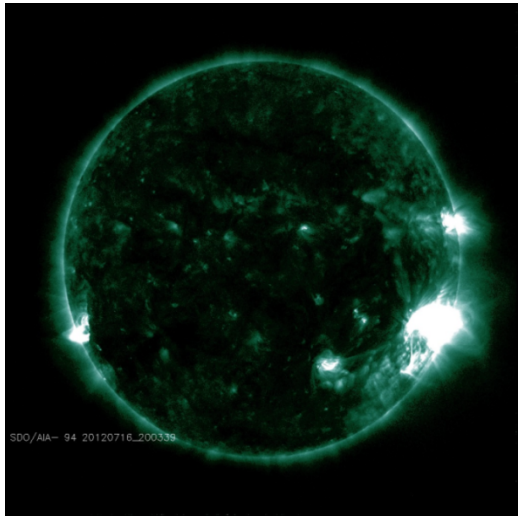
Preliminary GOES Calibrations

Janet Machol
NOAA National Geophysical Data Center
University of Colorado CIRES

Rodney Viereck
NOAA Space Weather Prediction Center



Inter-Calibration and Degradation Workshop
Belgium Solar-Terrestrial Center of Excellence
15 – 18 April 2013

GOES EUVS Sensors

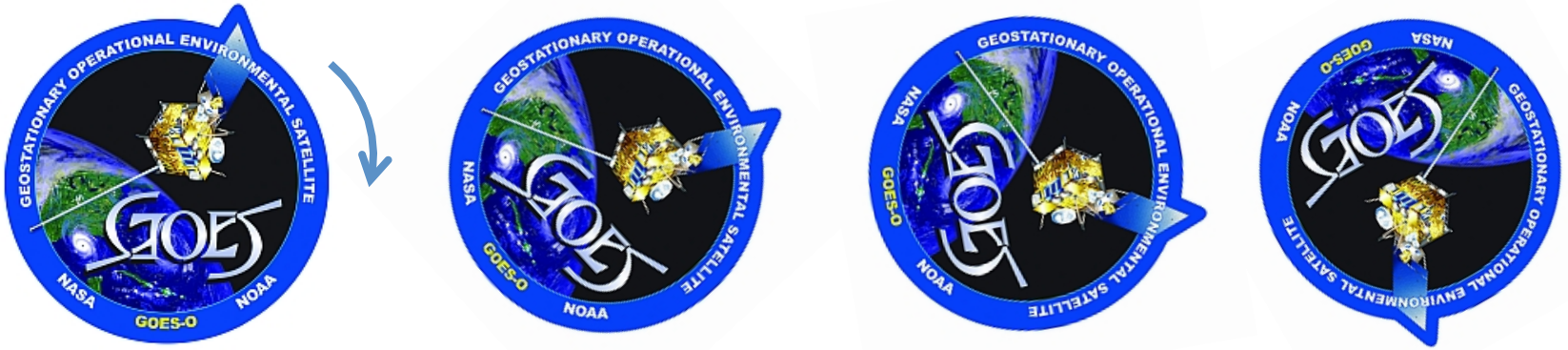
GOES: Geostationary Operational Environmental Satellite

current GOES	**XRS**	2 x-ray bands: A 0.05-0.4 nm, B 0.1-0.8 nm, since 1972
NOP→13-15	**SXI**	x-ray imager, 3 channels: 0.6-6 nm
	EUVS	5 EUV bands, 5-127 nm

GOES-13	2006
GOES-14	2009
GOES-15	2010

Requirements: 30-s sample rate, 30-s latency, 20% uncertainty

Actual: *10 s* *3 s* *15%*

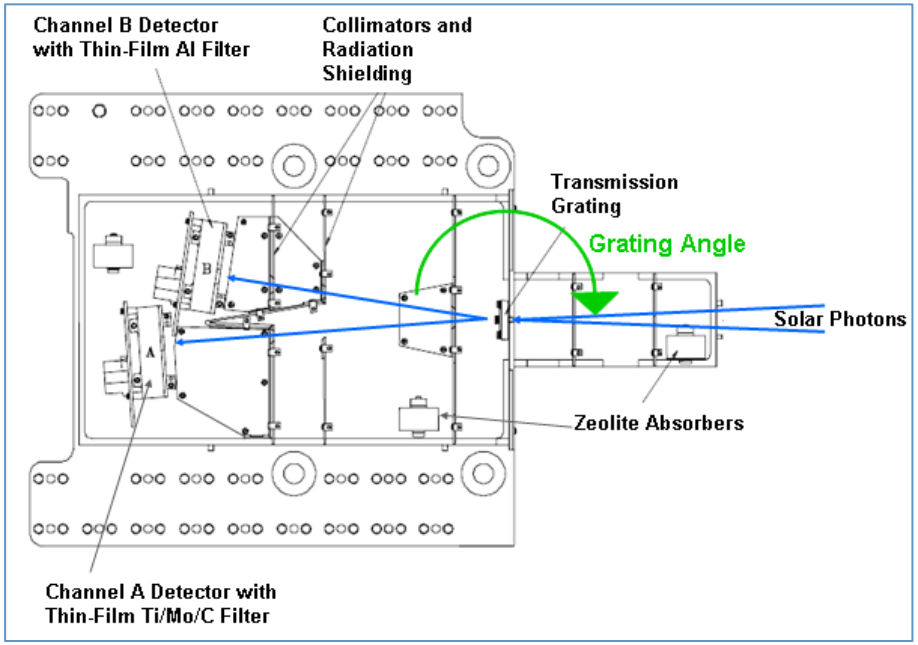


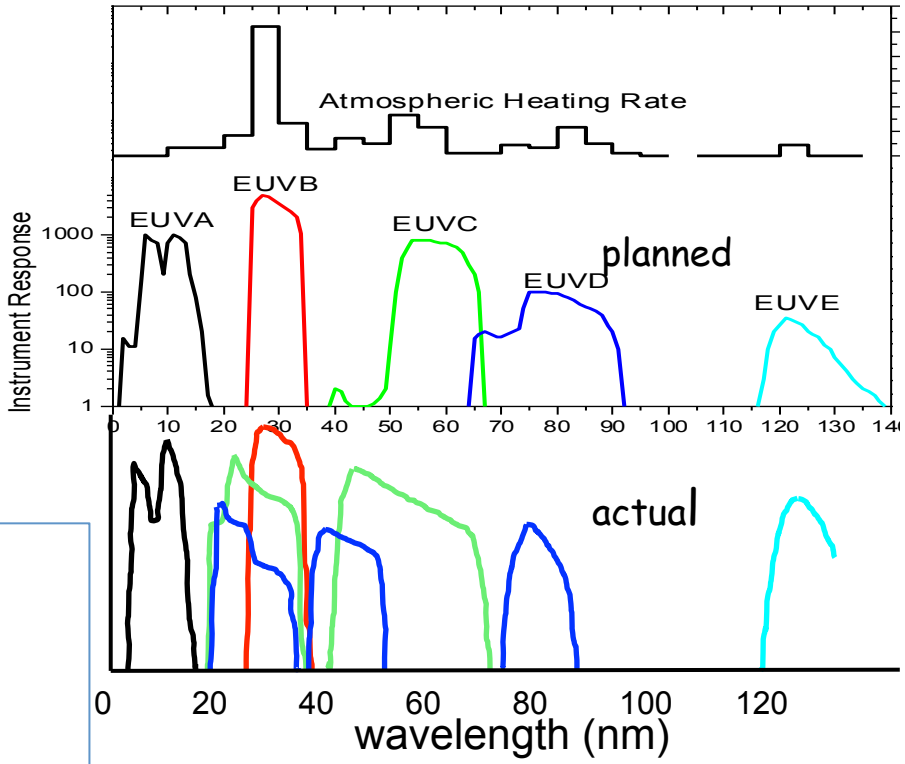
GOES EUVS

GOES EUVS (Panametrics → ATC)

- transmission grating spectrographs
  - shared gratings for A&B, C&D
  - detector: silicon photodiodes (IRD)
  - thin film filters on detector for A-D
  - no moving parts

- Calibrations at the NRL Beam Line at Brookhaven (John Seeley)





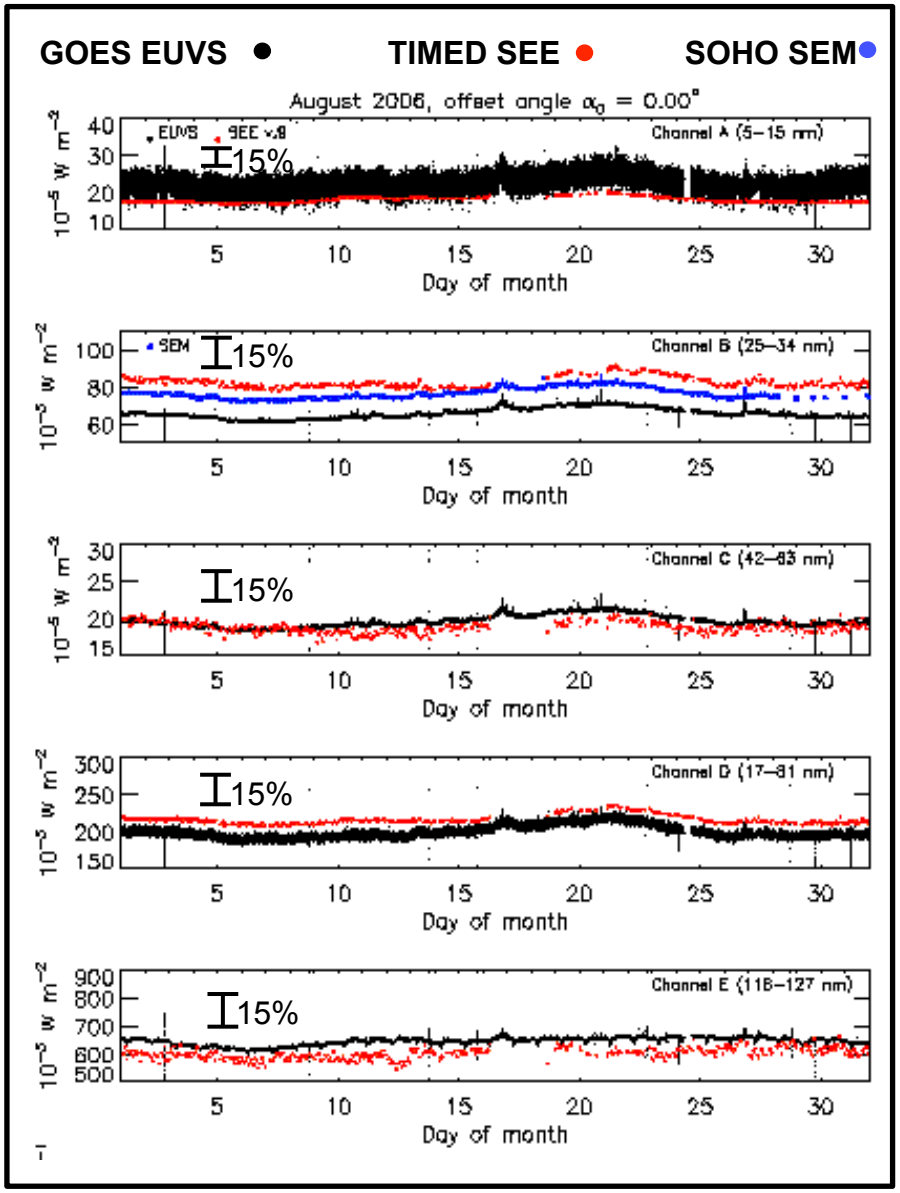
Earlier GOES EUVS Calibrations

GOES-13: Solar Phys (2010), Evans, Strickland, Woo, McMullin, Plunkett, Viereck, Hill, Woods, and Eparvier

Looked at post-launch test period in 2006 (X9 flare).

Compared with TIMED SEE and SOHO SEM.

All five channels within specified uncertainties



GOES EUVS Calibrations

How good are the GOES bands?

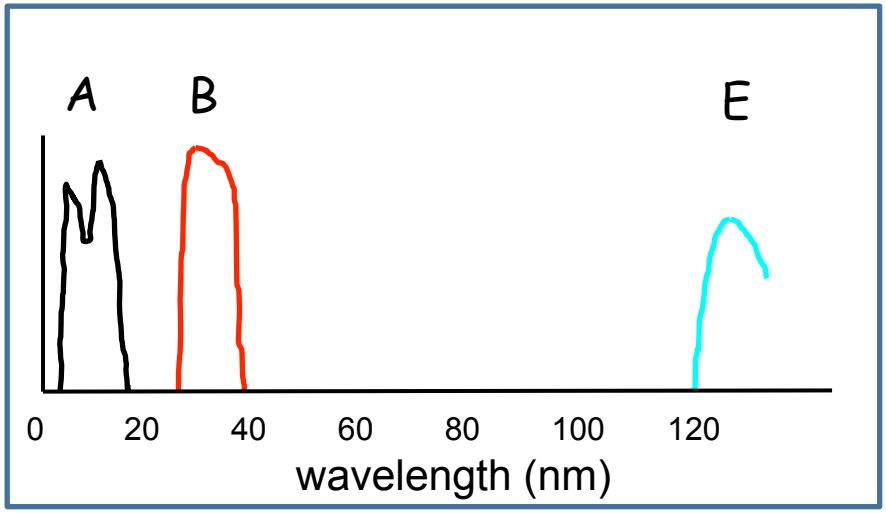
Focus on channels A, B, and E

Long term comparisons

- daily averages
- EVE V3 L3, SOHO SEM
- corrected to 1 AU

Flare (9 August 2011)

- 1-min data



GOES EUVS Calibrations

The irradiance measured in a channel is

J [W/m^2] =
((Counts - Offset [counts]) * Gain [A/count] –VisibleLightContamination [A])
/ ConversionFactor [A/(W/m^2)]

Offset, Gain, and VisibleLightContamination are determined before launch.

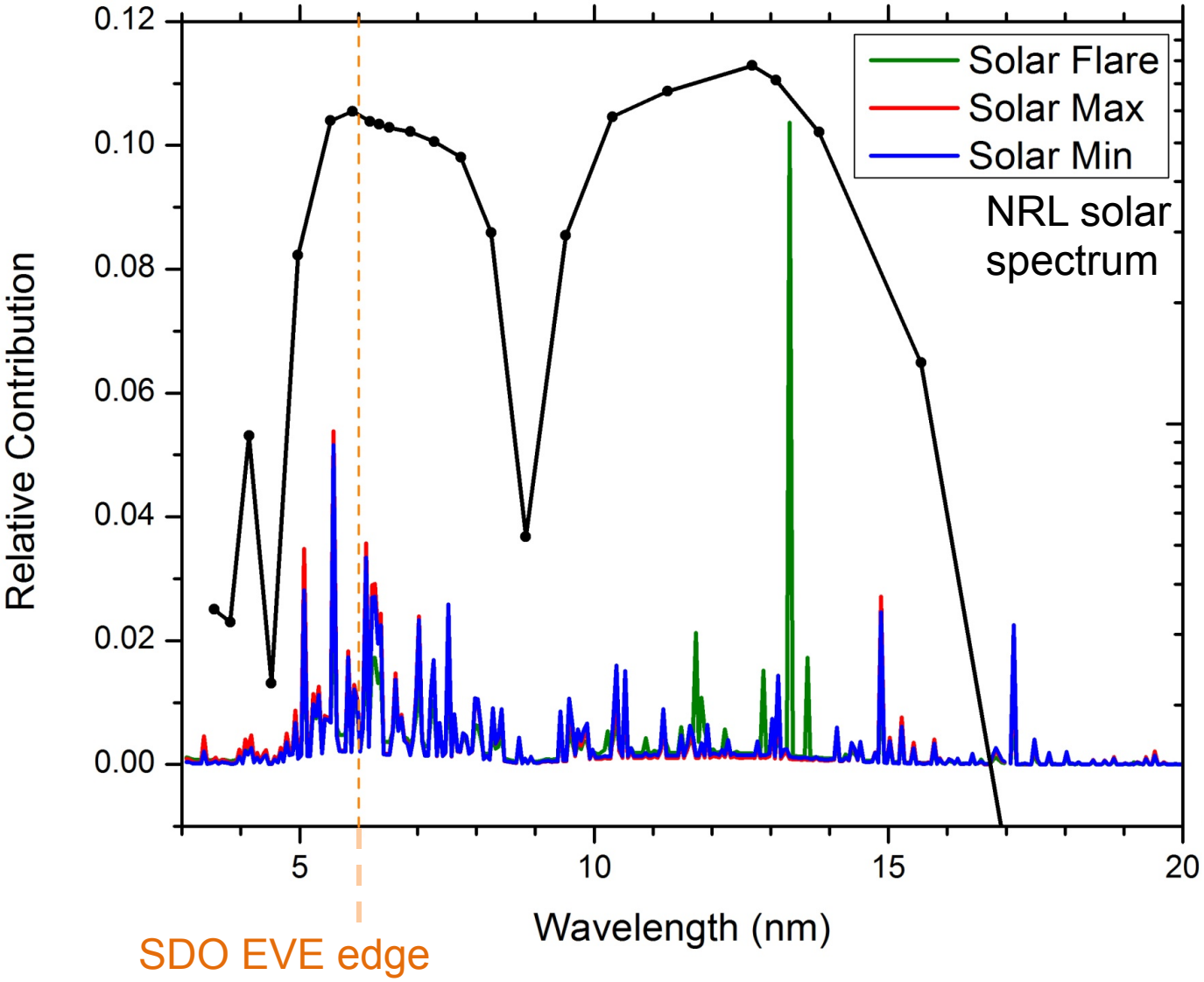
ConversionFactor is a function of wavelength and bandpass and requires an assumed spectrum and response function. (Current conversion assumes boxcar response.)

We assume the quiet Sun NRL spectrum and calculate

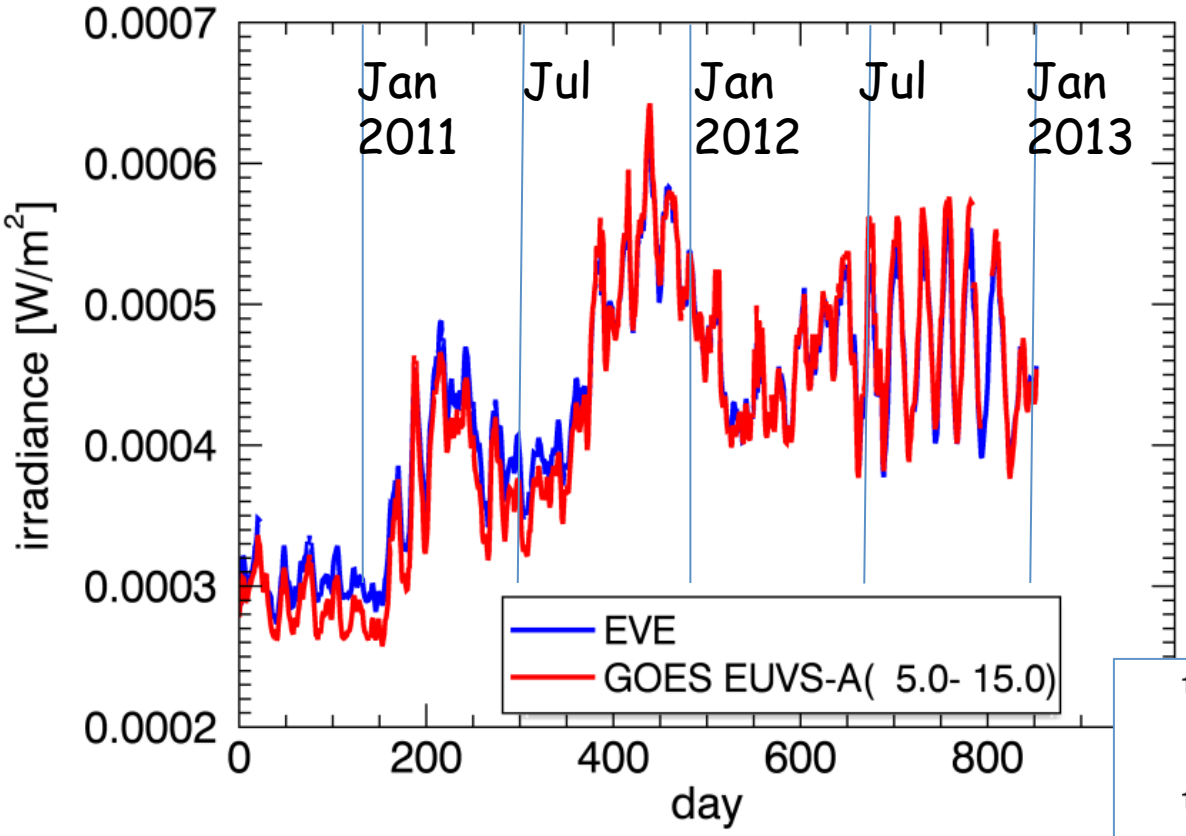
J_{tot} [W/m^2] = $\sum J_i$ total irradiance of detector band for NRL model
J_{subset} [W/m^2] = $\sum J_i$ total irradiance of subset of band for NRL model
I_{tot} [A] = $\sum R_i \cdot J_i$ total current of band= detector response x irradiance

$J_{meas} = (J_{tot} / I_{tot}) \cdot I_{meas}$ measured irradiance in full channel
$J_{meas\_subset} = (J_{subset} / J_{tot}) \cdot J_{meas}$ measured irradiance in subset of channel

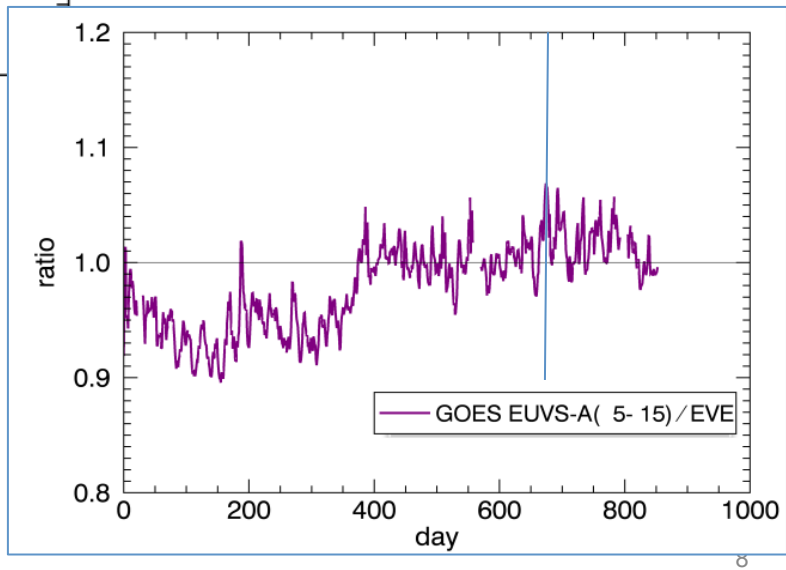
GOES EUV-A Bandpass



GOES EUV-A Irradiances

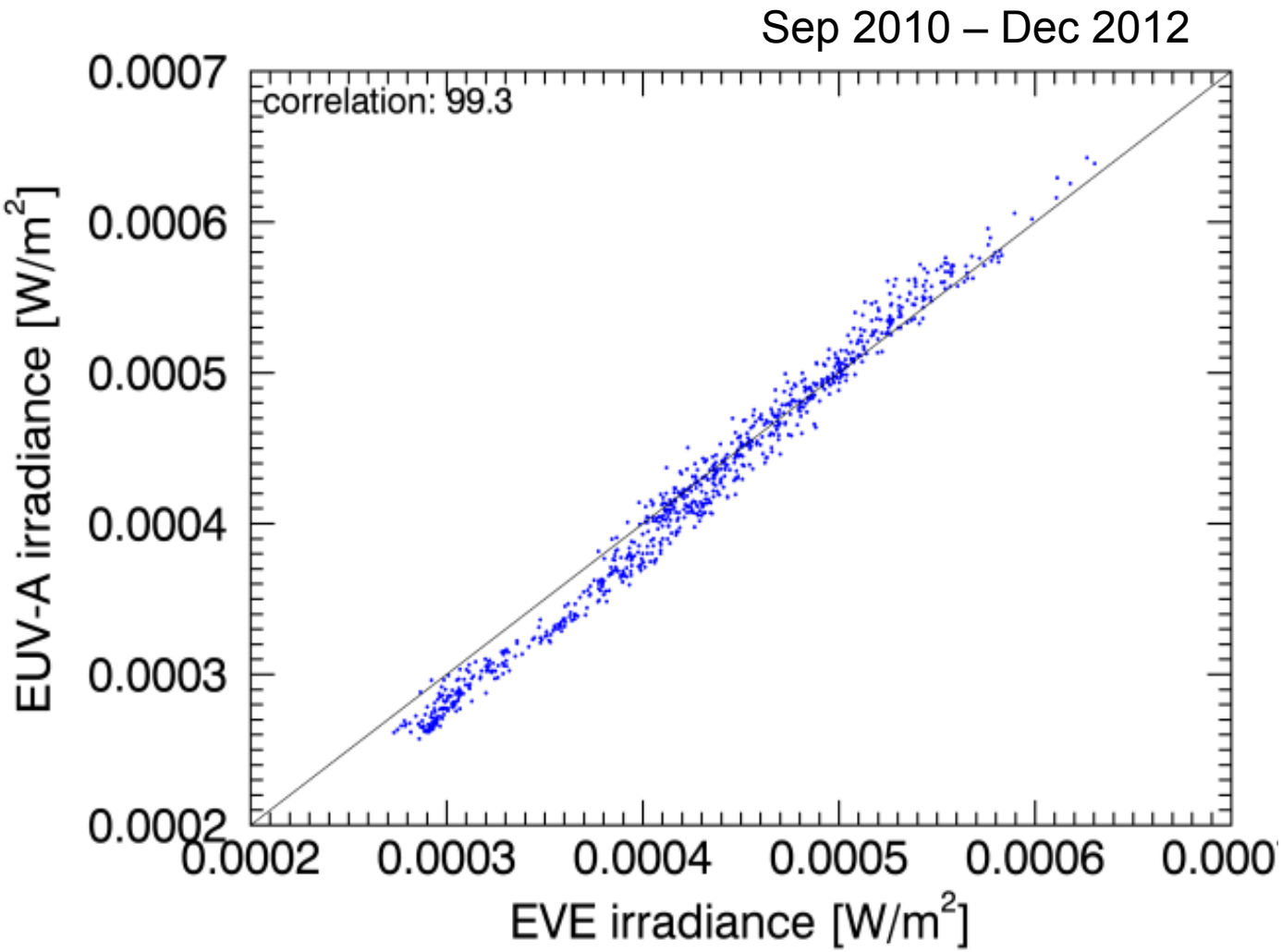


Ratio

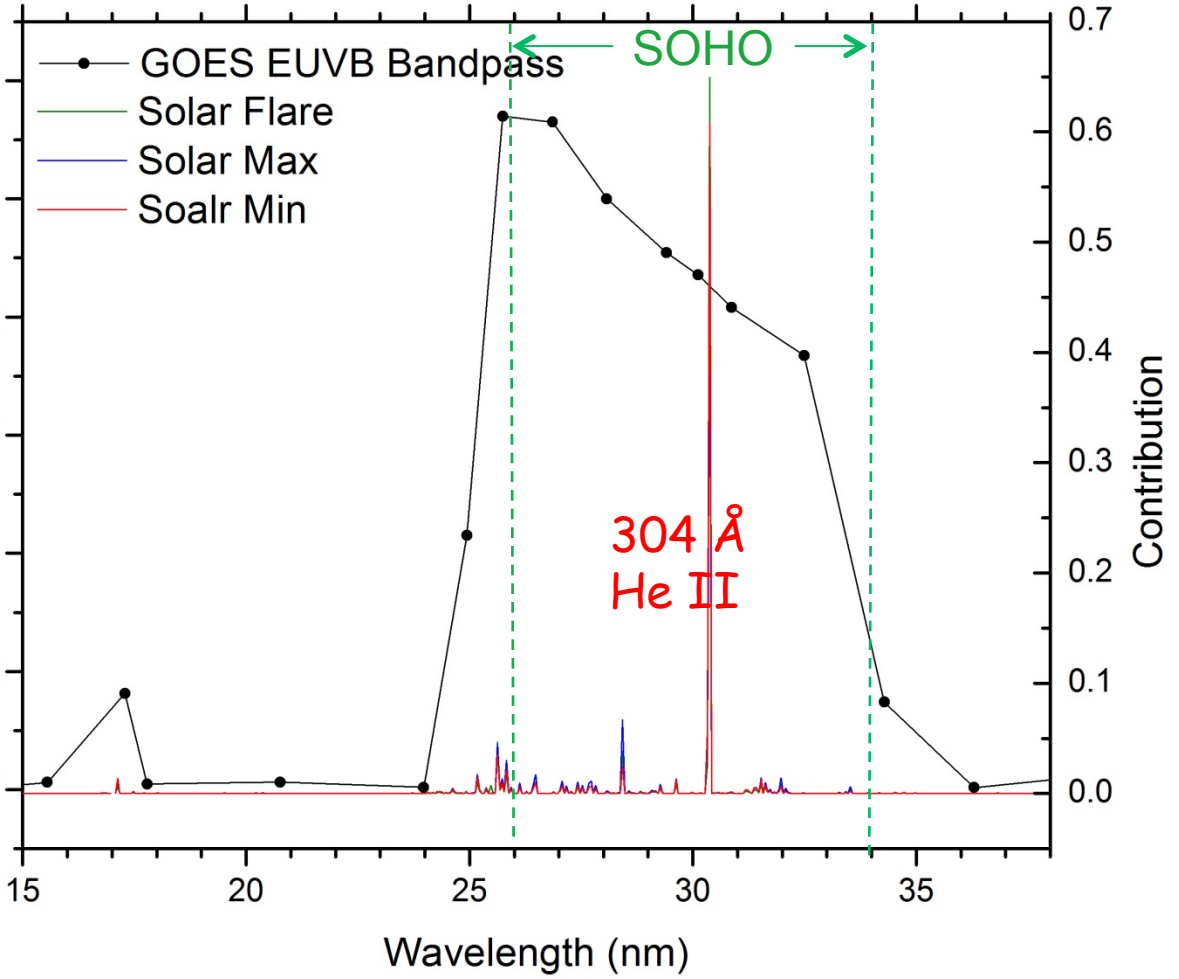


Sept 2010 to Dec 2012
Comparing with EVE 'GOES-A band' 5-15 nm

GOES EUV-A Correlations

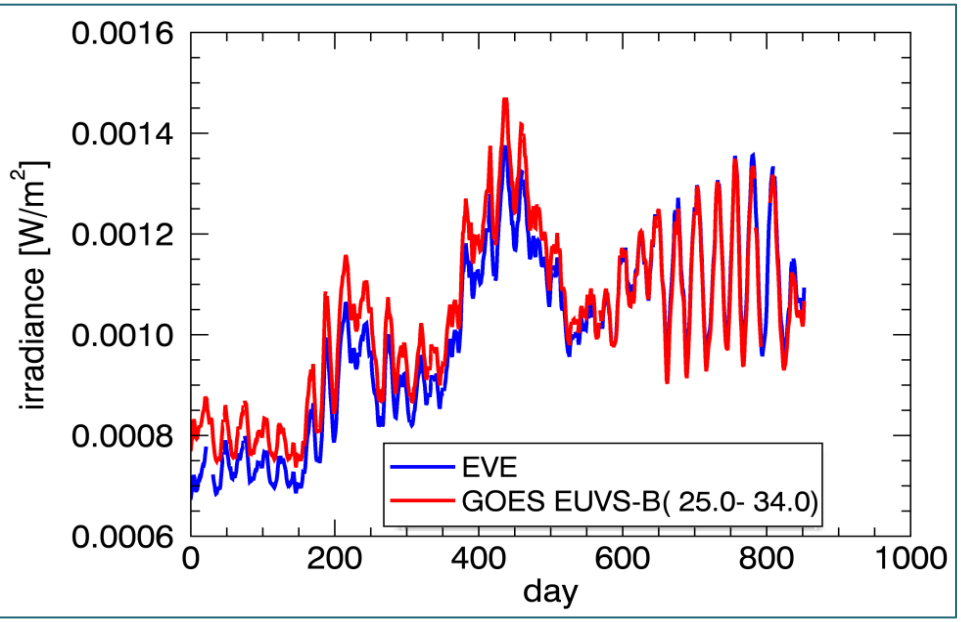


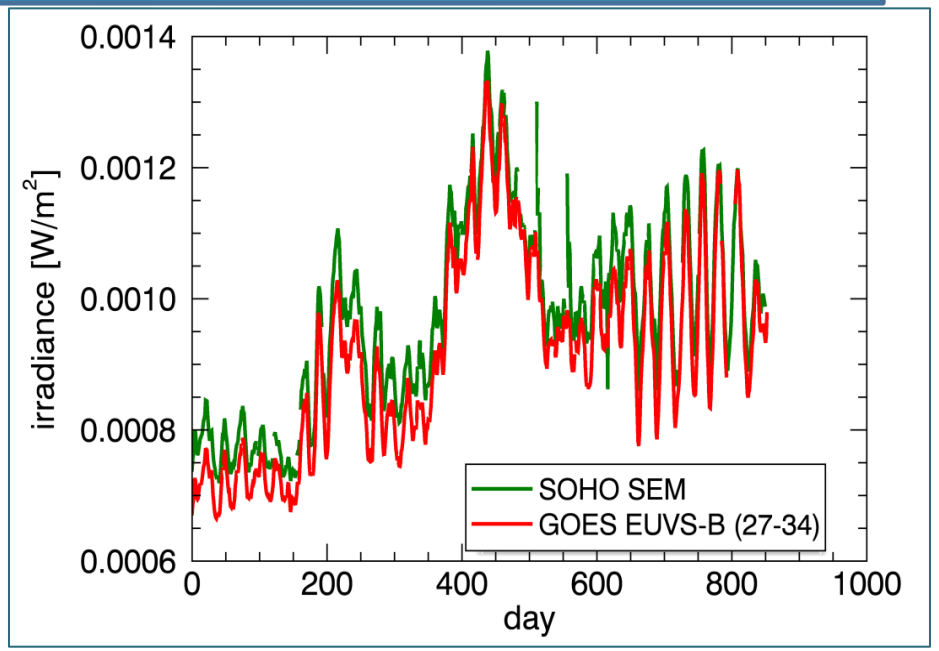
GOES EUV-B

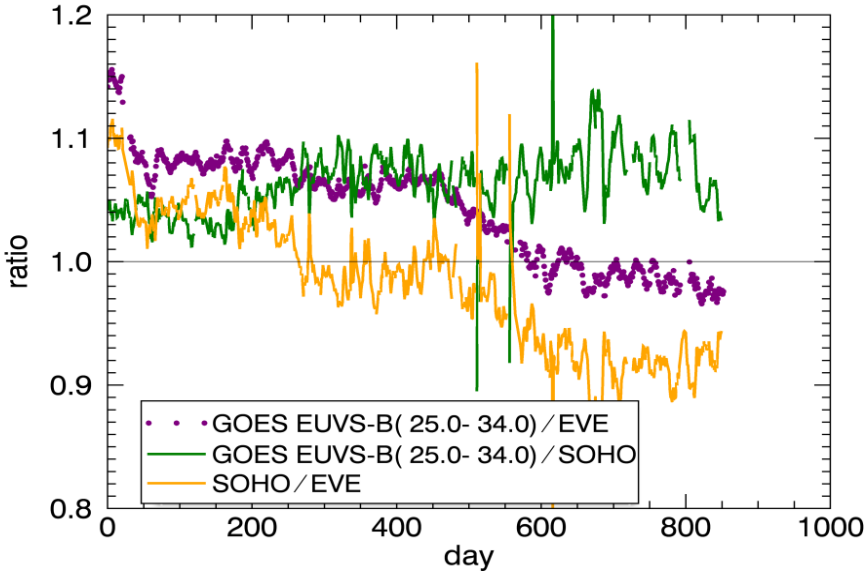


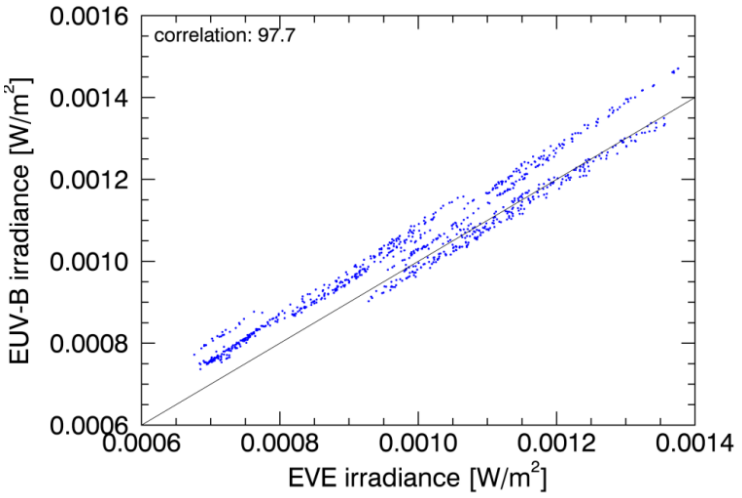
Comparisons
SDO EVE “GOES-B” (25-34 nm), SOHO SEM (26-34 nm)

GOES EUV-B

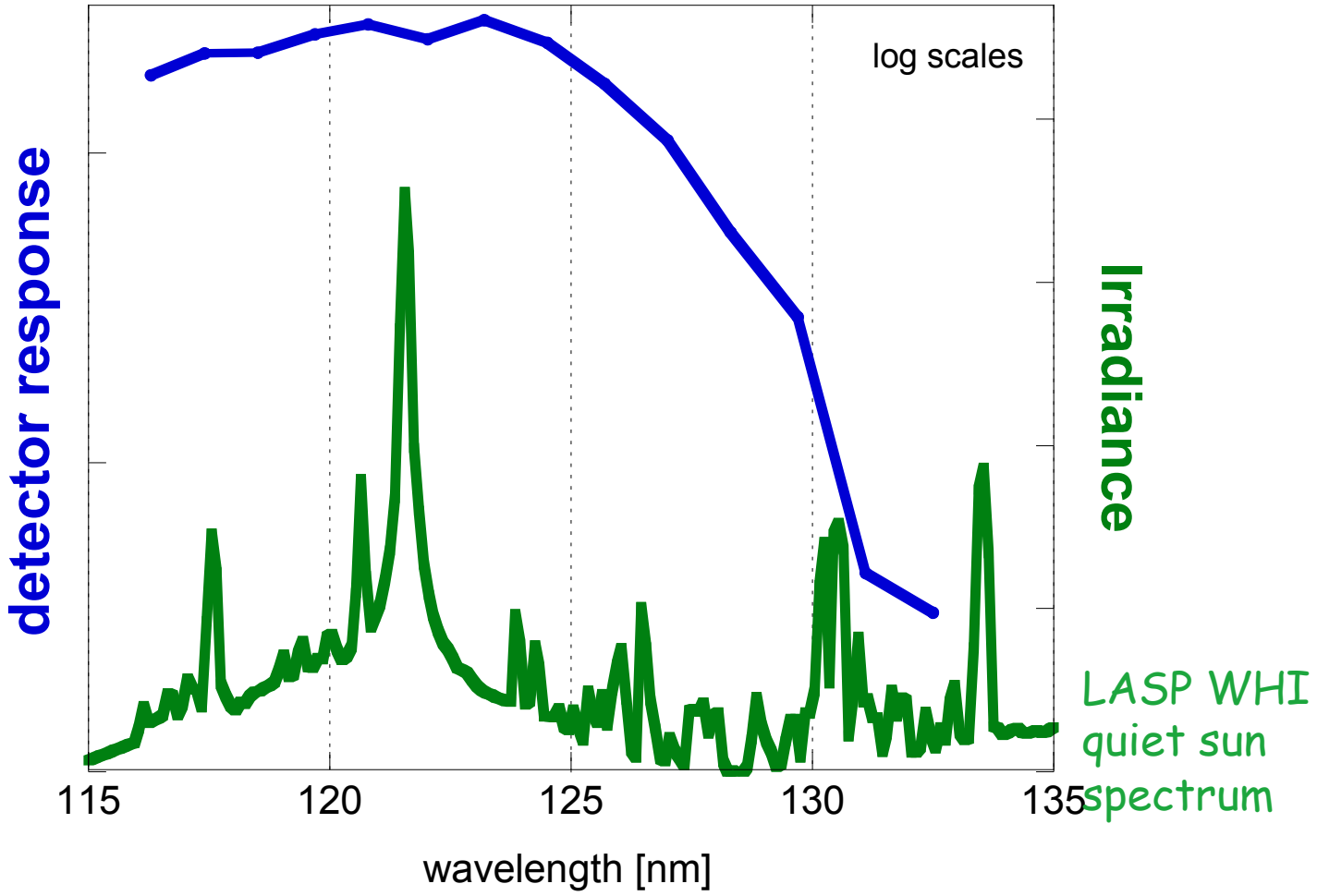

irradiance [W/m^2]
day
EVE
GOES EUVS-B(25.0- 34.0)


irradiance [W/m^2]
day
SOHO SEM
GOES EUVS-B (27-34)

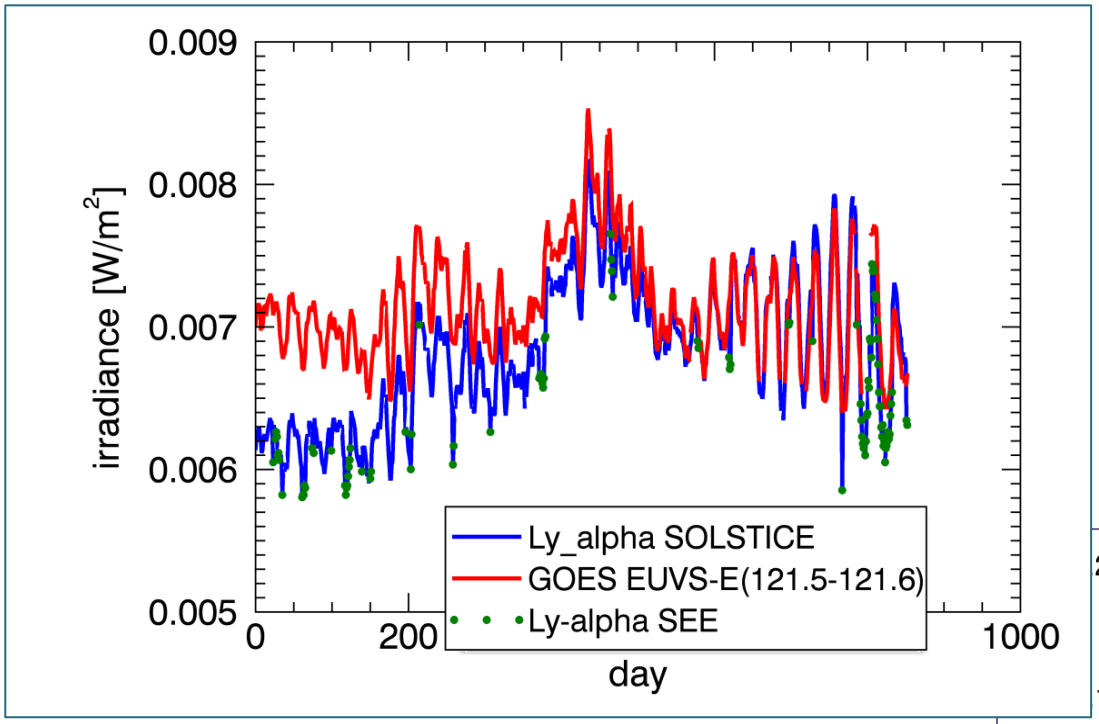

ratio
day
GOES EUVS-B(25.0- 34.0)／EVE
GOES EUVS-B(25.0- 34.0)／SOHO
SOHO／EVE

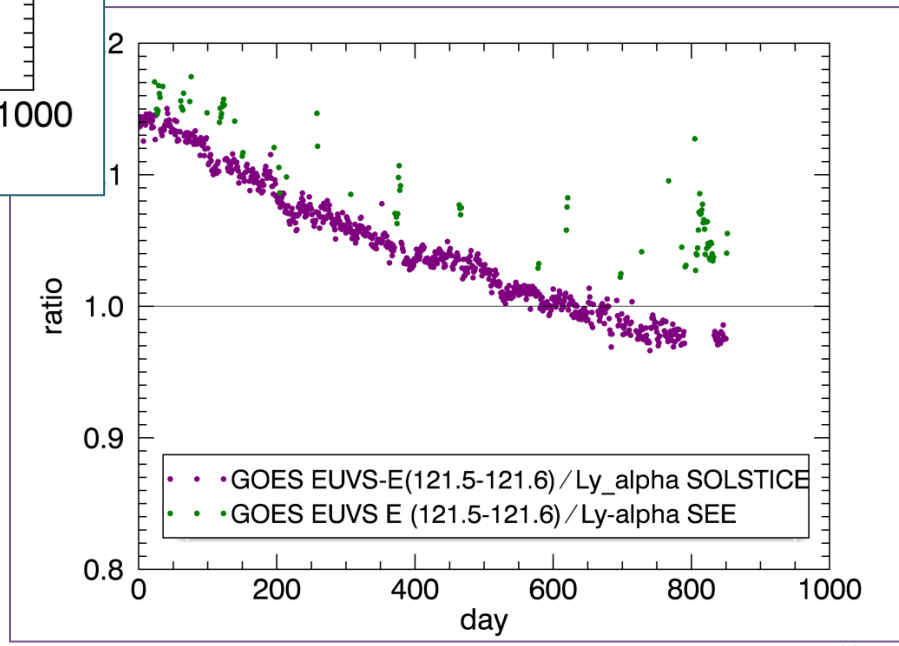

correlation: 97.7
EUV-B irradiance [W/m^2]
EVE irradiance [W/m^2]

GOES EUV-E (Lyman α, 121 nm)



GOES EUV-E (Lyman α, 121 nm)

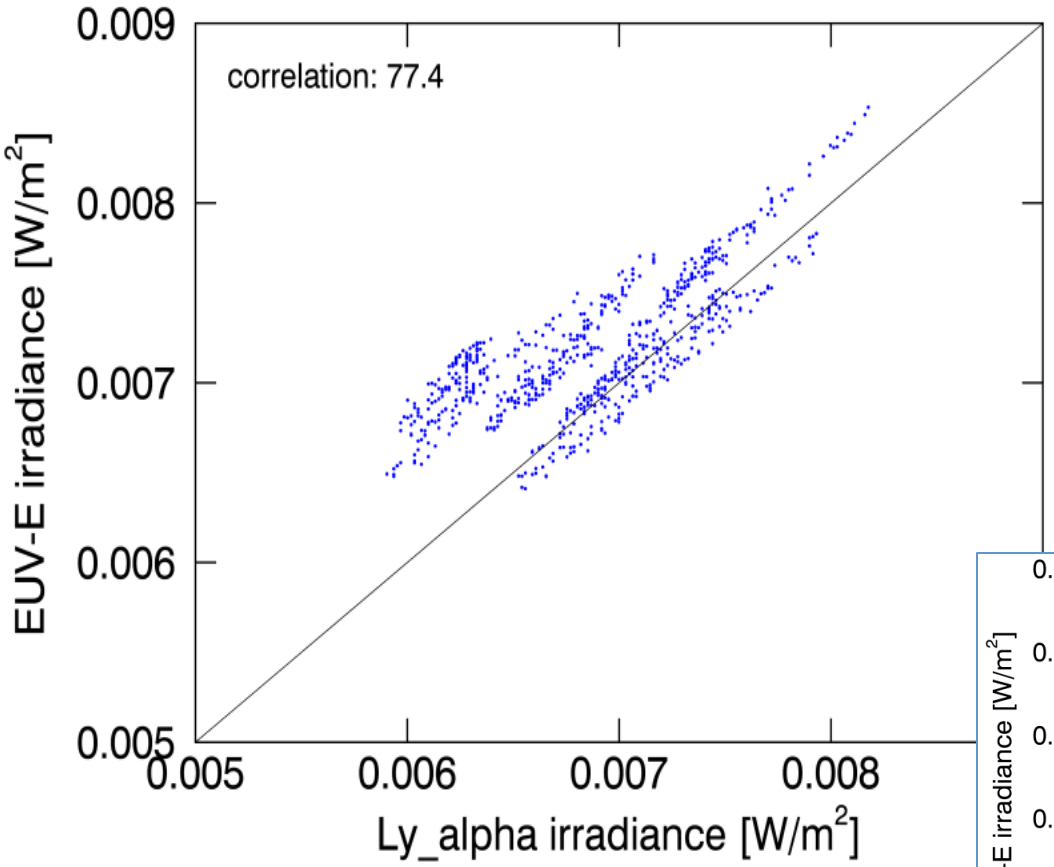




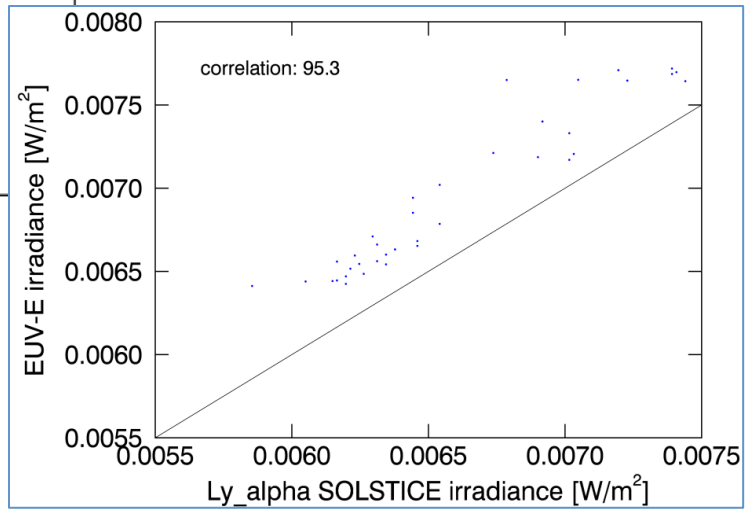
GOES EUV-E degradation of about 7% per year.
-- radiation damage to filter
-- need to do a fit

GOES EUV-E

Sep 2010 – Dec 2012

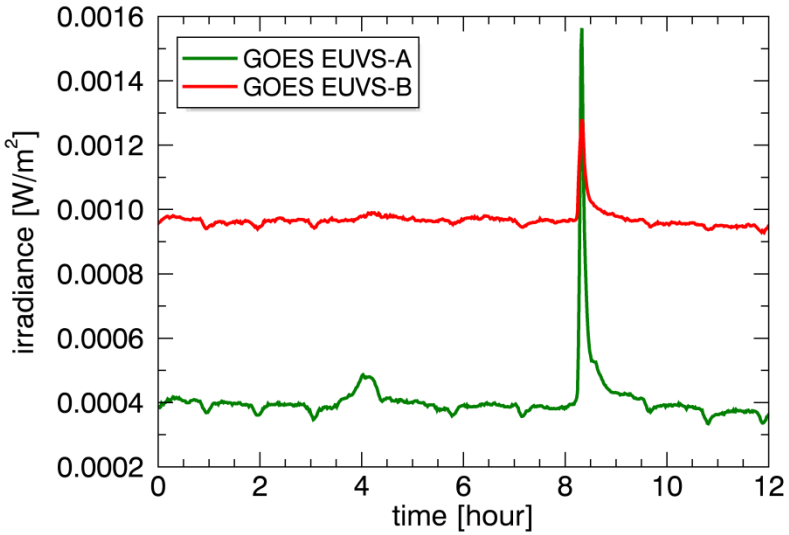


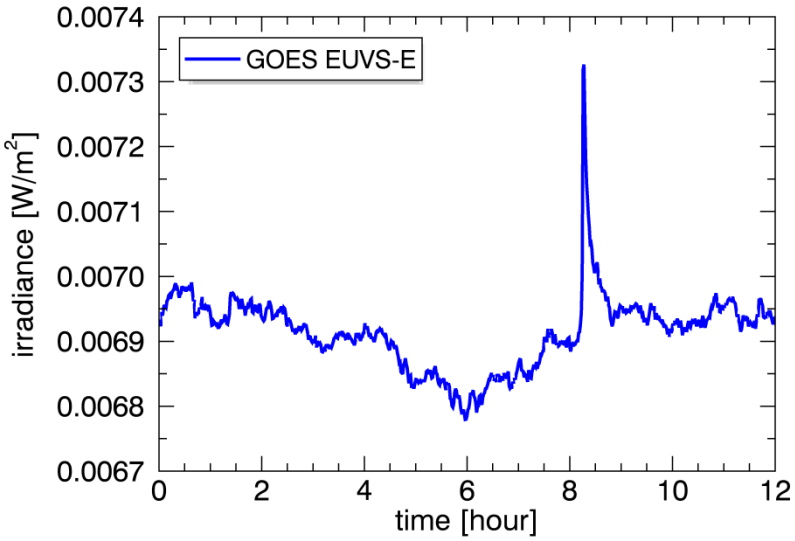
Jul-Dec 2012



9-Aug-2011 Flare

1-minute data
See dips from heater
E-geocorona impact

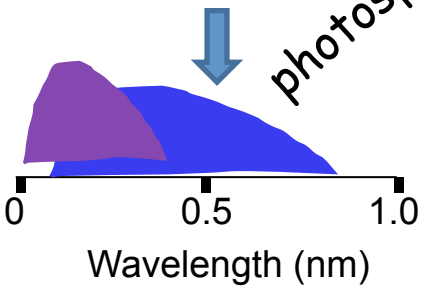




Next Generation…GOES-R EXIS

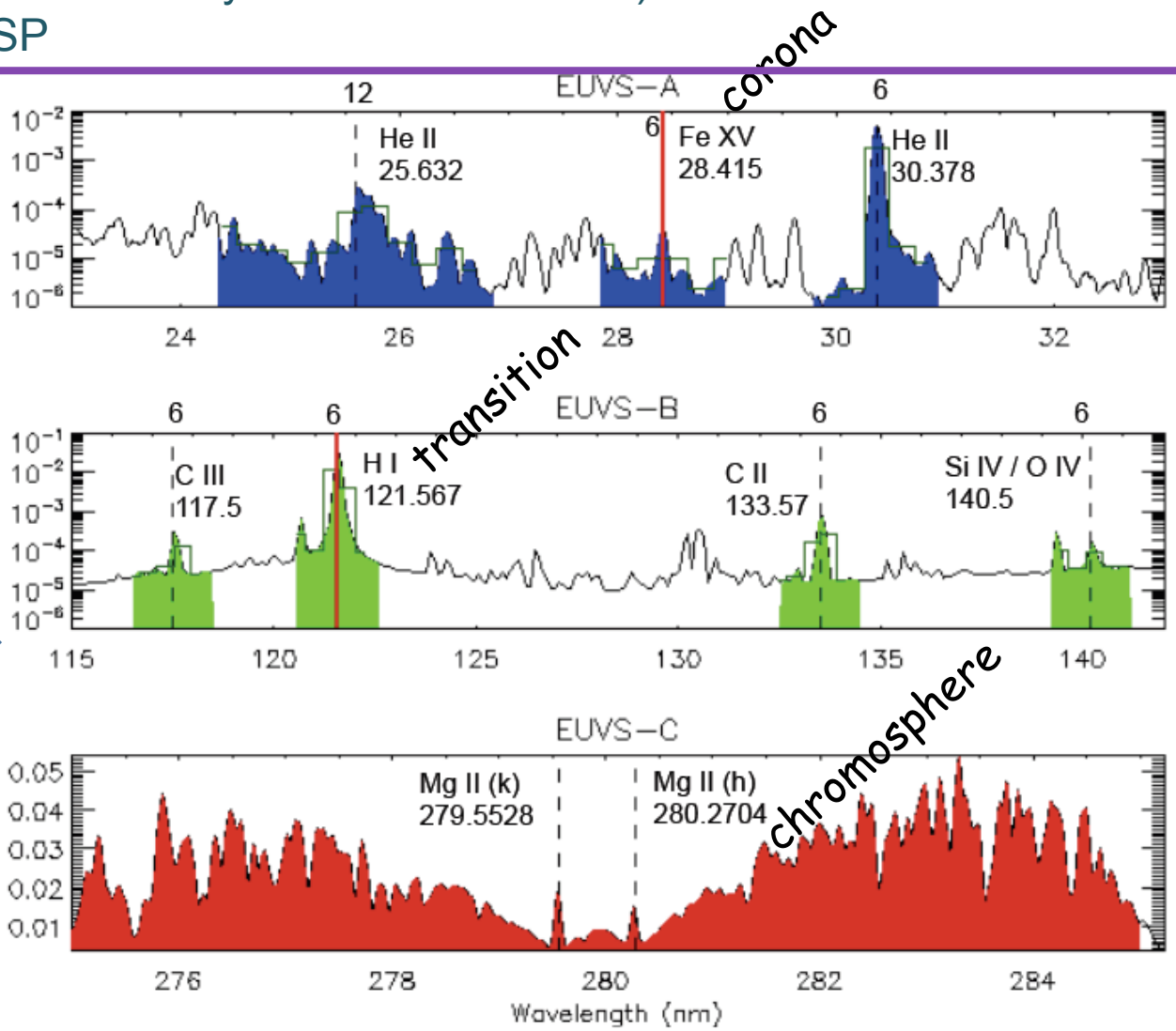
GOES-R launch 2015?
EXIS (Extreme ultraviolet and X-ray Irradiance Sensors)
designed, built by LASP

XRS-A, -B



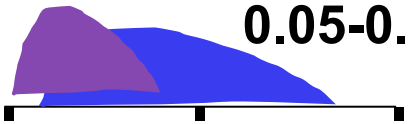
EUVS-A, -B, -C

- High resolution
- Lines representative of different solar regions



GOES-R EXIS…Instruments

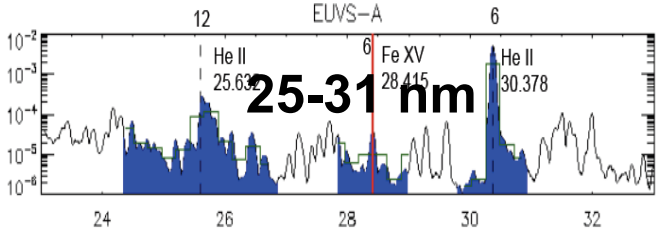
XRS-A, -B



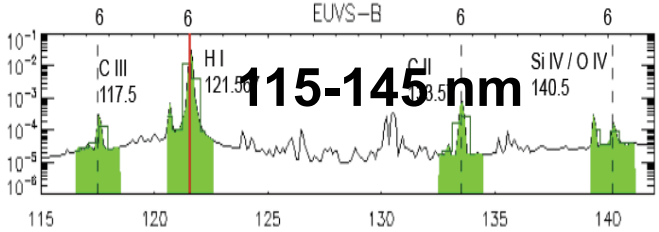
Si detectors and Be filters

- better SNR and dynamic range

EUVS-A



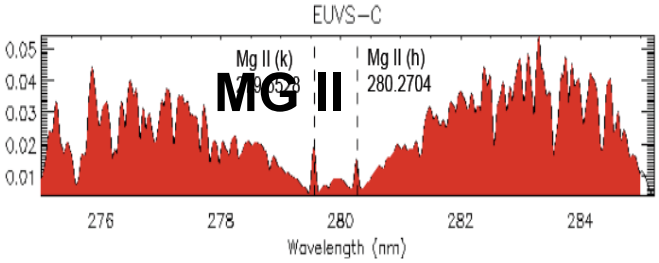
EUVS-B



reflection grating spectrographs

- better degradation tracking with redundant filters and bootstrap technique

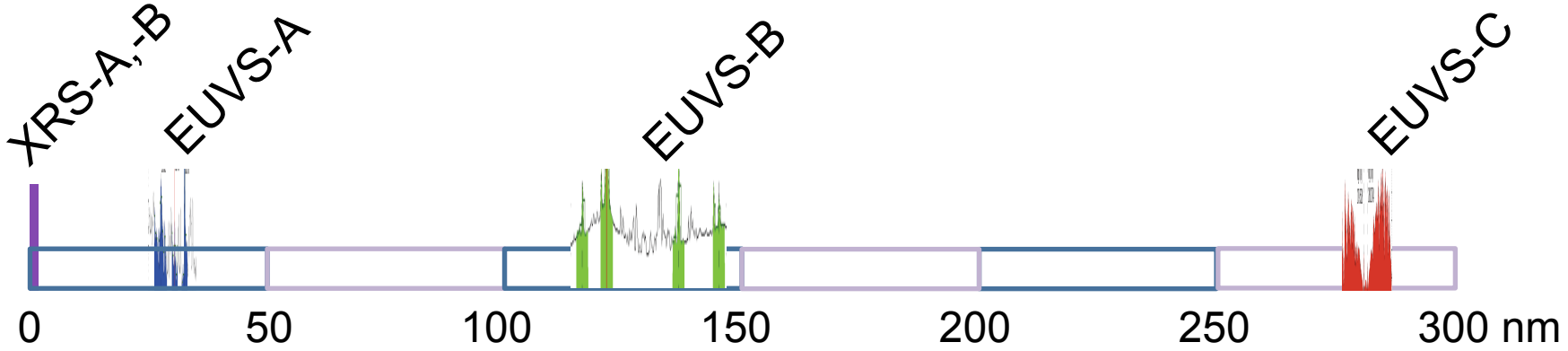
EUVS-C



EUV from GOES-R EXIS

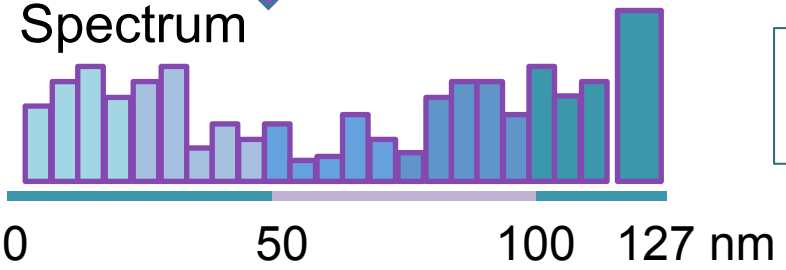
High res. spectra of lines, bands representative of different solar regions.
Reconstruct full EUV spectra from sparse measurements….

Assumes spectral features that have the same source regions in the solar atmosphere vary similarly.



$$E(\lambda\downarrow 5nm\,,\,t) = A(\lambda\downarrow 5nm\,) + \sum i=1\uparrow 10 \blacksquare j\downarrow i\,(\lambda\downarrow 5nm\,)\,P\downarrow i\uparrow m\downarrow i\,(t) + \sum i=1\uparrow 10 \blacksquare k\downarrow i\,(\lambda\downarrow 5nm\,)\,Q\downarrow i\uparrow n\downarrow i\,(t)$$

5-nm Output Spectrum

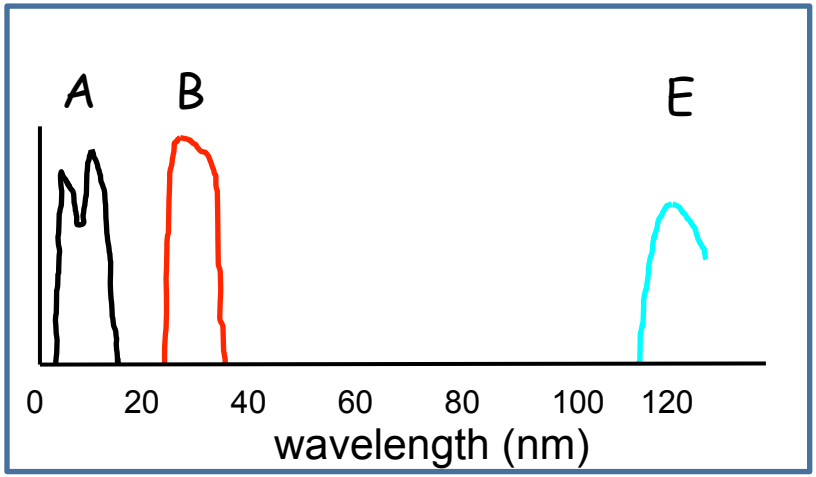


Previous studies validate technique (FISM).
LASP writing algorithm.

Summary

GOES-15 Comparisons

- daily data, 2010- 2012
- Ch A ±3% relative to EVE in 2012
- Ch B ~3% lower than EVE
  trend same as SOHO
- Ch E 7% degradation / year



Future

- Characterize XRS channels
- Use XRS to parameterize flare signals between quiet sun and flare spectra
- Calibrate and characterize C,D channels
- Look at GOES-13, GOES-14 (-14 duplicates A, B for angular effects on FOV)
- Put out GOES EUVS data on web.