

Prediction of Solar Cycle 25

Leif Svalgaard
Stanford University

SORCE 2018, Lake Arrowhead, CA
March 23, 2018

The Origin of the Polar Field Precursor Method

VOL. 5, NO. 5 GEOPHYSICAL RESEARCH LETTERS MAY 1978

USING DYNAMO THEORY TO PREDICT
THE SUNSPOT NUMBER DURING SOLAR CYCLE 21

Kenneth H. Schatten, Philip H. Scherrer, Leif Svalgaard and John M. Wilcox
Institute for Plasma Research, Stanford University, Stanford, California

Abstract. On physical grounds it is suggested that the sun's polar field strength near a solar minimum is closely related to the following cycle's solar activity. Four methods of estimating the sun's polar magnetic field strength near solar minimum are employed to provide an estimate of cycle 21's yearly mean sunspot number at solar maximum of 140 ± 20 . We think of this estimate as a first order attempt to predict the cycle's activity using one parameter of physical importance based upon dynamo theory.

Was
165

The Authors One Cycle Ago

SPD 2009



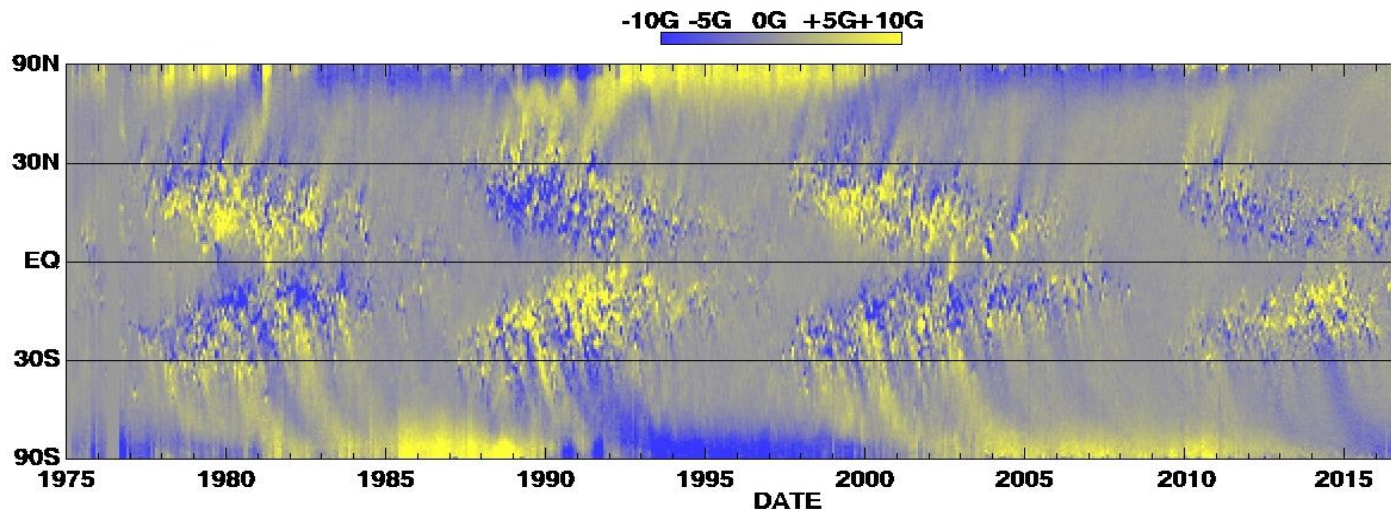
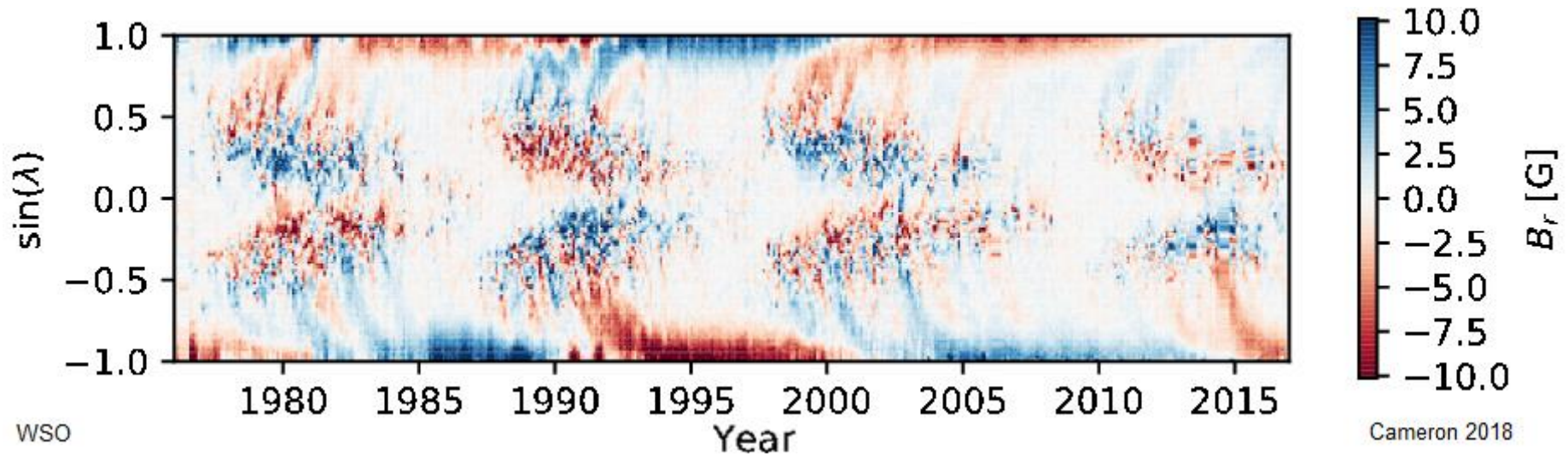
Scherrer

Svalgaard

Schatten

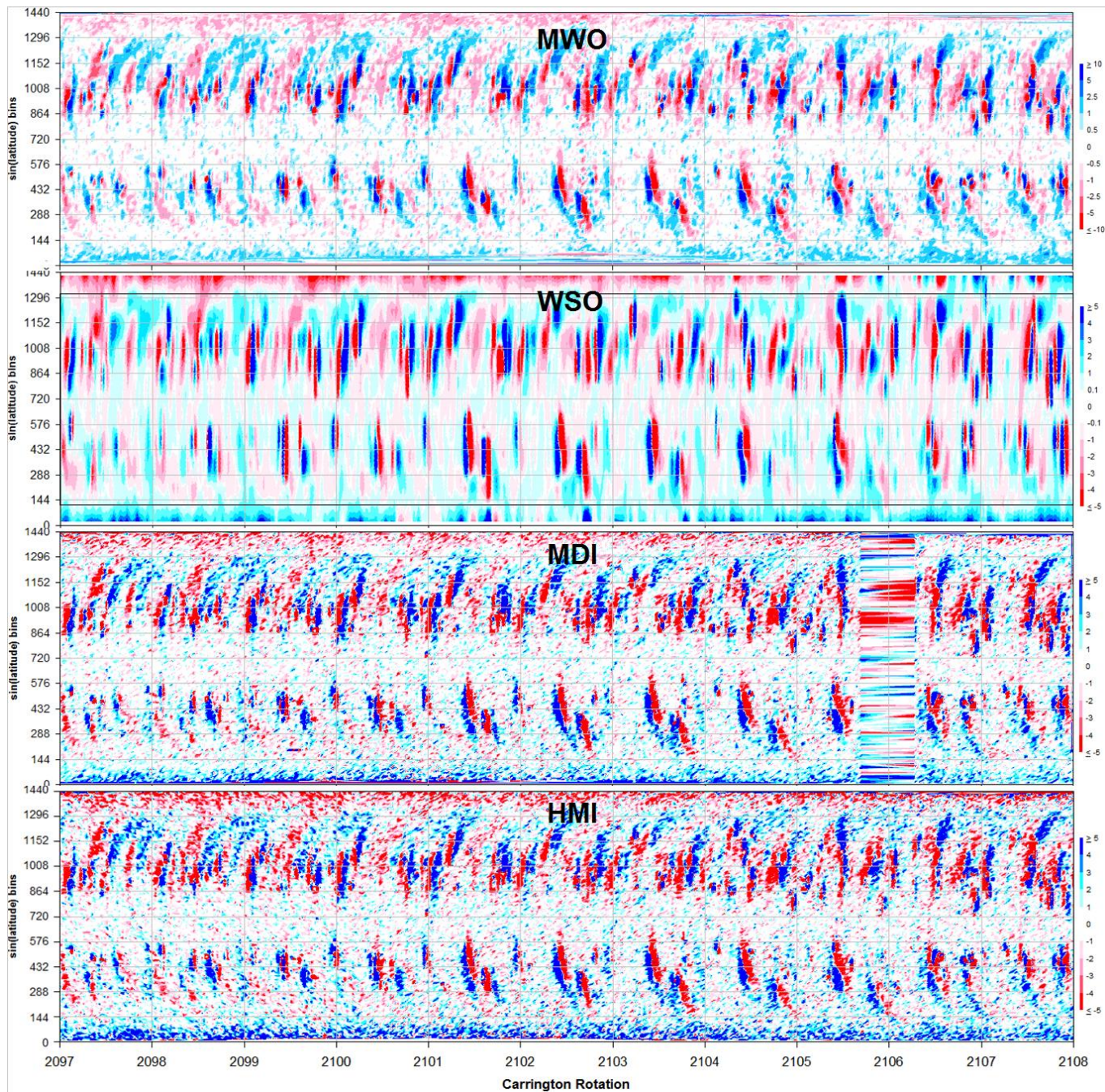
Wilcox

Standard (but Misleading) View of Magnetic Fields Migrating to the Polar Regions



Hathaway NASA ARC 2016/10

Zonal averages in time producing broad unipolar migrating areas 4



Super-Synoptic Maps show what is really going on: The flux is concentrated in narrow 'streaks' and the two polarities move together

The maps are shown for the period of overlap of MWO, WSO, MDI, and HMI

This is No News, of Course

B.1 Polar Crown Filaments and the Polar Magnetic Field, K. TOPKA and R. L. MOORE, Caltech, BBSO, and B. J. LABONTE and R. HOWARD, Mt. Wilson Obs., Carnegie Institution of Washington. We report on the results of a follow up study to the recent results of Howard and LaBonte (submitted to Solar Physics) concerning the evolution of solar photospheric magnetic fields

....

conclude that the observed behavior of polar crown filaments during the solar activity cycle supports the results of Howard and LaBonte in that the solar polar magnetic field arises from discrete injections of field from active region latitudes and that there exists in the sun a meridional flow. We further

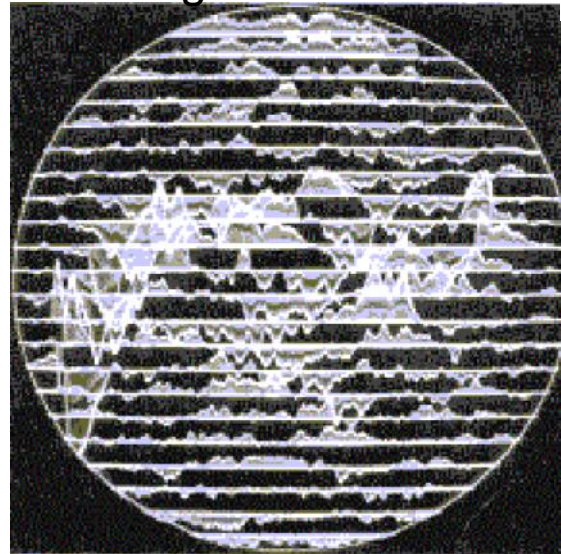
conclude that magnetic field of both polarities must be migrating poleward, but that the following polarity dominates slightly.

Early MWO Observations

after Babcock Invented the Magnetograph “by doing everything right”



Strong Polar Fields



Weak Polar Fields

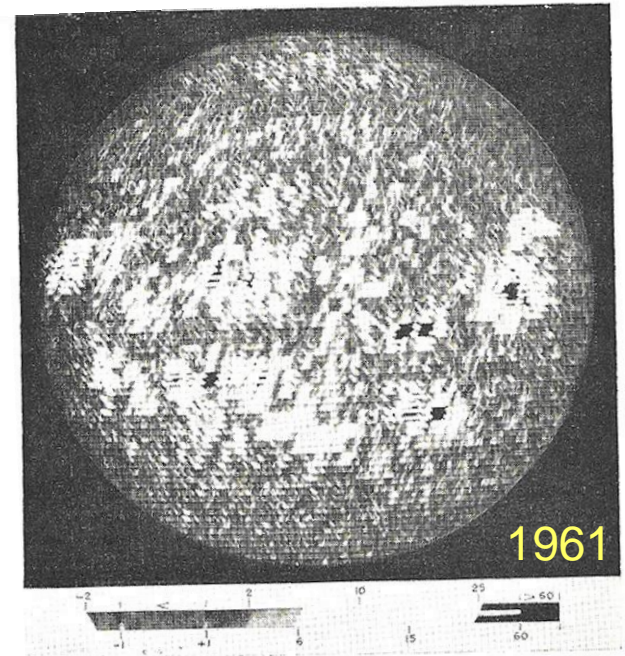
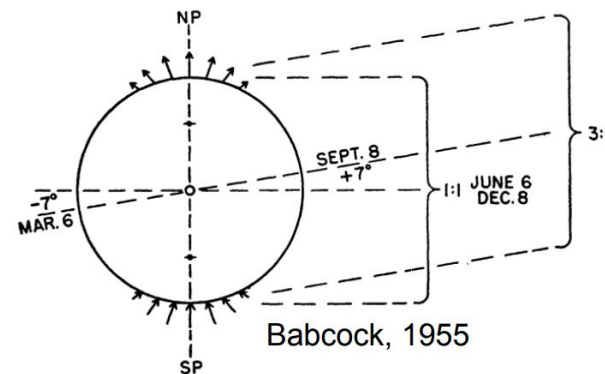
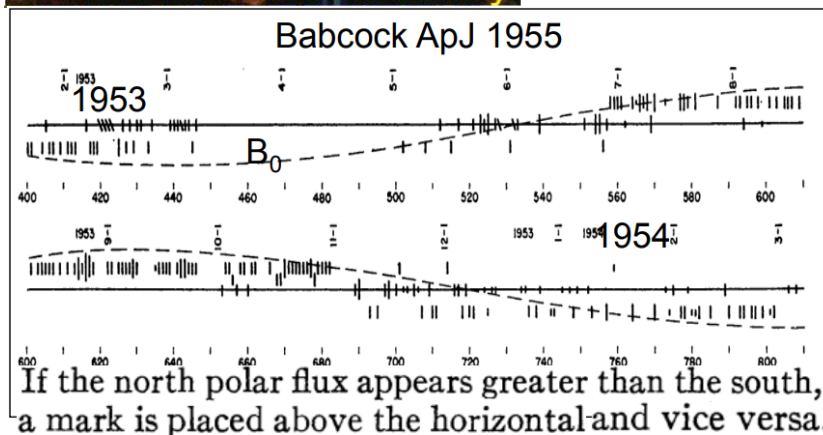
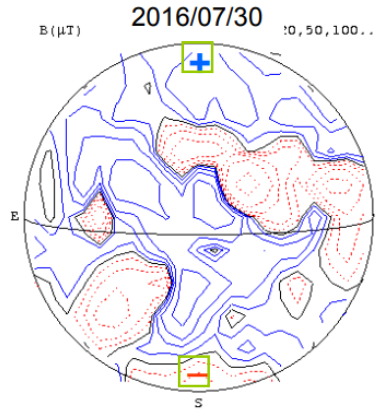
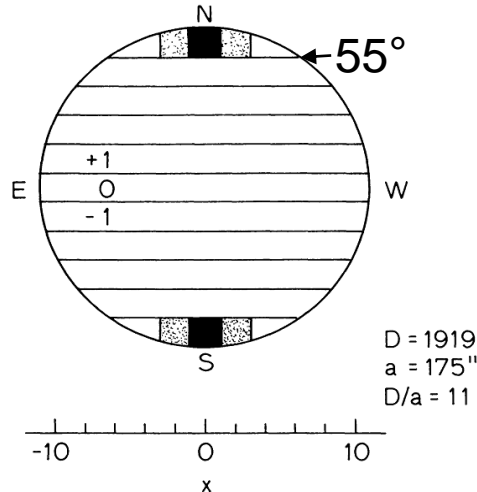
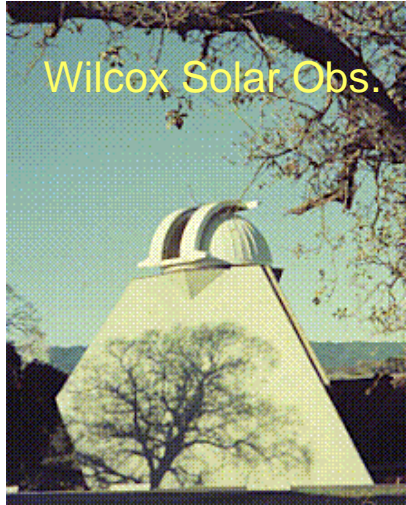


Fig. 1—The Solar Magnetogram for 21 July 1961.

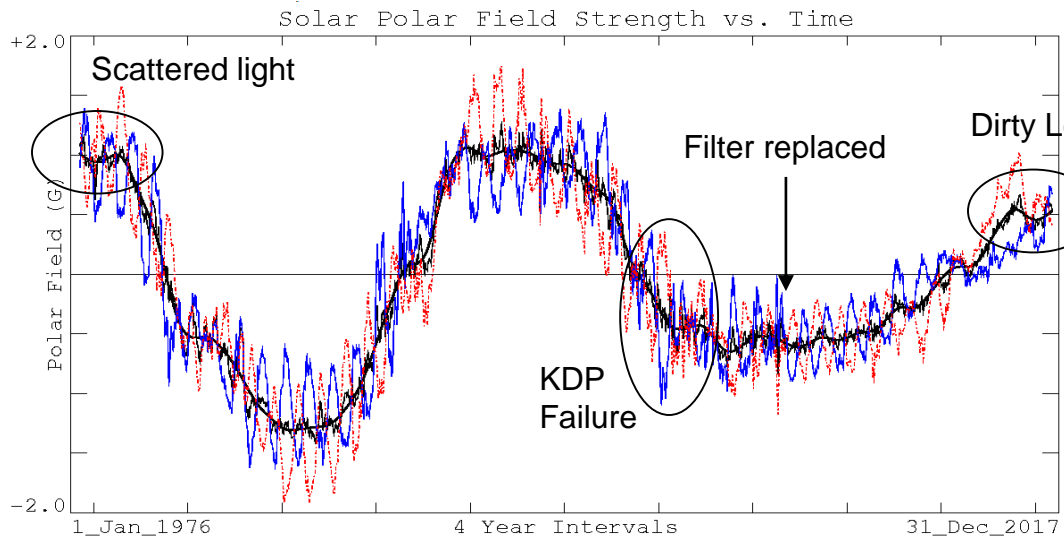
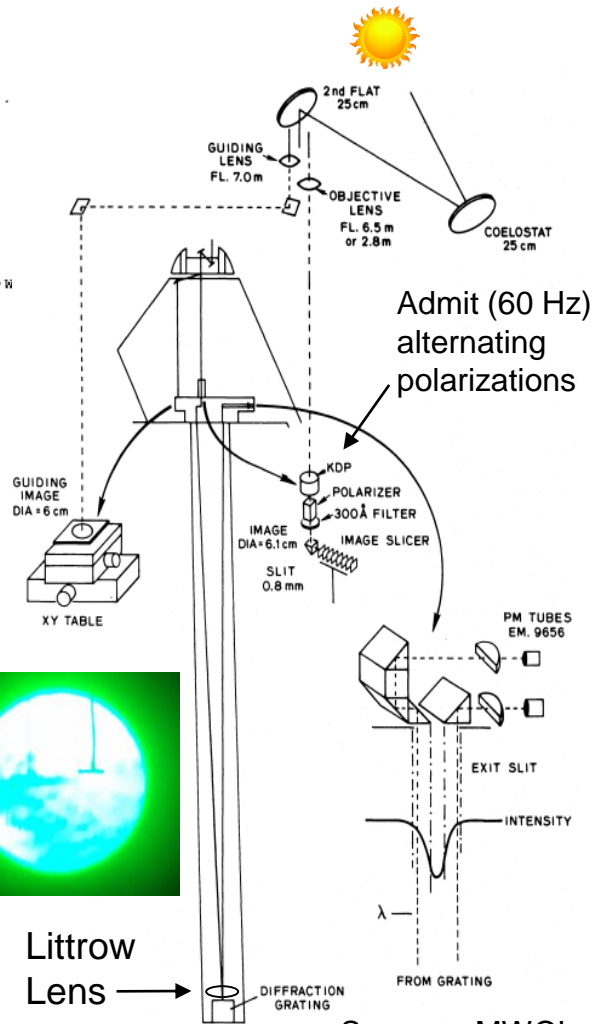


Explanation of the annual variation: concentration at the poles

WSO Observations since 1976



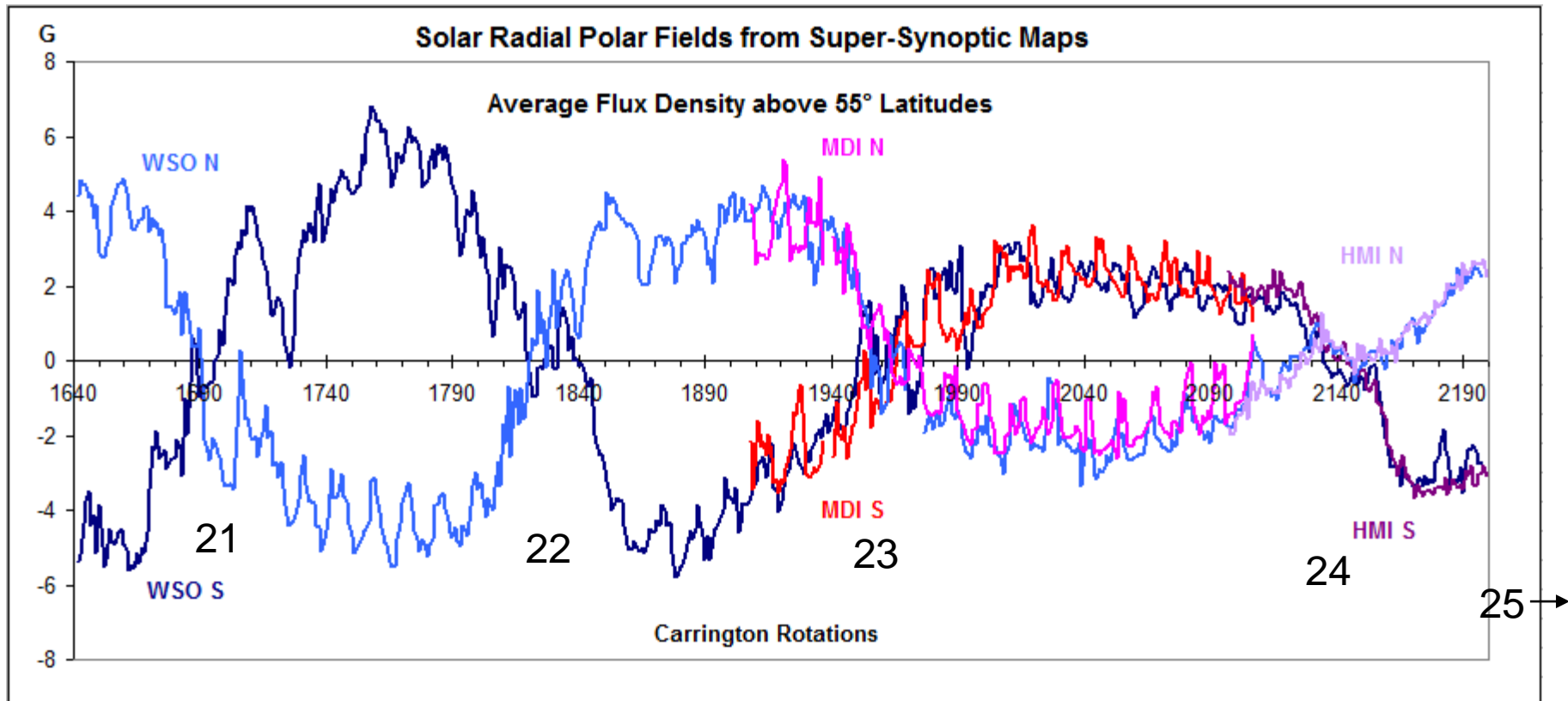
WSO Magnetogram



Key: Lt.Solid = North; Dashed = -South; Med.Solid = Average: (N-S)/2; Hvy.Solid = Smoothed Average

The magnetograph has never been upgraded

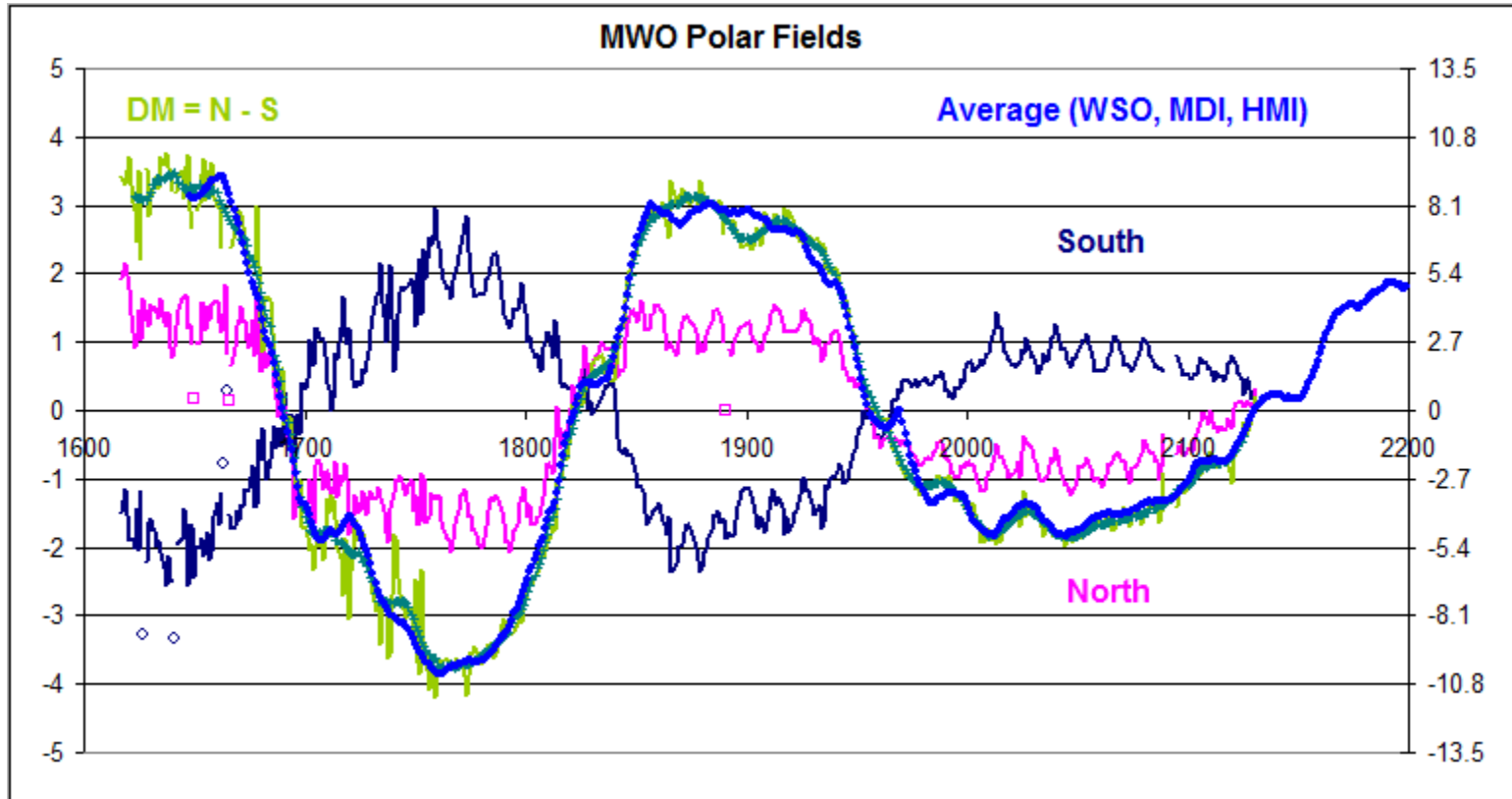
Polar Fields from WSO, MDI, and HMI from Radial Super-Synoptic Maps



WSO multiplied by 1.8 to correct for saturation.

MDI multiplied by 0.6 to put on HMI scale [for polar region]

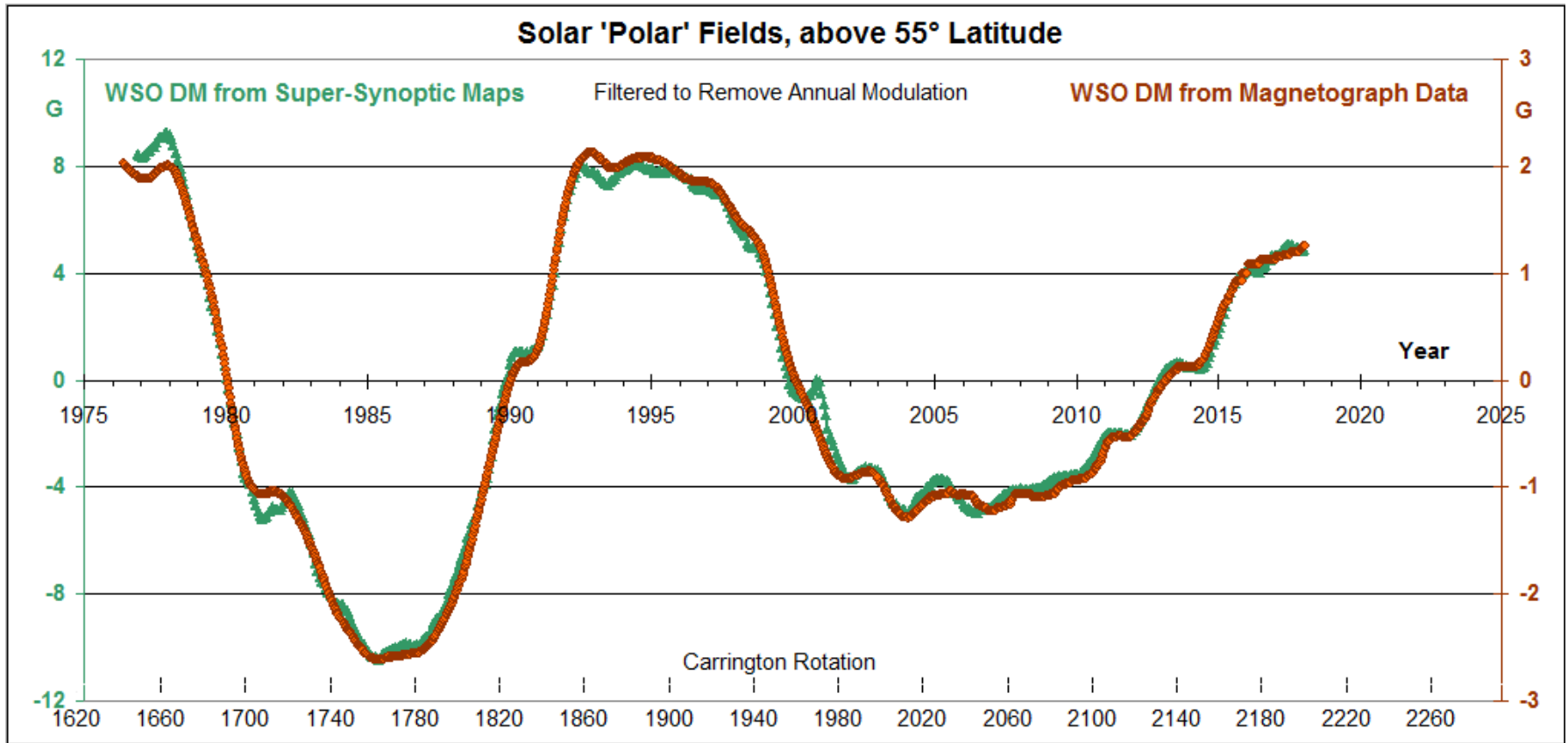
Comparing with MWO Polar Fields



It is amazing how good the agreement is (after scaling).

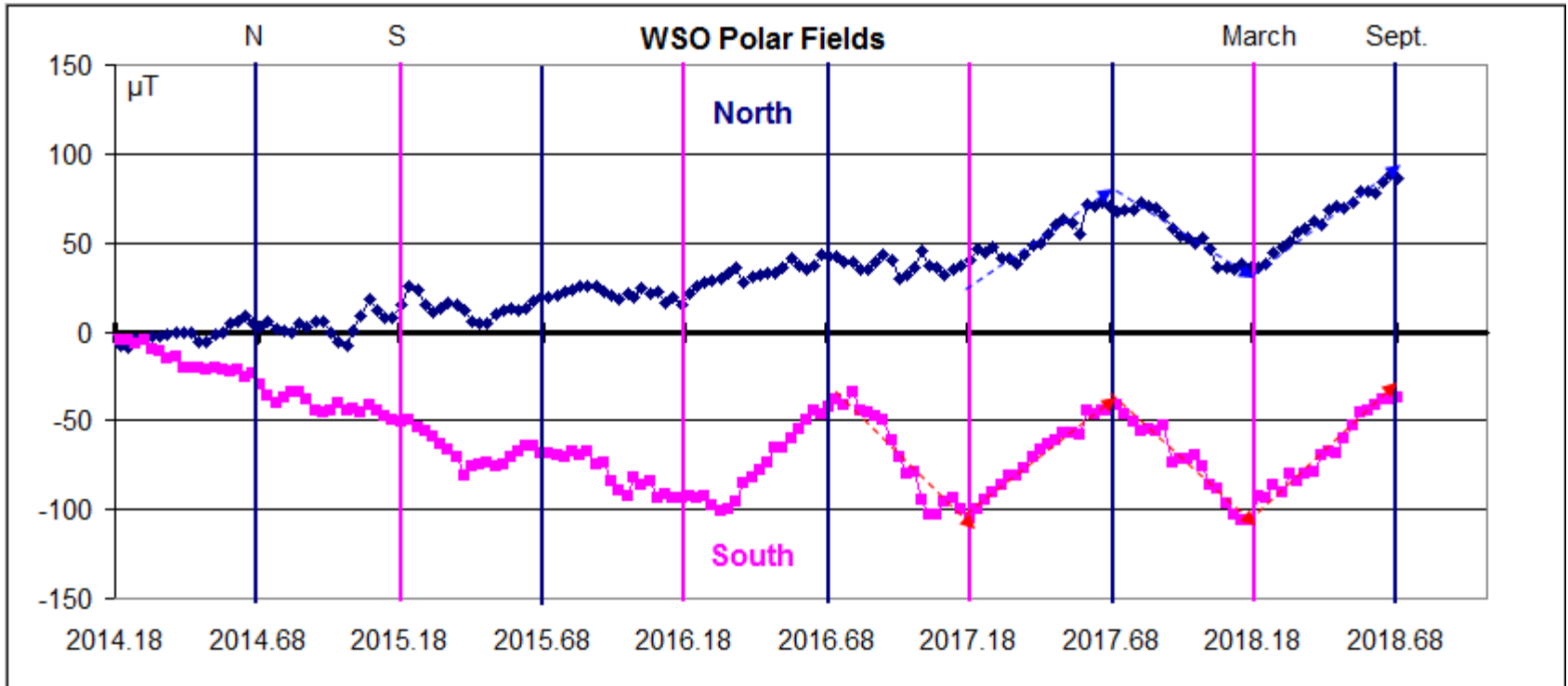
This allows us to take the polar fields back to 1974

Comparison with Magnetograph Polar 'Pixel' Fields



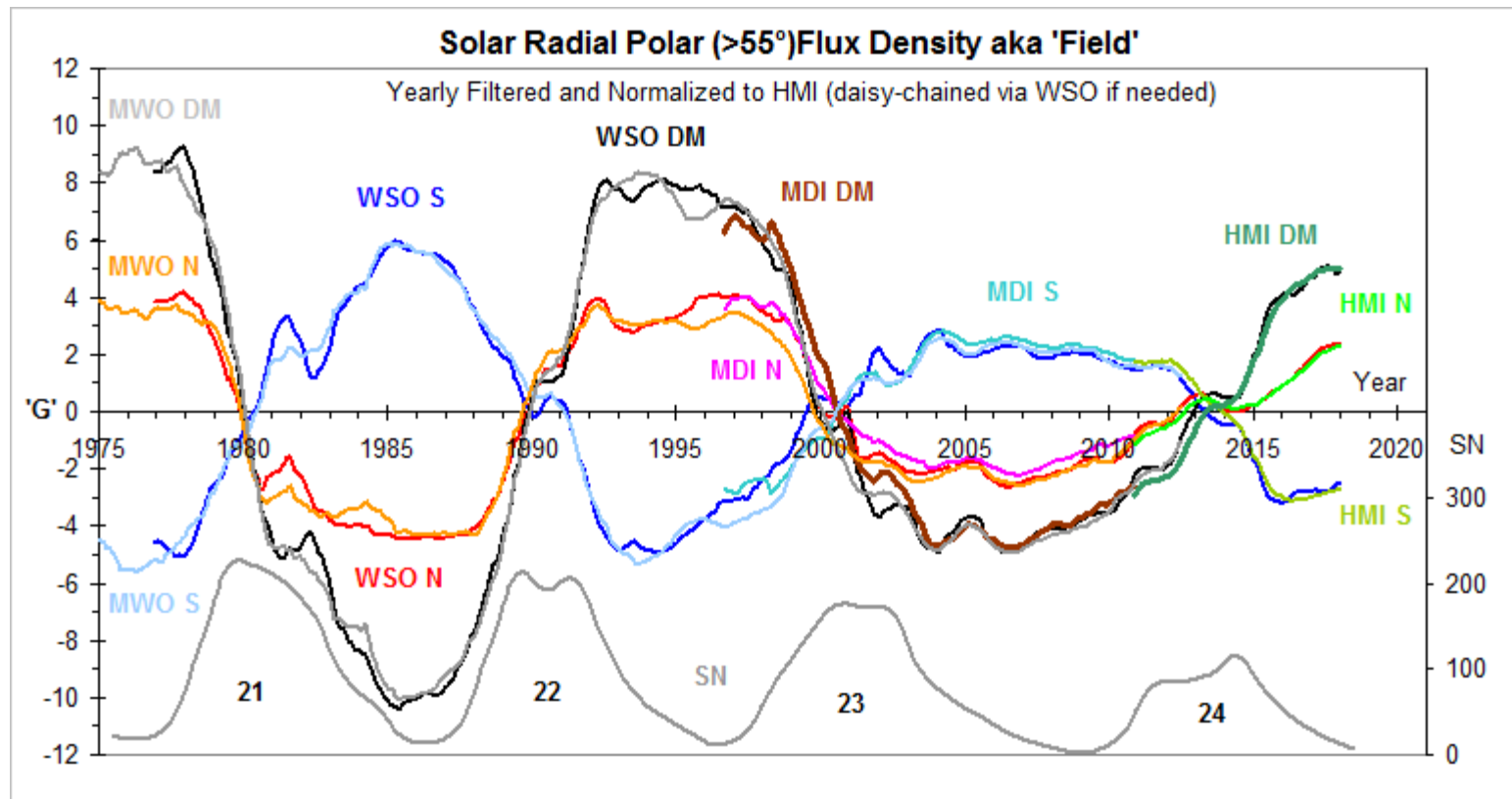
Conversion factor: WSO Radial = 4.0 WSO Pixel

Most Recent WSO 'Pixel' Polar Fields

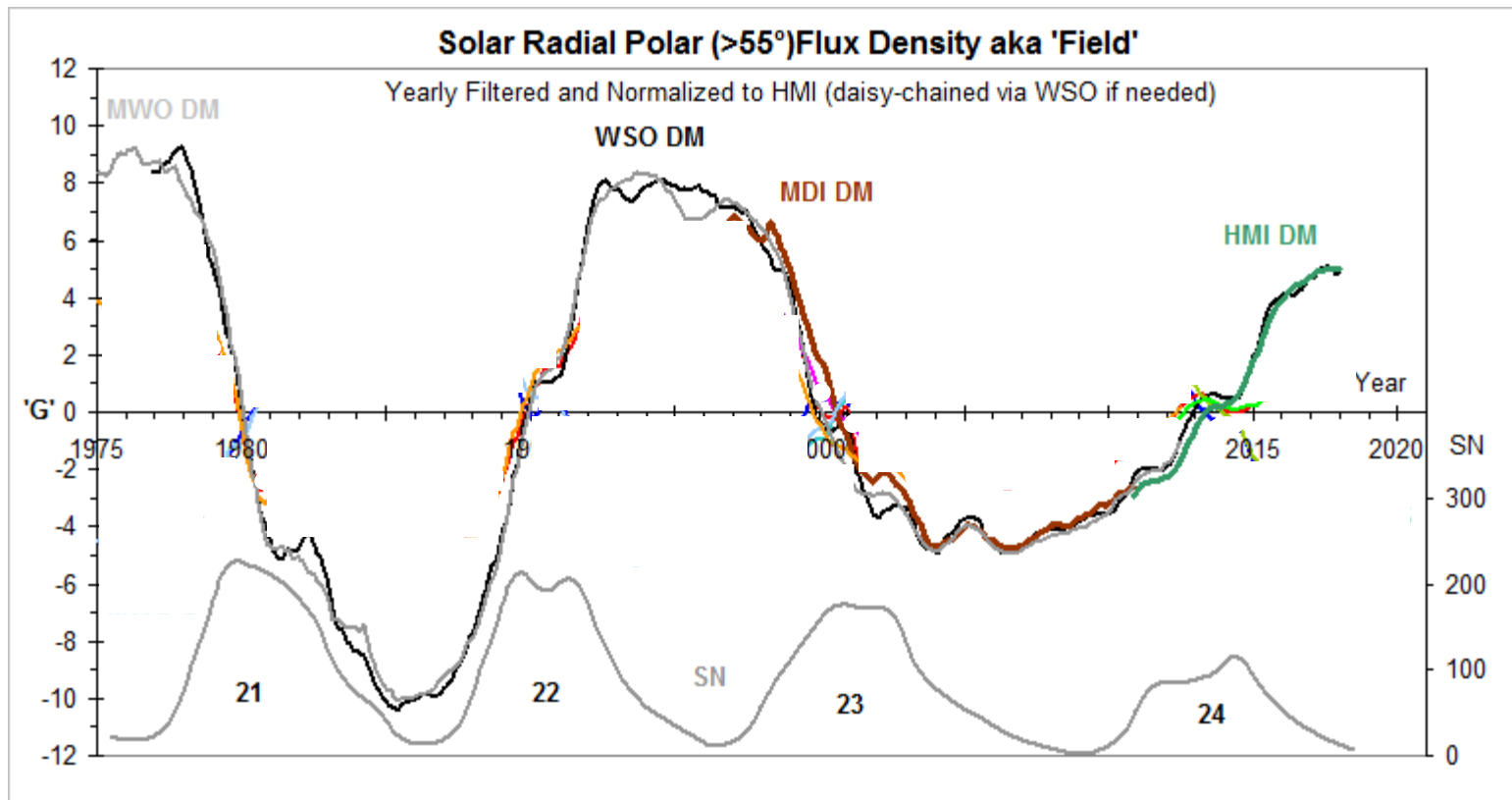


The data in the yellow rectangle [and reported on the WSO website] were faulty [too small by factor 1.55] due to dirty Littrow lens, but have now been corrected. The onset of the annual modulation can now be clearly seen.

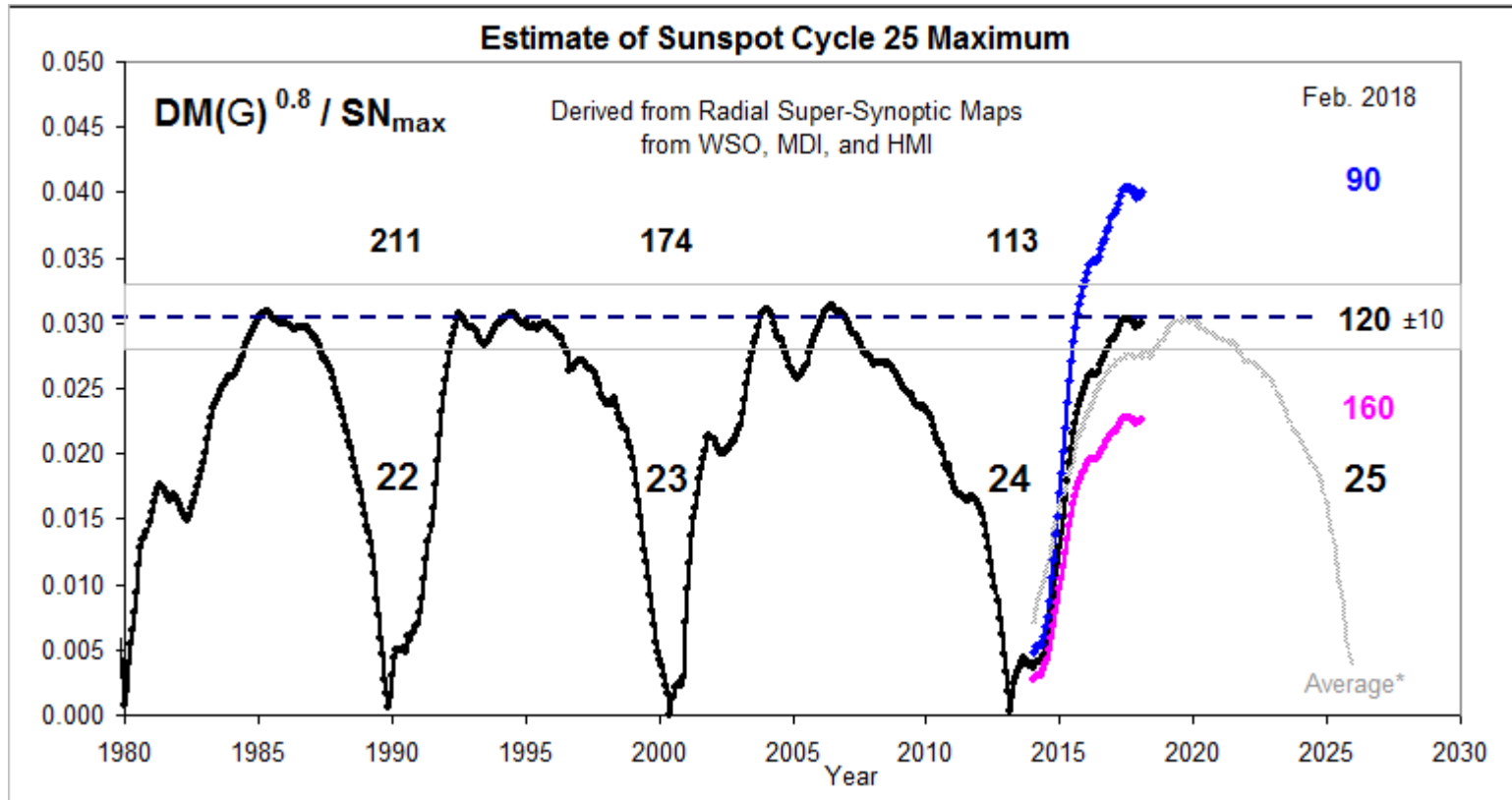
Remove the Annual Modulation by 1-yr Boxcar Averaging



Remove the Annual Modulation by 1-yr Boxcar Averaging

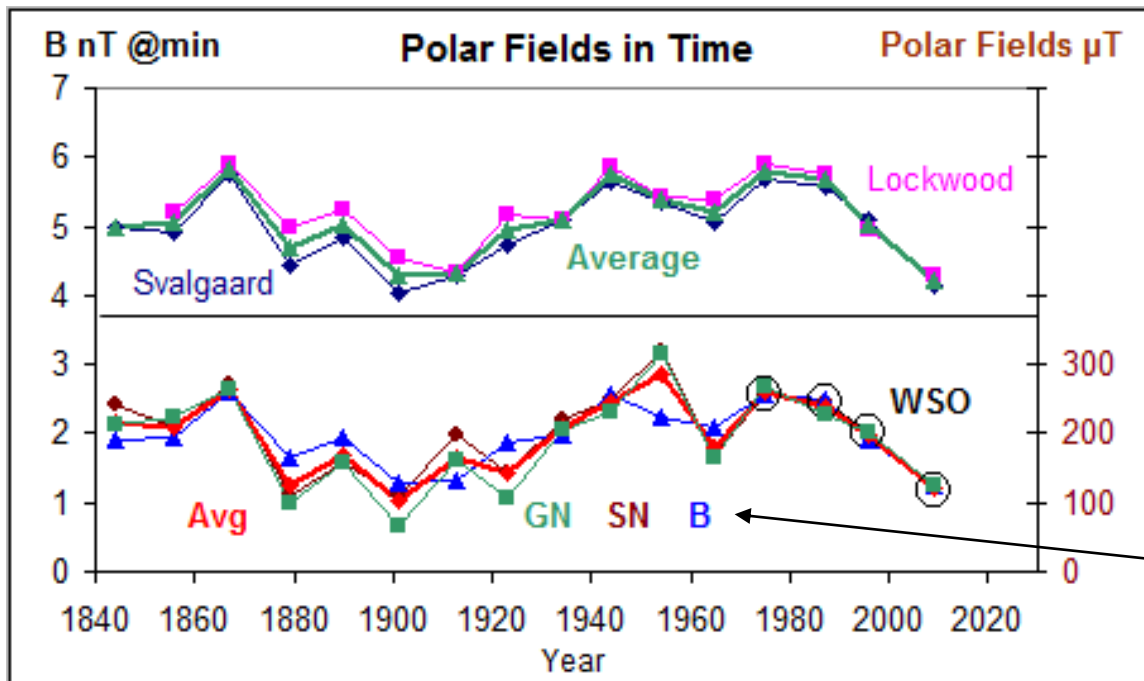
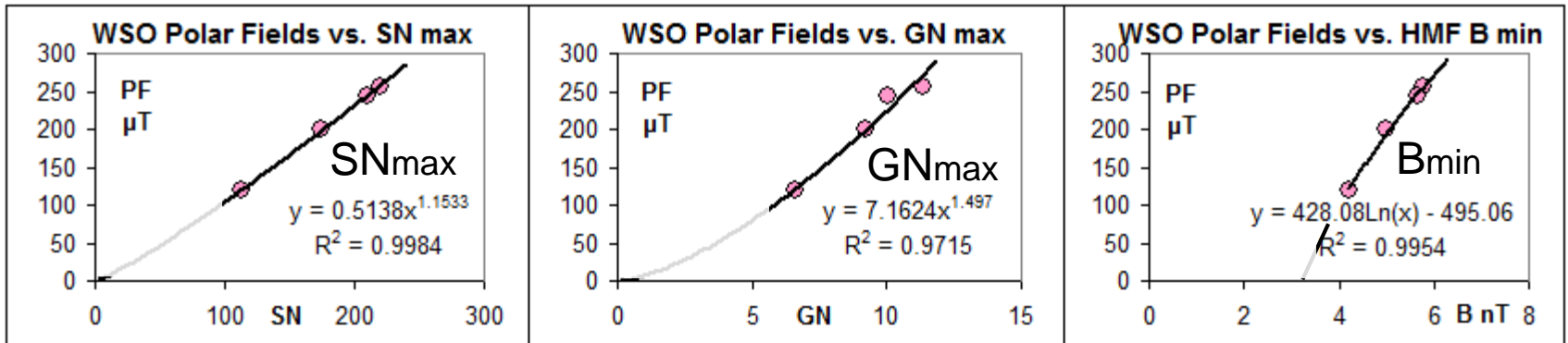


Prediction of Cycle 25



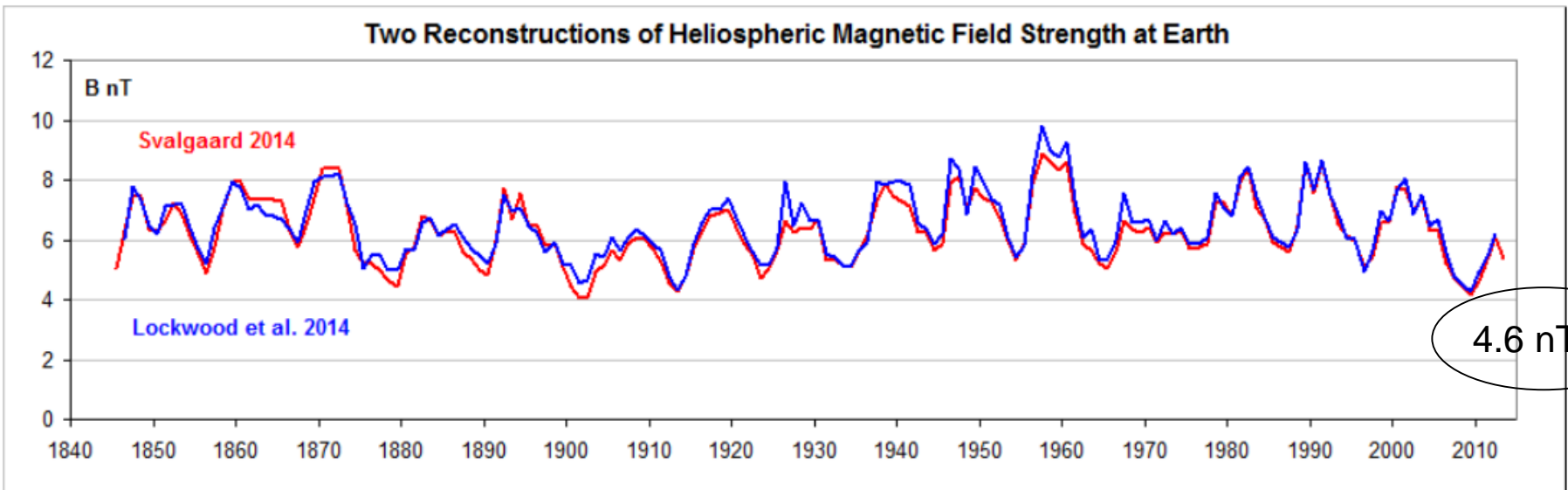
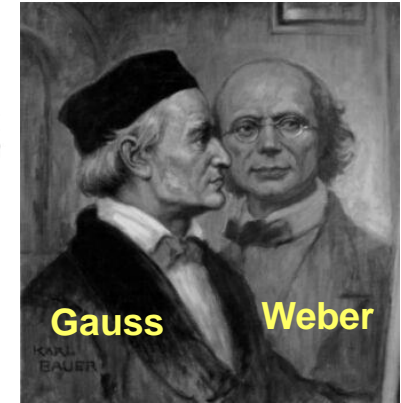
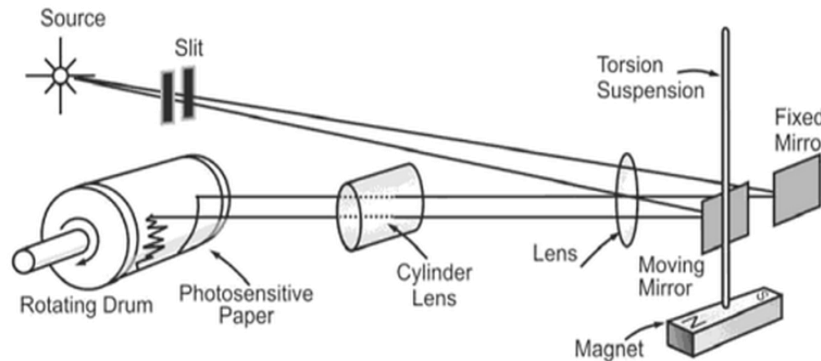
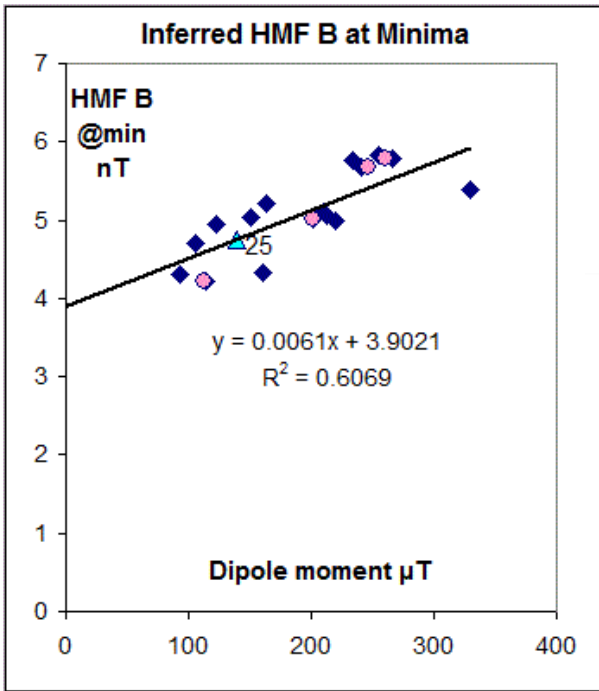
Should the polar fields increase further, SC25 would be correspondingly higher

Hindcasting Polar Fields in Time

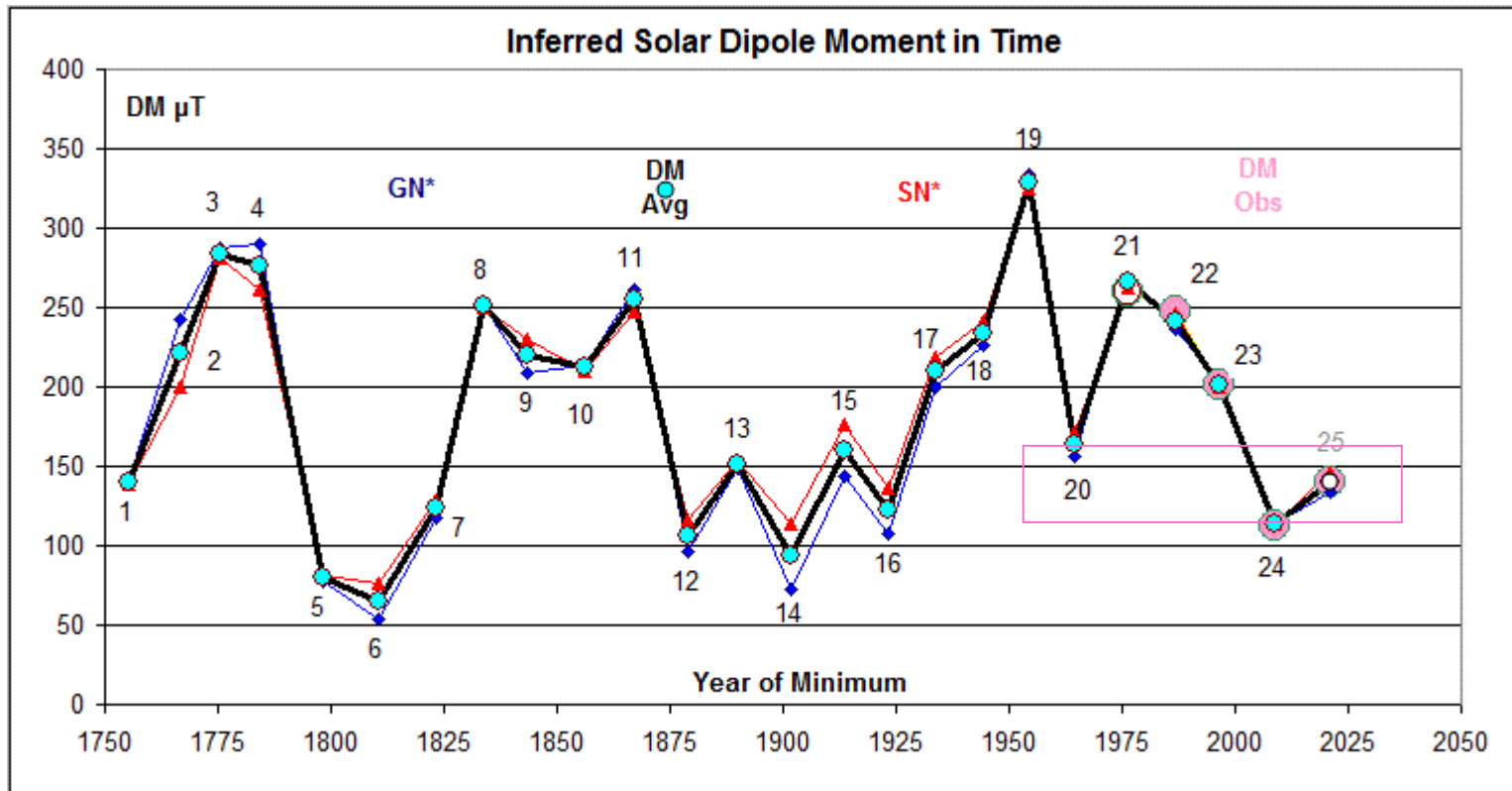


If we can forecast cycle maximum activity from the polar fields, we should be able to hindcast the polar fields from the cycle's maximum activity. If HMF B at minimum (proxy for polar fields) forecasts activity maximum, then such maxima hindcast HMF B . How do we get B for the past?

From the Geomagnetic Record we can reconstruct HMF magnetic field B with Confidence



The Prediction (At Last)



SC25 will be somewhere between SC24 and SC20, provided the Polar Field Precursor Relationship holds.