Solar EUV inter-calibration workshop

LASP, University of Colorado, Boulder

October 25-27, 2011

Solar EUV Monitor (SEM) instrument overview background and calibration

Seth R. Wieman, Leonid V. Didkovsky, Darrell L. Judge,

Univ. of Southern Calif.; Space Sciences Center; SHS-274; UPC;
Los Angeles, CA 90089

USC
UNIVERSITY
OF SOUTHERN
CALIFORNIA

Space Sciences Center

Part 2 - SEM calibration

2a) Alternative (variable) reference spectra

How irradiance is calculated

$$\textbf{SEM EUV flux} = k_1 \frac{DN_{SEMch} - bkgrd}{\left(\frac{A\int_{\lambda_1}^{\lambda_2} \eta \cdot \phi_{S22} \cdot f_{carbon-trans} \cdot d\lambda \cdot f_{1AU}}{\int_{\lambda_1}^{\lambda_2} \phi_{S22} \cdot d\lambda} \right)}$$

where:

k_1 = correction for SEM sensitivity band which extends slightly beyond 26-34 nm (including second order contributions from wavelengths near 17 nm)

bkgrd = background signal due to diode/electrometer dark current and residual light leaks

DN_{SEMch} = data channel raw count rate

A = entrance aperture area

η = SEM channel efficiency from NIST calibration

ϕ_{S22} = Solar flux from SOLERS22 reference spectrum

$f_{carbon\text{-}trans}$ = transmission through carbon contamination layer, f(time)

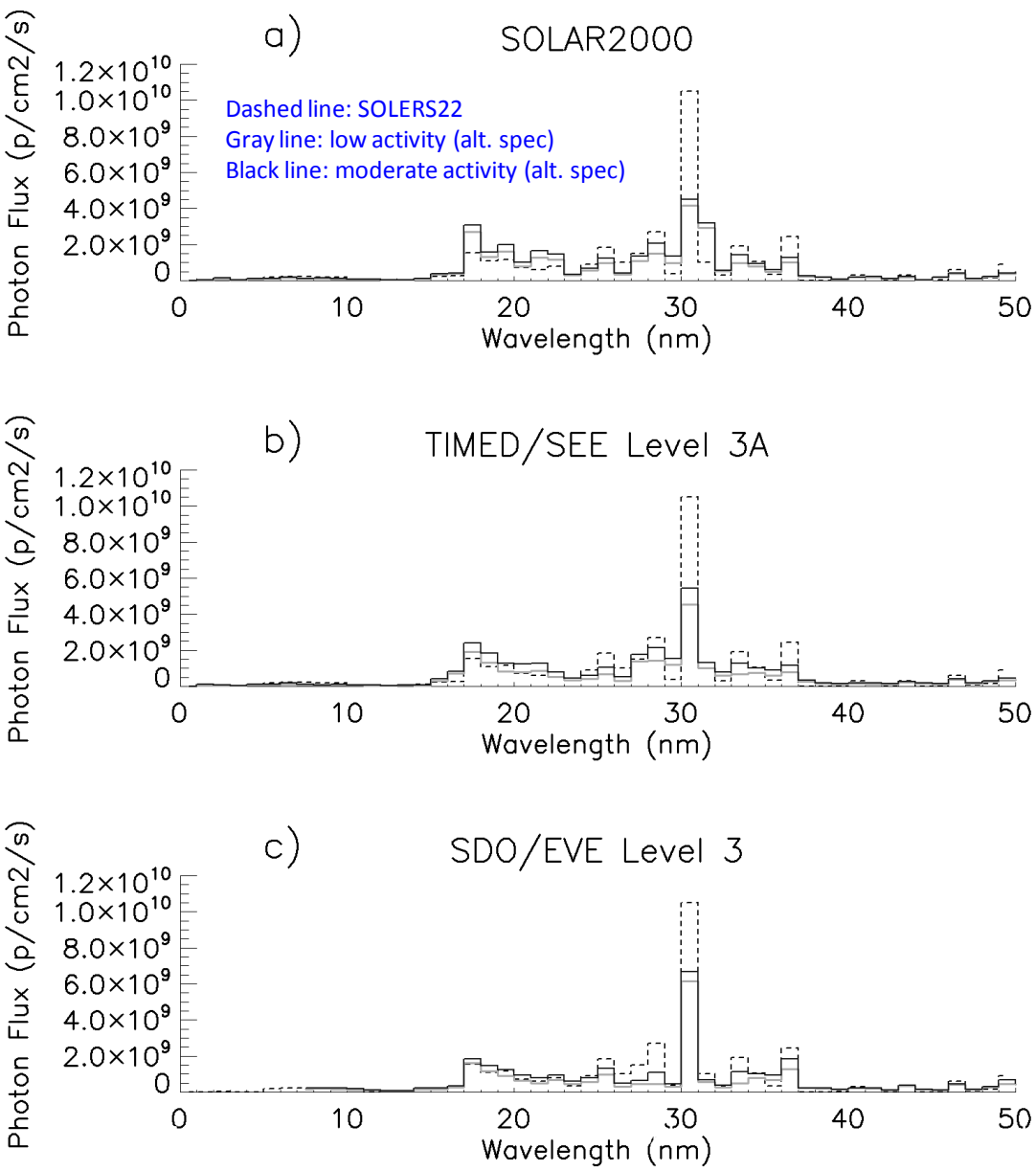
f_{1AU} = correction for 1 AU, and

λ_1 - λ_2 = range of wavelengths over which SEM the first order channel is sensitive

$$k_1 = \frac{\int_{26nm}^{34nm} \phi_{S22} \cdot d\lambda}{\int_{\lambda_1}^{\lambda_2} \phi_{S22} \cdot d\lambda}$$

} all functions of λ

Alternate reference spectra

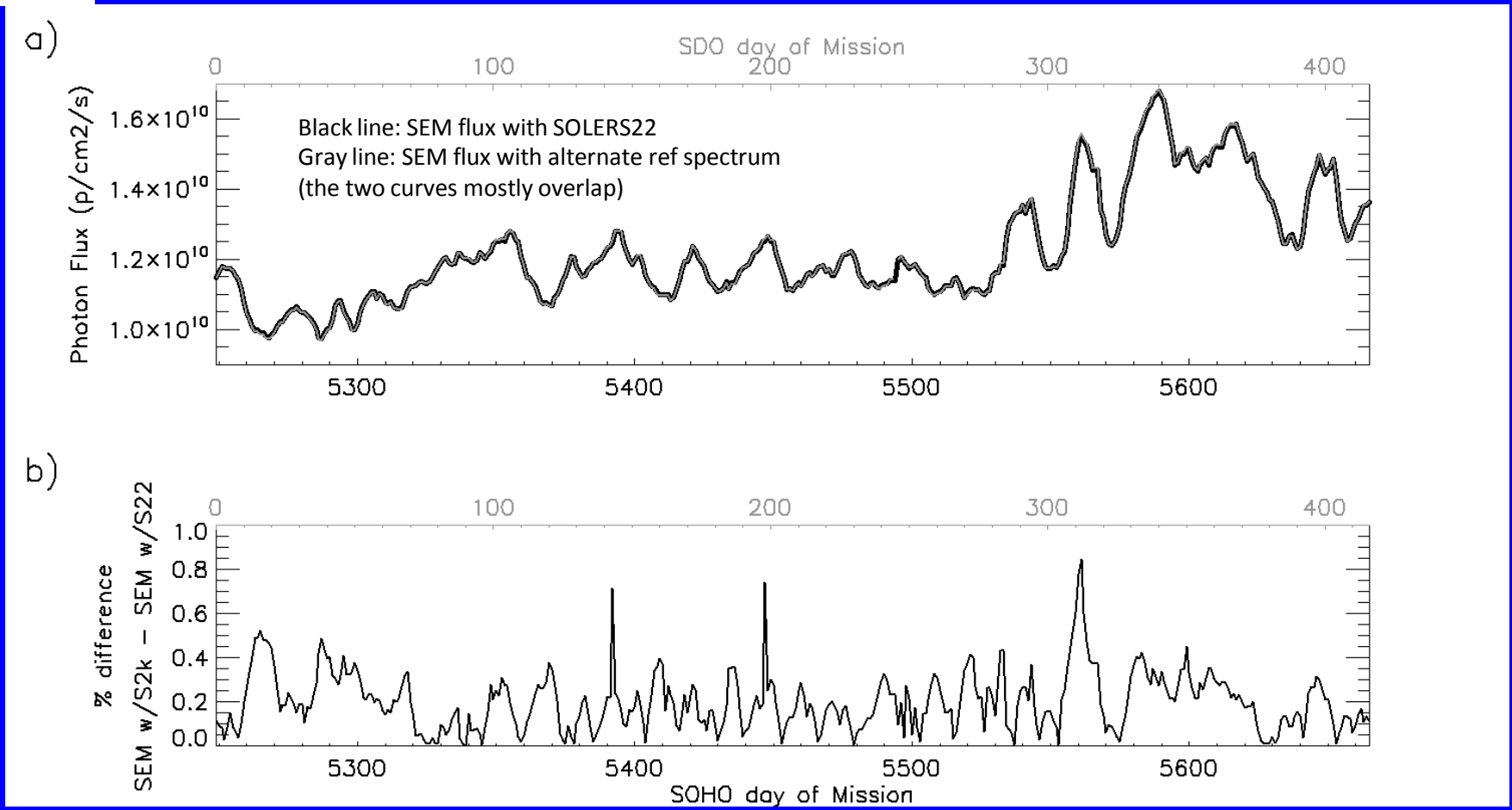


Solar Irradiance Platform historical irradiances are provided courtesy of W. Kent Tobiska and Space Environment Technologies. These historical irradiances have been developed with partial funding from the NASA UARS, TIMED, and SOHO missions.

Woods, T. N., F. G. Eparvier, S. M. Bailey, P. C. Chamberlin, J. Lean, G. J.Rottman, S. C. Solomon, W. K. Tobiska, and D. L. Woodraska, **The Solar EUV Experiment (SEE): Mission overview and first results**, J. Geophys. Res., 110, A01312, 2005.

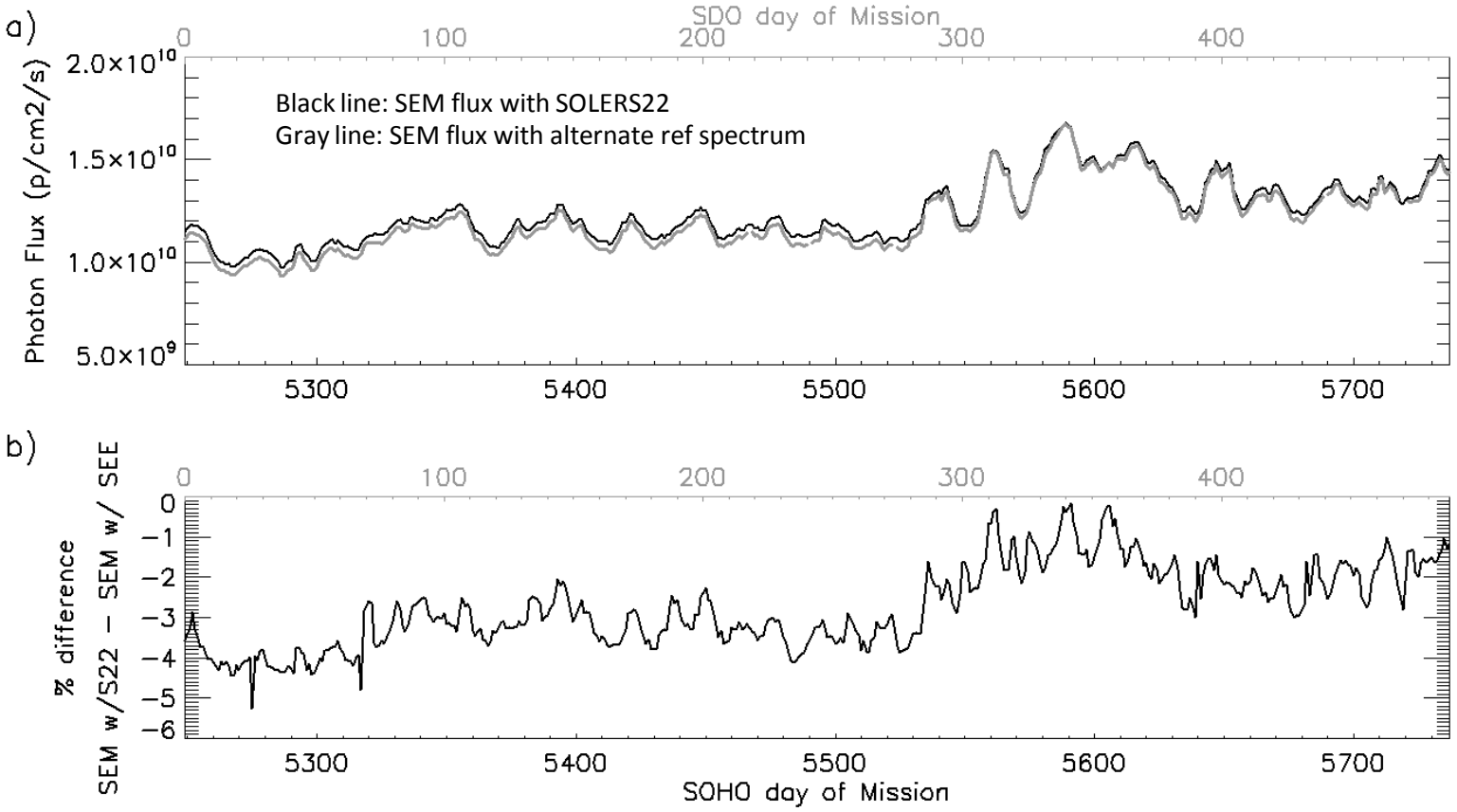
Woods, T. N., F. G. Eparvier, R. Hock, A. R. Jones, D. Woodraska, D. Judge, L. Didkovsky, J. Lean, J. Mariska,H. Warren, D. McMullin, P. Chamberlin, G. Berthiaume, S. Bailey, T. Fuller-Rowell, J. Sojka, W. K. Tobiska,and R. Viereck, **Extreme Ultraviolet Variability Experiment (EVE) on the Solar Dynamics Observatory(SDO): Overview of Science Objectives, Instrument Design, Data Products, and Model Developments**, Solar Physics, p. 3, Jan. 2010.

SIP/SOLAR 2000 ref. spectra



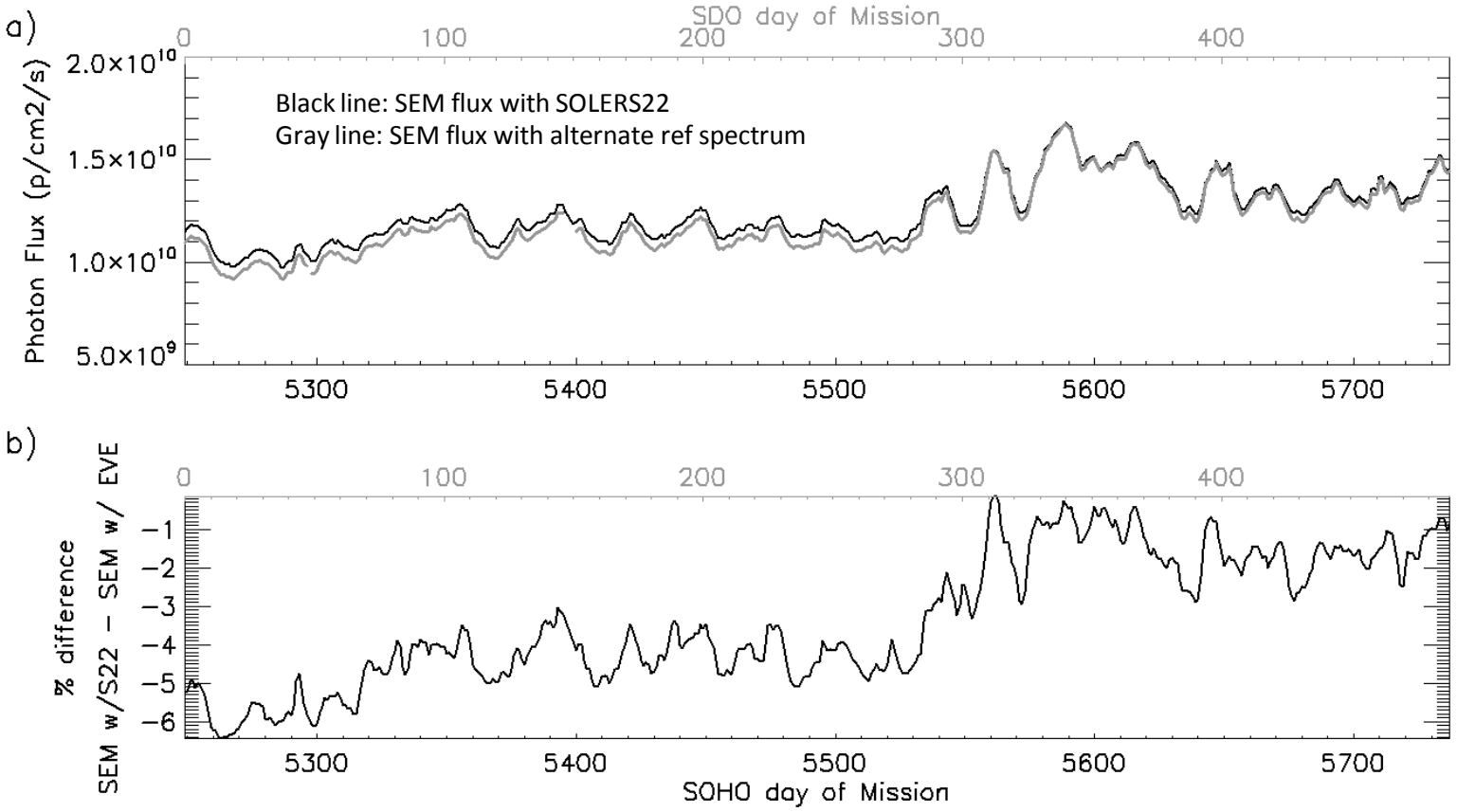
- SEM fluxes calculated with SOLAR2000 model agree well with those calculated using SOLERS22
- Relative spectral shape of SOLAR2000 doesn't change significantly with activity in SEM band

TIMED/SEE Level 3A



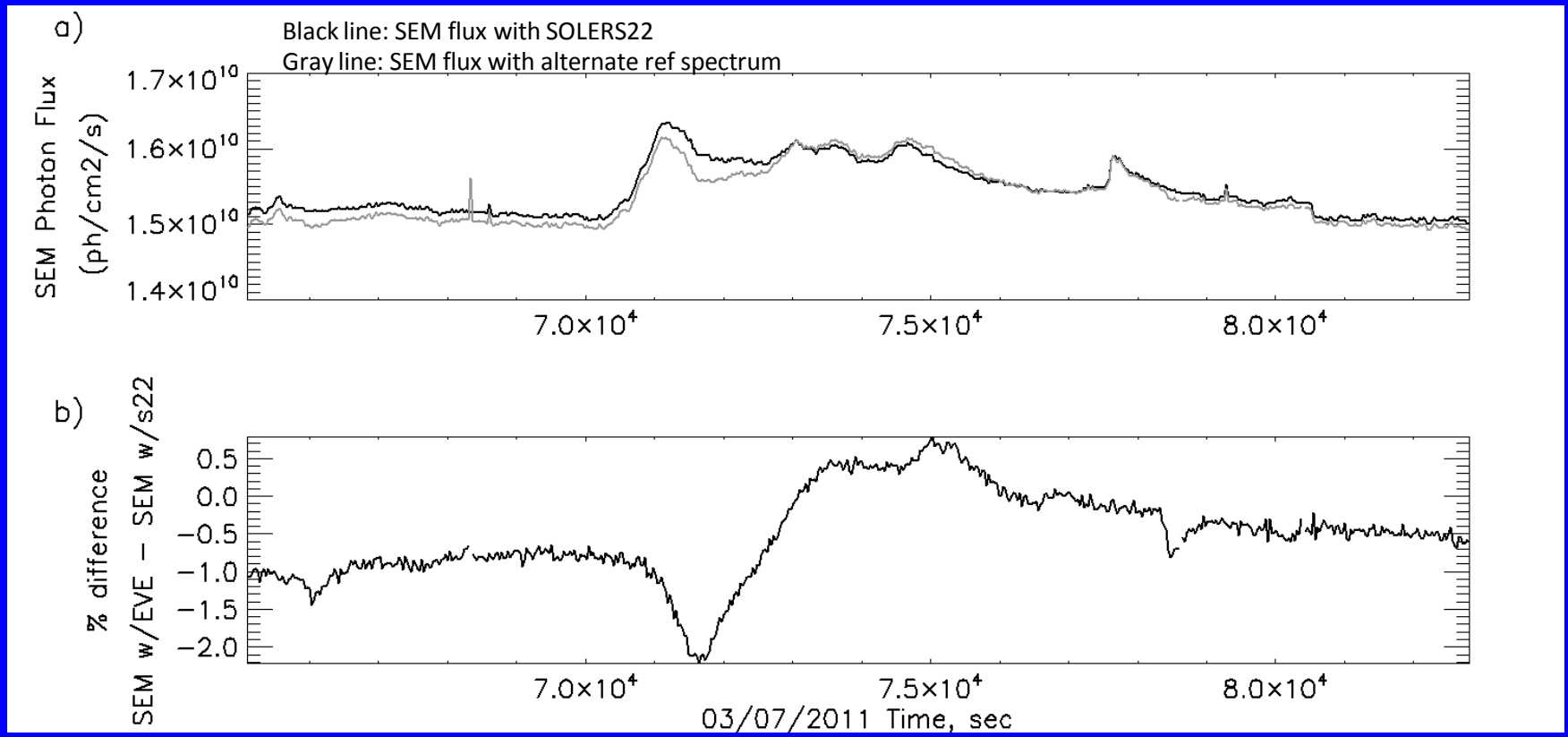
- The improved agreement observed with the transition from low to moderate activity is presumably related to the SOLERS22 spectrum better representing the solar spectral shape associated with mid levels of activity

SDO/EVE Level 3



- Results for EVE ref. spectra are similar (i.e. decreasing discrepancy with increasing activity)to those obtained with TIMED/SEE

SDO/EVE Level 2 during flare



- 30 sec average SDO/EVE reference spectra are used to calculate SEM flux

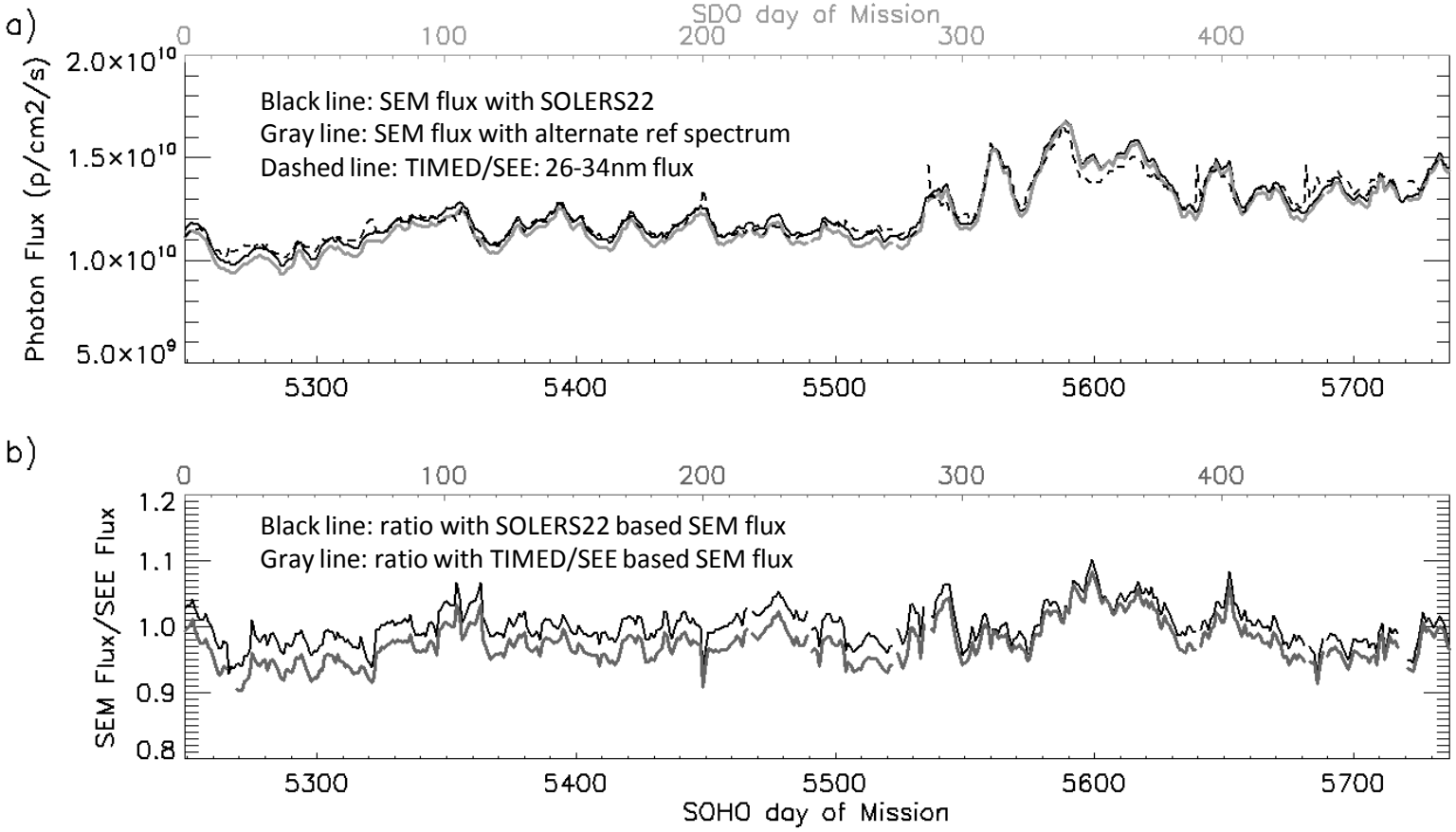
Average discrepancy due to choice of reference spectrum

Reference spectra	MAX abs(% difference)	MIN abs(% difference)	MEAN abs(% difference)
TIMED/SEE	5.27	0.15	2.72
SDO/EVE	6.43	0.15	3.35
SDO/EVE(flare)	2.22	0.00	0.65

- Reference spectrum related discrepancies are averaged over the SDO mission
- For the flare (bottom row) discrepancies are averaged only over a 5-hr period on 3/7/2011 during which the flare occurred. Because the flare mean does not include the period of lower activity at the beginning of the SDO mission (i.e. the period for which reference spectrum related differences are the greatest) it is lower than the mission averaged discrepancies in the rows above.

Absolute irradiance comparison

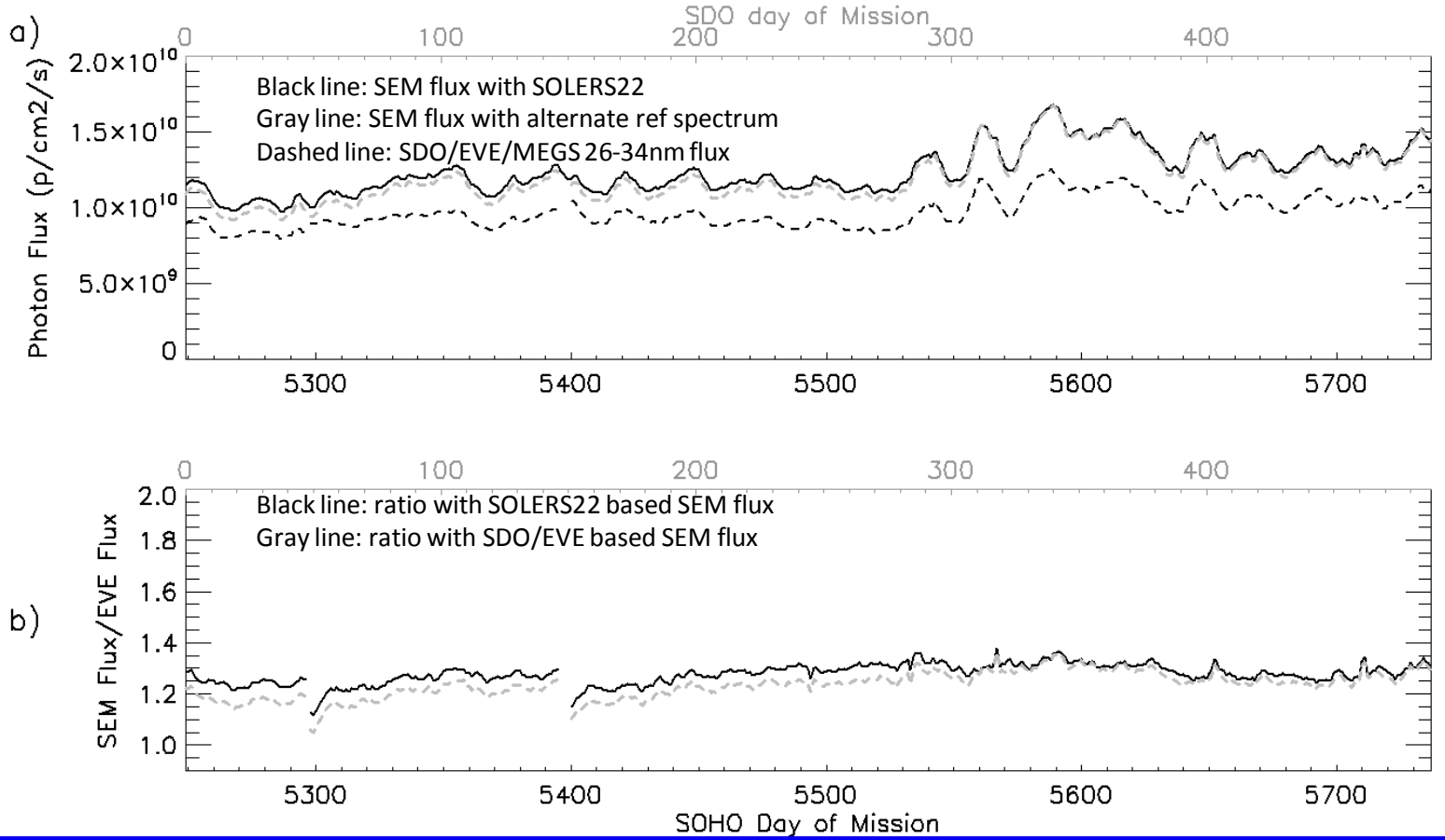
SEM vs. TIMED/SEE



- Daily averaged TIMED/SEE level 3A spectra (dashed line in panel a) are integrated over 26-34 nm (i.e. SEM band) for this comparison

Absolute irradiance comparison

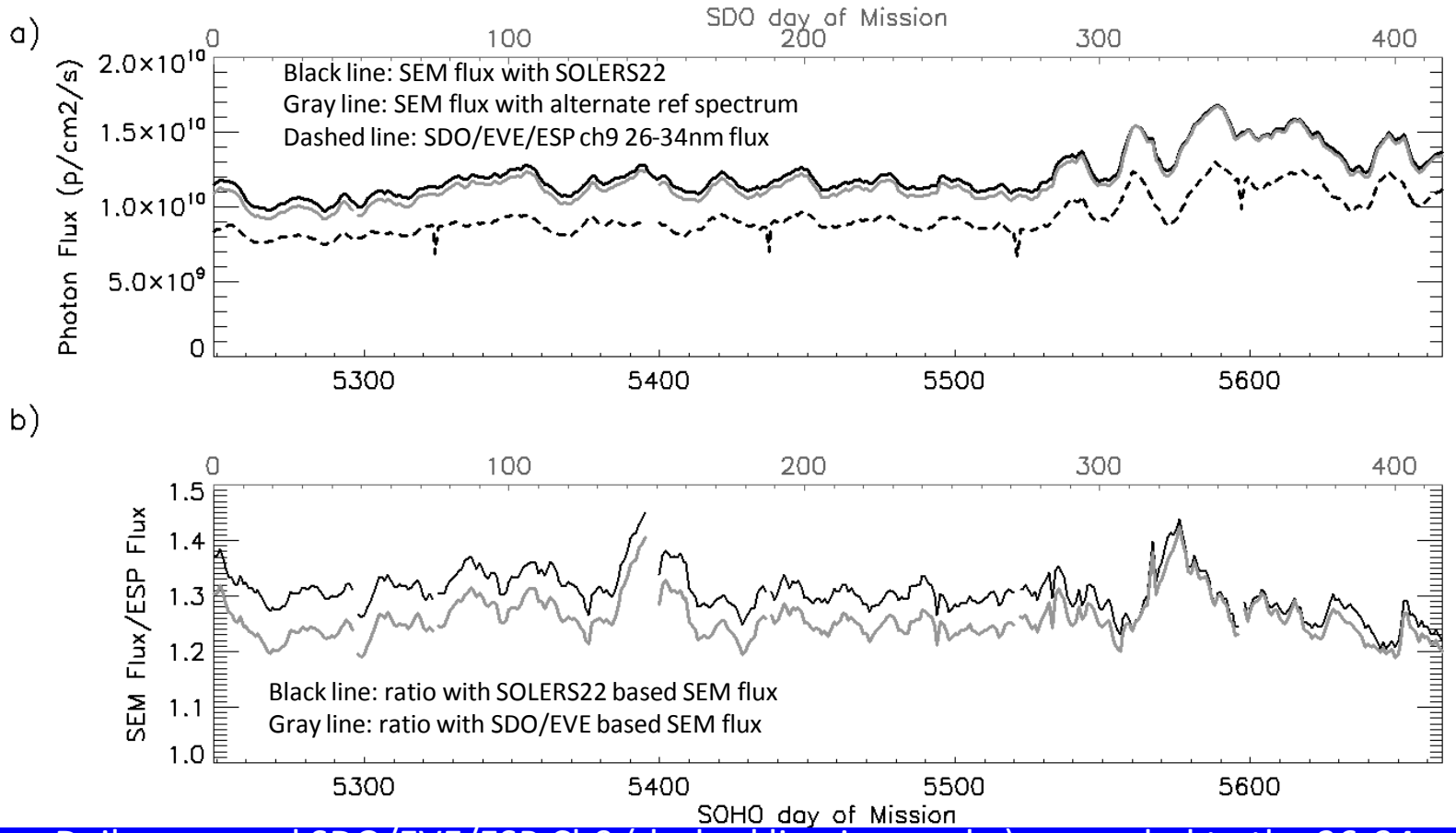
SEM vs. SDO/EVE



- Daily averaged SDO/EVE level 3 spectra (dashed line in panel a) are integrated over 26-34 nm (i.e. SEM band) for this comparison

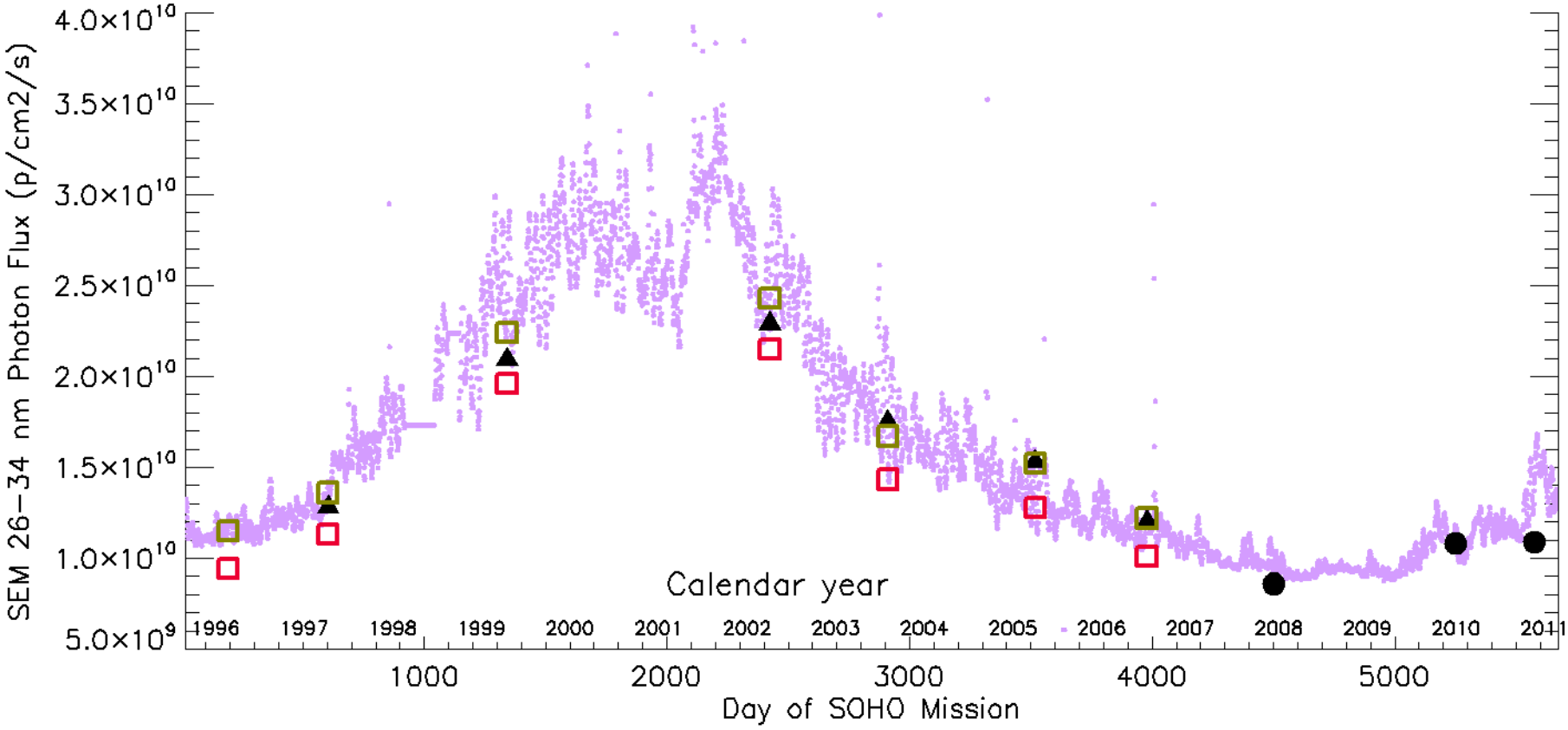
Absolute irradiance comparison

SEM vs. SDO/EVE/ESP CH9



- Daily averaged SDO/EVE/ESP Ch9 (dashed line in panel a) are scaled to the 26-34 nm SEM band (based on the corresponding daily SDO/EVE spectra) for this comparison

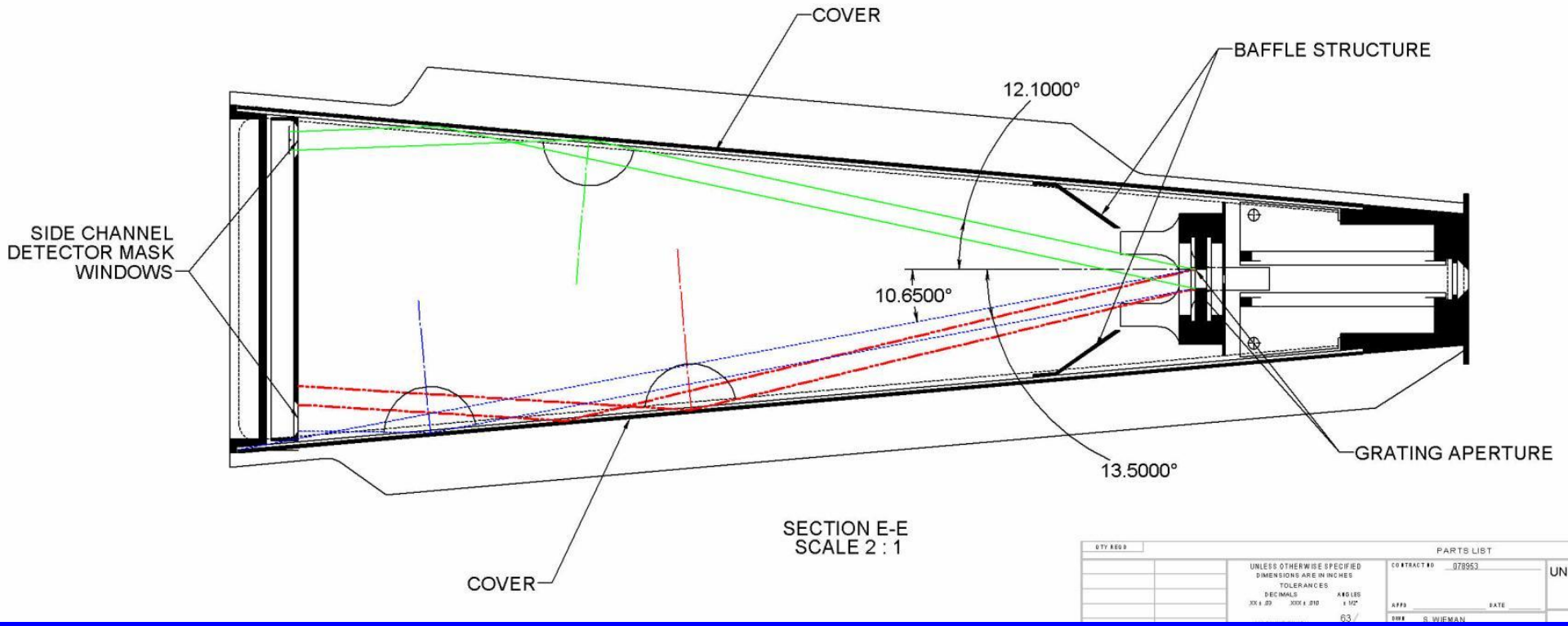
SEM 26-34 nm irradiance



- Time series, January 1996 – Present. Black squares, triangles and circles represent sounding rocket measurements using a Rare Gas Ionization Cell (RGIC), the SEM clone instrument, and the SDO/EVE/ESP clone instrument, respectively. Green squares are the Ne RGIC measurements converted to SEM bandpass using SpaceWx/Kent Tobiska Solar 2000 ref spectrum instead of SOLERS22

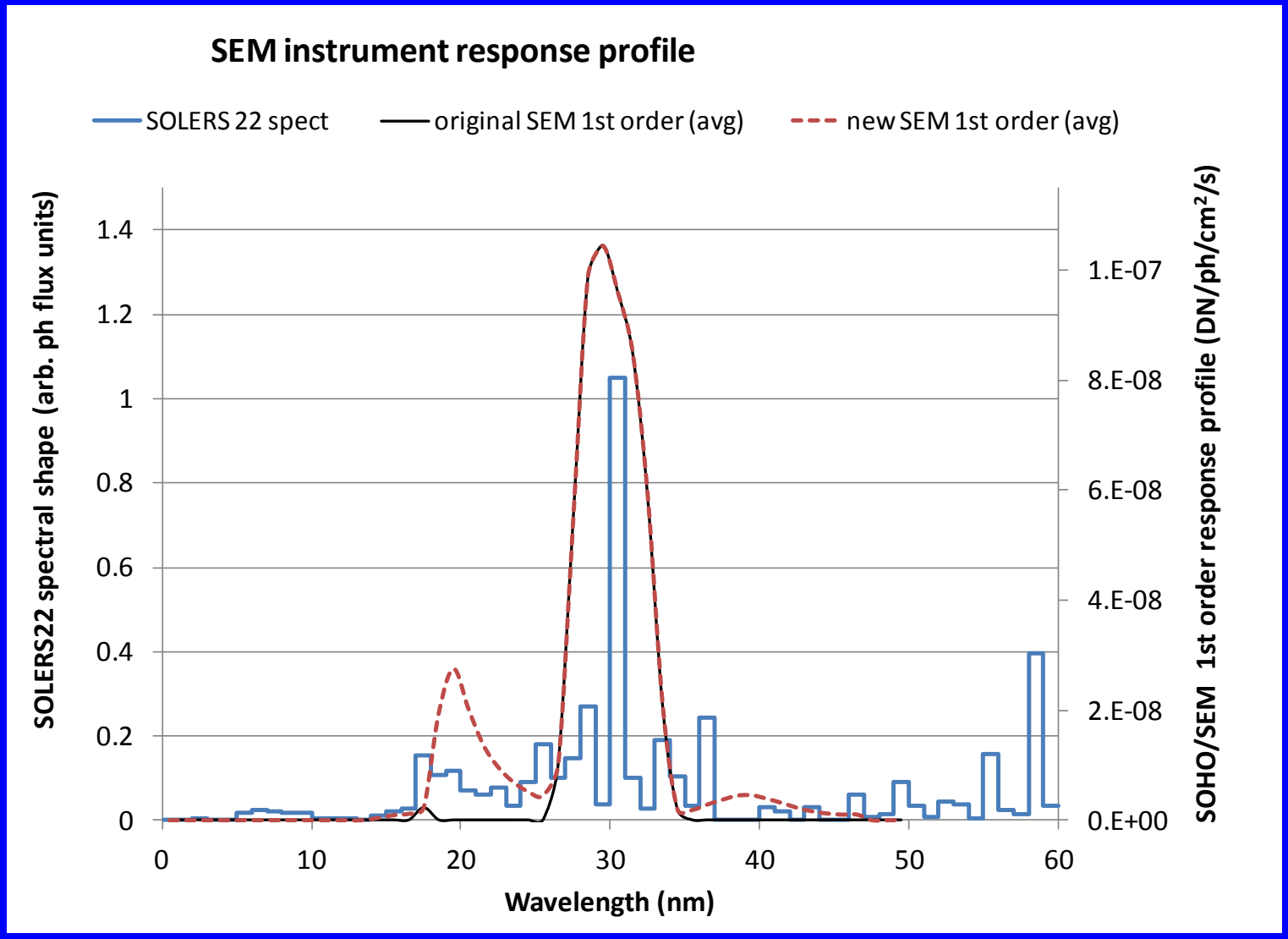
b) Updated efficiency profiles

Updated efficiency profile



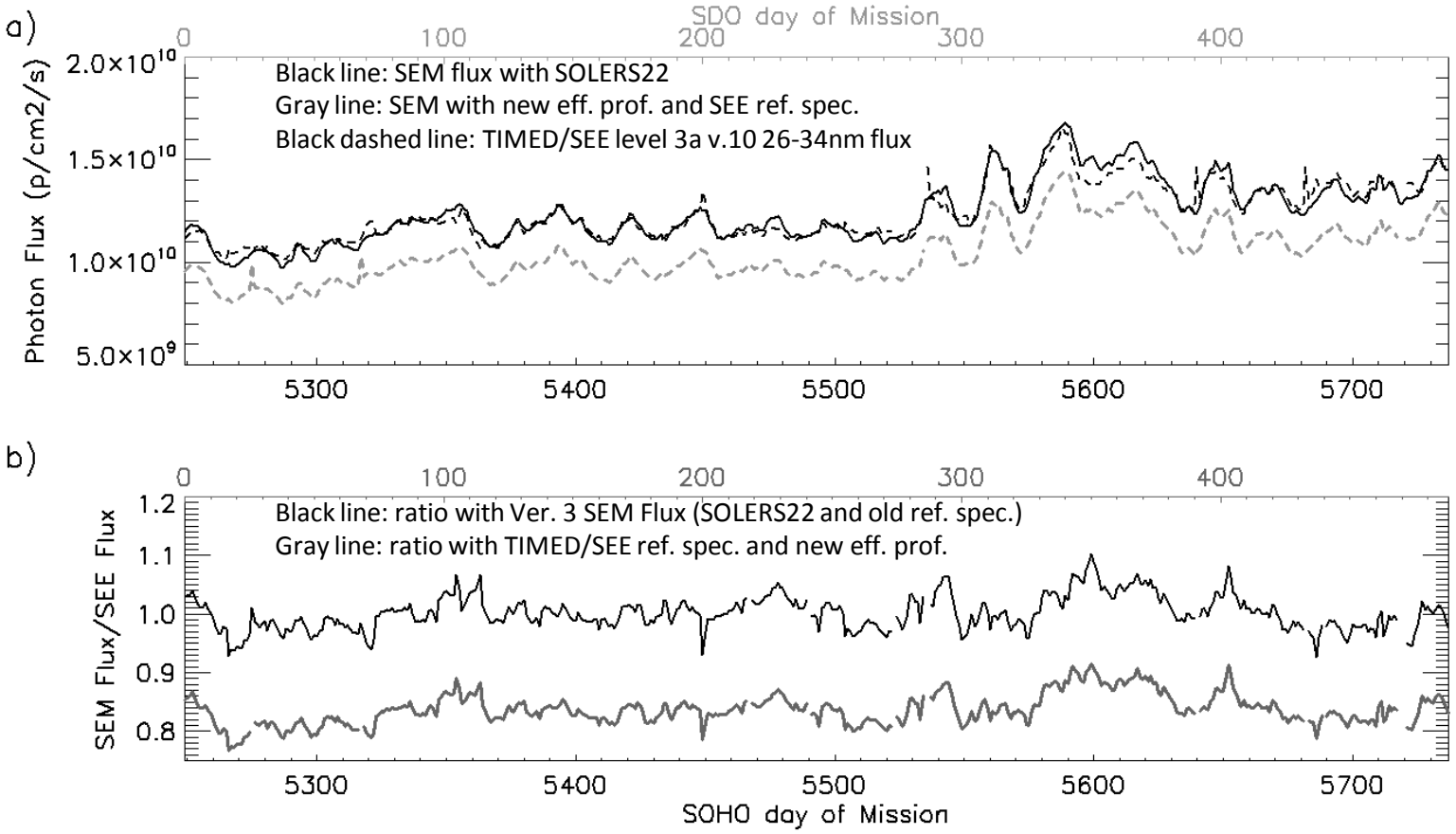
- Techniques for calibrating SEM at NIST BL-9 have improved over many years of calibrating the sounding rocket clone instrument
- Additional sensitivity around 39nm and 19.5nm due to grazing incidence reflection of the first and second diffraction orders respectively discovered when calibrating with SEM cover ON.

Updated efficiency profile



Absolute irradiance comparison

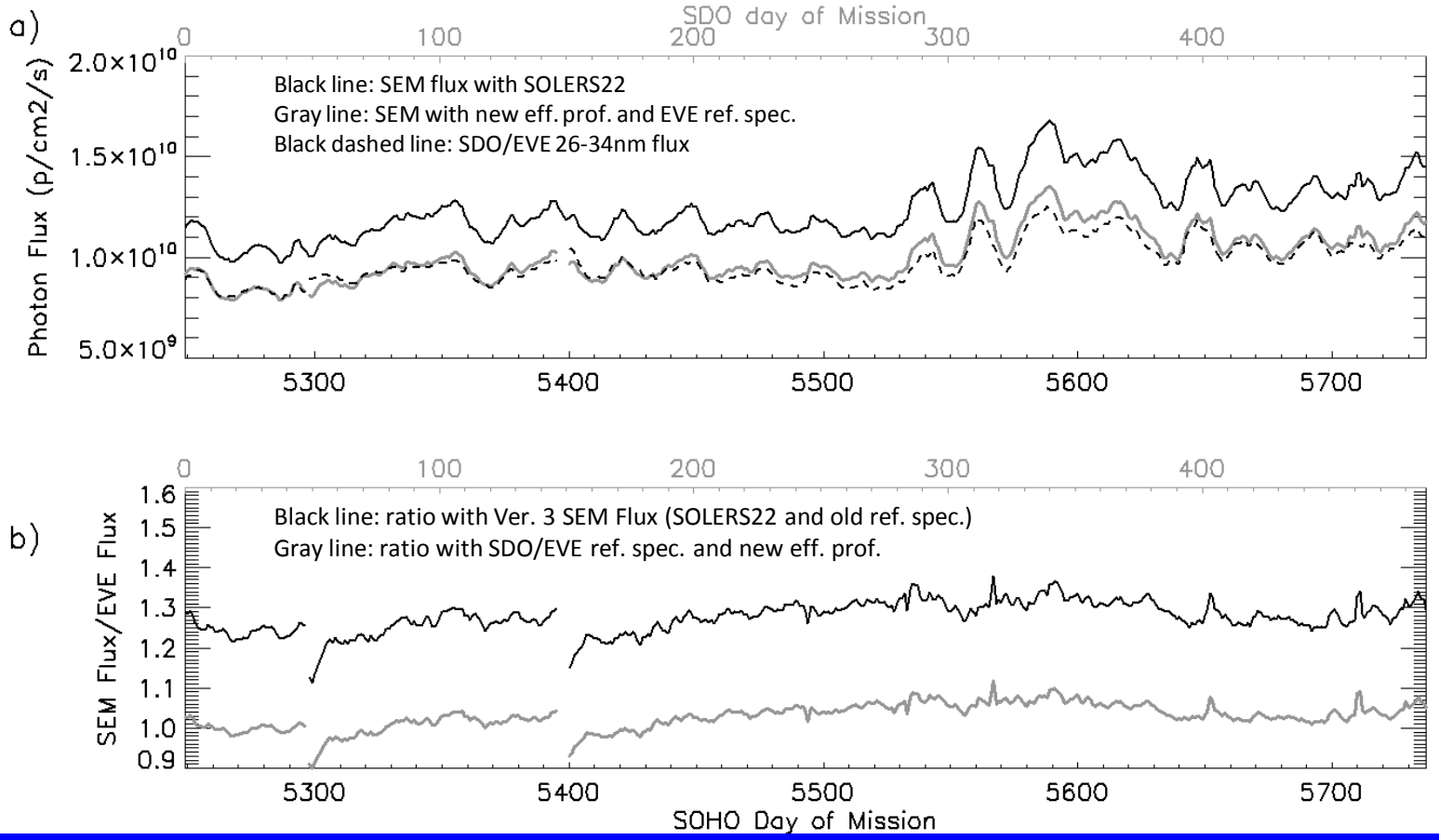
SEM vs. TIMED/SEE



- Daily averaged TIMED/SEE level 3A spectra (dashed line in panel a) are integrated over 26-34 nm (i.e. SEM band) for this comparison

Absolute irradiance comparison

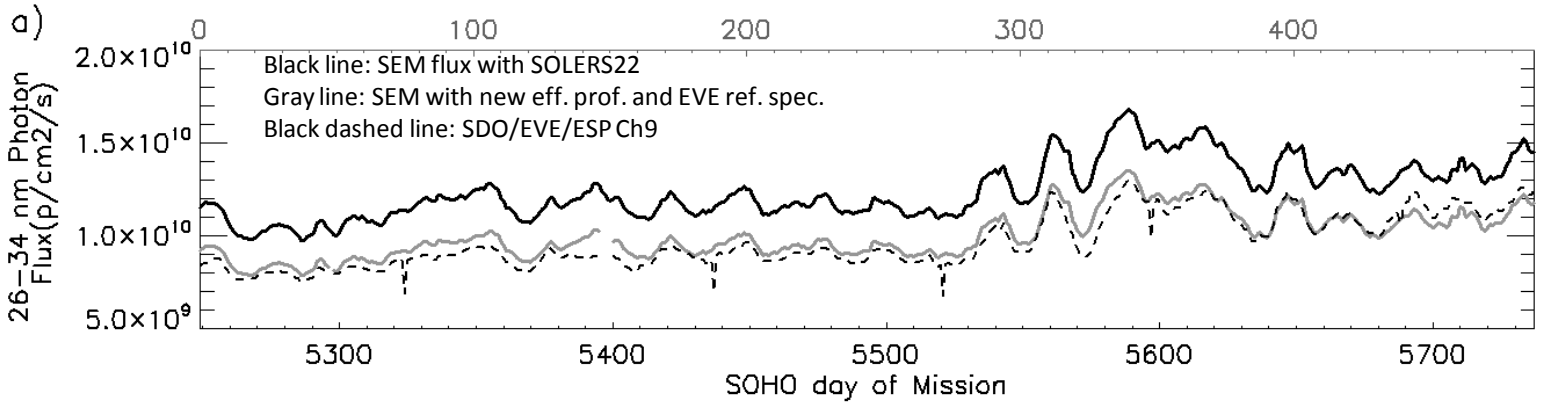
SEM vs. SDO/EVE

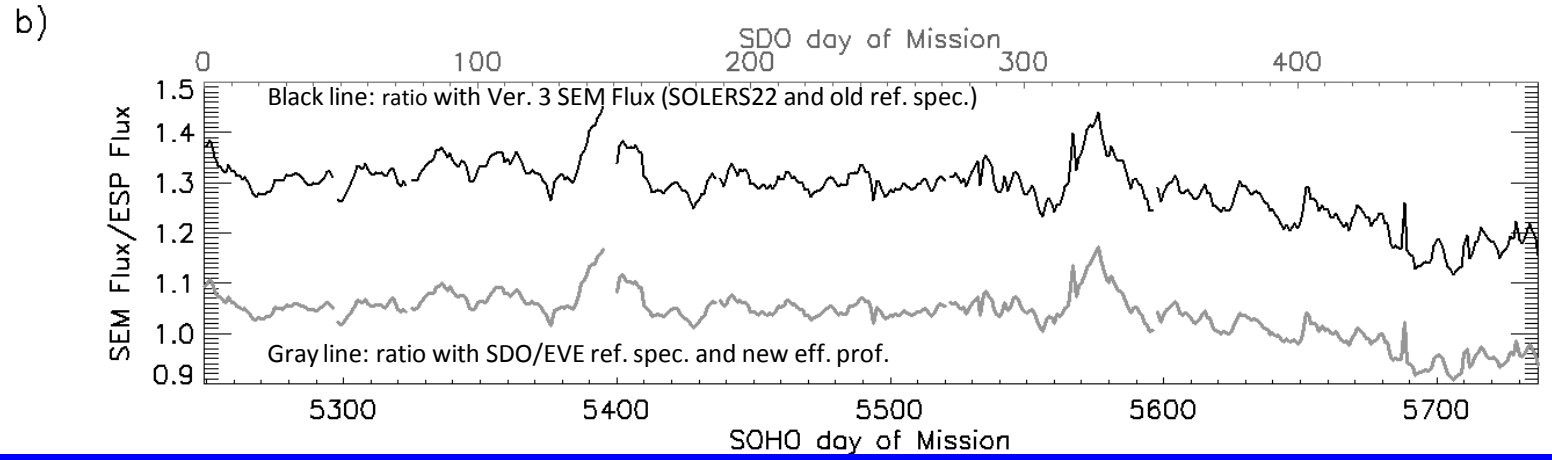


- Daily averaged SDO/EVE level 3 spectra (dashed line in panel a) are integrated over 26-34 nm (i.e. SEM band) for this comparison

Absolute irradiance comparison

SEM vs. SDO/EVE/ESP CH9





- Daily averaged SDO/EVE/ESP Ch9 (dashed line in panel a) are scaled to the 26-34 nm SEM band (based on the corresponding daily SDO/EVE spectra) for this comparison

Conclusions

- Use of EVE/MEGS spectrum as a reference can affect calculated SEM absolute irradiance by approx. 7% (max. seen so far) versus fixed SOLERS22 spectrum
- Difference between SOLERS22 and EVE/MEGS calculated SEM irradiances is dependent on activity level (greater for low solar activity, lower for moderate activity)
- Revised efficiency profile results in a shift of SEM calculated irradiance. This shift is less dependent on activity level, and results in better agreement with EVE/MEGS and EVE/ESP but worse agreement with TIMED/SEE

Acknowledgments

- The authors wish to thank W. Kent Tobiska and Dave Bouwer of Space Environment Technologies for their generous time and assistance with the Solar Irradiance Platform/SOLAR 2000 model.
- This work was supported in part by University of Colorado award 153-5979, and by NASA Grant NNX08AM94G.
- SOHO is a project of international cooperation between ESA and NASA

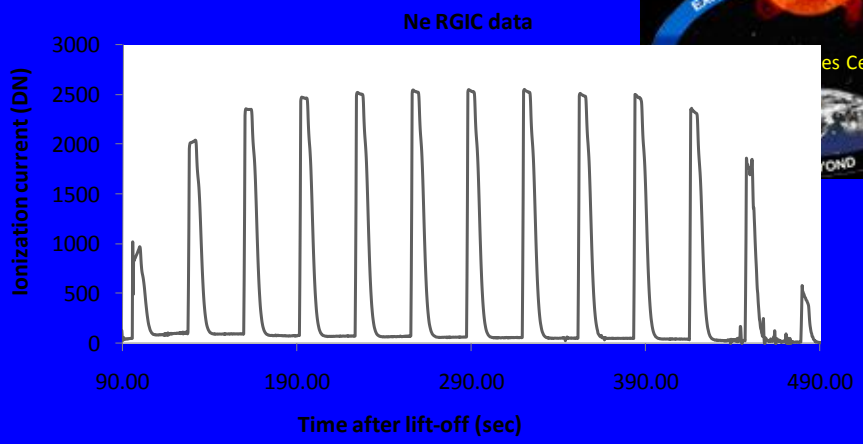
Extra slides

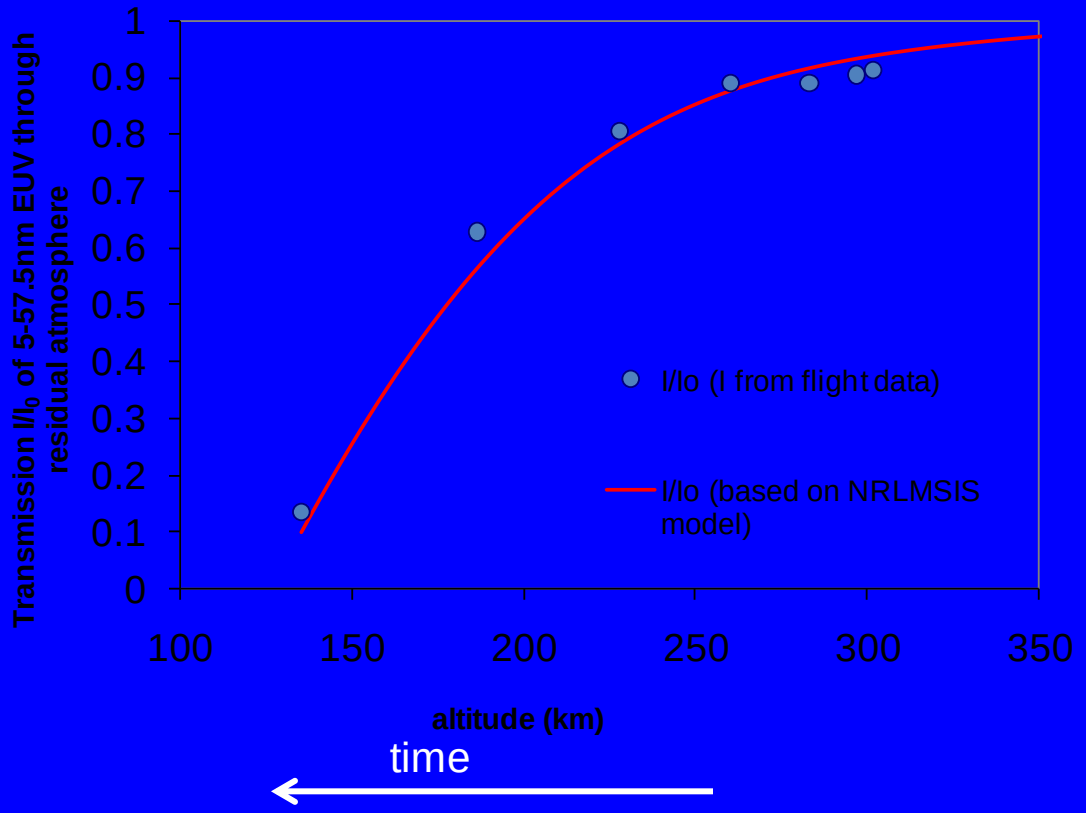
Part a) Conclusions

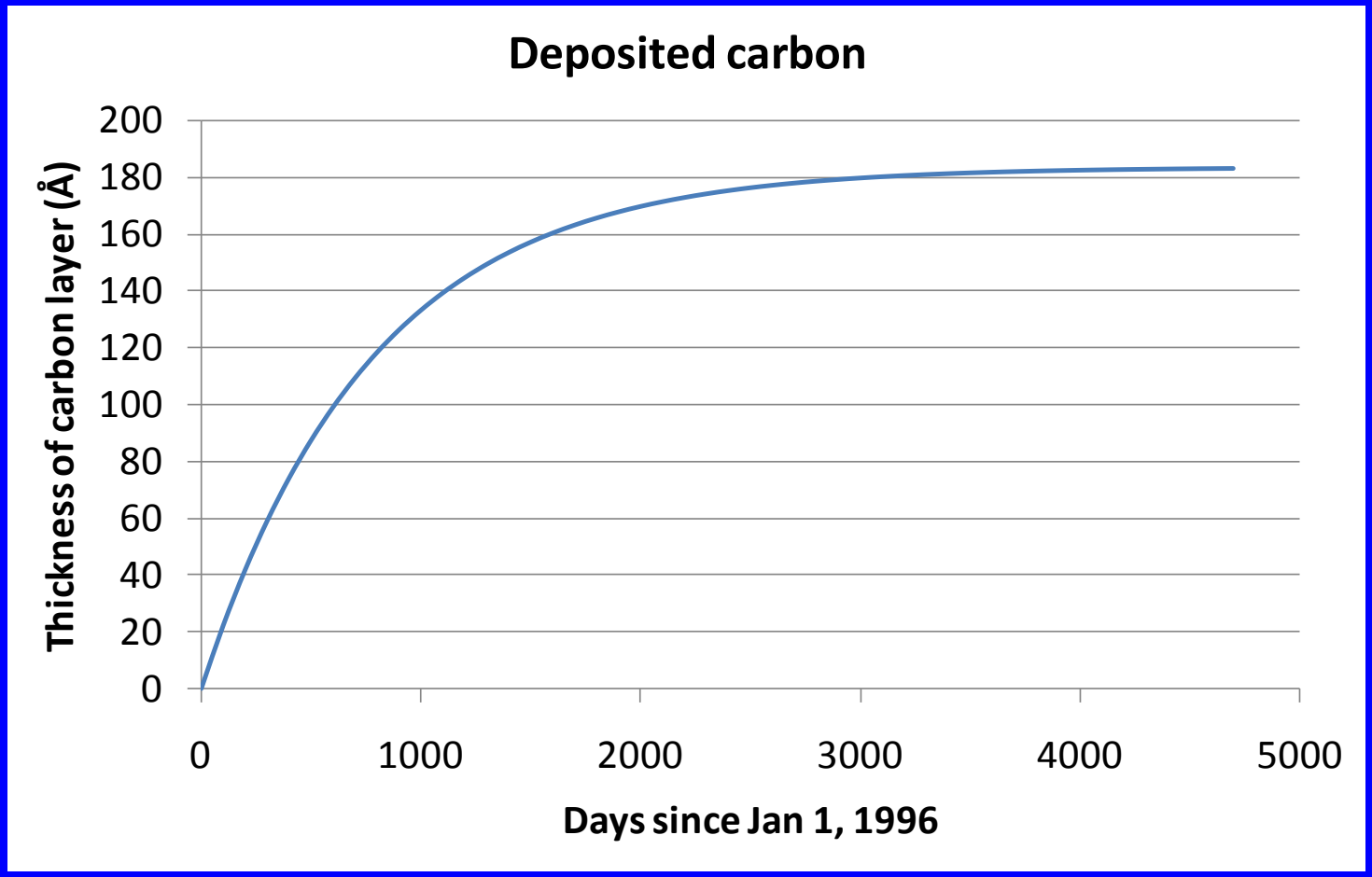
- Using the newly available time-varying reference spectra can change the calculated SEM irradiances by several percent
- Discrepancies are generally lower during conditions of moderate solar activity, corresponding to the period best represented by SOLERS22
- Using the varying reference spectra improves the agreement between SEM and SDO/EVE and between SEM and SDO/EVE/ESP Ch9

Ne RGIC

- Flux values for the downward leg (lower background) measurements are fit to a modeled 5-57 nm atmospheric absorption profile based on NRLMSIS and O_2, N_2 and O cross sections.
- The above atmosphere flux (i.e. zero absorption flux, referred to as I_0 in plot at right) is the value which provides the best fit between RGIC measurements and the modeled profile






Deposited carbon
Thickness of carbon layer (Å)
200
180
160
140
120
100
80
60
40
20
0
0
1000
2000
3000
4000
5000
Days since Jan 1, 1996