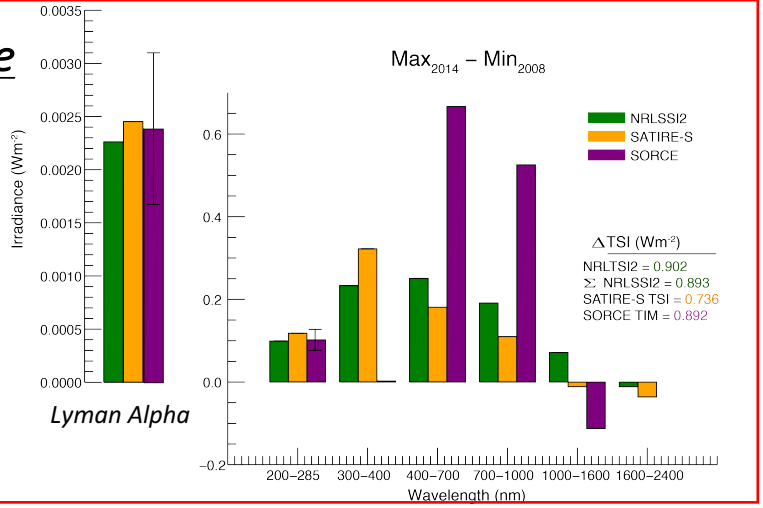
Inter minima Change



Solar Cycle 21



Solar Cycle 24



TSIS on the International Space Station

TSIS SIM Development Approach

TSIS SIM designed for long-term spectral irradiance measurements

Incorporate lessons learned from SORCE SIM (& other programs) into TSIS SIM to meet measurement requirements for long-term SSI record

Specific areas of improvement & enhancement over SORCE SIM to address both accuracy and stability

✓ ***Improve uncertainty quantification in prism degradation correction to meet long-term stability requirement***

- ***Ultra-clean optical environment to mitigate contamination***
- ***Addition of 3rd channel to reduce degradation uncertainties***

✓ ***Improve noise characteristics of ESR and photodiode detectors to meet measurement precision requirement***

- ***Improved ESR thermal & electrical design (sensitivity)***
- ***Larger dynamic range integrating ADC's (21 bits)***

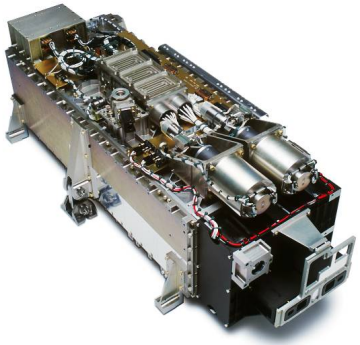
✓ ***Improve absolute accuracy (pre-launch) verification***

- ***SI-traceable Unit and Instrument level pre-launch spectral irradiance calibration (LASP SRF-NIST SIRCUS-L1 Cryo Rad)***

✓ ***Improve operations and processing approach***

- ***Operations will maintain a constant duty-cycle exposure ratio.***

SORCE SIM



TSIS SIM

Summary

- We have shown:
  - *TSI and SSI comparisons with models and observations over different time scales (solar rotation, solar cycle, multi-decadal).*
  - *NRL2 reproduces much of the variability in the SORCE TIM observations.*
  - *SATIRE has greater UV variability than NRL2 and larger near-infrared out-of-phase solar cycle change.*
  - *NRL2 and SATIRE SSI differ in their solar cycle magnitudes (esp. SC 21) and inter minima trends.*
- As we obtain new observations (TSIS), we will update the NRL2 model and the Solar Irradiance Climate Data Record.

Thank you!