The Effect of Weighting in Counting Sunspots & More…

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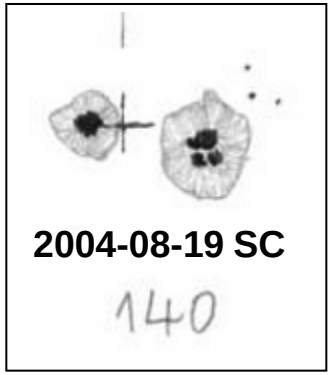
SSN4 Workshop, Locarno 21 May, 2014

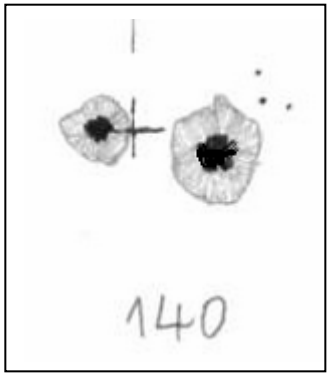
After Waldmeier took over the production of the sunspot series he stated {*100 Jahre Sonnenfleckenstatistik, Astron. Mitt. Eid. Sternw. Zürich, No.152, 1948*}:

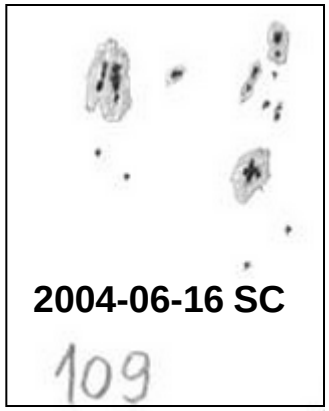
[…] Allerdings hat Wolfer, während seiner Assistentenzeit 1877-1893 eine andere Zählweise wervendet [...] dass die Hofflecken, die bei Wolf nur als **ein** Fleck galten, je nach ihrer Grösse und Unterteilung mehrfach gezählt werden.

([…] “Though Wolfer used an different counting method during his tenure as assistant 1877-1893 [...] that spots with penumbra, that by Wolf was counted as **one** spot, would be counted multiple times according to size and how they were divided into spots”).

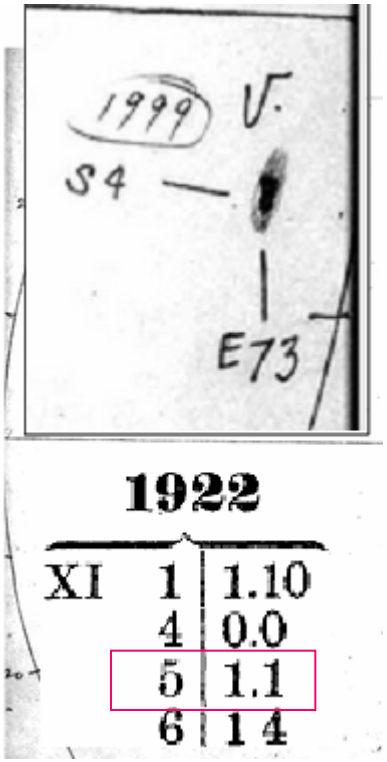
‘je nach ihrer Grösse und **Unterteilung** mehrfach gezählt werden’

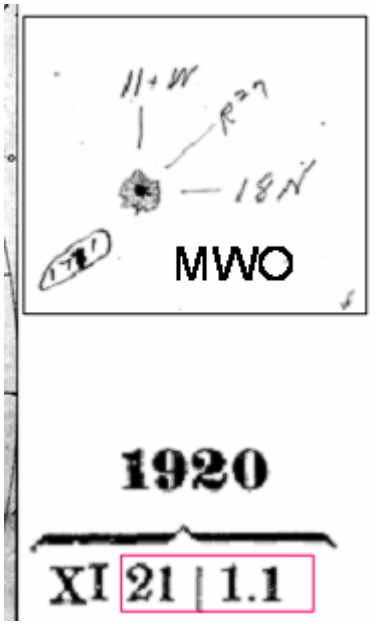






My interpretation of the ‘Unterteilung’ rule





Wolfer counted these spots with penumbra as single spots so the size of the spot does not matter

Wolfer in 1907: Ohne Rücksicht auf deren Grösse

Astronomische Mitteilungen,

gegründet von

Dr. Rudolf Wolf.

Nr. XCVIII,

herausgegeben von

A. Wolfer.

Die Häufigkeit und heliographische Verteilung der Sonnenflecken im Jahre 1906; Vergleichung mit den Variationen der magnetischen Deklination. Fortsetzung der Sonnenfleckenliteratur.

Der nachstehenden Übersicht über die Häufigkeit der Sonnenflecken während des Jahres 1906 liegen erstlich die Beobachtungen zu Grunde, die ich auf der Zürcher Sternwarte selbst an 278 Tagen mit dem von jeher dafür benutzten Fraunhoferschen „Normalfernrohr“ von 8 cm Öffnung, und während vorübergehender Abwesenheit an 7 weiteren Tagen mit einem kleineren von 4 cm Öffnung, dem „Handfernrohr I“, gemacht habe. Dazu kommen die korrespondierenden Beobachtungen des Herrn Assistent Broger mit demselben 8 cm-Fernrohr an 265 Tagen, und diese beiden Reihen zusammen lieferten allein schon die Flecken-Relativzahlen für 311 Tage des Jahres. Alle noch fehlenden Tage, an denen wir hier in Zürich wegen bedeckten Himmels keine Zählungen erlangt haben, konnten mit Hülfe von 20 weiteren Beobachtungsreihen gedeckt werden, die zum Teil bereits veröffentlicht vorlagen, teils mir von den betreffenden Herren Beobachtern mit sehr verdankenswerter Bereitwillig-

November 1907. 1

keit zur Verwendung mitgeteilt worden waren, und für welche auf die unten folgende „Sonnenfleckenliteratur“ zu verweisen ist. Die Relativzahlenreihe ist durch sie auch für dieses Jahr wieder eine lückenlose geworden.

Die in Tab. I gegebene Übersicht über die benutzten Beobachtungsreihen enthält die zu ihrer Verbindung mit unsern eigenen erforderlichen Reduktionsgrössen, über welche an folgendes zu erinnern ist. Notiert ein Beobachter mit seinem Instrumente an irgend einem Tage g Fleckengruppen mit insgesamt f Einzelflecken, ohne Rücksicht auf deren Grösse, so ist die daraus abgeleitete Relativzahl jenes Tages $r = k\,(10\,g + f)$, wo k einen für jeden Beobachter und sein Instrument besonders zu ermittelnden Faktor bezeichnet, durch welchen

Wolfer himself in 1907 (Mitteilungen, Nr. 98) explicitly states: “If an observer with his instrument on a given day notes *g* spot groups with a total of *f* single spots, without regard to their size, then the therefrom deduced relative number for that day is $r = k(10g+f)$”

Wolf reduzierten Reihe berechnet. Diese Werte k findet man in Tab. I zusammengestellt, ebenso unter „Vgl.“ die Zahl der korrespondierenden Beobachtungen, aus denen k abgeleitet wurde; für die meisten Beobachtungsorte stimmen die beiden Halbjahrswerte von k soweit unter sich überein, als es bei gleichbleibender Beobachtungsweise erfahrungsmässig ungefähr erwartet werden kann. Die in Zürich gemachten Zählungen mit den Handfernröhren I, II und III bilden die Fortsetzung der Reihe vergleichender Beobachtungen, die ich 1894 begonnen habe, um eine allfällige Veränderlichkeit der Faktoren k mit der Grösse der Fleckenzahlen im Verlaufe der 11jährigen Periode festzustellen. Die drei letzten Kolonnen der Tab. I enthalten die Zahl der Beobachtungstage jeder Reihe, die Zahl der unter diesen zur Ausfüllung von Lücken benutzbaren „Ersatztage“ und die No. der Sonnenfleckenliteratur, unter der die betreffenden Reihen in extenso mitgeteilt sind.

Waldmeier's Description of the Weighting Scheme

Astronomische Mitteilungen der Eidgenössischen Sternwarte Zürich
Nr. 285

1968

Die Beziehung zwischen der Sonnenflecken-relativzahl und der Gruppenzahl

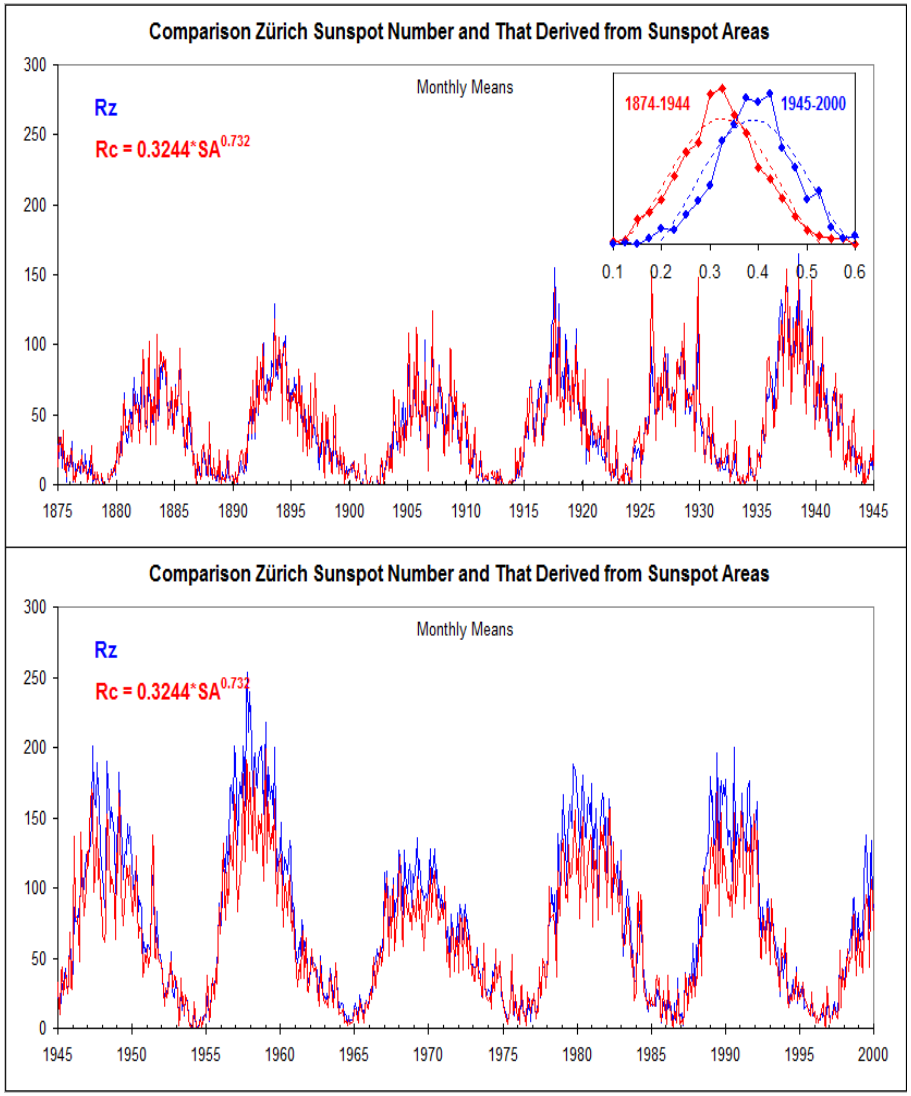
Von

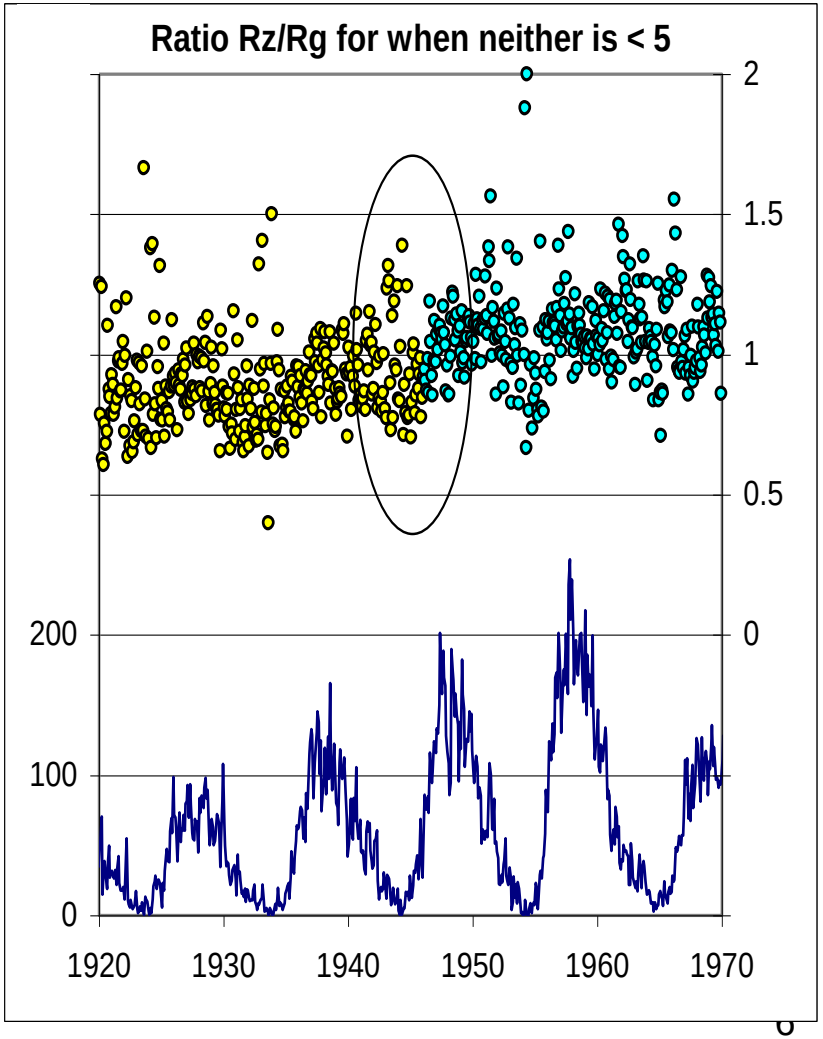
M. Waldmeier

Hofflecken handelte. Später wurden den Flecken entsprechend ihrer Größe Gewichte erteilt: Ein punktförmiger Fleck wird einfach gezählt, ein größerer, jedoch nicht mit Penumbra versehener Fleck erhält das statistische Gewicht 2, ein kleiner Hoffleck 3, ein größerer 5. Die Gruppen- und

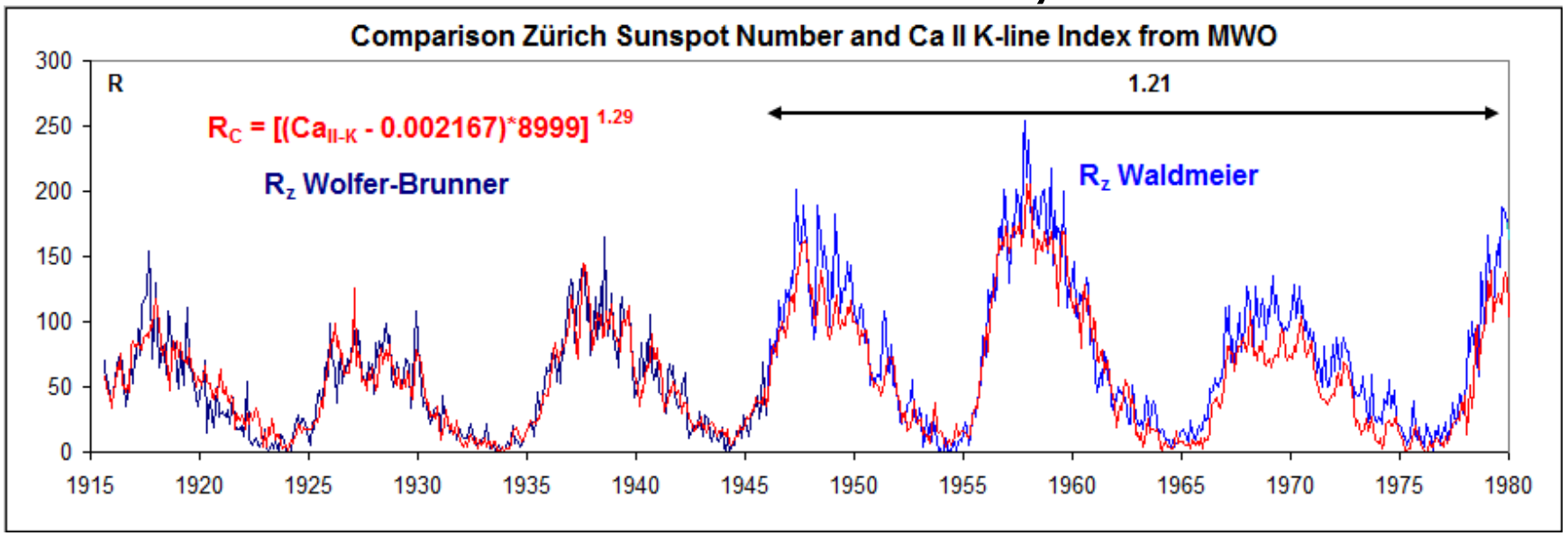
"A spot like a fine point is counted as one spot; a larger spot, but still without penumbra, gets the statistical weight 2, a smallish spot with penumbra gets 3, and a larger one gets 5." Presumably there would be spots with weight 4, too.

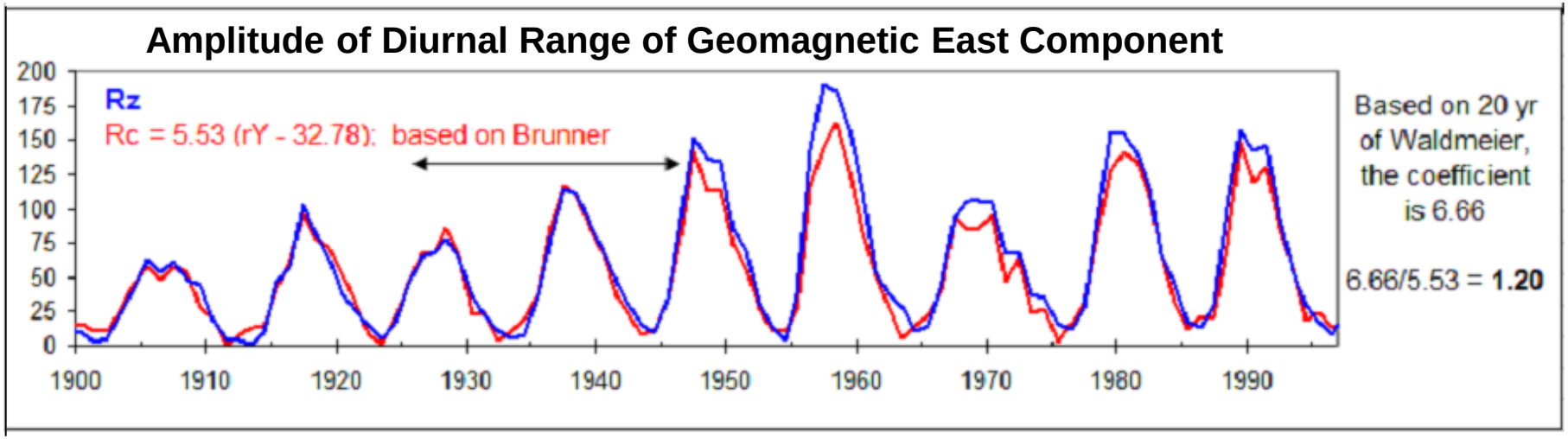
Can we see the Effect of Weighting in other Indices, I?





Can we see the Effect of Weighting in other Indices, II?





What did Brunner Have to Say?

Brunner himself writes in 1936 (Brunner JGR 1936) that “The subjective method of counting may also have an influence. In large centers of activity one is inclined – and this perhaps rightly – to give some single spots according to their sizes a different weight”, but then continues “In the spot-statistics, introduced for our observatory by Rudolf Wolf 80 years ago, all these circumstances have been considered as far as possible by introducing a reduction-factor on Wolf’s unit. The latter is determined by comparison of corresponding observations. In determining the Wolf relative-number a weight of ten is given for the groups of spots and **a weight of one for the number of single spots or nuclei**”.[1] This seems to indicate that spots were not weighted, although Brunner at times might have been inclined to do so. His assistant Max Broger (observed 1897-1936) appears to have weighted some of his counts, so it is conceivable that discussion was going on at Zürich about the preferred counting method.

[1] Presumably meaning umbrae (spots) within each penumbra

Digitizing Luft's Notebooks

Herb Luft's notebooks: new science from the AAVSO Archives

Posted by Matthew Templeton on May 10, 2013 - 12:25pm

The AAVSO Solar section and AAVSO headquarters are hosting a special guest this week and next, Leif Svalgaard (at center in this photo) of Stanford University/Solar Dynamics Observatory. Leif is here to digitize sunspot records from the original notebooks of AAVSO member Herbert A. Luft (1908-1988), housed in the Thomas R. and Anna Fay Williams Archives.

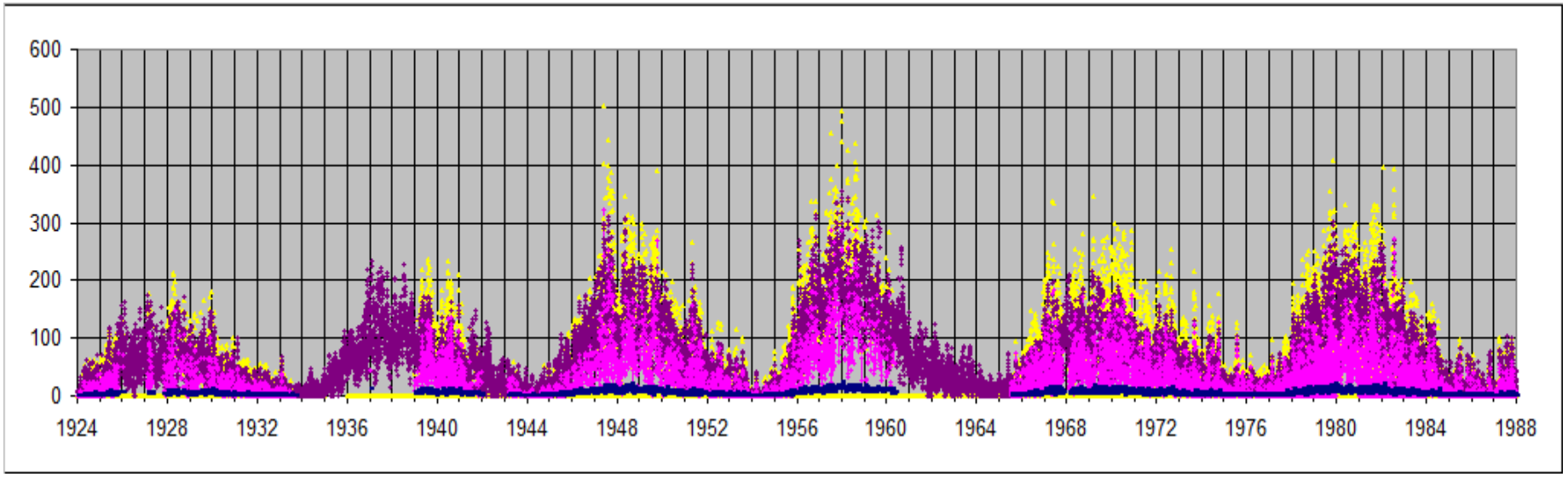
Michael Saladyga (L), Leif Svalgaard (C), Matthew Templeton (R)

Herbert A. Luft
Sunspot Observer

Luft observed from 1923 to 1987

Herbert Luft was born in 1908 in Breslau, Germany and died 1988 in New York, USA

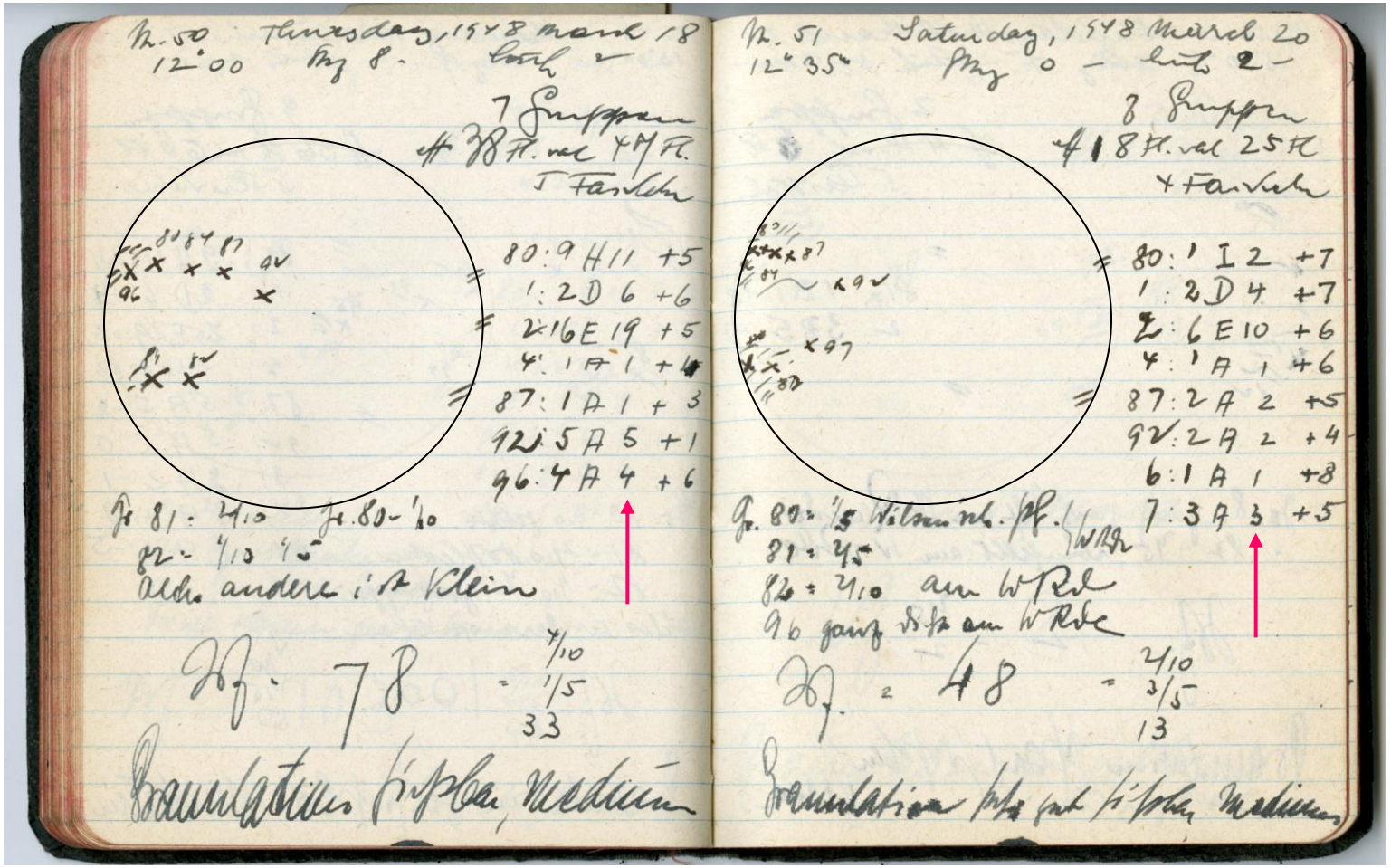
As a teenager he joined various Amateur Associations and was mentored by the slightly older Wolfgang Gleissberg who suggested Luft concentrate on Sunspots.



The nearly 12,000 pages yielded 10,434 usable observations [when image quality was good enough].

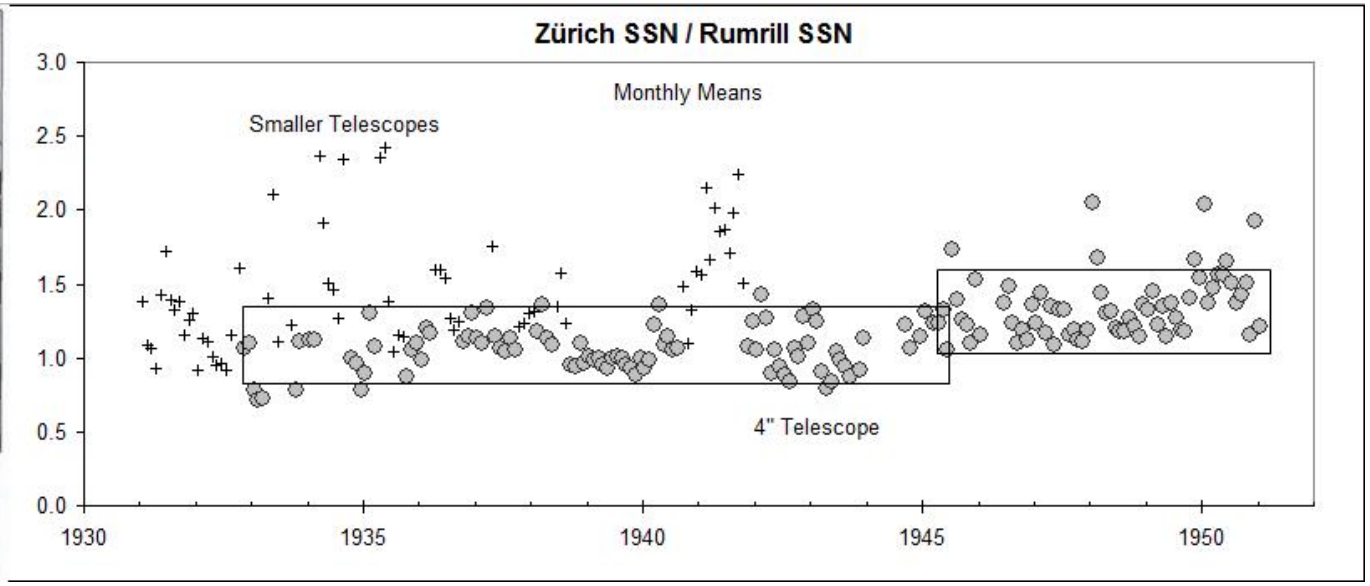
Blue = groups, Pinks = spots, Yellow = SSN, Purple = SIDC Official SSN.

Used Weighting from 24th February 1947, but abandoned the scheme April 5th the next year



Observations by Harry B. Rumrill (1867-1951)

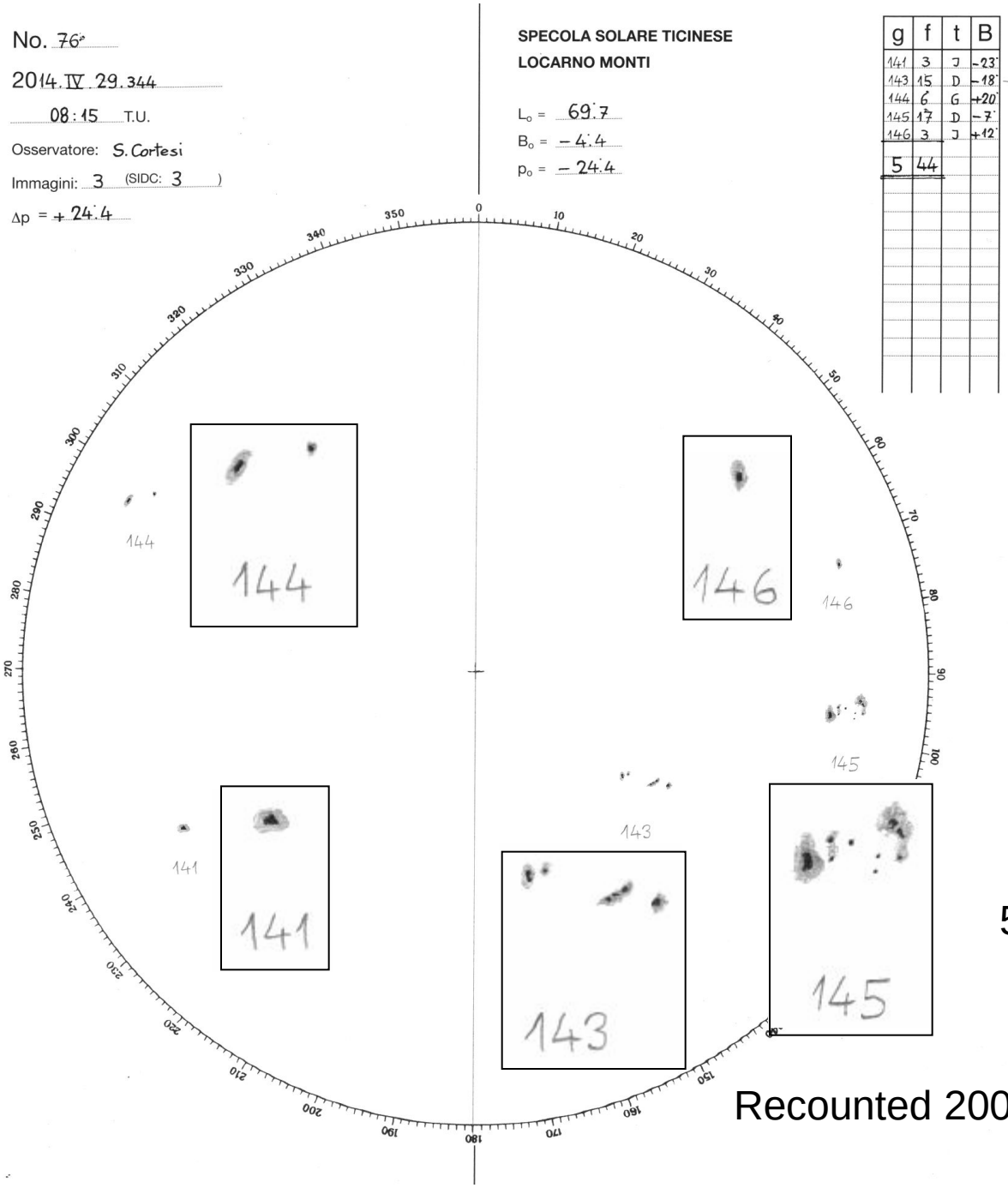
Harry Barlow Rumrill, president of the Rittenhouse Astronomical Society in 1932, with his 4-inch Brashear refractor. From *History of the Rittenhouse Astronomical Society*, courtesy Joy Crist.



Ratio of monthly means RZ/(Rumrill SSN). Data taken with small telescopes are plotted as small "+" symbols. The ratio between the Zürich Sunspot Number and Rumrill's indicates an increase of the Zürich values from ~1945, by about 20%.

His data and notebooks were considered lost until L.Svalgaard, with the help of "The Antique Telescope Society" (Bart Fried, Jack Koester), located most of them in early 2012. Rumrill used 2" telescopes early on, but from 1942 employed exclusively a 4" Brashear refractor (Figure, at left).

Counting with no Weighting



g	f	t	B
141	3	J	−23
143	15	D	−18
144	6	G	+20
145	17	D	−7
146	3	J	+12
5	44		

g	f	
141	3	1
143	15	6
144	6	2
145	17	9
146	3	1
5	44	19

5x10+44=94 5x10+19=69

94/69 = 1.36

Recounted 2003-2014: ~50,000 spots

The Recount

At the reference station Locarno, weighting has been used since the beginning in 1957, closely following Waldmeier's prescription (Sergio Cortesi, personal communication). To assess the magnitude of the increase due to weighting, Leif Svalgaard undertook to examine all the drawings and individual counts of groups and spots made at Locarno for the past decade and re-count the spots with and without weighting. There were 3229 observation days with 9532 groups containing 49,318 un-weighted spots at the time of writing. The weighted spot count was 72,548, for an excess of 47%. The counts translate into an average sunspot number of 26.88 [(10*9532 + 49318)/3229*0.6] without weighting and 31.19 with weighting, for an excess of 16% for this rather low solar activity. It is, perhaps, noteworthy that the average number of (unweighted) spots per group for this period (2003-2014) is low, only 5.17.

A parallel effort is conducted by Francesca Marenzi

Some (Rare) Difficult Cases

2005. IX. 15. 333

8.00 T.U.

Osservatore: S.Cortesi

Immagini: 3

105

74 spots

g	f	t	B	L
105	58	E	-11	
1	58			

36

3,2,3,2,2,3,2,3,3,3,3,3,3: sum 35, 58-35+13 spots = 36

Francesca Marenzi

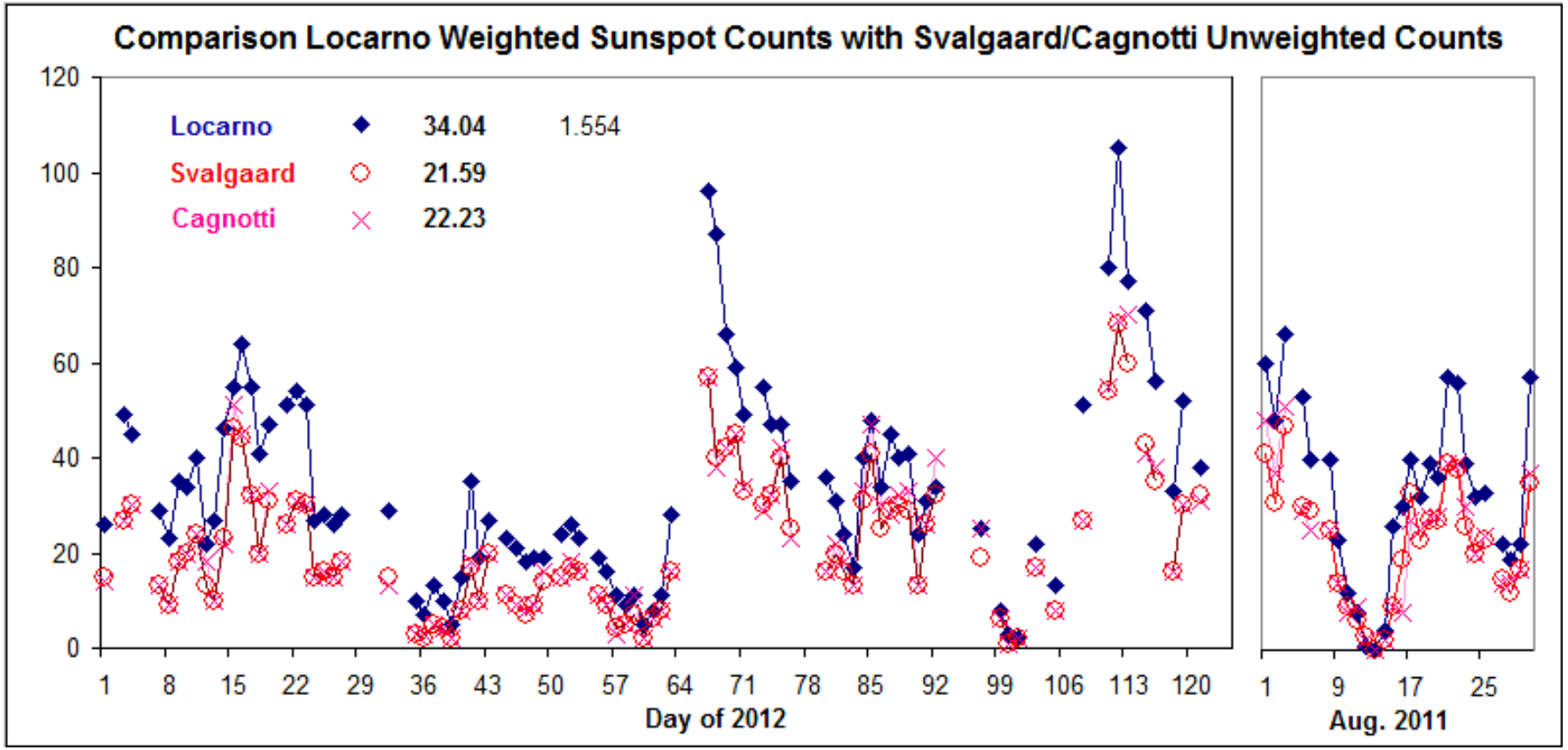
g	f	t	B	L	△
134	55	E	-13		40
136	3	J	+10		1
138	2	A	+17		1
139	5	C	-8		2
4	65				44

46
1
1
2

50

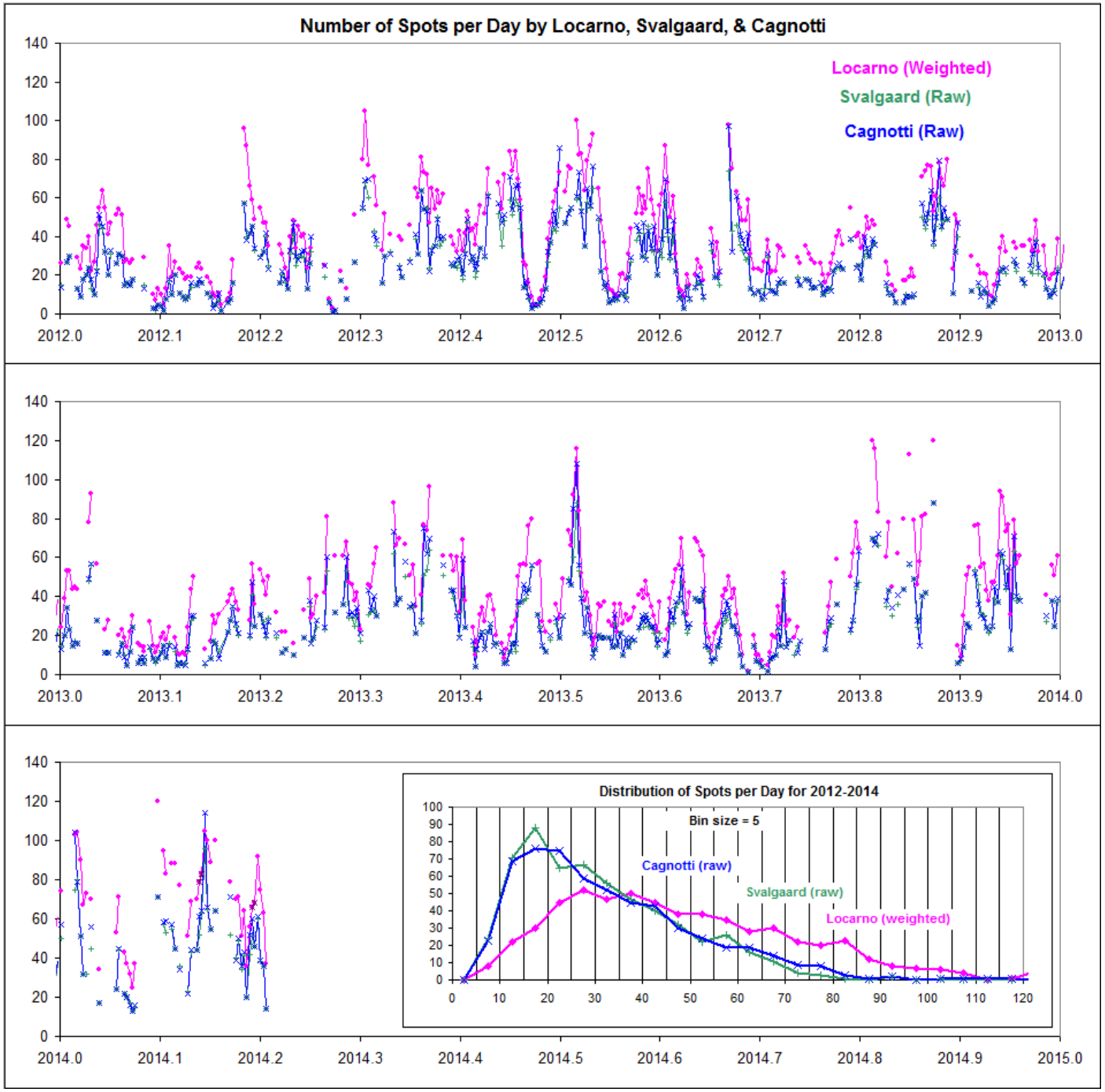
2004-08-12 (group 134)

Double-Blind Test of My Re-Count



I proposed to the Locarno observers that they should also supply a raw count without weighting

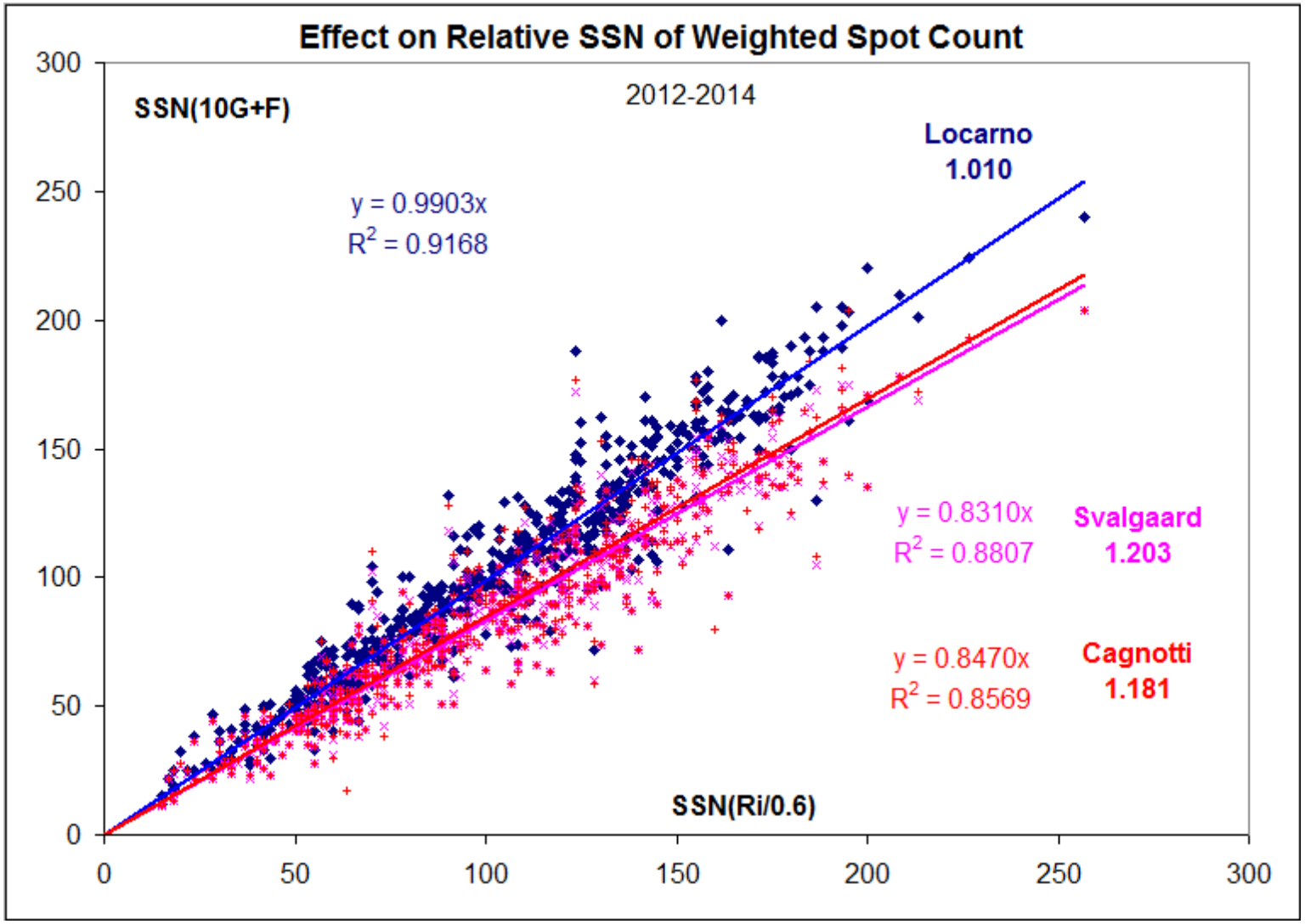
For typical number of spots the weighting increases the 'count' of the spots by 30-50% (44% on average)



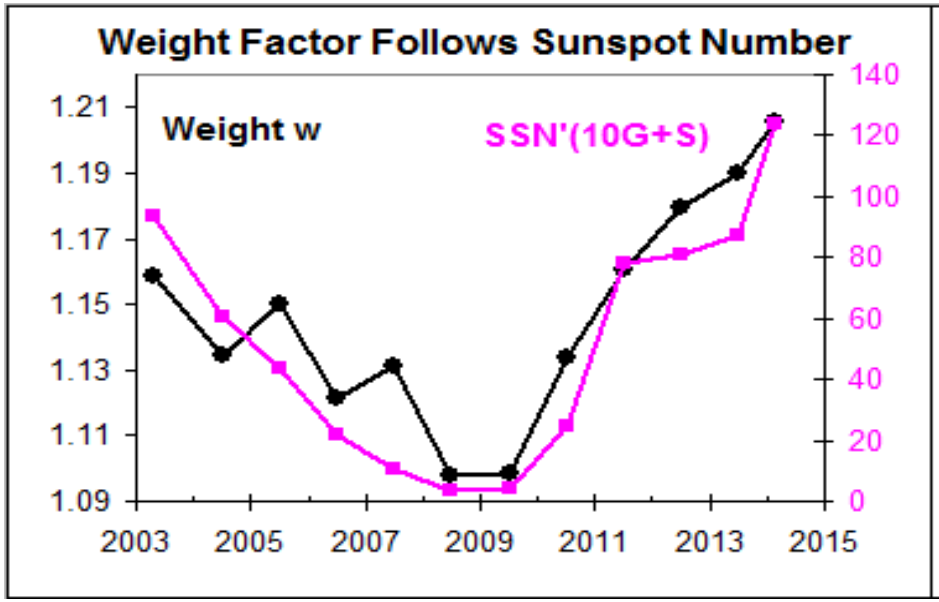
Compare Cagnotti & Svalgaard

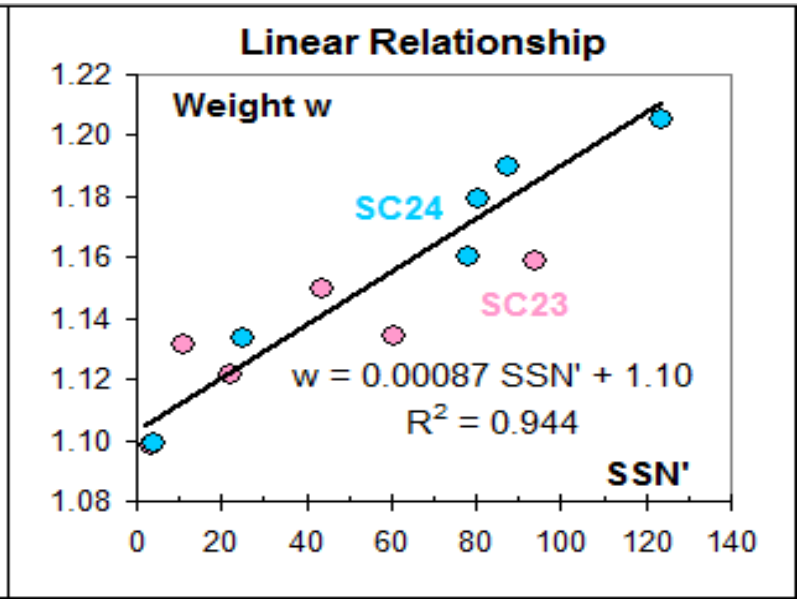
My raw counts match Marco's very well

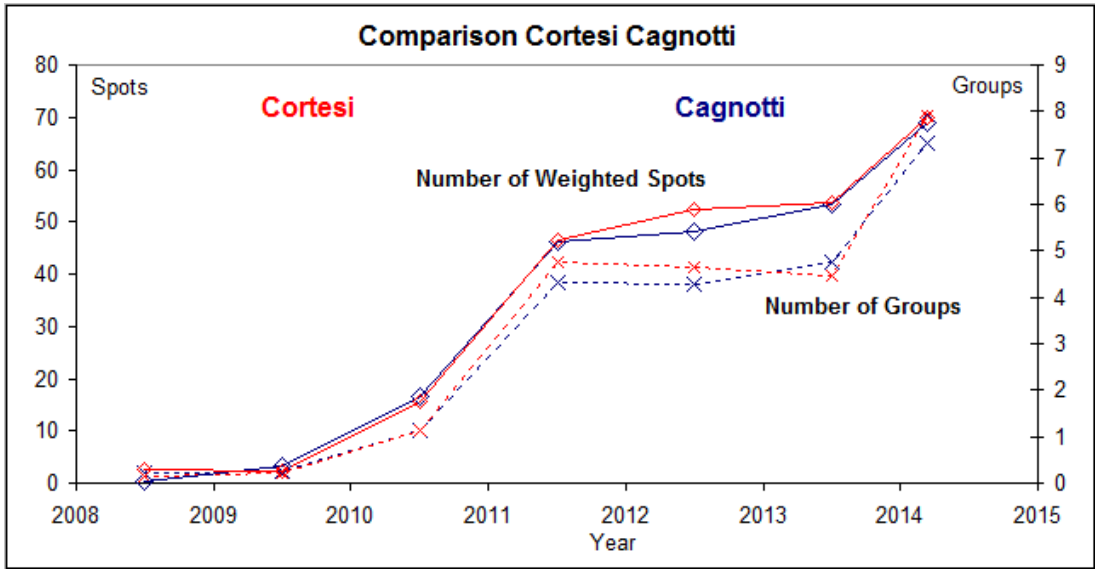
Effect on Relative SSN



Weight Factor depends on SSN





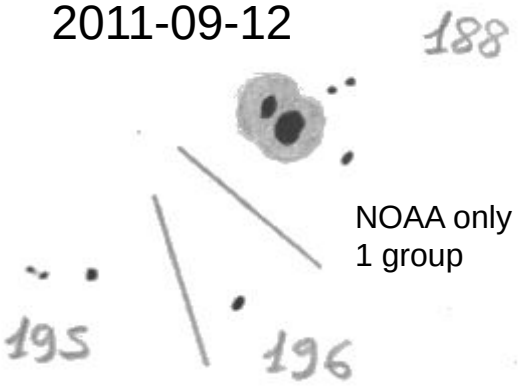


But, apparently, not on the [well-educated] Observer

How Many Groups?

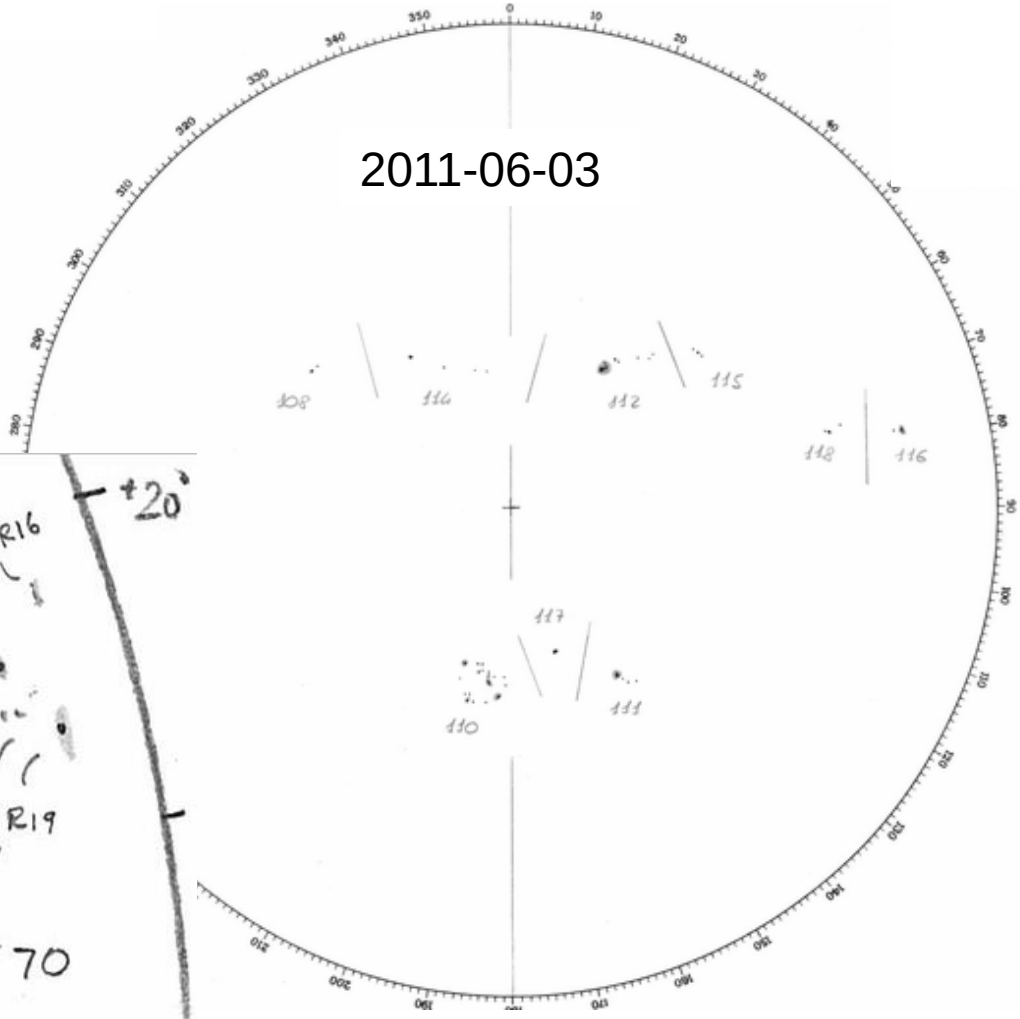
(The Waldmeier Classification May lead to Better [larger] Determination of Groups)

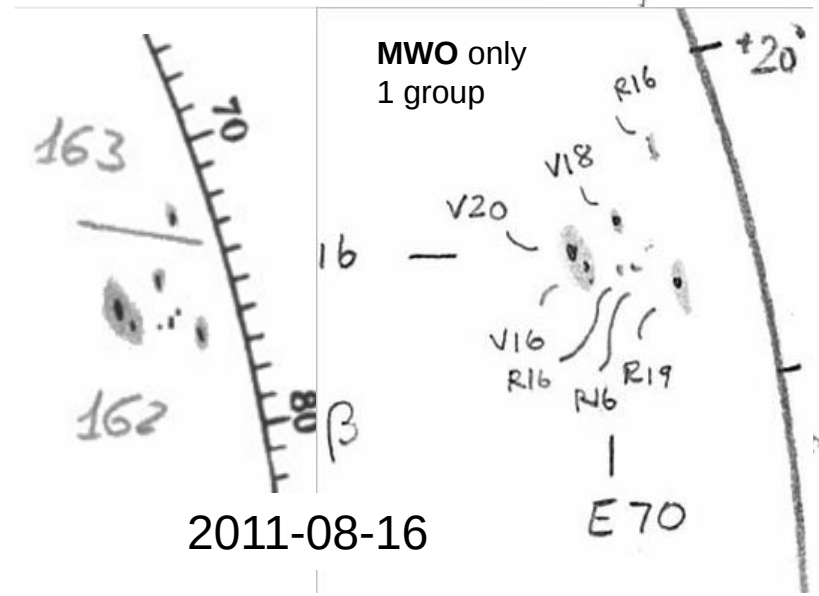
2011-09-12



NOAA only
1 group

2011-06-03





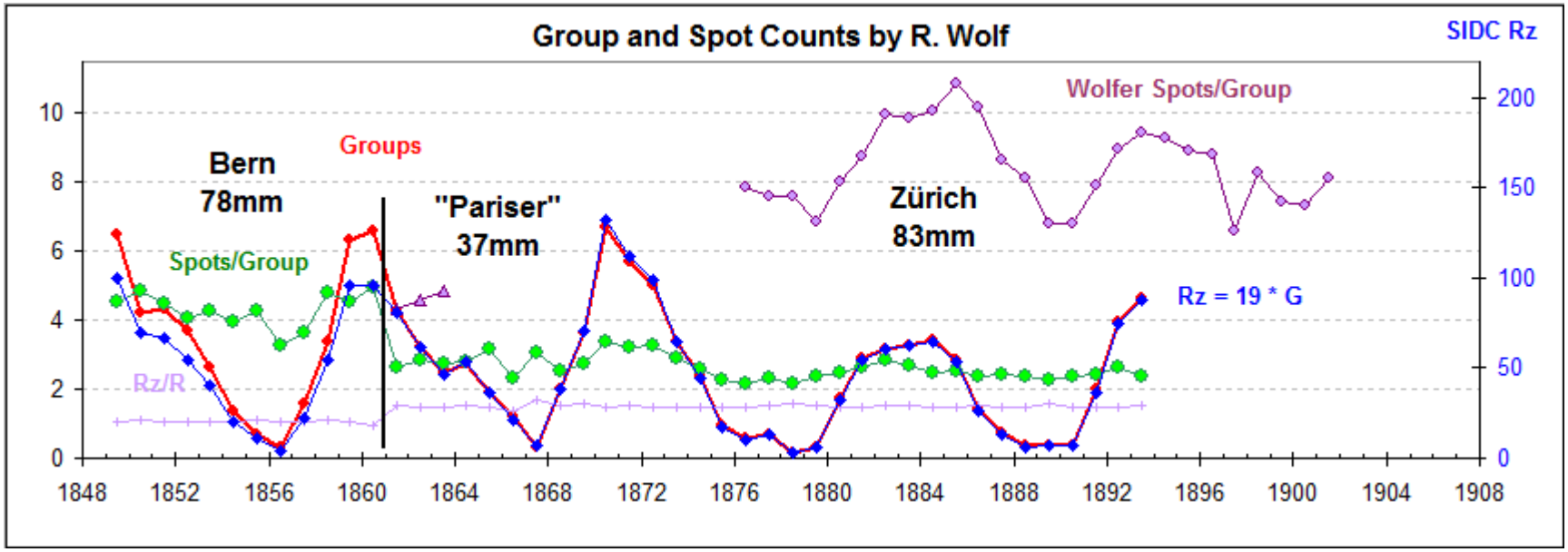
MWO only
1 group

2011-08-16

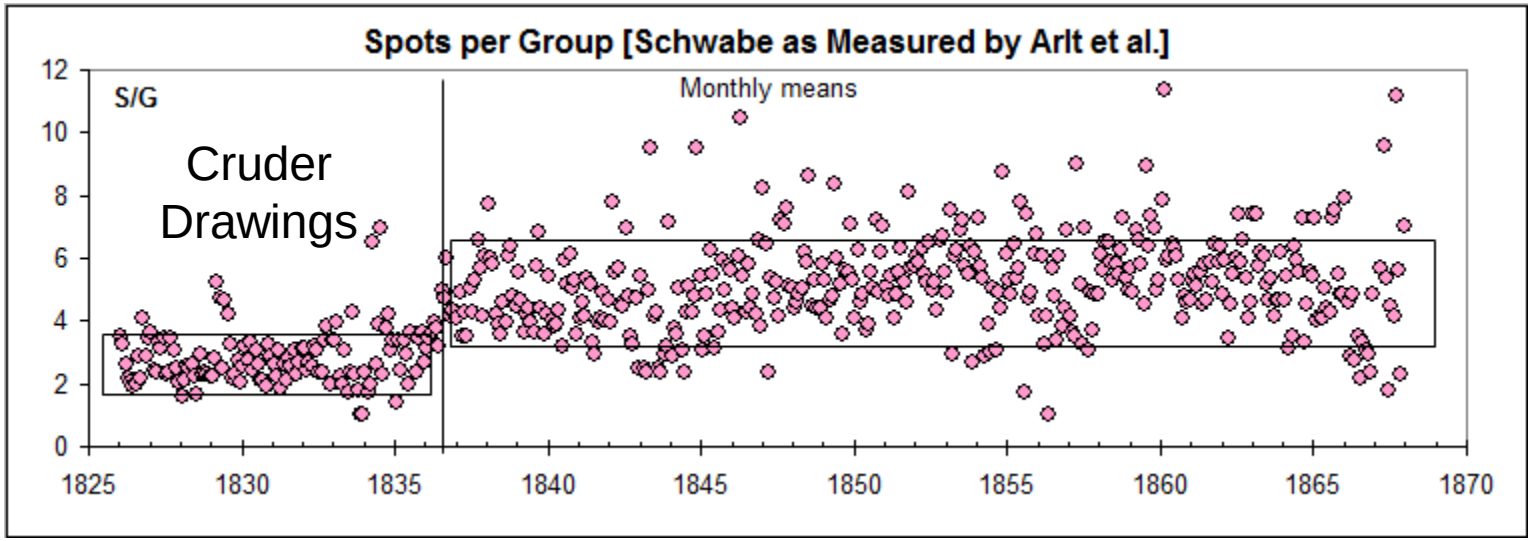
The Importance of Groups

- Groups go into the formula for the Relative Sunspot Number with a weight factor of 10
- Getting the number of Groups correct is therefore of primary importance
- Counting spots is easy
- Counting groups is HARD
- The number of spots per group reported by an observer is a measure of his k-factor

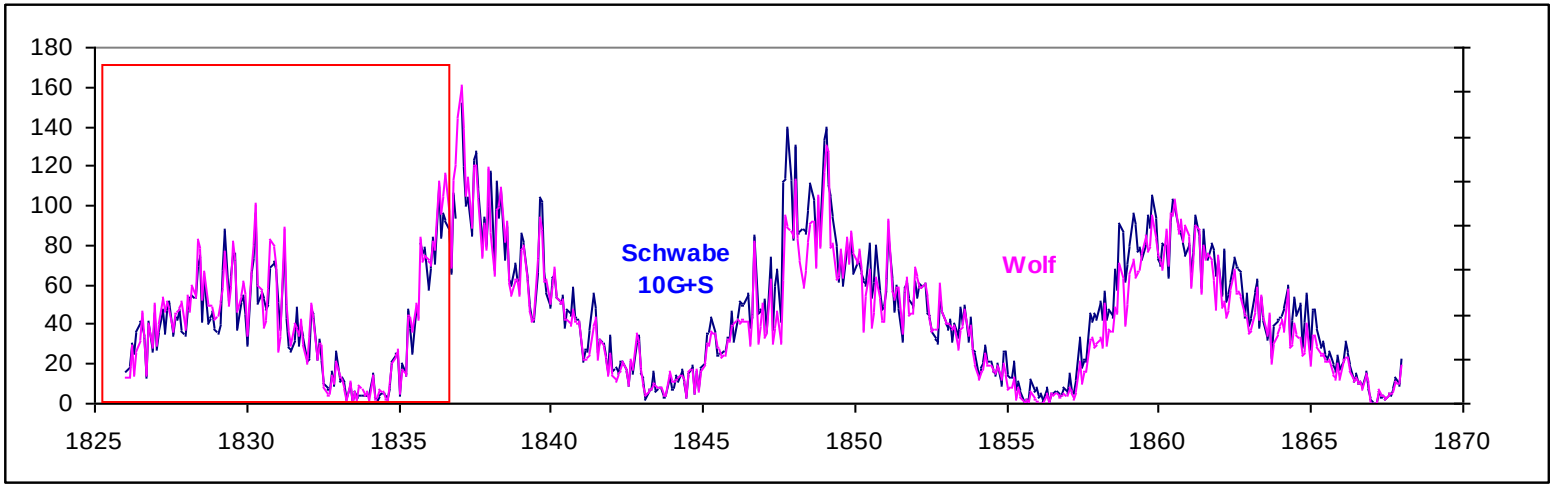
Wolf Spot to Group Ratio



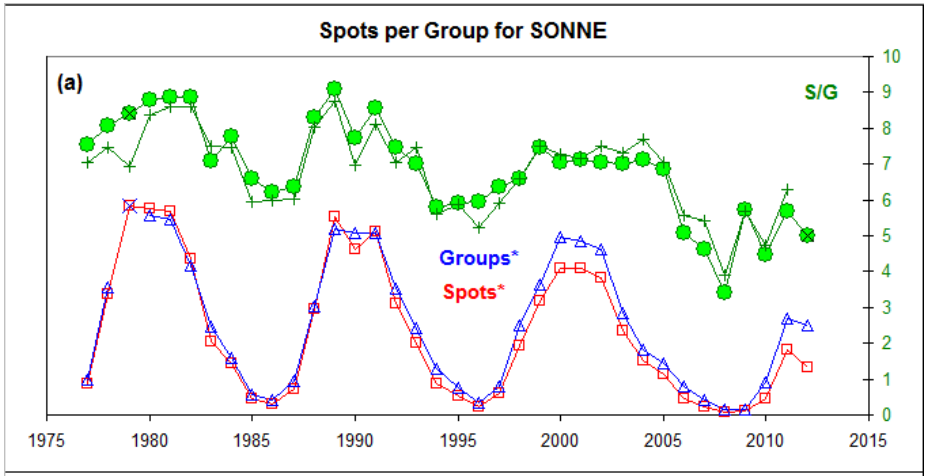
Schwabe Spot to Group Ratio

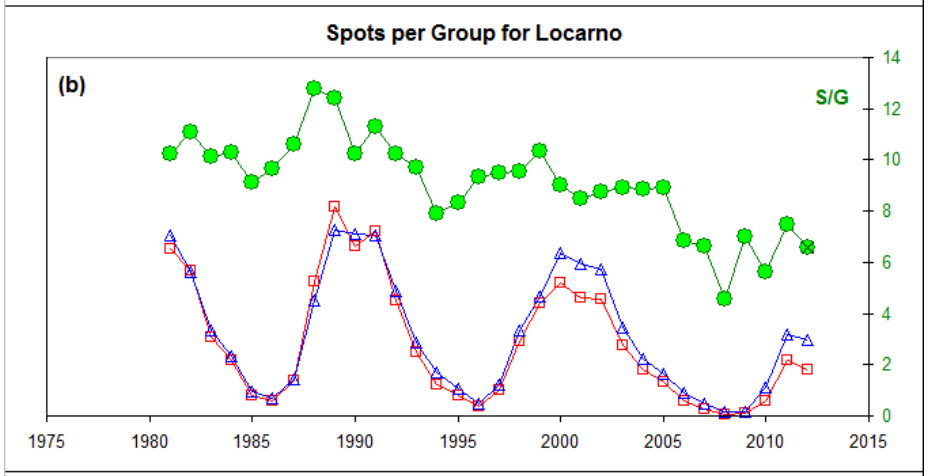


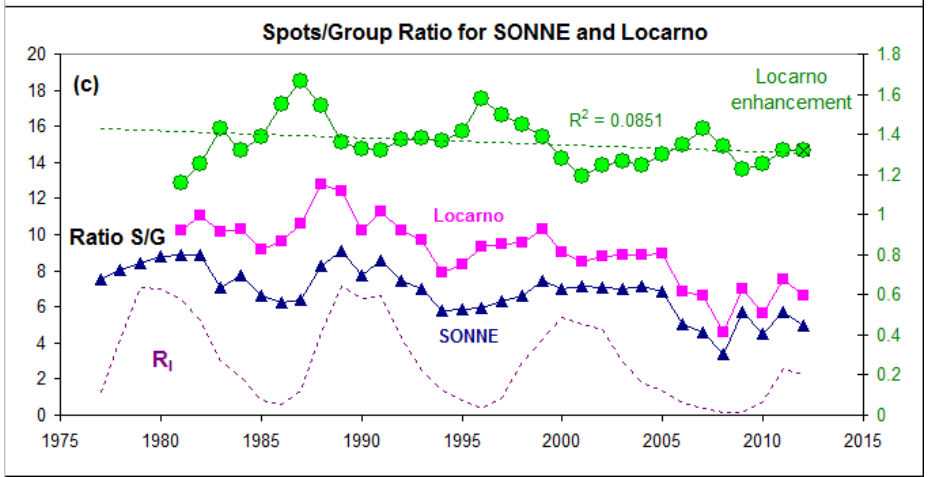
Schwabe used a 2.5' telescope at magn. 47X



Cycle 7 with max in 1830 too low?







Recent variation of Spot/Group ratio

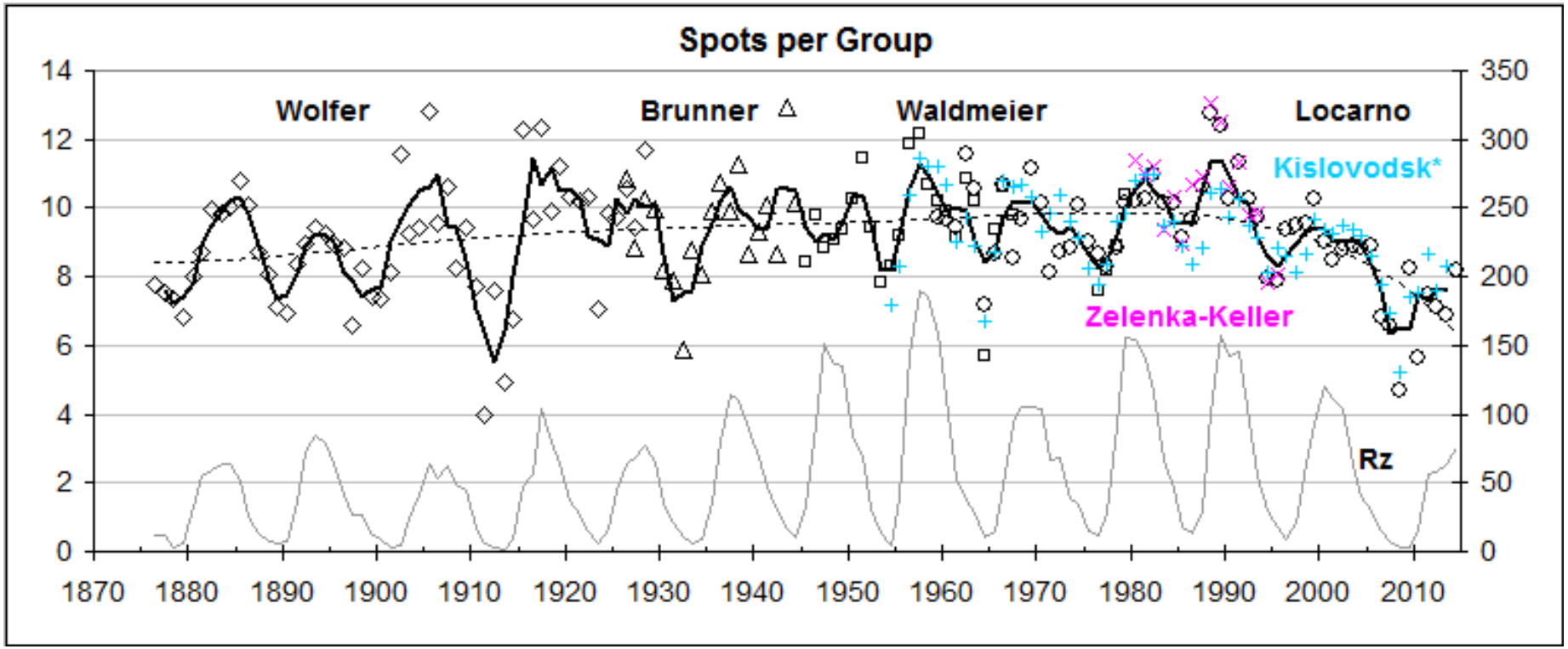
1: the ratio is not constant

2: it has been decreasing

3: there is a solar cycle variation

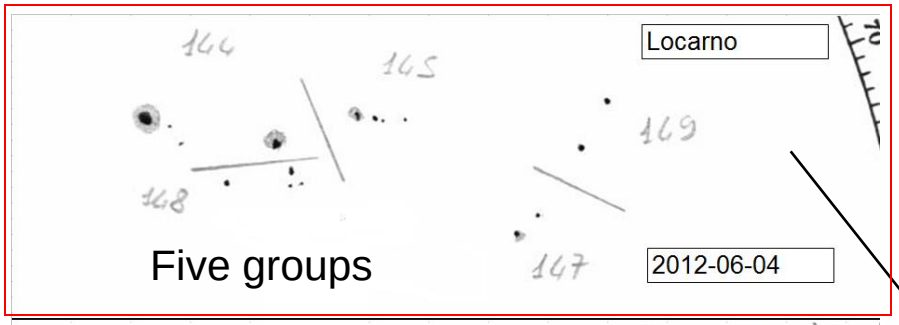
4: the effect of weighting is clear at Locarno

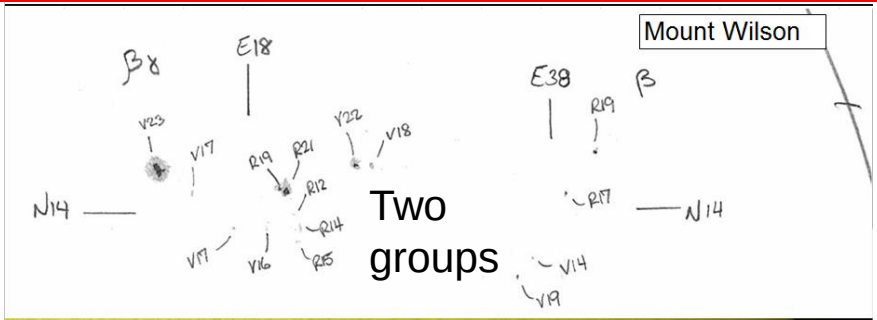
The Spot/Group Ratio Since 1877

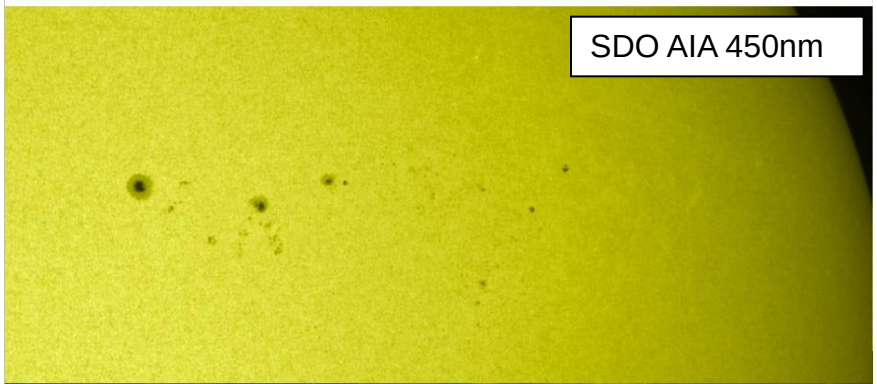


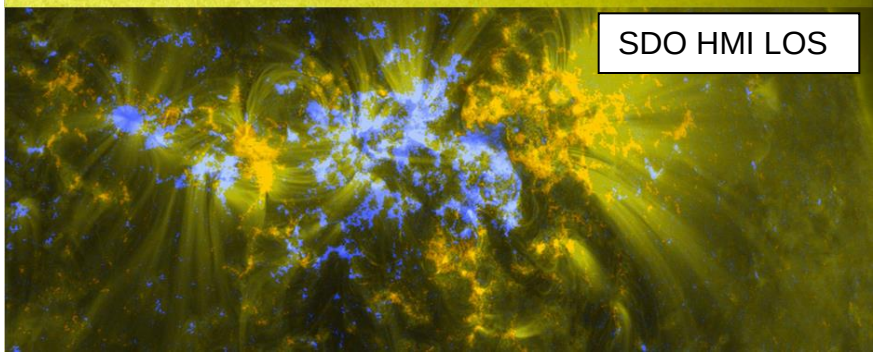
Puzzle: where is the ‘jump’ we expect from weighting? Hypothesis: the Group number is also inflated.

Combined Effect of Weighting and More Groups is an Inflation of the Relative Sunspot Number by 20+%









No Weight

g	f		B
143	4	2	-16°
144	7	4	+15°
145	5	4	+15°
146	12	6	-21°
147	4	2	+8°
148	5	4	+11°
149	4	2	+15°
150	6	2	+10°
151	1	1	+11°
152	2	2	+6°
153	2	1	-18°
11	52	30	

Groups

'Weighted Spots'

I have re-counted 50,000 spots without weighting for the last ten years of Locarno observations.

http://www.leif.org/EOS/Kopecky-1980.pdf specifically notes that "according to [observer] Zelenka (1979a), the introduction of the Zürich group classification with regard to their morphological evolution by Waldmeier and Brunner, has led to increased estimates of number of groups in comparison with Wolfer's estimates". Wolfer was assistant to Wolf and later his successor.

The Procession of Echternach

1883 Month	Day	Wolf G	Wolf S	Wolf R	Wolfer G	Wolfer S	Wolfer R
8	16	3	4	34	7	29	99
8	17	3	6	36	11	29	139
8	18	3	6	36	7	31	101
8	19	3	5	35	8	30	110
8	20	2	3	23	7	18	88
8	21	2	3	23	7	40	110
8	22	2	4	24	7	41	111
8	23	2	4	24	5	37	87
8	24	2	4	24	6	35	95
8	25	2	4	24	5	32	82
8	26	4	8	48	4	55	95
8	27	3	9	39	4	60	100
8	28	4	12	52	5	91	141
8	29	4	10	50	5	62	112
8	30	6	12	72	7	82	152
8	31	6	16	76	6	88	148
9	1	5	15	65	8	81	161
Average		**3.29**	**7.35**	**40.29**	**6.41**	**49.47**	**113.59**
				x1.5	G Ratio	S Ratio	x0.6
To place on Wolf's scale with the 80mm				**60**	**1.95**	**6.73**	**68**

1: Where does the k-factor 5/4 for Schwabe's observations come from?

In Mittheilungen XII (1861) Wolf writes [my translation]:
"The observations from years 1859 and 1860 that Mr. Carrington recently sent me and also the observations that Mr. Schwabe already had sent me earlier for the year 1859 and very recently for the year 1860 together with my own series of corresponding observations in 1860 with my 4-foot telescope at magnification 64 and with my 2-foot telescope at magnification 20, allow me to make the following comparisons. If I denote the number of groups counted on a given day by *g*, the number of spots by *f*, then I compute my well-known relative number according to the formula $A\ (10 \cdot g + f)$ where *A* for me at my 4-footer is set equal to 1.

If I now set *A* for Mr. Carrington equal to *c*, for Mr. Schwabe equal to *s*, and for my small telescope equal to *k*, then one finds as average of 109 comparisons $c = 1.03$. And further as averages of 109 comparisons $k = 1.50$. And finally as averages of 72 comparisons $s = 1.50$.

2: Where does the k-factor 5/4 for Schwabe's observations come from?

"One could then by the computation of the relative number use the observations reported by Mr. Carrington's with the same factor 1 as for mine, while the remaining observations (marked with an '*' in the table) get the factor $s = 1.5 = k$". In Mittheilungen XIV (1862) Wolf continues [my translation]:
"Observations in the table marked with a dagger '†' are by the untiring solar observer Schwabe […]. His observations are as earlier made with a 2½-foot telescope at magnification 42 [LS: thus weaker than Wolf's 'Norm' telescope], "

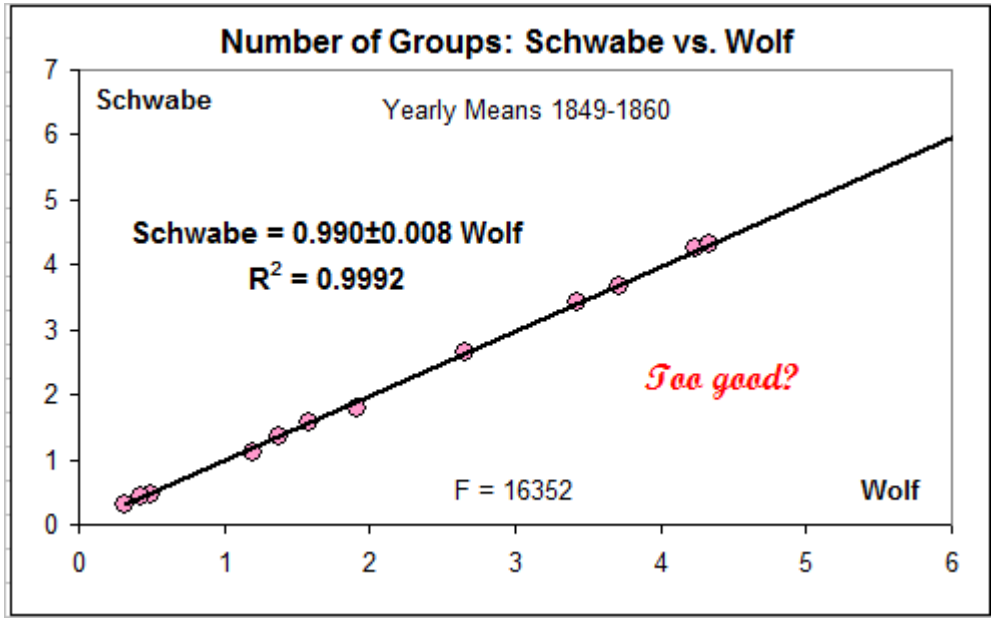
"For the calculation of the relative number using the earlier formula $A\ (10 \bullet g + f)$ I set for the observations with the 'Norm' telescope [4-foot X 64] $A = 1$. For the observations with my smaller telescope, marked in the table with an '*', I had up to now adopted $A = 3/2$ based on numerous corresponding observations. In the course of 1861 I made 26 new comparisons that gave me the value $A = 1.43$, so I thought it permissible to continue to use the value 3/2."

3: Where does the k-factor 5/4 for Schwabe's observations come from?

"While I earlier, before I even had introduced the *A*-factor, gave Schwabe's observations the same weight – i.e. *A* = 1 – as my observations with the Norm-telescope, I found in Mittheilungen XII as the average of several comparisons the value *A* = 3/2 as being more applicable for Schwabe and used that for the calculation of the relative numbers for 1859 and 1860, although that value for several reasons seemed me to be too large. Aided by the observations contributed by Mr. Hornstein [Prague] I can now make a new comparison:
1 Schwabe = 1.25 Wolf and used for the reduction of the 1861 observations marked with '†' the, in any case, more correct determination *A* = 5/4." [LS: Hornstein's observations are not published in Mittheilungen nor in Hoyt & Schatten's data base. The 1 Schwabe = 1.25 Wolf should be read: Schwabe => Wolf, multiply by 1.25.].
In Mittheilungen XV (1863) Wolf writes [my translation]:
"His [Schwabe's] observations were, as before, made with a 2½-foot telescope at magnification 42, and could therefore for his observations in the calculation of the relative number settle on the in XIV determined value 5/4 as reduction factor." The same factor is used in later Mittheilungen.

4: Where does the k-factor 5/4 for Schwabe's observations come from?

In "Abstracts of his latest Results", Monthly Notices of the Royal Astronomical Society, Vol. 21, p.77 (1861) dated Jan. 19th, 1861 Wolf publishes his series without the Schwabe correction which he had not yet determined.
The observations given by Wolf for 1849-1860 are a mixture of his own and Schwabe's. This invalidates comparisons between Wolf and Schwabe for that interval [e.g. Leussu, R., Usoskin, I. G., Arlt, R., and Mursula, K., 2013: Inconsistency of the Wolf sunspot number series around 1848, Astronomy and Astrophysics, 559, A28.



Comparison of number of groups in H&S's database ascribed to Schwabe and to Wolf.

5: Where does the k-factor 5/4 for Schwabe's observations come from?

We have here shown that Wolf introduced the 1.25 factor with the 1860-1861 [and thereafter] tables of his relative sunspot numbers and that the factor was not determined using the 'magnetic needle', but by comparisons with other observers and consistent with Schwabe's use of a weaker instrument. Now, it is true that Wolf in 1874 got the Milan data from Schiaparelli and found that they corroborated his 1.25 factor for Schwabe leading to an overdue recalculation of the entire series.

But, to reiterate: **Wolf's adjustment was not determined by comparison in 1874 with the 'magnetic needle' data as assumed by Hoyt and Schatten [**In Geophysical Research Letters, Vol. 21, No. 18, Pages 2067-2070, September 1, 1994, doi/10.1029/94GL01698 Hoyt and Schatten write:

"Curiously, our Group Sunspot Numbers are similar to the Wolf Sunspot Numbers published by Wolf prior to 1868. In 1874, Wolf revised his original sunspot numbers by multiplying them by a factor of 1.25 for 1826 to 1848 and by about 1.2 to 1.5 for the earlier years. Wolf's correction was apparently determined using variations of the magnetic needle at Milan. Based upon our analysis, this correction is erroneous."] **and others, but by comparison with Carrington and Hornstein in 1860-1861, and consistent with Schwabe's use of a smaller telescope at lesser magnification**.

Comparison with Geomagnetic Data