Magnesium II Index: Thirty Five Years and Counting

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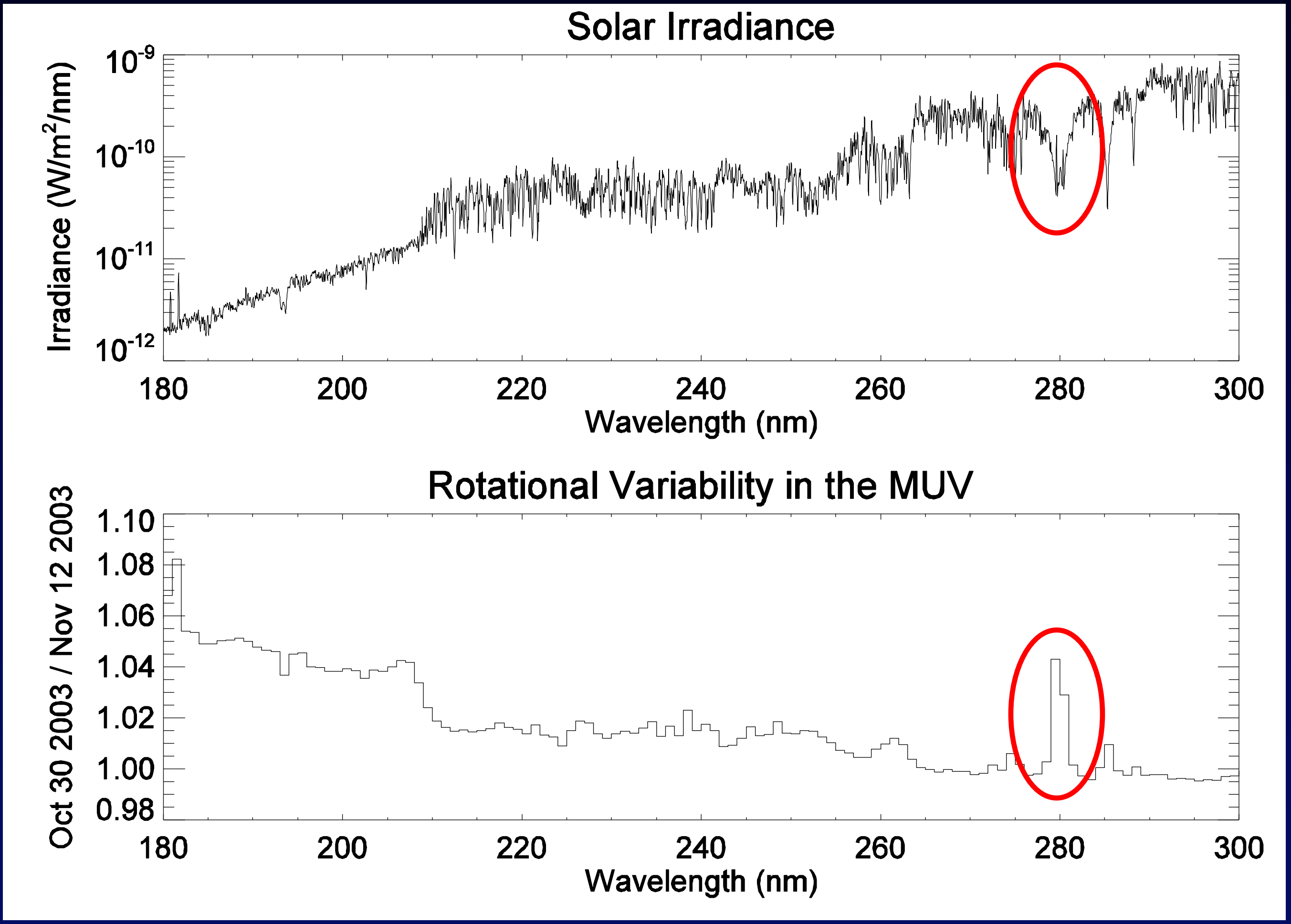
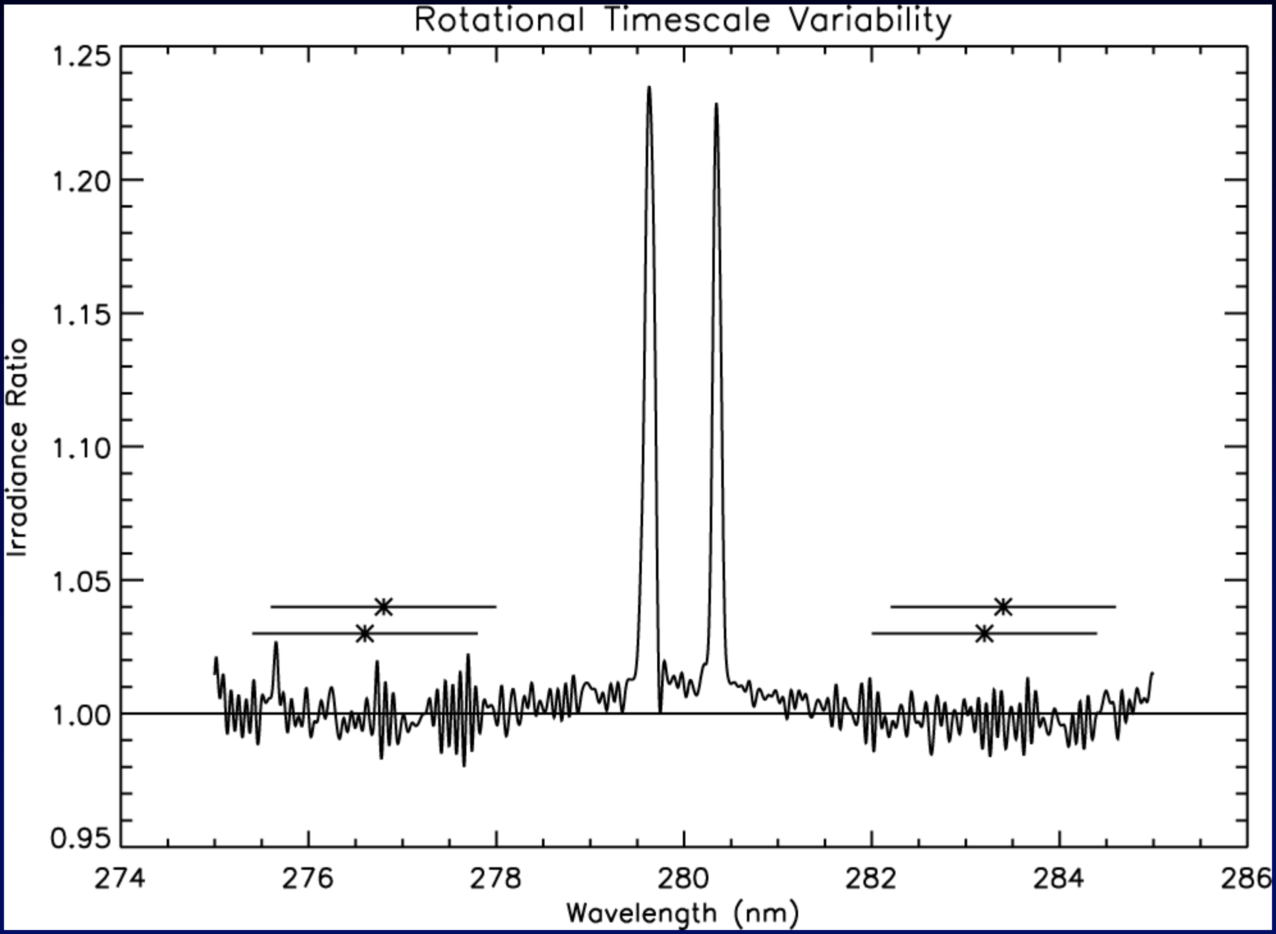
Outline

- The core to wing ratio – What
- A proxy for chromospheric activity – Why
- Observational history – When
- Composite Time Series – Work (in progress)
- Future measurements – Where "R" we going

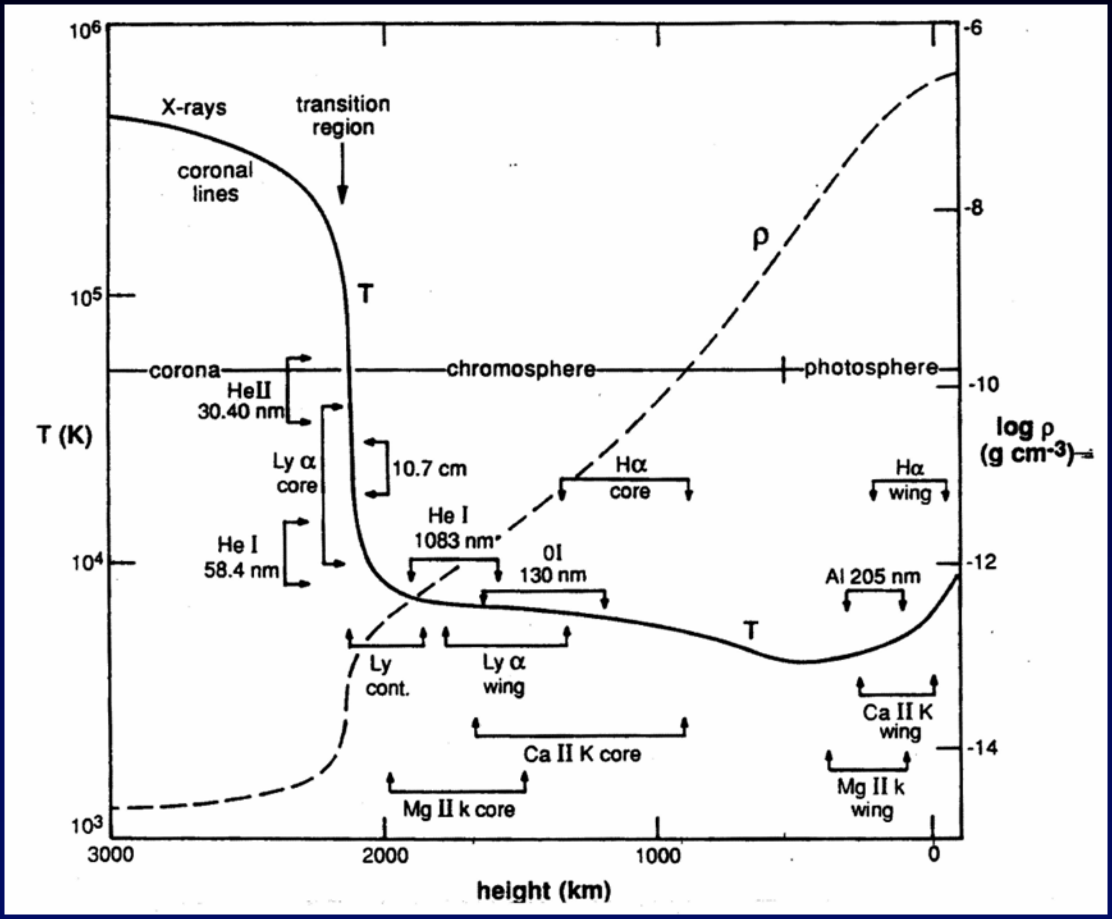
Solar Irradiance Variability



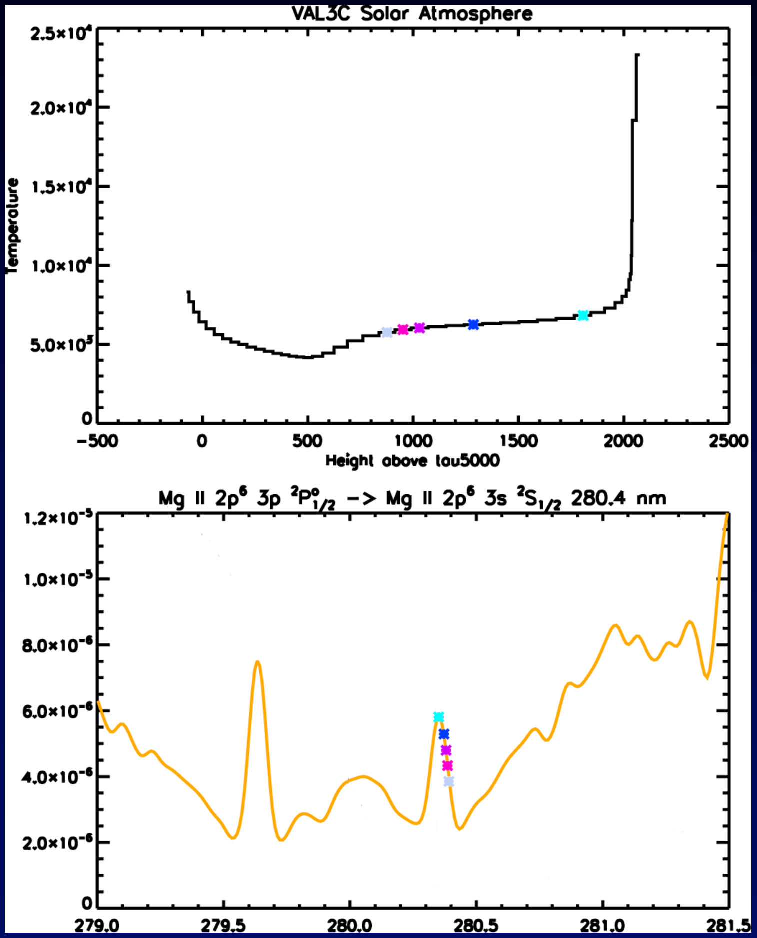
Variability near 280 nm



Formation Heights

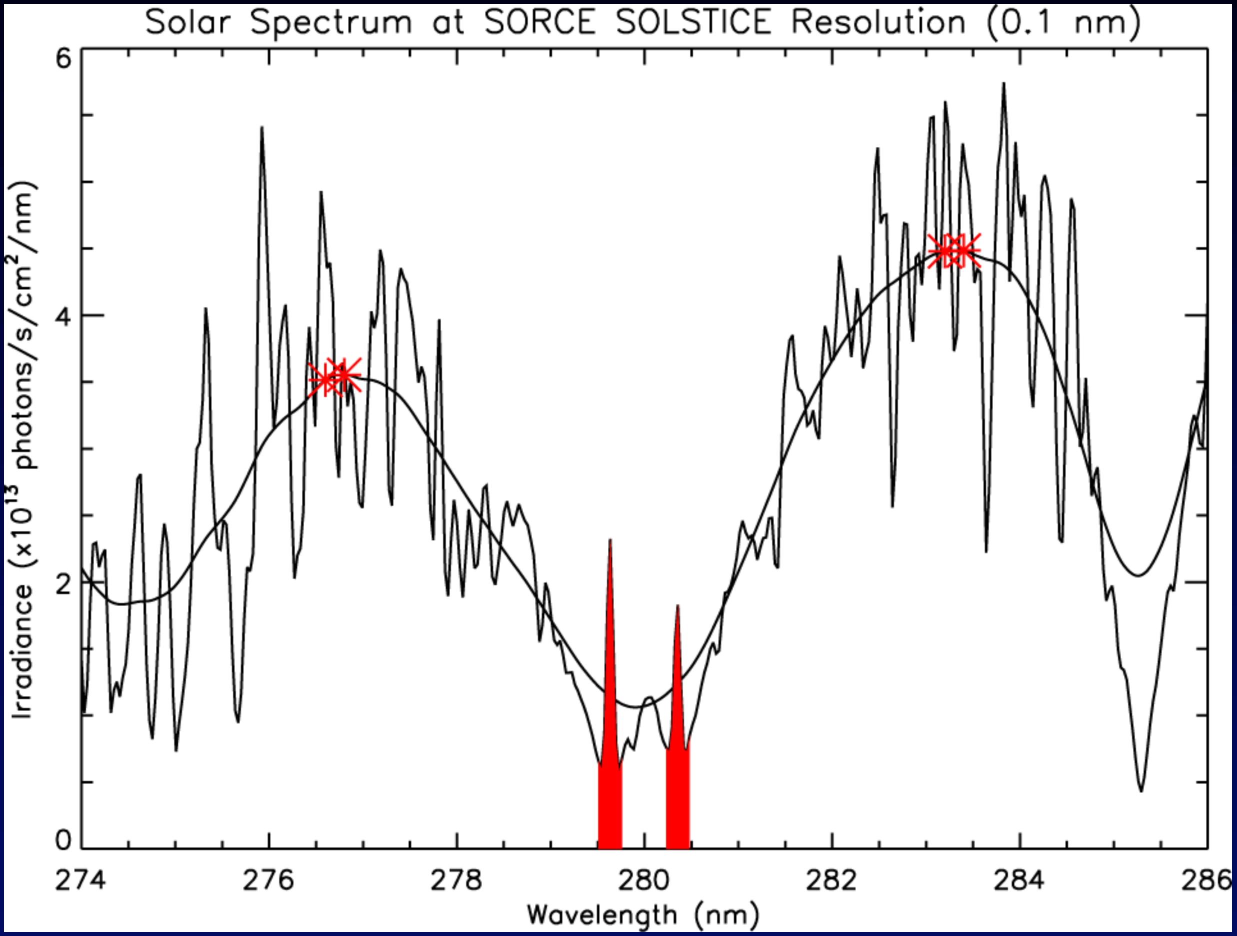


Adapted from Vernazza et al. (1976)

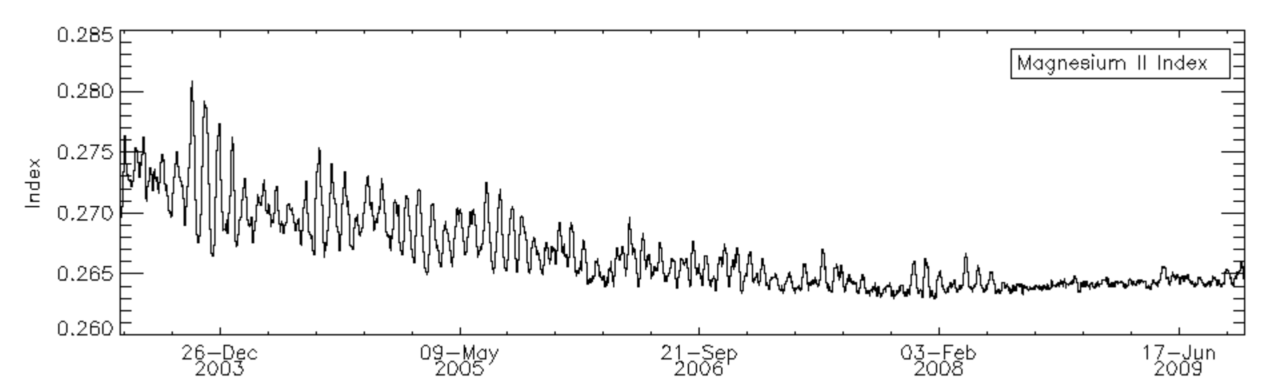


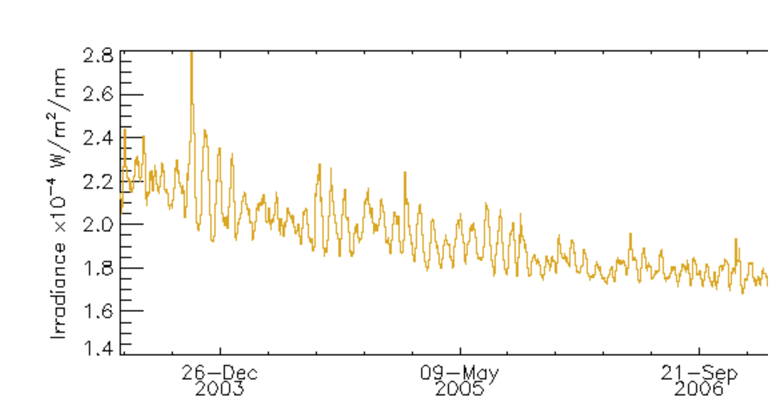
From 1-D model using MULTI

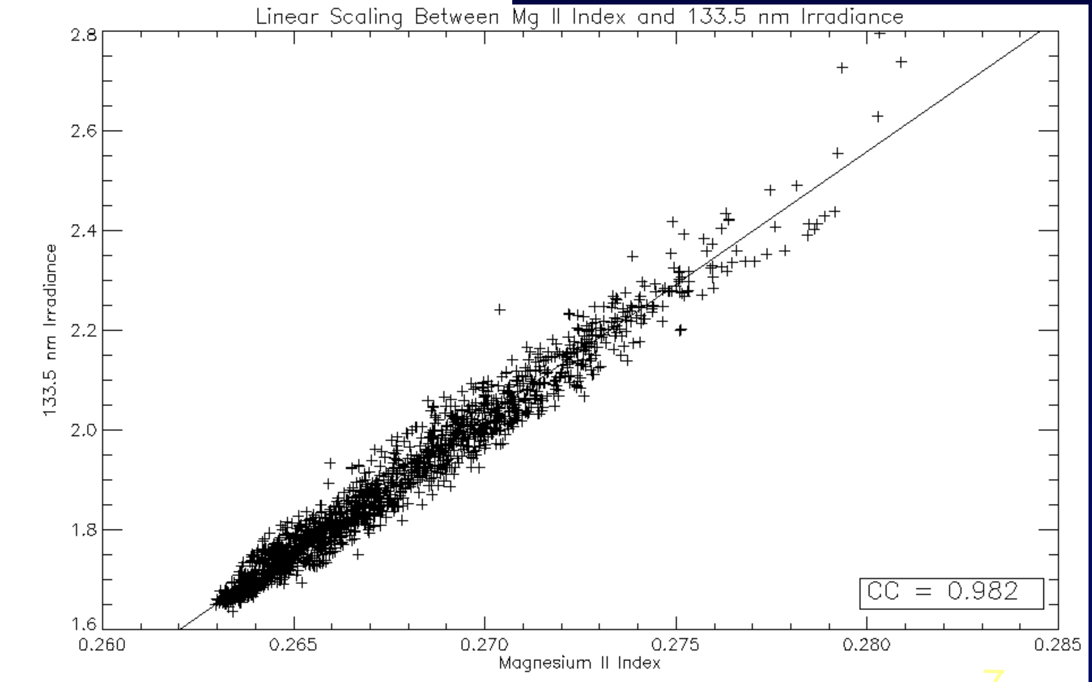
SORCE MgII Index Definition



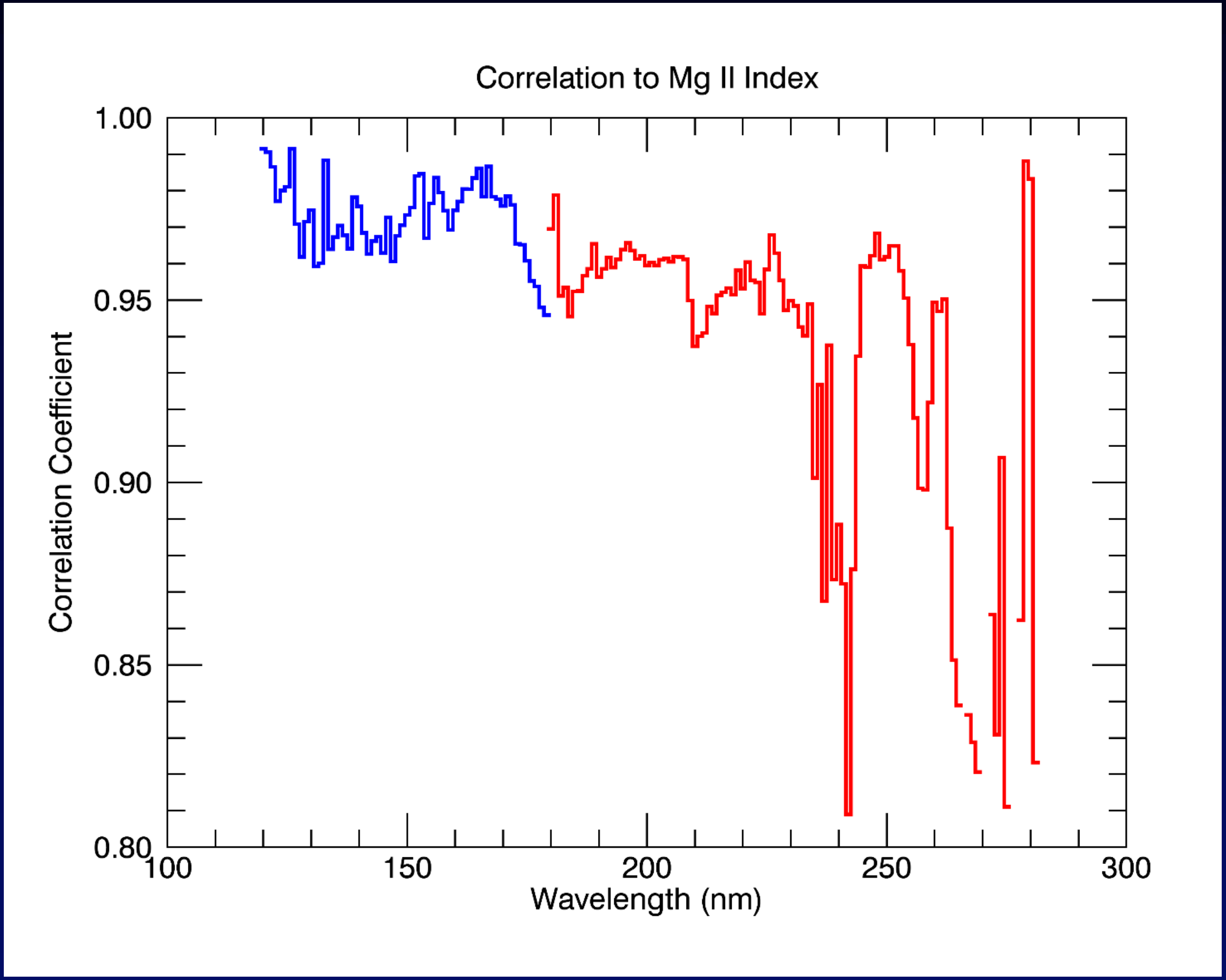
Correlation to FUV Emission



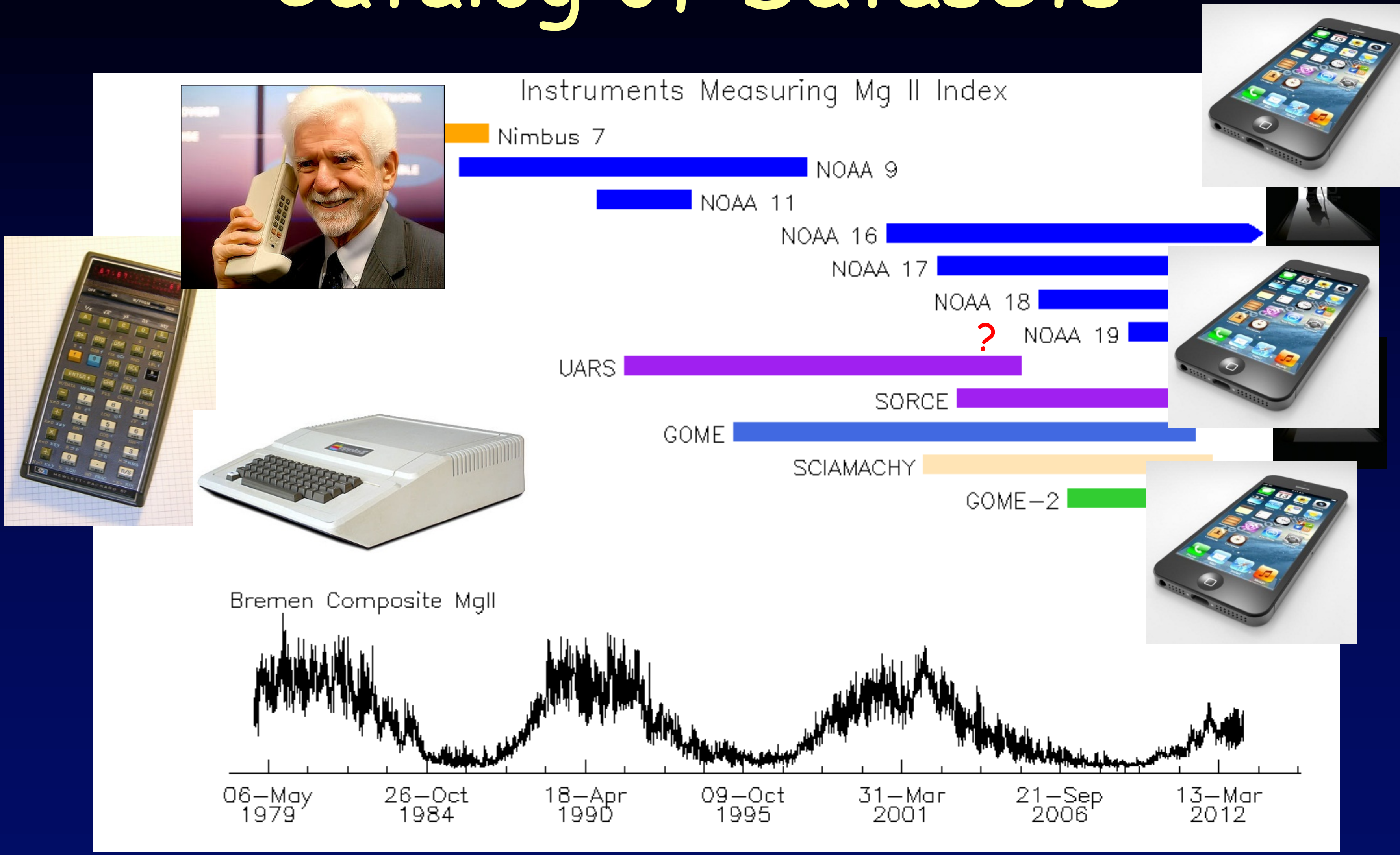




Correlation with UV SSI



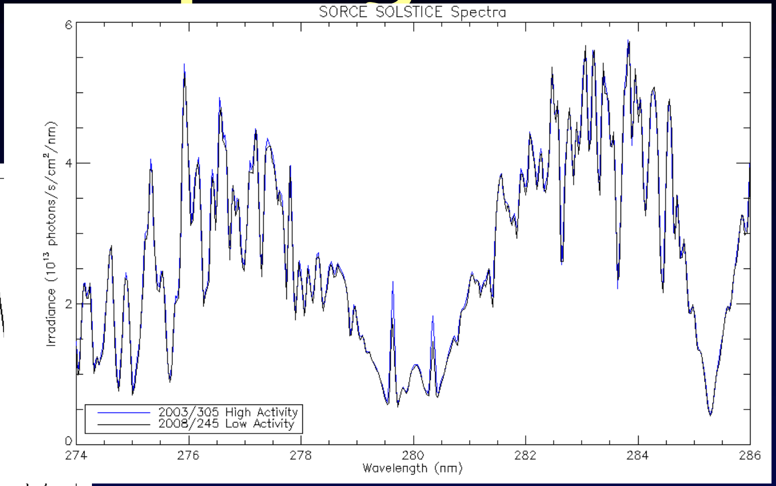
Catalog of Datasets



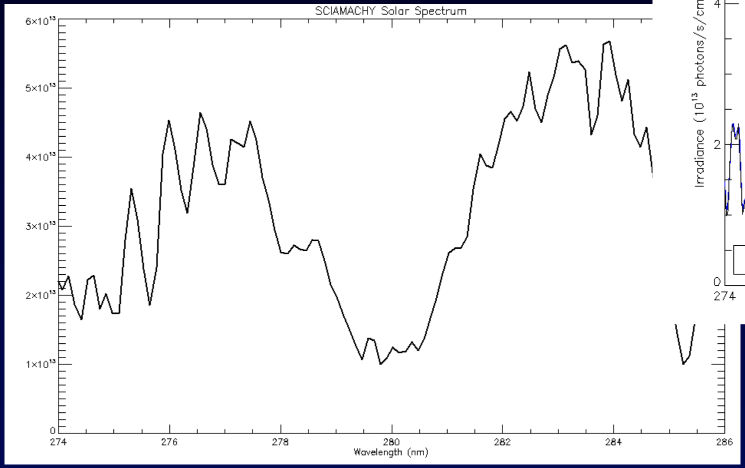
Building a Composite

Resolution & Sampling

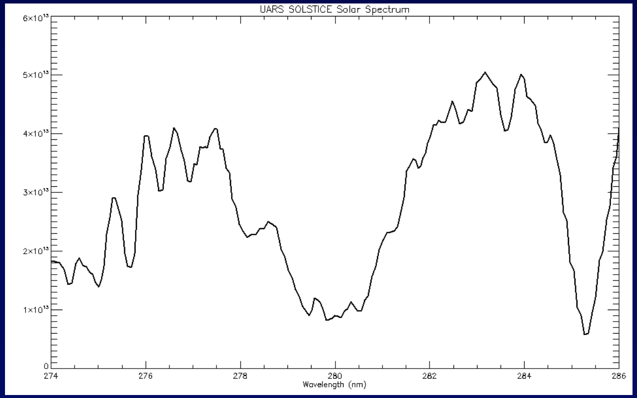
SOLSTICE-II 2003-present
Δλ=0.10nm (3 samples)



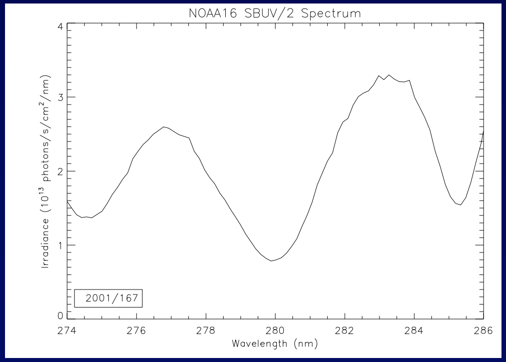
SCIAMACHY 2002-2012
Δλ=0.21nm (2 samples)
GOME 1995-2011
Δλ=0.17nm (2 samples)
GOME-2 2007-present



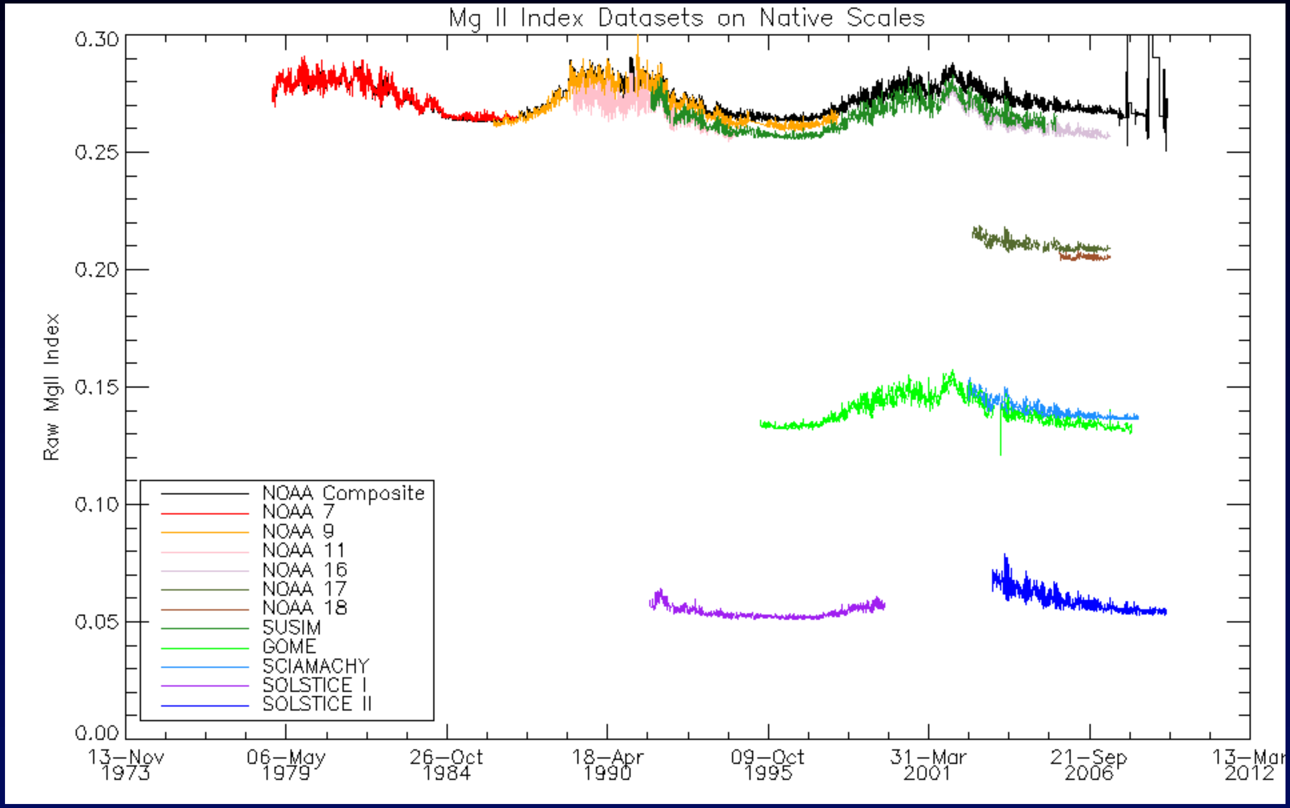
SOLSTICE-I 1991-2005
Δλ=0.2nm (3 samples)



SBUV Solar Backscatter Ultraviolet
Δλ=1.1nm (approximate)
Nimbus-7 1978-1990
NOAA-9 1985-1998
NOAA-11 1989-1994, 1998-2001
NOAA-14 1996-2004
NOAA-16 2000-present
NOAA-17 2002-2011
NOAA-18 2005-2012
NOAA-19 2010-present (once per week)

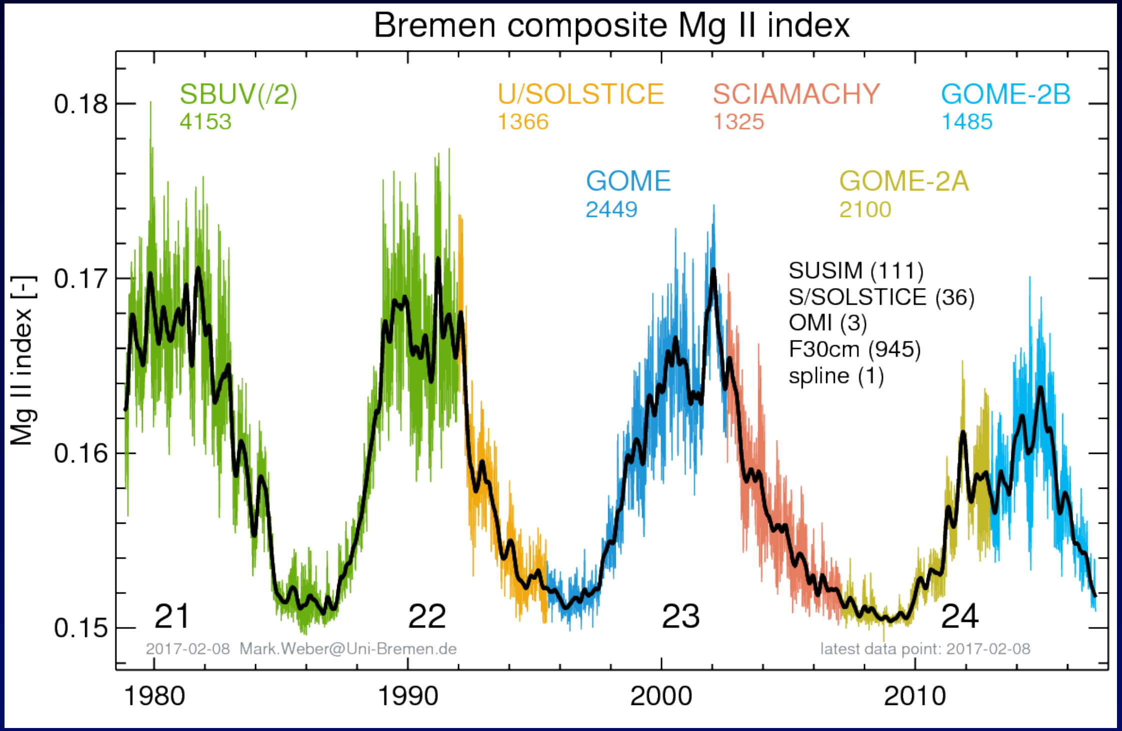


Building a Composite



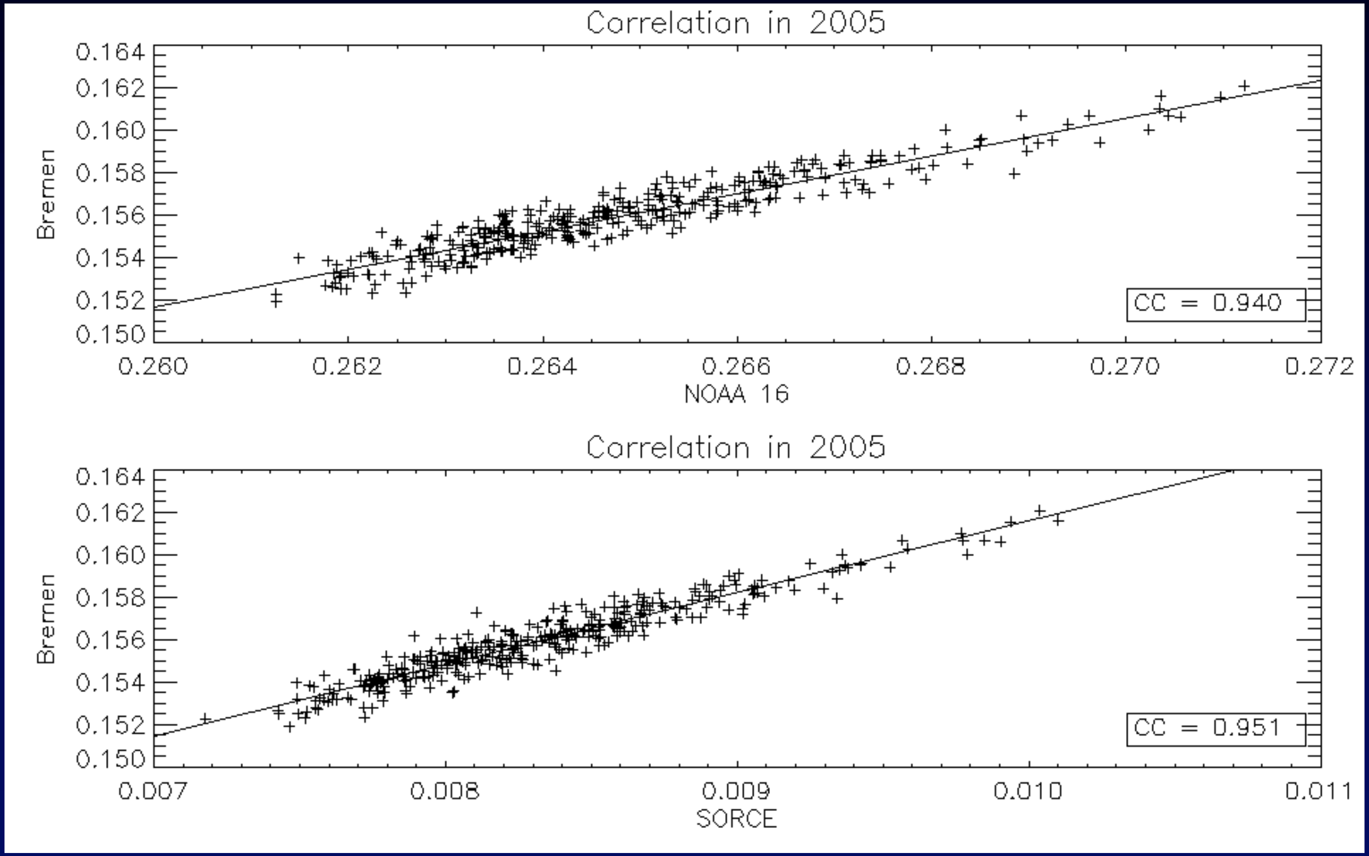
Difference in absolute scale is due to different spectral resolution in raw measurement and how wing irradiance is determined.

Goal is a uniform Composite

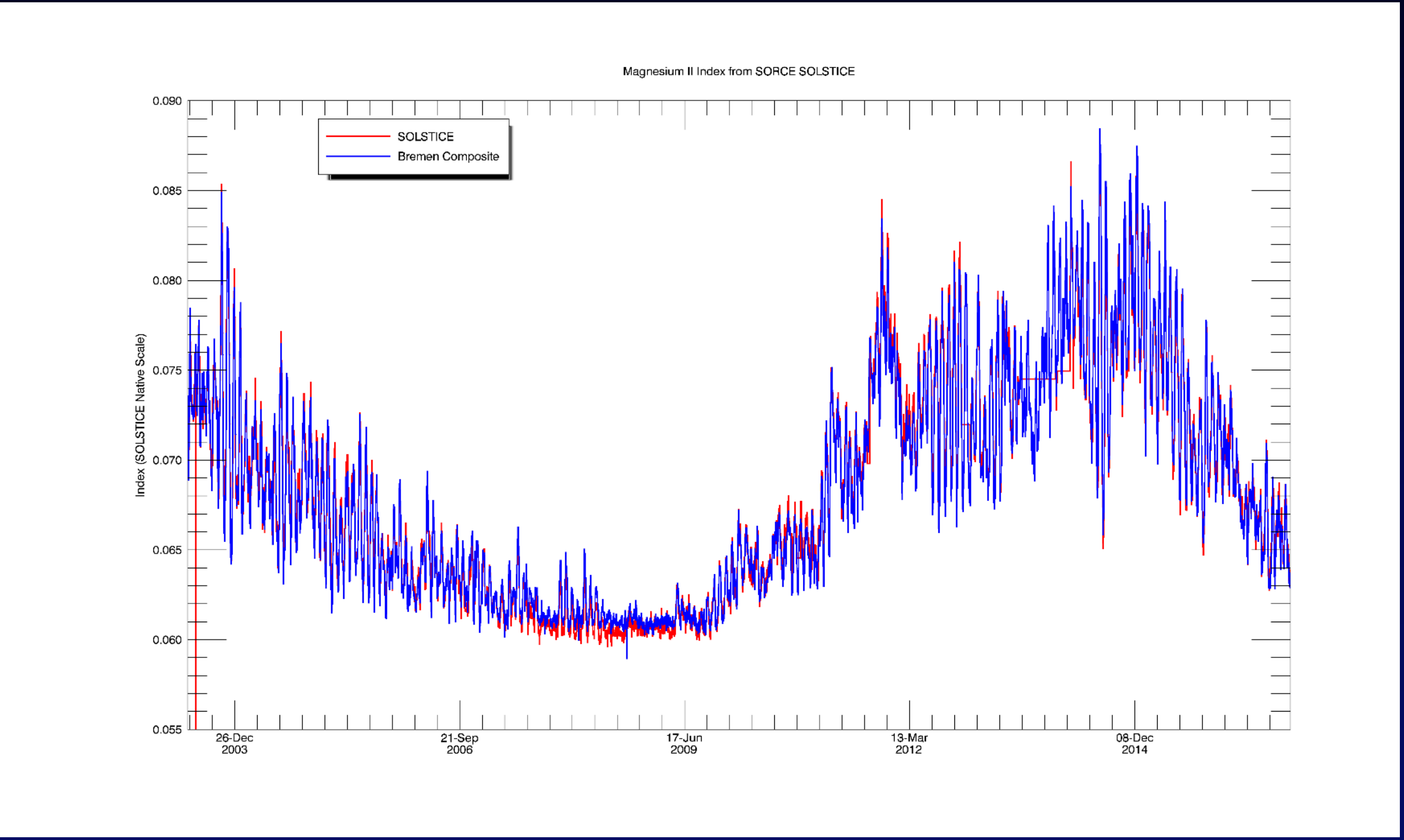


Normalization is usually set by Nimbus 7 SBUV in Cycle 21. All later datasets are daisy-chained to line up with the first in the composite.

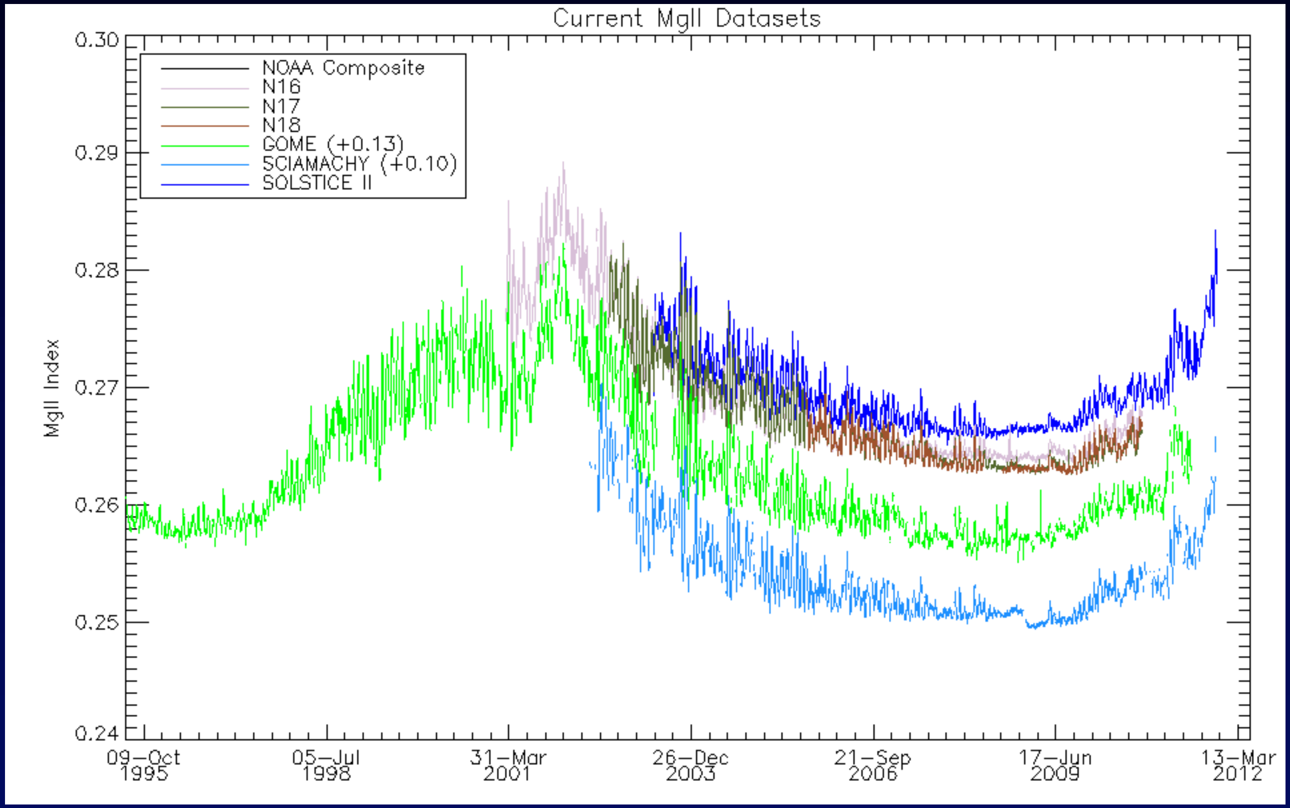
Find linear scaling factors



Scaled Datasets



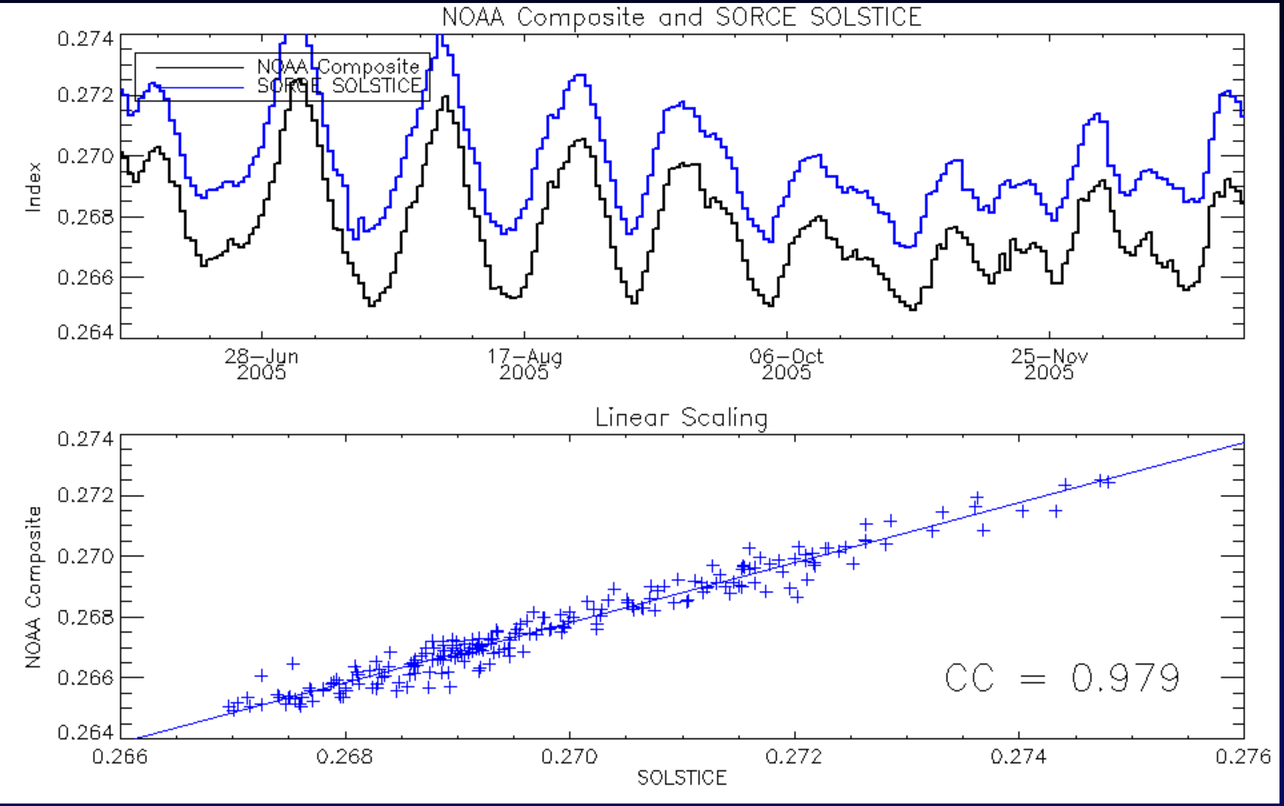
Does it always work?



The man with one cat always knows who barfed on the rug.

The man with two is never sure.

Linear Scaling

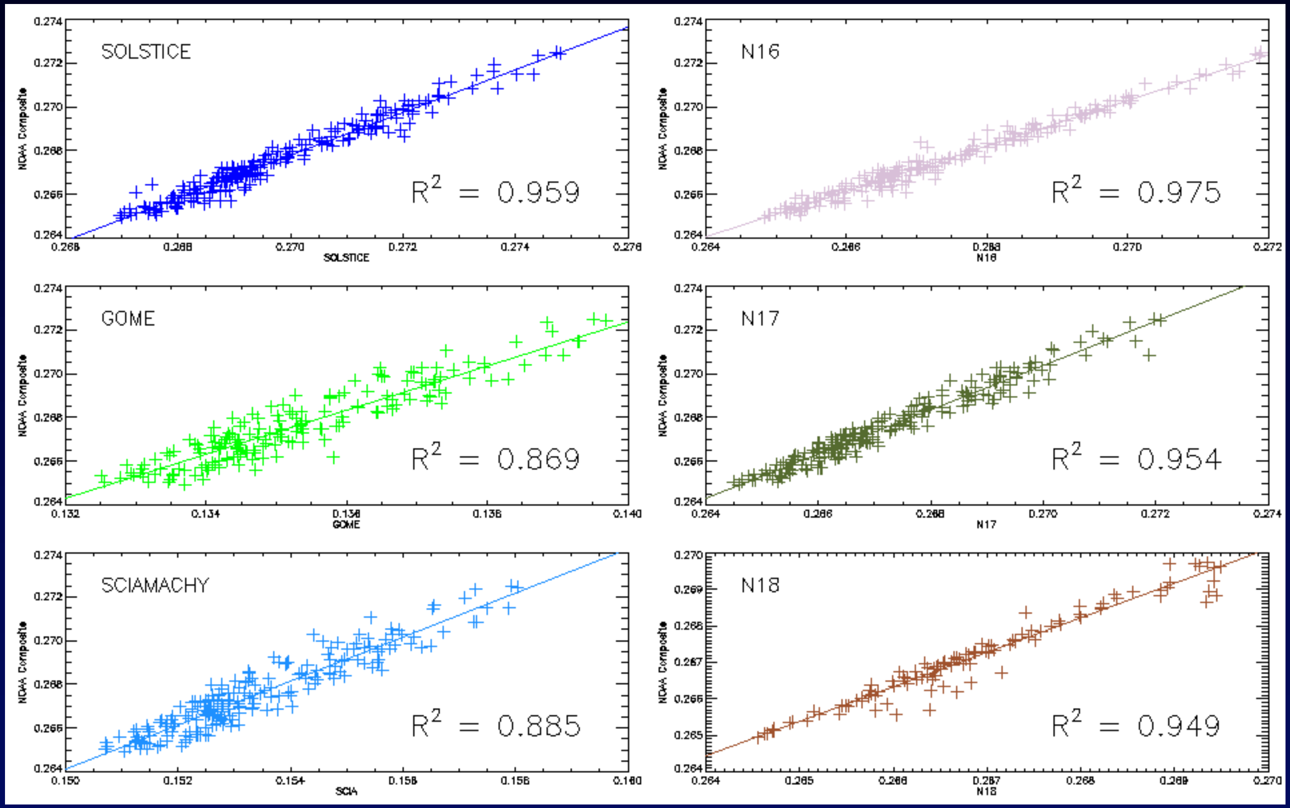


All rescaling to normalize datasets uses only June 2005 - December 2005.

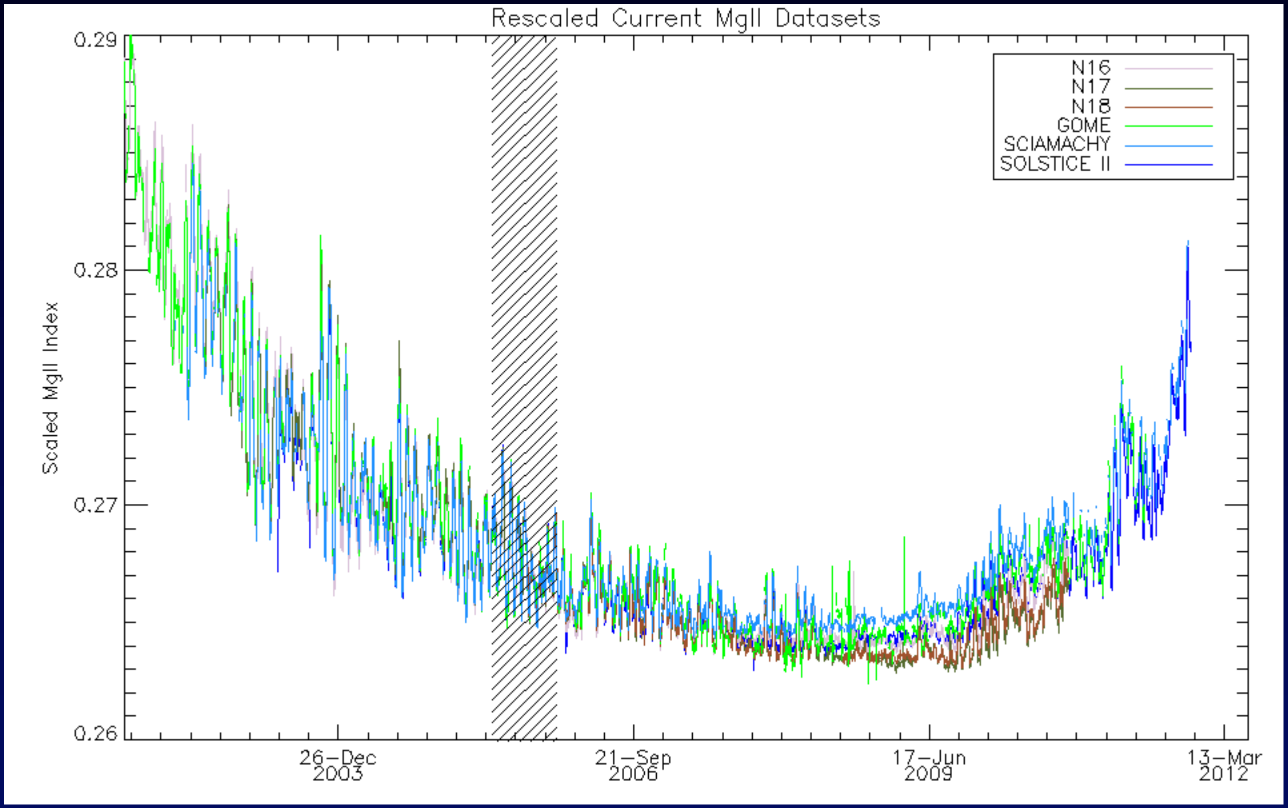
What scaling interval to use?

- Scaling over short time intervals (months):
  - matches rotational variability
  - does not force same solar cycle variability across datasets
  - does not transfer long-term trends from one dataset to another
- Scaling over medium time intervals (<2 years):
  - matches more of the solar cycle variability
    - Rotational scaling not necessarily same as Solar Cycle scaling
- Scaling over full datasets (many years):
  - forces solar cycle variability to match
  - transfers any long-term artifacts to later datasets

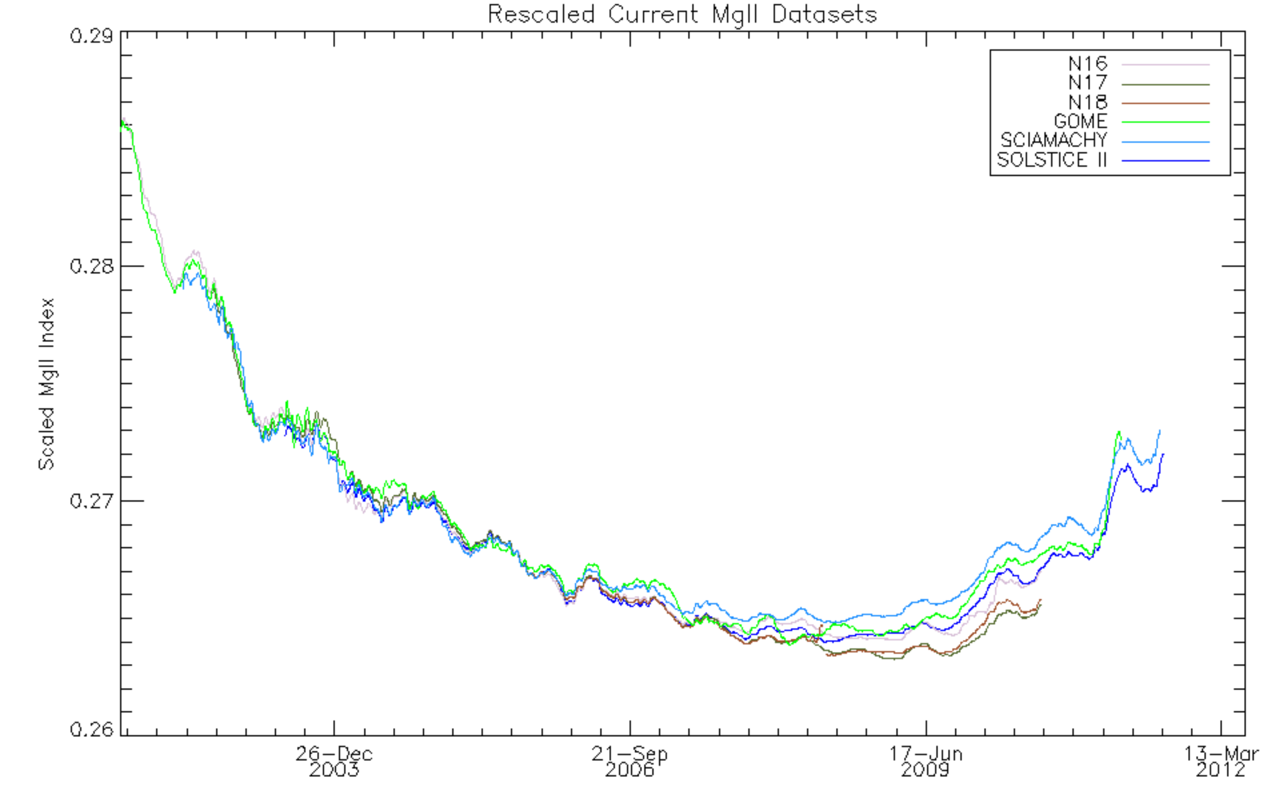
Each dataset scaled to NOAA



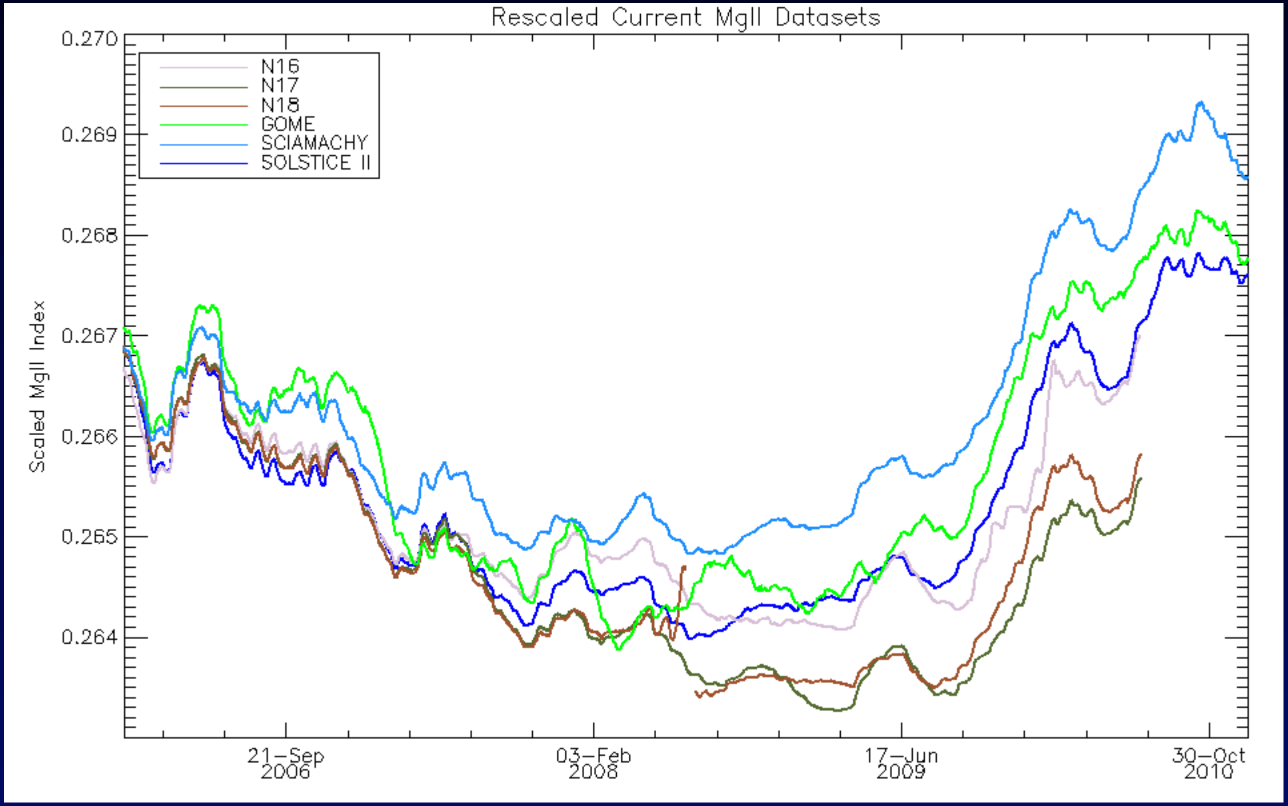
Normalize to NOAA in 2005



Normalized time series diverge

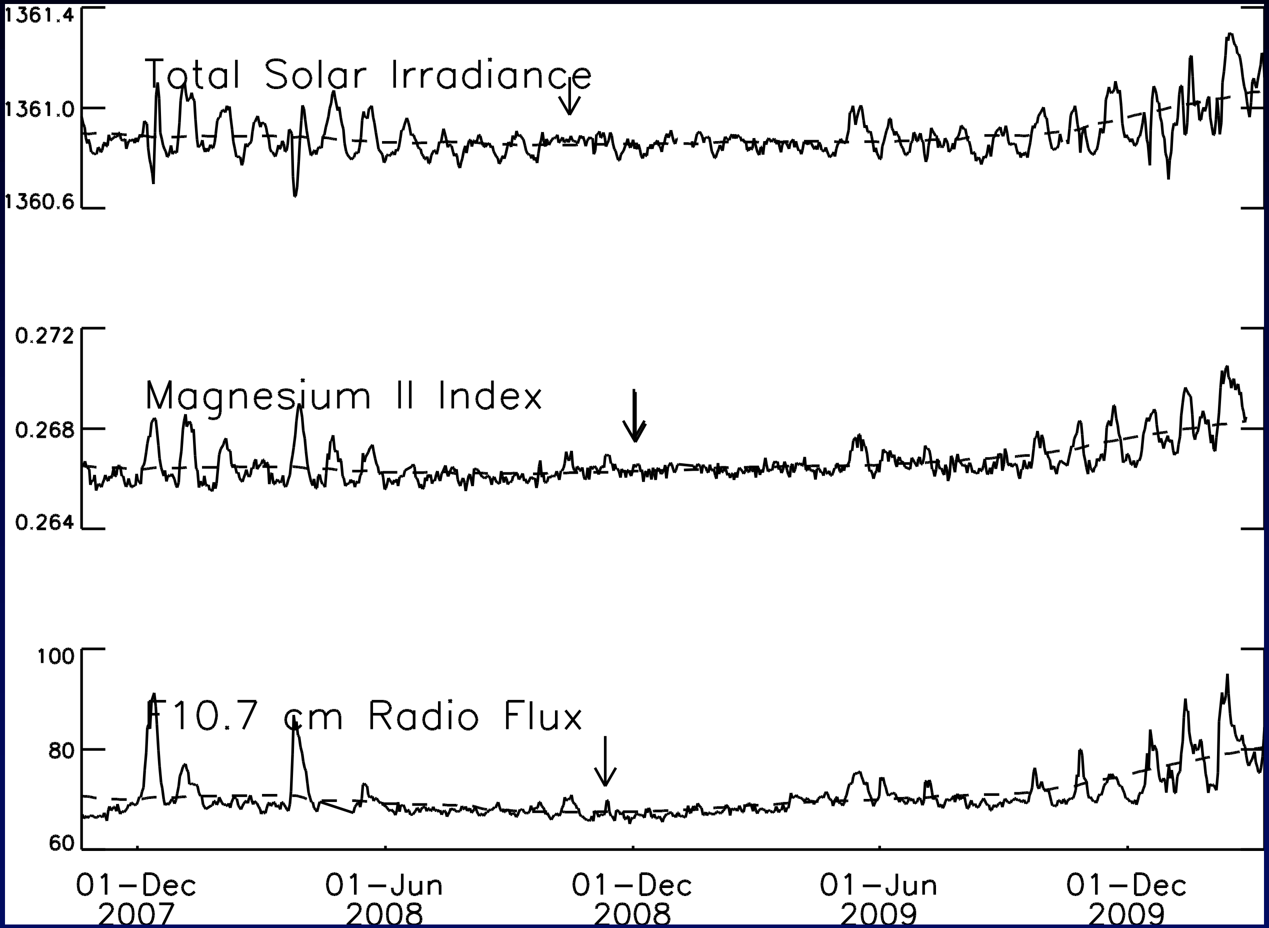


Solar Minimum Timeframe



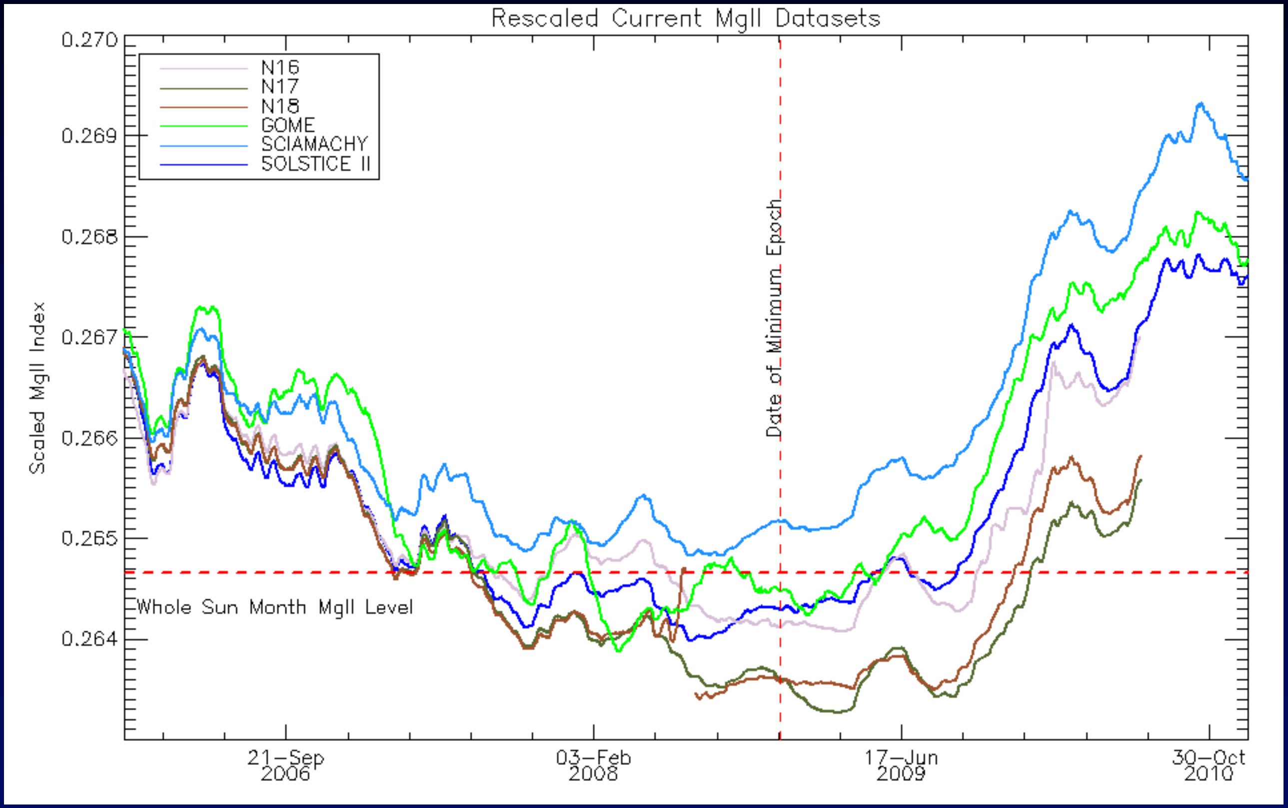
Spread between datasets is about 10% of the full solar cycle variation.

When was solar minimum?



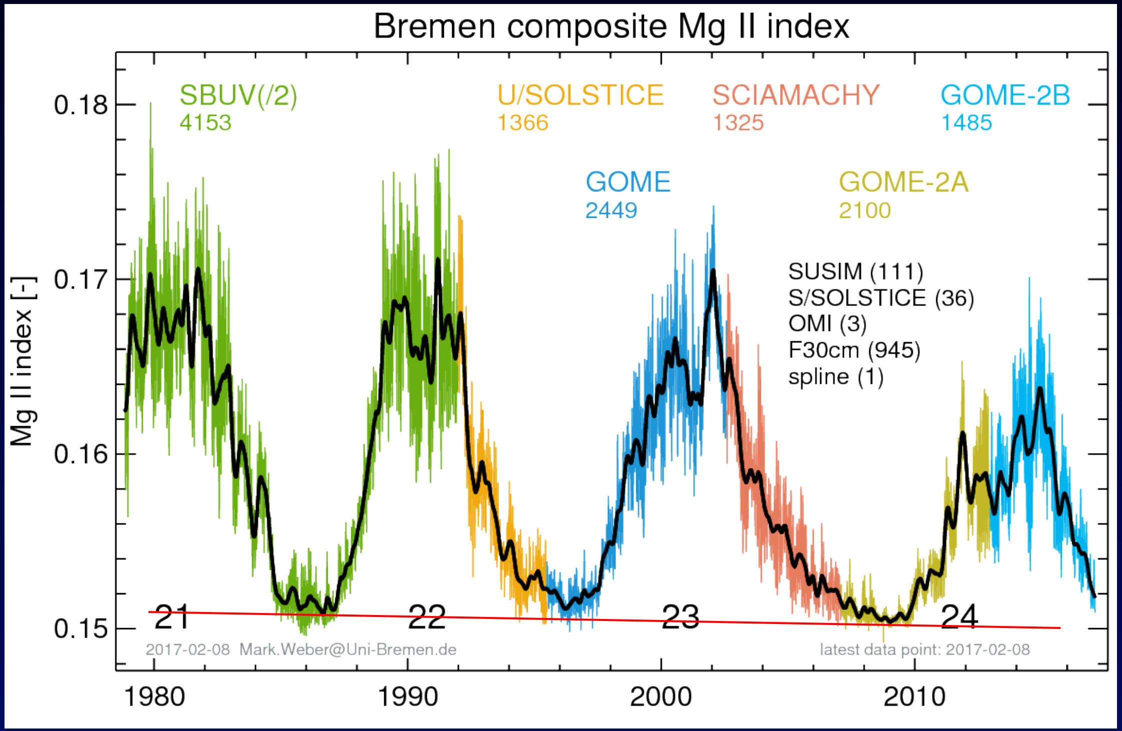
White, Kopp, Snow, & Tapping (2011)

Solar Minimum and WSM

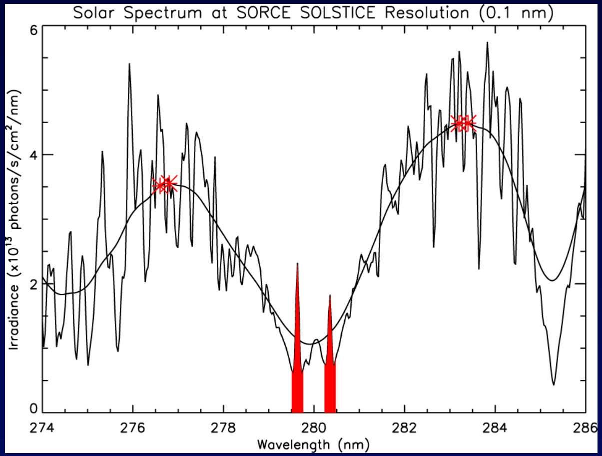


Newer version of SOLSTICE improves agreement with Bremen composite
Snow et al. (2014).

Discussion Question: Is there a floor?



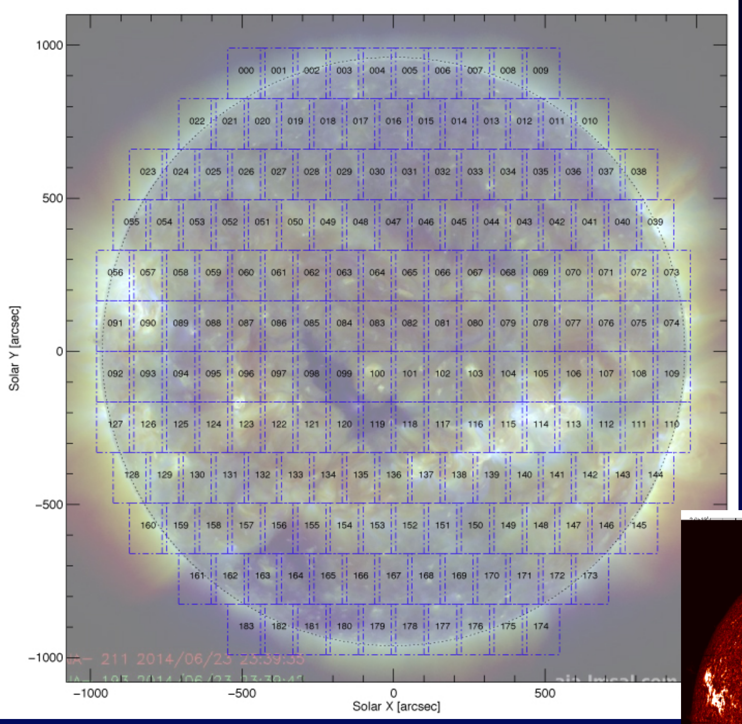
$$P_{MgII} = \frac{Core}{Wing}$$



What does this ratio look like in the limit of no chromospheric activity?

New Frontiers

Interface Region Imaging Spectrograph (IRIS)



Mosaic of spectral images taken by IRIS will lead to greater understanding of sources of index variability (assuming we can write a winning proposal).

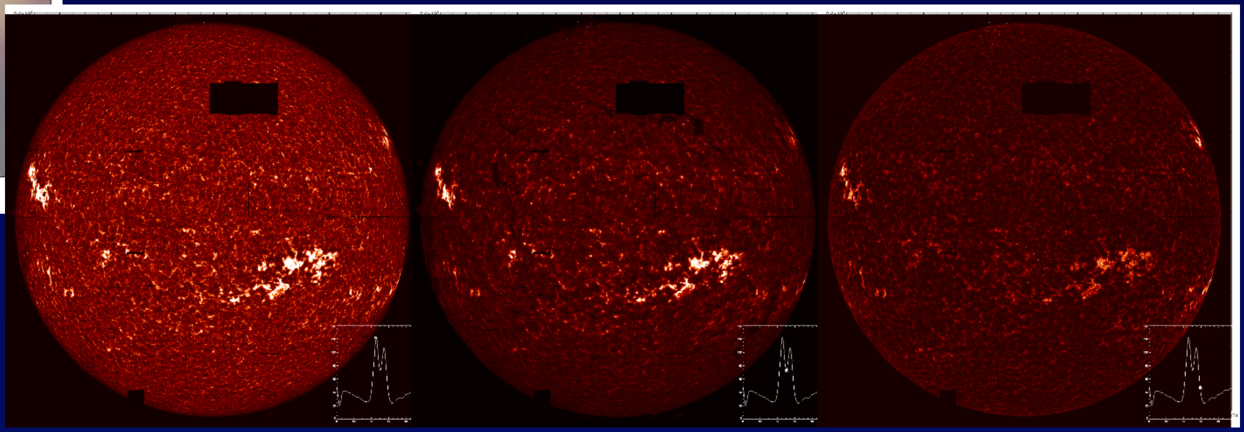
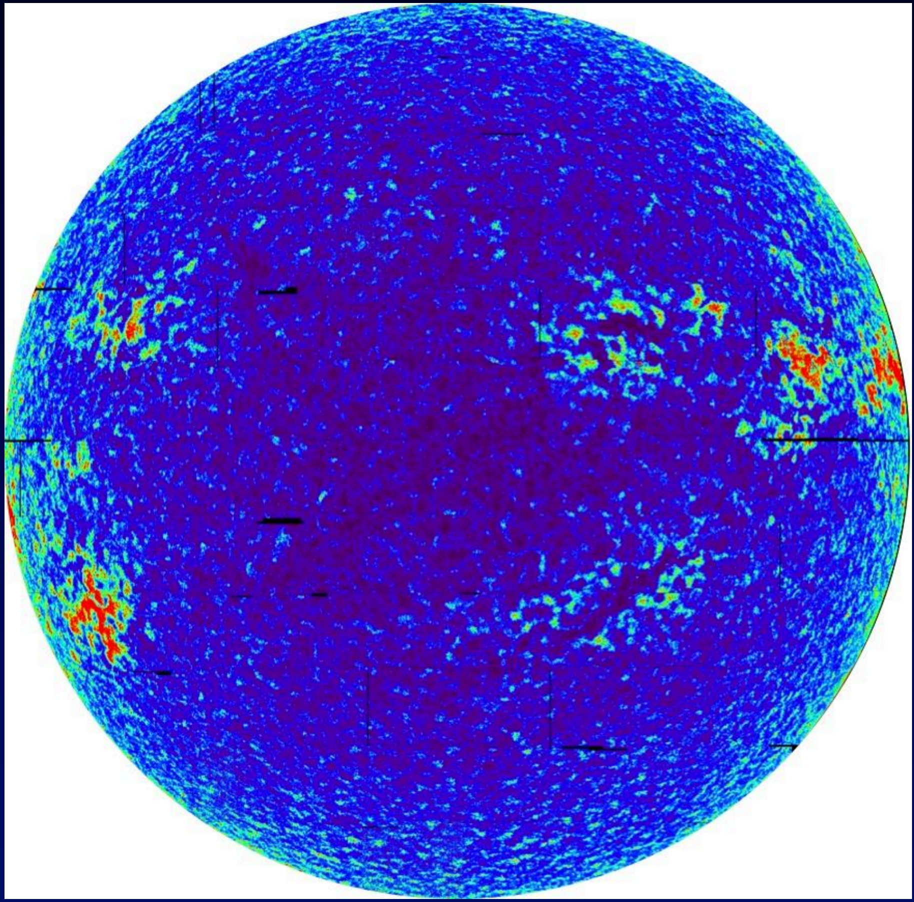
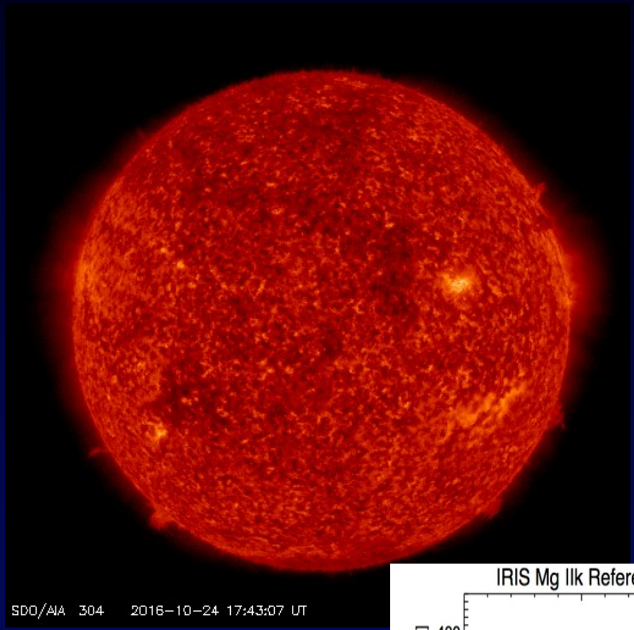
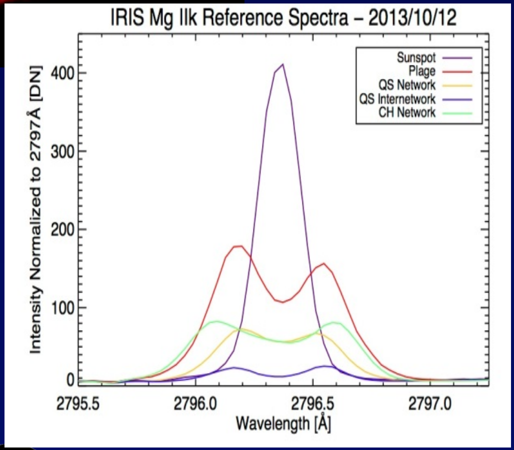


Image of the Sun in MgII Index from IRIS





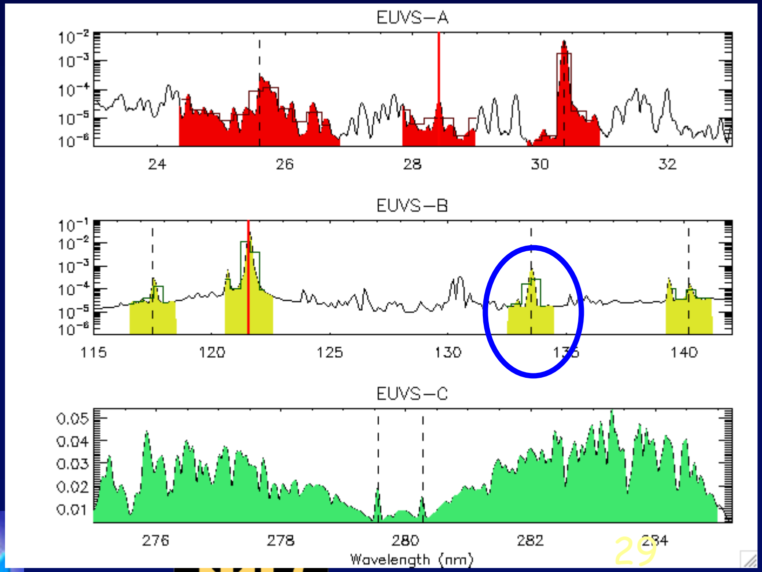


McIntosh et al. 2017 (in preparation)

GOES-R EXIS Overview

- EUV and X-ray Irradiance Sensors (EXIS)
  - X-ray Sensors (XRS) (0.05-0.4nm and 0.1-0.8 nm)
  - Extreme UltraViolet Sensor (EUVS)
    - Channel A: Coronal measurement (25-31 nm)
    - Channel B: Transition Region measurement (117-140 nm)
    - Channel C: Chromospheric Measurement (275-285 nm)

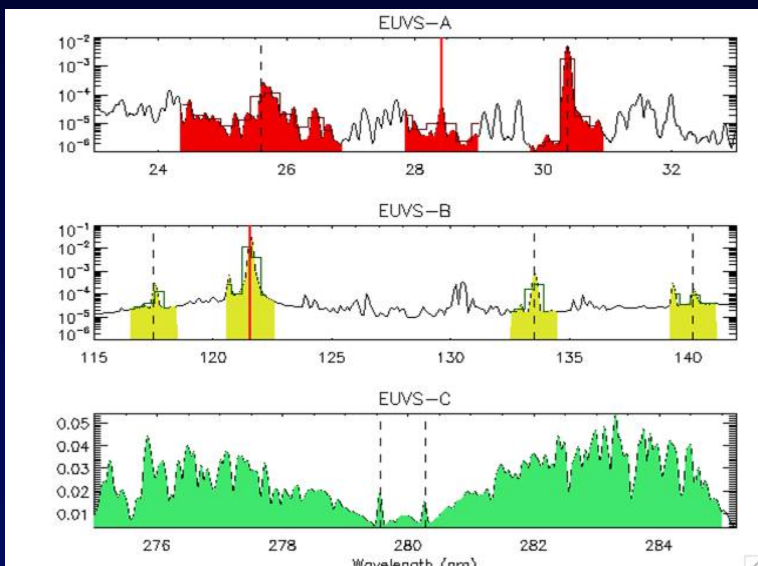
Channel C measurement will also be used to correct for degradation in other EUVS channels.



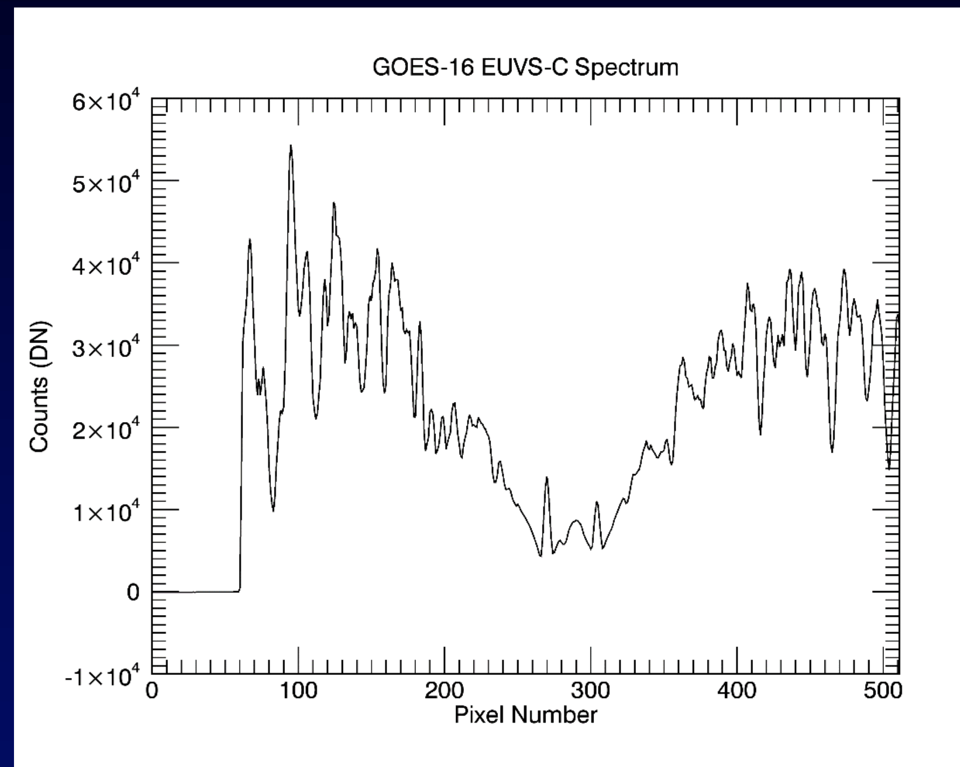
EUVS C Capabilities

- Grating Spectrograph:
  - 512 element diode array (Hamamatsu 3924)
  - filter 15 nm wide bandpass, 10^7 out of band rejection
- Wavelength Range: 275-285 nm
- Spectral Resolution: 0.1 nm
- Sampling: 5 pixels per resolut
- Measurement Cadence: 3 seco

EUVS Measurements First Light: 21 January 2017



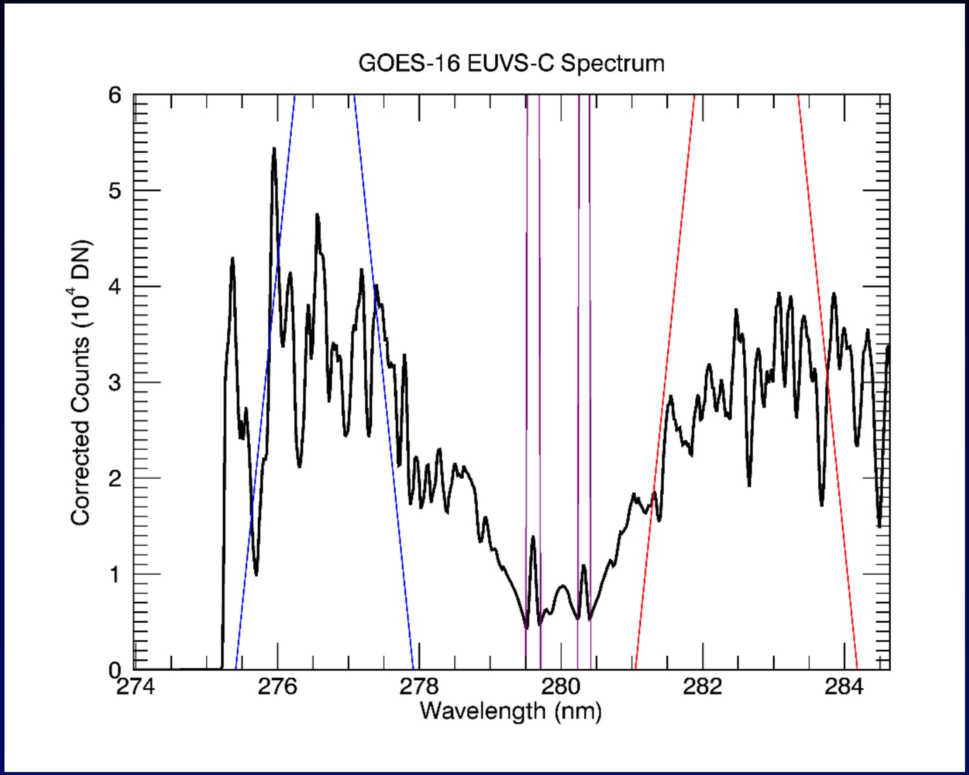
Preflight



On-Orbit

GOES16 Mg II Index

In the EUVS-C calculation, the wings are weighted sums over wide spectral regions as shown. Wing masks are preliminary. This simulates the SBUV 1.1 nm triangular instrument function similar to the SORCE SOLSTICE formulation (Snow et al. 2005).



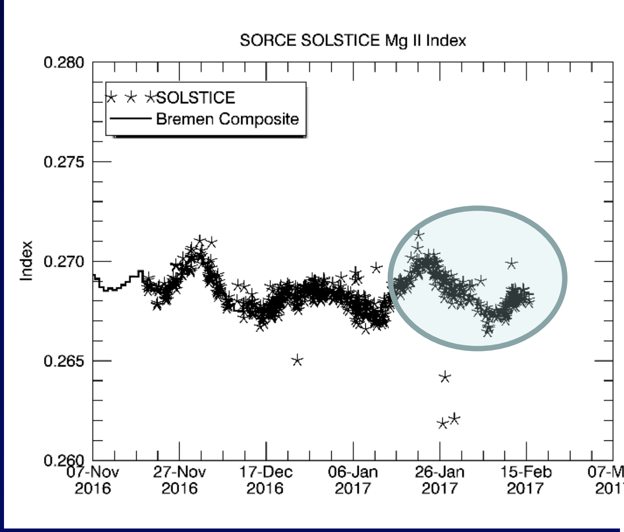
Dark Masked Pixels

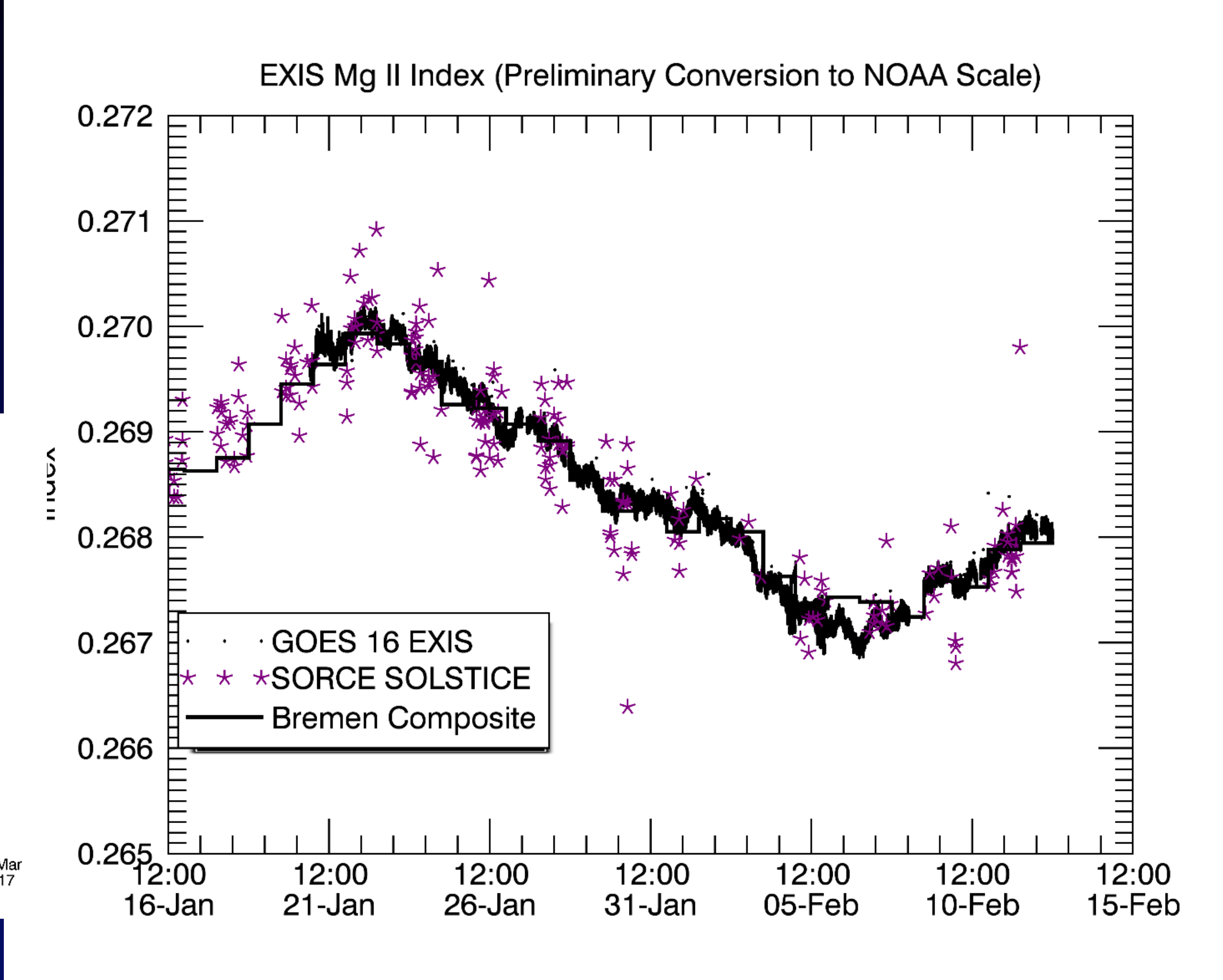
Blue Wing

k h

Red Wing

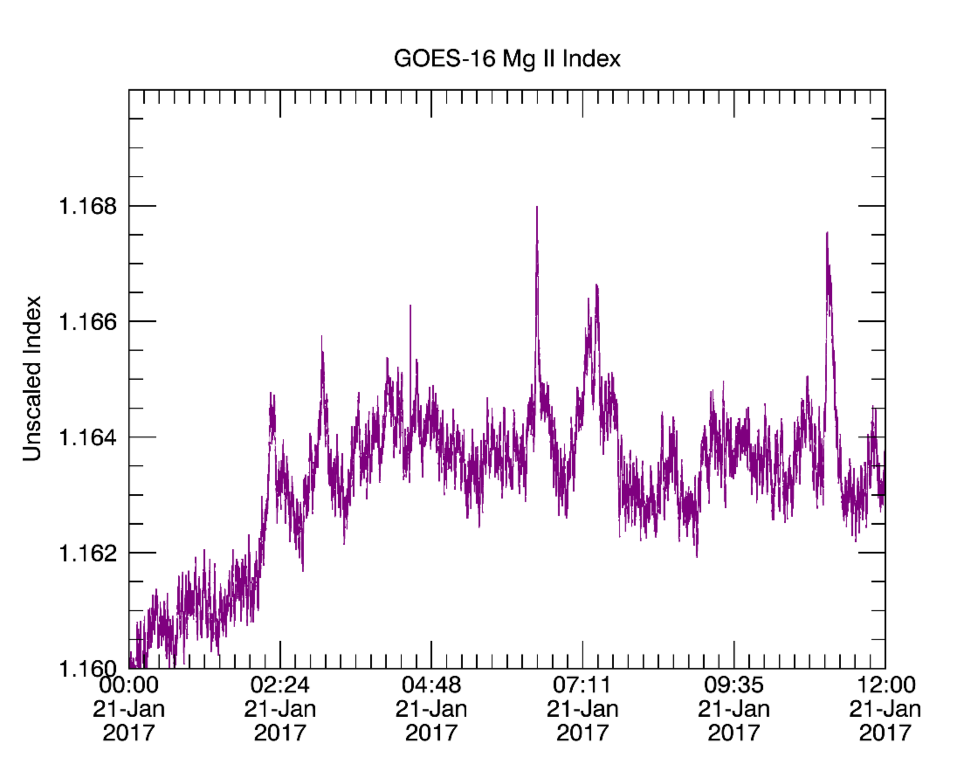
New Measurements

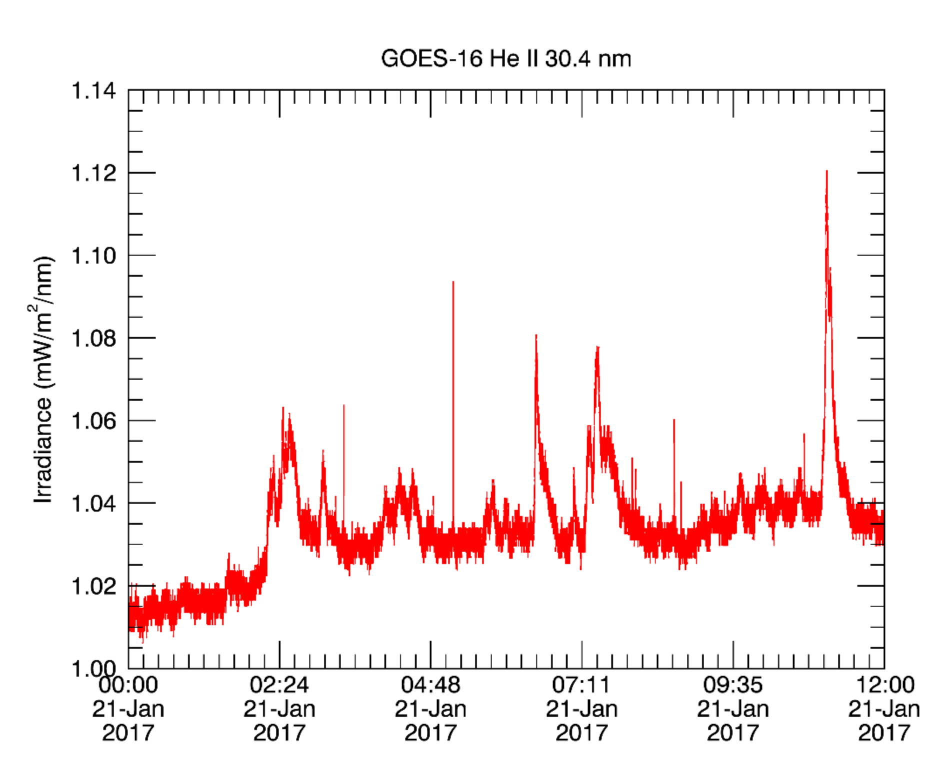




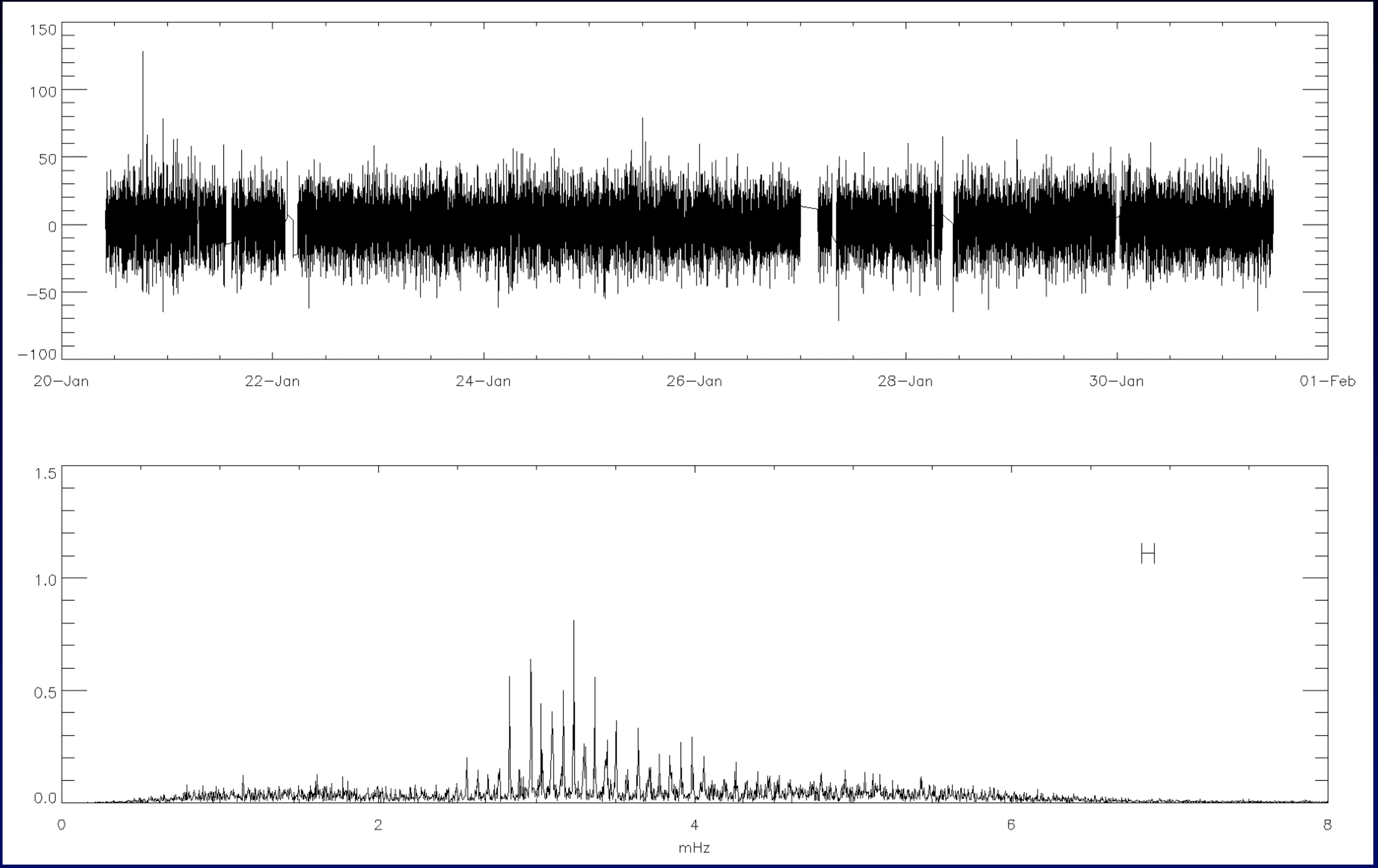
21 Jan 2017

EXIS MgII cadence is 3 seconds, He II cadence is 1 s.





Global Oscillations



Conclusions

- The MgII core to wing ratio is a proxy for chromospheric activity with a long history.
- Although it is mostly free of instrument artifacts, detailed analysis is still required to produce a reliable composite.
- Future of MgII proxy began with GOES-16 EXIS.