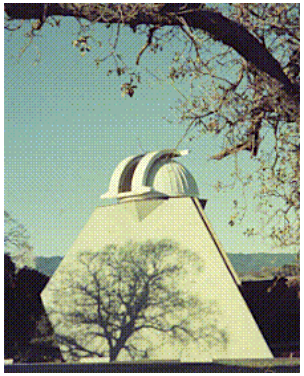

New Backbone Reconstructions of Sunspot Group Numbers

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Stanford University

20 Aug. 2019

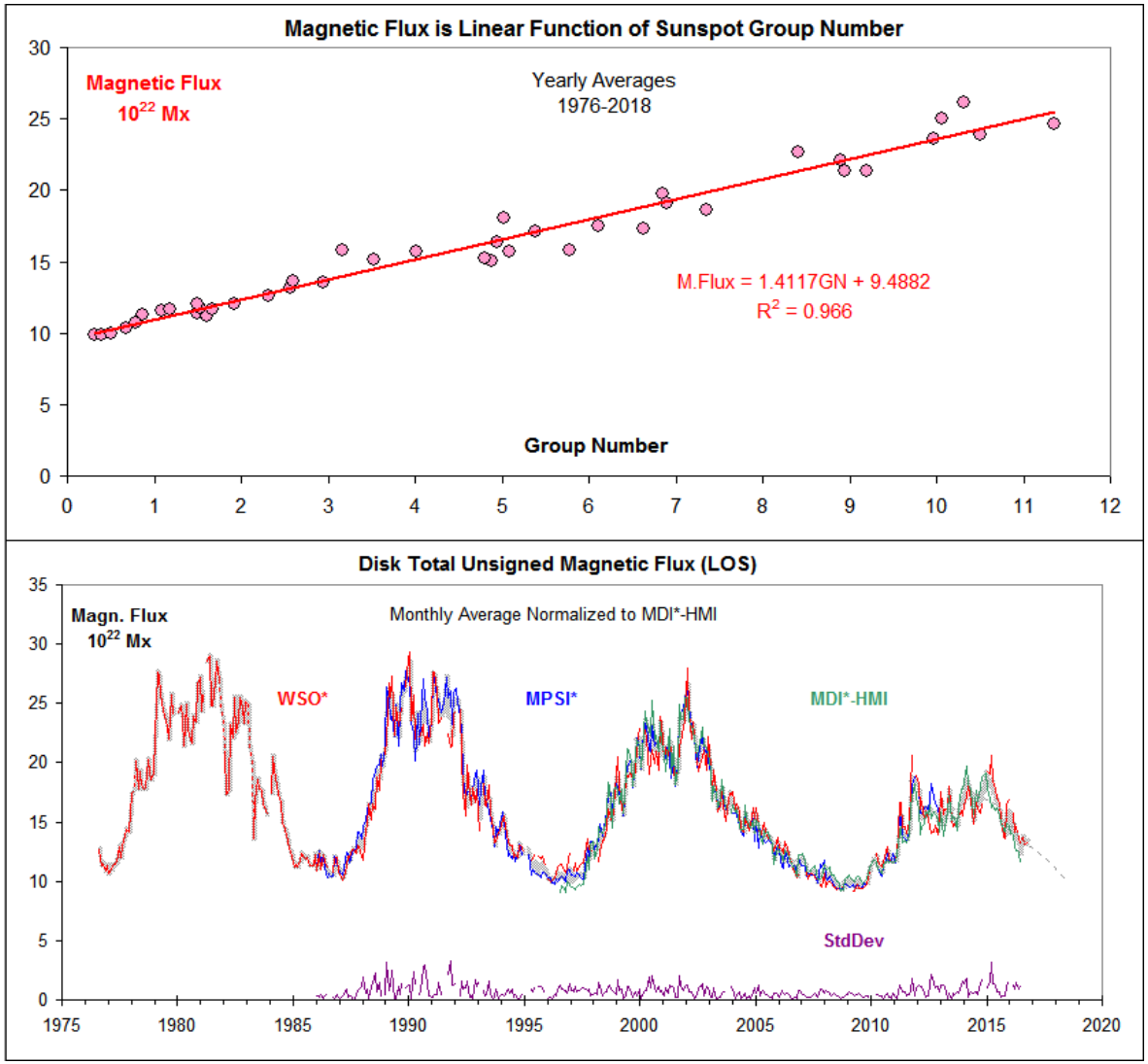
ISSI 417, Bern via Skype

https://leif.org/research/SC7-WBB-Poster.pdf

https://leif.org/research/Re-analysis-Wolfer-Backbones.pdf

https://arxiv.org/ftp/arxiv/papers/1704/1704.07061.pdf

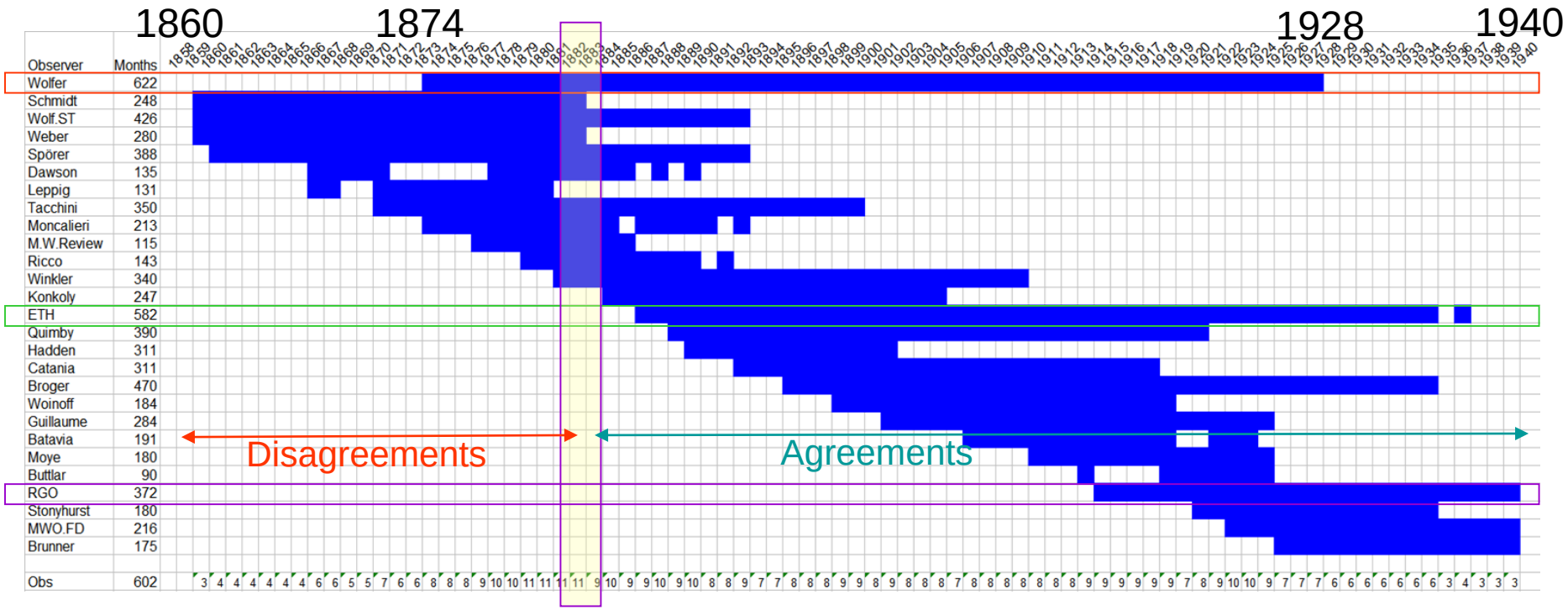
Magnetic Flux back to 1976 and the Sunspot Group Number (SS16)



Scaling MWO to MDI-HMI and WSO to the result yields a good measure of the LOS unsigned full disk magnetic flux which turns out to be a linear function of the Sunspot Group Number (S&S 2016).

Even at the limit of zero Groups there is still a significant amount of solar magnetic flux as needed to explain the interplanetary flux.

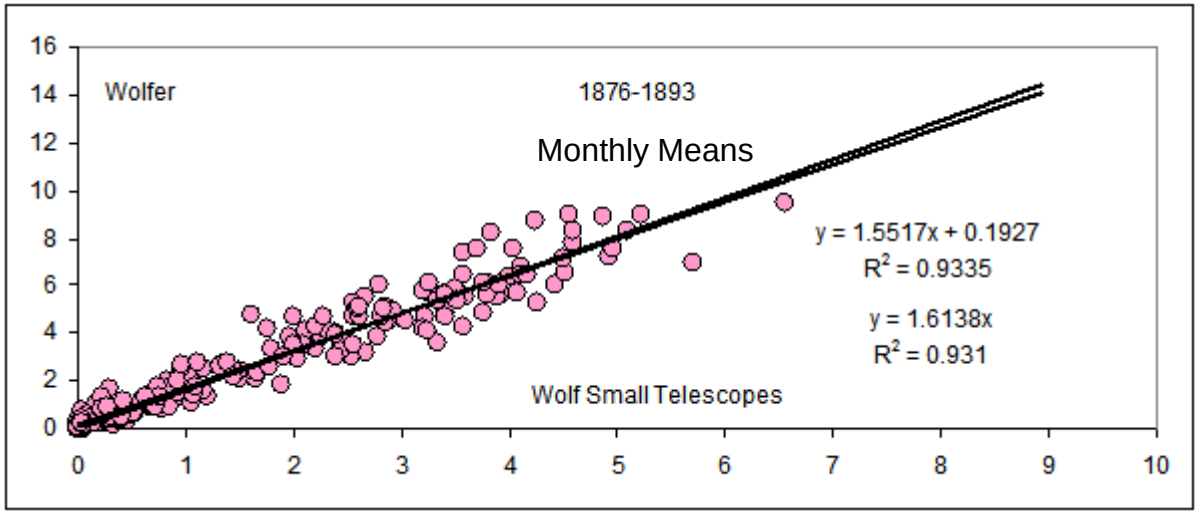
New Wolfer Backbone (Monthly)



Svalgaard & Schatten (2016) used a 'backbone' method to reconstruct the Sunspot Group Number since 1610. Five backbones where used, centered and anchored on the Wolfer Backbone, which then defines the scale of the series. Backbones are constructed by scaling observers directly to the primary observer (e.g. Wolfer) without daisy-chaining through intermediary observers thus avoiding accumulation of errors. Each observer is scaled to Wolfer and we check that the relation is linear with insignificant offset, defining a k-value. The data is taken from Svalgaard (2019) for the newly digitized Zürich drawings (ETH) and from Vaquero et al. (2016) for all other observers. To improve the time resolution (better determination of error bars) the new Wolfer Backbone has **monthly** resolution rather than the previous one's yearly values.

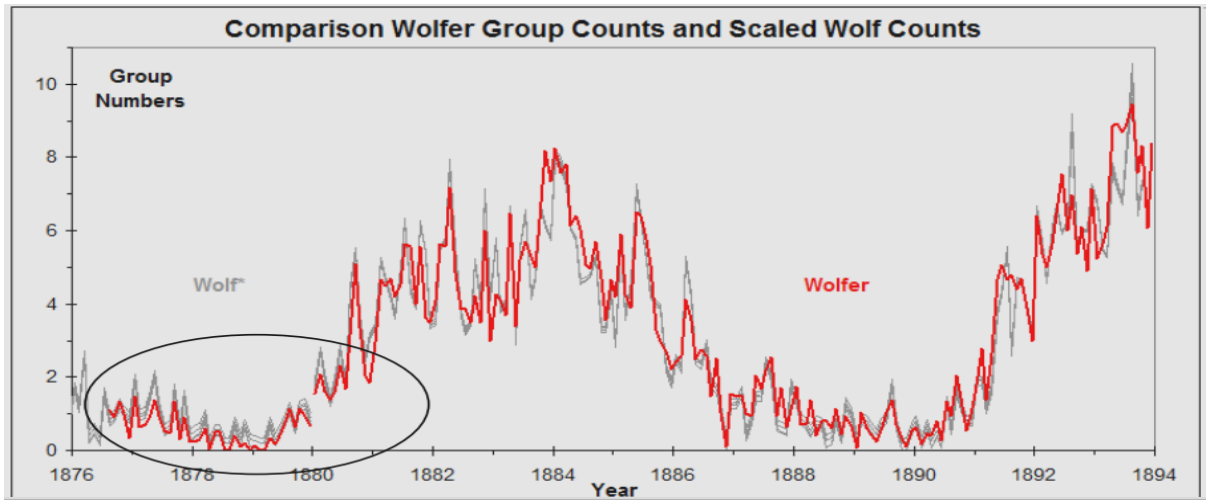
With a few exceptions (e.g. RGO) we use ALL the data from ALL observers

How Well Can We Reconstruct Wolfer's Count From Wolf's?



Wolfer = 1.6 Wolf ST

Aperture 37 mm X20

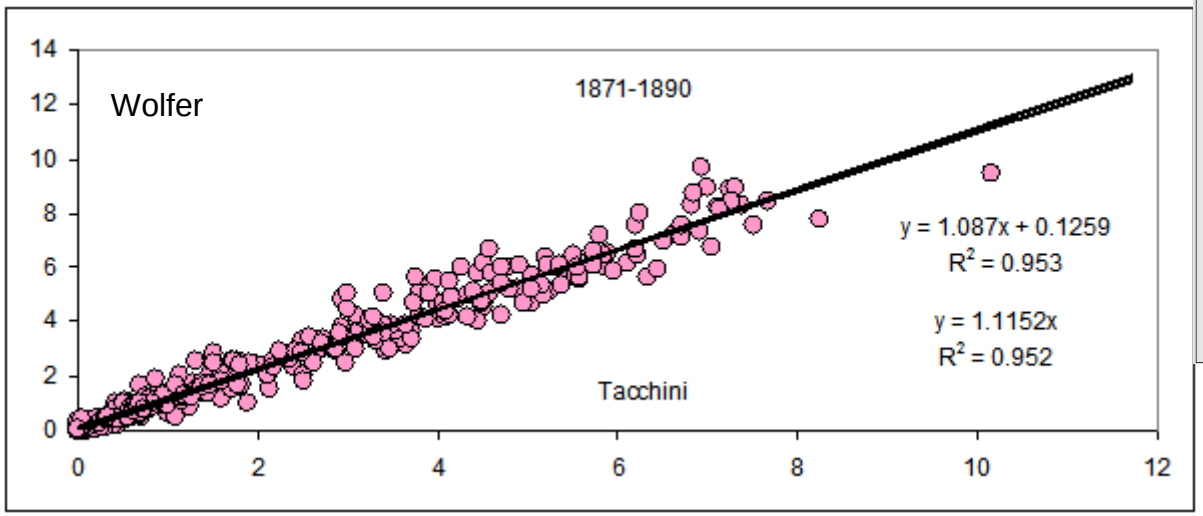


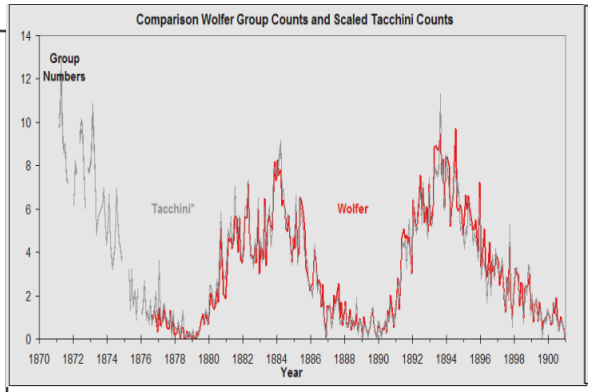
We can reproduce the Wolfer count from Wolf (ST) with only 7% 'unexplained' variance

The relationship is linear and proportional

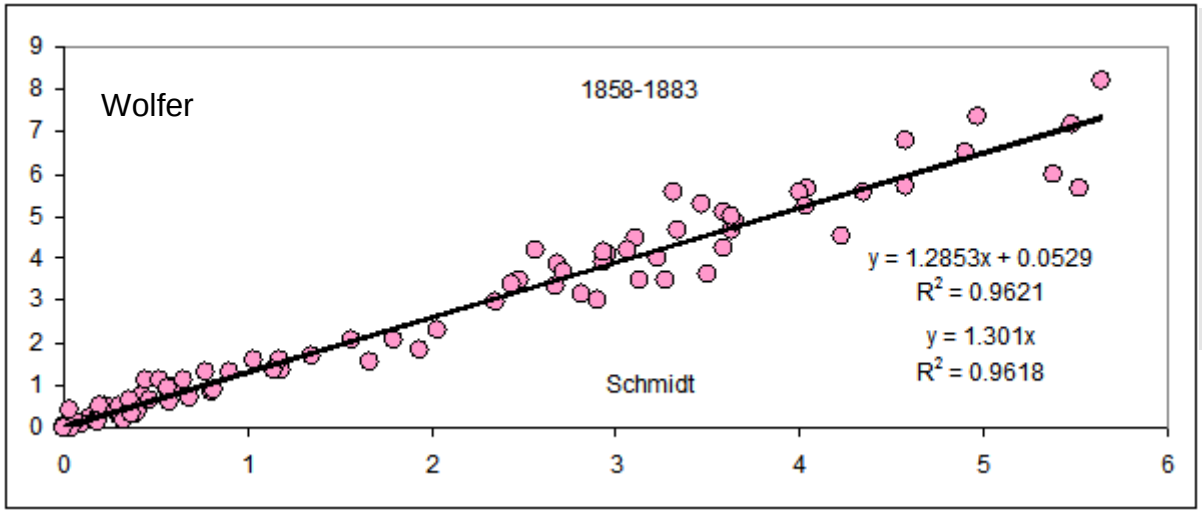
Learning curve…

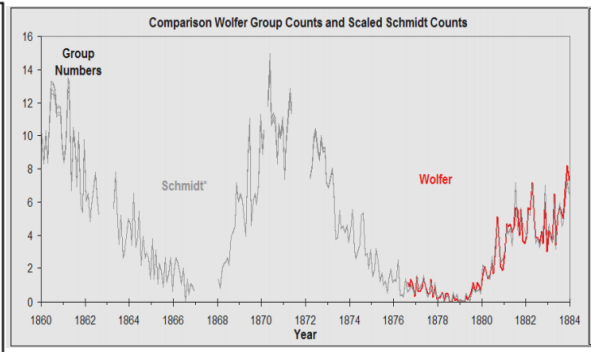
Early Regressions to Wolfer





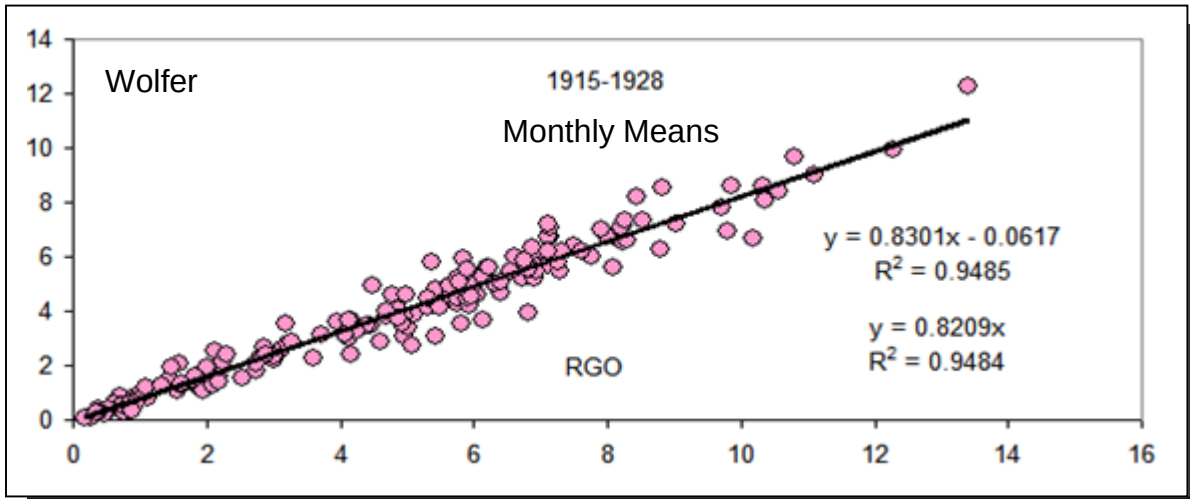
Just as for Wolf, the reproduction of Wolfer is very good (only 5% unexplained variance.

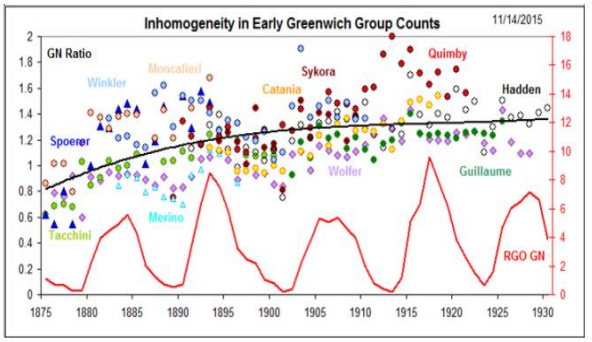




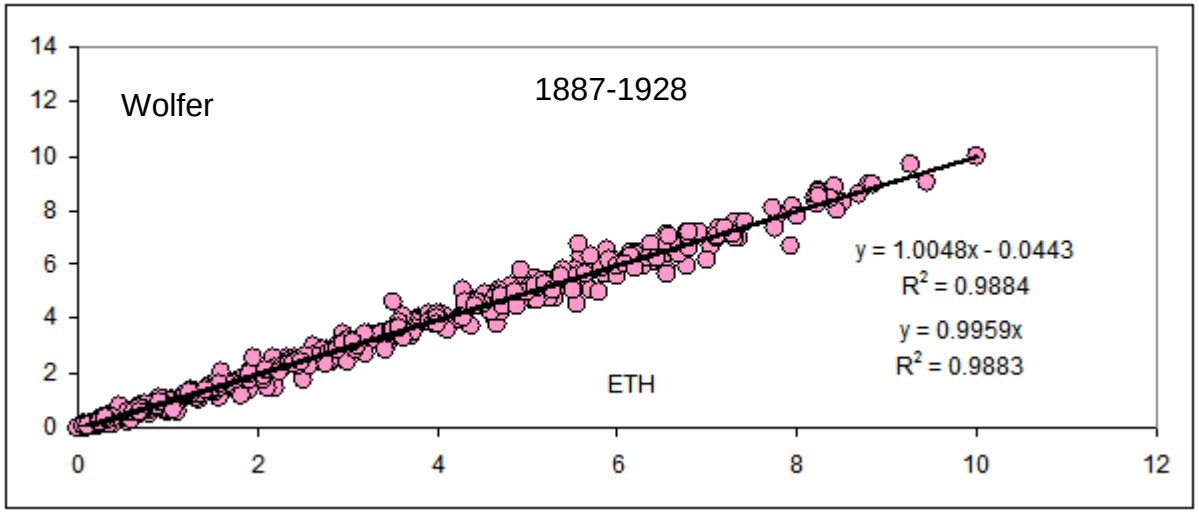
Same for Schmidt in Athens…

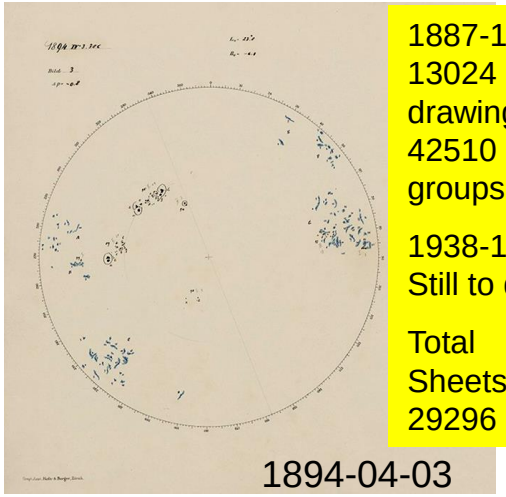
Later Regressions to Wolfer





RGO was drifting before ~1915 so we start in 1915



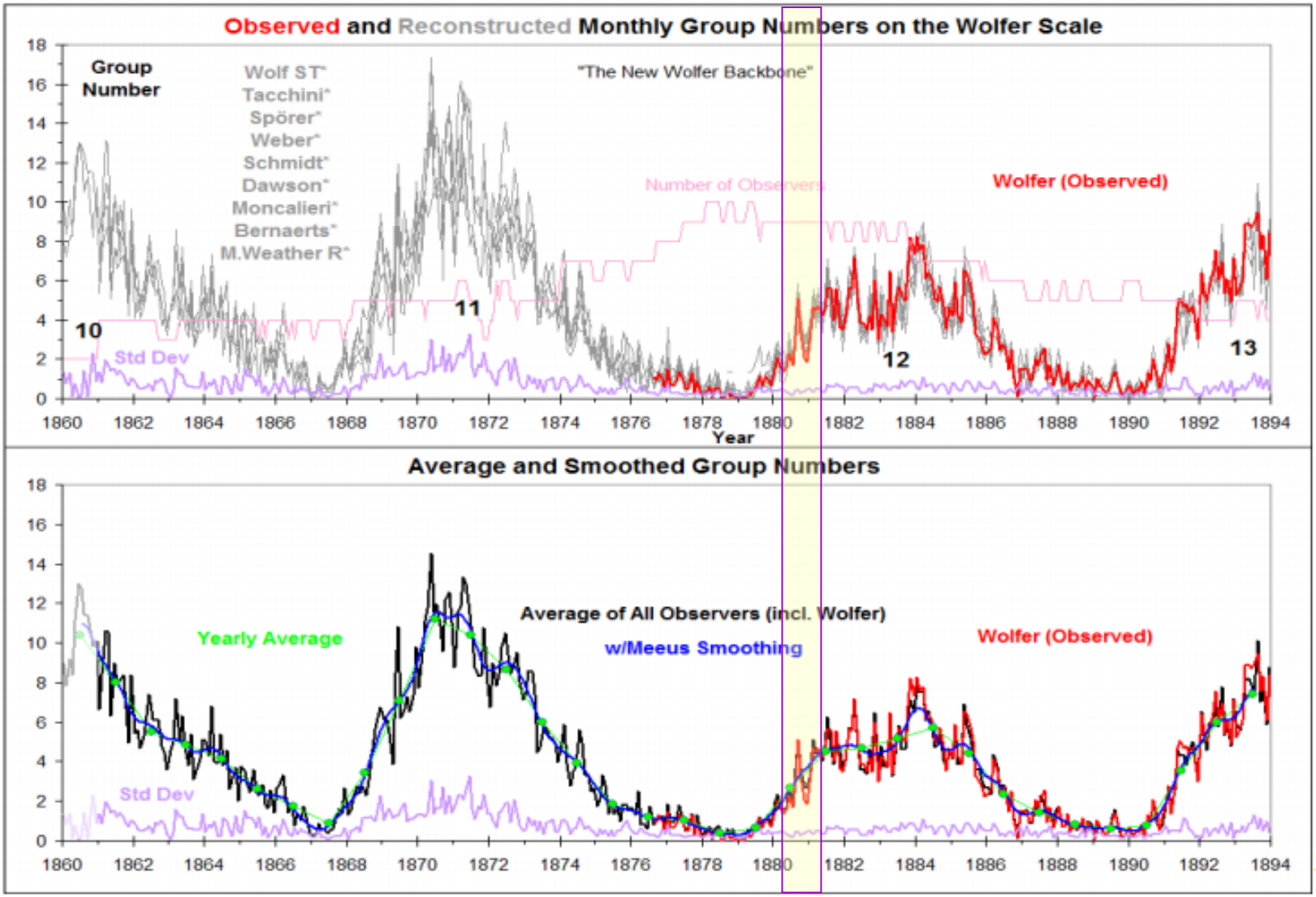


1887-1937: 13024 drawings, 42510 groups.

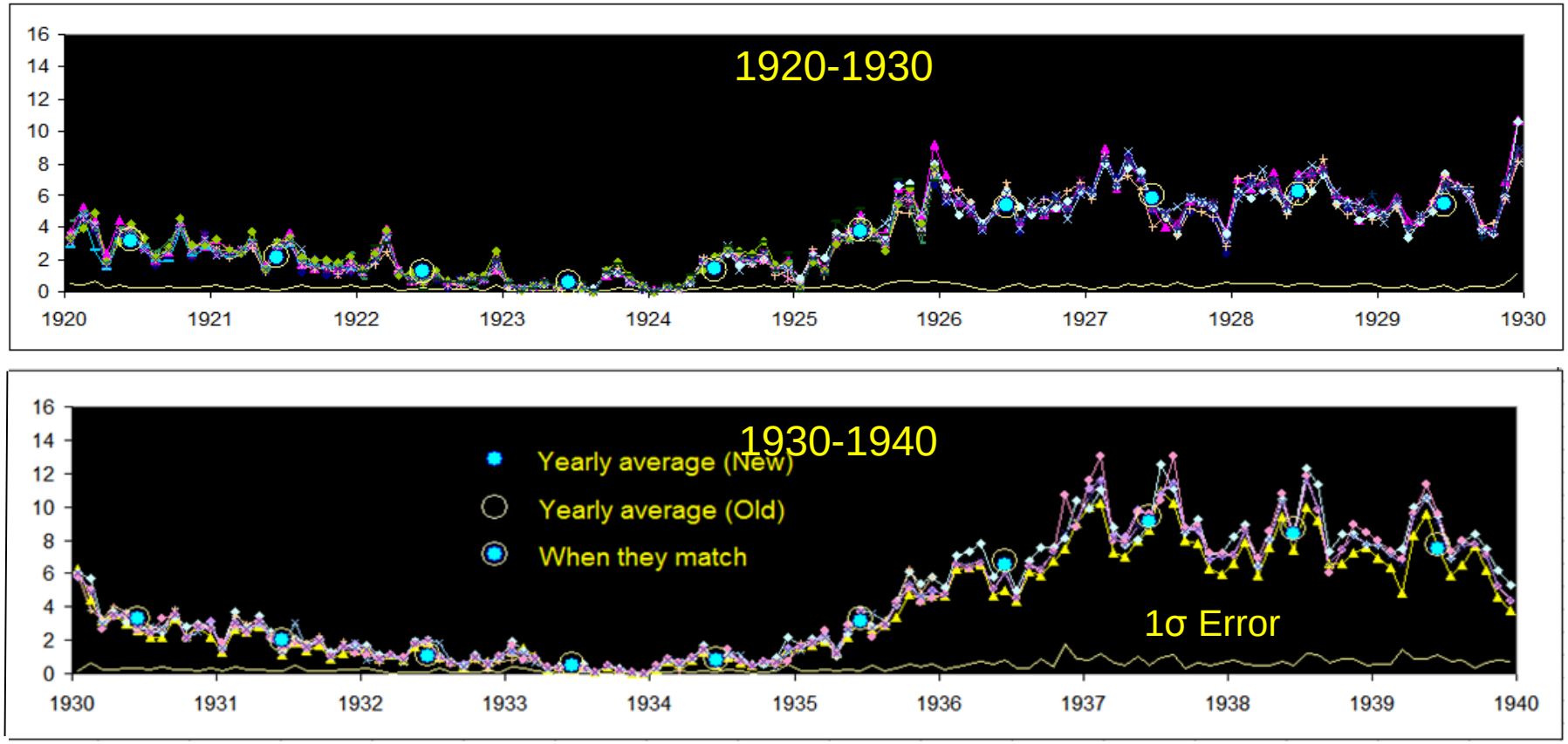
1938-1996 Still to do

Total Sheets: 29296

Compilation of Early Observers

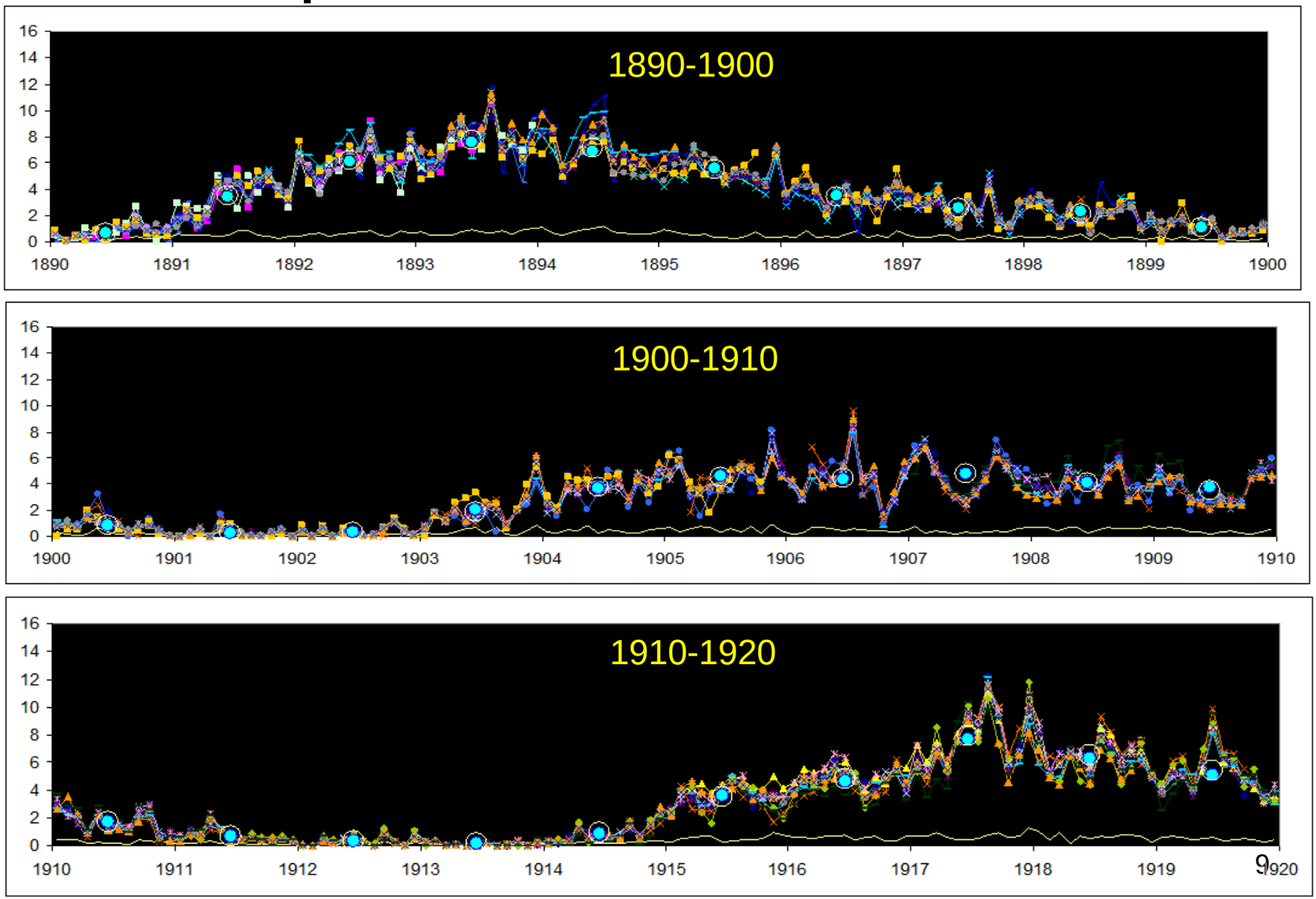


Composite of All Observers, III

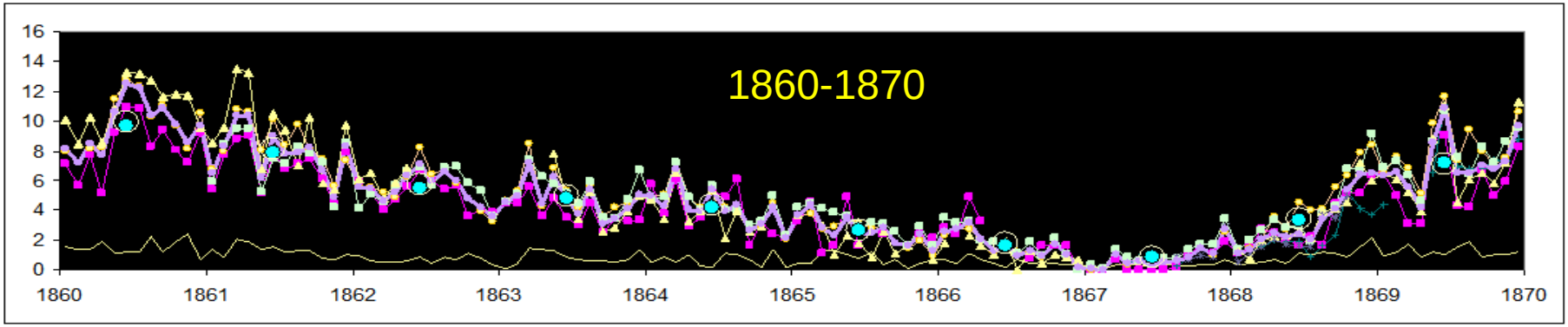


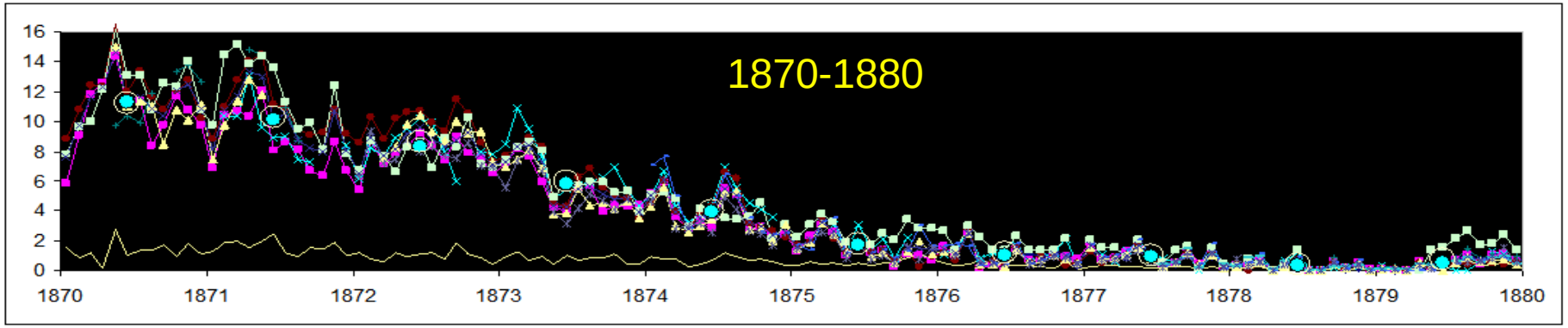
Using the scaling factors (k-values) for the best fit for each observer they are all put on the Wolfer Scale and plotted with different colors per observer for each decade. The 1-σ error (bottom yellow curve) is calculated as the standard deviation for the month divided by the square-root of the number of observers. Large blue dots show the yearly average group number (GN). Yellow circles show the old (S&S16) yearly GNs.

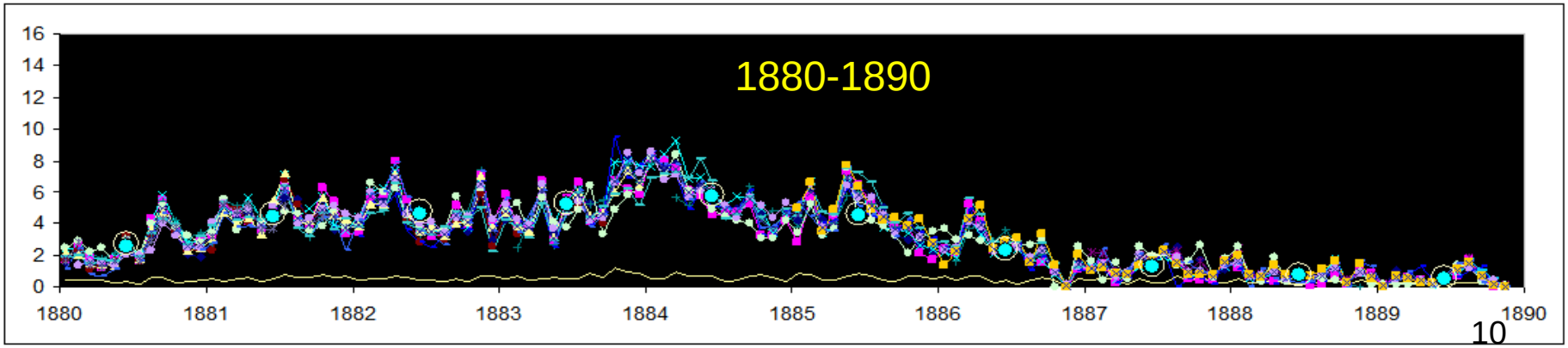
Composite of All Observers, II



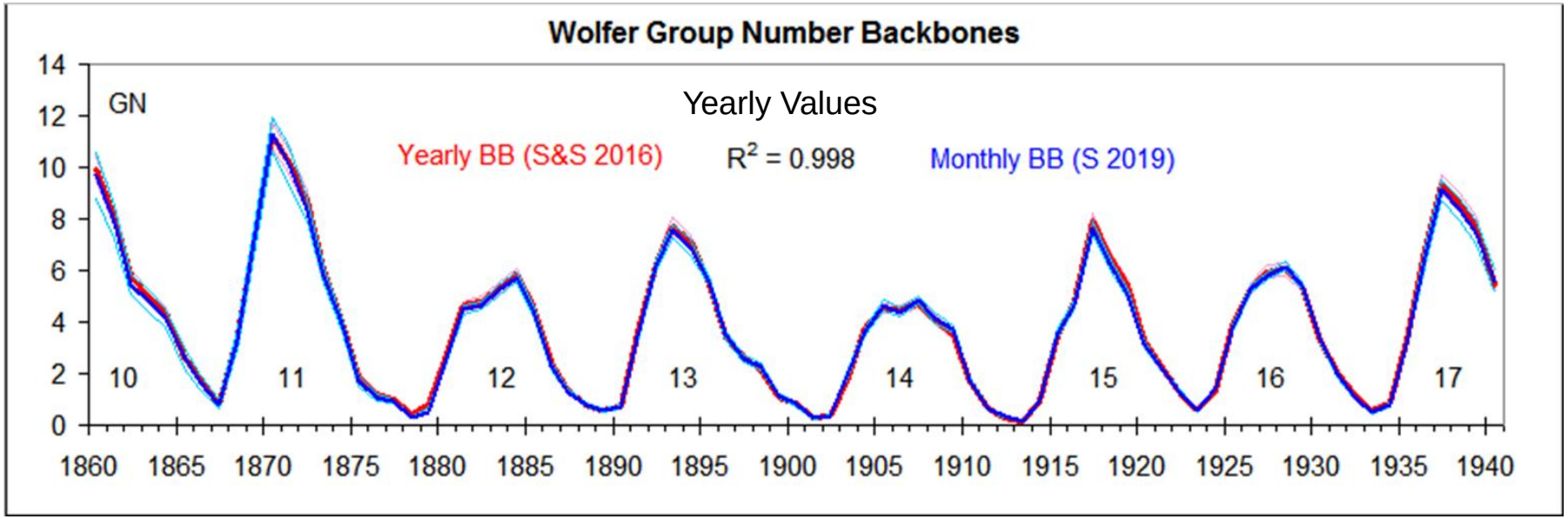
Composite of All Observers, I



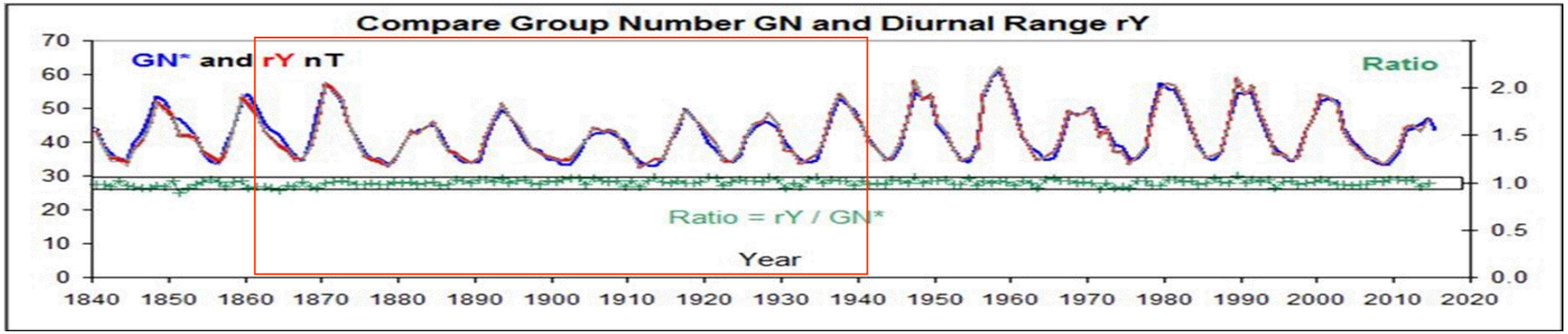




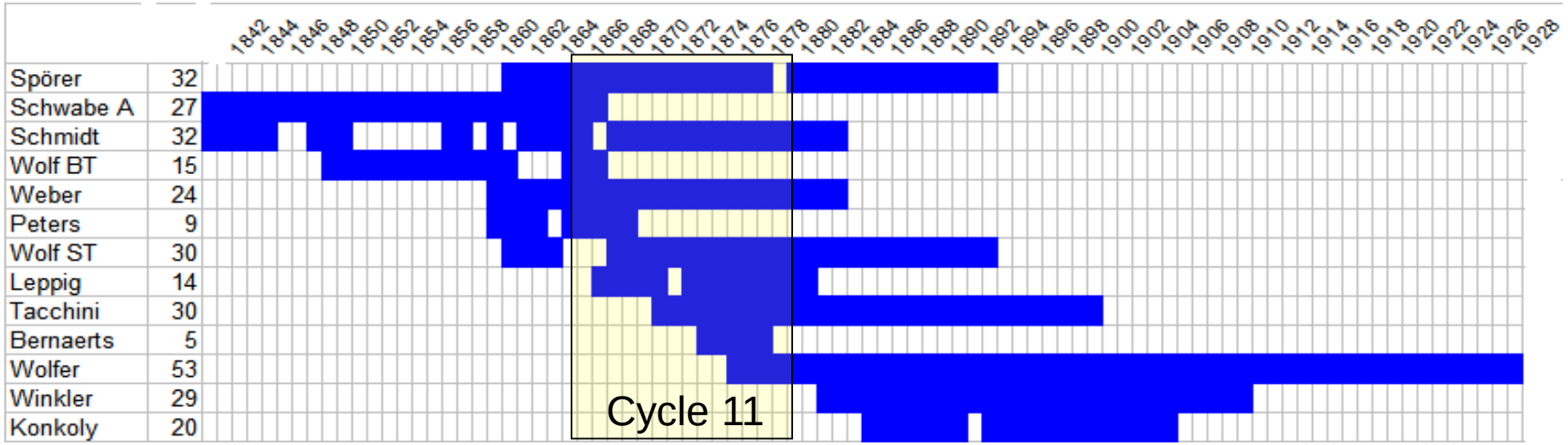
New Wolfer BB Agrees with Old

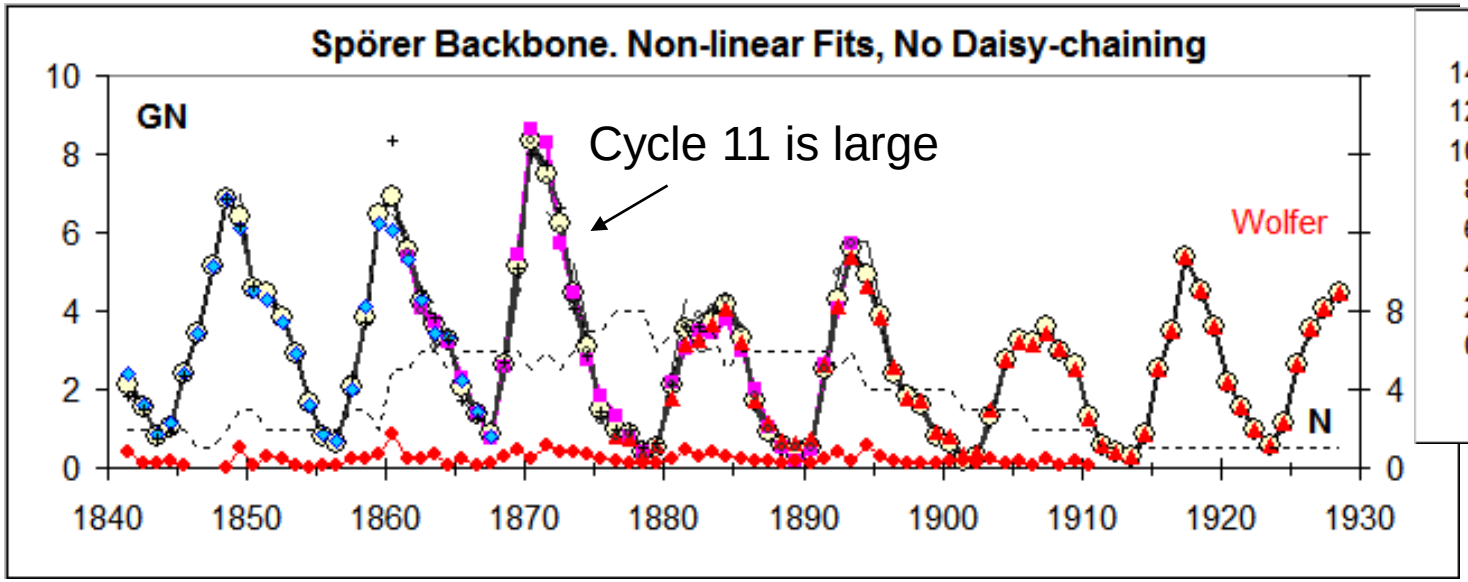


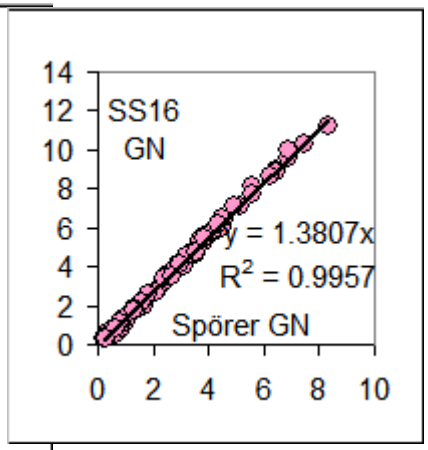
This Figure compares the yearly GNs for the old Wolfer Backbone (red curve) and the new Backbone presented here (blue curve). The two agree within their respective error bars.



Spörer Backbone Around Cycle 11

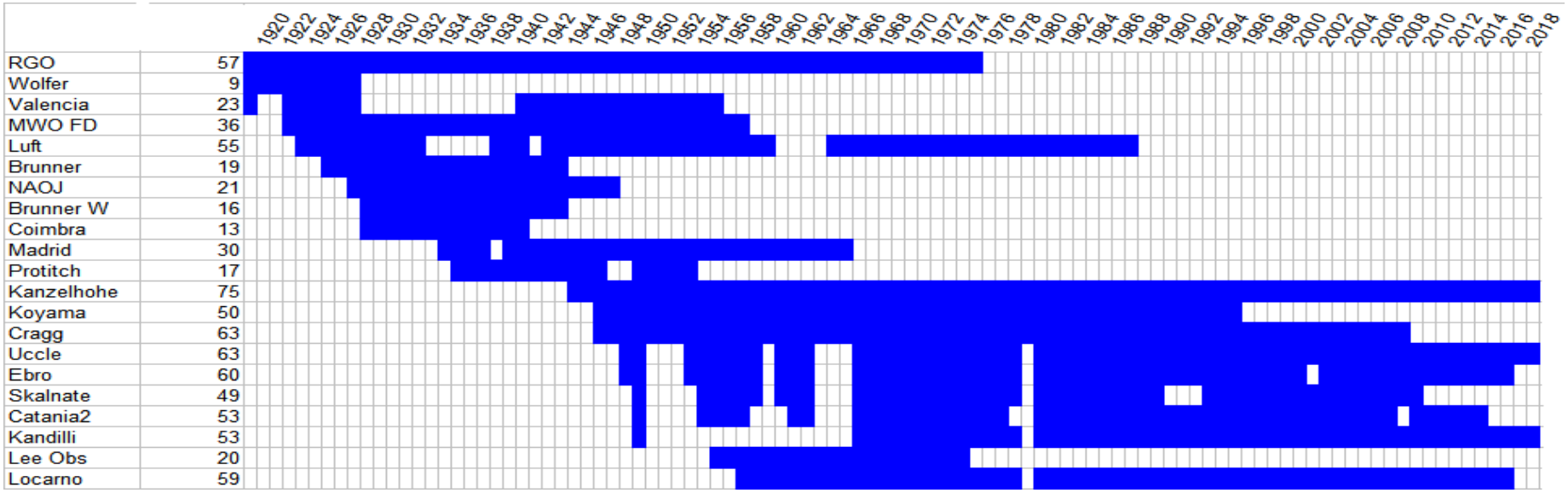


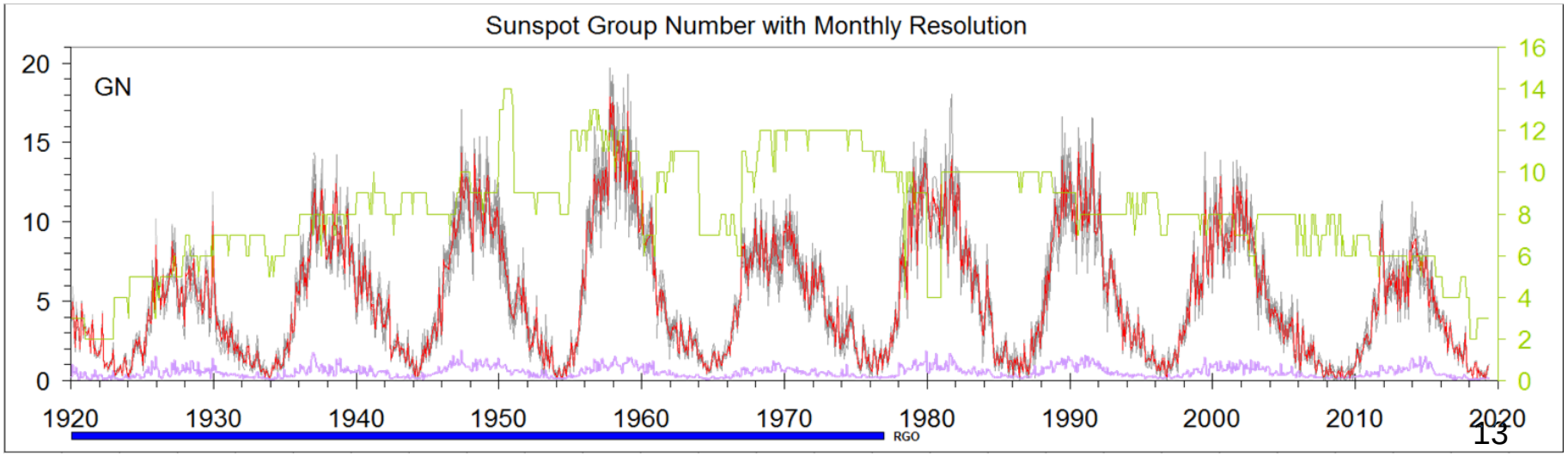




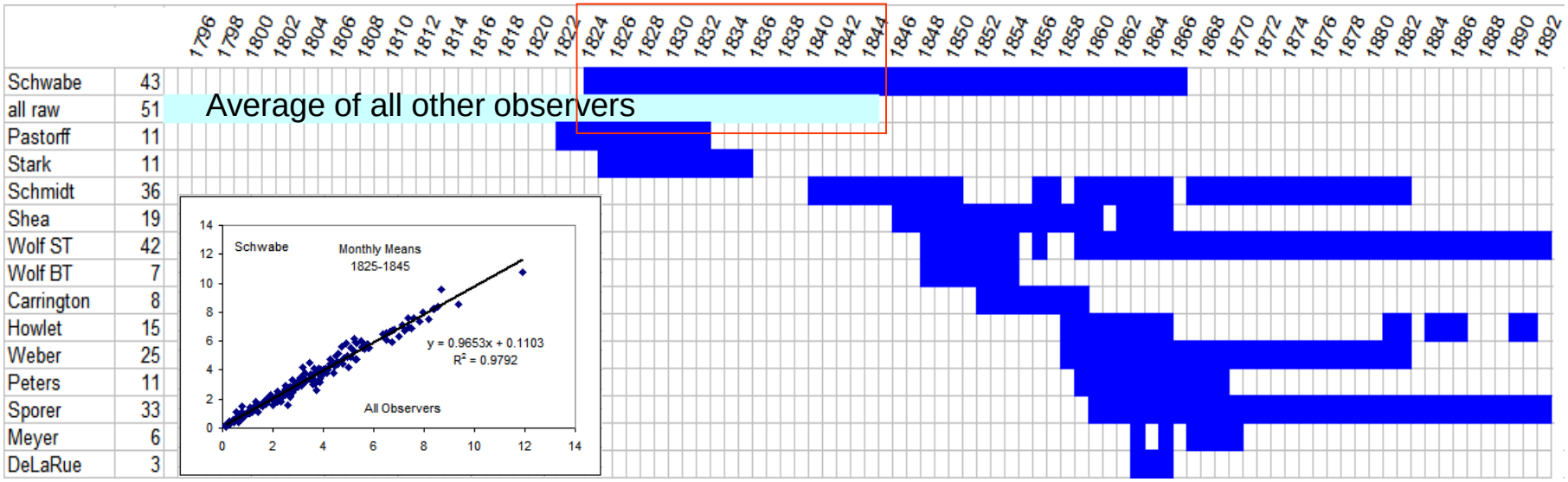
1.38*8.5 = 11.7

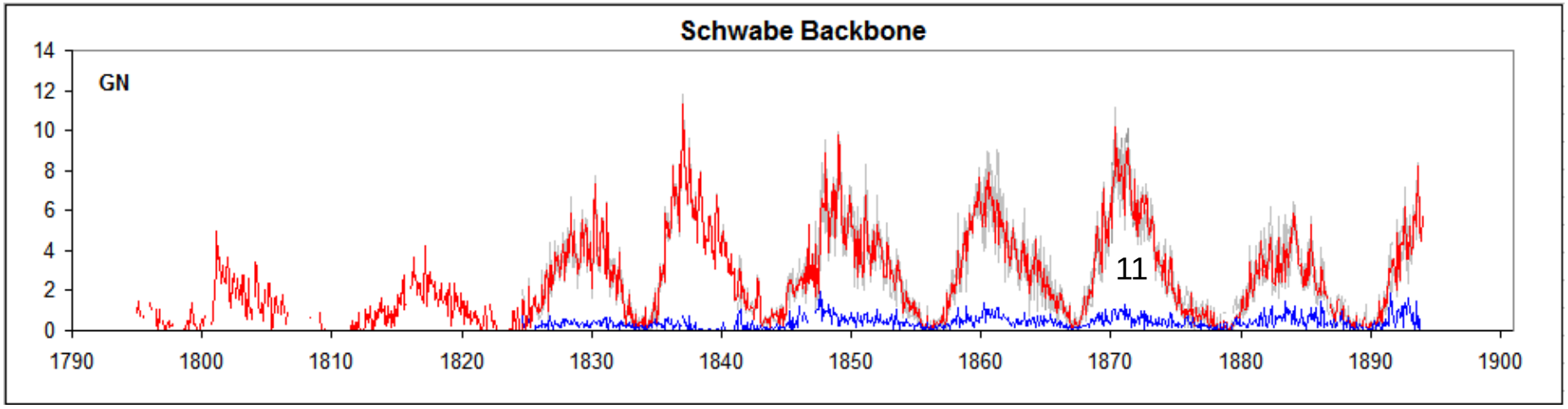
RGO Sunspot Group Number Backbone



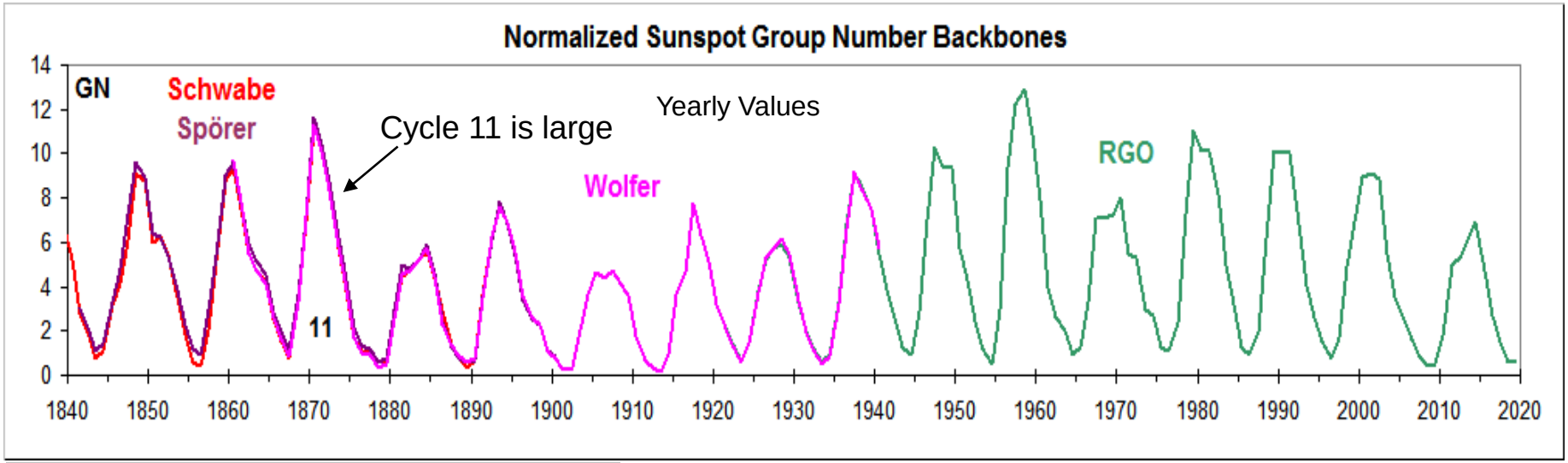


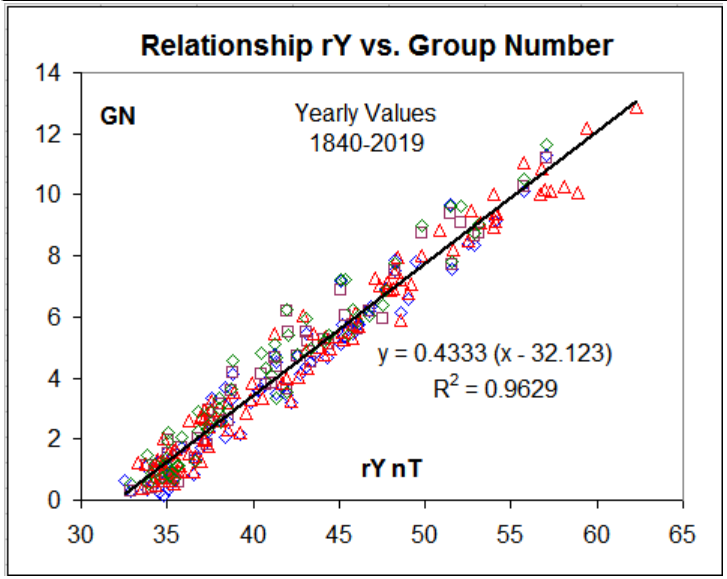
Schwabe Sunspot Group Number Backbone





Composite Sunspot Group Number Series

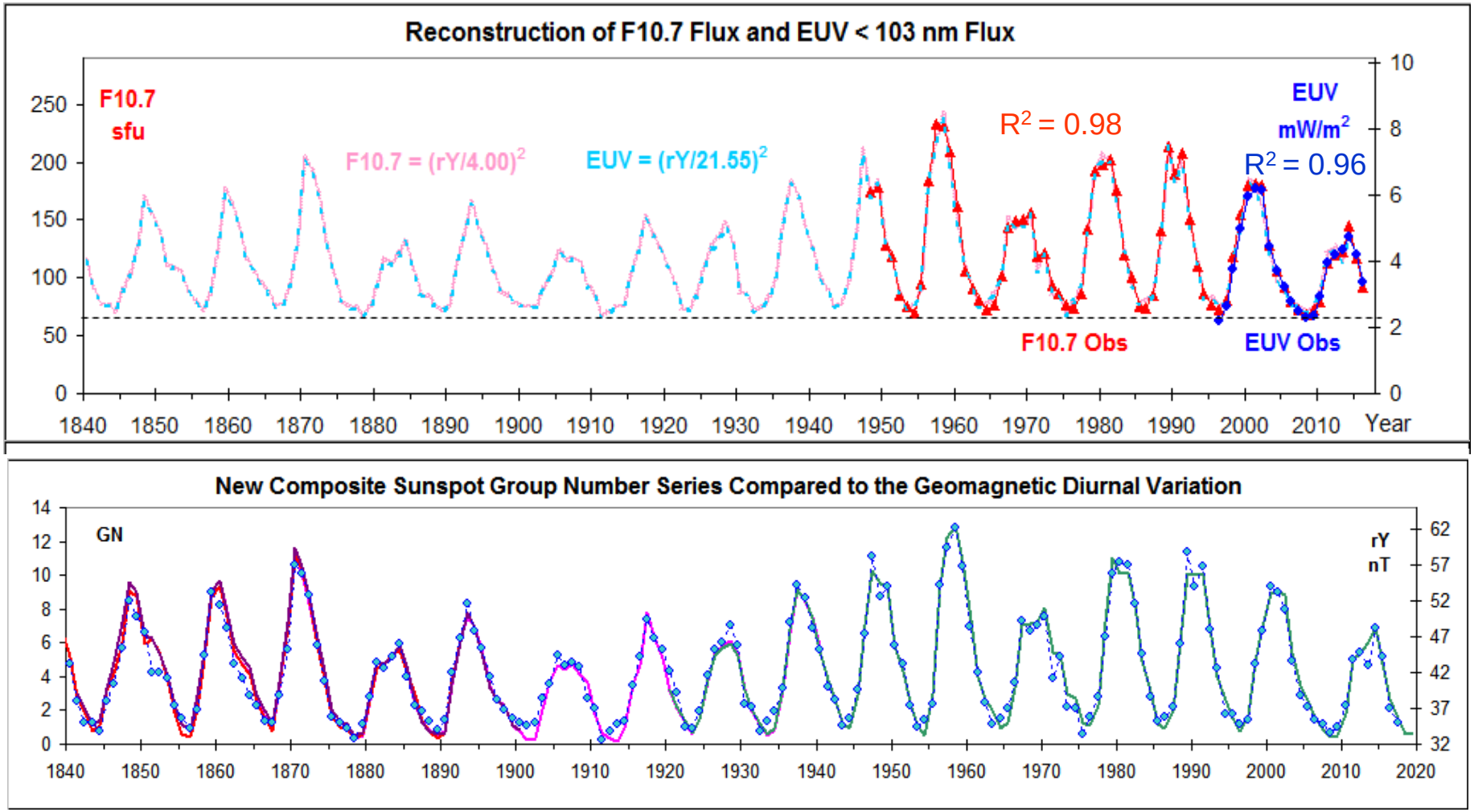




The Schwabe, Spörer, and RGO backbones overlap with the anchor Wolfer Backbone and can thus be scaled to the reference Wolfer Backbone. The scaling is found to be linear to high accuracy. The new composite is statistically indistinguible from the published S&S 2016 composite

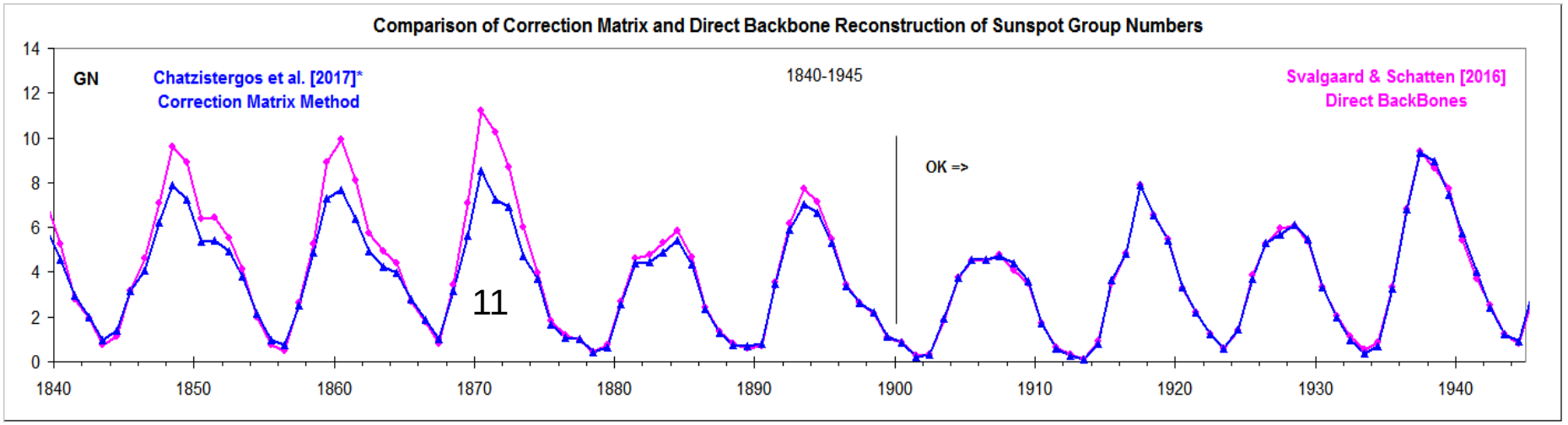
The four individual new backbones each have the same relationship with the geomagnetic diurnal range variation [at left with different colors]

Reconstructions of EUV, F10.7, and GN



As the Group Number and the EUV both depend simply on the solar magnetic field it is no surprise that they agree. If they did not, you would have to explain why not.

I End With a Sample Disagreement



All the analysis, hand waving, and gnashing of teeth can be boiled down to a simple issue: what was the size of sunspot cycle 11? Our analysis suggest that cycle 11 was on par with recent high cycles 21 and 22. Most of the dissenting analyses suggest that cycle 11 and cycles before that were considerably smaller thus leading to a significant upwards secular trend over the past three centuries that we do not support.

Our analysis presumes that the cause of the geomagnetic diurnal variation is well understood. If this is accepted, our conclusion follows. As the sunspot number SN closely matches the Group Number, the SN is also validated.