The Group Sunspot Number

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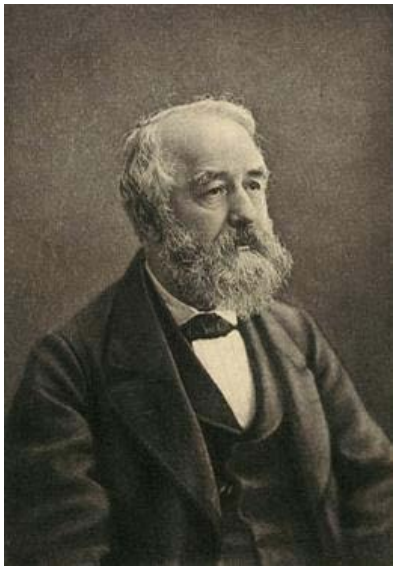
2nd Sunspot Workshop
Brussels, 21 May 2012

The [Wolf] Sunspot Number

J. Rudolf Wolf (1816-1893) devised his Relative Sunspot Number ~1856 as $R_{Wolf} = k\ (10\ G + S)$ [also R_Z, R_I, *WSN*]

The *k*-factor serving the dual purpose of putting the counts on Wolf's scale and compensating for observer differences



The Group Sunspot Number

Douglas Hoyt and Ken Schatten devised the Group Sunspot Number ~1993 as $R_{Group} = 12\ G$ using only the number, *G*, of Groups normalized [the *12*] to R_{Wolf}

But Groups have *K*-factors too

Schaefer (ApJ, **411**, 909, 1993) noted that with

R_{Group} = *Norm-factor G* , there is no *K* factor. In essence, this is because all telescopic observers see the same groups (at least statistically), so a spot count based on *G* alone will be free of biases.

Alas, as H&S quickly realized, different observers do ***not*** see the same groups, so a correction factor, *K*, had to be introduced into the Group Sunspot Number as well:
$R_{Group} = 12\ K\ G$ [averaged over observers]

And therein lies the rub: it comes down to determination of a *K*-value for each observer [and with respect to what?]

With respect to what?

H&S compared with the number of groups per day reported by RGO in the ‘Greenwich Photographic Results’. The plates, from different instruments on varying emulsions, were measured by several [many] observers over the 100-year span of the data. *We’ll hear more about this later*.

H&S – having little direct evidence to the contrary - assumed that the data was homogenous [having the same calibration] over the whole time interval. *We’ll later see that that probably is not the case*.

Reminding you of some Primary Actors

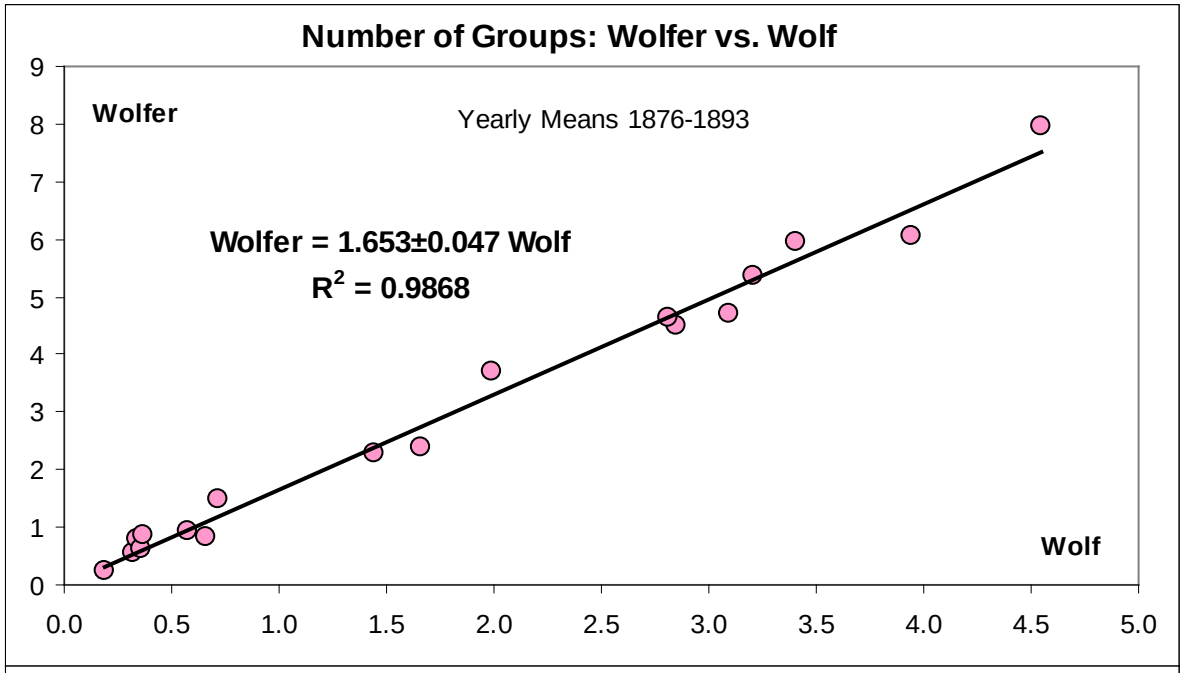
1826-1867 Samuel Heinrich Schwabe (Dessau)
1849-1863 Johann Rudolf Wolf (Berne)

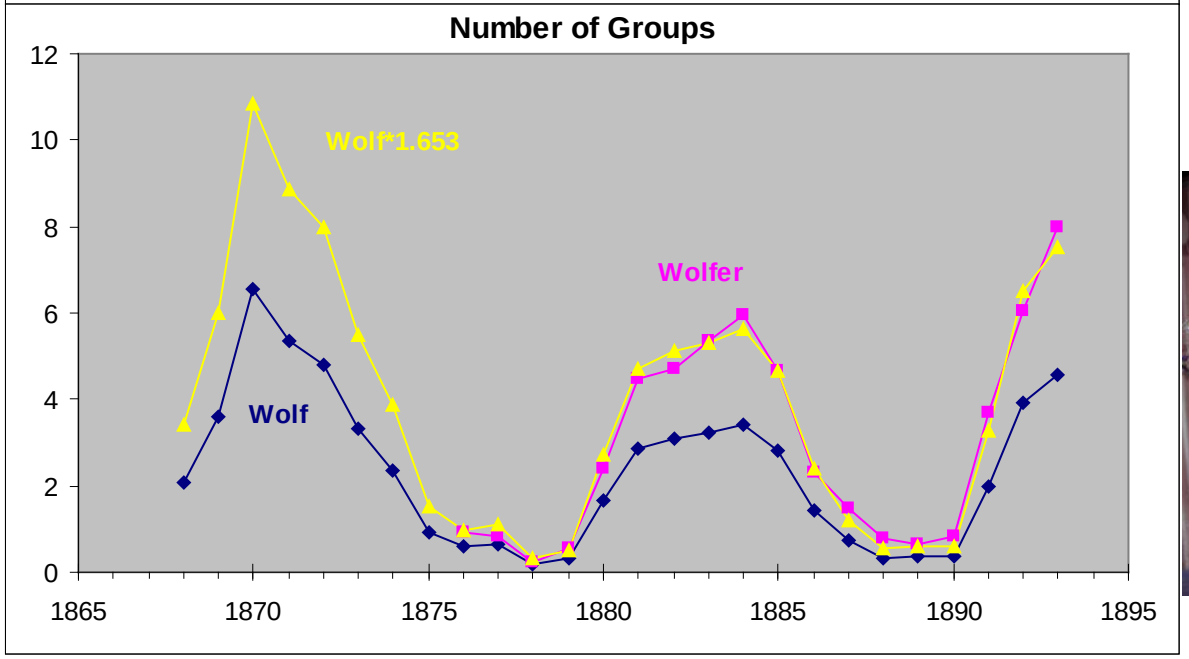
The directors of Zürich Observatory were:

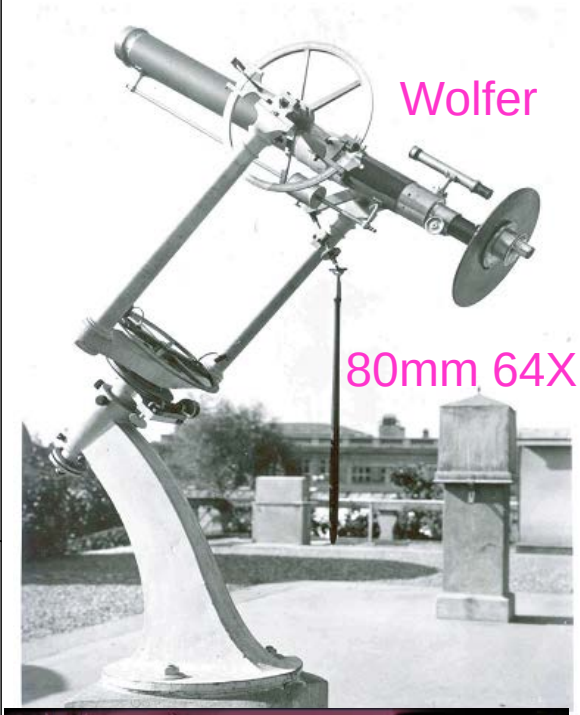
1864-1893 Johann Rudolf Wolf (1816-1893†)
1894-1926 Alfred Wolfer (1854-1931†)
1926-1945 William Otto Brunner (1878-1958†)
1945-1979 Max Waldmeier (1912-2000†)

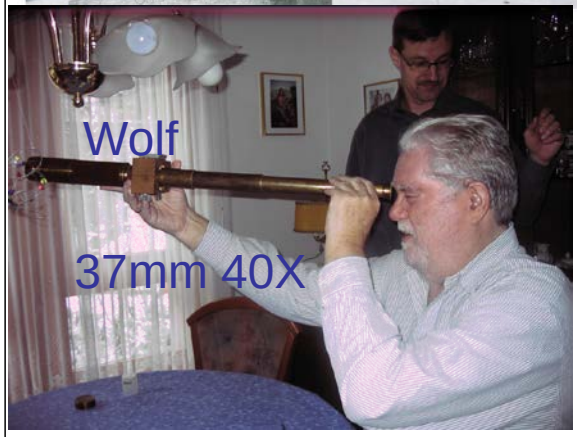
Wolfer was Wolf's assistant 1876-1893 so we have lots of overlapping data

Wolf-Wolfer Groups









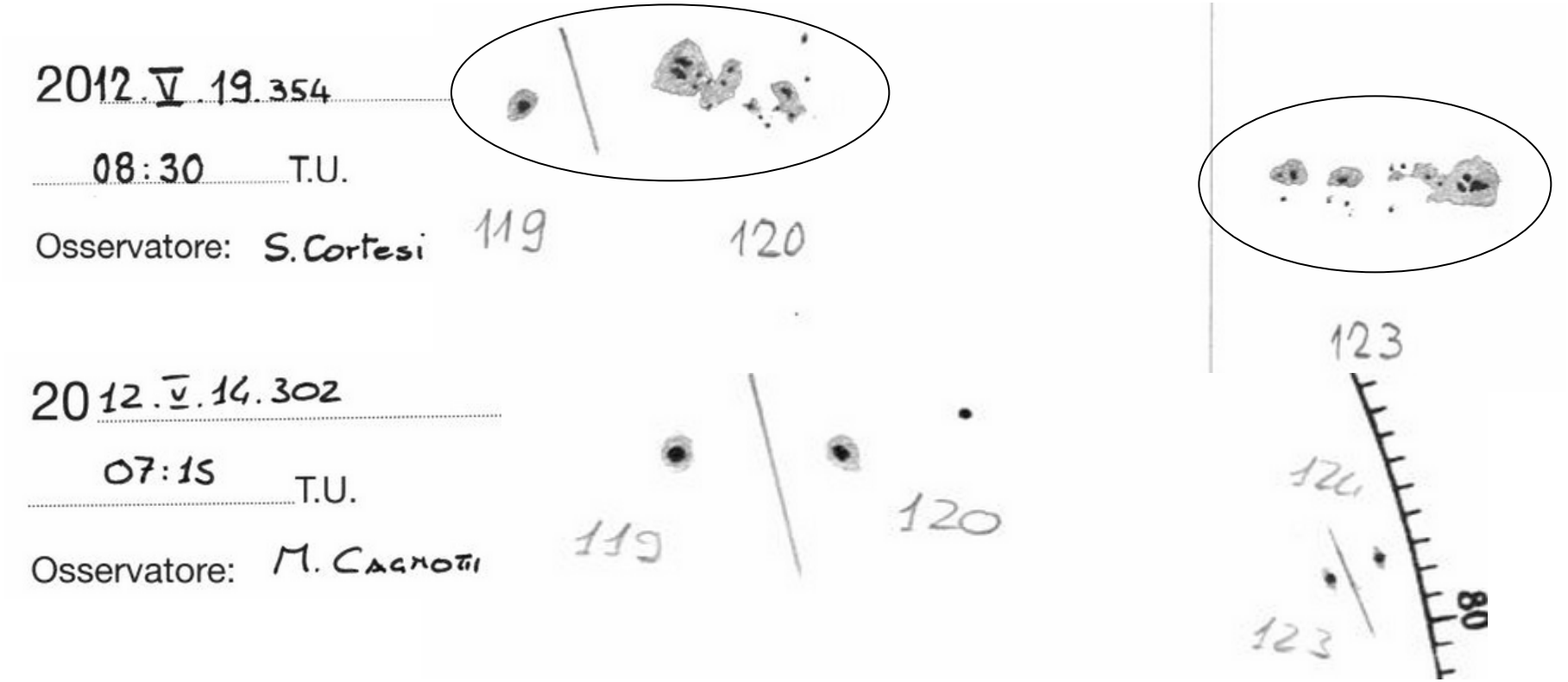
Different K-factors

Observer	K RGO	K Wolfer	Comparison Interval
Wolf, R, Zürich	1.117	1.653	1875-1893
Wolfer, A, Zürich	1.094	1.000	1875-1928

H&S calculated their K-factor for an observer to RGO using only days when there was at least one spot seen by the observer.
This systematically removes about the lower half of the distribution for times of low solar activity.
Thus skews the K-factors (but is not the only reason).

Direct comparisons between observers show very different K-factors from those reported by H&S. We need to understand why [see later talk on Thursday].

What is a Group?

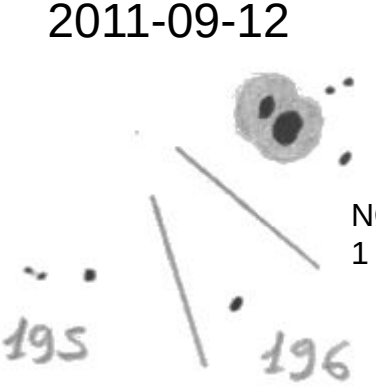


Defining a Group solely on basis of *proximity* leads to an undercount of groups compared to counting methods that take the time-evolution of the group into account [as modern observers do ?]

How Many Groups?

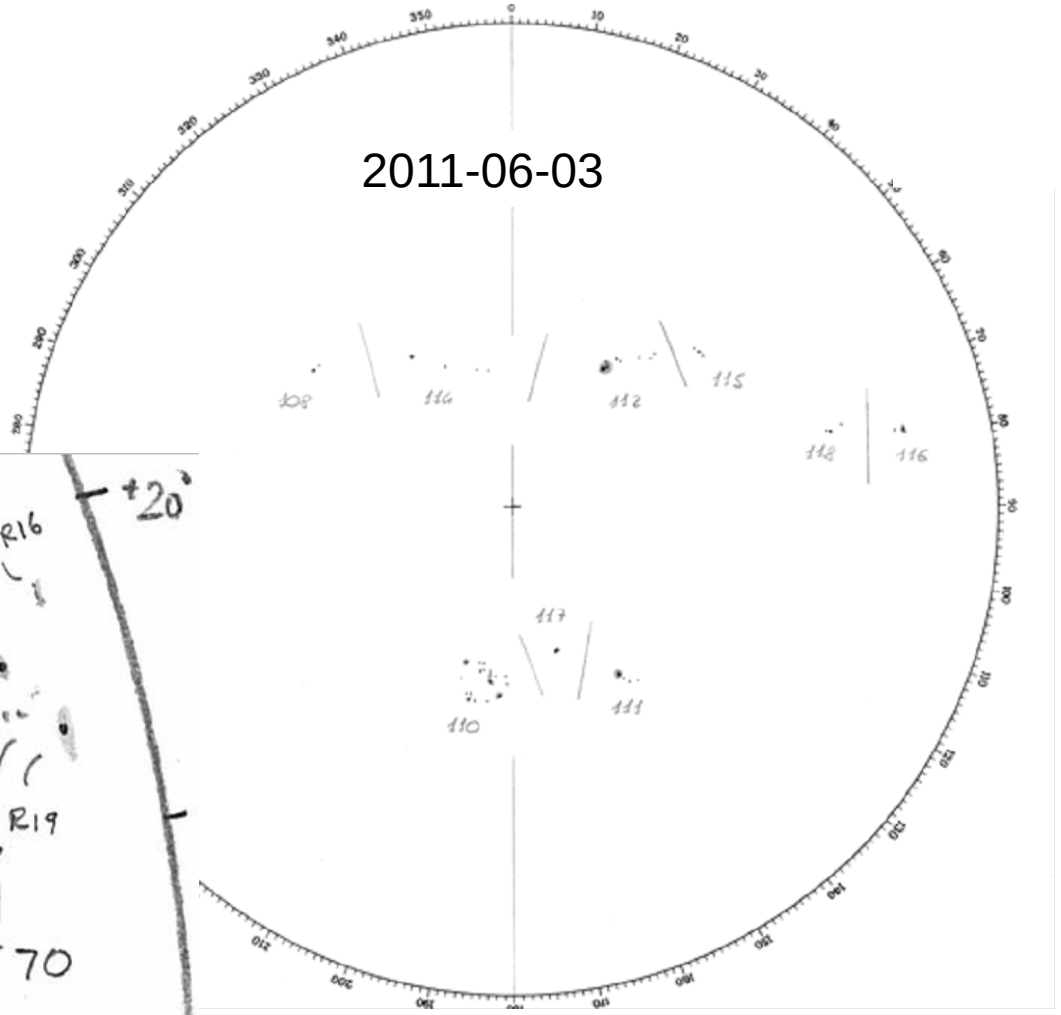
The Waldmeier Classification May lead to Better [larger] Determination of Groups

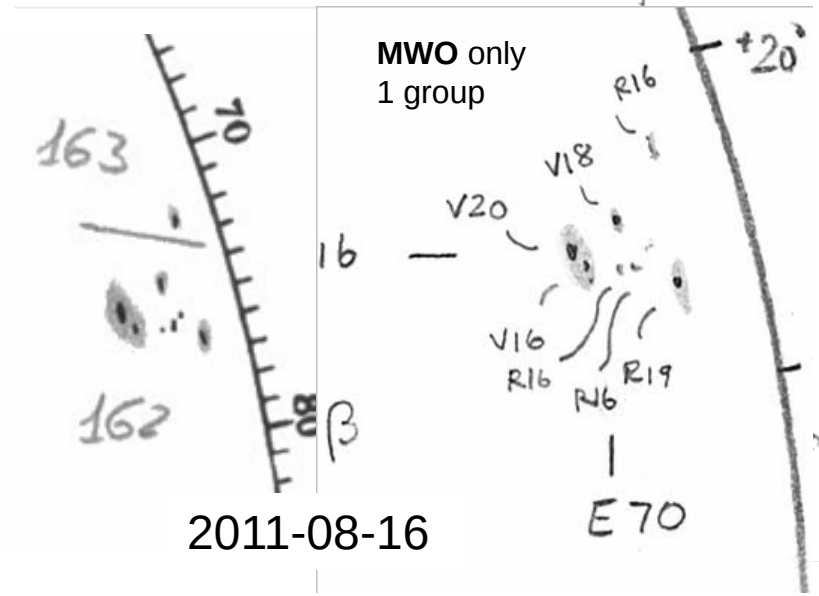
2011-09-12



NOAA only
1 group

2011-06-03





MWO only
1 group

2011-08-16

‘Optimistic’ Coverage

NUMBER OF SUNSPOT GROUPS FOR THE YEAR: 1658
AS OBSERVED BY: PICARD/KEILL, PARIS

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0
29	0	-99	0	0	0	0	0	0	0	0	0	0
30	0	-99	0	0	0	0	0	0	0	0	0	0
31	0	-99	0	-99	0	-99	0	0	-99	0	-99	0
means:	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

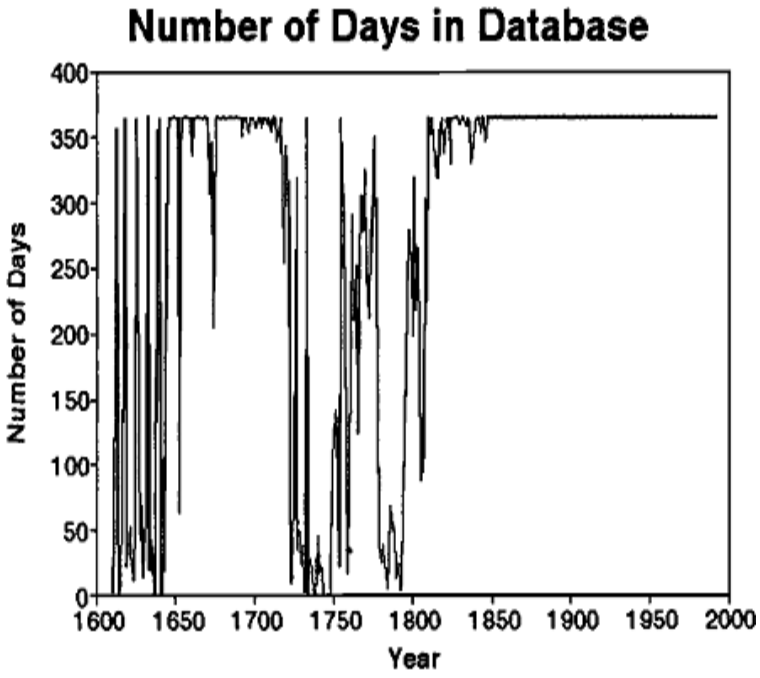
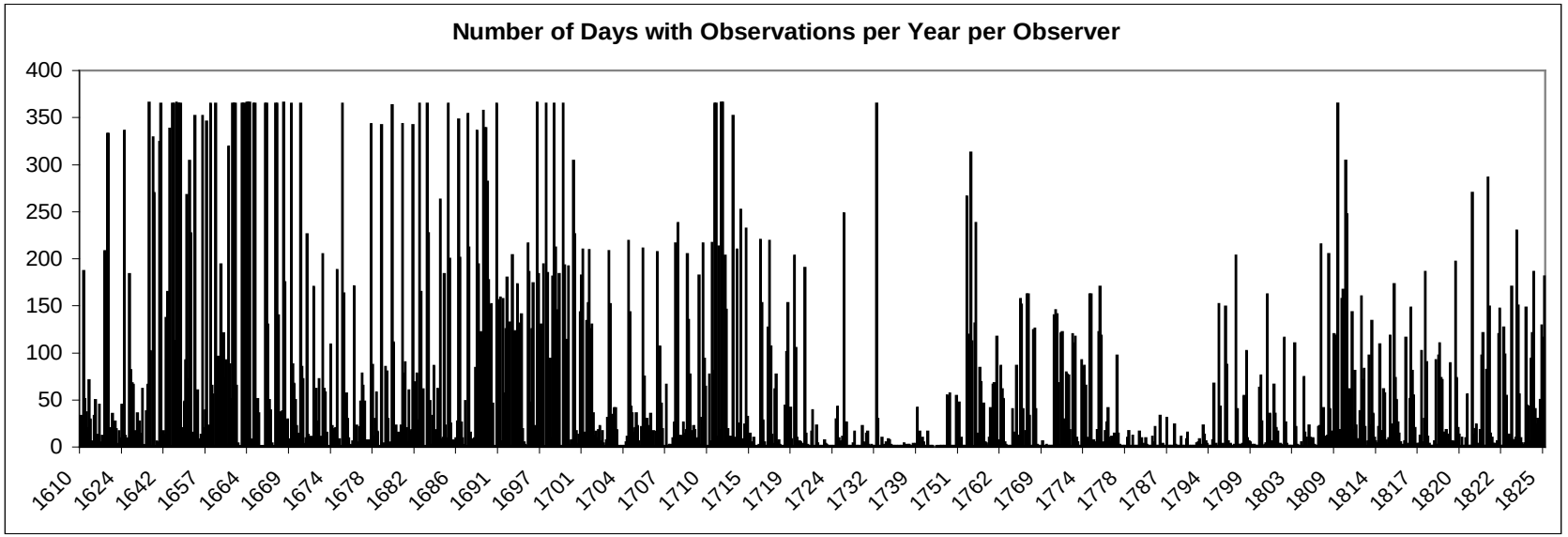
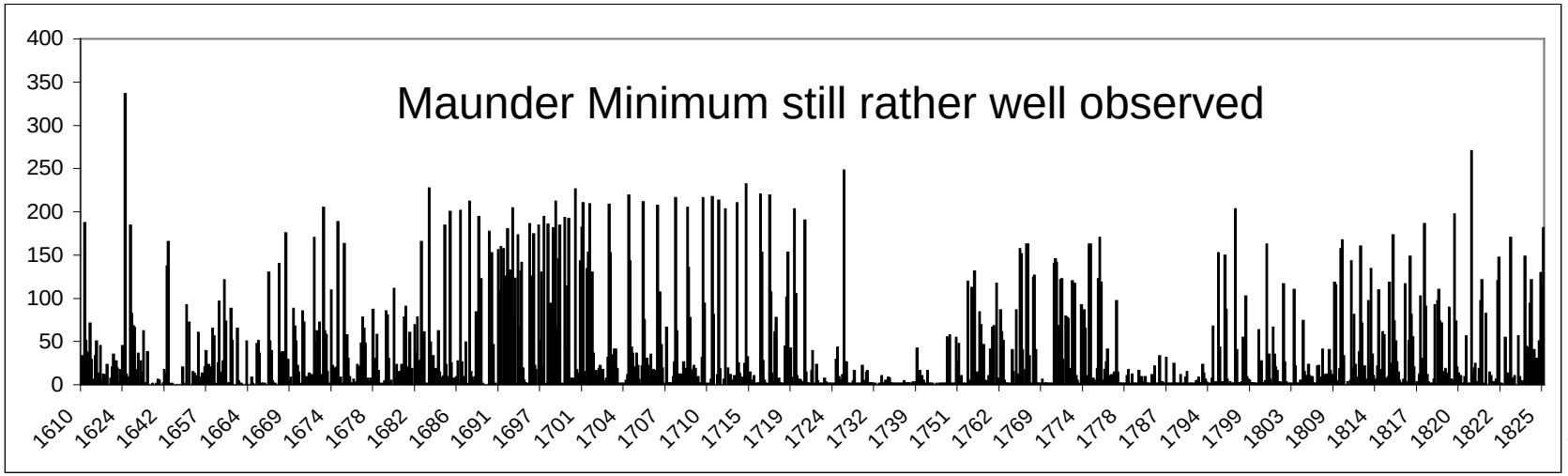


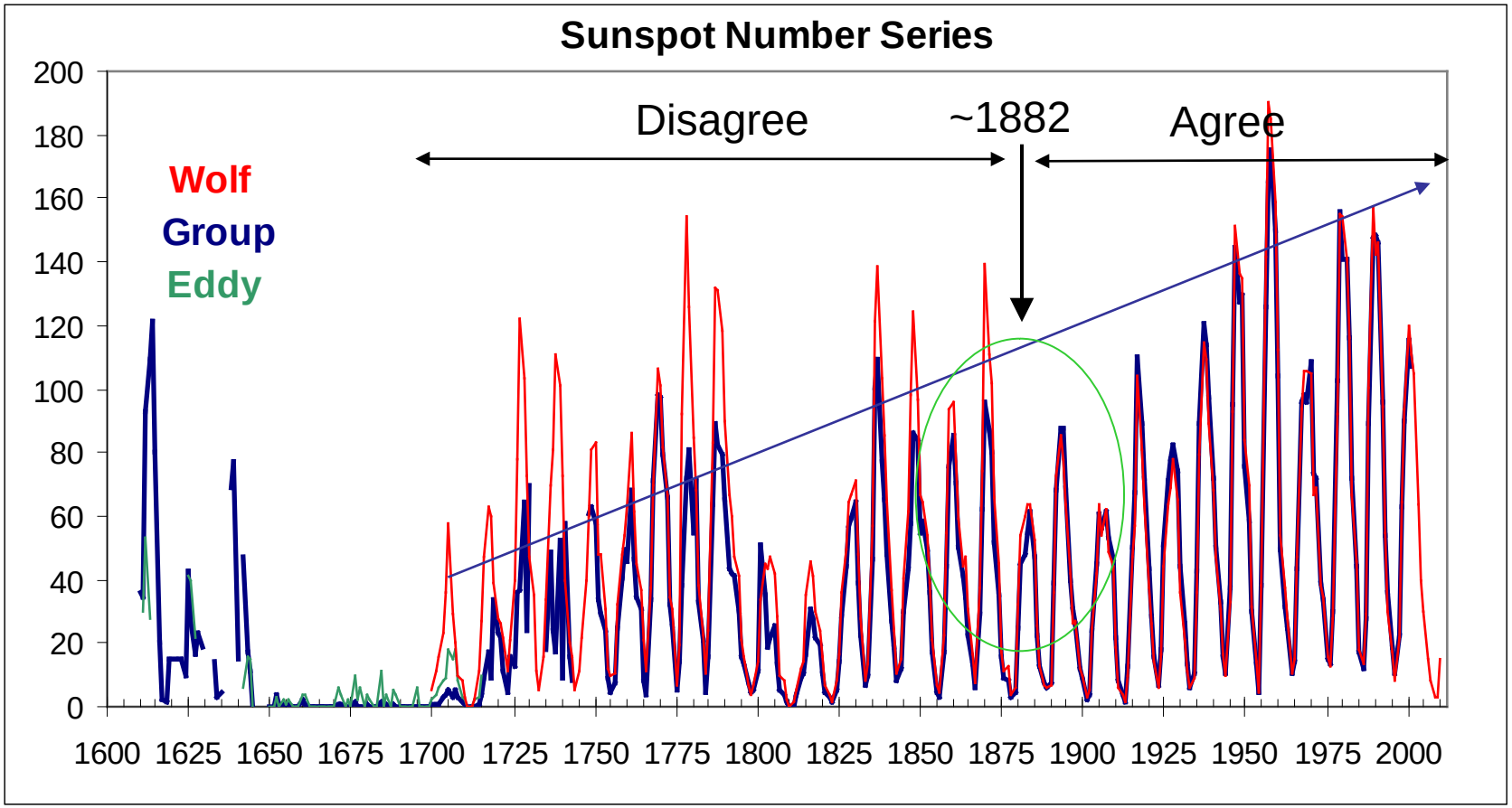
Figure 3. The number of days each year for we which have observations or interpolated values. If more than 5% of the days are observed in a year, a good yearly mean can usually be found. Most years meet this criteria. Note that the Sun was well observed during the Maunder Minimum.

More Realistic Coverage [?]





The Problem: Two Sunspot Series



Researchers tend to cherry-pick the one that supports their pet theory the best – this is not a sensible situation. We must do better.

The Hoyt-Schatten recovery of old observations is of immense value

- What we need to do is to assure that the calibration of the Group Sunspot Number is correct
- Resolve the ‘Daisy Chain’ problem with overlapping observers
- Utilize the Geomagnetic Record [based on Wolf’s discovery of the relationship]
- Reconcile with the Cosmogenic Record