New calibrated sunspot group series since 1749

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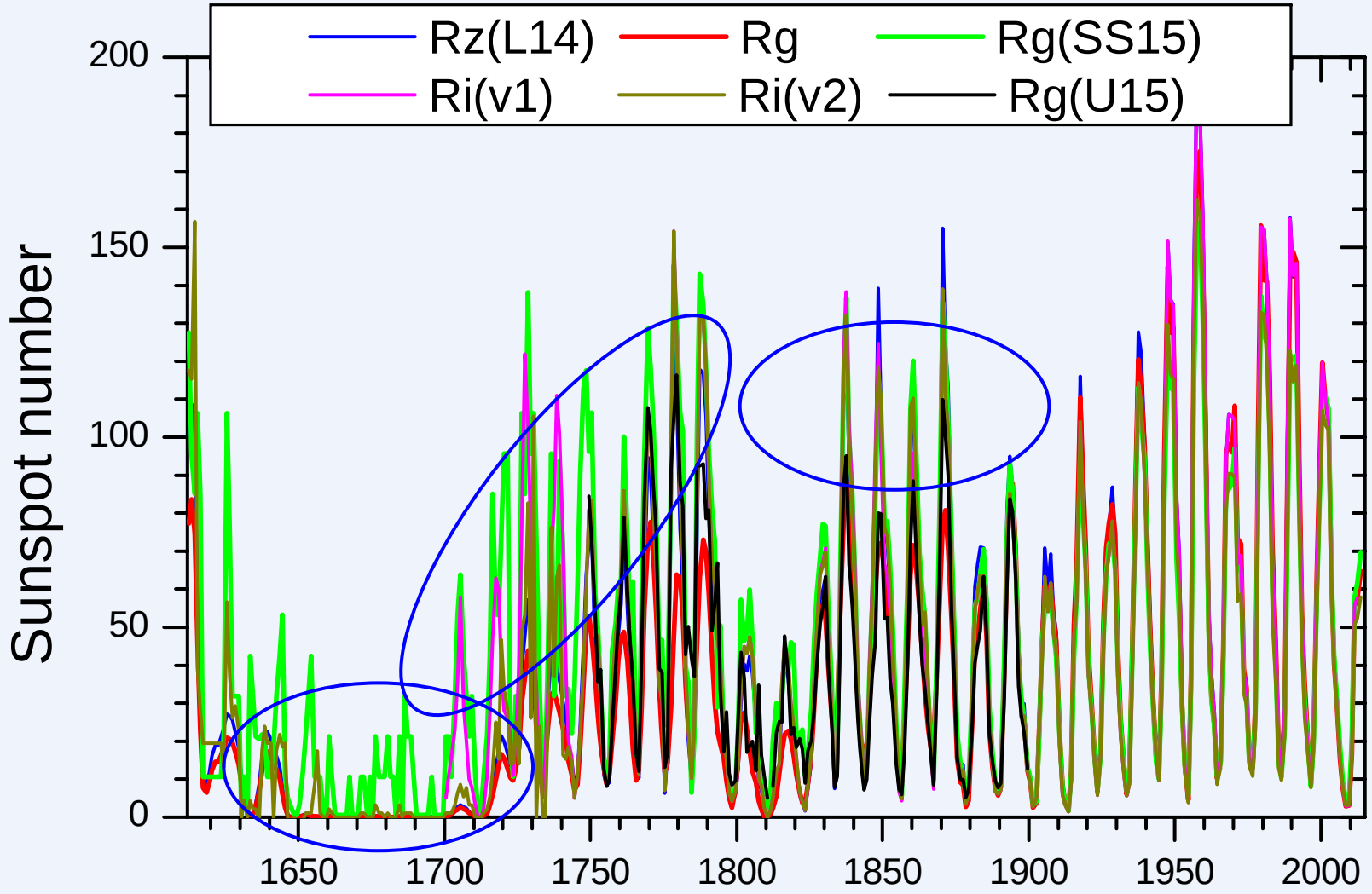
8 SN series around

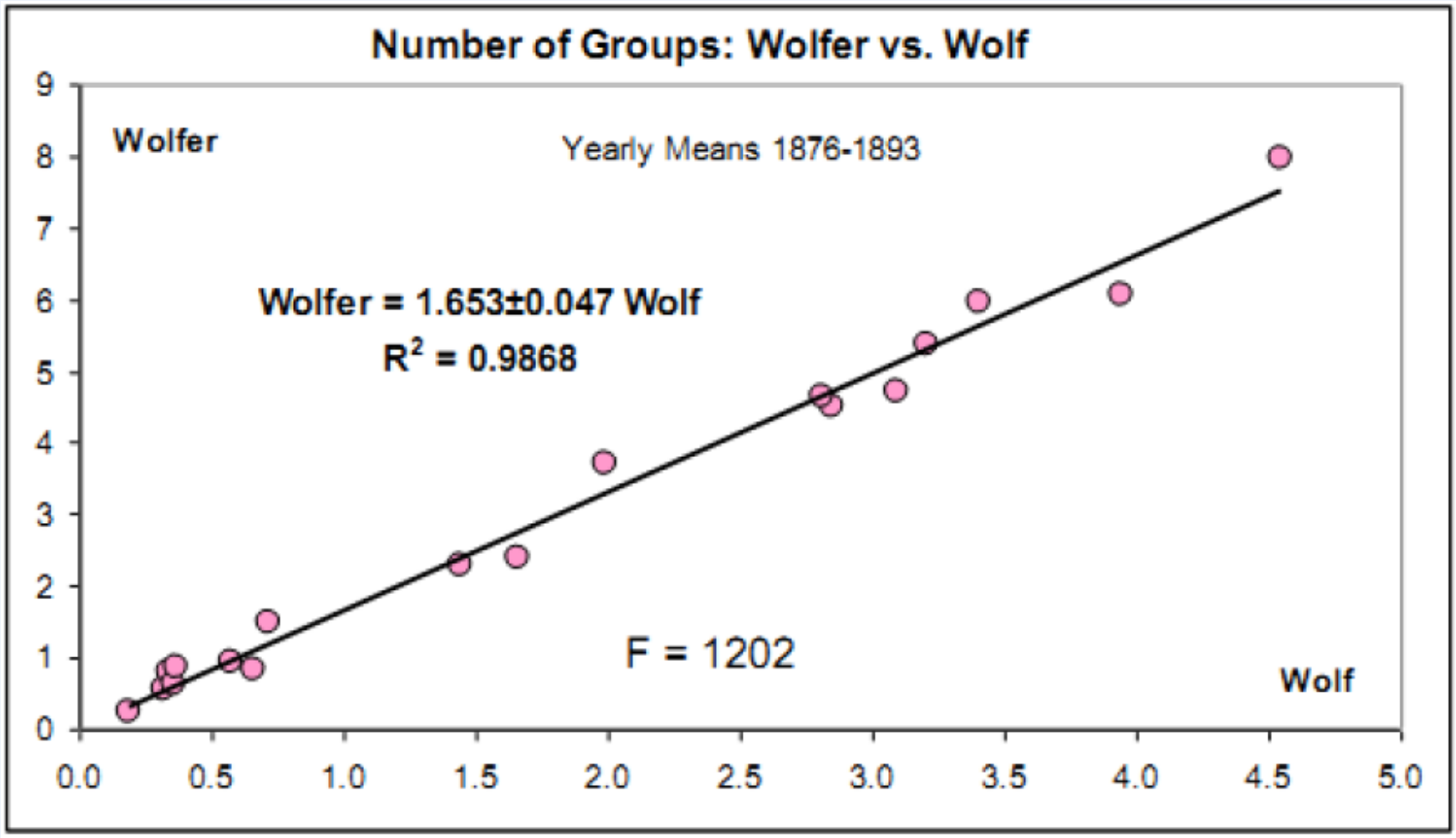


Lets have a look

$$Rg = 12.08 * \langle k_i * G_i \rangle$$

is here!

Linear scaling: Wolf-vs-Wolfer



Linear scaling over annual data points

(Svalgaard & Schatten (2015); Clette et al. (2014); Wolfer (1895))

Is this simple linear scaling correct?

Linear regression?

Assumptions for the ordinary least square regression:

X – X-values are known exactly → *X is a fixed value, not a random variable.*

X - Linearity → *relation X ←→Y is linear in the entire range.*

X - Normality → *errors are normally distributed.*

x? Constant variance (homoscedasticity) → *additive noise, not multiplicative.*

V - Independence of errors.

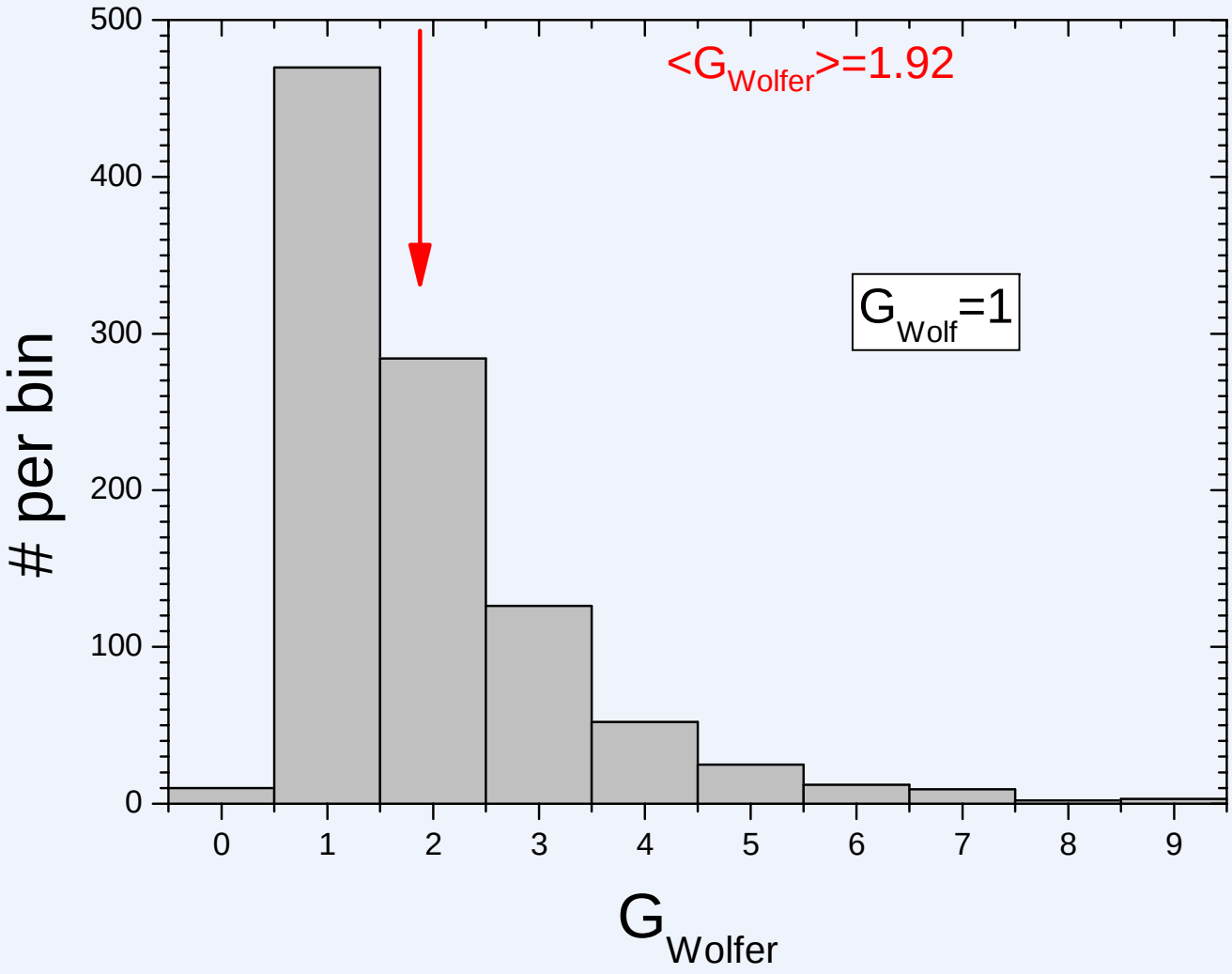
x? - Lack of multicollinearity

X - Forcing through the origin

X – Annual averaging

4-6 out of 7 assumptions are violated →
OLS regression is formally invalid

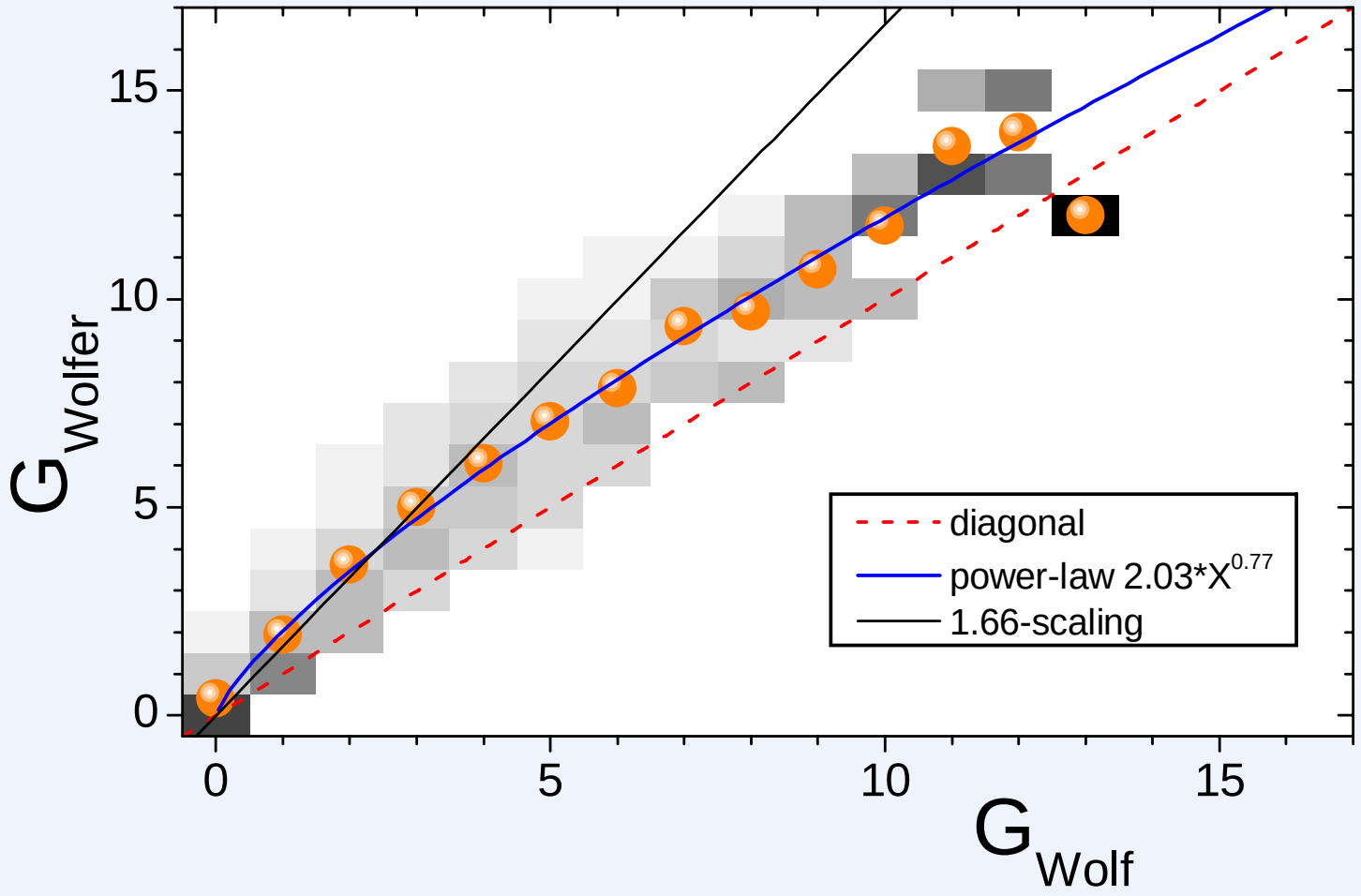
Is the relation really one-to-one?



Mean = 1.92
Mode = 1
Median = 0.95

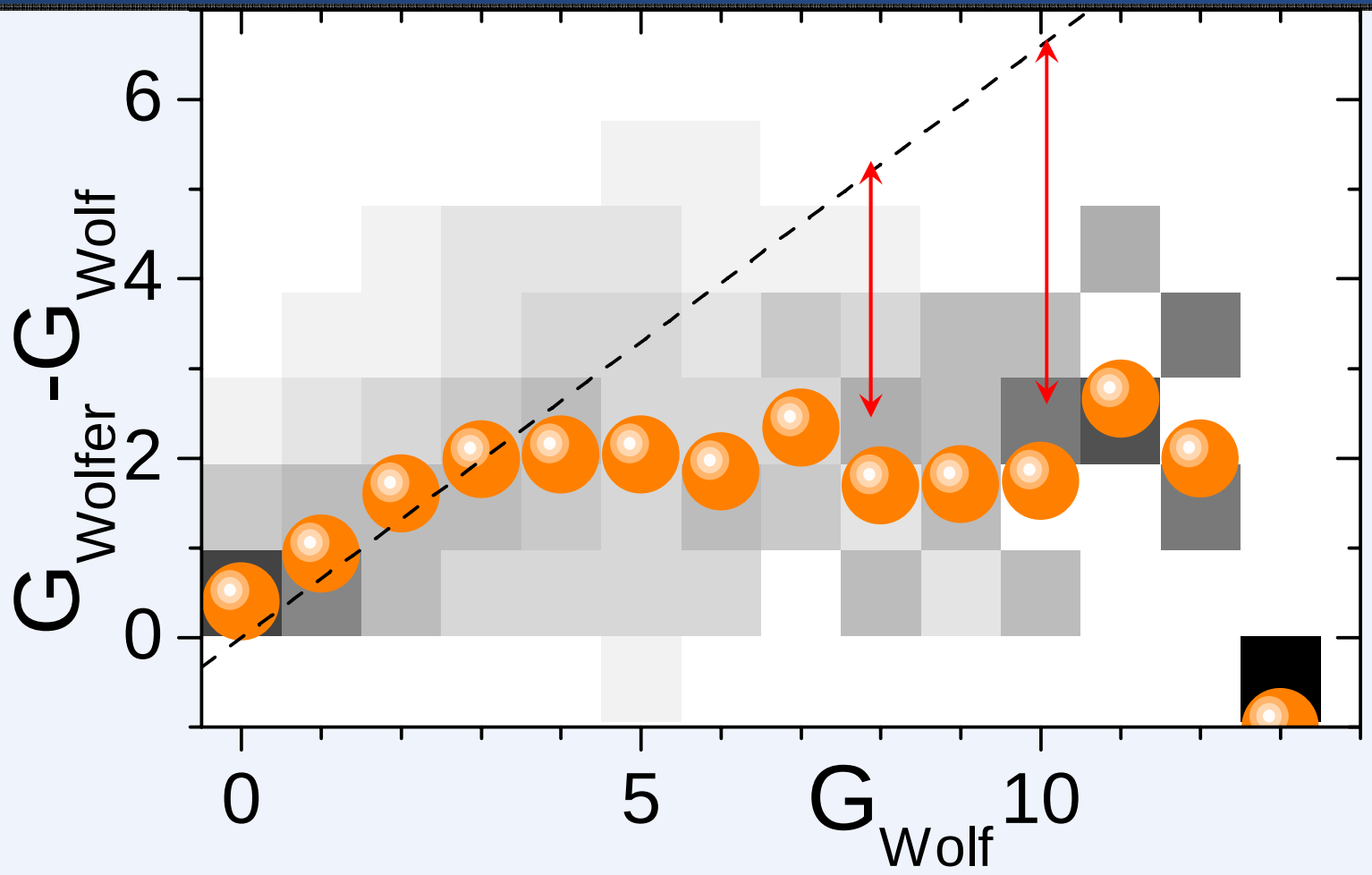
Distribution of daily (1876 -1893) G_{Wolfer} for G_{Wolf}=1:

Matrix of Wolfer-vs-Wolf daily G



Raw daily data Wolfer-vs-Wolf for the days when both reported sunspot observations.

Relation is non-linear



* None-zero offest; * Constant offset G>3;
* No uniform scaling; * 1.66x scaling OK only for daily G<4

Sub-conclusion

1. Annual averaging is inadequate for calibration.

2. The linear scaling does not work.

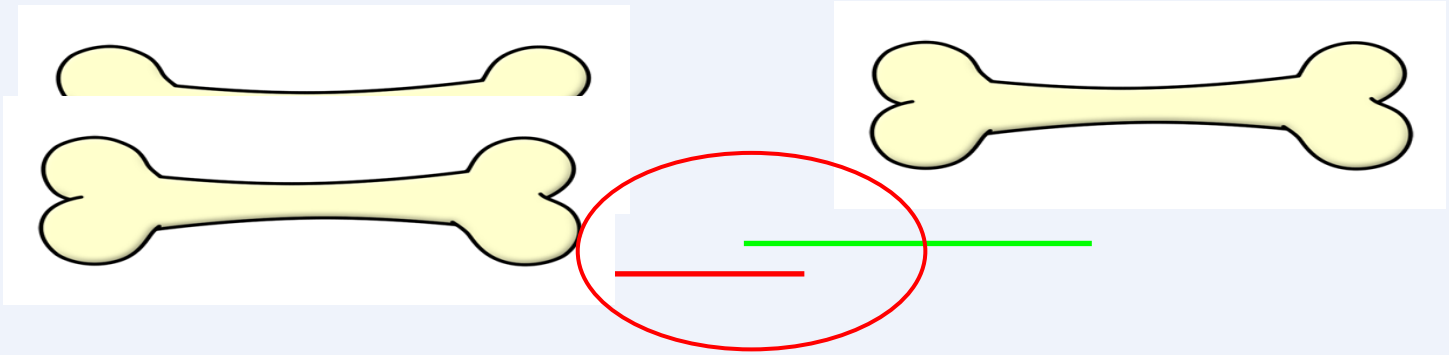
3. 1+2 => Over-correction, particularly for periods with high activity.

4. A direct correction method is proposed using daily values for the overlap period.

Calibration

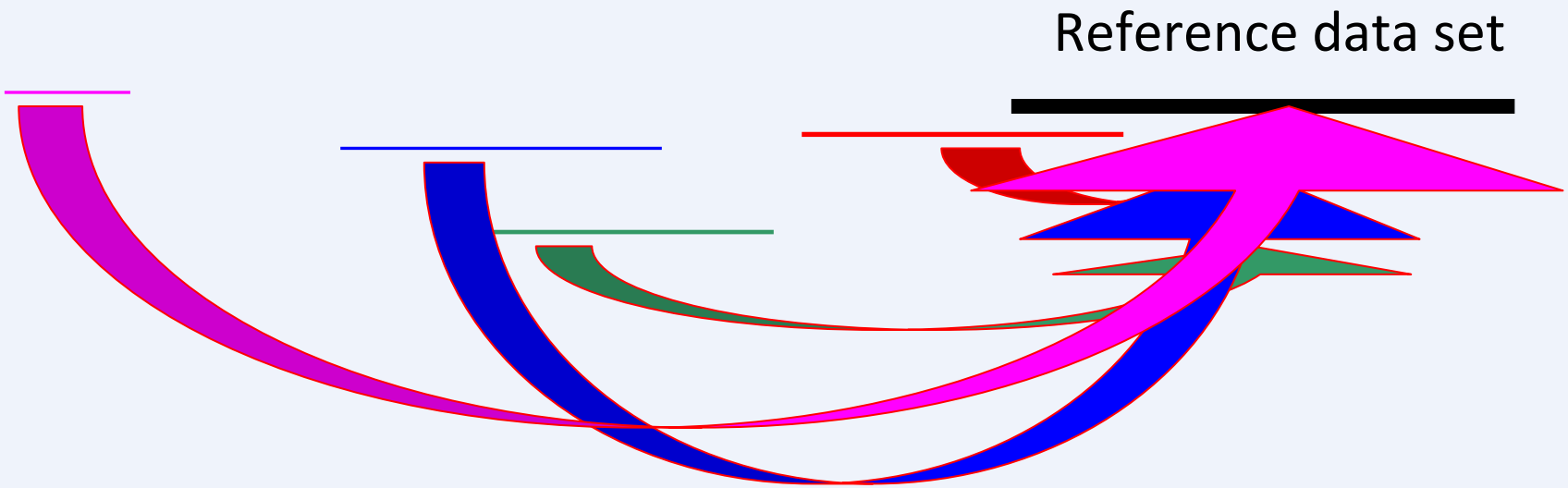
Daisy chain linear regression (Ri, Rg)

'Backbone' daisy chain (SS15)



Can we propose something better?

New independent calibration

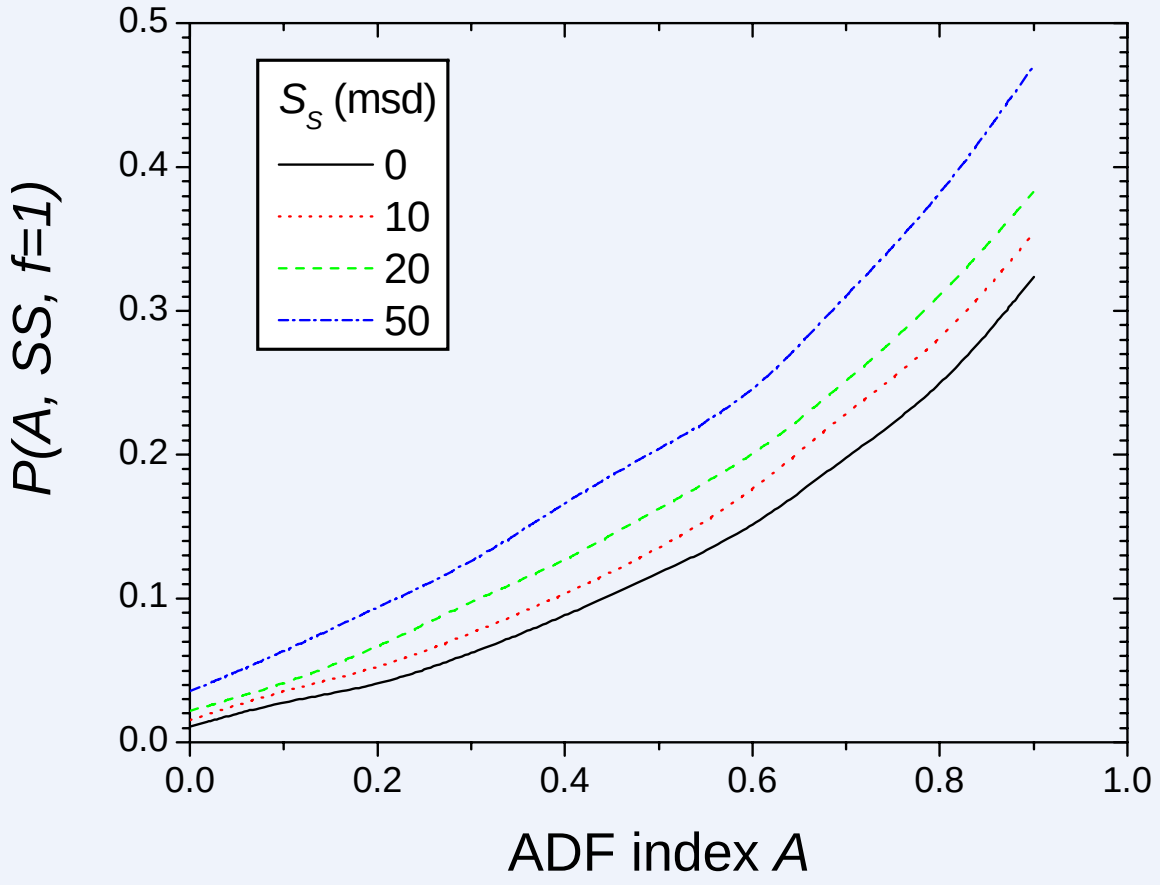


Active day fraction → No daisy-chain.
All calibrations independent.

** Another daisy-chain-free method by Thomas Friedli*

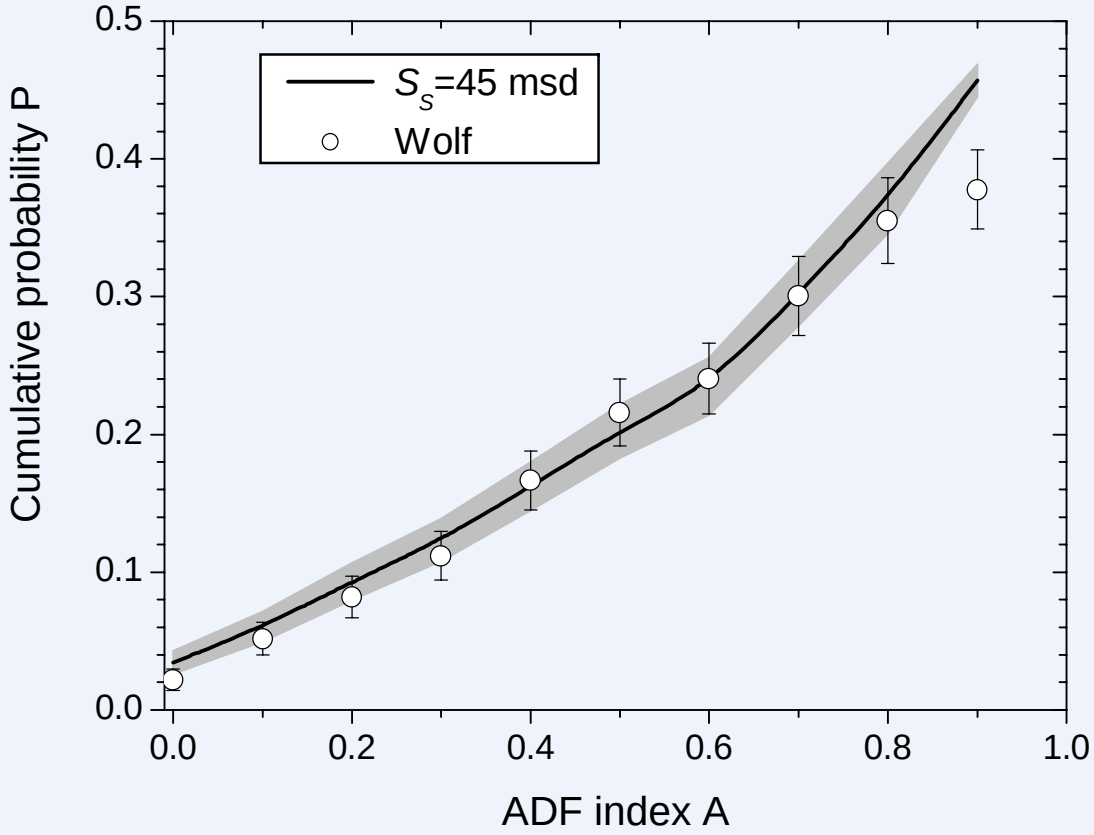
1. Calibration curve

- Reference data set (RGO, 1900-1976), sunspot groups with area.
- For each month → ADF: $A=N_{active}/N_{obs}$
- Apply a threshold S_s → Cumulative pdf $P(A, S_S)$



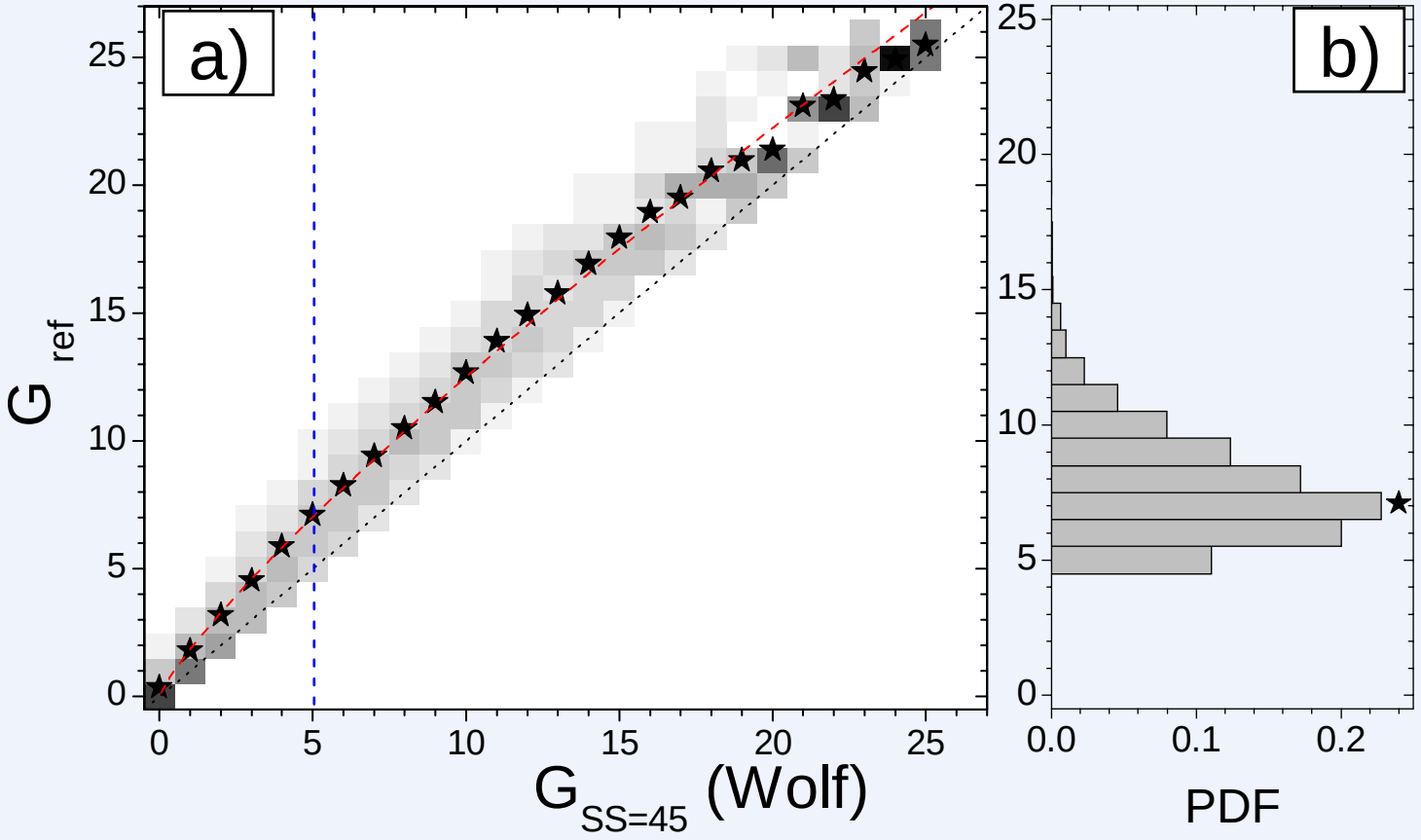
2. Finding S_S

- For each observer we find P and compared with the calibration curves to find the observational threshold S_S



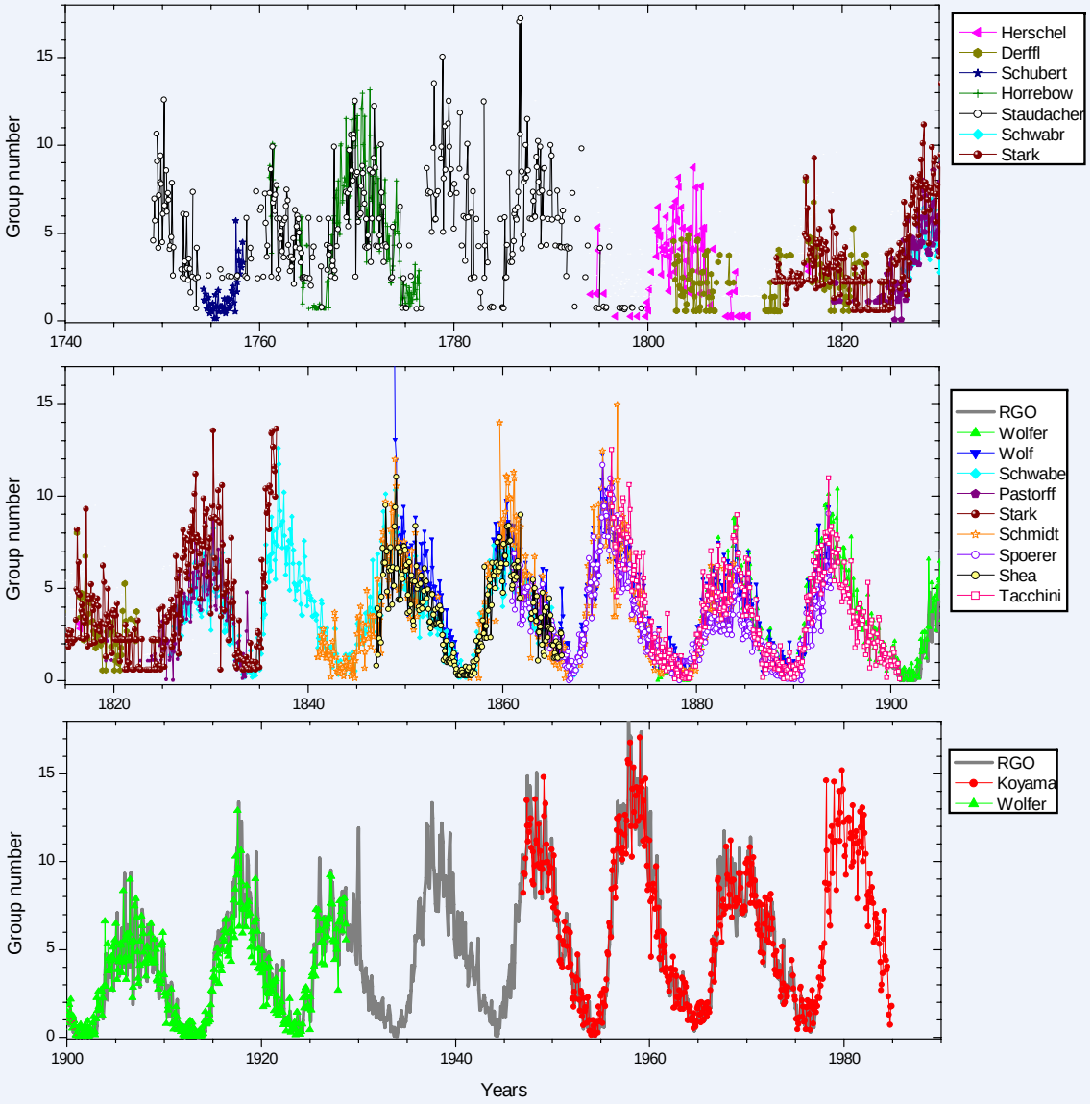
3. Correction matrix

- Using the reference data set (RGO, 1900-1976) we build a correction matrix for each observer, using S_S

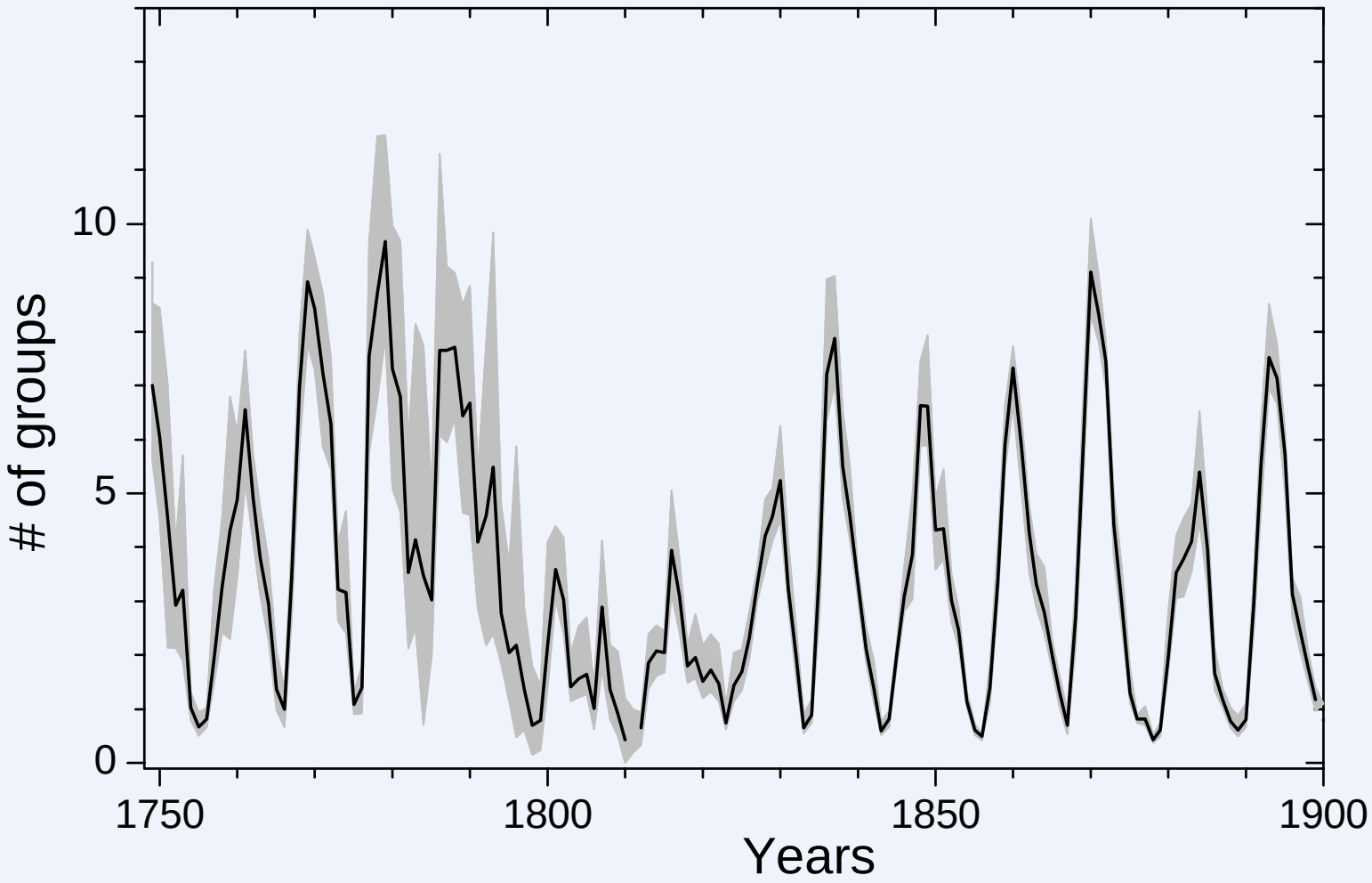


Individual corrections

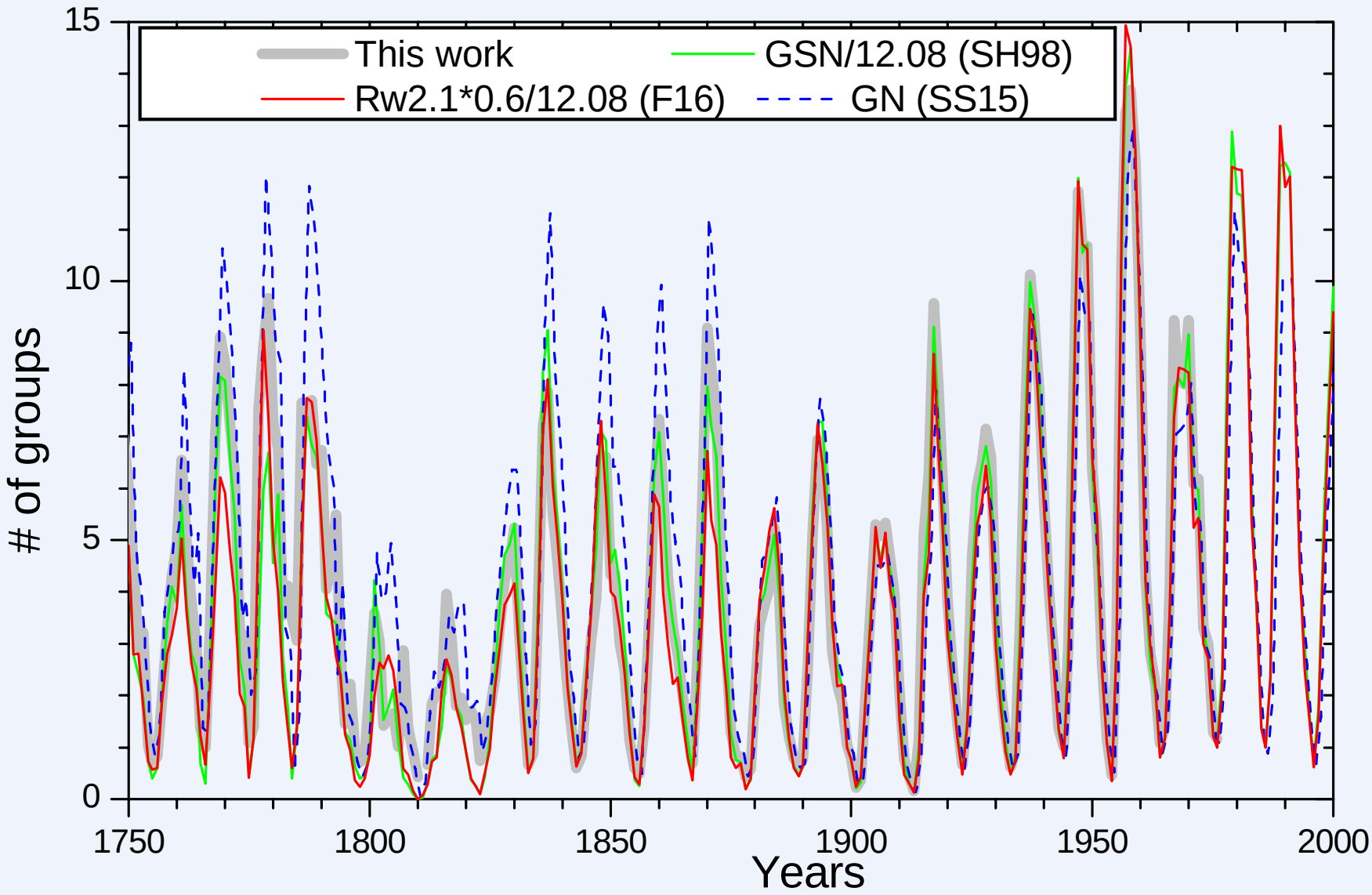
Each observer is calibrated independently to the reference data set.



Summary series with 95% c.i.



Final series



Conclusions

- A new sunspot group series is constructed using the direct calibration method since 1749.
- The series is normalized to the reference data set (RGO, 1900-1976).
- It is close to the GSN series (Hoyt & Schatten, 1998) but higher than that in the 18th century.
- The high level of activity in the 18th and 19th century (Clette et al., 2014; Svalgaard & Schatten, 2015) is not confirmed.
- The Grand Modern maximum is confirmed.
- The new reconstruction is consistent with (but slightly higher than) the result by Thomas Friedly (2016)


THANK YOU !