Solar Spectral Irradiance Variability

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What will be discussed?

- Why is SSI Variability important?
- What are the goals for my project?
- Where does all this data come from?
- What are normal variations?
- How to find the days of interest?

Spoiler Alert!

- The Data!
- What we can learn from the data, and what is next?

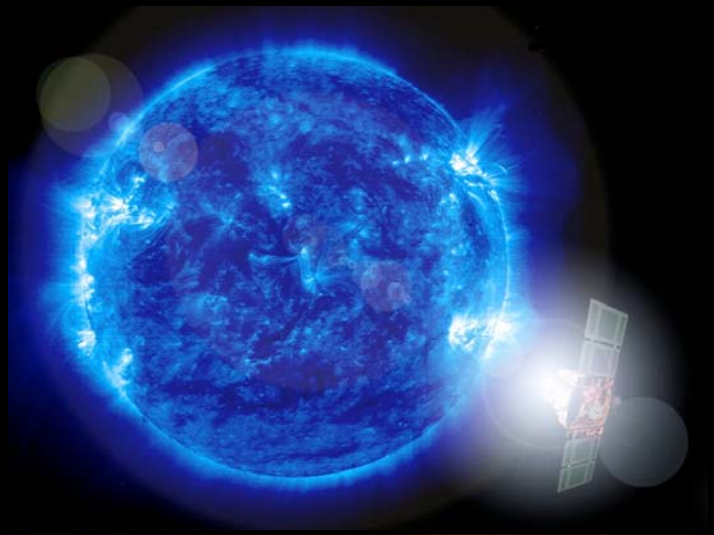
Why Study It?

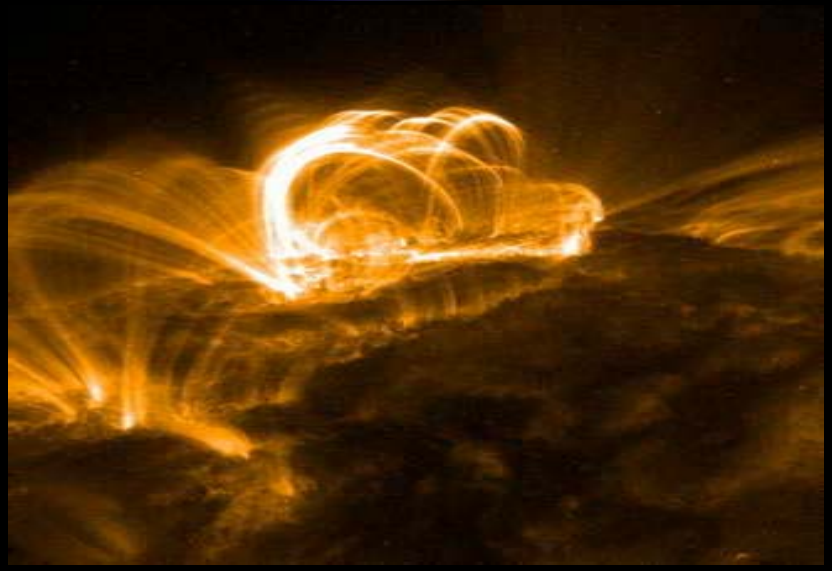
The Sun gives us the energy needed to support life.

Any change in the sun leads to changes here on earth… sometimes drastic.

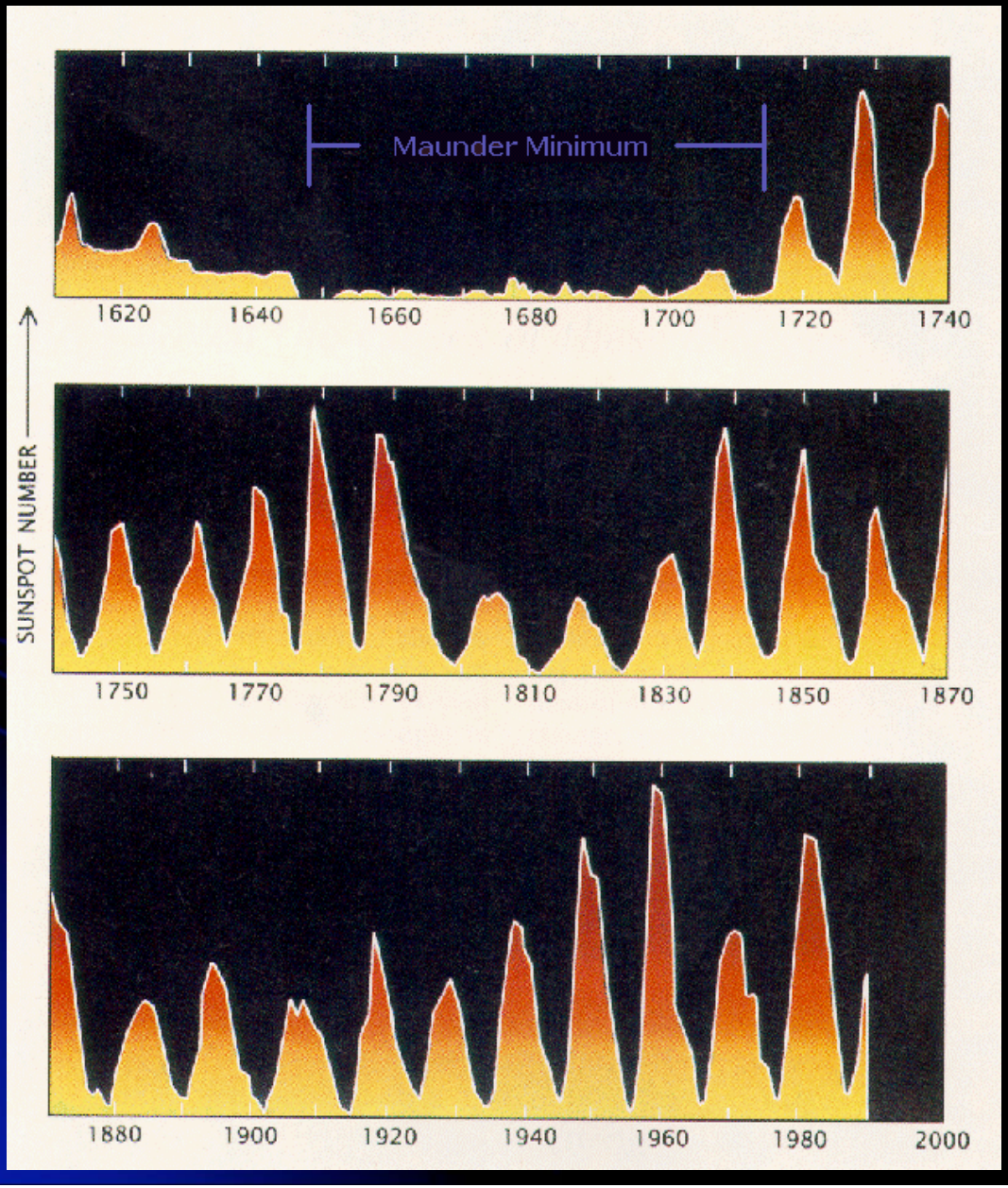
Not only can the sun disable electronic services and damage transformers…

Long term changes in Solar Activity can affect our climate.





Maunder Minimum



- This uncharacteristically long period of solar minimum has been attributed to a very cold period in Europe.
- Europe saw several rivers freeze over that haven't since.
- An estimate of the average global temperature decrease is 0.3º-0.4ºC.
- This leads to about 1º-2ºC cooler winters in Europe

  [Shindell, Drew et al.,2001]

Courtesy: Davison Soper's 'Sunspot Cycle'

The Temperature Relation to TSI
(Total Solar Irradiance)

- According to an estimate from George Reid's paper 'Solar variability and its implications for the human environment', the average global temperature relation to irradiance change is about 0.6°C per 1% irradiance variation. However, the temperature adjustment can be delayed due to the ocean's thermal inertia.
- That means the change in average global temperature of 0.3°C, as approximated for the Maunder Minimum, would be equivalent to a 0.5% drop in TSI.
- It is important to note that the 1% variation does not have to be constant over the entire spectrum, and that it may even be over only a small section of the spectrum.

  (Assuming the section makes up at least 1% of the TSI)

Goals for this Project

- In studying the SSI variability, we hope to have a better understanding of how much the SSI affects the TSI.
- With an understanding of how SSI relates to TSI in Facular Brightening (to be described next slide) cases, we can determine how the SSI would vary if it disappeared. From that, it might be possible to described what happened during the Maunder Minimum.
- It is preferred to use SSI over TSI for this estimate because the sun doesn't vary consistently over all wavelengths. Instead it is likely limited spectral ranges that vary more.

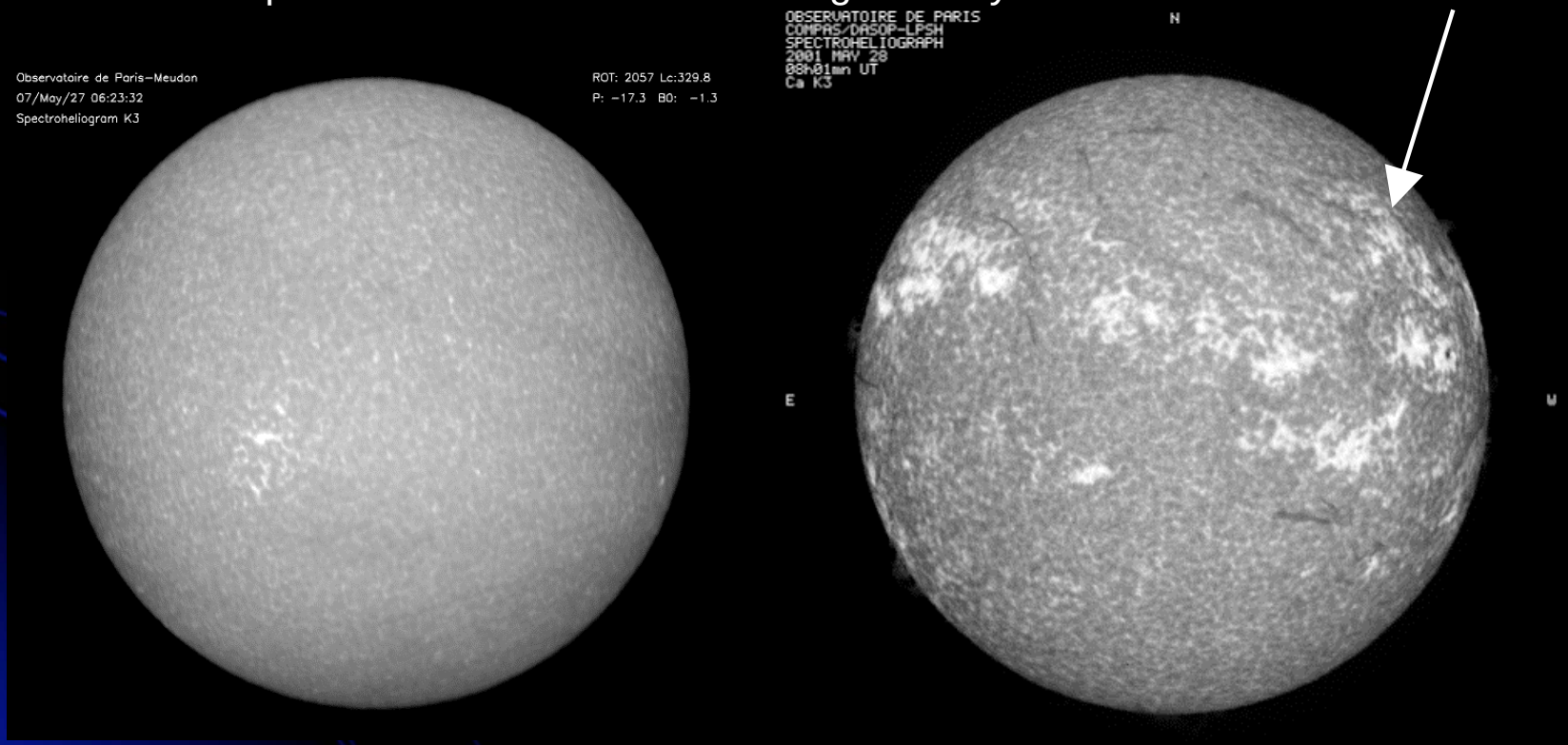
Rather than TSI…

Instead of the TSI varying, a part of the decrease in solar irradiance is a lessening of the active network.

Worden et al. (ApJ,1999) also suggestioned that the active network could have disappeared during the Maunder Minimum.

Example of low active network and high activity.

Faculae



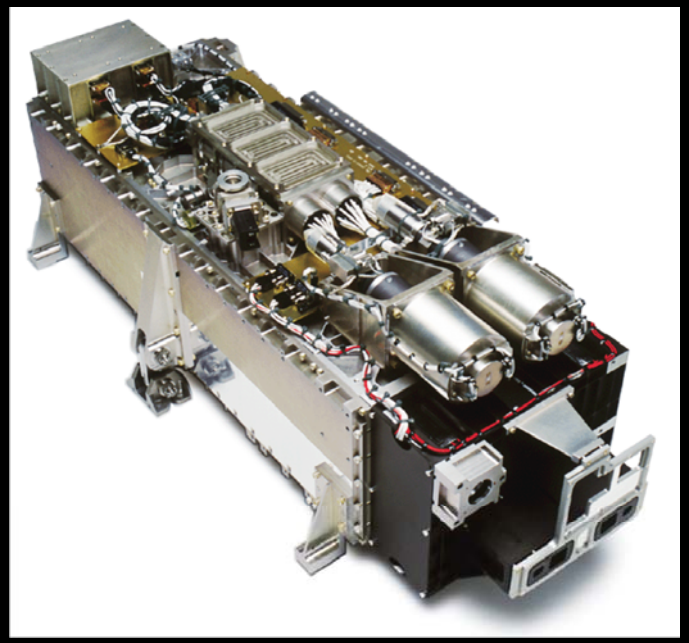
Courtesy: BASS 2000

Where the Data comes from

SIM instrument collects data.

The light enters through a slit in the front of SIM. It is then sent through a Fery prism.

The Fery prism has a convex back and a concave front which allows it to both focus and disperse the light.

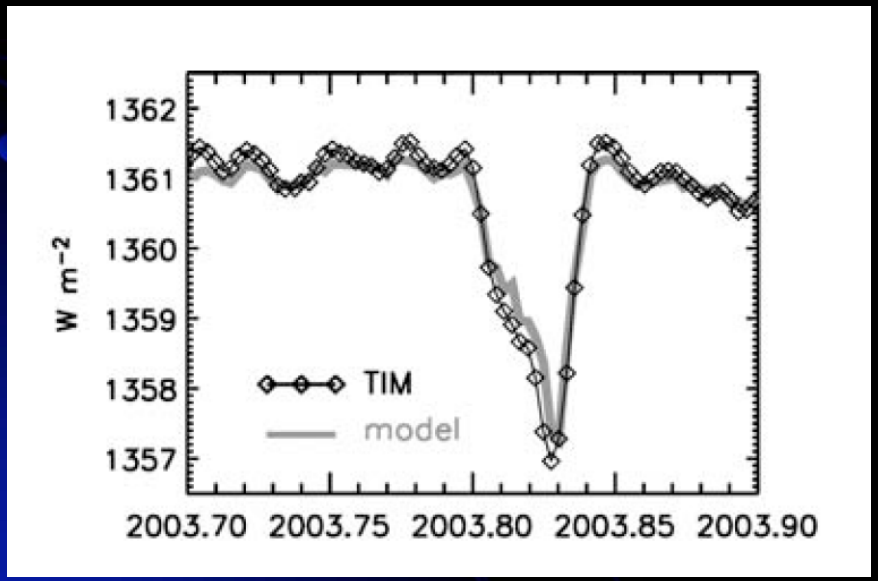


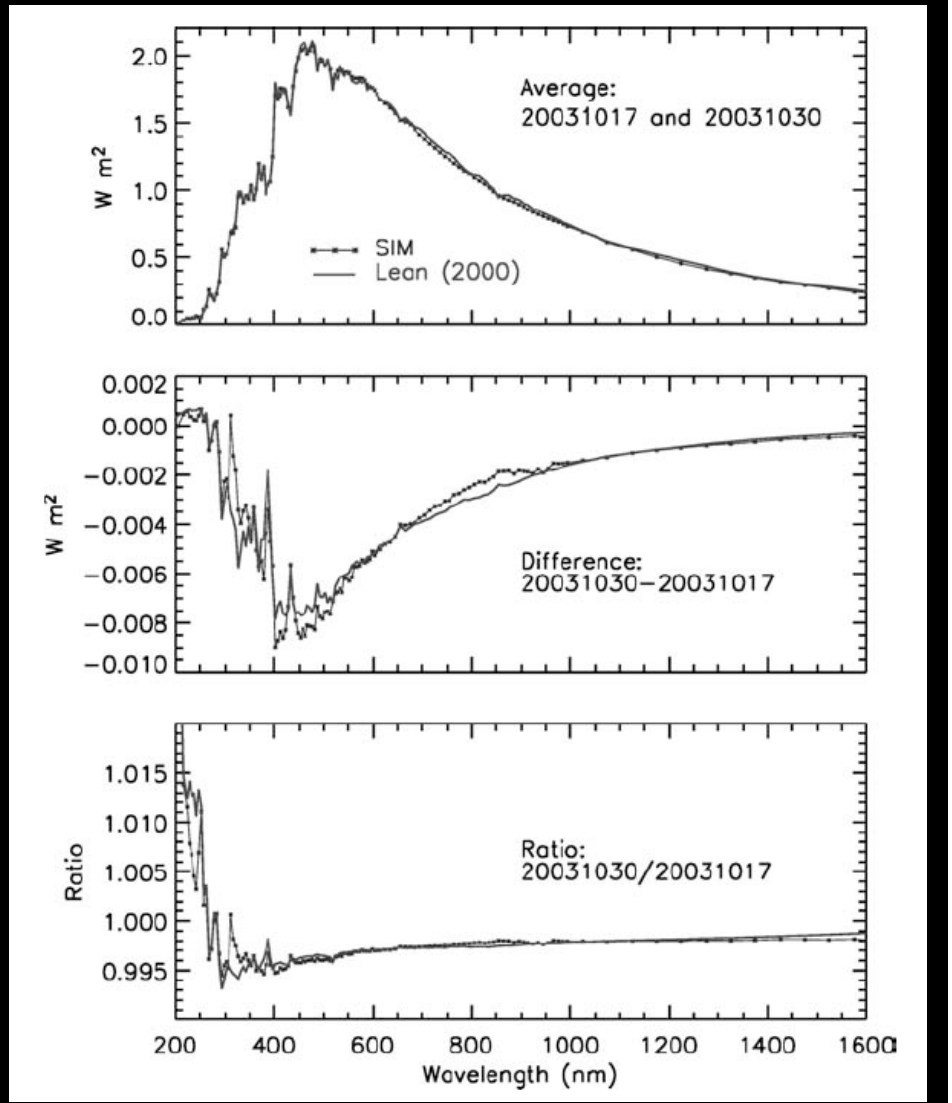
Courtesy: LASP

The main benefit of using the Fery is the fact that it only produces one spectral order where regular gratings produce several overlapping orders.

Normal Variation

- Here we can see what would happen in both TSI and Ratio Variation of a sunspot crossing the sun.
- Where Lean uses Ratio to compare the days, I use Fractional Difference, (Ratio – 1)

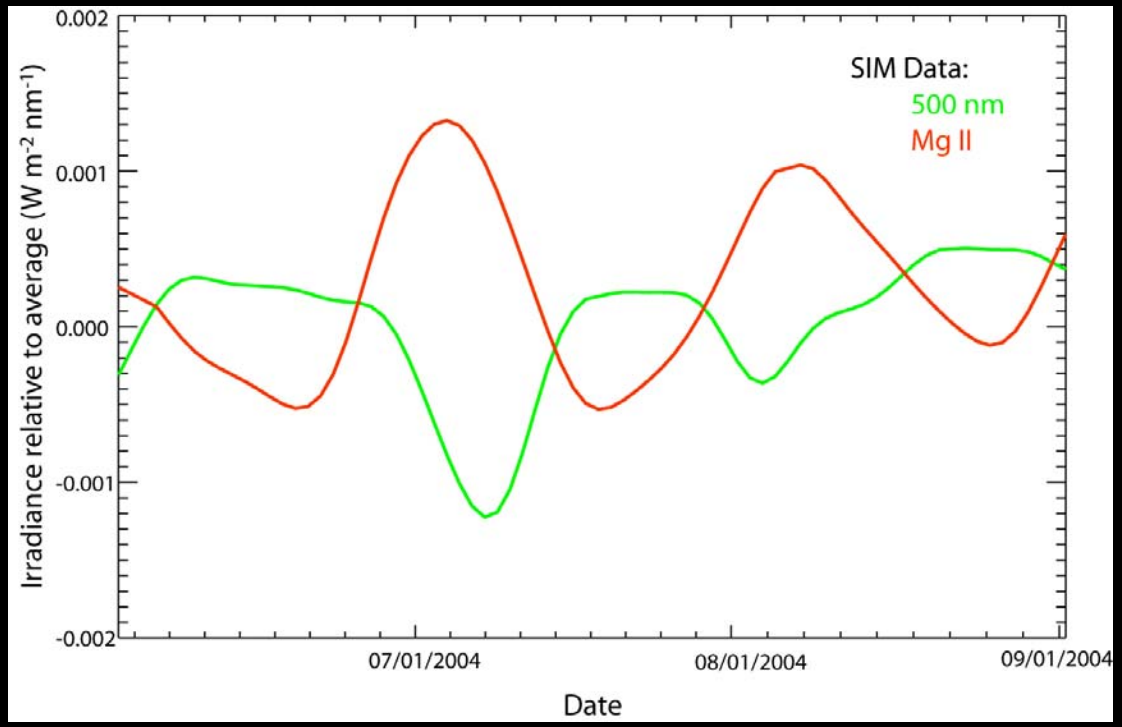




Courtesy: Lean et al. (Solar Physics, 230, 2005)

The Usual Fluctuations

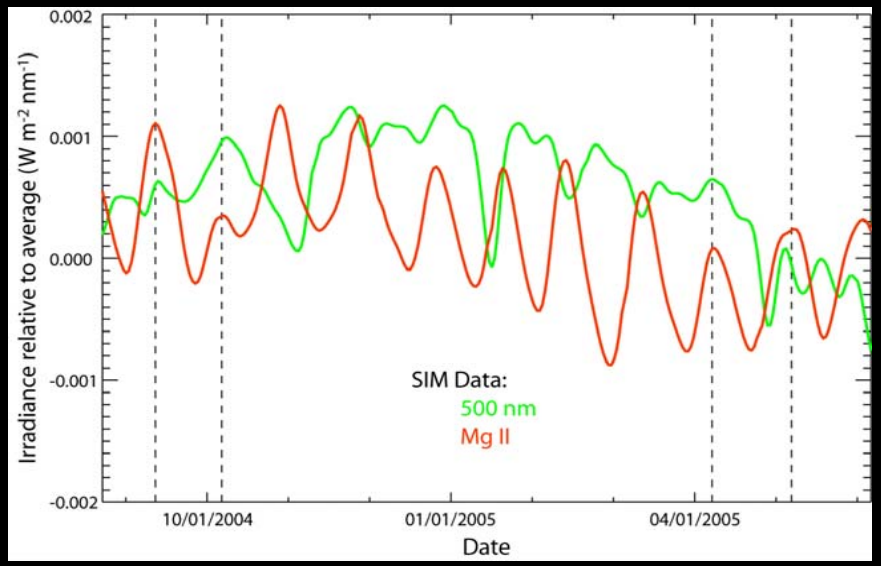
- For most of a plot of 500nm and 280nm variations, the two would be out of sync as they appear in this plot.
- For the days of Facular Brightening, the 500nm line and the Mg II (280nm) would peak at the same time, or close to it.

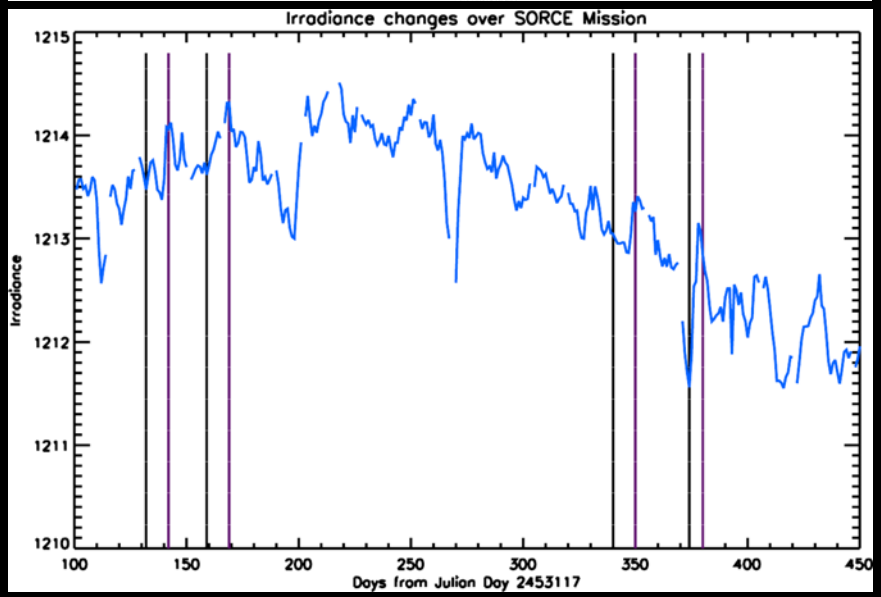


Include the finding of FB plots

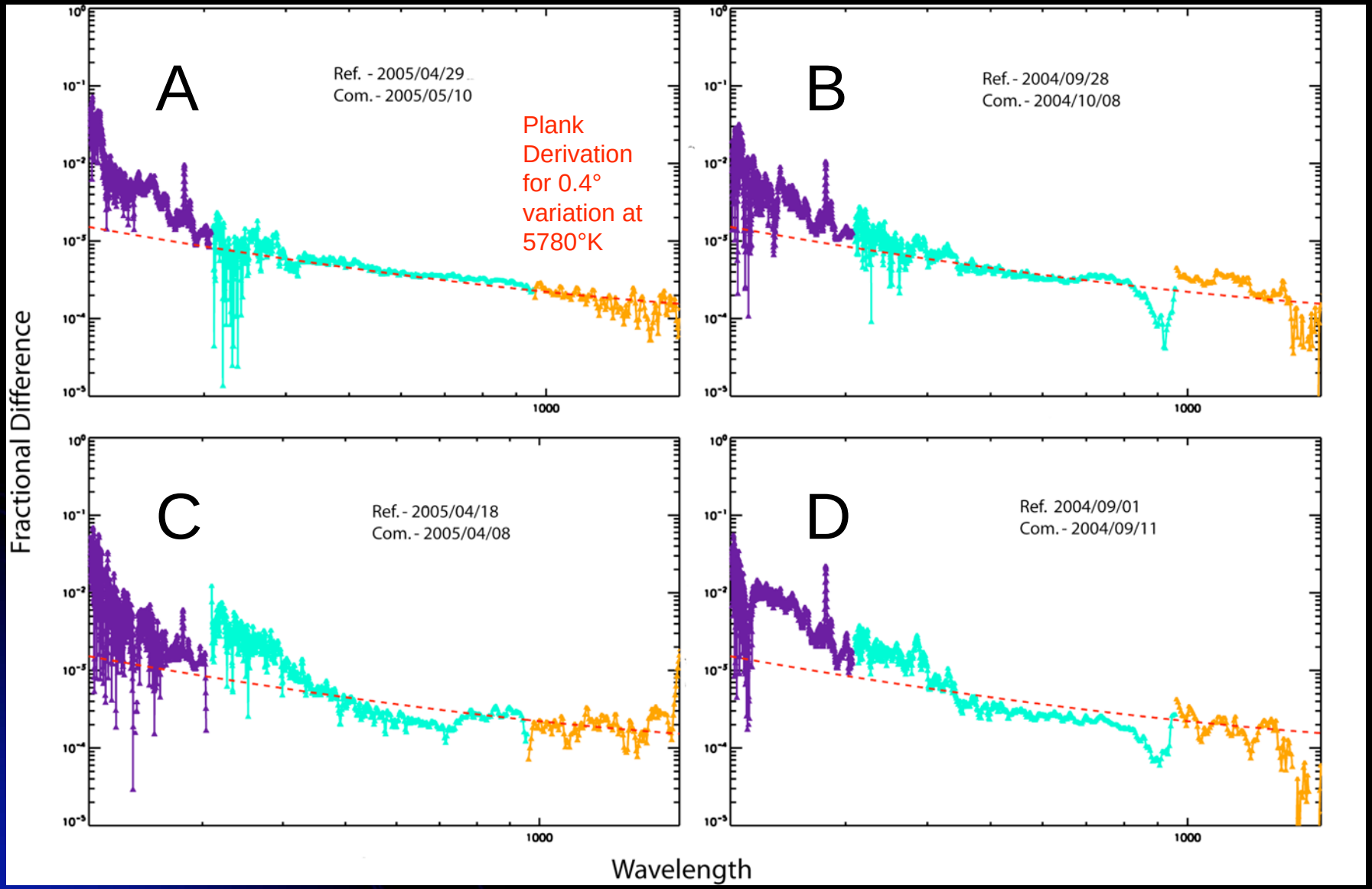
- The way of finding these FB days was simply when both wavelengths peaked at the same time.
- After the days have been selected, to get a more precise day selection, one looks at the Ca K images to find the lowest activity day, and the highest for each case.

  (Missing parts in line are bad data points)





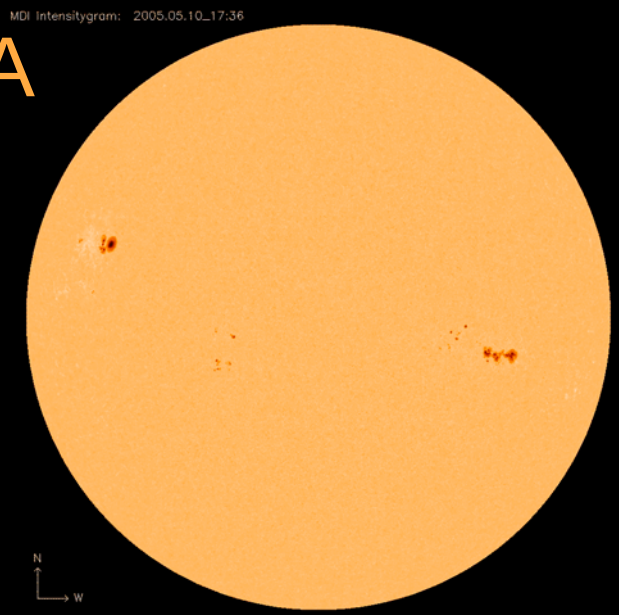
Observations from data



Interpretation of the Data

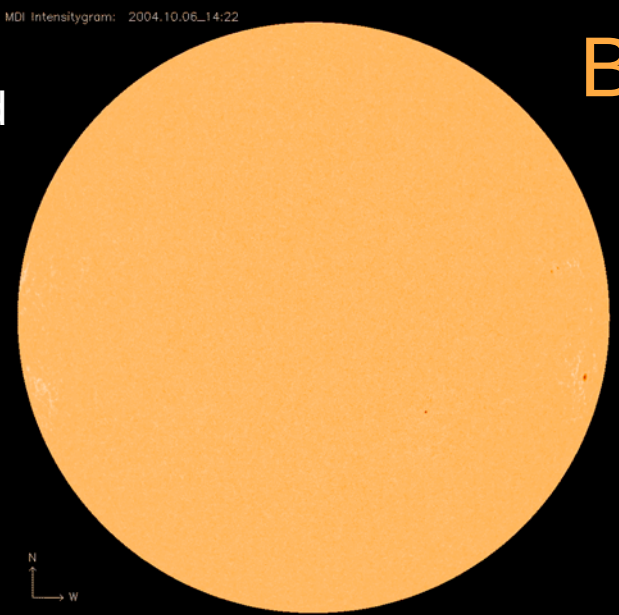
- There is obviously an overwhelming amount of information in the plots, but we can easily see some common and important features.
- You must also be careful of misidentifying a system or hardware feature as actual results.
- We are ideally looking for days without sunspots. To do so one must examine the solar images to find which of these plots has the data we are looking for.
- Though from the plots we see that, the the visible and infrared, A fits the 0.4°K Plank derivation best.
- Should also note that UV light shows marked increase in all of the plots.

Sun on Facular Brightening Days

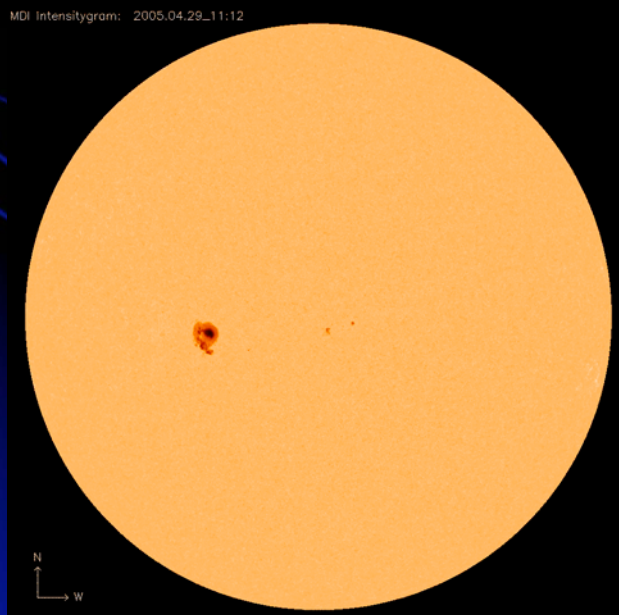


A

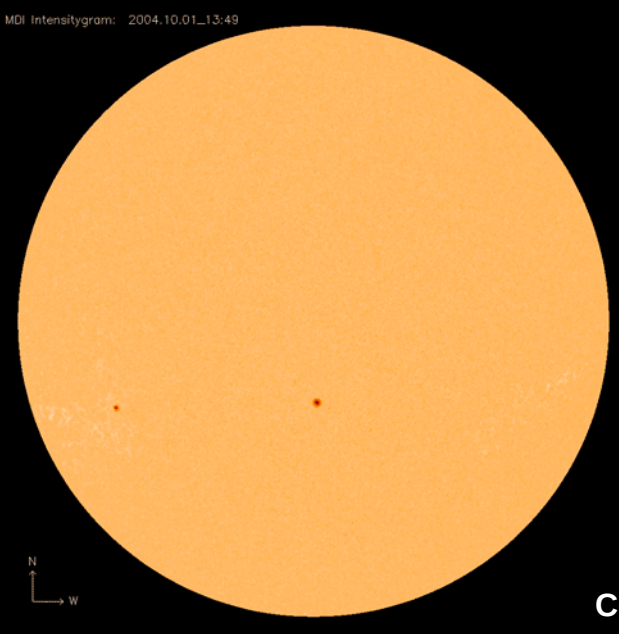
Compared Days



B



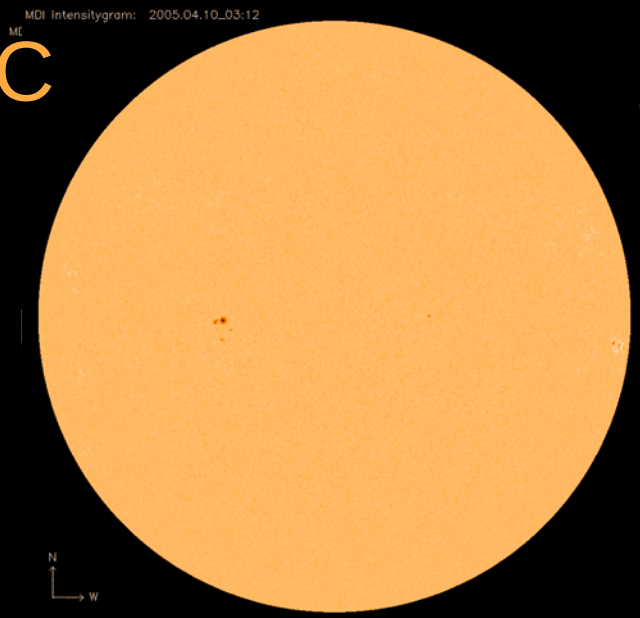
Reference Days



Courtesy: MDI

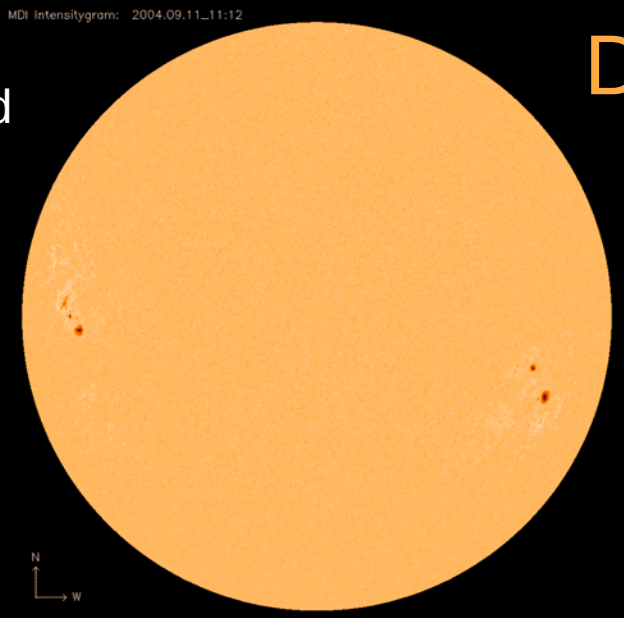
Sun on Facular Brightening Days (cont.)

C

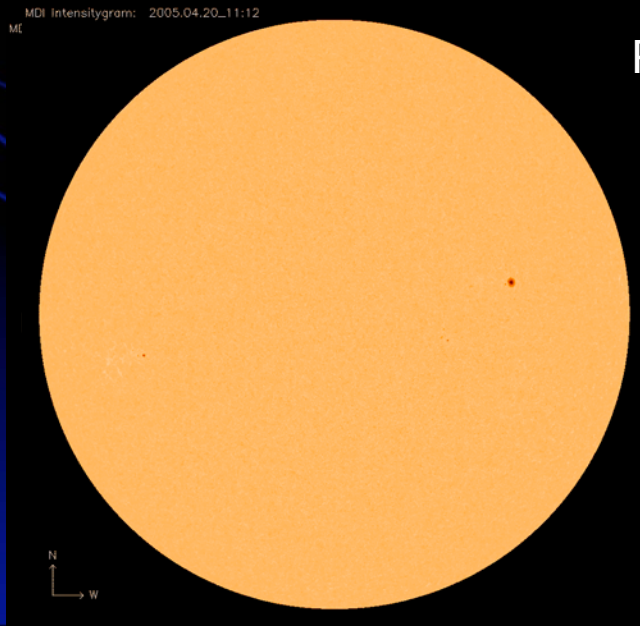


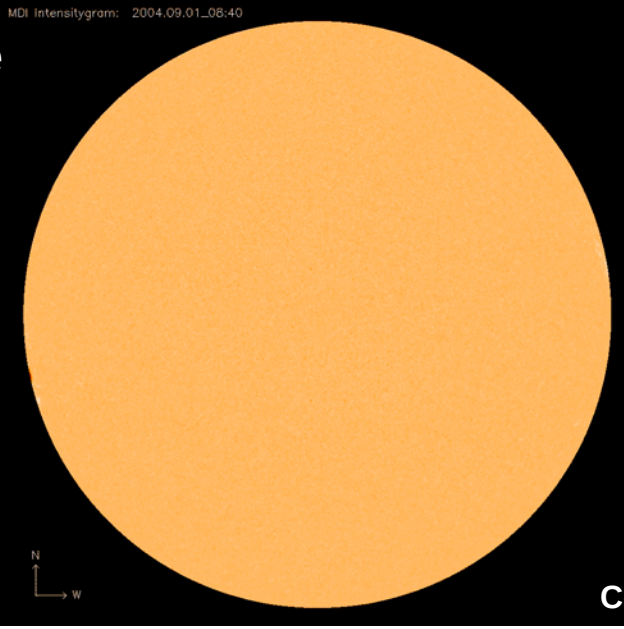
Compared Days

D



Reference Days





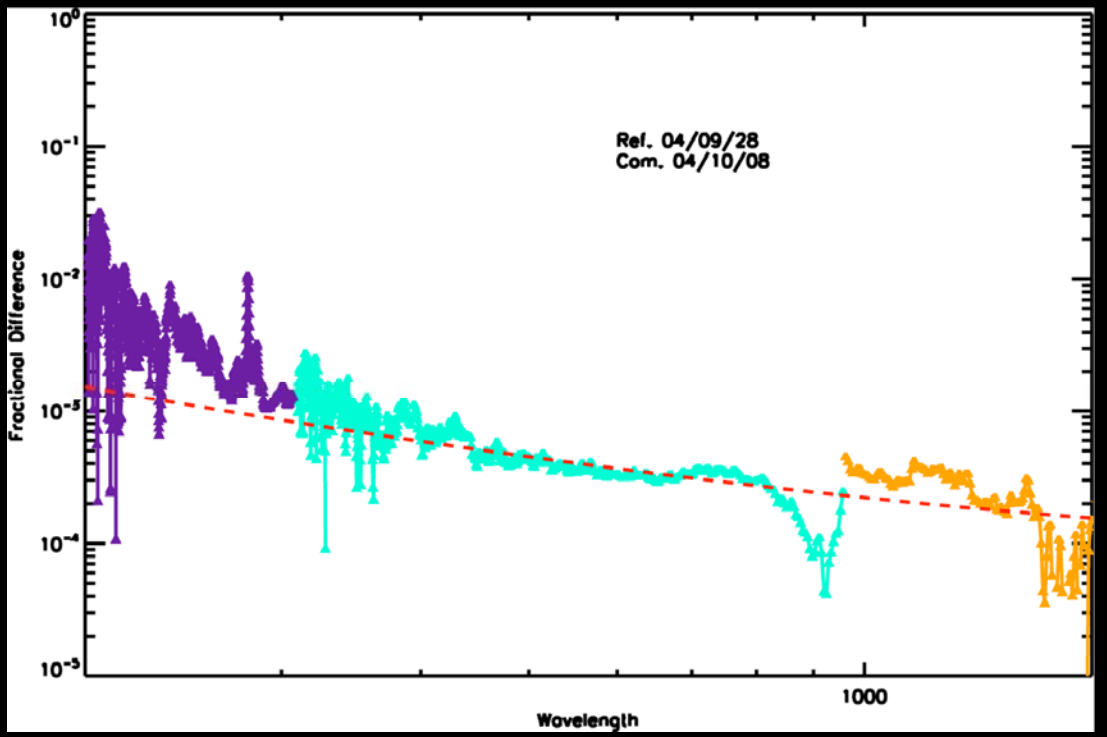
Courtesy: MDI

Conclusions

After seeing the solar images for the corresponding plots, B has the lowest number of sunspots. And because of this. B is the plot which shows us the data we are interested, namely, facular brightening without interference (or minimal) from sunspots.

(The dip around 900nm is likely an instrument artifact)

B



Where does all this lead?

- Now that there are some good relations drawn between the SSI and TSI, and their effect on temperatures here, we can begin to look at other periods of time and make estimates of what the sun may have been acting like during those time periods.

- With the SSI variation data, climate modelers could use the irradiance variation derived to estimate temperature changes on Earth.

References

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