

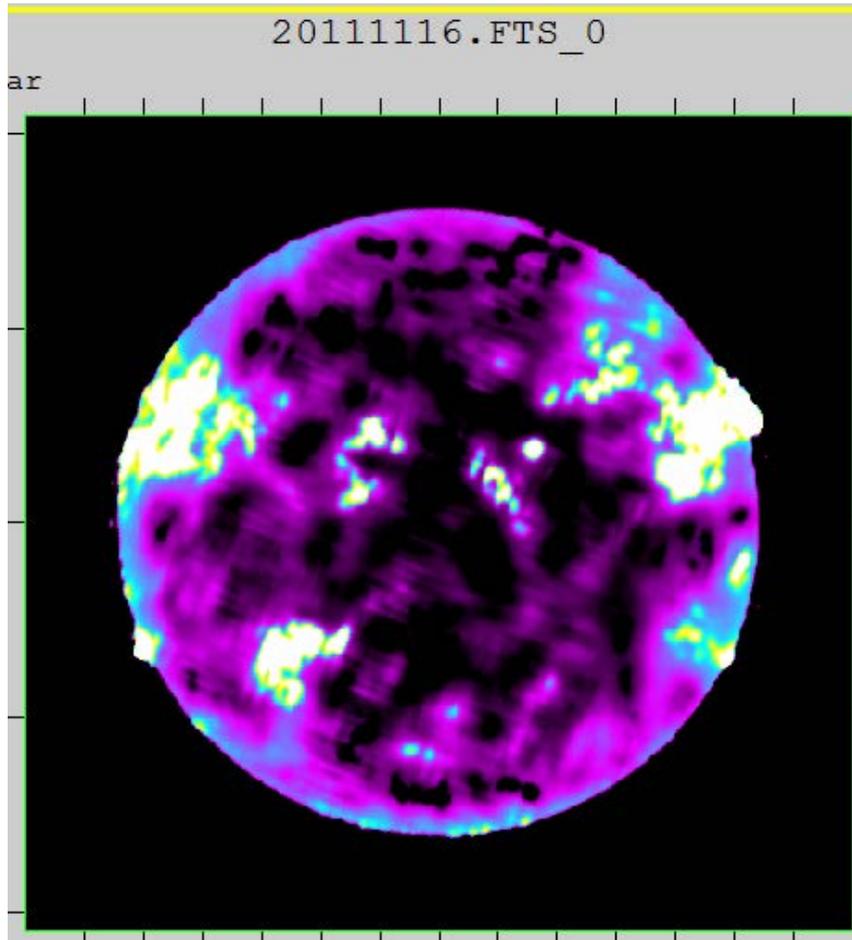
The Polar Fields Seen in 17 GHz Microwave Flux

Leif Svalgaard
Stanford University
18 November, 2011

Nobeyama Radioheliograph



Image of 17GHz Emission, beam width 5''



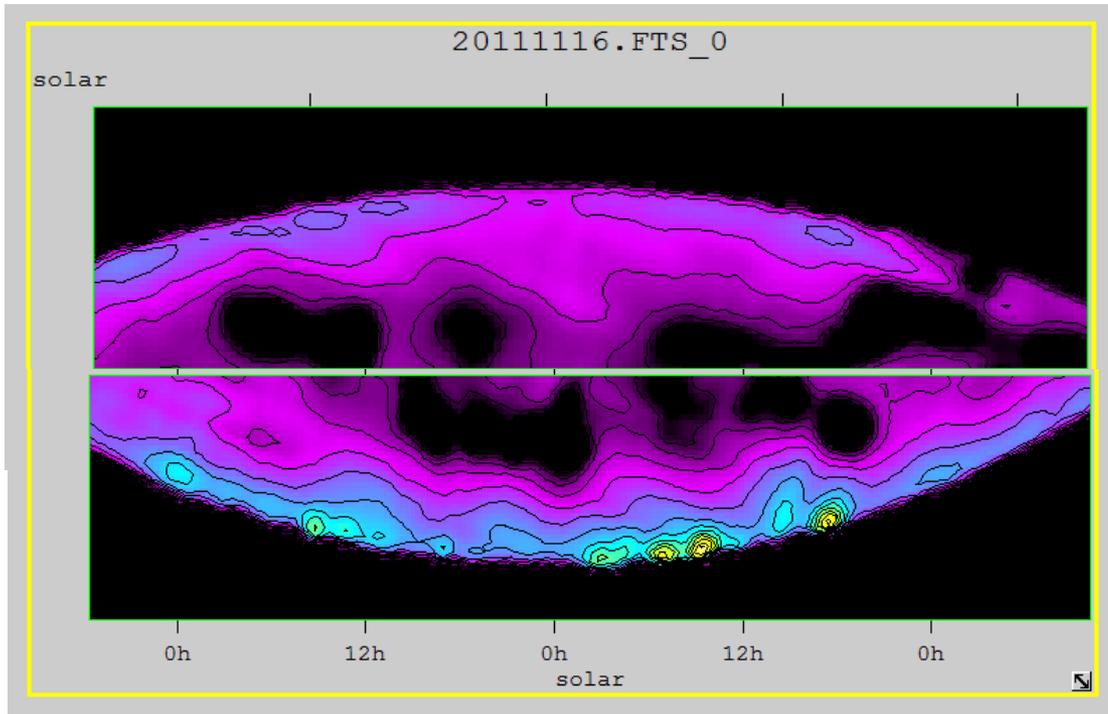
$$\nu_{17 \text{ GHz}} = \lambda 1.76 \text{ cm}$$

$$\nu_e = B \text{ (Tesla)} \cdot 28 \text{ GHz}$$

17 GHz is 3rd harmonic ν_e for 2000 G

1. General Limb brightening
2. Active regions bright
 - A. Gyro-resonance is thought (?) to result as 3rd harmonic of 2000 G
 - B. Also Bremsstrahlung from hot atmosphere [10,000 – 13,000 K]

Bright Patches in Polar Regions



Polar regions at brightness temperature 10,000 and 13,000 K. (333 K between contour lines).

Bright Patches Mark Strong Magnetic Fields (?)

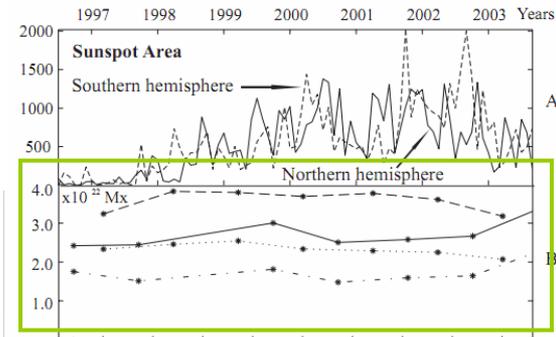
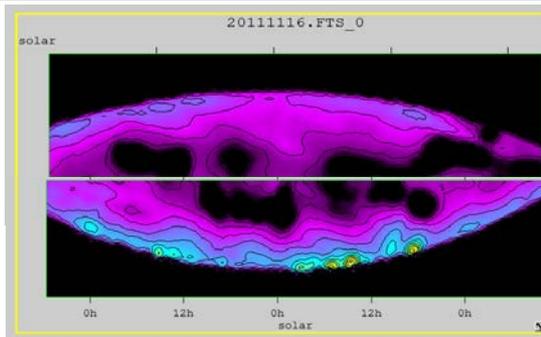
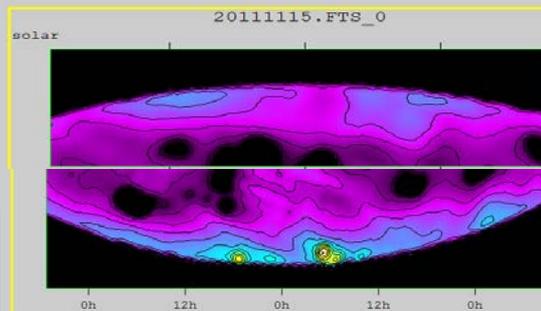
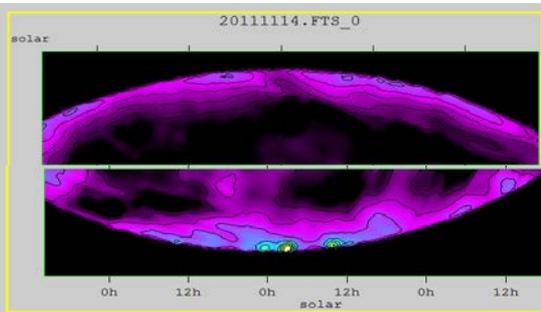
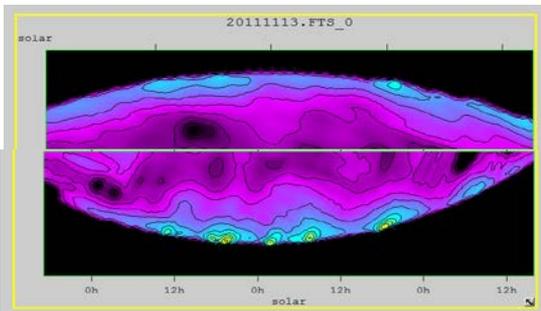
“One still **unresolved puzzle** about the chromosphere is why at some frequencies (at least 10-100 GHz) the polar coronal holes appear brighter than the rest of the quiet Sun. There is some evidence that all coronal holes, even those not at the poles, are brighter”

<http://web.njit.edu/~gary/728/>

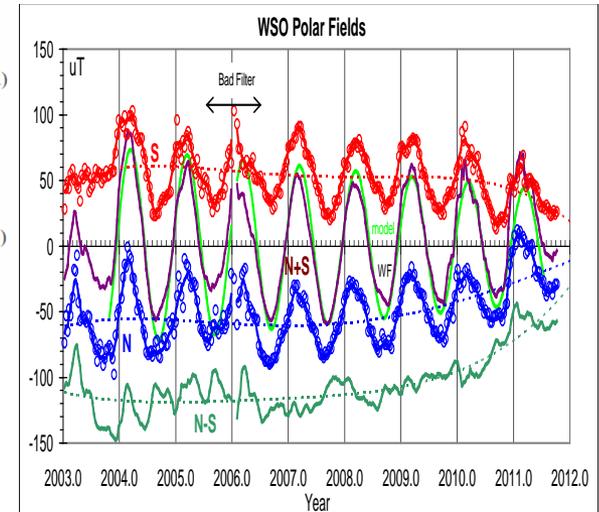
Lectures 10 & 11

“still-mysterious polar brightenings” *Bastian et al.* (1998, FASR)

Magnetic Flux in the Polar Caps



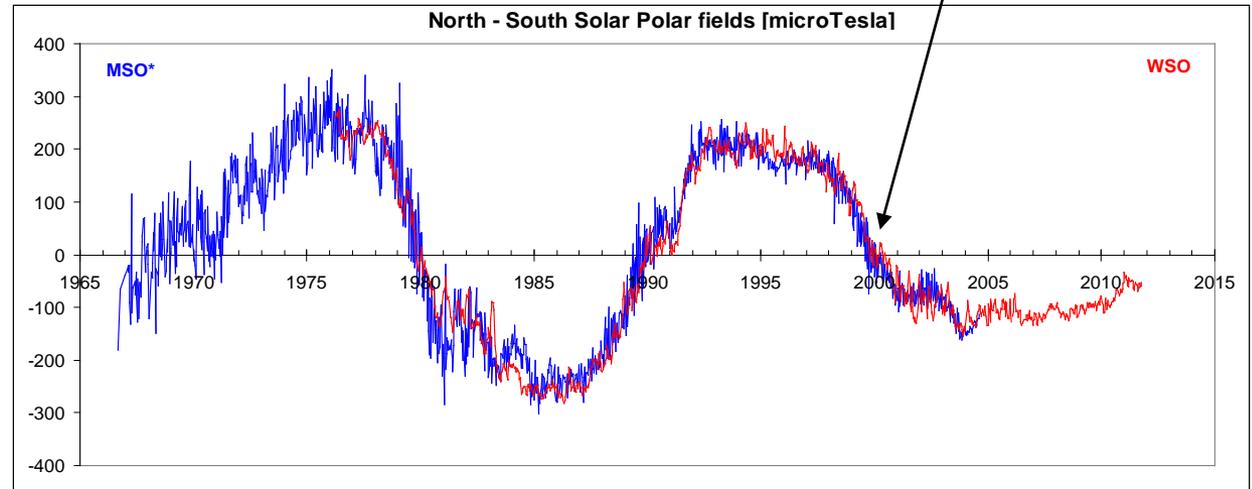
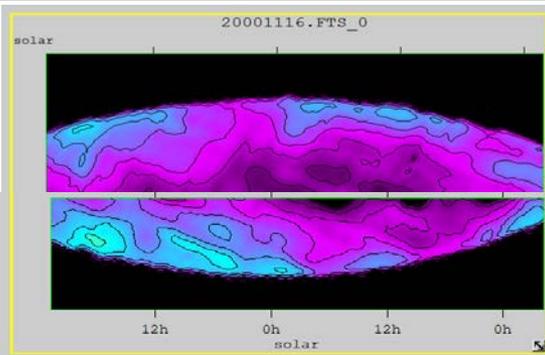
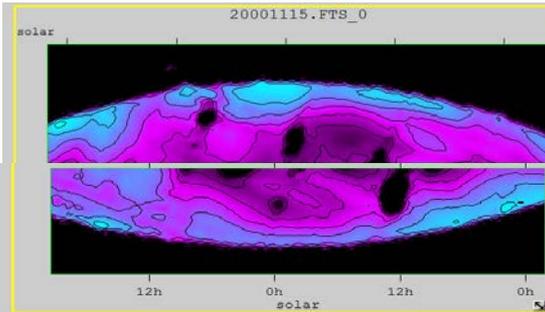
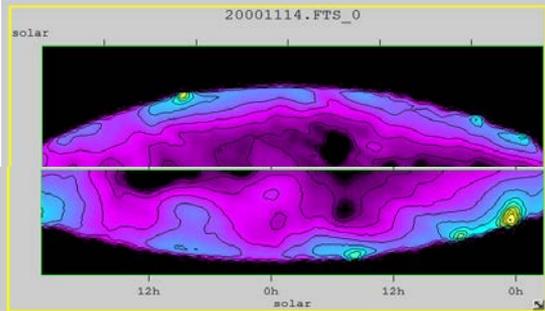
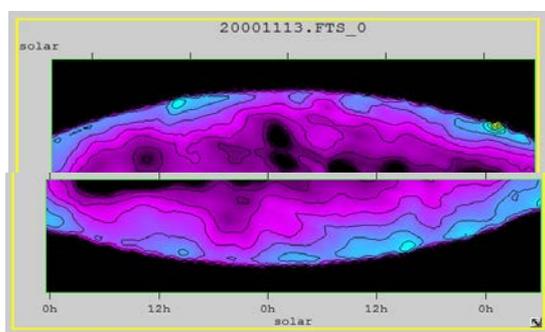
“magnetic flux of the radial field component in the latitude zones from 78° to 88° in N (dash and dots line) and S hemispheres (dash line) is \sim constant”. *Elena B.*



Average flux above 55° ; North is now getting weaker than South.

Question: At solar maximum, are the polar caps, when reversing field, covered with equal amounts of opposite polarity magnetic fluxes or isn't there any flux?

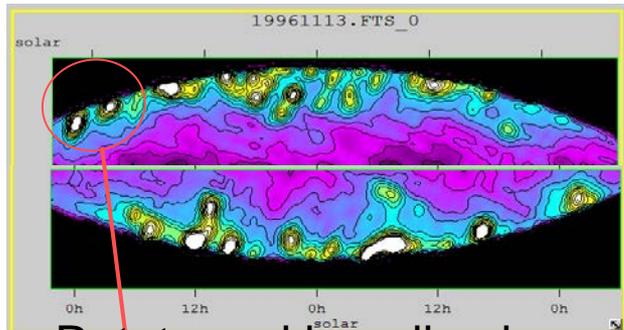
Not More Bright Patches at Solar Maximum, 2000



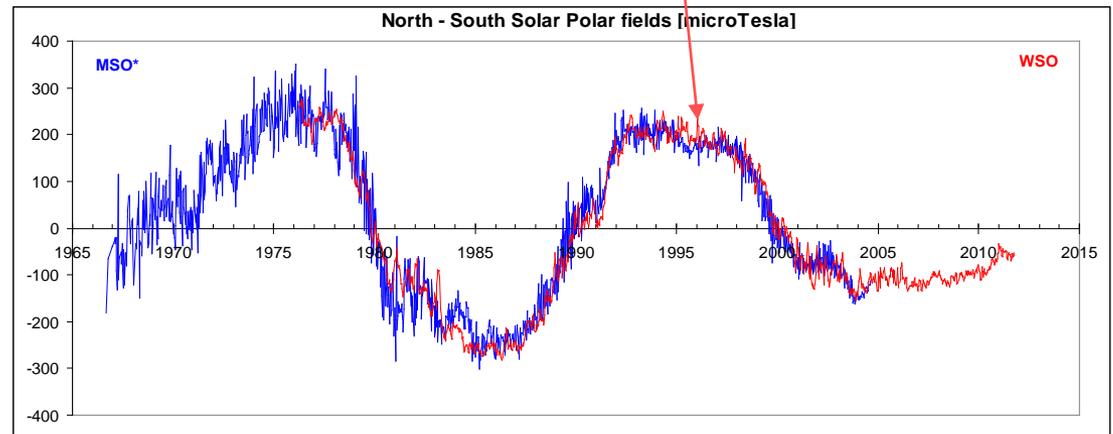
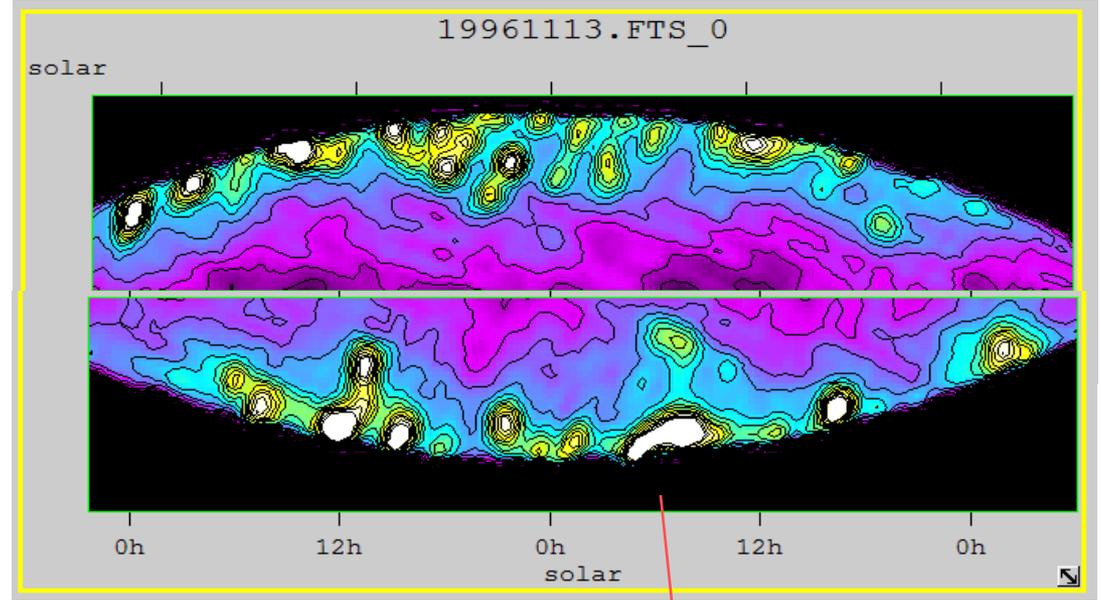
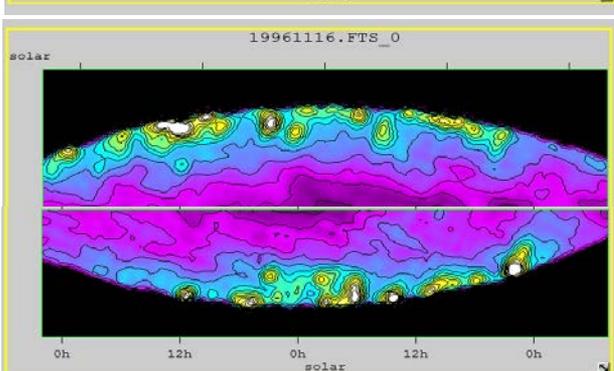
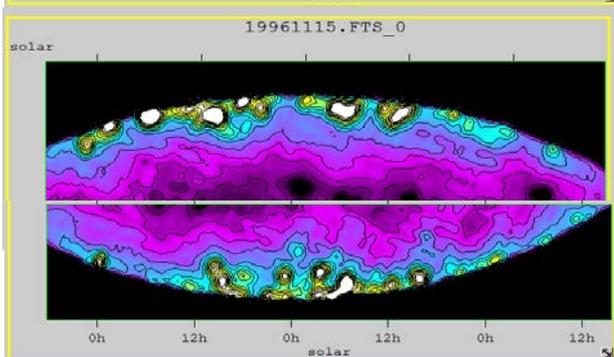
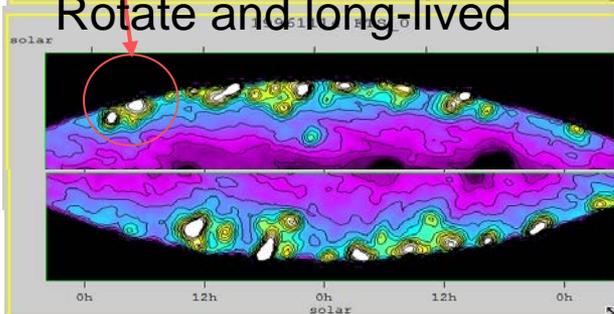
Only a few scatted, weak patches. So no magnetic flux of the kind that makes patches [~ 2000 G], thus the polar fields are not an equal mixture of opposite polarities. There aren't any.

What does WSO measure? Not the 'pepper and salt'

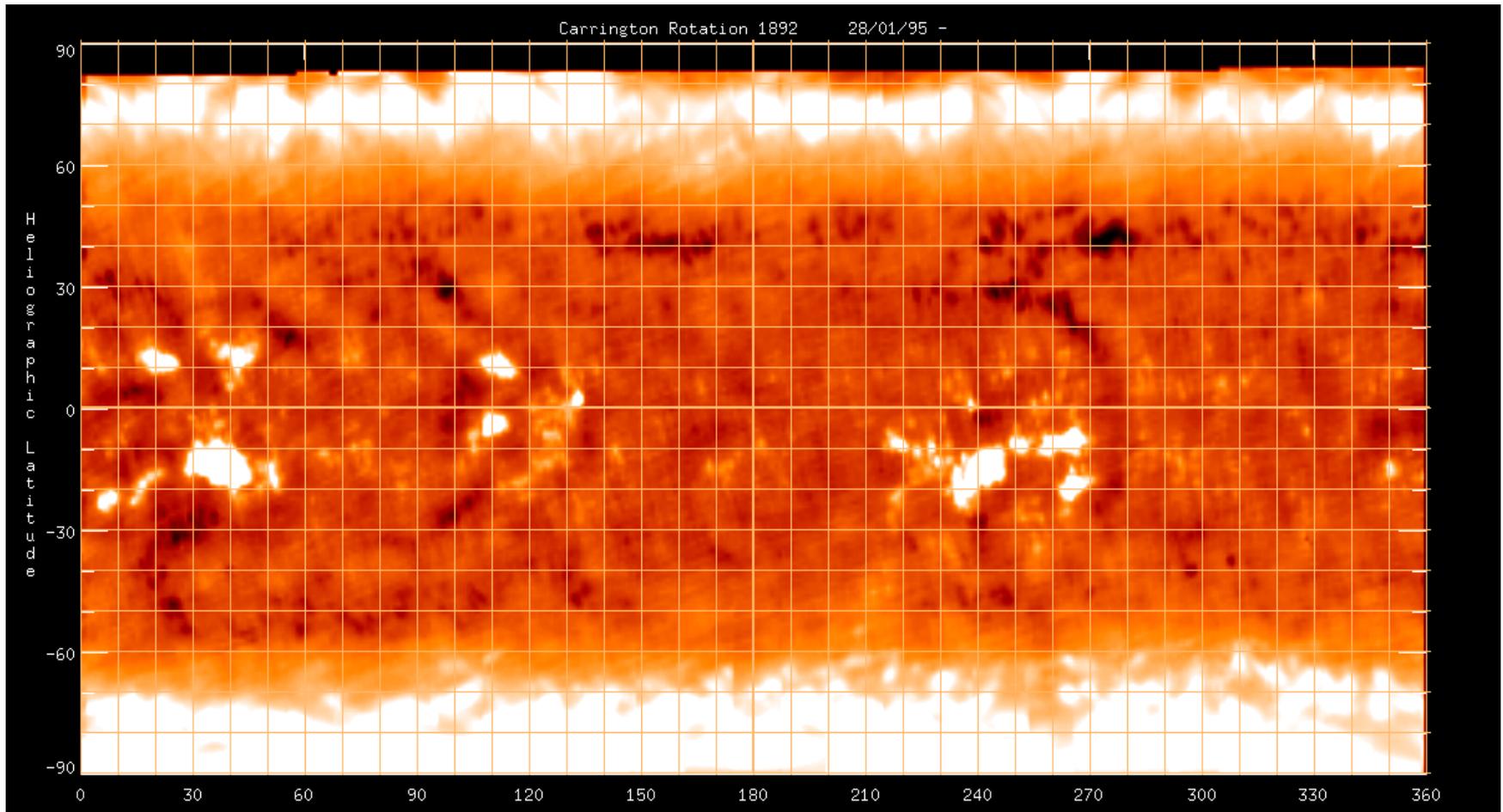
But at Solar Minimum, Oh Boy!



Rotate and long-lived

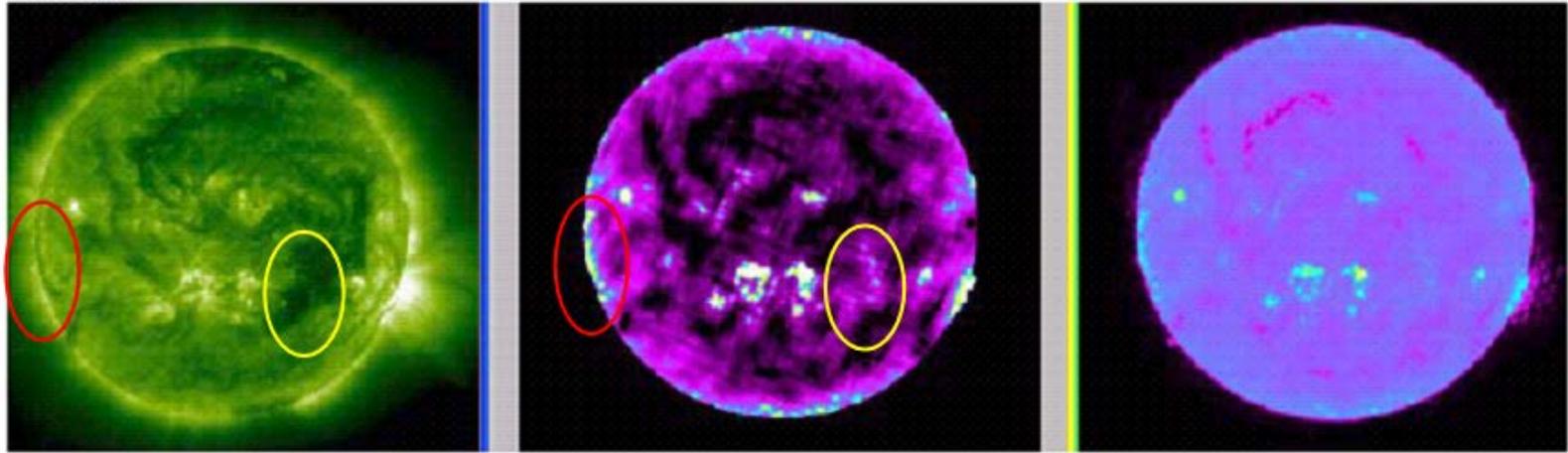


Here is what a synoptic map of the 17 GHz radiation looks like at minimum

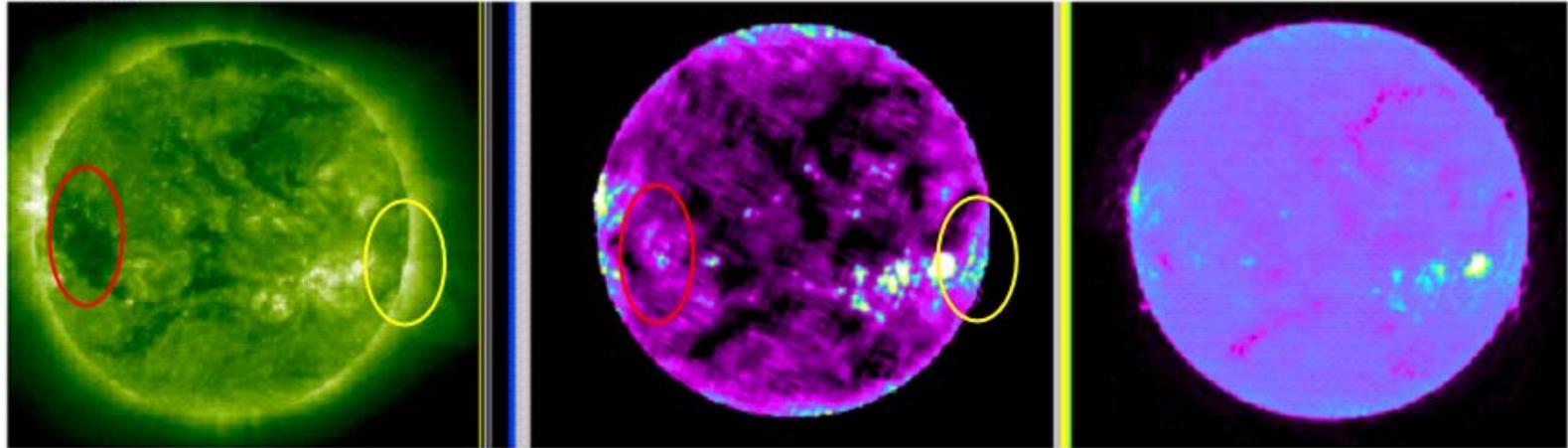


Coronal Holes everywhere show same behavior as the polar holes

2003/09/10

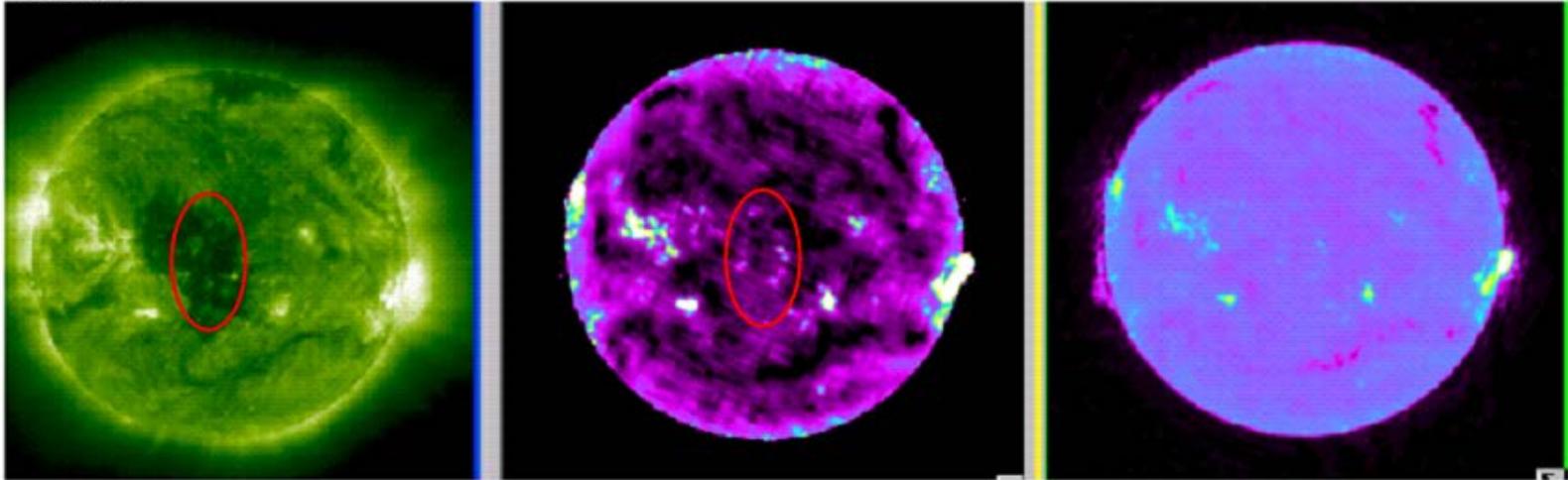


2003/09/13

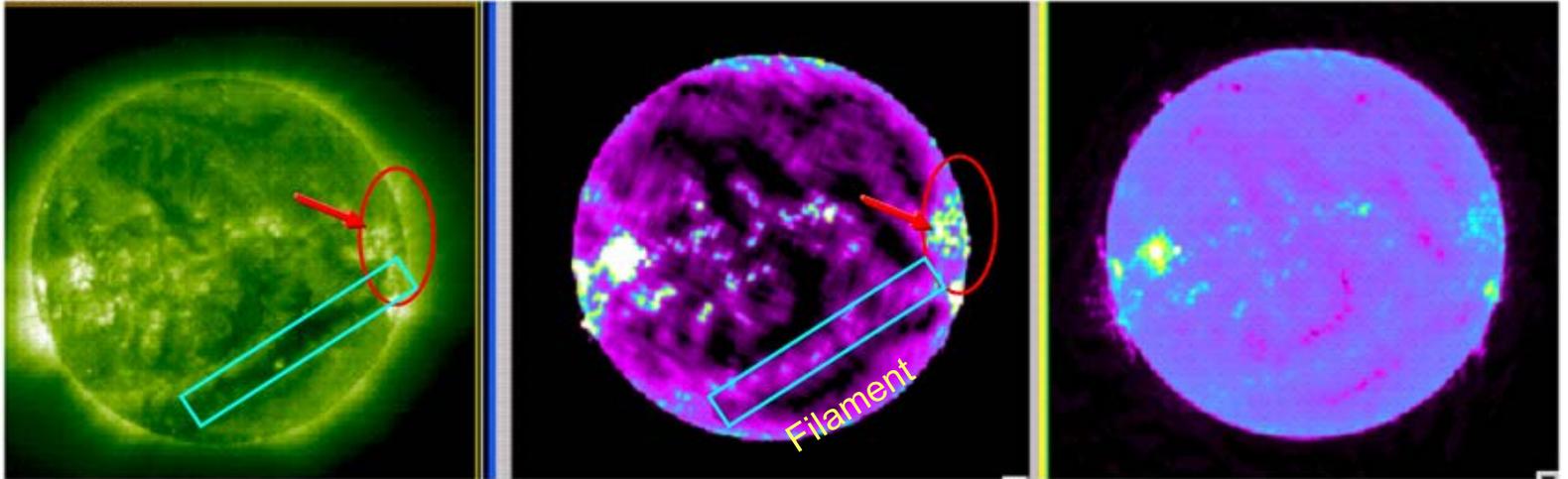


Another Example of Coronal Hole at Limb

2003/09/16

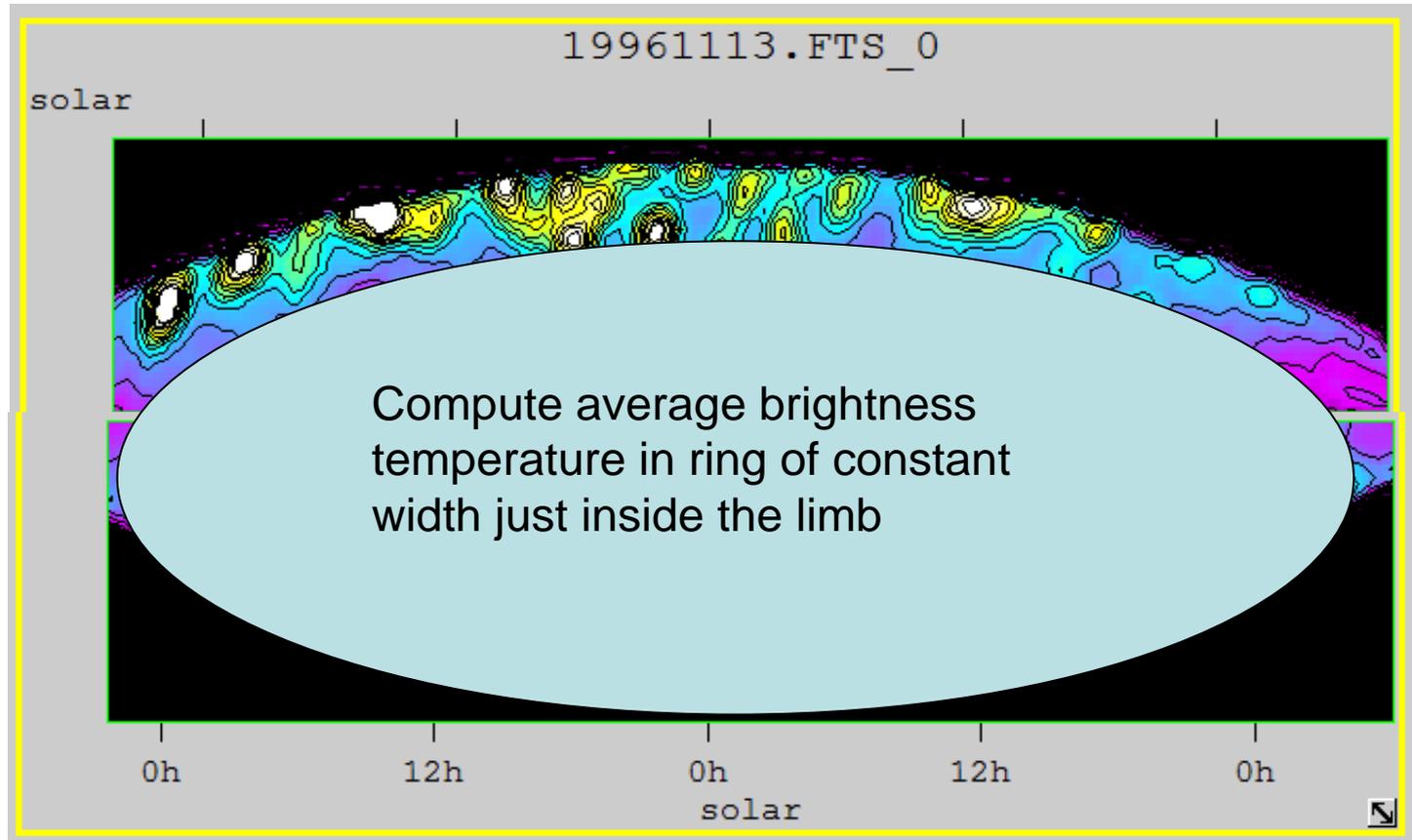


2003/09/23

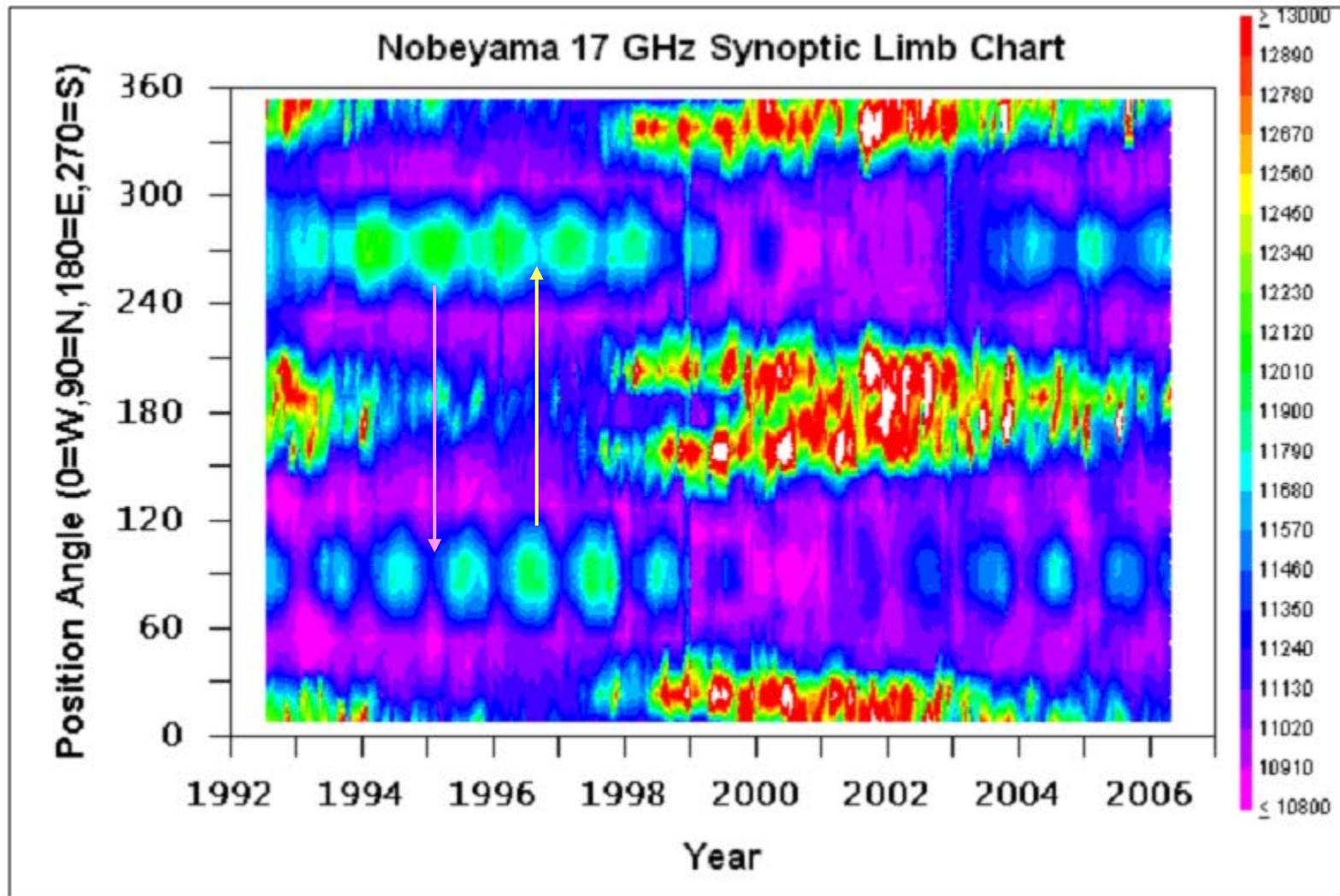


I think we can learn about the polar patches by studying low-latitude coronal holes

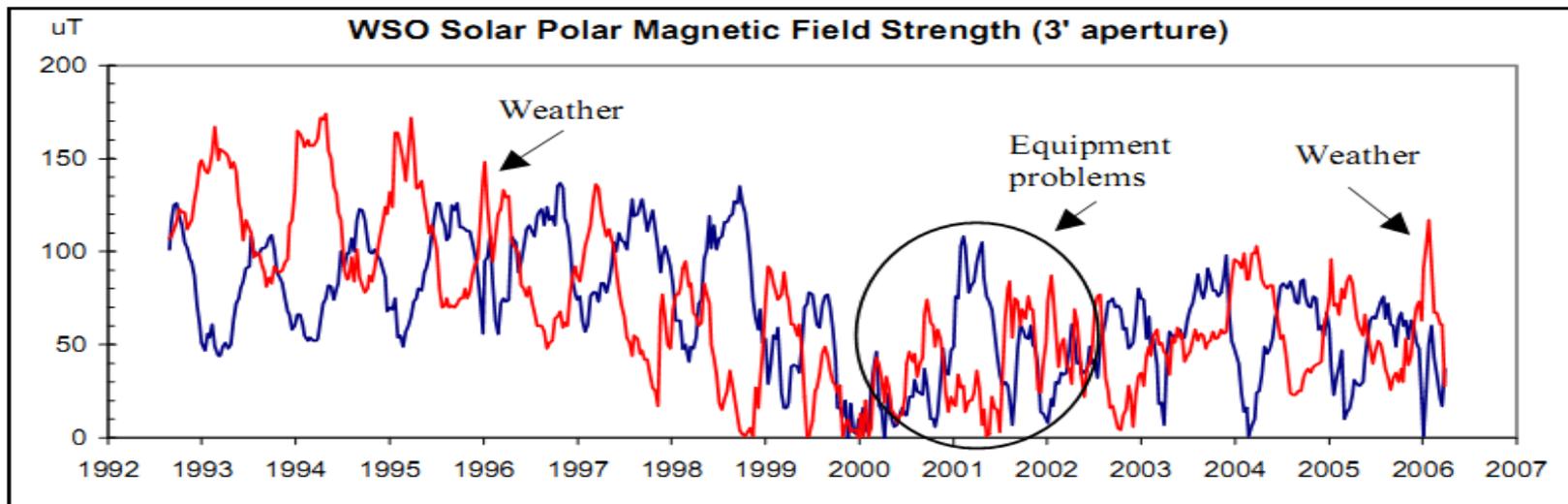
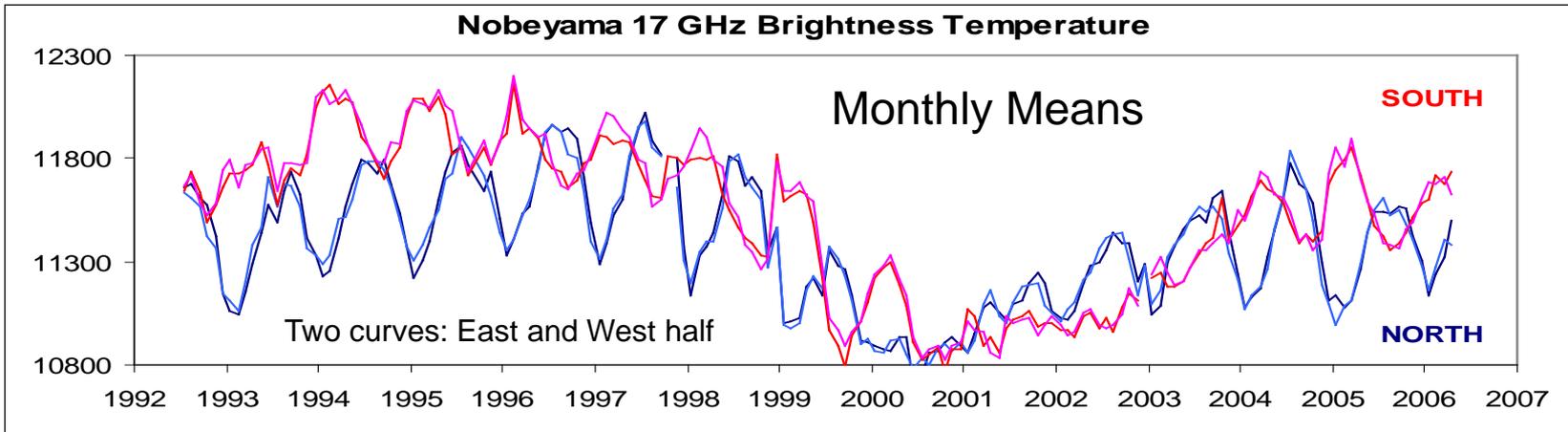
Quantifying the Brightening



Evolution of Patches over the Cycle

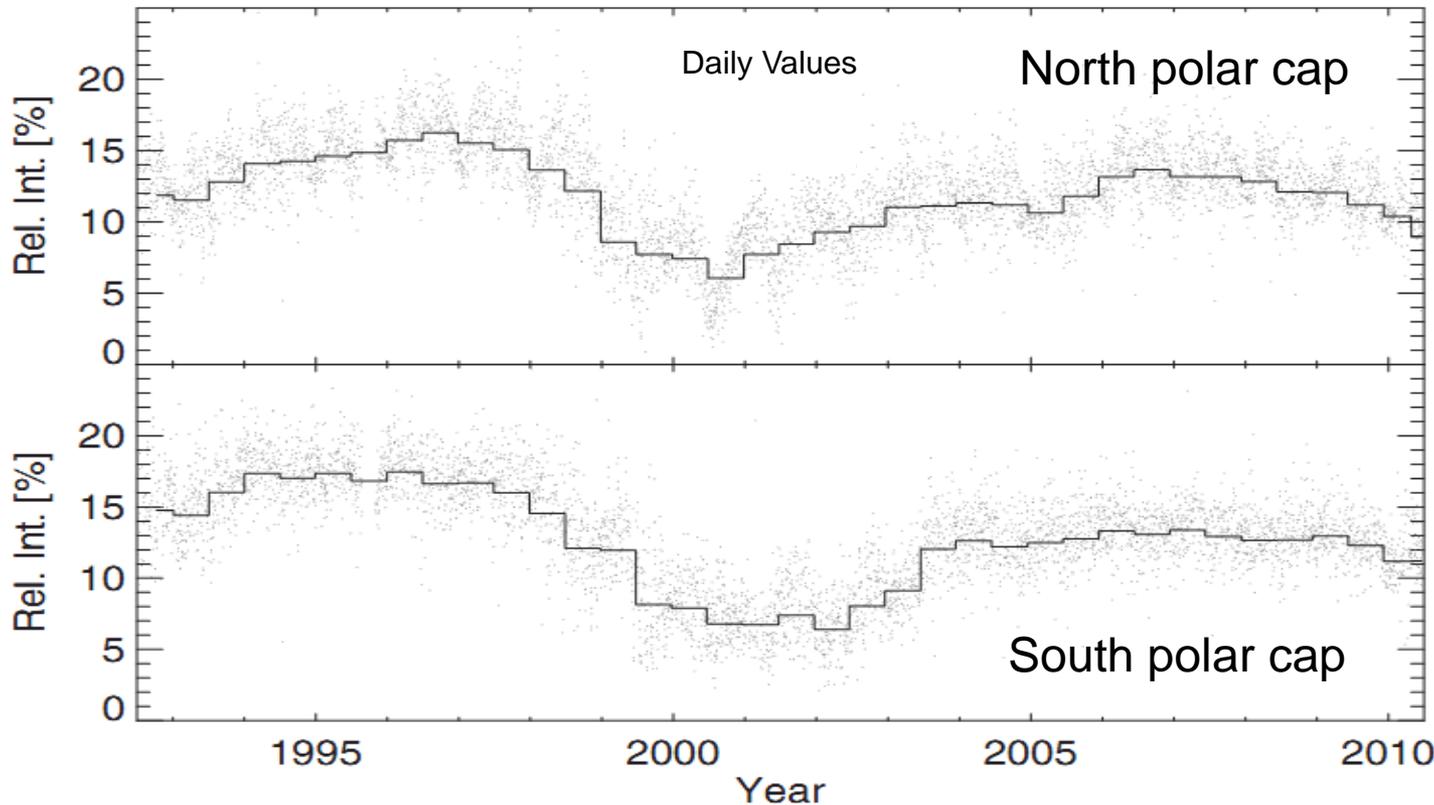


Annual $[B_0]$ Modulation

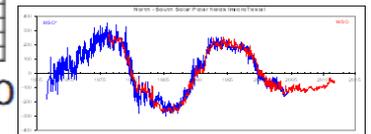


This shows that the brightening is not just general limb brightening, but is concentrated at the pole just as the polar magnetic field (is this due to the field?)

17 GHz Updated through 2010

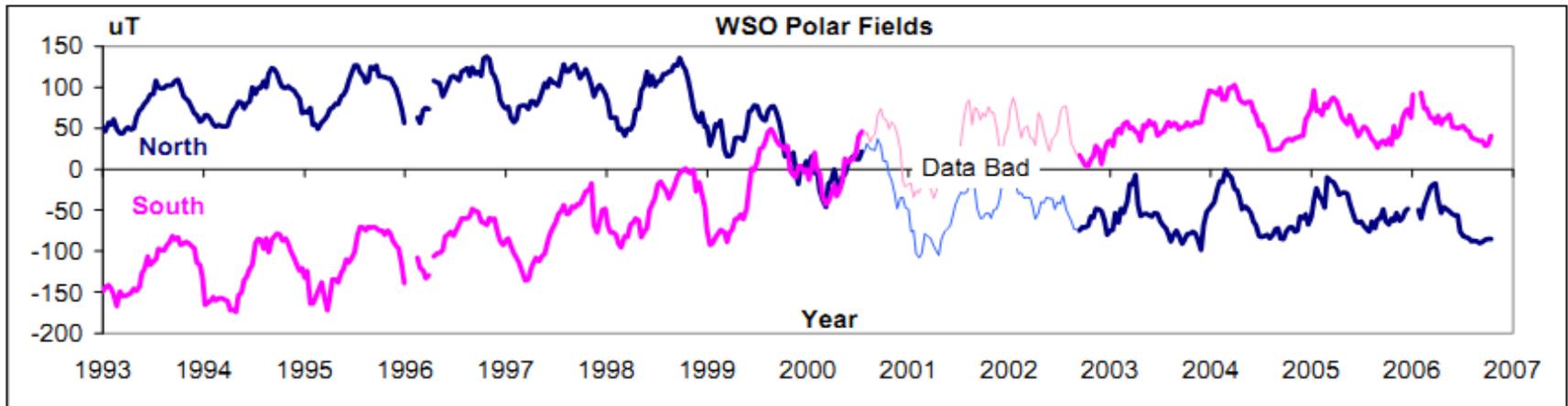
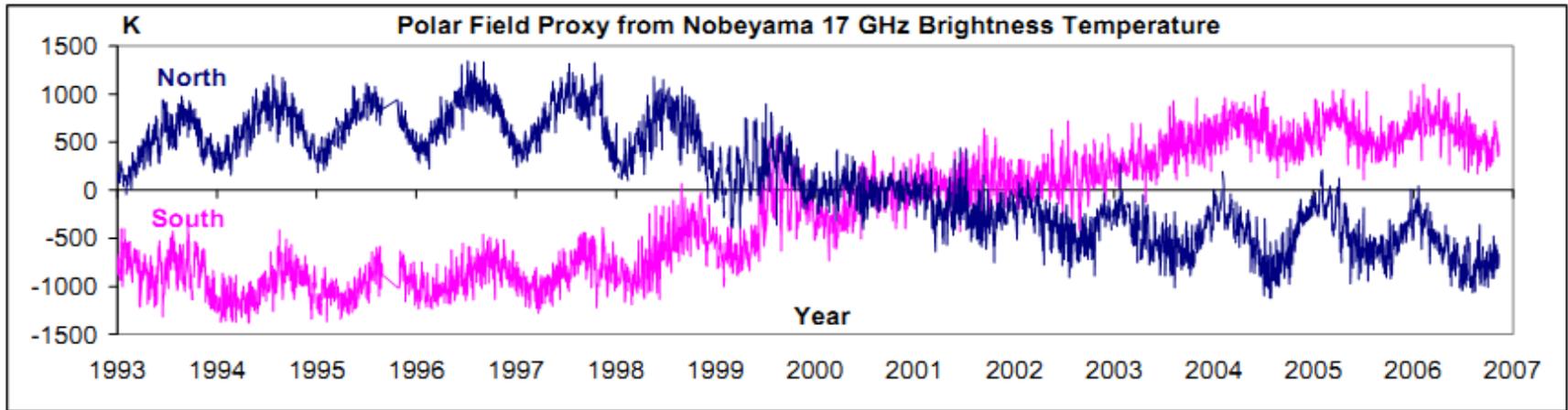


Caius Selhorst

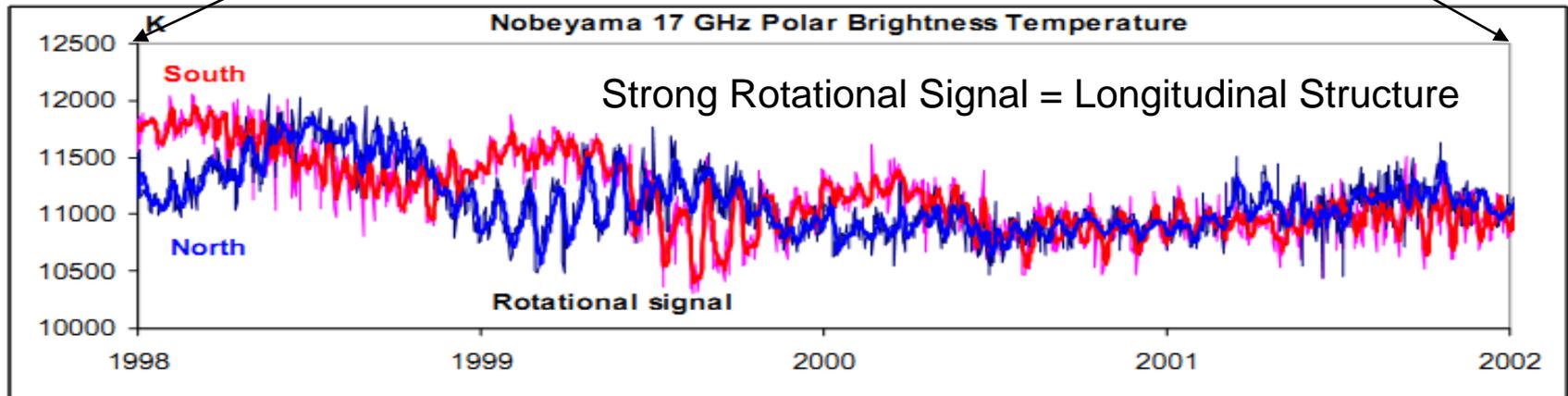
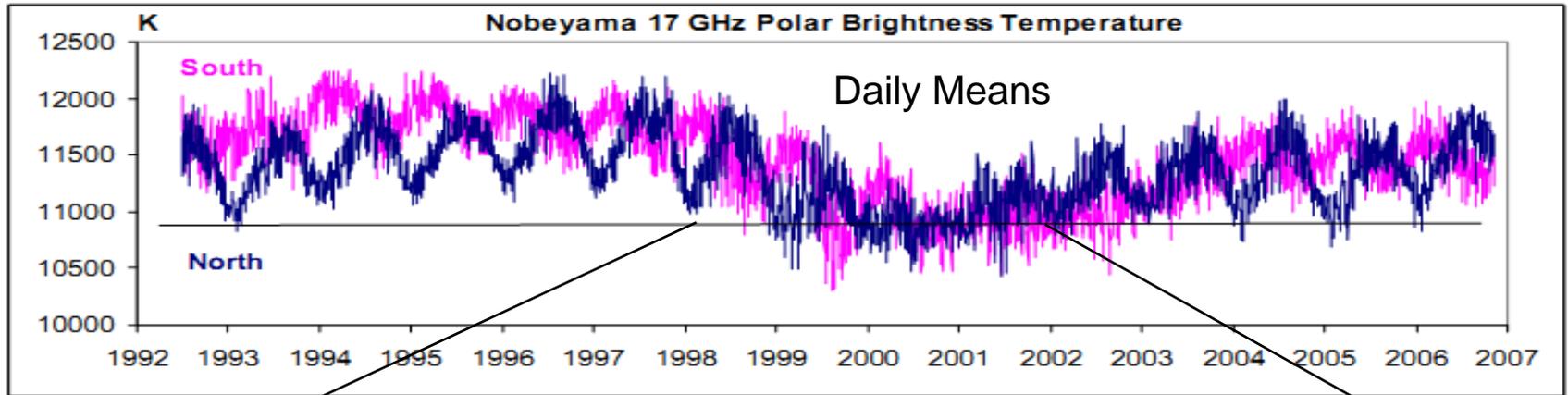


Selhorst, Caius L., Svalgaard, L.,
Giménez de Castro, C. G., Válio, A., Costa, J. E. R., Shibasaki, K.; IAU286, 2011

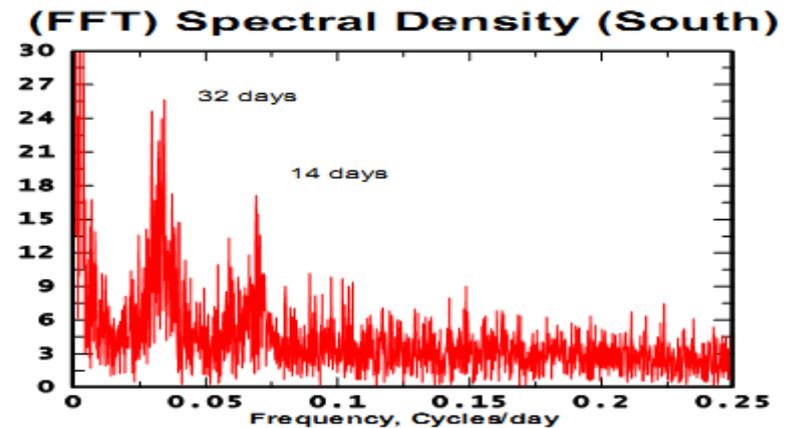
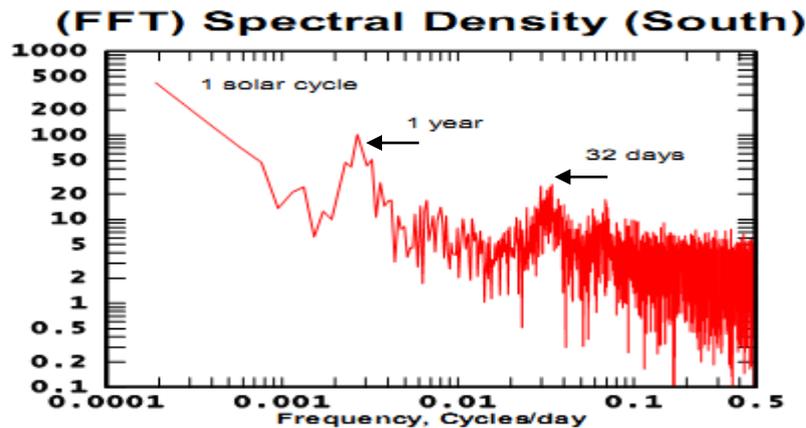
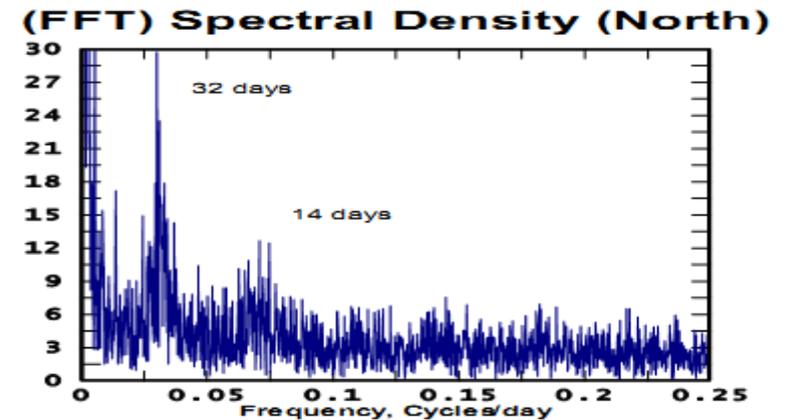
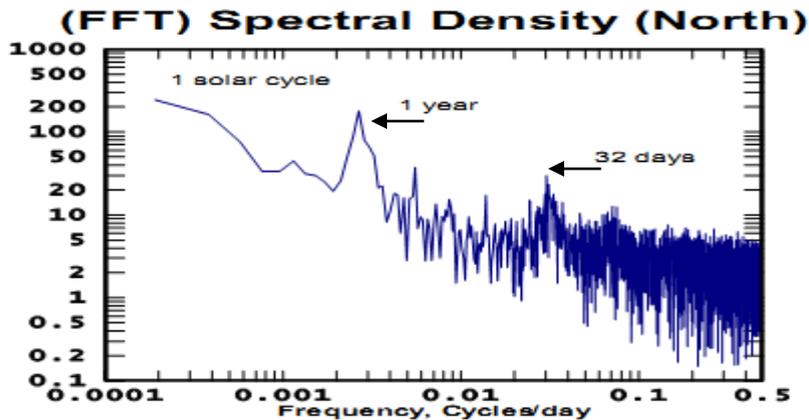
Excess T_b over 10,800K, signed according to WSO polar field sign



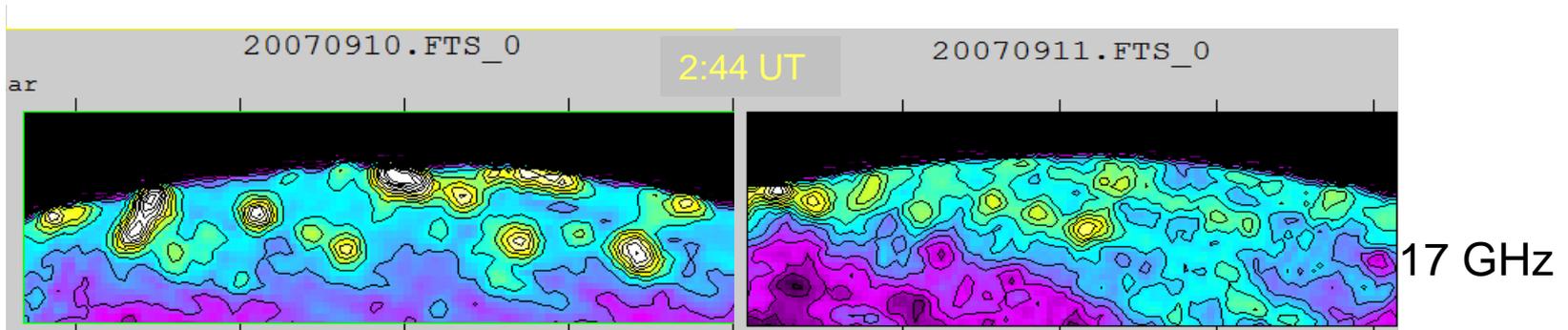
Strong Rotational Modulation



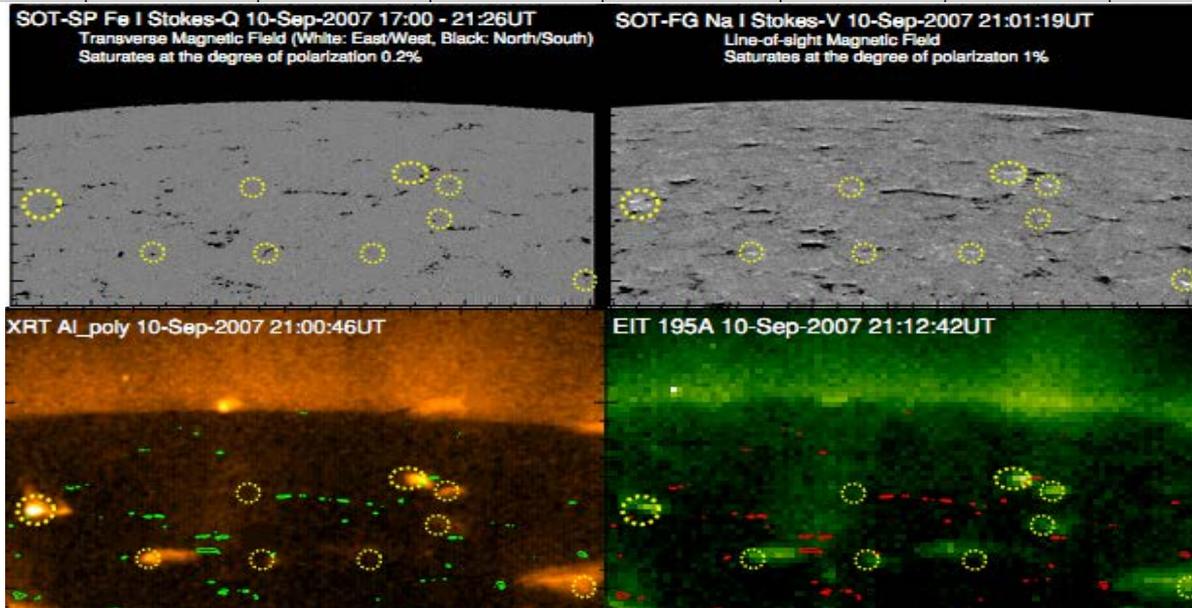
Rotational Period and 14-day Signal



So what are those bright patches?



I don't see any clear match ups

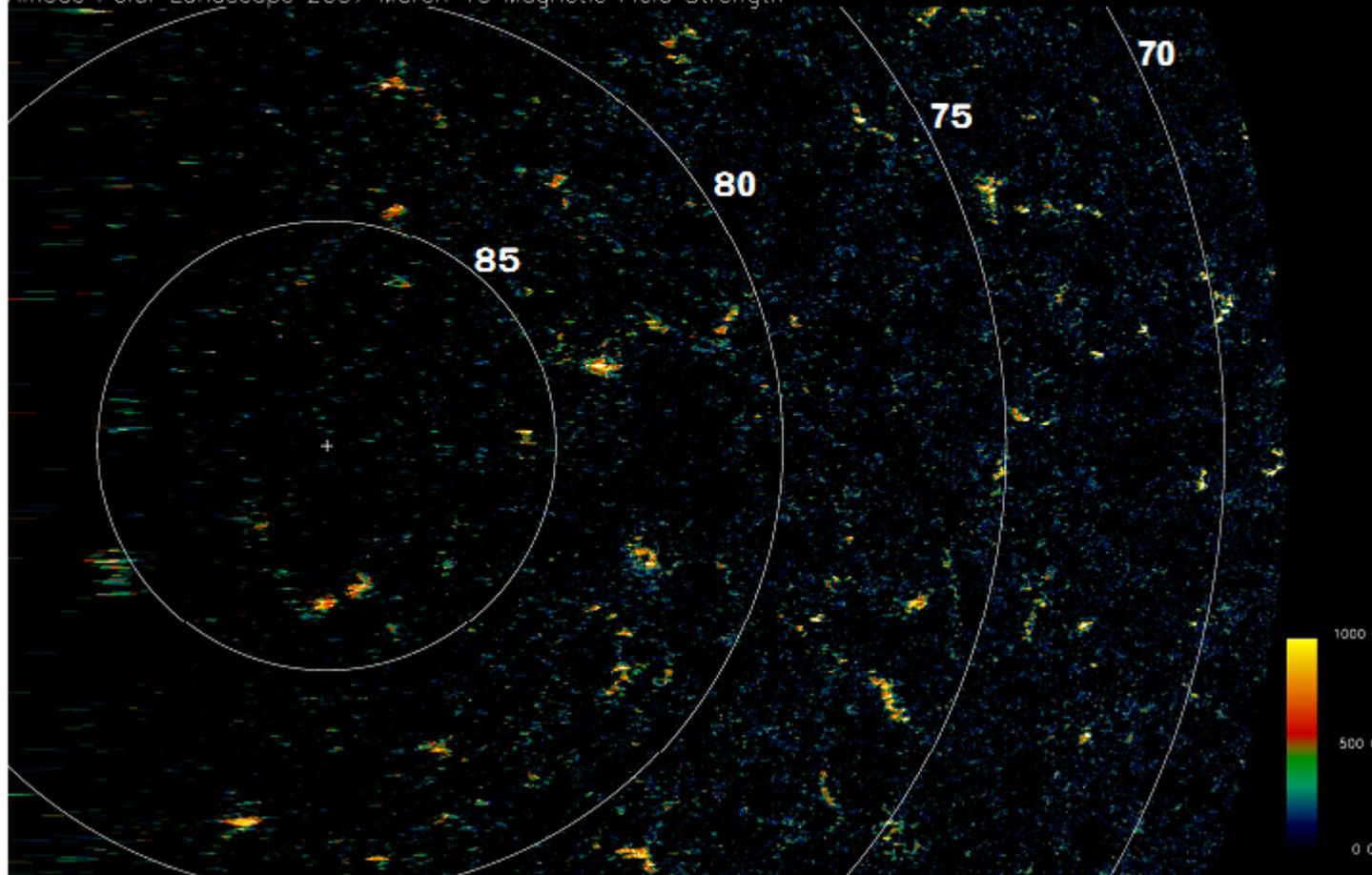


Shimojo & Tsuneta, *Ap*, 2009

The magnetic concentrations have magnetic polarity opposite to that of kG-patches. Our results suggest that the coronal activities and structures in the polar coronal hole can be used as a tracer of the appearance of the minority (?) polarities in the polar region". Shimojo & Tsuneta, *Ap*, 2009

Polar landscape kG field

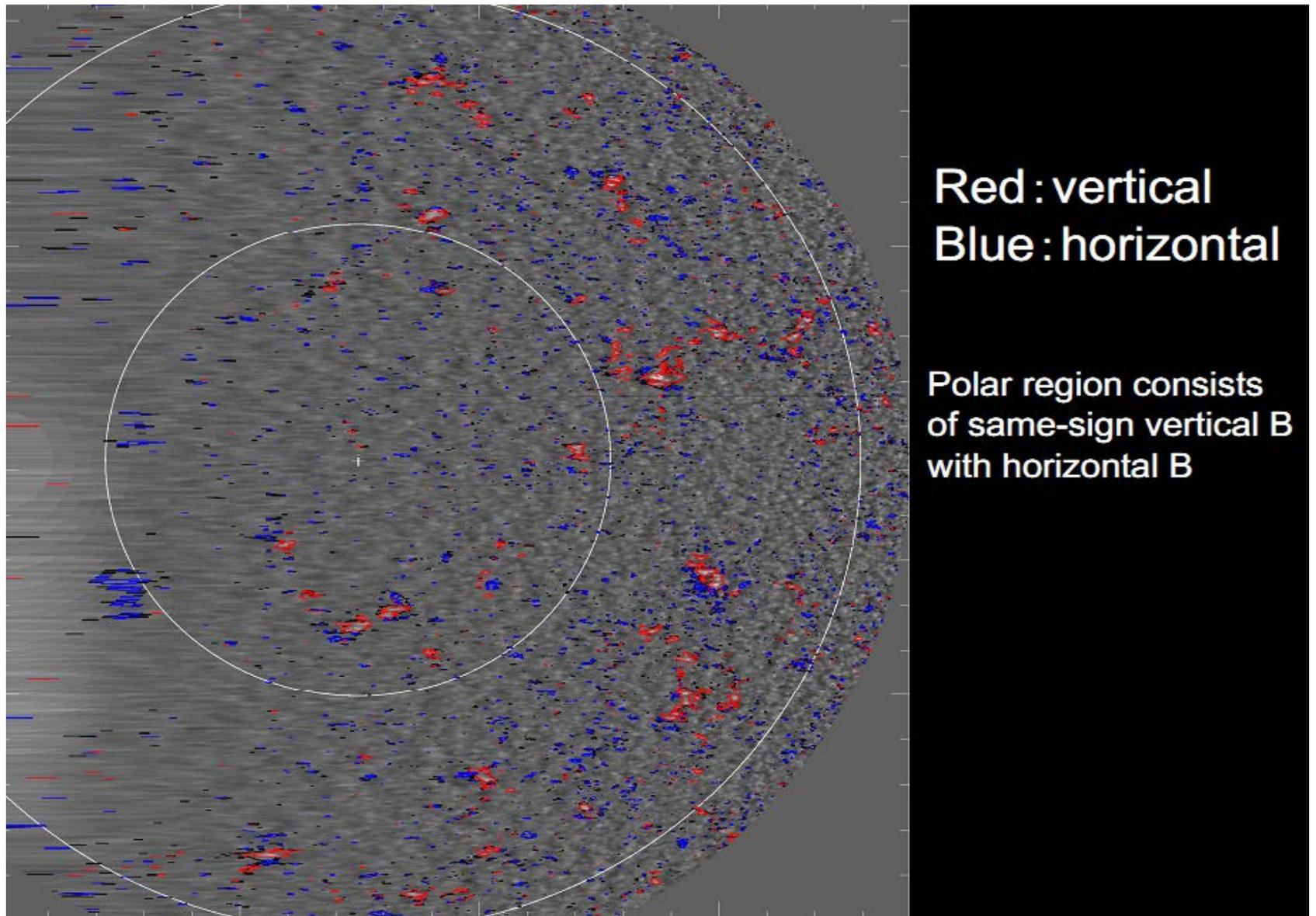
Hinode Polar Landscape 2007 March 16 Magnetic Field Strength



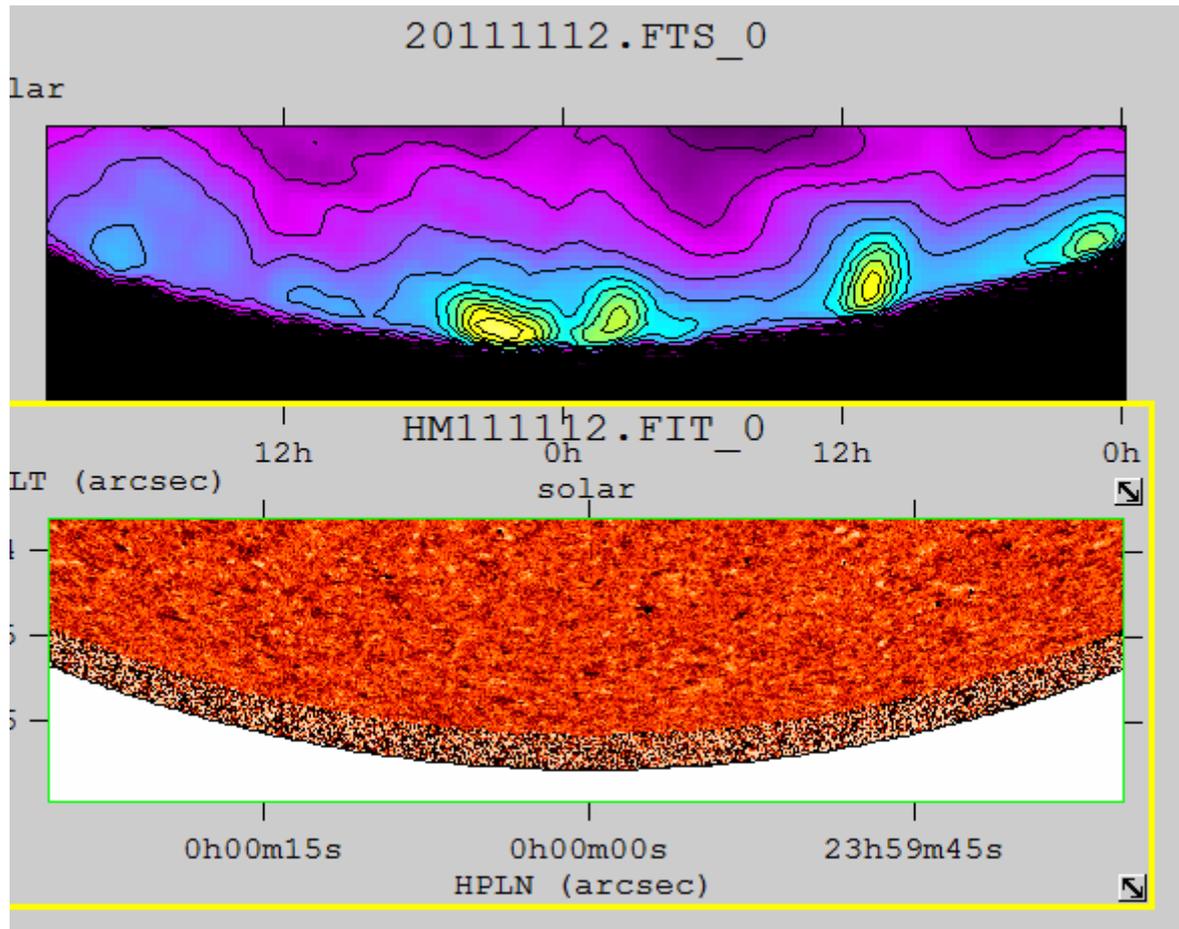
“Tsuneta et al. (*ApJ*, 2008) found many vertically oriented magnetic flux tubes with field strength as strong as 1 ~ 1.2kG are scattered in latitude between 70° and 90° and all the fluxes have the same sign consistent with the global polar field.”

If the flux tubes extend to the interplanetary space, there will be a possibility that they serve as the guide fields for X-ray jets, coronal plumes, and the fast solar wind”.

How to Interpret this slide [Tsuneta et al.]?



So, Look for this in HMI data

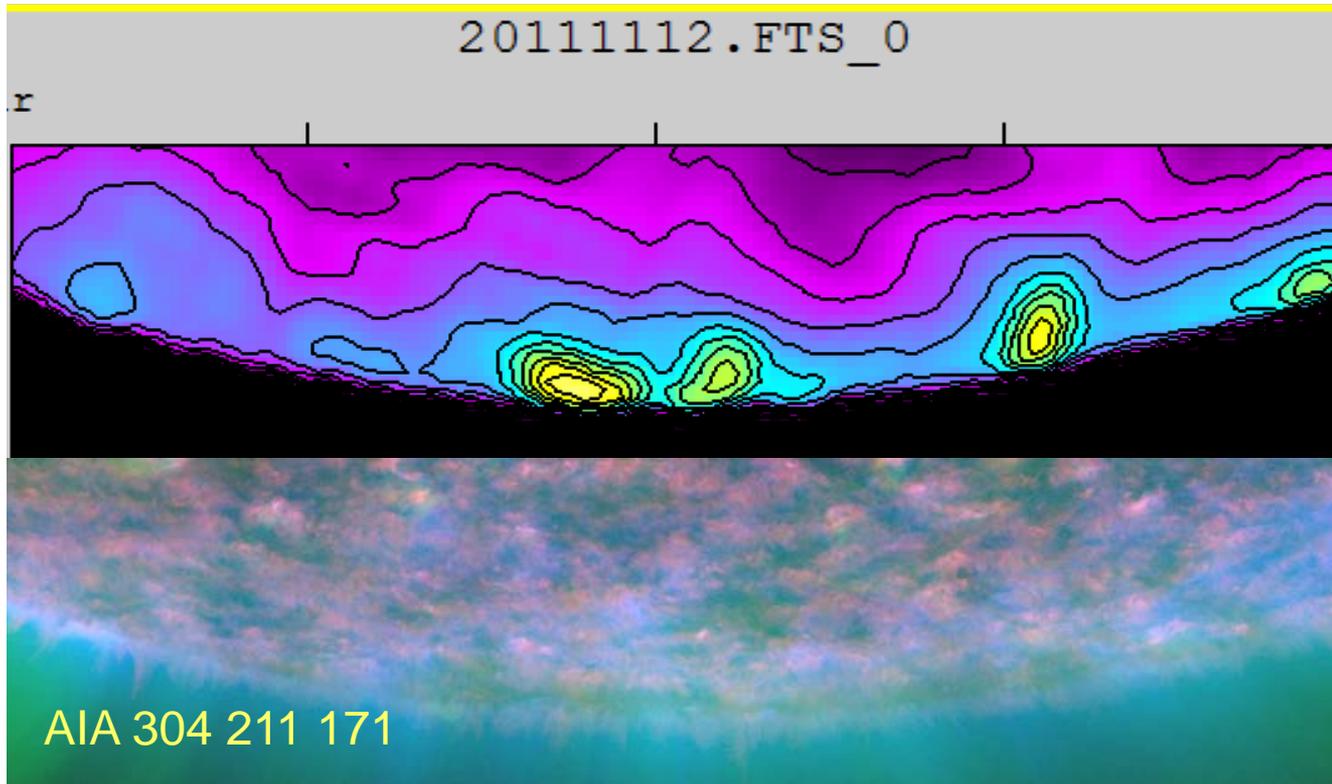


I don't see anything that would match in the LOS field.

Wrong contour level choice?

But perhaps the LOS will not show the field as it is transverse...

But AIA then?



No strong concentrations match.

Perhaps there is a faint glow at the right places...

We must remember that the 17 GHz flux in question has a brightness temperature of 10,000-13,000 K, so does not come from the hot corona, but I would have expected some signature of the flux somewhere. We should look for such.



The end