Re-analysis of the Wolfer Group Number Backbone

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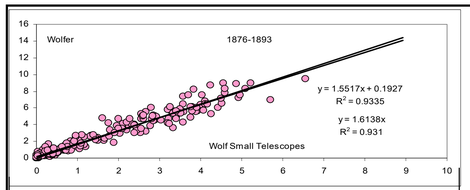
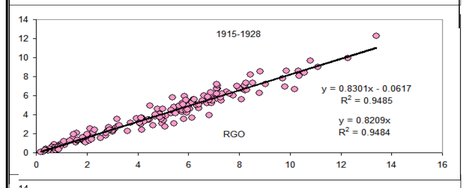
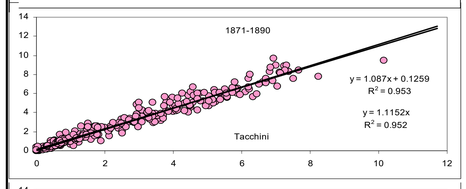
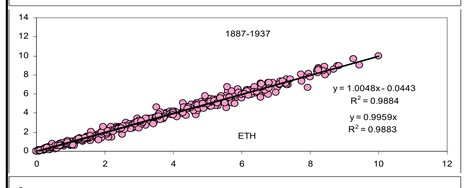
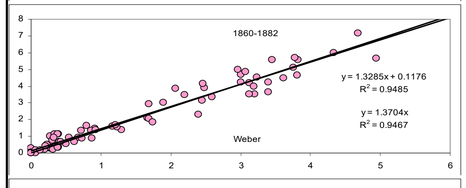
Svalgaard & Schatten (2016) used a 'backbone' method to reconstruct the Sunspot Group Number since 1610. Five backbones where used, centered and anchored on the Wolfer Backbone, which then defines the scale of the series. Backbones are constructed by scaling observers directly to the primary observer (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 (correlation plots at the left and below) 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 (with better determination of error bars) the new Wolfer Backbone has monthly resolution rather than the previous one's yearly values. The Figure below shows the years for which good-quality observers have overlap with Wolfer (on average 22 years).

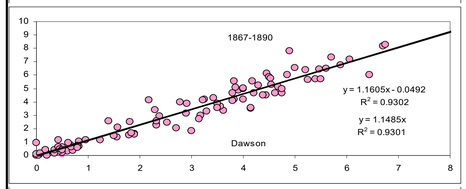


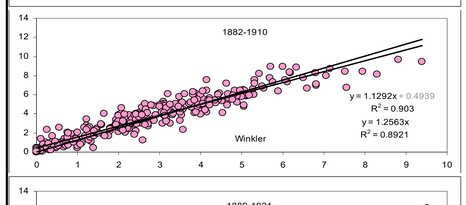


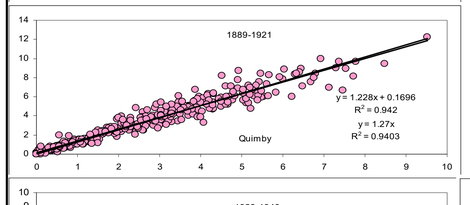








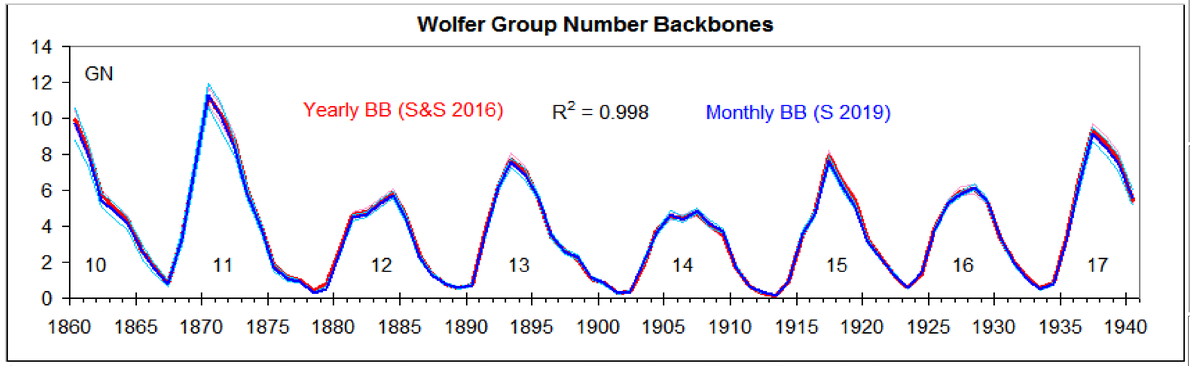


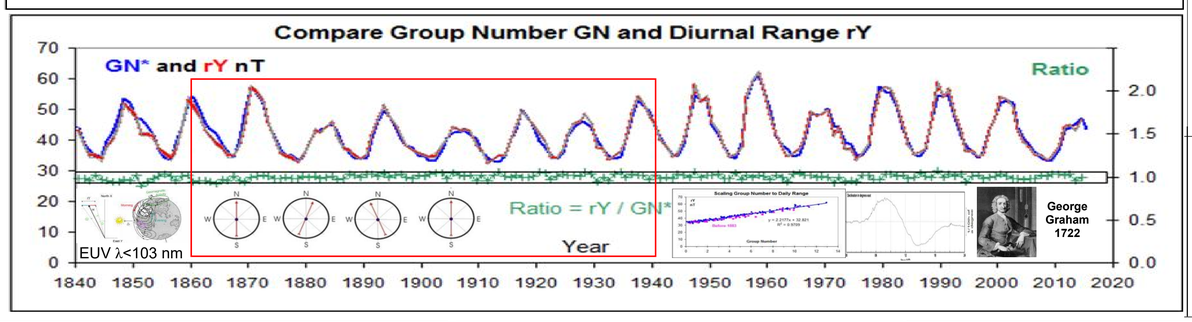


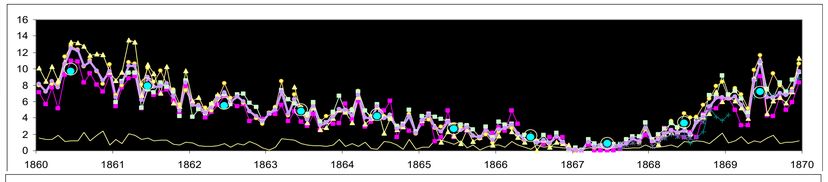
Observer	Months
Wolfer	622
Schmidt	248
Wolf.ST	426
Weber	280
Spörer	388
Dawson	135
Leppig	131
Tacchini	350
Moncalieri	213
M.W.Review	115
Ricco	143
Winkler	340
Konkoly	247
ETH	582
Quimby	390
Hadden	311
Catania	311
Broger	470
Woinoff	184
Guillaume	284
Batavia	191
Moye	180
Buttlar	90
RGO	372
Stonyhurst	180
MWO.FD	216
Brunner	175
Obs	602

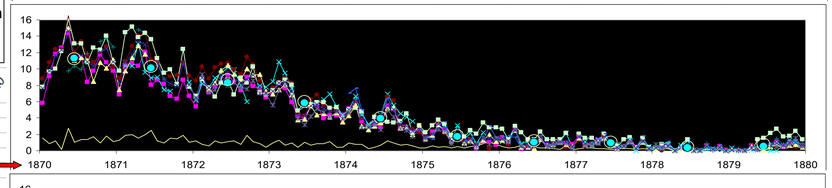
Using the scaling factors (*k*-values) for each observer they are all put on the Wolfer Scale and plotted with different colors (to the right) for each decade. The 1-σ error (yellow curve) is calculated as the standard deviation for the month divided by the square-root of the number of observers. Large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

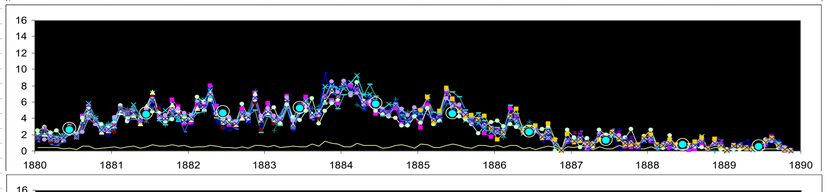
The Figure below compares the yearly GNs for the old Wolfer Backbone (red curve) and the new Backbone presented here (blue curve). The two agree within their respective error bars. The Group Number [either one, as they agree] follows closely the amplitude of the diurnal variation of the geomagnetic east component caused by currents in the ionosphere due to EUV.

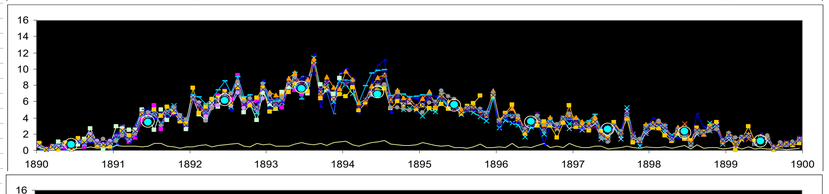


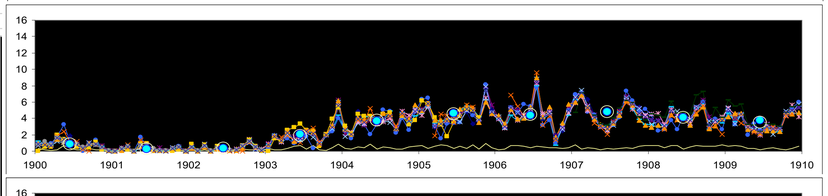


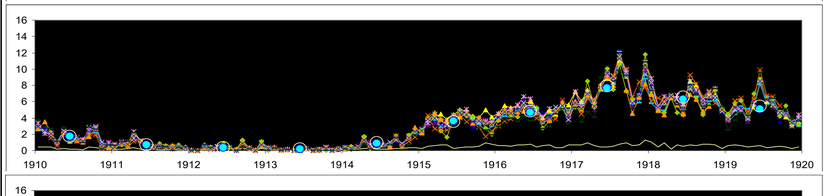


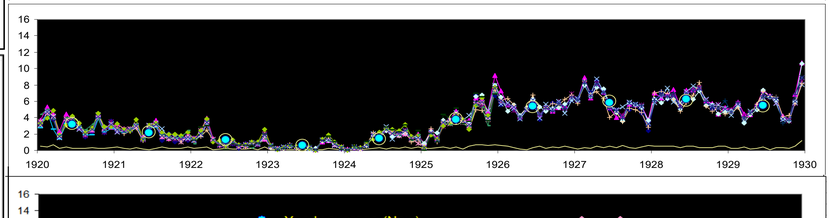


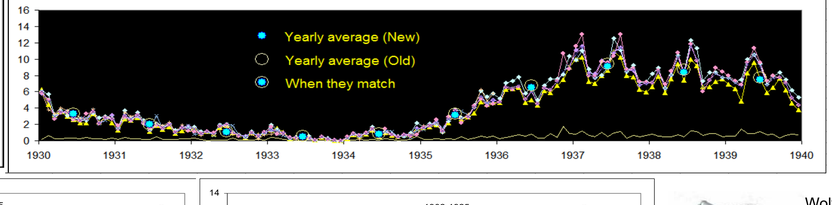


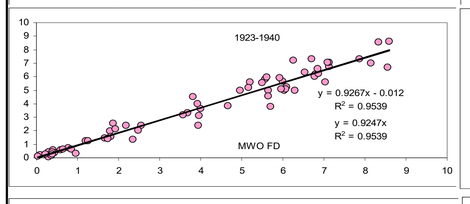


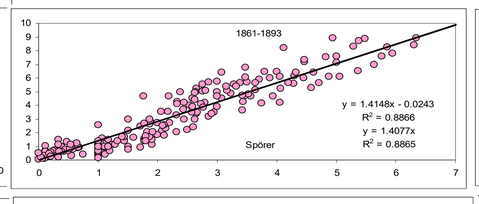


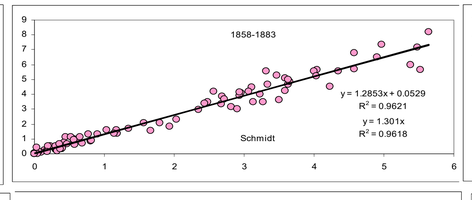


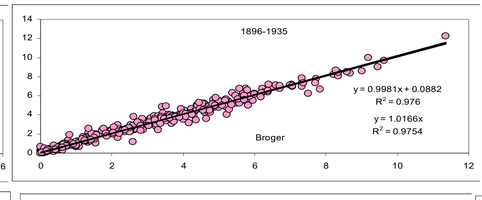


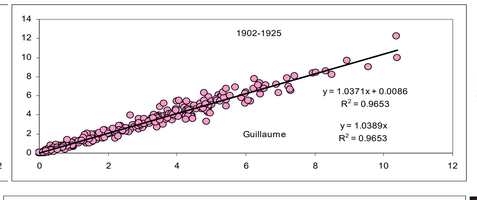


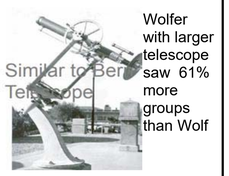




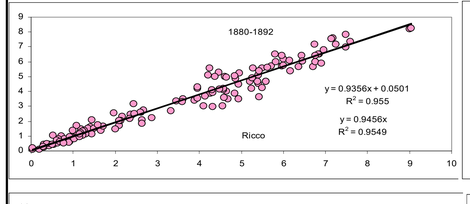


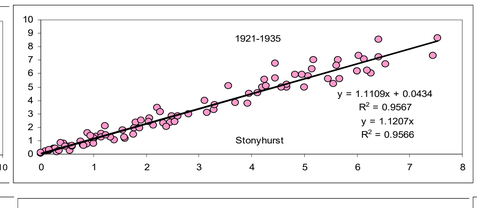


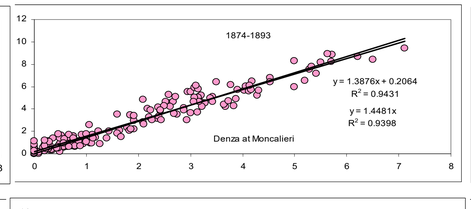


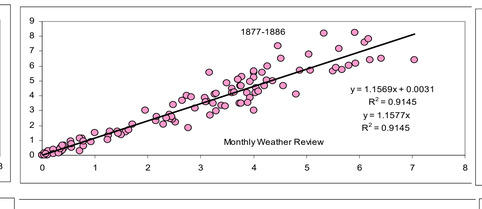


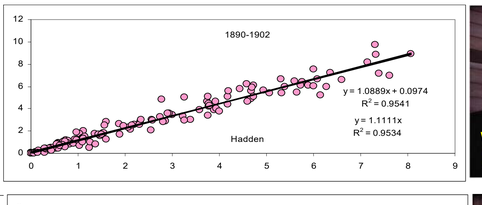
Wolfer with larger telescope saw 61% more groups than Wolf

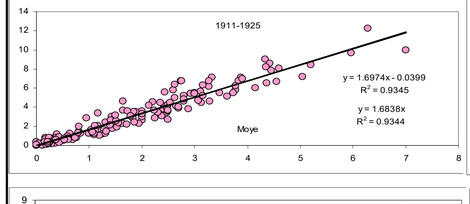


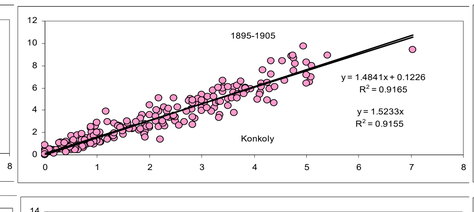


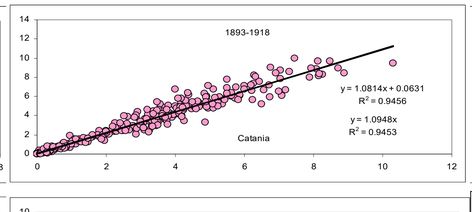


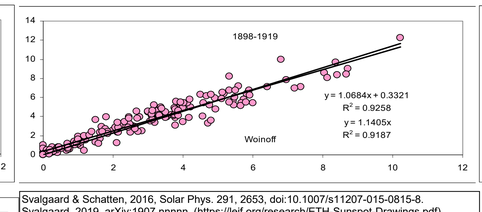


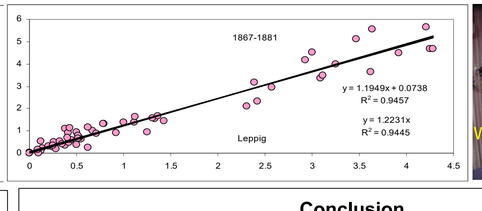


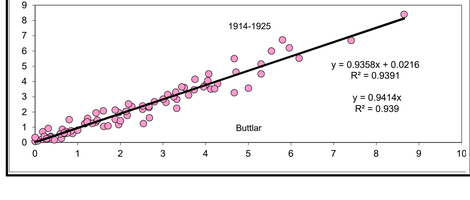


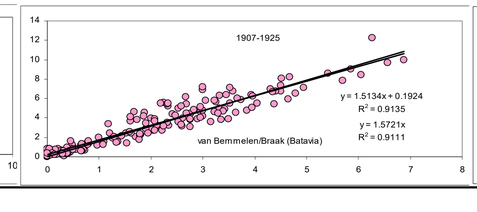


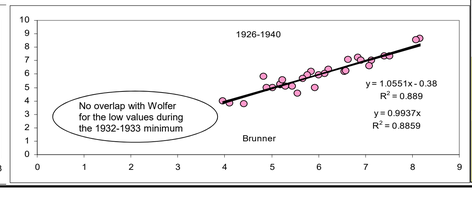












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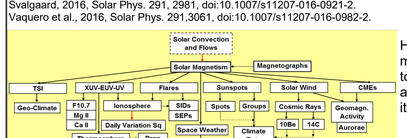

How it all must fit together and how it does

Conclusion

The Backbone Reconstruction of the Sunspot Group Number is anchored by the Wolfer Backbone. A new reconstruction with monthly time resolution covering the interval 1860-1940 using all long-term observers overlapping with Wolfer agrees well with a preliminary series (Svalgaard & Schatten, 2016) with yearly resolution. This resolves the problem of the correct level of activity in the latter part of the 19th century and paves the way for trustworthy reconstructions of TSI and the Open Magnetic Flux, and for calibration of the cosmic ray proxies.