SOLSTICE: Seventeen Years, Eighteen Versions

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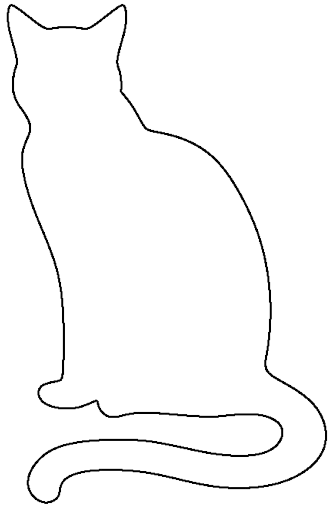
Outline

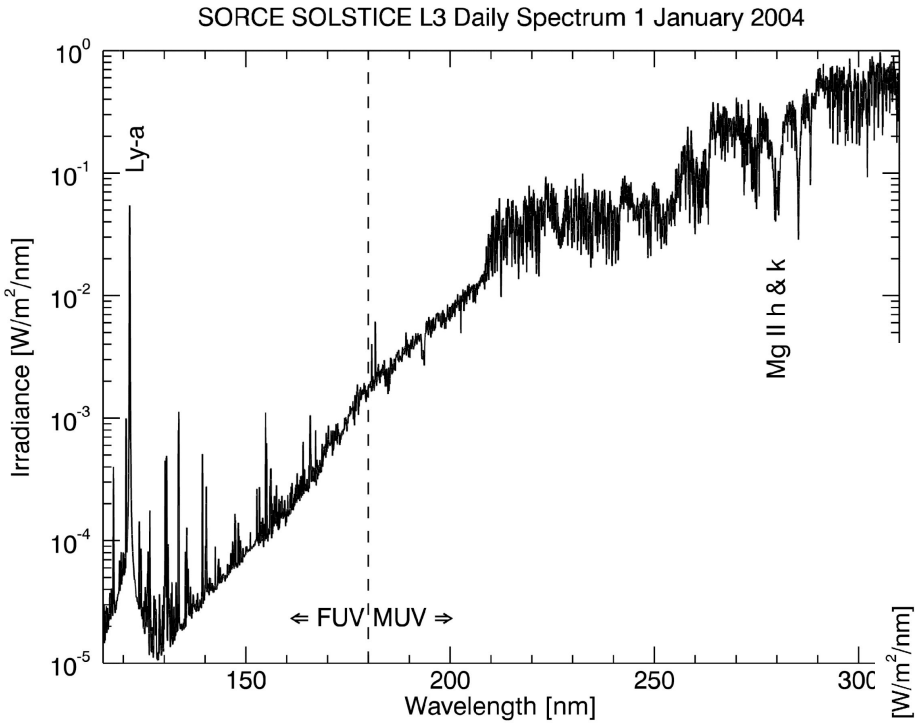
- SOLSTICE Capabilities
- Inflight Calibration Techniques
  - Stellar Measurements
  - FOV Correction
- Final version uncertainties
- Final version results
  - Comparison to other measurements
  - Comparison to models
- Future plans



References

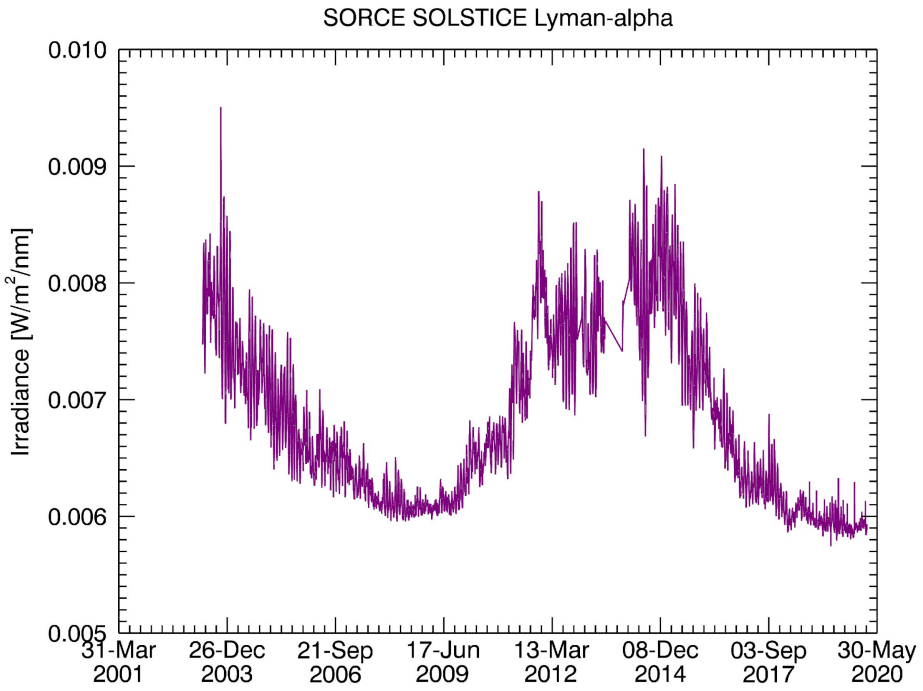
- Snow et al. (2021) Algorithm Theoretical Basis Document – Post Launch update: SOLar-STellar Irradiance Comparison Experiment (SOLSTICE), Technical Report, University of Colorado Boulder, https://doi.org/10.25810/meav-4g65
- Snow et al. (2022) SOLar-STellar Irradiance Comparison Experiment II (SOLSTICE II): End-of-Mission Validation of the SOLSTICE Technique, Solar Physics, 297,55, https://doi.org/10.1007/s11207-022-01984-9
- Woods et al. (2021) Overview of the Solar Radiation and Climate Experiment (SORCE) Seventeen-Year Mission, Solar Physics, 296, 127, https://doi.org/10.1007/s11207-021-01869-3
- Woods et al. (2022) Solar-Cycle Variability Results from the Solar Radiation and Climate Experiment (SORCE) Mission, Solar Physics, 297, 43, https://doi.org/10.1007/s11207-022-01980-z

SOLSTICE Measurements



Daily SSI from 115-300 nm:

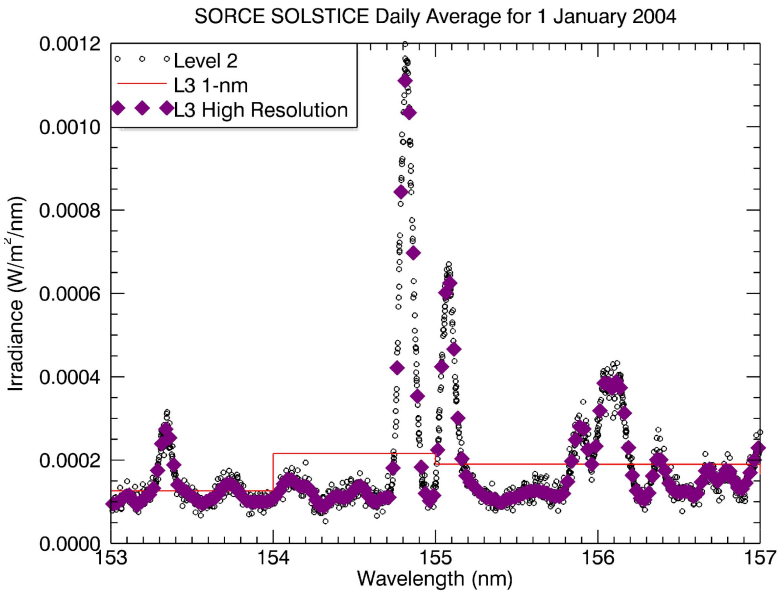
- Level 3: 1-nm binned
- Level 3: 0.1-nm native resolution sampled on a regular grid with 0.025 nm spacing



Additional:
High cadence Lyman alpha scans

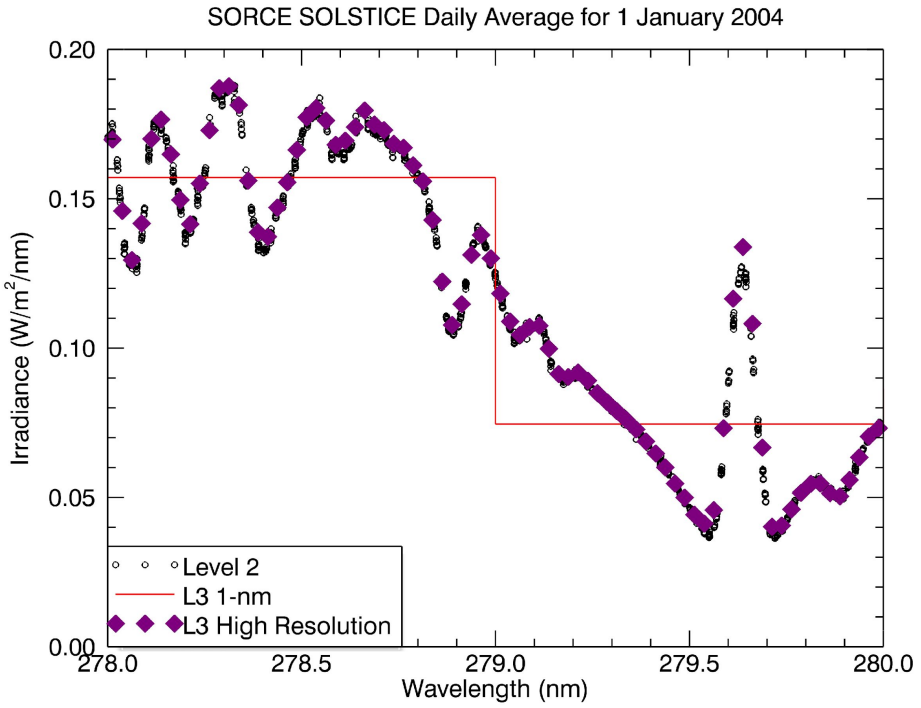
https://lasp.colorado.edu/home/sorce/data/

Example Full-resolution spectra

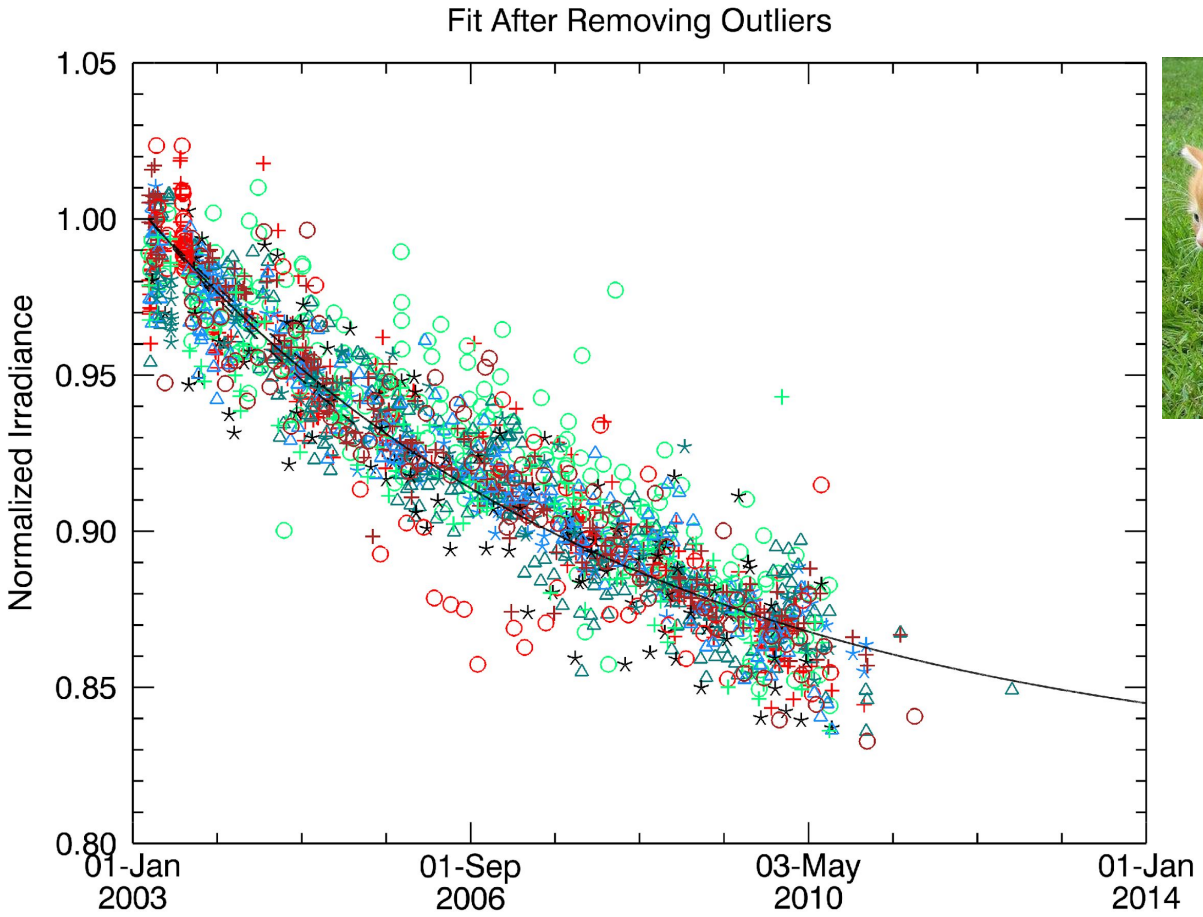


1-nm data product compatible with legacy datasets, but full-resolution spectra are recommended.

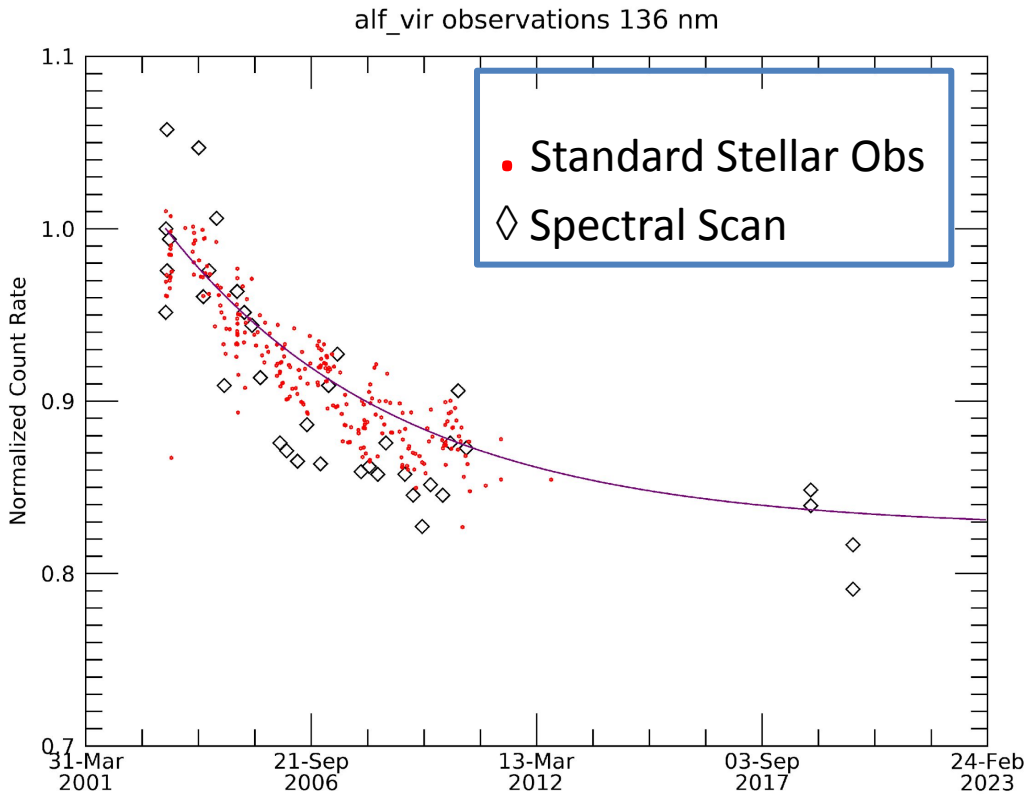
Long-term trends are identical. 1-nm product is numerically integrated from high-res



Stellar Observations



Late-mission stellar observations

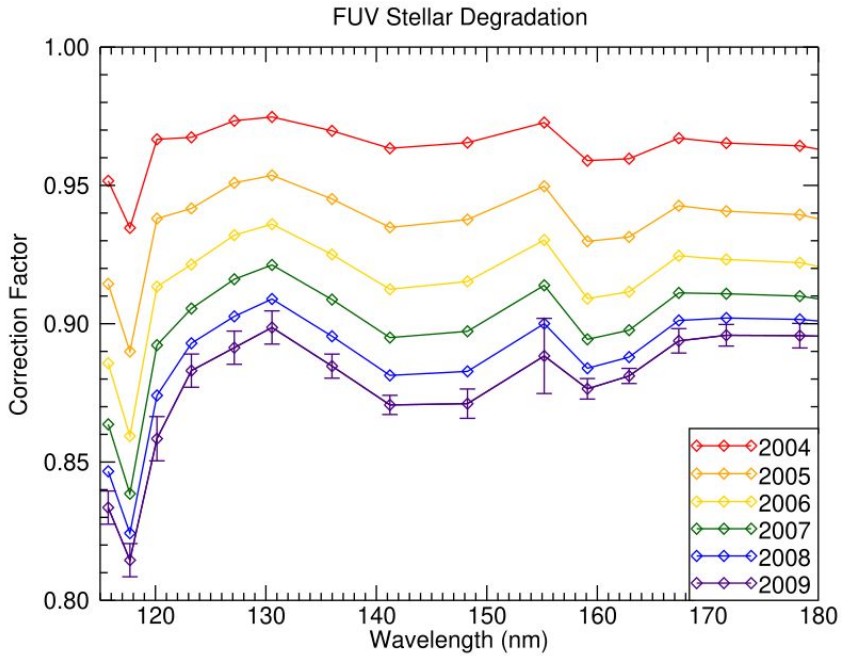


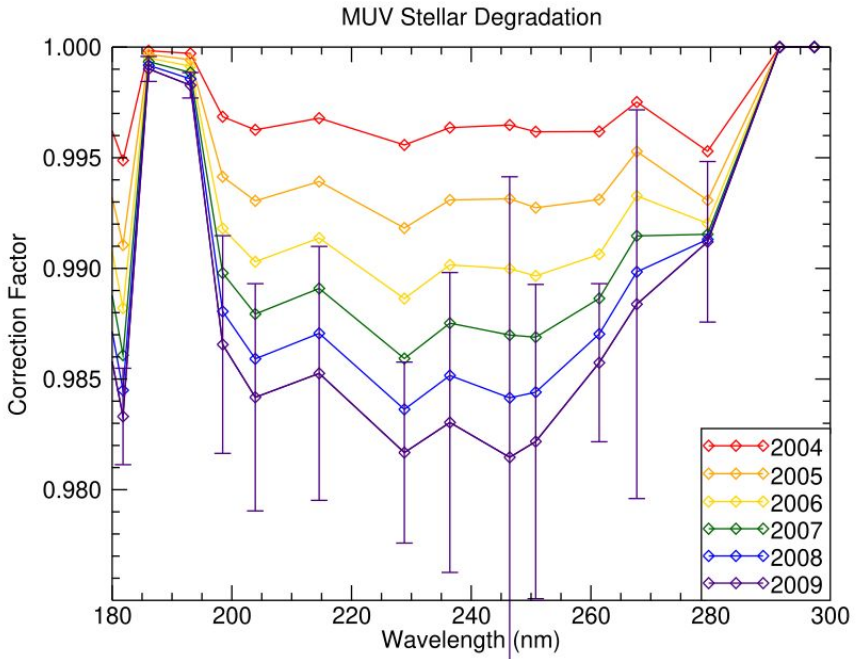
Battery degradation prevented standard eclipse activity. Stellar degradation trends were extrapolated after 2011.

Late in the mission, two daytime stellar observing campaigns in the FUV confirmed that prior extrapolation was reasonable.

Too few observations to warrant new curve fit.

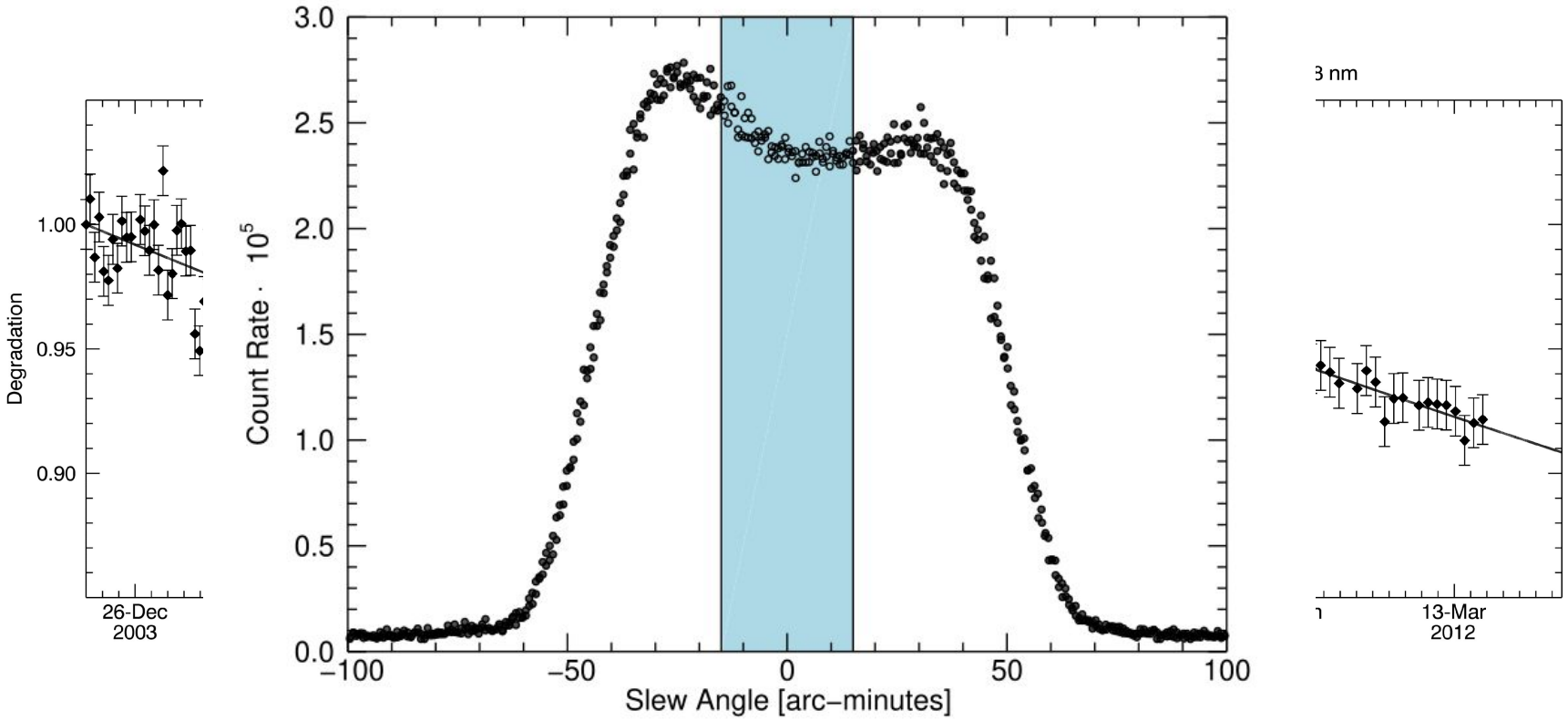
Summary of Stellar Trending





For clarity, error bars are only included on 2009 curves.

Solar/Stellar Correction (FOV)



Observations at some wavelengths began in 2003, other wavelengths began later in the mission.

Ratio of center of FOV to edge was normalized to beginning of the mission up to version 16.

Illumination on primary mirror and grating is not the same for solar and stellar modes.

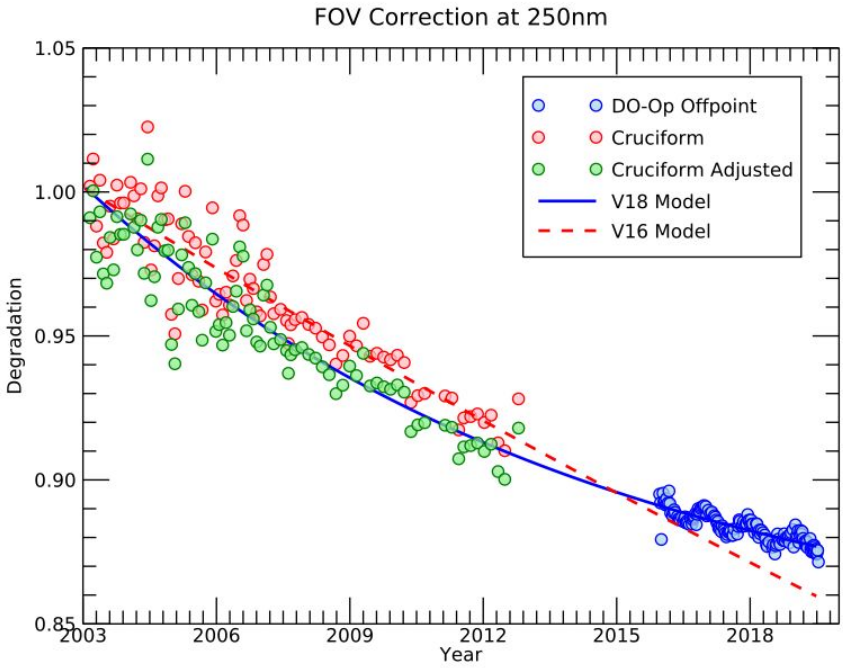
An additional degradation correction from field of view measurements is required.

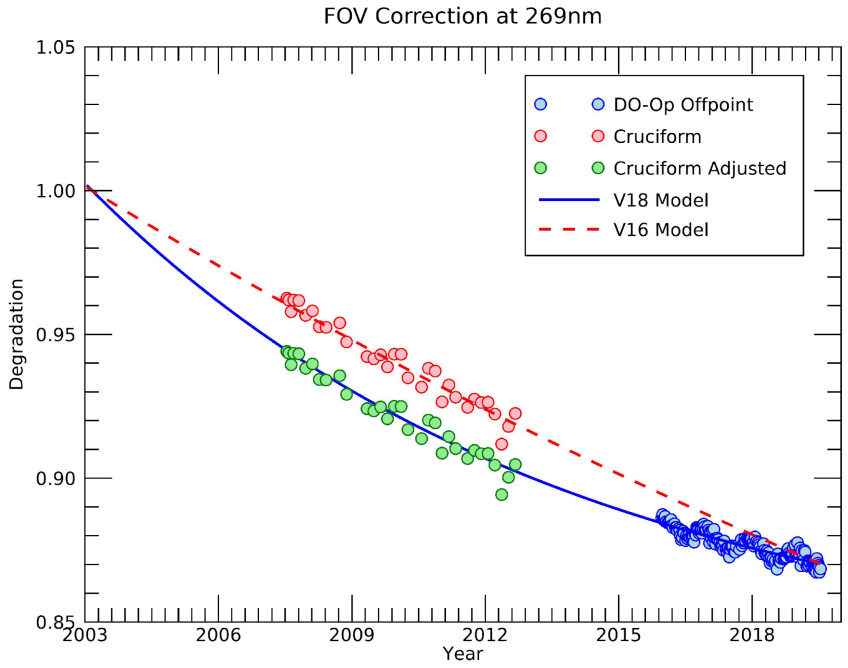
Needed to revise for DO-Op

- Spacecraft operation starting in 2014 changed dramatically.
- Day Only Operation (DO-Op, Woods et al. 2021)
- Weekly spacecraft slews were no longer possible.

- Replacement operation was to offpoint the spacecraft and take an entire spectrum.
- Con: only sample one spot on the “haystack”
- Pro: measure entire wavelength range rather than 4 or 8 discrete wavelengths

DO-Op trend did not match…





Red dashed line is a fit to the earlier observations.
Does not agree with DO-Op measurements (blue).
Remember: Data was arbitrarily normalized to be unity at the start of the mission.
Allowing that scaling factor to be a fitting parameter produces the blue curve that fits all of the data.

Summary for V18

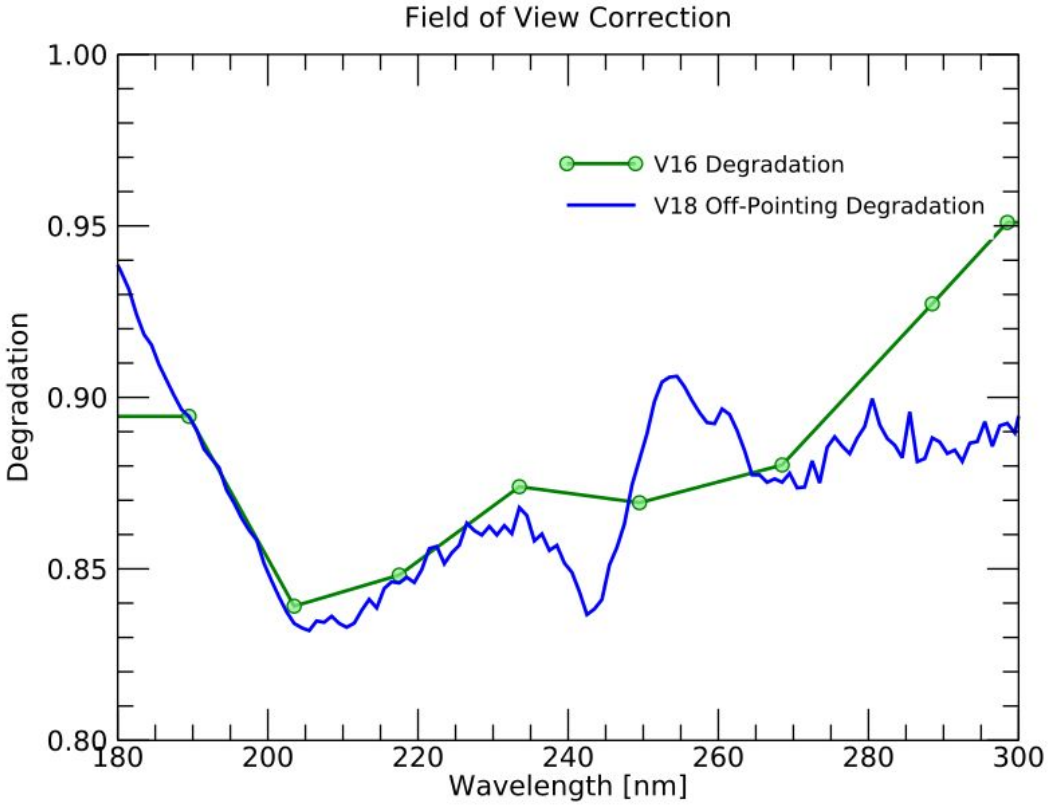
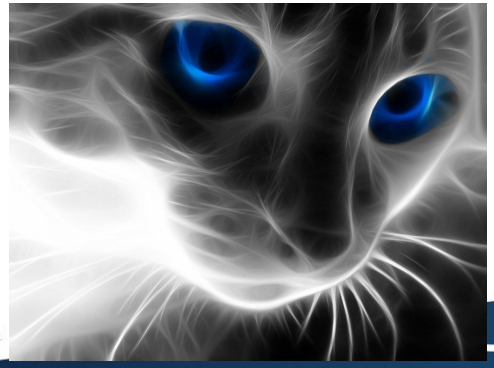


Table 1. Estimates of uncertainty in SOLSTICE degradation correction as a function of time for the MUV channel. The uncertainty in comparing any two SOLSTICE measurements depends on the time interval between them.

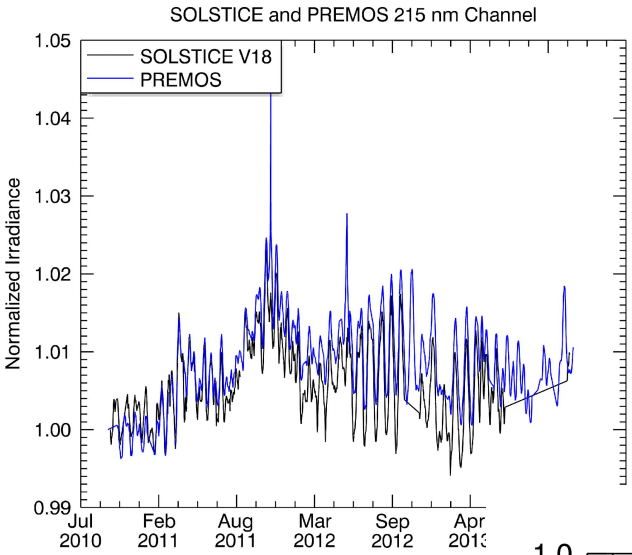
Component of degradation	Estimated trend uncertainty
Stellar correction	~0.1%/year
FOV correction	~0.2%/year
AB-Comparison correction (SOLSTICE A MUV Only)	~0.2%/year
Combined uncertainty:	~0.3%/year

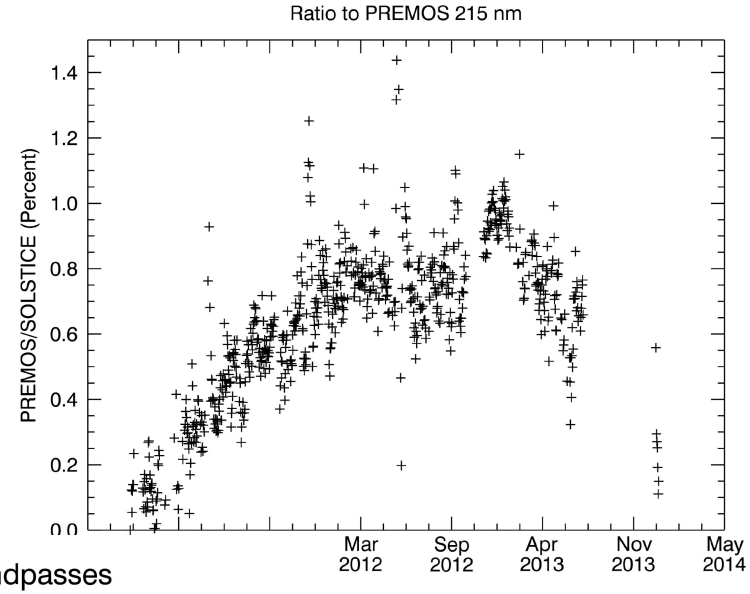
FUV stability 0.1%/year
MUV stability 0.3%/year

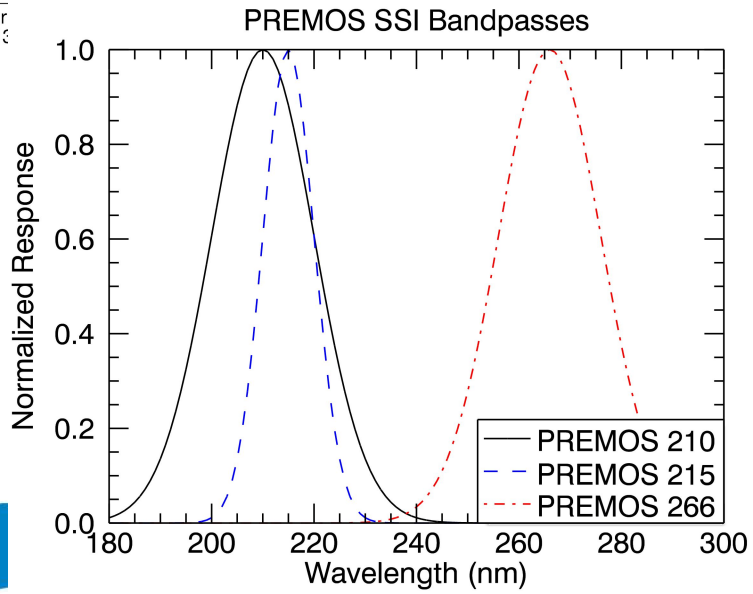


Validation of Final Version!

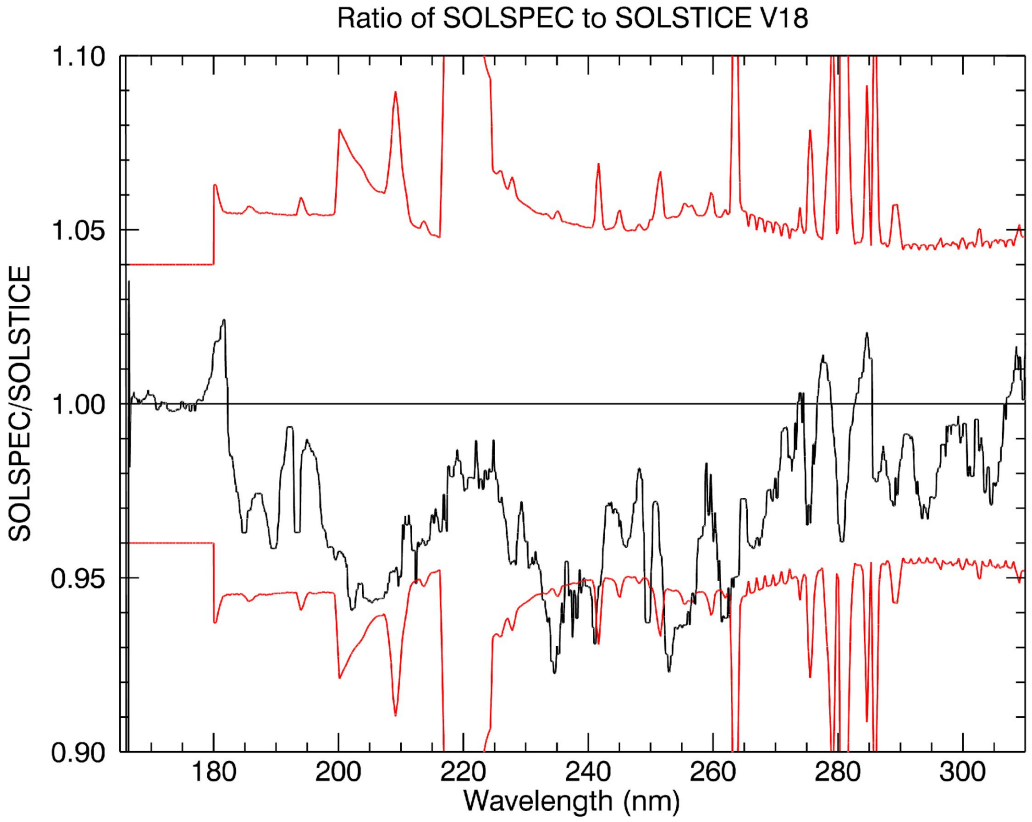
Picard/PREMOS







SOLAR/SOLSPEC

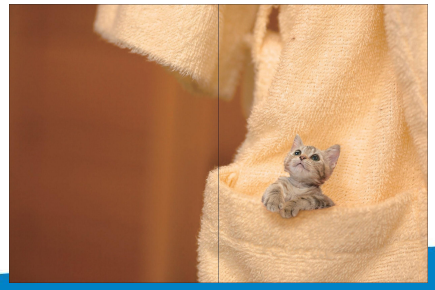


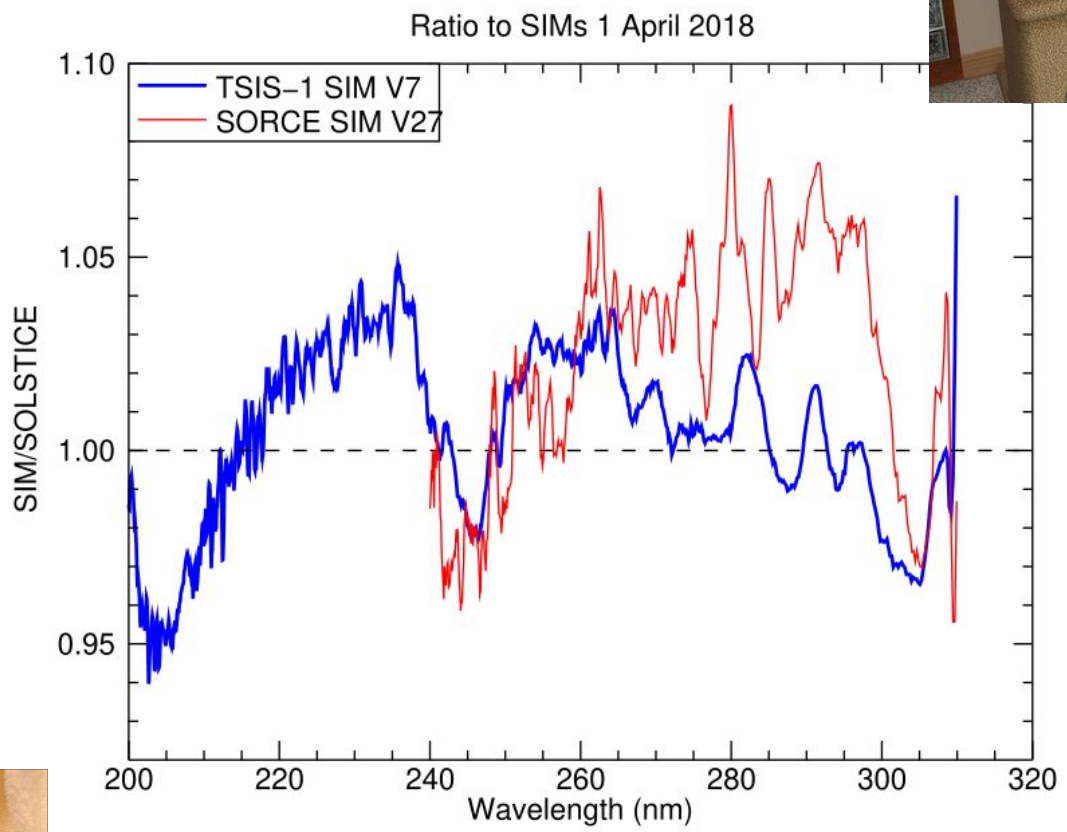
Ratio of SOLSTICE to “first light” SOLSPEC spectrum April 2008
Red curves mark upper and lower uncertainty envelopes.

The SIMs

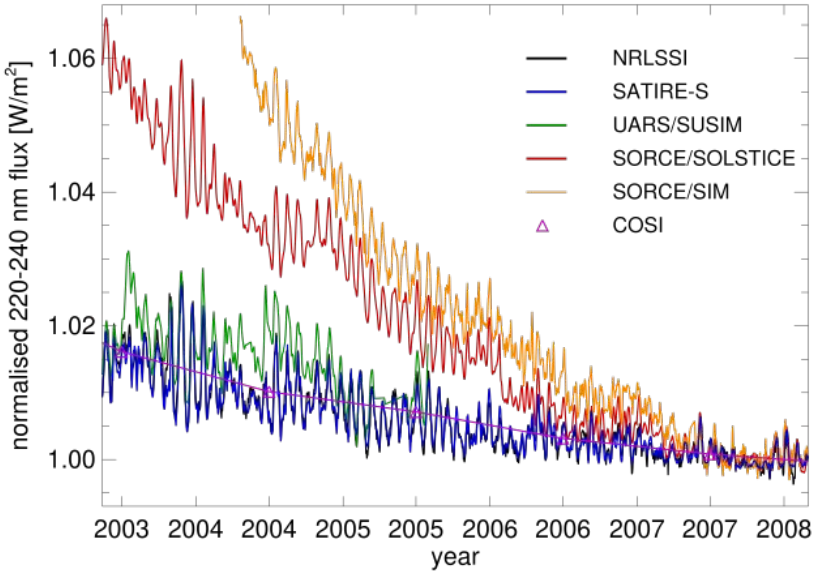
Uncertainty in SOLSTICE stability after 15 years is about 5%, so this agreement is well within the combined uncertainty.

Uncertainty of TSIS/1 SIM on this date is very small.

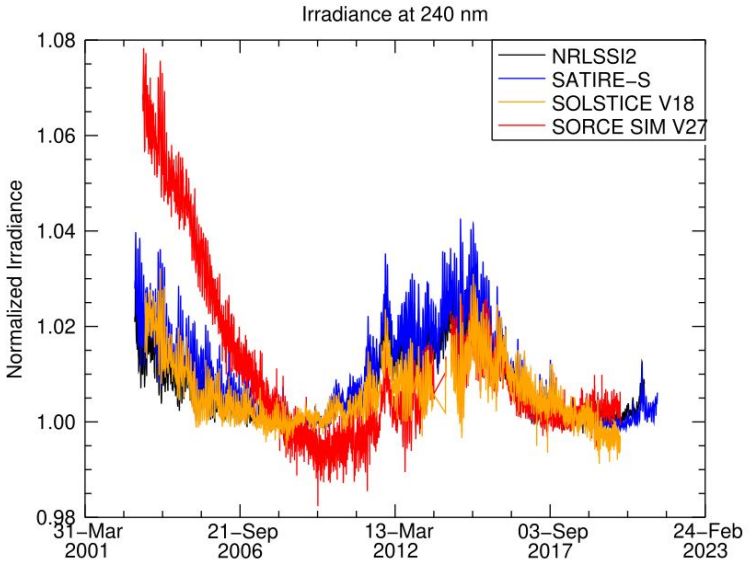




UV Time Series



From Ermolli et al. (2013)

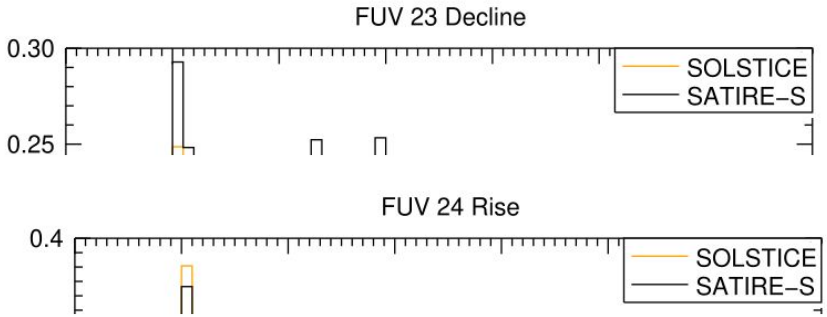


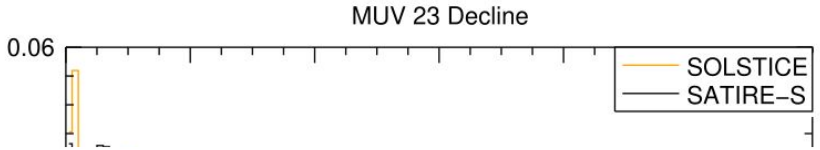
From Snow et al. (2022)

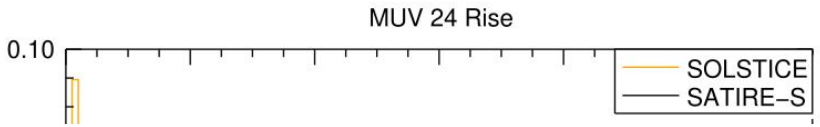
Controversy over long term trends early in the SORCE mission has now been reduced due to improved FOV correction.

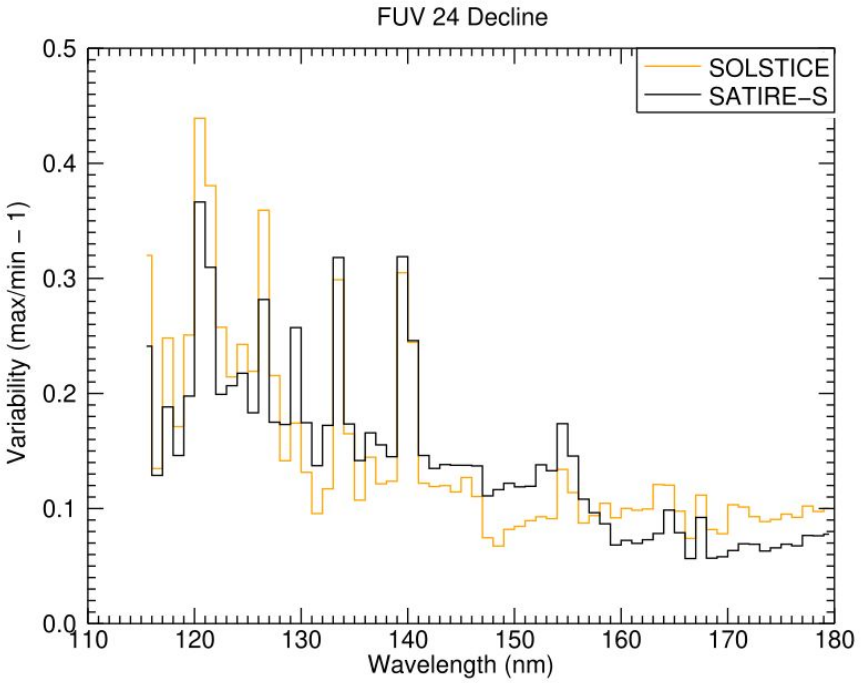
Using solar cycle dates as defined in Woods et al. (2022)

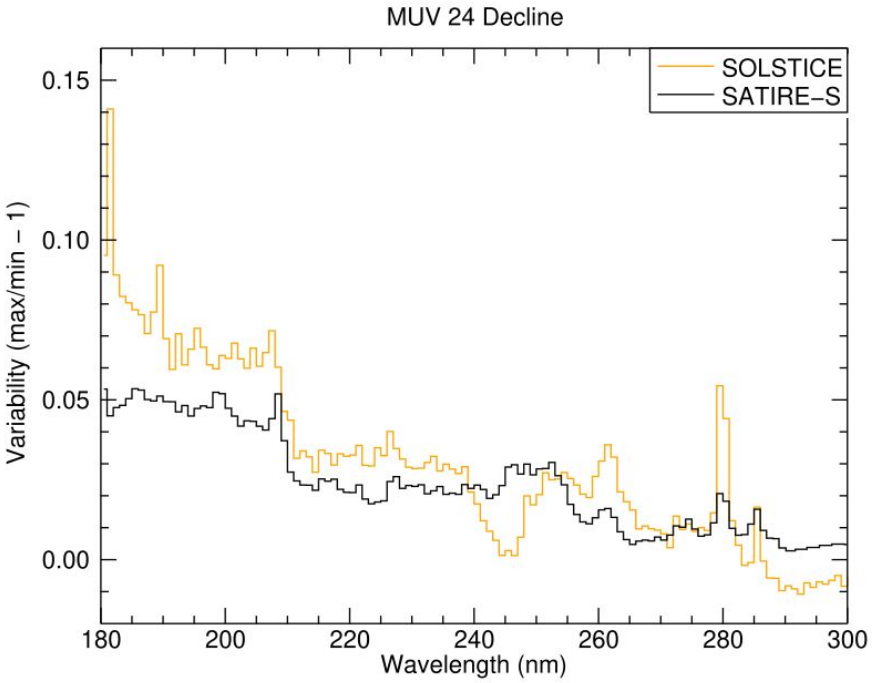
Comparison to SATIRE-S



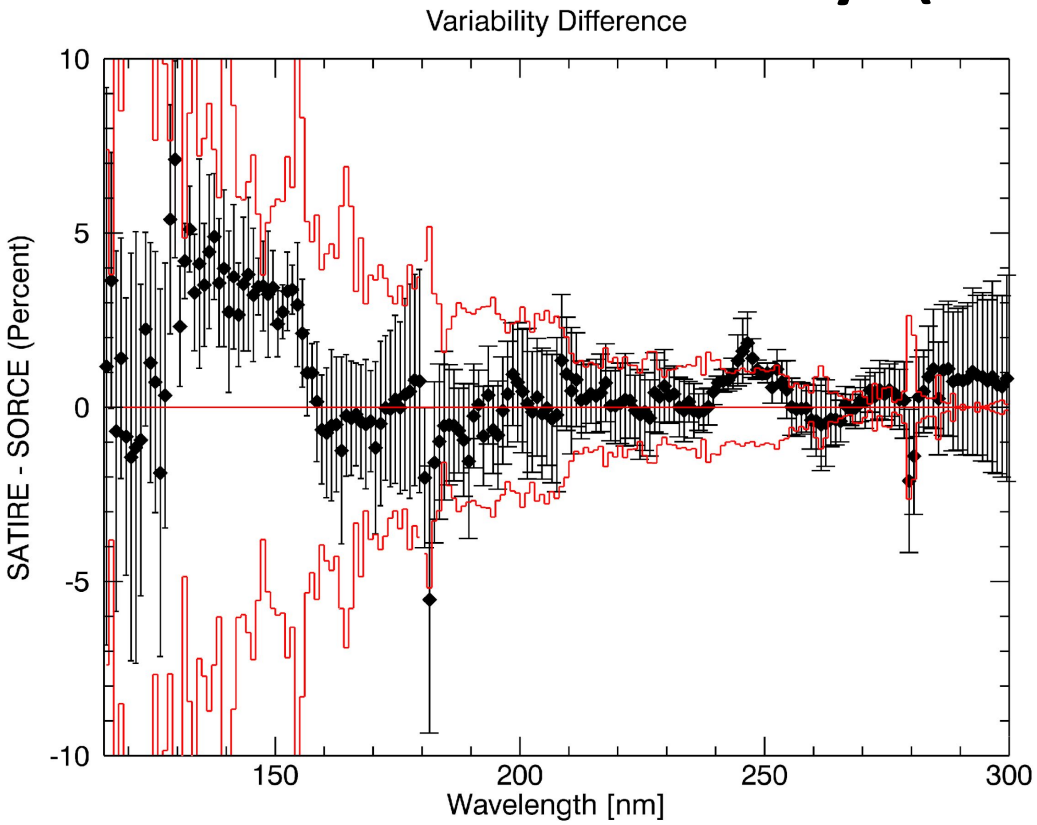








SATIRE-S Summary (S^3)



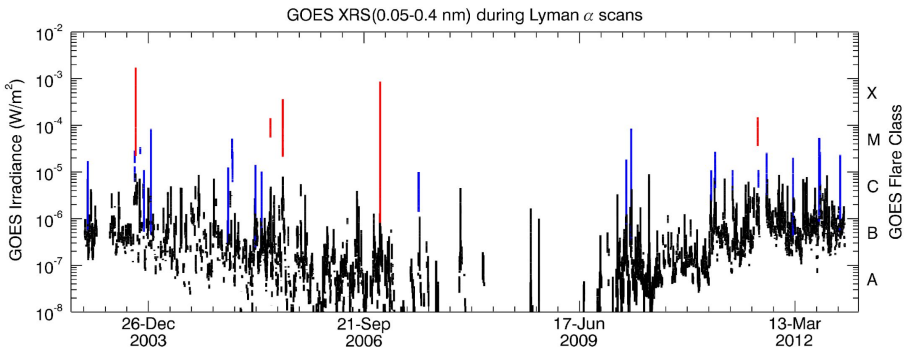
Black points are average difference between SOLSTICE and SATIRE-S for the three intervals from the previous slide. Error bars are the standard deviations. The red curve shows the solar cycle variation. Differences are smaller than the SC variation below about 260 nm.

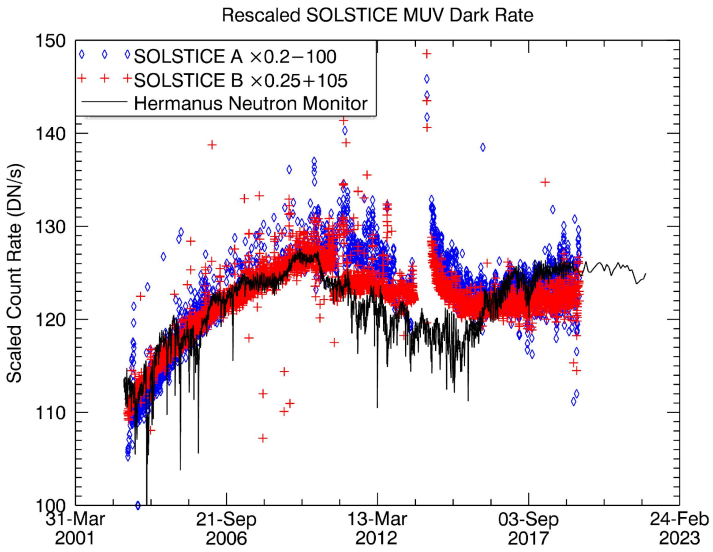
Summary

- SOLSTICE successfully measured UV SSI throughout the SORCE mission
- Version 18 degradation corrections solve the previous controversies
  - Good agreement with simultaneous measurements
  - Good agreement with empirical models
- Results now published!

Future SOLSTICE Projects

- Progress in Understanding Ultraviolet iRRadiance (PUURR), part of the SIST-3 program.
- Lyman alpha high cadence observations from SORCE SOLSTICE
- Radiation Environment Observed by SORCE SOLSTICE





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Thank You