Long-term Evolution of Magnetic Fields in Sunspots From Measurements from MWSO: Part II

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National Solar Observatory

3rd Sunspot Number Workshop
January 22 - 25, 2013 - NSO Tucson, Arizona

Solar Phys
DOI 10.1007/s11207-012-0220-5

SOLAR ORIGINS OF SPACE WEATHER AND SPACE CLIMATE

Cyclic and Long-Term Variation of Sunspot Magnetic Fields

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Received: 28 August 2012 / Accepted: 22 December 2012

Abstract Measurements from the Mount Wilson Observatory (MWO) were used to study the long-term variations of sunspot field strengths from 1920 to 1958. Following a modified approach similar to that presented in Pevtsov *et al.* (*Astrophys. J. Lett.* **742**, L36, 2011), we selected the sunspot with the strongest measured field strength for each observing week and computed monthly averages of these weekly maximum field strengths. The data show the solar cycle variation of the peak field strengths with an amplitude of about 500 – 700 gauss (G), but no statistically significant long-term trends. Next, we used the sunspot observations from the Royal Greenwich Observatory (RGO) to establish a relationship between the sunspot ar-

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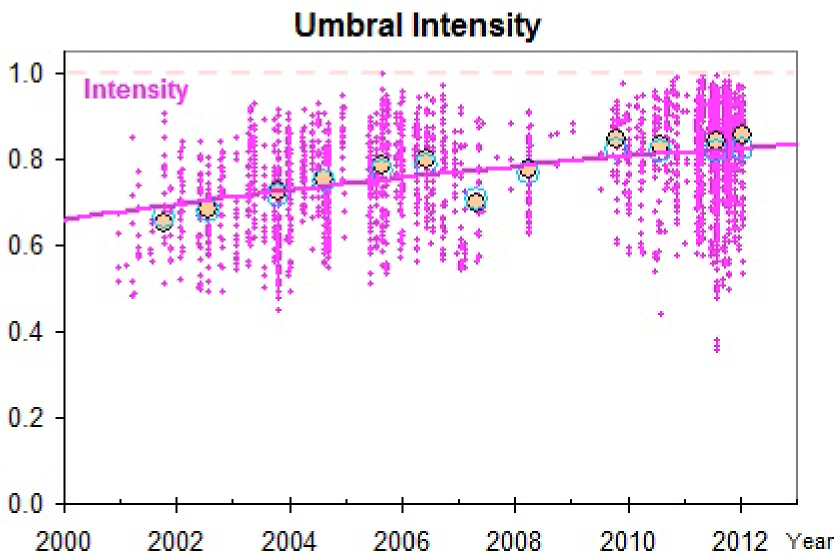
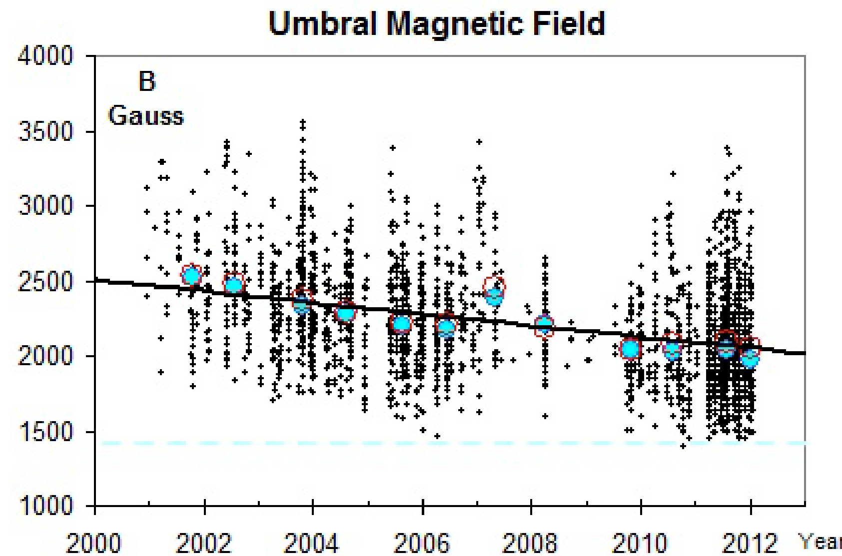
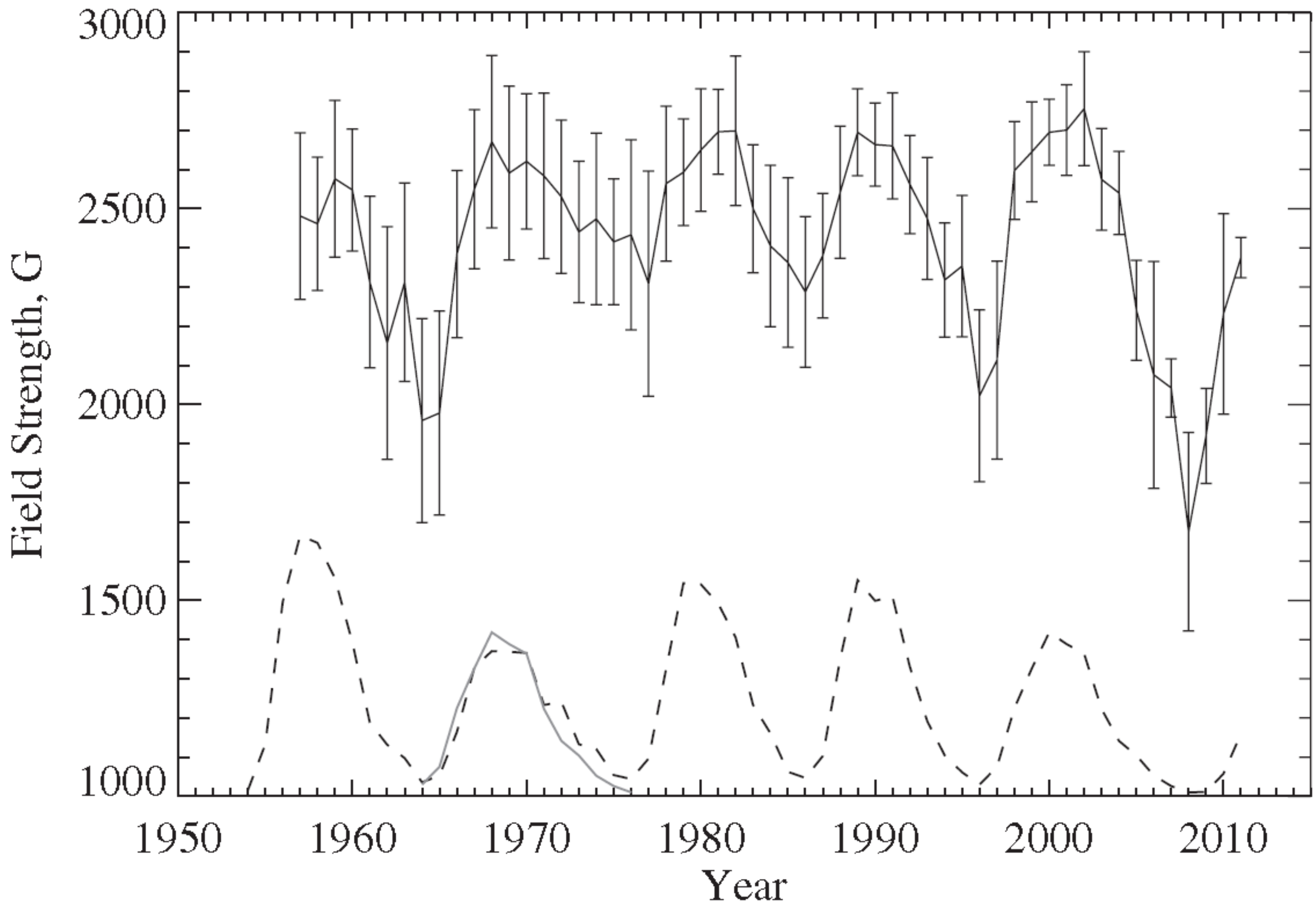
Motivation



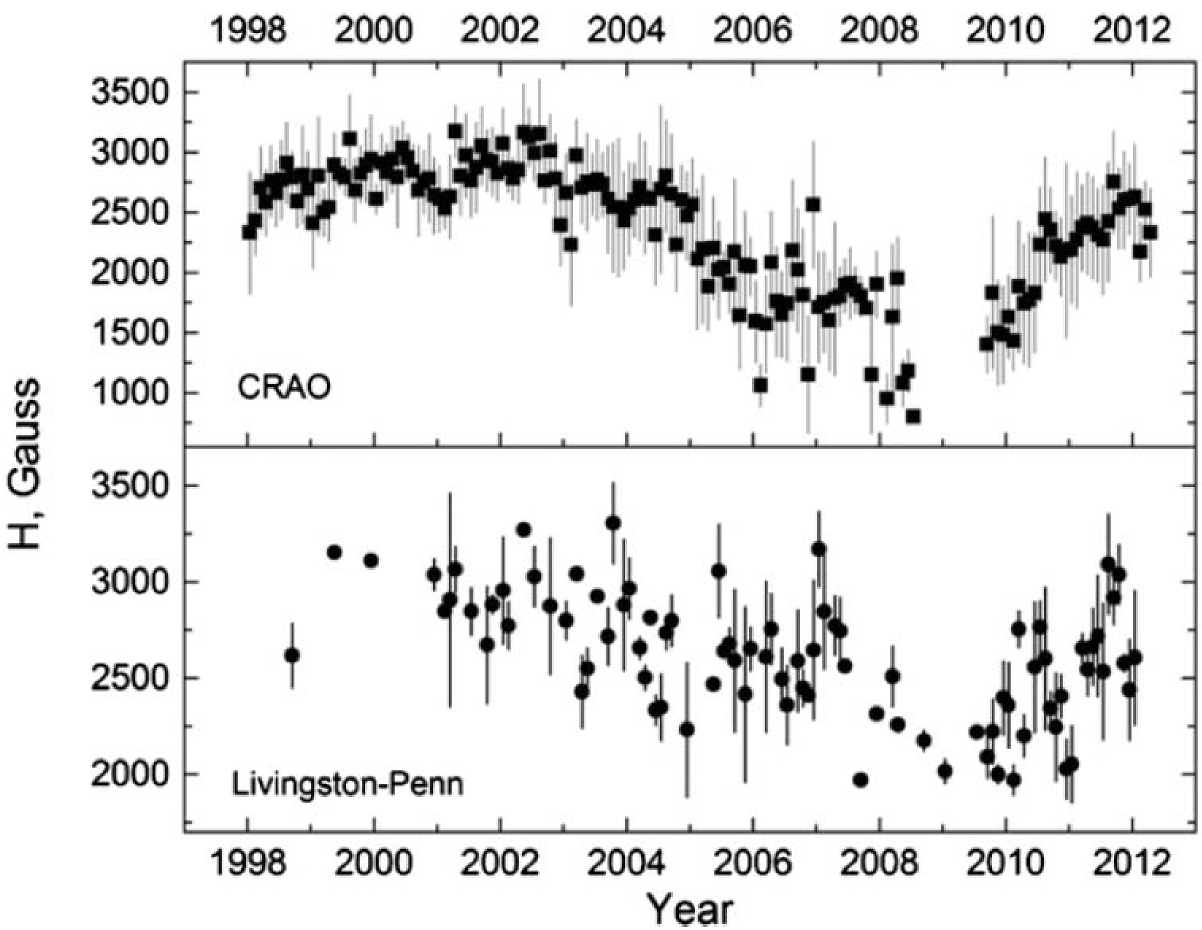


Livingston (private communication)



Pevtsov et al. (2011, ApJL; Mag. field measurements from 7 stations)

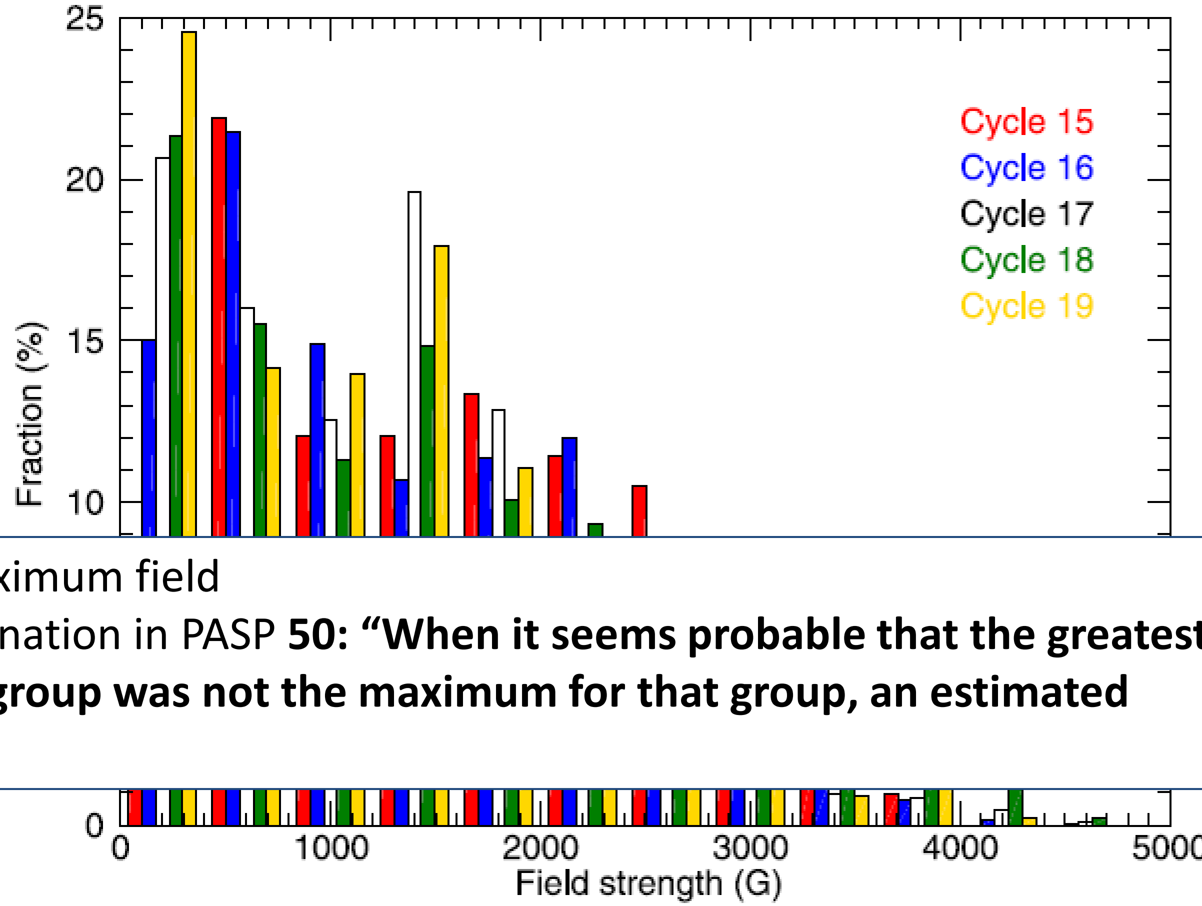
(see also Watson et al., 2011; Rezaei et al., 2012)



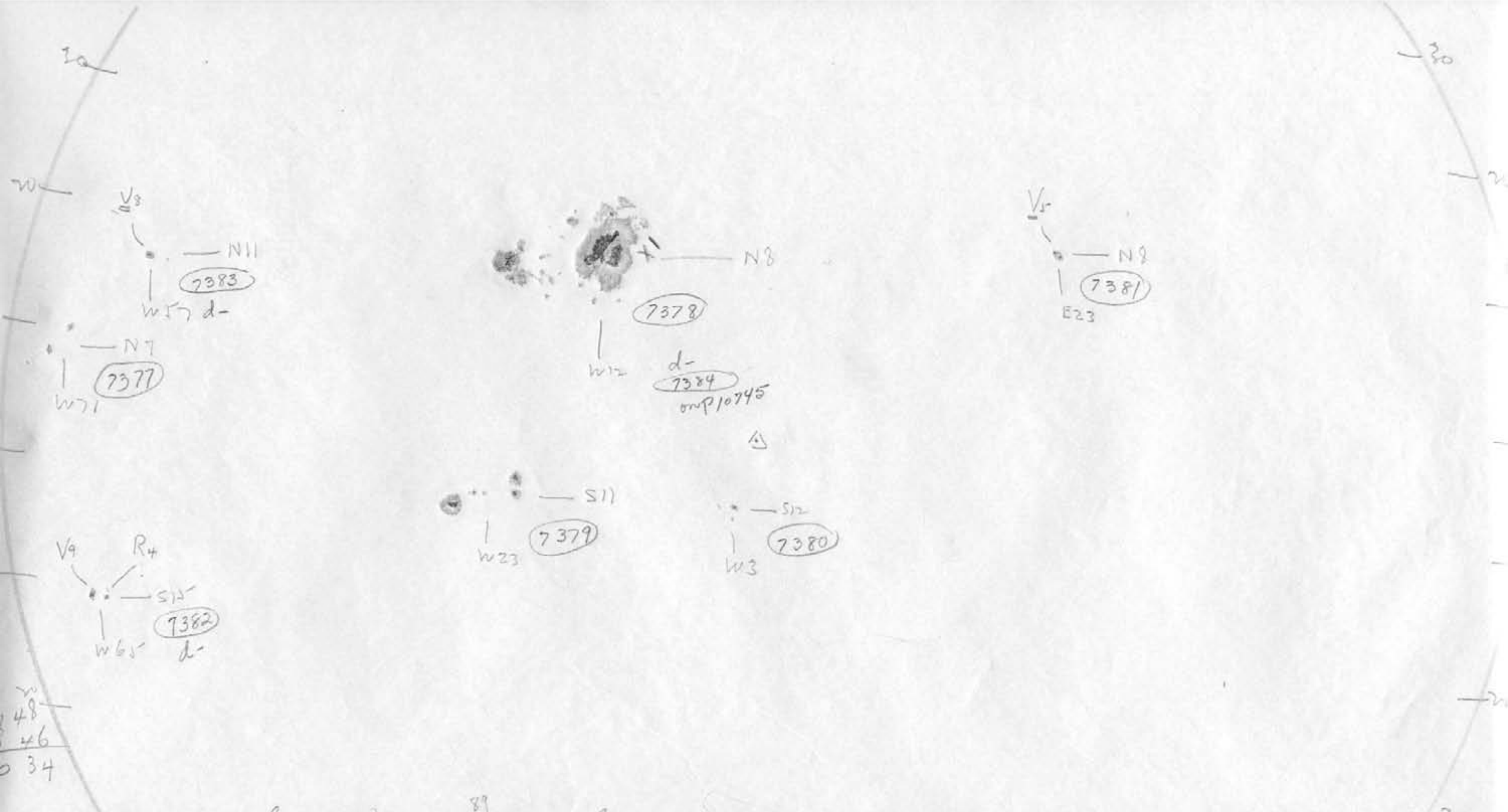
Nagovitsyn, Pevtsov, Livingston (2012, ApJL)

Data Set: MWO 1920-1959

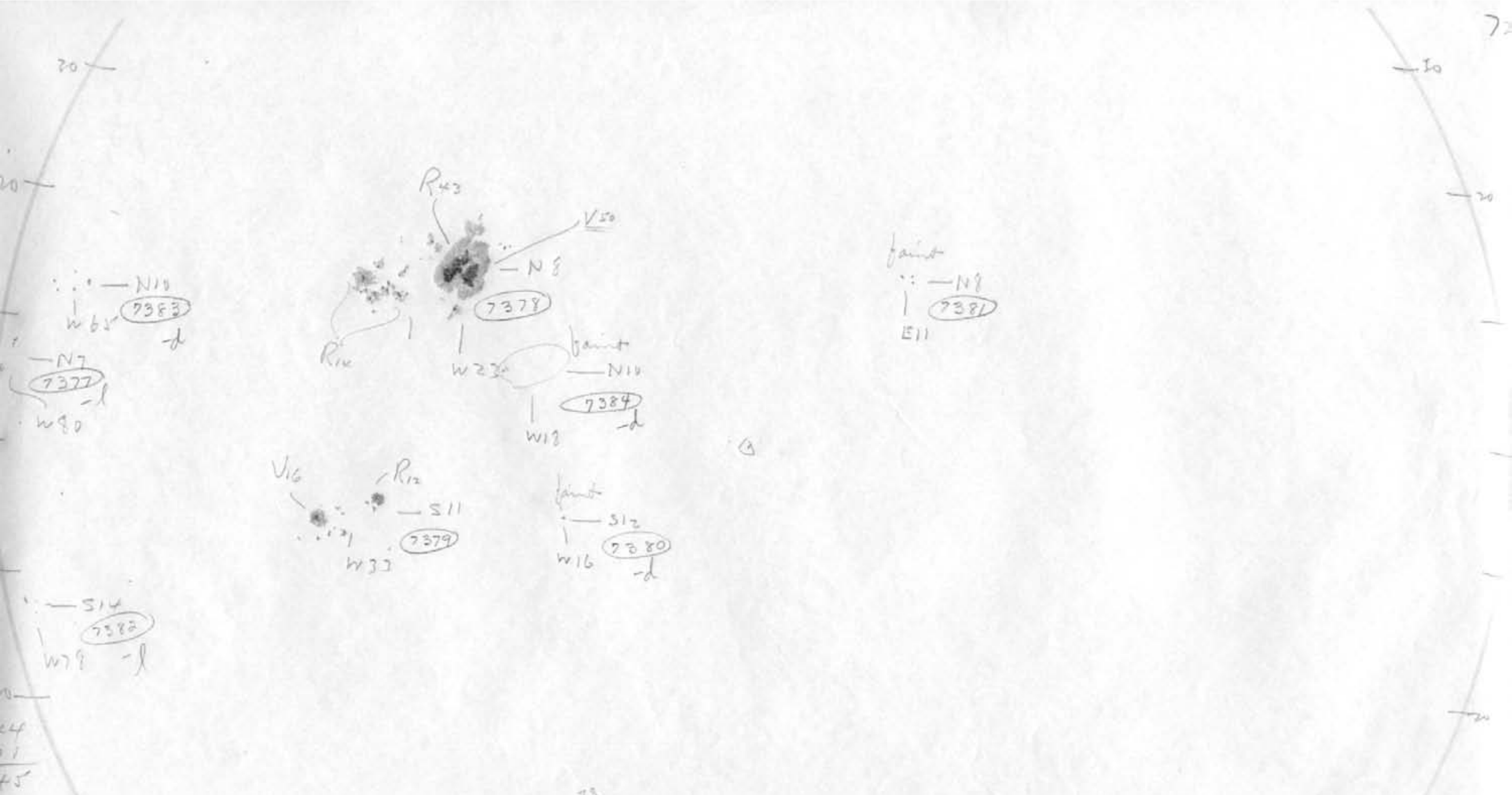
Figure 1 Fractional distribution of sunspot field strengths for different cycles. The bin size is 400 G. Measurements with zero field strength are excluded.



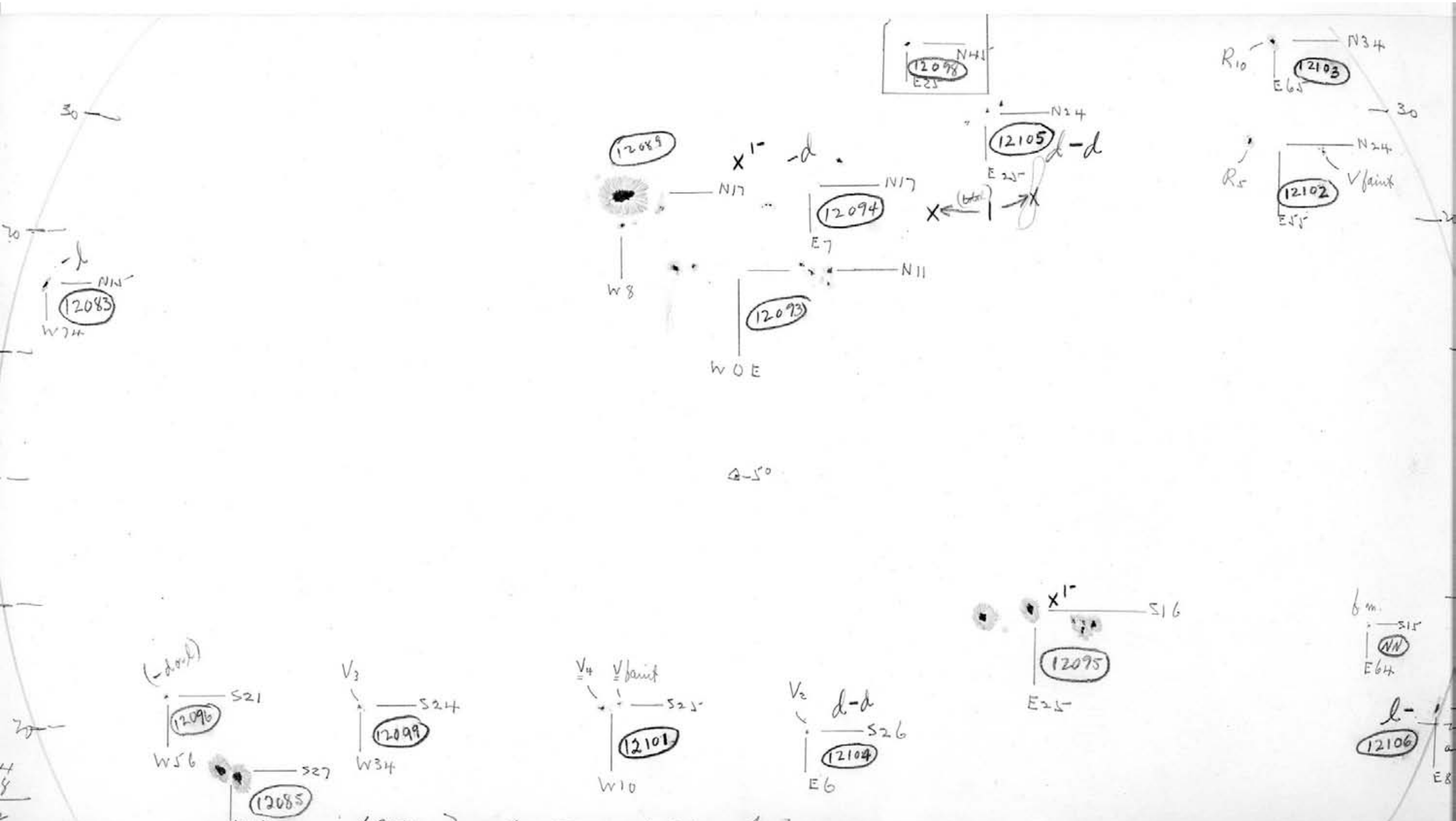
For some active regions the maximum field strength is estimated (see explanation in PASP **50: "When it seems probable that the greatest field-strength observed in any group was not the maximum for that group, an estimated value is given in parentheses"**).



1942 Sunday March 1 .89 1 10 Seeing 4 JJH



1942 Monday March 2 9 30 Seeing 6 through thin clouds.



1957 Tuesday Jan 22nd 8 30 Seeing 4 DOH

Methodology

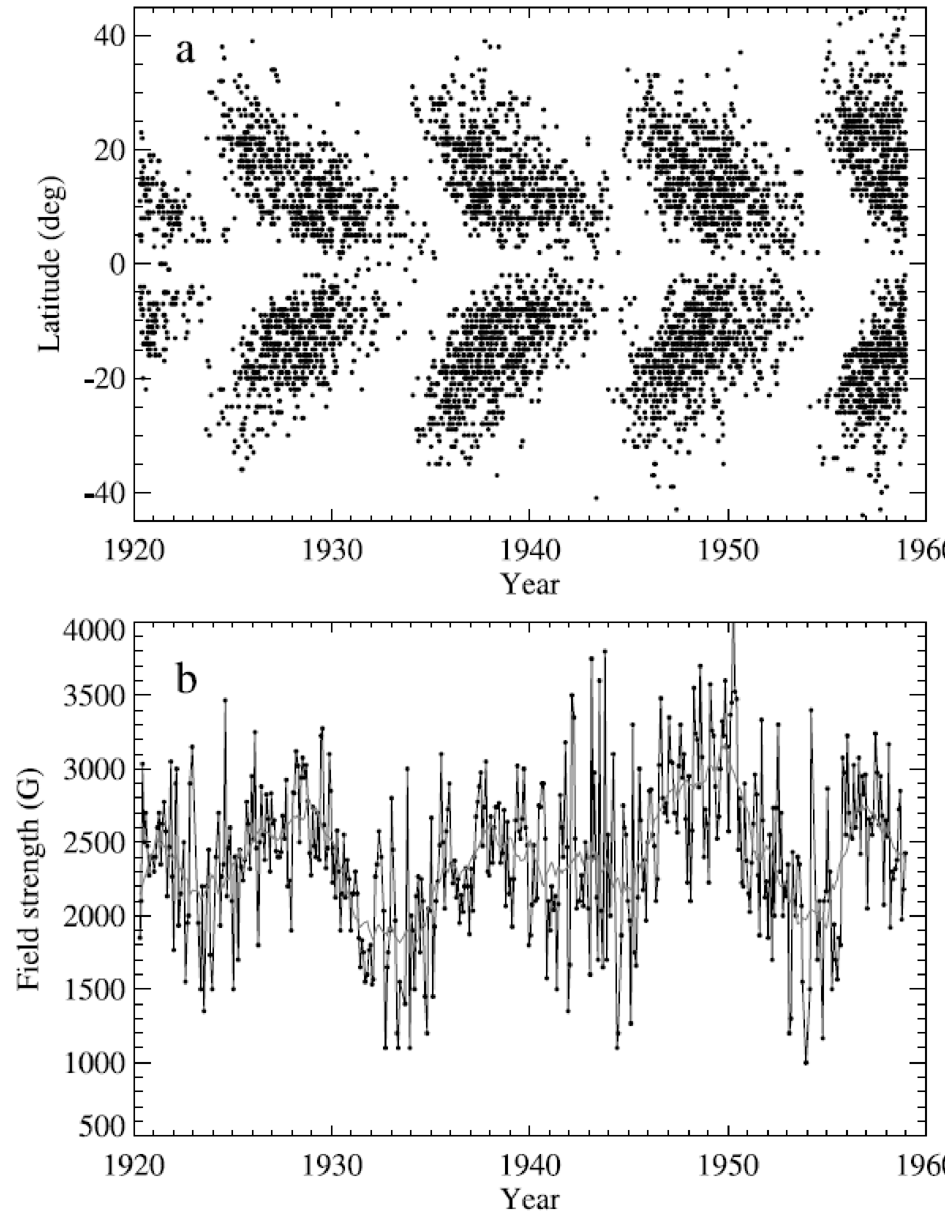
-Excluded mag. field weaker than 1000G (splitting is comparable to the Doppler width, Livingston et al., 2006)

-Use date of central meridian crossing as proxy for “day of observations”

-Applied modified criteria from Pevtsov et al (2011): one strongest measurement per week.

-To compare with RGO data, used difference in latitude and date of CM crossing.

Figure 2 Time-latitude distribution of sunspots in the MWO data set included in our study (upper panel), and monthly average of daily peak sunspot field strengths (lower panel, dots connected by thin line). The thick gray line is the 18-point running average.

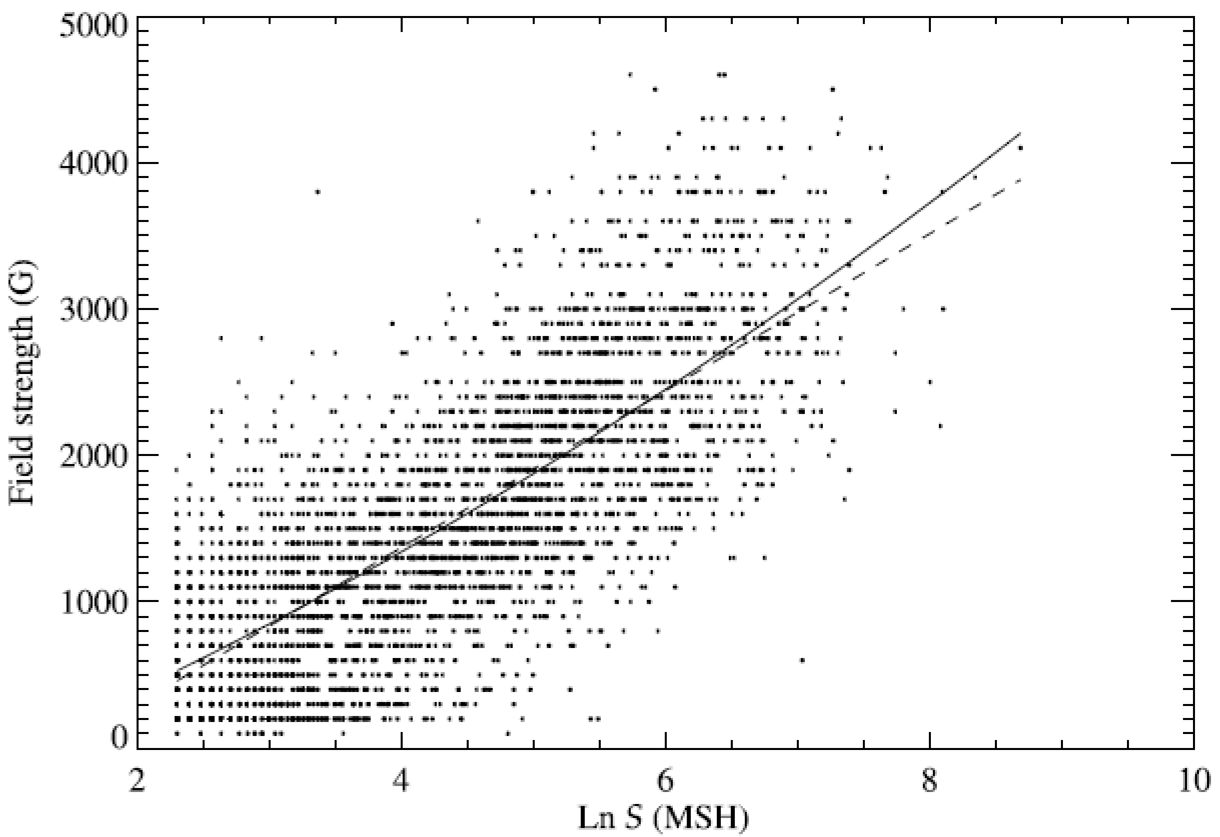


Solar cycle		Sunspot field	
Minimum	Maximum	Minimum	Maximum
1923		1923.6	
	1928		1928.8
1933		1933.3	
	1937		1938.1
1944		1944.7	
	1947		1949.8
1954		1953.9	

Pevtsov et al (2013, Solar Physics)

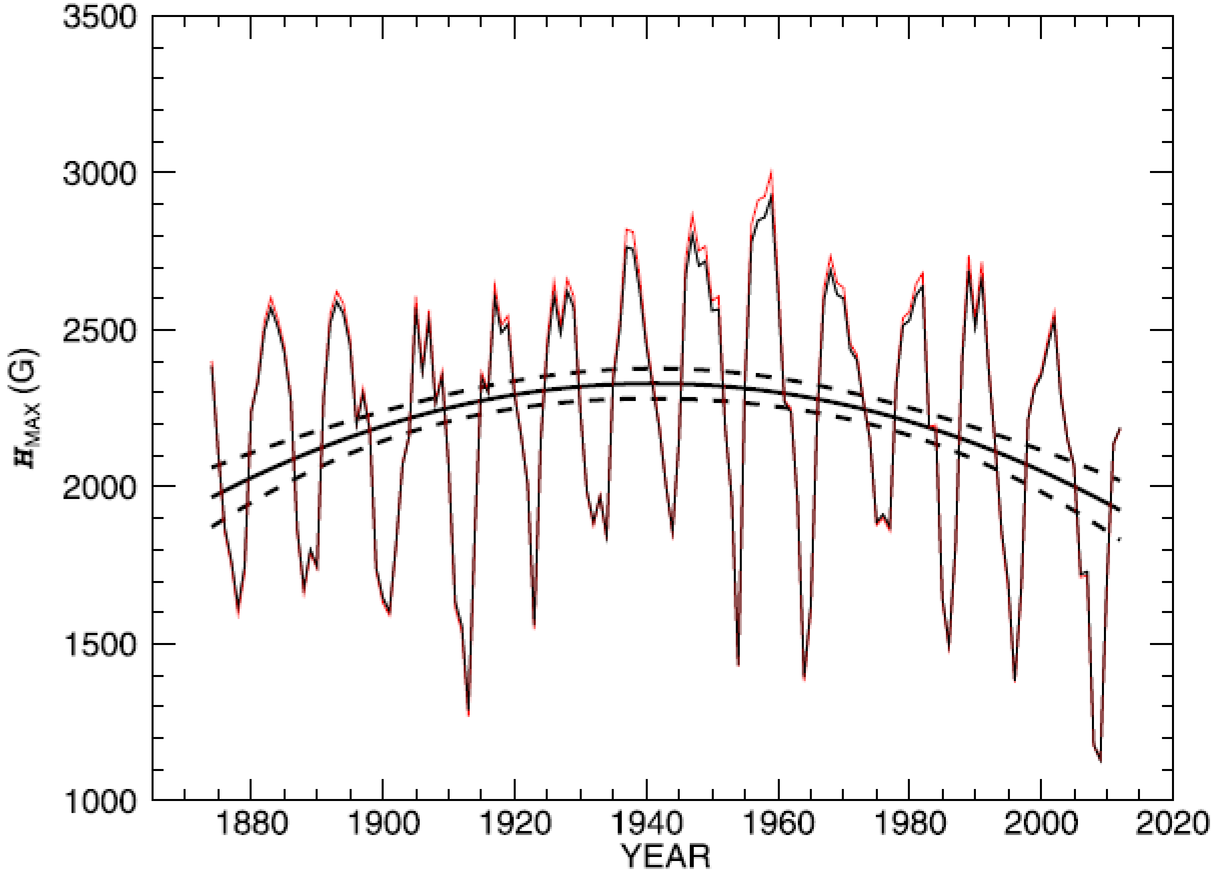
Bmax-Area Correlation

Figure 3 Magnetic field strength (from MWO observations) vs. the natural logarithm of the sunspot area (from RGO observations) for cycles 15 – 19. The dashed line is a first-degree polynomial fit to the data. Fitted coefficients are shown in Table 2, in the entry for "all cycles". For comparison, the solid line shows a fit by a quadratic function.

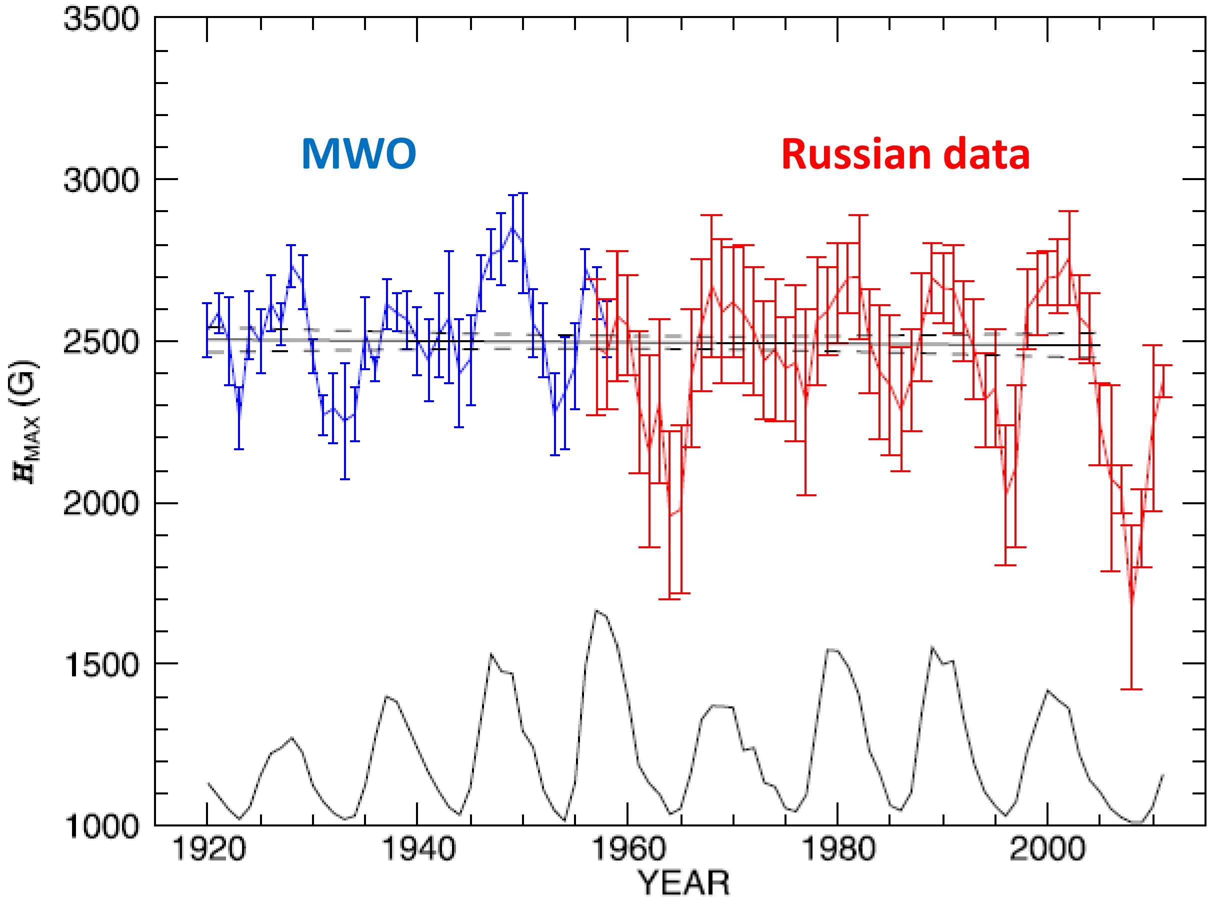


Pevtsov et al (2013, Solar Physics)

Figure 4 Proxy of the magnetic field strength computed from the deprojected sunspot areas. Annual averages are shown as a thin solid line. The thick solid line is a second-degree polynomial approximation to the data, and the two thick dashed lines represent a one-standard deviation error band for the fit. The red line shows the magnetic field proxy derived using the quadratic dependency shown in Figure 3.



Pevtsov et al (2013, Solar Physics)



Pevtsov et al (2013, Solar Physics)

Conclusions

•No significant secular trend is found for the period covered by the MWO data (cycles 15 – 19).

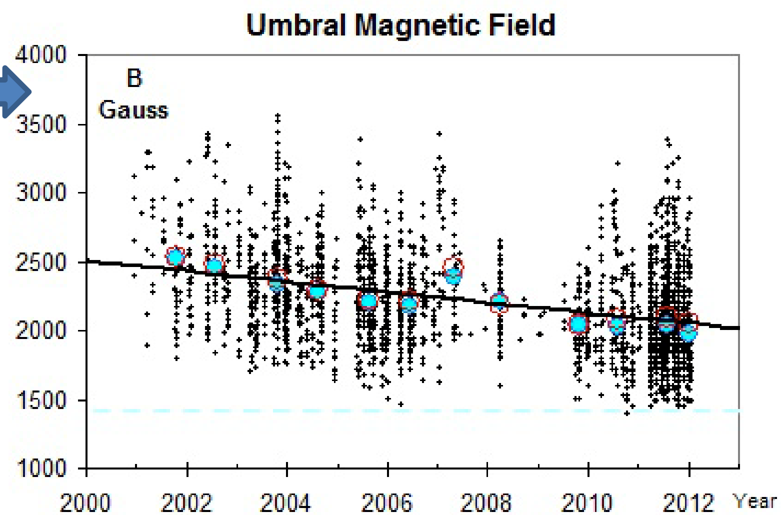
•11-year cycle variation in the sunspot daily strongest field strengths similar to that found in the previous studies for solar cycles 19 – 23 (Pevtsov *et al., 2011; Watson et al.*, 2011; Rezaei et al., 2012).

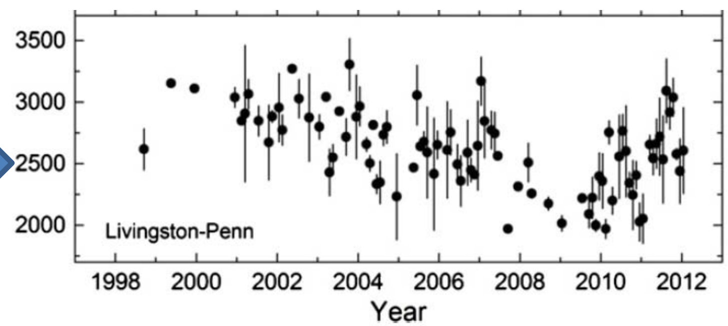
•Magnetic field proxy (based on area of sunspot) shows the cycle variations during cycles 11 – 24 (1874 – early 2012). The amplitude of these cycle variations is about 1000 G between the solar activity minima and maxima.

•The magnetic field strength proxy does show a secular trend: between 1874 and ≈ 1920, the mean value of the magnetic field proxy increased by about 300 G, and following a broad maximum in 1920 – 1960, it decreased by 300 G. The nature of this trend is unknown, but we note that the broad “maximum” in 1920 – 1960 includes the mid-twentieth century maximum of the current Gleissberg cycle, which began at about 1900.

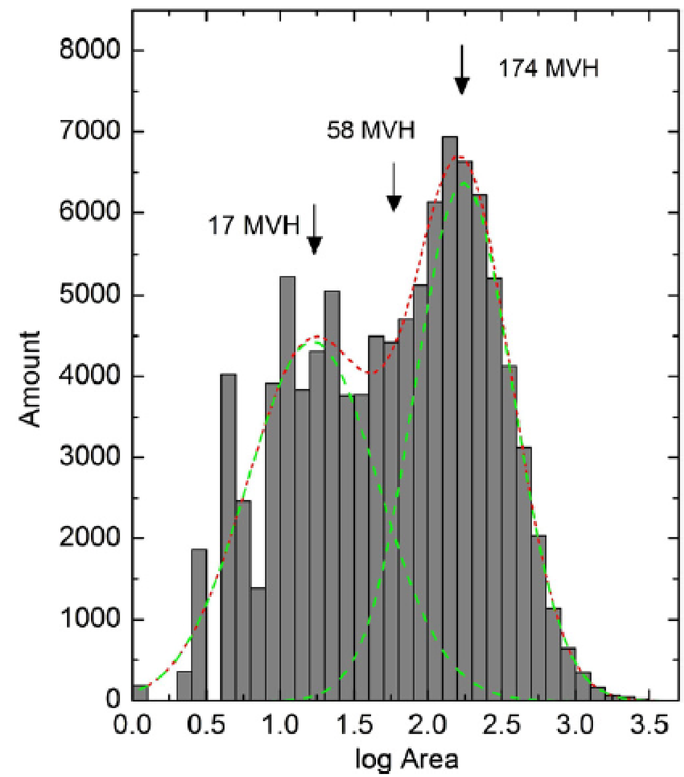
Average of all measurements

How about LP-effect?





Average of daily strongest measurements



Change in fractional distribution of sunspots can explain both trends

Nagovitsyn et al (2012, ApJL)