

Rudolf Wolf Was Right

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The Sunspot Number(s)



Rudolf Wolf (1816-1893)

- Wolf Number = $k_W (10 * G + S)$
- G = number of groups
- S = number of spots
- Group Number = $12 k_G G$

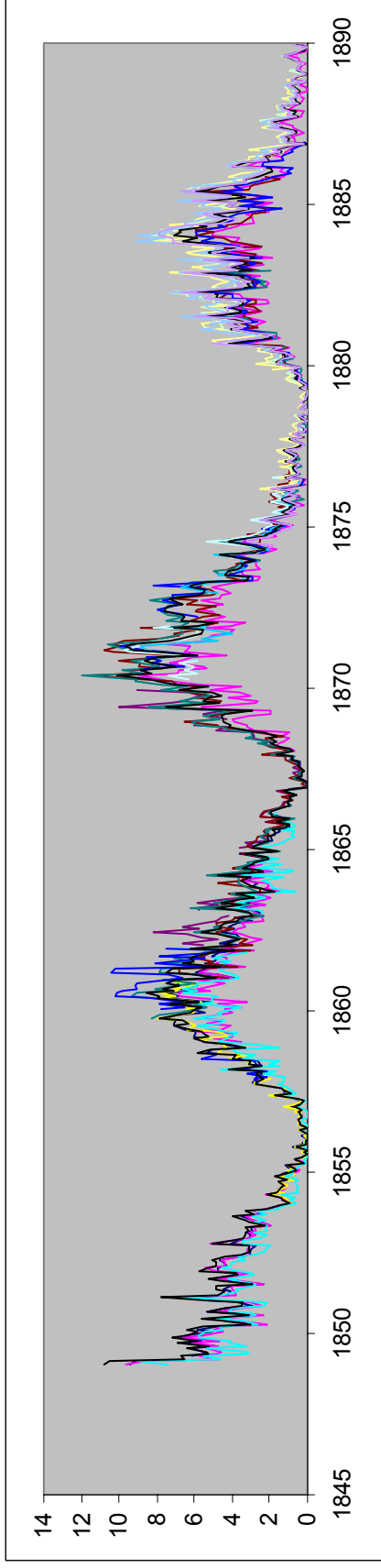


The '12' is to make
the mean for the past
~100 years the same
as the mean Wolf
Number

Ken Schatten

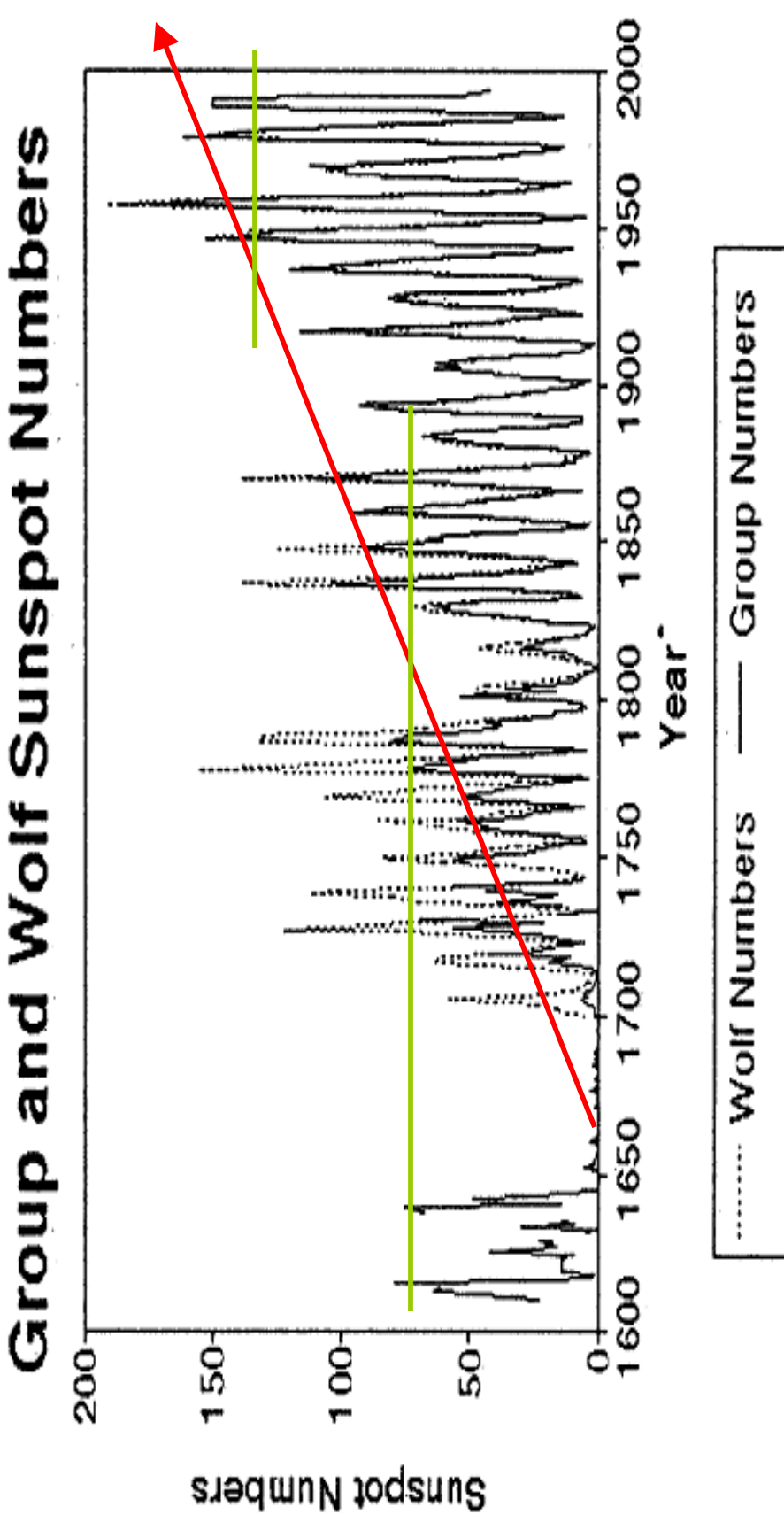
The Number of Sunspot Groups is However also Observer Dependent

Schwabe	Wolf	Carrington	Shea
Peters	Spoerer	Weber	Schmidt
Secchi	Bernaerts	Wolfer	Aguilar
Ricco	RGO		



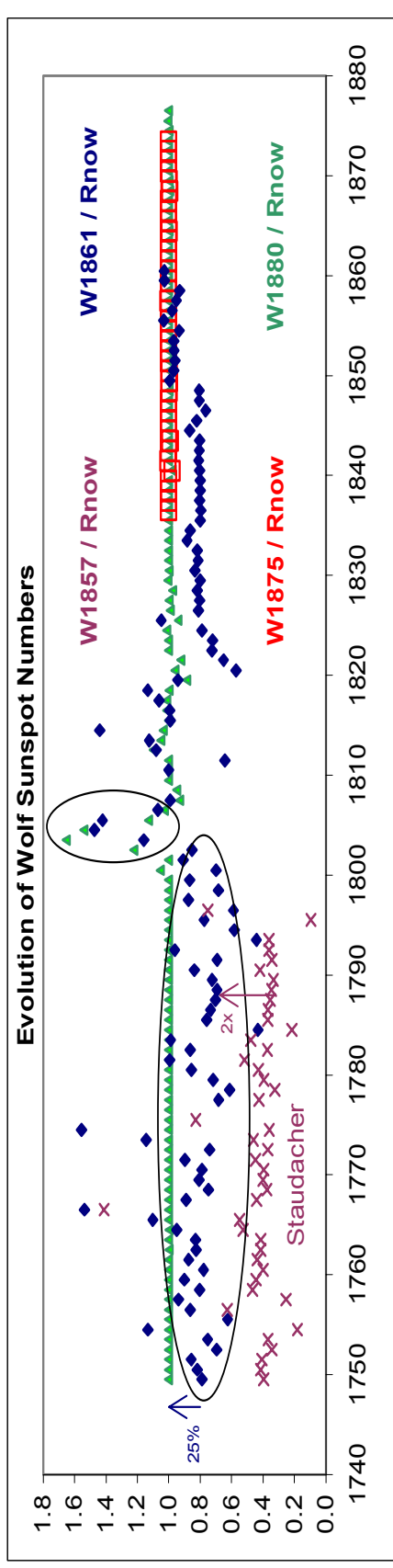
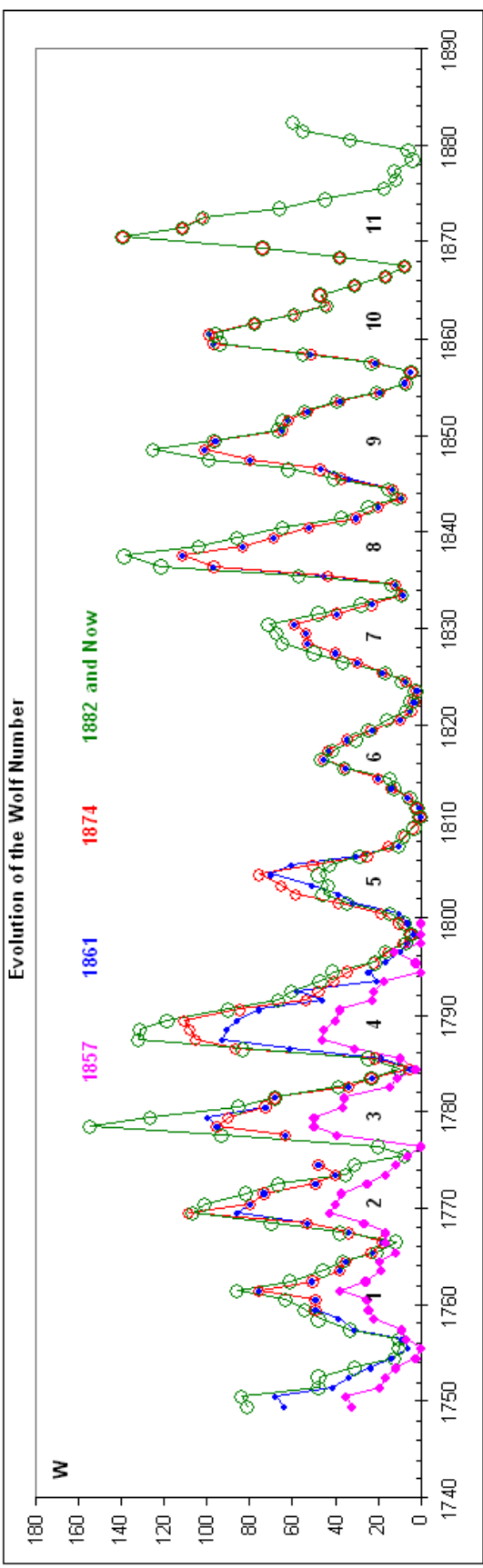
GSN = 12 k_G Groups

The Problem: Discordant Sunspot Numbers



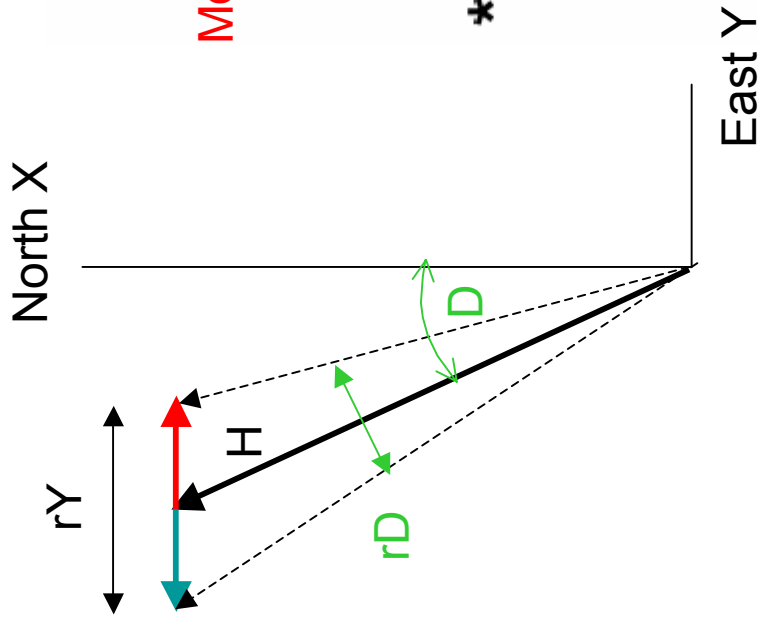
Hoyt & Schatten, GRL 21, 1994

Wolf's early SSNs were also low as the Group Numbers, but
 Wolf found a way of calibrating independently the SSN



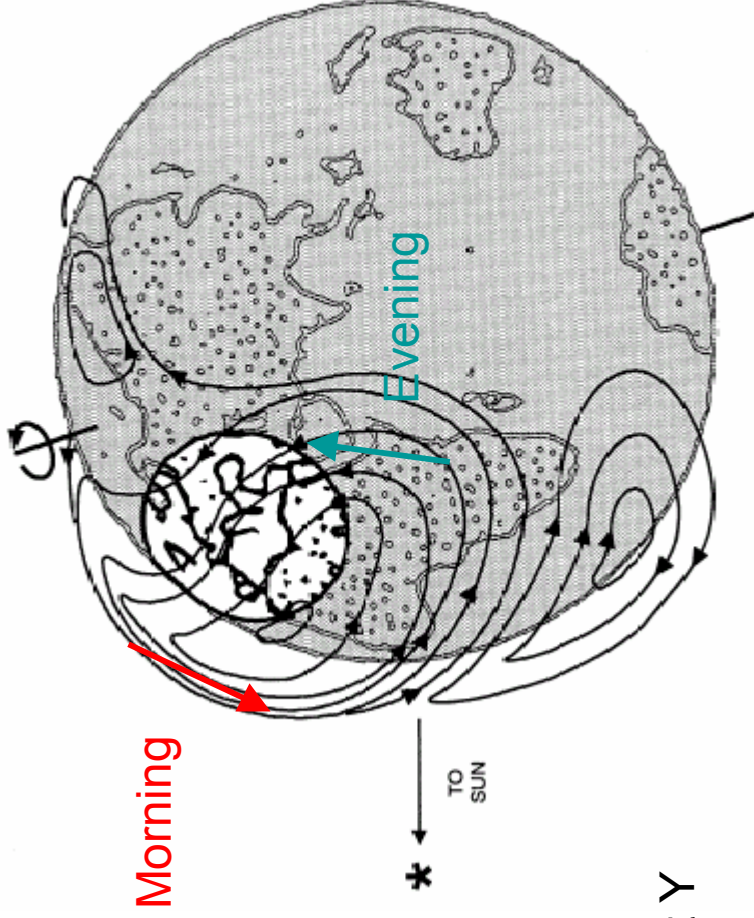
Was this justified?

Wolf's Discovery: $rD = a + b R_W$



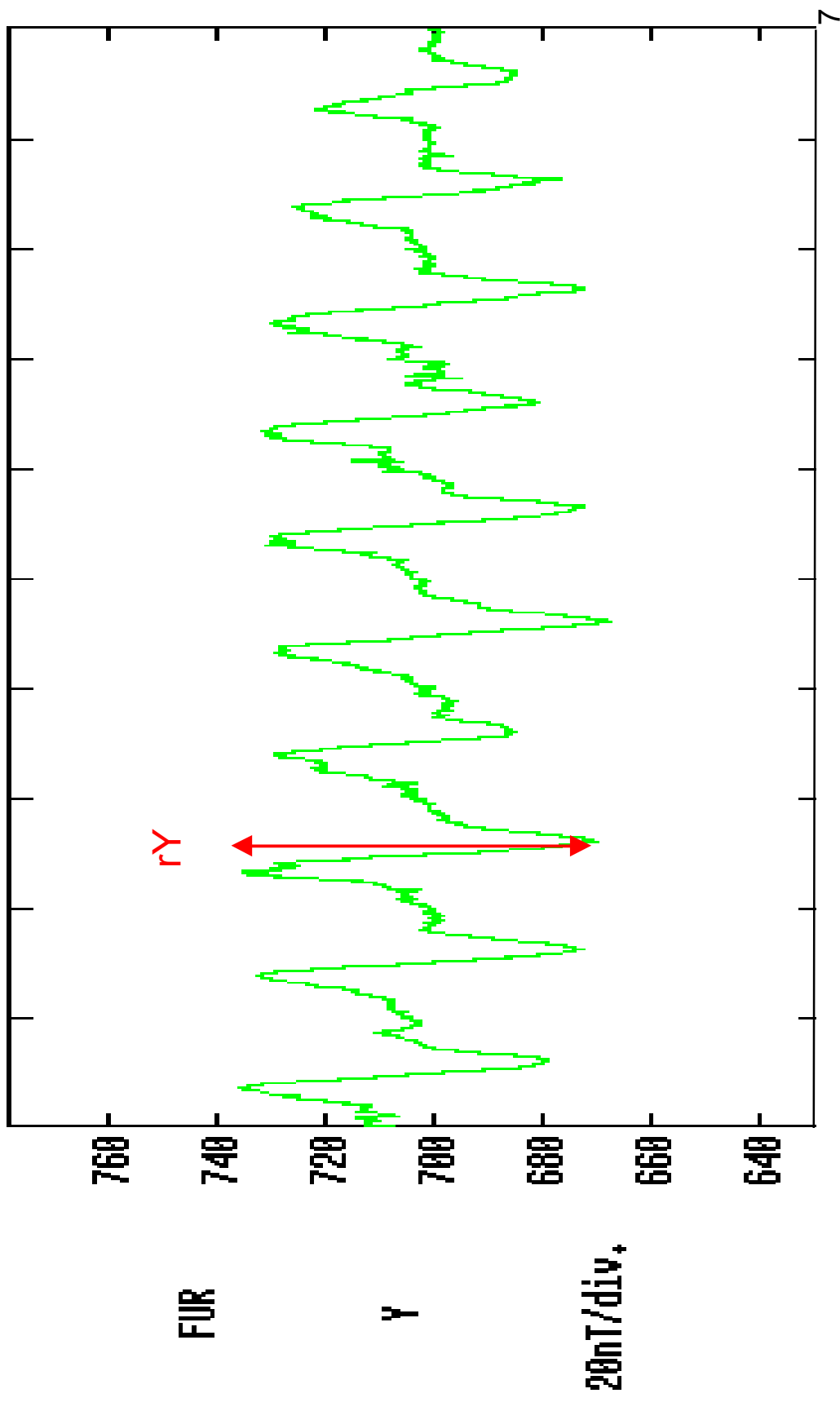
$$Y = H \sin(D)$$

$$dY = H \cos(D) dD \text{ For small } dD$$



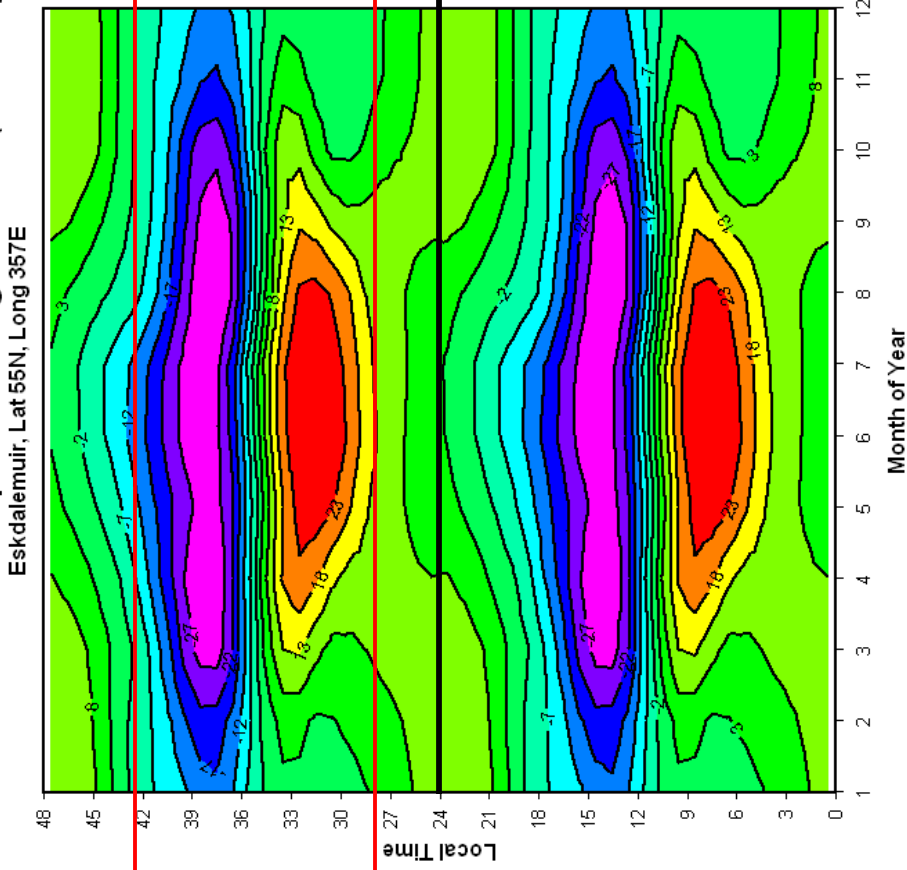
A current system in the ionosphere is created and maintained by solar FUV radiation

10 Days of geomagnetic variations



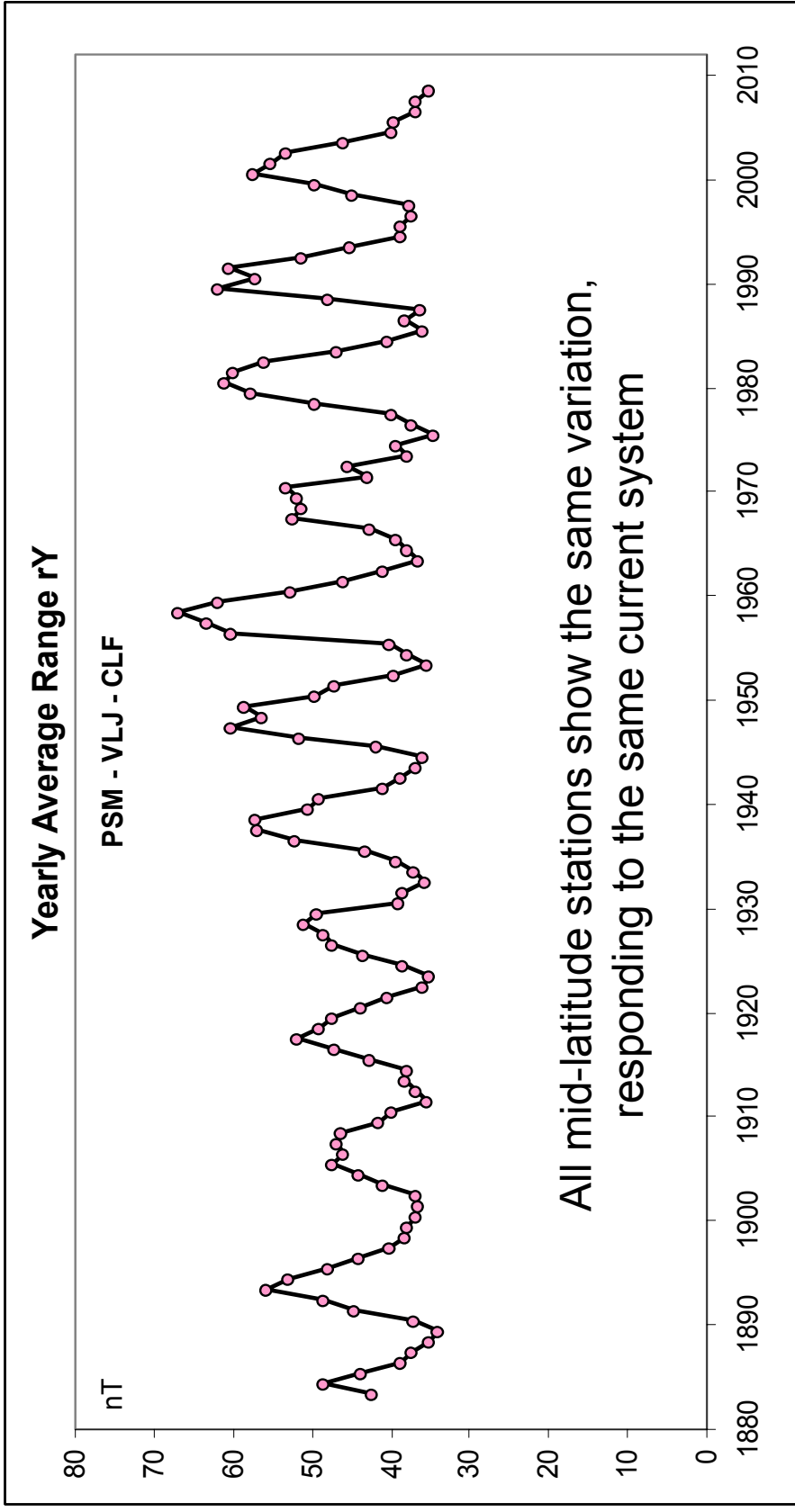
Definition of the Range, rY , of the Day-time variation of the Y-component.
X points towards North, **Y** points towards East, **Z** points Downwards.

Diurnal Variation of East Component Through the Year (from daily mean)



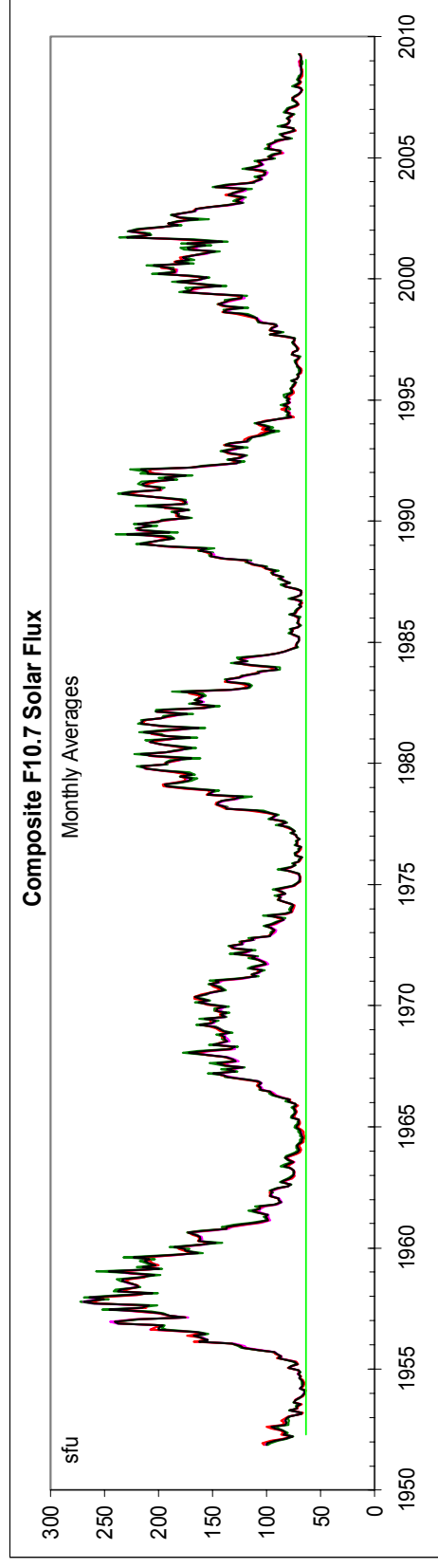
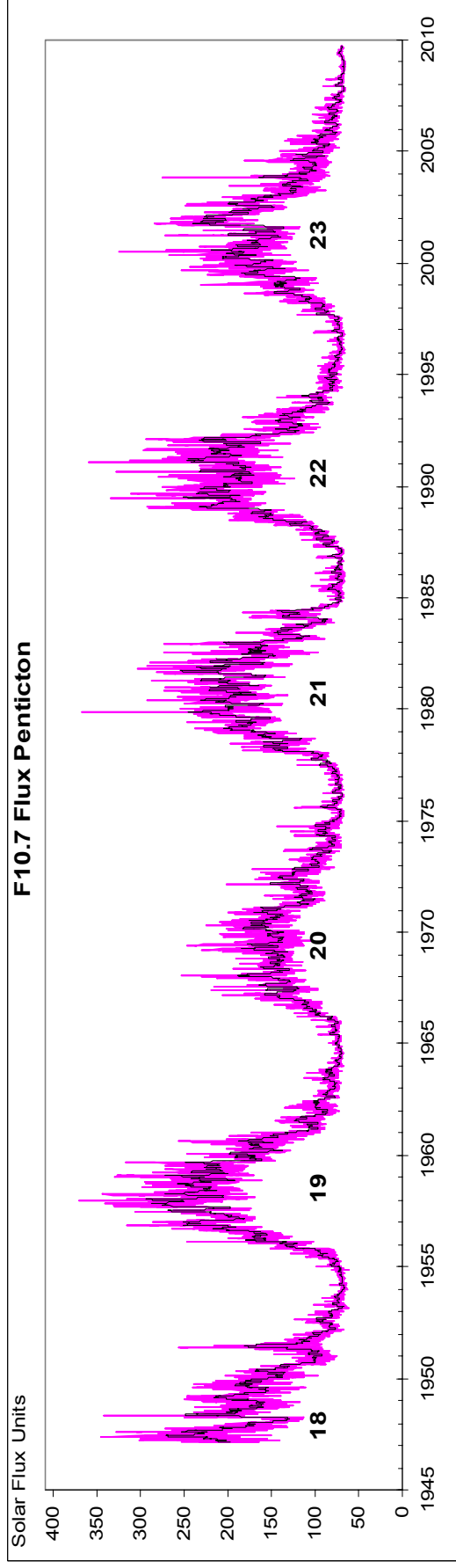
The diurnal variation consists of two 'waves': 1) a day wave [the Sq current system] and 2) a weaker night wave of return currents from the auroral electrojets. There is a clear seasonal variation in the relative strength of the two current systems. We are only interested in the day wave

The clear solar cycle variation of r_Y



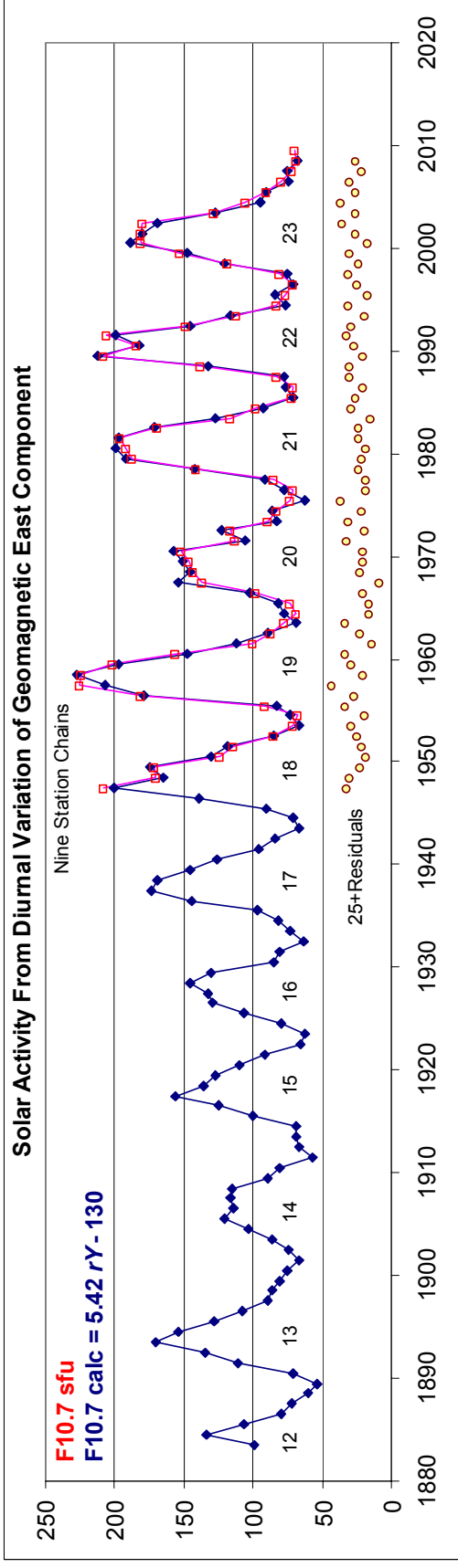
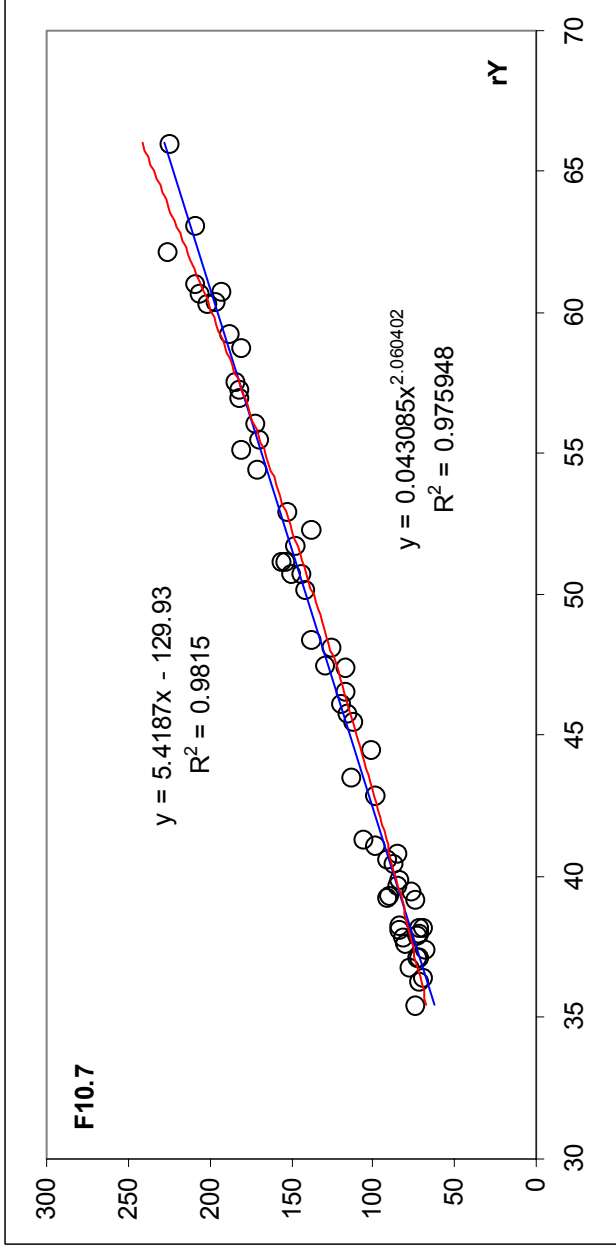
This was Wolf's justification for his calibration of the SSN

Solar Activity: Radio Flux at 2.8 GHz or 10.7 cm



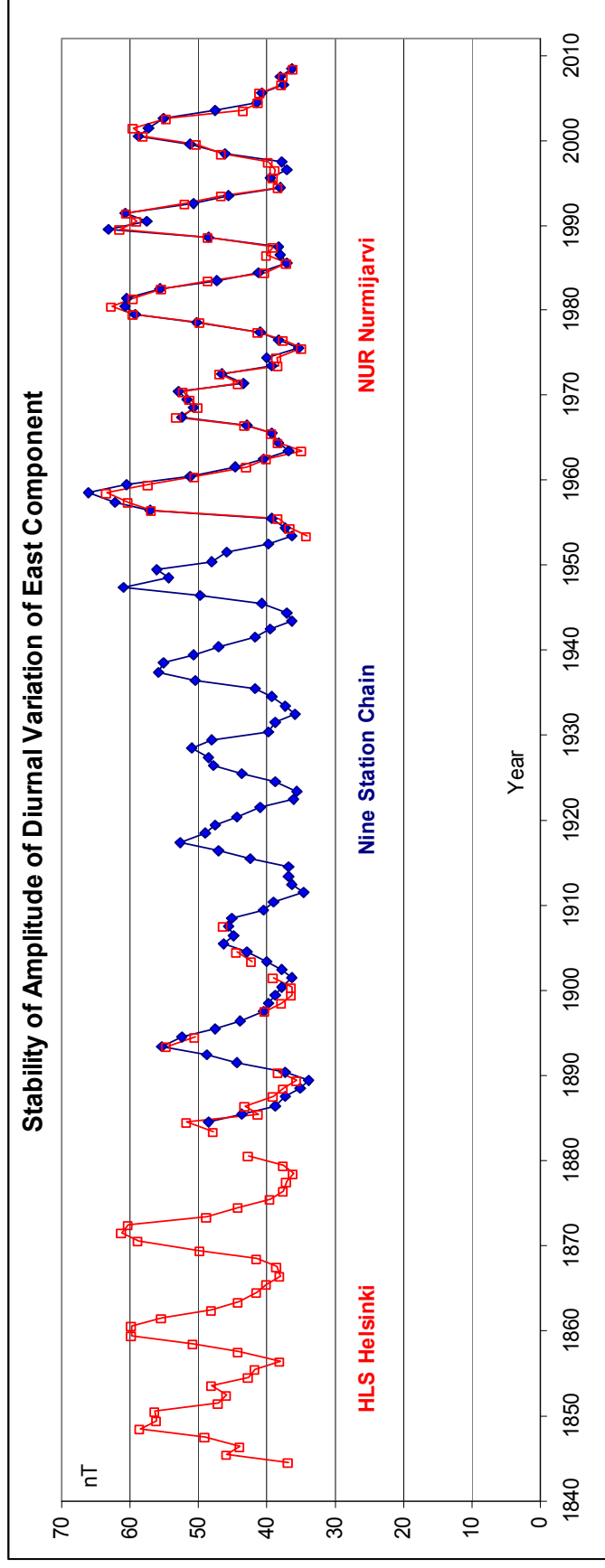
Very stable and well-determined from Canadian and Japanese stations

Using rY from nine 'chains' of stations we find that the **correlation** between $F10.7$ and rY is extremely good (more than 98% of the variation is accounted for)



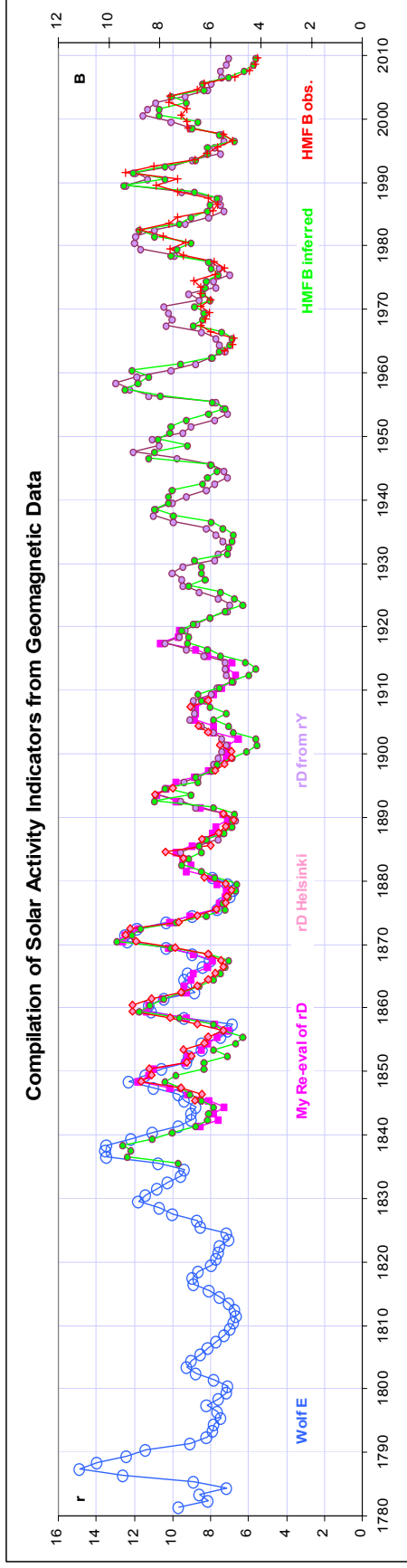
This establishes that Wolf's procedure and calibration are physically sound

The diurnal range rY is thus an extremely good proxy for the F10.7 radio flux and [presumably] for ‘solar activity’ in general

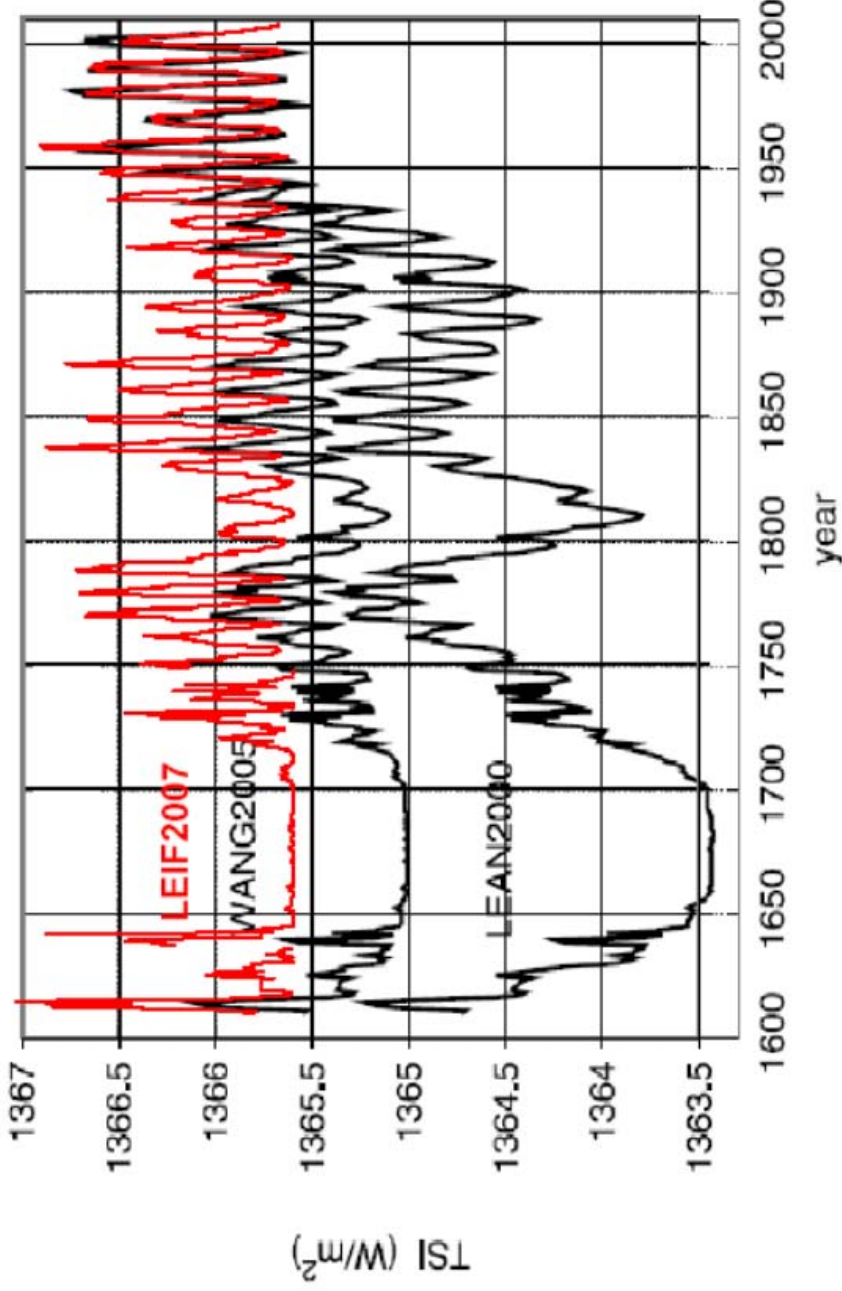


Here is the response at Helsinki and at its replacement station Nurmijärvi

We conclude that Wolf was justified
in using the geomagnetic data to
calibrate his sunspot number series
and that the Group Sunspot
Number does not represent a true
picture of solar activity



No Long-Term Trend in TSI



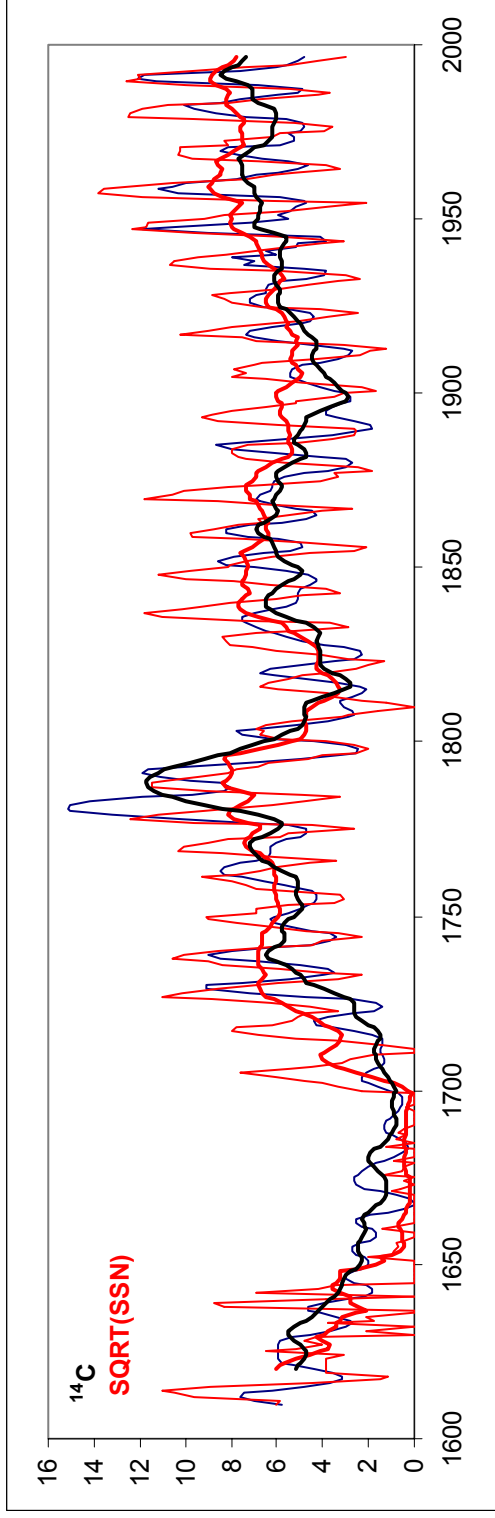
The justification for a long-term trend in Total Solar Irradiance is now largely gone.

This may have implications for Climate Change due to the Sun.

Abstract

The 'inventor' of the Sunspot Number [SSN], Rudolf Wolf, also discovered that the radiation from the Sun was controlling the daily variation of the compass needle [discovered by George Graham in 1722]. Wolf used this solar-terrestrial relationship to calibrate the Sunspot Number observed by many observers before Wolf's own observations and to bring all observers on to a common scale. After Wolf's death, later researchers forgot this and the sunspot number calibration drifted as even the counting method changed over time. Hoyt and Schatten's [H&S] Group Sunspot Number [GSN] also suffers from unknown calibration and H&S even concluded that Wolf's calibration was erroneous. The difference between the Wolf number, SSN, and the GSN at times amounts to a factor of two and has given rise to the Myth that we have just passed t 'Modern Grand Maximum' and that solar activity in recent cycles was the highest in ~10,000 years. We show that solar activity in the 20th century was not significantly different from the preceding two centuries and that Wolf was correct in his reconstruction of the SSN. That the GSN thus is not a correct representation of solar activity has severe impact on reconstructions and calibrations of several solar activity indicators, such as Total Solar Irradiance and Cosmic Rays proxies, with potential impact on modeling of Climate Change

Cosmic Ray Proxy ^{14}C and SSN



For Q/A session