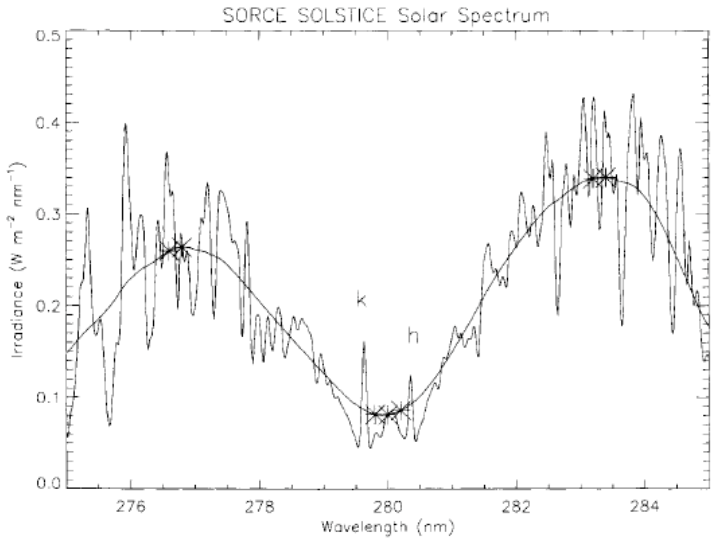
Mg II Index Comparisons and Correlations

Jim McGrail
Mentors: Marty Snow, Erik Richard
July 31,2008

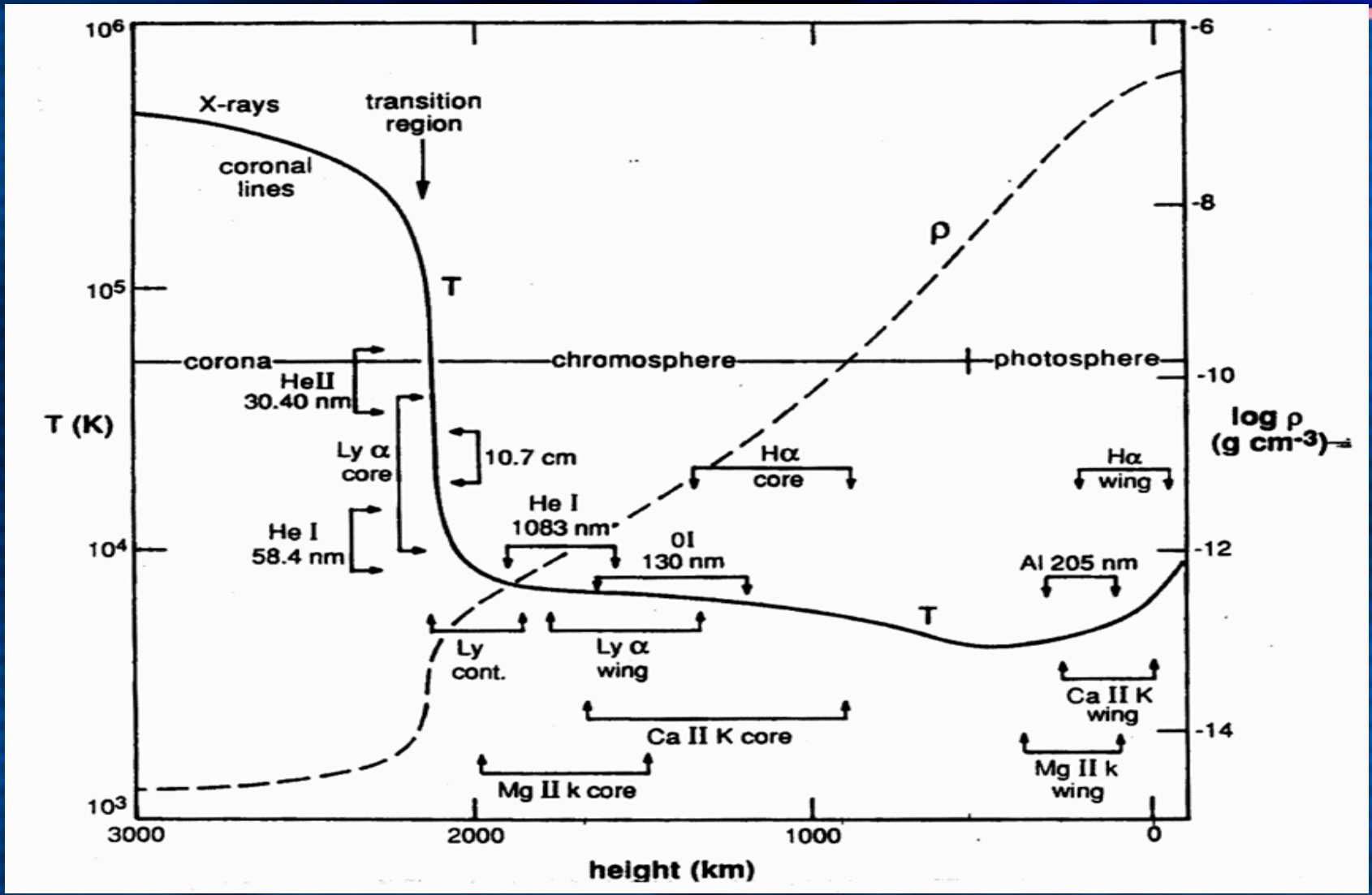
What is the Mg II Index?

- It is a measure of the amplitude of the chromospheric Mg II ion (Mg^{+}) emission
- Is highly correlated to EUV/ FUV variability
- Measured around 280nm - UV part of spectrum
- Ratio of irradiances rather than absolute irradiance

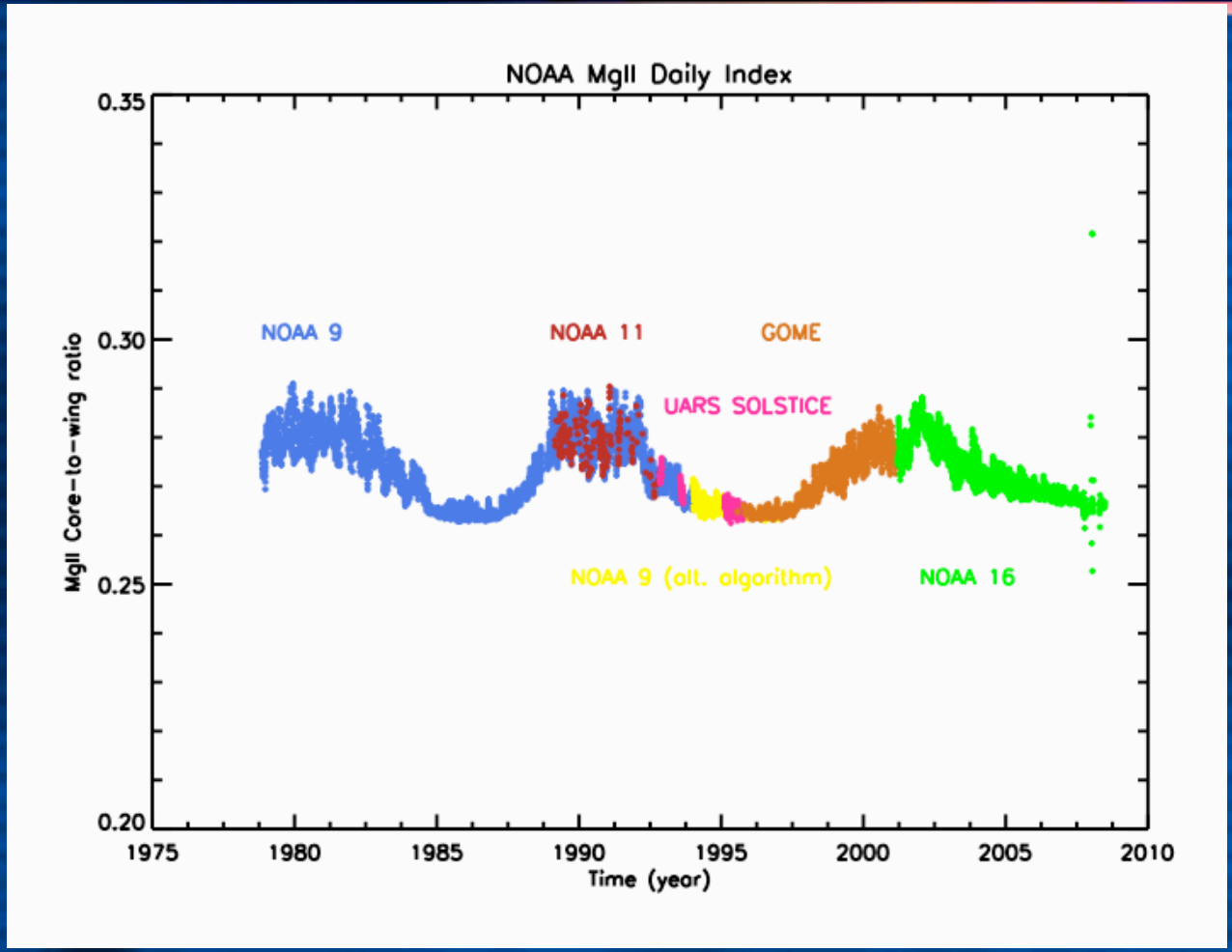


$$\mathrm{Mg\ II_{SIM}} = \frac{4[I_{279.8} + I_{280.0} + I_{280.2}]}{3[I_{276.6} + I_{276.8} + I_{283.2} + I_{283.4}]},$$

Solar atmosphere



NOAA daily Index since 1978

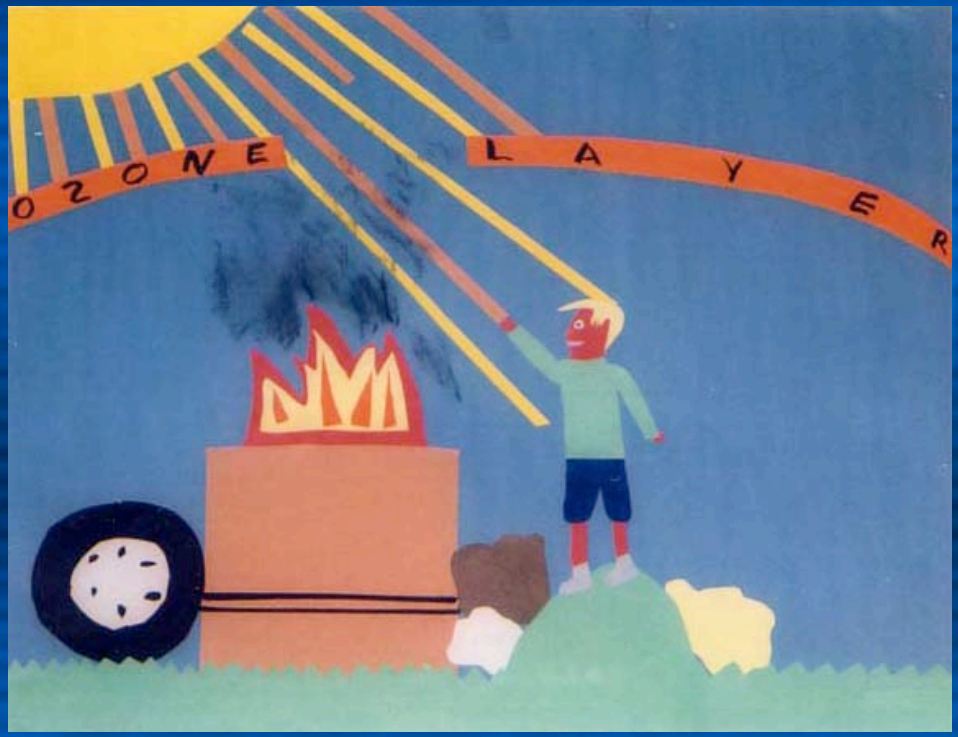


Official NOAA data

Why is solar variability important?

- UV light is absorbed in the upper atmosphere, primarily by ozone
  - Mg II can't be measured from the ground
    - Wavelength < 310 nm get absorbed
  - This controls the amount of ozone
    - $O_3 + hv \rightarrow O_2 + O^*$ (excited state)
  - Ozone is an important factor in the Earth's climate

Why solar variability is important

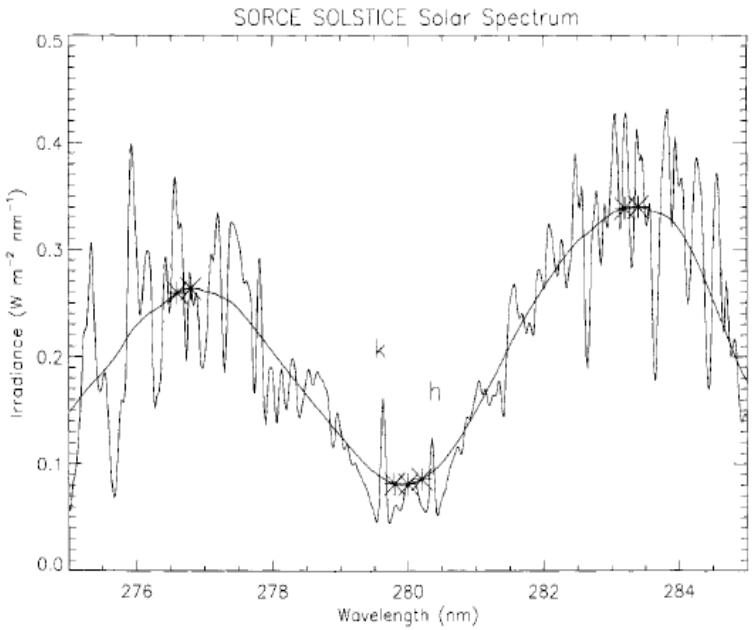


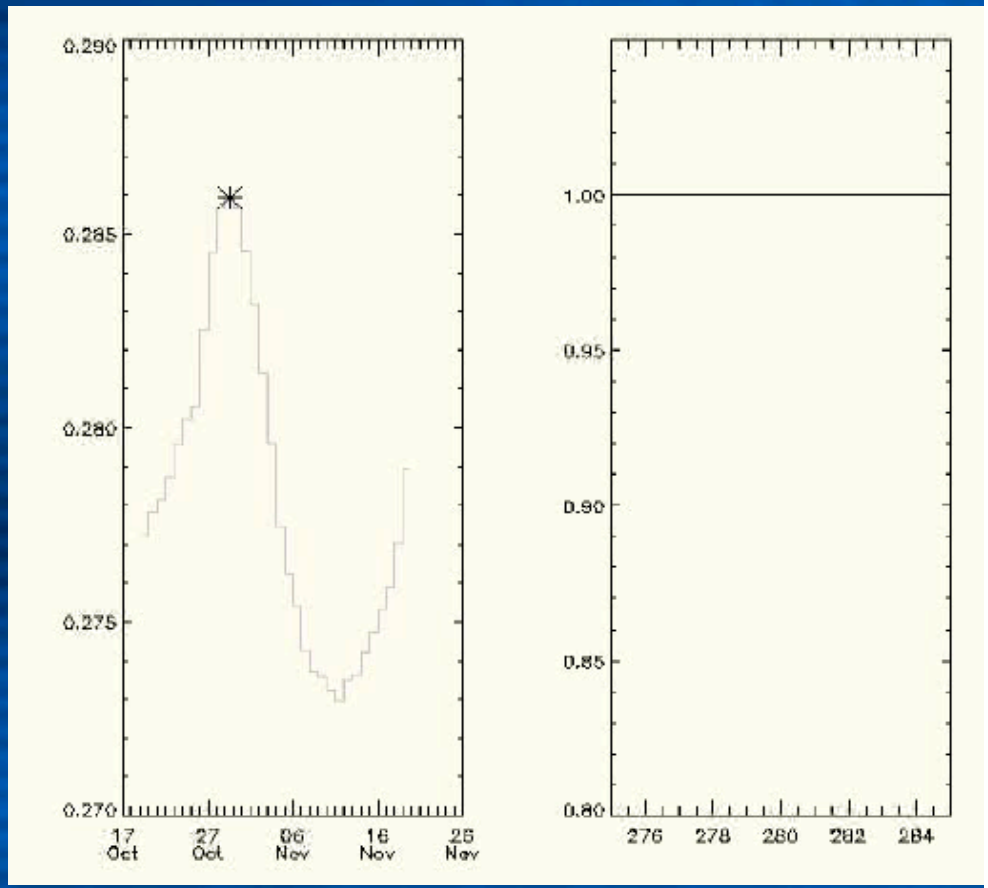
Why is the Mg II index important?

- It is one of the main inputs into models of the ionosphere
  - Important for: satellite drag, GPS, etc.
- Straight forward to measure (from space)
  - Mg emissions around 280 nm change a lot (~20%)
  - Wings change very little (~0.5%)
  - Measured as a ratio

Why is the Mg II index important?

- Easy to measure

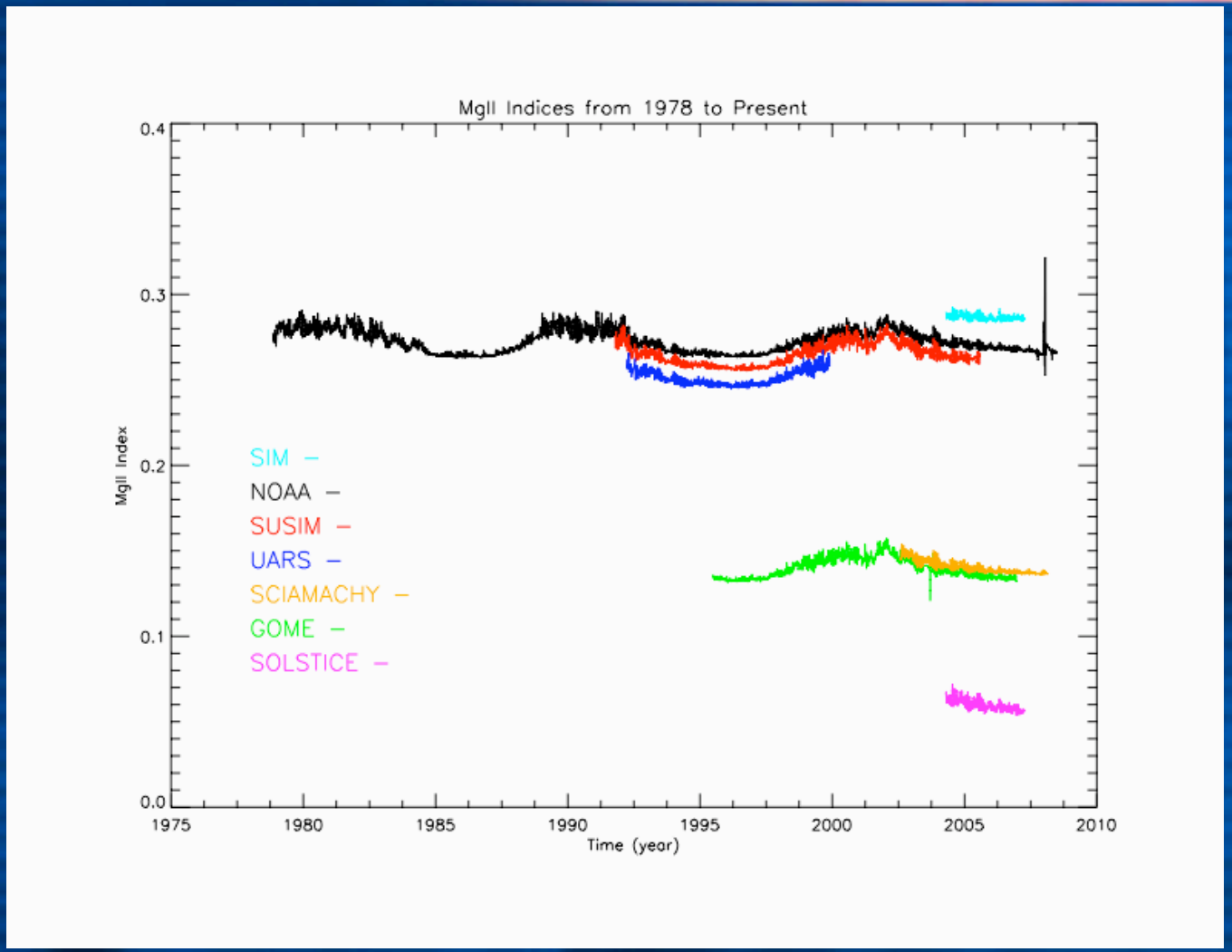




Problems with the index

- There is no continuous measurement
- Multiple satellites/ instruments
  - SIM, GOME, SCIAMACHY, UARS SOLSTICE, SORCE SOLSTICE, NOAA SBUV series, SUSIM
    - Measurements are on different scales
  - Data collection rates are different

Problems with the Mg II index

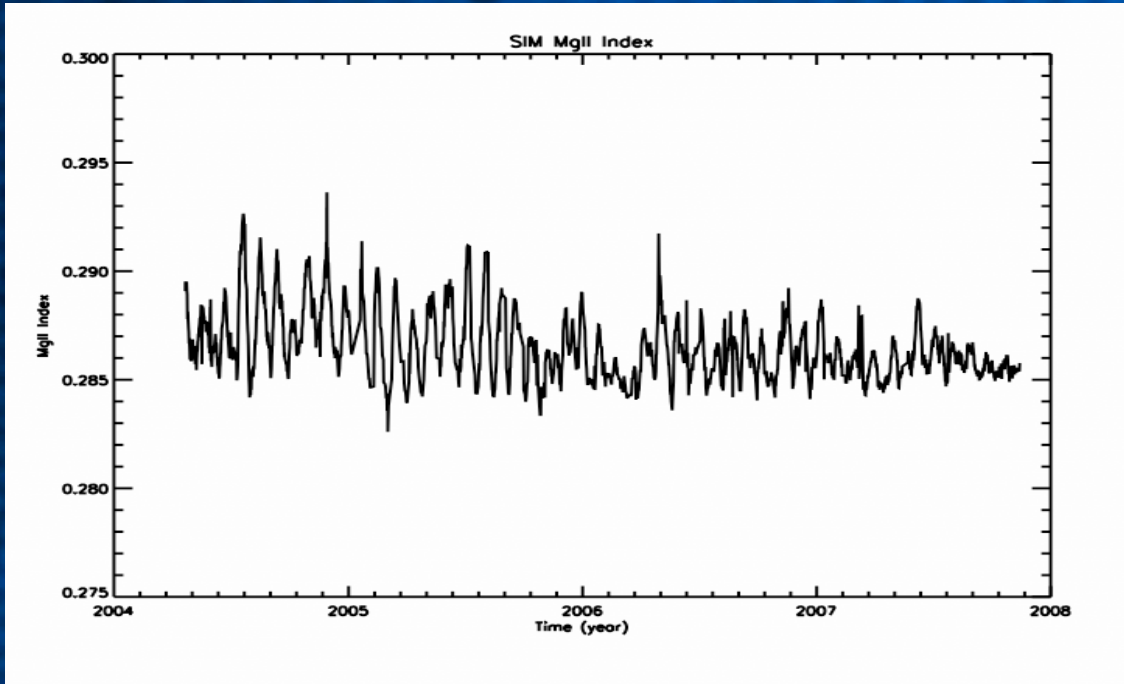


My goals

- Main goal: create an index from all of the data that can predict solar irradiance
- Compare the Mg II index to other indices
  - Ex: Ca II index
- To look at short time scale variations
  - One day
  - One rotation

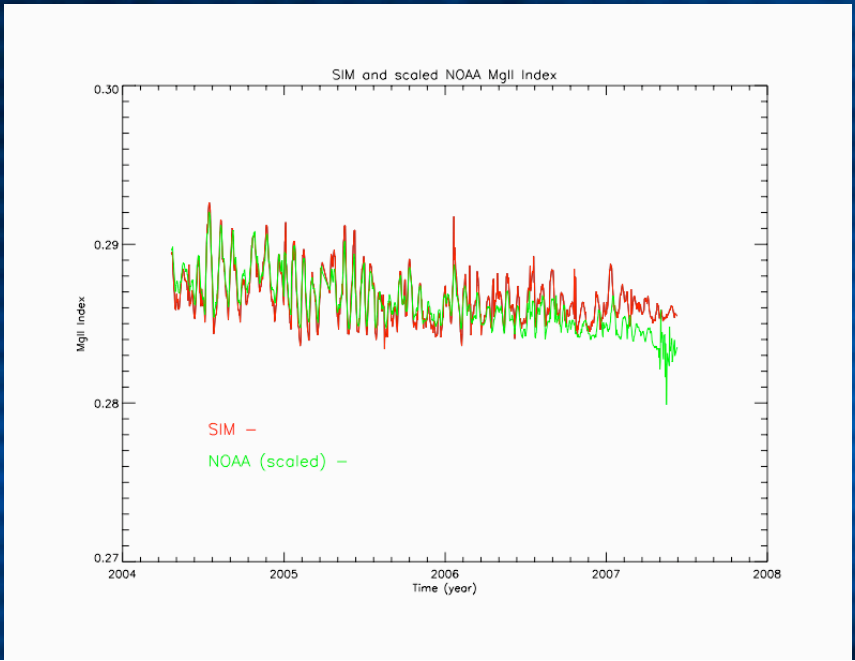
Creating a new Mg II index

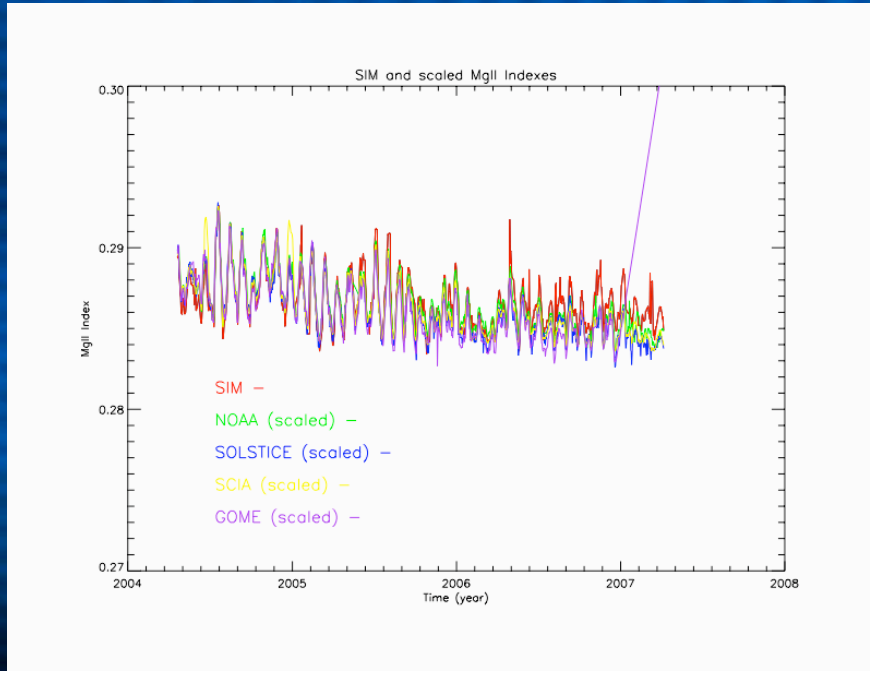
- First, I needed to get data from different satellites
  - SIM instrument measures irradiance; used ratio to create a Mg II index for it



Creating a new Mg II index

- Next step, compare the different data sets
  - Look at data over similar time ranges
  - Use linear scaling factors

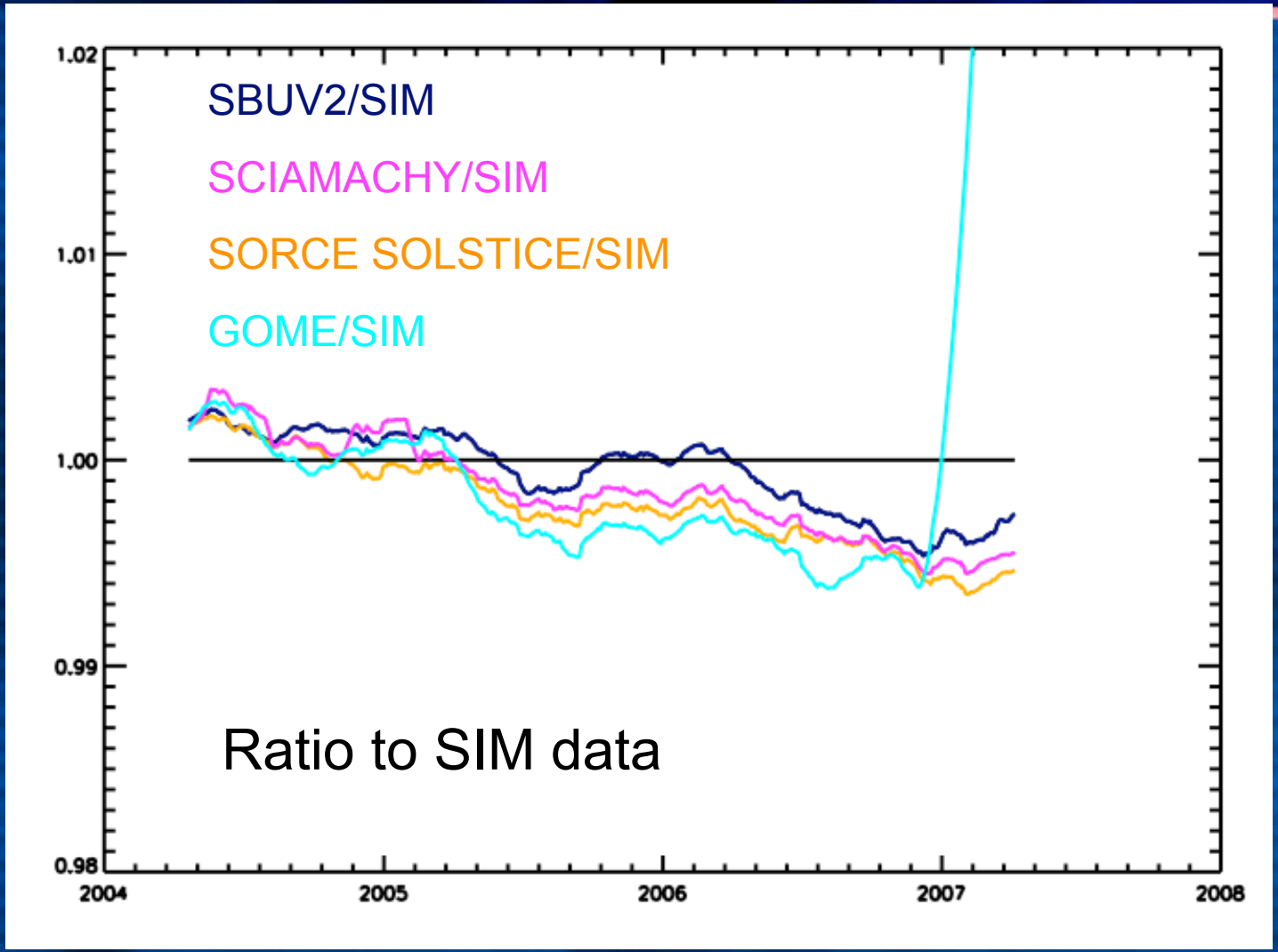




Comparing different data

- To get a better understanding of the differences, I smoothed the data with a 81 day average (~3 rotations)
- Then, took ratio's of the smoothed data
  - This should make it easier to tell which instruments have similar trends in their data

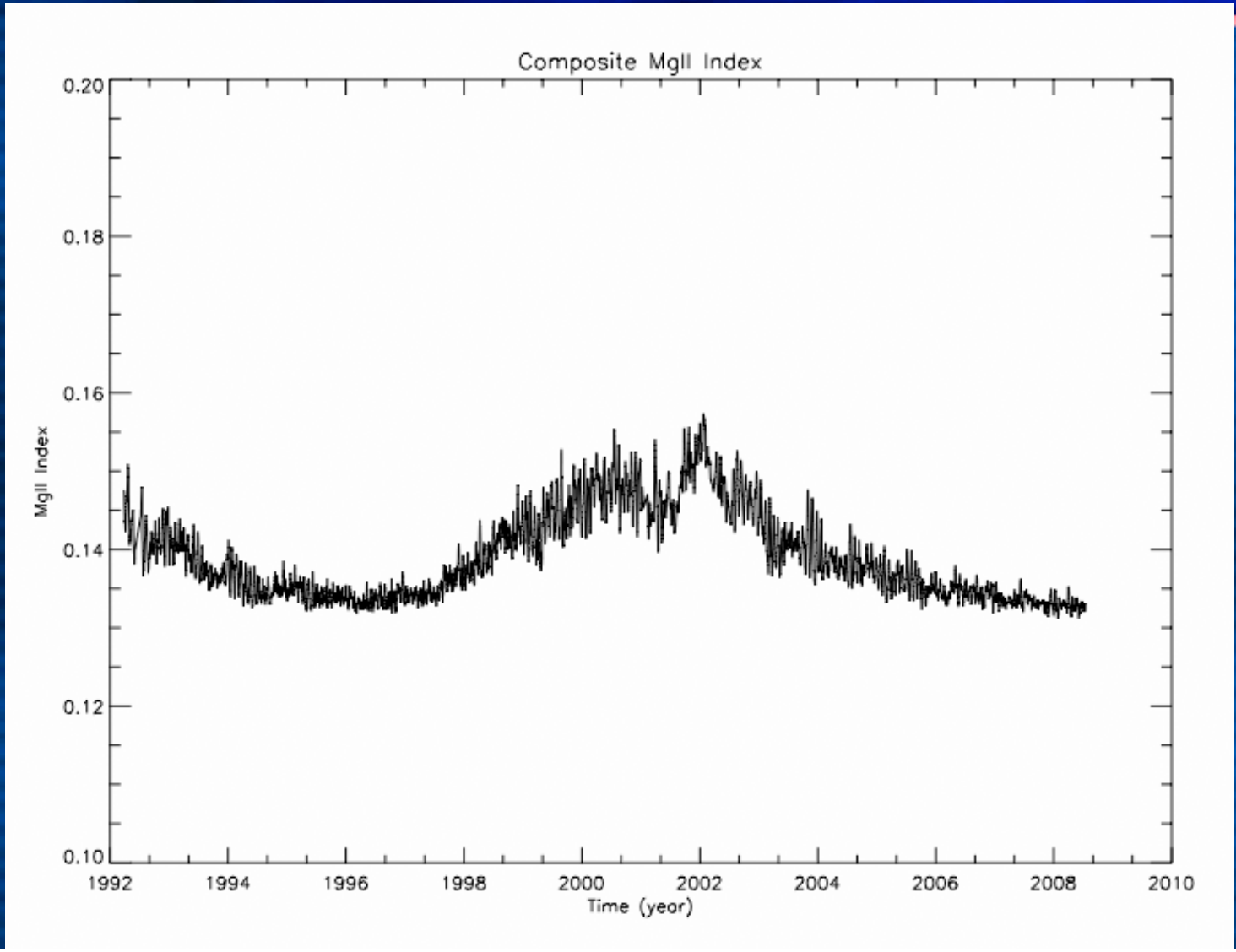
Comparing different data



Comparing different data

- I did these same steps for data from earlier missions
  - Decided that the best data sets would be: UARS SOLSTICE, GOME, and SORCE SOLSTICE
- Created a new Mg II index using this data

New Mg II Index



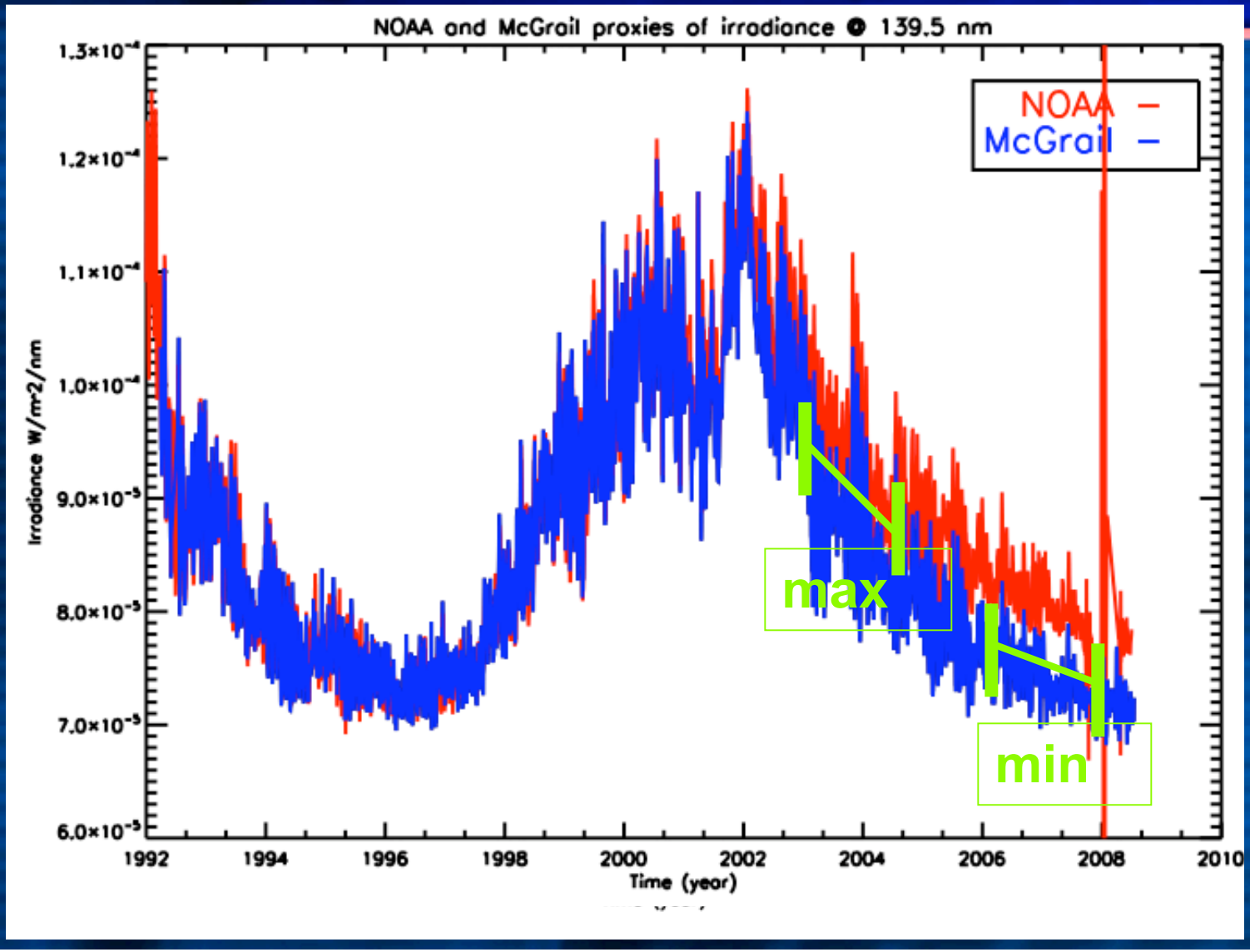
Using Mg II index to predict irradiance

- The next step was to see if the new composite index could predict solar irradiance better than the NOAA index
- I created two models of irradiance, one for each index, to compare to the SORCE measurement
  - To do this, I scaled the Mg II indices to UARS SOLSTICE irradiance between 1997 and 1999
  - I now have predicted irradiances from my index and the NOAA one extending to 2008

Predicting irradiance

- To average out the short term variations in irradiance, I took a year long averages from 3/1/03 thru 3/31/04 and 6/1/07 thru 6/30/08
- This helps distinguish the long term trend from solar max. to solar min. from any short term trend
- I then took the ratio of the max/min to represent the spectrum
- I did this for all wavelengths from 119.5 to 185.5 nm

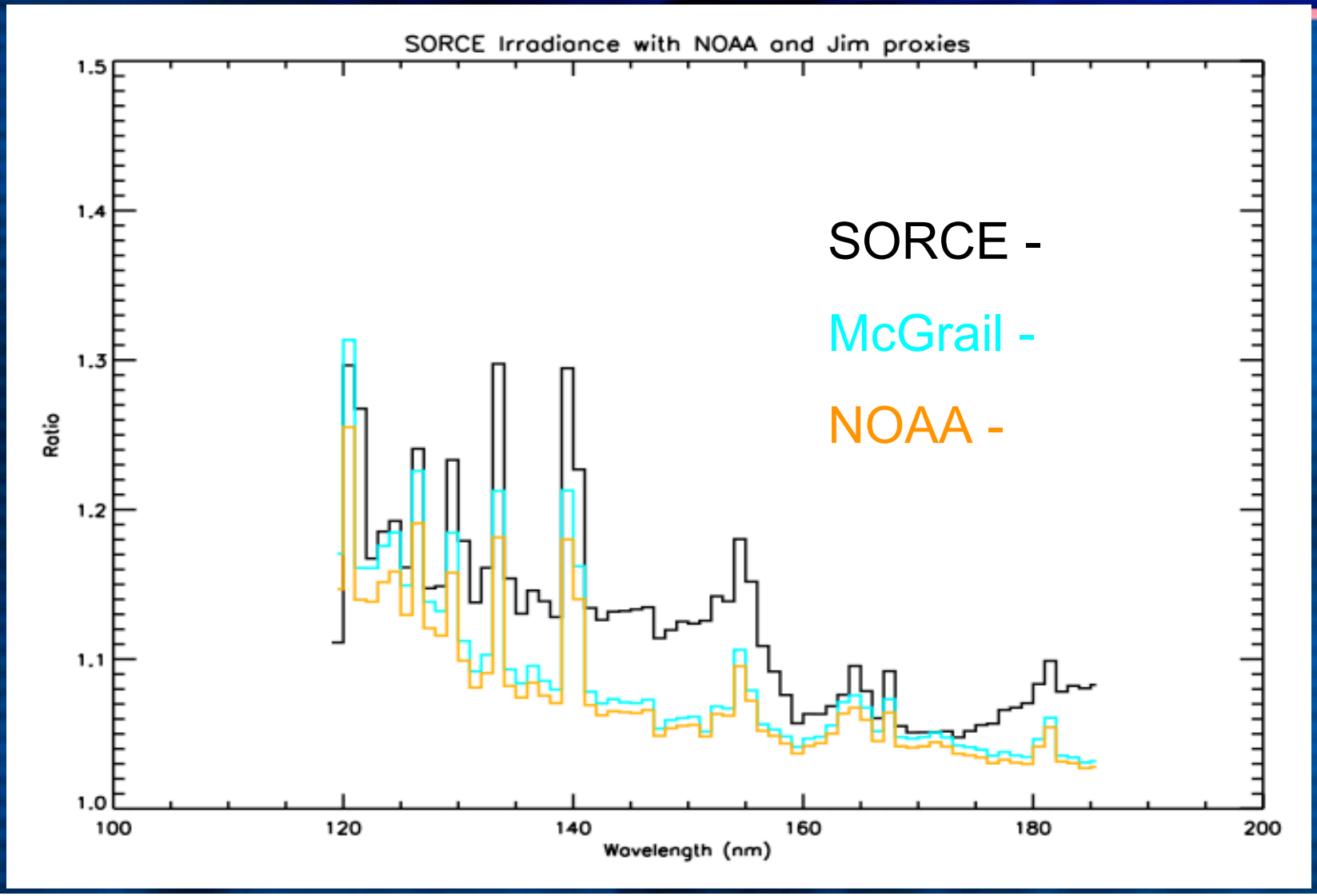
Making irradiance proxies



Making irradiance proxies

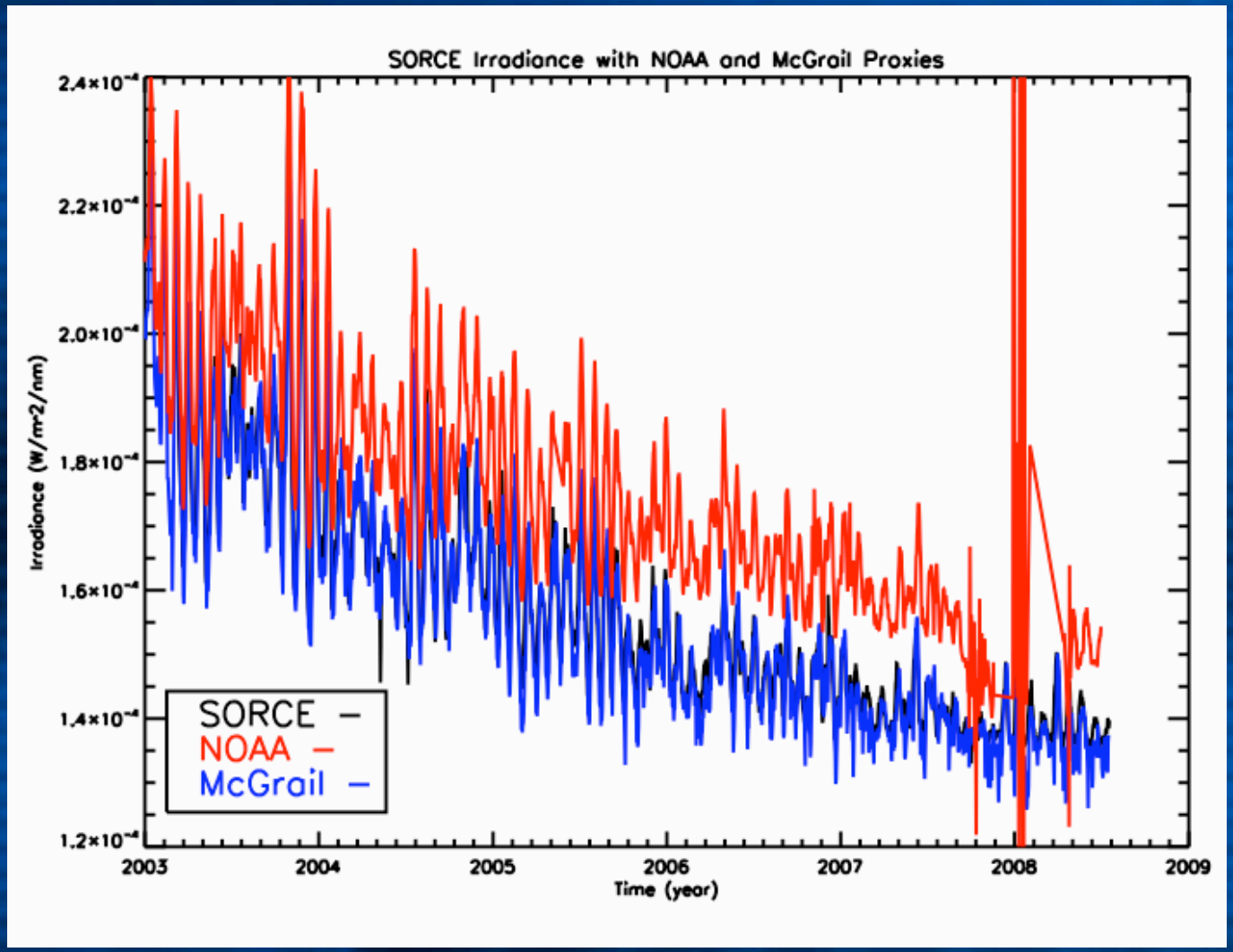
1. Take year long average near solar max. and solar min. for each wavelength
2. Divide the average at max. by the average at min. for each wavelength
3. Do this for NOAA and McGrail proxies and for observed SORCE values

Predicting irradiance



Predicting irradiance

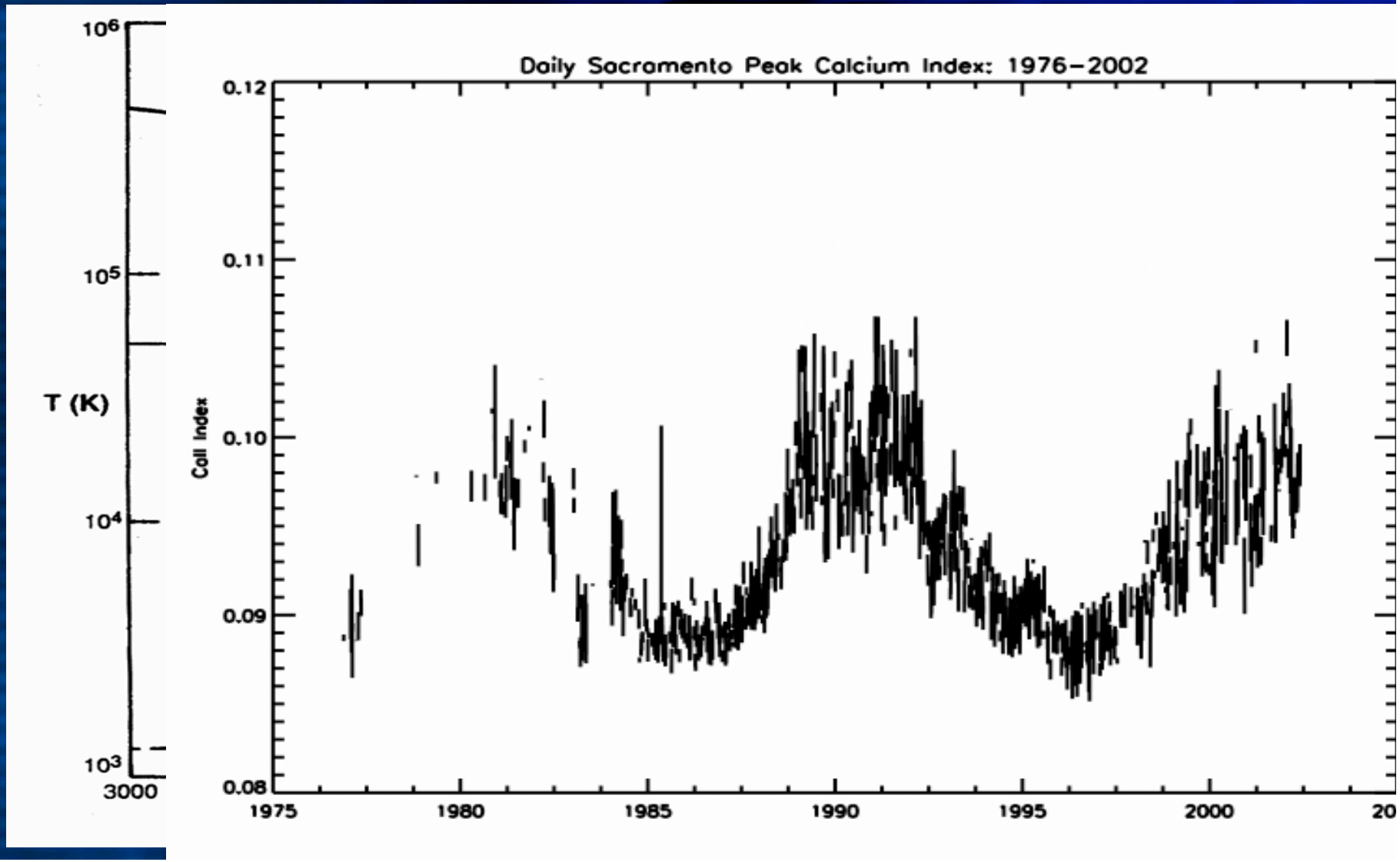
Ex: At 120.5 nm



Ca II index

- I briefly looked at the Ca II index
  - A ground based measurement
    - Good because there is a long record of measurements
    - Don't need to go to space to measure it
    - Bad because you have to look through the atmosphere
  - Also measured as a ratio
    - Wings aren't as far away from the core measurement in the solar atmosphere as in the Mg II index

Ca II index


T (K)
10^6
10^5
10^4
10^3
3000
Daily Sacramento Peak Calcium Index: 1976–2002
CaII Index
0.12
0.11
0.10
0.09
0.08
1975
1980
1985
1990
1995
2000
20

Summary

- The Mg II index is highly correlated with EUV and FUV variability
- This means it can be used to make proxy data
- Compared to NOAA index, my new composite was better at predicting solar irradiance

Questions?