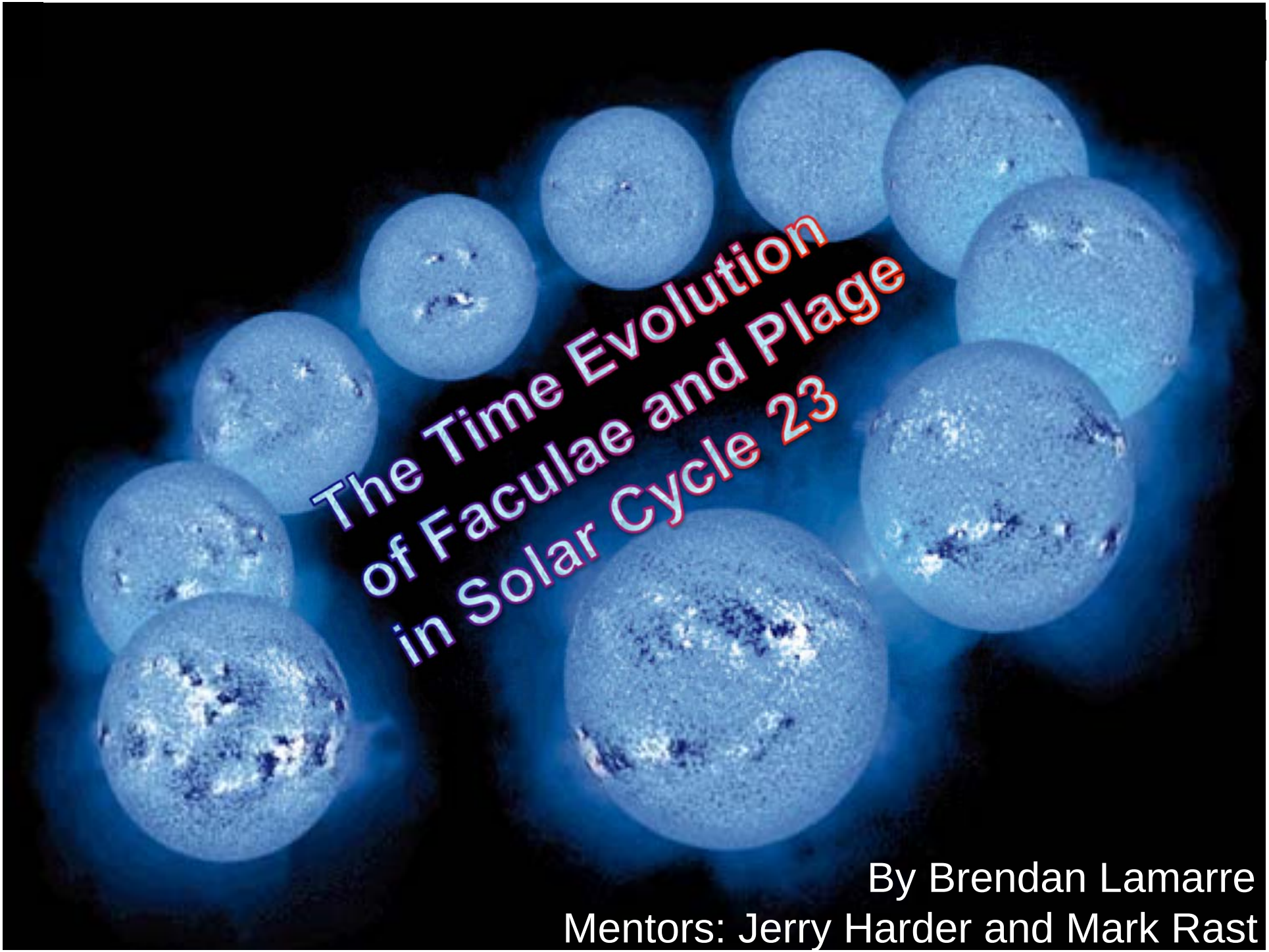
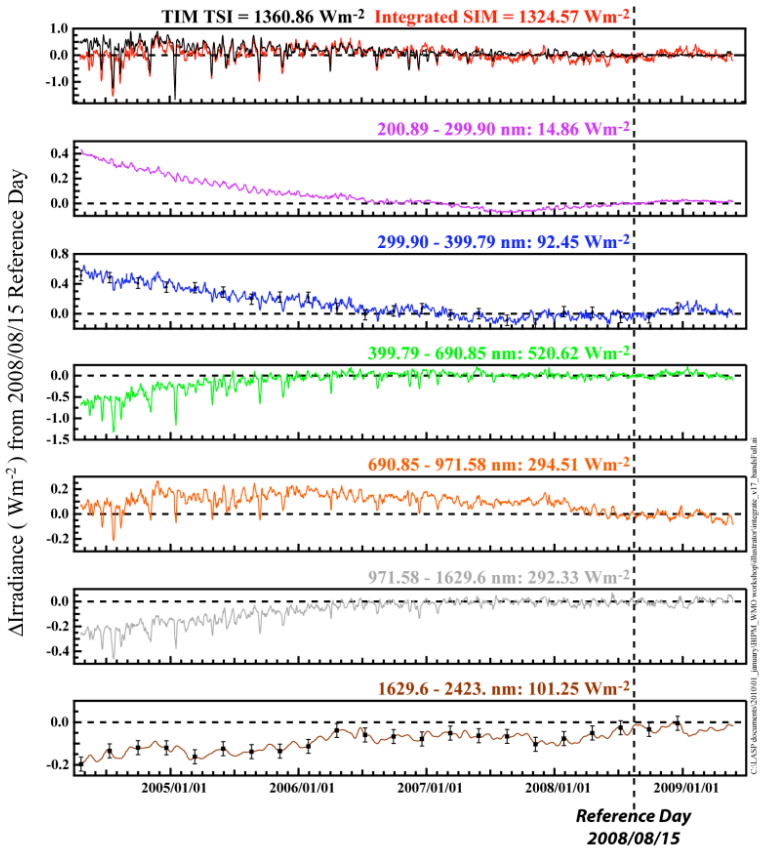
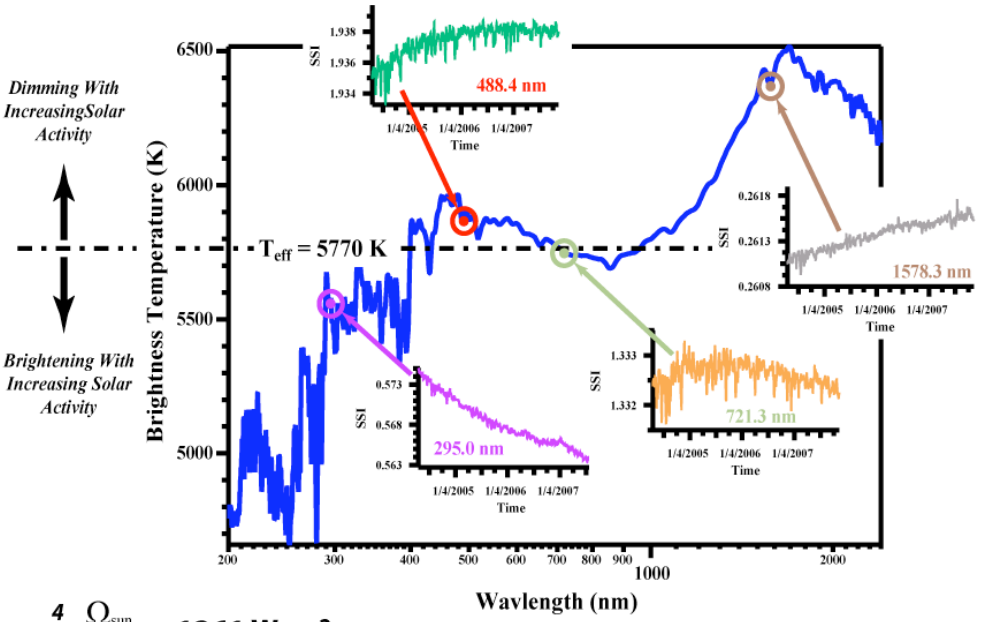


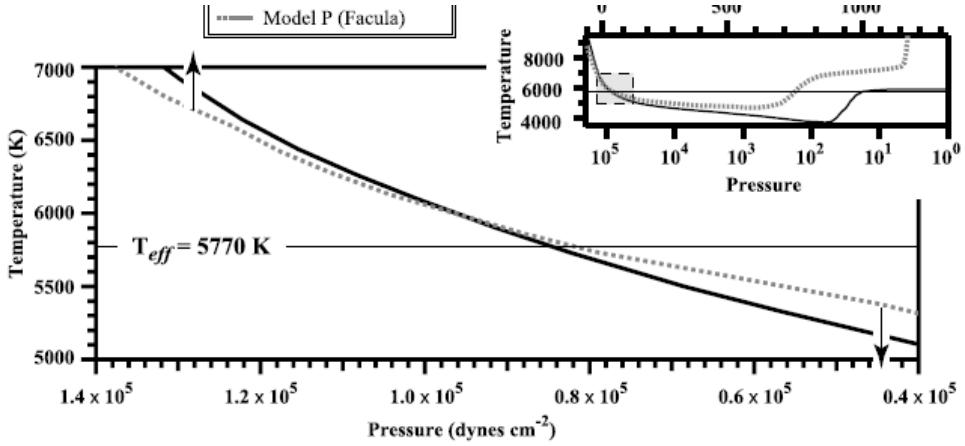
By Brendan Lamarre
Mentors: Jerry Harder and Mark Rast

Irradiance Trends





$$\sigma T_{eff}^{4} \frac{\Omega_{sun}}{\pi} \approx 1361 \text{ W m}^{-2}$$



200-300 nm, *300-400 nm* - *decreasing trend with decreasing solar activity*

400-691 nm - *increasing trend with decreasing solar activity*

- *affected by passage of active regions*

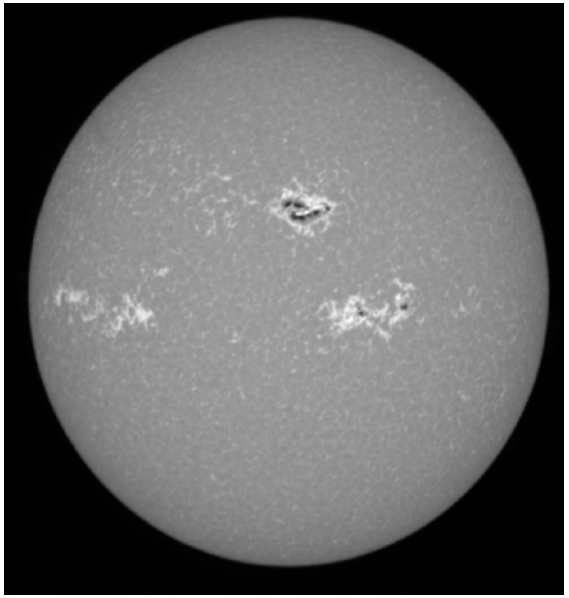
691-972 nm - *very TSI-like*

972-1629 nm, *1629-2423 nm* - *increasing trend with decreasing solar activity*

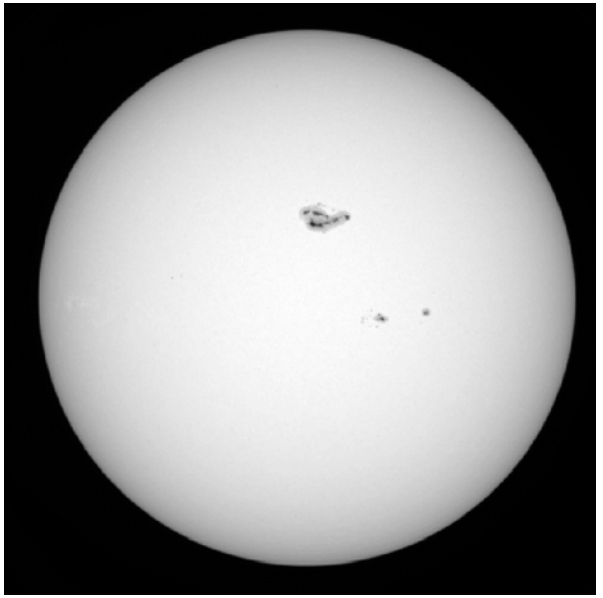
- *neutral by ~2000 nm*

(Harder et al., 2010)

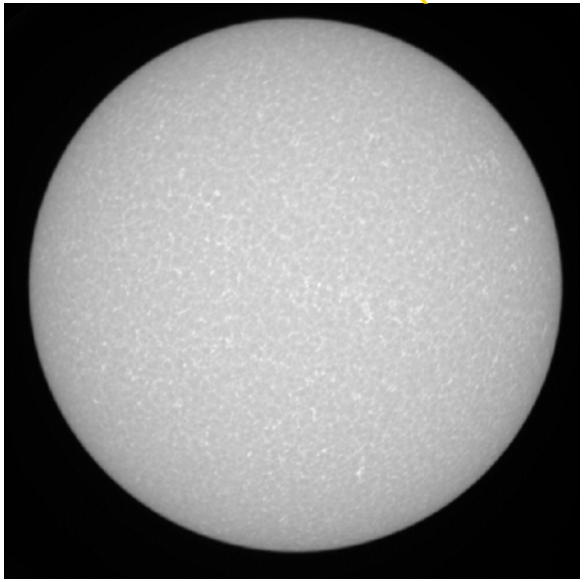
Jan 15th, 2005 Ca II K (393.45nm)



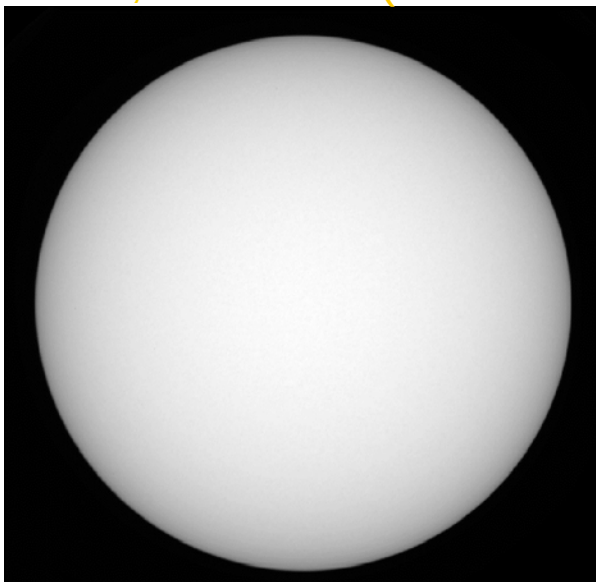
Jan 15th, 2005 Red (607.095nm)



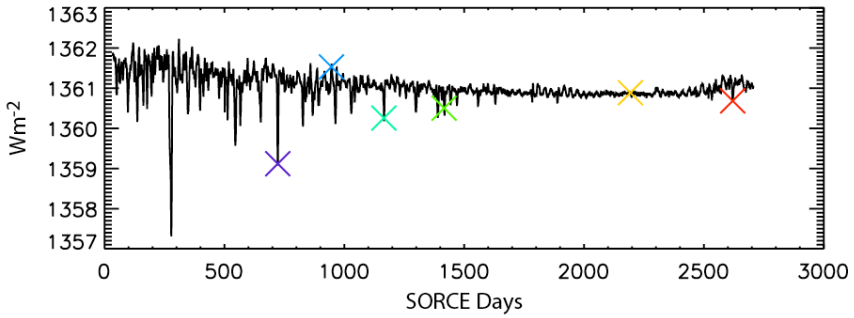
Jan 25th, 2009 Ca II K (393.45nm)



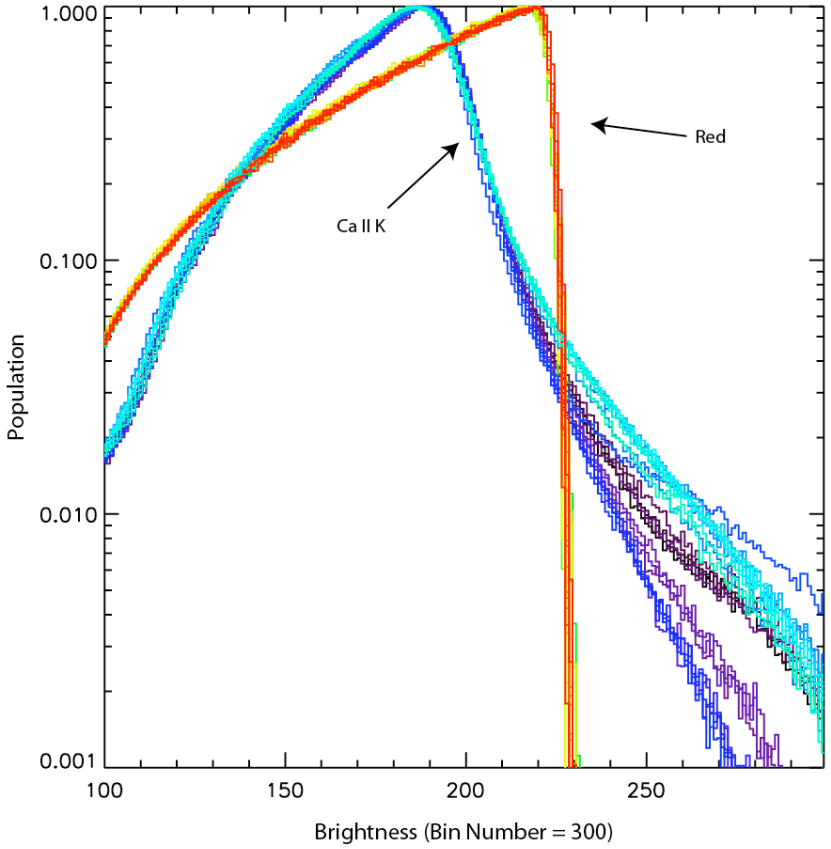
Jan 25th, 2009 Red (607.095nm)



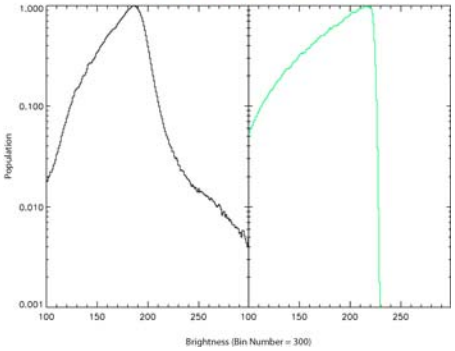
TOTAL SOLAR IRRADIANCE



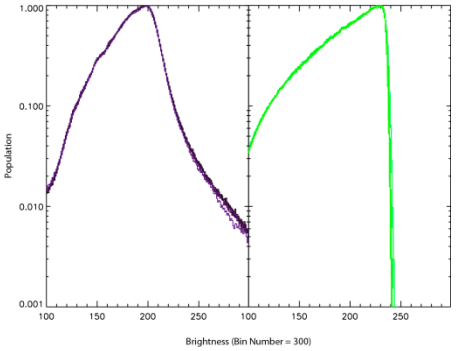
Ca II K AND RED HISTOGRAM



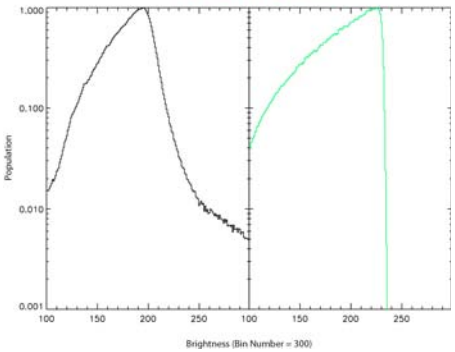
Jan 15th, 2005



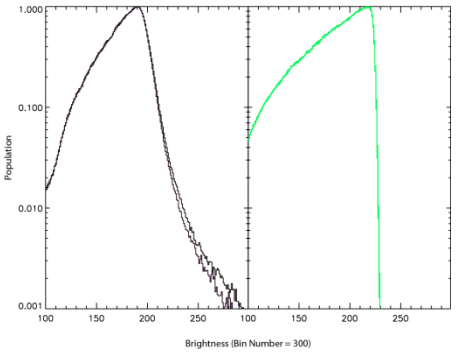
Aug 27th, 2005



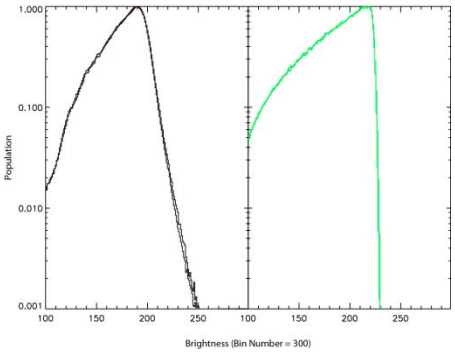
Apr 3rd, 2006



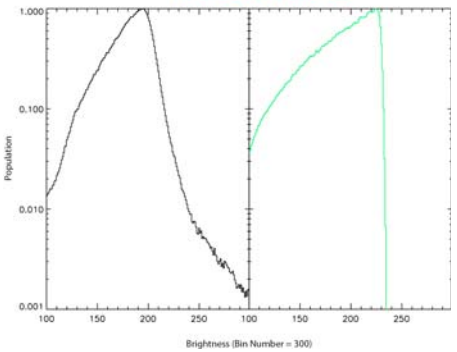
Dec 10th, 2006



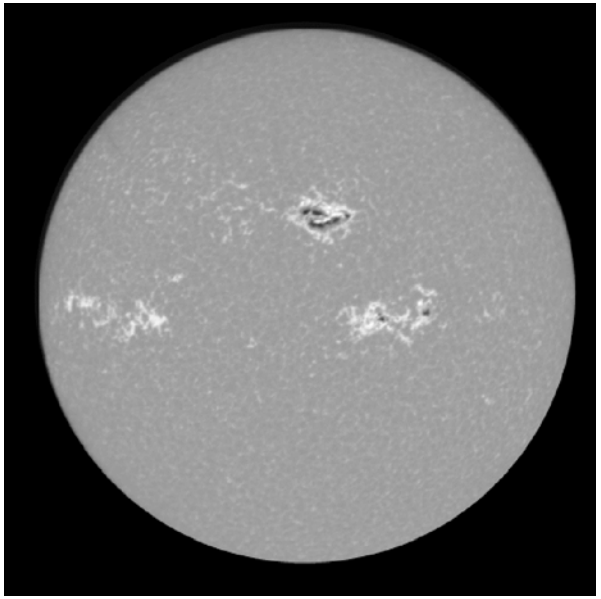
Jan 25th, 2009



Mar 28th, 2010

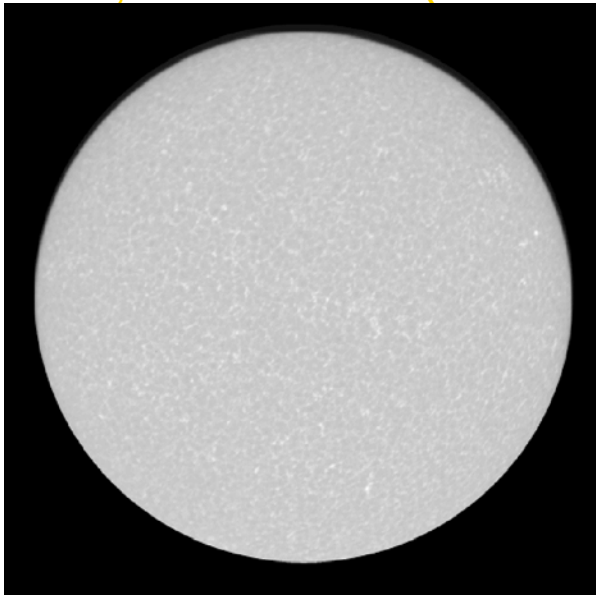


Jan 15th, 2005 Ca II K (393.45nm)

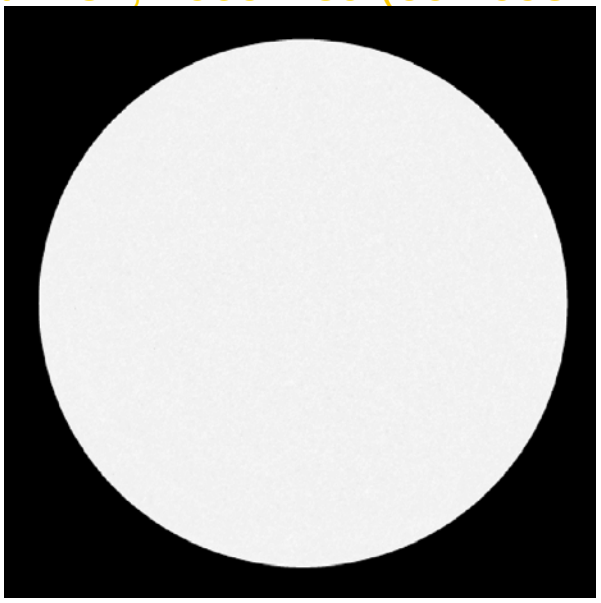


Jan 15th, 2005 Red (607.095nm)

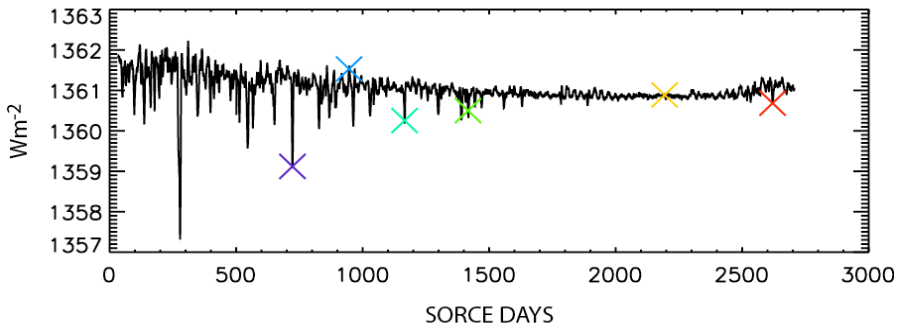
Jan 25th, 2009 Ca II K (393.45nm)



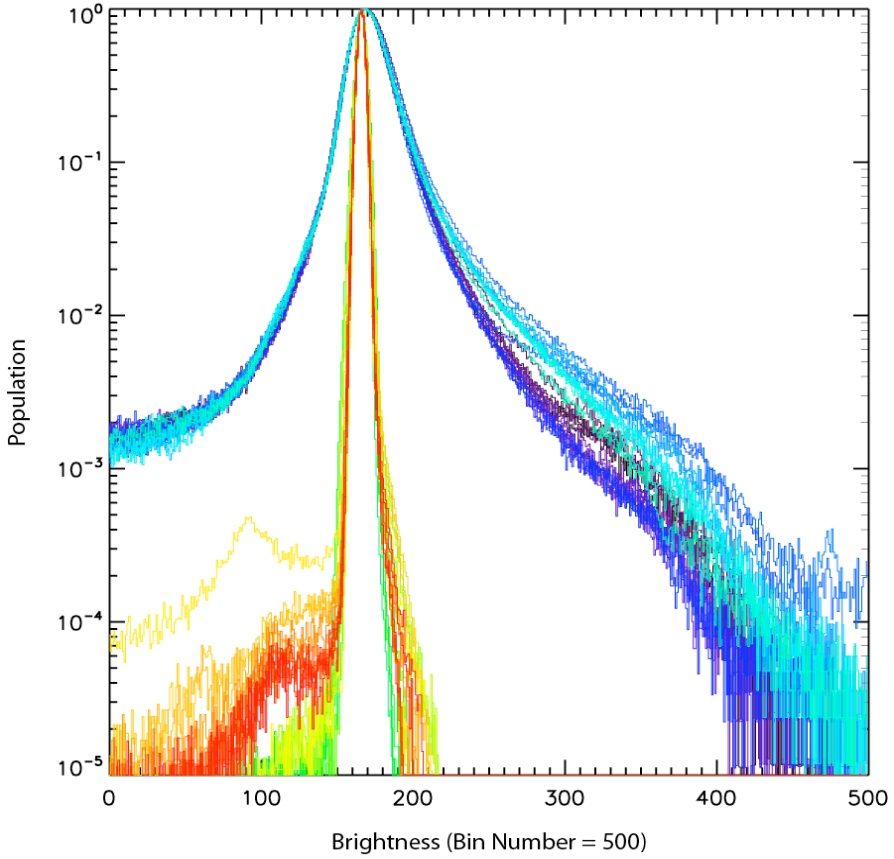
Jan 25th, 2009 Red (607.095nm)



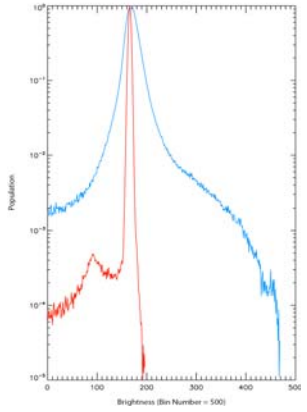
TOTAL SOLAR IRRADIANCE



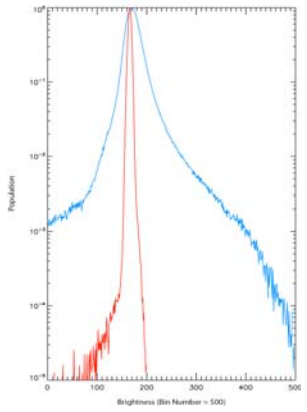
CLV REMOVED ALIGNED HISTOGRAM



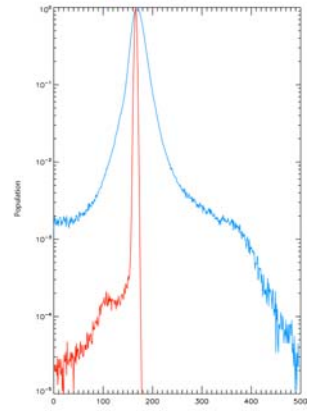
Jan 15th, 2005



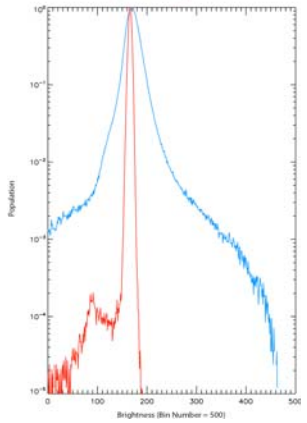
Aug 27th, 2005



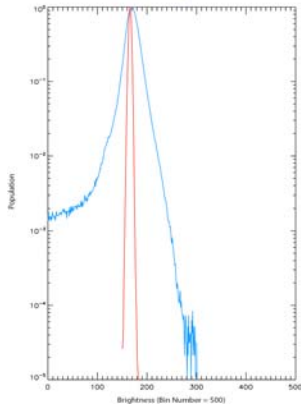
Apr 3rd, 2006



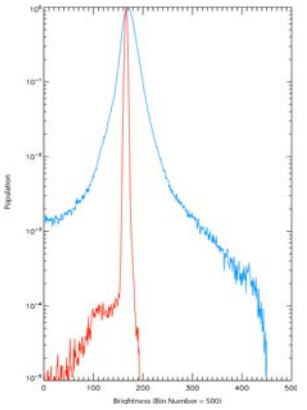
Dec 10th, 2006



Jan 25th, 2009

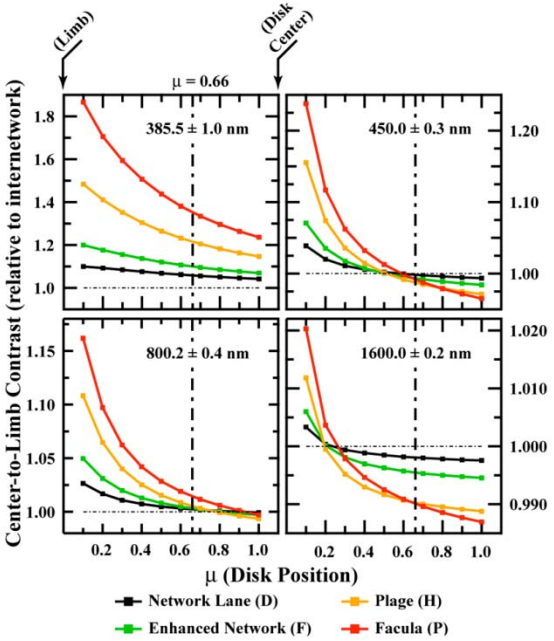


Mar 28th, 2010



What are Faculae and Plage?

- Faculae, plural of facula, means “small torch” in Latin
- Created by intense, vertical clusters of magnetic field lines in photosphere
  - On average 1-2kG
- Brightness (Darkness) is very dependent on disk position and wavelength
  - Bright in



(Harder et al., 2010)

- Plage is just faculae viewed in the chromosphere

Facula Hot Wall Model

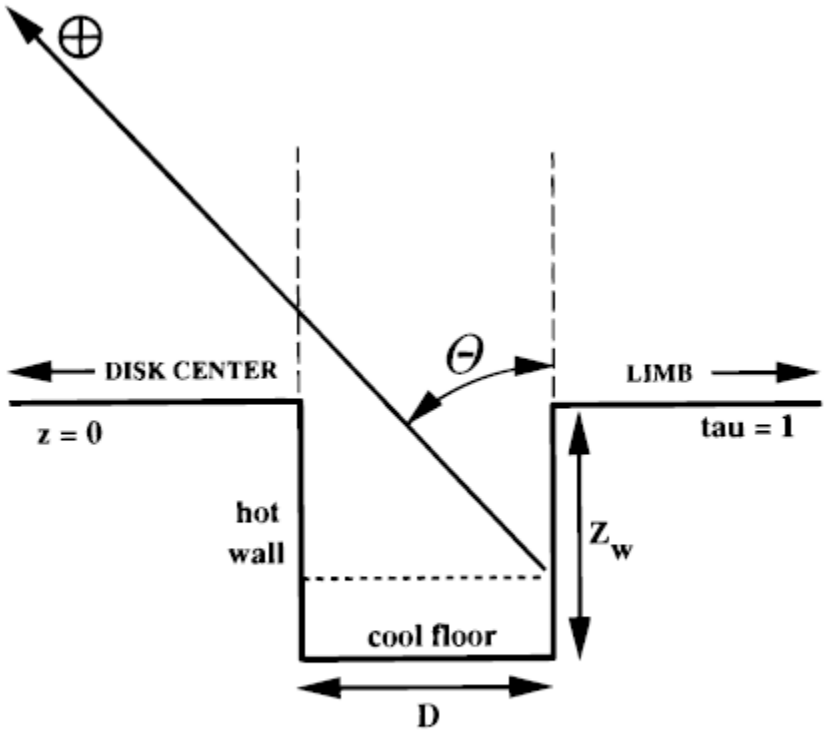
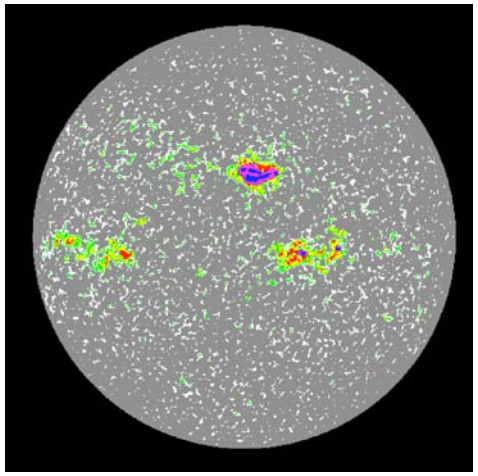


FIG. 2.—Geometry of a thin flux tube in the hot wall model. D is the tube diameter, Z_w is the Wilson depression, and θ is the angle between the local vertical and the line of sight (equal to the heliocentric angle).

(Topka et al., 1997)

Creating a Mask Image

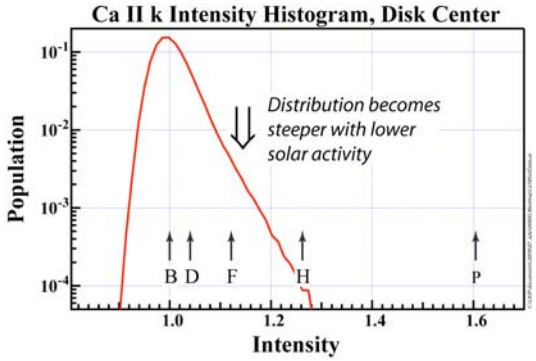
Mask



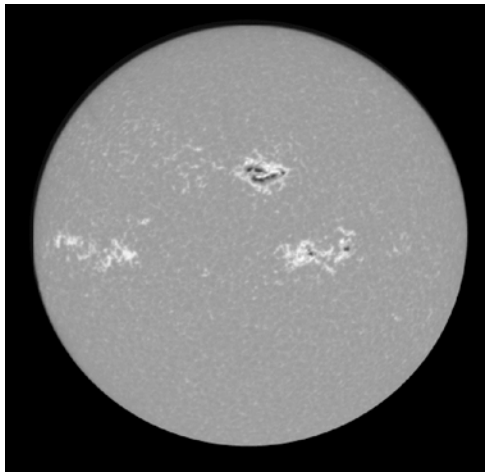
Red

Sunspot Penumbra (R, 1007)
Sunspot Umbra (S, 1006)
Facula (P, 1005)
Plage (H, 1004)
Active Network (F, 1003)
Network (D, 1002)
Internetwork (B, 1001)

A Mask image is the combination of the dark pixels of sunspots in the red wavelength and the bright pixels of active regions in Ca II K

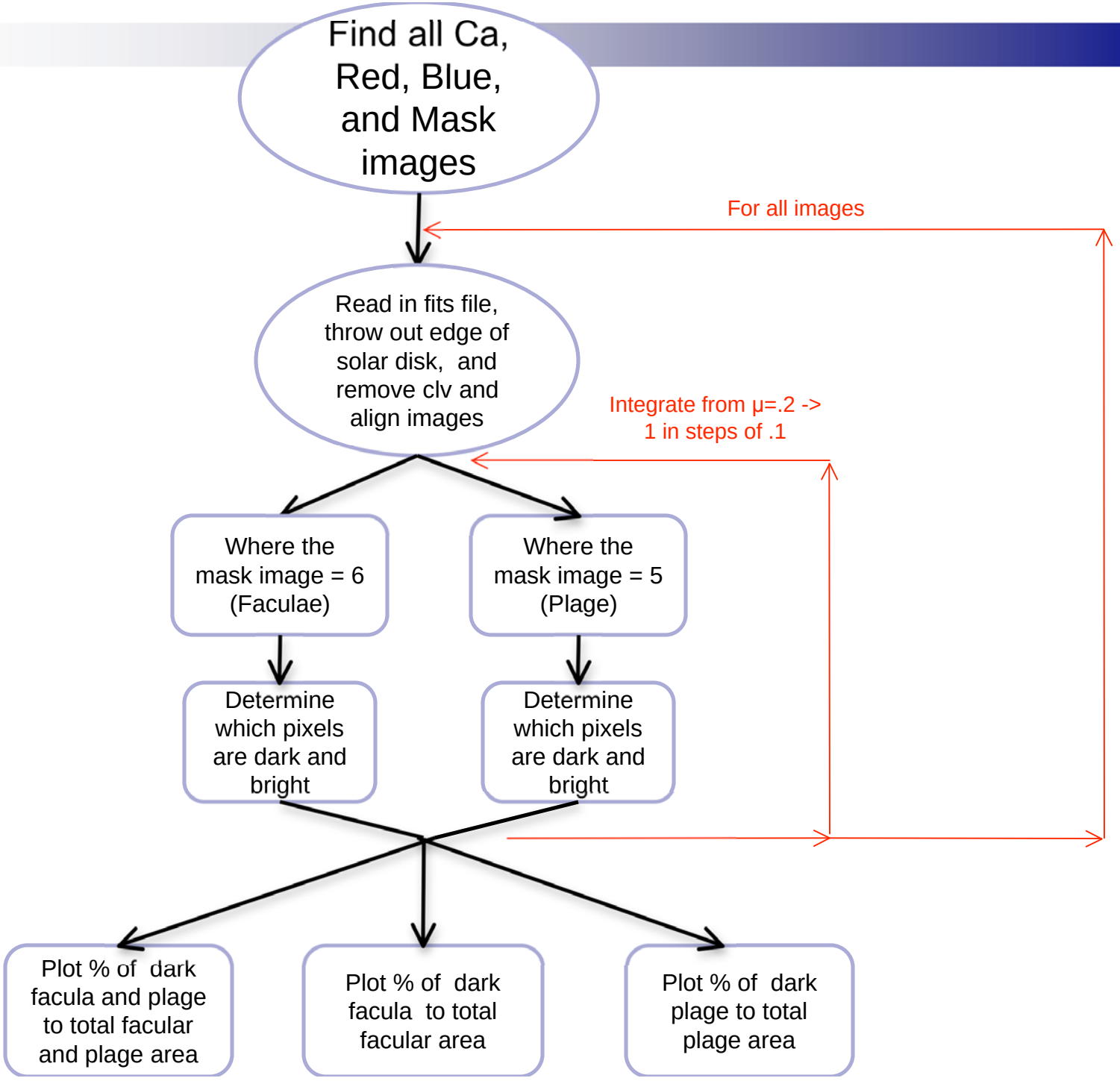


Ca II K

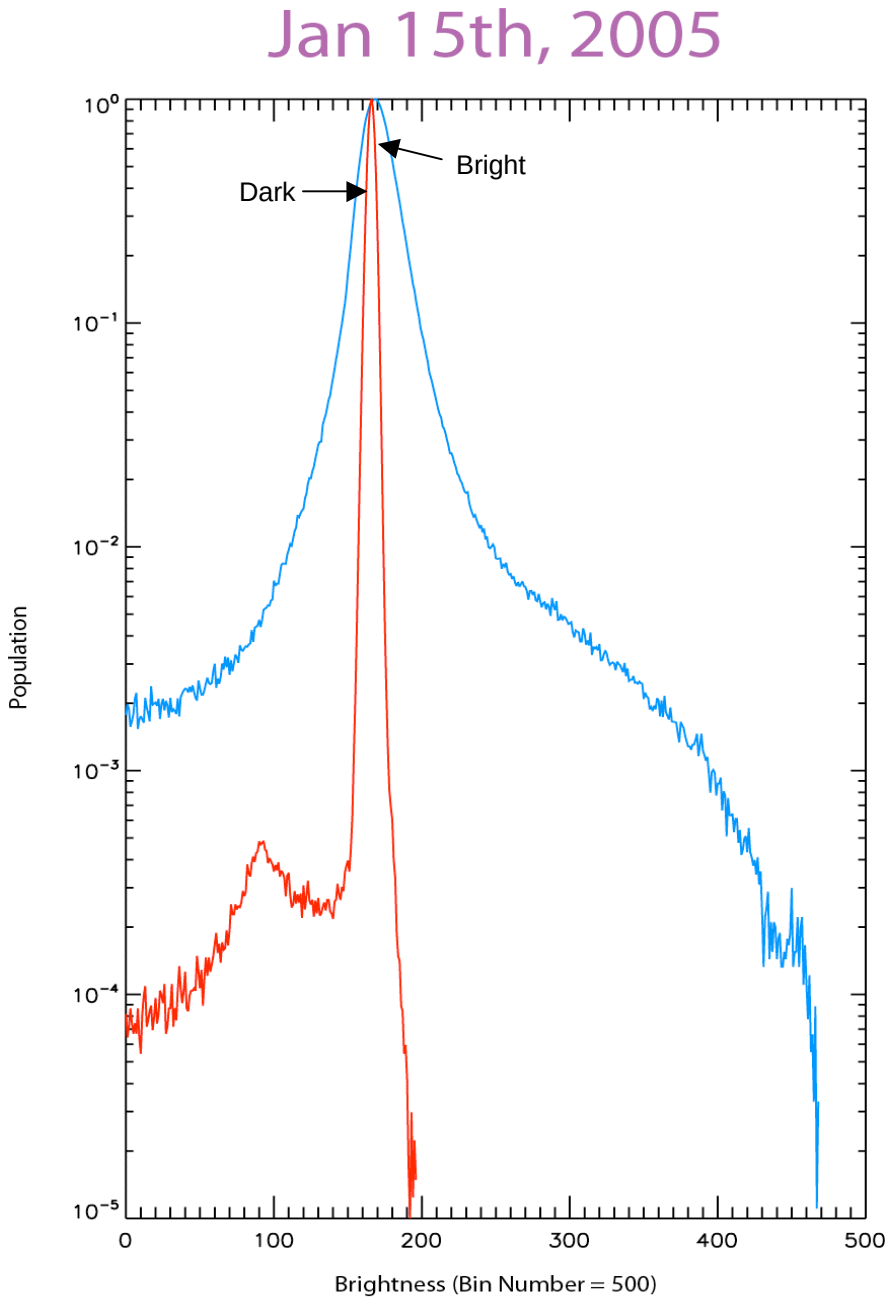


7 models are used to place the pixels in bins corresponding to active features

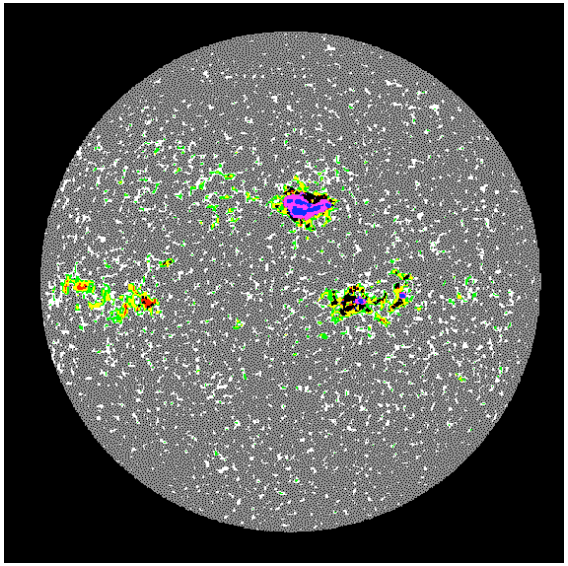
1 Internetwork
2 Network
3 Active Network
4 Plage
5 Facula
6 Sun Spot Penumbra
7 Sun Spot Umbra


Find all Ca, Red, Blue, and Mask images
For all images
Read in fits file, throw out edge of solar disk, and remove clv and align images
Integrate from μ=.2 -> 1 in steps of .1
Where the mask image = 6 (Faculae)
Where the mask image = 5 (Plage)
Determine which pixels are dark and bright
Determine which pixels are dark and bright
Plot % of dark facula and plage to total facular and plage area
Plot % of dark facula to total facular area
Plot % of dark plage to total plage area

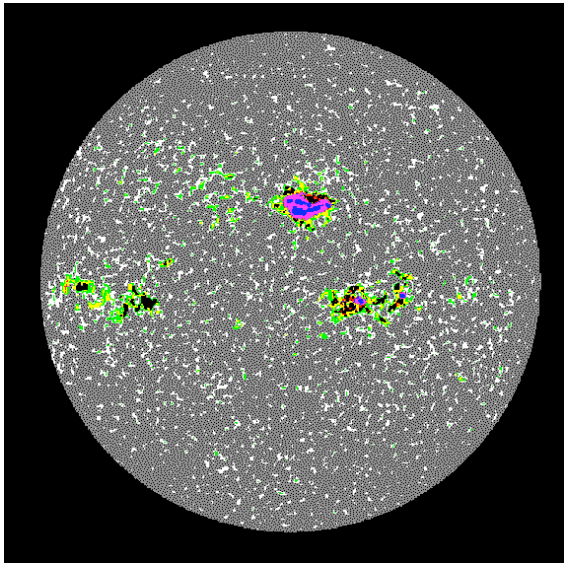
- Faculae and plage pixels are determined from Ca II histogram (blue curve)
- Once identification is made, where do this pixels lay on the Red Image histogram (red curve)?



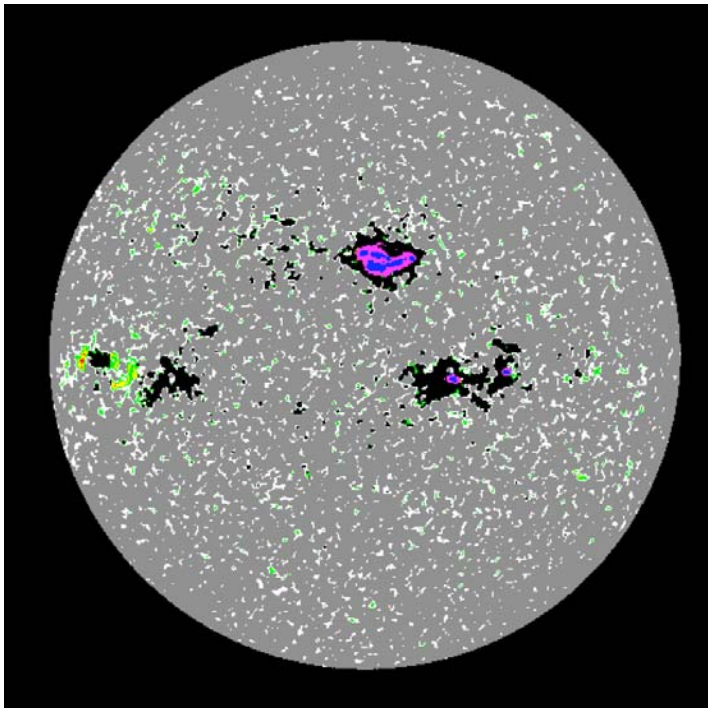
Dark Faculae



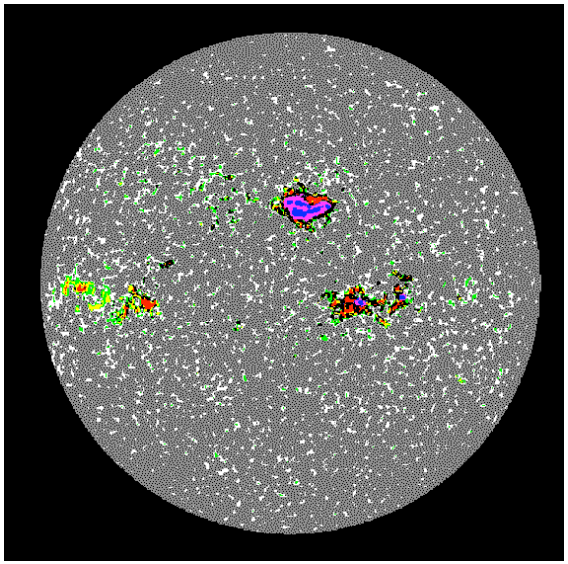
Bright Faculae



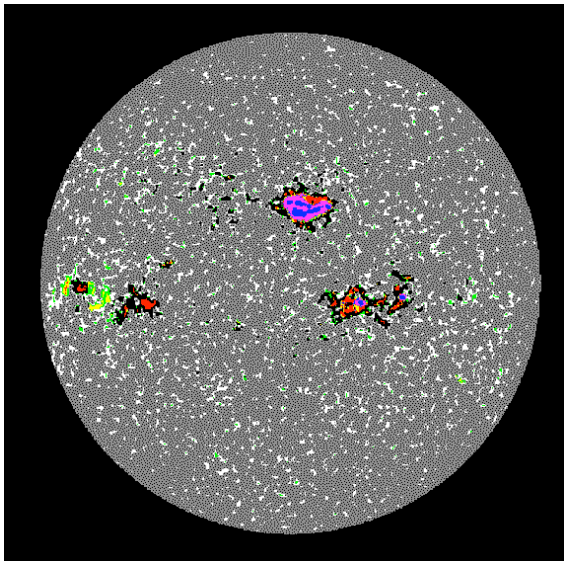
All Faculae and Plage

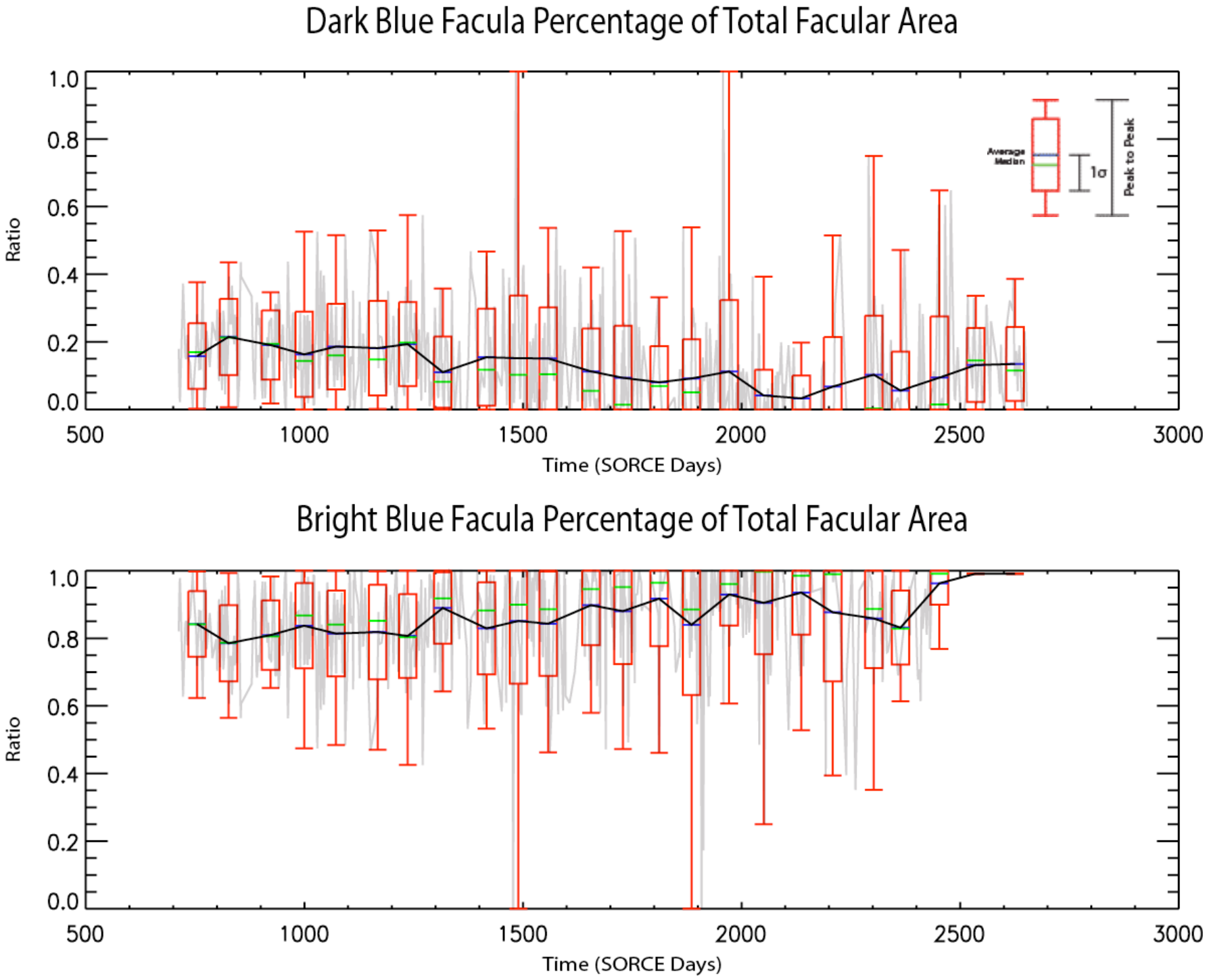


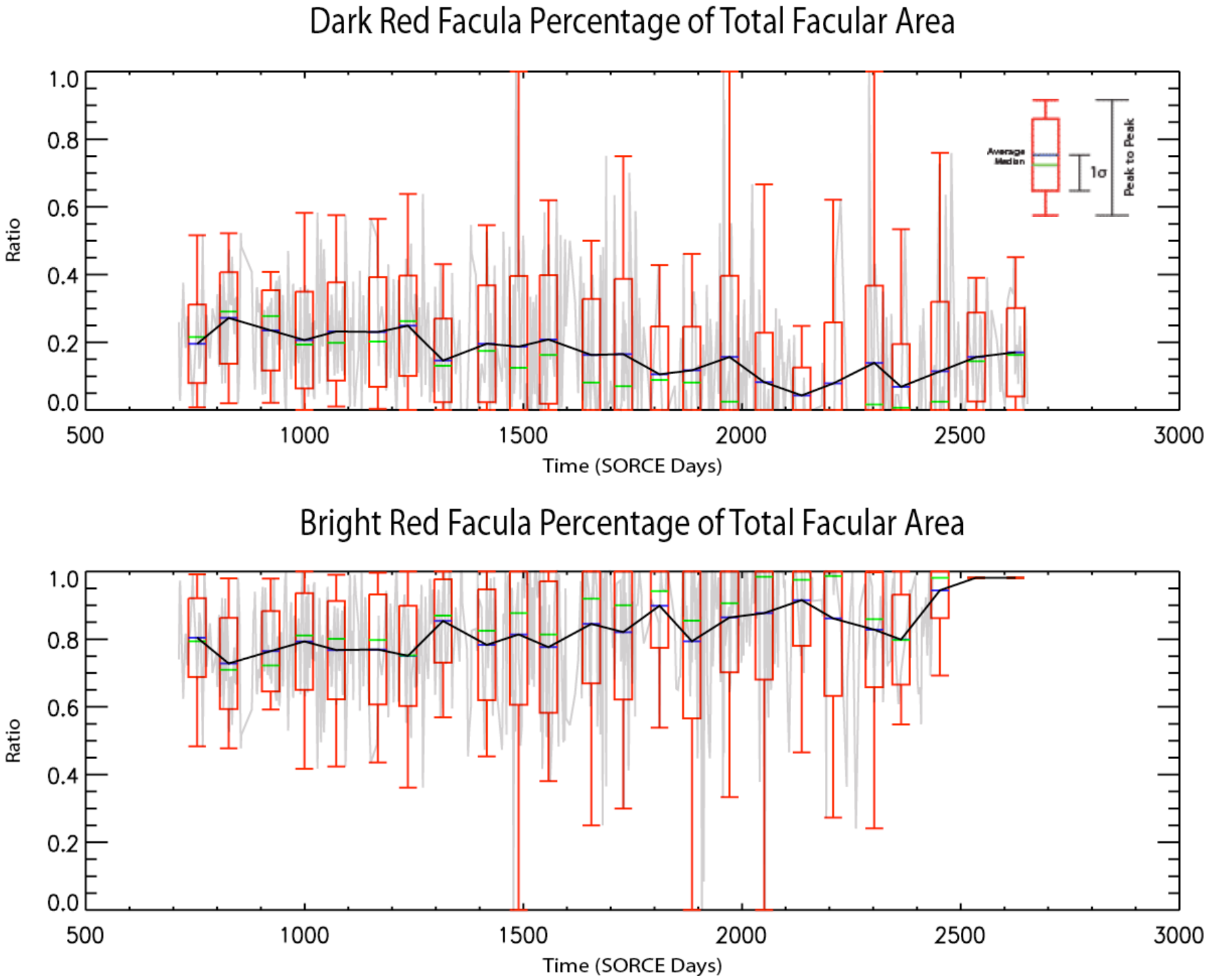
Dark Plage

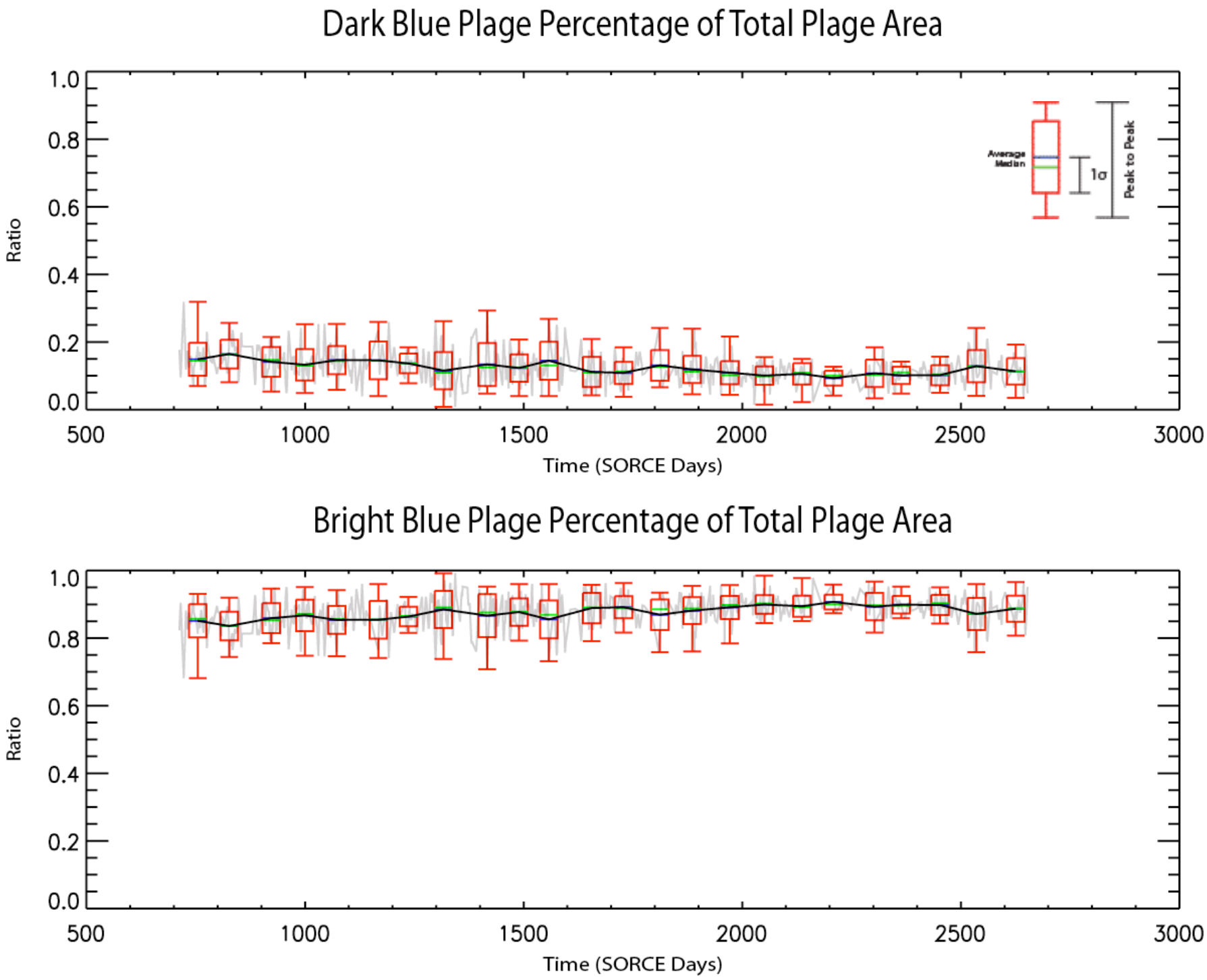


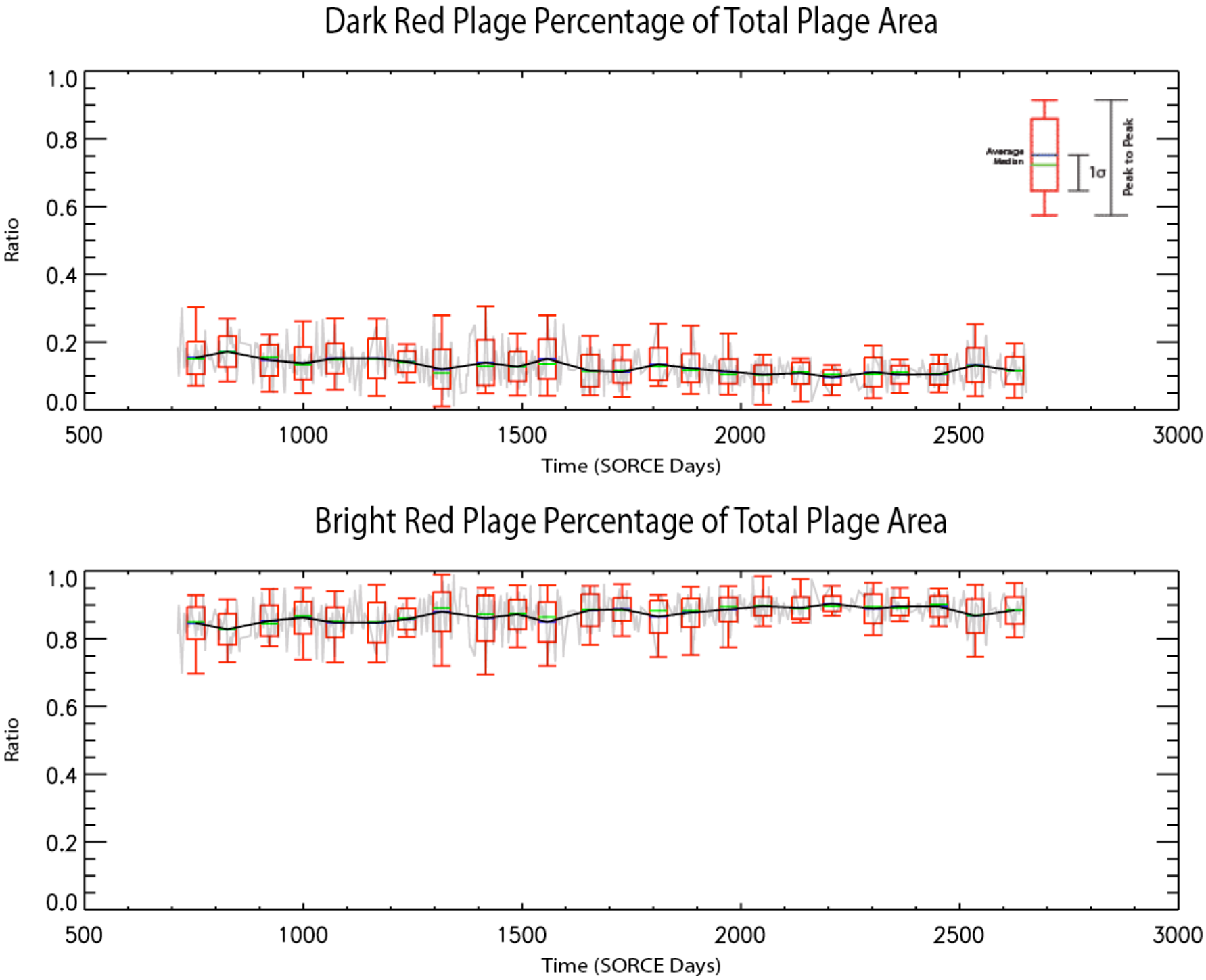
Bright Plage



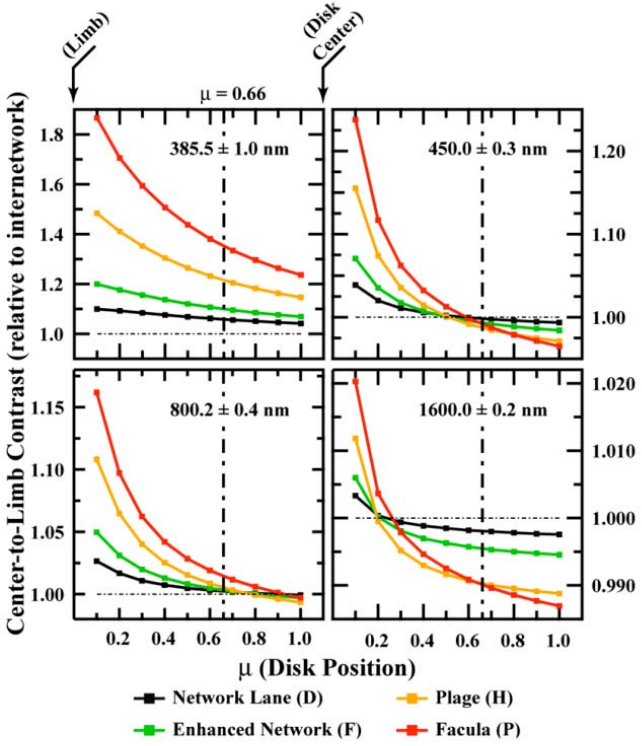

Dark Blue Facula Percentage of Total Facular Area
Ratio
1.0
0.8
0.6
0.4
0.2
0.0
500
1000
1500
2000
2500
3000
Time (SORCE Days)
Average
Median
1σ
Peak to Peak
Bright Blue Facula Percentage of Total Facular Area
Ratio
1.0
0.8
0.6
0.4
0.2
0.0
500
1000
1500
2000
2500
3000
Time (SORCE Days)

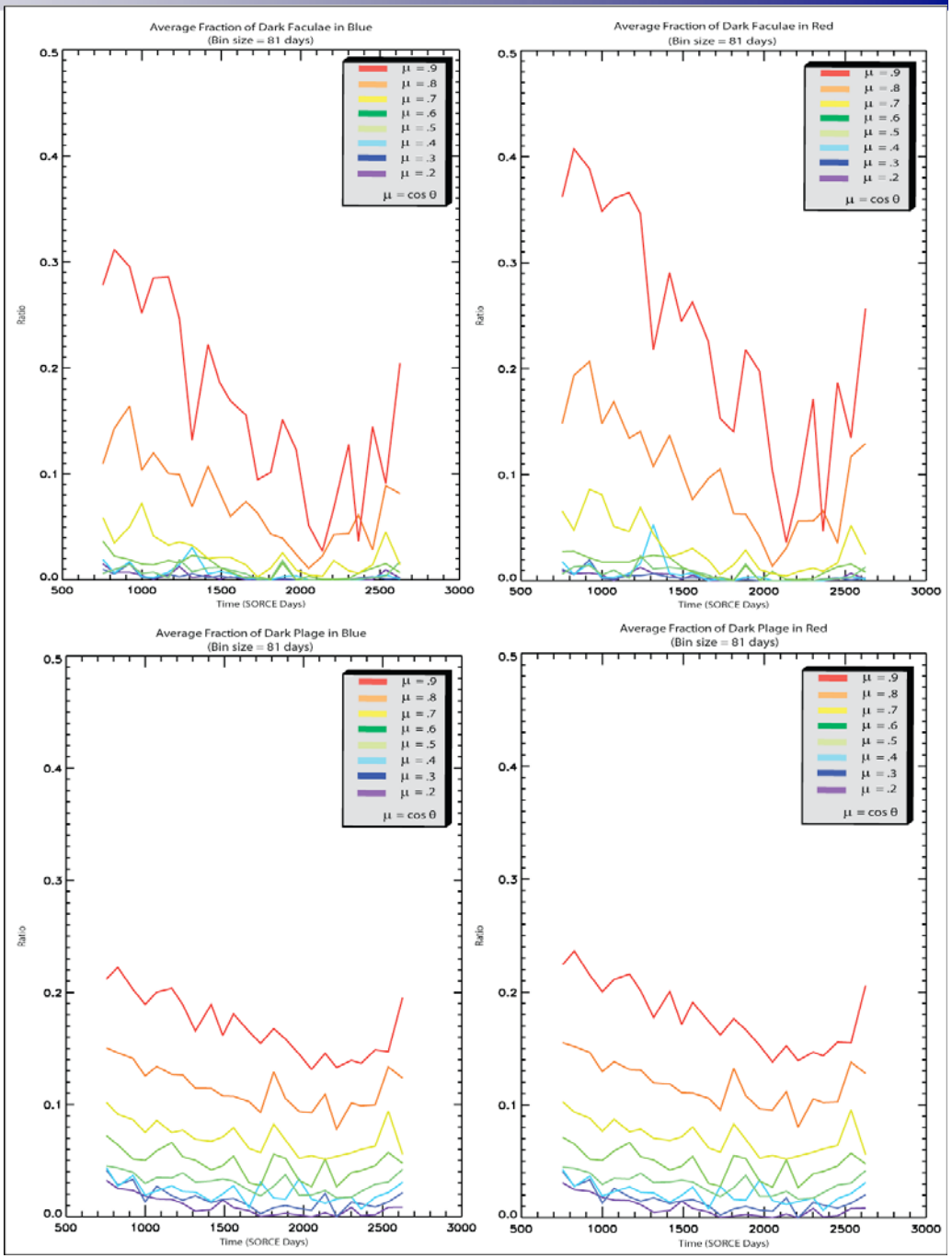

Dark Red Facula Percentage of Total Facular Area
Ratio
1.0
0.8
0.6
0.4
0.2
0.0
500
1000
1500
2000
2500
3000
Time (SORCE Days)
Average
Median
1σ
Peak to Peak
Bright Red Facula Percentage of Total Facular Area
Ratio
1.0
0.8
0.6
0.4
0.2
0.0
500
1000
1500
2000
2500
3000
Time (SORCE Days)


Dark Blue Plage Percentage of Total Plage Area
Ratio
1.0
0.8
0.6
0.4
0.2
0.0
500
1000
1500
2000
2500
3000
Time (SORCE Days)
Average
Median
1σ
Peak to Peak
Bright Blue Plage Percentage of Total Plage Area
Ratio
1.0
0.8
0.6
0.4
0.2
0.0
500
1000
1500
2000
2500
3000
Time (SORCE Days)

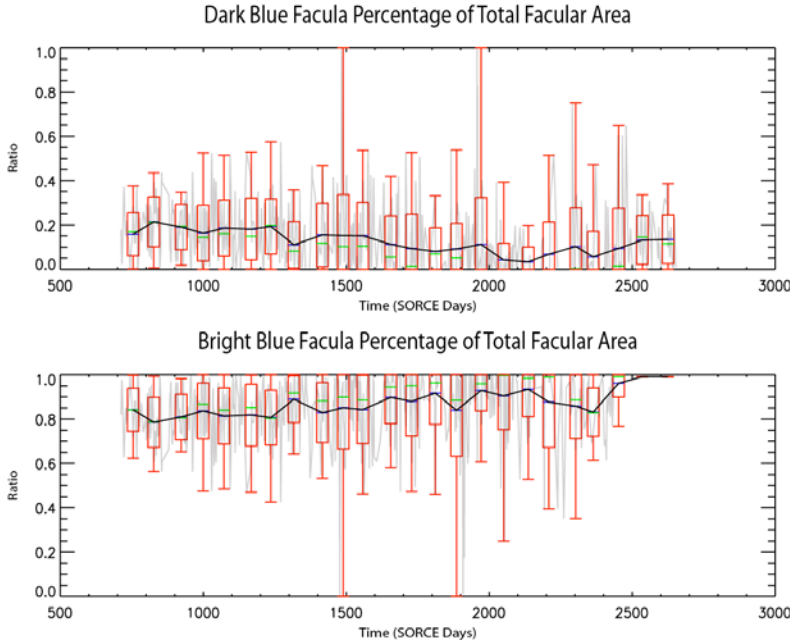

Dark Red Plage Percentage of Total Plage Area
Ratio
1.0
0.8
0.6
0.4
0.2
0.0
500
1000
1500
2000
2500
3000
Time (SORCE Days)
Average
Median
1σ
Peak to Peak
Bright Red Plage Percentage of Total Plage Area
Ratio
1.0
0.8
0.6
0.4
0.2
0.0
500
1000
1500
2000
2500
3000
Time (SORCE Days)

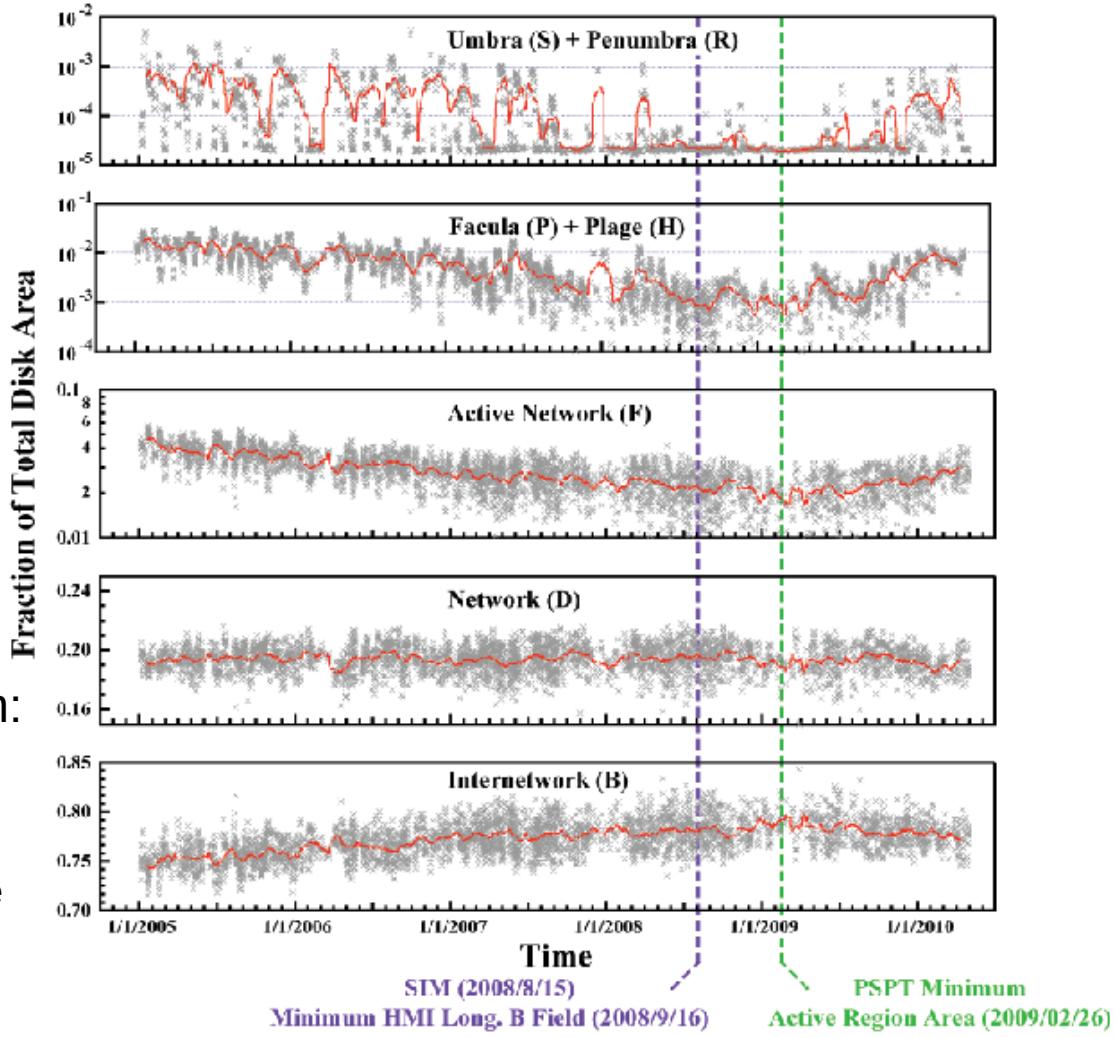
Averages of the percentage of area for 81 day bins at different disk locations





Irradiance Changes Compared with Solar Features' Areas





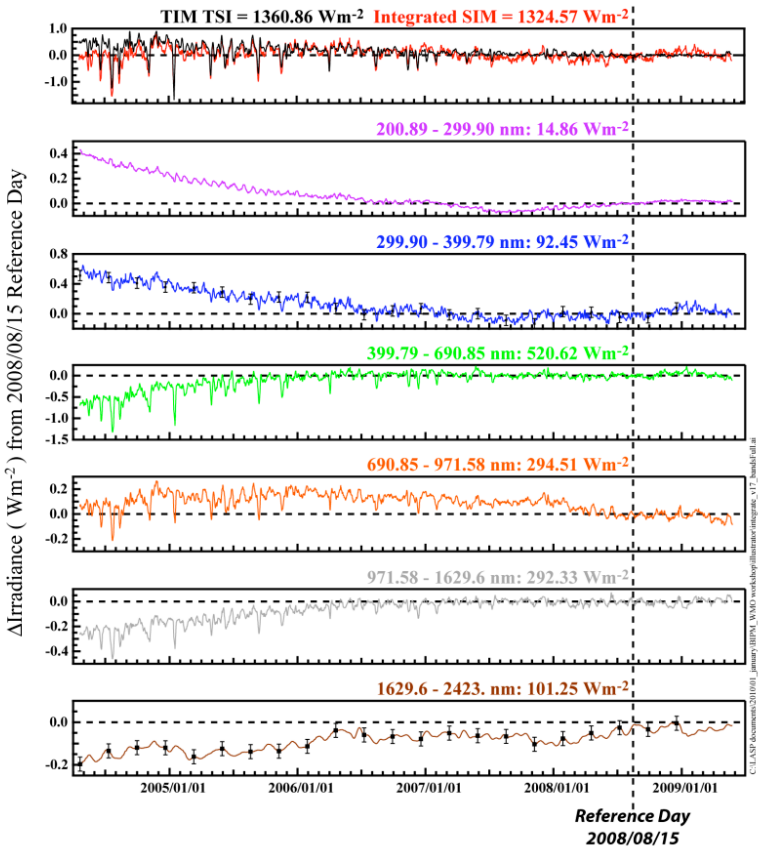
When progressing to solar minimum:

-Decrease in dark faculae and facular area causes increase in irradiance

-Increase in bright faculae and decrease in facular area means little irradiance change due to bright faculae

-Overall, increase in irradiance with decreasing solar activity

(Harder et al., 2010)



200-300 nm, *300-400 nm* - *decreasing trend with decreasing solar activity*

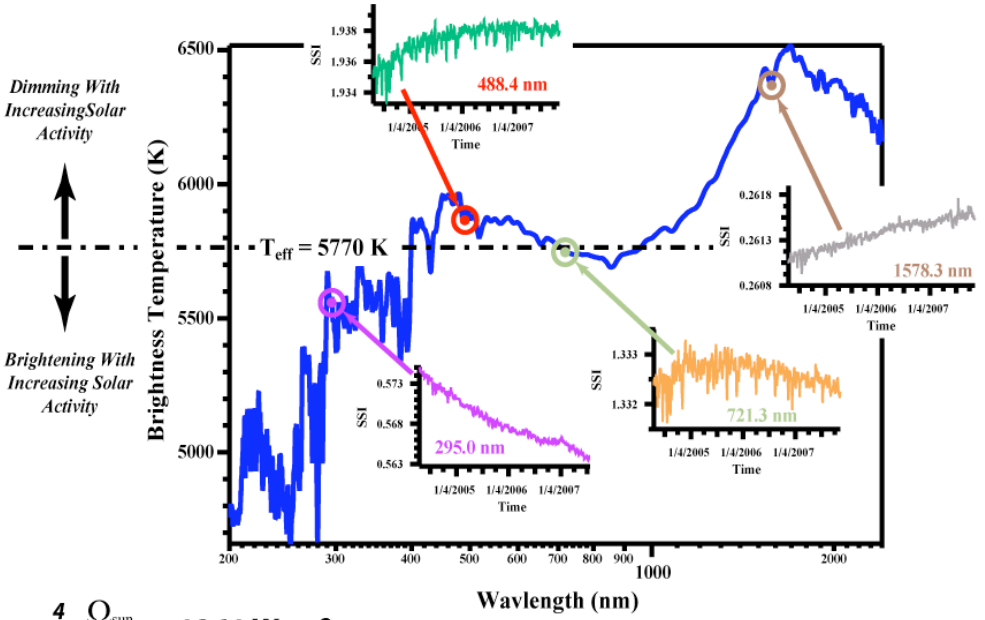
400-691 nm - *increasing trend with decreasing solar activity*

- *affected by passage of active regions*

691-972 nm - *very TSI-like*

972-1629 nm, *1629-2423 nm* - *increasing trend with decreasing solar activity*

- *neutral by ~2000 nm*



$$\sigma T_{eff}^{4} \frac{\Omega_{sun}}{\pi} \approx 1361 \text{ W m}^{-2}$$

Faculae and plage cannot completely account for the magnitude of the change in the increasing irradiances. This suggests that the internetwork and network may similarly influence the irradiance change. However, unlike changes in faculae and plage, the network is too big and diffuse to contribute observable changes.

Conclusion

- With High Solar Activity
  - Larger areas of faculae and plage
  - Larger fraction of dark faculae
    - Suppression of irradiance
- With Low Solar Activity
  - Smaller areas of faculae and plage
  - Larger fraction of bright faculae
    - Irradiance from bright faculae is about constant due to smaller facular area conflicting with larger fractional area of bright faculae

In conclusion, the evolution of faculae and plage in the descending phase of Solar Cycle 23 is consistent with the observation that there are offsetting trends in the spectral irradiance.

References

Harder, J., Fontenla, J., Rast, M., Merkel, A., Pilewskie, P., and Richard, E. “What the SORCE SIM observations tell about solar spectral irradiance”, Aspen Global Change Institute, 2010.
In Text Citation: (Harder et al., 2010)

Topka, K. P., Tarbell, T. D., & Title, A. M. 1997, The Astrophysical Journal, 484, 481
In Text Citation: (Topka et al., 1997)