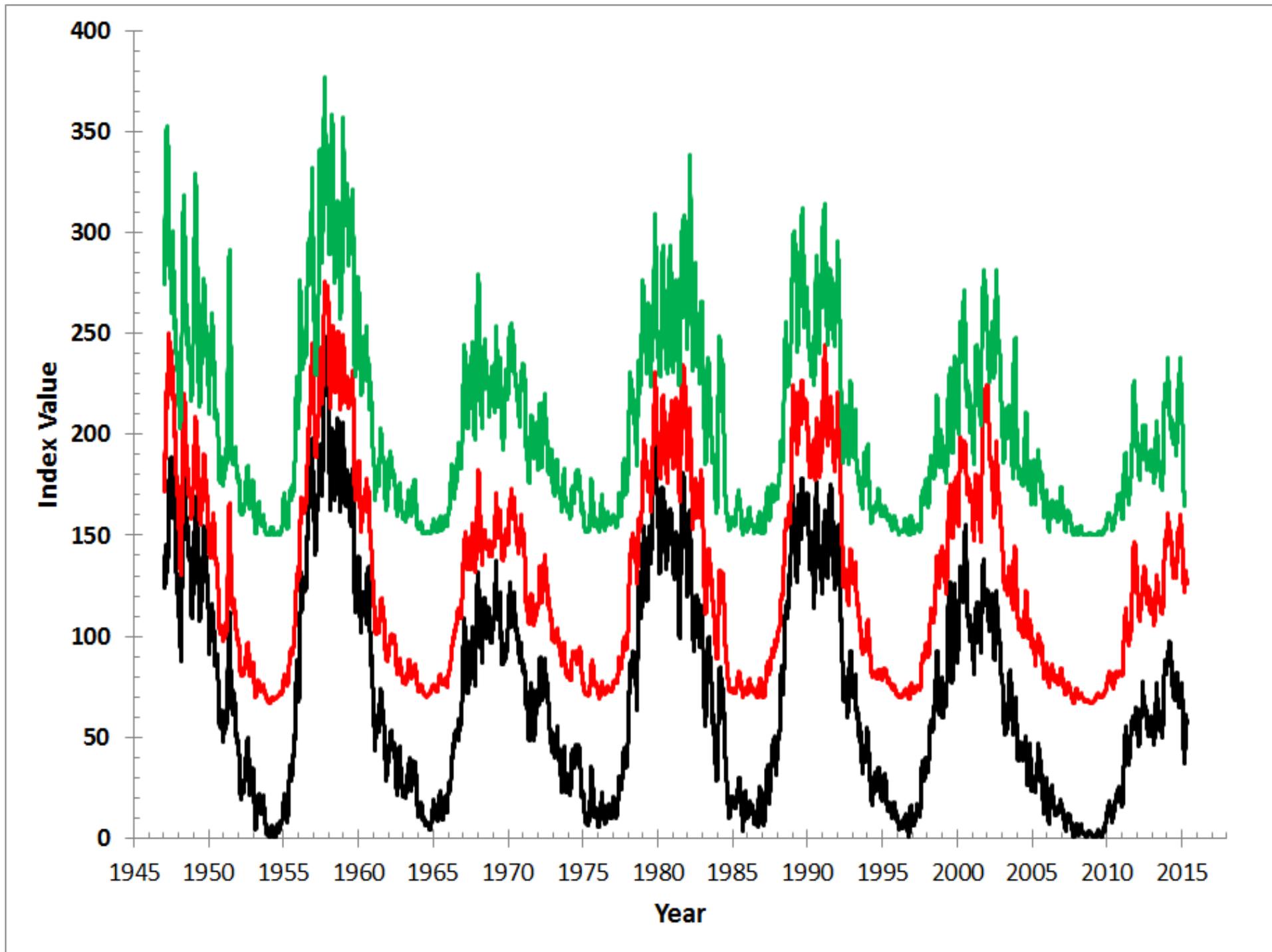


# Using Comparison of F10.7 and other activity Indices to Examine the Continuity of Solar Activity Cycles

Ken Tapping<sup>1</sup>, Carly Morgan<sup>2</sup>

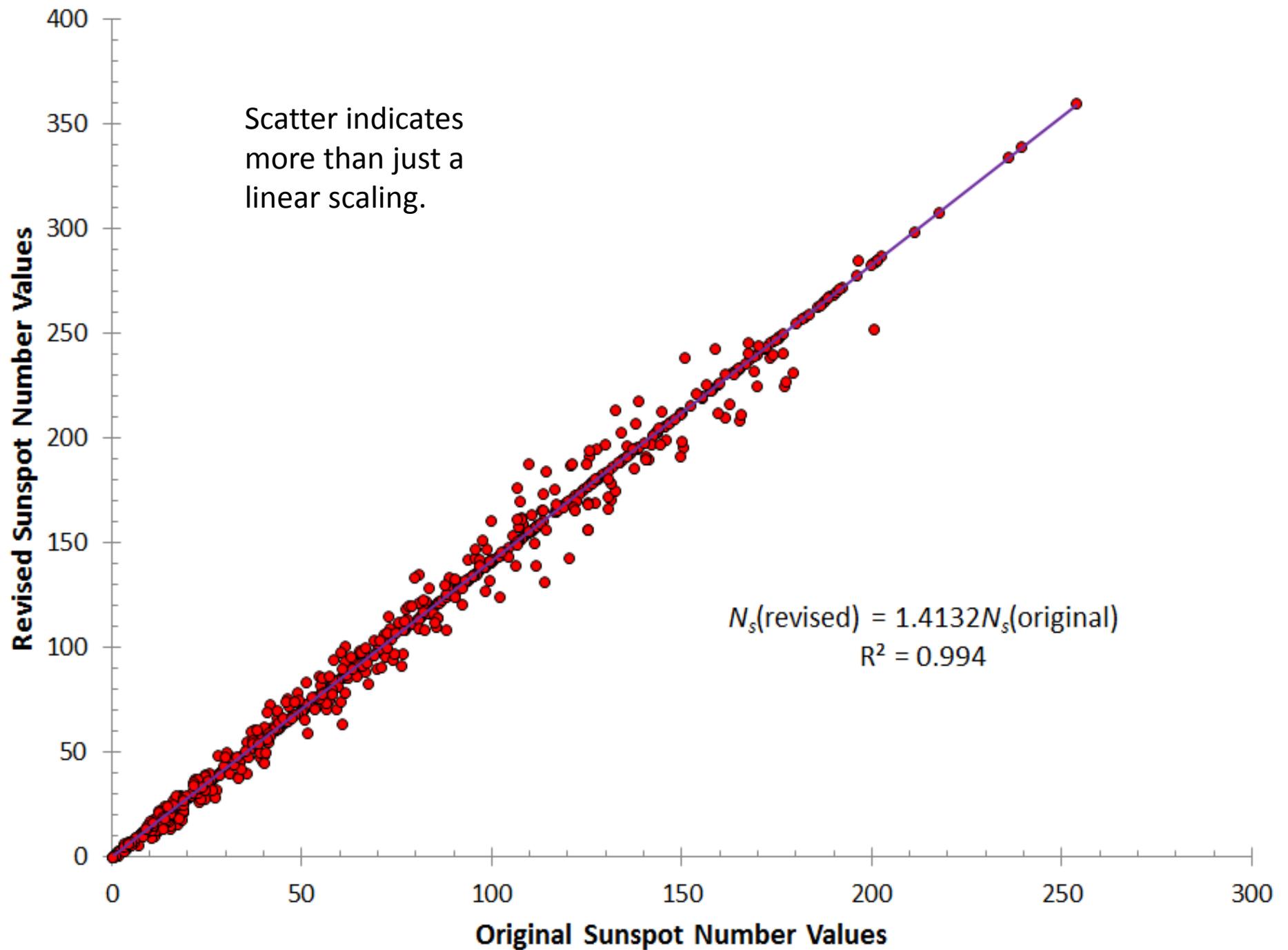
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2. University of Victoria, British Columbia, Canada

**NRC - CNRC**



# SIDC Revision of the Sunspot Number Data

- Following a series of international workshops examining the time-series of sunspot number data, the procedures used by various observers in the history of this index, and attempts at achieving some consistency of calibration, the SIDC (Belgium) has recalibrated the sunspot number data.
- This involved a combination of rescaling and recalibrating certain sections of the record.
- Here the unchanged data are referred to as “original”, and the revised data as “revised”.
- We use both records here, to see how results might differ.



# Methods for Index Comparison

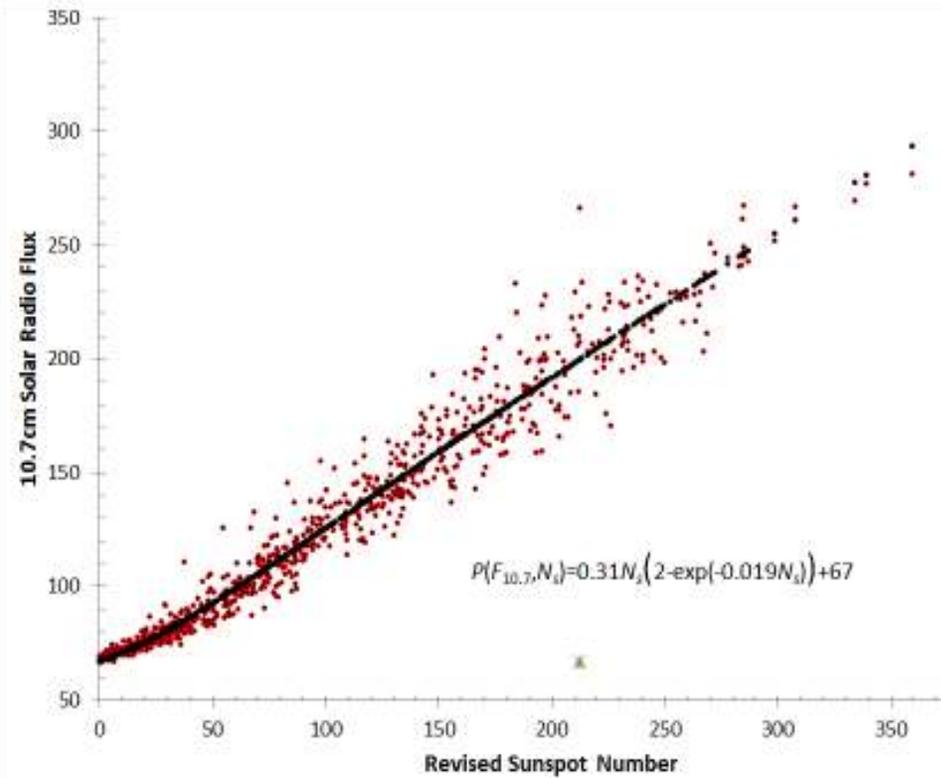
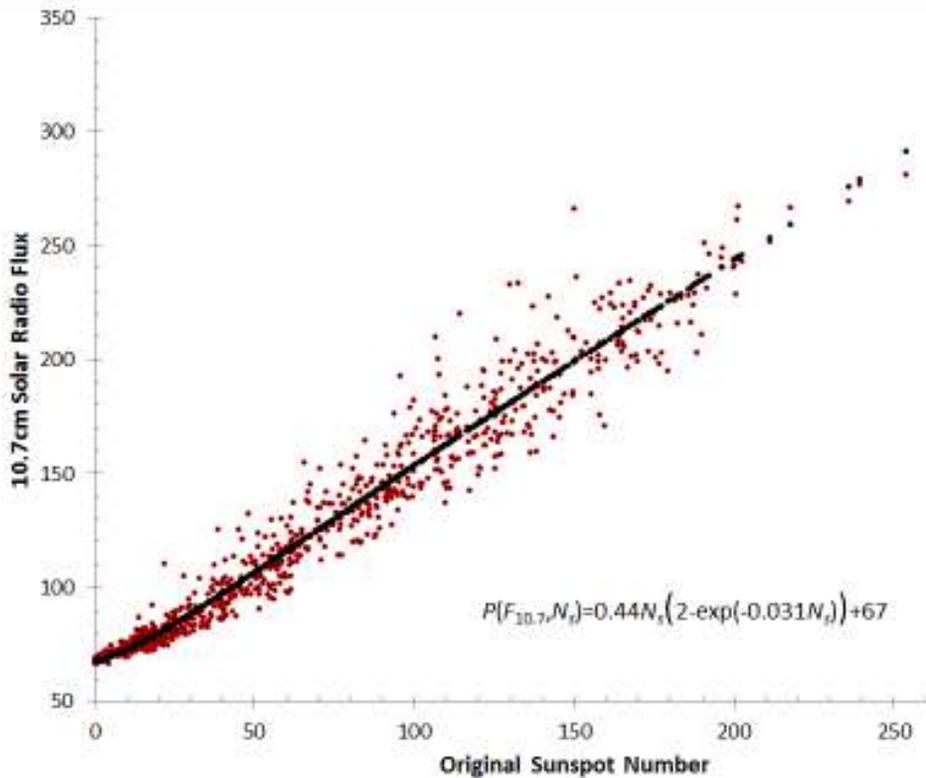
- Plot the index to be proxied on the  $y$ -axis and the source index of the proxy on the  $x$ -axis.
- Fit to the plot whatever arbitrary function seems to best fit. Underlying physics desirable but not required.
- Use that function with the source index to make a proxy for the other index. In the example below  $\alpha$  is being used to generate a proxy for  $\beta$
- Evaluate the comparison parameter:
- Plot  $\xi$  against time.

$$\xi(\beta, \alpha) = \frac{\beta - P(\beta, \alpha)}{\beta + P(\beta, \alpha)}$$

Or, more simply, examine the difference between the index and its proxy:

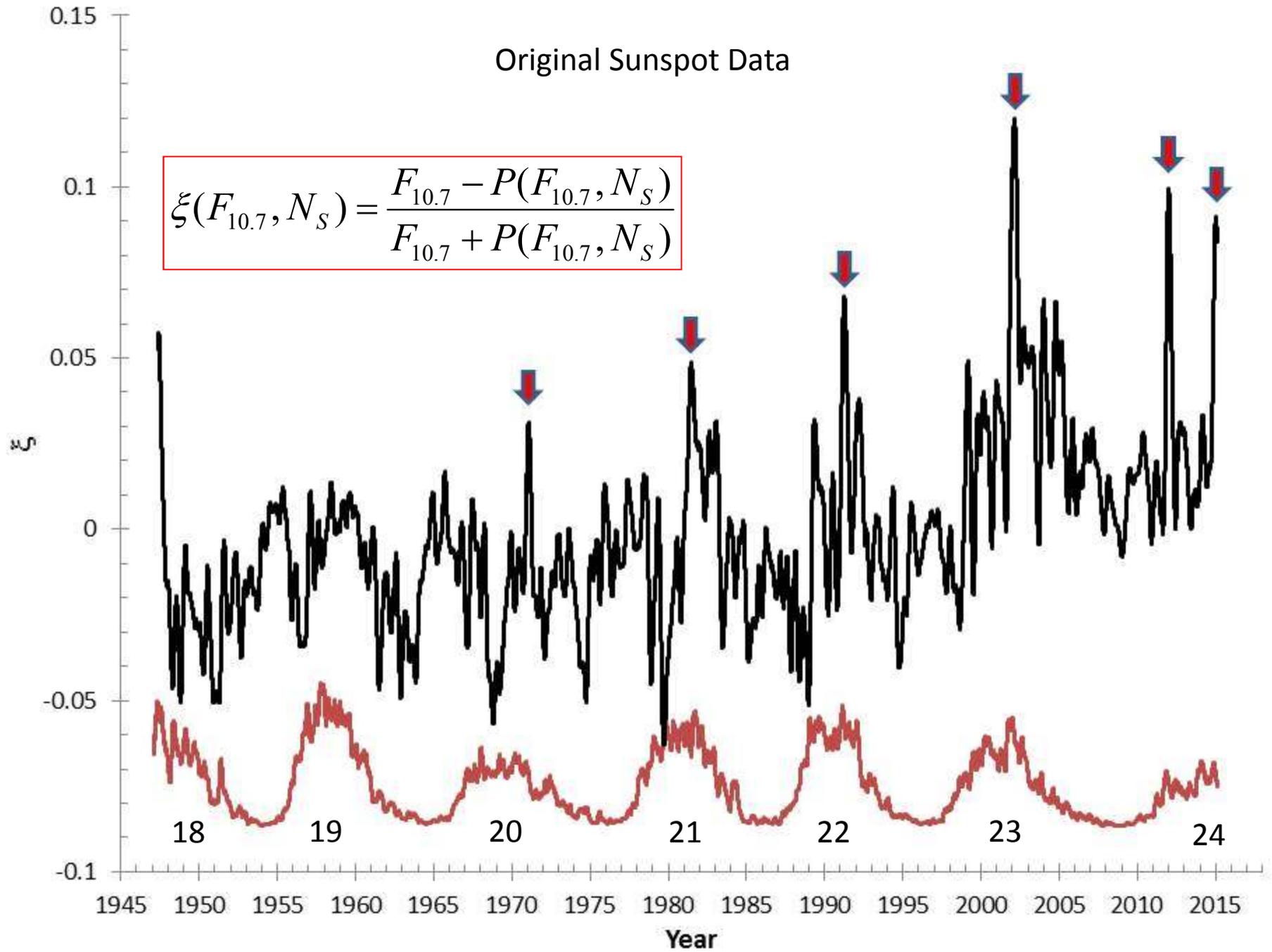
$$\eta(\beta, \alpha) = \beta - P(\beta, \alpha)$$

# Original and Revised Sunspot Number: Step 1 – Generate the Empirical Relationships



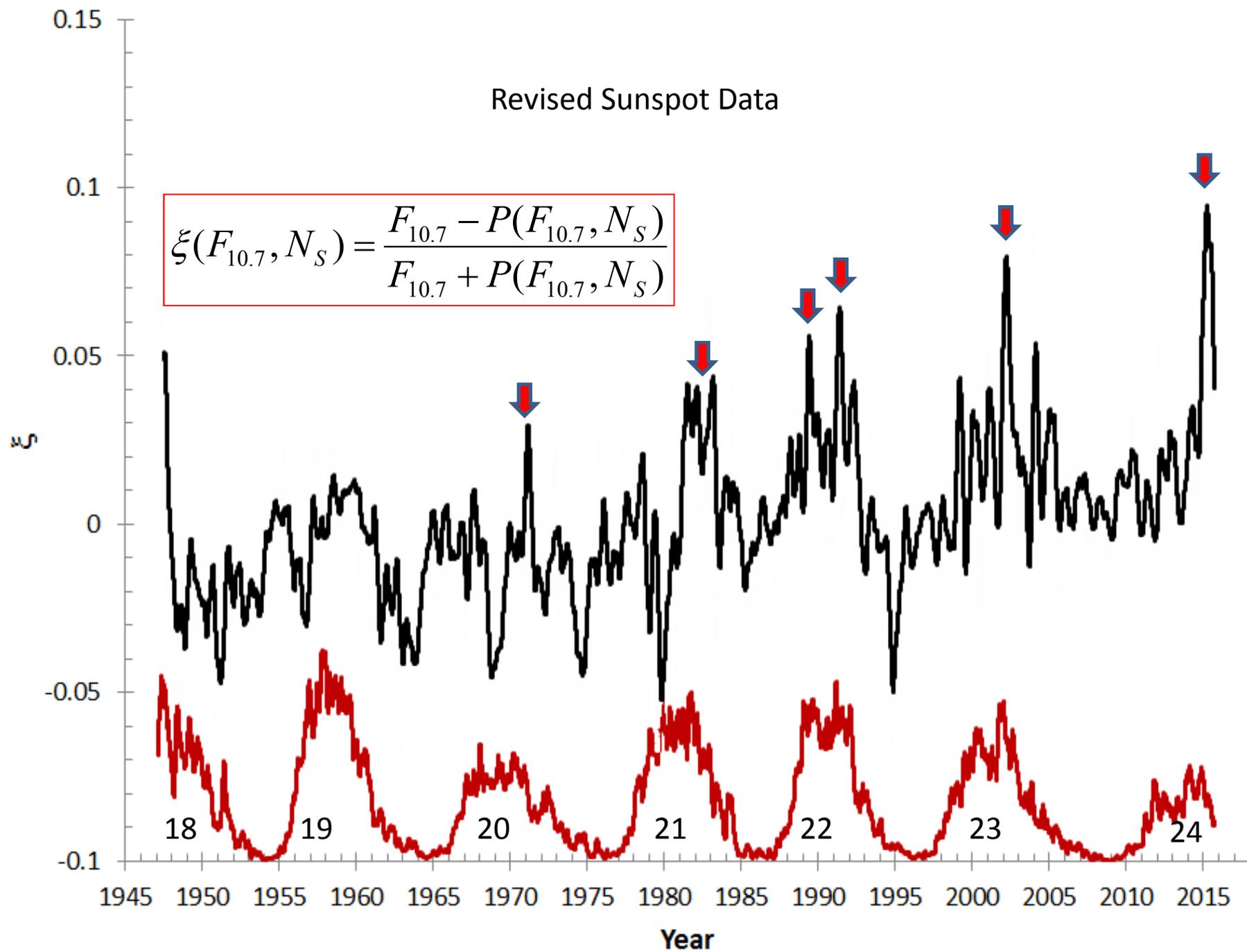
### Original Sunspot Data

$$\xi(F_{10.7}, N_S) = \frac{F_{10.7} - P(F_{10.7}, N_S)}{F_{10.7} + P(F_{10.7}, N_S)}$$



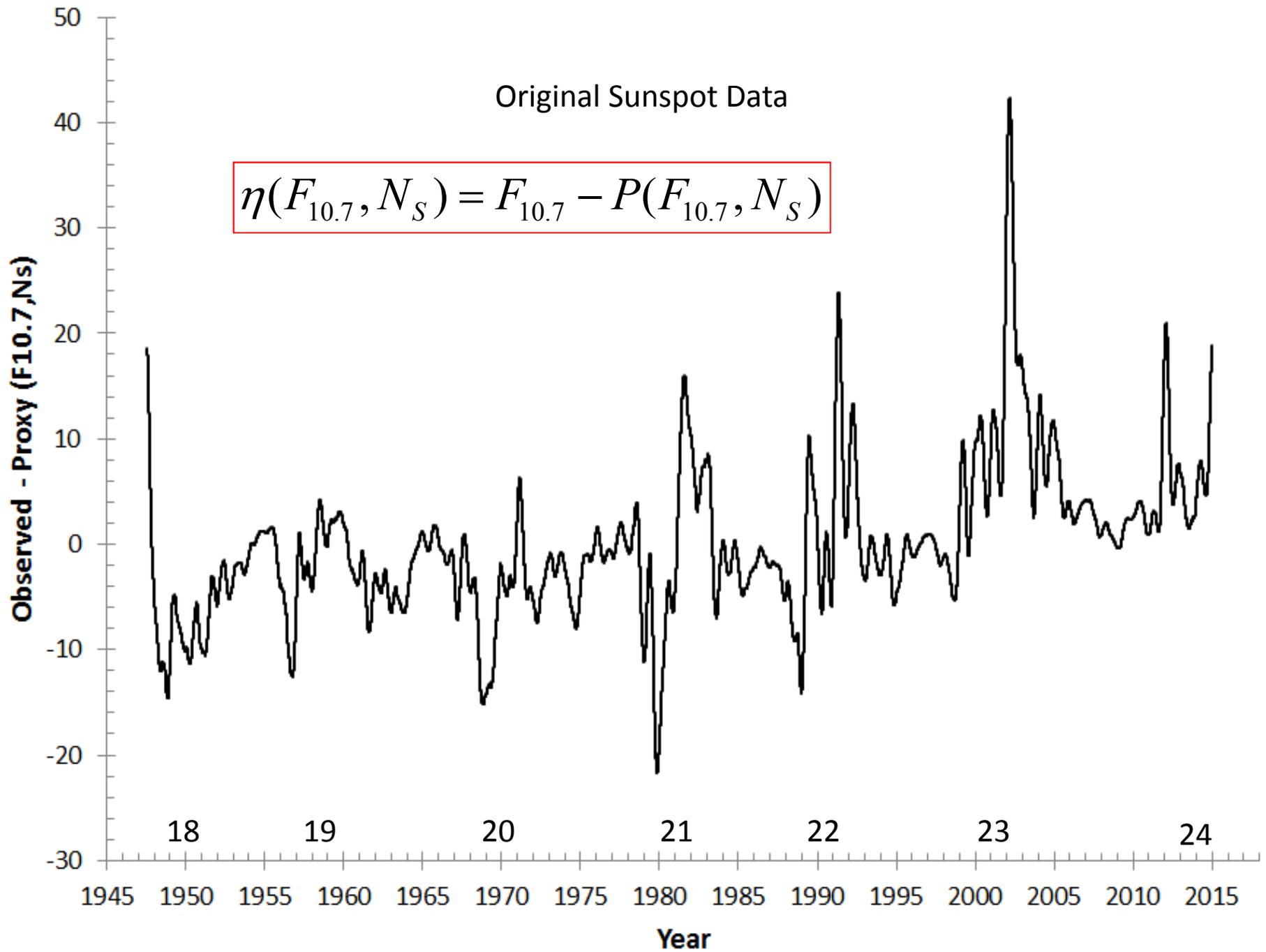
### Revised Sunspot Data

$$\xi(F_{10.7}, N_S) = \frac{F_{10.7} - P(F_{10.7}, N_S)}{F_{10.7} + P(F_{10.7}, N_S)}$$



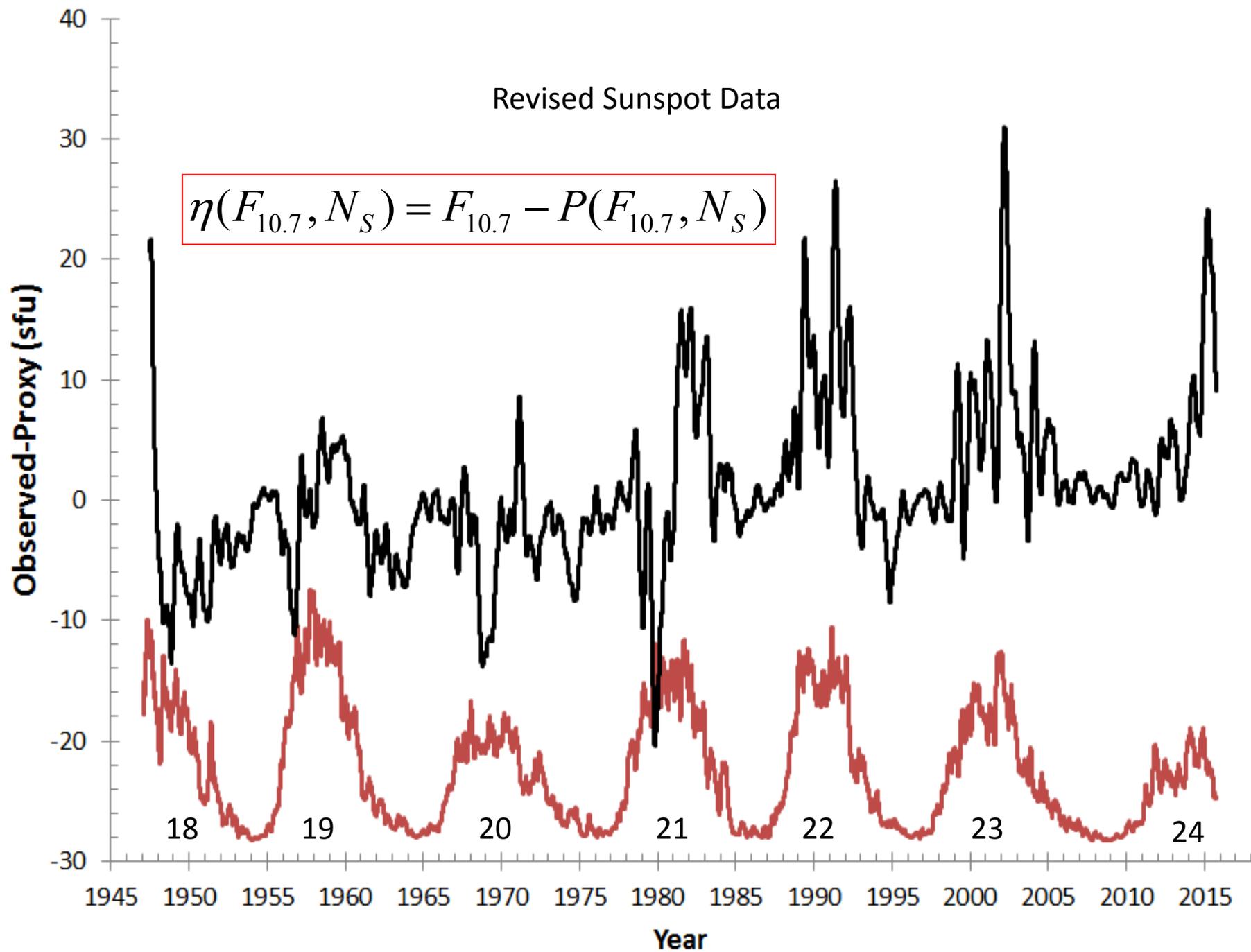
Original Sunspot Data

$$\eta(F_{10.7}, N_S) = F_{10.7} - P(F_{10.7}, N_S)$$



Revised Sunspot Data

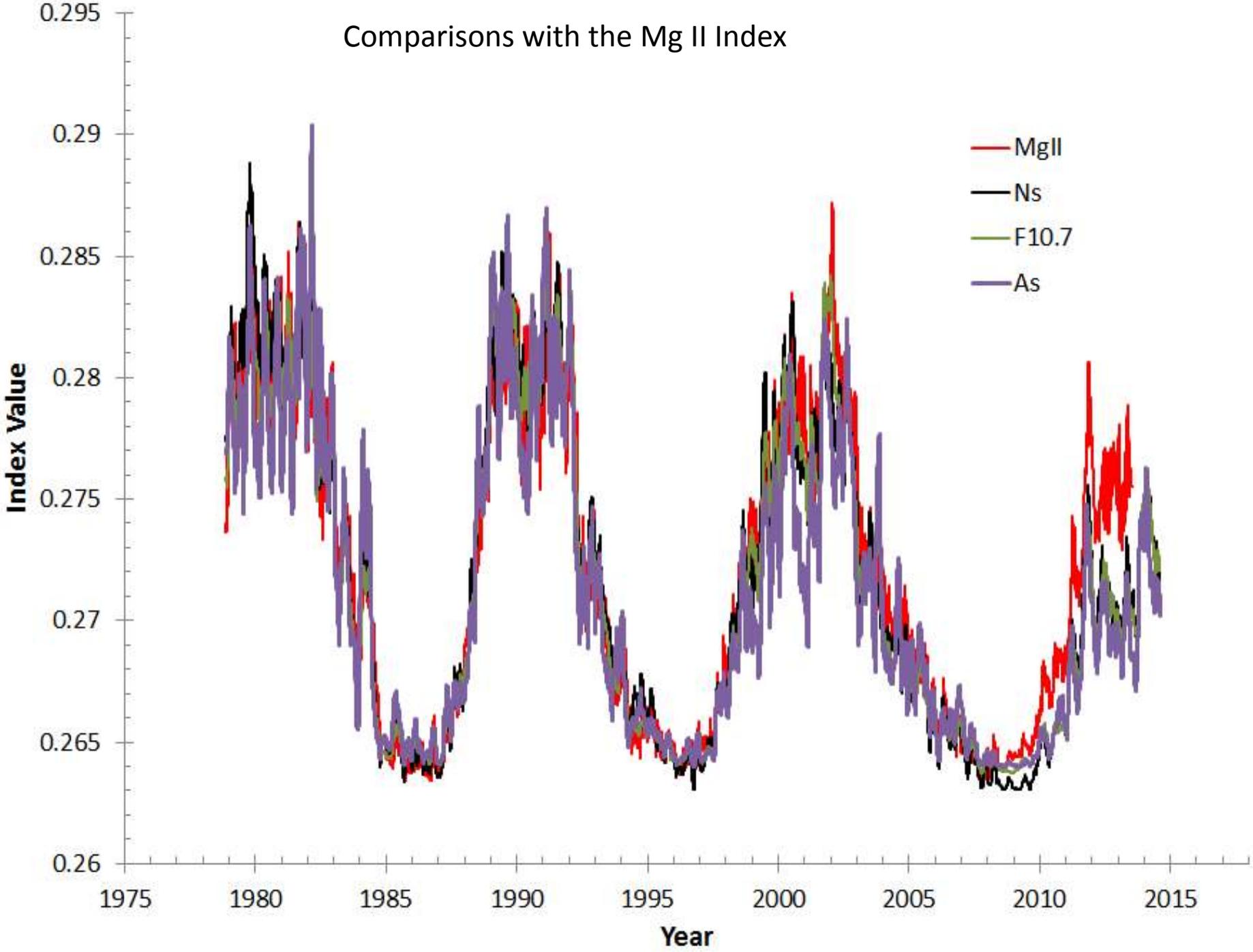
$$\eta(F_{10.7}, N_S) = F_{10.7} - P(F_{10.7}, N_S)$$

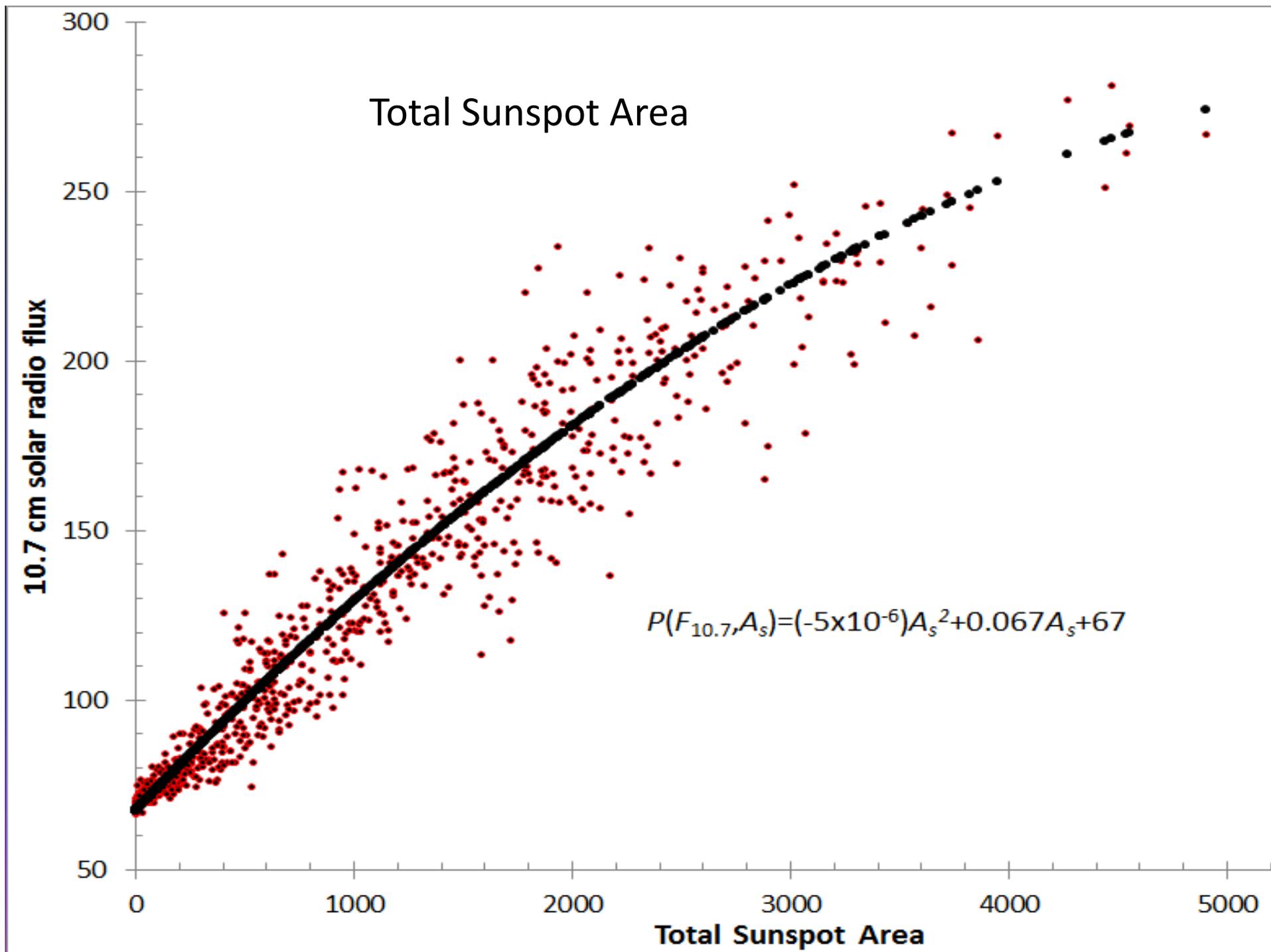


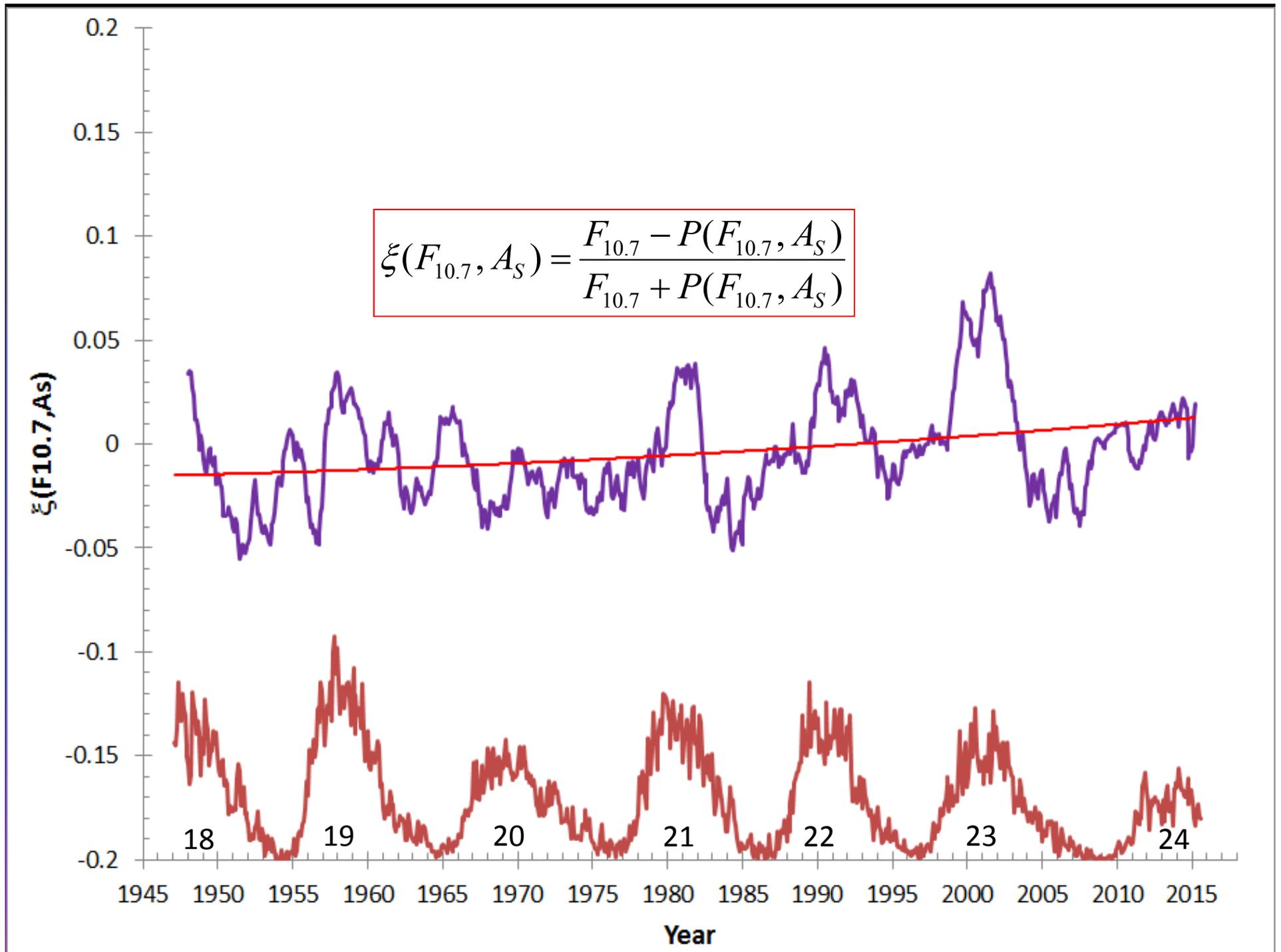
# Discrepancies

- The  $F_{10.7}$  values are showing excesses over what would be expected on the basis of the sunspot number values.
- $F_{10.7}$  comprises at least three contributory emission processes, as a time-varying mixture: thermal free-free emission, thermal gyroresonance, and on occasion non-thermal emission (gyrosynchrotron).
- Could get an excess if there is an increased contribution of free-free thermal emission from the non-sunspot parts of active region. **The increasing densities would give increased u-v etc.**
- Could the sunspots be bigger, so sunspot number does not change but there could be more thermal gyroresonance etc. going on? **Then there could be a connection with total sunspot area (as a rough proxy for total umbral magnetic flux).**

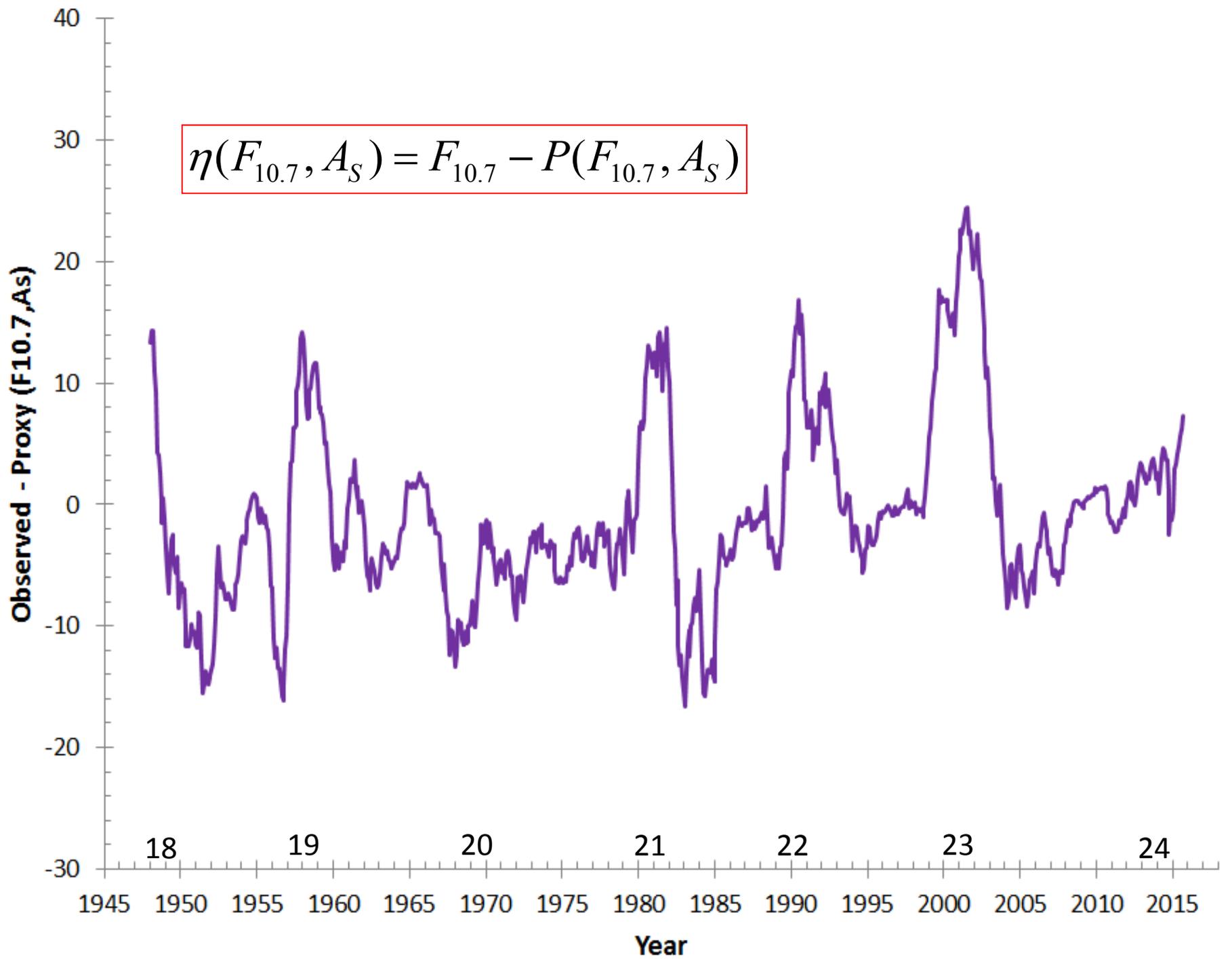
Comparisons with the Mg II Index







$$\eta(F_{10.7}, A_S) = F_{10.7} - P(F_{10.7}, A_S)$$



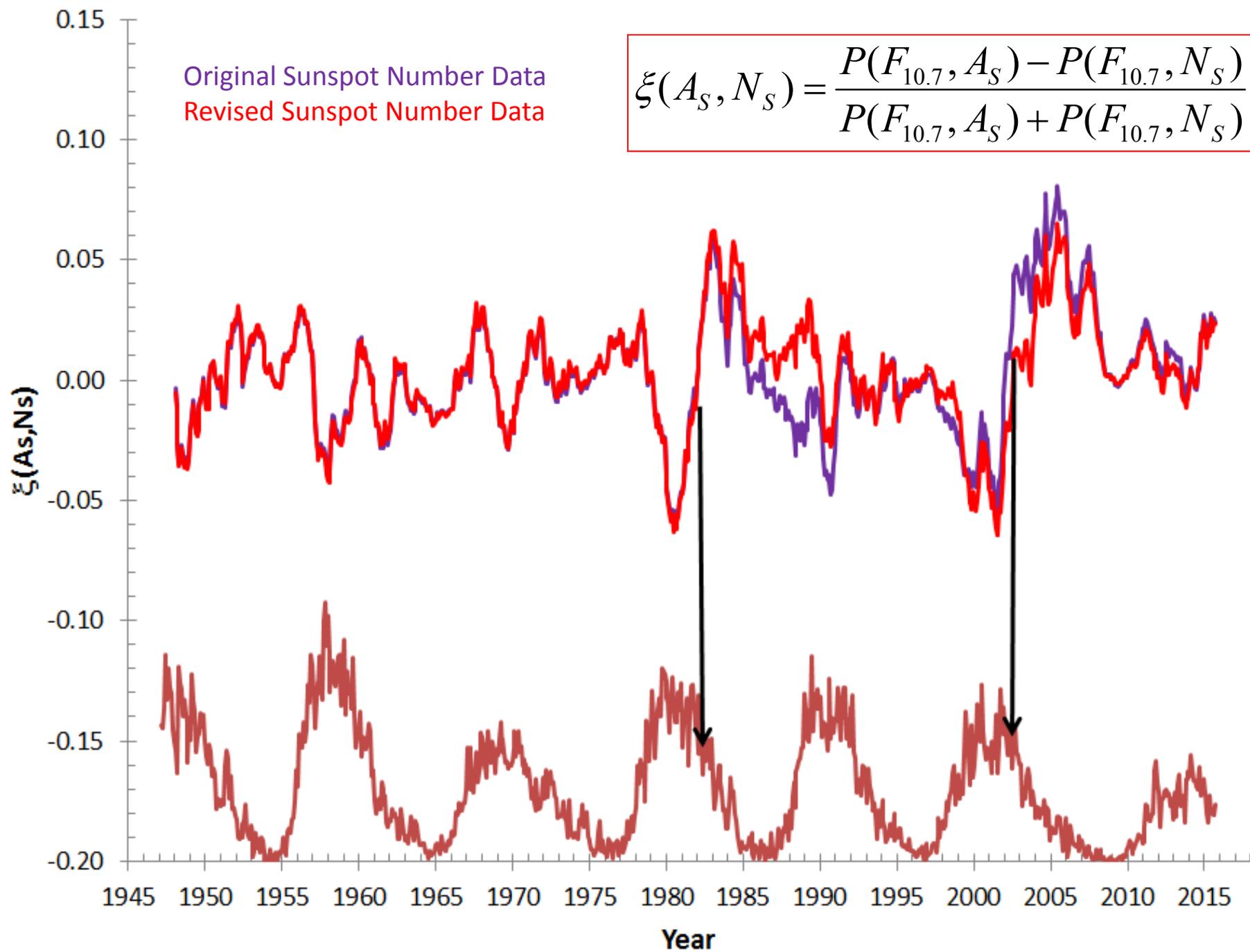
# Comparing Total Sunspot Area with Sunspot Number

- It is not feasible to compare these using the  $(O-P)/(O+P)$  approach because total sunspot area and sunspot number can fall to very low values or even fall to zero during activity minima.
- We can fix this by adding an arbitrary constant offset to both indices.
- It is a bit less arbitrary to do the comparison via the  $F_{10.7}$  proxies:  $P(F_{10.7}, A_s)$  and  $P(F_{10.7}, N_s)$  because they are functions of  $A_s$  and  $N_s$  respectively and have been brought to a similar state of linearity.

Original Sunspot Number Data

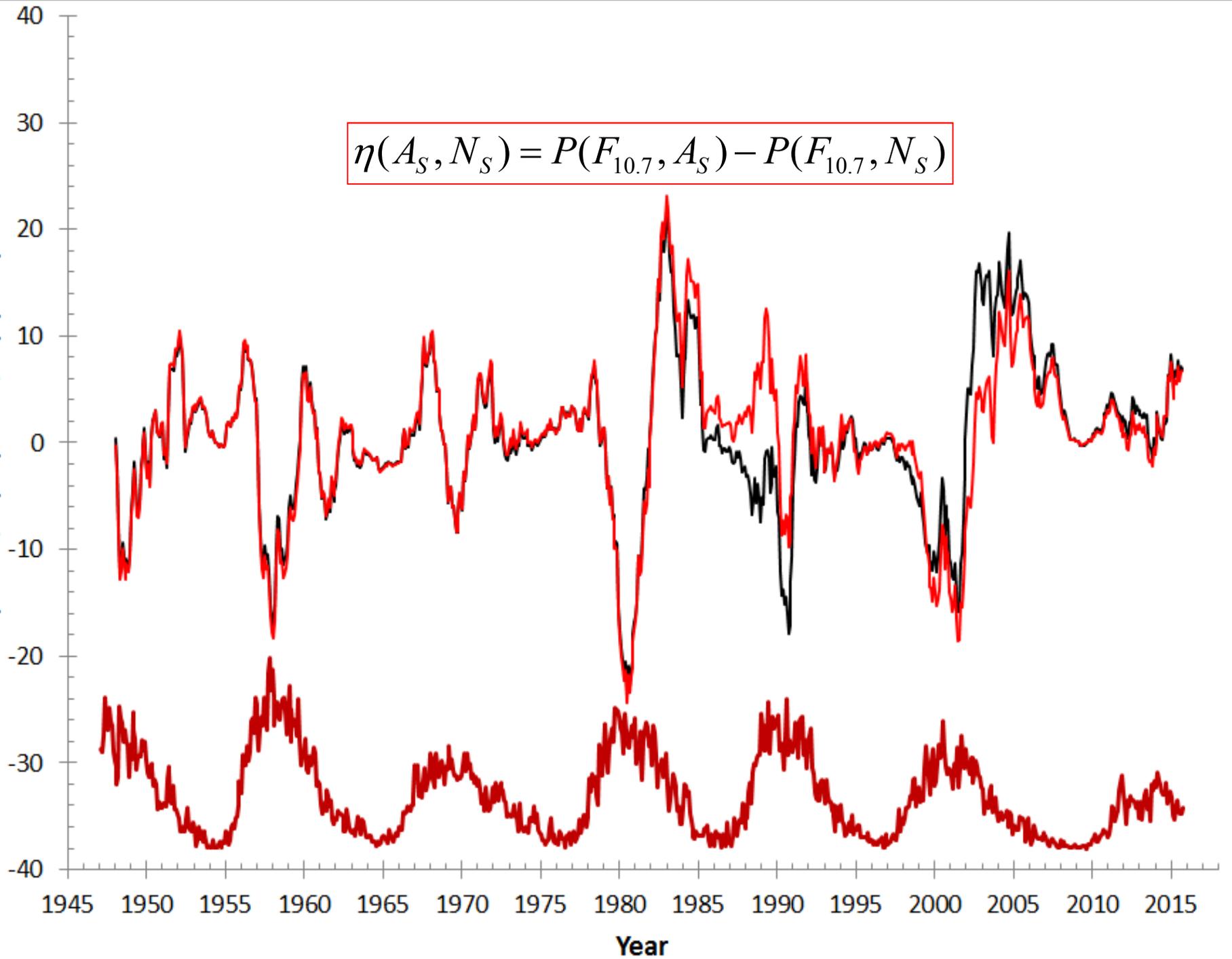
Revised Sunspot Number Data

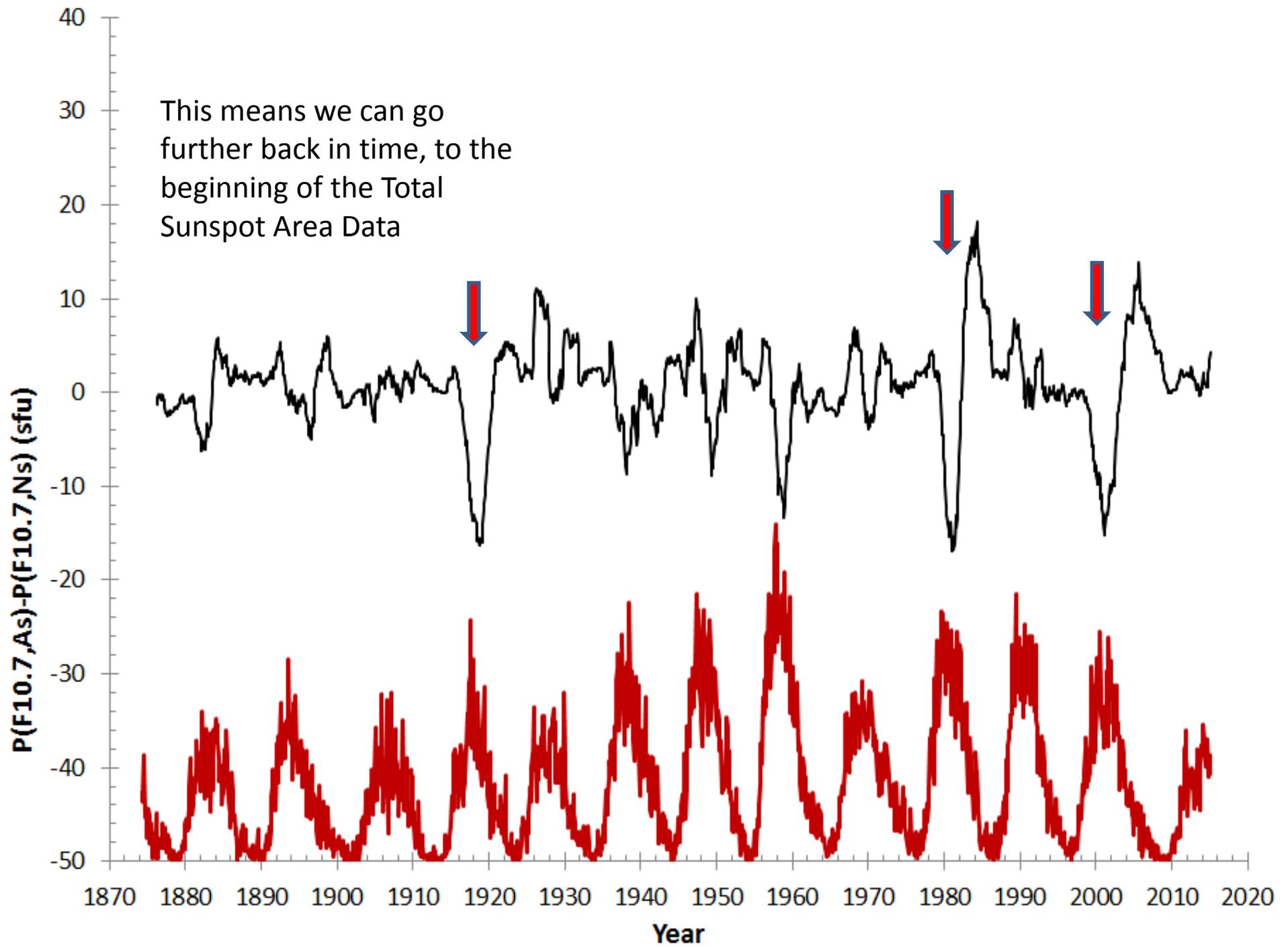
$$\xi(A_S, N_S) = \frac{P(F_{10.7}, A_S) - P(F_{10.7}, N_S)}{P(F_{10.7}, A_S) + P(F_{10.7}, N_S)}$$



$$\eta(A_S, N_S) = P(F_{10.7}, A_S) - P(F_{10.7}, N_S)$$

$P(F_{10.7}, A_S) - P(F_{10.7}, N_S)$  (sfuu)





# Points/Discussion: 1

- Since 1981 there have been spikes showing an excess of F10.7 over what we would expect on the basis of sunspot number.
- The transitions in Cycle 23 and the strange Cycle 24 could be part of this succession.
- Ns/As comparisons give indications of a similar event in 1919.
- Is a certain level of hiccupping – changes in the relative ways different solar phenomena respond to changes in the magnetic activity machine – a standard feature of solar behaviour?
- Are events such as the Maunder and Dalton Minima extremes in a distribution of such events?
- On the basis of the available data, it is impossible to tell whether what the Sun is up to at the moment is a deviation, or just an aspect of “Business as Usual”.

## Points/Discussion: 2

- Since the gyroresonant contribution to F10.7 is associated with sunspots, a relative increase in F10.7 is hard to explain that way (increasing magnetic field strengths? Larger sunspots?)
- Comparisons with sunspot area suggest larger sunspots not the explanation.
- More plasma in the corona would give more thermal bremsstrahlung. This would give more uv etc. Maybe the excess of Mg II in Cycle 24 suggests this.
- This would be reflected in variations in the S-component spectrum.

