High-Spectral Resolution SORCE SOLSTICE Degradation Model and Improved Irradiance Data Products

Joshua Peter Elliott, Blake Vanier, Marty Snow, Tom Woods
University of Colorado Boulder – Laboratory for Atmospheric and Space Physics (LASP)

Laboratory for Atmospheric and Space Physics
University of Colorado **Boulder**

Abstract

The SOlar Stellar Irradiance Comparison Experiment (SOLSTICE) aboard the SORCE spacecraft performs solar irradiance measurements in the FUV and MUV spectral ranges. In order to properly calibrate the data it is important to understand the evolution of the degradation of the instrument throughout the life of the mission. To first order, the degradation of the instrument is defined as a simple exponential decay model that is wavelength dependent. However, changes in spacecraft operation changed the way in which we measure the degradation of the instrument. Degradation measurements earlier in the mission were only collected at eight different wavelengths in the MUV. Later, higher spectral resolution measurements were collected. We present an algorithm that takes advantage of these new measurements. The new degradation spectrum, in combination with the lower spectral resolution degradation spectrum collected earlier in the mission, is then used to retroactively calibrate the entire mission MUV dataset. The resultant preliminary data products benefiting from this update will also be presented.

Introduction

Prior to the DO-Op (Day Only Operation) phase of the mission, Solar Alignment experiments were conducted at eight defined wavelengths. Each of these experiments consisted of two orthogonally oriented scans, each of which slewed across the solar disc. With each scan a "haystack" is collected, which consists of the detector counts for the full range of slew angles. During normal scans, the center of the detector experiences a higher flux than the edges of the detector and thus is expected to experience a higher degree of degradation. Therefore, this haystack can be used to measure the degradation of the instrument by taking the ratio of the "shoulders" of the haystack, which experiences less solar flux, to the center of the haystack. Repeated measurements over time allow us to fit an exponential decay model to these ratios, which we use to calculate the degradation throughout the mission.

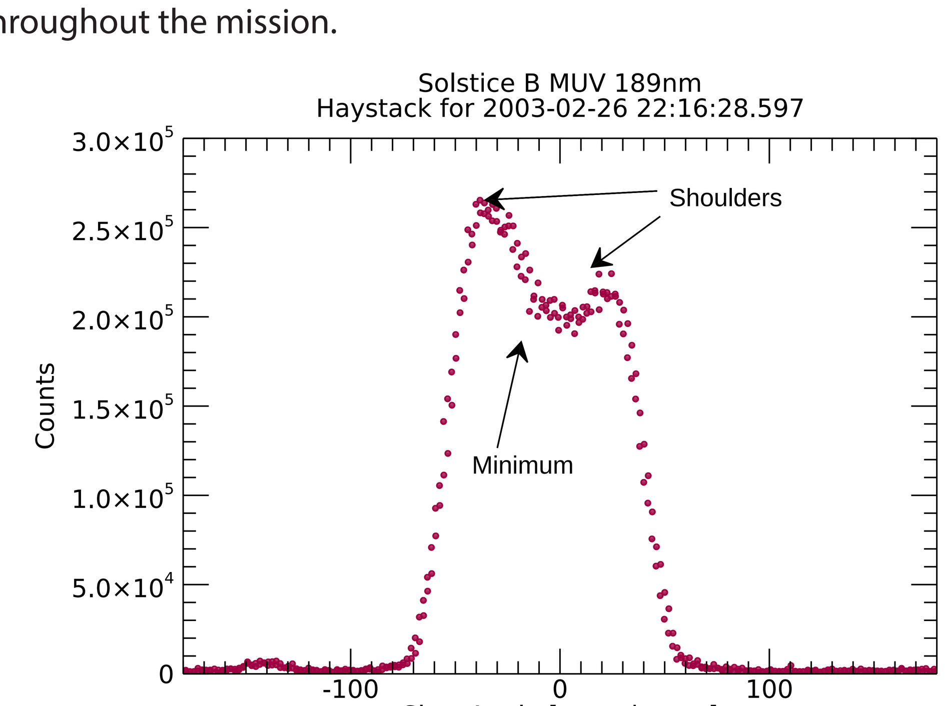


Figure 1. Haystack measurement at 189nm for Solstice B MUV.

Degradation (1)

During the DO-Op phase of the mission, we no longer measure each of these full haystacks. Instead, in order to gain higher spectral resolution degradation measurements, we point the spacecraft 22 arc-minutes off the center of the solar disc (which corresponds to the shoulder of the haystack) and take normal scan data to represent the center of the haystack across the full range of MUV wavelengths covered by SOLSTICE. We refer to these as "off-pointing" measurements.

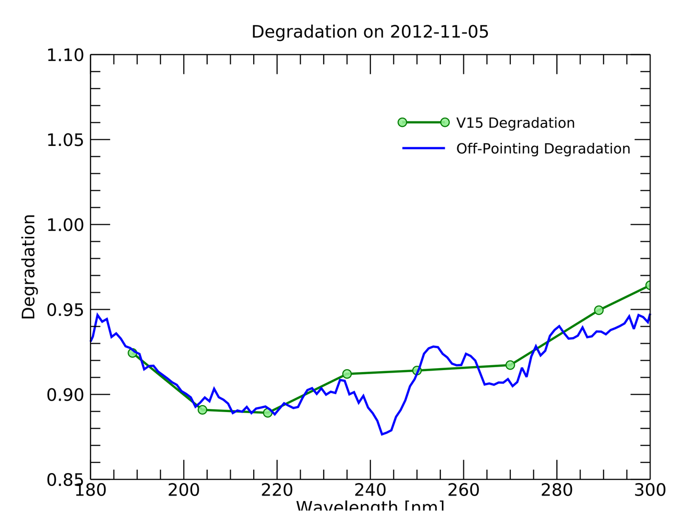
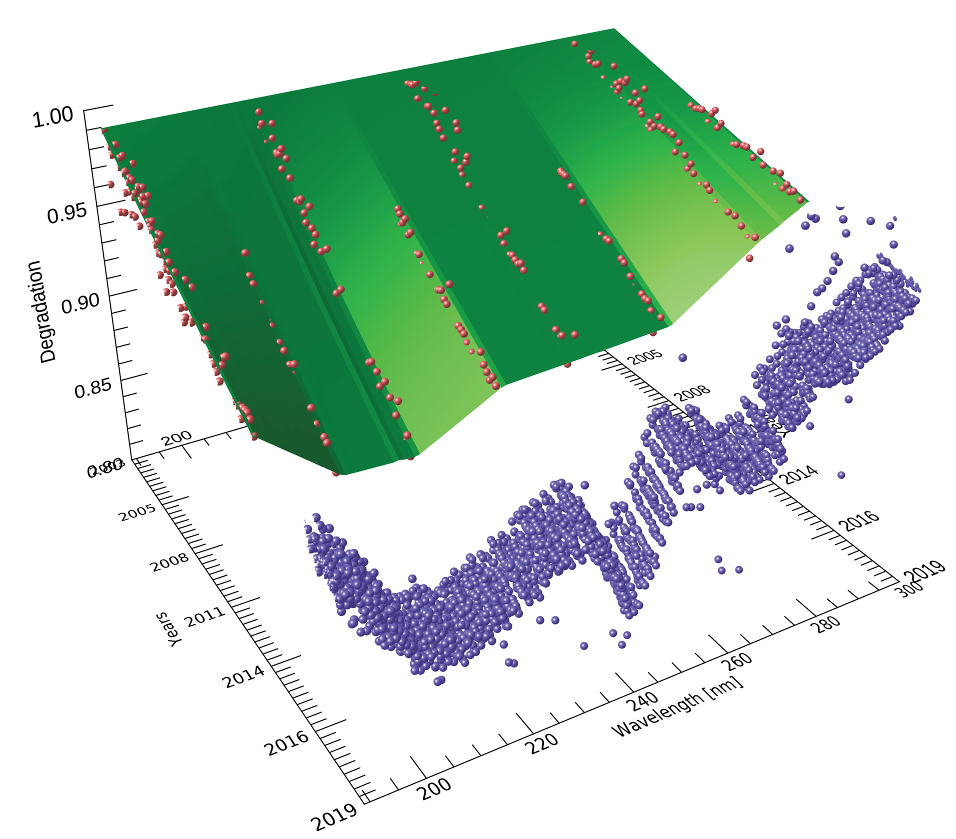


Figure 2. (Left) Example degradation plots for the haystack method and the off-pointing method.

Figure 3. (Below) Degradation surface for pre-DO-Op mode. Haystack degradation and off-pointing degradation points are over-plotted in red and blue respectively.

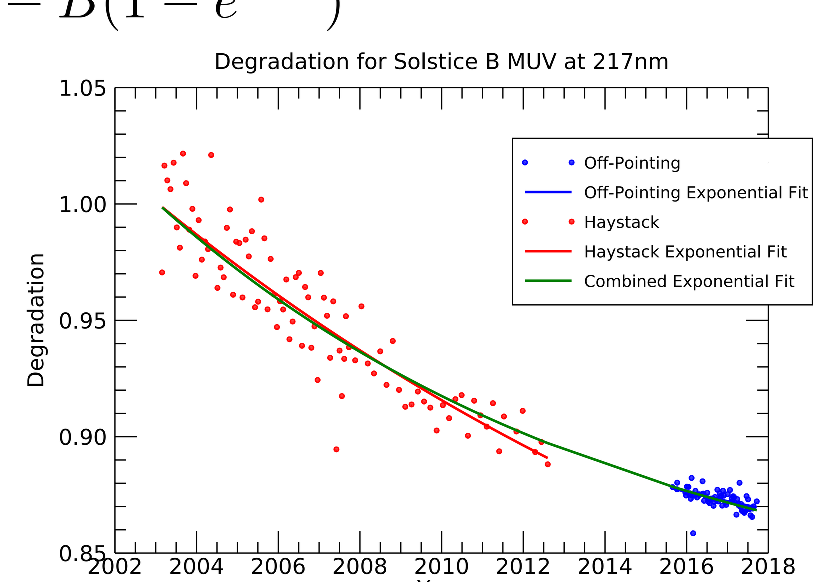


If we wish to use the higher resolution degradation measurements to extrapolate backward in time, we must first define a relationship between the two datasets. We start by defining an exponential model which passes through 1 at the start of the mission with the following form:

$$f(t) = A + Be^{-Ct};\, f(0) = 1$$

$$f(t) = 1 - B(1 - e^{-Ct})$$

Figure 4. (Right) Exponential decay models for each of the haystack and off-pointing methods as well as a combined exponential model.



Degradation (2)

This works well for the wavelengths defined by the Solar Alignment scans. But for wavelengths in-between, we have no haystack degradation information. Currently, degradation exponentials are linearly interpolated between these values. However, with the new off-pointing degradation measurements we can do better. We can instead use the old linearly interpolated haystack exponential as a guide, to inform a new degradation exponential that passes through the off-pointing measurements for each wavelength.

By holding the decay coefficient constant and adjusting the scale factor B, and passing through the off-pointing points (illustrated in figure 5 by [t',y']), we can adjust the linearly interpolated haystack exponential to come in line with the DO-Op exponential. This allows us to then produce a degradation surface which can be extrapolated backwards in time.

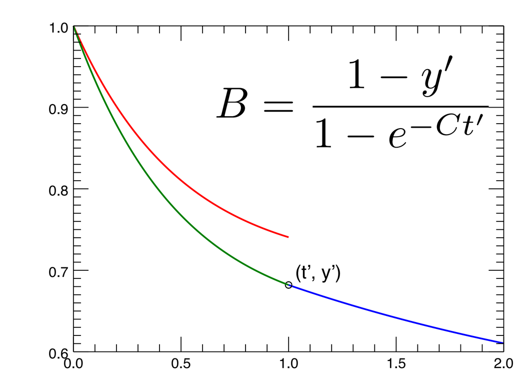


Figure 5. Example plot showing the method described above.

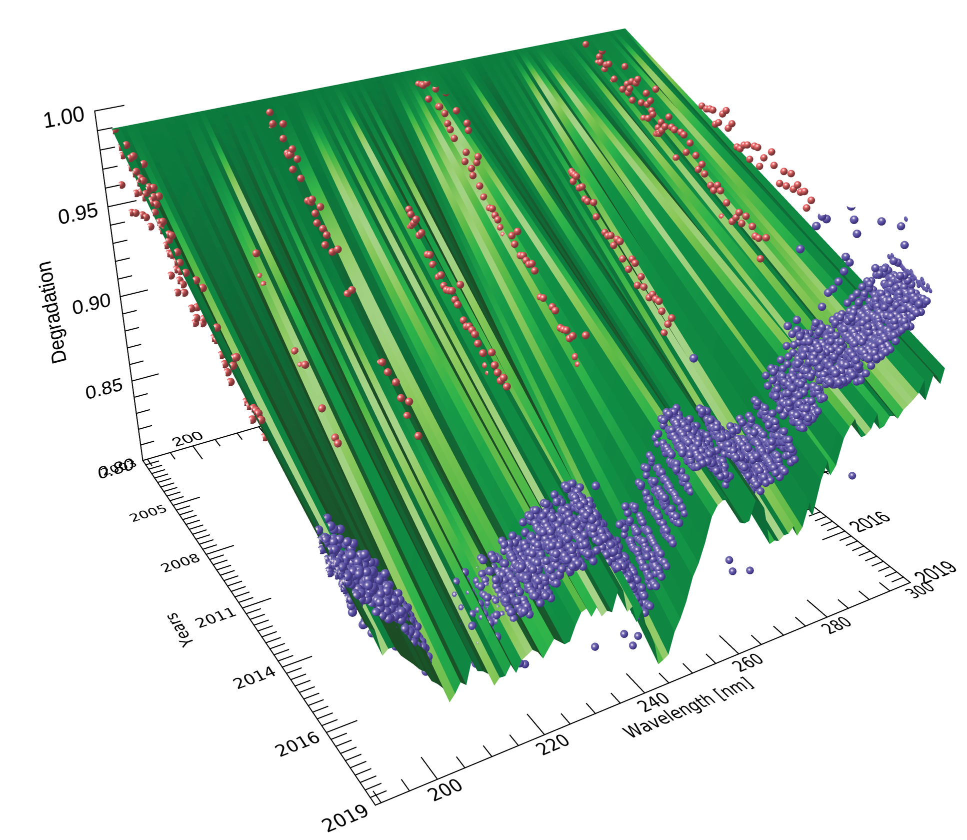
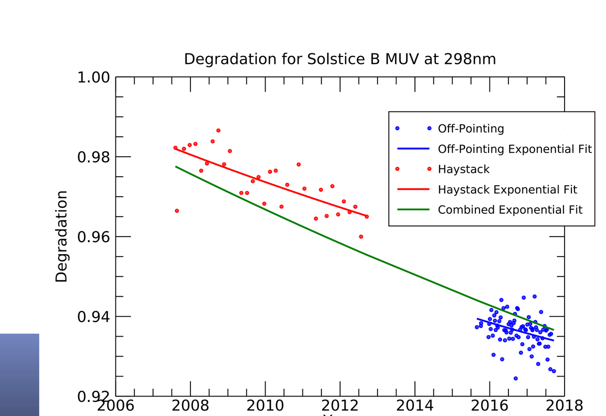


Figure 6. Degradation surface for the entire mission, calculated using both the haystack and off-pointing experiment data.

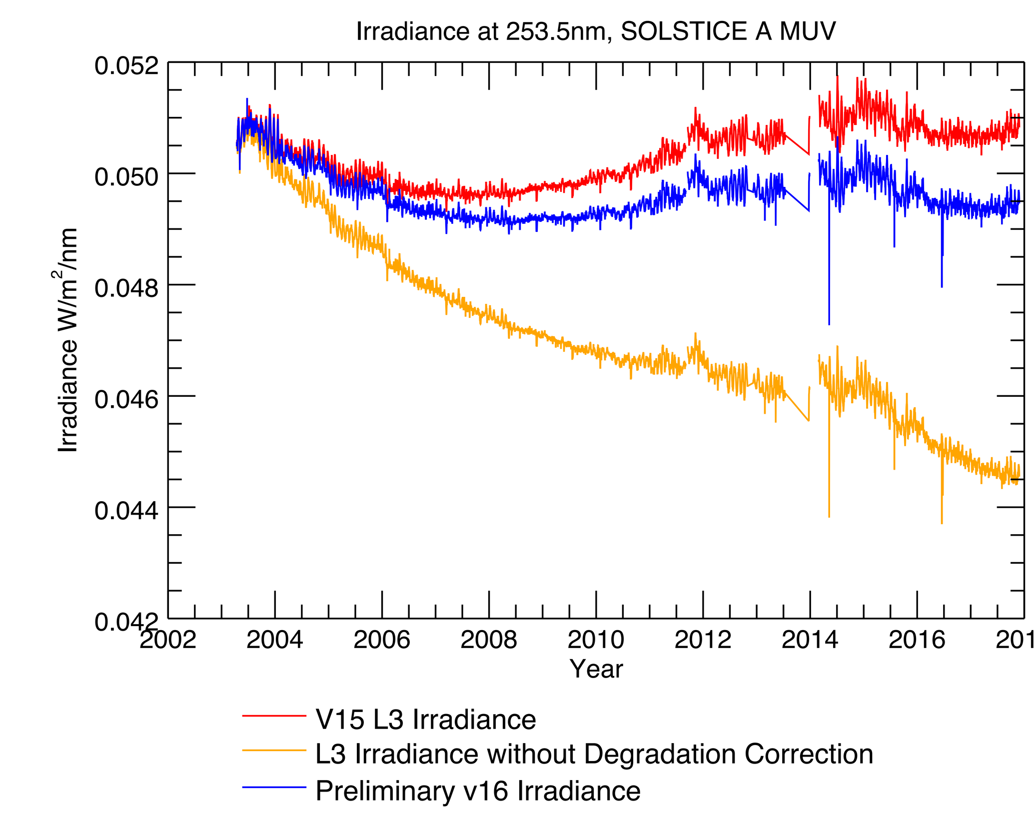
Next Steps

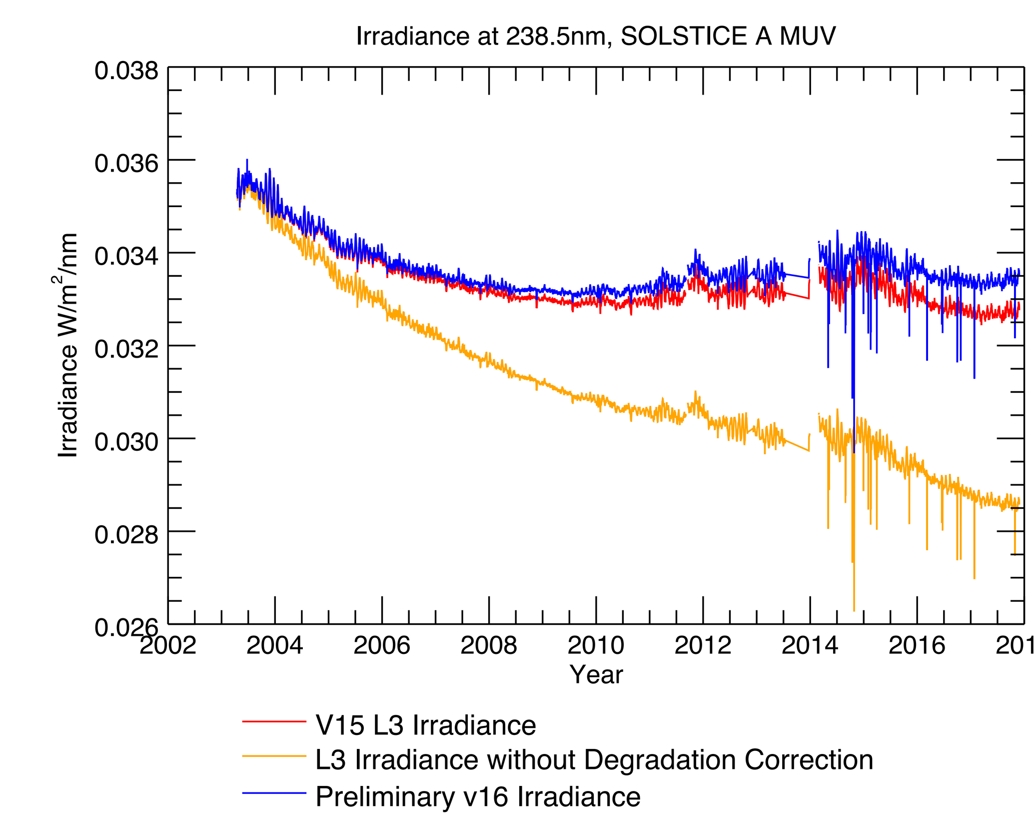
This model does not currently work well for wavelengths longer than about 280nm. We are currently investigating this issue to determine the reason for the disagreement between the haystacks and off-pointing data in this wavelength range. We have also identified possible pointing inaccuracies between Solstice A and B which may be related. This investigation is not yet complete. Once we resolve these discrepancies, a new data product version will be released.

Figure 6. At long wavelengths, the haystack and off-pointing data do not agree.



Results





Figures 7 and 8. Preliminary SOLSTICE MUV V16 Irradiance data product. The new degradation model improves the Irradiance values considerably, removing the upward and downward slopes respectively that were present before due to an over or under estimation of the degradation in the previous model.

Contact

Joshua P. Elliott	joshua.elliott@lasp.colorado.edu
Blake Vanier	blake.vanier@lasp.colorado.edu
Marty Snow	marty.snow@lasp.colorado.edu

https://orcid.org/0000-0002-7209-008X