Early Sunspot Numbers Are Too Low

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On the one-hundredth year of Rudolf Wolf's death, *Hoyt et al.* [1994] asked "Do we have the correct reconstruction of solar activity?" In the present paper we show that today, in the year 2008, the answer to that question is negative. Two sunspot number series that cover more than a century are the Wolf (Zürich, International) Sunspot Number series [WSN: *Clette et al.*, 2007; *Hossfield*, 2001] and the Group Sunspot Number series [GSN: *Hoyt and Schatten*,1998]. The two series agree reasonably well back to ~1875, but before that the GSN is systematically lower (by up to 40%) than the WSN. Most of the discrepancy comes from an upward adjustment [*Wolf*, 1874] of Wolf's original series [*e.g. Wolf*, 1861]. This adjustment was described as 'erroneous' by *Hoyt et al.* [1994]. Here we review the basis for Wolf's adjustment and show that it was sound and that therefore the GSN is systematically too low before ~1875. In addition, we show that the WSN does not have constant calibration after ~1875 and that further adjustment is needed to make the series compatible with the modern Sunspot Numbers.

Captions

Figure 1. Upper panel: The diurnal variation of the Declination at Praha (Pruhonice, 15 km from the original Praha Geomagnetic Observatory) in minutes of arc for solar maximum years, 1957-July - 1959-Dec, (dark blue curve, $<R_Z>$=176.6) and for solar minimum years, 1964-Jan - 1965-Dec, (light blue curve, $<R_Z>$=12.6). The variation from the mean through the local day is plotted for each month, and for the year (in red and pink). Lower panel: Same at the original Praha Geomagnetic Observatory for the interval 1840-Jan - 1849-Dec (black curve, $<R_Z>$=57.2).

Table 1.

Figure 2

Figure 3

References

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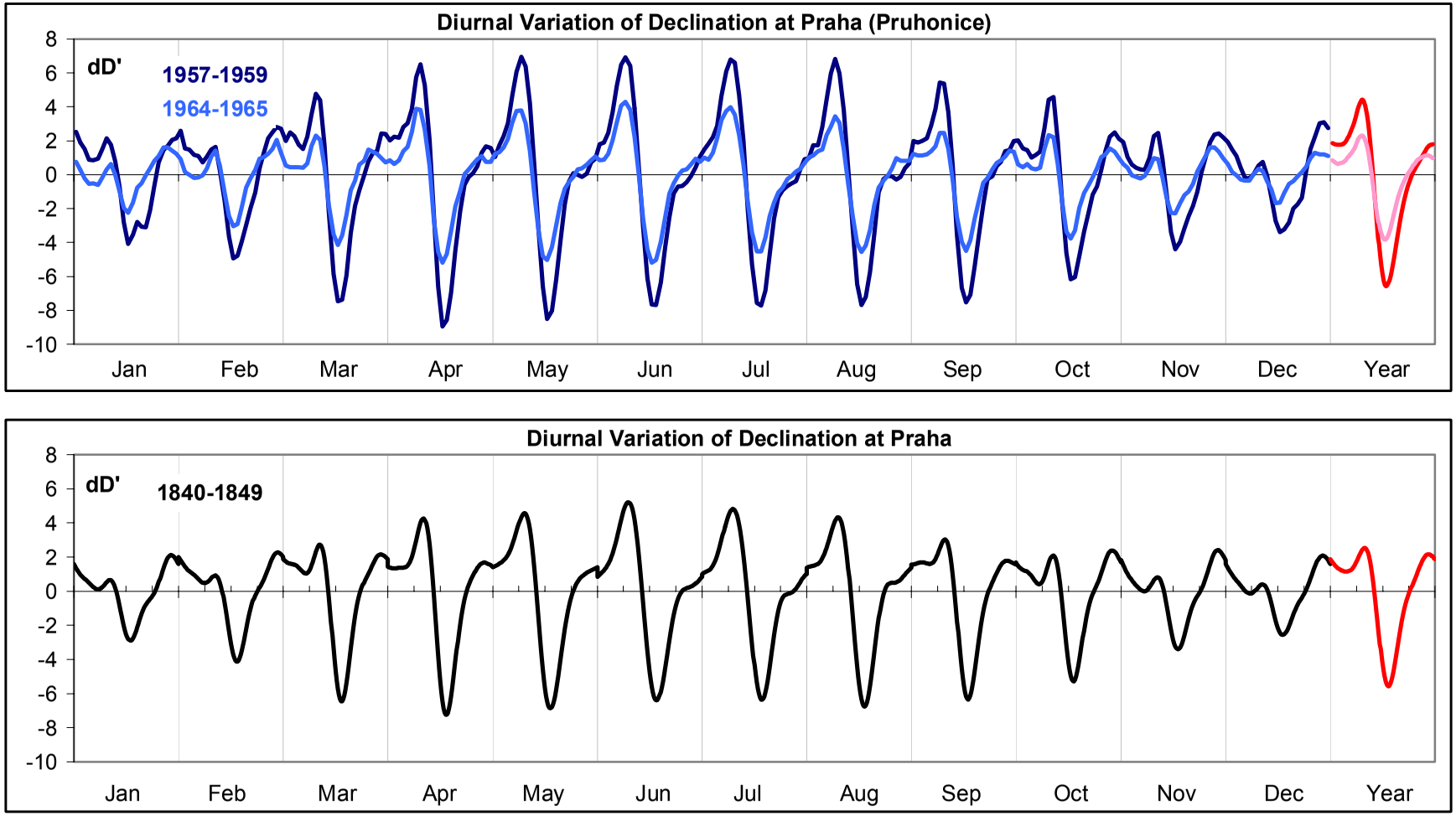
Diurnal Variation of Declination at Praha (Pruhonice)
dD'
1957-1959
1964-1965
8
6
4
2
0
-2
-4
-6
-8
-10
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Year
Diurnal Variation of Declination at Praha
dD'
1840-1849
8
6
4
2
0
-2
-4
-6
-8
-10
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Year

Figure 1

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Name	Obs	Lat	Long	Interval	<rY>	<Rz>	<Rg>	1.4*<Rg>	Cycle #
Washington D.C.	WDC	38.9	283.0	1840-1842	38.6	40.6	30.1	42.1	8
Dublin	DUB	53.4	353.7	1840-1843	40.2	34.1	25.5	35.7	8
München	MHN	48.2	11.6	1841-1842	37.8	30.0	22.0	30.8	8
Philadelphia	PGC	40.0	284.8	1840-1845	39.8	31.9	23.9	33.5	8
St. Peterburg	SPE	60.0	30.3	1841-1845	38.0	25.3	19.0	26.7	8,9
Greenwich	GRW	51.5	0.0	1841-1847	39.2	41.0	28.1	39.4	8,9
Praha	PRA	50.1	14.4	1840-1849	46.9	57.2	41.5	58.1	8,9
Hobarton	HBT	-42.9	147.5	1841-1848	45.1	51.4	35.4	49.5	8,9
Makerstoun	MAK	55.6	357.5	1843-1846	36.8	31.8	23.4	32.8	8,9
Kremsmünster	KRE	48.1	14.1	1839-1850	49.2	60.4	44.6	62.4	8,9
Toronto	TOR	43.7	280.6	1842-1848	42.3	53.5	36.6	51.2	8,9
Wilhelmshaven	WLH	53.7	7.8	1883-1883	49.7	63.7	54.7		12
Greenwich	GRW	51.5	0.0	1883-1889	33.0	33.0	30.3		12
Washington D.C.	WDC	38.9	283.0	1891-1891	37.9	35.6	38.9		13
Parc Saint-Maur	PSM	48.8	0.2	1883-1899	43.5	40.0	40.1		12,13
Potsdam	POT	52.4	13.1	1890-1899	45.8	45.0	46.9		13
København	COP	55.7	12.6	1892-1898	46.2	56.4	58.5		13
Utrecht	UTR	52.1	5.1	1893-1898	46.5	53.6	56.9		13
Irkutsk	IRT	52.3	104.3	1899-1899	32.1	12.1	12.3		13

Table 1

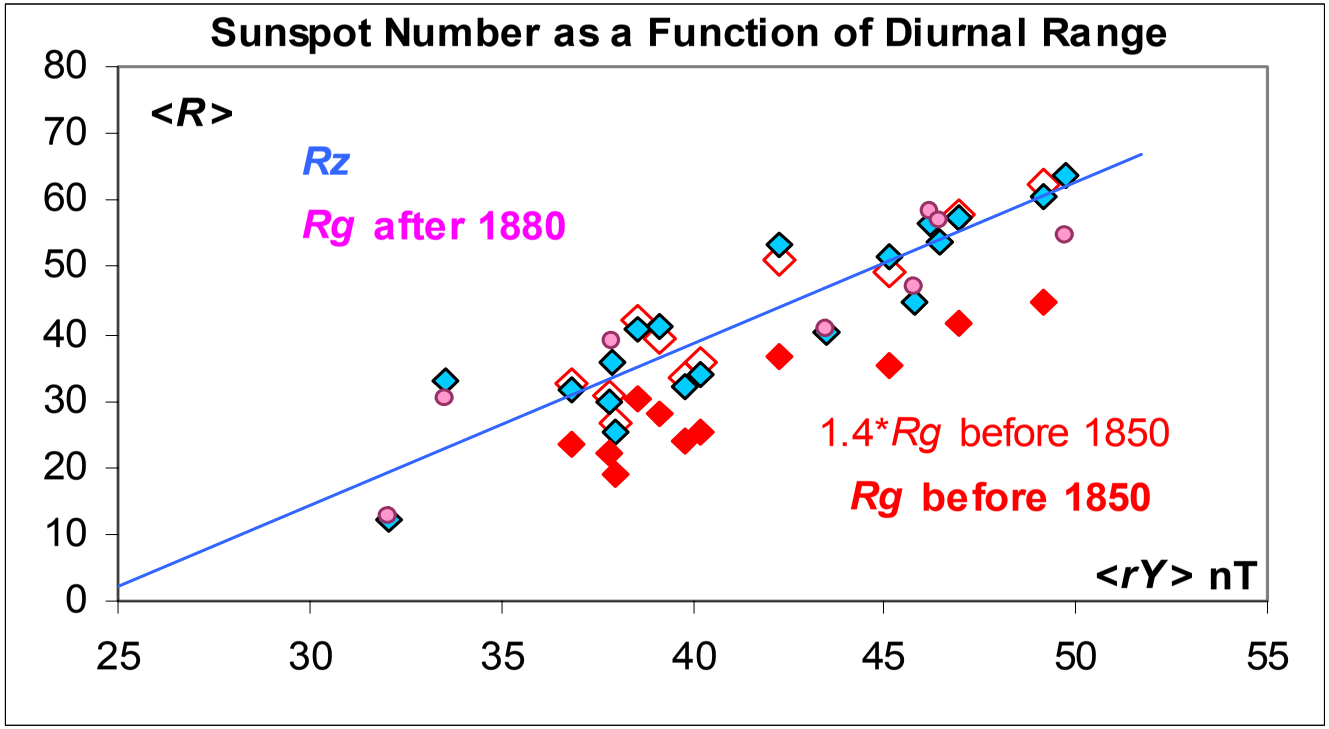
Sunspot Number as a Function of Diurnal Range
<R>
Rz
Rg after 1880
1.4*Rg before 1850
Rg before 1850
<rY> nT
80
70
60
50
40
30
20
10
0
25
30
35
40
45
50
55

Figure 2

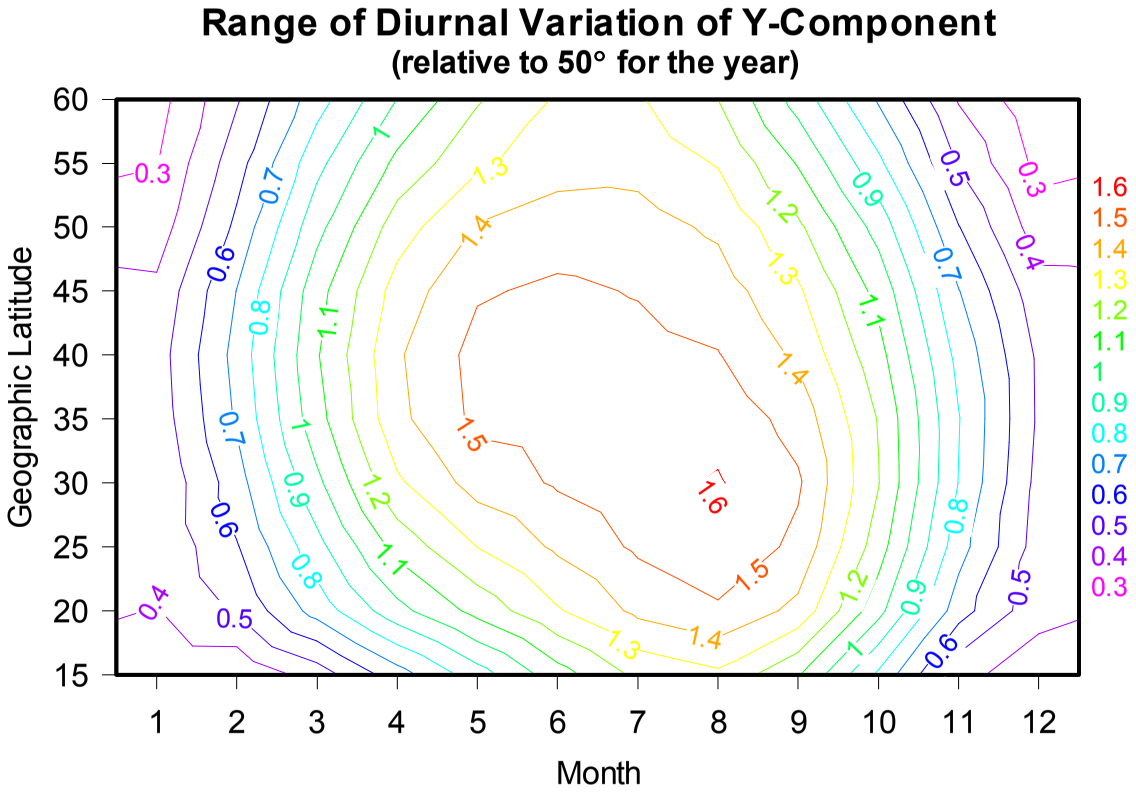
Range of Diurnal Variation of Y-Component
(relative to 50° for the year)
Geographic Latitude
Month
60
55
50
45
40
35
30
25
20
15
1
2
3
4
5
6
7
8
9
10
11
12
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3

Figure 3.