The Mean Field of the Sun

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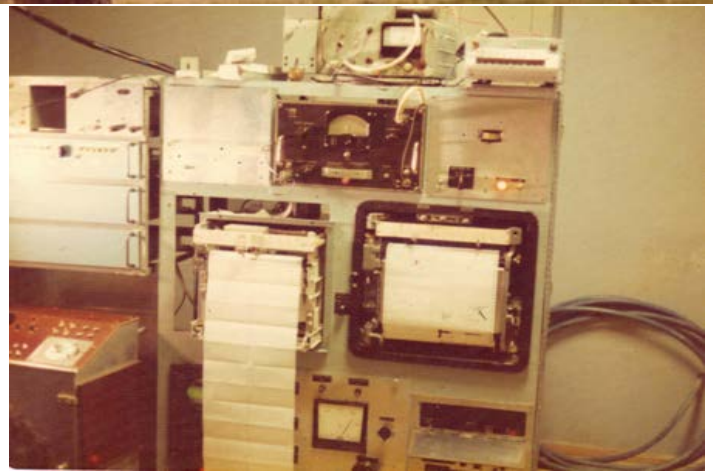
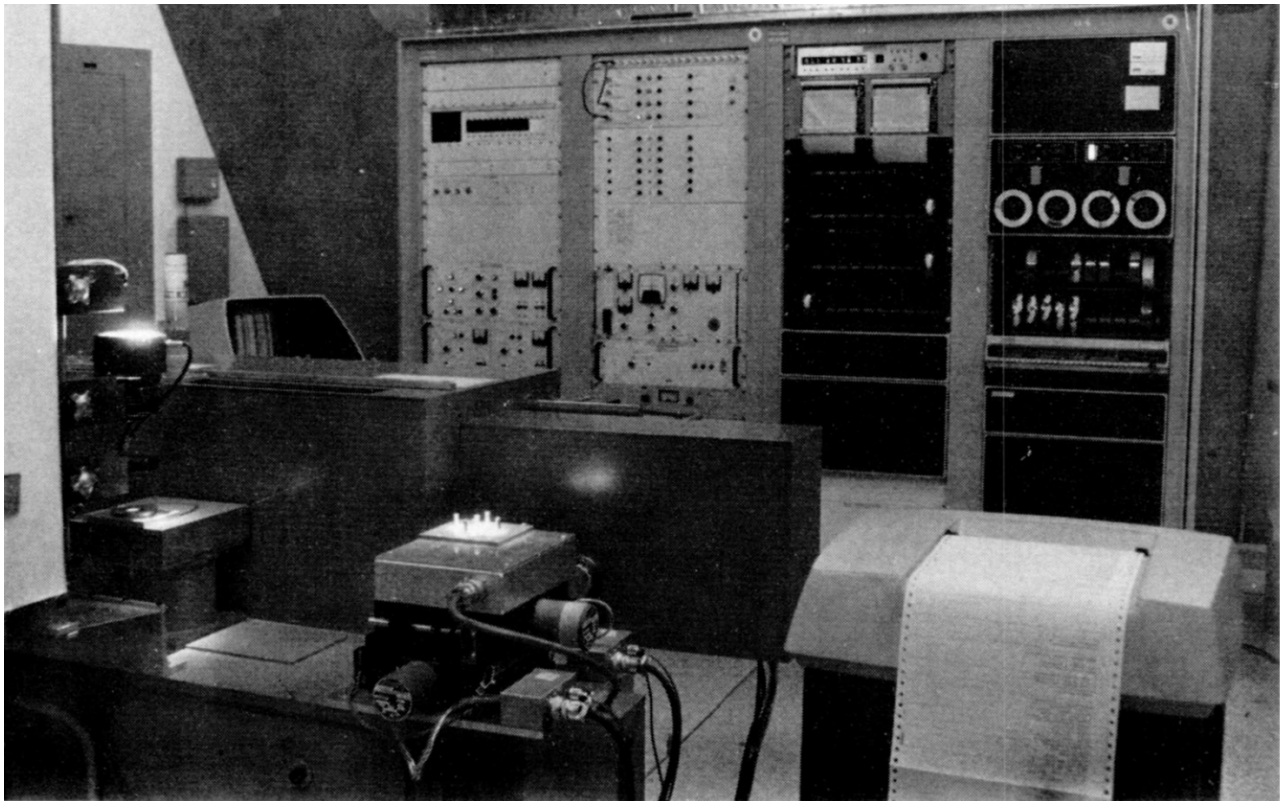
Stanford University
Sept. 2, 2011

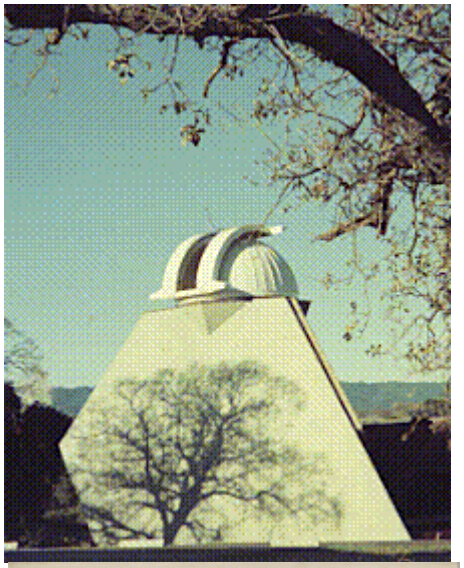
Crimean Astrophysical Observatory [since 1968]



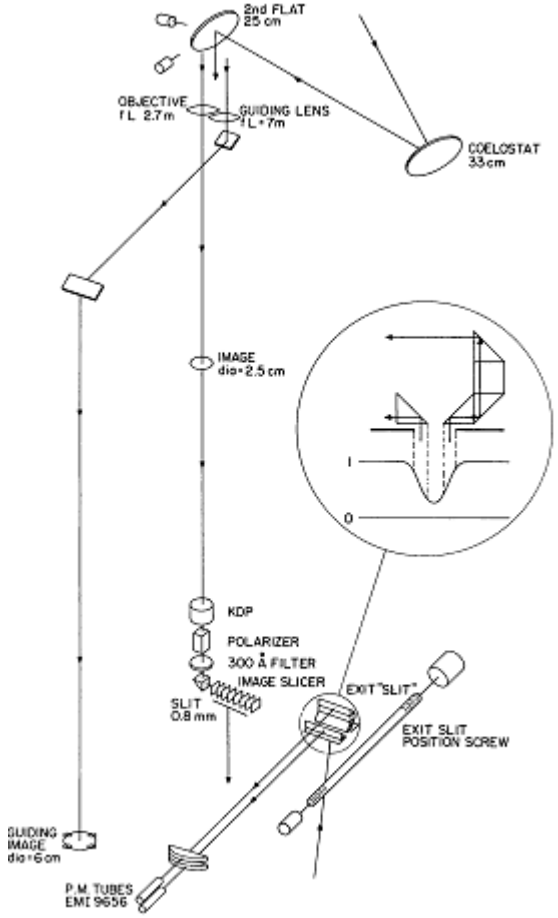
Mount Wilson Observatory [1970-1982]

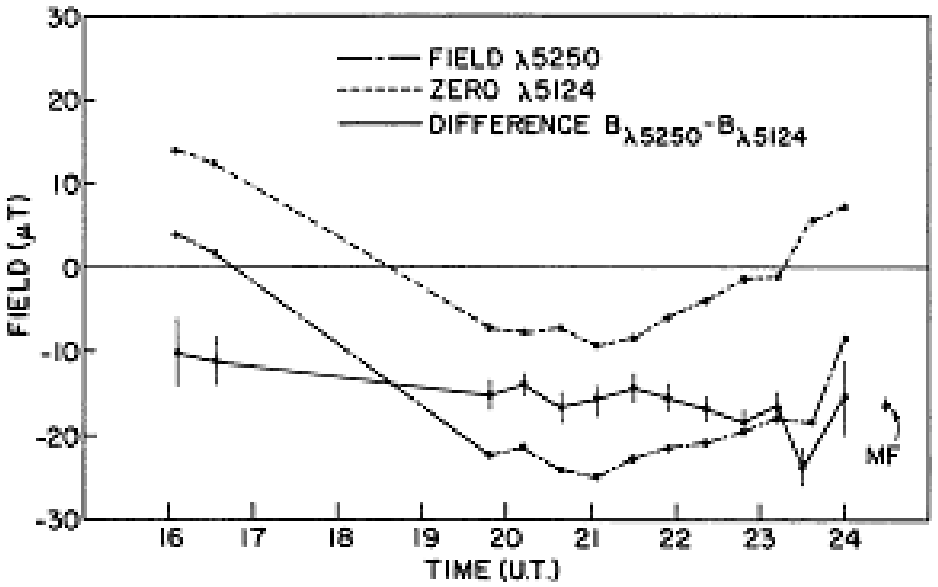
Wilcox Solar Observatory [since 1976]





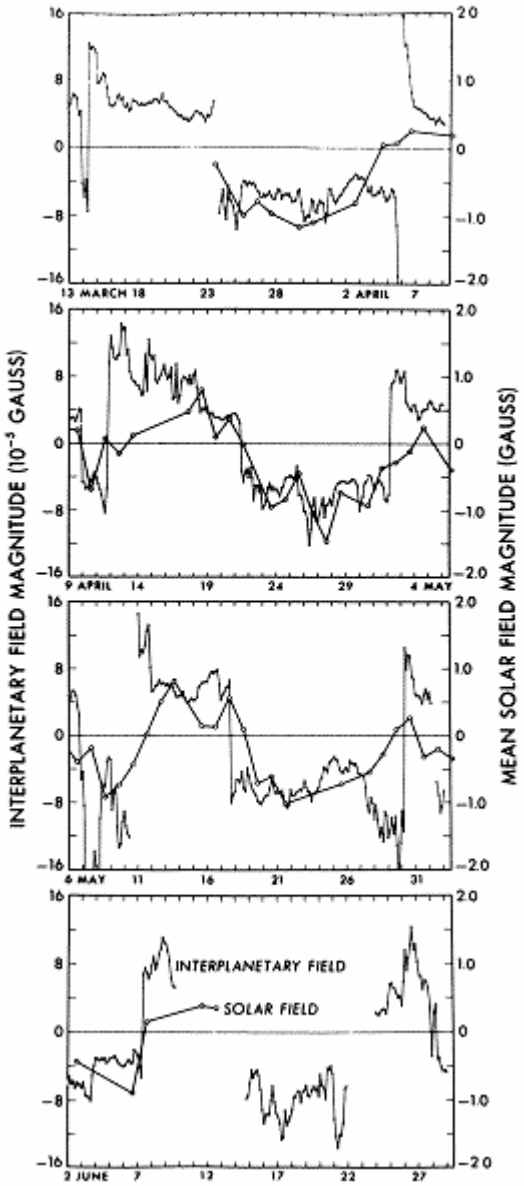
How the Mean Field is measured



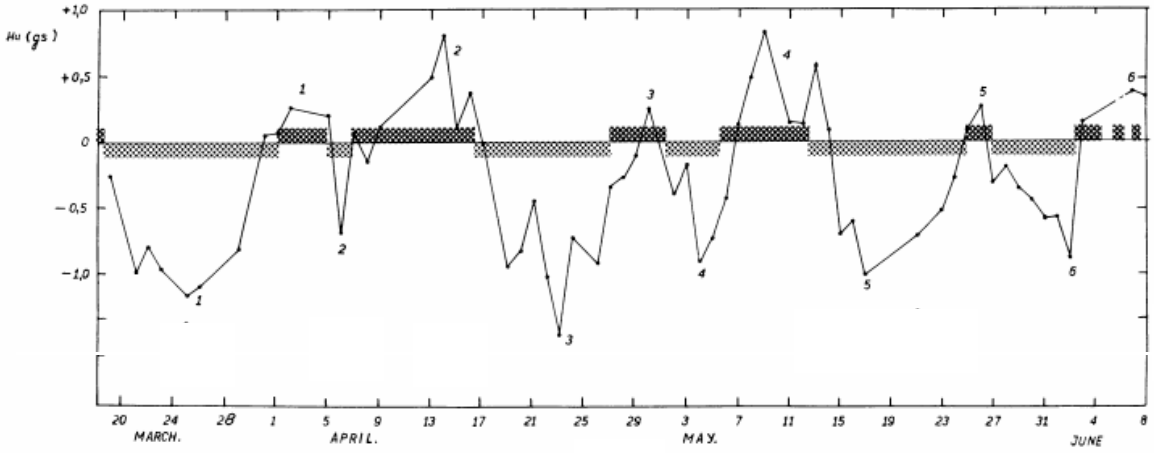


The MF is taken to be the difference between the magnetic signal in λ525.0 nm and the non-magnetic line λ512.4 nm.

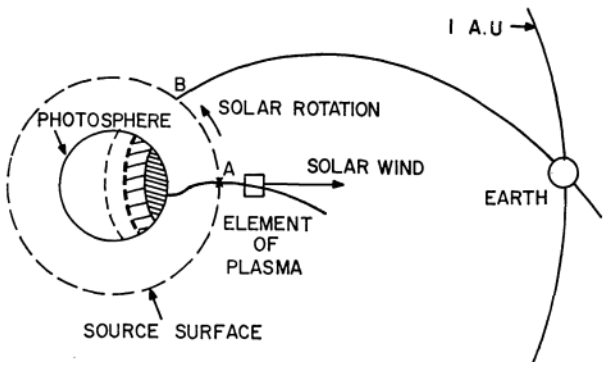
The Early Interpretation



MF as measured at CrAO

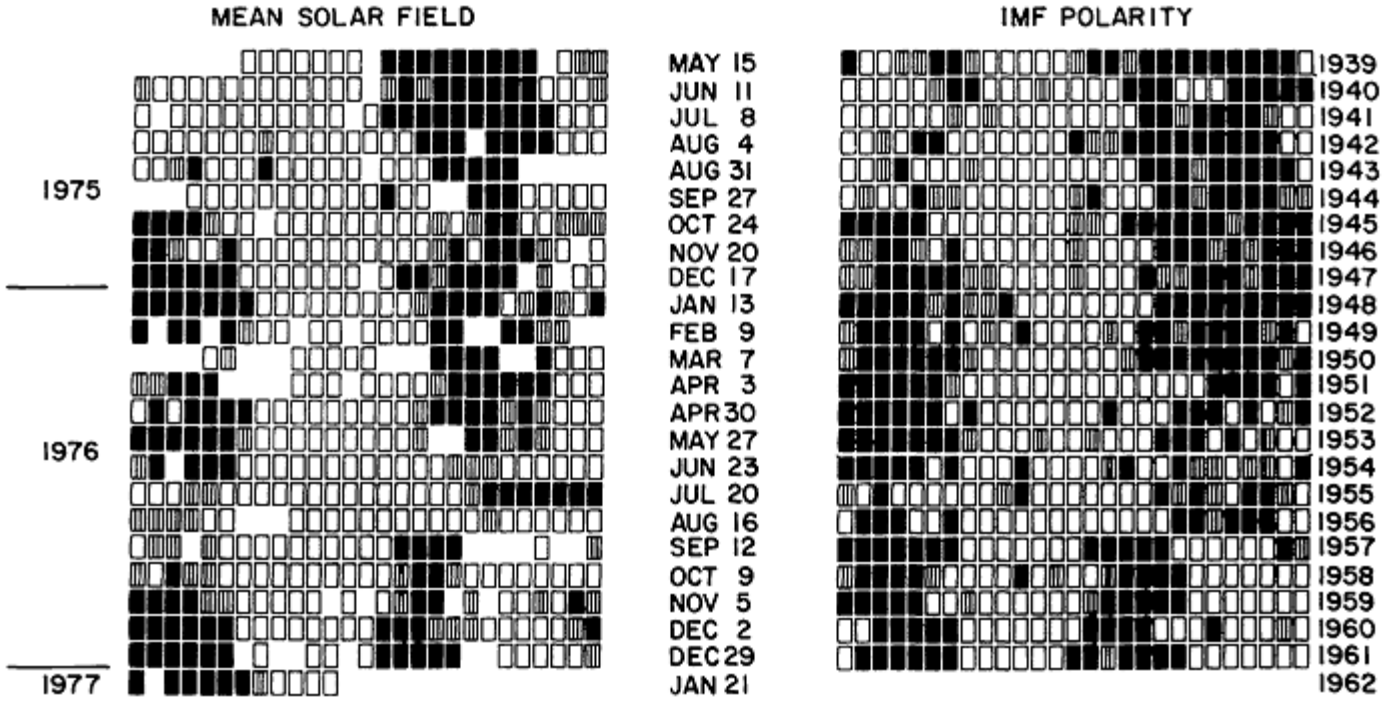


1968



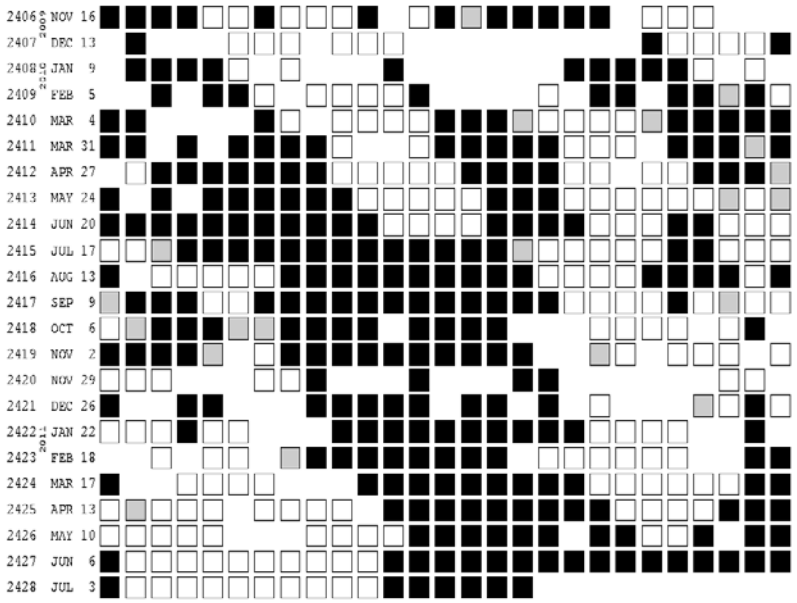
$\mathbf{B}_{INT} = 7.2\times10^{-5}\ \mathbf{B}_{MF}$ (for 2.0 $R_{\odot}$). "Thus there is a very direct relationship in *polarity* and in *magnitude* between the mean solar field and the observed interplanetary field with a 4½ day delay" (Schatten, 1970)

The Polarity Relationship [then]



WSO 5 days before

The Polarity Relationship [now]



WSO 5 days before

```
2009 11 21  2406  XXX........*..*XXXX*XX.XXXX
2009 12 18  2407  *XX.............*..XXX*.XXX
2010 01 14  2408  XXXX..*..........XXXXXXXXXX
2010 02 10  2409  XXXXXX.............X*XXXXXX
2010 03 09  2410  XXXXXX..........*...*XXXXXX
2010 04 05  2411  XXX*X*XX......*X*.....X.*XX
2010 05 02  2412  *XXXXXXX*......XX.......XXX
2010 05 29  2413  XXXXXXXXX......XX*.........
2010 06 25  2414  *XXXXXXXXXXXX*...XX*....XX.
2010 07 22  2415  .XXXXXXXXXXXXXXX*X....XX...
2010 08 18  2416  ..*XXXXXXXXXXXXXXX...*XXX*
2010 09 14  2417  .*XXX*X*XXXXXXXXXXXX...XX*
2010 10 11  2418  *..XX...XXXXXXXXXXXXX..*XX
2010 11 07  2419  *....*XXXXXXXX*XXXXX*....*
2010 12 04  2420  ...X*.XXXXXXXXXX*XXX.......
2010 12 31  2421  ..X*..XXXXXXXXXX***.....*XX
2011 01 27  2422  XX*..XXX*XXXXXXXXXX...*.X*X
2011 02 23  2423  X..X.*XXXXXXXXXX*........XX
2011 03 22  2424  *.......*..XXX*XXXXX.....**
2011 04 18  2425  ..........XXXXXXXXX.*.X..
2011 05 15  2426  ...........*XXXXXXXXX.XXXXX
2011 06 11  2427  *..........XXXXXX*XXXXXXXXX
2011 07 08  2428  X.........XXXXXXXXXXXXXX*X*
2011 08 04  2429  X**....*..XXXXXXXXXXXXXXXXX
2011 08 31  2430  XX
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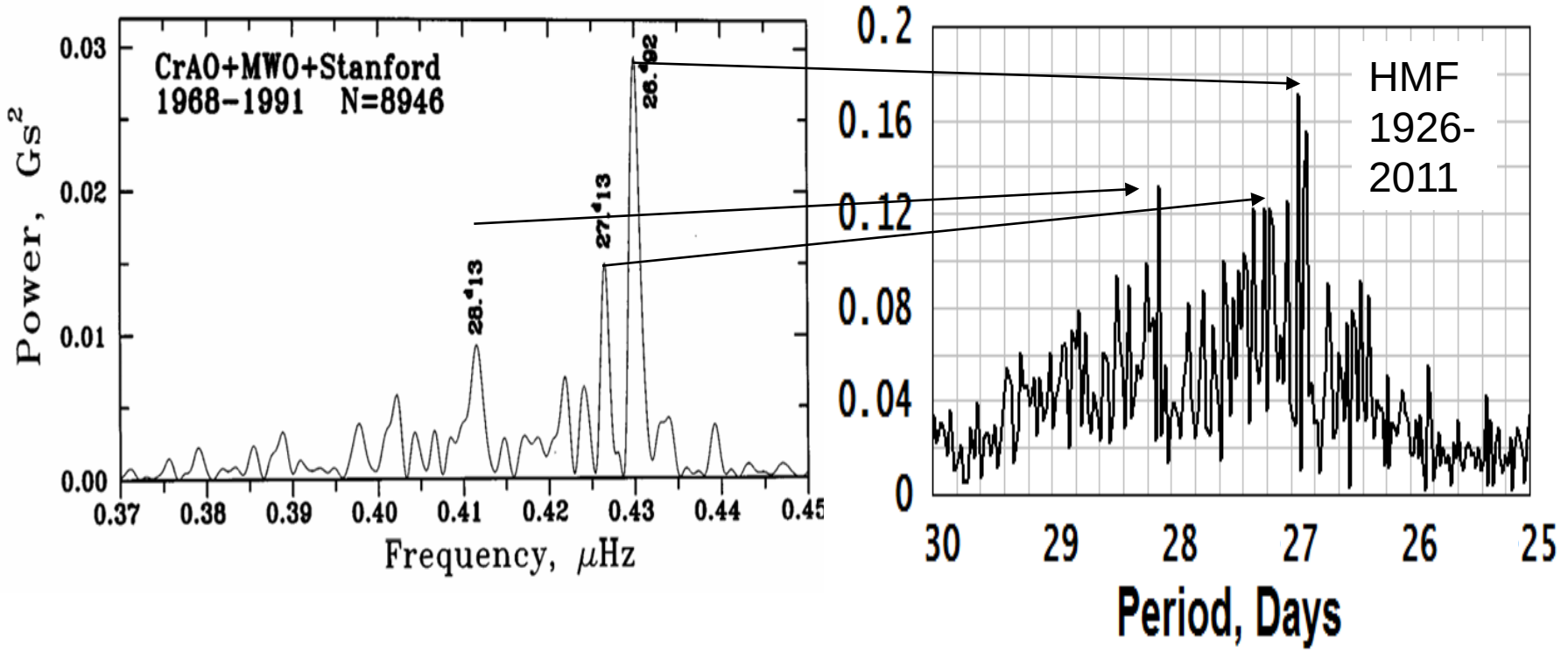
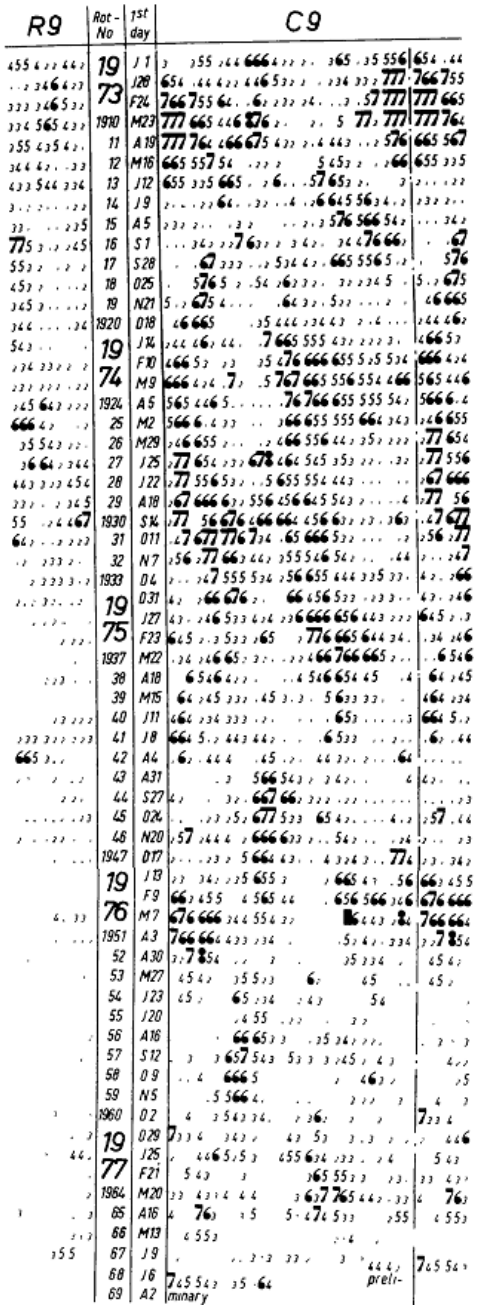
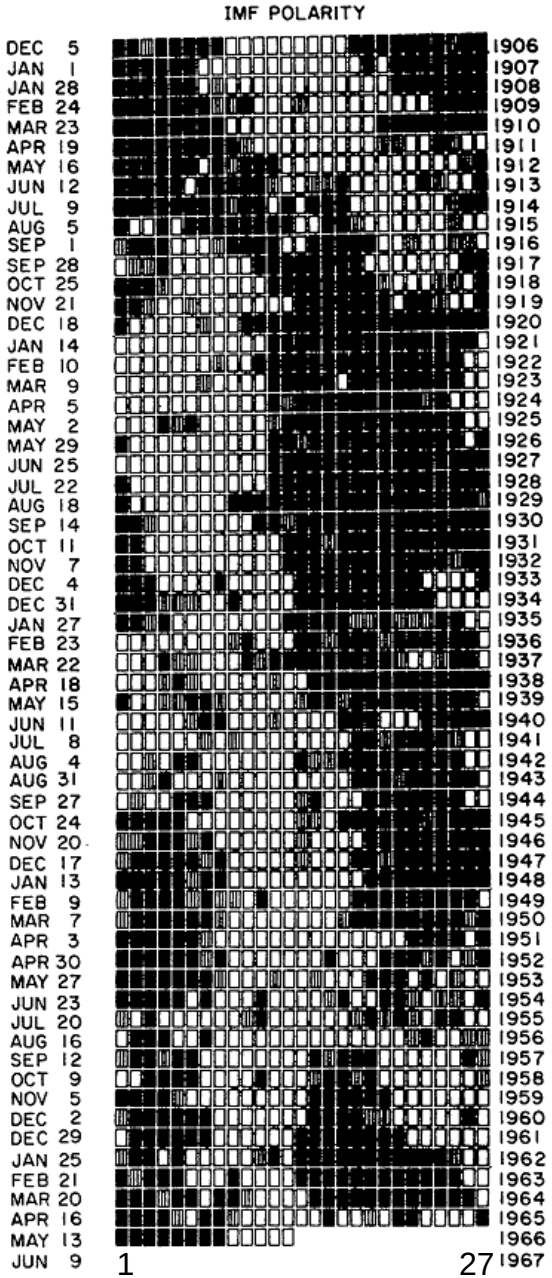
IMF

Same Recurrence Periods over Time for MF and HMF [IMF]

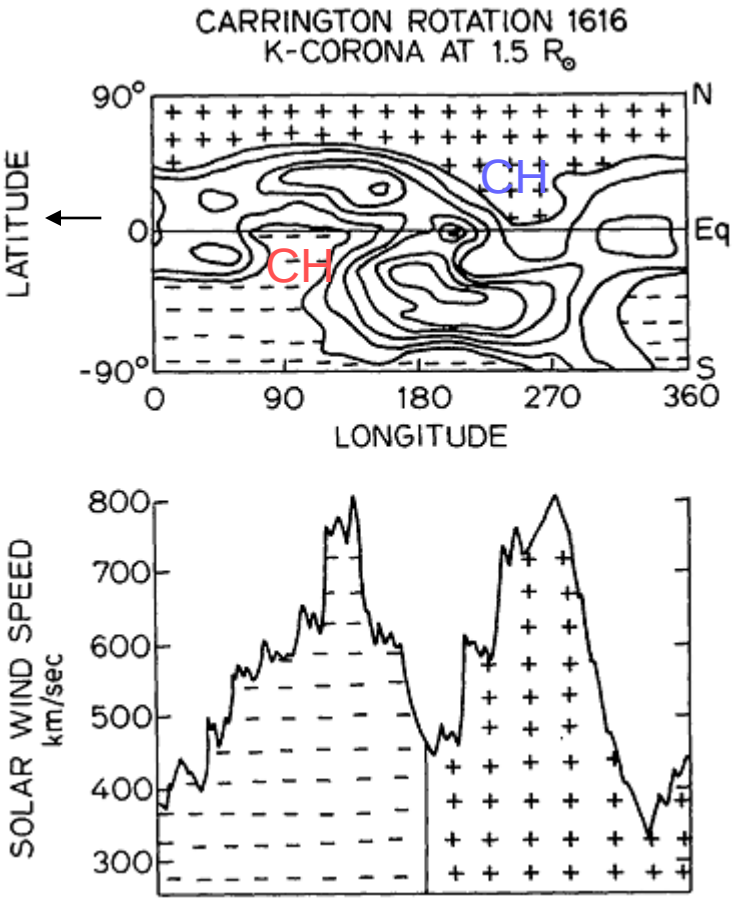


Rotation Plots of the Sector Polarity



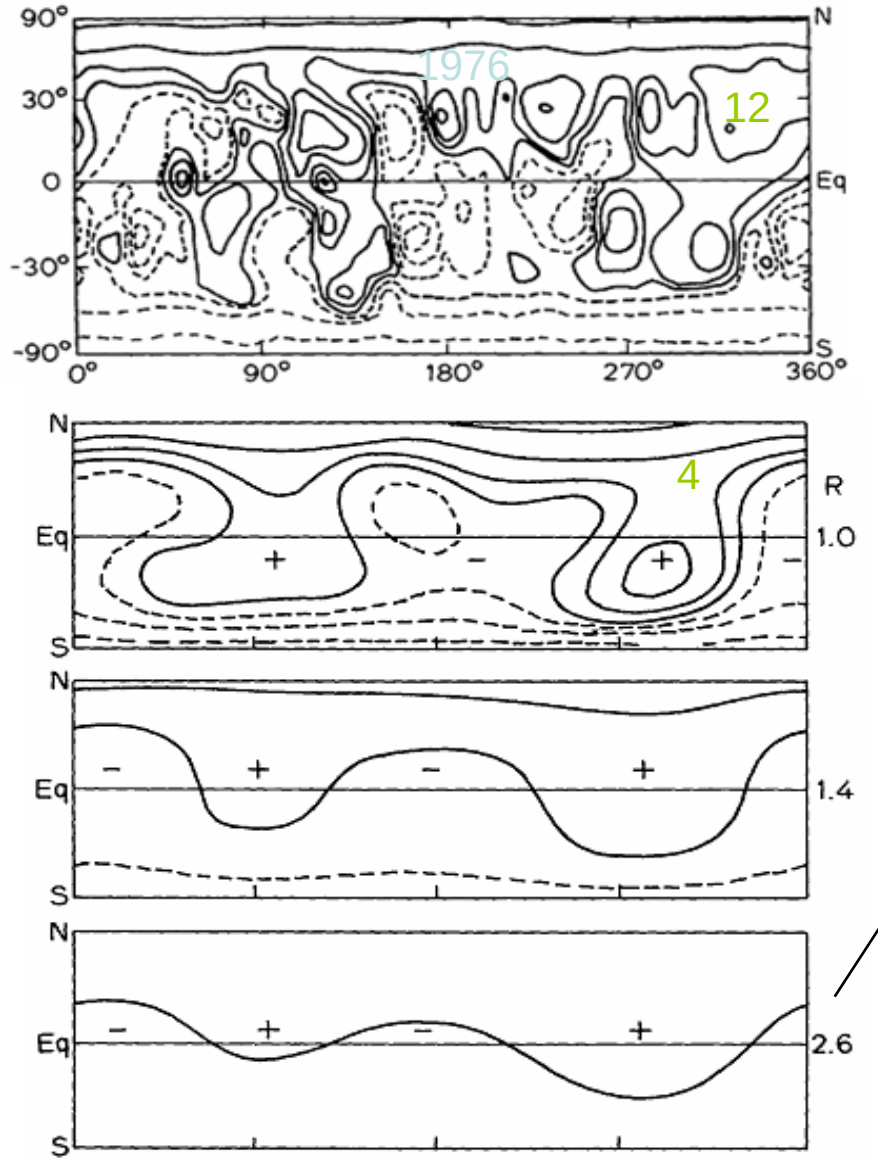


Bartels Rotations

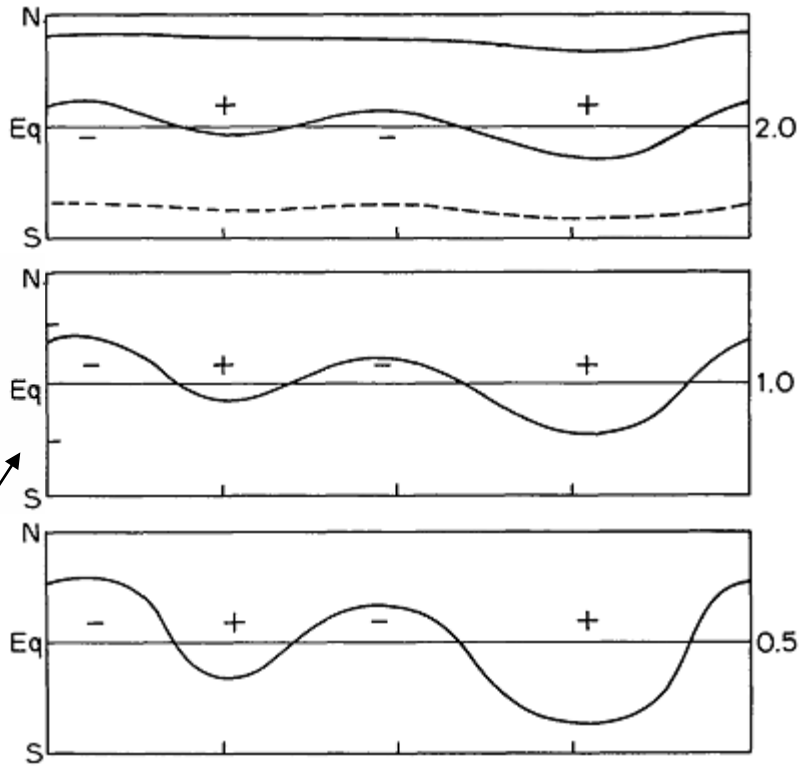


Skylab Workshop, 1976

The Potential Field Source Surface Model Illustrates Many First-Order Effects

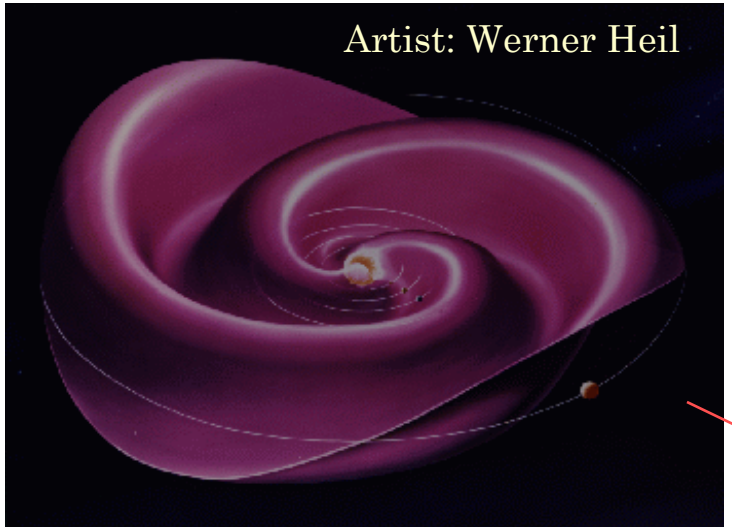


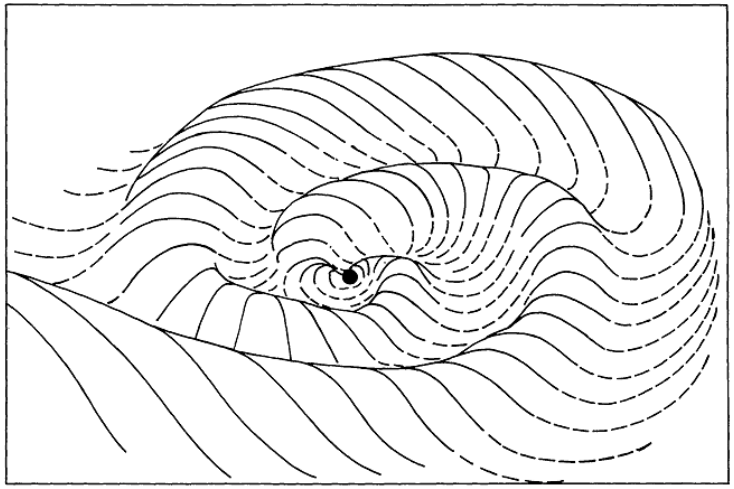
Simplification and Flattening with Height
"Domes of closed field lines"

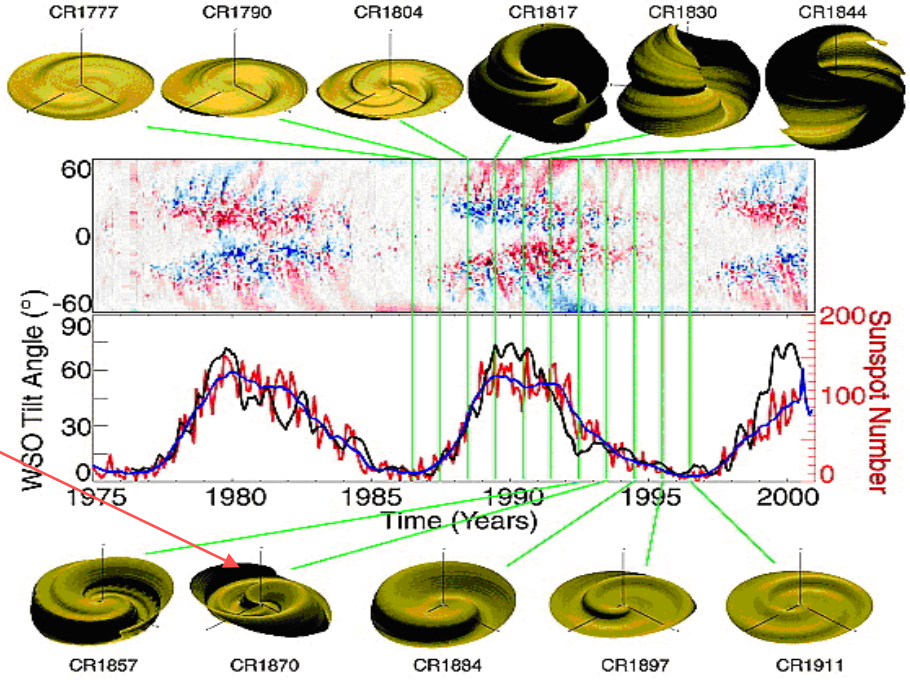


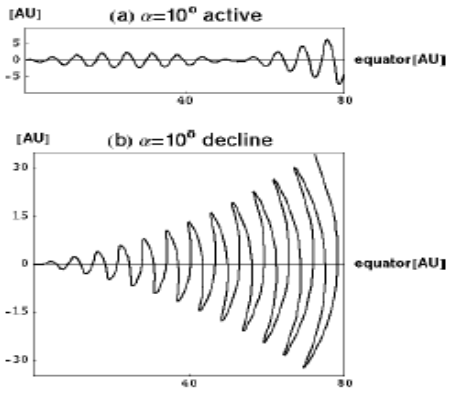
Flattening with Polar Fields

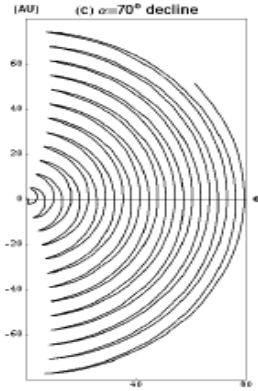
The Heliospheric Current Sheet through the Solar cycle







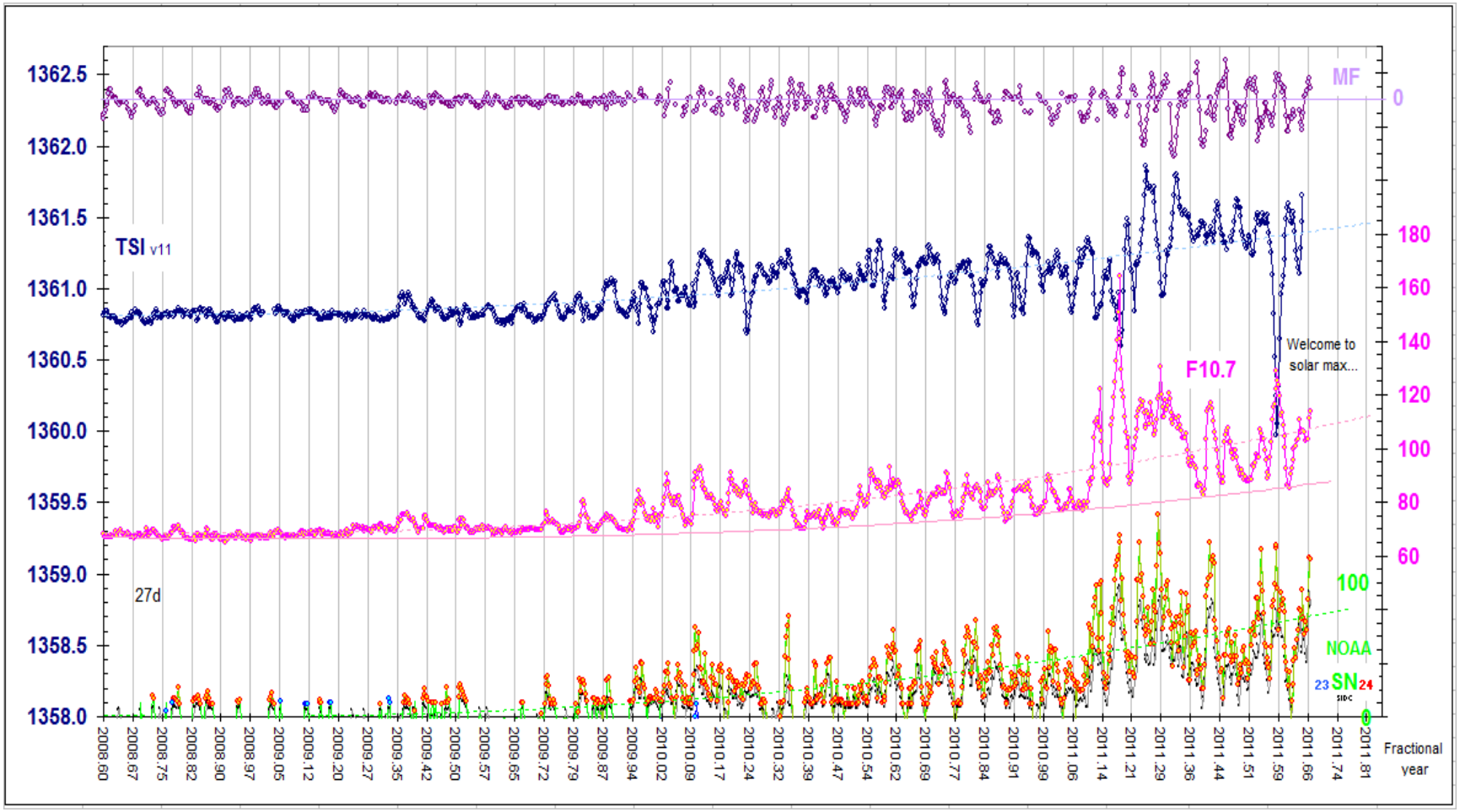




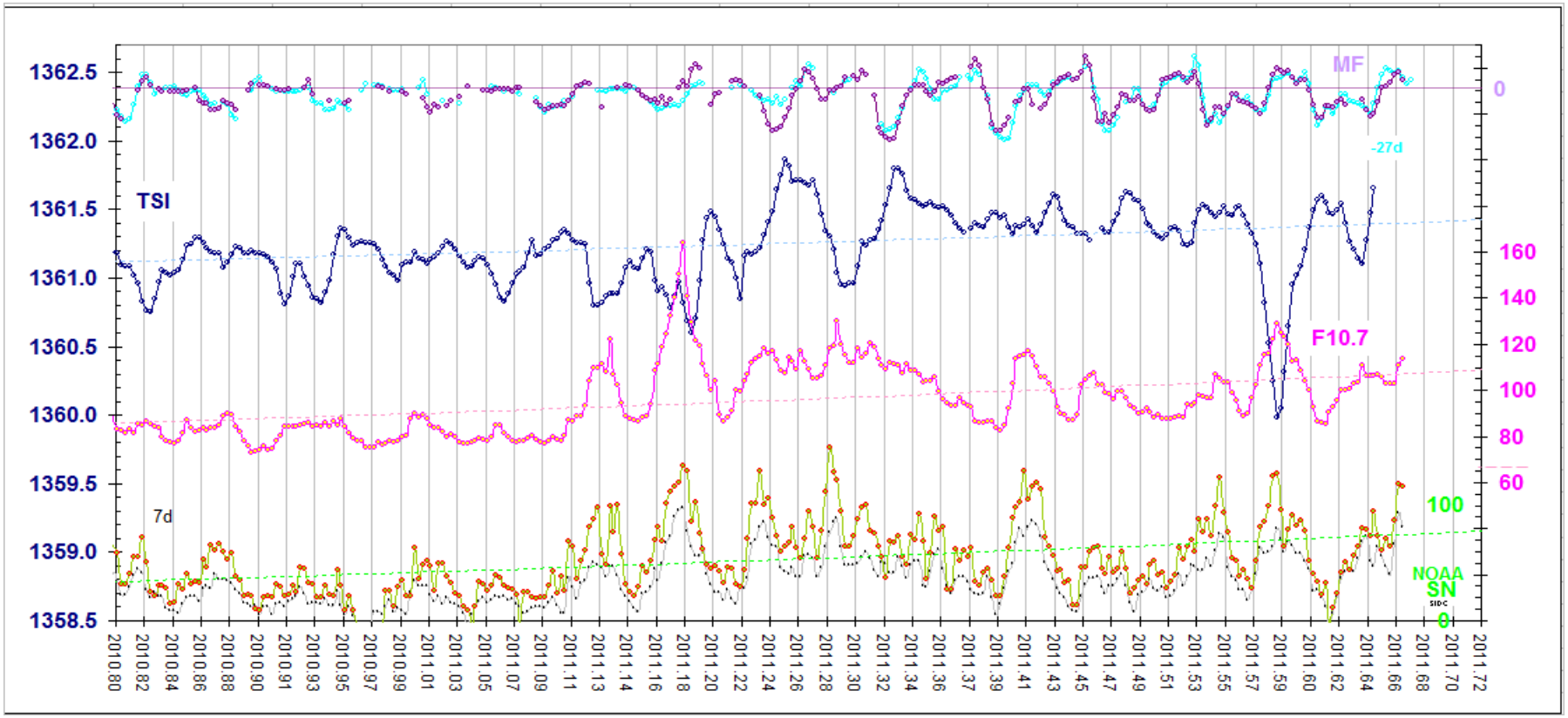
Cosmic Ray Modulation caused by latitudinal variation of HCS and CIRs

Svalgaard & Wilcox, *Nature*, 1976

The MF at the Start of Cycle 24

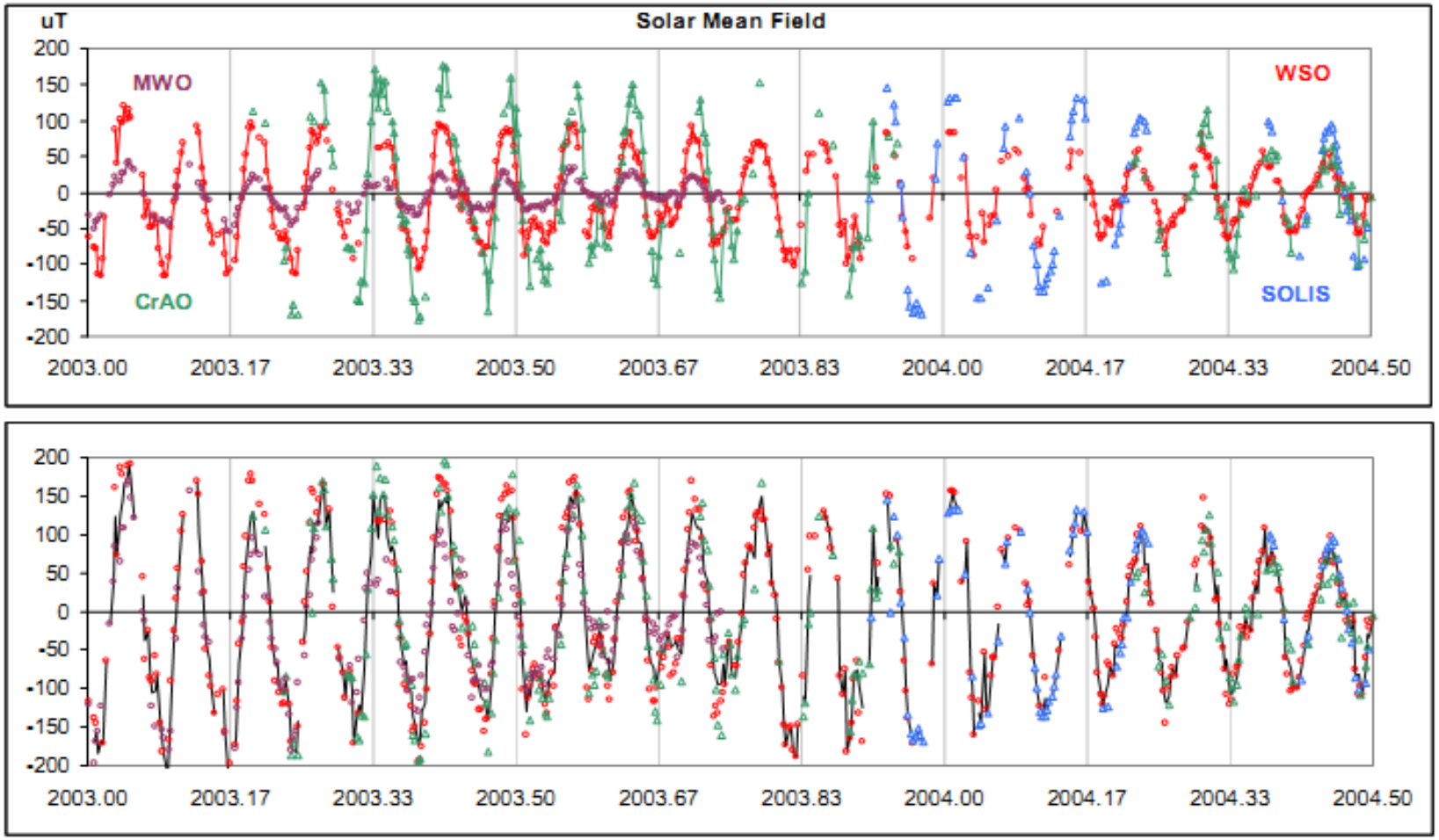


And in Detail



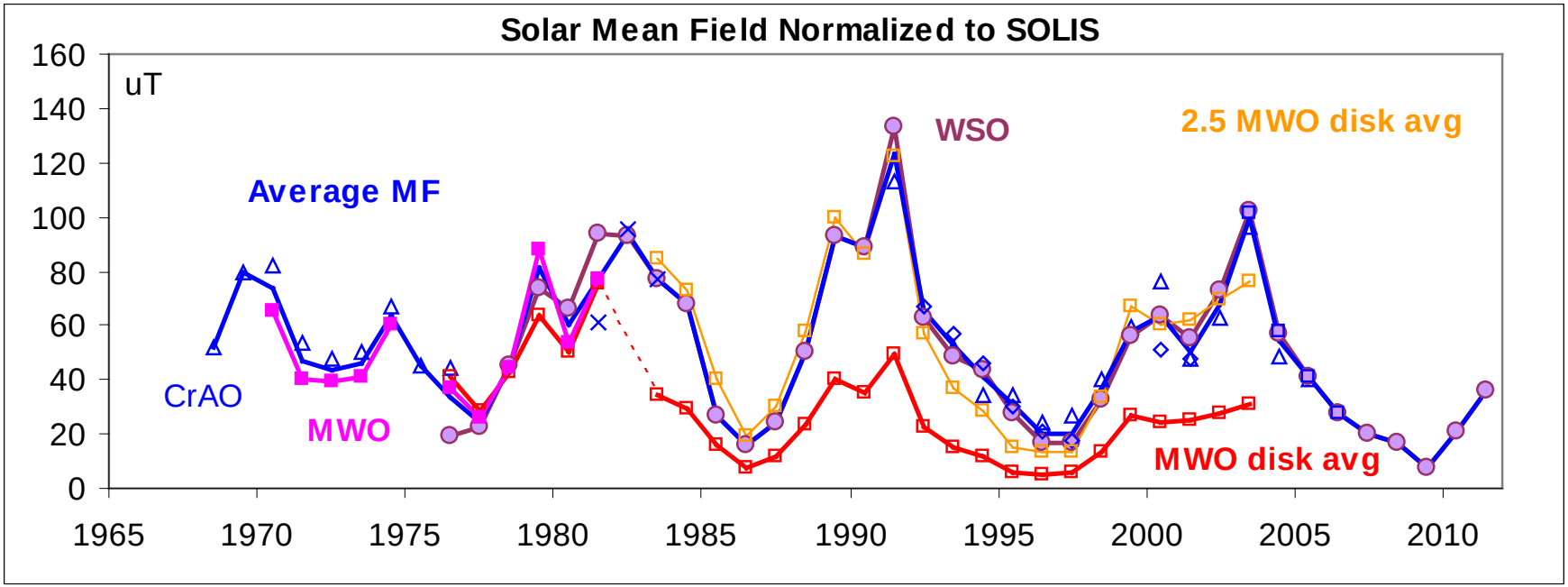
Note the detailed 27-day recurrence in sign and magnitude of the MF

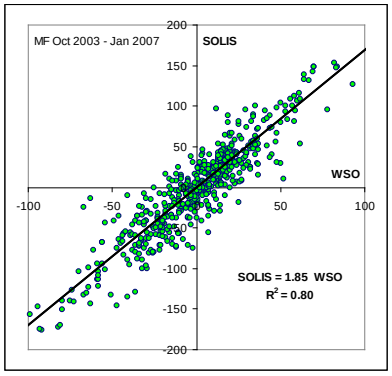
Different Observatories Agree on the Polarity, but NOT on the Magnitude



Roughly: WSO = 2, CrAO = 1, MWO = 4, and SOLIS = 1

MWO Anomaly

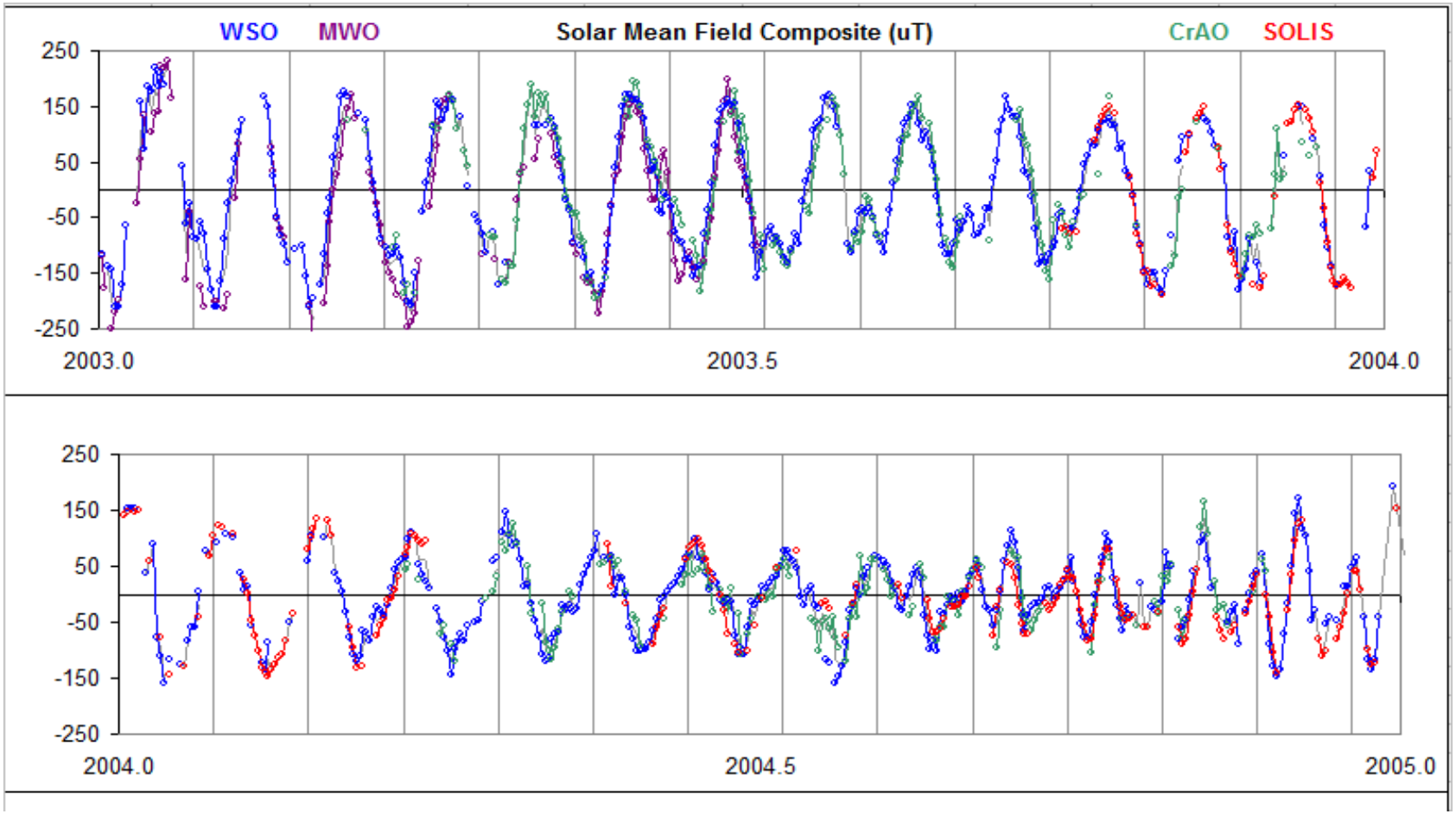




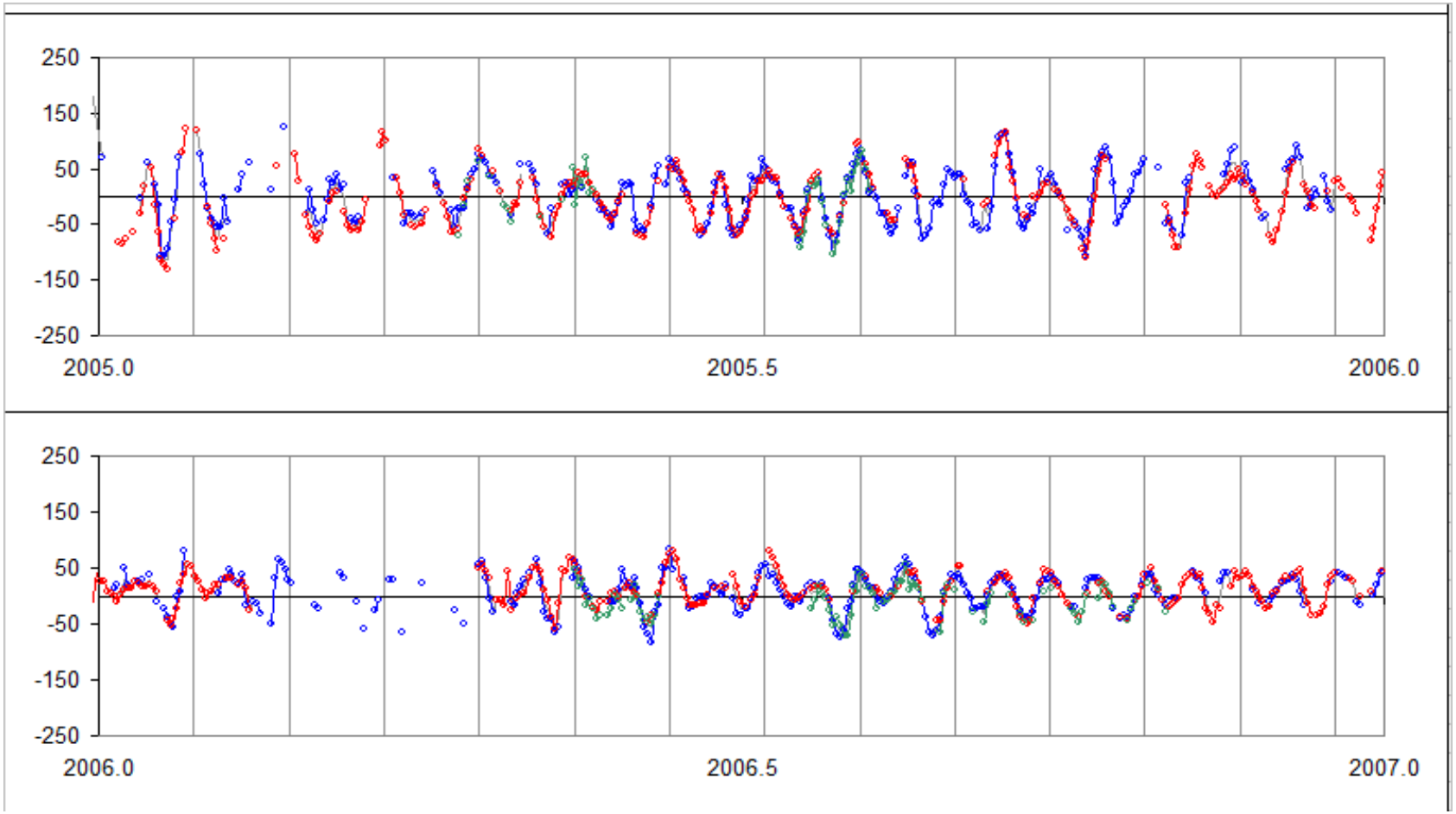
Using the regression factors for each observatory we can bring them all onto the same scale and compute the yearly average of the magnitude

After the upgrade of MWO their MF is much too small

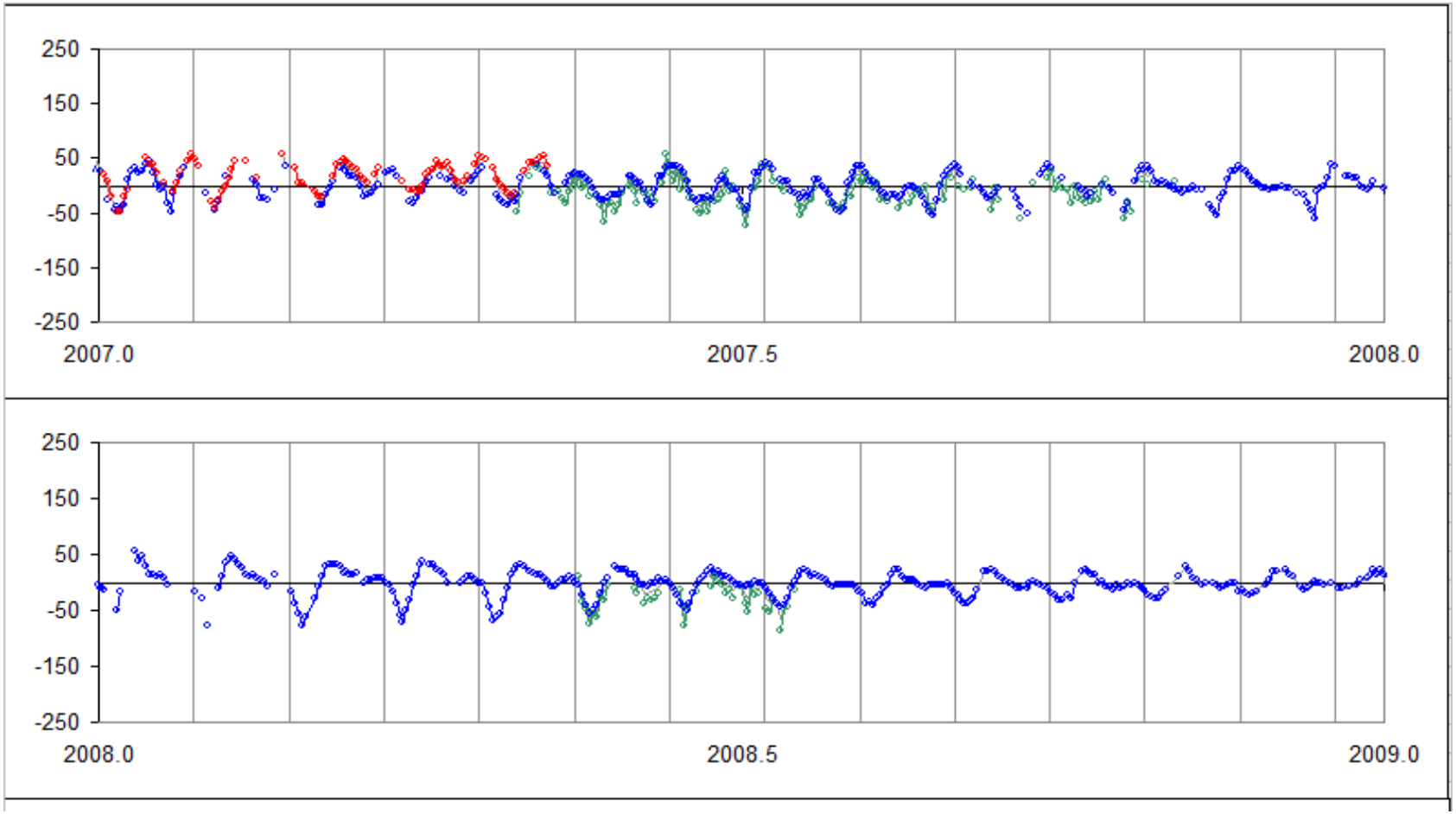
Evolution of the MF Since 2003



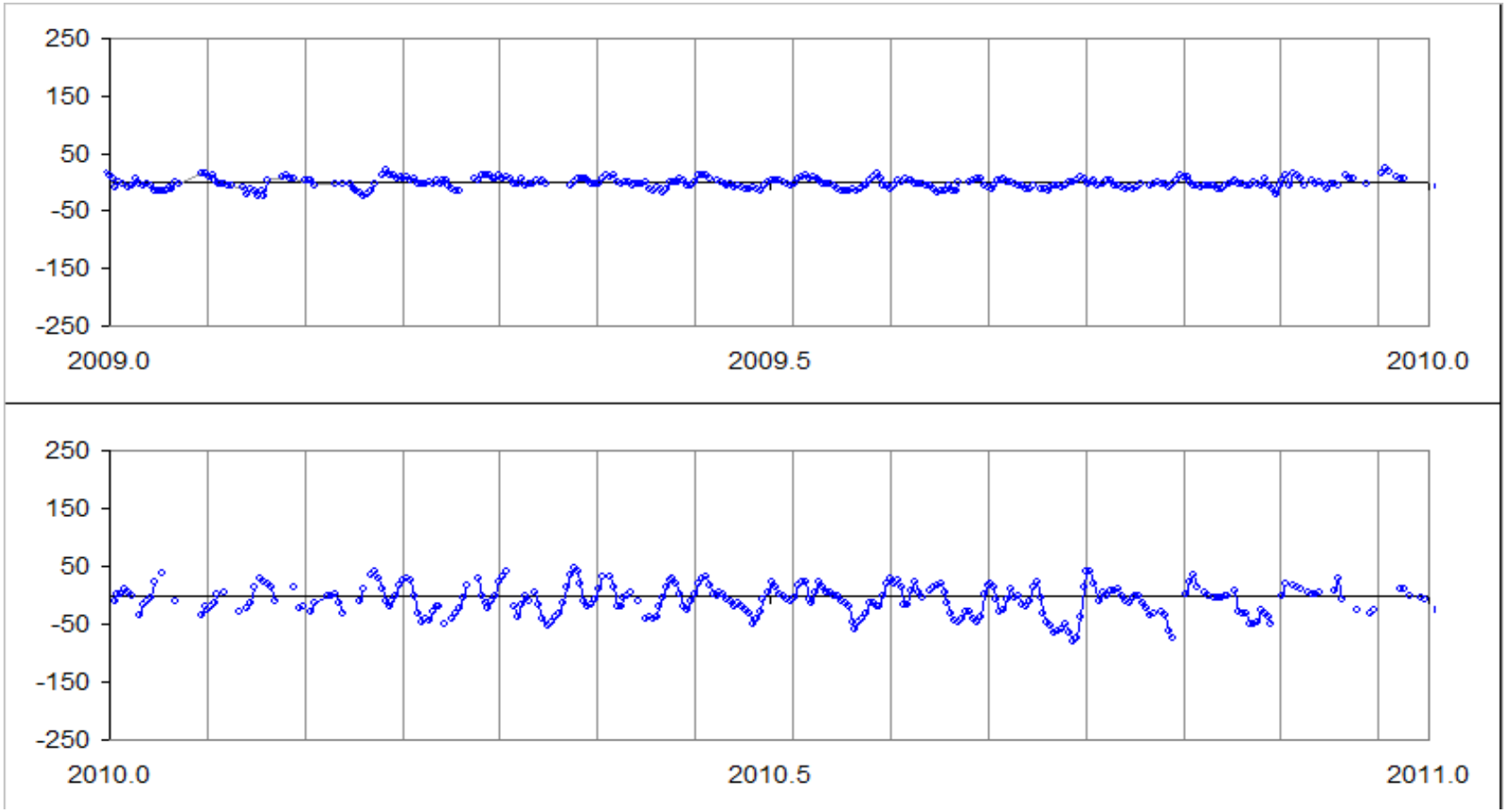
Getting Smaller



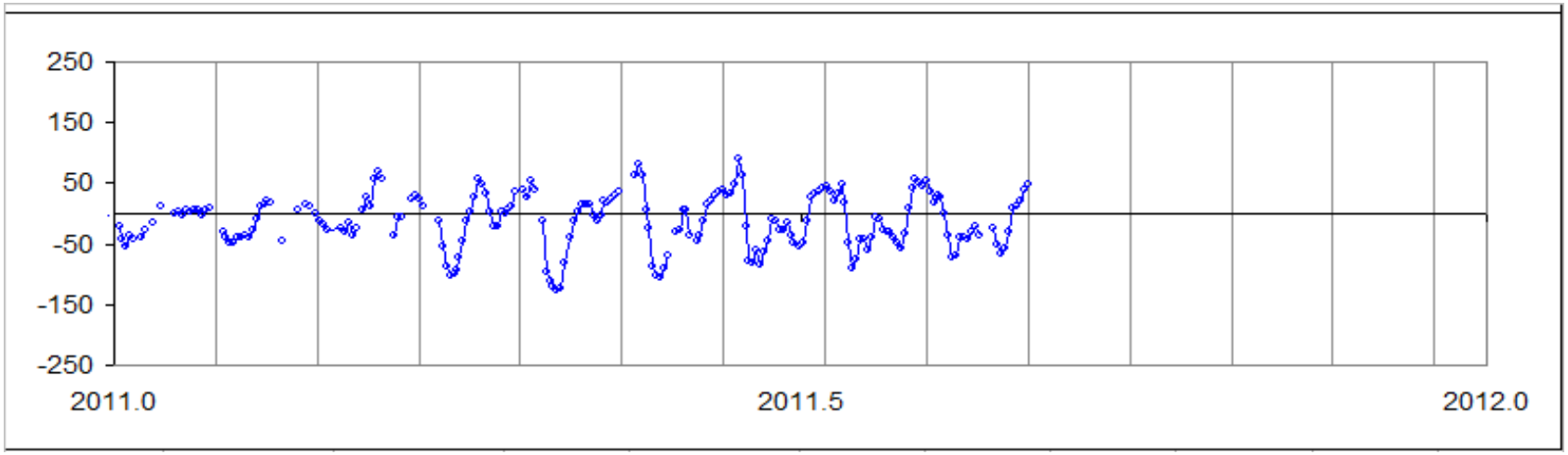
And Smaller

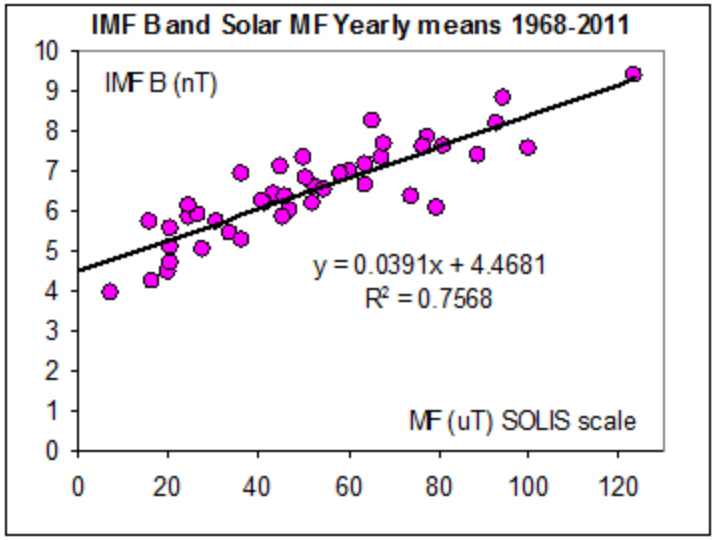

250
150
50
-50
-150
-250
2007.0
2007.5
2008.0
250
150
50
-50
-150
-250
2008.0
2008.5
2009.0

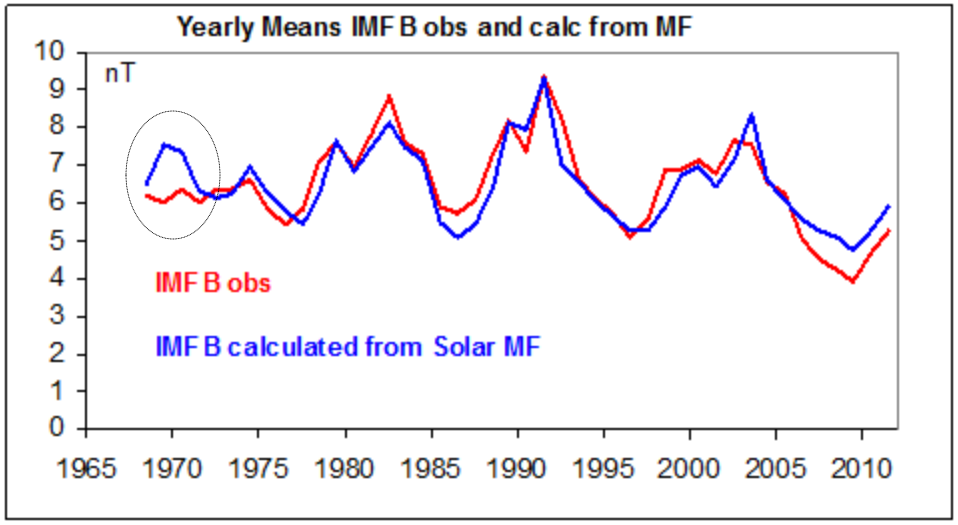
And Smaller, but still matching HMF polarity



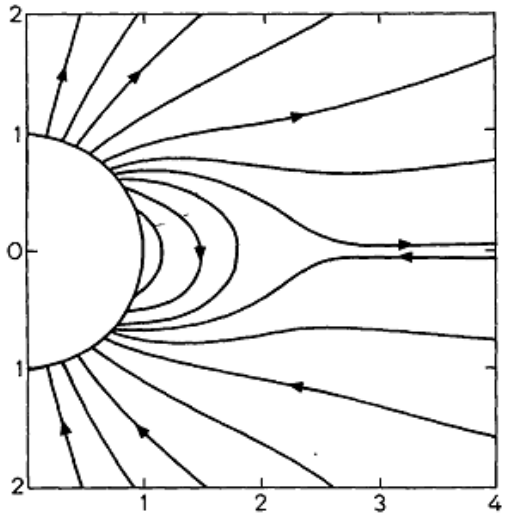
The MF is Riding on a Background HMF that does not Fall Below ~4 nT







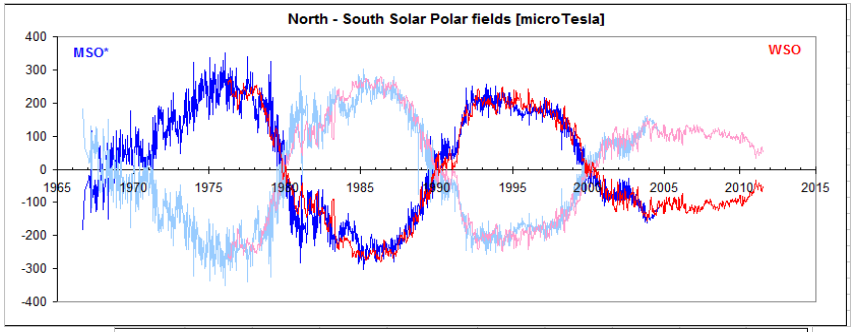
The Importance of the Polar Fields [?]

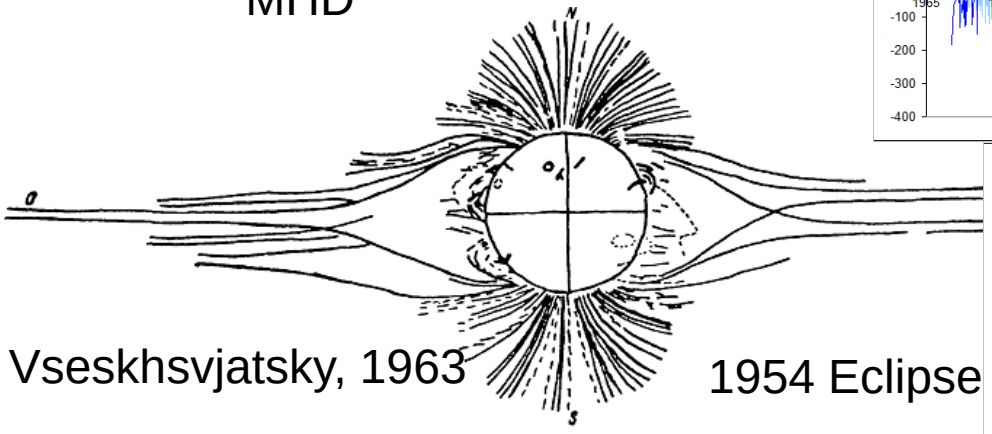


Pneuman & Kopp, 1971
MHD

Even with all the sophistication of current models of the Corona and HMF they are hostage to the correct value of the solar polar fields, which may be different at the two poles and even have longitudinal structure within the polar caps.

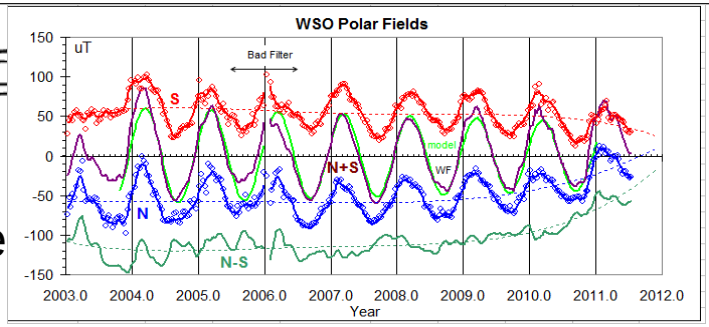
This is particularly important at solar minimum when the HCS is largely flat.





Vseskhsvjatsky, 1963

1954 Eclipse



Conclusion

- The Solar Mean Field continues to track the polarity of the HMF
- The magnitude of the MF does not reflect that of the HMF, but rides on top of a fixed [?] background [i.e. that does not track the polar fields]
- The MF can be used to monitor the calibration of magnetographs
- We should calculate the MF from HMI as a product.