Developing a Continuous Record of the Data from the GOES Extreme Ultraviolet Sensor

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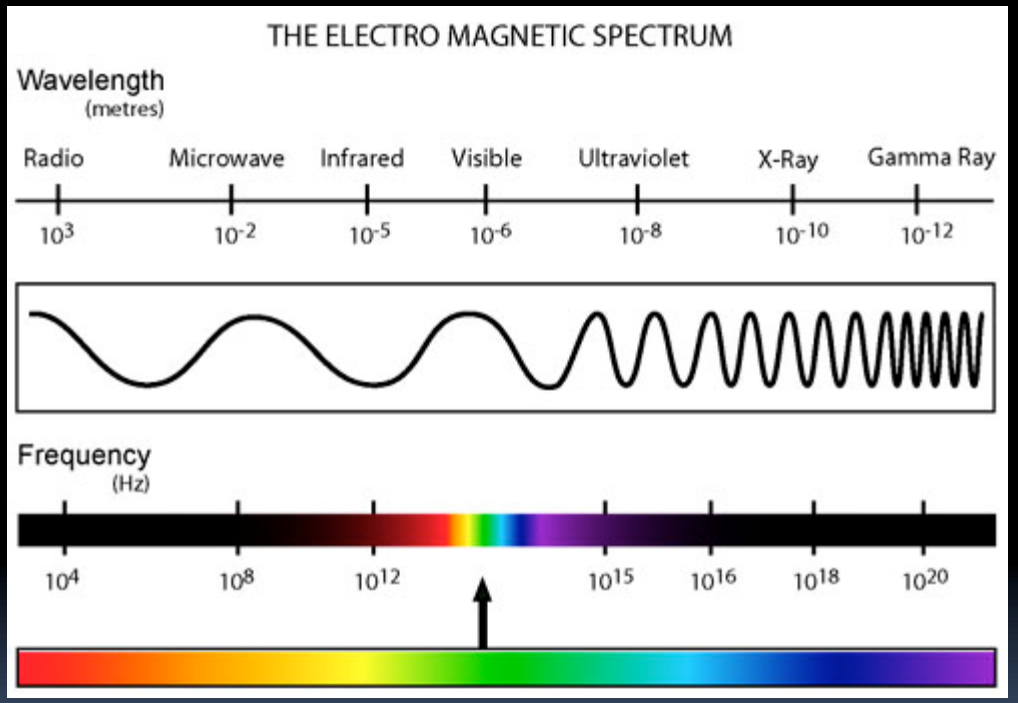
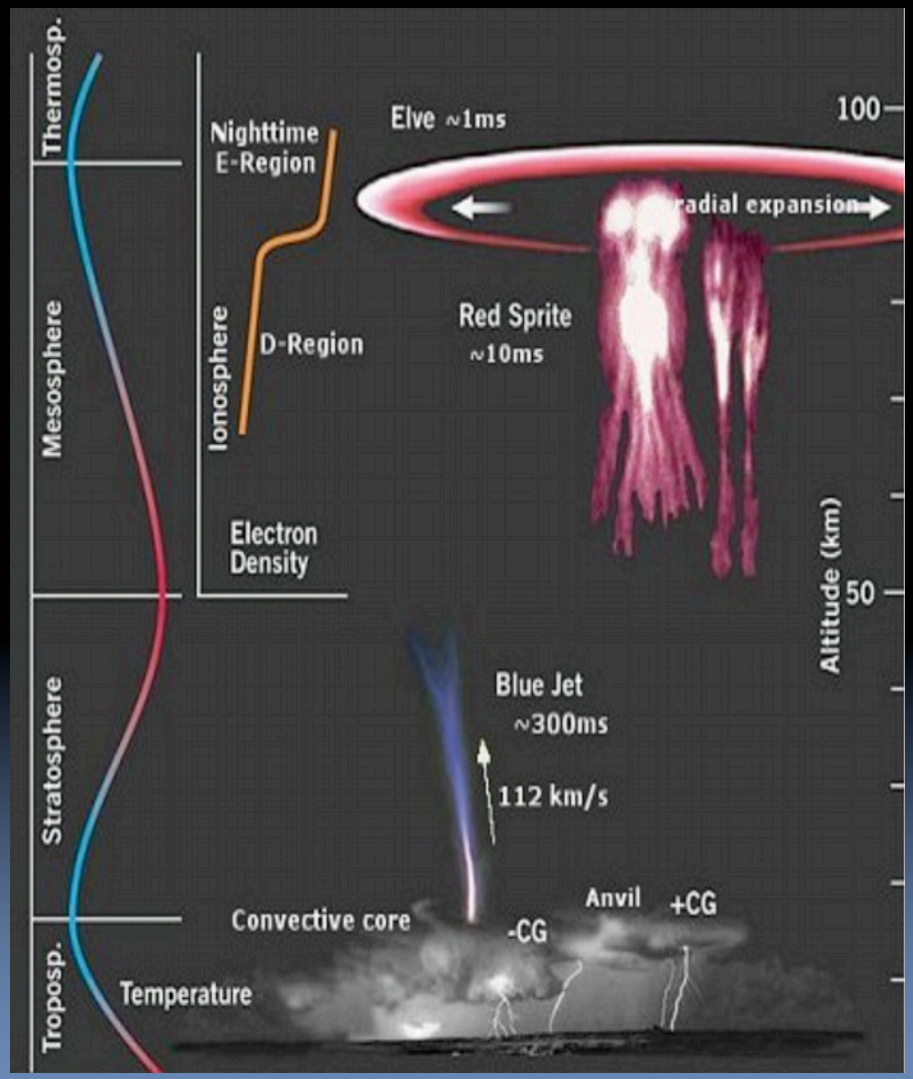
Background

- Ultraviolet ranges from 10nm-400nm in wavelength
- Extreme ultraviolet (EUV) ranges from 10nm-120nm

- Solar Irradiance: W/m^2*nm
- Total amount of EM radiation incident per unit area at a distance of 1 AU from the Sun

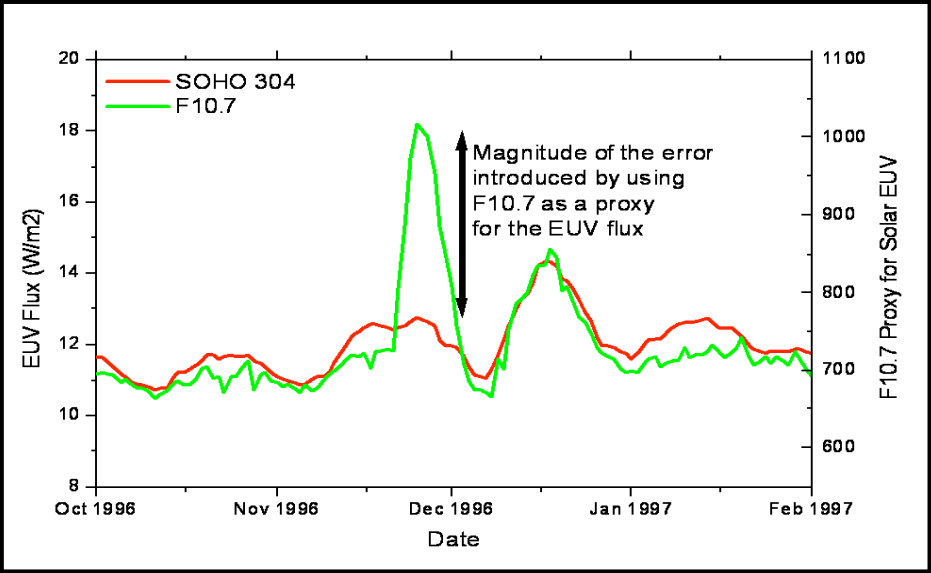


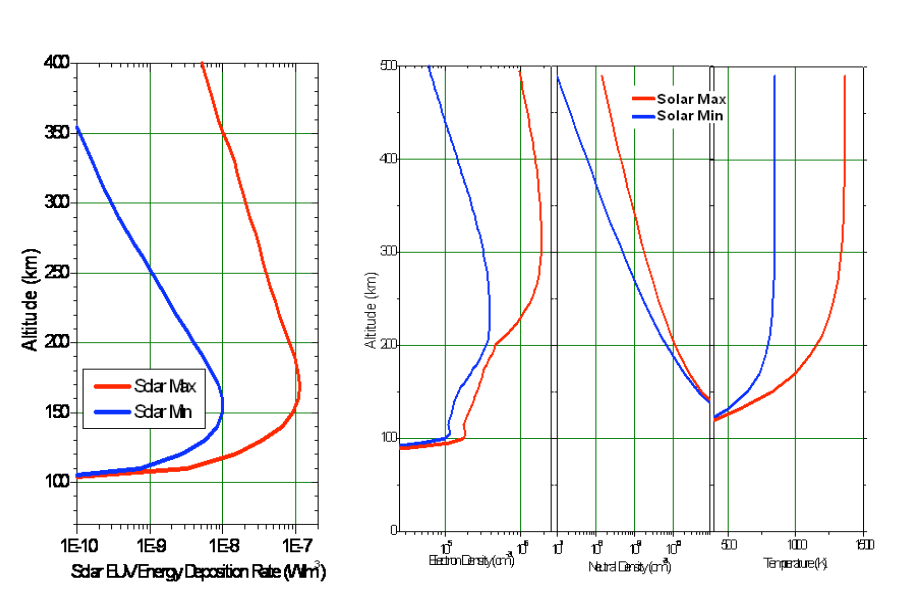
Who Cares about EUV?



- EUV is absorbed in the upper atmosphere and creates the Ionosphere. Responsible for heating the Thermosphere.
- Variations in EUV produce large variations in neutral and electron densities anywhere from minutes to years.
  - Causes satellite drag and tracking issues.
  - Interferes with GPS and navigation.
  - Also effects communications in both ground to ground and ground to space

The Need for an EUV Sensor

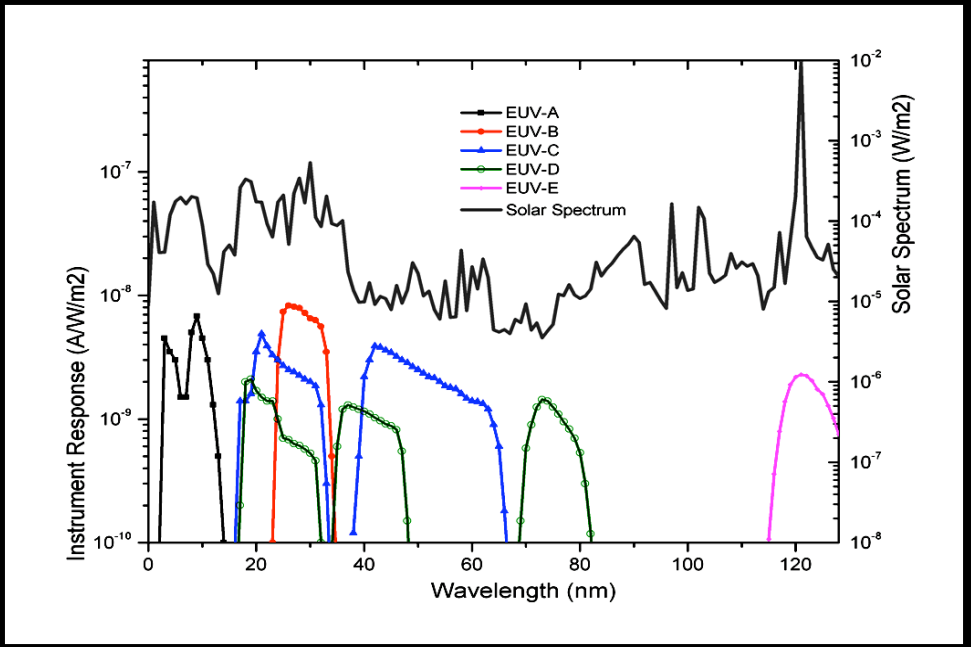


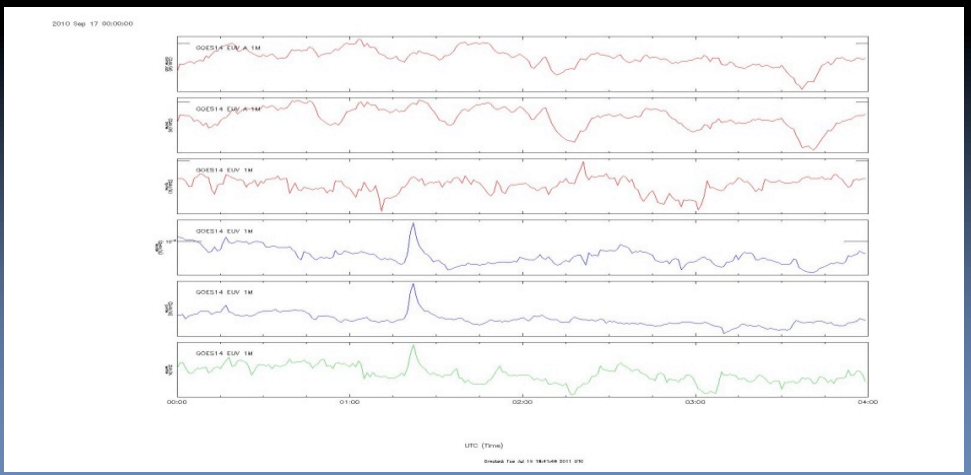


- Currently F10.7 cm radio flux data is being used as a proxy for EUV.
- F10.7cm only available at daily cadence
- Using proxies instead of the actual EUV Flux introduces large errors in models and calculations, anywhere from 20-40 %

EUV Sensor (EUVS)

- EUVS has several channels where atmospheric heating is the greatest.
- **EUV-A**: λ=5-17nm. Measures coronal emissions.
  - GOES 14 has A' (Same just inverted)
- **EUV-B**: λ= 30.4nm of the bright He chromospheric line.
  - GOES 14 has B' (Same just inverted)
- **EUV-E**: λ=121.6nm of the very bright H Lyman Alpha line.





History

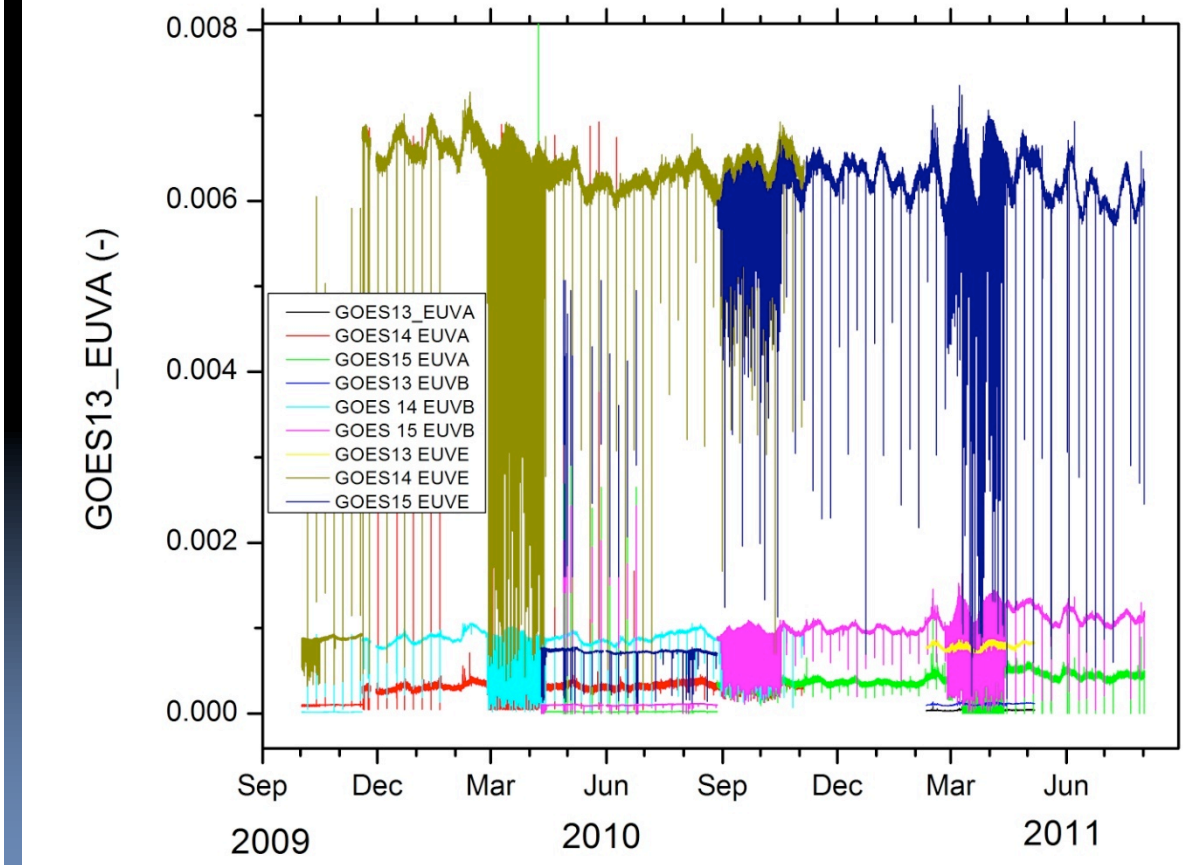
- Due to stricter requirements from NOAA and DOD, EUV sensors were added to the space weather suites on the GOES 13, 14, & 15 satellites.
- GOES 13 was launched in 2006
  - Put into storage for several years due to the needs of the tropospheric weather sensors
- GOES 14 summer 2009
- GOES 15 spring 2010

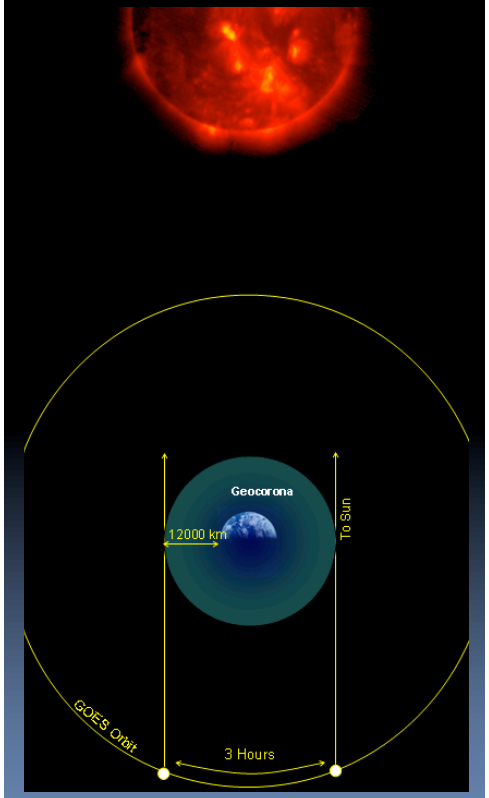
Project Goals

1. **Compare GOES 13,14,&15 EUVS data during the overlap periods**
2. **Establish operational scaling coefficients for the GOES 15 EUVS data**
3. **Combine G13, 14, 15 data to create continuous record of EUV irradiance going back to Nov 2009**
4. **Update the EUVS web page to display real-time GOES EUVS data**
5. Compare G15 to SOHO, EVE, & SDO data
6. Evaluate G13, 14, 15 trends and attempt to remove instrument degradation and artifacts from data.
7. Combine GOES irradiance data with other research data to create a record going back a full solar cycle.

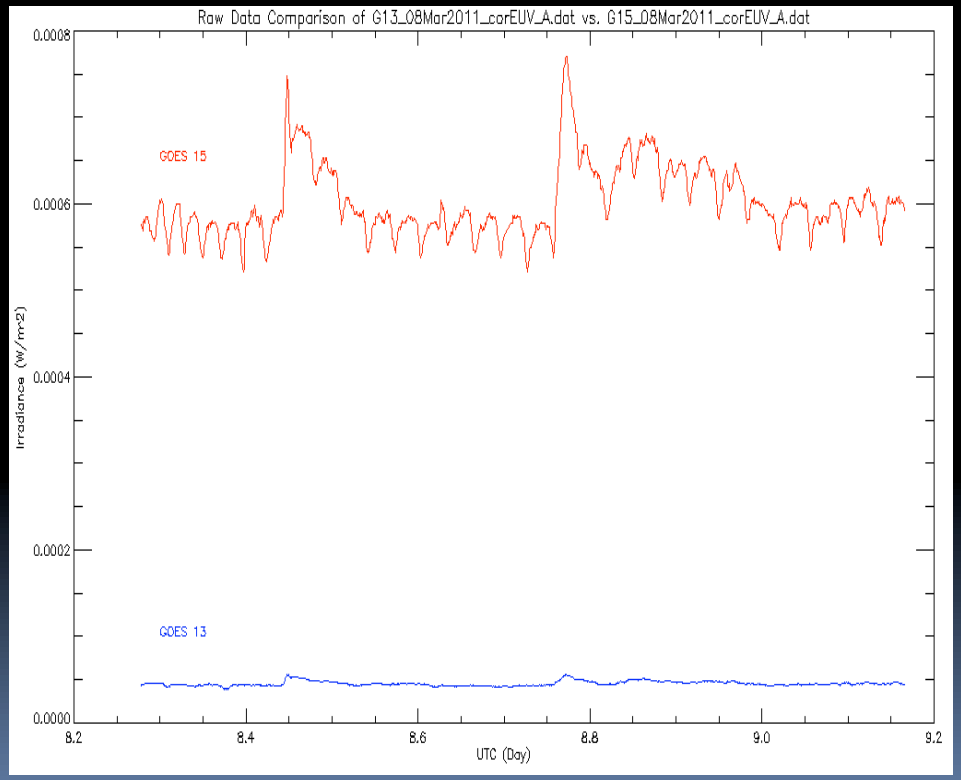
Getting Started: The Raw Data

Weekly calibrations
Eclipse periods
Daily dips due to the Geocorona





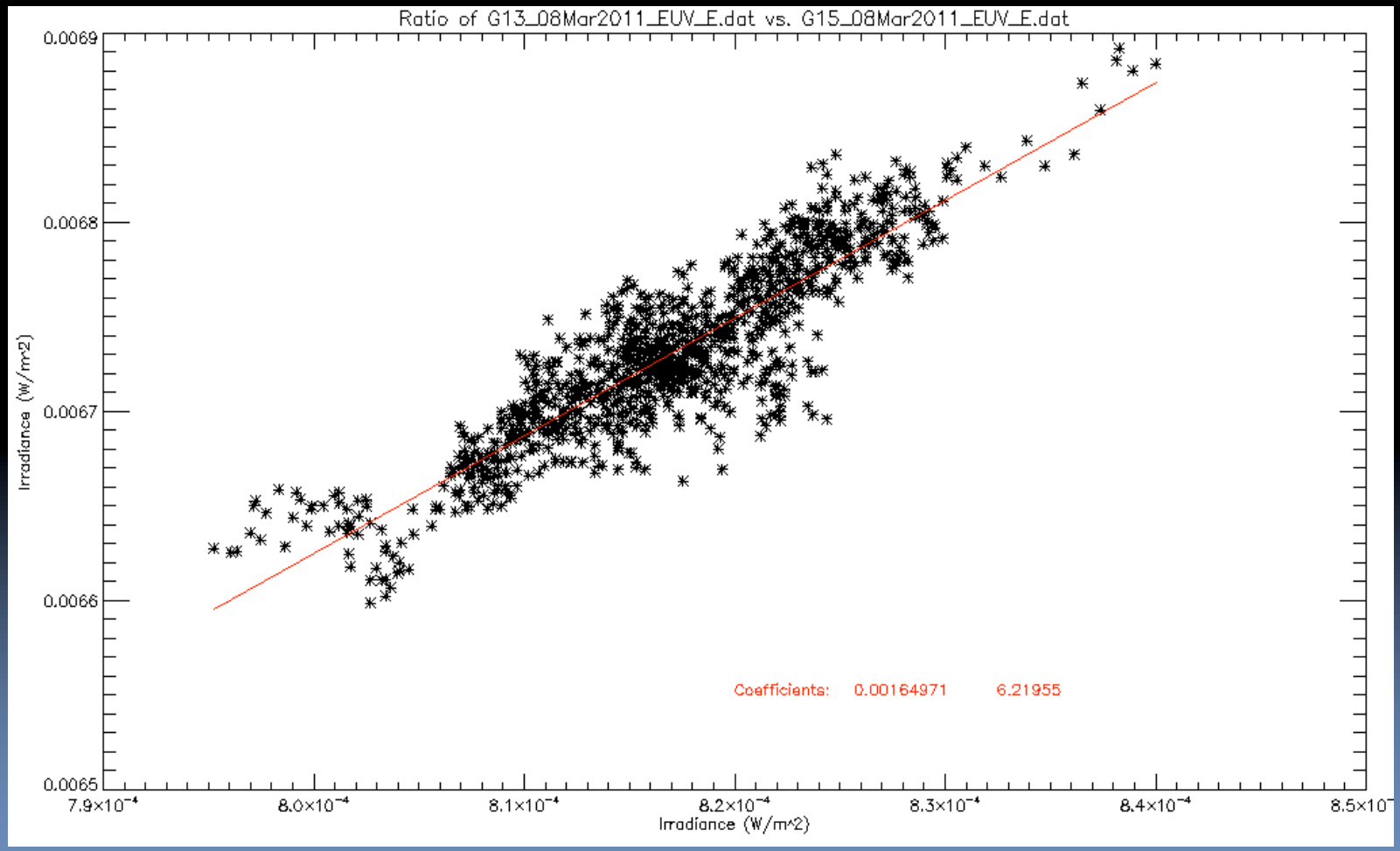
Finding the Overlapping Time Periods



- Used the program FRODO to compare
  - G14 Jul2009-Nov2010
  - G13 Feb2011-May2011
  - G15 Apr2010-Present
- Found flares within the overlap periods to provide some variability for better scaling

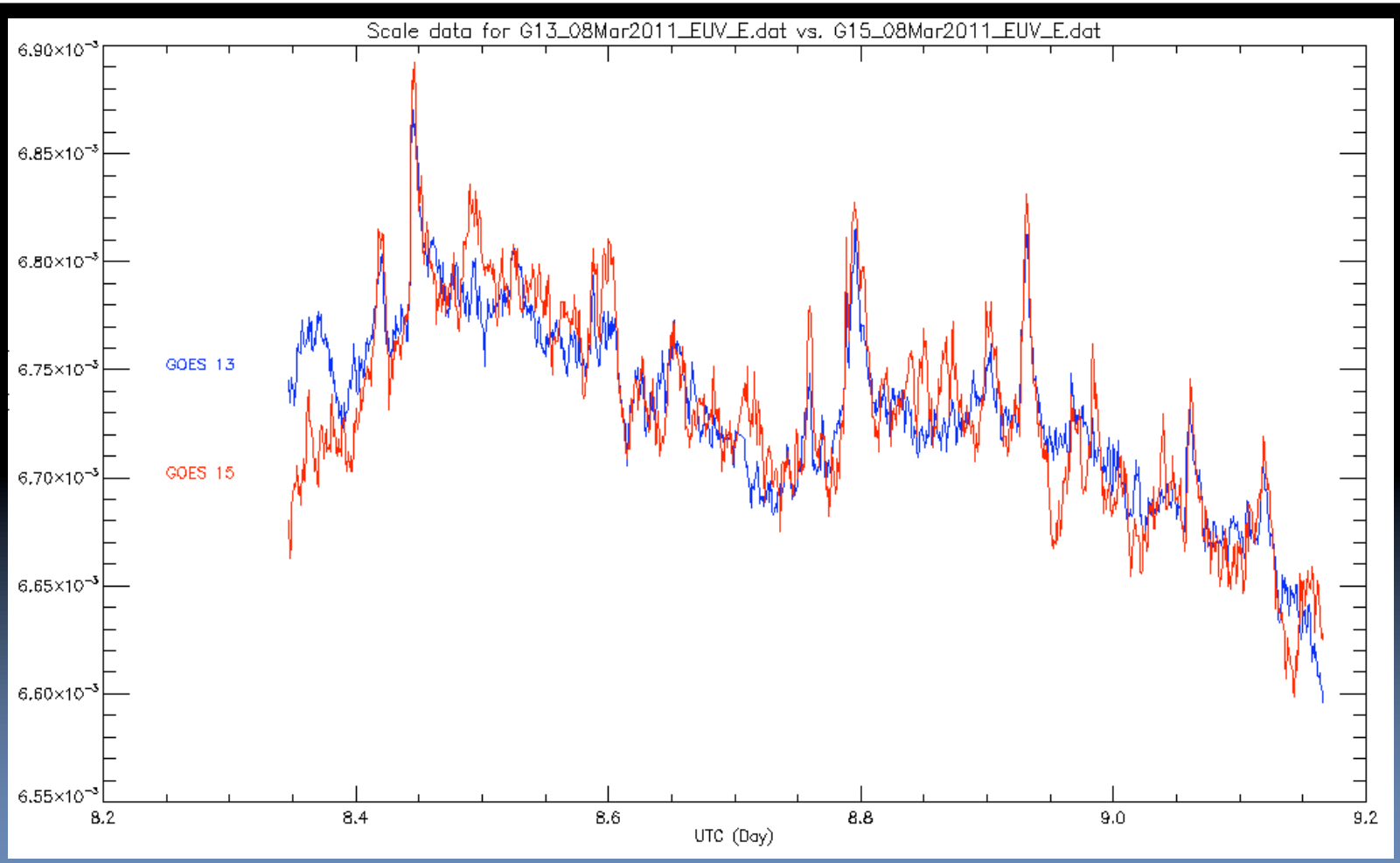
Finding the Scaling Coefficients

Plotted one against the other.
Used POLY_FIT to find line of best fit and scaling coefficients to apply to chosen data set.



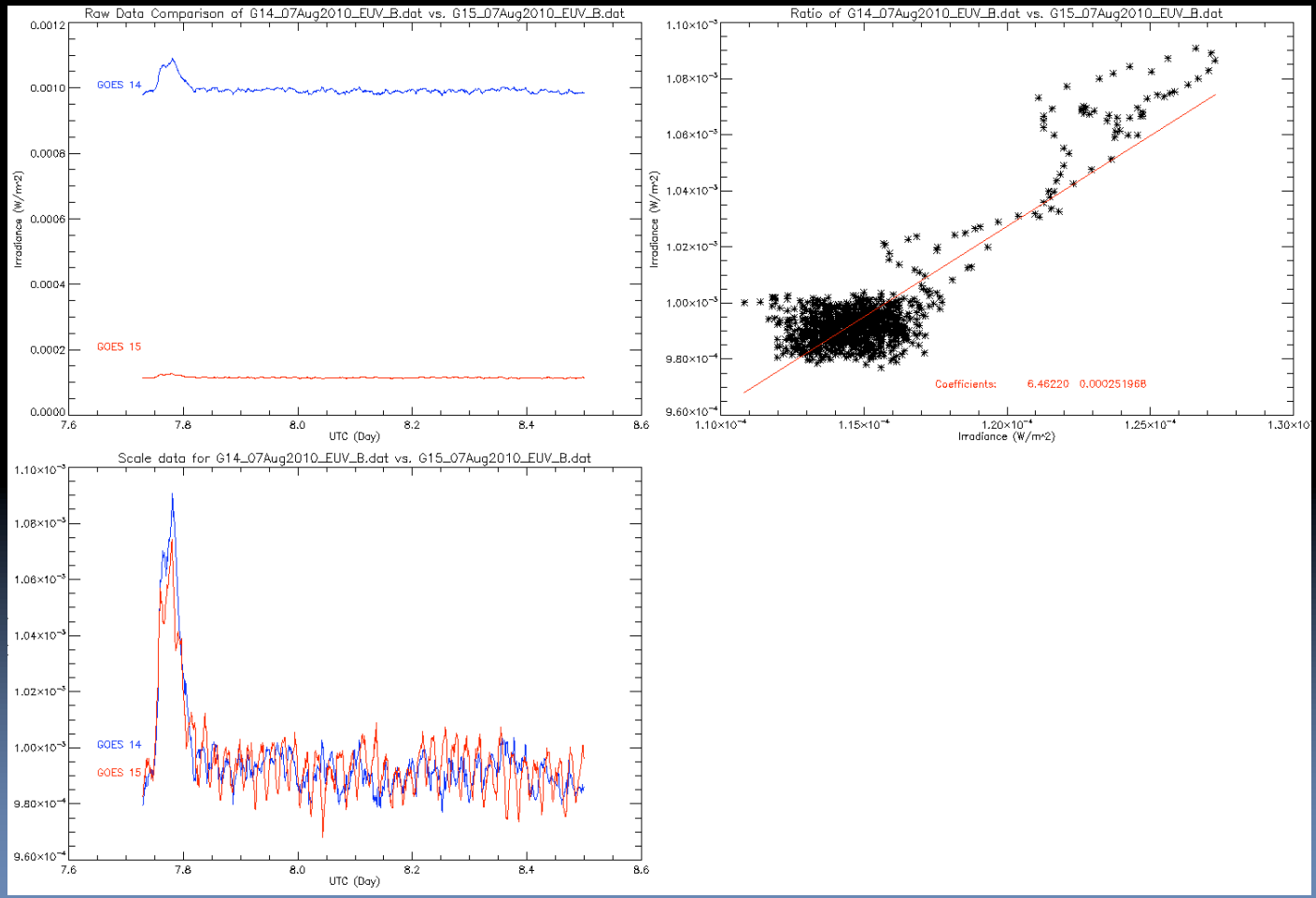
Applying the Scaling Coefficients

After finding scaling coefficients, then applied them to the chosen GOES and plotted the scaled data vs. raw data of the opposing GOES.



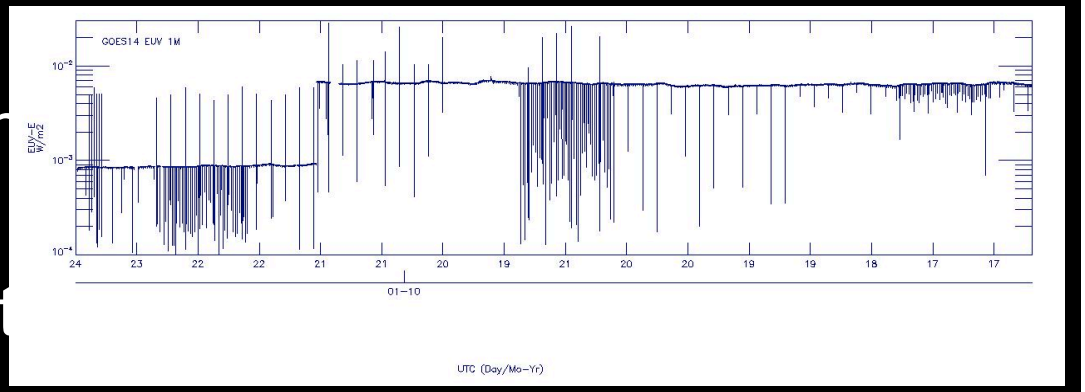
Streamlining the Process

Since each channel needed to be analyzed, and at least one chunk from each GOES needed to be scaled, I modified the program to speed up the process.



Challenges with GOES 14

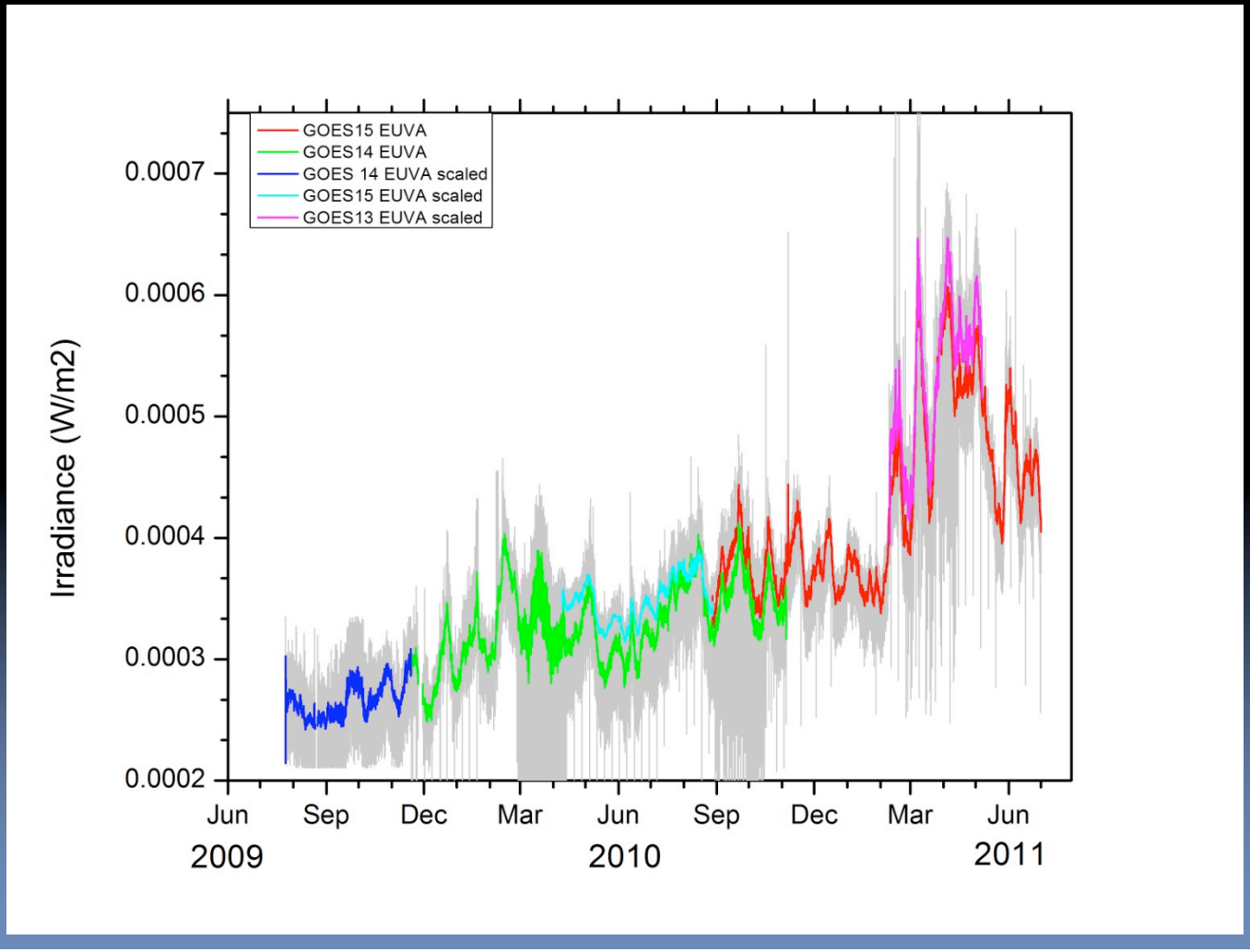
- Change in calibrations coefficients occurred in Nov 2009.
- GOES 13 & 15 weren't operational at that time, couldn't make the same comparison.
- Had to use the calibrations before and after to scale GOES 14 early to the rest of the data.



$$\text{EUVFlux} = \text{EUVcor} * \frac{(((\text{Cnts} - \text{Background}) - \text{VisLight}) * \text{Gain})}{\text{Flux Conversion}}$$

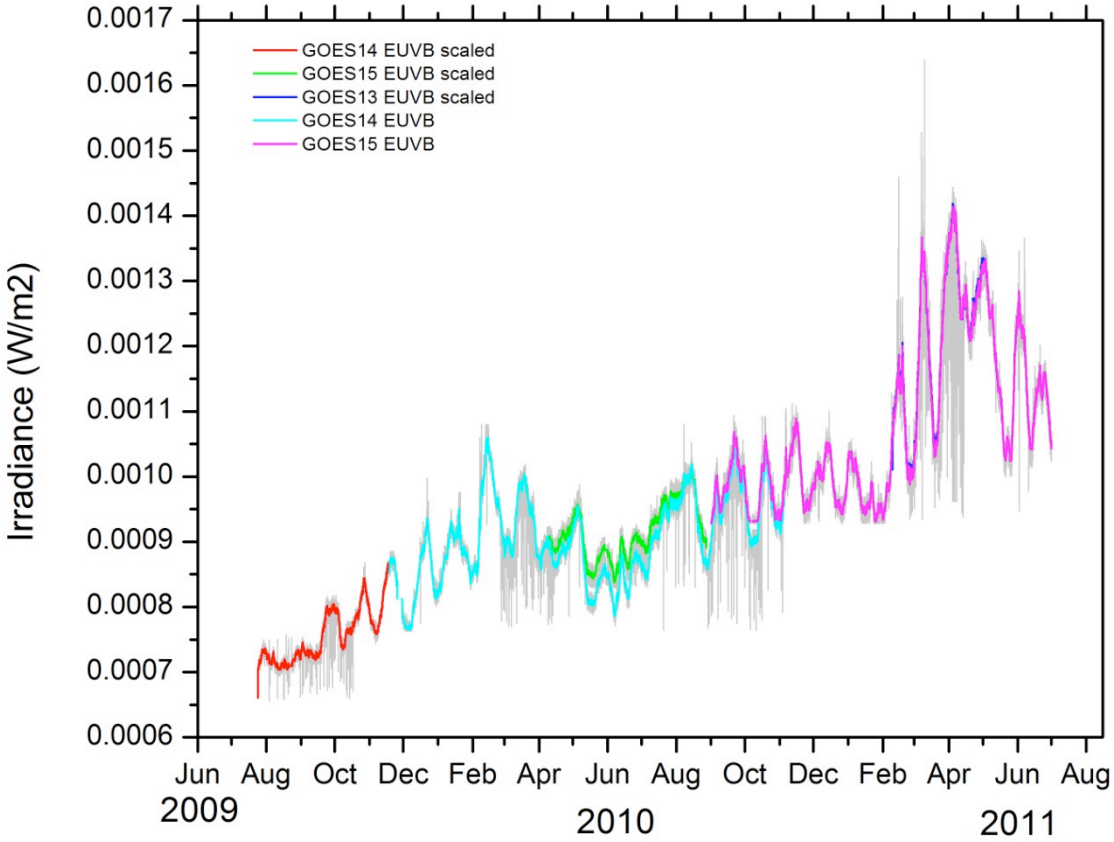
The Final Product: EUV A

EUV A channel showing gradual increase as we come out of solar minimum.
Color = 6 hour average
Grey = 1 minute data



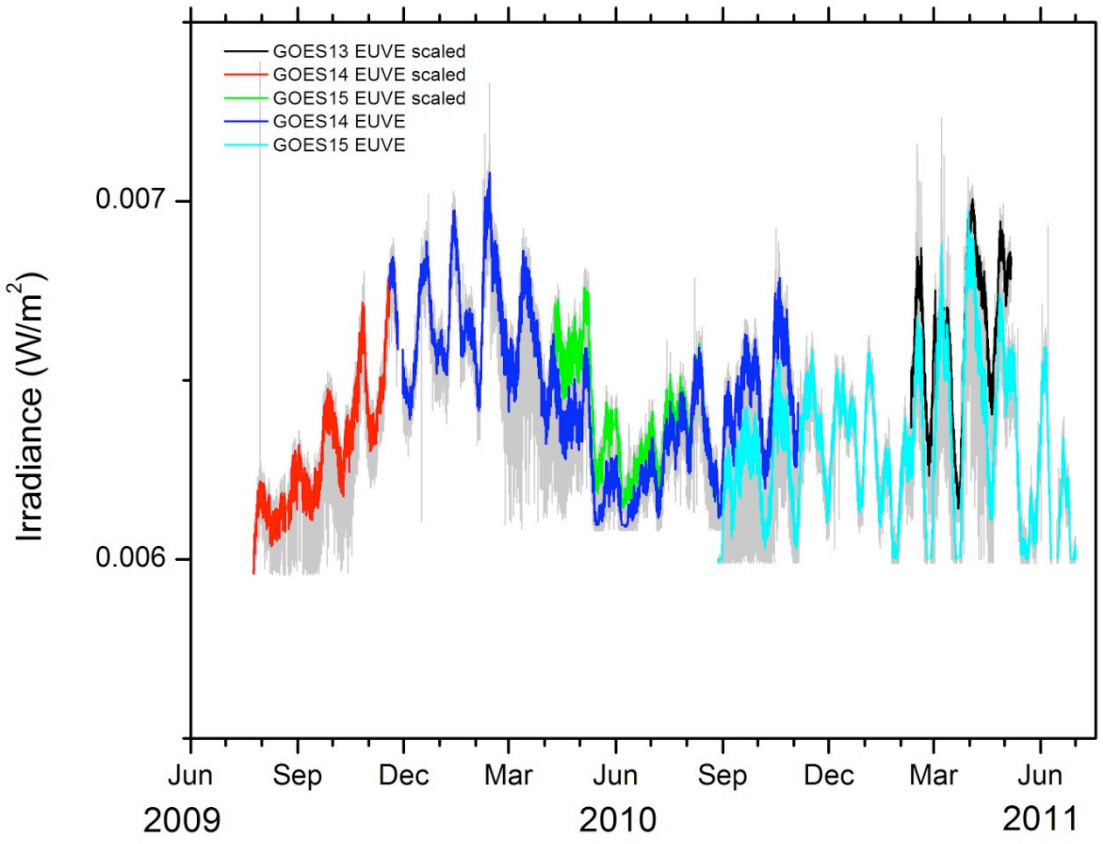
The Final Product: EUV B

EUV B channel also showing gradual increase as we come out of solar minimum.
Color = 6 hour average
Grey = 1 minute data



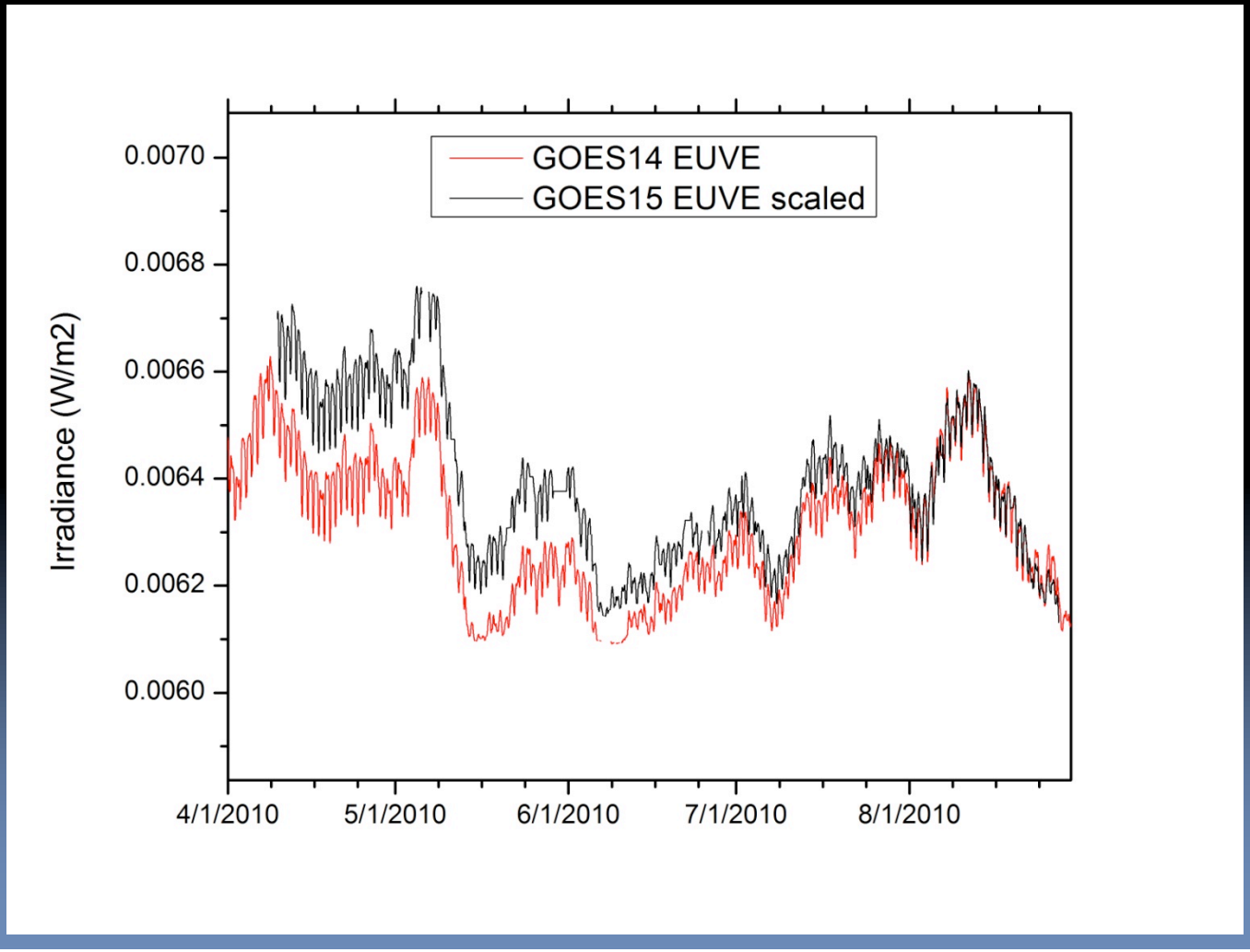
The Final Product: EUV E

EUV E channel not showing the same trend as the A & B channels.
Color = 6 hour average
Grey = 1 minute data



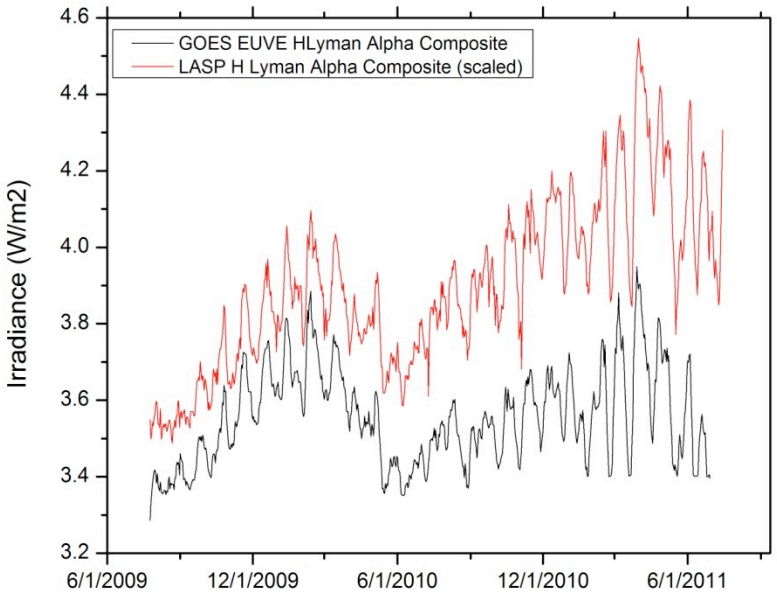
Instrumental Drift

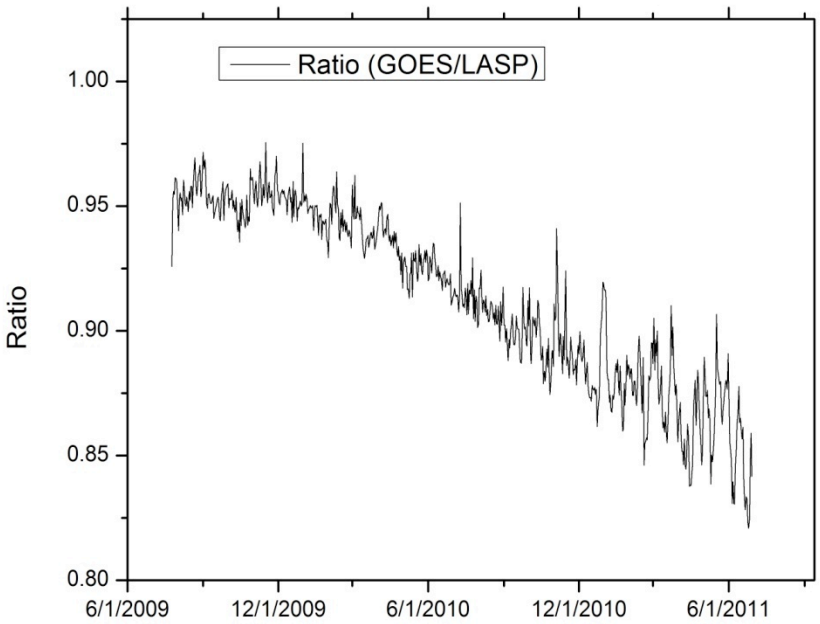
Found scaling coefficients using a very small portion of the data, so a drift begins to occur between the two data sets.



Instrumental Degradation

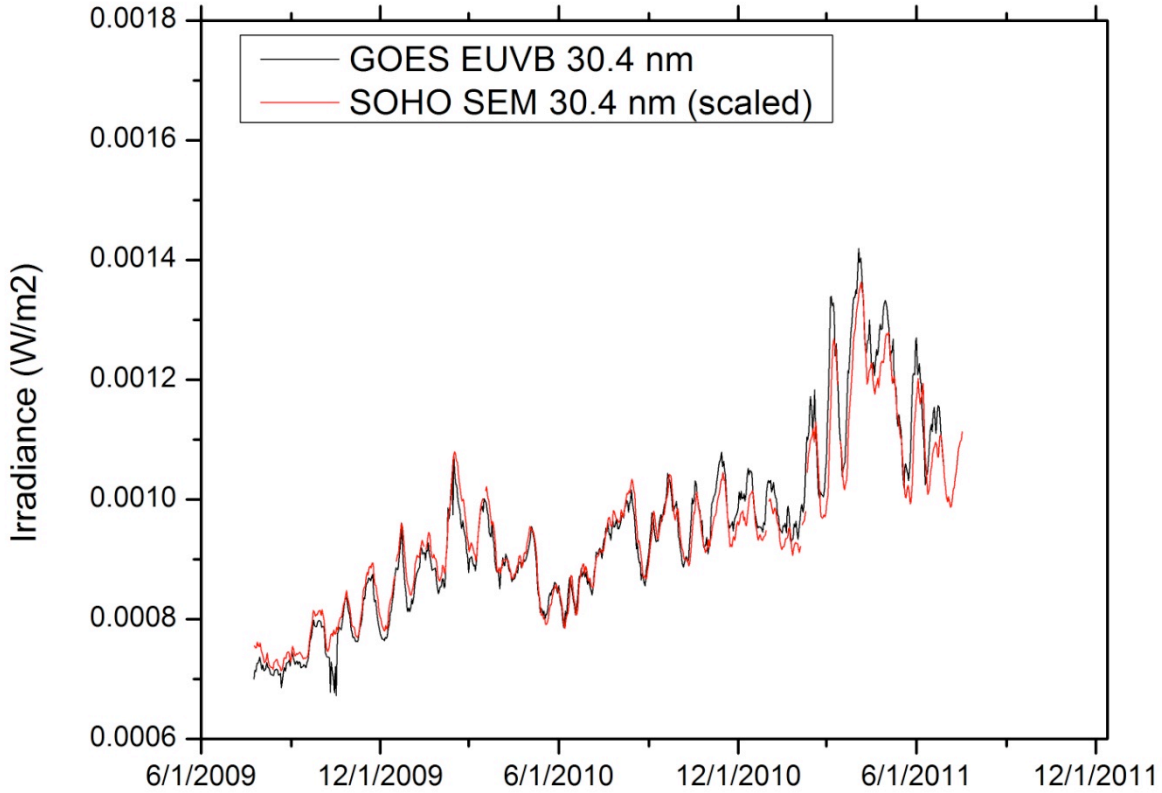
Filter degradation occurring in the EUV E channel.





How Does it Compare?

GOES vs. SOHO



What now?

- Make further comparisons to SOHO, EVE & **SDO** data.
- Evaluate G13, 14, 15 trends and attempt to remove instrument degradation and artifacts from data.
  - Heater noise, especially in A channel
  - Weekly calibrations
  - Quantify E Channel degradation
- Once the data is cleaned up, make absolute calibrations.
- Update the EUVS web page to display real-time GOES EUVS data.
- Combine GOES irradiance data with other research data to create a record going back a full solar cycle.

Questions?

Acknowledgments

Many thanks to Rodney Viereck and Alysha Reinard who helped me along the way. I've learned a great deal during my time at NOAA and found this experience to be truly invaluable thanks to you.

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