Creation of the V2 Composite Solar Spectral Irradiance Data Set

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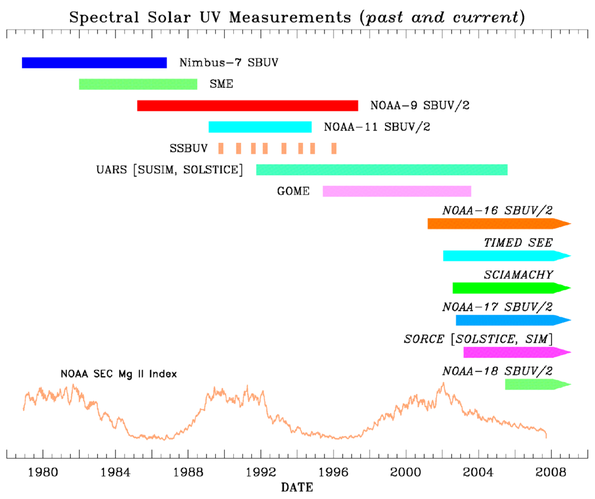
Introduction

- Climate studies require multi-decadal solar spectral irradiance (SSI) data sets to capture atmosphere/ocean forcing.
- Most of UV spectral region has been observed continuously since 1978, but temporal coverage varies between instruments.
- *DeLand and Cebula* [2008] created composite SSI data set using measurements from six instruments and proxy data.



- **Goal of this project is to update composite SSI product and extend coverage to present.**

V1 Composite SSI Rationale

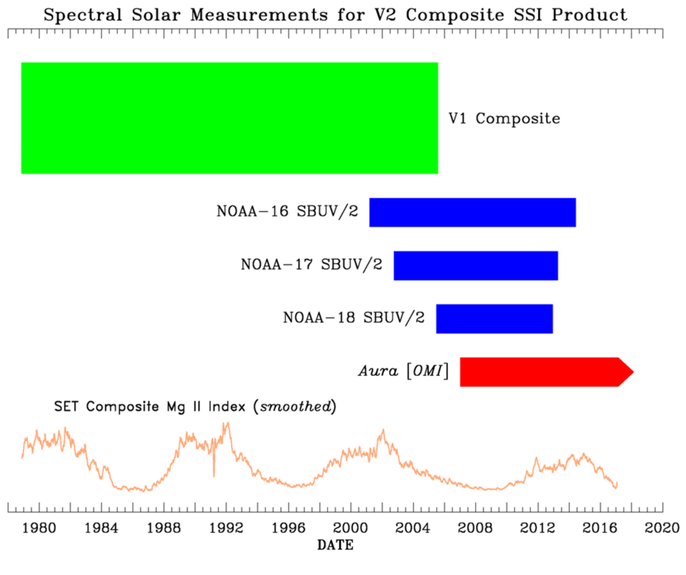
- Use 1 nm gridded irradiance product from each instrument.
- Normalize each data set to single reference spectrum Thuillier et al., ATLAS-1).
- Select single data set for each large spectral and temporal region (no averaging in overlaps).
- Fill data gaps with synthetic data from proxy.

Limitations of V1 Product

- Data set stops in July 2005 → Need to extend to present with additional instruments.
- Normalization spectrum corresponds to high solar activity (March 1992) → Prefer lower level to accommodate more recent data.
- Clean up step changes at inter-instrument transitions (noted by some users) and outlier data points.

New Data Sets for V2 Product

- Currently omit SORCE data due to questions about early degradation corrections.
- SBUV/2 instruments cover some portion of needed interval, but long-term characterization is required.
- Aura OMI data cover most of required interval, allow continuation of data set to present.

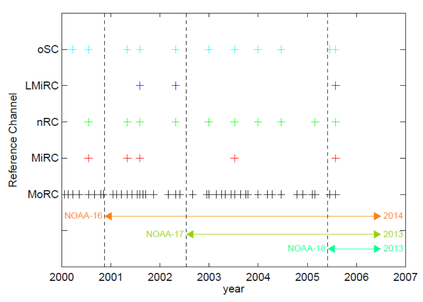


SBUV/2 Data Sets

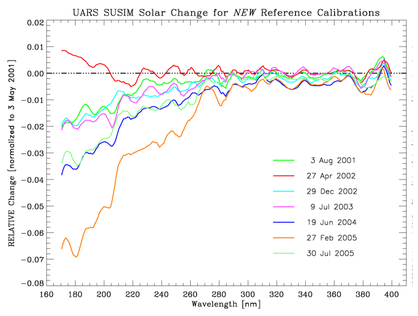
- NOAA-16 daily spectra cover March 2001 – September 2007 before satellite orbit drift causes problems (shadowing of diffuser plate).
- NOAA-17 daily spectra cover October 2002 – December 2010 before shadowing starts.
- Correction for long-term degradation is adapted from NOAA-9, NOAA-11 SBUV/2 approach (comparisons to periodic absolute reference data set).
- Use UARS SUSIM reference calibration spectra during 2001-2005 as standard (replacing SSBUV).
- Remove "Day 1" calibration bias, then use coincident ratios between SBUV/2 and SUSIM to isolate NOAA-16 SBUV/2 degradation.
- Create smooth fits (wavelength, time) to derive SBUV/2 degradation correction for full data set.

SUSIM Reference Measurements

- UARS SUSIM used multiple reference channels (combinations of optical elements) during 14-year mission. Each channel typically covered only a portion of the full spectral range (115-410 nm).
- Changes in deuterium lamp transmissivity and optical path degradation were considered in this analysis.
- New Reference Channel (nRC) data are available at 6-9 month cadence during 2000-2005 (see figure below).
- The ratio of two nRC spectra represents the actual solar change between those dates.



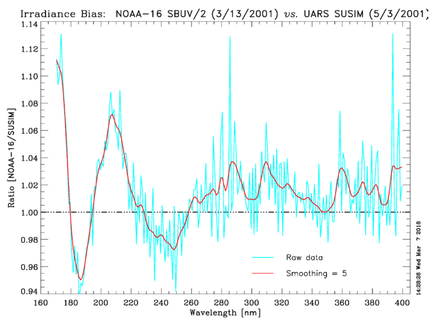
RC = Reference Channel
nRC = new Reference Channel
MiRC = Mission Reference Channel
LMiRC = Lower Mission Reference Channel
MoRC = Monthly Reference Channel
oSC (SRC) = Standard Reference Channel

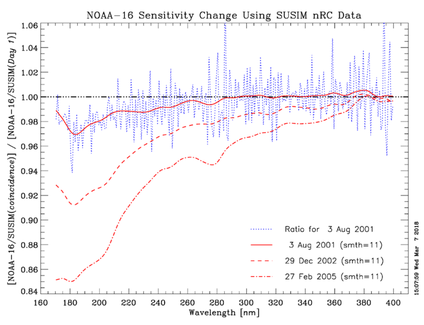


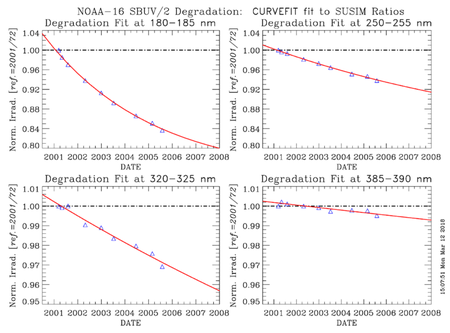
- Reference channel measurements are made at 5 nm spectral resolution.
- All solar change curves shown here are ratios to 3 May 2001.
- nRC spectra agree with each other to better than 1% for wavelengths > 290 nm.

Characterization of SBUV/2 Degradation

- Determine NOAA-16 instrument changes by adjusting normalized spectrum for solar variation (based on SUSIM results).
- In practice, we characterize the "Day 1" bias between NOAA-16 and SUSIM first, create smoothed fits for spectral dependence at each SUSIM reference date, then fit these data to get time dependence.



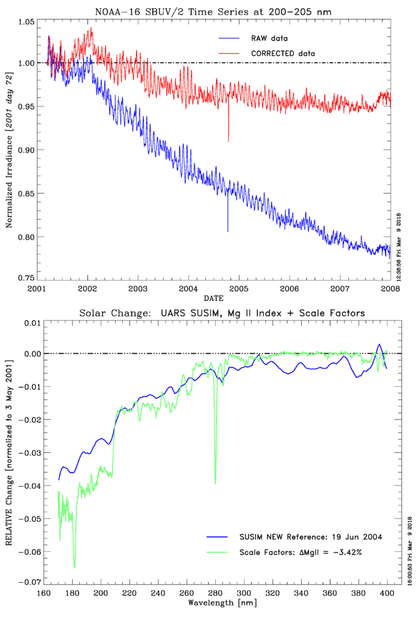


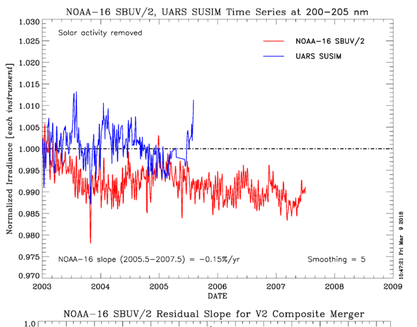


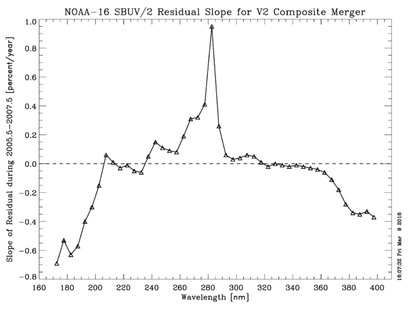
- NOAA-16 fits are extrapolated to create degradation correction through September 2007.
- NOAA-17 has shorter overlap with SUSIM. **This method did not work well enough to be useful for providing NOAA-17 data.**

NOAA-16 Corrected Data

- Corrected NOAA-16 data show drift vs. SUSIM in selected wavelength bands (remove solar variation to evaluate).
- Spectral locations are consistent with differences between SUSIM results and scale factor calculation (particularly at Mg II line).
- Since these data will be used in V2 composite SSI product only as "bridge" to connect UARS SUSIM and Aura OMI, apply adjustment to remove drift for that purpose.

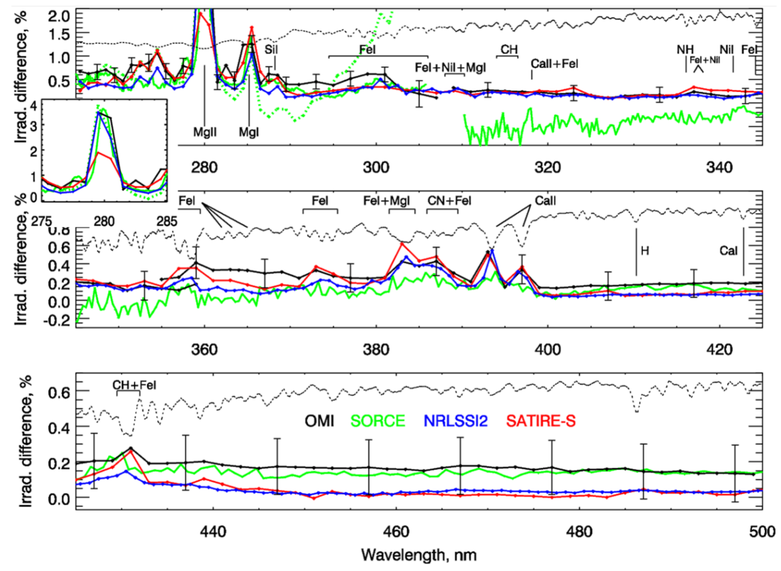


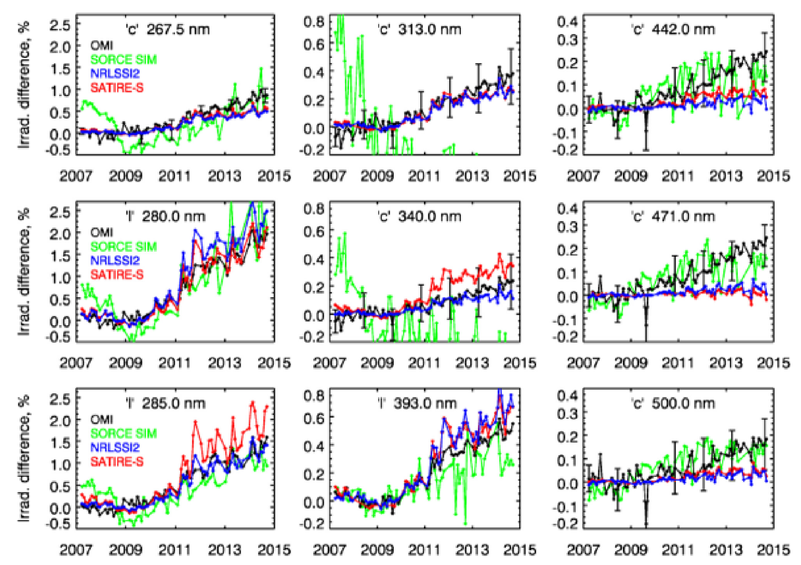




Aura OMI Data

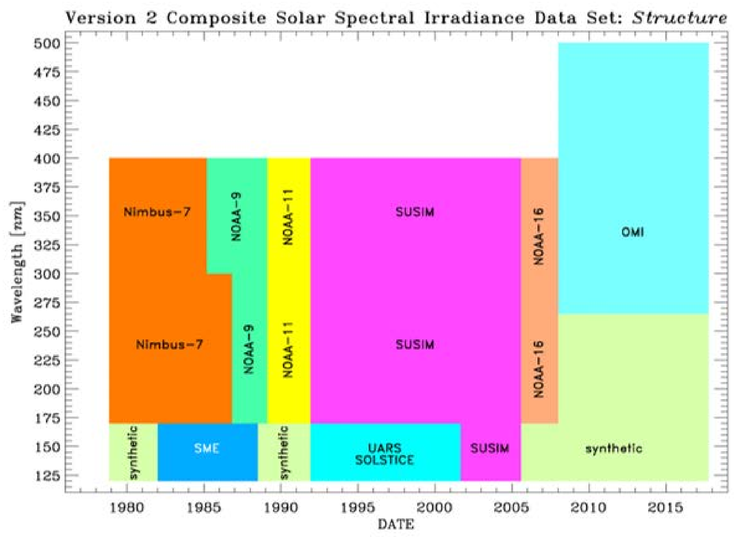
- Measurements cover 265-500 nm, resolution = 0.4-0.6 nm.
- Daily solar measurements since December 2004 to present.
- Characterize diffuser change using multiple elements.
- Excellent stability (stable wavelength scale, low degradation.
- Characterize throughput change using solar minimum in 2007-2009 as basis for time dependence.
- Refine functional form by assuming consistent irradiance level at solar minimum (2007-2009, 2017).
- Estimated long-term uncertainty is ~0.1% in UV, < 0.1% in visible.
- **See Marchenko presentation at 5:15 on Tuesday 3/20 for more discussion.**





V2 Composite SSI Product

- Start using NOAA-16 data in March 2005 (day 80) to help fill SUSIM data gaps near end of mission.
- Transition to OMI data in January 2007.
- Fill gaps at shorter wavelengths using proxy models (*Woods et al.* [2000] for 120-170 nm, *DeLand and Cebula* [1994] for 170-265 nm) and scaled Bremen composite Mg II index.



Next Steps

- Assemble all elements and review behavior of merged product at transition locations.
- Compare to other comprehensive products (NRLSSI2, SATIRE-S, SOLID) for validation.
- Write up results for journal paper.
- Proposed enhancements to V2 product:
  - Implement revised SME data from current SIST project for FUV and MUV regions during 1982-1988.
  - Use SORCE SOLSTICE data for FUV and MUV regions during 2005-2017.

Acknowledgements

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