The Newly Published Status Report by the ISSI-417 Team

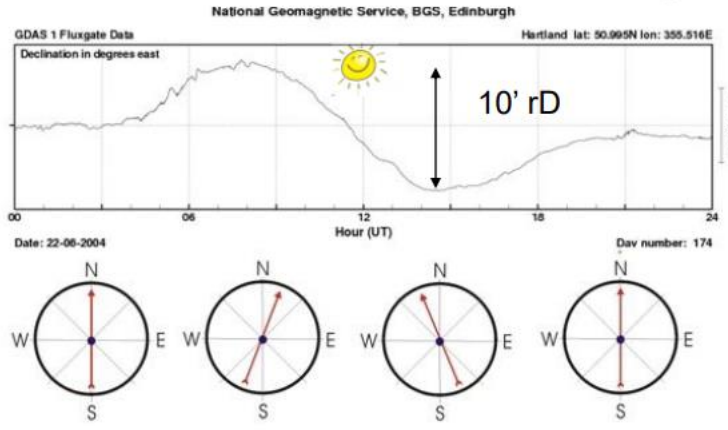
Leif Svalgaard Feb. 2023

The 300th Anniversary of Graham's Discovery

IV. *An Account of Obſervations made of the Variation of the Horizontal Needle at* London, *in the latter Part of the Year* 1722, *and beginning of* 1723. *By Mr.* George Graham, *Watchmaker, F. R. S.*

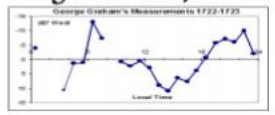
THE Figure of the three Needles, with which the Experiments were made, was priſmatick; their Lengths were nearly 12,2 Inches; their Ends, which pointed to the Diviſions, being filed to an Edge, which made a fine Line perpendicular to the Horizon. The Caps of two were of Chryſtal, the other of Glaſs; they were well poliſhed on the Inſide, in that Part which touched the Pin they moved upon. The Box was Braſs, and of a Breadth ſufficient to admit of

The Diurnal Variation of the Direction of the Magnetic Needle



IV. *An Account of Obſervations made of the Variation of the Horizontal Needle at* London, *in the latter Part of the Year* 1722, *and beginning of* 1723. *By Mr.* George Graham, *Watchmaker, F. R. S.*

Made ~1000 observations



George Graham [London] discovered [1722] that the geomagnetic field varied during the day in a regular manner.

On the 100th Year of Wolf's Death: H&S 1994

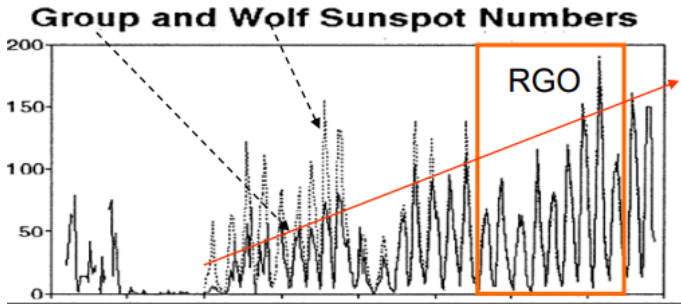
The H&S Papers That Started it All

Hoyt, Douglas V.; Schatten, Kenneth H.; Nesme-Ribes, Elizabeth: The one hundredth year of Rudolf Wolf's death: **Do we have the correct reconstruction of solar activity?** *Geophysical Research Letters, Volume 21, Issue 18, p. 2067-2070, 1994*

Hoyt, Douglas V.; Schatten, Kenneth H.: Group Sunspot Numbers: a new solar activity reconstruction. *Sol. Phys. 179, 189–219, 1998*. [HS98 in what follows]

"In this paper, we construct a time series known as the Group Sunspot Number. […] The generation and preliminary analysis of the Group Sunspot Numbers allow us to make several conclusions: (1) **Solar activity before 1882 is lower than generally assumed** and consequently **solar activity in the last few decades is higher than it has been for several centuries.**" [Other researchers have claimed for more than ≈10,000 years]

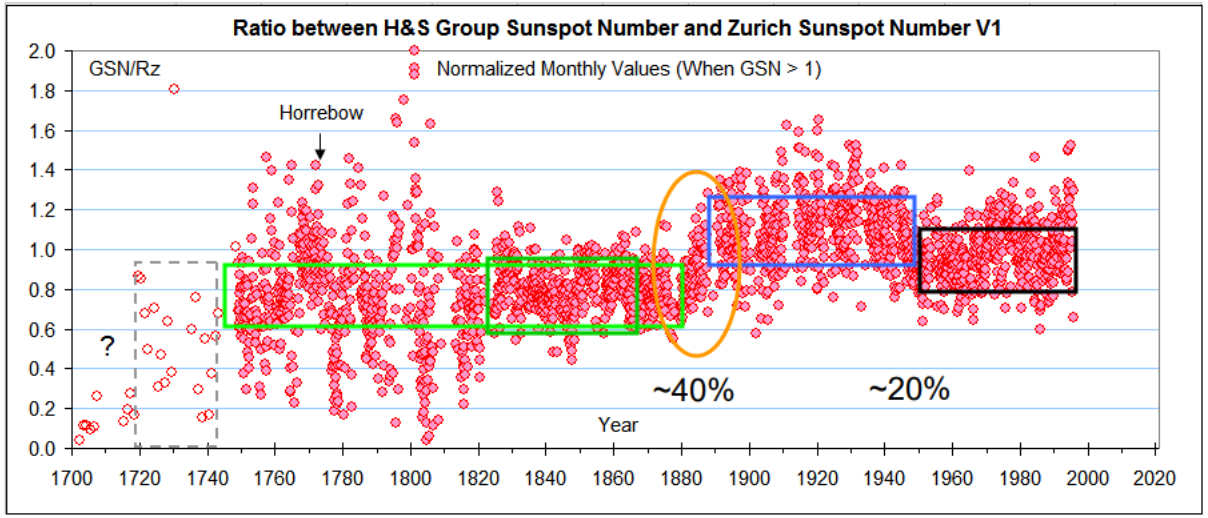
The Problem: Two Very Different 'Sunspot Series'. Which One to Use?



Original Wolf Number: W_o = Groups + 1/10 Spots. ('1/10 Spots' was assumed to be a measure of the area of the group). $W = k\ 10\ W_o$

H&S GSN = 12 G where the '12' was chosen to make the GSN = W for the interval 1874-1976

Discrepancies were Both Large and Systematic



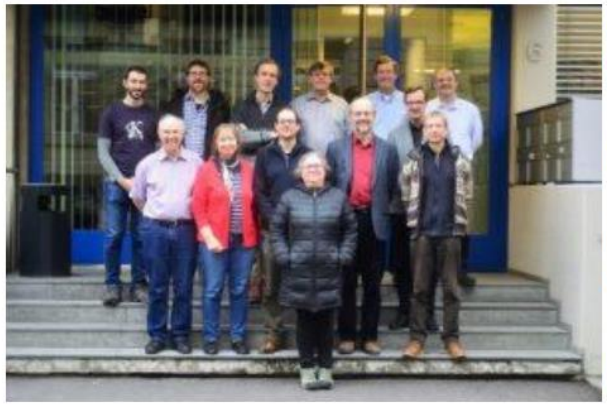
The ratio of the H&S GSN and the Official ["Zürich"] Relative Sunspot Number [version 1] (when not too small) reveals some systematic variations, related to choice of observers…

The Sunspot Workshops: 2011-2024?

I proposed a solution for reconciliation: The SSN Workshops (Utterly Failed the Goal)

Goal: a community-vetted and agreed-upon solar activity series;
Failure: we now have almost a dozen dissenting and different series…

The Principal Issue is Still Unresolved



A second attempt has recently been made to resolve the problem: **ISSI Team 417 (2017):** "This ISSI Team aims to resolve the uncertainties related to the sunspot series and to produce a consensus new-generation series, based on the modern methods and knowledge of physical processes leading to sunspot variability. The ultimate **goal is to provide a consensus "best" sunspot number** including accurate estimates of the uncertainties, for use by the whole scientific community (Meetings 2018 and 2019)

We now have basically two *classes* of reconstructions:

1: A set of series that closely resemble the original H&S reconstruction

2: A set of series that closely resemble the 'official' Sunspot series (both V1and V2; V2 is essentially just V1/0.6)

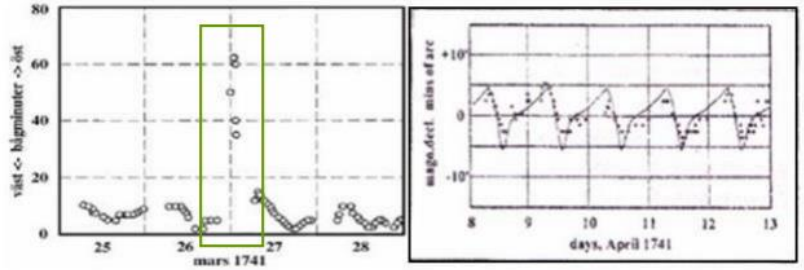
The main difference is (as pointed out by H&S) a discontinuity around 1880-1885 with up to 40% discrepancy between the two classes.

Instead of resolving the issue, opinions and claims have become more polarized and new reconstructions have marred the discourse with no end in sight

As the SSN workshops, this new effort also looks like a failure ??

Back to History: Anders Celsius and Olav Hiorter [1740s]

Observations in the 1740s



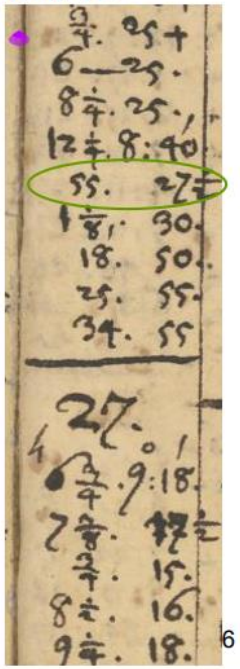
Right: Hjorter's measurements of the magnetic declination at Uppsala during April 8-12, 1741 (old style). The curve shows the average variation of the magnetic declination during April 1997 at nearby Lovö (Sweden).

Left: Variation during strong Northern Light on March 27th. Also observed by Graham in London, showing that the aurorae and magnetic field are connected on a large scale and not just local meteorological phenomena.

Note there are really two phenomena going on, regular daily variation and sporadic, large aurora-related excursions…

This is from Hjorter's original notebook for that day. Observations were made with an instrument constructed by Graham.

Olof Petrus Hjorter was married to Anders Celsius' sister and made more than 10,000 observations of the magnetic declination in the 1740s.



Celsiusobservatoriet i Uppsala, grundat 1739.

Om MAGNET-NÅLENS
Åtskillige ändringar, som uf framledne Profeſſoren Herr AND. CELSIUS blifvit i akt tagne och ſedan vidare obſerverade, ſamt nu framgifne

Af

OLAV. PETR. HIORTER.

Af Kongl. Vetenſkaps Academiens Handlingar för år 1740 pag. 296 -- 299, kan inhämtas, huru ſal. Herr Profeſſoren låtit ifrån Engeland hitkomma en ſtor och accurat Compaſs, at på denſamma tilſe, huru med den ändring ſig förhåller, ſom Magnet-Nålen, utan någon viſs och til den tiden bekant ordning, befunnits giöra.

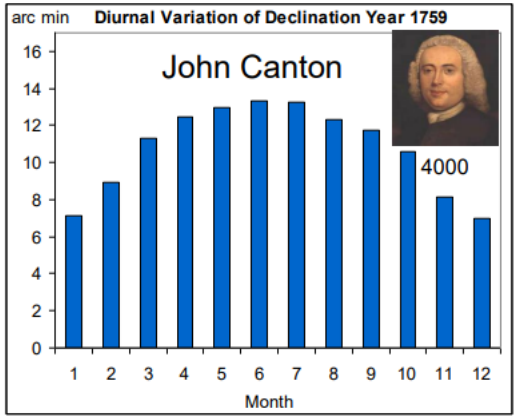
På ſådane obſervationer har man Herr Profeſſorens journal, ifrån den 29 April. til den 9 Jun. det året; hvaraf de, ſom höllos den 30 April. och 1 Maj. åro i ofvannämde Handling, pag. 299 införde, til et prof af Magnet-viſningens ſtundeliga förändring, den der ſedan alla dagar vid ſamma timar märktes ſke, faſtän til mindre minut tal och ſtorlek, än då obſerverades.

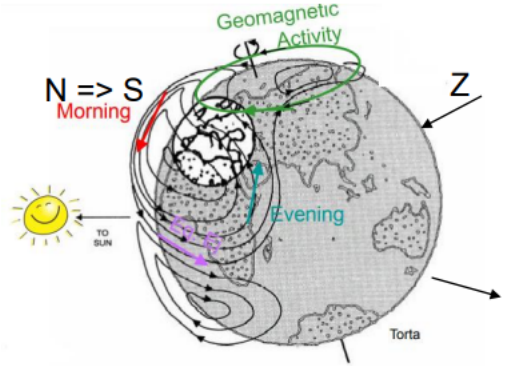
A Breakthrough Occurred in 1759 by John Canton

XXXVIII. *An Attempt to account for the regular diurnal Variation of the horizontal magnetic Needle; and also for its irregular Variation at the Time of an Aurora Borealis: By* John Canton, *M. A. and F. R. S.*

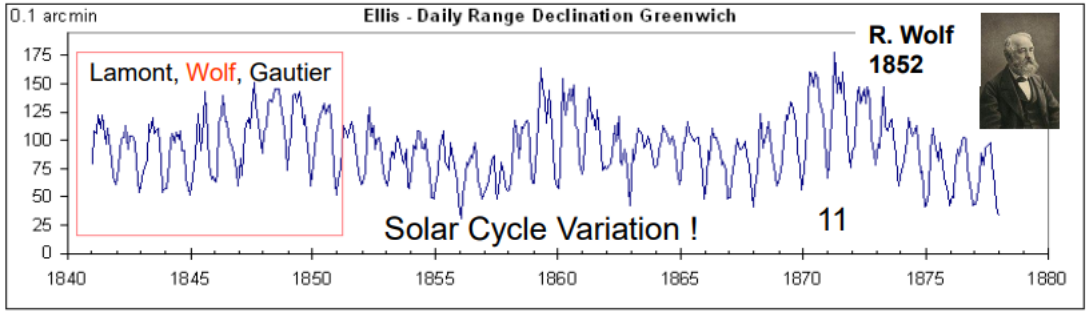
Read Dec. 13, 1759. THE late celebrated Mr. George Graham made a great number of obſervations on the diurnal variation of the magnetic needle, in the years 1722 and 1723; but declared himſelf ignorant of the cauſe of that variation, in No 383 of the Philoſophical Tranſactions, where many of thoſe obſervations are to be found. About

Zenith Angle Dependence Discovered





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

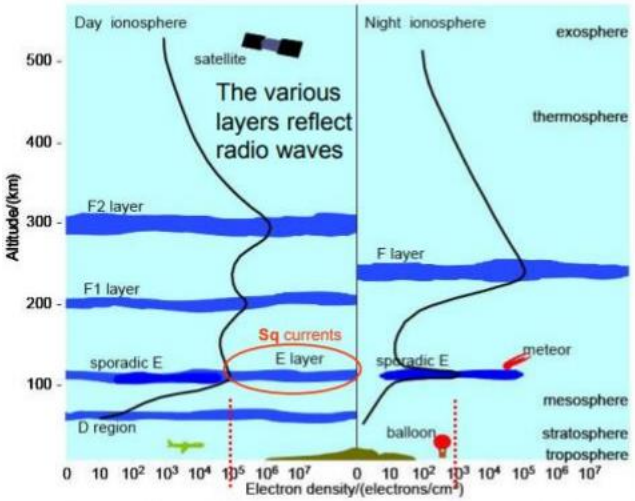


Canton believed that the variation was caused by the variable solar heating of the Earth and its magnetic field

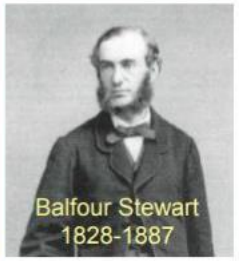
Today we Know the Physics of the Variations

The Physics of the Daily Variation

Ionospheric Conducting Layers



Winds moving the charges across the magnetic field creates a dynamo current, whose magnetic effect we can observe at the surface as Graham discovered



1882, Encyclopedia Britannica, 9th Ed.:

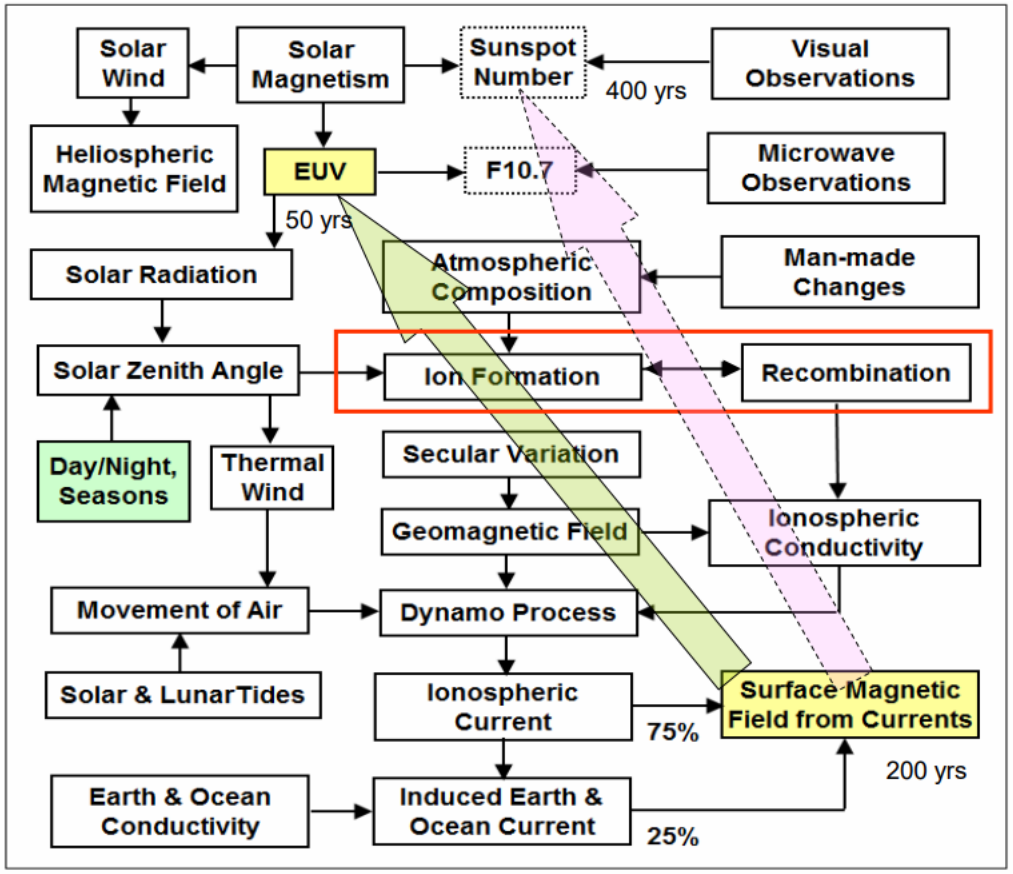
"there seems to be grounds for imagining that their **conductivity may be much greater than has hitherto been supposed.**"

But why?

Dynamo

An effective dynamo process takes place in the dayside E-layer where the density, both of the neutral atmosphere and of the electrons are high enough.

14



Determining EUV Flux from the magnetic effect of dynamo currents in the E-region of the ionosphere

The physics of the boxes is generally well-known

We can determine the EUV from the magnetic effects

17

And can actually compute the variation from the solar EUV flux (or its proxy: the F10.7 flux. Wolf marveled at this already back in the 1850s: "who would have thought that we can derived a terrestrial phenomenon from observation of sunspots?"

Which Brings us back to the “Status Report”:

Recalibration of the Sunspot Number: Status Report

F. Clette[a], L. Lefèvre[a], T. Chatzistergos[b], H. Hayakawa[c], V.M. Carrasco[d], R. Arlt[e], E.W. Cliver[f], T. Dudok de Wit[g], T. Friedli[h], N. Karachik[j], G. Kopp[j], M. Lockwood[k], S. Mathieu[l], A. Muñoz-Jaramillo[m], M. Owens[k], D. Pesnell[n], A. Pevtsov[f], L. Svalgaard[o], I.G. Usoskin[p], L. van Driel-Gesztelyi[q], J.M. Vaquero[d]

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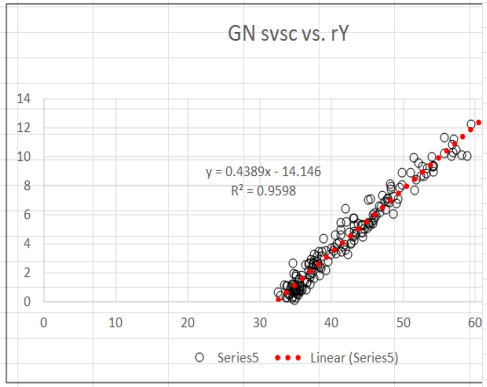
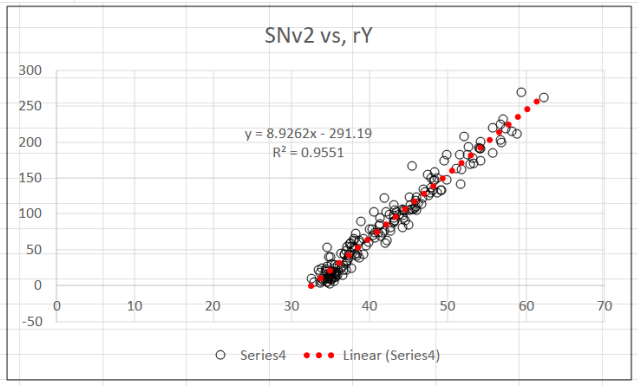




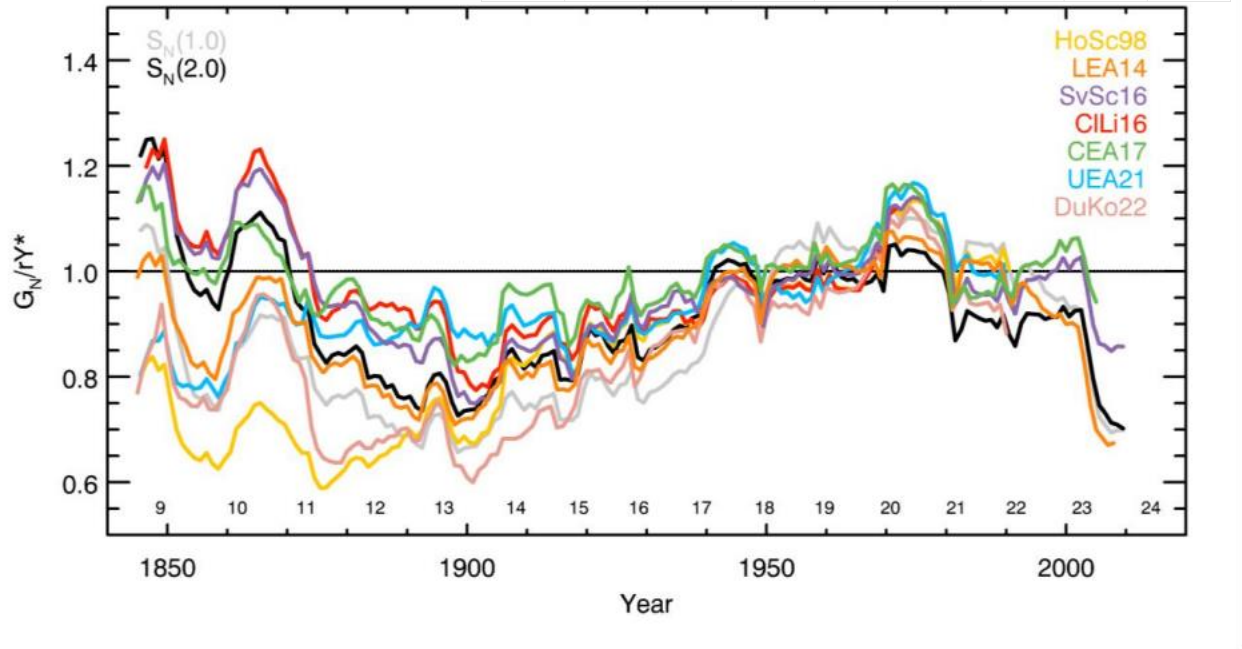
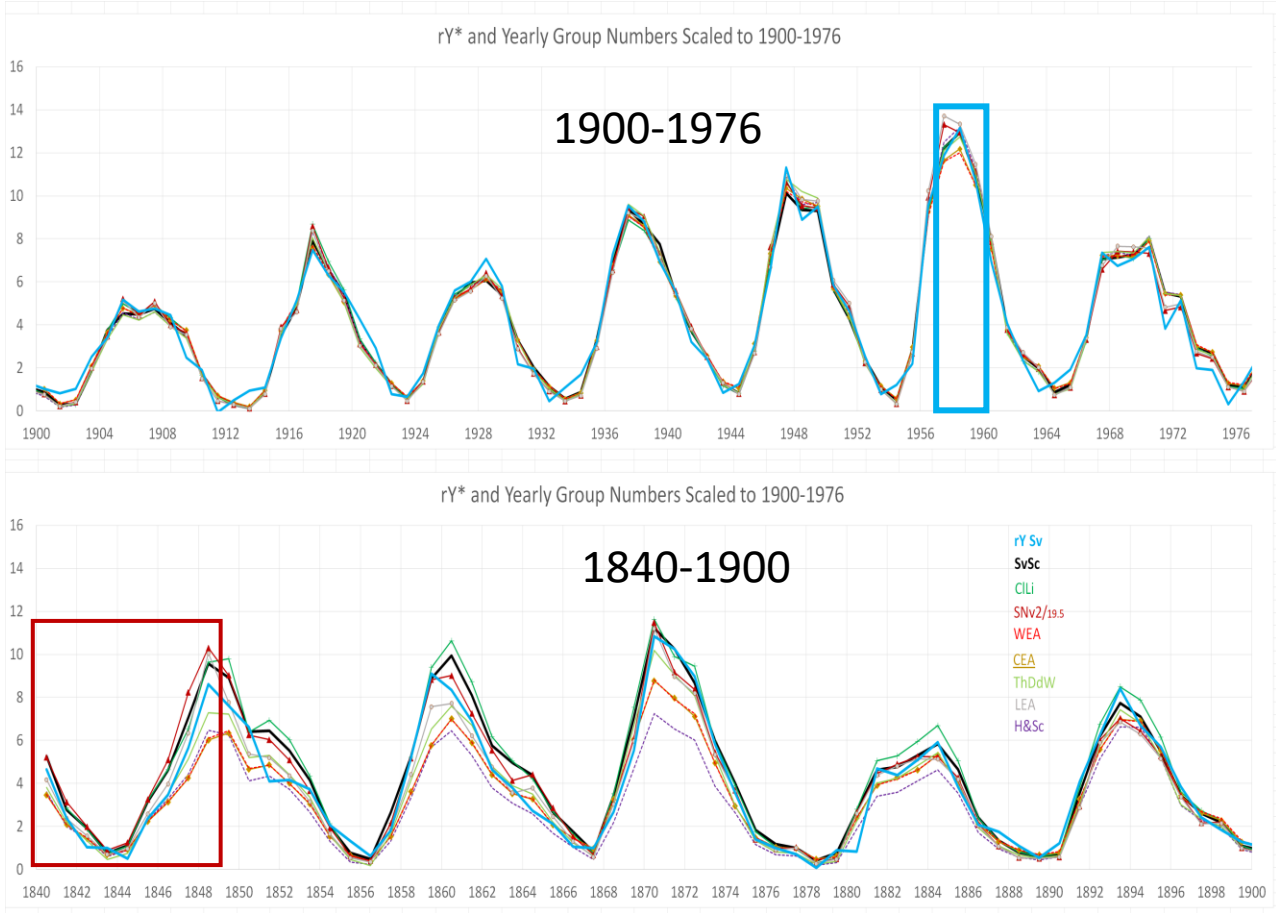
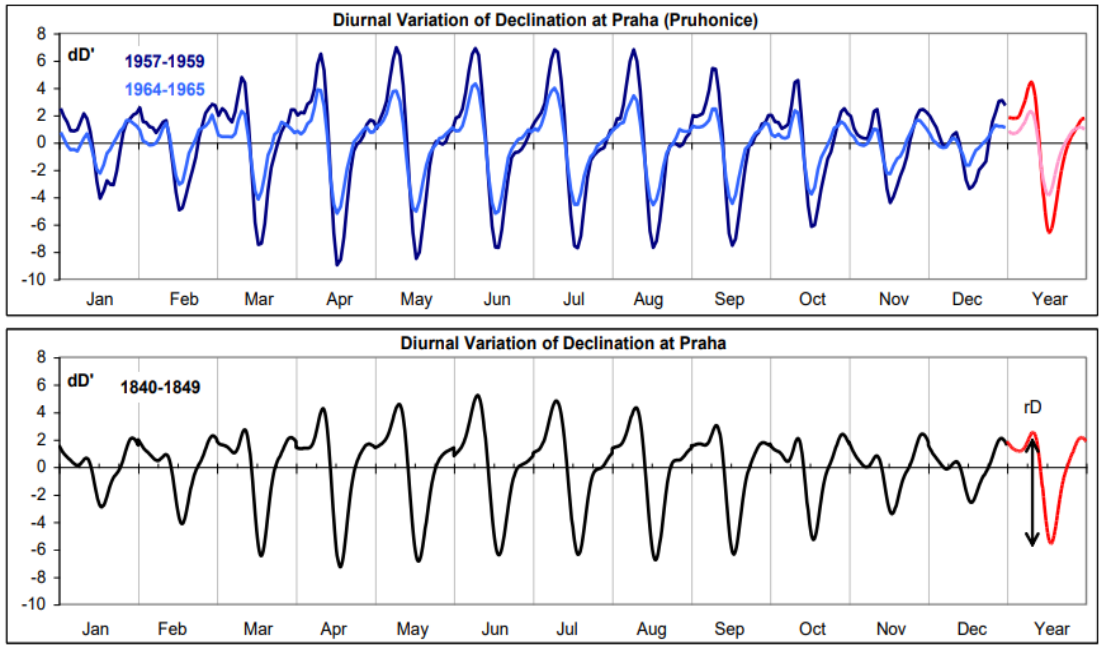


Figure 19. Ratios between the annual mean group sunspot number and annual mean range rY in nT smoothed with a 11-year running mean window. The sunspot number series were normalized to $S_N(2.0)$ over the period 1920-1974. rY was linearly scaled to CEA17 G_N series to render the ratio (G_N/rY*) around

Normalize to a Period When All Agree



The Diurnal Variation of the Declination for Low, Medium, and High Solar Activity



This is, in Fact, No News (Loomis, 1870)

The Observational **Facts** are Not New

THE AMERICAN JOURNAL OF SCIENCE AND ARTS. Second Series

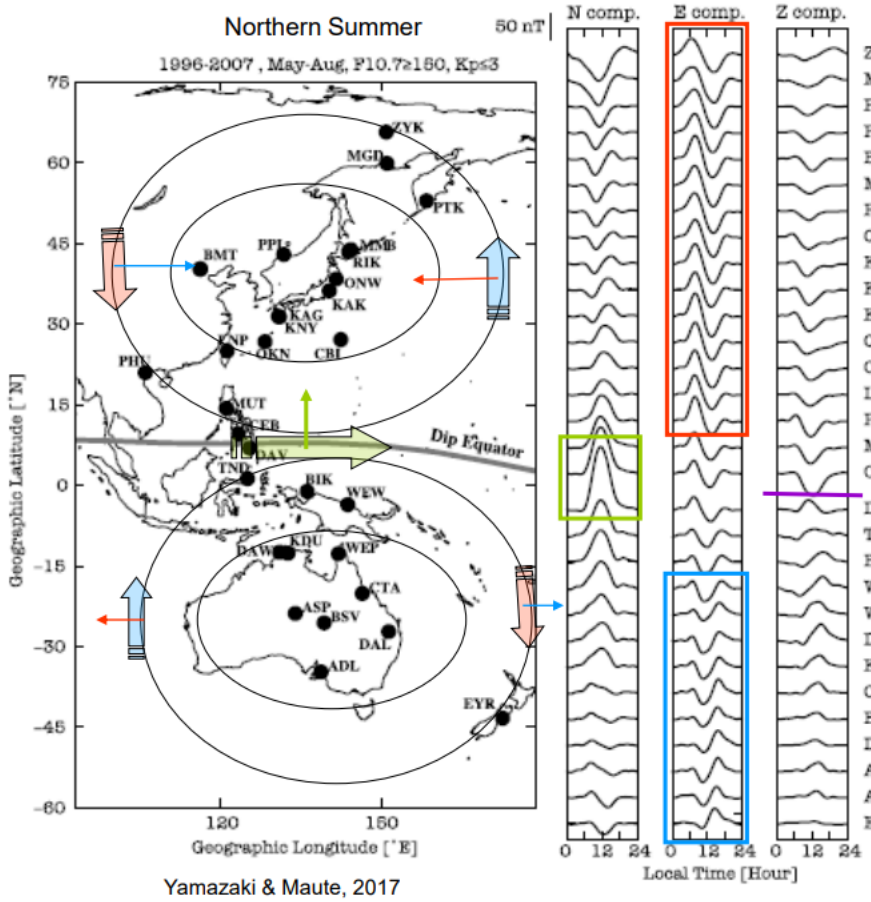
ART. XVI.-Comparison of the mean daily range of the Magnetic Declination, with the number of Auroras observed each year, and the extent of the black Spots on the surface of the Sun, by ELIAS LOOMIS, Professor of Natural Philosophy in Yale College. Vol. L, No.149. Sept.1870, pg 160.

This comparison seems to warrant the following propositions:

1. A diurnal inequality of the magnetic declination, amounting at Prague to about six minutes, is independent of the changes in the sun's surface from year to year.

2. The excess of the diurnal inequality above six minutes as observed at Prague, is almost exactly proportional to the amount of spotted surface upon the sun, and may therefore be inferred to be produced by this disturbance of the sun's surface, or both disturbances may be ascribed to a common cause.

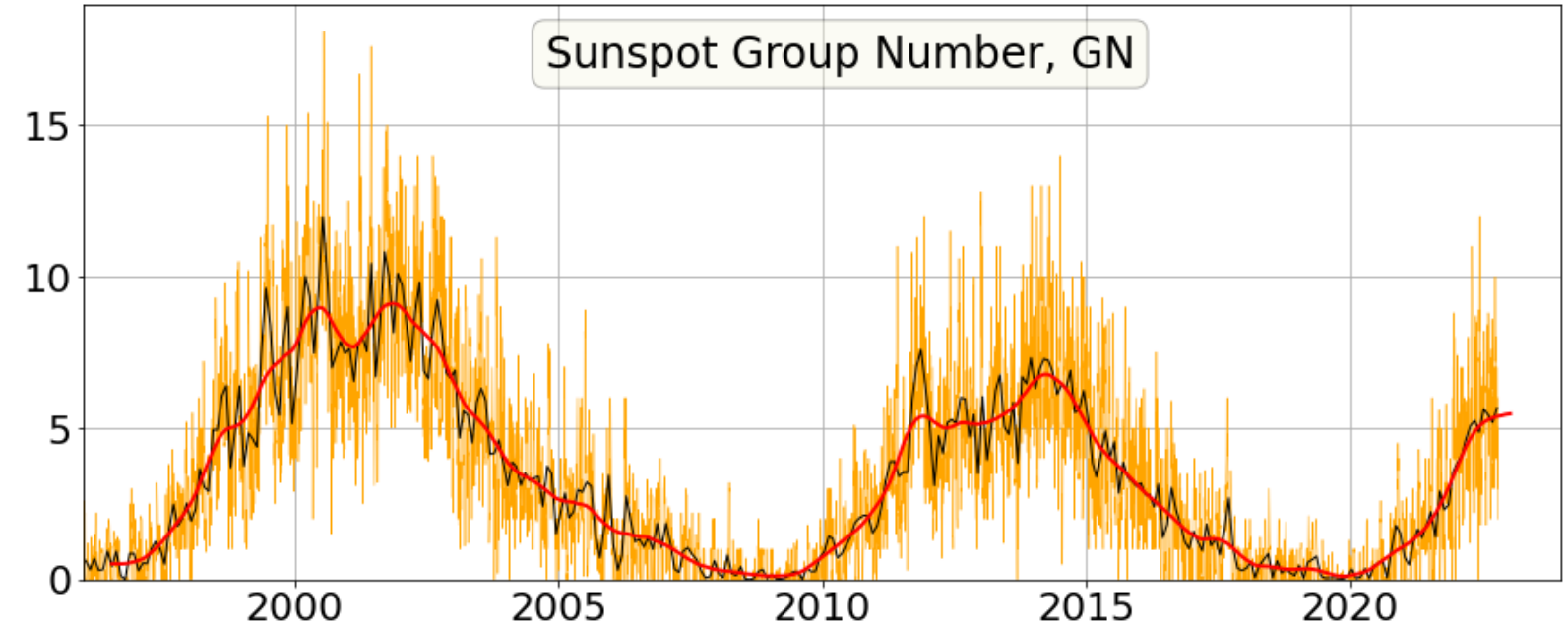
19th century 'Inequality' = deviation from [i.e. 'not equal to'] the mean

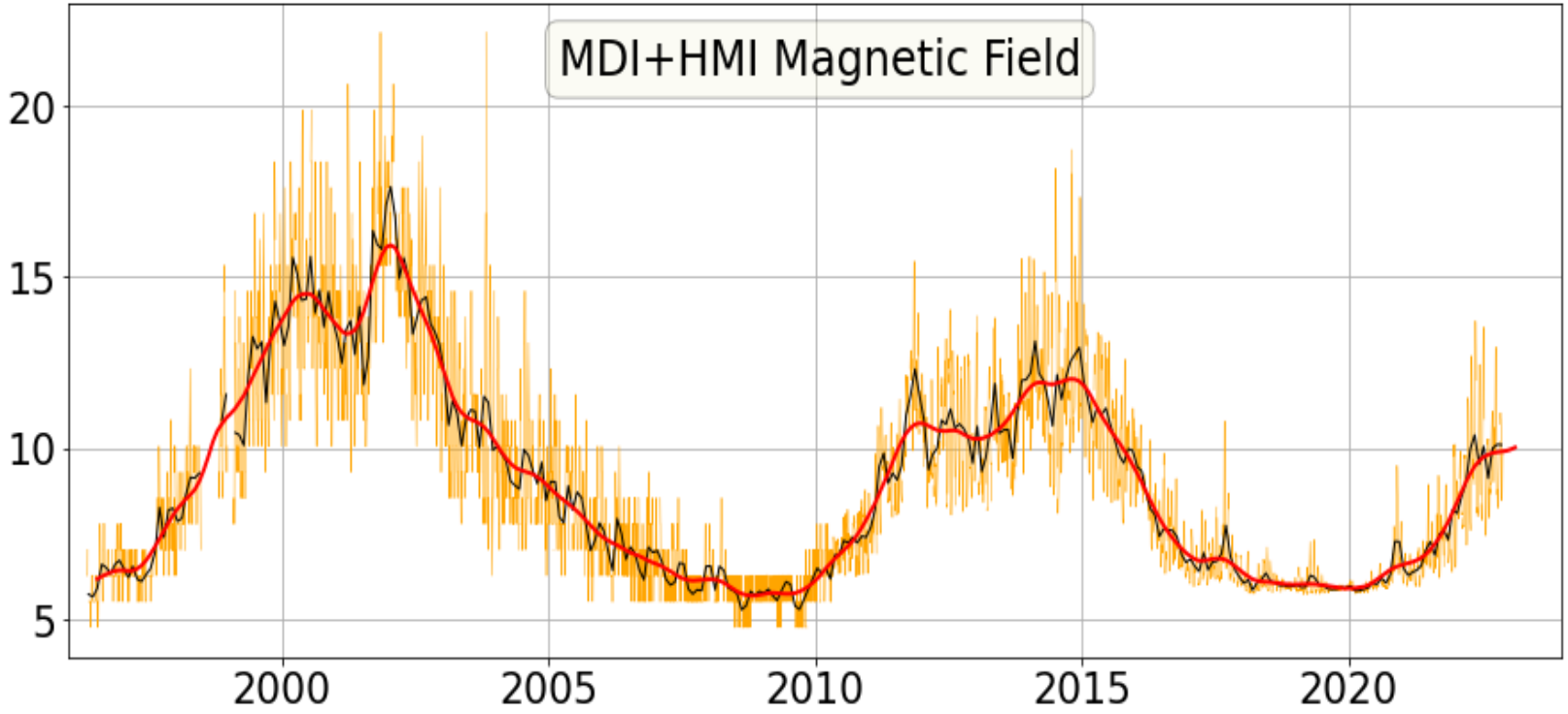


Yamazaki & Maute, 2017

Diurnal Variation of Geomagnetic Field

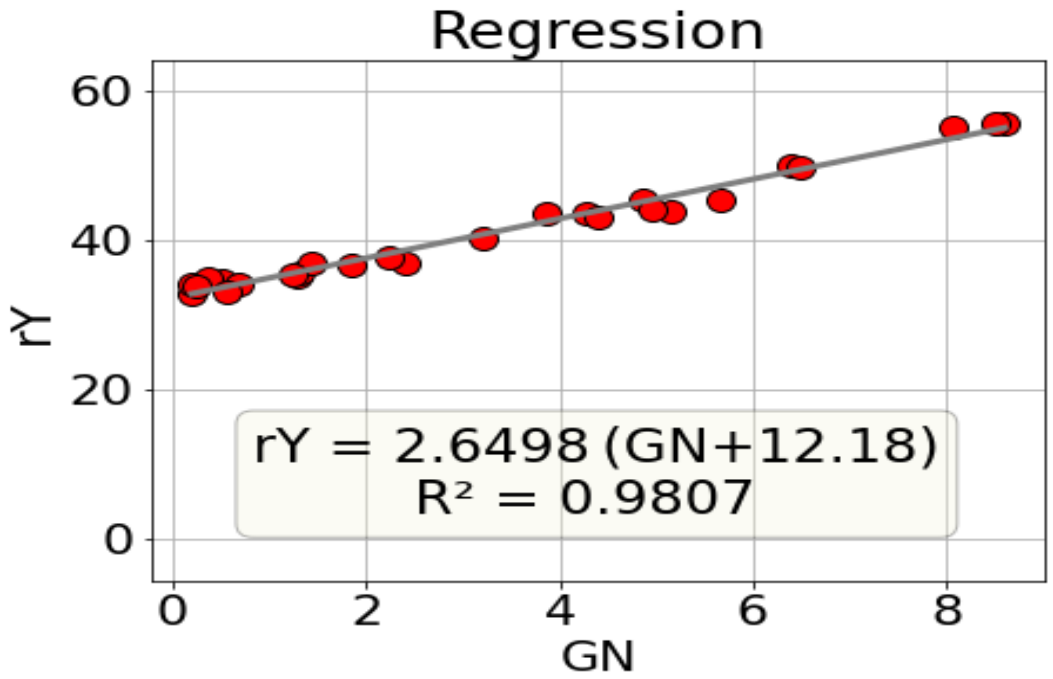
Already Julius Bartels (1946) emphasized the importance of the diurnal variation: ""The correlations between R and his W (wave-radiation)… are the **closest found so far** between solar and terrestrial phenomena"

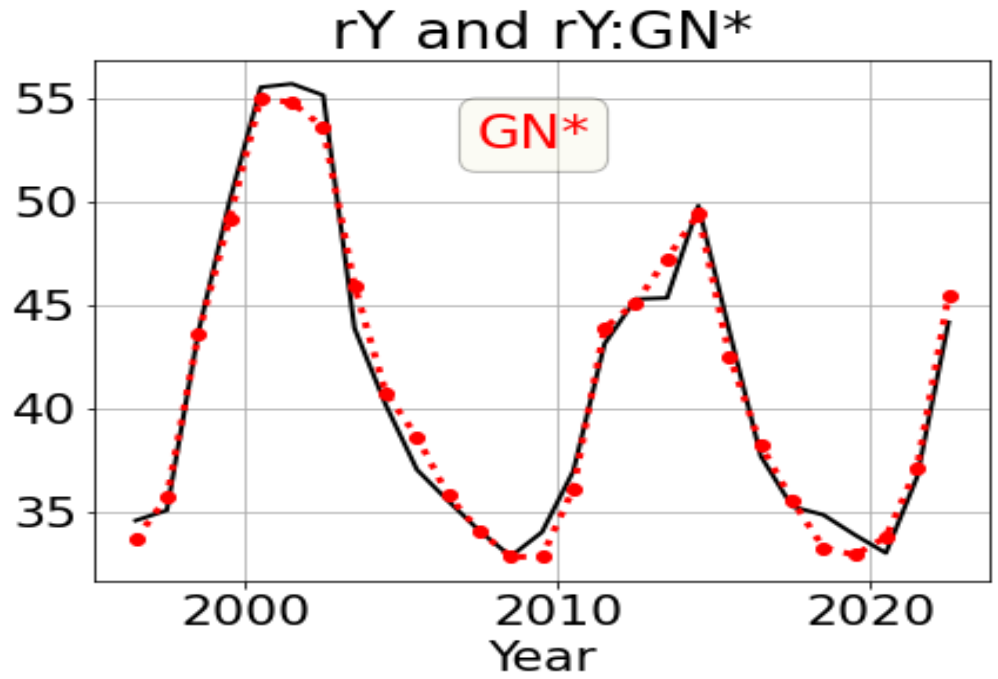


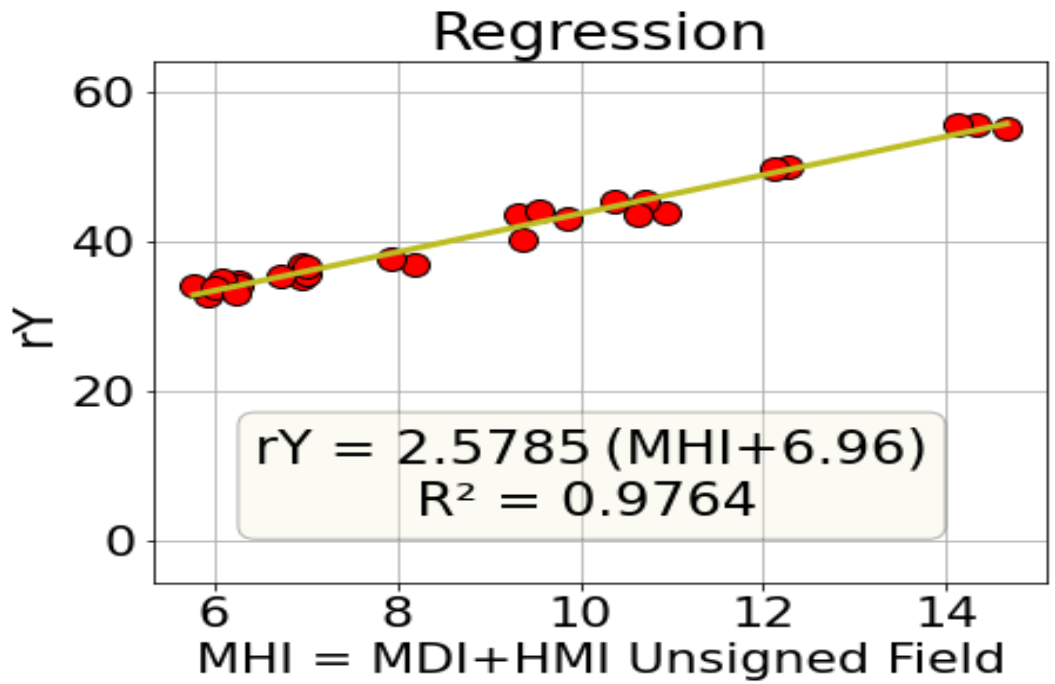


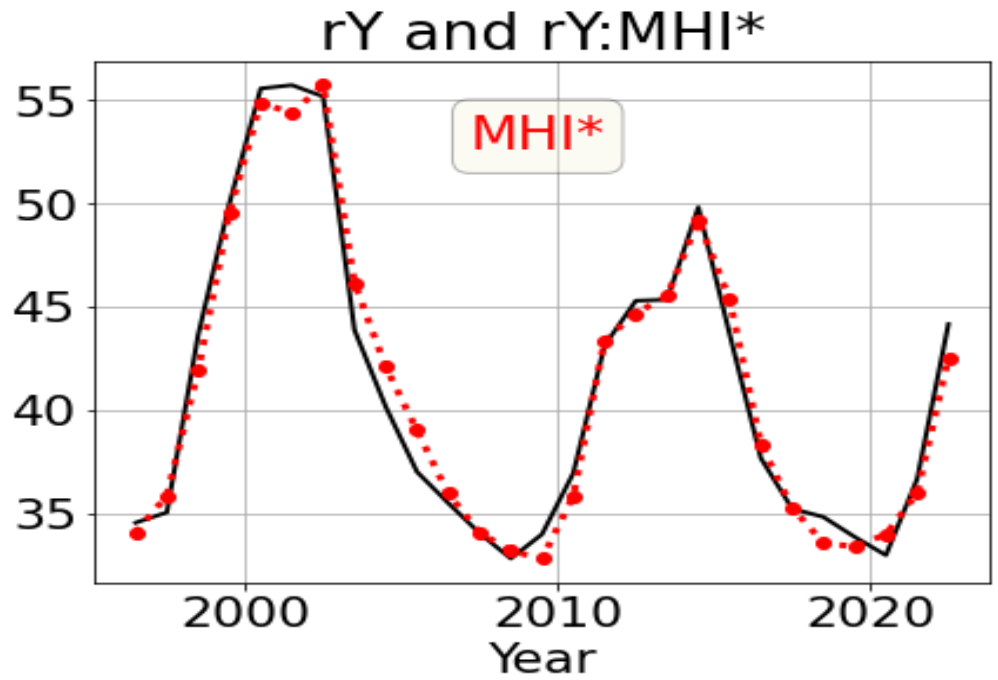
Daily [orange], Monthly [black[and Yearly [red] averages of the sunspot Group number

And of the Combined MDI+HMI total disk unsigned magnetic flux [lower plot] on the HMI scale


Regression
rY
GN
rY = 2.6498 (GN+12.18)
R² = 0.9807
0
20
40
60
0
2
4
6
8


rY and rY:GN*
GN*
Year
35
40
45
50
55
2000
2010
2020


Regression
rY
MHI = MDI+HMI Unsigned Field
rY = 2.5785 (MHI+6.96)
R² = 0.9764
0
20
40
60
6
8
10
12
14


rY and rY:MHI*
MHI*
Year
35
40
45
50
55
2000
2010
2020

Conclusion

- The Diurnal variation of the geomagnetic field can be computed from the sunspot [groups and numbers], which then are excellent proxies for solar activity
- The Diurnal variation can be computed from the magnetic field
- **It is time to stop arguing over this and get to the consensus that the community needs.**