Reconciling Group and Wolf Sunspot Numbers Using Backbones

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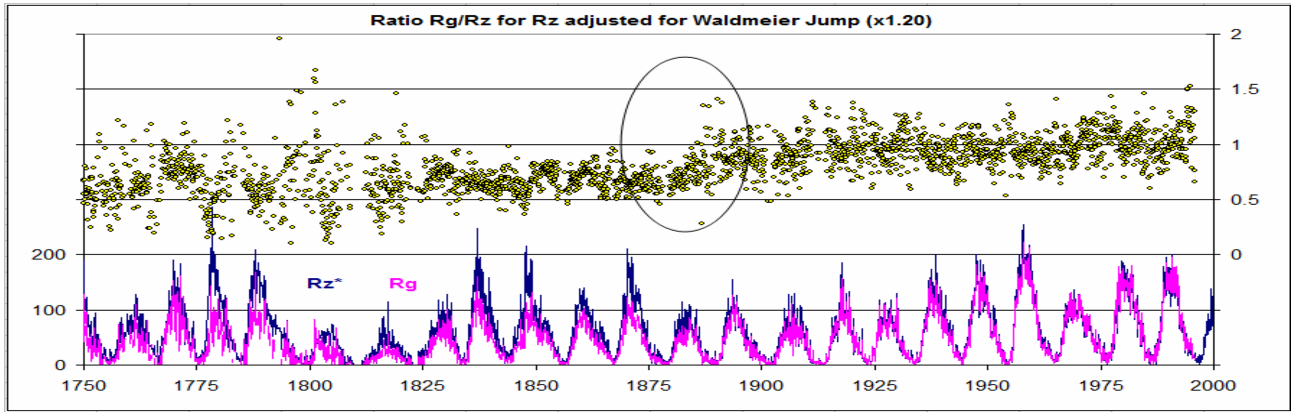
The ratio between Group SSN and Wolf [Zürich, International] SSN has a marked discontinuity ~1882:

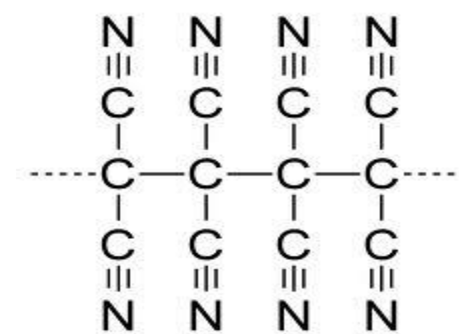


Reflecting the well-known secular increase of the Group SSN

Why a Backbone? And What is it?

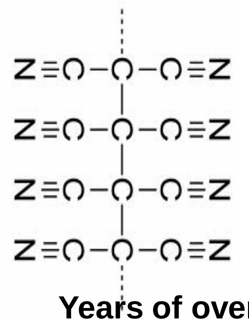
Building a long time series from observations made over time by several observers can be done in two ways:

- Daisy-chaining: successively joining observers to the 'end' of the series, based on overlap with the series as it extends so far [accumulates errors]
- Back-boning: find a primary observer for a certain [long] interval and normalize all other observers individually to the primary based on overlap with only the primary [no accumulation of errors]



Carbon Backbone

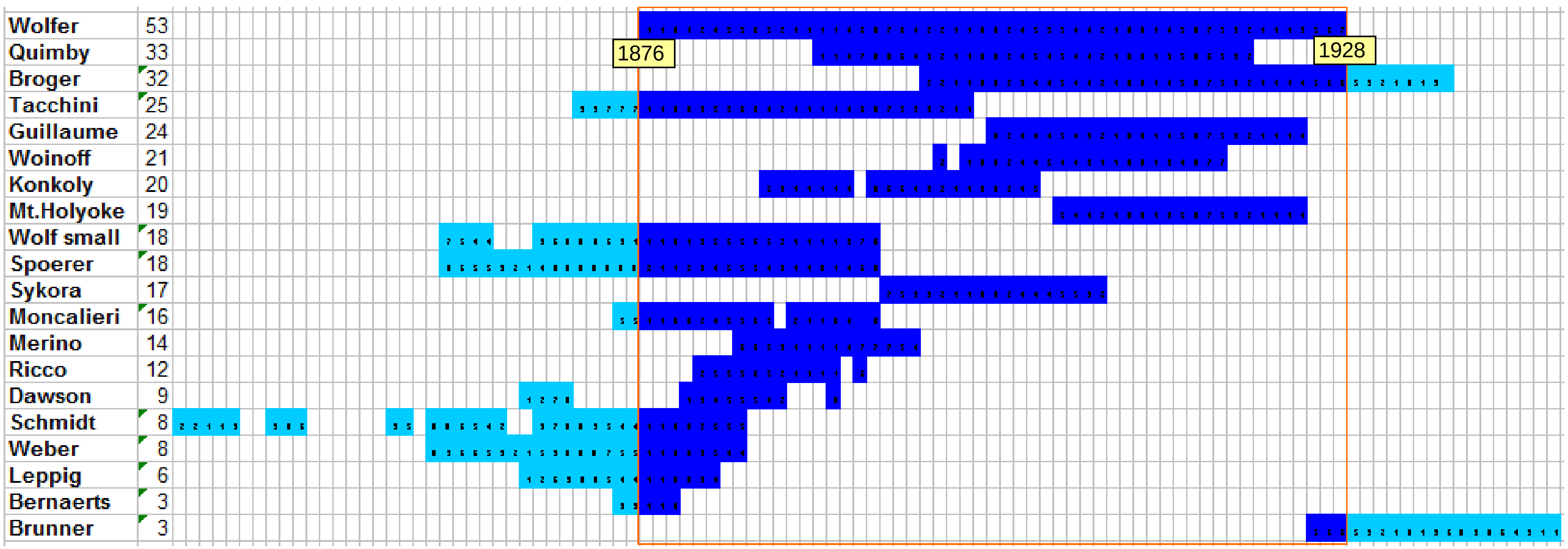
When several backbones have been constructed we can join [daisy-chain] the backbones. Each backbone can be improved individually without impacting other backbones

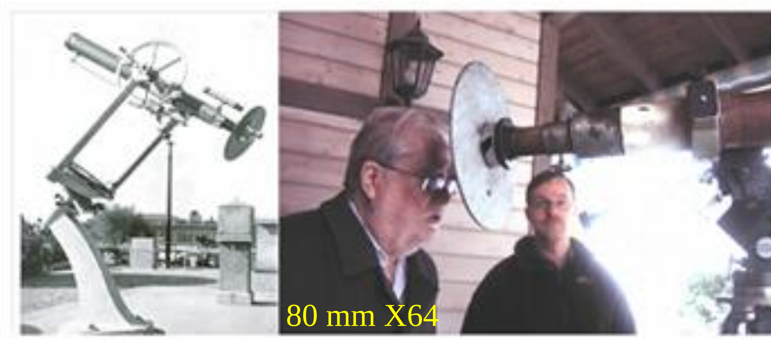


The Wolfer Backbone

Alfred Wolfer observed 1876-1928 with the ‘standard’ 80 mm telescope

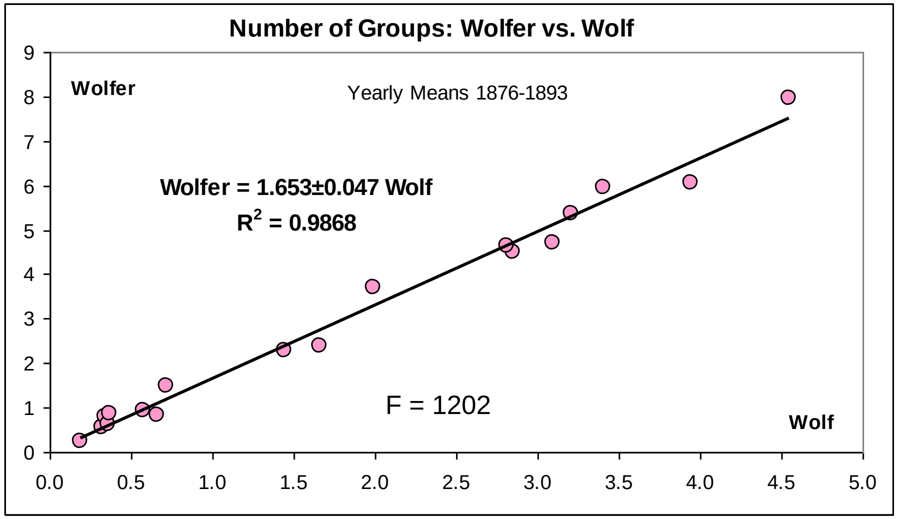
Years of overlap

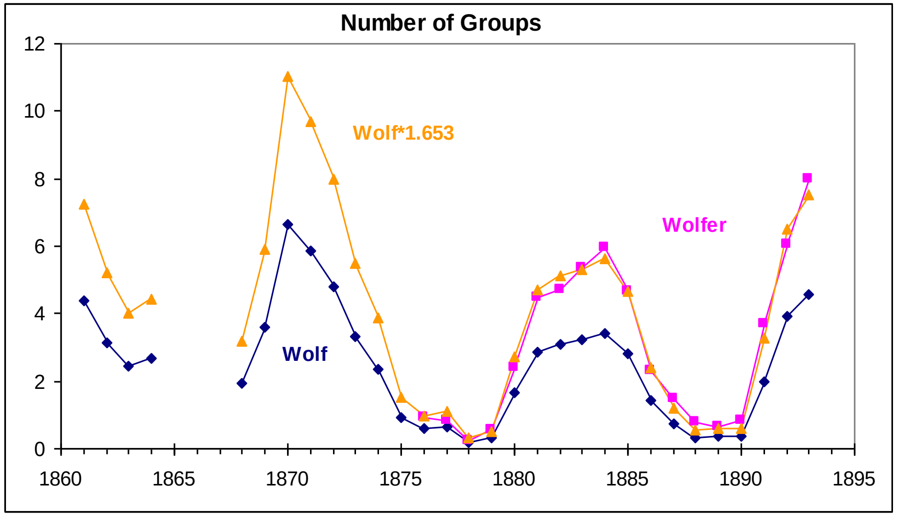




Rudolf Wolf from 1860 on mainly used smaller 37 mm telescope(s) so those observations are used for the Wolfer Backbone

Normalization Procedure

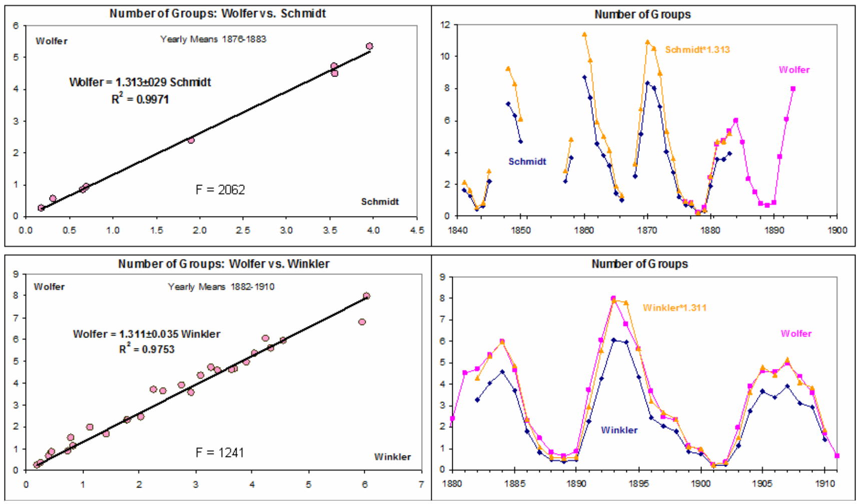




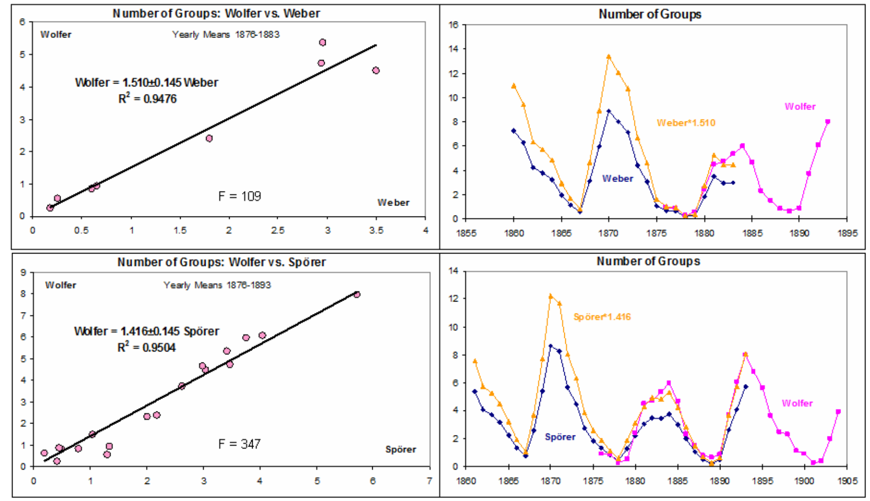
For each Backbone we regress each observers group counts for each year against those of the primary observer, and plot the result [left panel]. Experience shows that the regression line almost always very nearly goes through the origin, so we *force* it to do that and calculate the slope and various statistics, such as 1-*σ* uncertainty. The slope gives us what factor to multiply the observer's count by to match the primary's. The right panel shows a result for the Wolfer Backbone: blue is Wolf's count [with his small telescope], pink is Wolfer's count [with the larger telescope], and the orange curve is the blue curve multiplied by the slope. It is clear that the harmonization works well [at least for Wolf vs. Wolfer].

Regress More Observers Against Wolfer…

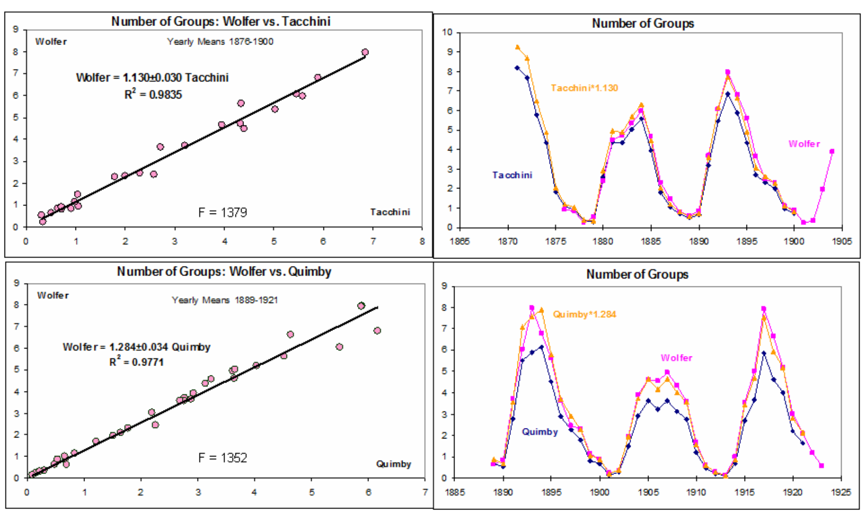
Schmidt, Winkler



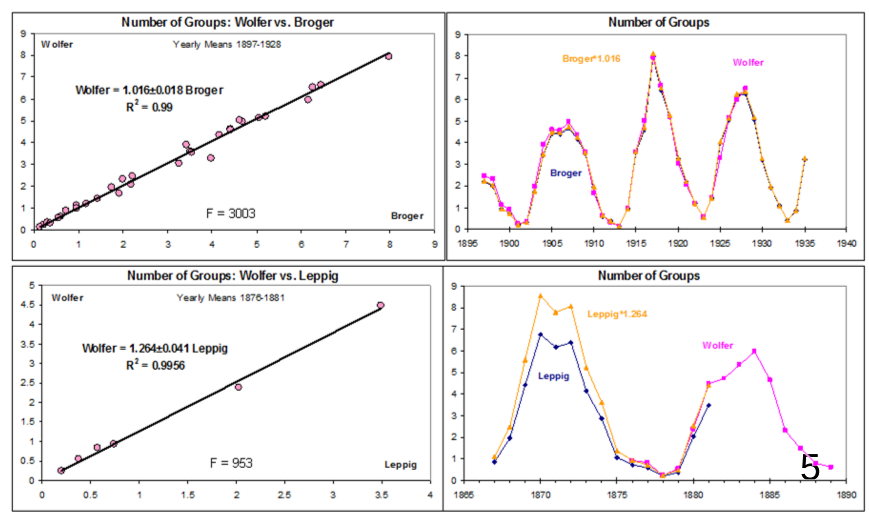
Weber, Spörer



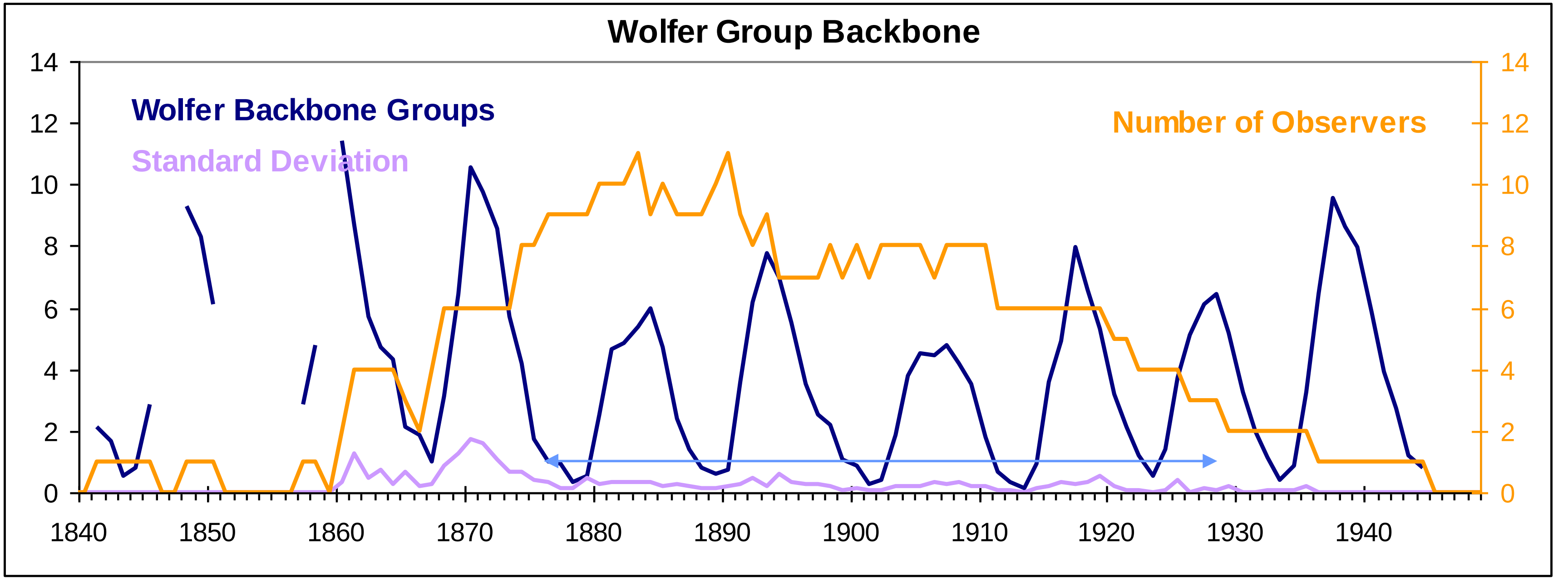
Tacchini, Quimby



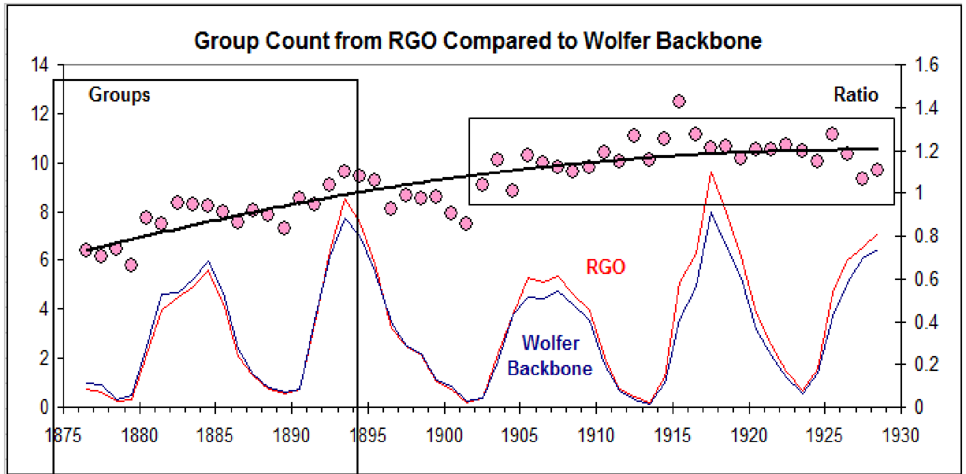
Broger, Leppig



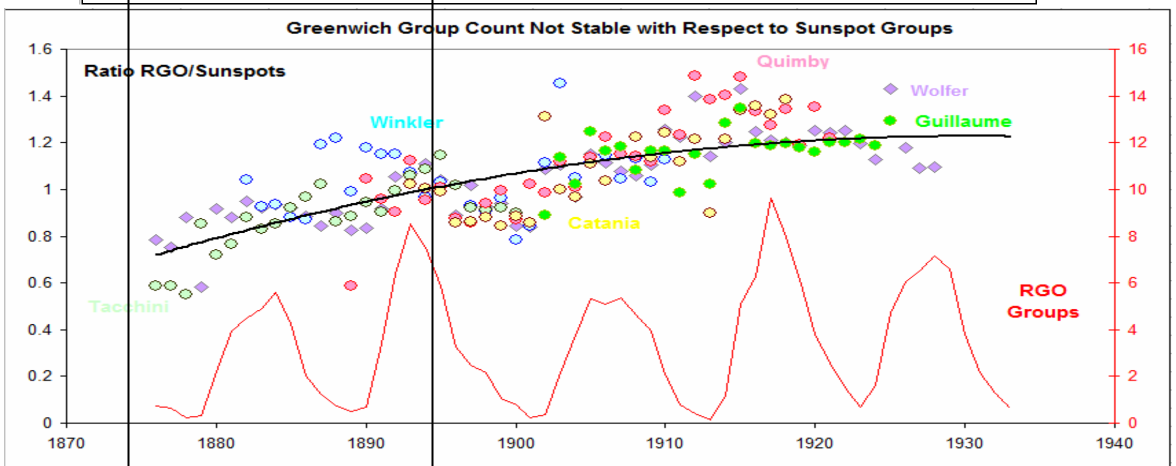
The Wolfer Group Backbone



The Wolfer Backbone straddles the interval around 1882 with good coverage (~9 observers) and with reasonable coverage 1869-1925 (~6 observers). Note that we do not use the Greenwich [RGO] data for the Wolfer Backbone.

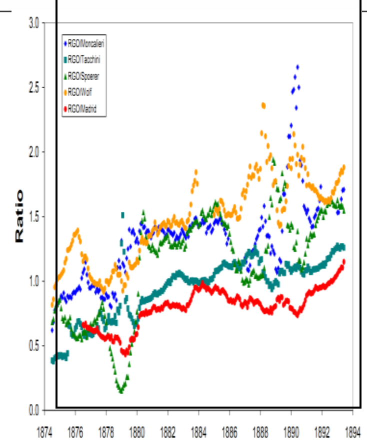


Hoyt & Schatten used the Group Count from RGO [Royal Greenwich Observatory] as their Normalization Backbone. Why don’t we?



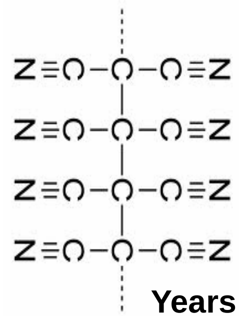
Because there are strong indications that the RGO data is drifting before ~1900

Could this be caused by Wolfer’s count drifting? His *k*-factor for R_Z *was*, in fact, declining slightly the first several years as assistant (seeing fewer spots early on – wrong direction). The group count is less sensitive than the Spot count and there are also the other observers…



José Vaquero found a similar result which he reported at the 2nd Workshop in Brussels.

Sarychev & Roshchina report in Solar Sys. Res. 2009, *43*: “There is evidence that the Greenwich values obtained before 1880 and the Hoyt–Schatten series of Rg before 1908 are incorrect”.

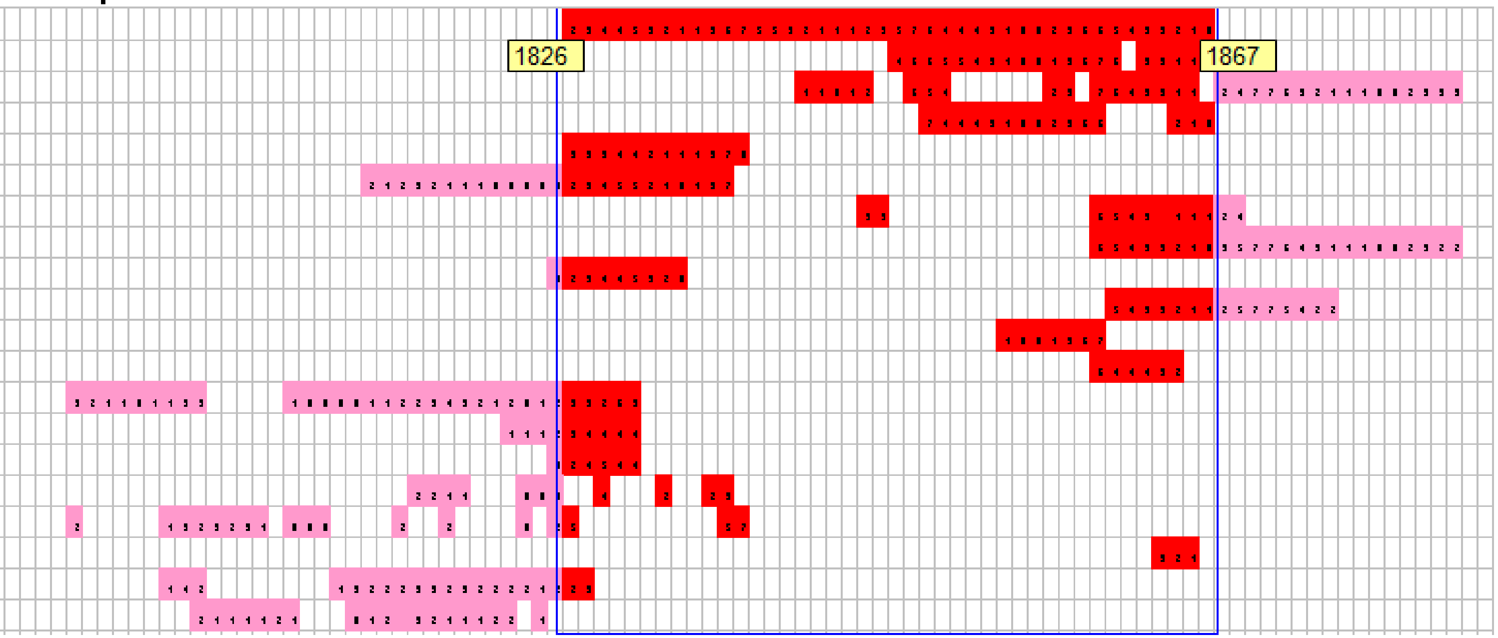


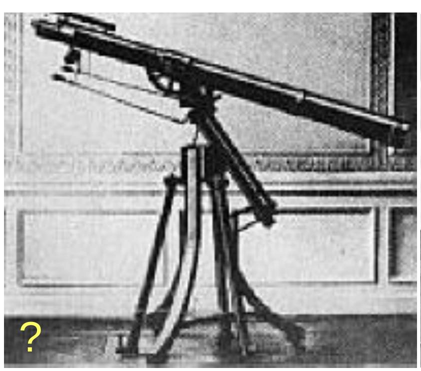
The Schwabe Backbone

Schwabe received a 50 mm telescope from Fraunhofer in 1826 Jan 22. This telescope was used for the vast majority of full-disk drawings made 1826–1867.

Years of overlap

Schwabe	42
Shea	19
Schmidt	17
Wolf big tel.	15
Hussey	12
Stark	11
Peters	9
Weber	8
Pastorff	8
Spoerer	7
Carrington	7
Howlet	6
Flaugergues	5
Arago	5
Schwarzenbrunner	5
Tevel	4
Herschel	3
DeLaRue	3
Lindener	2
Derfflinger	0

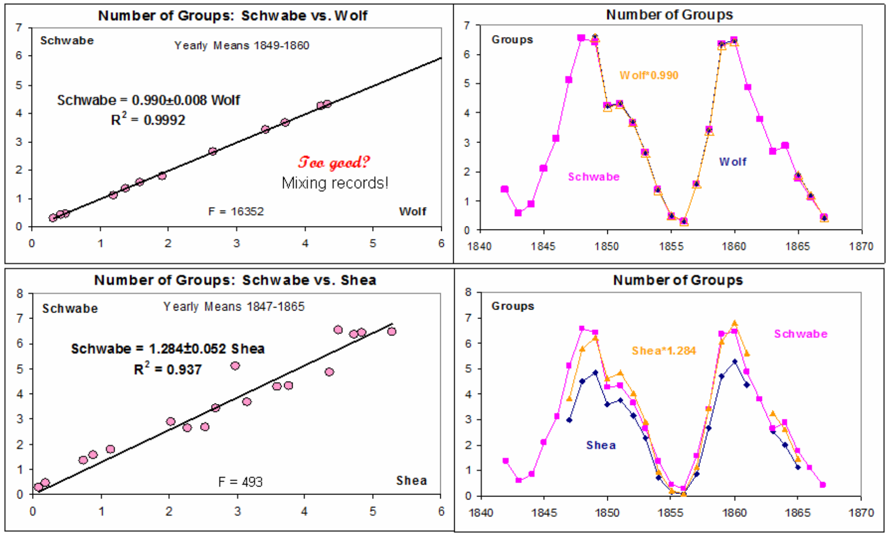




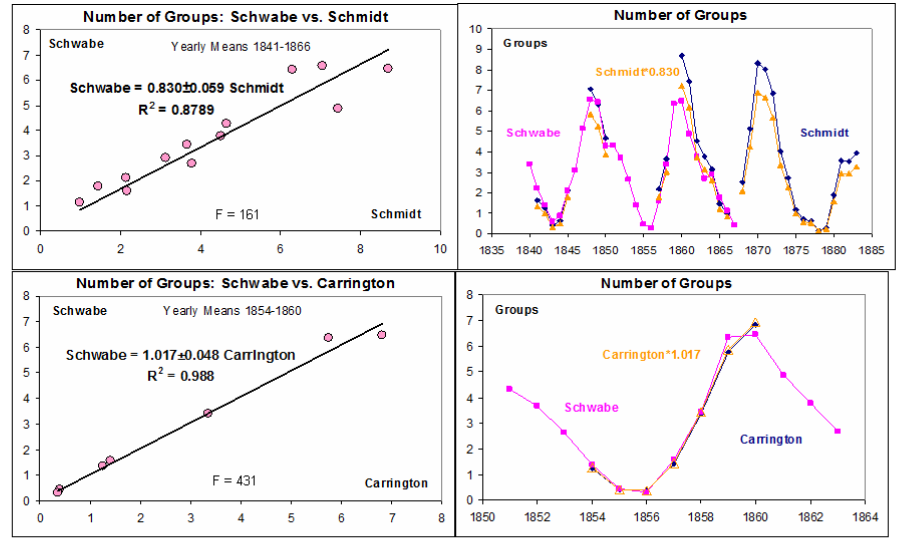
For this backbone we compare with Wolf's observations with the large 80mm standard telescope

Regressions for Schwabe Backbone

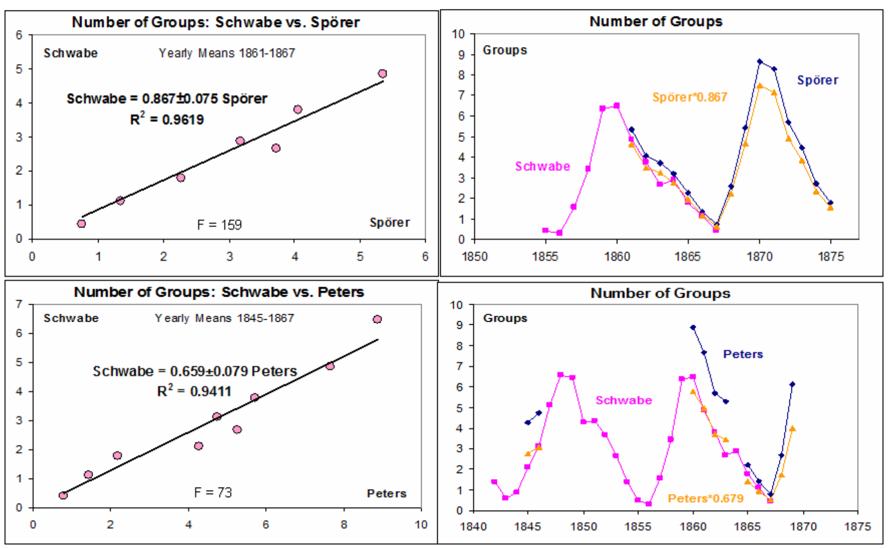
Wolf, Shea



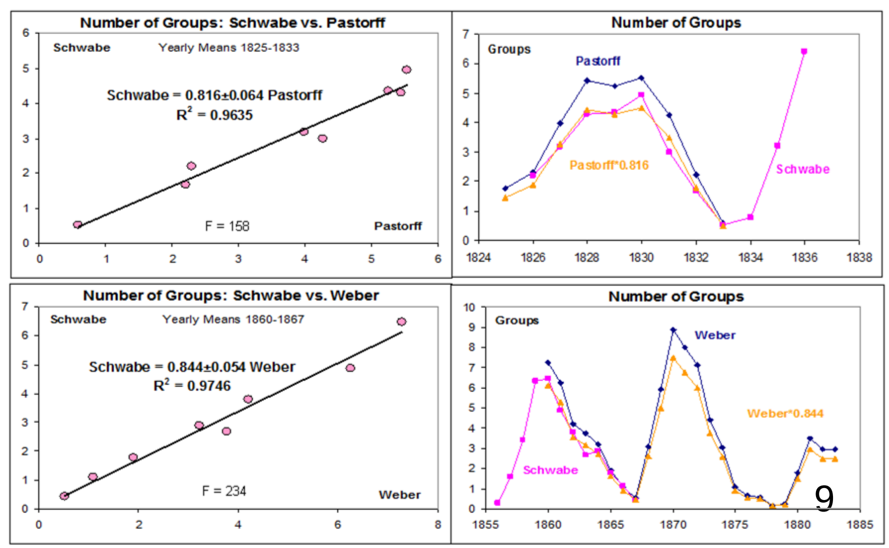
Schmidt, Carrington



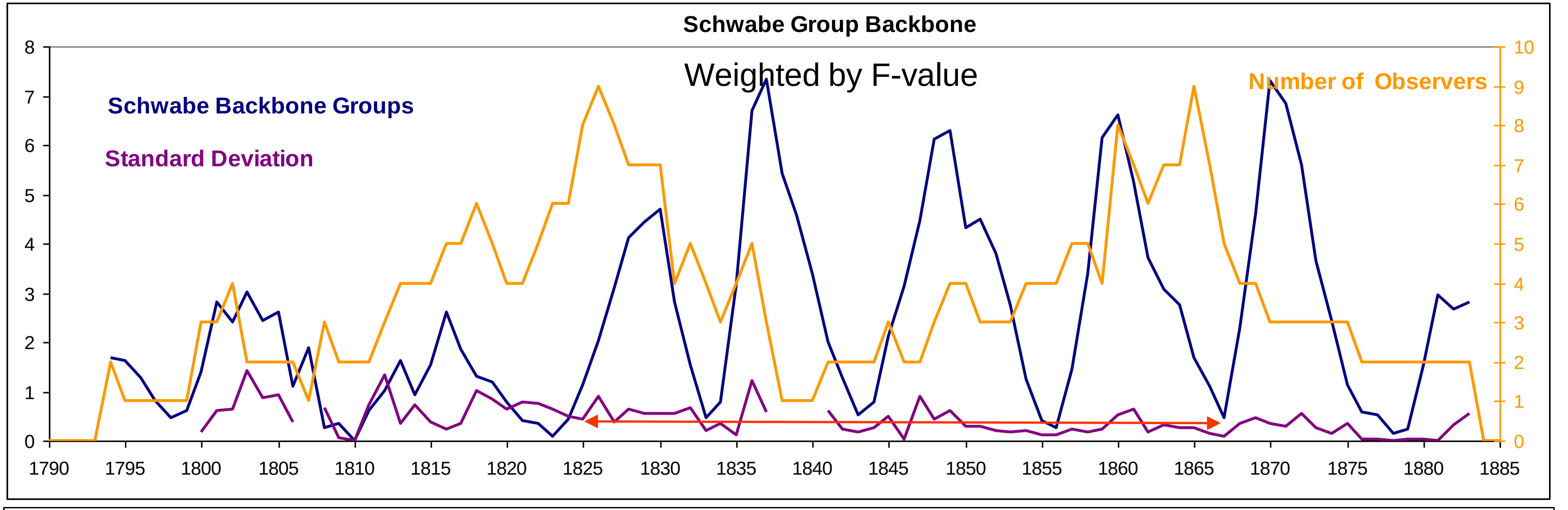
Spörer, Peters

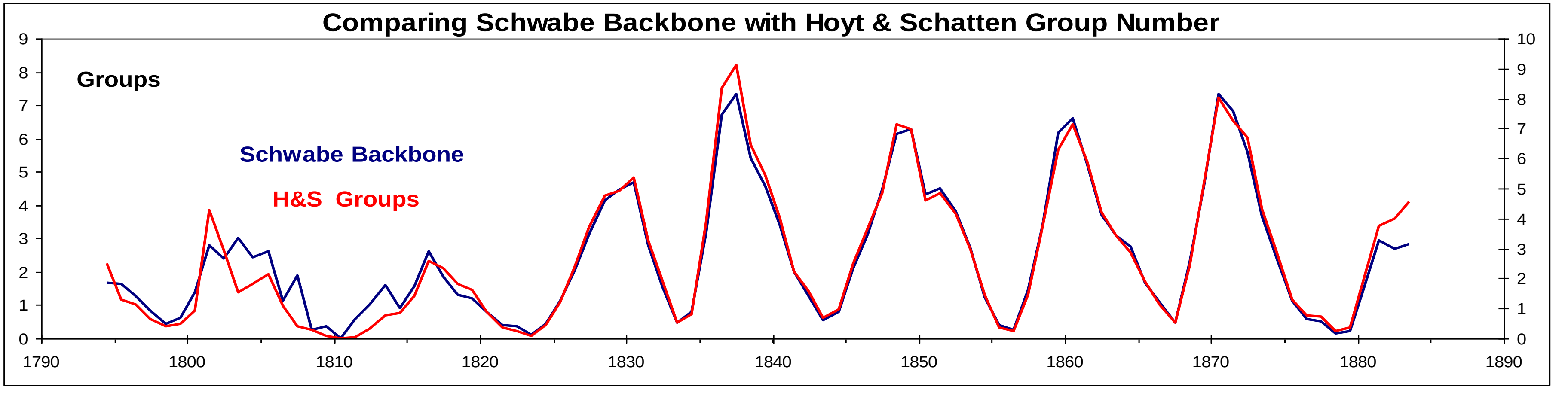


Pastorff, Weber

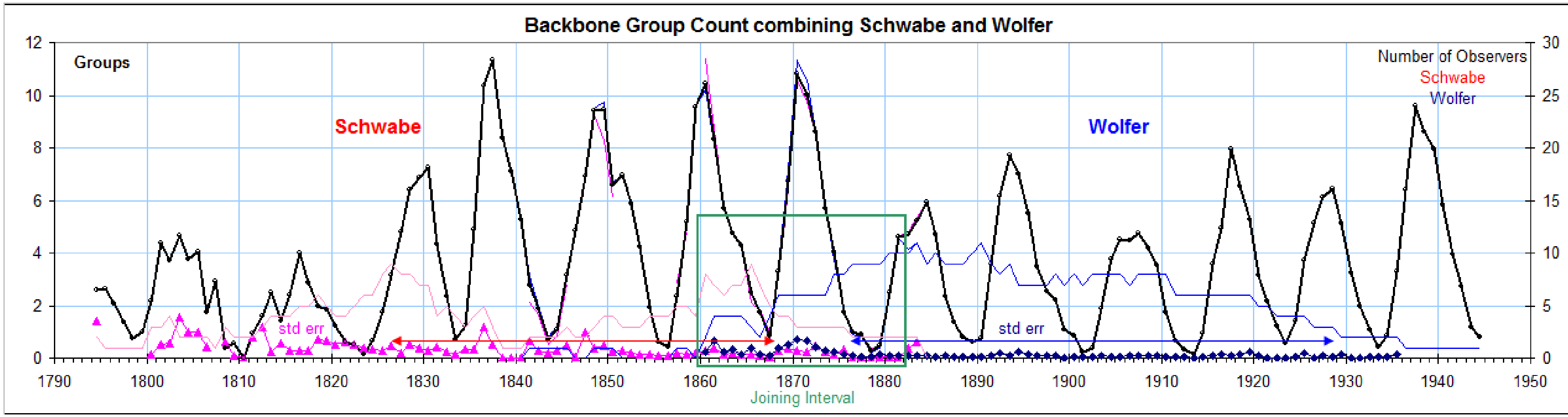


The Schwabe Group Backbone

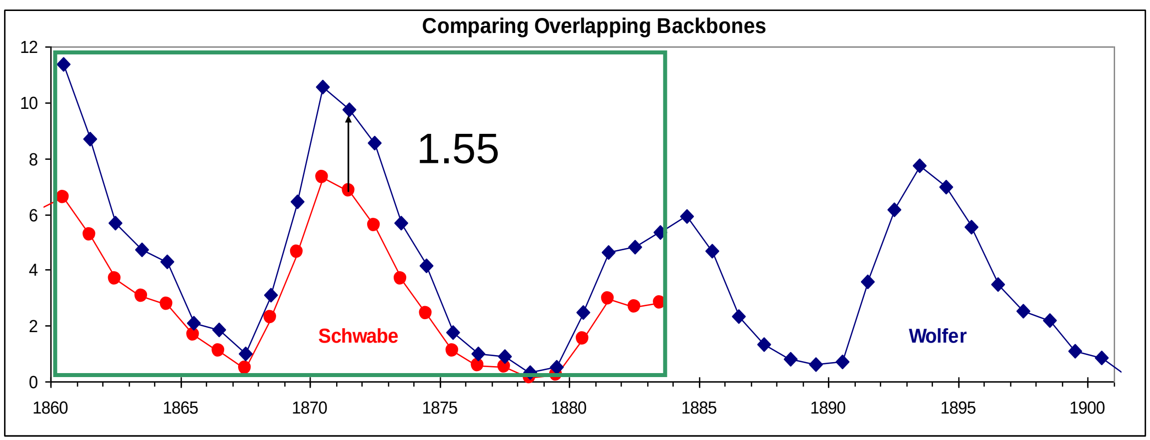


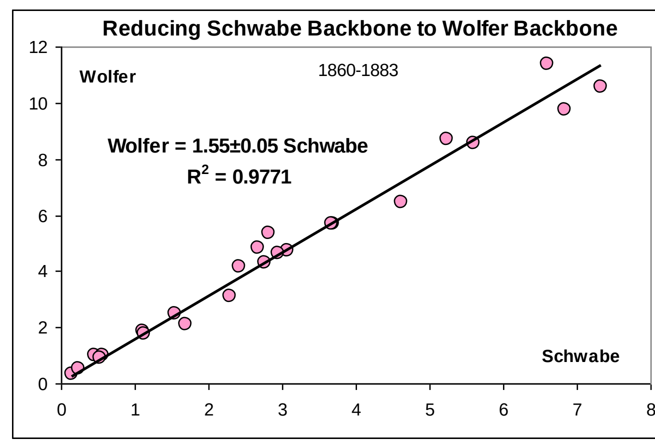


Joining the Two Backbones



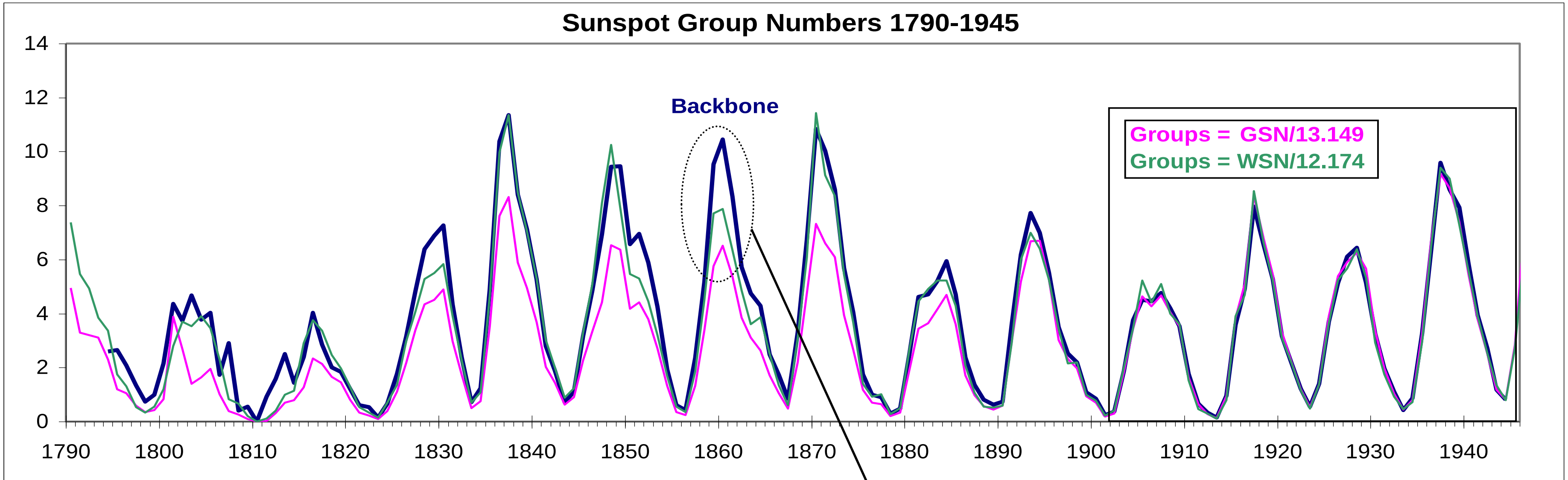
Comparing Schwabe with Wolfer backbones over 1860-1883 we find a normalizing factor of 1.55

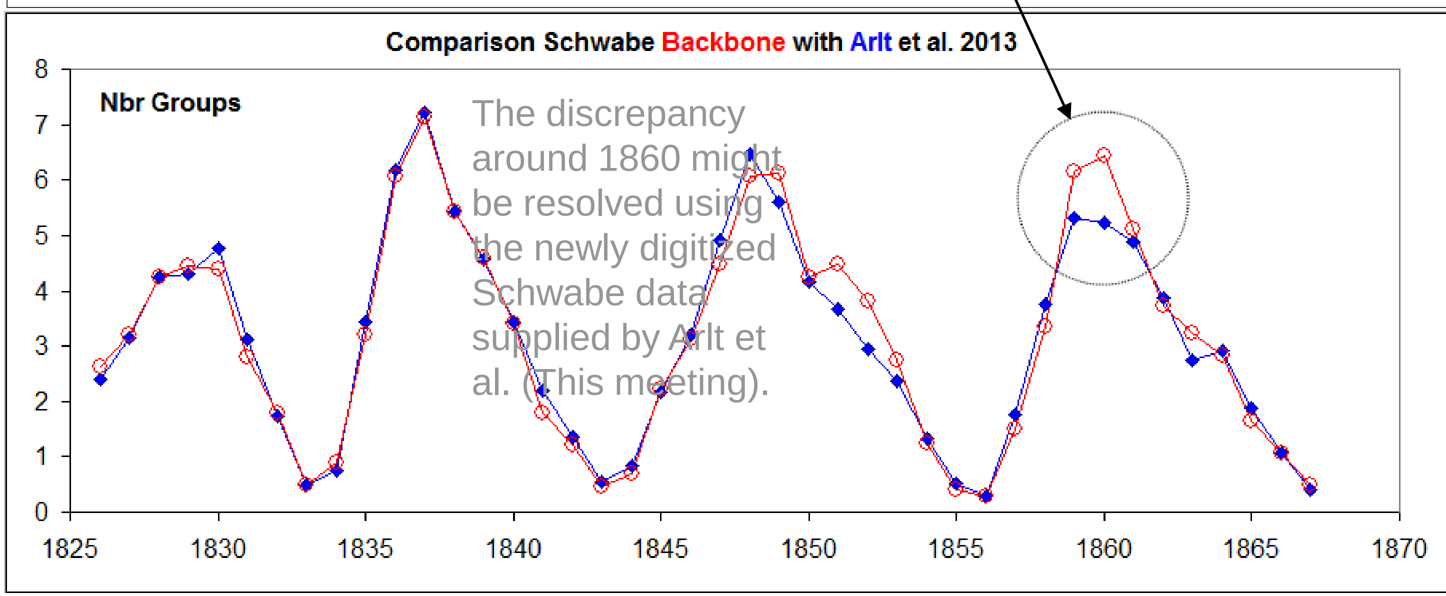




And can thus join the two backbones covering ~1825-1946

Comparison Backbone with GSN and WSN





Scaling all curves to match for 1912-1946 shows that the combined backbone matches the scaled Wolf Number

Conclusions

- Using the ‘Backbone’ technique it is possible to reconstruct a Group Sunspot Number 1825-1945 that does not exhibit any systematic difference from the standard Wolf [Zürich, Intnl.] Sunspot Number
- This removes the strong secular variation found in the Hoyt & Schatten GSN
- And also removes the notion of a Modern Grand Maximum