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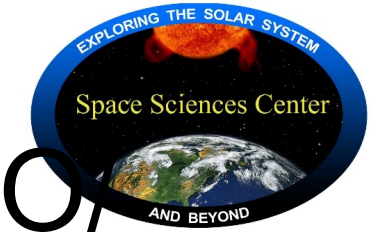


SDO/EVE/ESP and SOHO/SEM Inter-Calibration and Degradation

Inter-Calibration and Degradation of EUV Instruments
June 10 to 13, 2014
Royal Observatory of Belgium, Brussels, Belgium

Seth Wieman, Leonid Didkovsky

Overview

a) Slides 3 and 4: Analysis of SEM and ESP degradation based on ESP daily calibrations and comparison with MEGS;

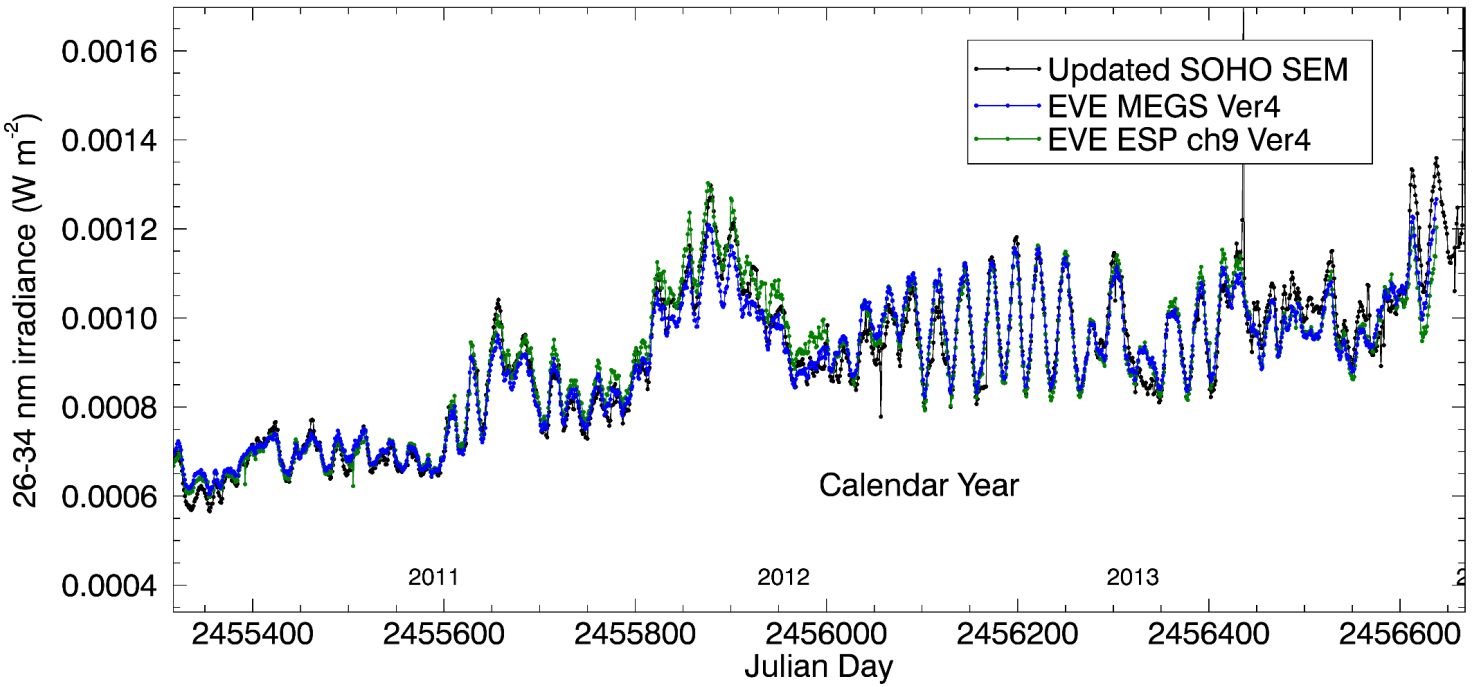
b) Slides 5 and 6: reference spectra and second order during flare times;

c) Slide 7: evolution of Voltage to Frequency Converter (VFC) full-scale frequency;

d) Slides 8 and 9: Evolution of ESP darks;

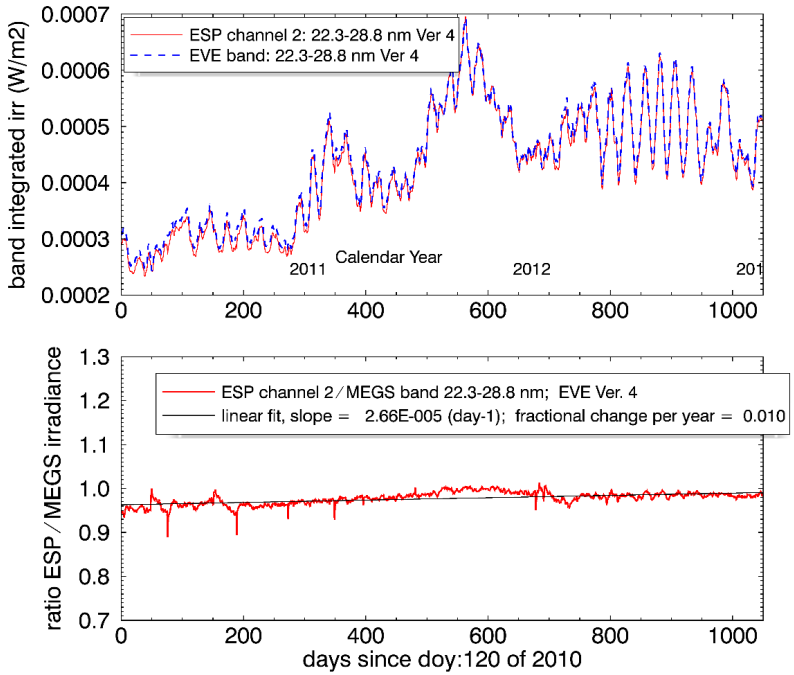
e) Slides 10 and 11: Progress in SEM first order absolute irradiance based on more accurate degradation and SR flights.

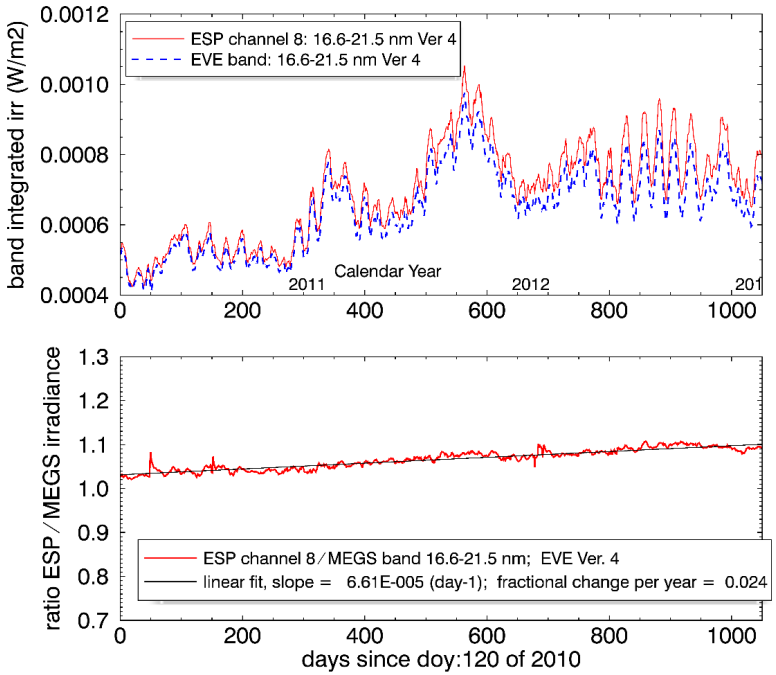
EVE Ver. 4 Daily Average Comparison: 26-34nm band from MEGS, ESP ch9, and SOHO/SEM



For the 26-34 nm band the EVE MEGS and EVE ESP Version 4 irradiances are in good agreement. They are also in good agreement with SOHO SEM first order irradiances calculated using the updated approach reported in Wieman, Didkovsky, and Judge, (Solar Phys 2014) and using the FISM model spectra (Chamberlin, et al., 2007) as reference spectra.

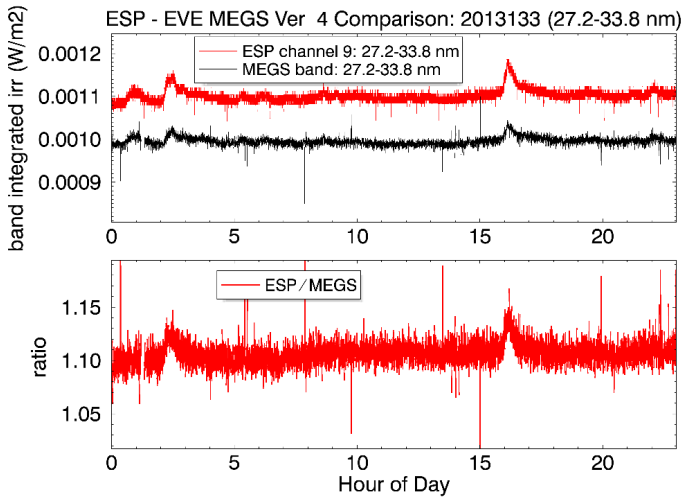
EVE Ver. 4 Daily Average Comparison: MEGS and ESP; band from MEGS, ESP ch2

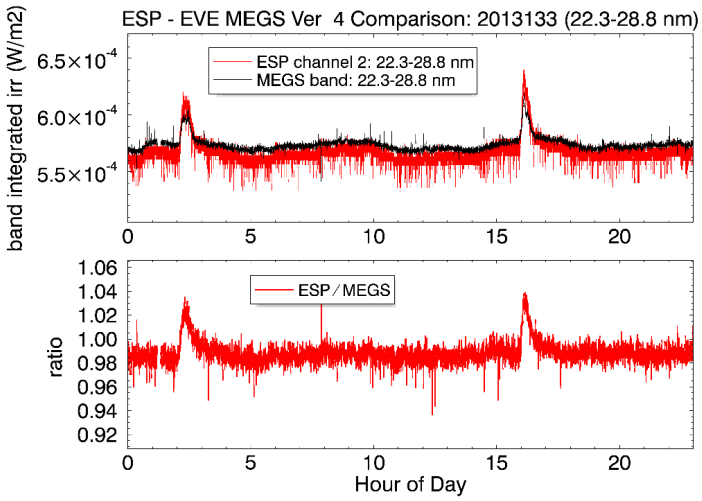


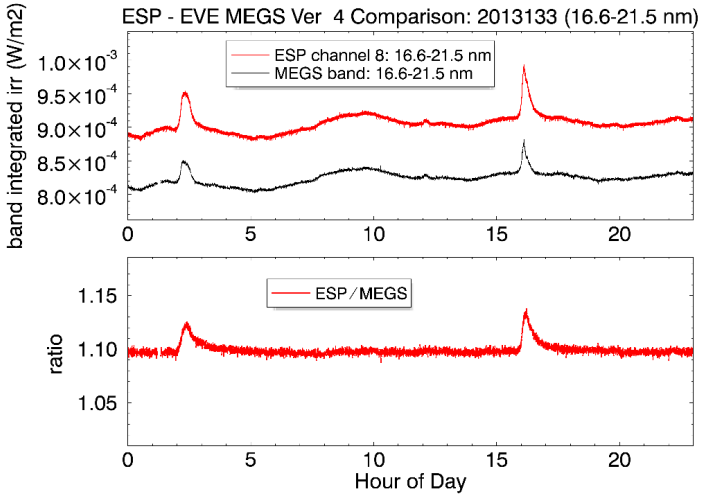


For both the ESP ch9, 26-34nm (previous slide) and ESP ch2 16.6-21.5nm absolute differences and long term trends compared to MEGS have been reduced between EVE Ver. 3 and Ver. 4. For ESP ch8 16.6-21.5 nm the trend and differences are about the same between EVE versions 3 and 4, although the long term trend has reversed direction – ESP is increasing relative to MEGS in Version 4.

EVE Ver. 4 MEGS, ESP flare comparisons

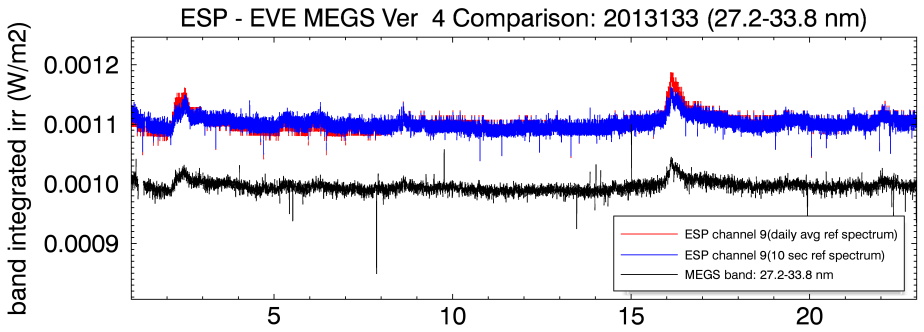


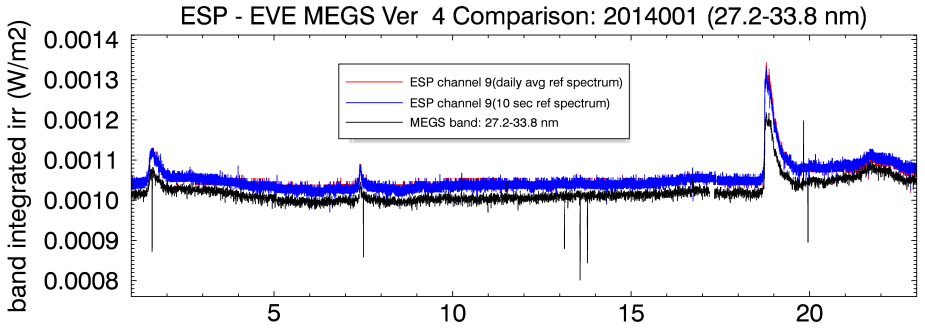


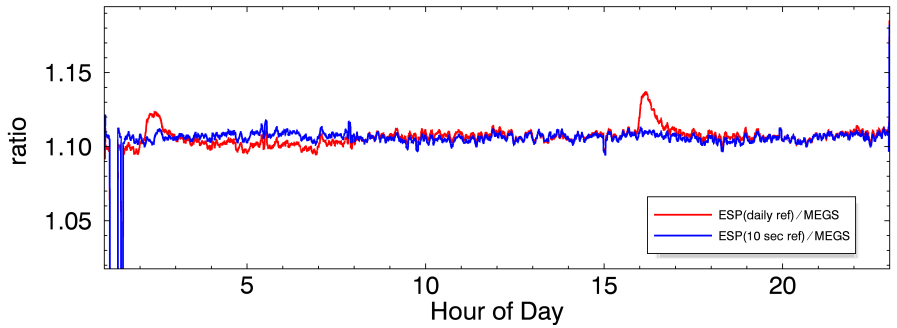


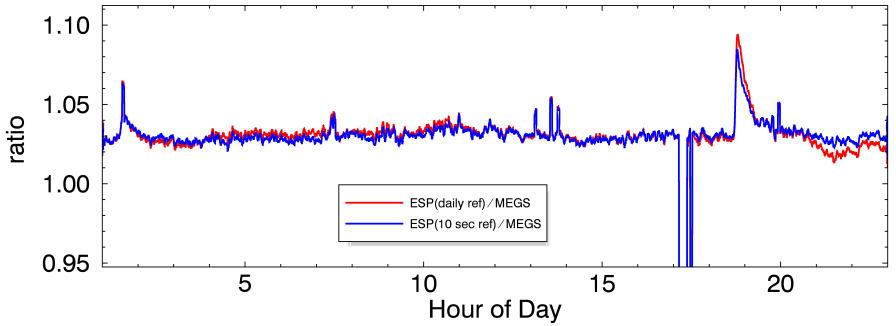
For all three of the ESP first order channels, the ESP flare response (i.e. peak irradiance relative to pre-flare irradiance) is typically greater than that for MEGS.

EVE Ver. 4 MEGS, ESP flare comparisons



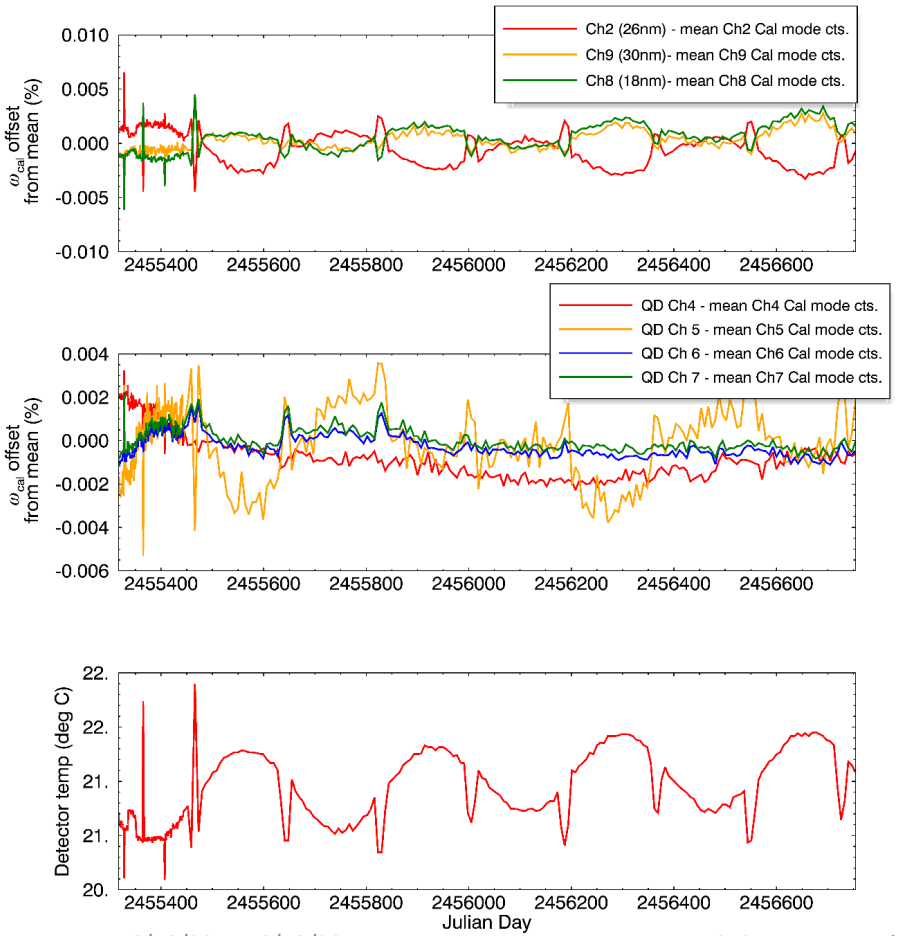






The difference in flare response between ESP and MEGS (previous slide) can be eliminated for some flares by processing the ESP data using MEGS reference spectra at their full 10-sec time resolution rather than using a daily average MEGS spectrum (e.g., for x-class flares on doy: 2013133 at left) but not for all flares (e.g., for doy: 2014001 at right)

Minimal change in ESP electrometer full-scale frequency

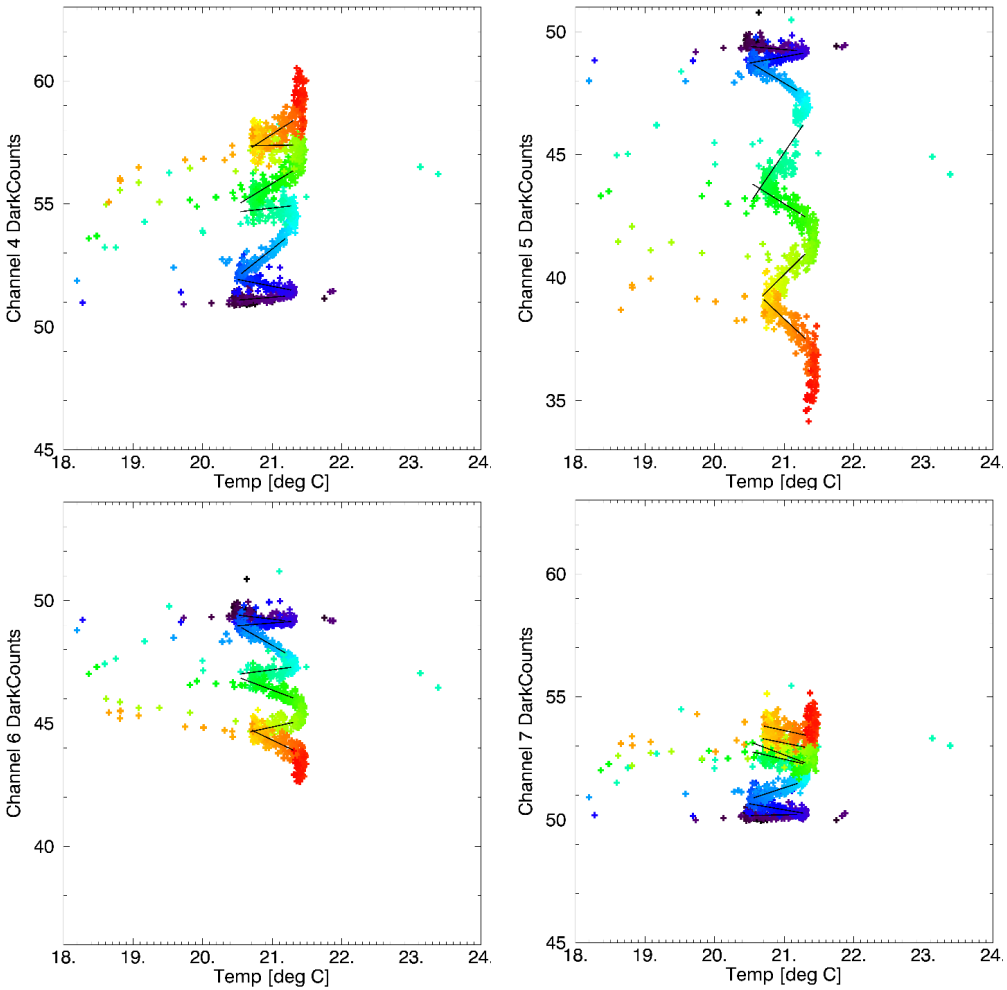


Weekly measurements of the full-scale frequency (i.e. "calibration mode" frequency) of the Voltage to Frequency Converters on the ESP channel electrometers indicate that this value remains quite stable for all channels.

The top (first order channels 2, 8, 9) and middle (zeroth order channels 4, 5, 6, 7) plots at left show the calibration mode frequency, ω_{cal}, percent offset from the mean (calculated as: $[\omega_{cal} - \text{mean}(\omega_{cal})]/\text{mean}(\omega_{cal})]$ x 100%) for all in-flight calibration measurements between April 30, 2010 and April 6, 2014.

Daily average temperature over the same period is shown in the bottom panel.

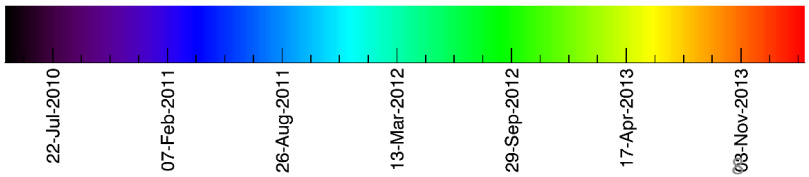
ESP Dark Currents vs. Time and Temperature



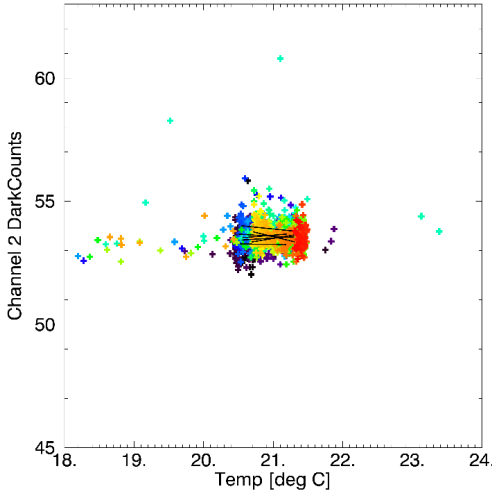
Zeroth Order Quad Diode (QD) channels

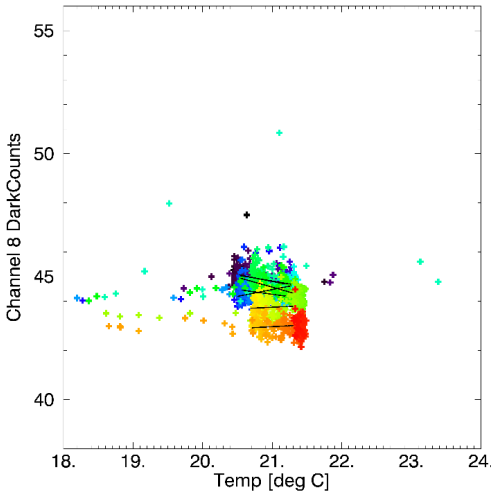
Daily dark measurements are shown for the ESP zeroth order QD channels. Data point color indicates the date of the dark measurement according to the color bar below. Black lines show the linear trend of dark counts vs. temperature for each transition back and forth between perihelion and aphelion.

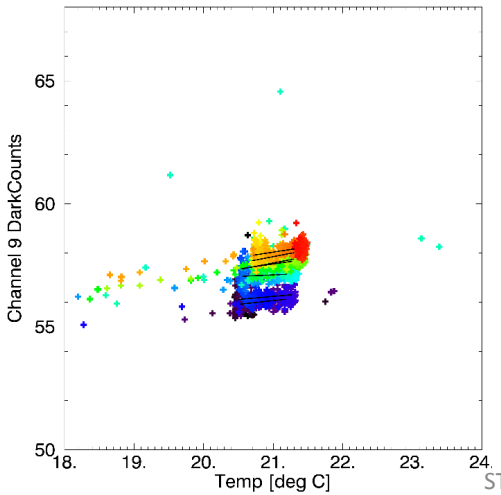
Channel 5, for which an abrupt shift in dark counts occurred following a mid-2012 proton event, continues to show the greatest change in dark counts (the ordinate scale is the same among plots).



ESP Dark Currents vs. Time and Temperature



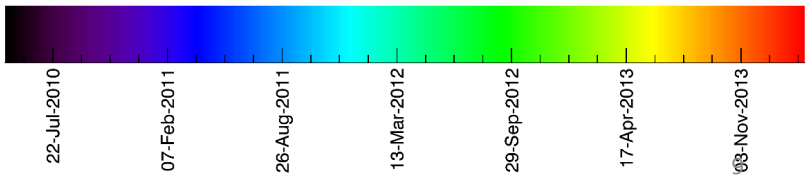




First Order channels 2, 8, and 9

Daily dark measurements are shown for the ESP first order channels. Data point color indicates the date of the dark measurement according to the color bar below. Black lines show the linear trend of dark counts vs. temperature for each transition back and forth between perihelion and aphelion.

The amount of change with time for the first order channels is in general lower than that for the zeroth order channels (the ordinate scale is the same among plots on this slide and those of the previous slide).



Revised SOHO/SEM degradation model

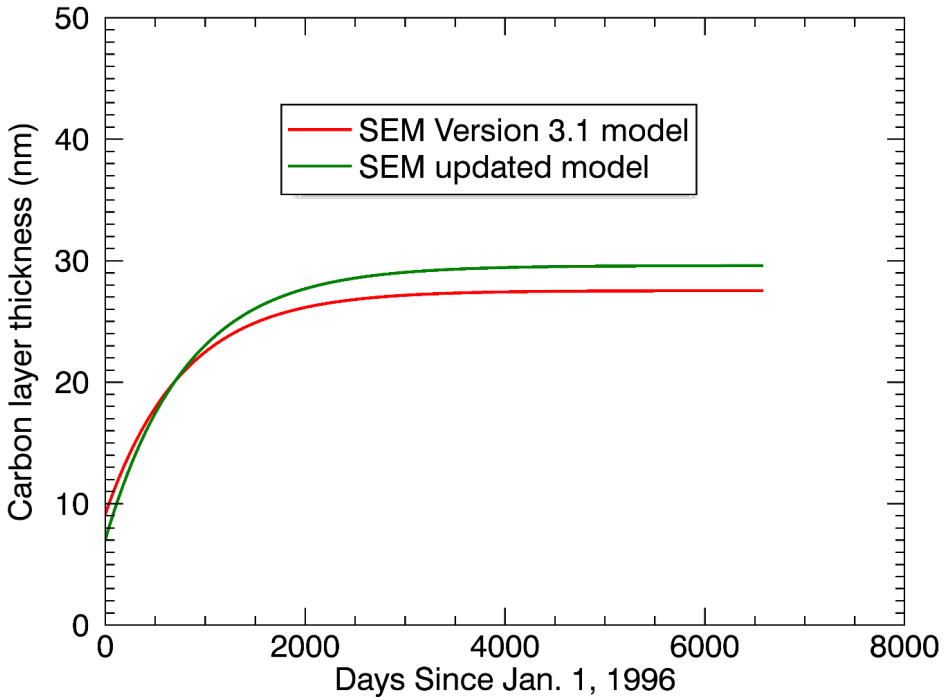
Date	Sounding Rocket Flight number	Calibration Instrument	26-34 nm flux reprocessed (ph/cm2/s)	26-34 nm flux Version 3.1 (ph/cm2/s)	Ratio: Reprocessed/ Version 3.1
26 June 1996	36.147	SEM clone	1.13E+10	1.32E+10	0.86
		RGIC	9.71E+09	1.15E+10	0.84
11 August 1997	36.164	SEM clone	1.12E+10	1.28E+10	0.87
		RGIC	1.17E+10	1.36E+10	0.86
18 August 1999	36.181	SEM clone	1.76E+10	2.09E+10	0.84
		RGIC	1.90E+10	2.24E+10	0.85
6 August 2002	36.202	SEM clone	2.25E+10	2.29E+10	0.98
		RGIC	2.21E+10	2.43E+10	0.91
5 December 2003	36.211	SEM clone	1.59E+10	1.75E+10	0.91
		RGIC	1.50E+10	1.67E+10	0.90
3 August 2005	36.227	SEM clone	1.43E+10	1.53E+10	0.94
		RGIC	1.37E+10	1.52E+10	0.90
7 November 2006	36.236	SEM clone	1.11E+10	1.20E+10	0.92
		RGIC	1.05E+10	1.22E+10	0.86
24 July 2012	36.263	SEM clone	1.32E+10	1.51E+10	0.87
		RGIC	1.26E+10	1.51E+10	0.84

The sounding rocket under-flight irradiance measurements for maintaining the SOHO/SEM absolute calibration have been recalculated based on the updated SEM response function for the SEM clone instrument and time dependent reference spectra from FISM for both the SEM clone and the Rare Gas Ionization Cell (RGIC) measurements.

= sounding rocket measurements used to determine the SEM Ver. 3.1 degradation model

= reprocessed sounding rocket measurements used to determine a revised degradation model, which include an additional rocket flight (36.263 in July 2012) of the SEM clone and RGIC.

Revised SOHO/SEM degradation model



Reduction in SEM sensitivity is attributed to the build-up (and subsequent polymerization by UV photons) of a hydrocarbon contaminant layer.

This degradation is modeled as a pure carbon layer that grows at an exponentially decreasing rate with the growth curve determined to provide the best agreement between the degradation corrected SOHO/SEM data and the sounding rocket measurements

The growth curve (green line) determined from the revised sounding rocket measurements (processed using the FISM reference spectra and updated SEM response function) is compared to the SEM Version 3.1 growth curve (red line).

Summary

- Based on EVE Version 4 data for the 26-34 nm bandpass, ESP ch9, MEGS, and SEM are all in good agreement when SEM is processed using time dependent (FISM) reference spectra and a refined degradation model based on more accurate sounding rocket irradiance values.
- Daily and weekly EVE/ESP in-flight calibrations have shown that throughout the SDO mission negligible change has occurred in VFC full-scale frequency, and while some changes in channel dark currents have occurred, the daily dark current measurements prevent these changes from affecting the accuracy of the calculated irradiance values.
- Comparisons between ESP and MEGS using 10-sec time resolution show that ESP first order channels typically have a few percent greater flare response (flare peak irradiances relative to pre-flare values). For some flares however, these differences can be eliminated by processing the ESP data using MEGS reference spectra with their full 10-sec time resolution in place of daily average reference spectra.