A LITTLE AAVSO HISTORY

For #3 Sunspot Work Shop, January 22 - 25

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AAVSO Solar Section Chair

A LITTLE AAVSO HISTORY

REDUCTION OF SUNSPOT-NUMBER OBSERVATIONS

A. H. SHAPLEY
National Bureau of Standards

Abstract.—Collation of sunspot-number data from many observers is accomplished by a method adapted from regression statistics for variables equally subject to error. A sunspot number, R_A, is derived for each day from December 1944 through December 1947 based largely on the reports of members of the American Association of Variable Star Observers Solar Division. The scale is adjusted to that of the Zurich relative sunspot numbers in the ten-month period beginning December 1944.

A.H. Shapley , 1949, Reduction of Sunspot –Number Observations

A LITTLE AAVSO HISTORY

- Max Waldmeier [1912-2000]
- (Director Zürich Observatory : 1945-1979)

- 1951: renovation of the Zürich Observatory buildings (solar tower).
- 1957-1958 (IGY): Zürich is designated by the URSI as **World Data Center** for the sunspot number.
- 1957: Foundation of a new station in Locarno
- Prior to 1944 – 1947 only Zürich Observatory sunspot counts were used by the United States.
- After 1945 the AAVSO was responsible for the U.S. sunspot count (American Relative number).

Slide courtesy; Frederic Clette

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October 1, 1945. The Zurich preliminary numbers were subsequently treated as those for any new observer and included in R_A for most of 1946 and 1947 with $k = 1.05$ and 1.09, respectively. Thus R_A includes the observations from Zurich during this period with the appropriate weight determined from comparison with other observers. The reduction factor, k, which would be applied to the direct Zurich observations, is thus 0.63 for 1946 and 0.65 for 1947, about one standard deviation from the value 0.60 which is used by Zurich to reduce its current observations to the same scale as the long Wolf series.

A.H. Shapley , 1949, Reduction of Sunspot –Number Observations

AAVSO PREVIOUS SOLAR DIVISION CHAIRS

- The solar sunspot number Ra, including myself and all the previous Solar Division/Committee chairs – from Paul Mortfield (2006-2010)
- Carl Feehrer (2000 - 2006)
- Joseph Lawrence (1998 - 2000)
- Elizabeth Stephenson (1994 - 1998)
- Robert Ammons (1992 - 1994)
- Peter Taylor (1984 – 1992)
- Casper Hossfield (1961 – 1984)
- Harry Bondy (1949 – 1961)
- Neil Heines (1944 – 1949)
- – have collected since 1944, which are submitted to NGDC as both the raw (Wolf) number and the Ra number in the American Relative Sunspot Number Program. The method of computing these numbers was revised in 1951:

AAVSO PREVIOUS SOLAR DIVISION CHAIRS

- Beginning with 1951, the observations collected by the Solar Division, AAVSO, have been reduced according to a new procedure, such that only high quality observations of experienced observers are combined into RA'.
- Observatory co- efficients for each of the 23 selected observers were recomputed on data for 1948-1950, years when there was a wide range of solar activity. Otherwise, the procedure is that outlined in "Publication of the Astronomical Society of the Pacific," "61," 13, 1949. The scale of the American numbers in 1951 will differ from that of the reports for earlier years because of these changes, and the new series is designated RA' rather than RA. . http://www.ngdc.noaa.gov/stp/solar/ssndata.html

HISTORY OF THE AAVSO K FACTORS

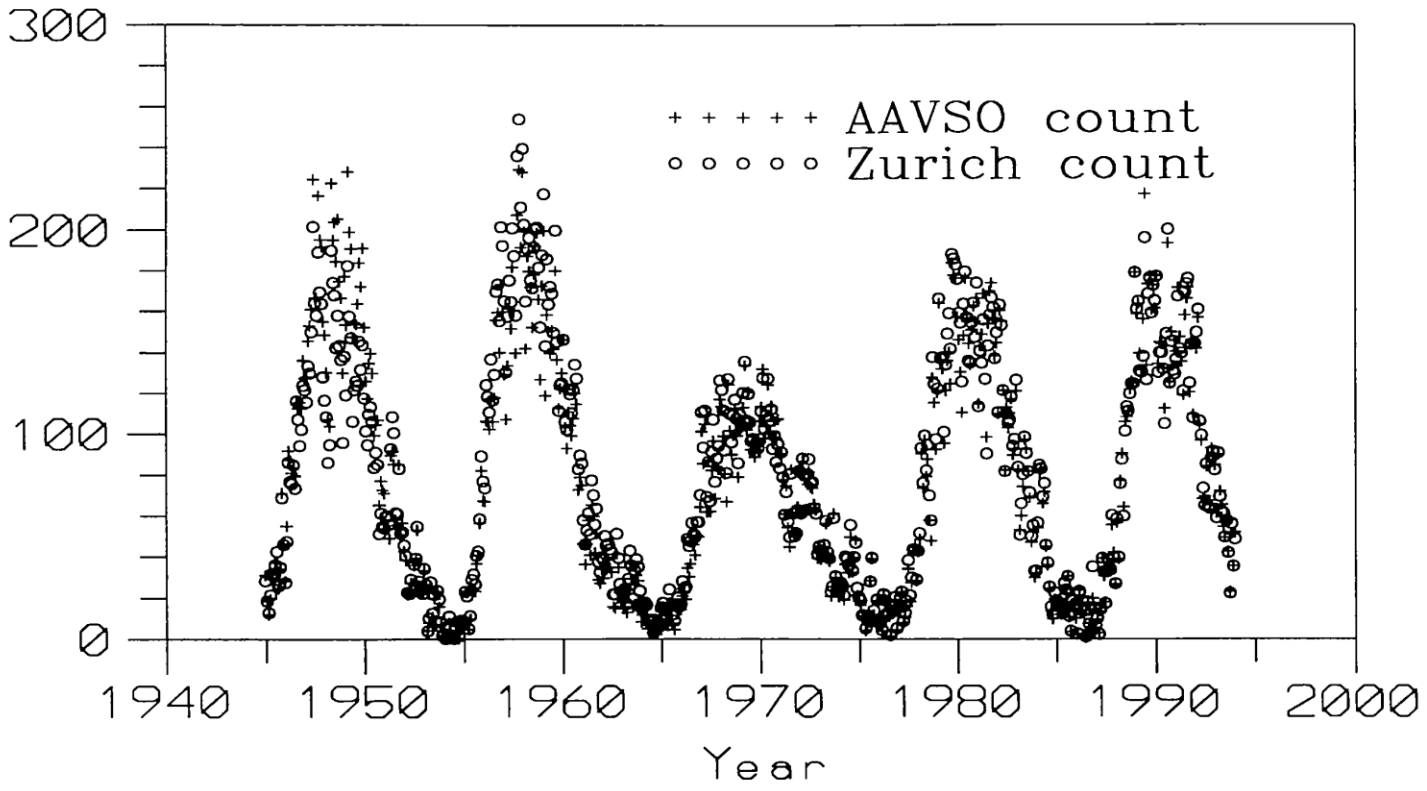

Figure 1. AAVSO sunspot counts (plus signs) compared to Zurich sunspot counts (circles).

Grant Foster, 1997, Inflation of AAVSO Sunspot Counts, JAAVSO, Vol 26, 1997

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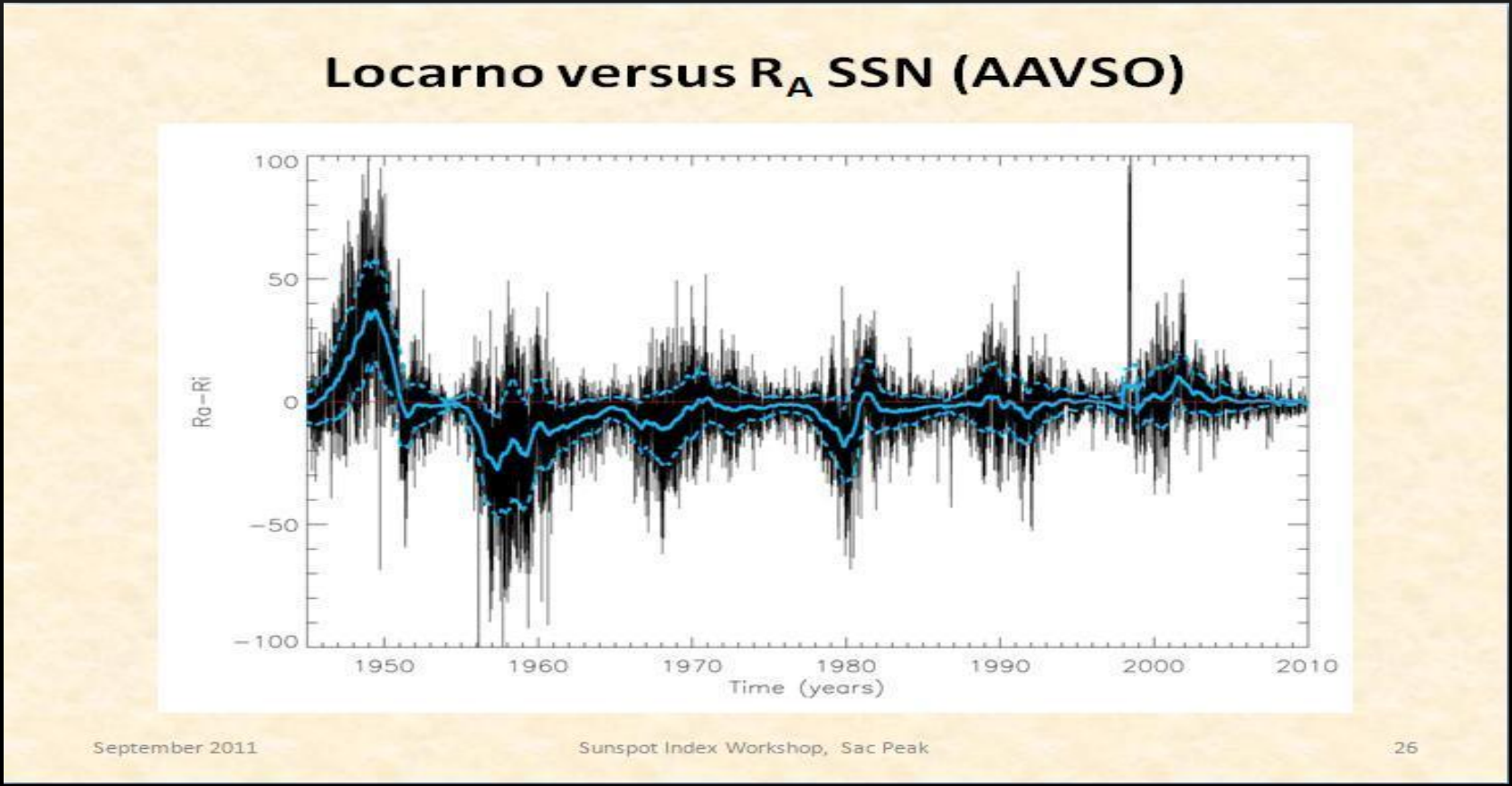

Notice the 'roller-coaster' from 1944 – 1967. It can be seen in the early AAVSO Solar Bulletins and in Locarno daily observations. Data from: http://www.ngdc.noaa.gov/nndc/struts/results?t=102827&s=1&d=8,4,9

Slide courtesy; Frederic Clette

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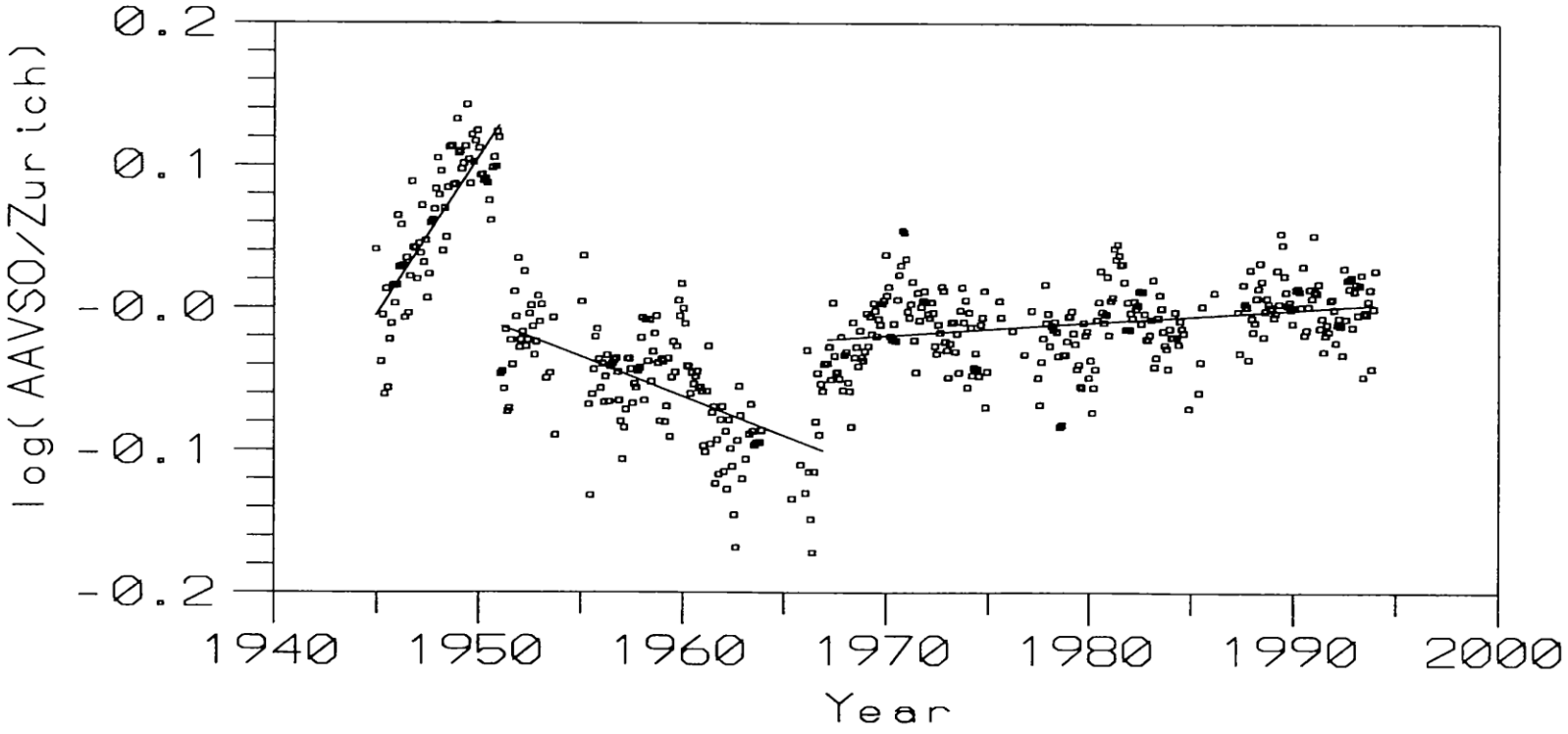
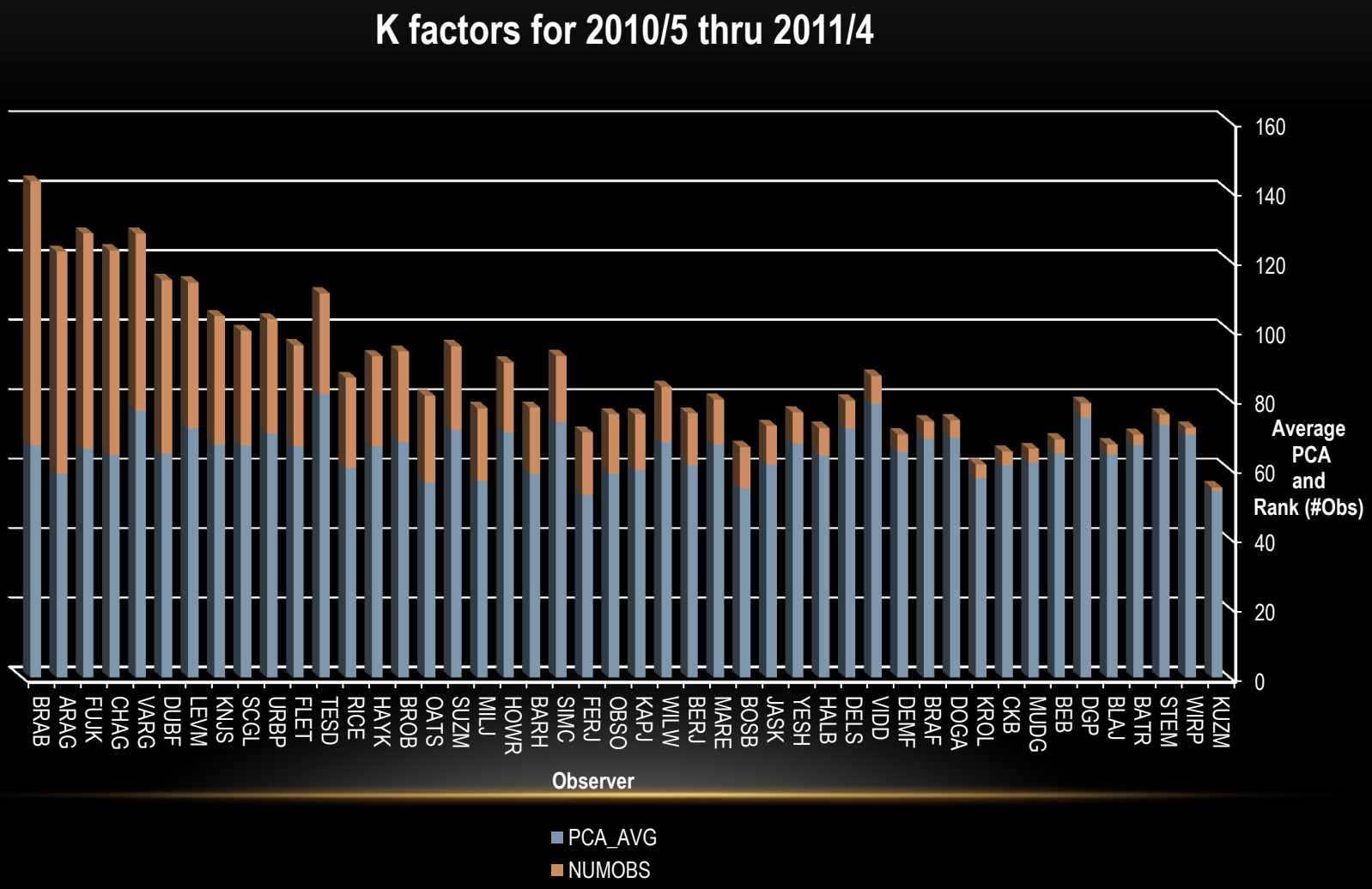


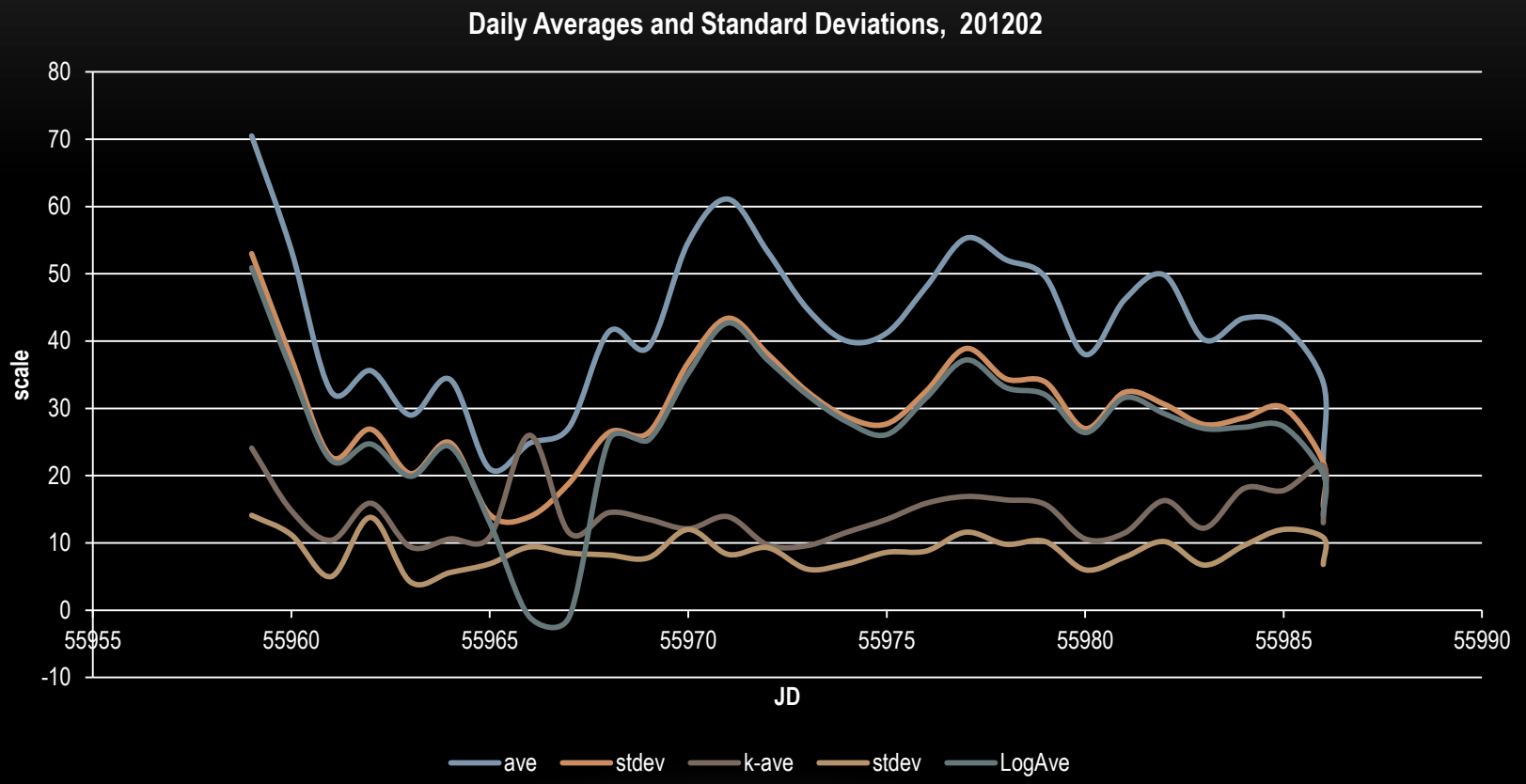
Figure 2. Logarithm of the ratio of AAVSO to Zurich sunspot numbers, $\log(R_A/R_Z)$, for the last 50 years. The straight lines are linear regression fits, showing the dramatic increase until 1951, an apparent decrease from 1951 to 1967, and a slow increase from 1967 to 1995.

Grant Foster, 1997, Inflation of AAVSO Sunspot Counts, JAAVSO, Vol 26, 1997

THE NOW OF THE AAVSO K FACTORS



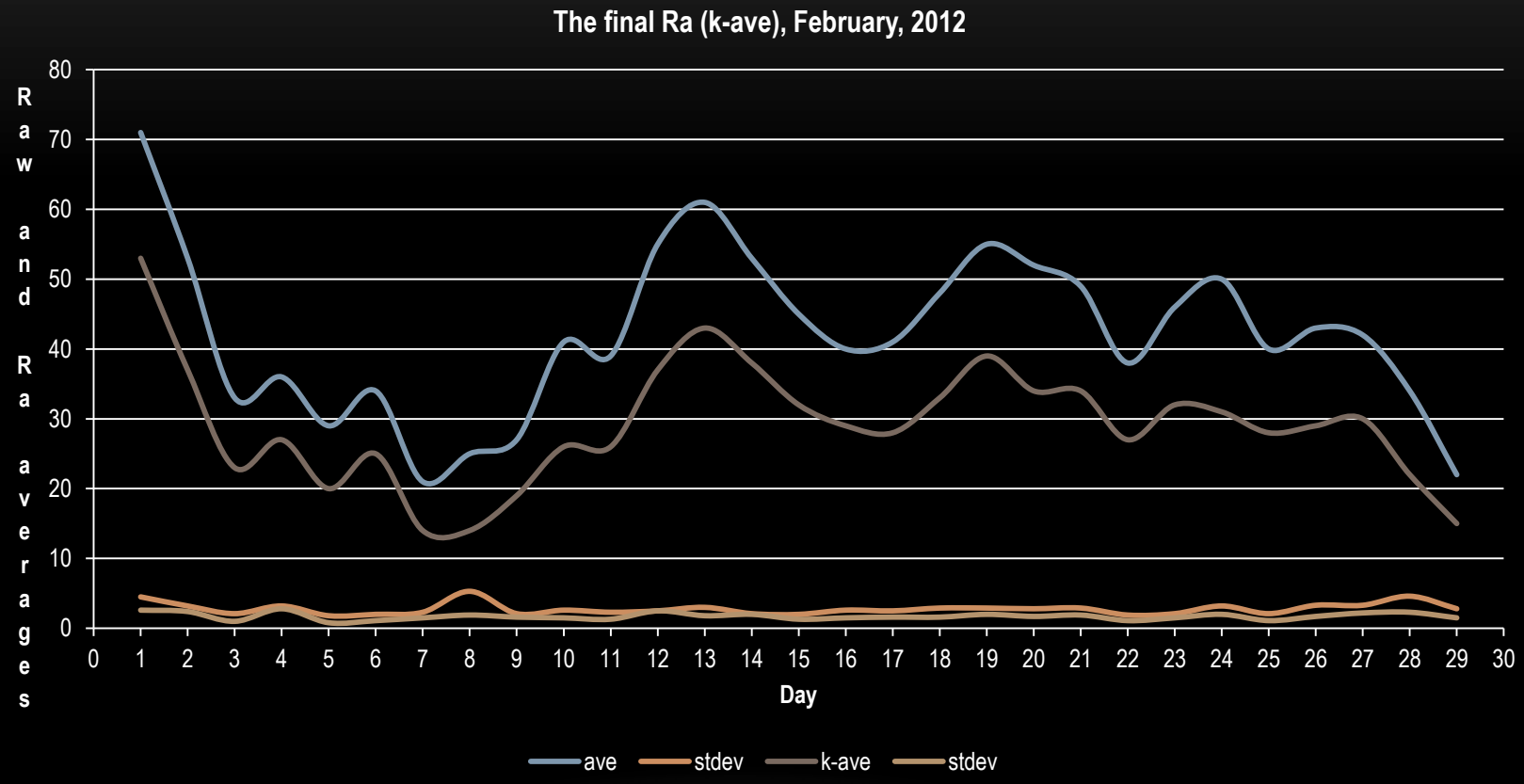
CALCULATION OF THE AAVSO K FACTORS



First estimate of all daily sunspot index values using current K factors

For each day of the month, all raw and *log(kc)* values are averaged and we compute the average and standard deviation of these values from all Observers: $R_a(d)$, $S_e(d)$. This gives a first estimate of the daily sunspot index.

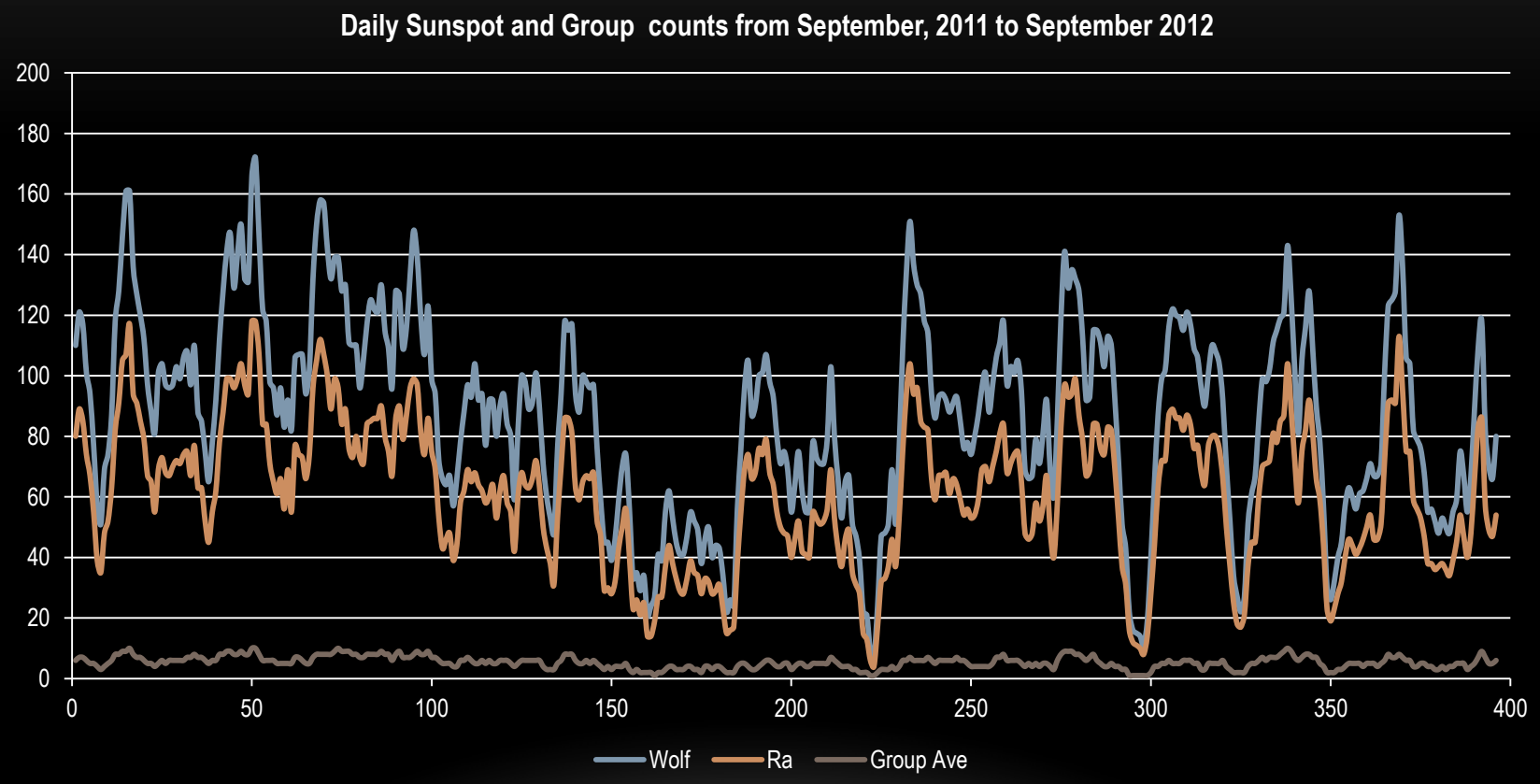
CALCULATION OF THE AAVSO K FACTORS



Final determination of the K coefficients for American Relative index (Ra)

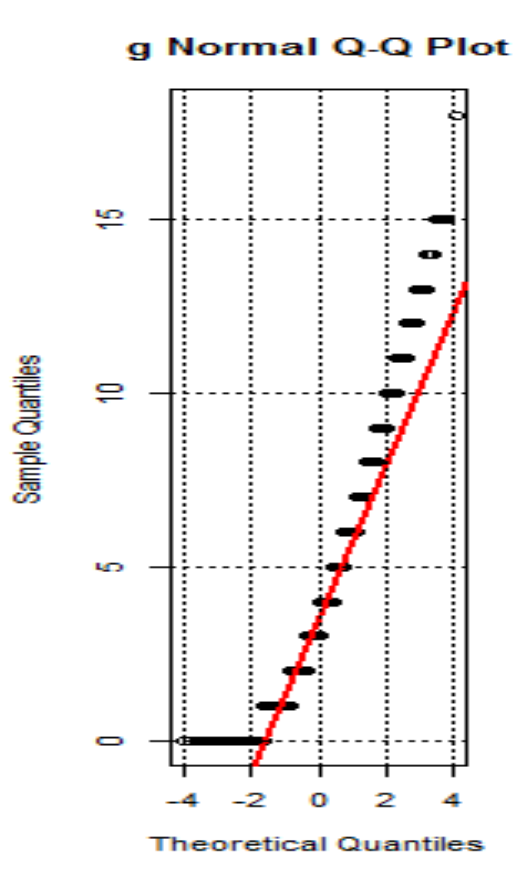
Next we compute the *exp(kc)* (inverse *log(kc)*). We then compute the average *exp(kc)* over all days with observations from the Observers who have valid K coefficients, and also their standard deviation S_{sta} of the daily averages.

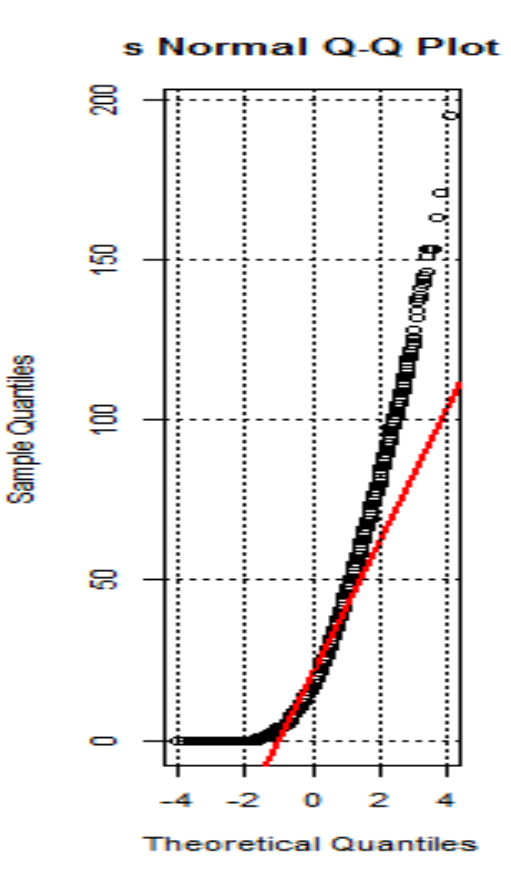
SOME INTERESTING OBSERVATIONS

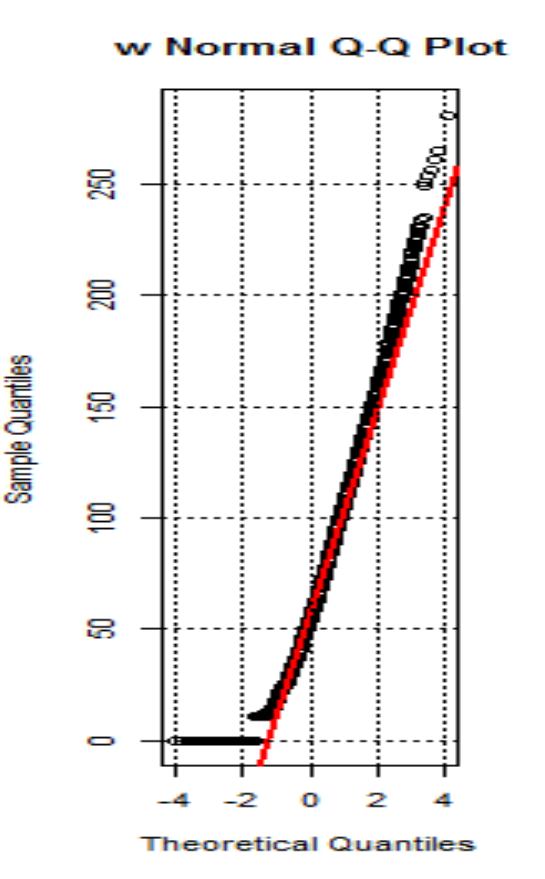


When all said and done, the average k factor for all observers with a k factor is .742

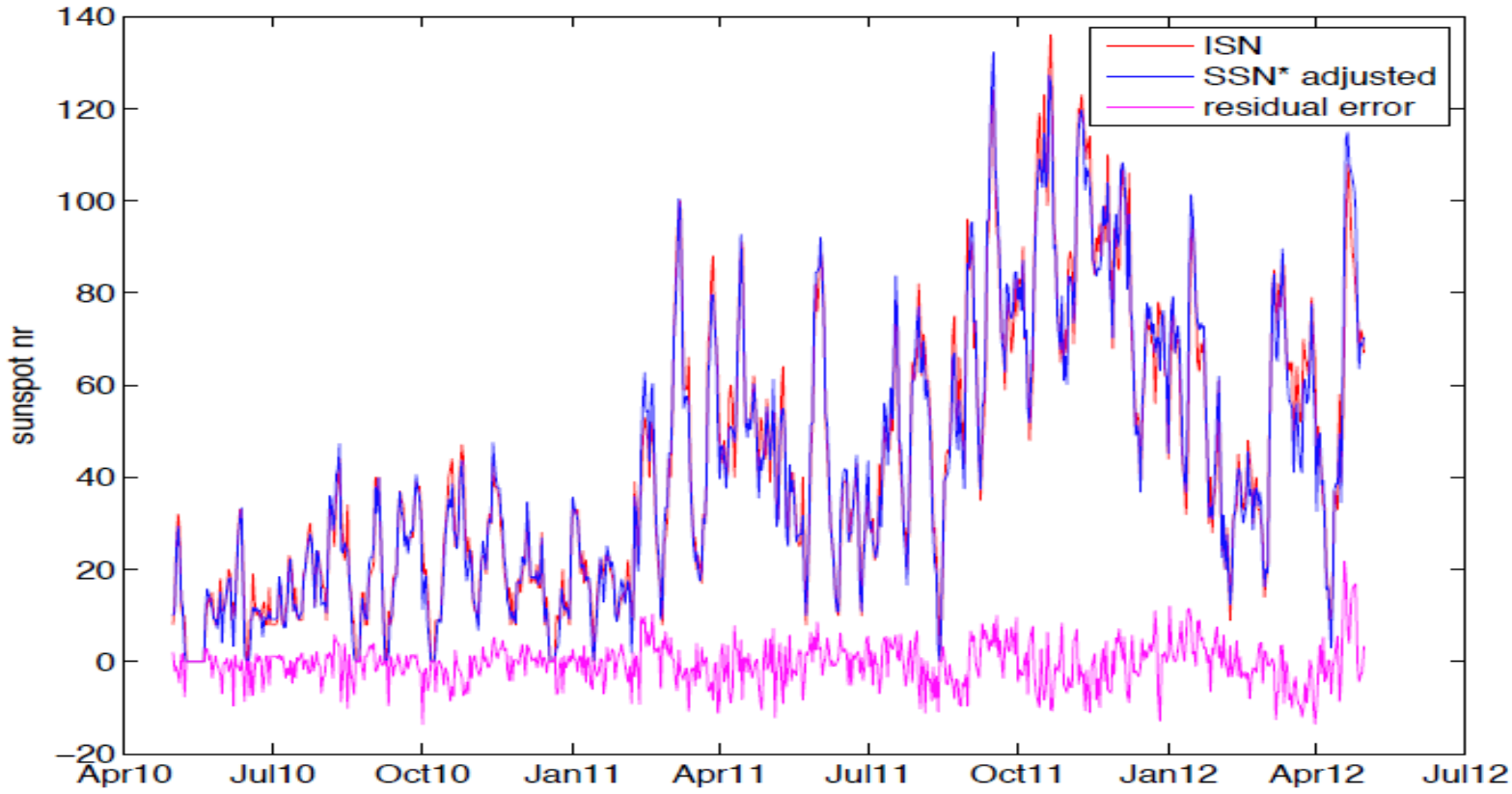
GROUP, SUNSPOTS AND WOLF NUMBER QQ PLOTS





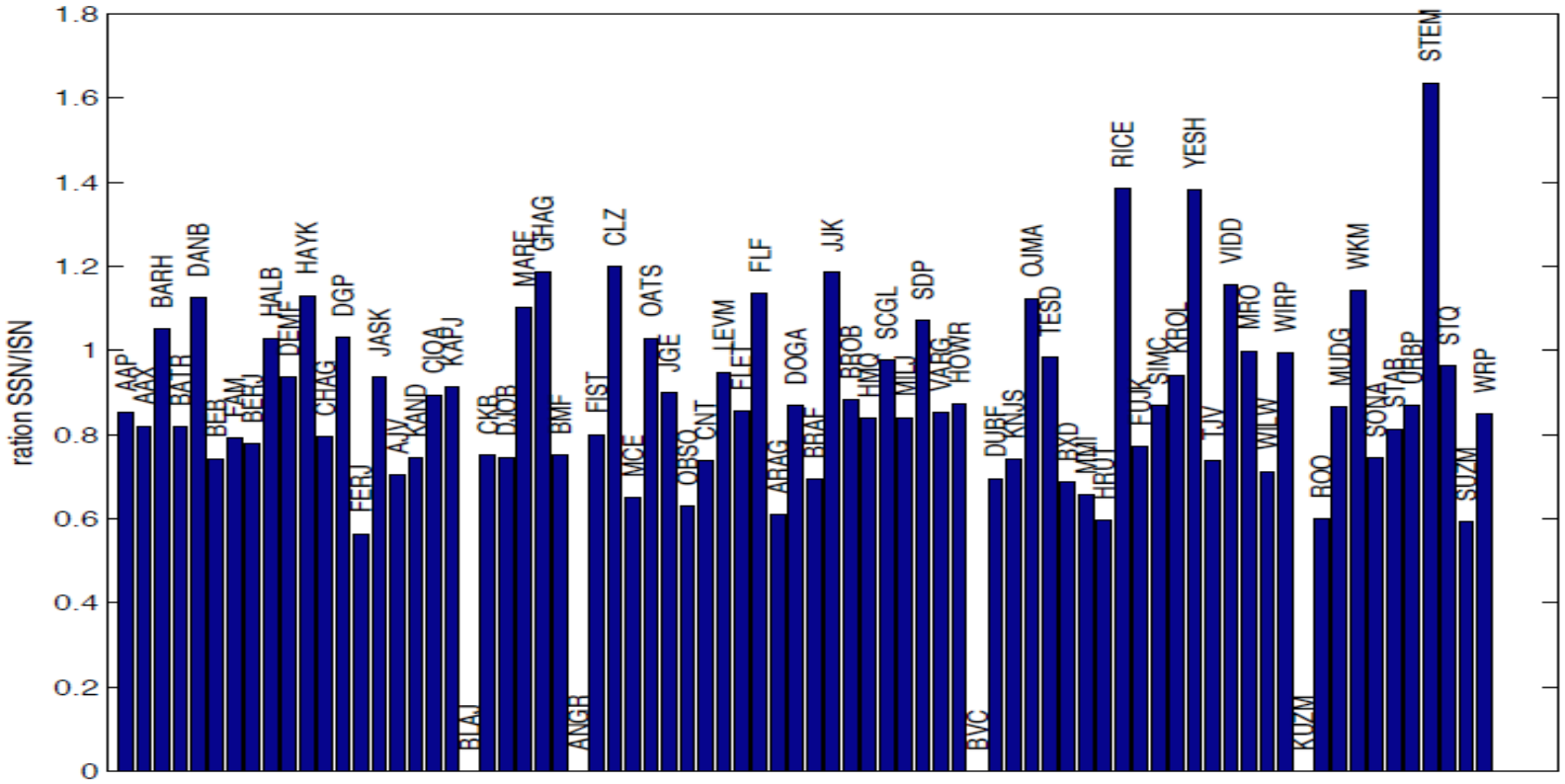


The value of SSN* and that of the international sunspot number (ISN) are compared below. In doing so, I adjusted the gain of the former in order to get the best matching. In magenta I show the residual error. Surprisingly, the residuals do not behave as white noise but show modulations on time scales of a few months. This is not so welcome. I checked that these modulations really come from the observations and not from the interpolation.



Slide courtesy; Thierry DuDok du Wit

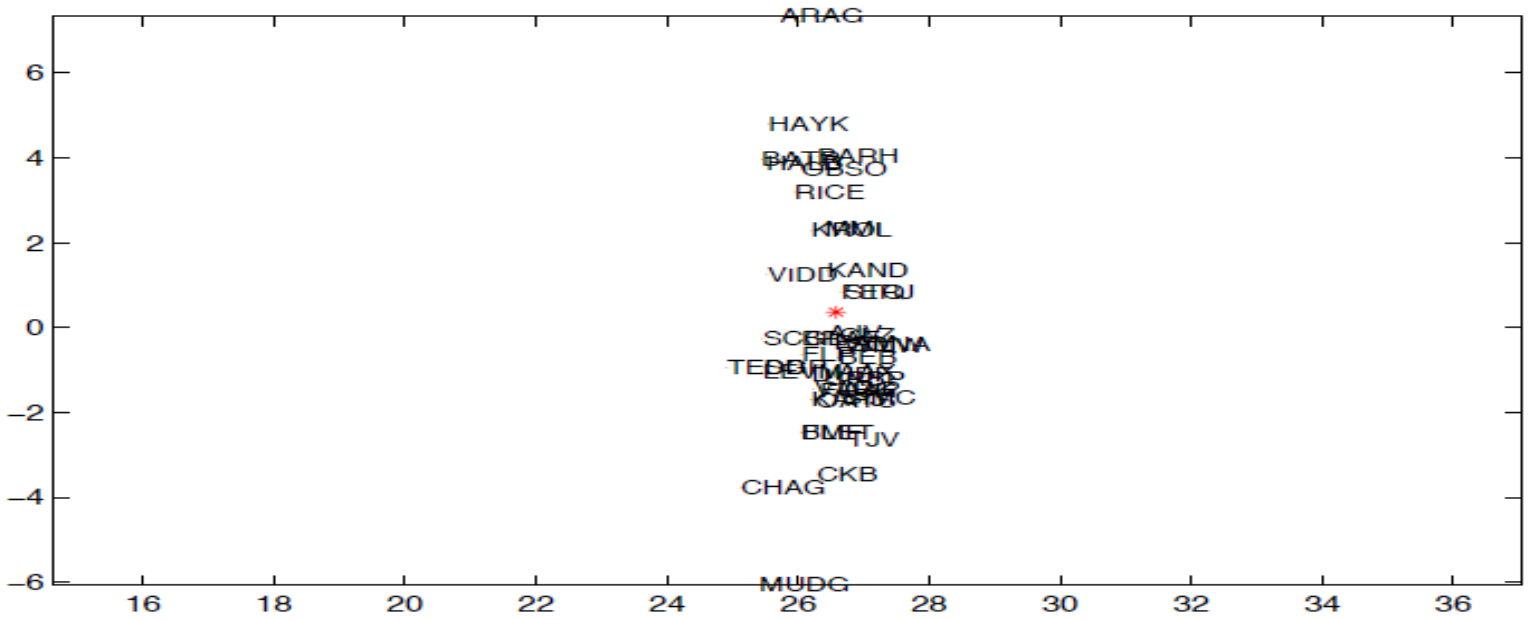
Note that the agreement between both sunspot numbers is remarkably good, compared to their noise level. The gains of the individual sunspot numbers, however, often departs from 1, as shown below



Some observers have 0 gain because they simply had not enough observations to enable a meaningful reconstruction of the missing data.

Slide courtesy; Thierry DuDok du Wit

Let us now discard these outliers and keep the other ones. This is what the new cluster looks like



There still is some scatter but the cluster is now much smaller. Note the red cross in the middle, which corresponds to the international sunspot number. From this I immediately conclude that :

1. all clusters are roughly aligned, which means that, as a first approximation, they differ by one contribution (or one degree of freedom). Otherwise you would have ended up with a cloud of points.
2. the observations are highly correlated indeed, for their separation is small.
3. all these observations are fully compatible with the ISN, because the latter is at the center of the cluster. If the ISN had been located near the border of the cluster, or outside it, then one would have concluded that it contains an extraneous contribution that is not properly reproduced by the AAVRO dataset.

Slide courtesy; Thierry DuDok du Wit

SO, HOW MANY AAVSO OBSERVERS SUBMIT DATA TO SIDC?

- AJV J. Alonso
- ARAG Gema Araujo
- BARH Howard Barnes
- CHAG German Morales Chavas
- DFS Sjoerd Dufoer
- DRAJ Jean Dragesco
- DUBF Franky Dubois
- FERJ Javier Ruiz Fernandez
- FUJK K. Fujimori
- KAND Kandilli Observatory
- KUZM Mikhail Kuzmin
- MCE Etsuiku Mochizuki
- SCGL Gerd-Lutz Schott
- SONA Andries Son
- SUZM Miyoshi Suzuki
- WILW William M. Wilson

This list represents 16 observers out of an average of 70 observers per month, or between 20 % and 25 %

Special acknowledgements go to:

Frederic Clette, SIDC, for his inspiration and encouragement

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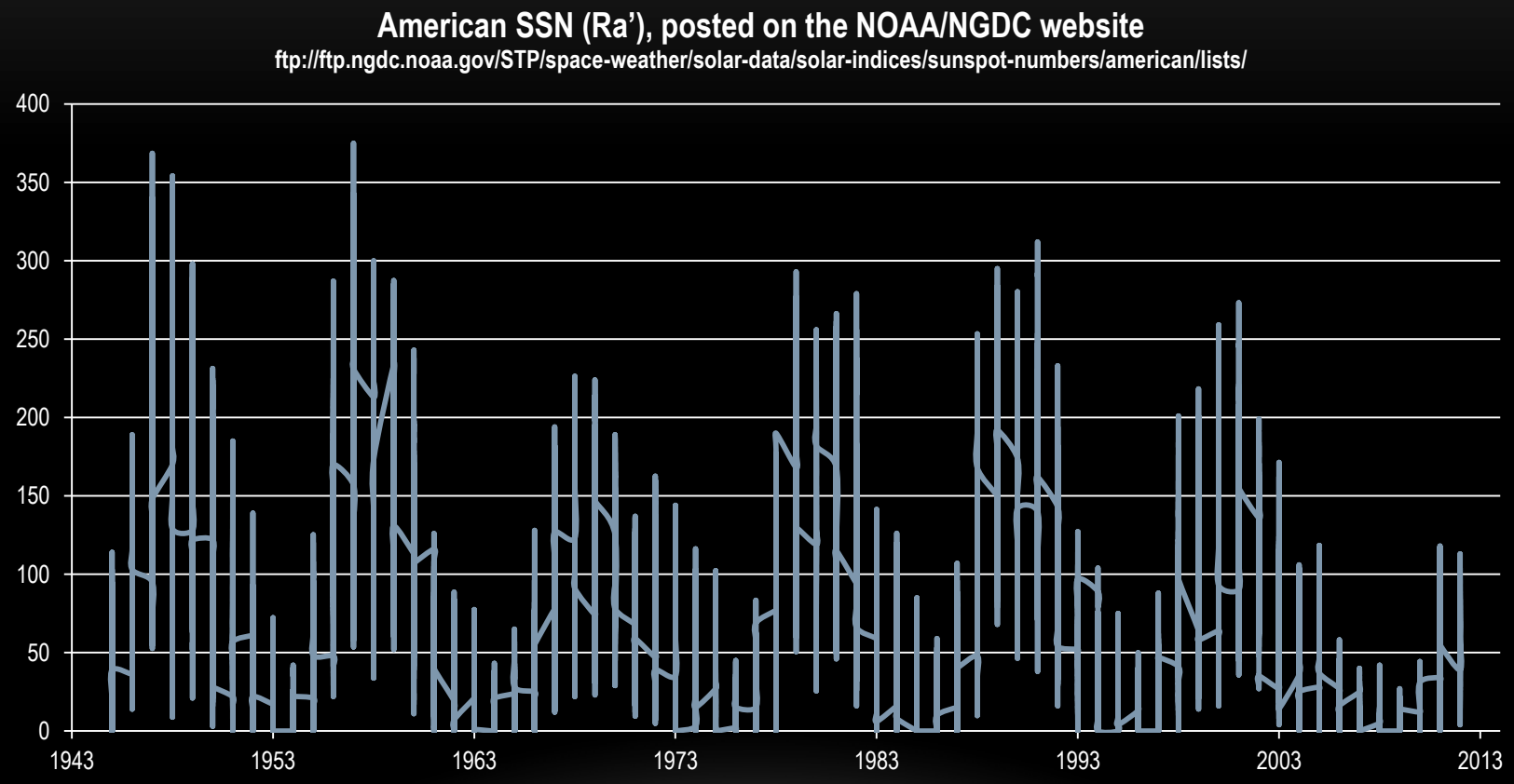
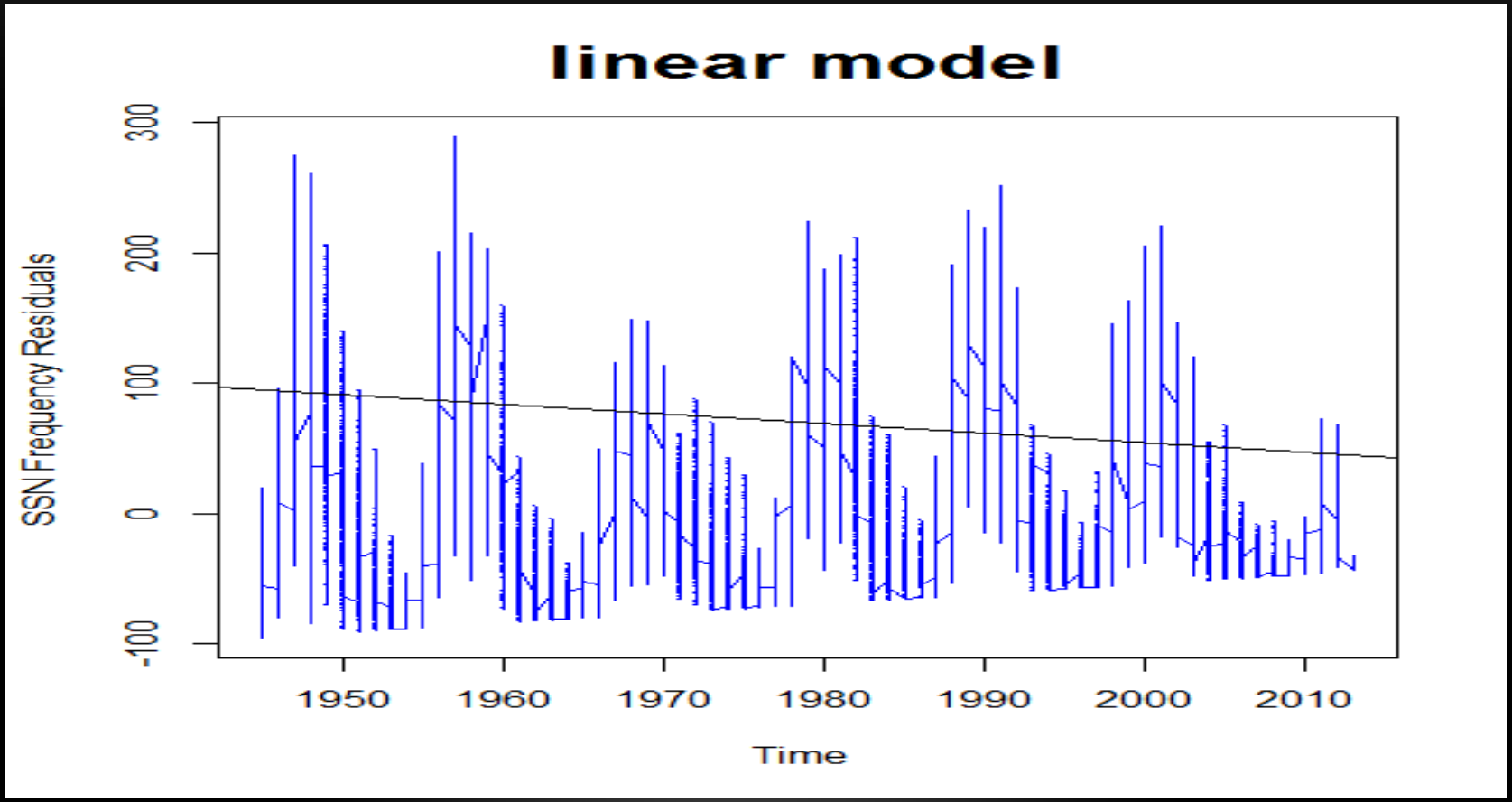
Susan Oatney for always listening and her careful reviews

All the AAVSO staff for their patience and understanding
And all our Solar observers World Wide

AAVSO K FACTORS VS. RA' SSN



REGRESSION LINE FOR RA' SSN



Slope = -.704 , Residual standard error: 60.74 on 25200 degrees of freedom
Multiple R-squared: 0.05573, Adjusted R-squared: 0.05569
F-statistic: 1487 on 1 and 25200 DF, p-value: < 2.2e-16

10 DEGREE POLYNOMIAL LINE FOR RA' SSN