A Comparison Between ESP 30.4 nm and SEM Measurements

Leonid Didkovsky, Darrell Judge, and Seth Wieman

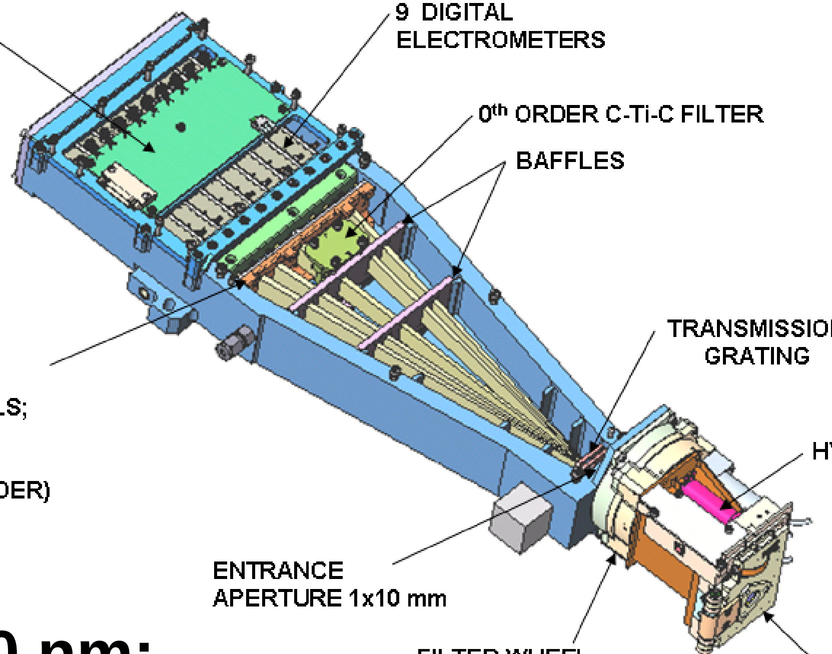
Space Sciences Center, USC

Why the Continuation of He II (30.4 nm) Irradiance Measurements is Important

- Long-term (14.5 years: 1996 -- now), practically uninterrupted absolute solar irradiance measurements from SEM to study long-term EUV variations during solar cycle
- A proxy for:

1. The Earth's ionosphere changes;
2. Atmosphere neutral density variations;
3. Thermosphere temperature and composition variations;
4. Solar models.

ESP *vs* SEM



	SEM	ESP
Made at	USC	USC
Channels	3	9
1st-order	2	4
0th-order	1	QD
Dark channel	No	Yes
Gain Correction	No	Yes
Filter Wheel	No	Yes

1st-order:

36, 25, 19, 30 nm;

0th-order: 4 channels (QD) with 0 – 7 nm

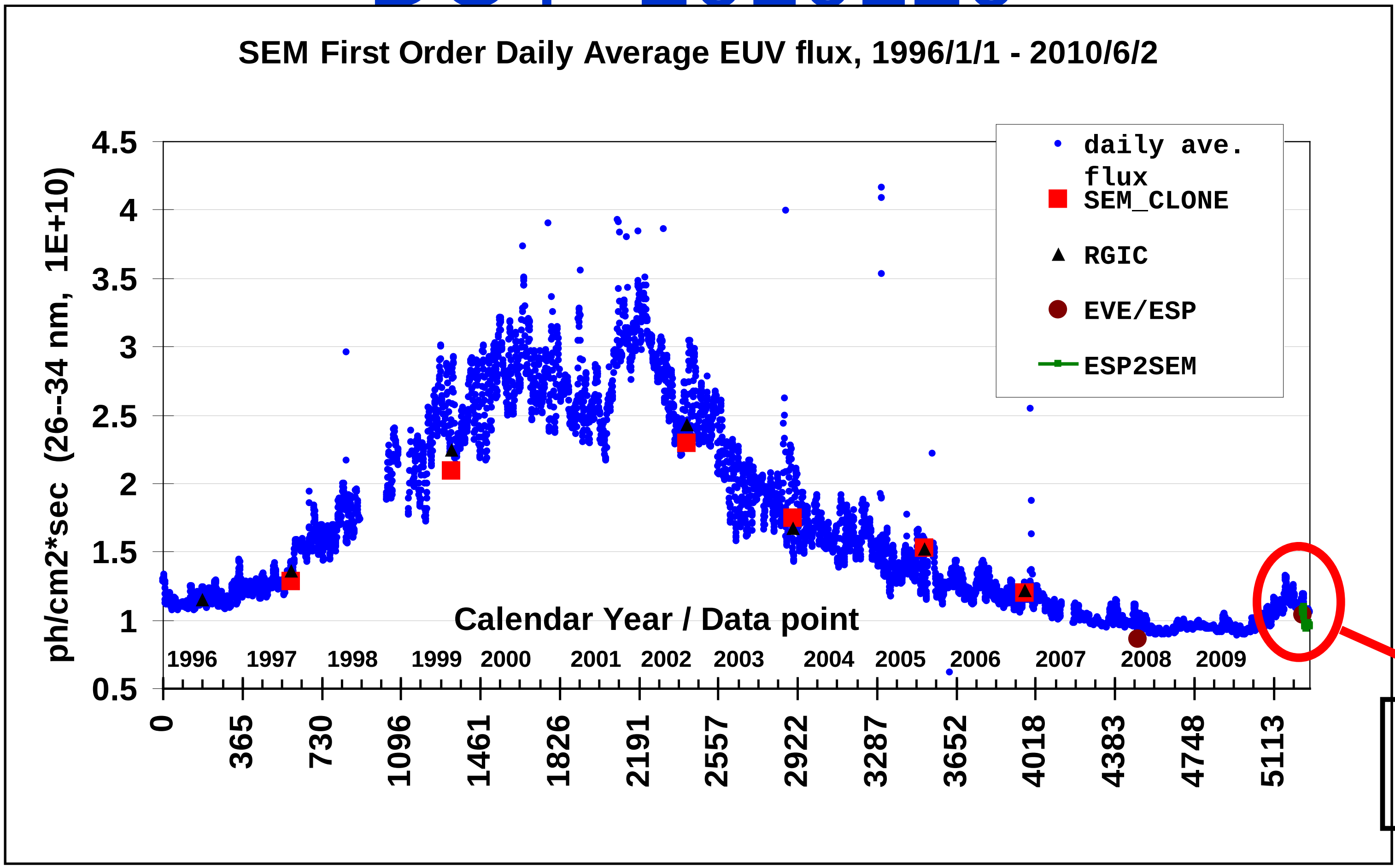
How ESP Irradiance is Calculated

$$E_i(\lambda, t) = \frac{C_{i,eff}\left[1 - \frac{dG_i(T,V,TID)}{\Delta t}\right]}{A \frac{\int_{\lambda 0-\Delta\lambda}^{\lambda 0+\Delta\lambda} R_i(\lambda,\alpha,\beta)\frac{\lambda}{hc}F_i(\lambda)d\lambda}{\int_{\lambda 0-\Delta\lambda}^{\lambda 0+\Delta\lambda} F_i(\lambda)d\lambda} f_{i,degrad}(t) f_{1AU}(t)} - E_{OS}$$

$$C_{i,eff}(t_j) = C_{i,meas}(t_j) - C_{i,ch.dark}(t_j) - C_{i,particleBG}(t_j) - \Delta C_{i,vis}(t_j),$$

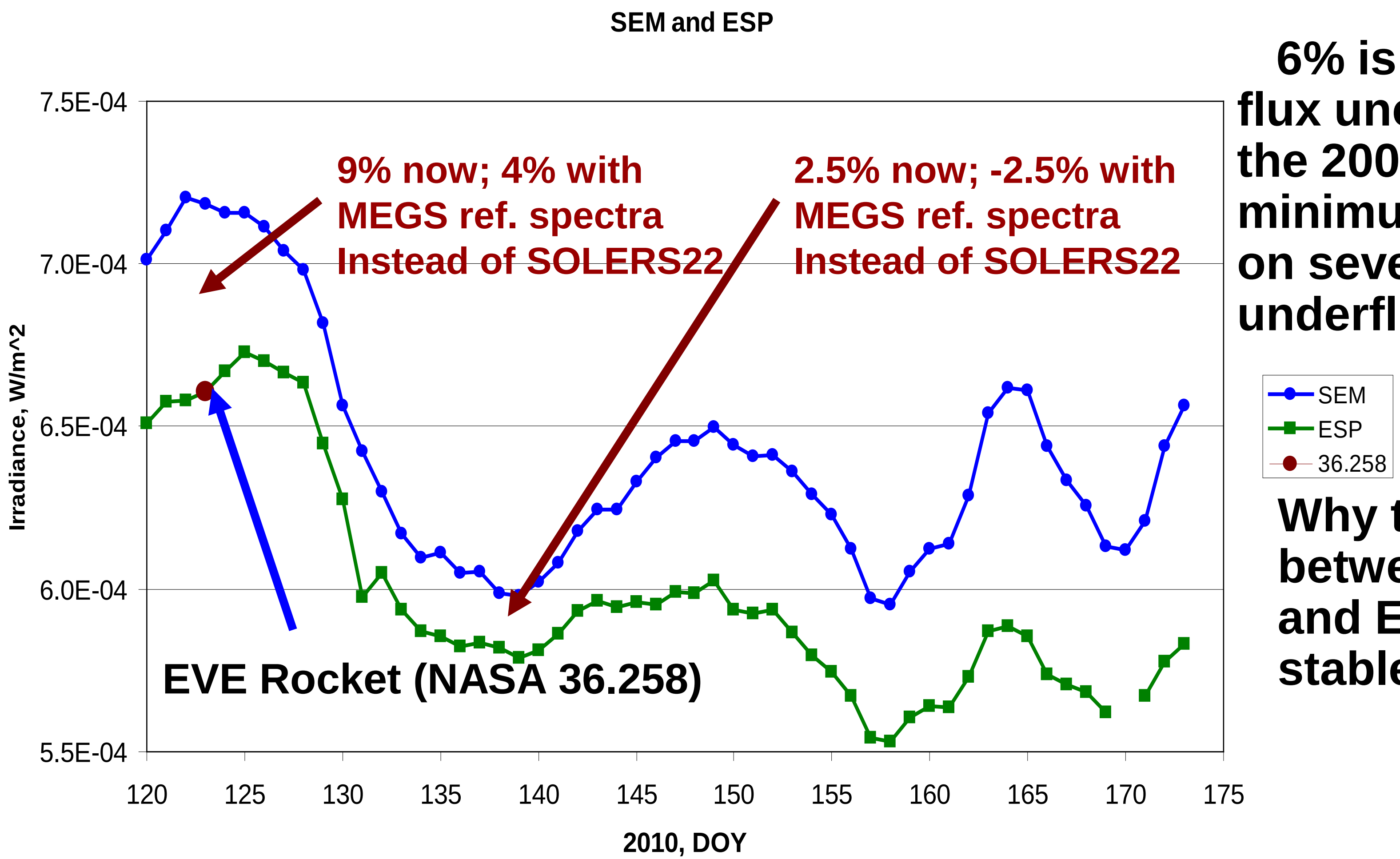
- See details: Didkovsky, L., D. Judge, S. Wieman, T. Woods, and A. Jones, "EUV SpectroPhotometer (ESP) in Extreme Ultraviolet Variability Experiment (EVE): Algorithms and Calibrations", Solar Physics, p. 182, doi: 10.1007/s11207-009-9485-8, Dec. 2009 (open access) or at http://www-rcf.usc.edu/~leonid/papers/SolPhys2010.pdf

14.5 Years of SEM EUV Flux With EVE/ESP Data Overlapping From DOY=2010120



NEXT slide

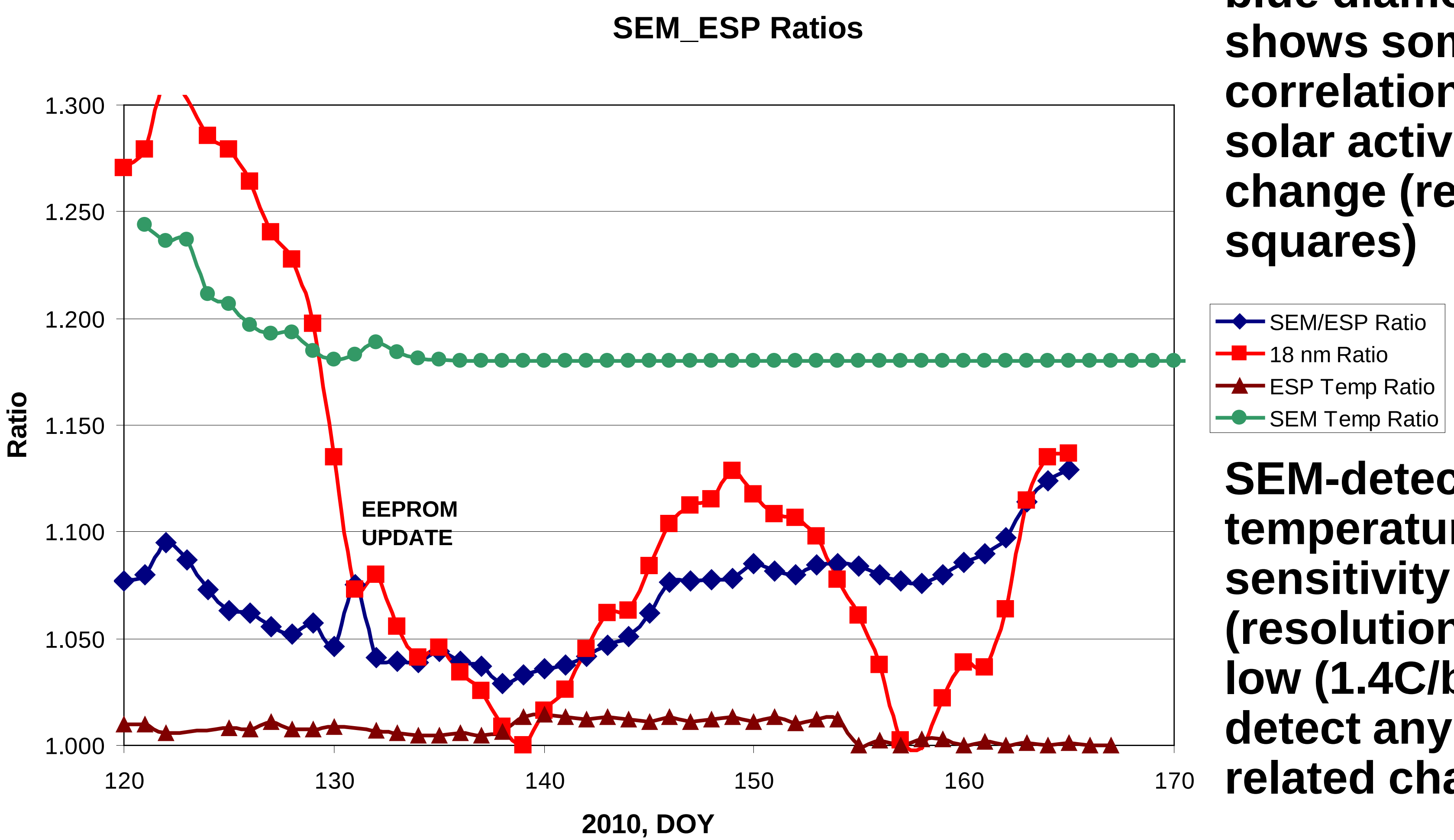
A comparison of SEM and ESP Fluxes (Details)



6% is the SEM-flux uncertainty for the 2008 solar minimum based on seven SEM underflights

Why the ratio between SEM and ESP is not stable?

SEM to ESP Ratios



The ratio (dark blue diamonds) shows some correlation with solar activity change (red squares)

SEM-detector temperature sensitivity (resolution) is too low (1.4C/bit) to detect any T-related changes.

A Search for the Sources of SEM-ESP Differences

Four possible sources:

- **Temperature-related change of dark countrates (SEM only);**
- **Uncorrected particle-related signal contamination if any (SEM only);**
- **Activity-related change of the second-order influence (both);**
- **ESP degradation (ESP only)**

ESP Measures Darks Daily

Measured ESP dark counts (dark-blue points) show some small (0.3 cnt) occasional fluctuations around the thermal proxy (red) used for irradiance calculations

ESP Detector Temperature

ESP temperature changes are very low, about 0.15 C° and are mainly corrected by the ESP Lev 1 program. The uncorrected part is too small to contribute to any significant change of ESP counts.

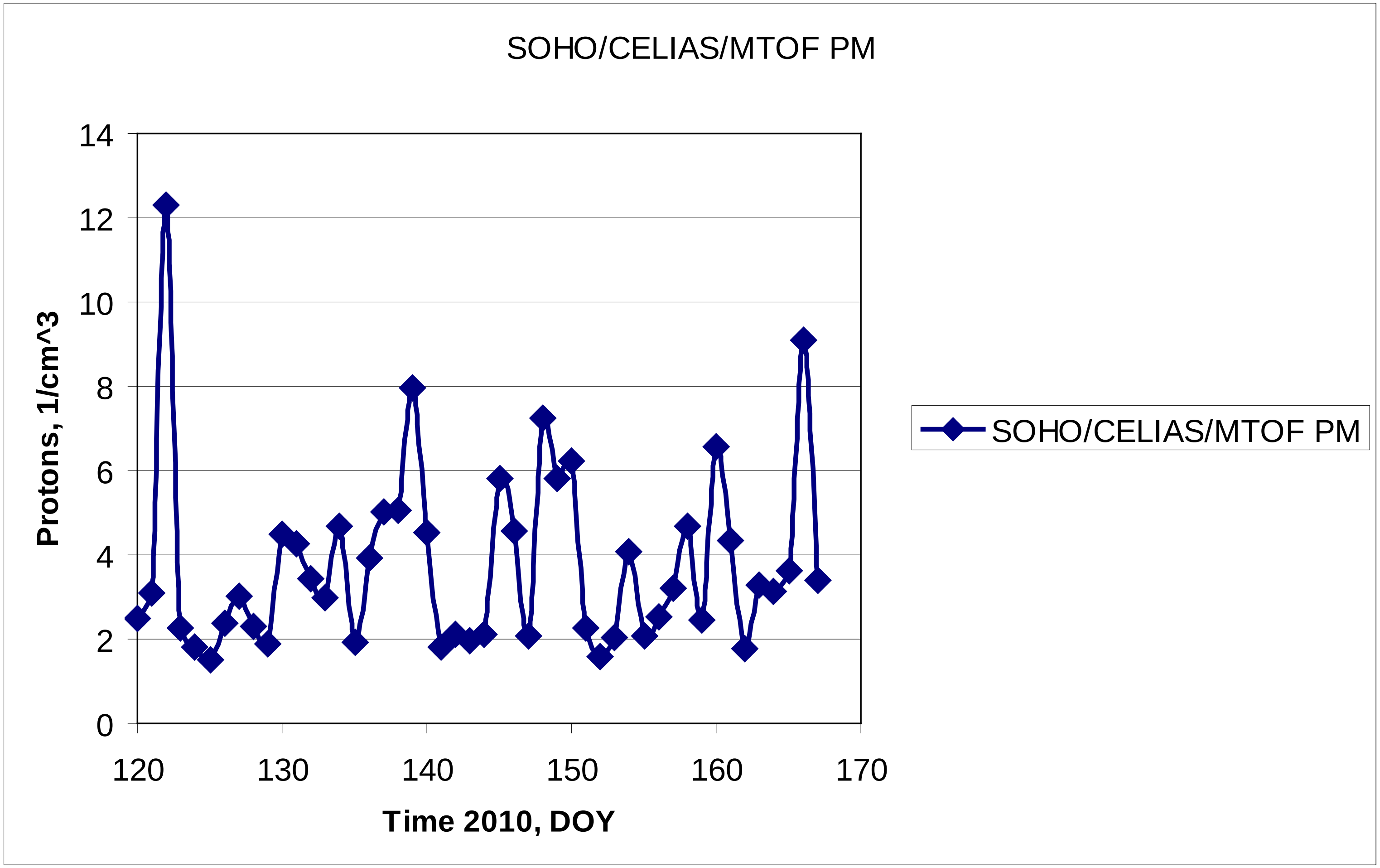
ESP and SEM Efficiency

- We compare below ESP and SEM effective counts with the same variation of dark counts of 1 cnt/0.25s (4 cnt/s).

Parameter	ESP (Ch9)	SEM (Ch1&3)
Maximal Efficiency, cnt/ph	1.62E-6	2.15E-7
Effective countrate, 1/s for 2010123	1051	149
Uncertainty with 4 cnt/s, %	0.38	2.7

This example shows that thermal variation in SEM darks could be one of the sources of SEM_ESP difference.

A Proxy for SEM Proton Flux



Proton flux at the SOHO location shows some sporadic fluctuations not correlated to the SEM_ESP changes

Sources of SEM-ESP Differences That Will be Corrected if…

Activity-related change of the second-order influence (both);

- **ESP will be corrected by resuming the use of MEGS (daily) spectra. This option in the ESP Lev 1 program was stopped for the current time while MEGS-B is evaluated;**
- **SEM would be further improved if modeled spectra of solar EUV variability for the 1996 – 2010 time period, with the level of MEGS accuracy, could be available.**

ESP degradation (ESP only)

- **SEM (if continued operation) may provide the ratio of ESP degradation till exact measurements on the next EVE SR flight in 2012.**

Summary

- ESP is an advanced version of SEM and allows us to measure solar irradiances with better accuracy than SEM;
- ESP Ch9 (30.4 nm) provides a SEM-proxy to continue long-term solar EUV measurements available from the USC SEM database since 1996;
- SEM/ESP ratio is changing with the solar activity, mostly due to the use of the SOLERS-22 spectrum for SEM flux calculations. If the SEM calculation would use the MEGS reference spectrum, the differences between SEM and ESP would be within 5%. Some other factors (SEM dark counts and ESP degradation) add some uncertainty (5 – 6%) to this ratio.

Acknowledgments

- This work was supported by the NASA grant NNX08AM74G and by the University of Colorado **award 153-5979**