Schwabe to Waldmeier: 1826 to 1980 reprised

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4rd Sunspot Workshop, Locarno, CH

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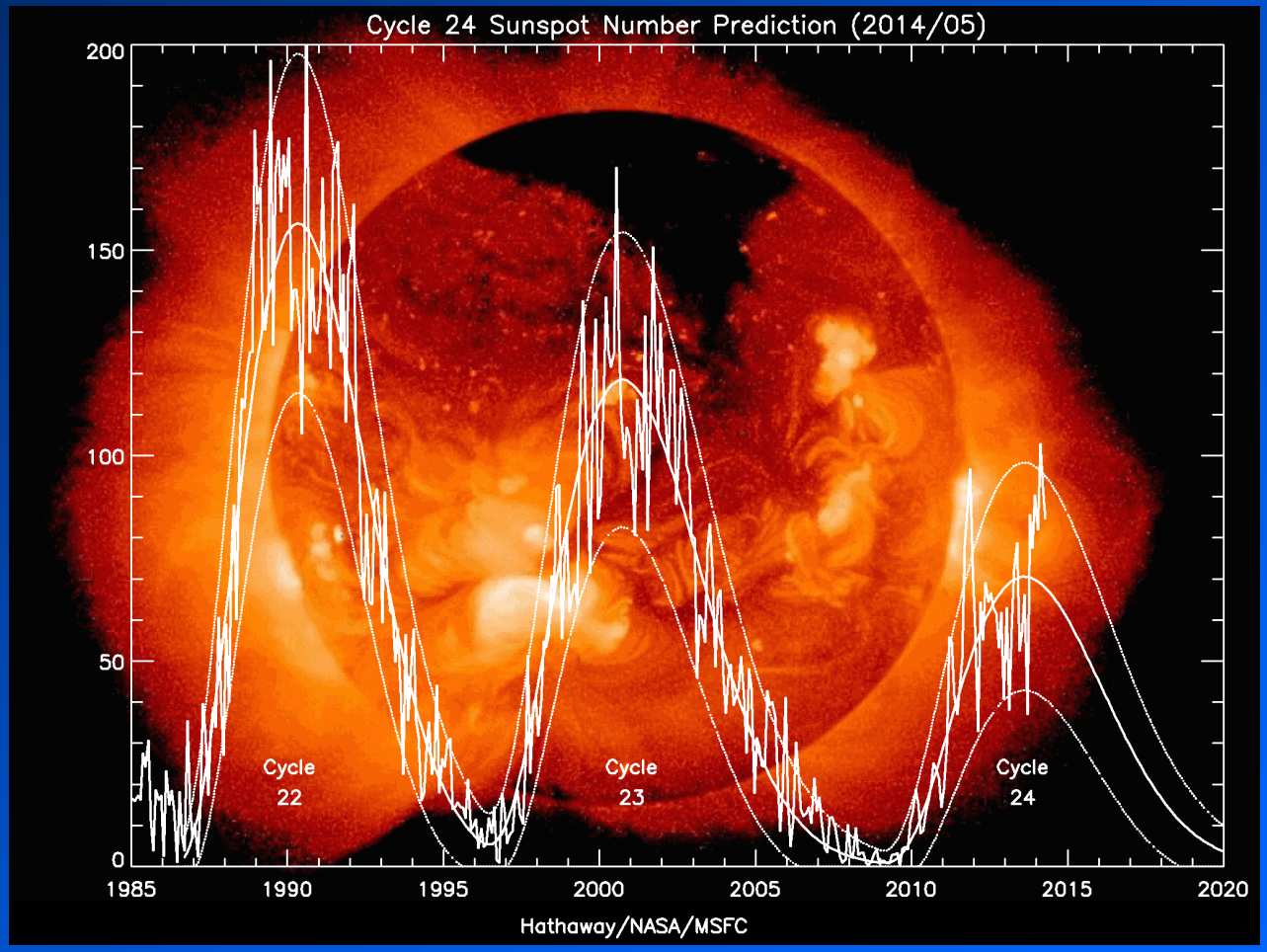
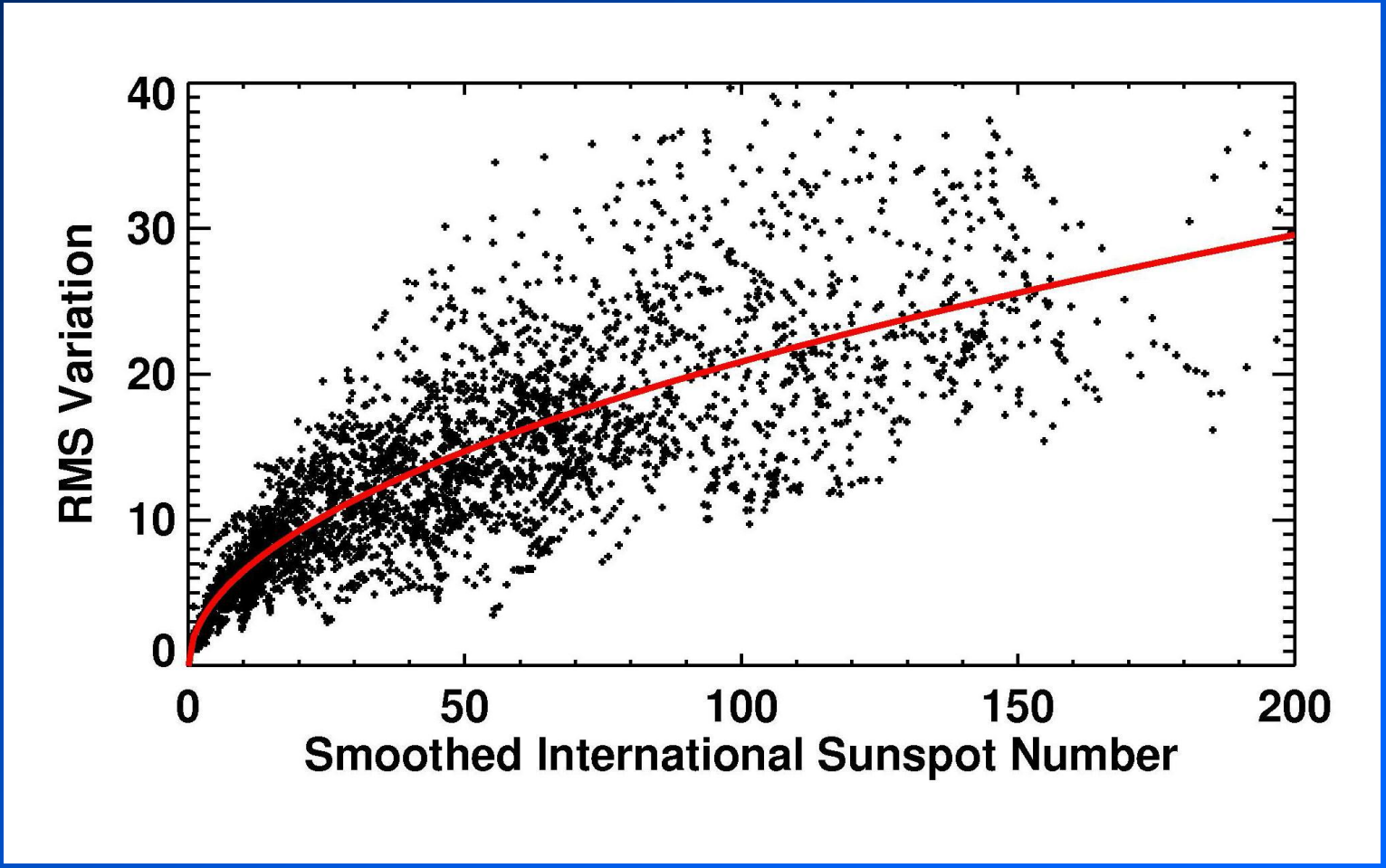
Monthly RMS Proportional to $\sqrt{R_I}$

For years I have shown the expected range of monthly values relative to my prediction as 3.3 $\sqrt{R_I}$ which seems to contain ~95% of the variations.



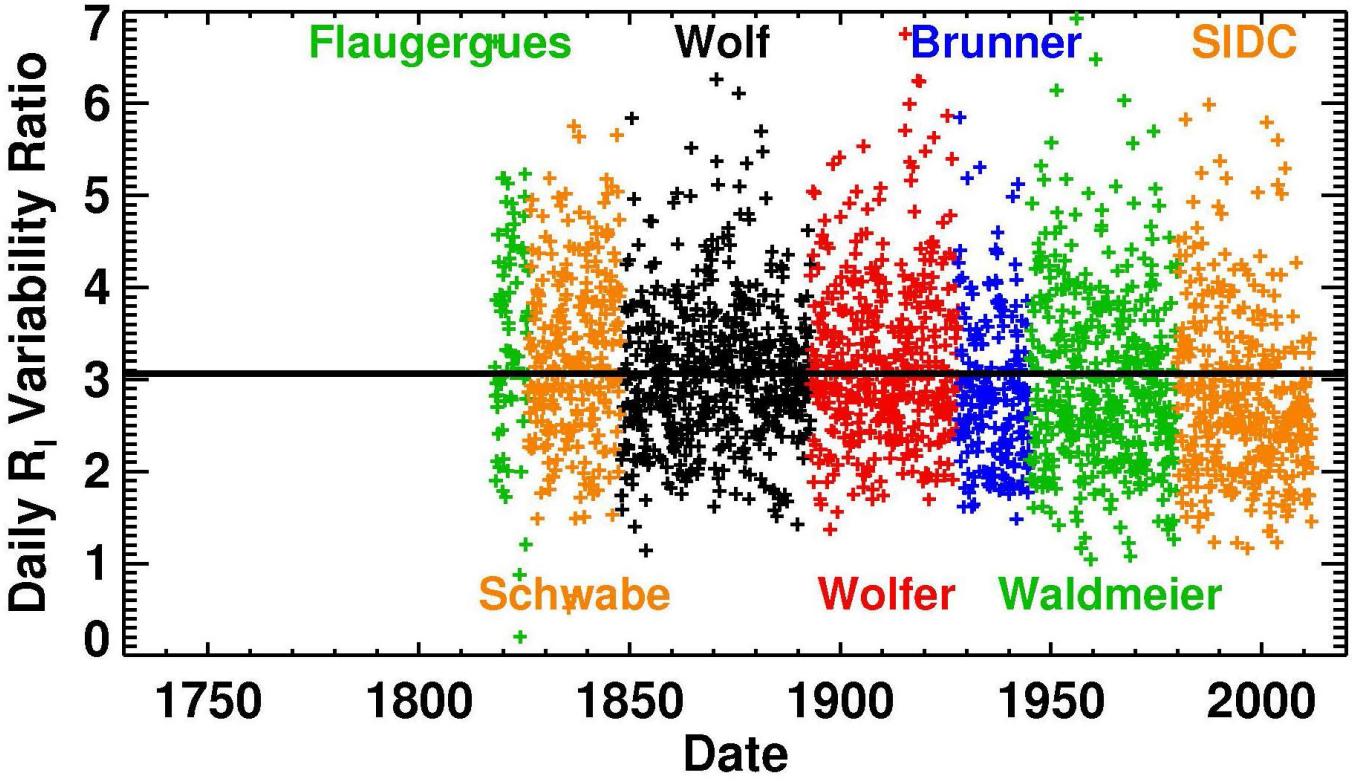
Variations in Monthly R_I

Plotting the RMS variation of the 13 monthly values in the 13-month running mean of R_I since 1749 shows a good fit (albeit with substantial scatter) to 2.1 $\sqrt{R_I}$.



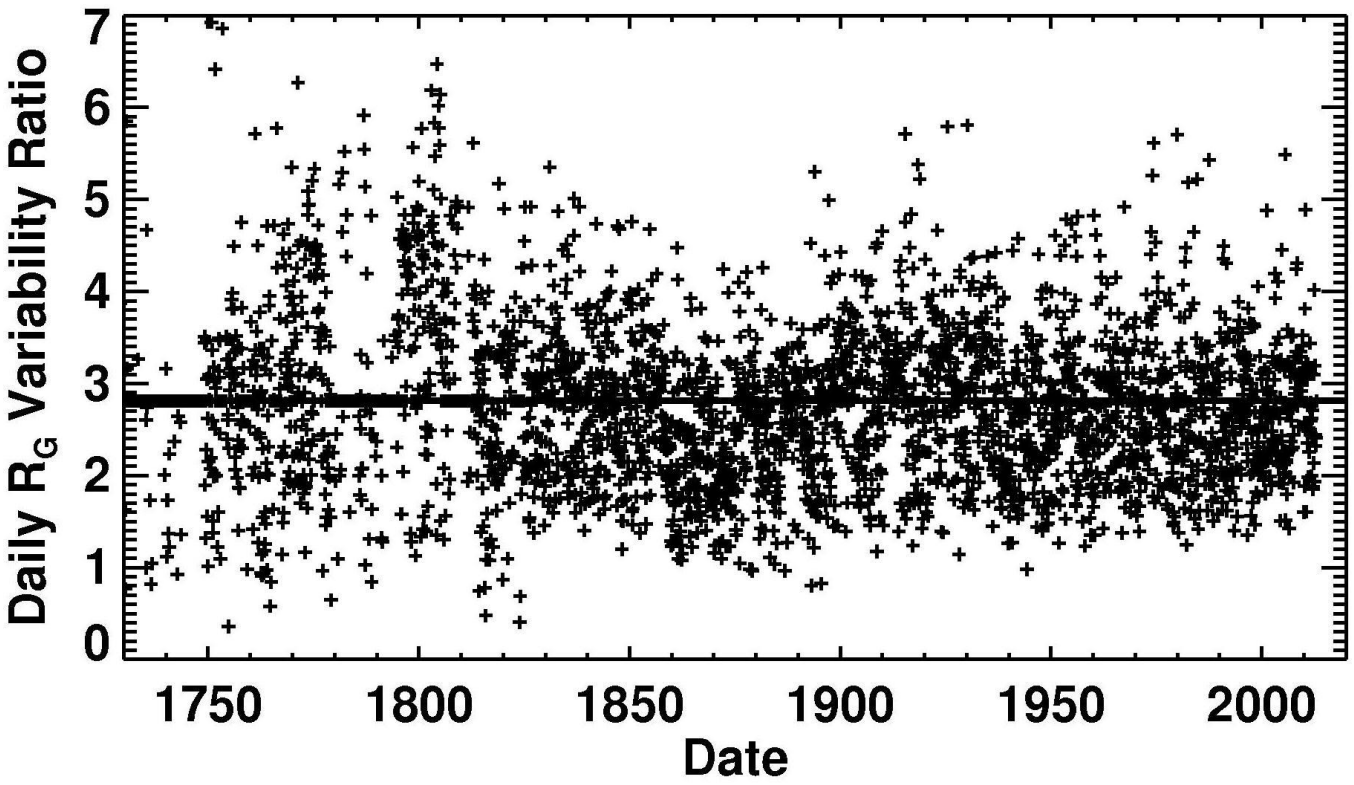
Daily R_I Variability Ratio History

Plotting the Daily Variability Ratio (the ratio of the RMS variation of the daily values from the monthly mean to the square-root of the monthly mean itself) as a function of time also shows a fairly constant value (a somewhat higher 3.0) with no indication of any long-term trends.



Daily R_G Variability Ratio History

Plotting the R_G Daily Variability Ratio as a function of time shows similar behavior - a fairly constant value from about 1900 to the present but with lower values from ~1850 to 1900 and higher values from ~1750 to 1810..



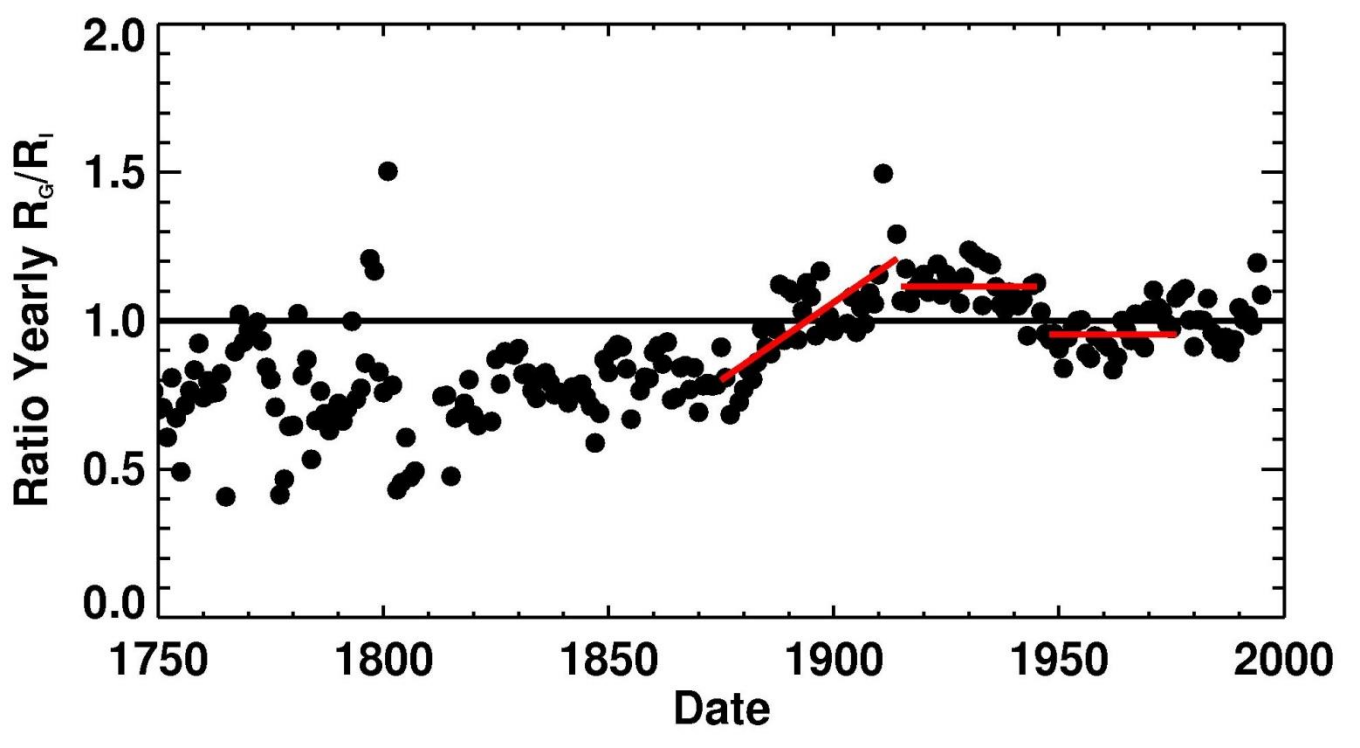
Statistical Test Conclusions

- Variations in the Sunspot Number follow Poisson Statistics and are proportional to the square-root of the number itself
- The ratio of the variability in the Sunspot Number to the square-root of the average value is relatively constant in time
- However, changes in this ratio do not appear to be helpful in finding scaling changes in the Sunspot Number

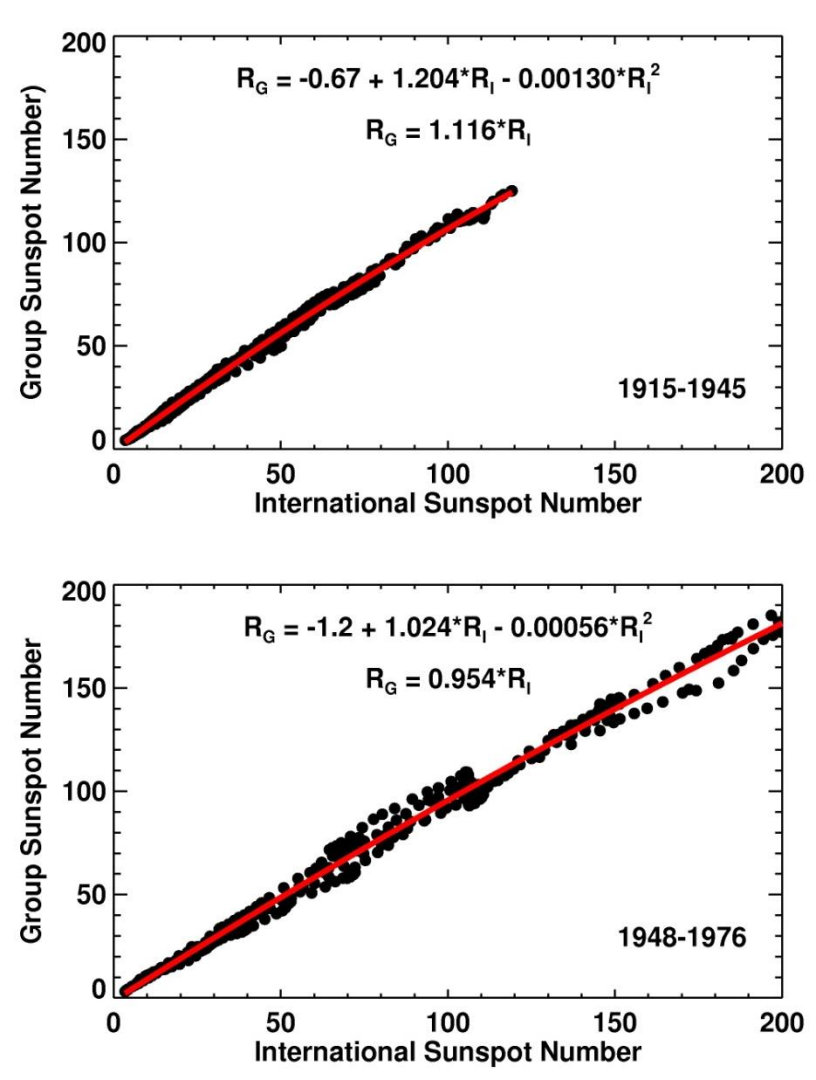
Ratio (R_G/R_I) of Yearly Averages

Per Svalgaard: Ratio if $R_I>4$ and $R_G>4$

1. The Waldmeier Discontinuity: 1946
2. Early RGO Trend: 1874-1910



Waldmeier Discontinuity 1



Using R_G for comparison,

Ratio After = 1.17 Ratio Before

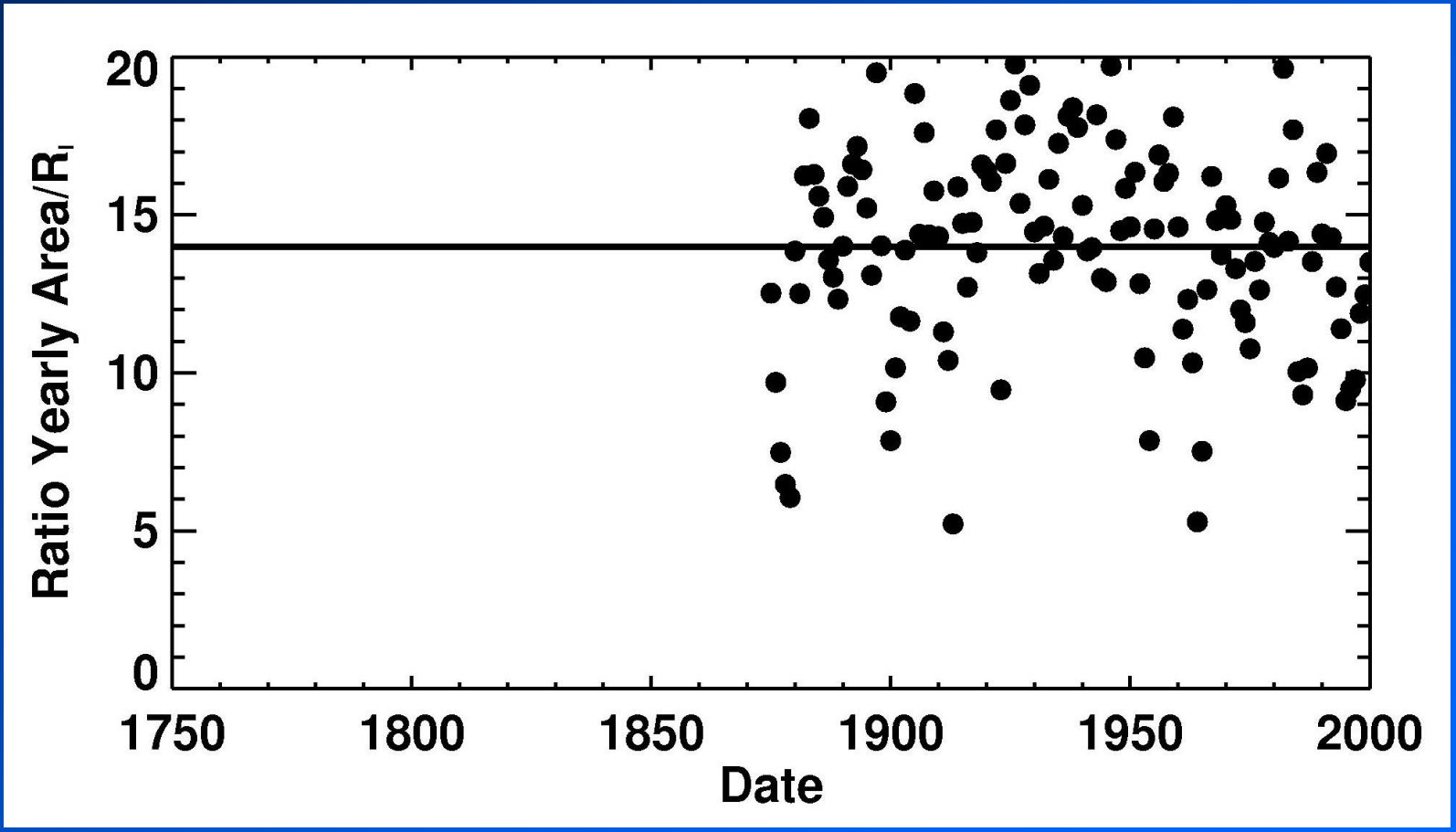
Slope After = 1.18 Slope Before

Result is fairly independent of smoothing but depends somewhat on the length of the interval before and after (~30 years here).

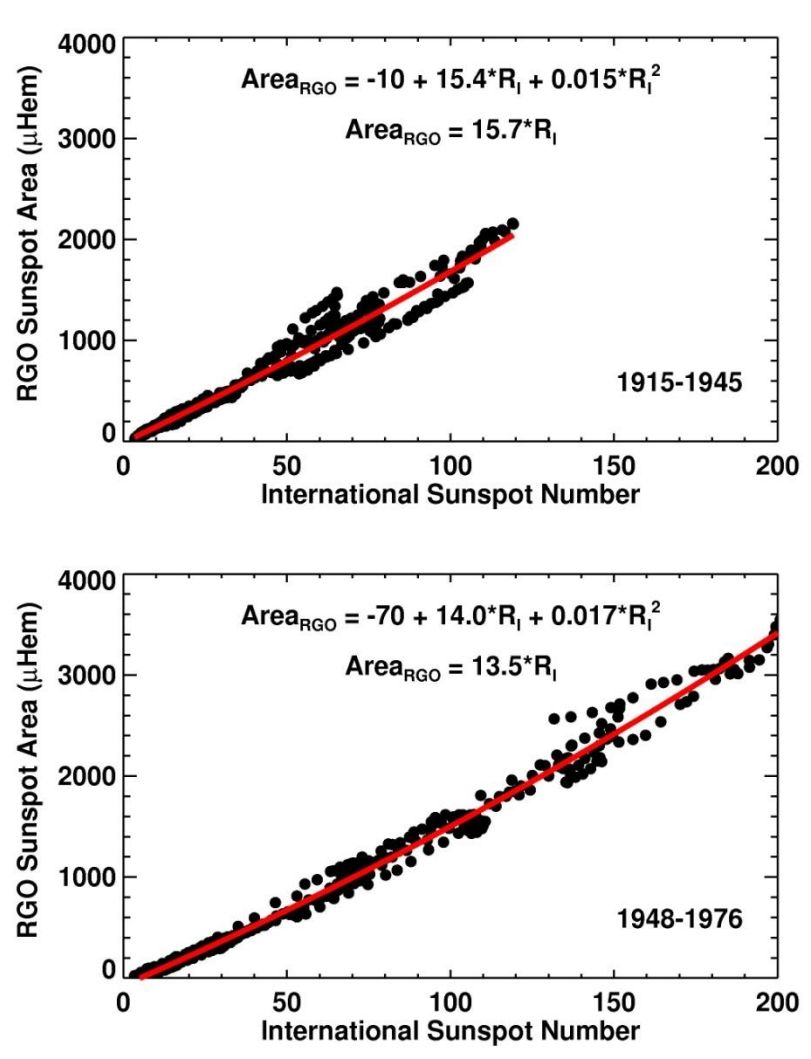
The relationship is nonlinear – there are more sunspots per group when the sunspot number is high.

Waldmeier Discontinuity 2a

Using RGO total area (corrected for projection) for comparison – not so clear, but…



Waldmeier Discontinuity 2b



Using RGO total area (corrected for projection) for comparison,

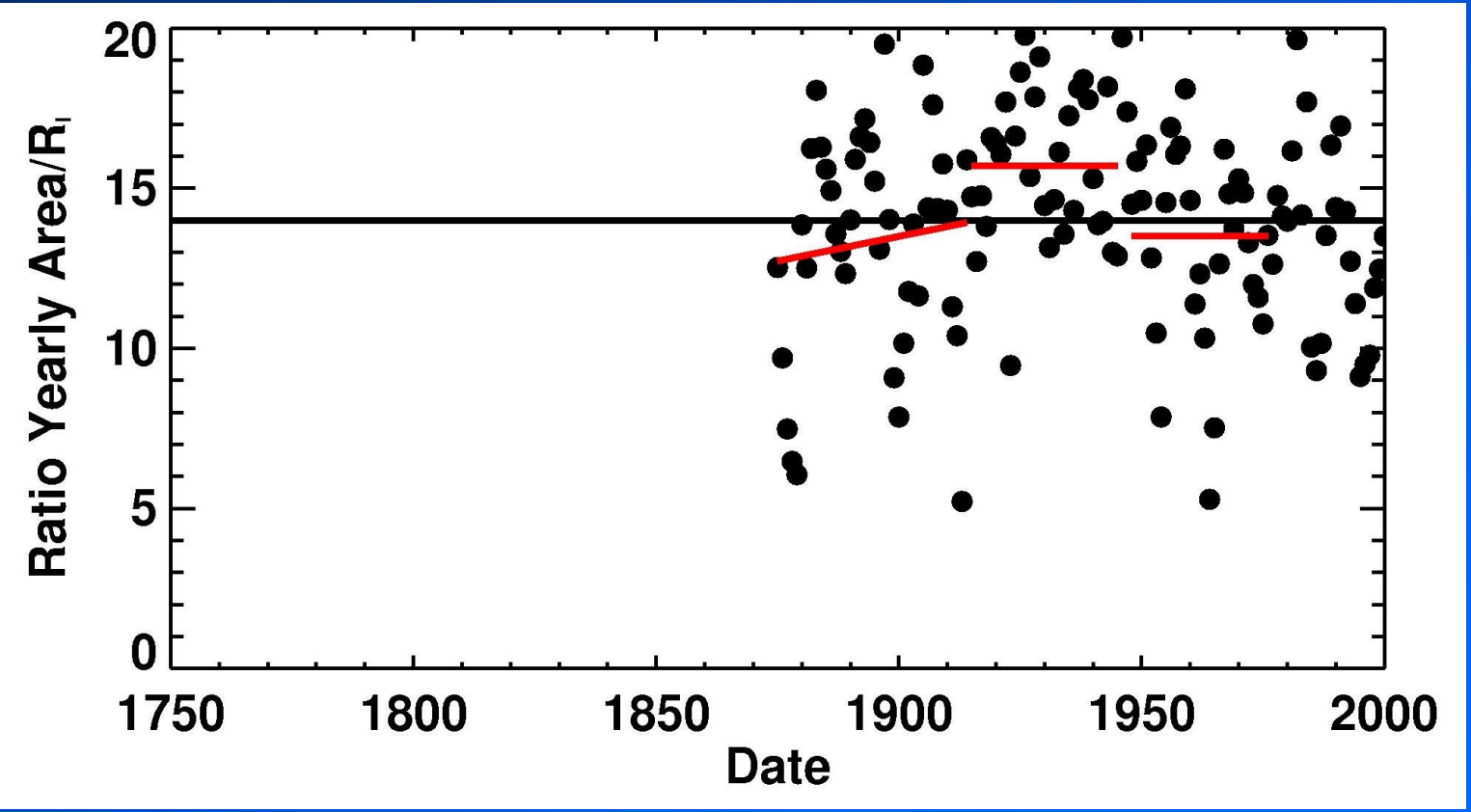
Ratio After = 1.16 Ratio Before

Slope After = 1.10 Slope Before

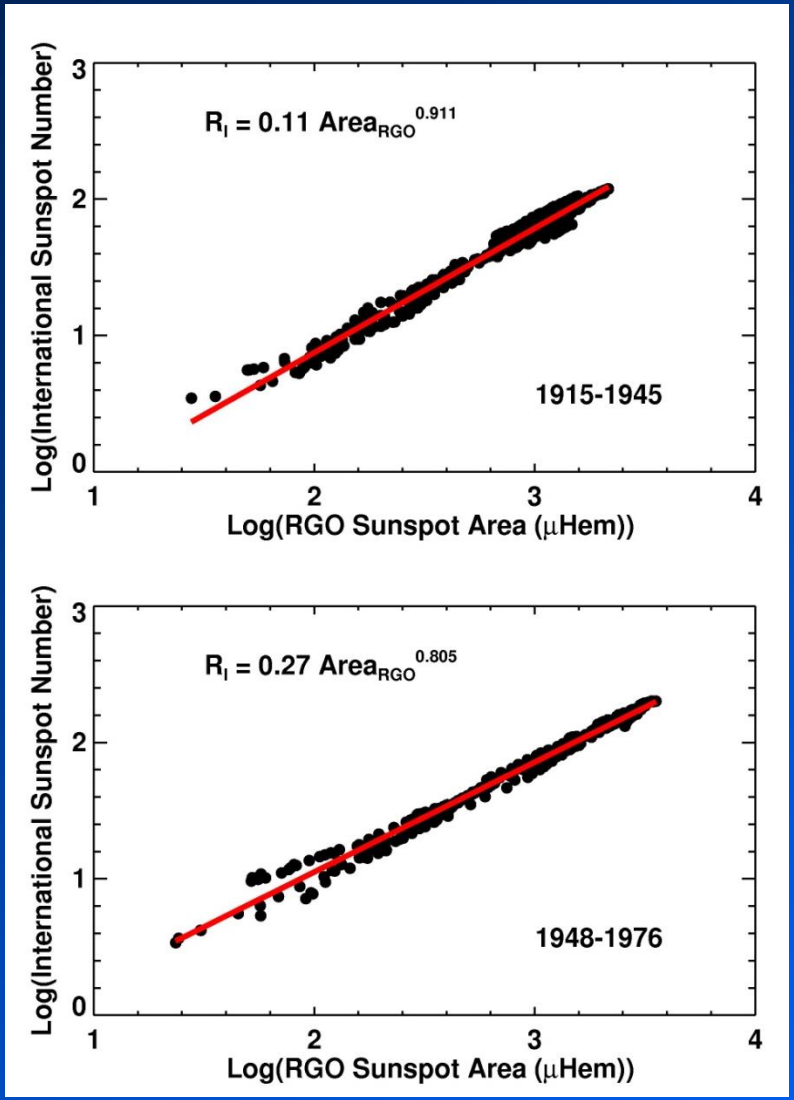
Relationship is nonlinear – more sunspot area per sunspot when sunspot number is high.

Waldmeier Discontinuity 2c

Using RGO total area (corrected for projection) for comparison – not so clear, but similar offsets and the early trend is seen.



Waldmeier Discontinuity 2d



Using RGO total area (corrected for projection) for comparison,

$R_I = 0.11\ Area^{0.911}$ before

$R_I = 0.27\ Area^{0.805}$ after

I suspect the same is true with projected areas.

Conclusions

- Comparing R_I to either R_G or area gives similar results:
  - The Waldmeier discontinuity in ~1946
  - An upward trend in RGO groups and total area from 1874 to ~1900 (consistent with missing small spots)

TSI vs. R_I

PMOD vs. ACRIM relationship to sunspot number