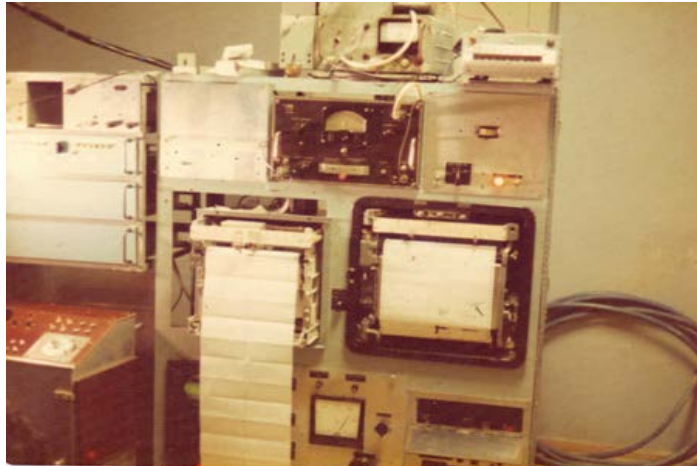


# The Mean Field of the Sun

Leif Svalgaard  
Stanford University  
Sept. 2, 2011

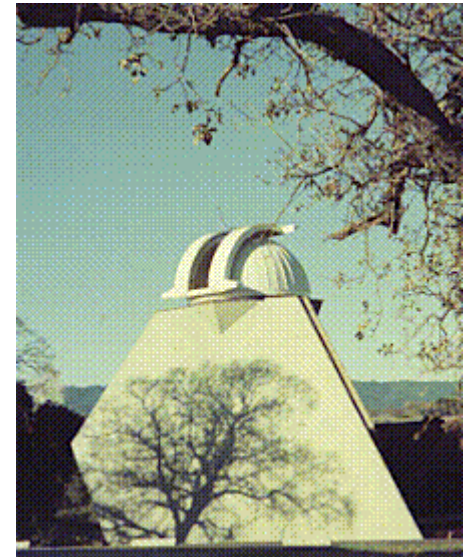
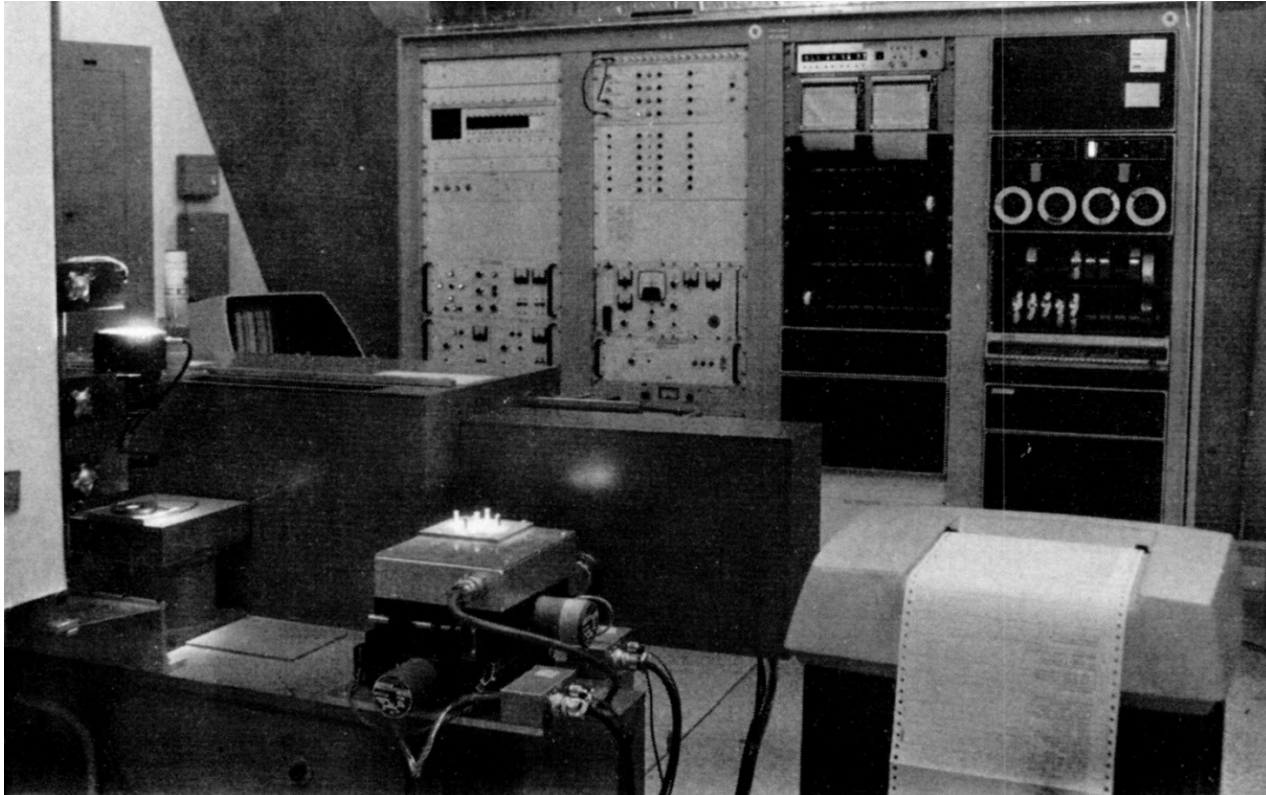
# Crimean Astrophysical Observatory [since 1968]



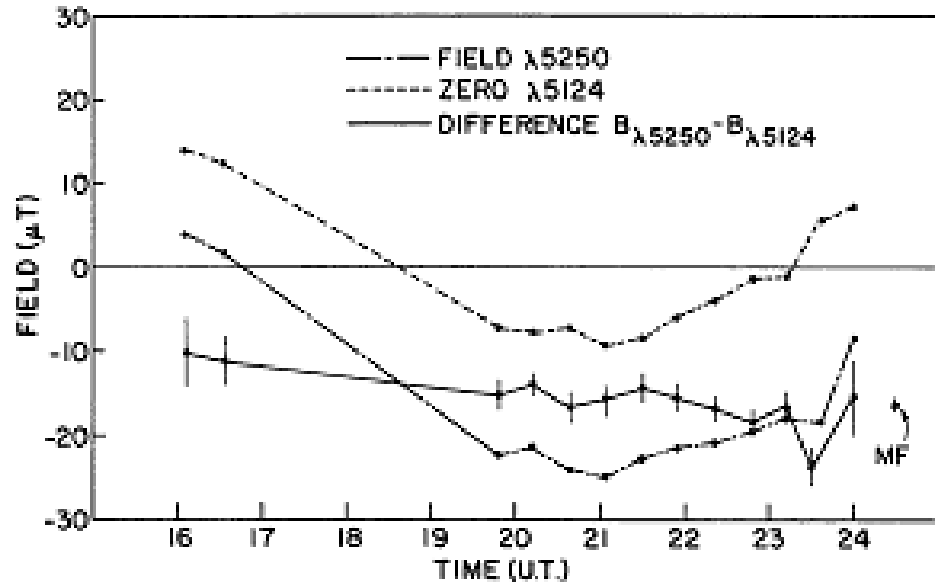
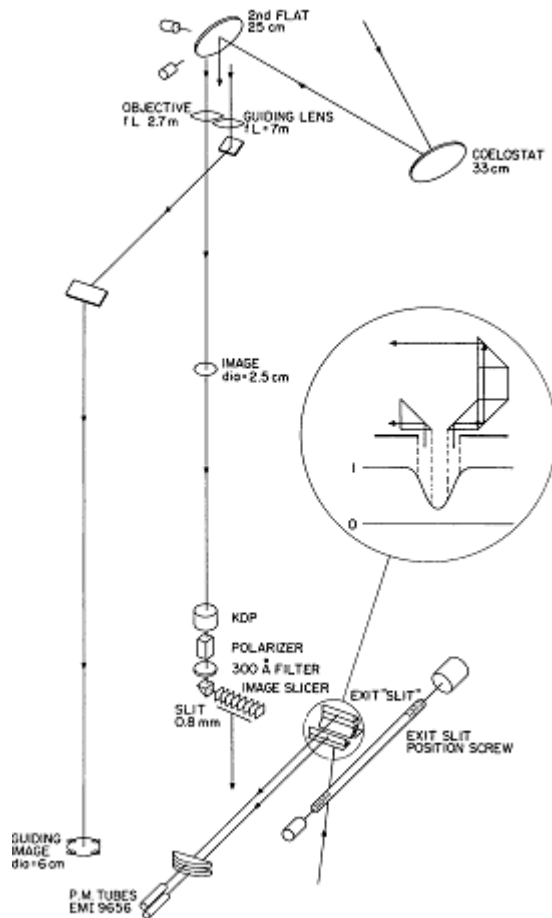
# Mount Wilson Observatory [1970-1982]



# Wilcox Solar Observatory [since 1976]



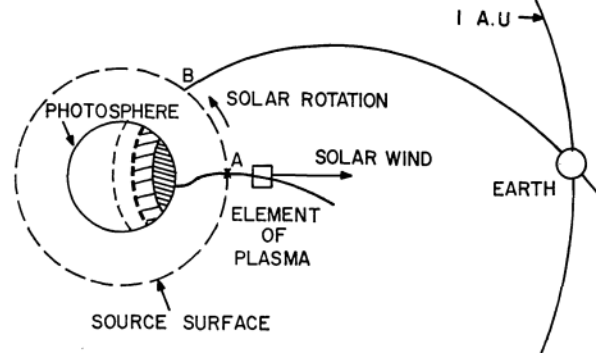
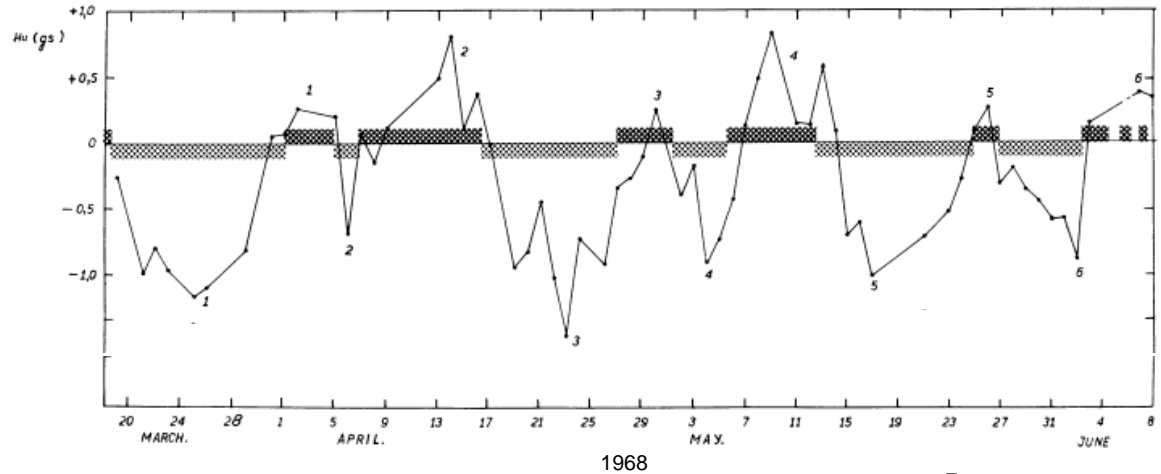
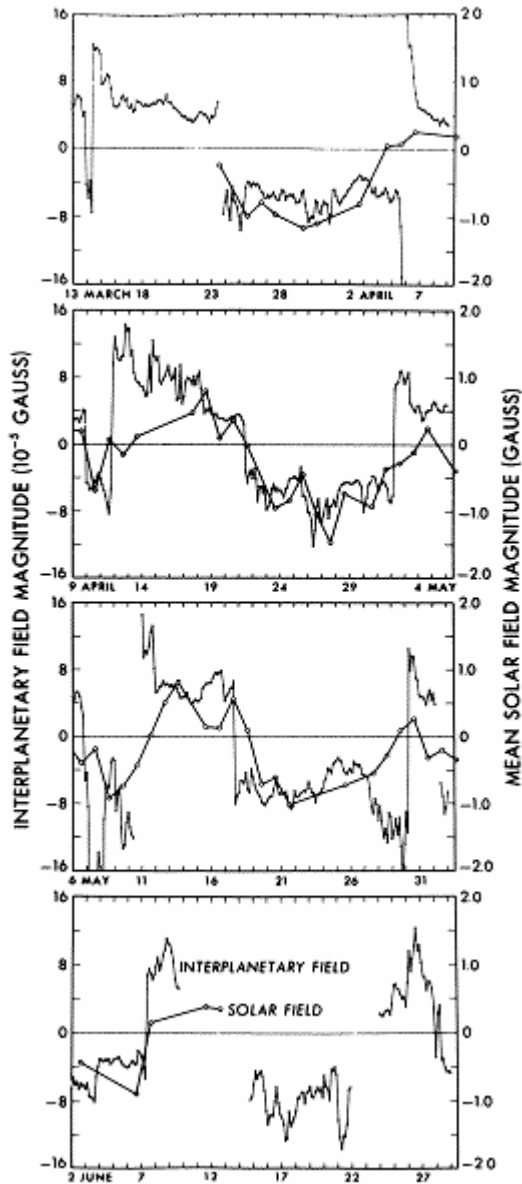
# How the Mean Field is measured



The MF is taken to be the difference between the magnetic signal in  $\lambda 525.0$  nm and the non-magnetic line  $\lambda 512.4$  nm.

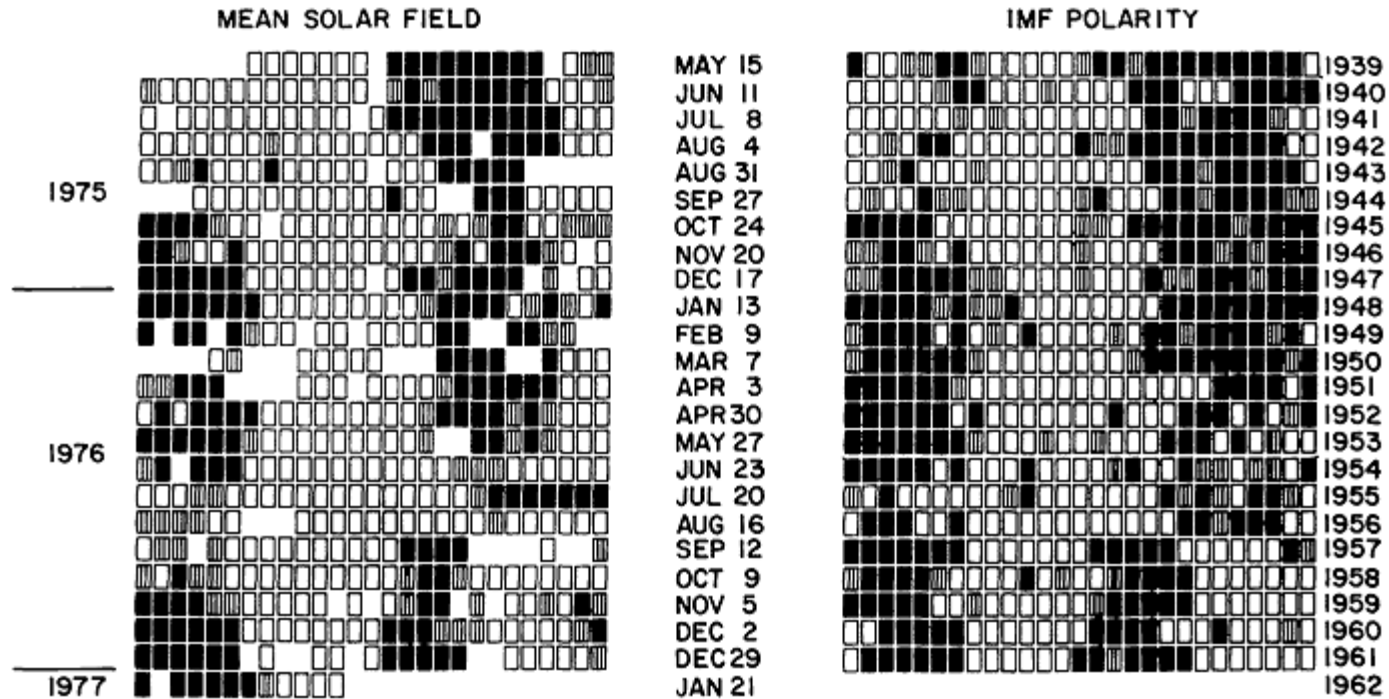
# The Early Interpretation

MF as measured at CrAO



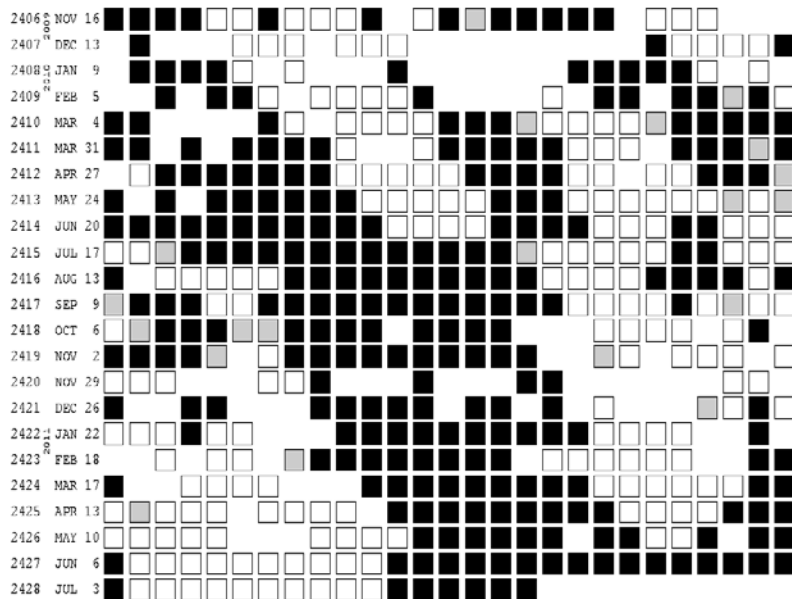
$B_{INT} = 7.2 \times 10^{-5} B_{MF}$  (for  $2.0 R_{\odot}$ ). "Thus there is a very direct relationship in *polarity* and in *magnitude* between the mean solar field and the observed interplanetary field with a 4½ day delay" (Schatten, 1970)

# The Polarity Relationship [then]

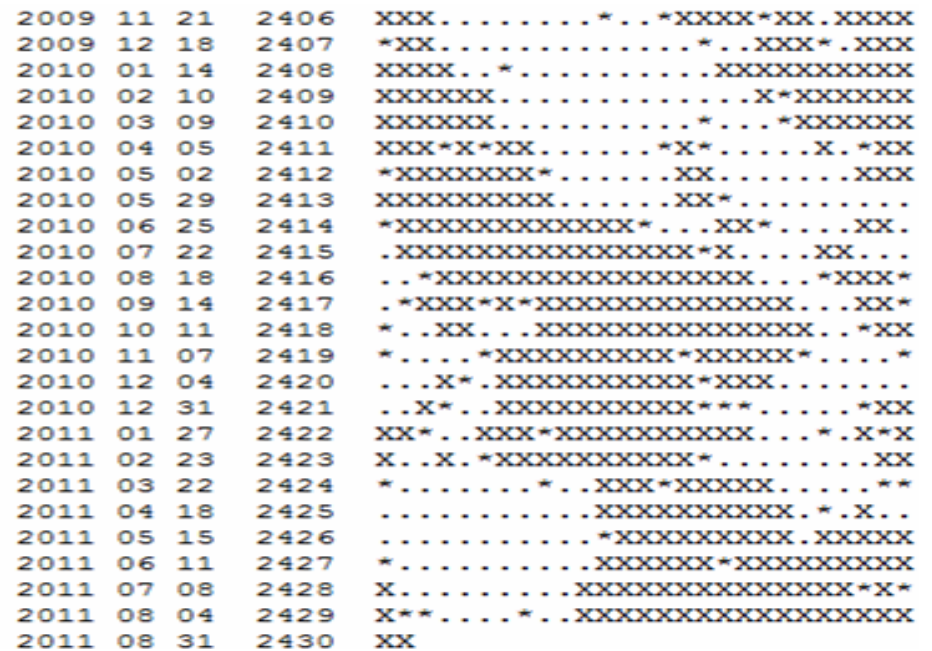


WSO 5 days before

# The Polarity Relationship [now]

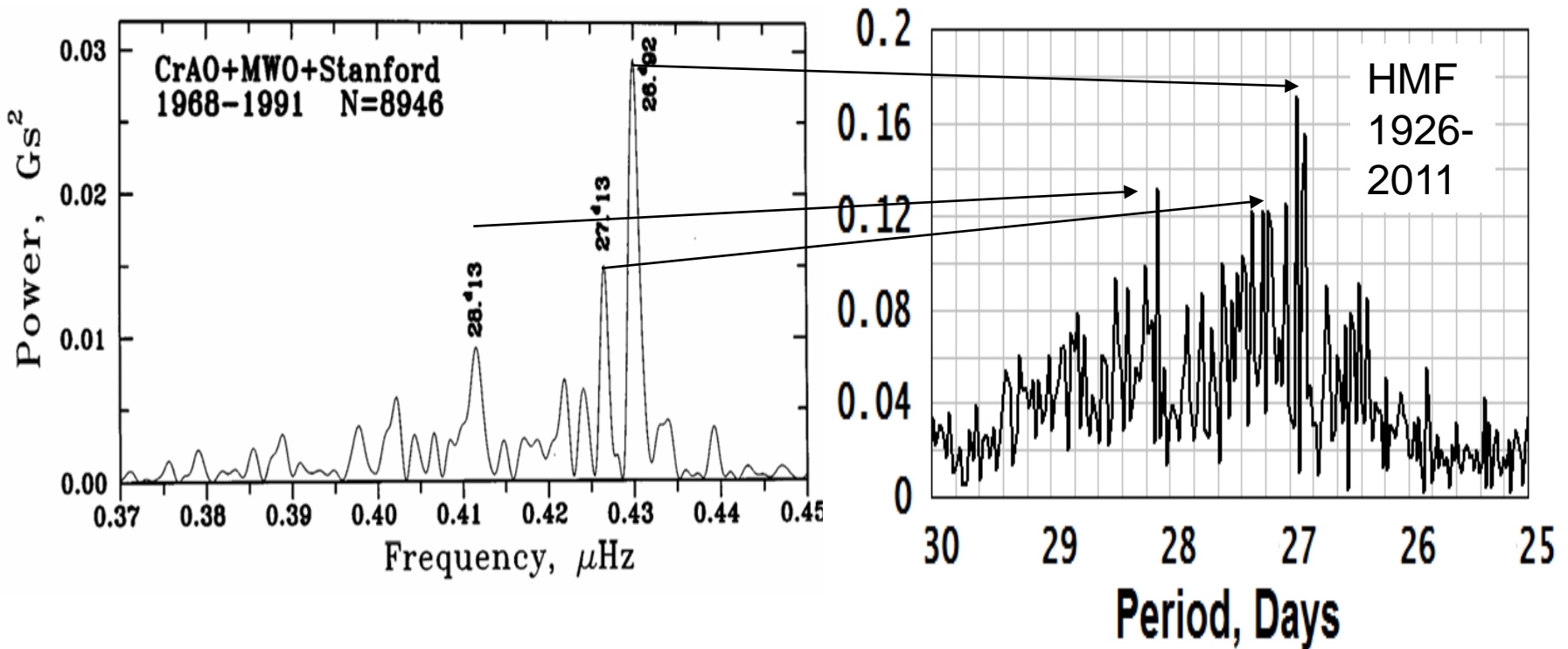


WSO 5 days before



IMF

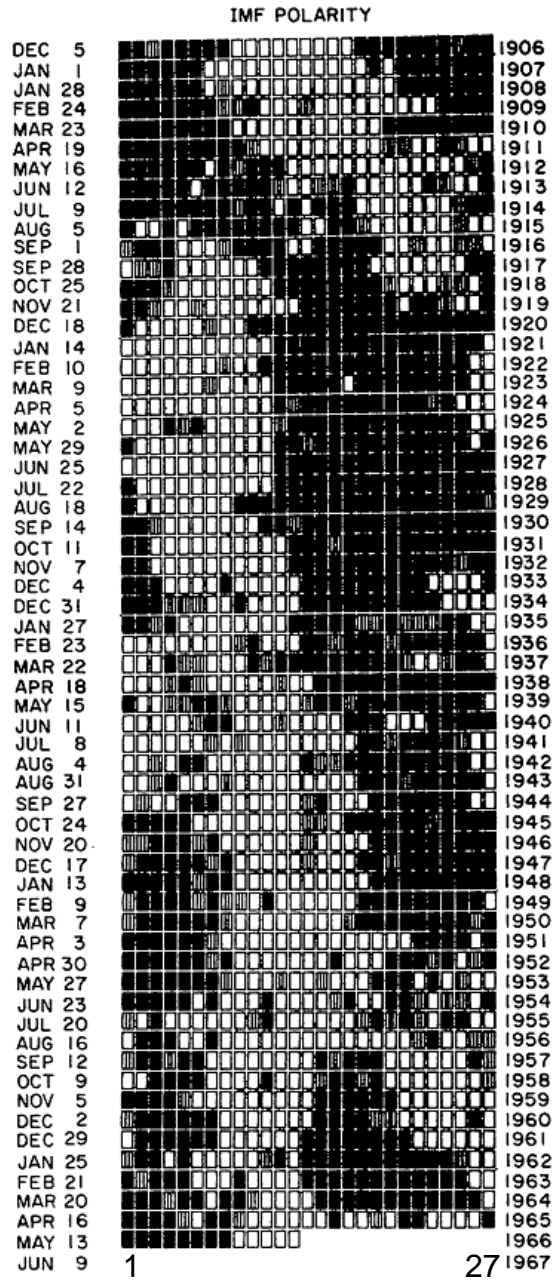
# Same Recurrence Periods over Time for MF and HMF [IMF]



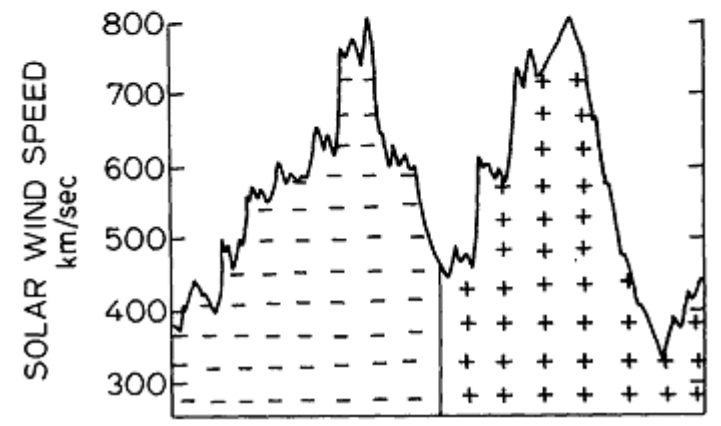
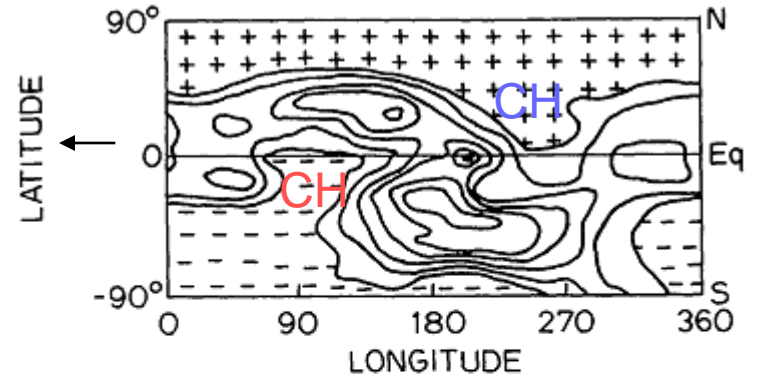


# Rotation Plots of the Sector Polarity

R9	Rot- No	1st day	C9
458 422 442	19	J 1	3 355 244 666 422 2 365 35 556 654 44
112 346 422	73	J20	654 444 422 446 522 2 234 322 777 766 755
322 346 522	F24	766 755 64 62 222 24 112 57 777 777 665	
324 565 422	1910	M29	777 665 446 476 2 2 2 5 77 777 777 764
355 435 422	11	A 18	777 766 466 675 422 2 4 442 112 576 665 567
344 42 222	12	M 18	665 557 54 222 2 5 452 2 2 666 655 225
422 544 224	13	J 12	655 325 665 2 6 11 57 652 2 2 2 2 2 2 2
3 2 2 2 2 2	14	J 9	2 2 2 2 6 2 2 2 2 4 2 6 6 4 5 5 6 2 2 2 2 2 2 2
32 2 2 2 5	15	A 5	2 2 2 2 2 2 2 2 2 2 2 2 2 576 566 542 2 2 2 2
775 2 2 2 5	16	S 1	2 2 2 2 2 2 7 6 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
552 2 2 2 2	17	S 28	2 2
452 2 2 2 2	18	O 25	2 2
345 2 2 2 2	19	N 27	2 2
344 2 2 2 2	1920	O 18	2 2
542 2 2 2 2	19	J 14	2 2
224 222 2 2	F 20	2 2	
222 222 2 2	M 9	2 2	
245 642 222	1924	A 5	2 2
666 42 2 2	25	M 2	2 2
35 542 2 2	26	M 29	2 2
36 64 224	27	J 25	2 2
443 222 454	28	J 22	2 2
322 2 2 2 5	29	A 18	2 2
55 2 2 2 4 67	1930	S 4	2 2
642 2 2 2 2	31	O 11	2 2
2 2 2 2 2 2	32	N 7	2 2
2 2 2 2 2 2	1933	D 4	2 2
2 2 2 2 2 2	19	O 31	2 2
2 2 2 2 2 2	75	J 27	2 2
2 2 2 2 2 2	1937	F 23	2 2
2 2 2 2 2 2	38	M 22	2 2
2 2 2 2 2 2	39	A 18	2 2
2 2 2 2 2 2	40	M 15	2 2
2 2 2 2 2 2	41	J 11	2 2
2 2 2 2 2 2	42	J 8	2 2
2 2 2 2 2 2	43	A 4	2 2
2 2 2 2 2 2	44	A 31	2 2
2 2 2 2 2 2	45	S 27	2 2
2 2 2 2 2 2	46	O 24	2 2
2 2 2 2 2 2	48	N 20	2 2
2 2 2 2 2 2	1947	D 17	2 2
4 2 33	19	J 13	2 2
2 2 2 2 2 2	76	F 9	2 2
2 2 2 2 2 2	1951	M 7	2 2
2 2 2 2 2 2	52	A 3	2 2
2 2 2 2 2 2	53	A 30	2 2
2 2 2 2 2 2	54	M 27	2 2
2 2 2 2 2 2	55	J 23	2 2
2 2 2 2 2 2	56	J 20	2 2
2 2 2 2 2 2	57	A 16	2 2
2 2 2 2 2 2	58	S 12	2 2
2 2 2 2 2 2	59	O 9	2 2
2 2 2 2 2 2	59	N 5	2 2
2 2 2 2 2 2	1960	D 2	2 2
2 2 2 2 2 2	19	O 29	2 2
2 2 2 2 2 2	77	J 25	2 2
2 2 2 2 2 2	1964	F 21	2 2
2 2 2 2 2 2	65	M 20	2 2
2 2 2 2 2 2	66	A 16	2 2
2 2 2 2 2 2	67	M 13	2 2
2 2 2 2 2 2	68	J 9	2 2
2 2 2 2 2 2	69	A 2	2 2

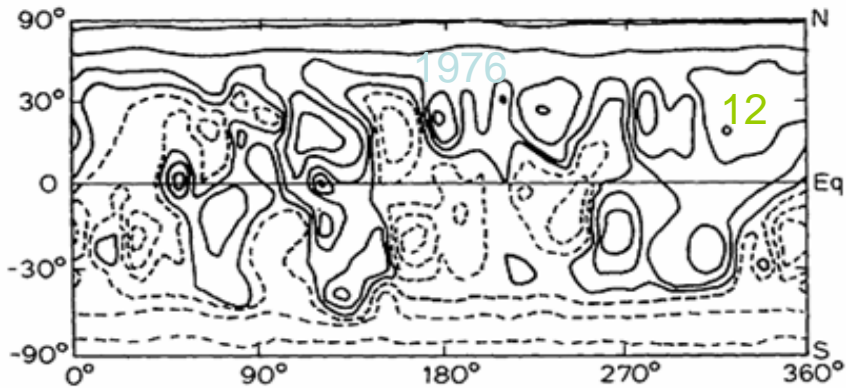


CARRINGTON ROTATION 1616  
K-CORONA AT 1.5 R<sub>☉</sub>

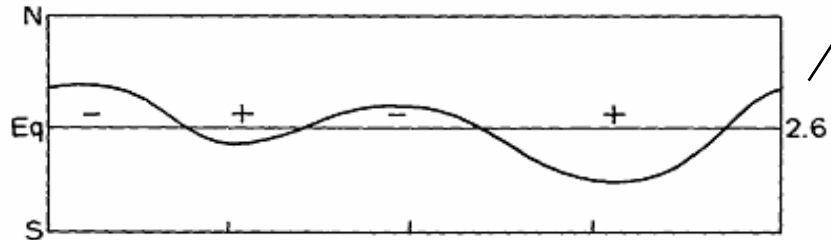
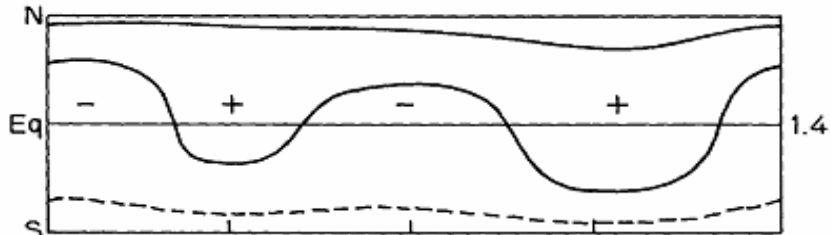
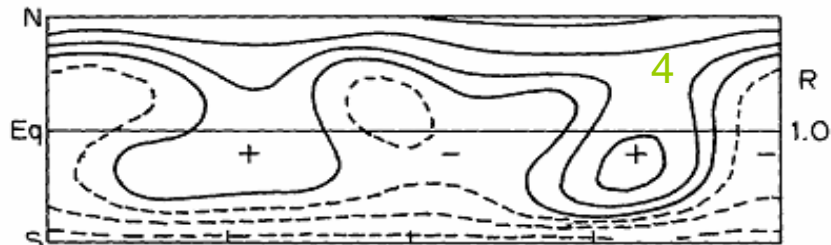


Skylab Workshop, 1976

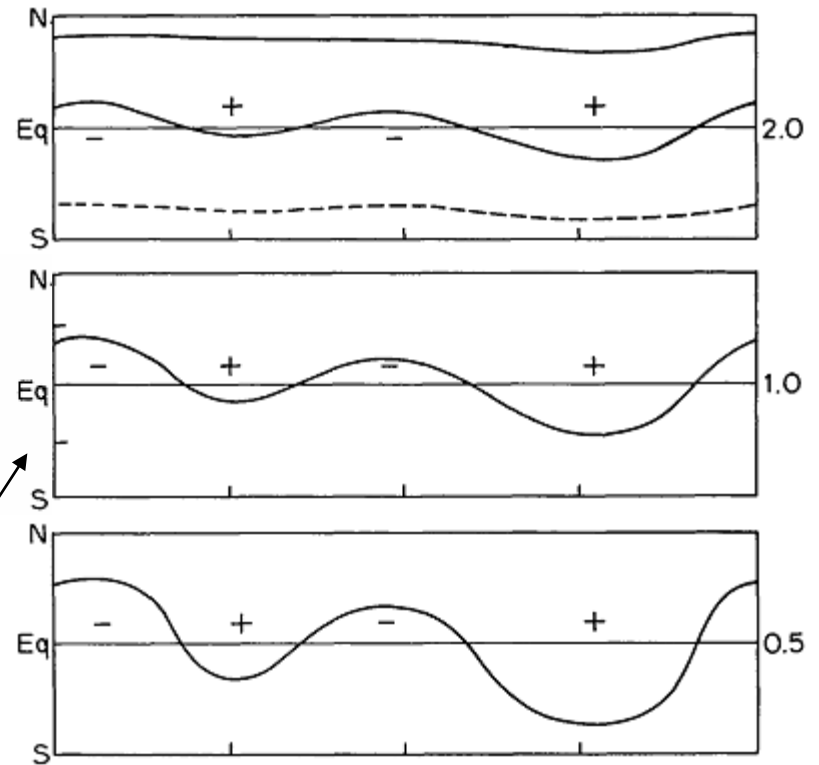
Bartels Rotations



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

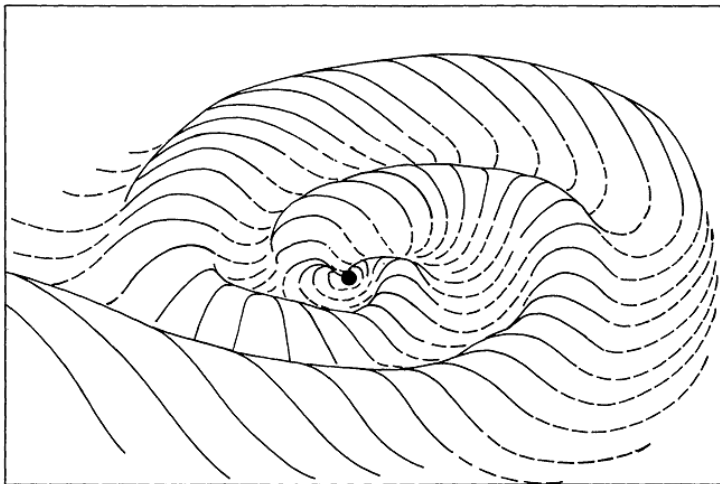
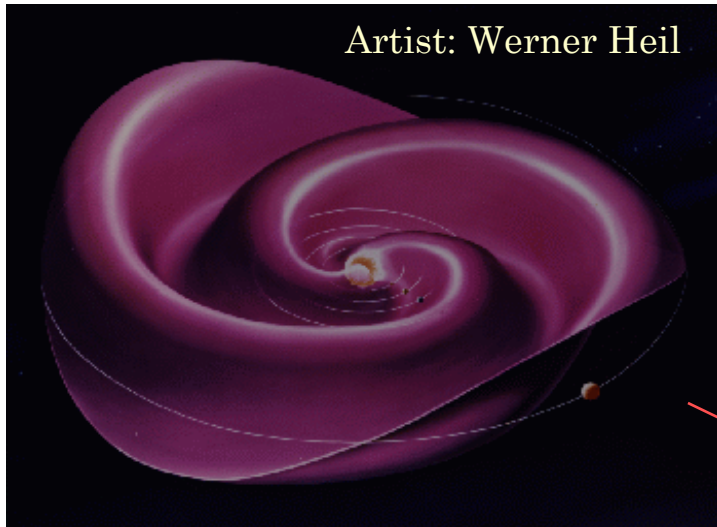


Simplification and Flattening with Height  
“Domes of closed field lines”

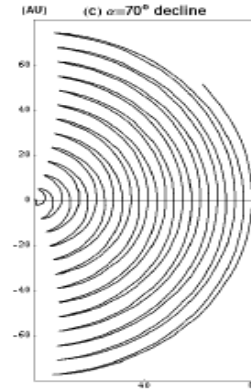
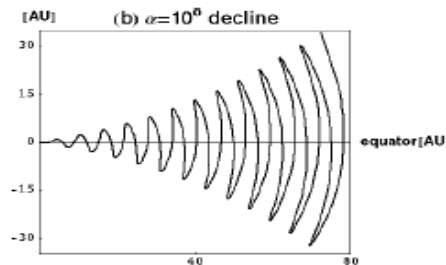
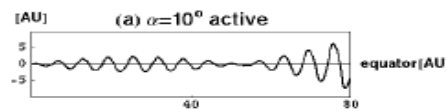
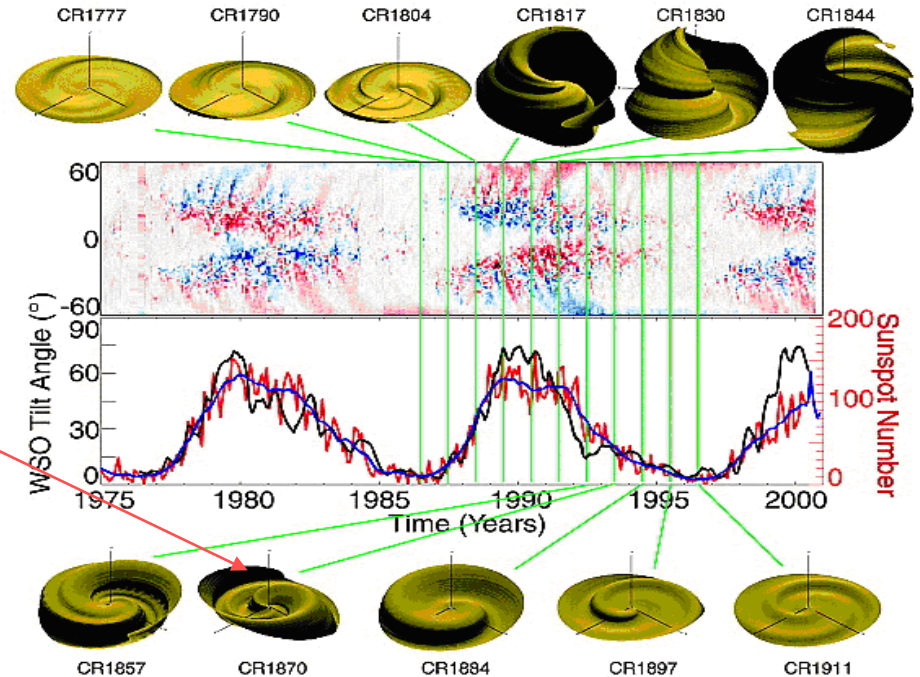


Flattening with Polar Fields

# The Heliospheric Current Sheet through the Solar cycle

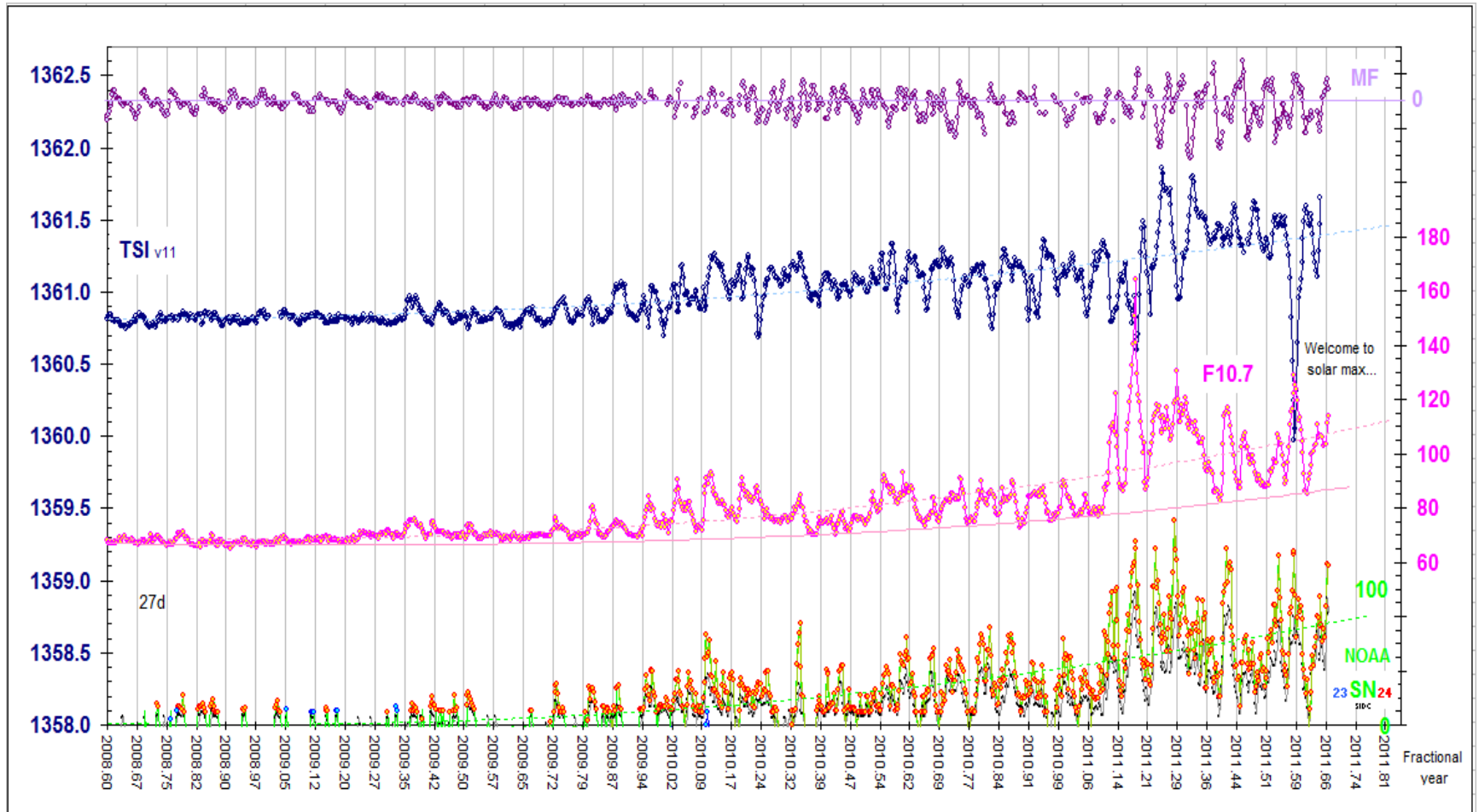


Svalgaard & Wilcox, *Nature*, 1976

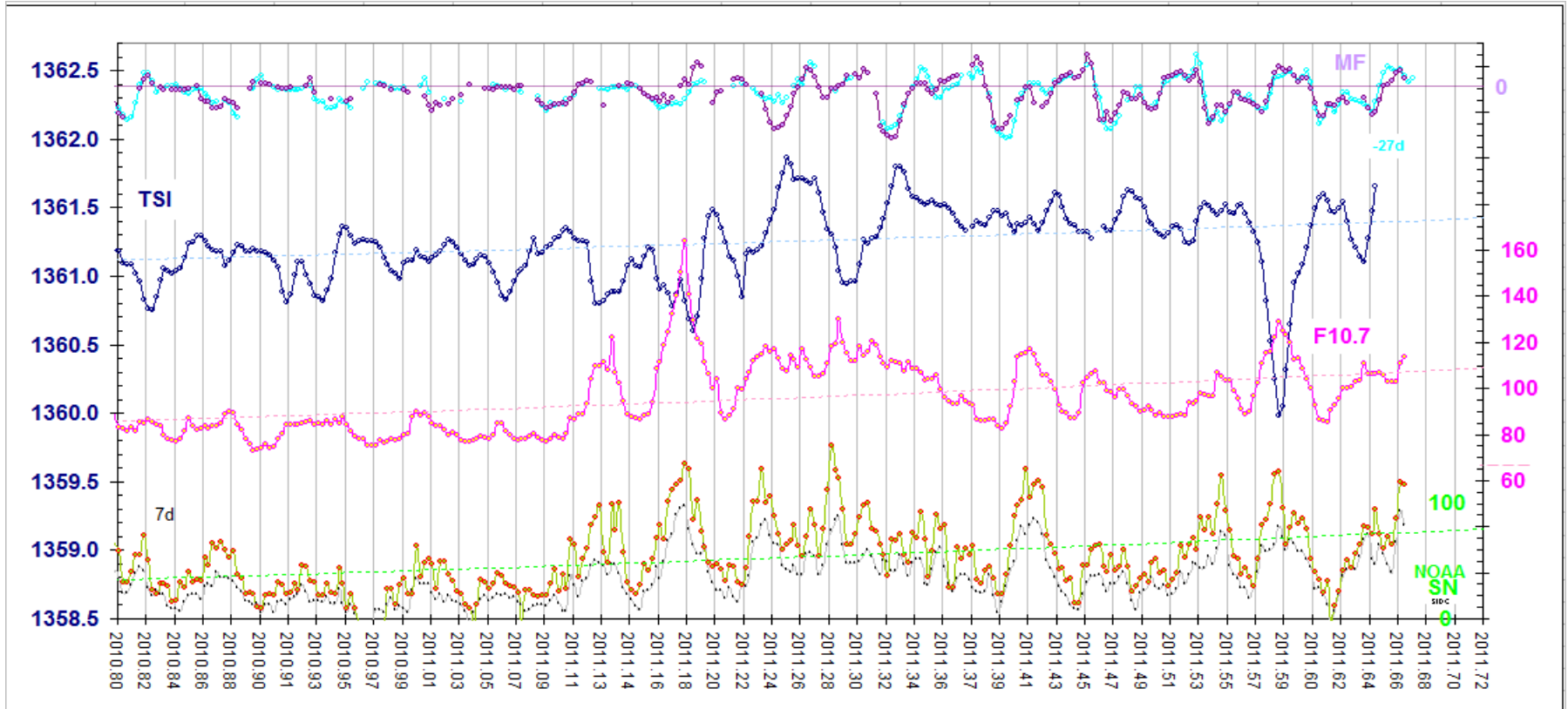


Cosmic Ray Modulation caused by latitudinal variation of HCS and CIRs

# The MF at the Start of Cycle 24

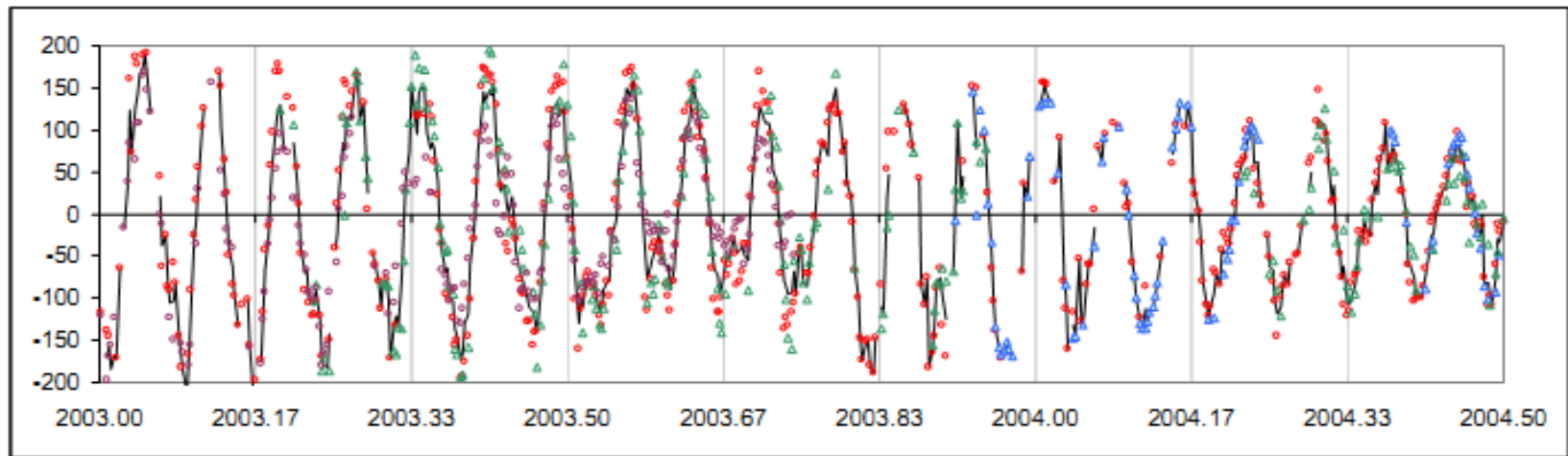
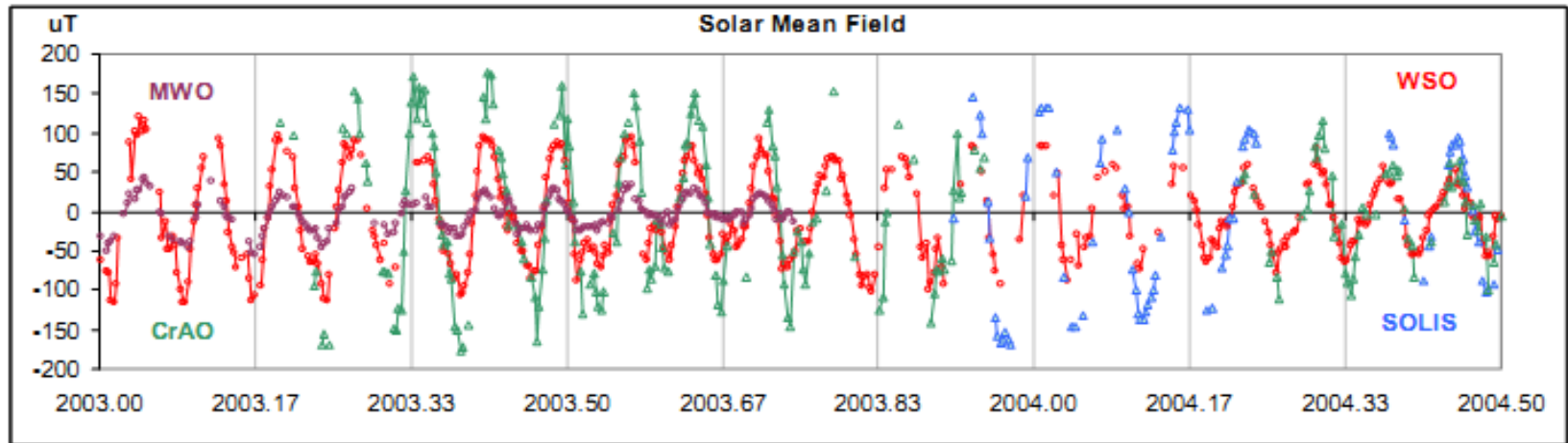


# And in Detail



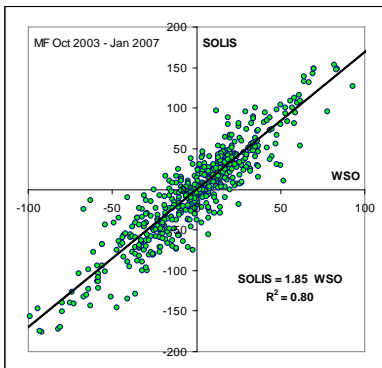
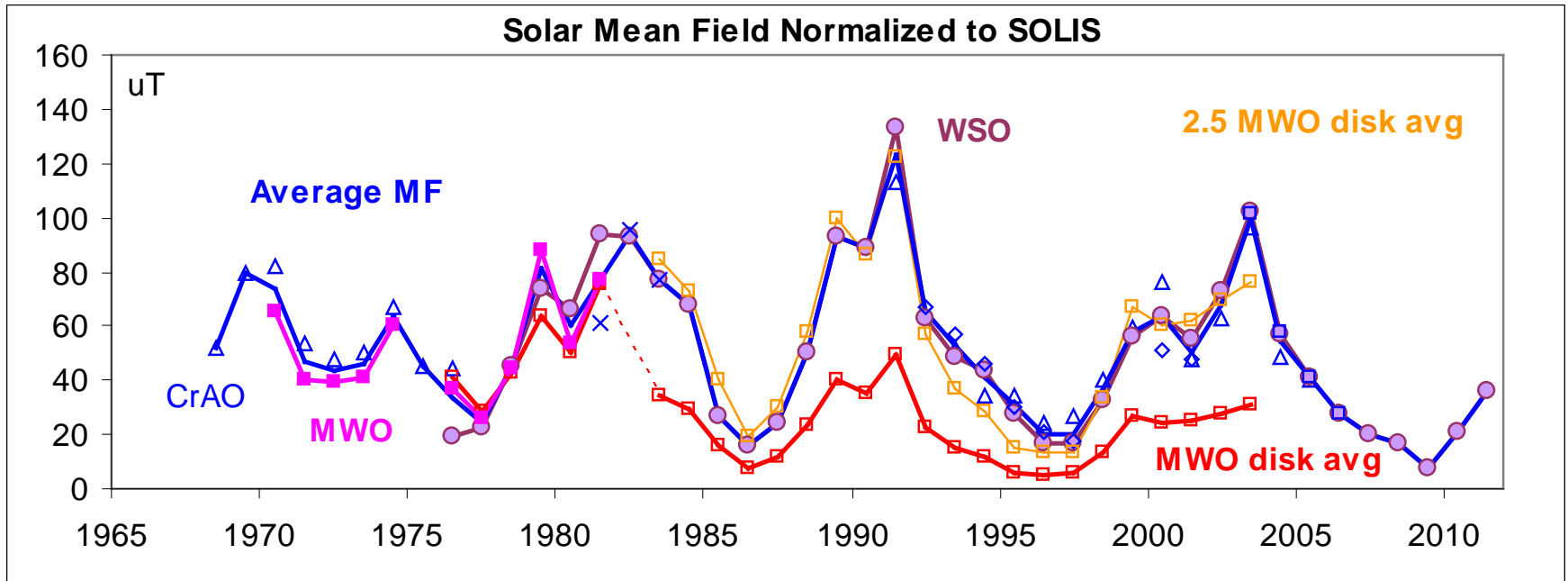
Note the detailed 27-day recurrence in sign and magnitude of the MF

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



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

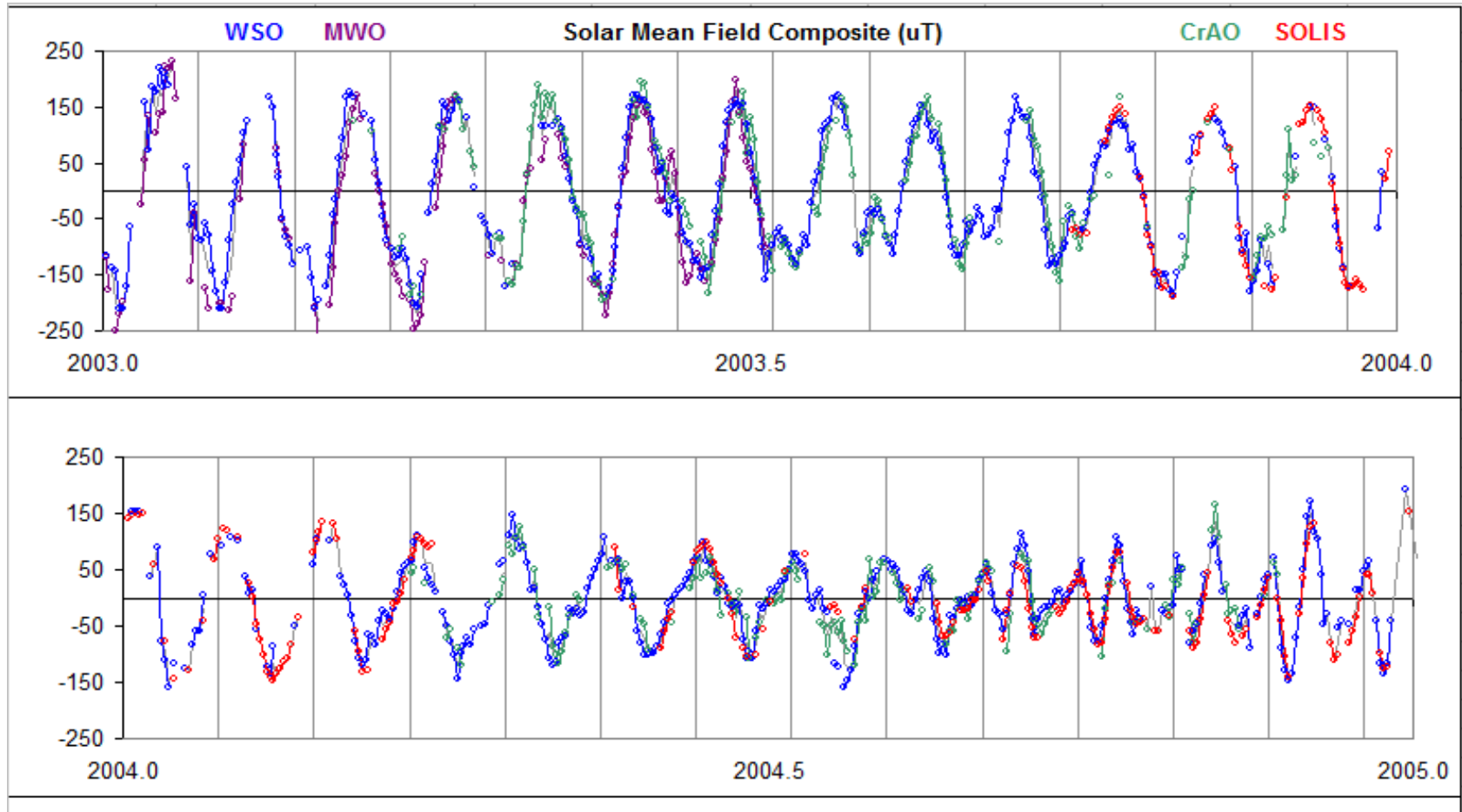
# MWO Anomaly



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

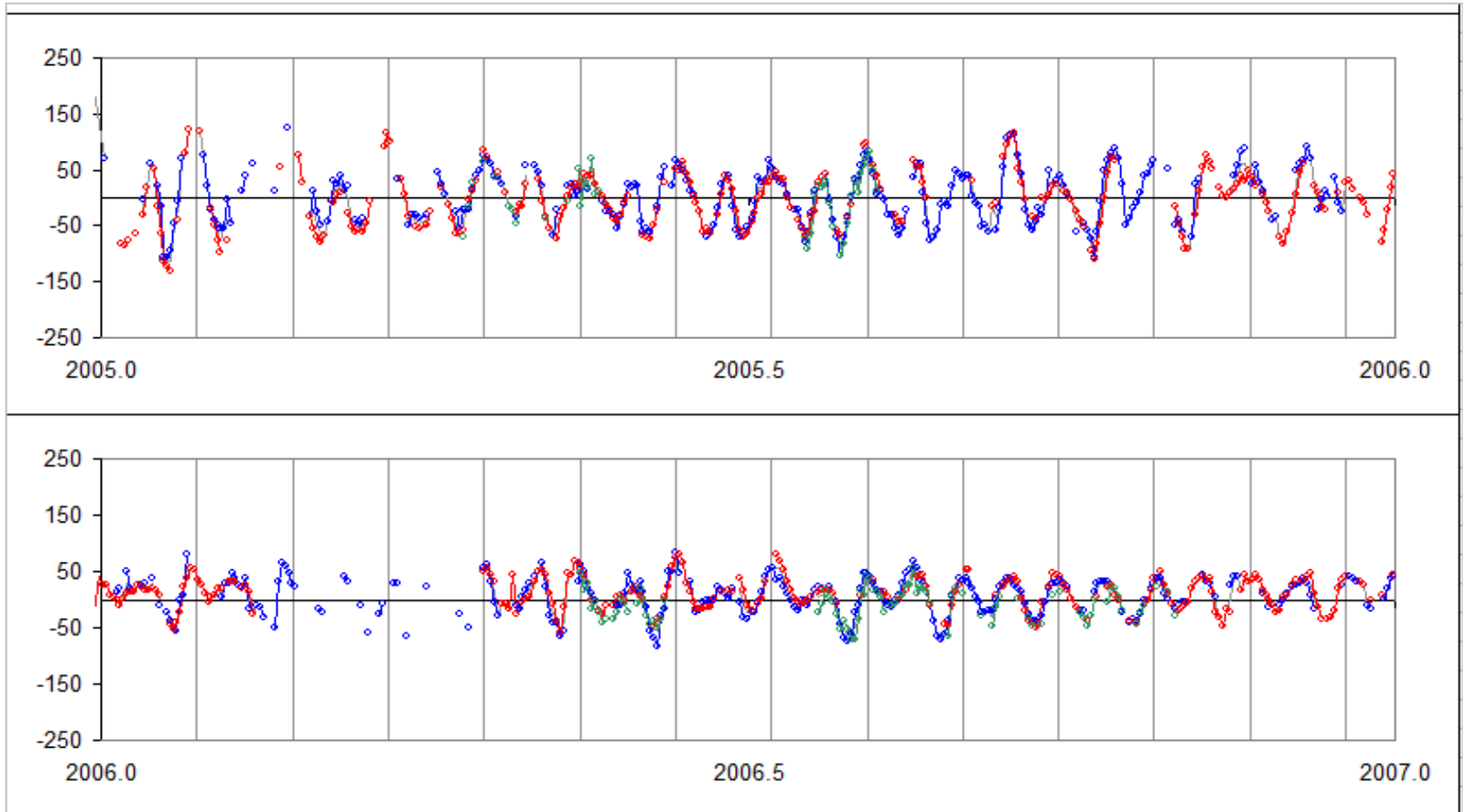
After the upgrade of MWO their MF is much too small

# Evolution of the MF Since 2003

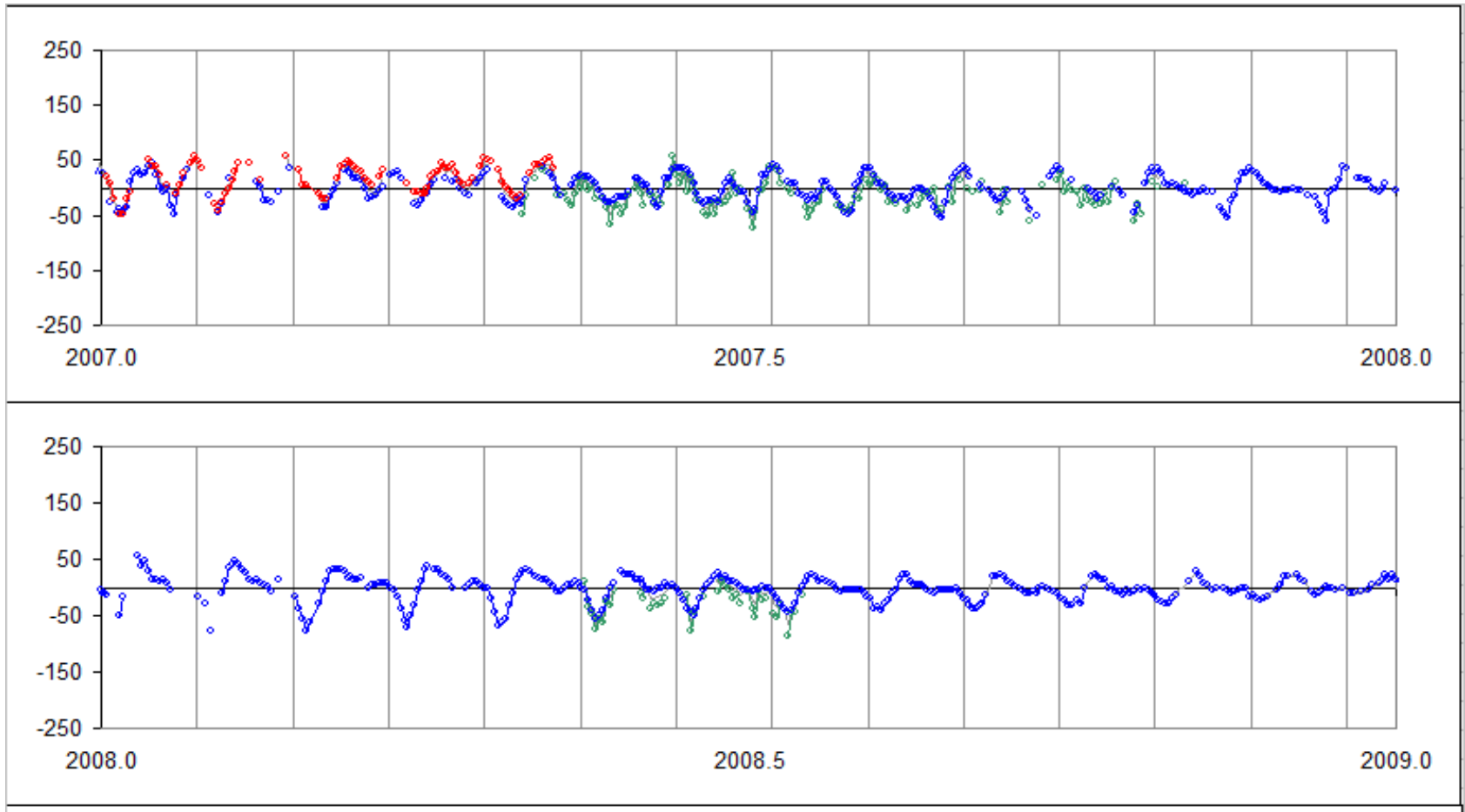




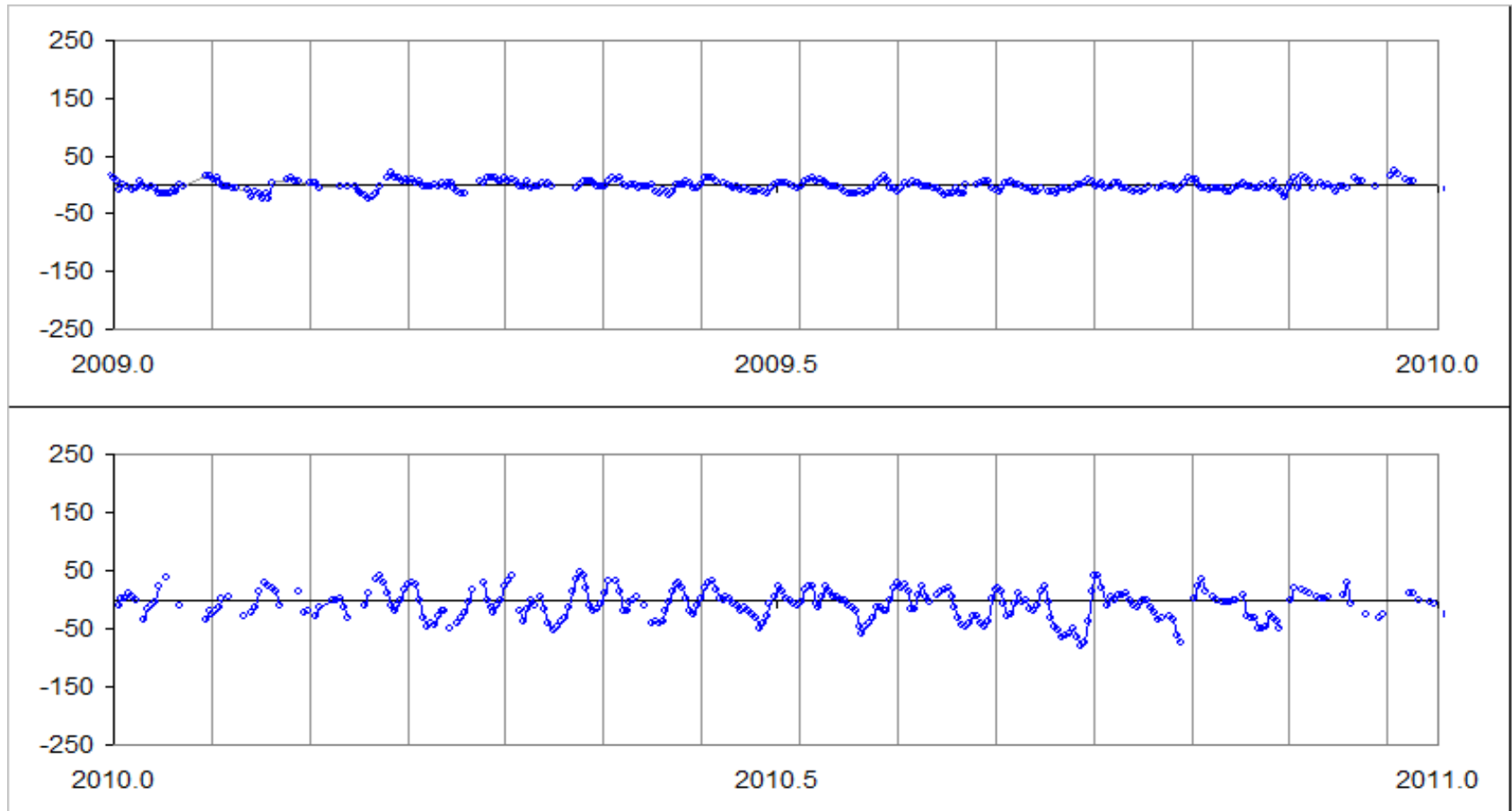
# Getting Smaller



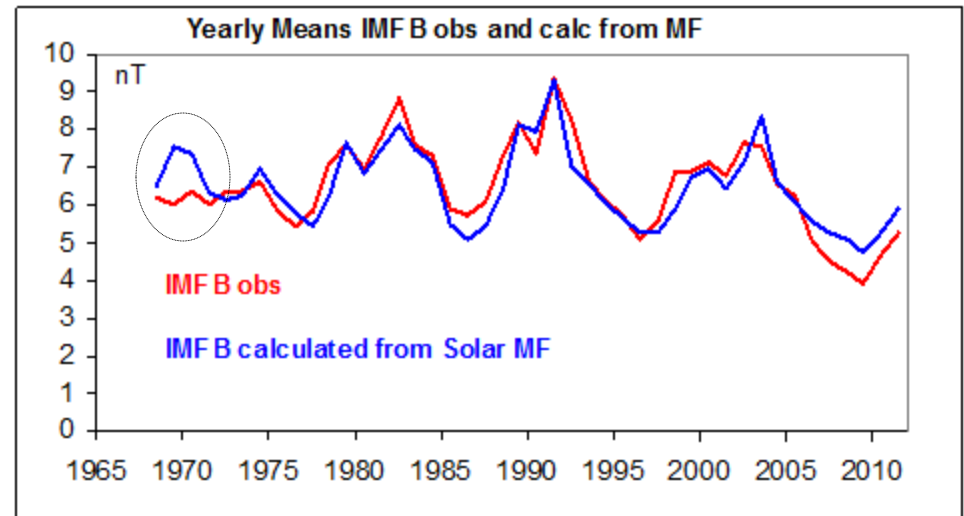
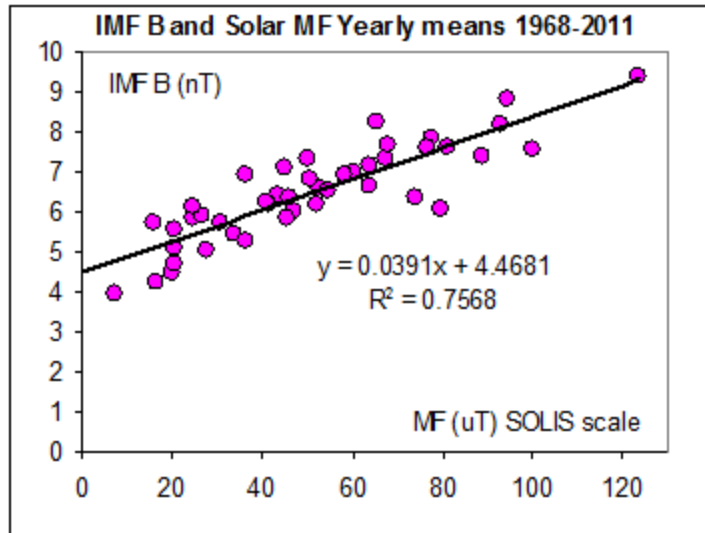
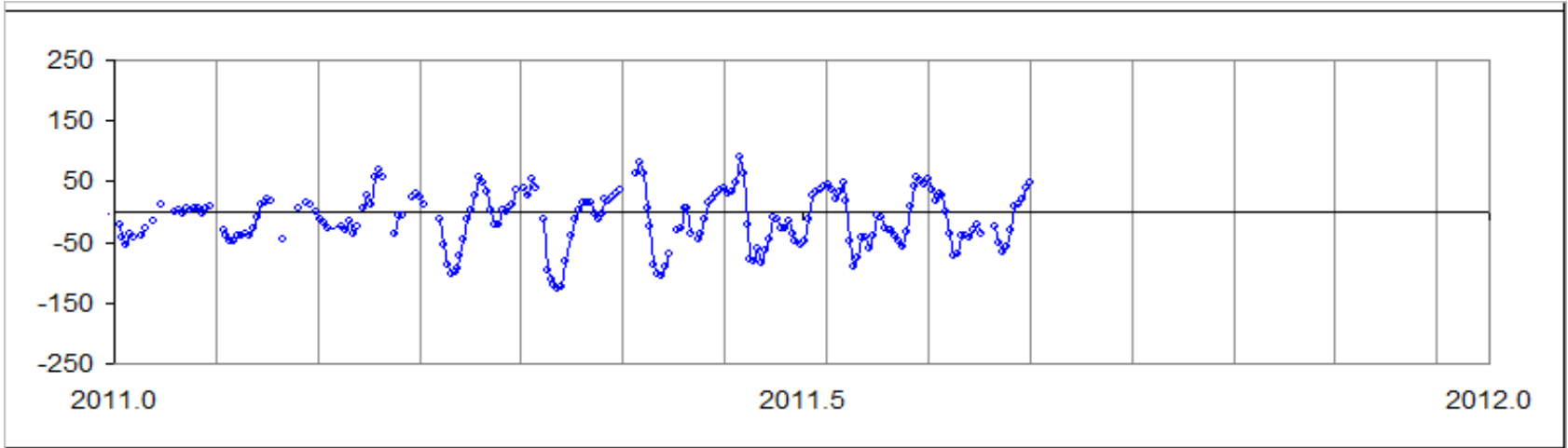
# And Smaller



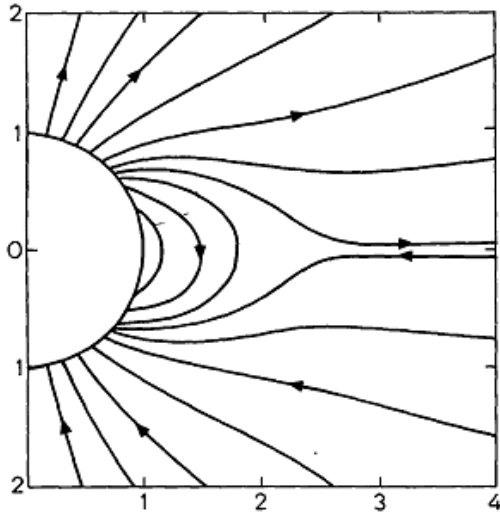
# And Smaller, but still matching HMF polarity



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



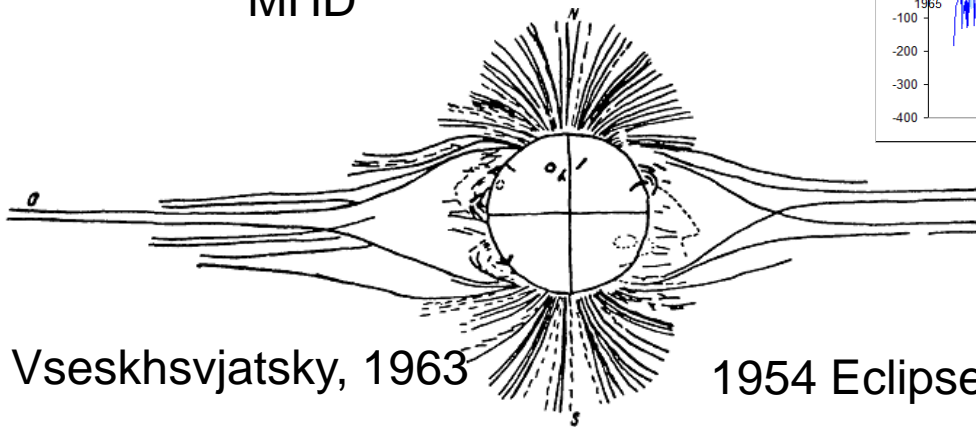
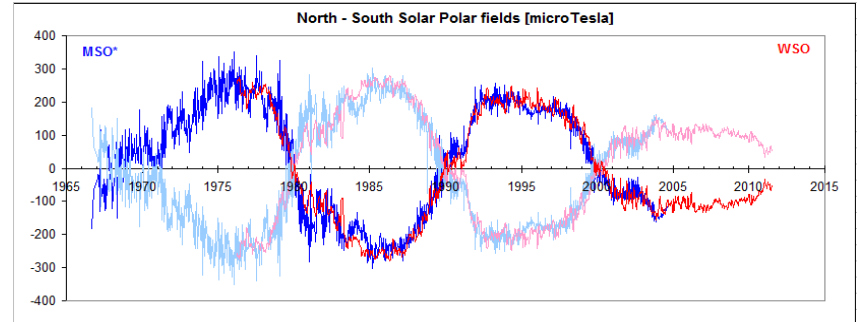
# The Importance of the Polar Fields [?]



Pnevman & Kopp, 1971  
MHD

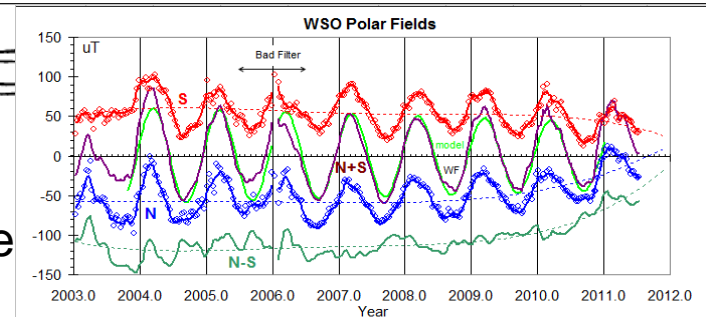
Even with all the sophistication of current models of the Corona and HMF they are hostage to the correct value of the solar polar fields, which may be different at the two poles and even have longitudinal structure within the polar caps.

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.