Using Old Geomagnetic Data to Say Something about the Sun

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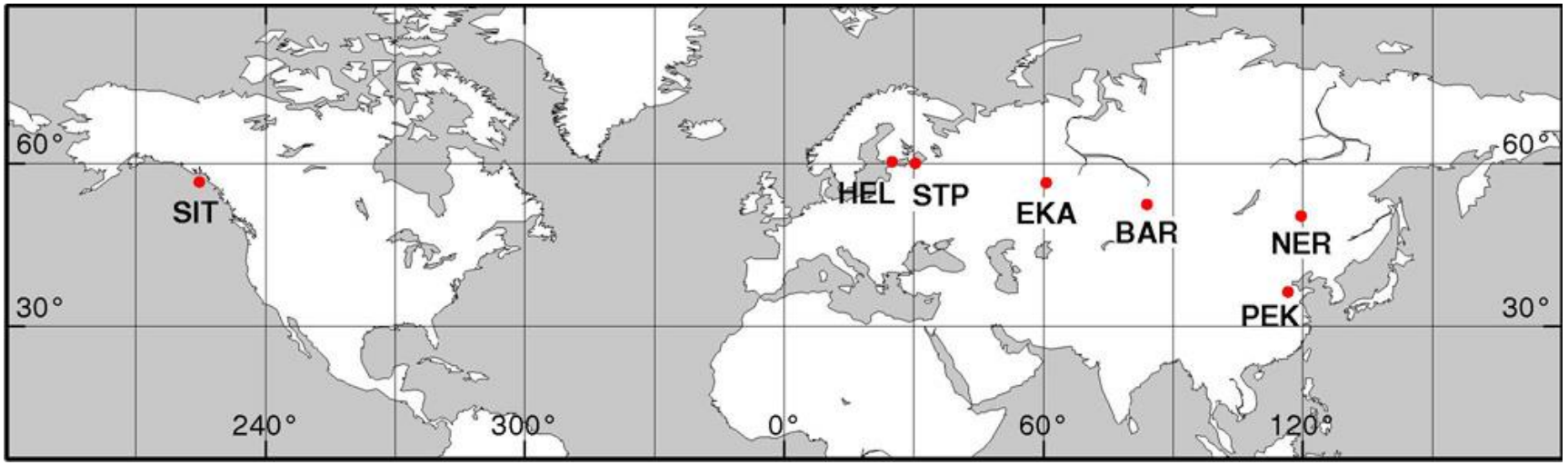
Oct. 16, 2013

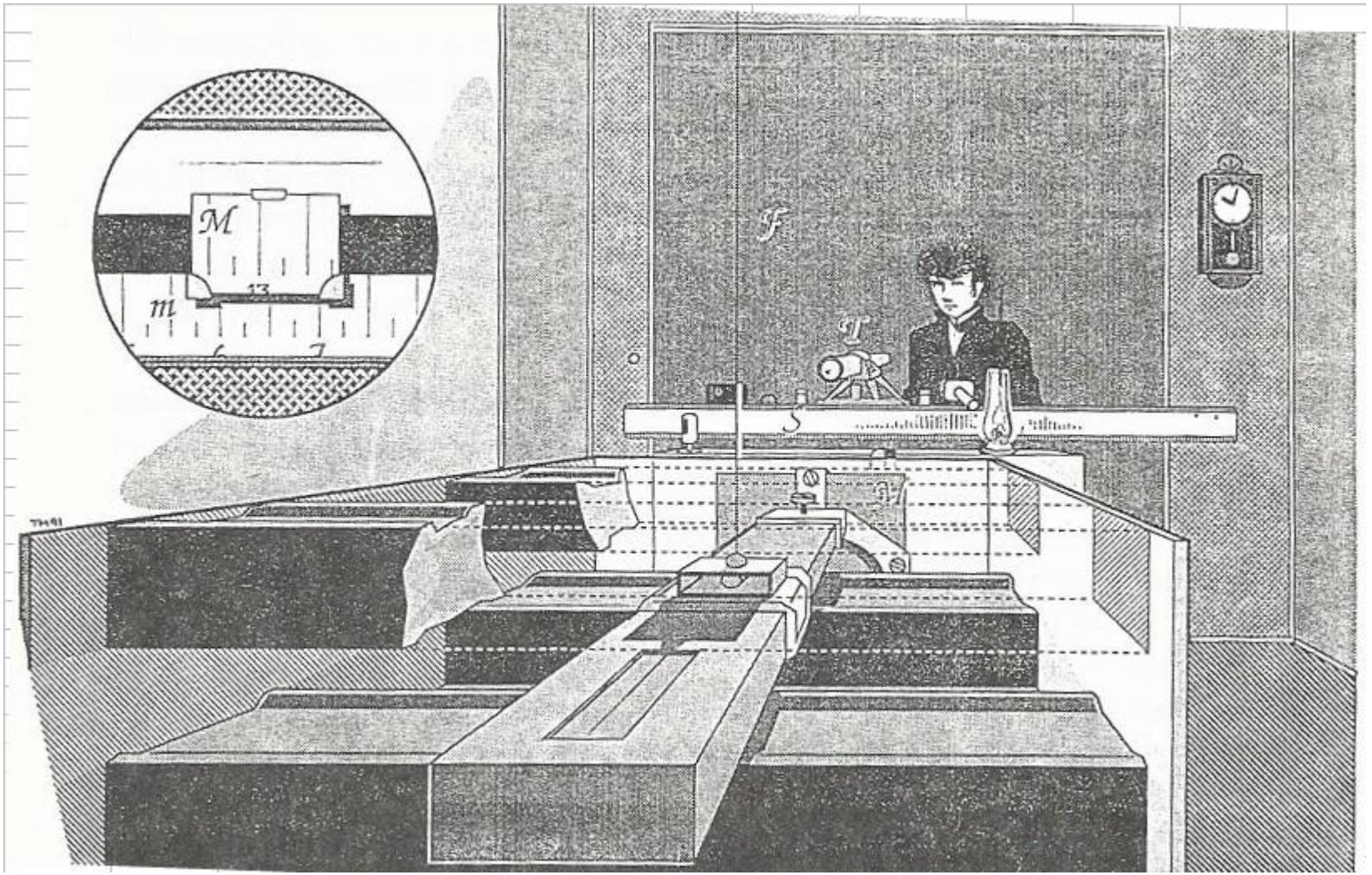
The Russian Observatories

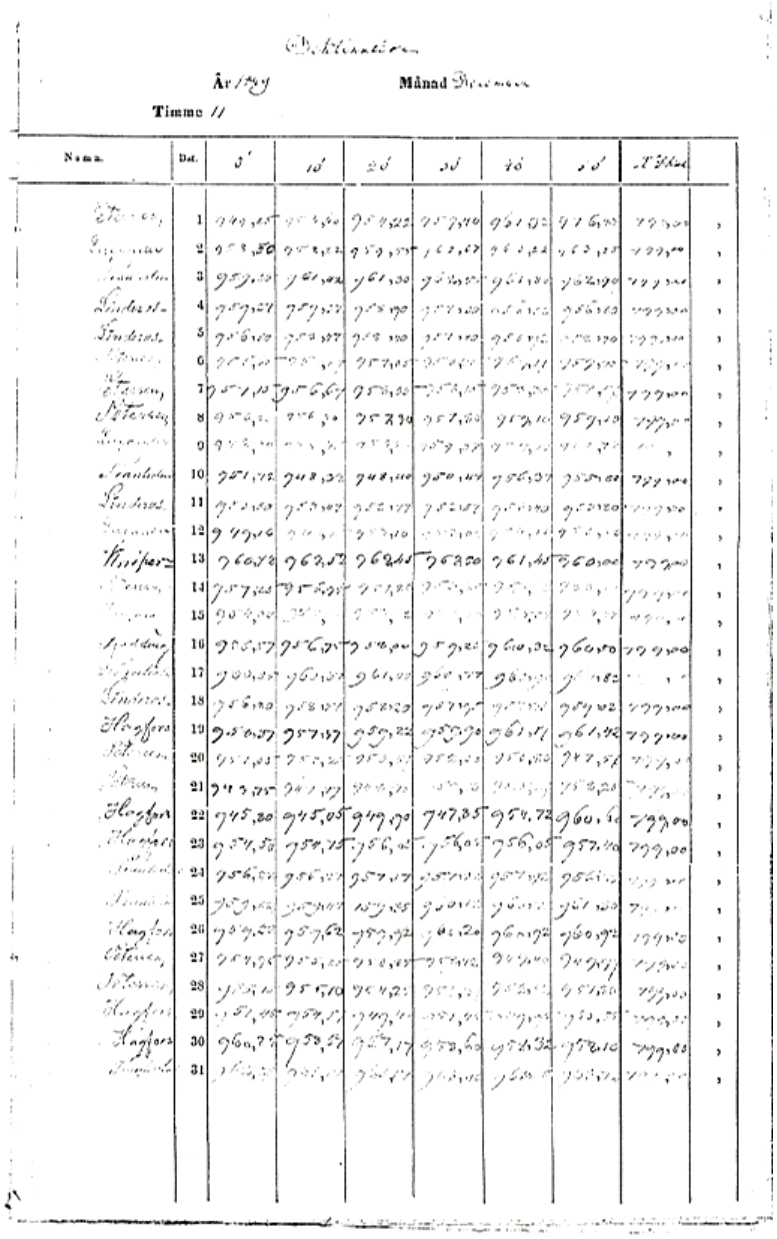


Helsinki [Finland] established on 28th March 1838 by imperial decree of Czar Nicholas I. First director J.J. Nervandor (1805-1848).

Ready for business: July 1st, 1844, continued until 1905. Last few years unreliable because of disturbances from electric tramway traffic started in 1901.

Variometer Invented by Gauss





The Raw Data

1844-1856 10 minute cadence

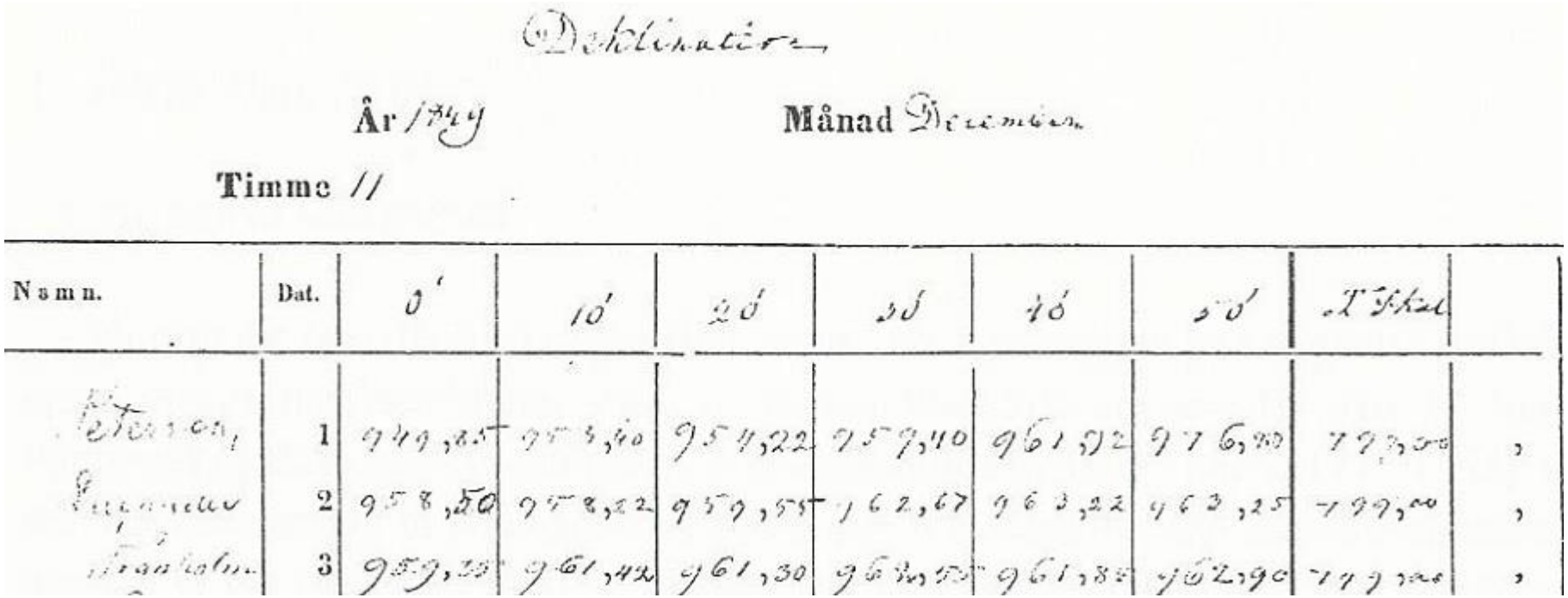
1856-1897 1 hour cadence

2.5 million observations

Staff: Director and 12 observers [students]

Many hundred notebooks

Detail of Raw Data



Deklination

År 1849 Månad December

Timme //

Namn.	Dat.	0′	10′	20′	30′	40′	50′	I Skal	
Etman	1	949,85	953,40	954,22	959,40	961,92	976,30	979,00	,
Lagman	2	958,50	958,22	959,55	962,67	963,22	963,25	979,00	,
Fänrik	3	959,33	961,42	961,30	963,50	961,85	962,90	979,00	,

Digitized by pupils in elementary schools all across Finland

Sample Data

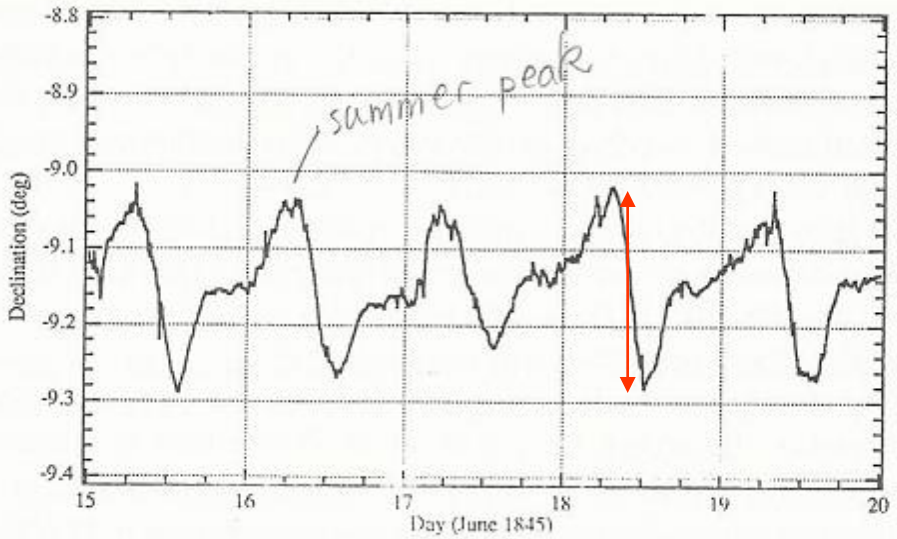


Fig. 10a. An example of magnetically quiet period. Displayed is the declination in June 15-20, 1845 showing the typical regular daily variation ranging within 0.3°.

Regular daily variation

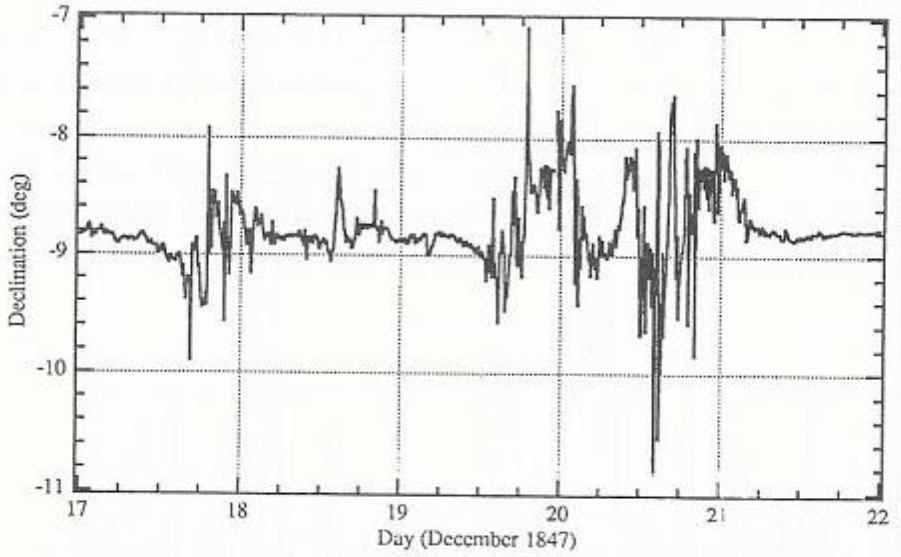
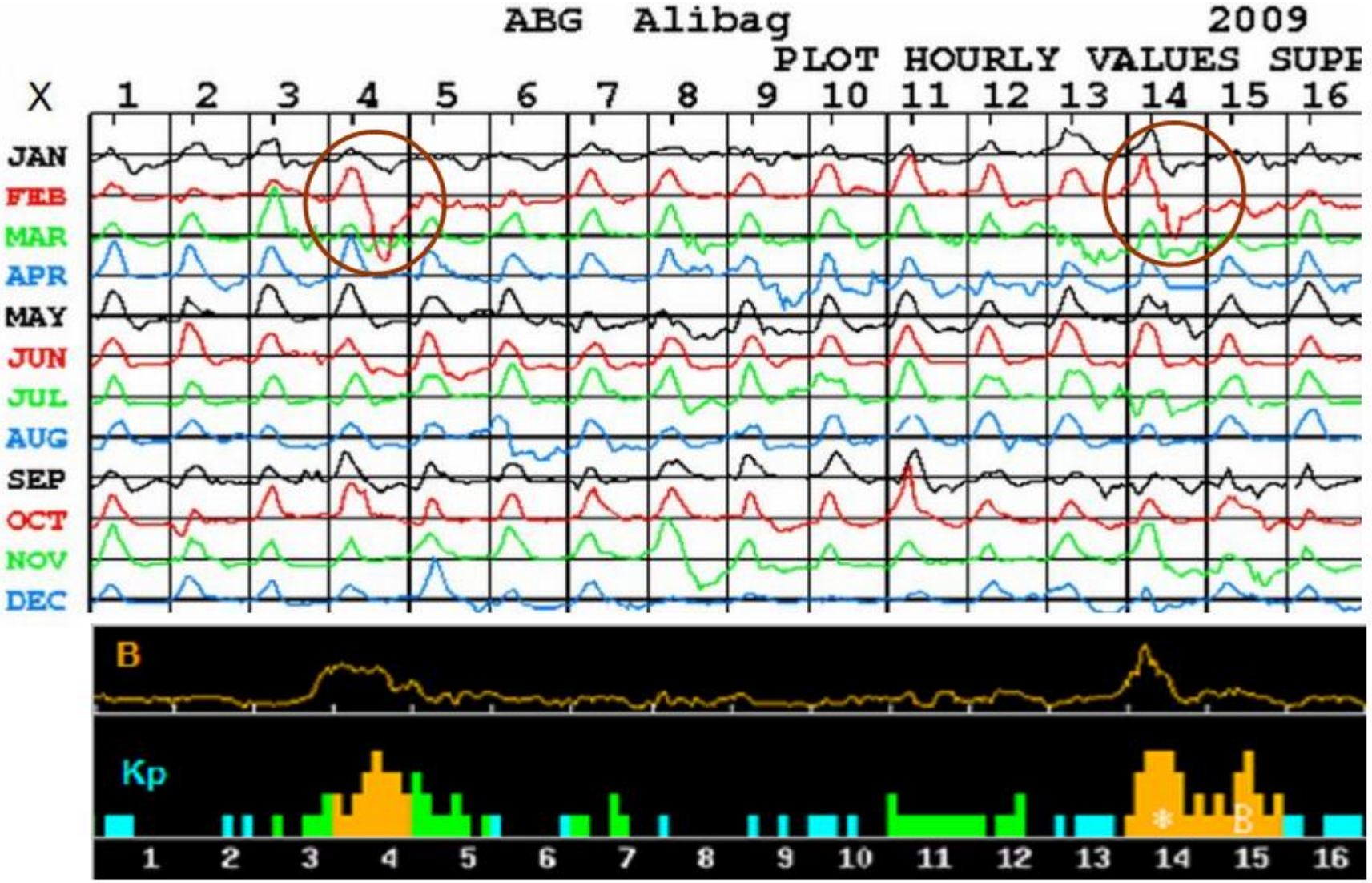


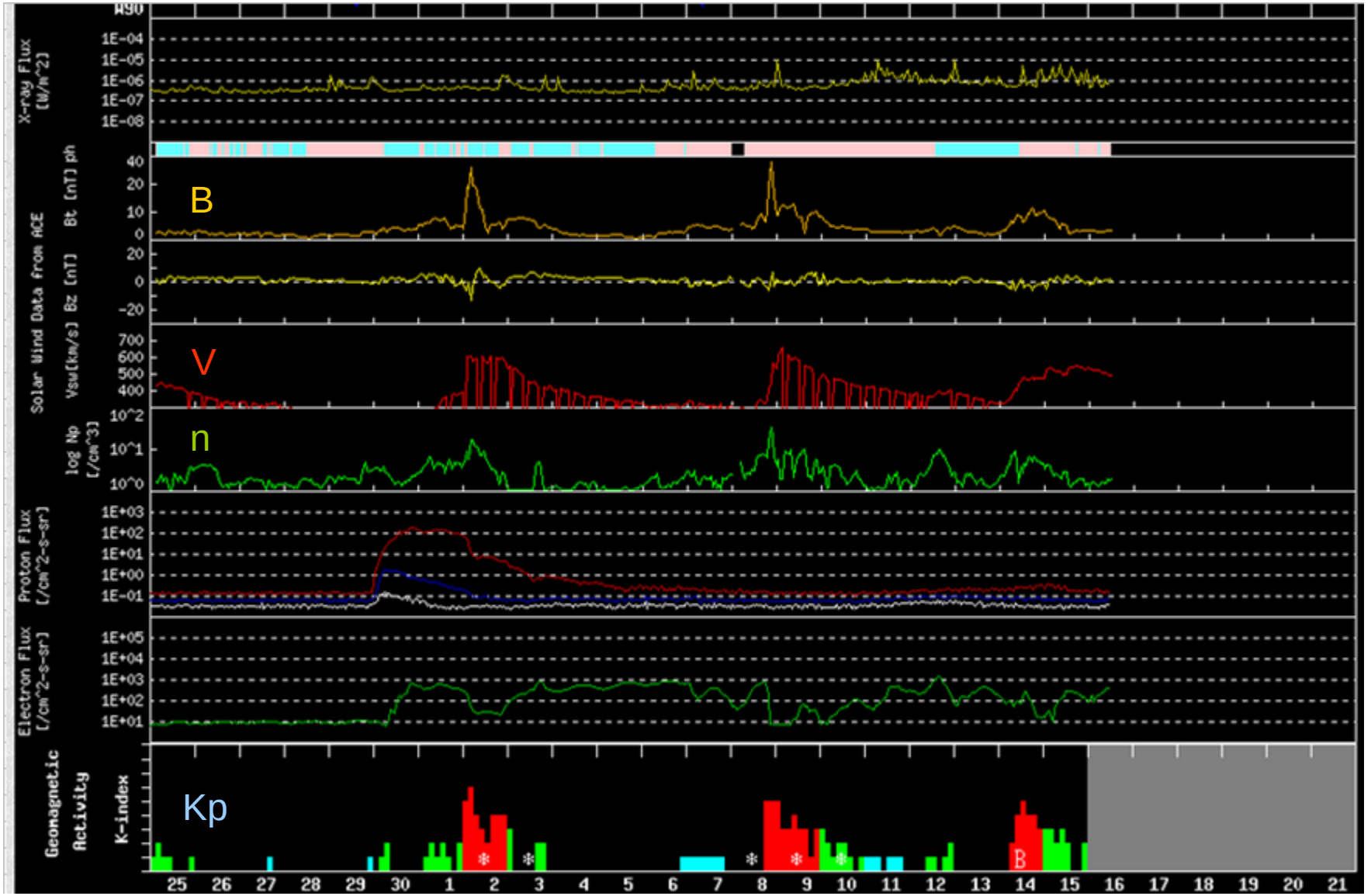
Fig. 10b. The most violent magnetic storm in 1844-1853 occurred on December 20, 1847. The figure depicts declination variations in December 17-22, 1847. The greatest peak-to-peak values of *D* were about 3° in a few hours being roughly ten times larger than the regular variation shown in Fig. 10a.

Magnetic storm

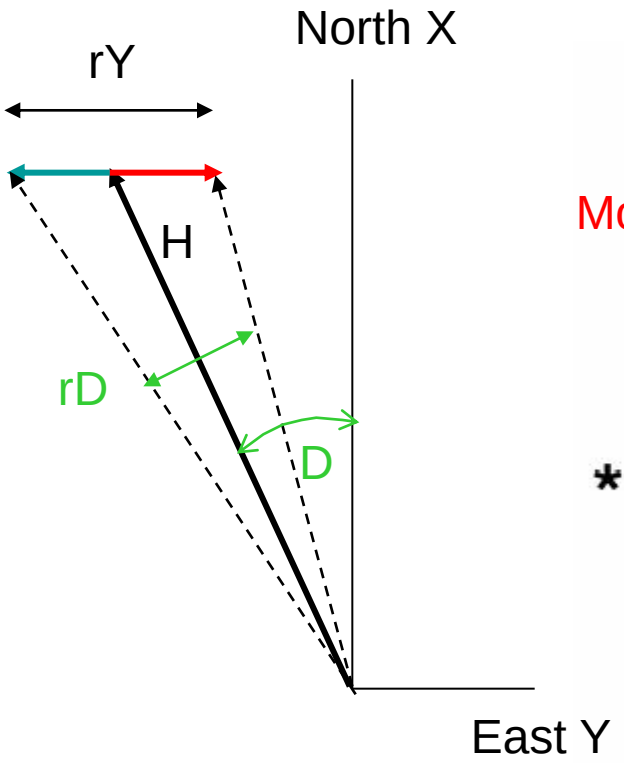
Relation to HMF Strength B



Today

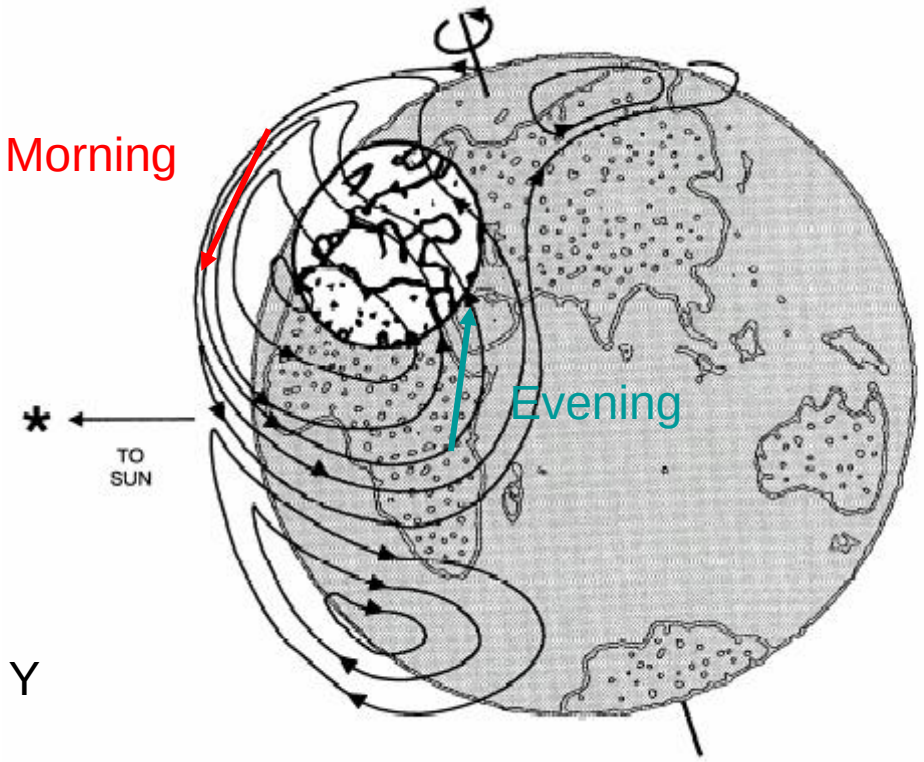

X-ray Flux (W/m^2)
Solar Wind Data from ACE
Bt (nT) ph
Vsw(km/s) Bz (nT)
log Np (/cm^3)
B
V
n
Proton Flux (/cm^2-s-sr)
Electron Flux (/cm^2-s-sr)
Geomagnetic Activity
K-index
Kp
25 26 27 28 29 30 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21

Wolf's Discovery: $rD = a + b\,R_W$



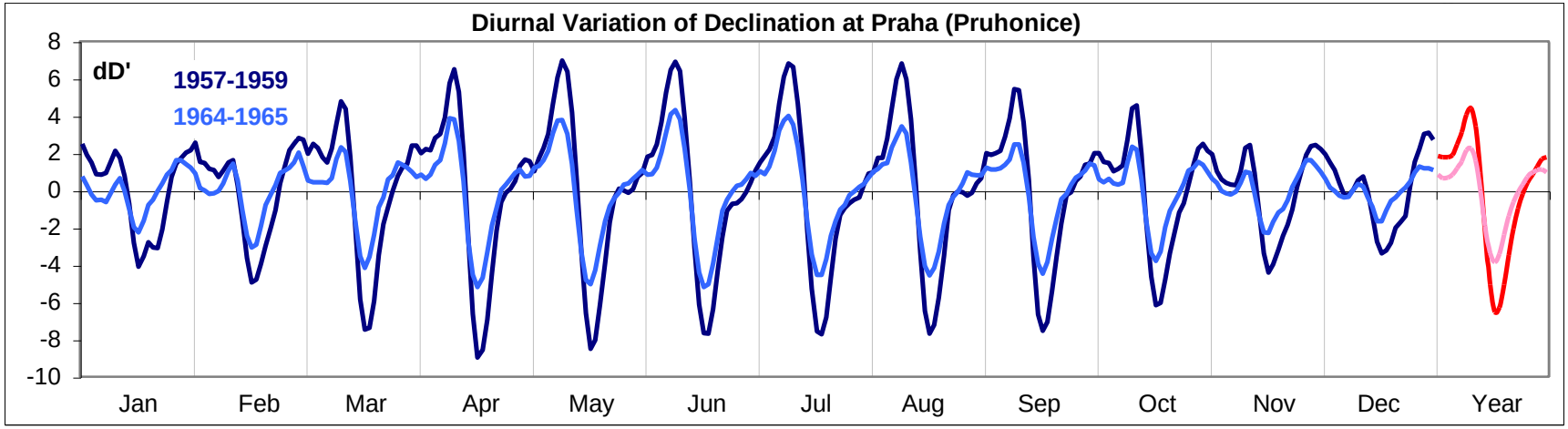
$Y = H \sin(D)$

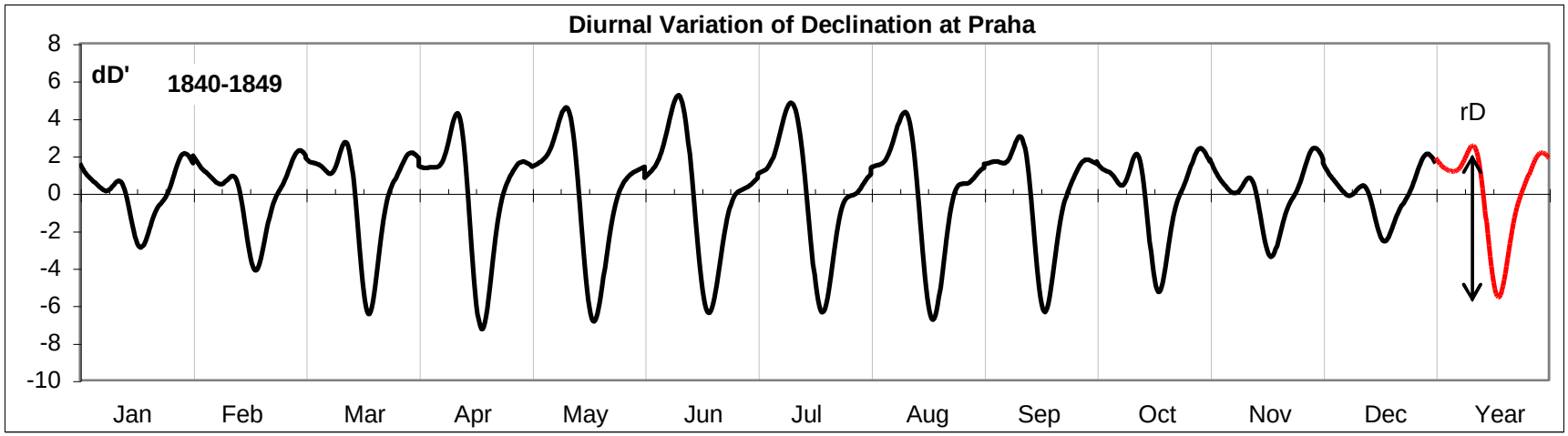
$dY = H \cos(D)\, dD$ For small dD



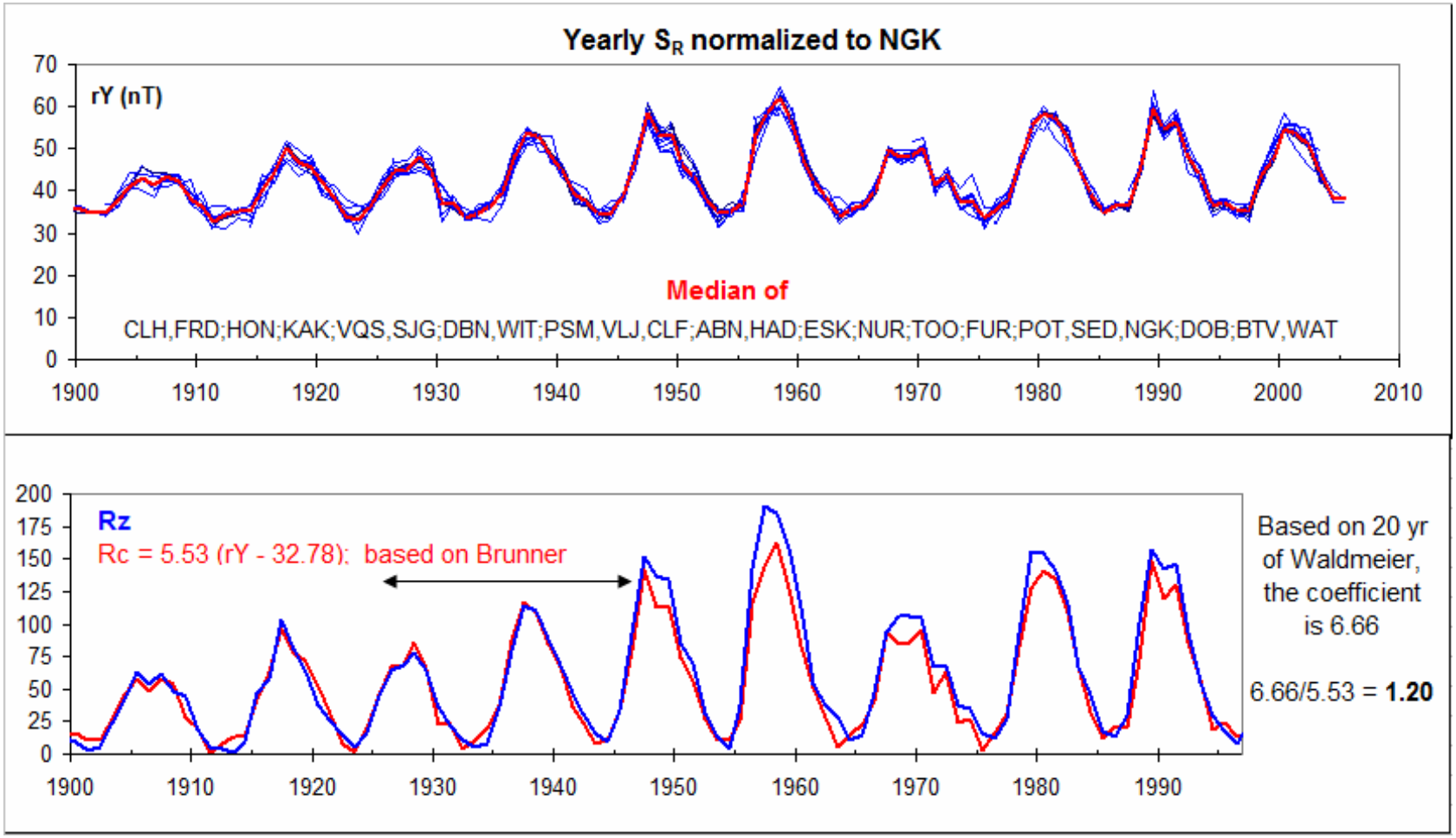
A current system in the ionosphere is created and maintained by solar FUV radiation

The Diurnal Variation of the Declination for Low, Medium, and High Solar Activity

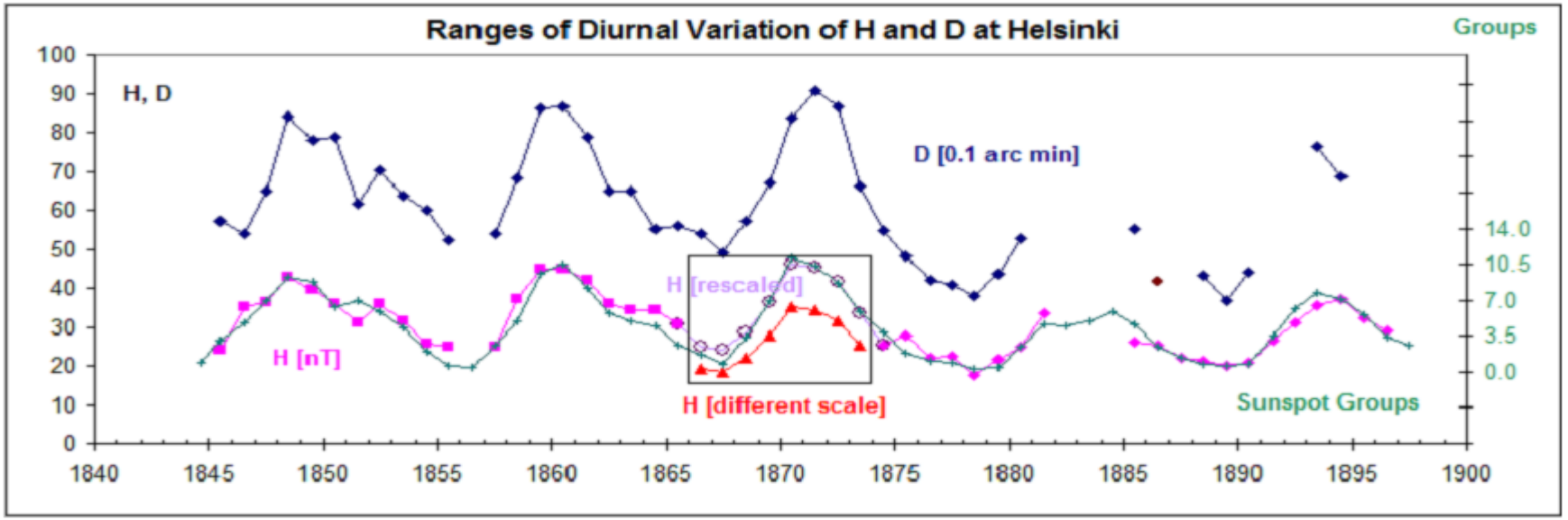


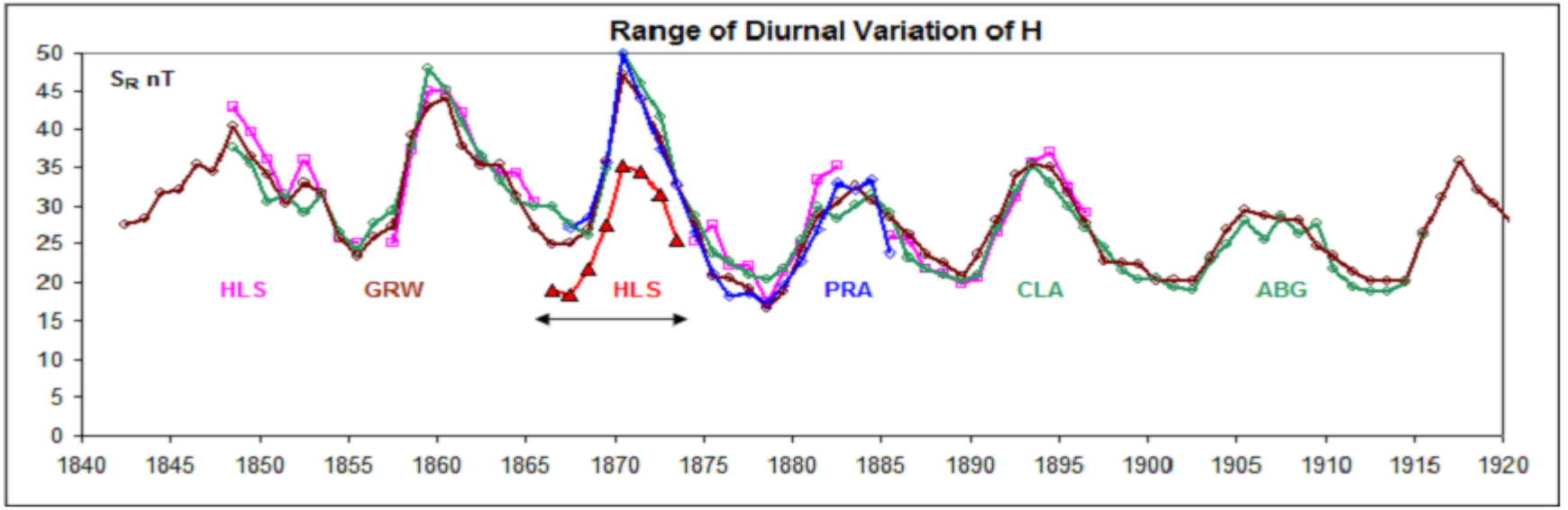


All Geomagnetic Observatories Show the Relationship with Sunspot Number



H Scale Value Problem at Helsinki





Also for Declination in 1886

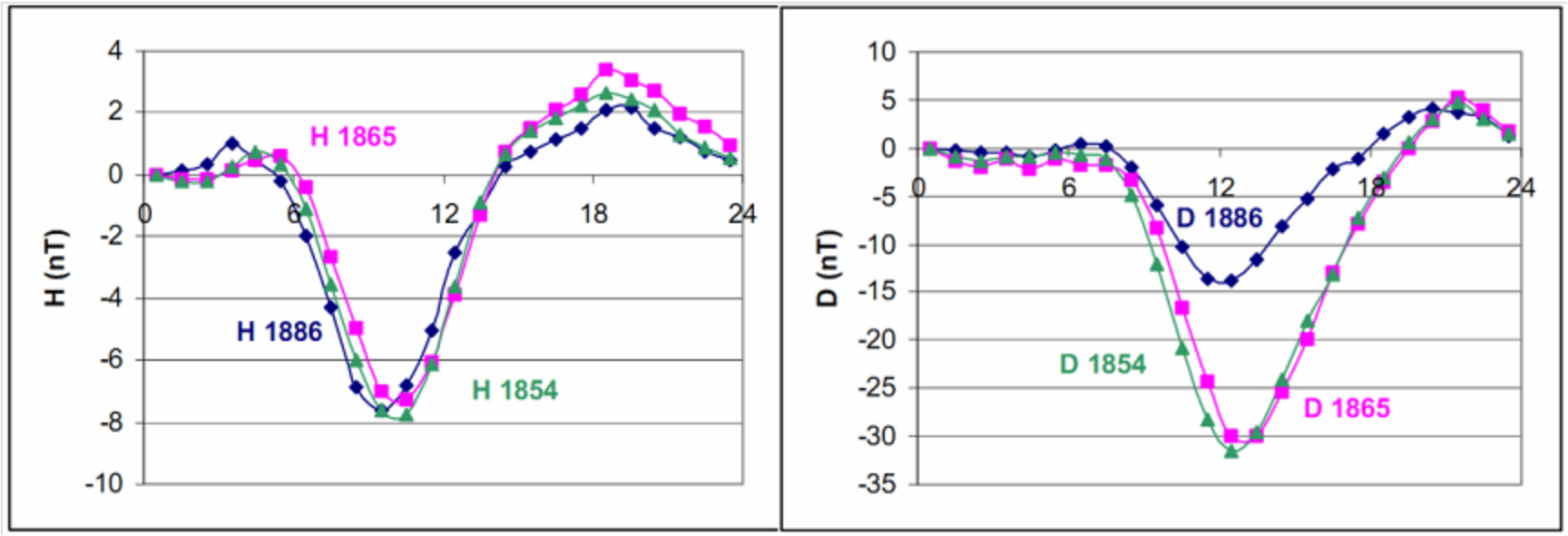
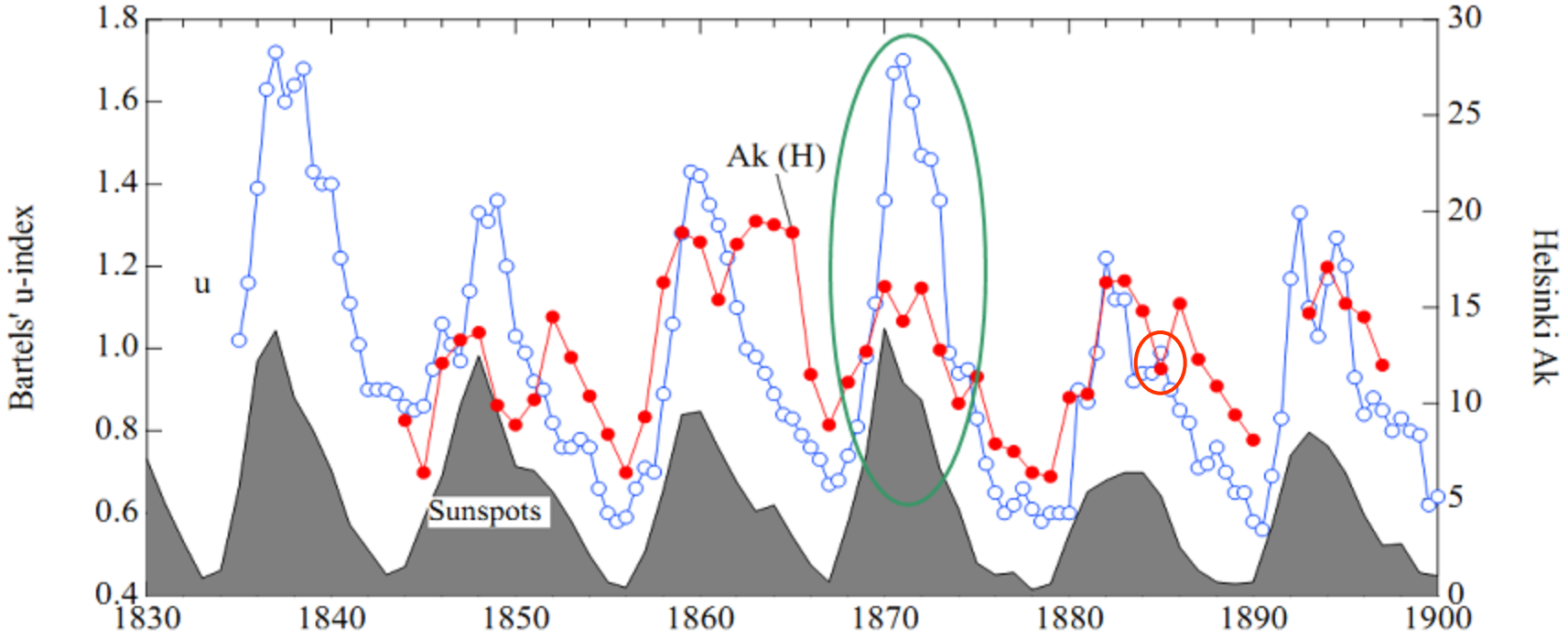
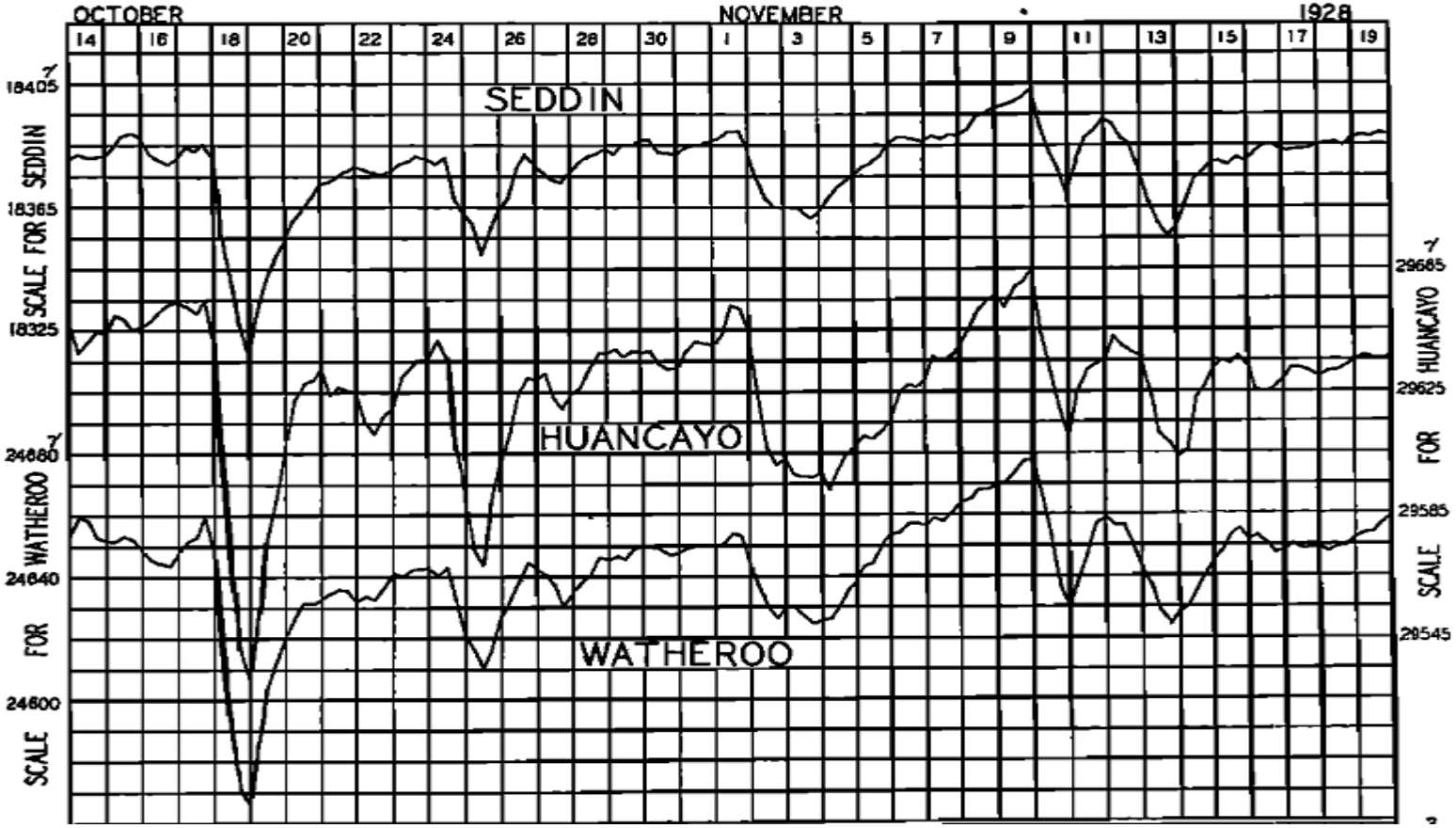


Figure 4: Diurnal variation of H [left] and of D [right] at Helsinki for three years with sunspot number ~25.

Creates Problems for Assessment of Long-Term Variation of Activity

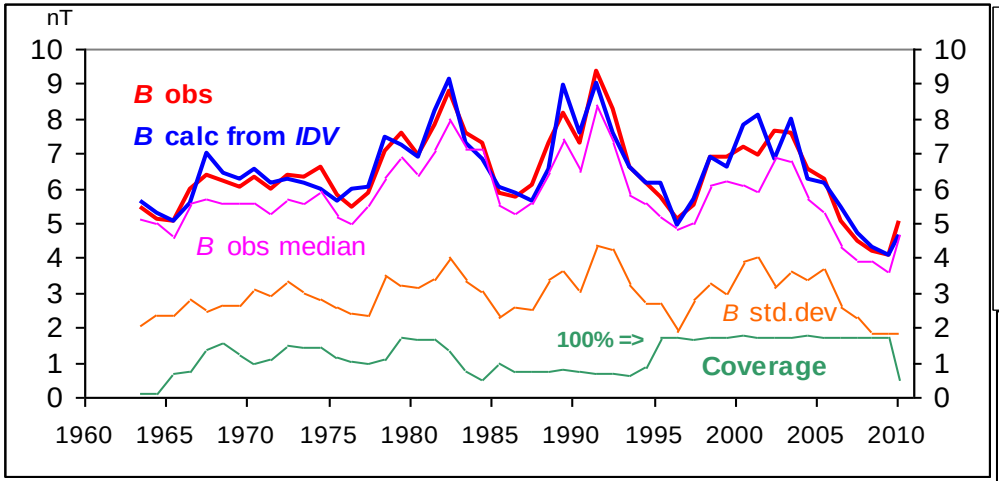


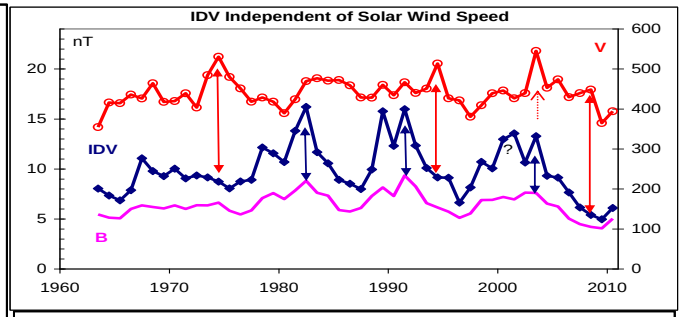
24-hour running means of the Horizontal Component of the low- & mid-latitude geomagnetic field remove most of local time effects and leaves a Global imprint of the Ring Current [Van Allen Belts]:

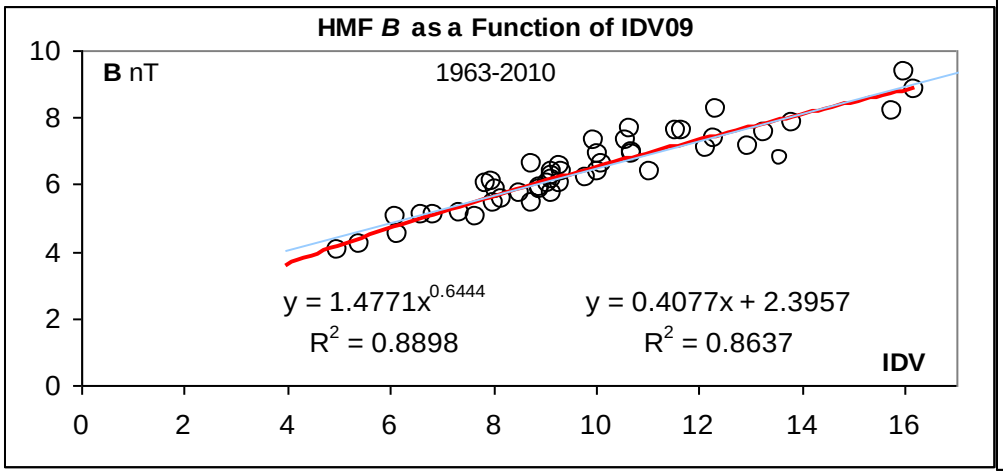


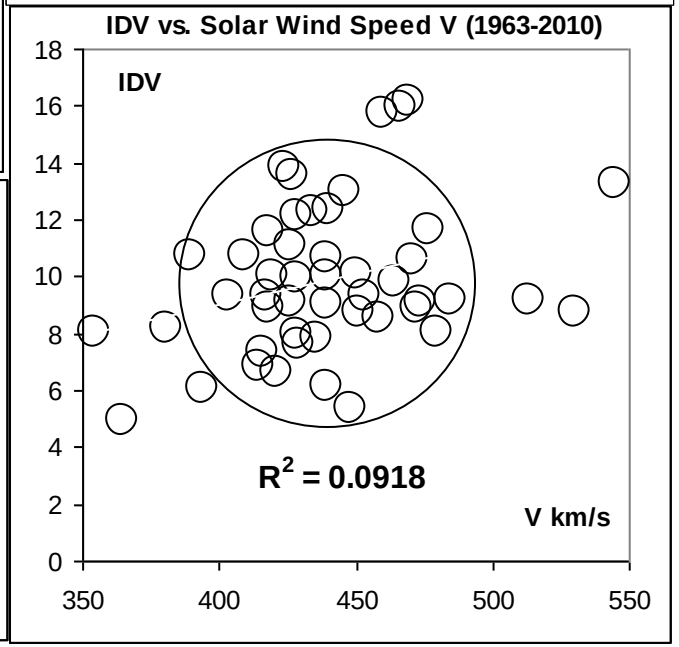
A quantitative measure of the effect can be formed as a series of the unsigned differences between consecutive days: The InterDiurnal Variability, IDV-index

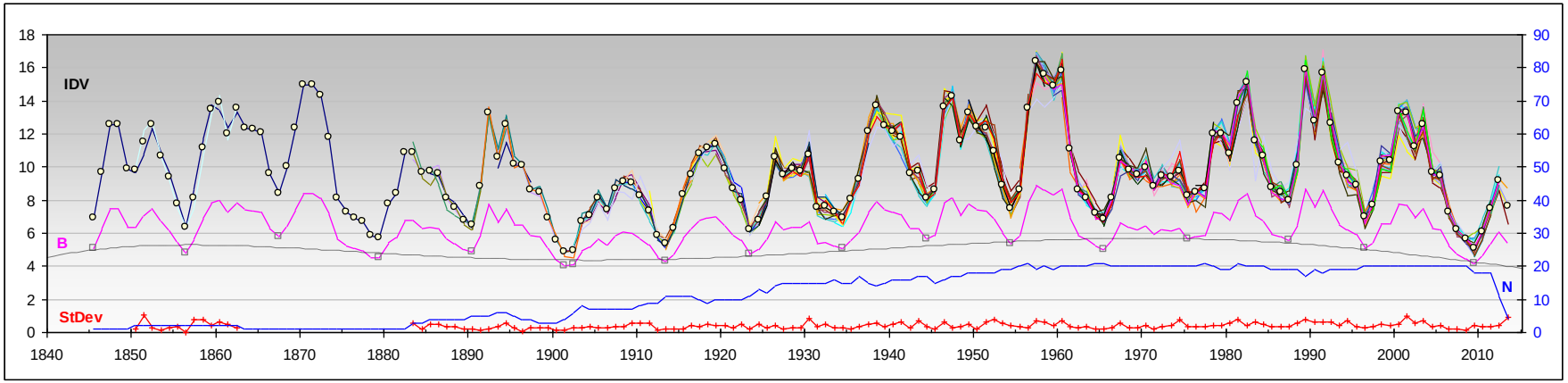
IDV is strongly correlated with HMF B, but is blind to solar wind speed V

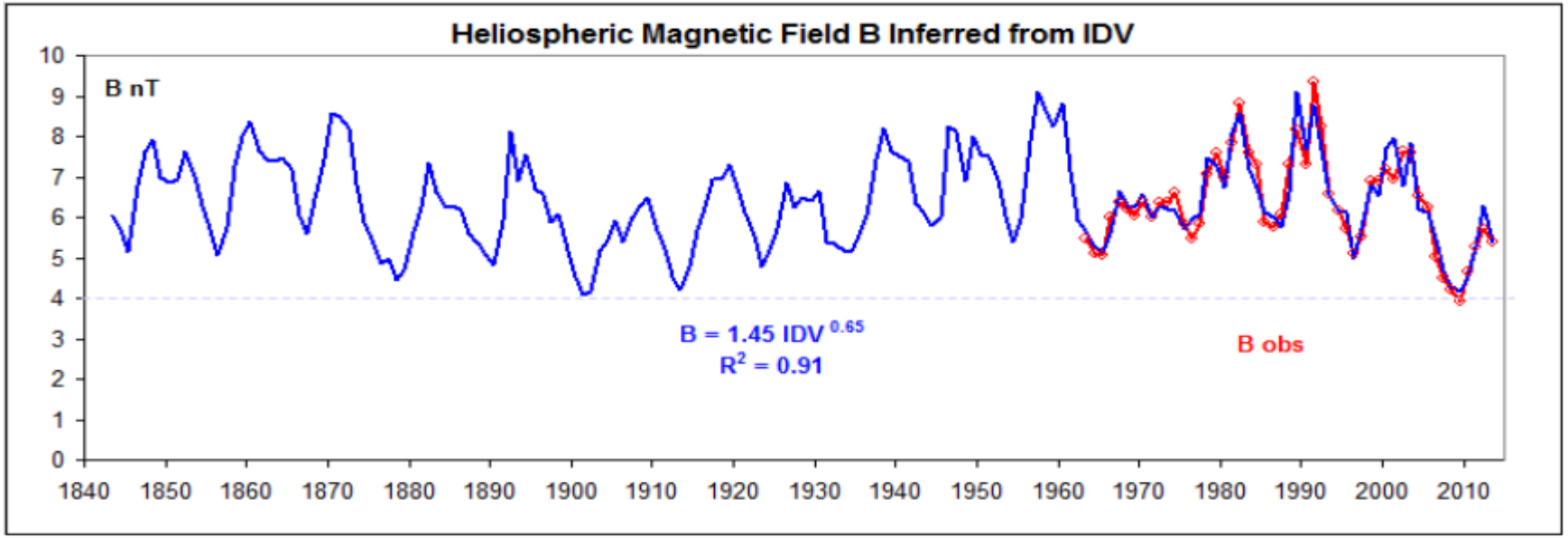




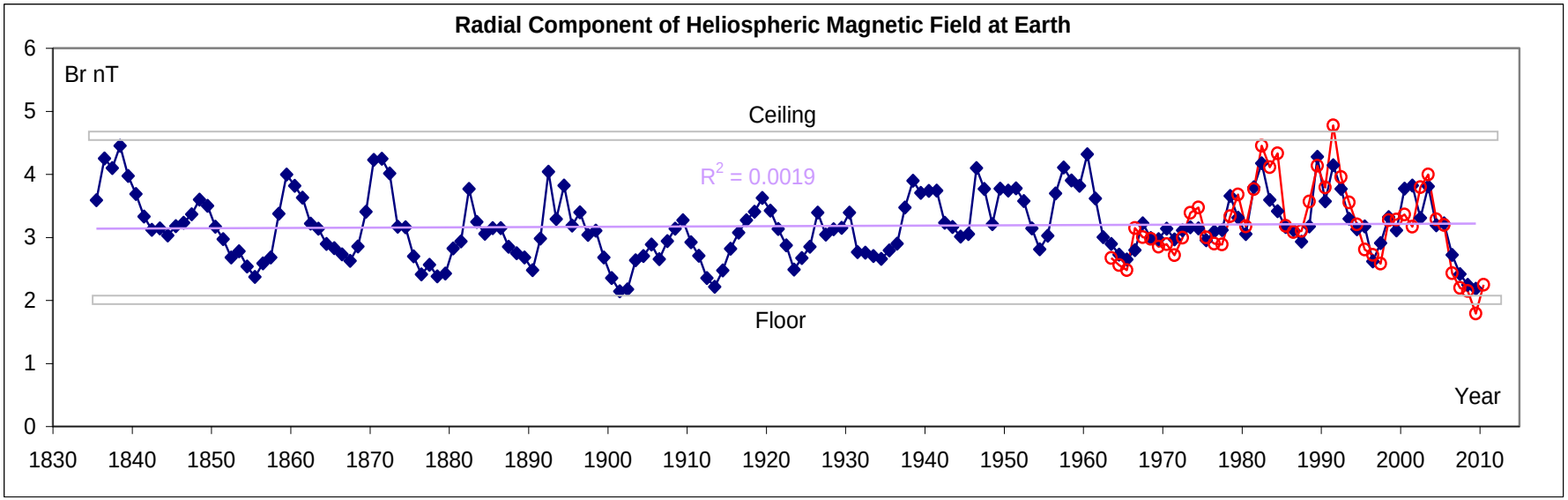





IDV
B
StDev
N
18
16
14
12
10
8
6
4
2
0
90
80
70
60
50
40
30
20
10
0
1840
1850
1860
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010


Heliospheric Magnetic Field B Inferred from IDV
B nT
B = 1.45 IDV 0.65
R2 = 0.91
B obs
10
9
8
7
6
5
4
3
2
1
0
1840
1850
1860
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

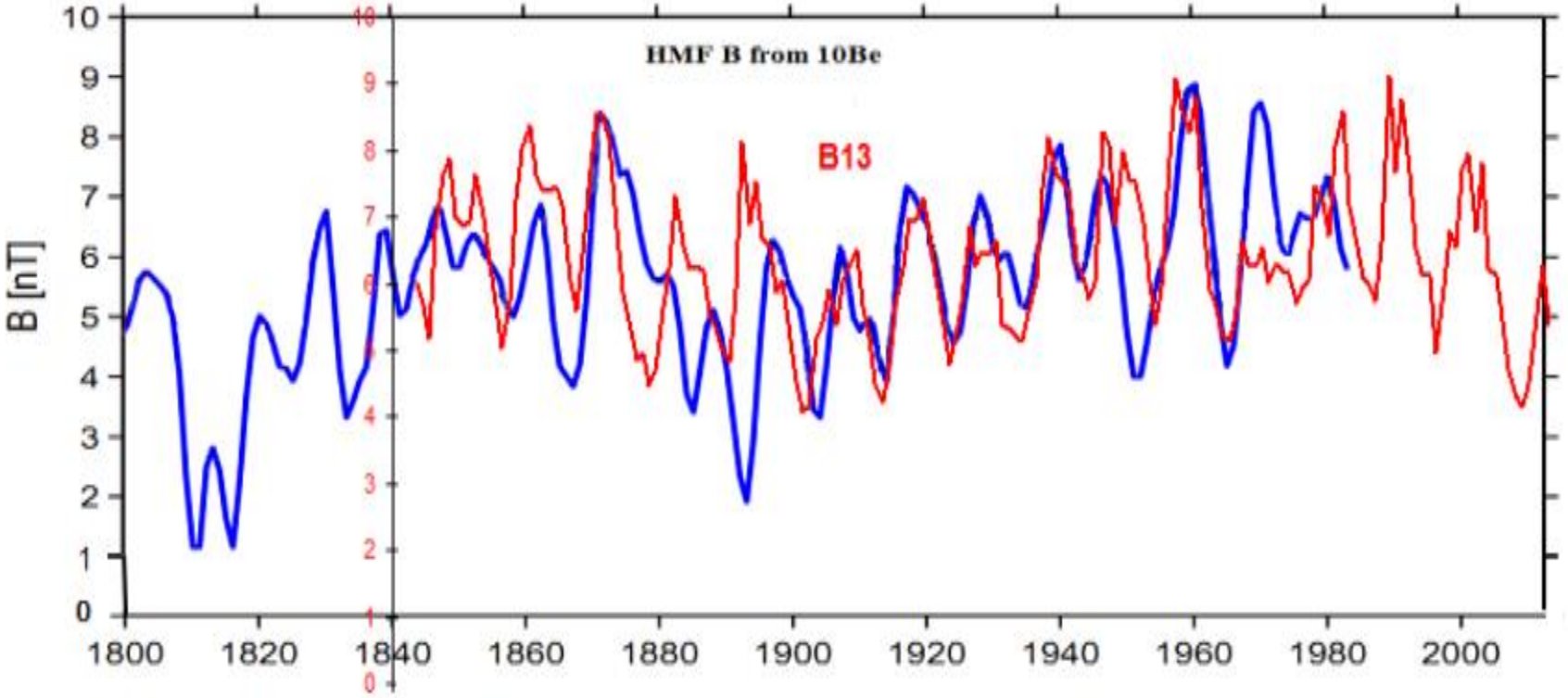
Since we can also estimate solar wind speed from geomagnetic indices [Svalgaard & Cliver, JGR 2007] we can calculate the radial magnetic flux from the total B using the Parker Spiral formula:



There seems to be both a Floor and a Ceiling and most importantly no long-term trend since the 1830s.

Re-evaluation of Cosmic Ray Data

Still problem with the 1880-1890s and generally with low values



Conclusion

- Important to correct data for scale value errors
- Signs of consensus on Cosmic Ray data
- No Modern Grand Maximum
- This is still controversial, hence my current interest