Rudolf Wolf and the Sunspot Number

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The Sunspot Number ~1856

Rudolf Wolf (1816-1893)

Observed 1849-1893

- Wolf Number = k_W (10**G* + *S*)
- *G* = number of groups
- *S* = number of spots
- k_W = scale factor + site + personal factor

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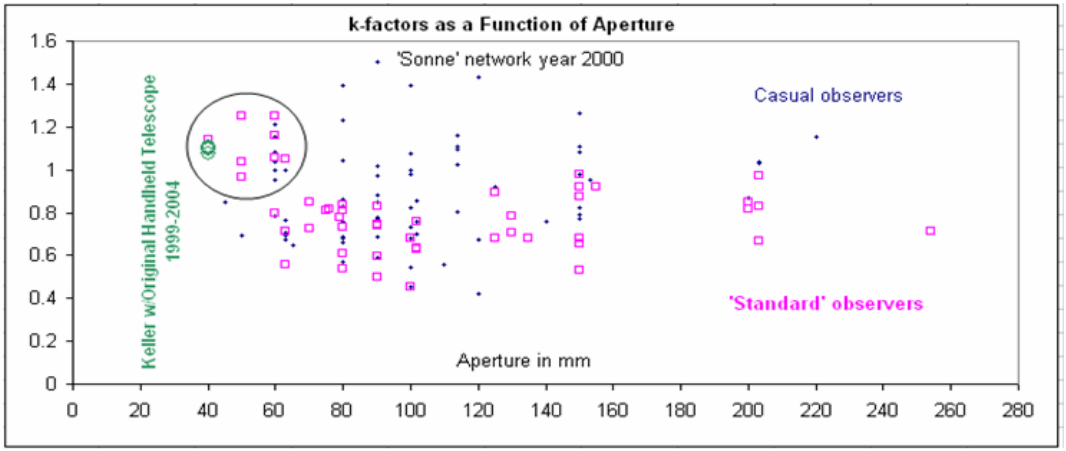

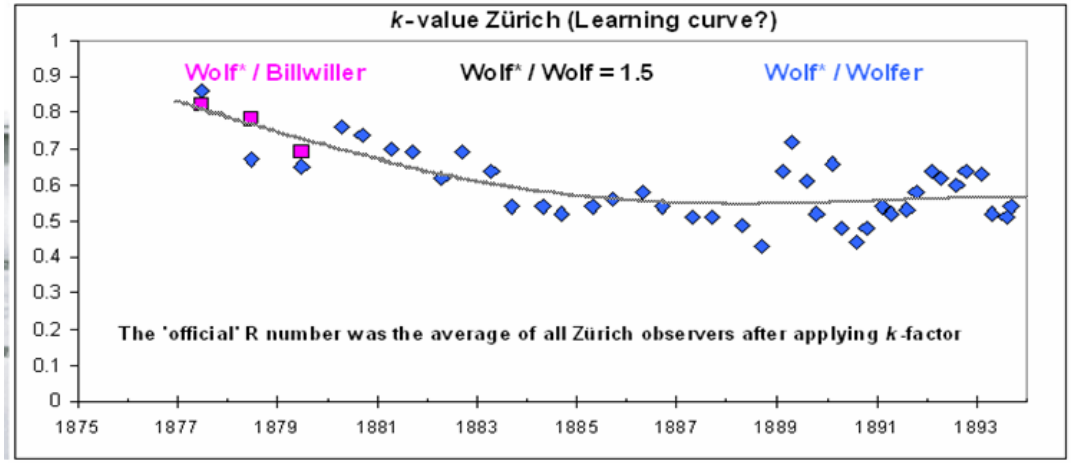

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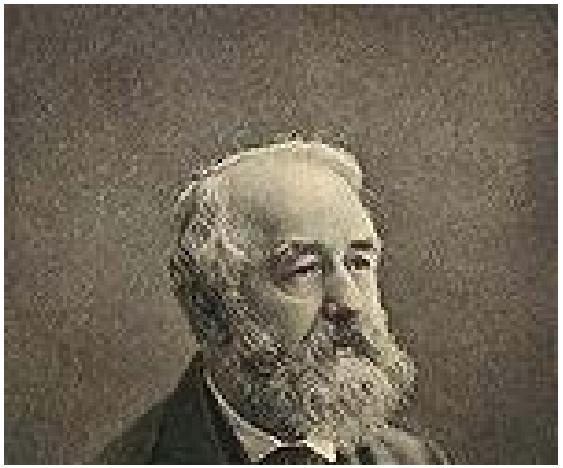

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Table 2. *k*-factors as a function of seeing for Kandilli Observatory (Atlas *et al.*, 1998)

Seeing	1(worst)	2	3	4	5(best)
Days	244	473	812	682	126
k	0.96	0.95	0.90	0.83	0.74

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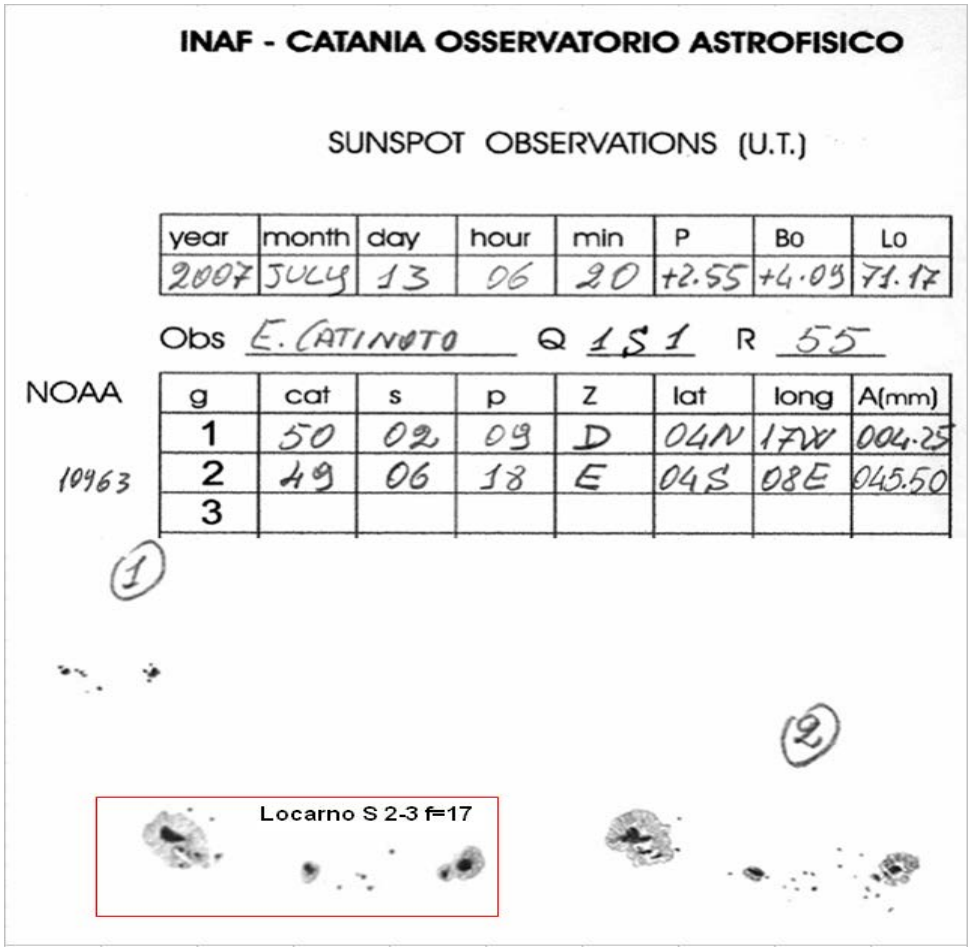


INAF - CATANIA OSSERVATORIO ASTROFISICO

SUNSPOT OBSERVATIONS (U.T.)

year	month	day	hour	min	P	Bo	Lo
2007	JULY	13	06	20	+2.55	+4.09	71.17

Obs E. CATINOTO Q 151 R 55

NOAA	g	cat	s	p	Z	lat	long	A(mm)
	1	50	02	09	D	04N	17W	004.25
10963	2	49	06	18	E	04S	08E	045.50
	3							

1

2

Locarno S 2-3 f=17

Wolf used 4’ Fraunhofer telescopes with aperture 80 mm [Magn. X64]

Still in use today [by T. Friedli] continuing the Swiss tradition [under the auspices of the Rudolf Wolf Gesellshaft]

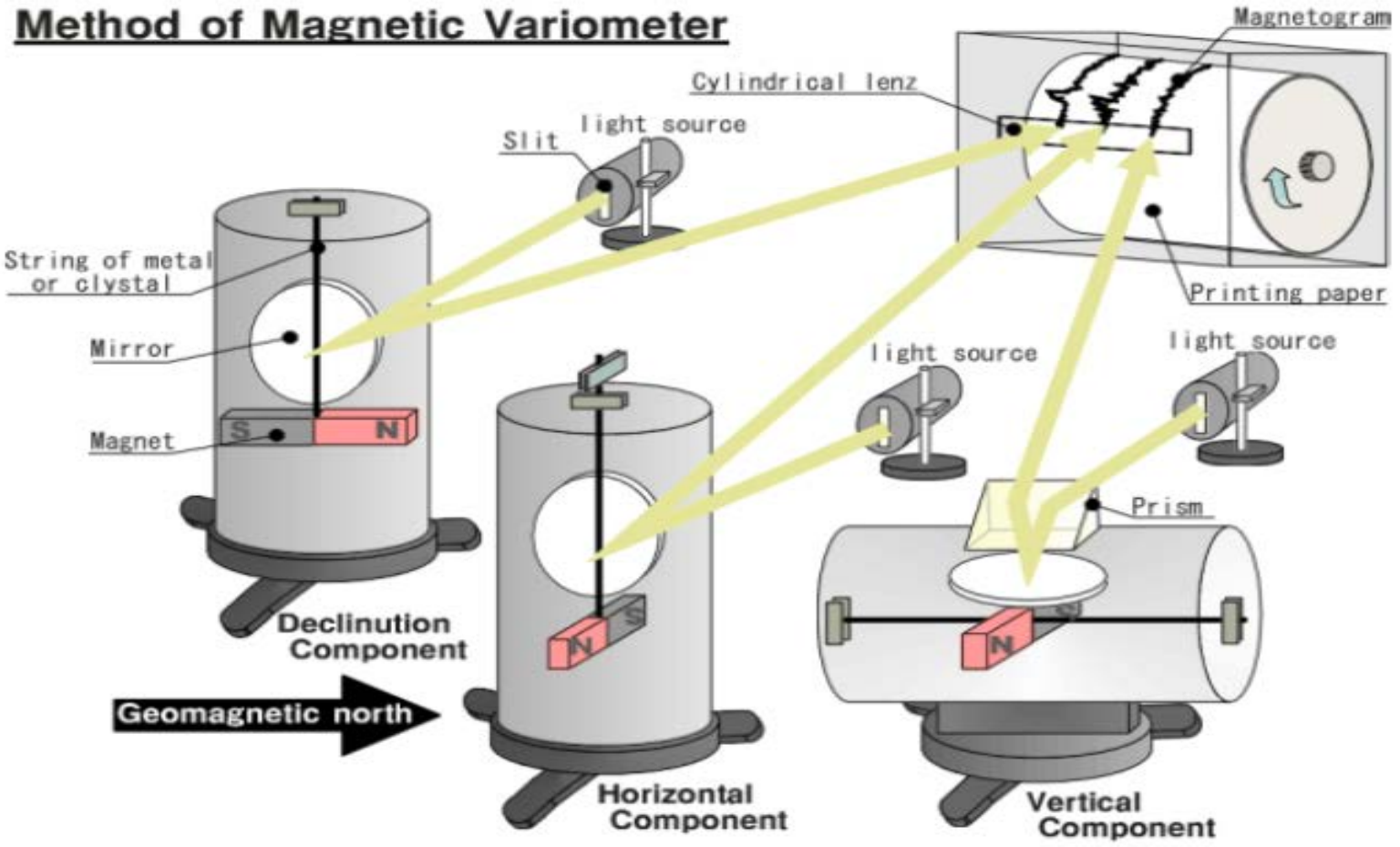
This is the ‘Norm’ Telescope

Wolf occasionally [and eventually – from 1870s on - exclusively] used much smaller handheld, portable telescopes [due to frequent travel], leaving the 80mm for his assistants or when he was home

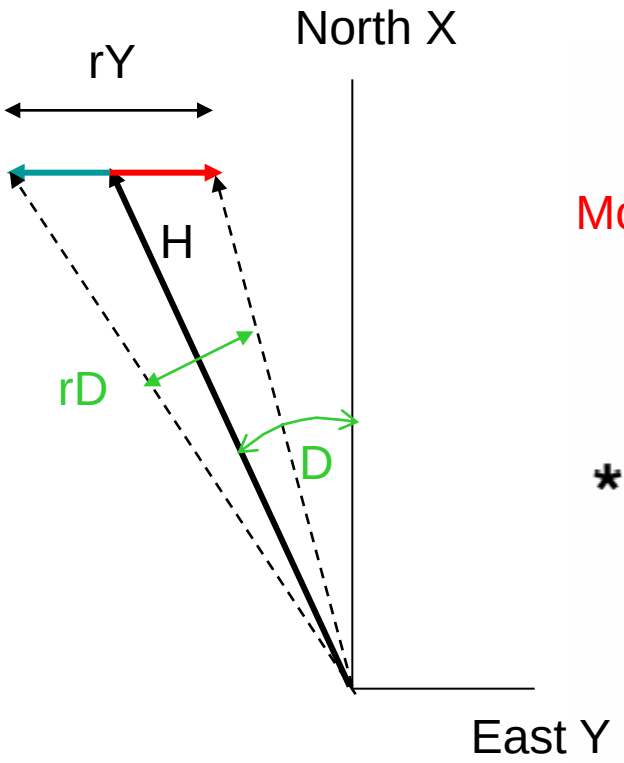
These telescopes also still exist and are still in use today to safeguard the stability of the series

Wolf estimated that to scale the count using the small telescopes to the 80mm Standard telescope, the count should be multiplied by 1.5

Recording Variations of the Geomagnetic Field

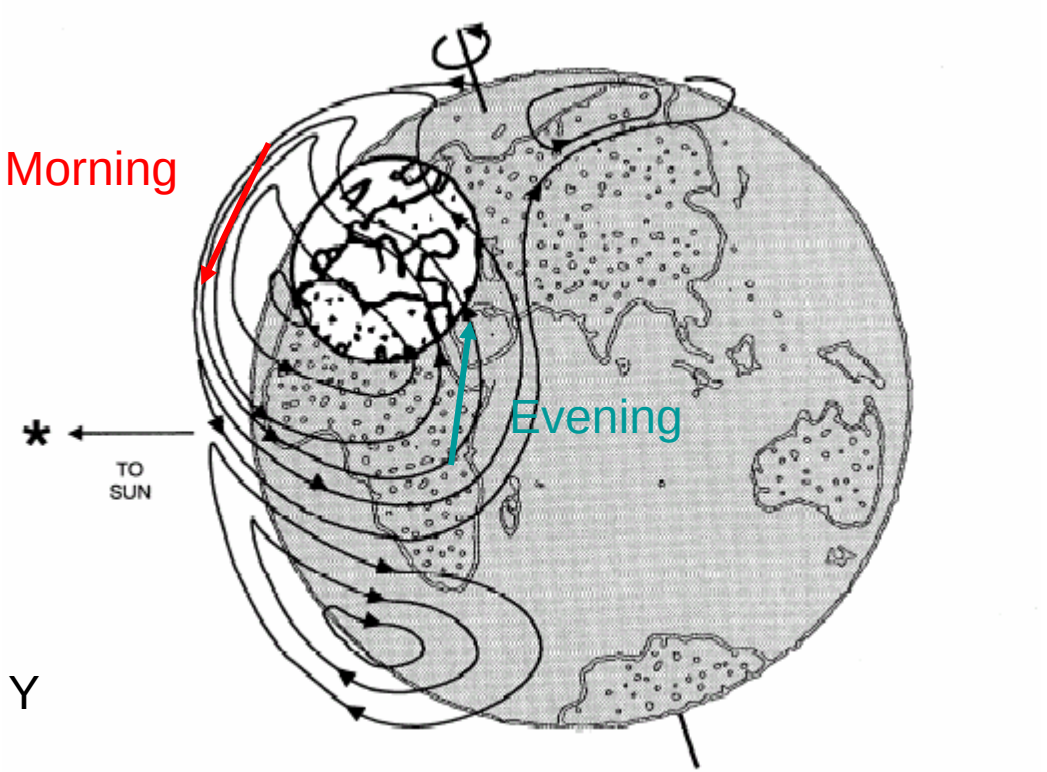


Wolf's Discovery: $rD = a + b\,R_W$



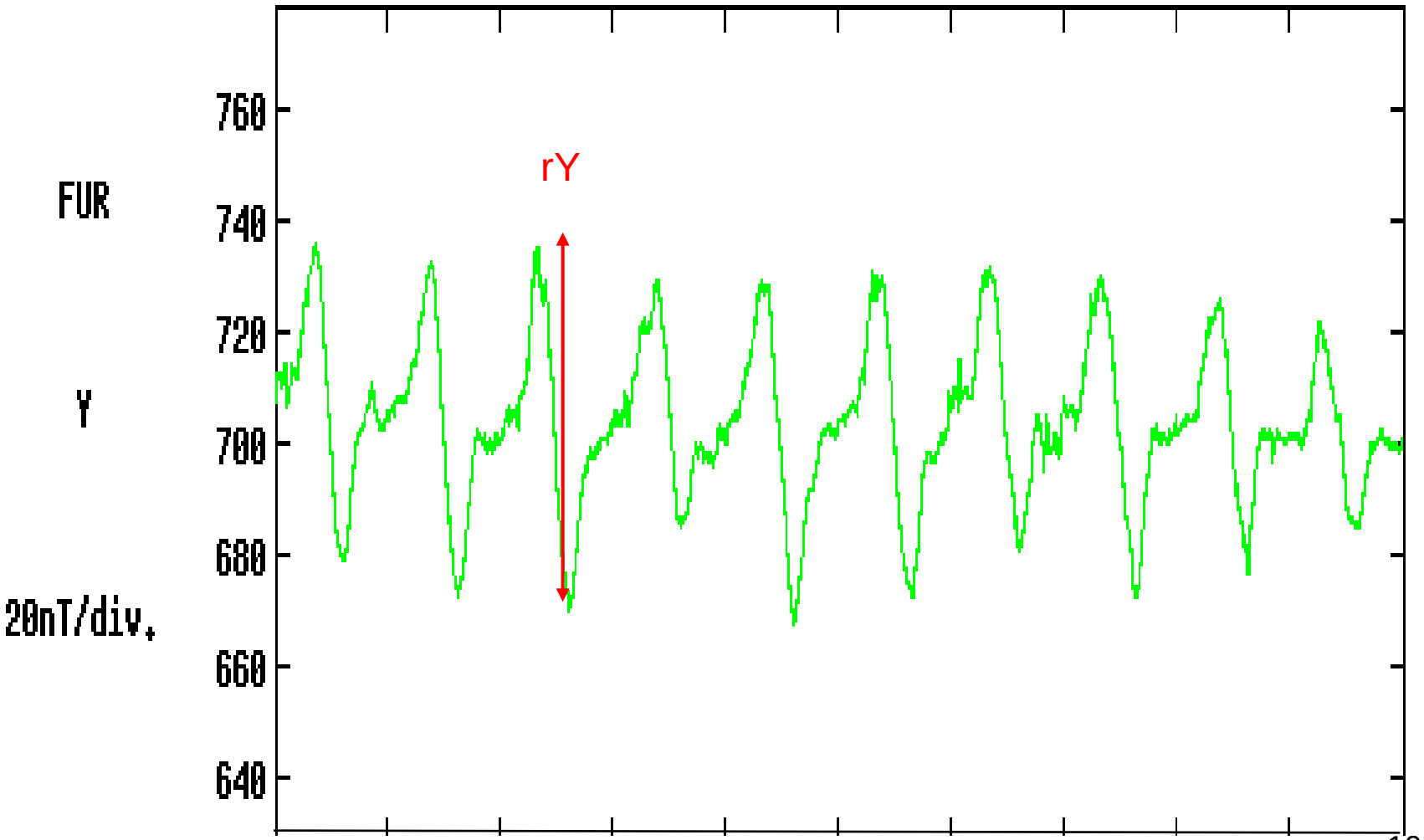
$Y = H \sin(D)$

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

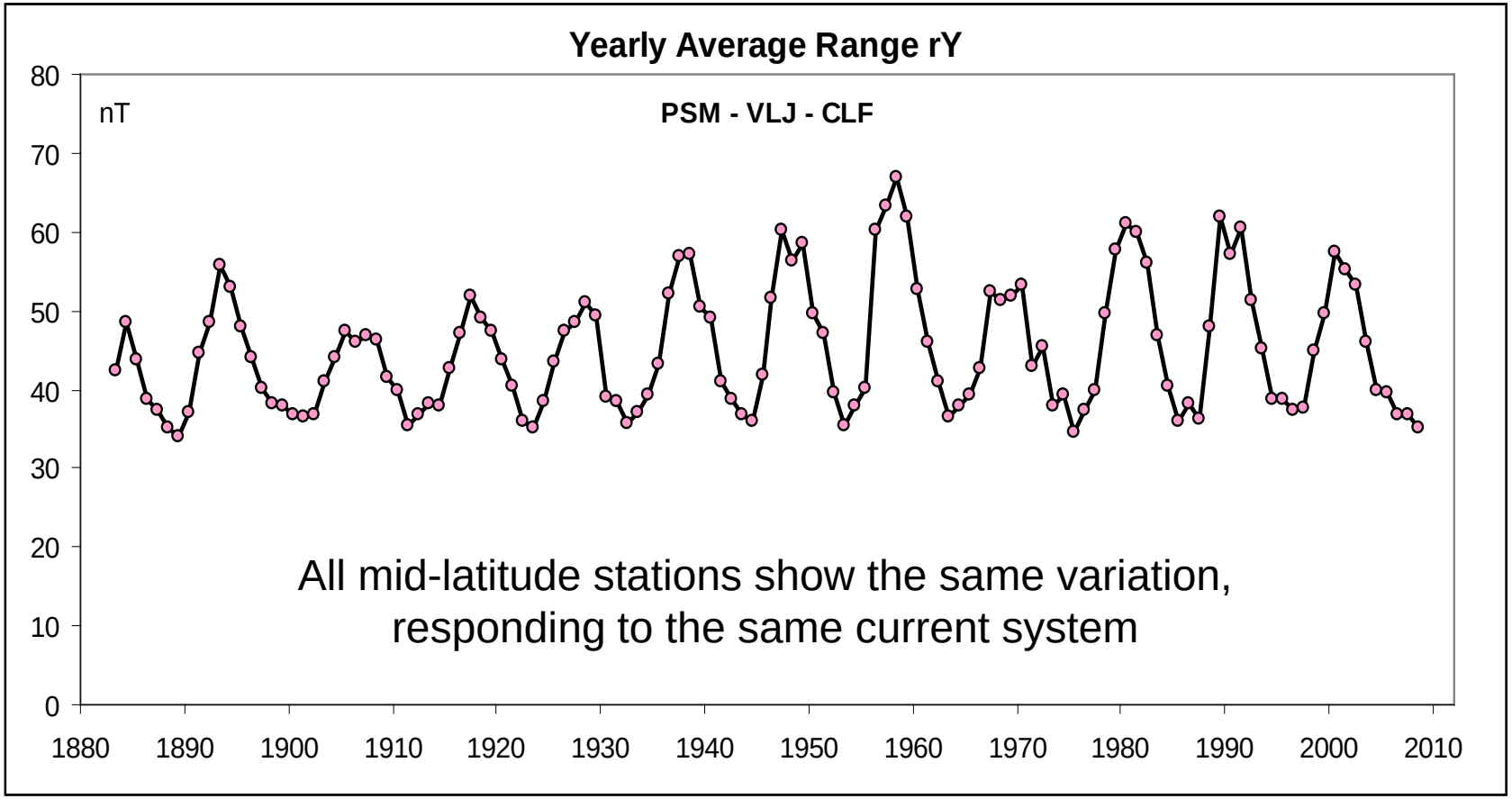


A current system in the ionosphere is created and maintained by solar FUV radiation

10 Days of geomagnetic variations

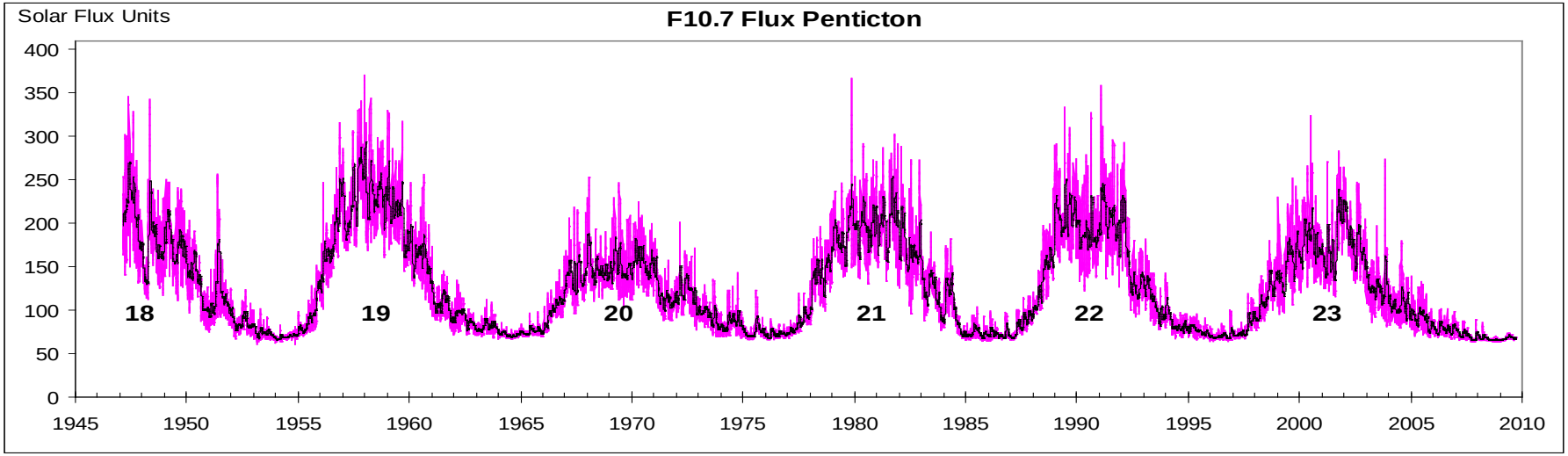


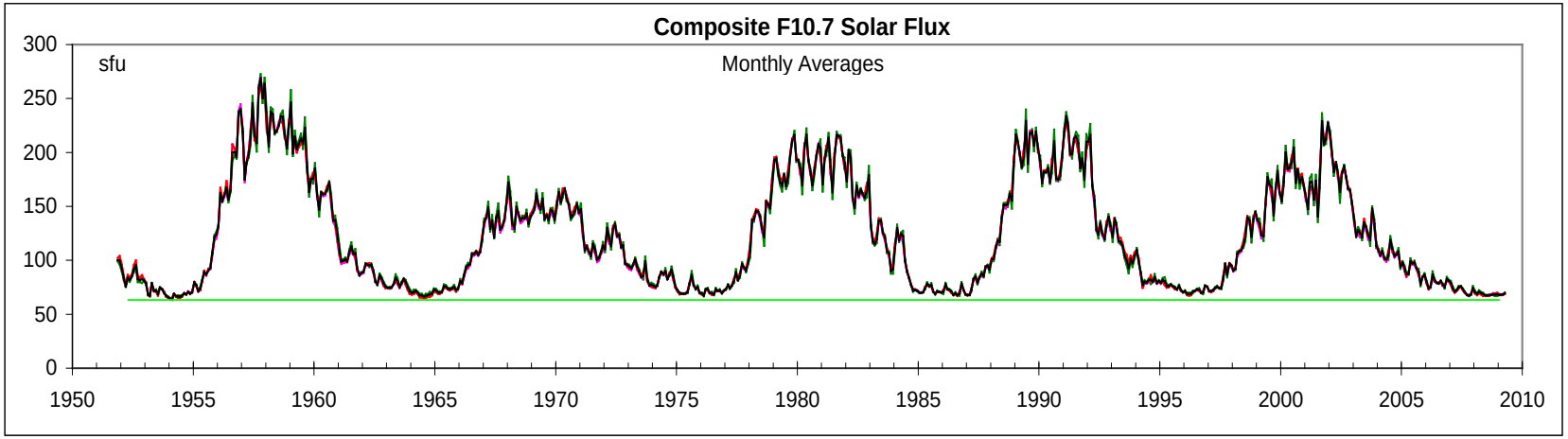
The clear solar cycle variation of *rY*



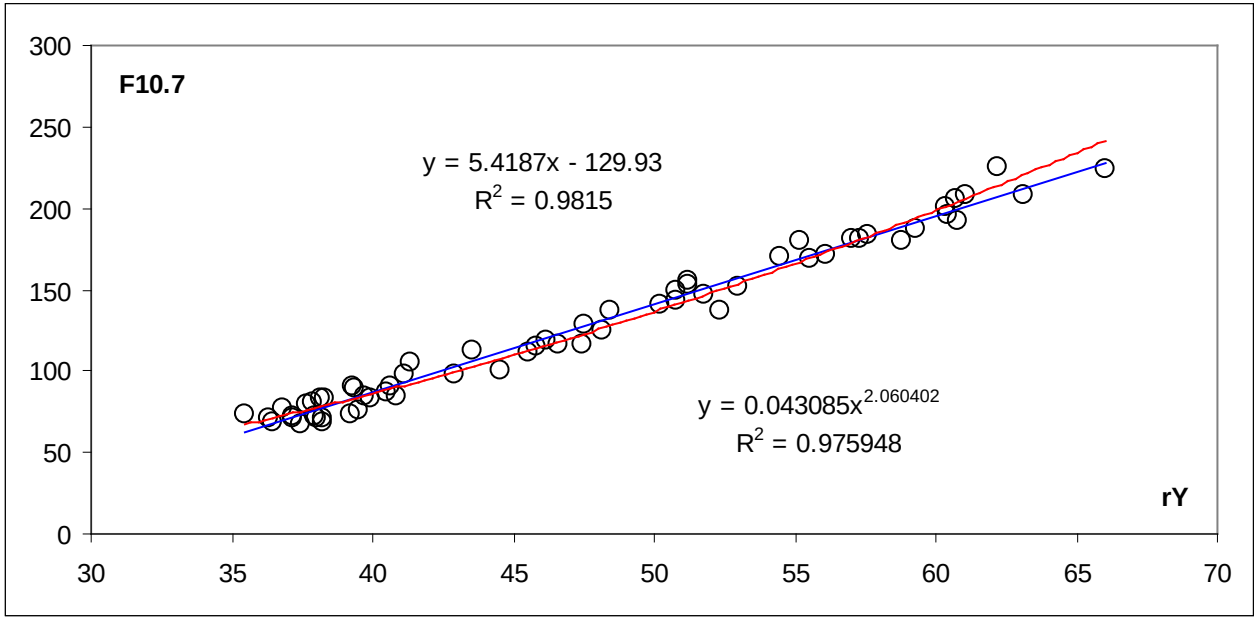
This was Wolf's justification for his calibration of the SSN

Solar Activity: Radio Flux at 2.8 GHz [or 10.7 cm]

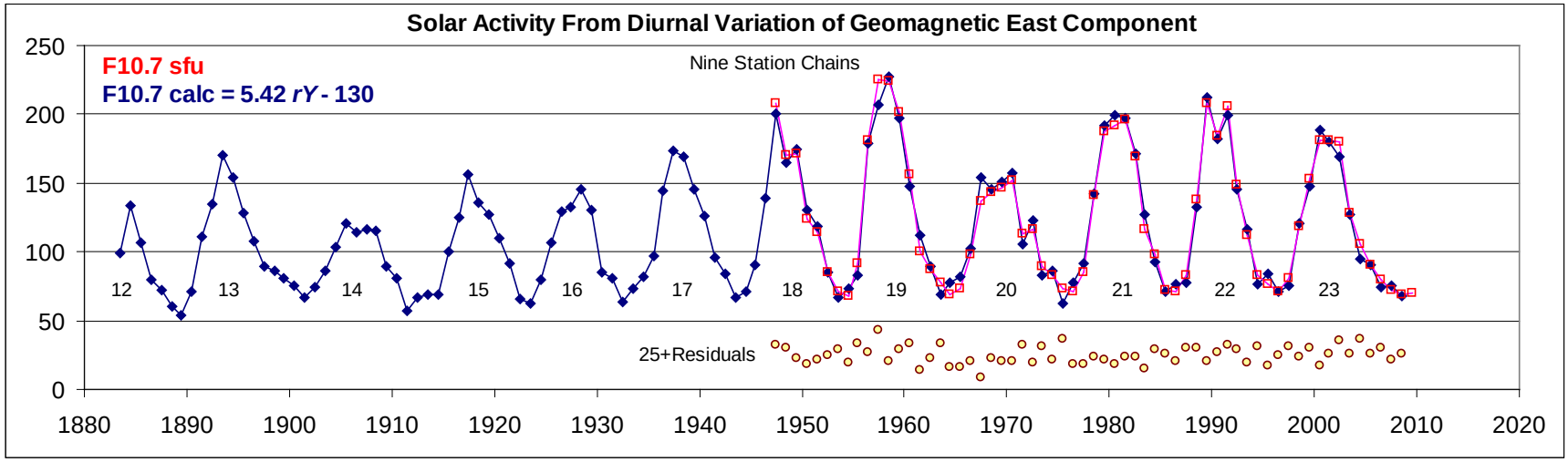




Very stable and well-determined from Canadian and Japanese stations

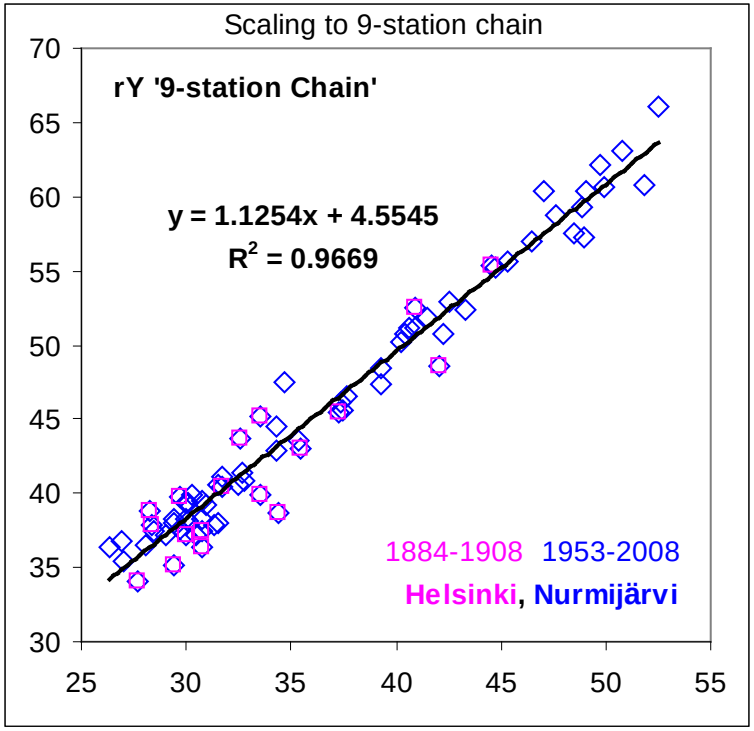


Using *rY* from nine 'chains' of stations we find that the **correlation** between *F10.7* and *rY* is extremely good (more than 98% of the variation is accounted for)

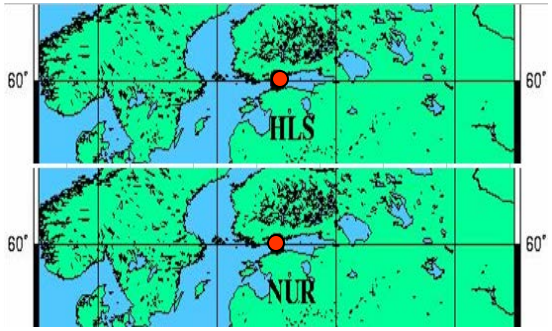


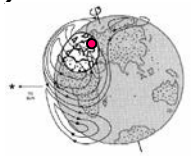
This establishes that Wolf's procedure and calibration are physically sound

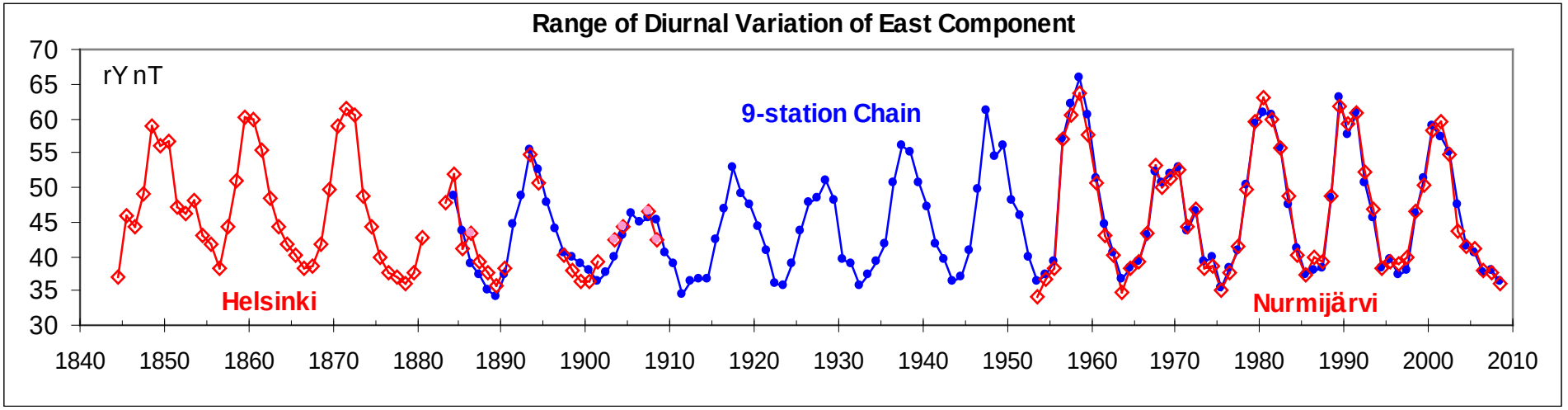
Helsinki-Nurmijärvi Diurnal Variation



Helsinki and its replacement station Numijärvi scales the same way towards our composite of nine long-running observatories and can therefore be used to check the calibration of the sunspot number (or more correctly to reconstruct the F10.7 radio flux)







Rudolf Wolf's 1861 List

Abstract of his latest Results. By Prof. Wolf.

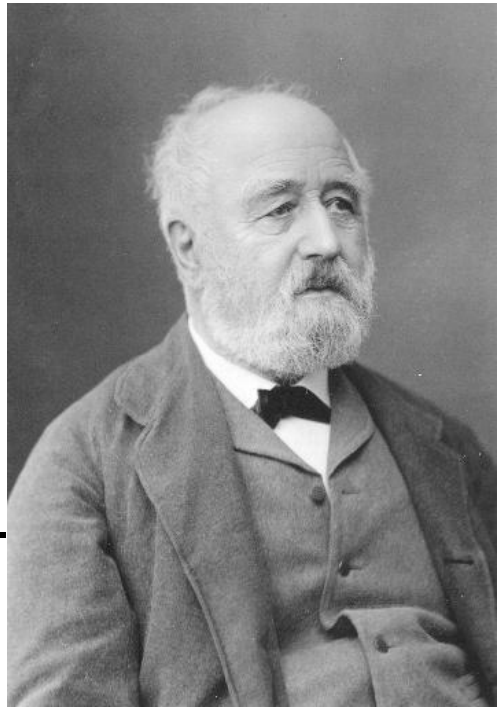
(*Translation communicated by Mr. Carrington.*)

Some fine series of observations of Flaugergues, Adams, Arago, and others, have enabled me to fill in previous breaks, and to express in the same unit my Relative numbers (for the abundance of Solar Spots in successive years) for the years from 1749 to 1860. They are as follows:—

1749	63·8	1777	63·0	1805	50·0?	1833	7·5 *m*
1750	68·2 M	78	94·8	06	30·0?	34	11·4
51	40·9	1779	99·2 M	07	10·0?	35	45·5
52	33·2	1780	72·6	08	2·2	36	96·7
53	23·1	81	67·7	1809	0·8	37	111·0 M
54	13·8	82	33·2	1810	0·0 *m*	38	82·6
55	6·0 *m*	83	22·5	11	0·9	1839	68·5
56	8·8	84	4·4 *m*	12	5·4	1840	51·8

1749	80.9	1777	92.5	1805	42.2	1833	8.5 m
1750	83.4 M	78	154.4	06	28.1	34	13.2
51	47.7	1779	125.9 M	07	10.1	35	56.9
52	47.8	1780	84.8	08	8.1	36	121.5
53	30.7	81	68.1	1809	2.5	37	138.3 M
54	12.2	82	38.5	1810	0.0 m	38	103.2
55	9.6 m	83	22.8	11	1.4	1839	85.7
56	10.2	84	10.2 m	12	5.0	1840	64.6

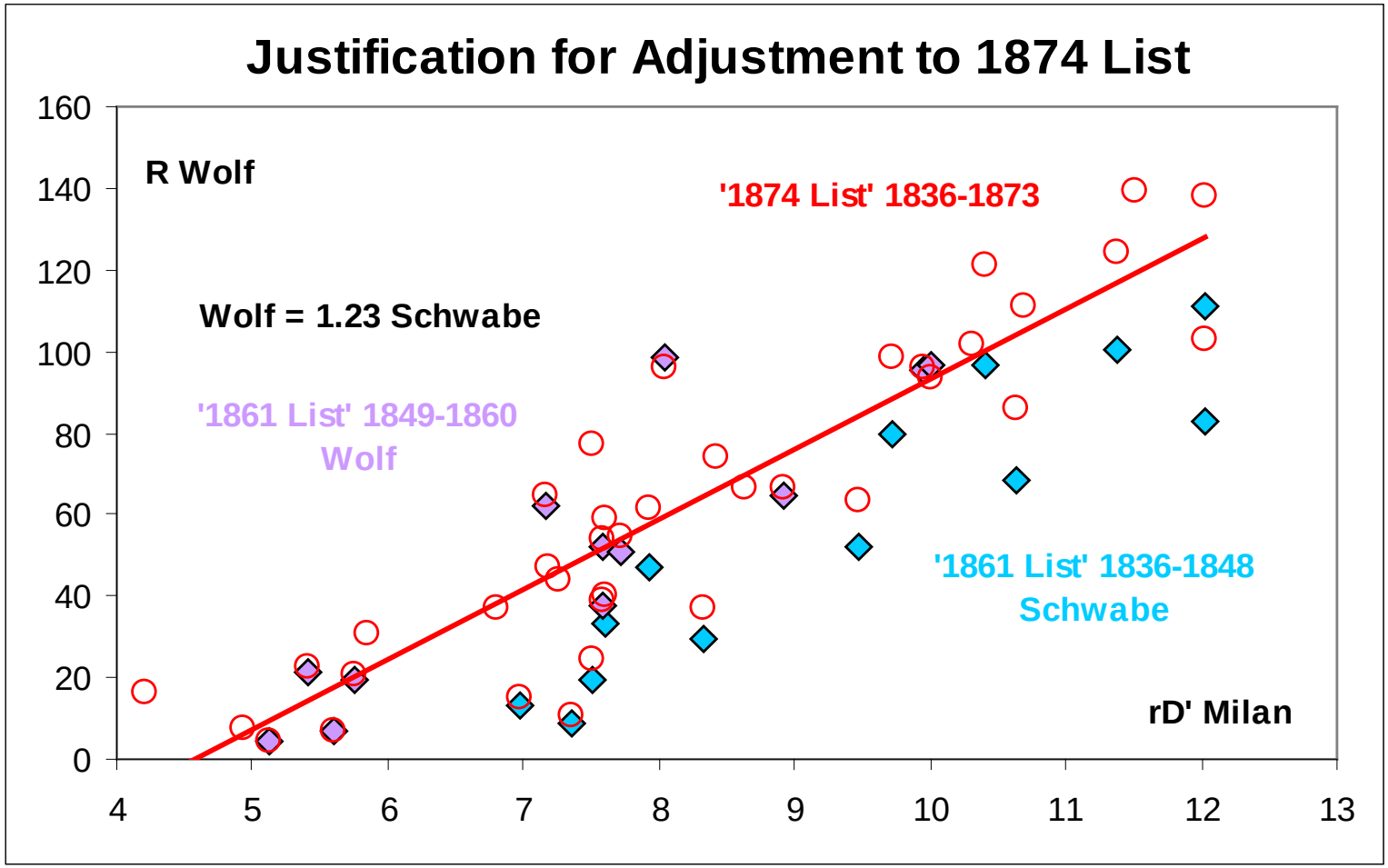
From MNRAS, 1861 and from the current dataset at SIDC in Brussels



1837 138.3

25% higher

Wolf got Declination Ranges for Milan from Schiaparelli and it became clear that the pre-1849 SSNs were too low



The ‘1874’ list included the 25% [Wolf said 1/4] increase of the pre-1849 SSN

Wolf increased all pre-1849 numbers by 25%

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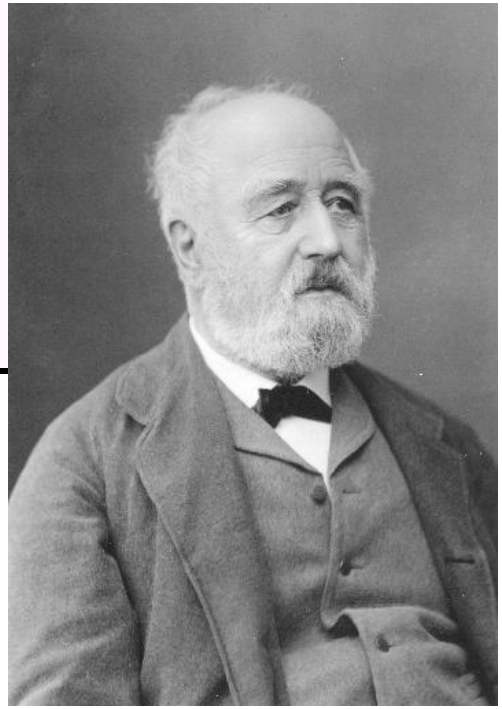
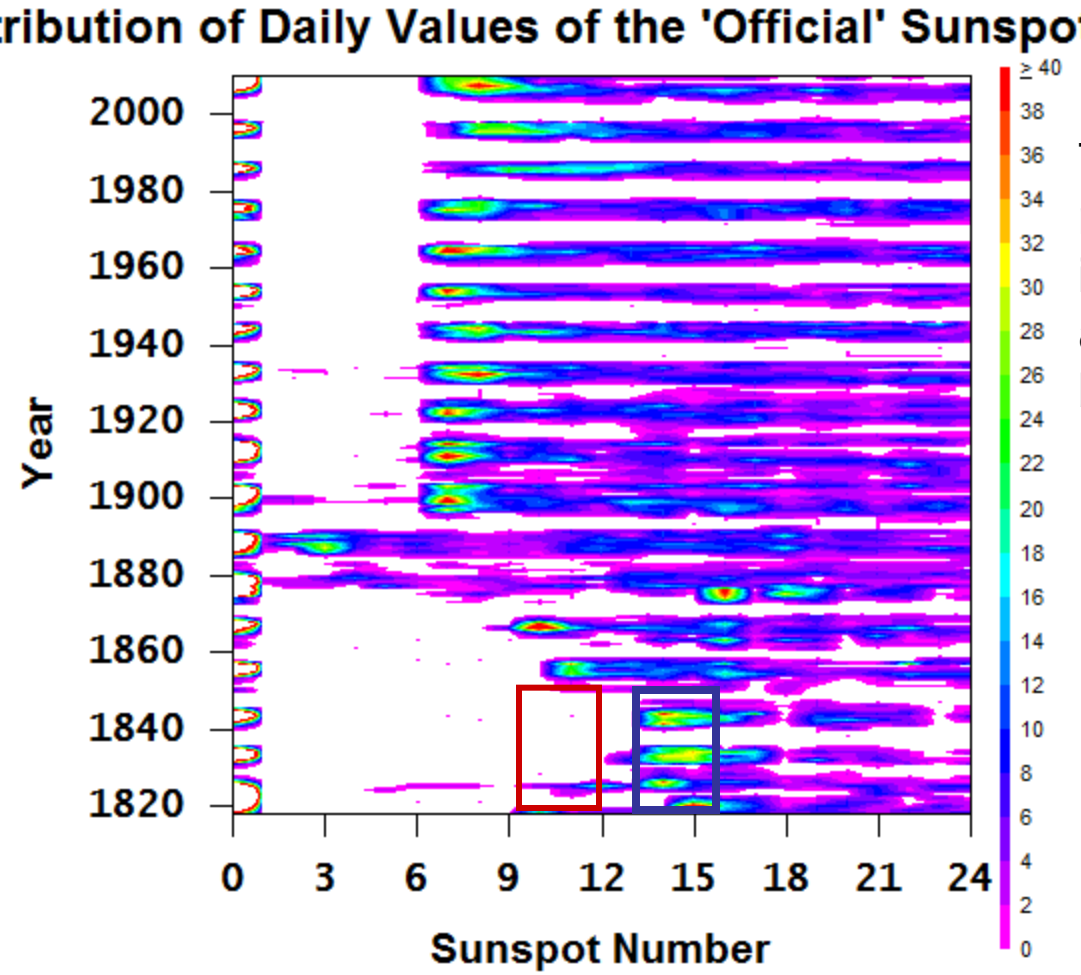
From MNRAS, 1861 and from the current dataset at SIDC in Brussels

Wolf started his own observations in 1849



The Wholesale Update of SSNs before 1849 is Clearly Seen in the Distribution of Daily SSNs



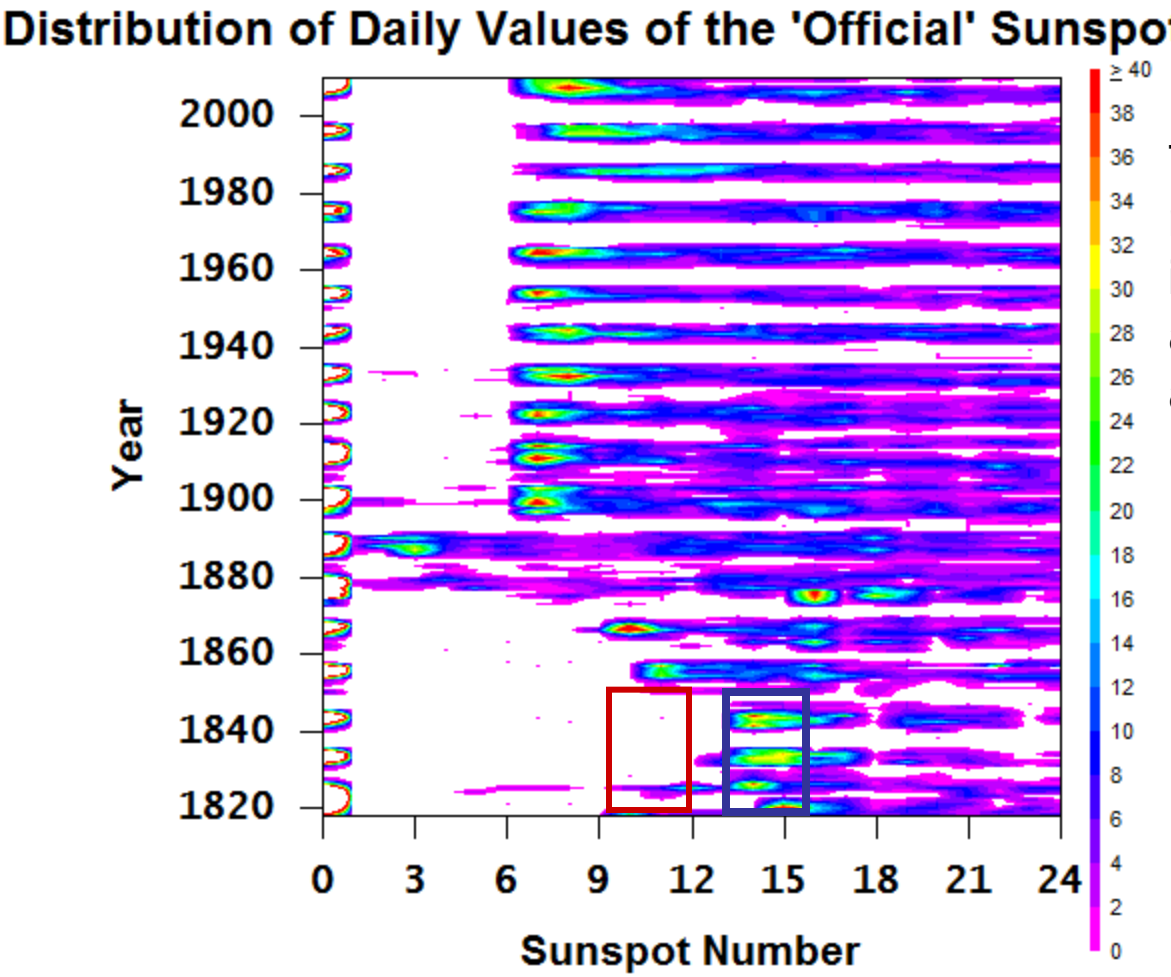
The smallest non-zero SSN is 11, but there are no 11s before 1849

11 * 5/4 = 14

Wolfer's Change to Wolf's Counting Method

- Wolf only counted spots that were 'black' and would have been clearly visible even with moderate seeing
- Wolfer disagreed that the above criterion was much too vague and advocating counting every spot that could be seen
- This, of course, introduces a discontinuity in the sunspot number, which was corrected by using a much smaller k value [~0.6 instead of Wolf's 1]

The Impact on the SSN after 1893 is Clearly Seen in the Distribution of Daily SSNs



The smallest non-zero SSN is 11, but there are lots of 7s after 1893

11 * 0.6 = 7