# Some Results From a New Algorithm for Using Available SDO/EVE/MEGS-A Data as Reference Solar Spectra for the EVE/ESP Absolute Solar Irradiance Calculations

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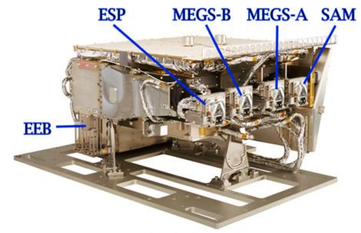
**Abstract**: A problem with the EVE/MEGS-A channel which changed its status from regular observations to a test mode has prompted the development of a new algorithm for EVE/ESP data reduction. This algorithm uses MEGS-A spectra measured before the problem occurred as reference spectra for determining irradiance values from EVE/ESP measurements taken after MEGS-A was put into test mode. We describe some results from our evaluation of this new algorithm using a number of available daily averaged MEGS-A spectra representing different levels of solar activity determined based on the ESP quad-diode effective count rates.

## I. Introduction:

The Multiple EUV Grating Spectrographs-A (MEGS-A) channel on the EUV Variability Experiment (EVE)[1] provided solar spectral irradiance measurements in the 6.0 to 37.0nm range with 10 sec time cadence and 0.1nm resolution[2] from 30 April 2010 until 26 May 2014 at which point its normal science operations ceased and it was put into a test mode due to a power supply malfunction. The EVE EUV Spectrophotometer (ESP)[3] channel continues to provide integrated irradiance with 0.25 sec time cadence in several spectral bands between 0.1 and 34nm. Prior to the MEGS-A anomaly, MEGS-A hourly average spectral distributions were used in ESP data processing to provide a spectral weighting for the ESP response functions for channels 2 (22.28 to 28.78 nm), 8 (16.64 to 21.5 nm), and 9 (27.16 to 33.8 nm). Daily average MEGS-A spectra were used to determine contributions to the signals in these channels from higher diffraction orders. Without MEGS-A, it has been necessary to find an alternative source of reference spectra for these data processing purposes. Establishing spectral distributions to interpret broadband measurements is a long standing problem that needed to be addressed, for example, with the Solar EUV Monitor (SEM[4]), an instrument similar to ESP that is on the Solar and Heliospheric Observatory (SOHO). Before the continuously measured EUV spectra of EVE were available, a single fixed reference spectrum (SOLERS22[5]) was used for SEM, but it was found in later investigations[6] that the accuracy of the SEM irradiance values could be improved through the use of time/activity-dependent reference spectra. Thus, for the new ESP algorithm we have adopted a system of multiple (11) reference spectra each representing a different level of activity.




The EUV Variability Experiment on SDO

## II. Assessment of daily solar Activity Level based on ESP Quad Diode (0.1-7 nm band) measurements

**Table 1:** For each day of ESP data to be processed a discrete activity level (numbered 0 to 10) is assigned based on the daily average ESP zeroth order quad diode (QD) effective count rates (raw counts corrected for dark current and time-dependent degradation) according to the ranges in the left column

| QD daily average effective count rate range (counts/0.25 sec) | Associated Activity level |
|---|---|
| Less than 100 | 0 |
| Between 100 and 336 | 1 |
| Between 336 and 536 | 2 |
| Between 536 and 736 | 3 |
| Between 736 and 936 | 4 |
| Between 936 and 1136 | 5 |
| Between 1136 and 1336 | 6 |
| Between 1336 and 1536 | 7 |
| Between 1536 and 1736 | 8 |
| Between 1736 and 1936 | 9 |
| Greater than 1936 | 10 |

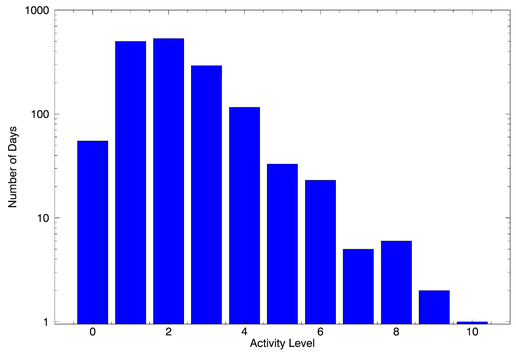



**Figure 1:** Histogram showing the number of days within each of the 11 activity levels defined based on ESP daily average QD effective count rates (as shown in Table 1). The plot covers the interval from 30 April 2010 through 26 May 2014.

## III. MEGS-A based reference spectra determined for each Activity Level

For each of the 11 activity levels a corresponding reference spectrum is determined by averaging previously measured MEGS-A spectra for one to three of the days for which the ESP QD effective counts are within the associated range.

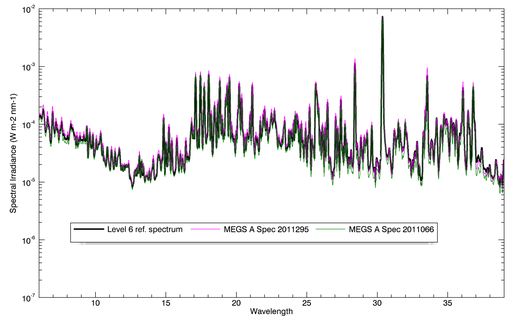



**Figure 2:** As an example, the black curve shows the reference spectrum used for days within activity level 6. The reference spectrum is compared to daily MEGS-A spectra for day of year (DOY) 295 (pink curve) and DOY 66 (green curve) at the upper and lower extremes of the Level 6 activity range.

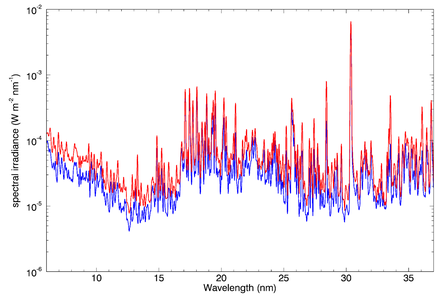



**Figure 3:** A comparison of reference spectra for the lowest activity level (level 0, blue curve) and the highest activity level (level 10, red curve).

## IV. Results

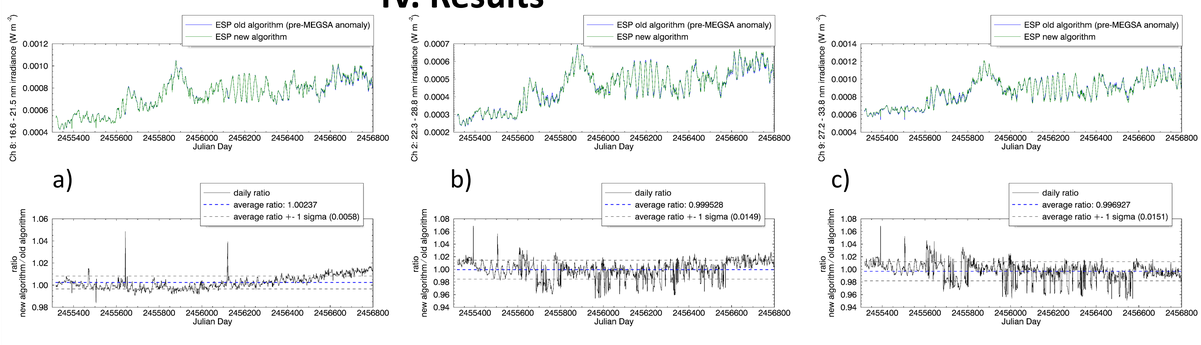



**Figure 4:** Comparisons of ESP irradiances calculated using the new algorithm (green curve, top panels) to those calculated using the old, pre-MEGSA-anomaly, algorithm (blue curve, top panels) for **a)** channel 8 in the 16.6-21.5 nm band, **b)** channel 2 in the 22.3-28.8 nm band, and **c)** channel 9 in the 27.2-33.8 nm band. Ratios of daily irradiance (black curves - new algorithm/old algorithm) are shown in the bottom panels along with the mean ratio (dashed blue line) and standard deviation (black dashed line) over the time series. The plots cover the interval from 30 April 2010 through 26 May 2014 during which MEGSA was in operation.

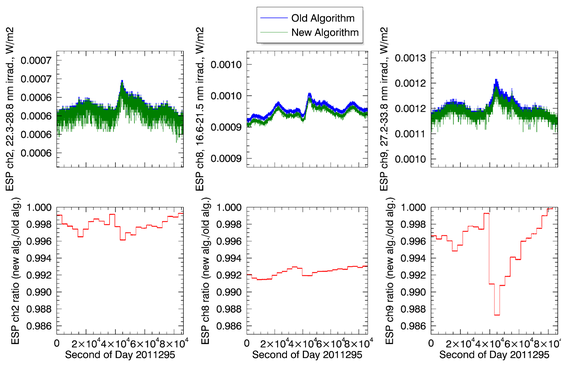



**Figure 5:** Example comparisons of high time-cadence ESP irradiances calculated using the old (green curve, top panels) and new (blue curve, top panels) algorithms for ch2 (left), ch8 (middle), and ch9 (right) on DOY 295 of 2011 with C2.5 and M1.3 class flares at around $1.5 \cdot 10^4$ and $4 \cdot 10^4$sec, respectively. Rapid changes in spectral distribution during flares lead to slightly greater differences between the old and new algorithms as is evident from ratio values in the bottom panels which are farther from 1.0 around the times of the flare peaks. Hourly steps in the ratio values are related to the use of daily average reference spectra in the new algorithm versus hourly average reference spectra in the old algorithm.

## V. Conclusions

A set of reference spectra representing different solar activity levels and a new data processing algorithm have been established for determining EVE/ESP irradiance values without the use of concurrently measured MEGSA spectra. Over the period for which MEGSA was in operation, daily average ESP irradiances calculated using the new algorithm are in very good agreement with those calculated using the old algorithm with a mean ratio (new algorithm/old algorithm) of 1.00 and a standard deviation from the mean ratio of less than ~ 1.5% for each of the ESP first order channels 2, 8, and 9, for which the MEGSA spectra were used.

Acknowledgments:

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References:

[1] Woods et al., 2012, *Solar Phys,* **275**, 115
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[5] Woods et al., 1998, *Solar Electromagnetic Radiation Study for Solar Cycle 22*, Kluwer, Dordrecht, 511
[6] Wieman et al., 2014, Solar Phys, **289**, 2907