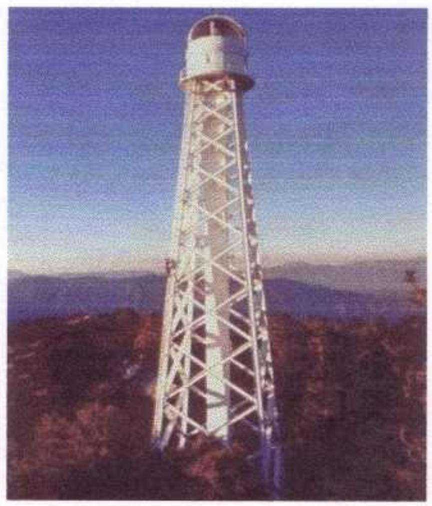
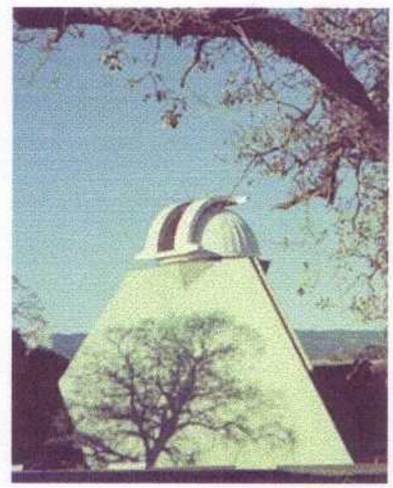
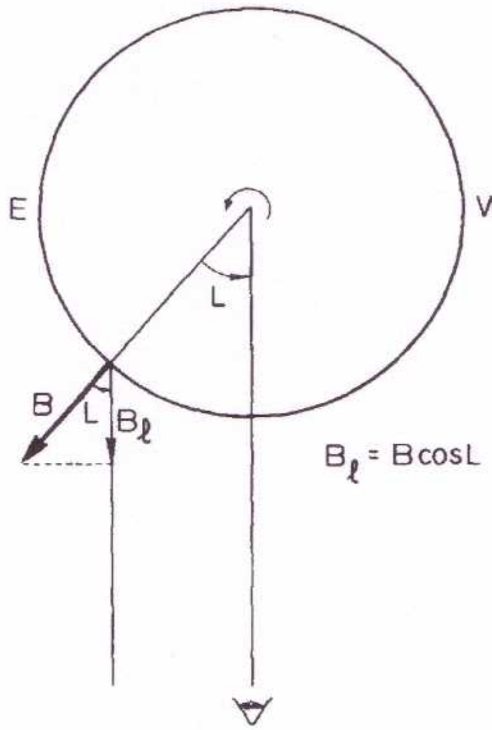
SH23C-05

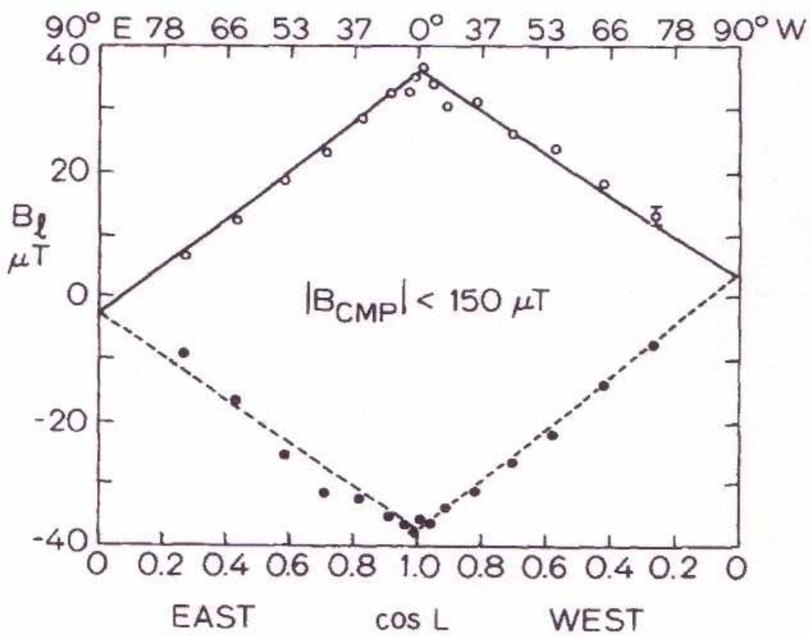
Magnetograph Saturation: Comparison of SOLIS, MWO, and WSO

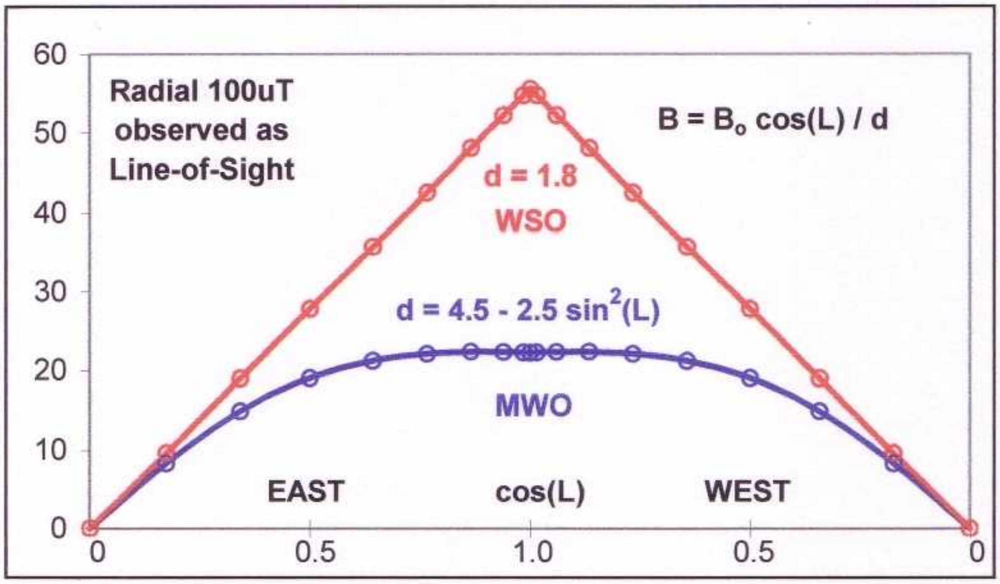
Leif Svalgaard



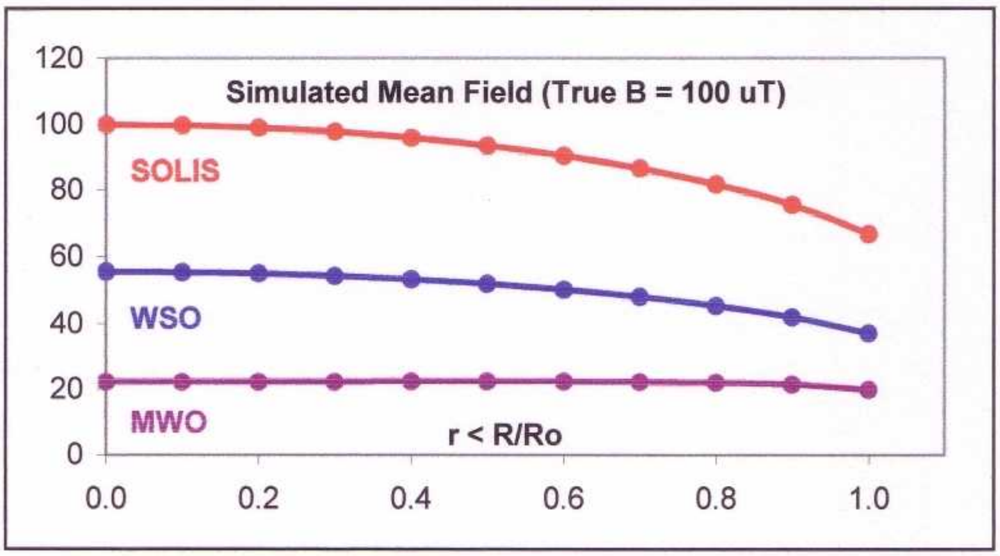



E
W
L
B
L
B_ℓ
B_ℓ = B cos L

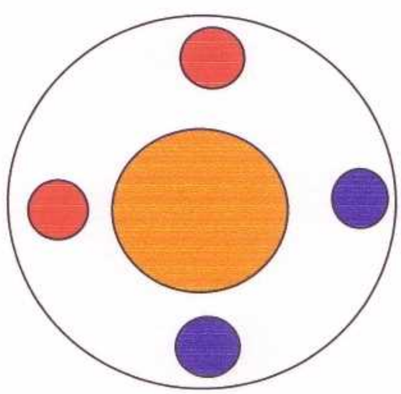

90° E 78 66 53 37 0° 37 53 66 78 90° W
40
20
0
-20
-40
B_ℓ
μT
$|B_{CMP}| < 150\ \mu$T
0 0.2 0.4 0.6 0.8 1.0 0.8 0.6 0.4 0.2 0
EAST
cos L
WEST



Radial 100uT
observed as
Line-of-Sight
B = B$_o$ cos(L) / d
d = 1.8
WSO
d = 4.5 - 2.5 sin^2(L)
MWO
EAST
cos(L)
WEST
60
50
40
30
20
10
0
0
0.5
1.0
0.5
0



Simulated Mean Field (True B = 100 uT)
SOLIS
WSO
MWO
r < R/Ro
120
100
80
60
40
20
0
0.0
0.2
0.4
0.6
0.8
1.0



4. Magnetograph Saturation

At Stanford we use the same slit sizes and arrangement as at Mt. Wilson for the line λ 525.02 nm. The two exit slits are λ 7.5 pm wide and have a separation of λ 1.8 pm. With these slits the magnetic signal as a function of effective Zeeman splitting is shown in Figure 7. The curve in Figure 7 is obtained by placing a right-hand circular polarizer in front of the KDP crystal and recording the magnetic signal while scanning across the line. For weak fields (i.e., less than 50 mT) the magnetic signal is proportional to the field strength. As the field increases the magnetograph response weakens and at 143 mT the magnetograph is saturated and any further increase actually decreases the magnetic signal. Assuming that a typical field strength within the magnetic elements is 150 mT (Stenflo, 1973; Ramsey *et al.*, 1977) the corresponding reading from the magnetograph would be only 83 mT; hence the effect of magnetograph saturation due to the strong fields in the elements is to reduce the measured flux by a factor $150/83 = 1.8$.

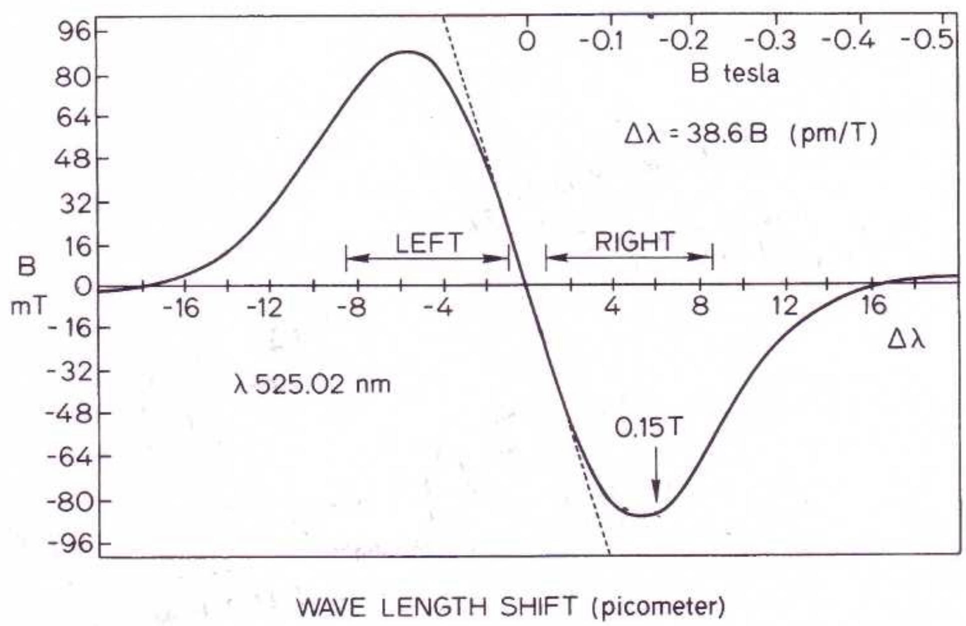
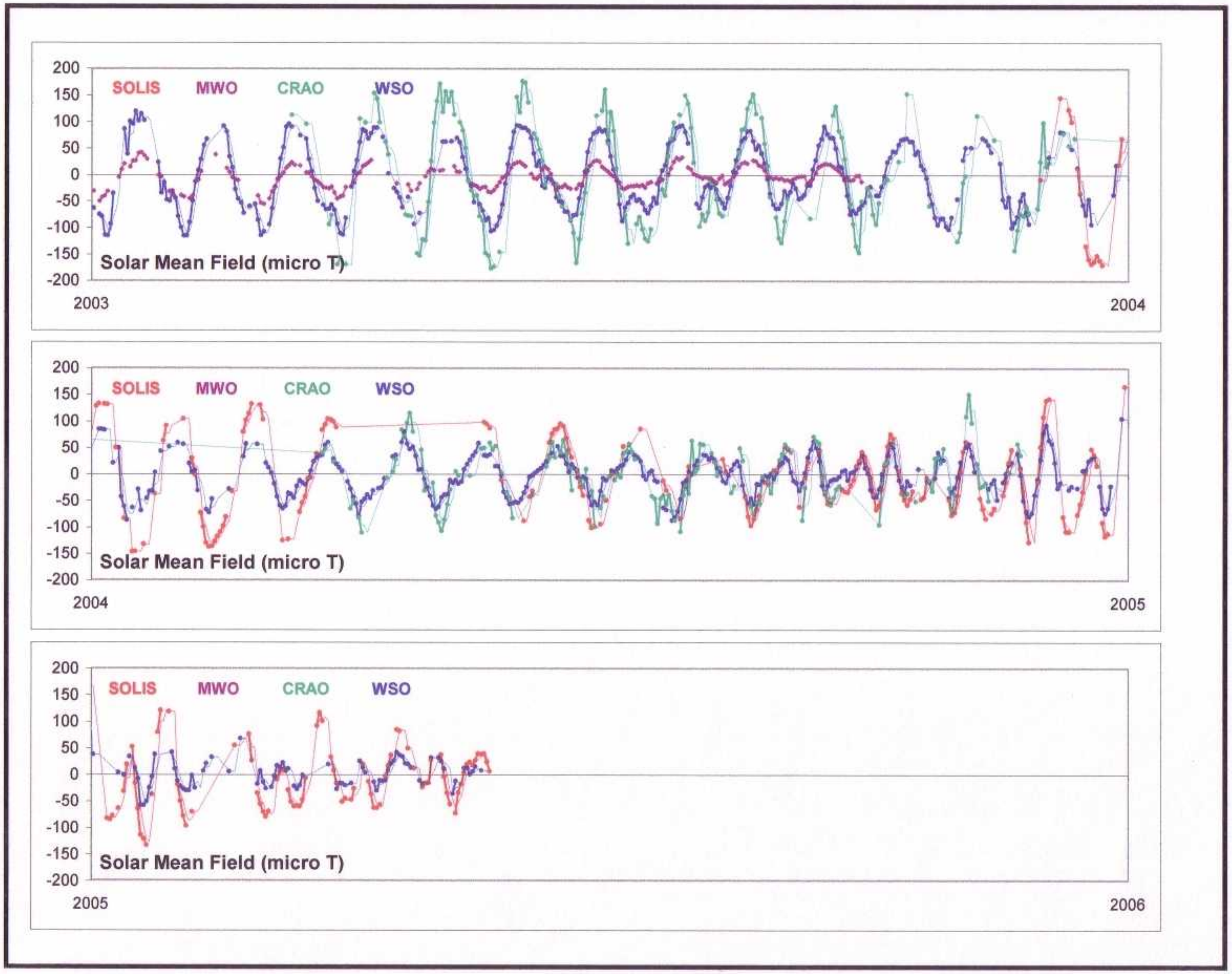
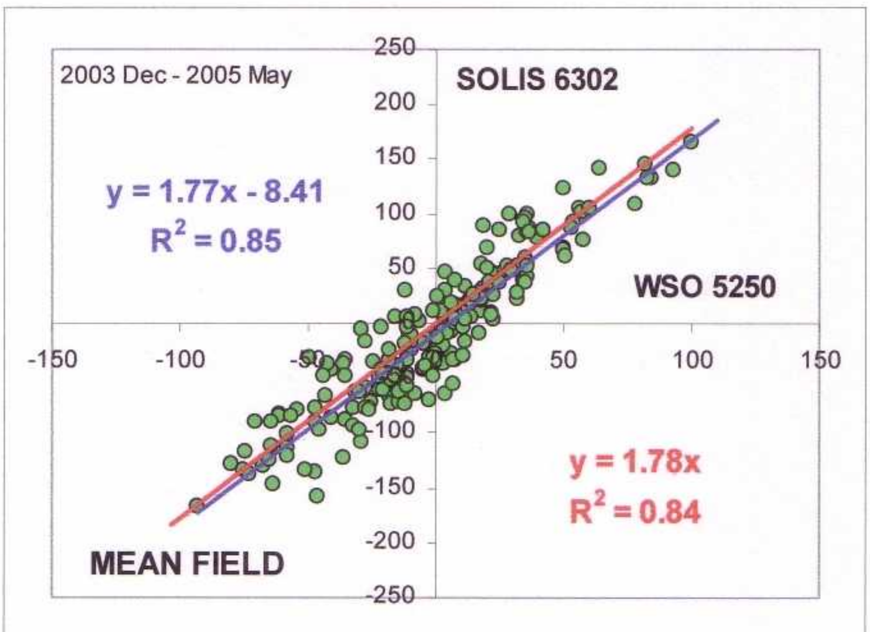


Fig. 7. Calibration curve for the Stanford magnetograph for the Fe I line λ 525.02 nm and for exit slits λ 7.5 pm wide separated by λ 1.8 pm. A magnetic field produces a Zeeman splitting of $\Delta\lambda =$ 38.6 pm/T. This relation is shown as the dotted line and is also used to calibrate the scale along the upper right boundary of the figure frame. Slit dimensions are shown in the middle of the figure.

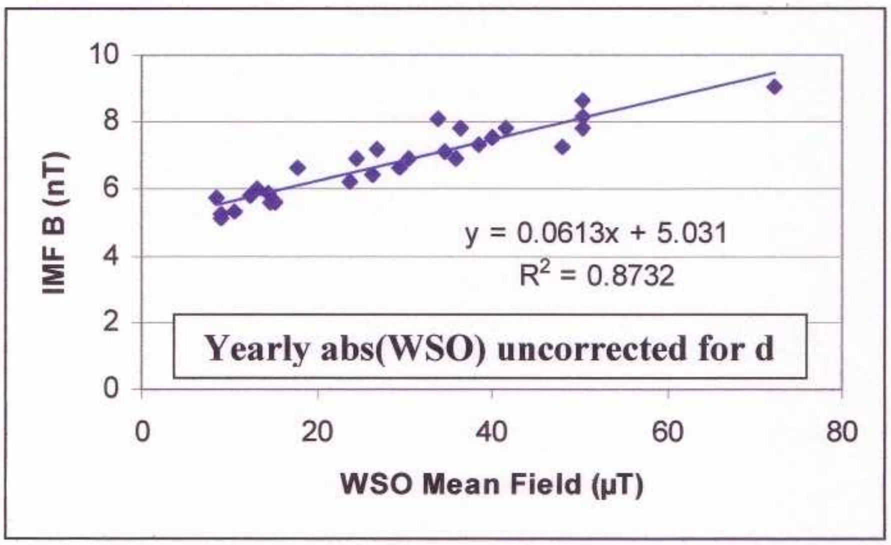
The careful, lengthy analysis by Stenflo (1973) gives essentially the same result. If the polar fields also exist mainly in the form of elements of the same strength as in lower latitudes we might expect a similar reduction of the measured flux. No detailed study of this problem has been carried yet specifically within the polar caps but preliminary data from the Stanford Solar Observatory suggests that there is no difference in the saturation between the polar and the equatorial limbs.

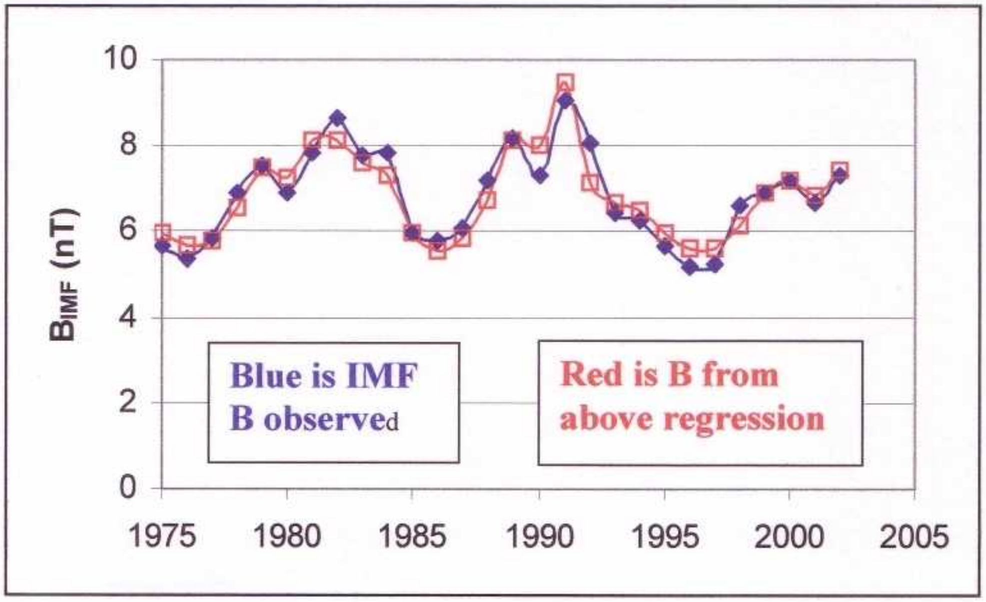


200
150
100
50
0
-50
-100
-150
-200
SOLIS
MWO
CRAO
WSO
Solar Mean Field (micro T)
2003
2004
200
150
100
50
0
-50
-100
-150
-200
SOLIS
MWO
CRAO
WSO
Solar Mean Field (micro T)
2004
2005
200
150
100
50
0
-50
-100
-150
-200
SOLIS
MWO
CRAO
WSO
Solar Mean Field (micro T)
2005
2006

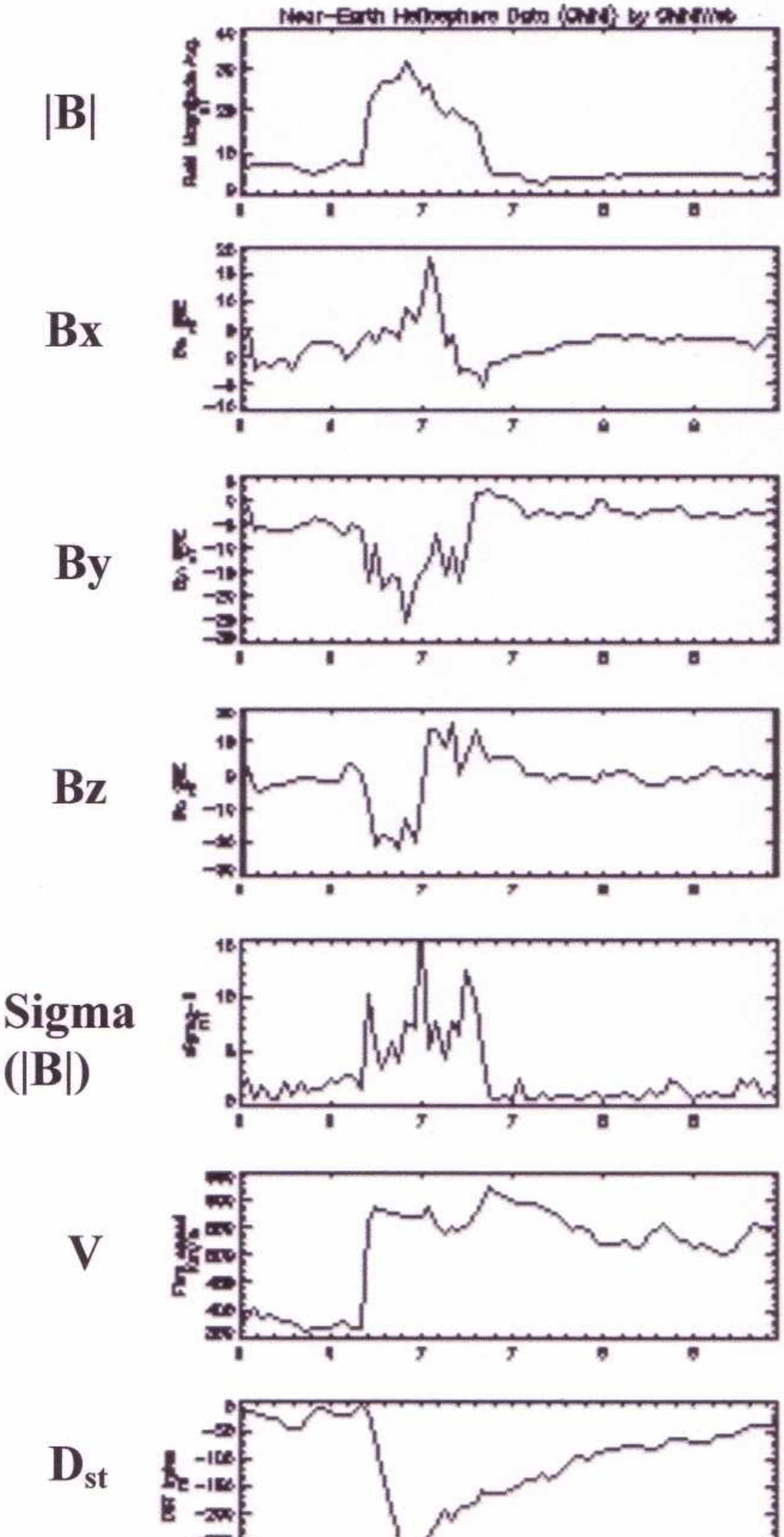


2003 Dec - 2005 May
SOLIS 6302
WSO 5250
MEAN FIELD
y = 1.77x - 8.41
R2 = 0.85
y = 1.78x
R2 = 0.84
250
200
150
100
50
-100
-150
-200
-250
-150
-100
-50
0
50
100
150





Solar cycle variation of |B| IMF is mainly a variation of the closed flux (in CmEs = Coronal magnetic Ejections!) on top of a much less varying open flux. The solar mean field (SMF) seems to be correlated with the closed flux (either globally [ropes] or locally [clouds]). Makes it suspect to directly scale SMF to IMF (Kotov *et al.*).


Near-Earth Heliosphere Data (OMNI) by OMNIWeb
|B|
Bx
By
Bz
Sigma
(|B|)
V
D_{st}

Conclusions:

A: Solar magnetograph data from SOLIS, MWO, and WSO are consistent using the following "saturation factors:

1: SOLIS $d = 1$
2: MWO $d = 4.5 - 2.5 \sin^2$ (center distance)
3: WSO $d = 1.8$

B: The differences between observatories are not understood

What not to do:

Mix data and "correction factors" for different observatories as in:

Prediction and understanding of the north-south displacement of the heliospheric current sheet {Z, H, & S, March 2005}:
"For the photospheric field measurements, we employ Carrington synoptic charts from the Wilcox Solar Observatory (WSO) from May 1976 to Dec. 2001. We correct for the saturation of the Fe I 5250 Å line profile by multiplying the measured magnetic fluxes by the latitude dependent factor $4.5 - 2.5 \sin^2$(latitude) [Wang and Sheeley, 1995]."