Description of the AAVSO's calculation of the American Relative Sunspot index R_a and the corresponding k personal scaling coefficients of contributing observers

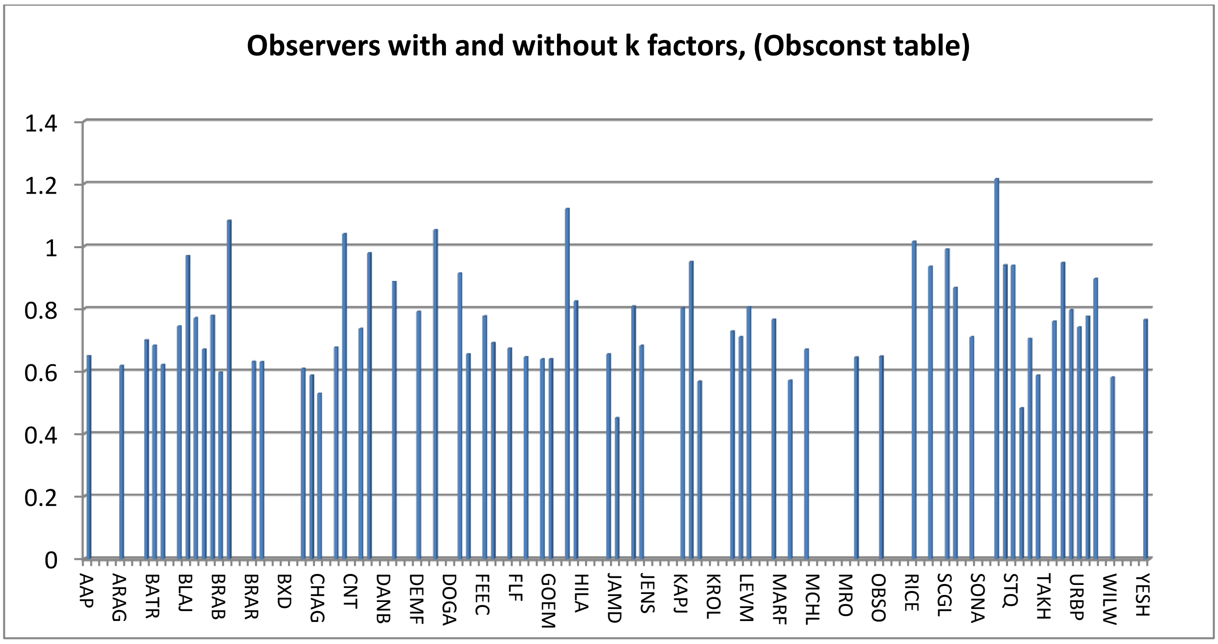
for AAVSO by R. Howe 12/02/2014.

Compute the two year k coefficient for each Observer:

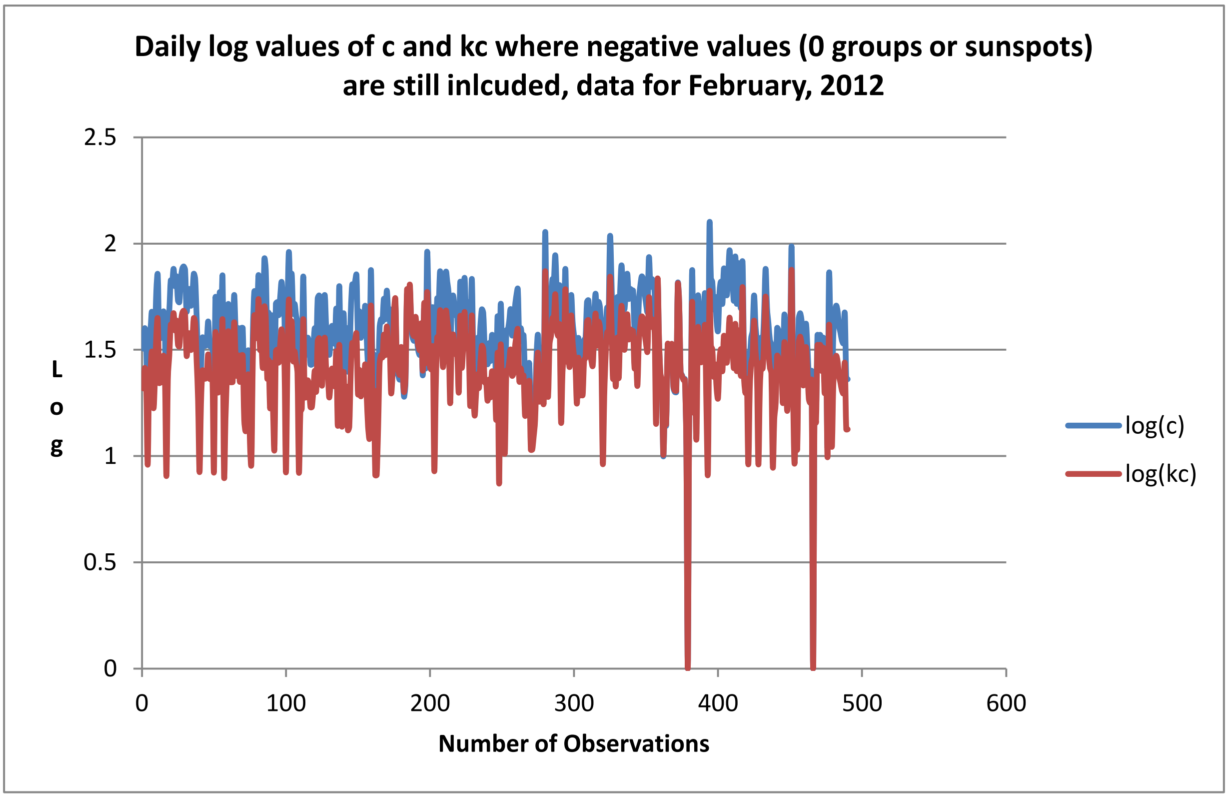
The k factor table in the AAVSO solar database should only be updated about once every 3 years or so. For example; the Obsconst table with the current k factors was updated 2012, next update will be 2015. To do that update we compute a value of *c * k* (k-corrected Wolf number: k*c= log(10g+s)*k*), which is based on observer's k coefficient from the past two years of observations. K factors are those values (between 0 and 1 generally, but may go as high as 1.5), which represent the observer's commitment to daily observation submissions into the SunEntry database for the previous two years; the k factor also includes their instrument stability over the past couple of years of daily submissions. An observer must have over 100 observations since the previous k factor update. Observers who have not had enough experience (less than 100 observations within the previous two years) or have been found to be inconsistent in their submissions during previous years will not have a k coefficient in the solar database Obsconst table.

First; k- factor computation assumes raw counts are a log normal distribution:

For the monthly Ra number we compute the log corrected Wolf number as: *kc = log(c * k)*, where c = Wolf number, (10g + s, and k = current k factor) over all days of observations from each observer for the month. All these data are then written to an intermediate file and sorted by Julian day and by Observer.



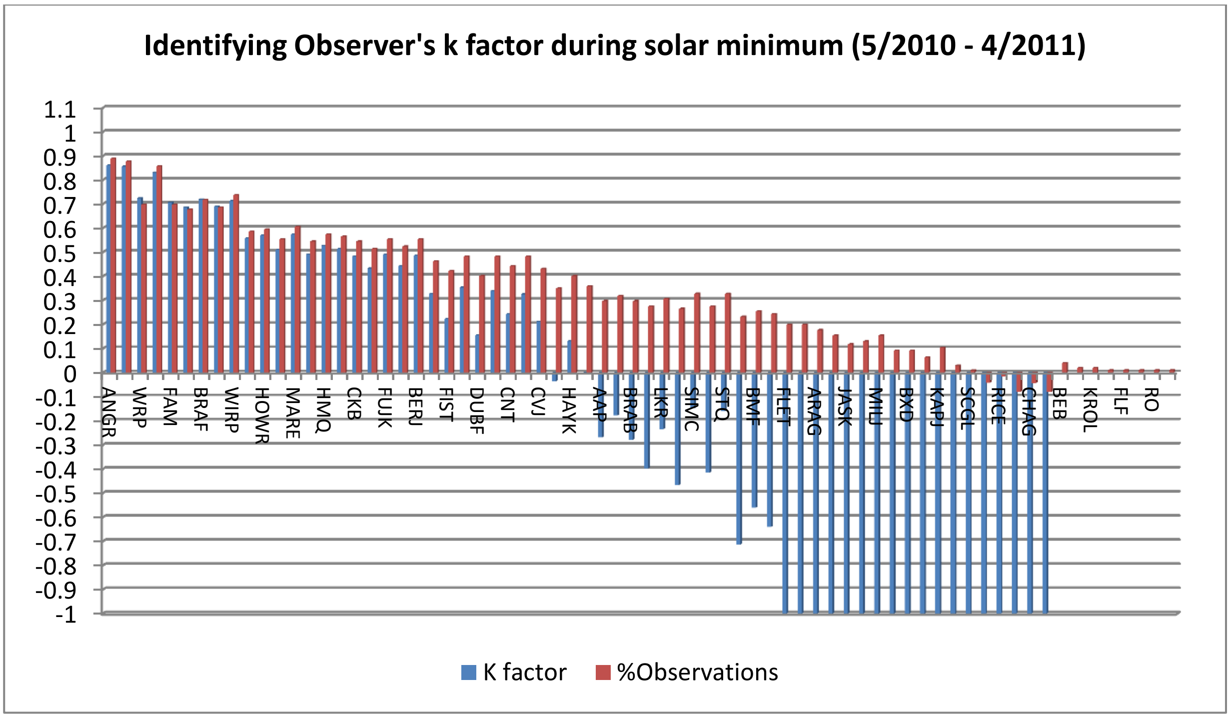
Daily counts for each observer are determined and allow raw values to be computed to the same Log scale. Errors and abnormal values in the daily raw observations are filtered based on their log values *(kc),* which if there are null values or zero submissions will become .1 where the Log of .1 = -1.



At this stage there are still daily gaps where observer's had no observations, which are given values of 0.1 for calculations of *log(kc).*

Special monthly "spotless" cases:

Although a monthly *log(kc)* can be computed as a negative value, the observer is not dropped.



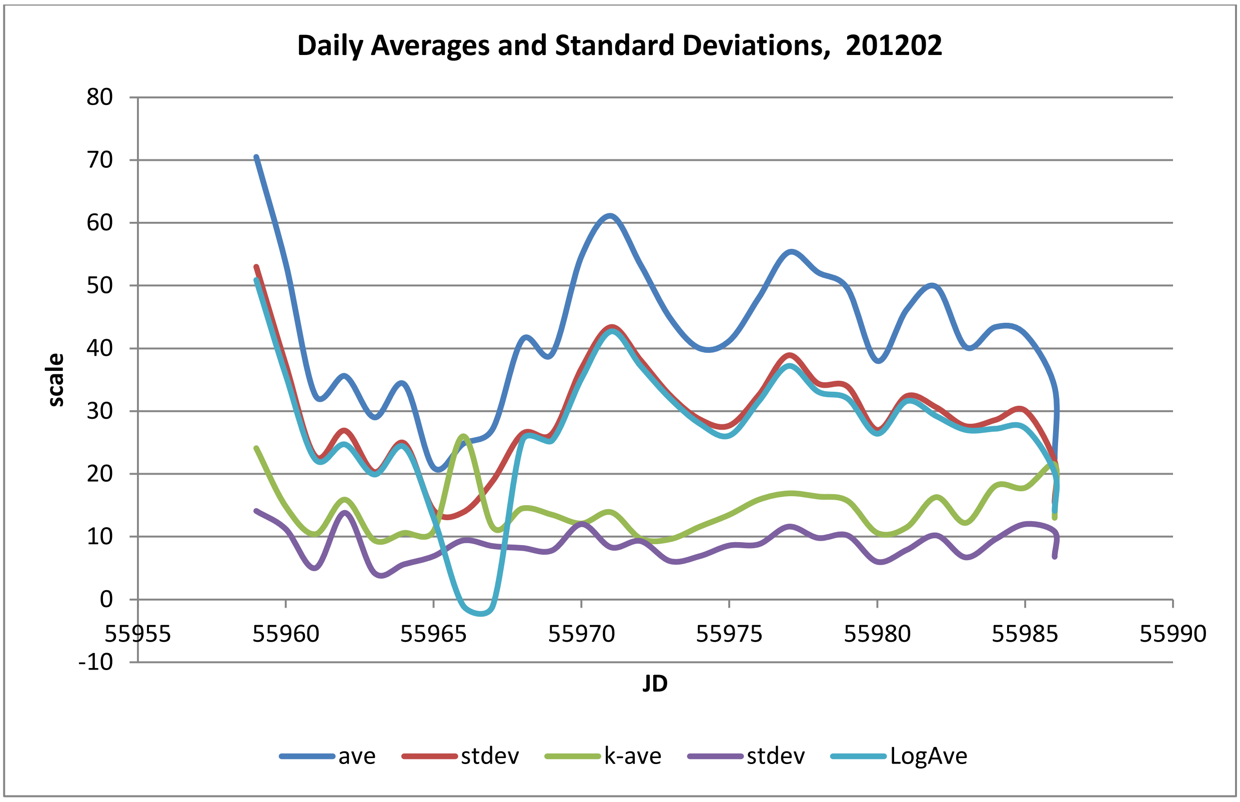
This happens for some observers of the network, mainly at low solar activity when there are a large number of spotless days. The k substitution (.1) should only happen massively when the sun is truly spotless during a whole month. At that time Ra is inevitably close to 0, however, the *log(kc)* scaling is still possible as we use 0.1 values for zero sunspot days.

Second; averages of all daily sunspot *log(kc)* values create a normal distribution

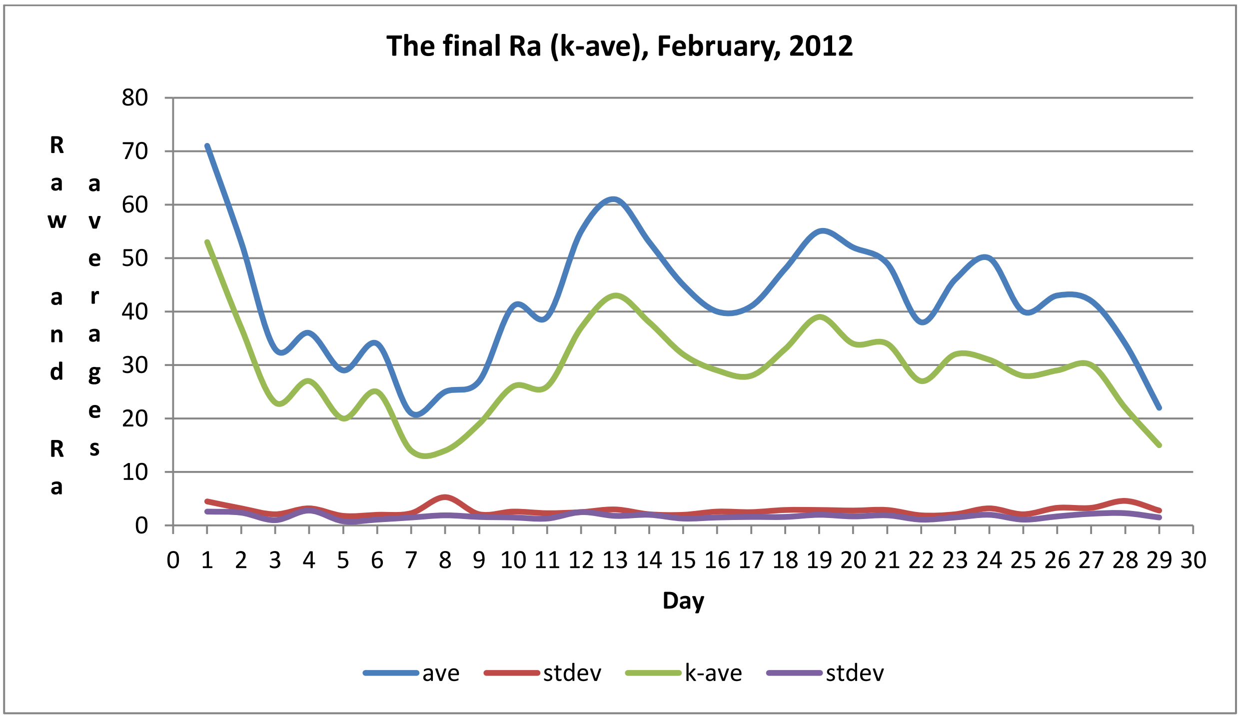
For each day of the month, all log values are inverse computed by *exp(kc)* and these values are then averaged as daily values so we can compute the standard error and standard deviation of these averages from all observers: $R_a(d)$, $S_e(d)$. This gives a first estimate of the daily sunspot index.

Results:

We now have Wolf values for all days of the month and the average Ra, which is the average *exp(kc)*. This can be considered as reliable for reporting the daily American Ra, even when there are zero sunspot observations.



Below, the final American Relative number, (k-ave as *exp(kc)*) has been calculated for each day.



Overall result:

By using all observations from the AAVSO network, this process allows us to detect and eliminate abnormal daily values from each observer and to fill in gaps for the observations of zero sunspot counts. This leads to an improved monthly American Relative (Ra) number average and reduces the errors in the resulting daily Ra values. As all observers are rescaled to all the other observer's daily average *exp(kc)* over the whole month, (there is no absolute scaling based on a standard reference observatory) , the American Relative number is entirely defined by all observer's submissions.

Timescales longer than 1 month

As pointed out in the previous section, the Ra scaling for each month corresponds to the observer's average *exp(kc)* delivered by those observers with about a 3 year adjusted k factor. Therefore, the stability over long duration rests entirely on the stability of the estimating our observer's k factor. This is a robust measure based on the following:

- Same observer, same site, same telescope and same observing principles for more than 2 years
- Statistical estimates of the observer's commitment for submissions during the solar minimum
- Cross–comparison of personal k coefficients of the each observer and all other contributing observers

The k_{sta} coefficients resulting from the 3 year assessments are adjusted during solar minimum and solar maximum, as they contain a long-term record of the ratios and possible drifts of each individual observer.

Imperfections in the archived sunspot indices

New k coefficients are updated every 3 years, based on the previous two years of data. K - Coefficients may be different and are archived, updates to the Obsconst table happen as new observers submit data, however no k factor is given to new observers with less than 100 observations.

Ad hoc requests for reporting the k coefficient to observers

For reporting the k coefficient to the observers, instead of taking the exact values resulting from the main calculation, new k_{sta} coefficients are calculated by a simple average monthly ratio between $W_{sta}(d)$ and the definitive Ra for that month. However, as this does not involve the complex log value calculation, the set of daily values used in this reported calculation can be different. The reported k_{sta} can thus differ slightly from the actual k_{sta} used in the monthly Ra calculation.

Conclusions

The same statistical processing for the AAVSO Ra has only been adjusted once during the mid 1990s mainly to correct for what was believed to be inflation in the yearly estimates of observer's k factors. Now, looking back with a 15 year perspective, we can see that correcting for the AAVSO Ra number has been shown to match the SILSO international index. However, the inflation problem implies a vulnerability of the Ra index as it still rests mainly on a 3 year update to observer k factors.