

Solar activity, magnetic field and links to volcanic eruption frequencies

<https://solargsm.com/solar-activity/>

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1 -University of Northumbria, Newcastle upon Tyne, UK

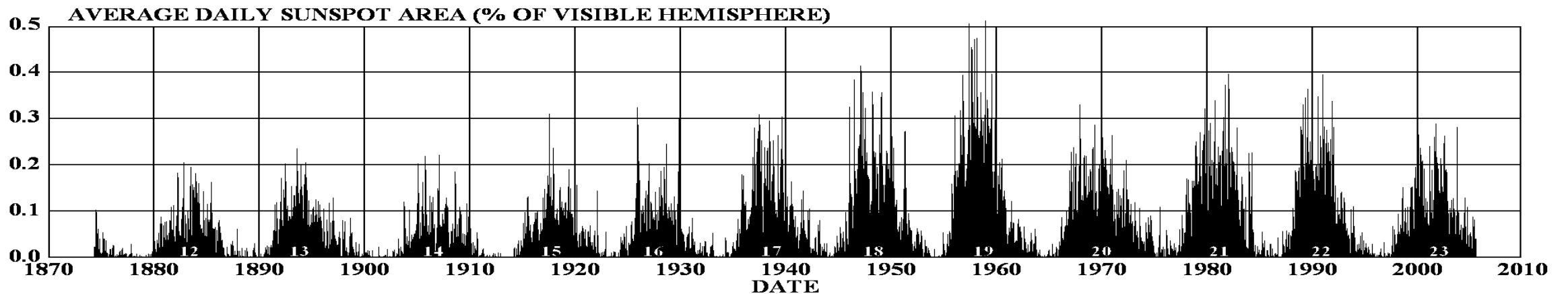
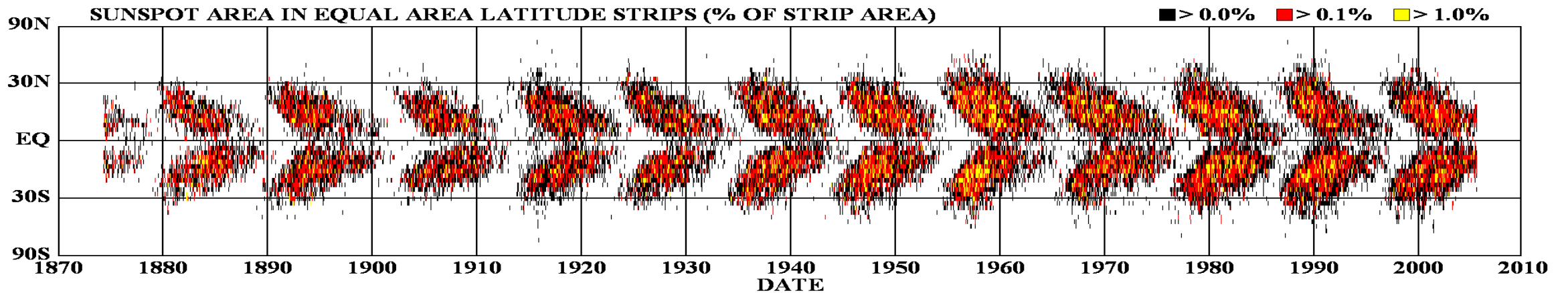
2 – ZVS Research Enterprise Ltd., London, UK

3 – Main Astronomical Observatory, Kyiv, Ukraine

<https://solargsm.com/publications/>

Current solar activity index

DAILY SUNSPOT AREA AVERAGED OVER INDIVIDUAL SOLAR ROTATIONS



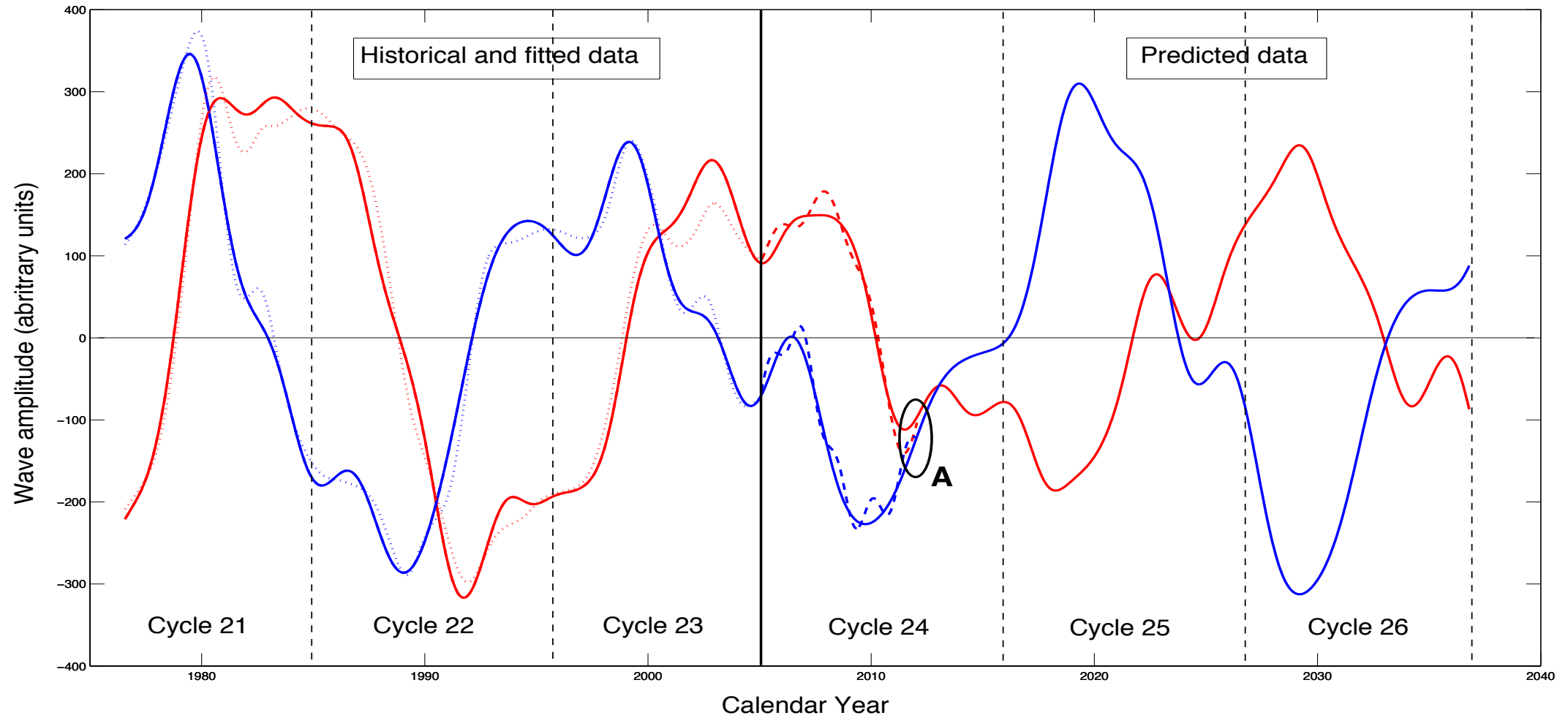
Solar



CO

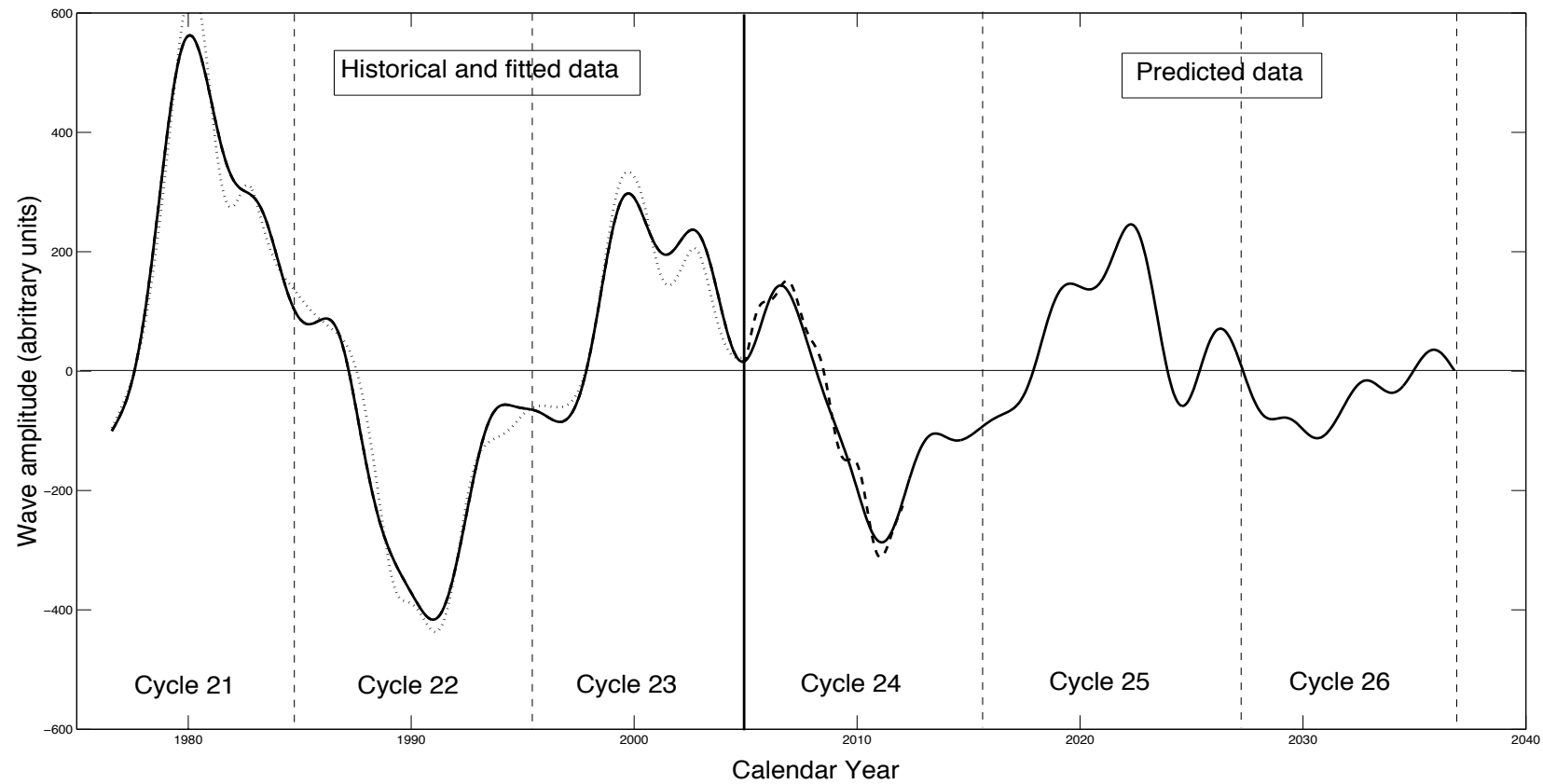
T

Eigen vectors come in pairs, here are PCs



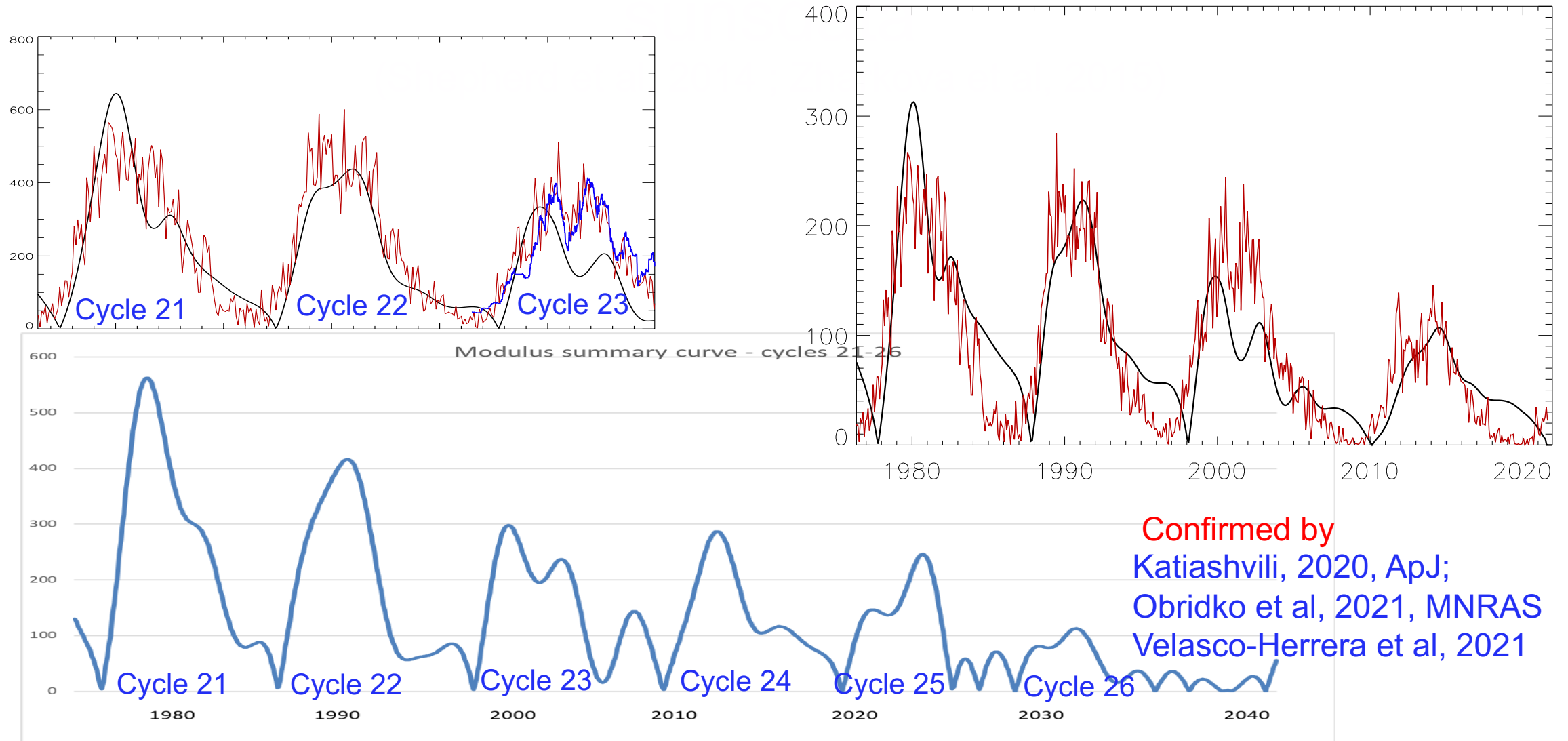
(Shepherd et al, 2014, Zharkova et al, 2015)

Summary curve of 2 PCs

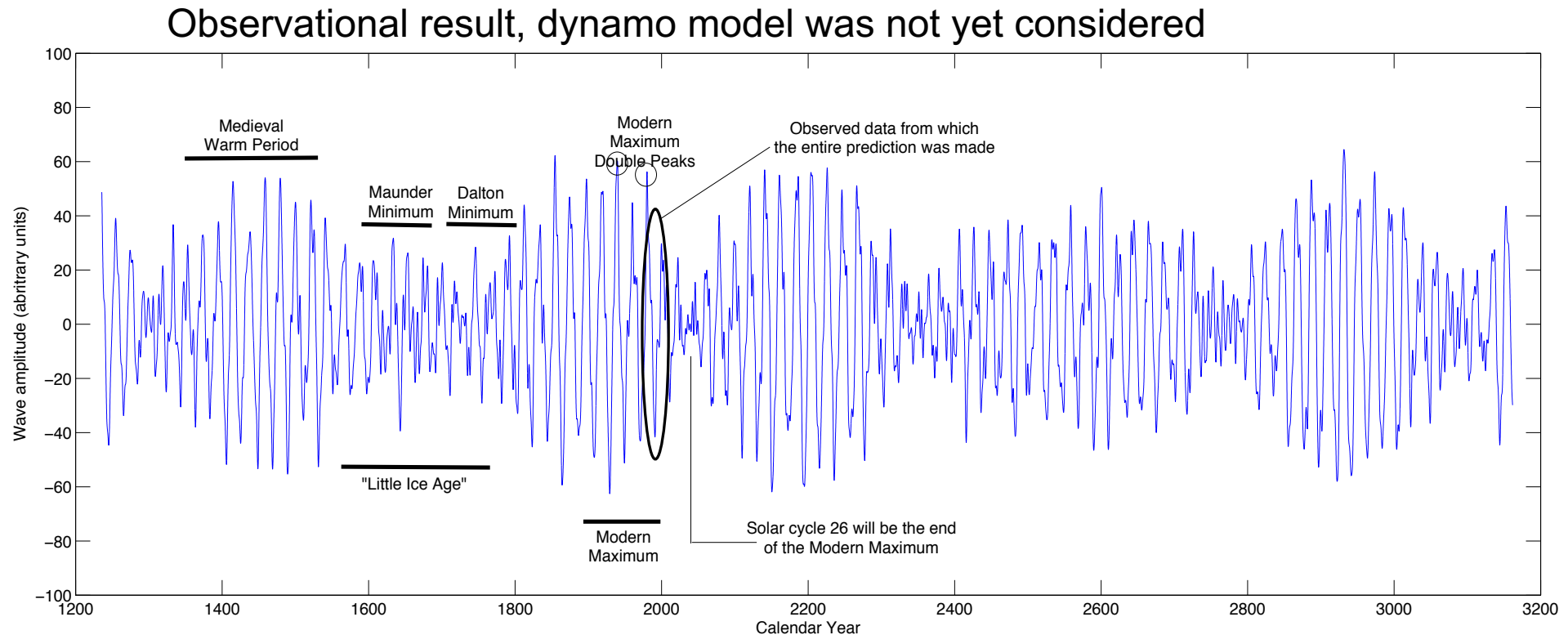


Modulus summary curve

Zharkova et al, 2015, SciRep; 2020, Temp., Zharkova et al, 2022, MNRAS



Predicted solar activity (Zharkova et al, 2015, SR <https://www.nature.com/articles/srep15689>)



Discovery of grand solar cycles :350-400 years
In addition to 11 year cycles

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The two waves interference

- $y_1(x,t)=A\cos(kx-\omega t)$ (top wave),
- $y_2(x,t)=A\cos(kx-\omega t+D)$ (middle wave)

$$y(x,t)=\underline{y_1(x,t)}+\underline{y_2(x,t)}$$

resulting wave with amplitude B

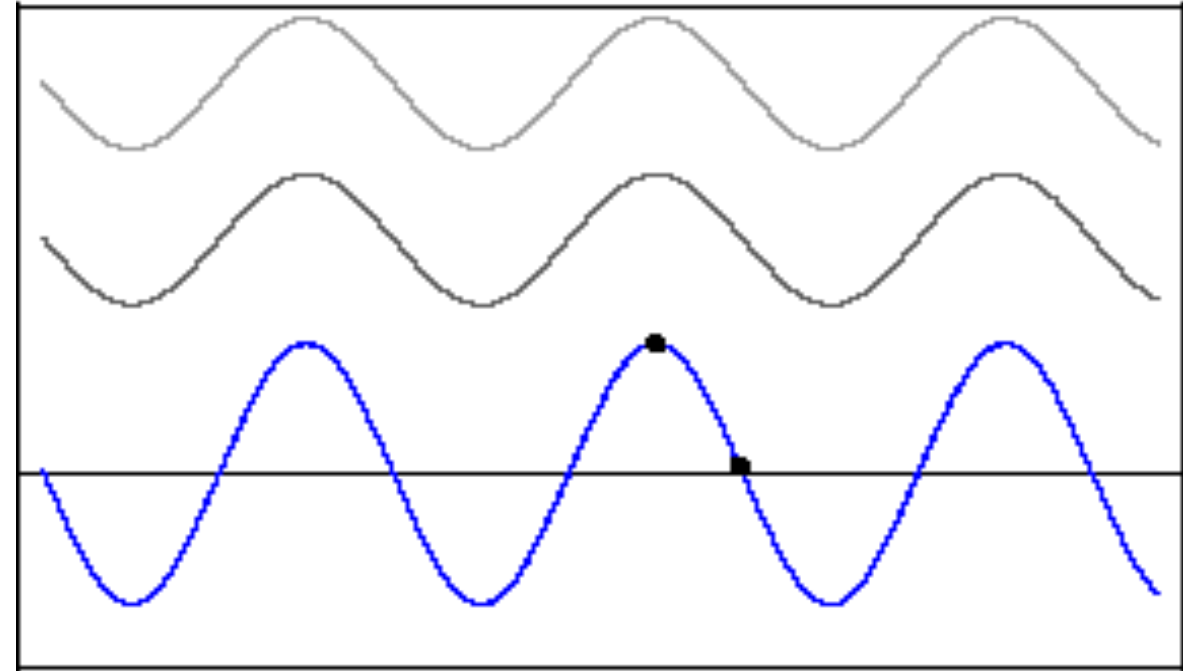
ω – frequency, k – wave number,

x – wave displacement

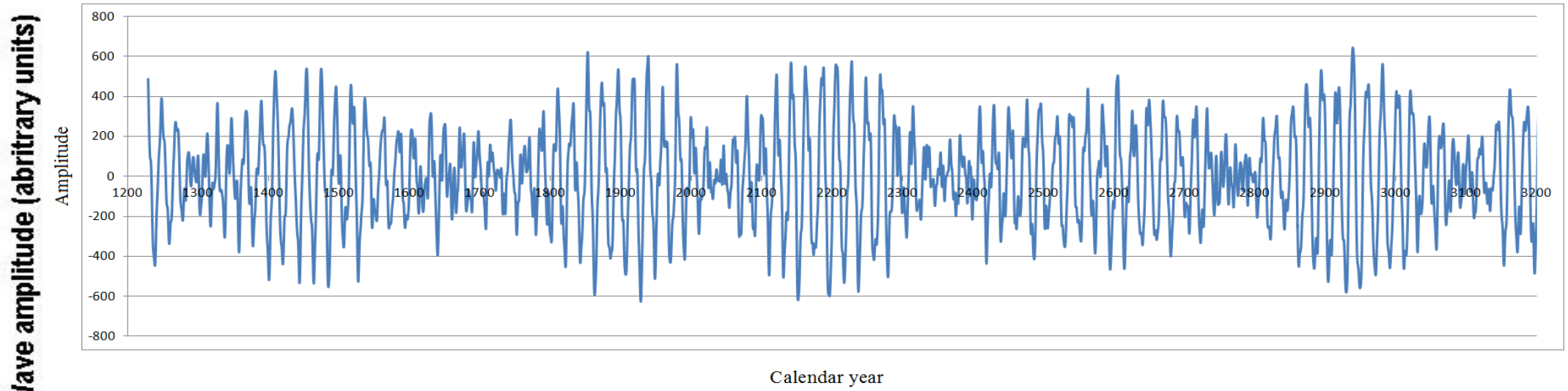
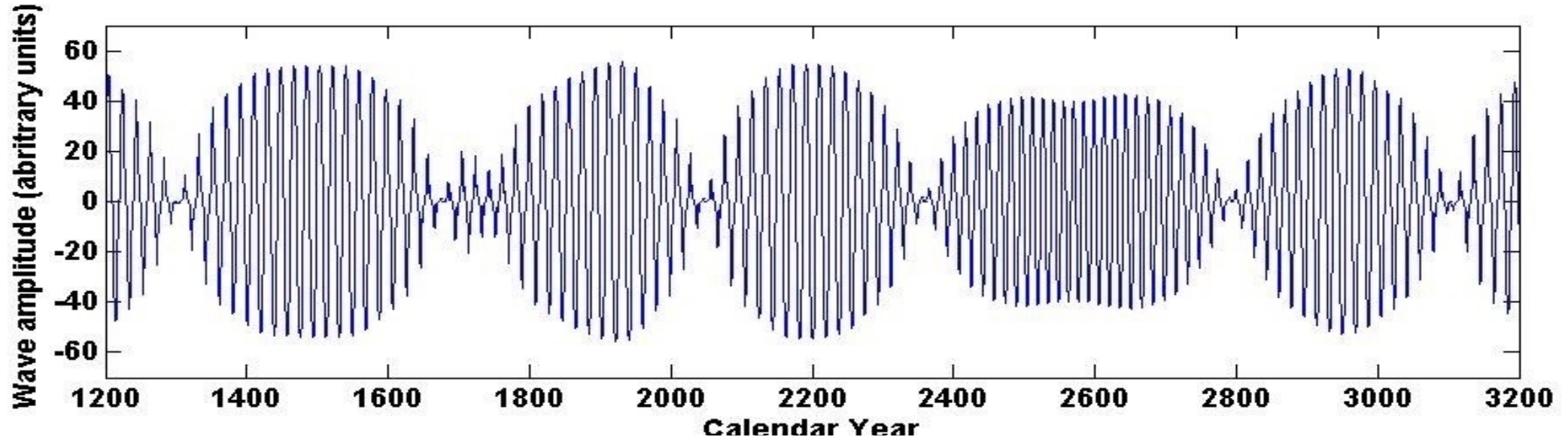
D – phase difference

A - Amplitude

- $D=0$ **constructive interference**, $B=2A$
- $D=\pi$ (180°) – **destructive interference**, $B=0$



Dynamo model (top) and summary curve (bottom)



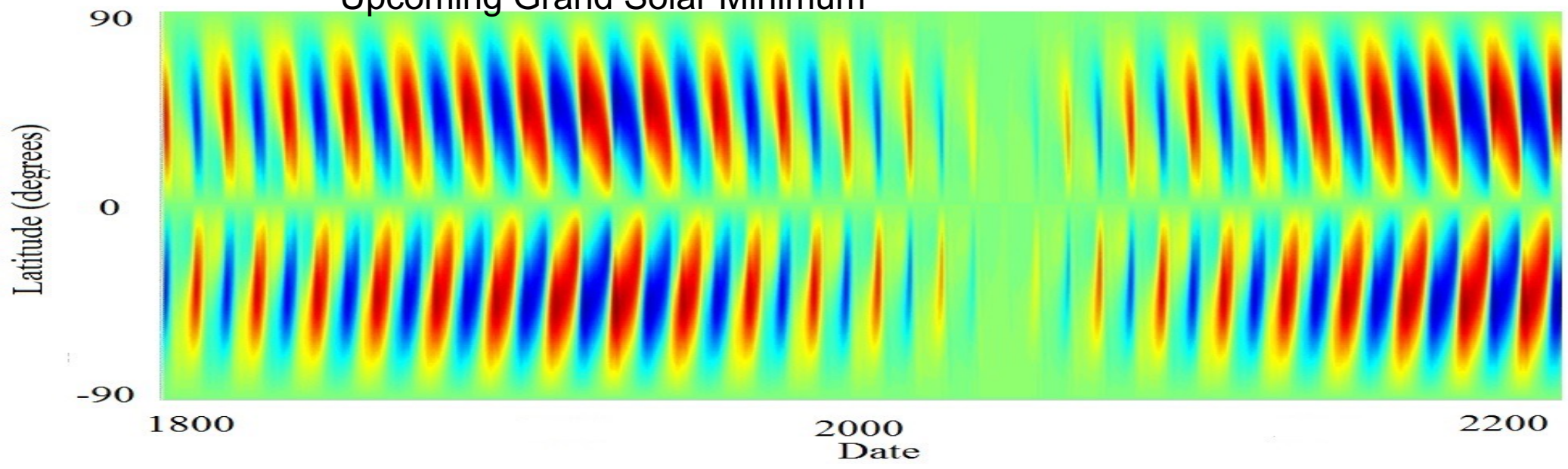
Popova et al, 2013

Calendar Year

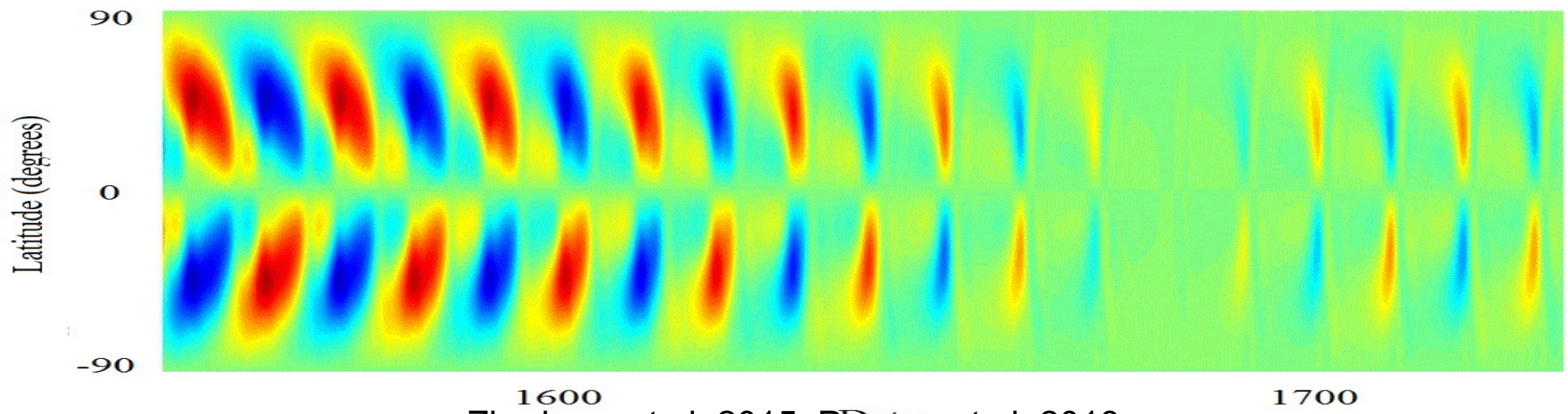
Zharkova et al, 2015, SR

<https://www.nature.com/articles/srep15689>

Upcoming Grand Solar Minimum



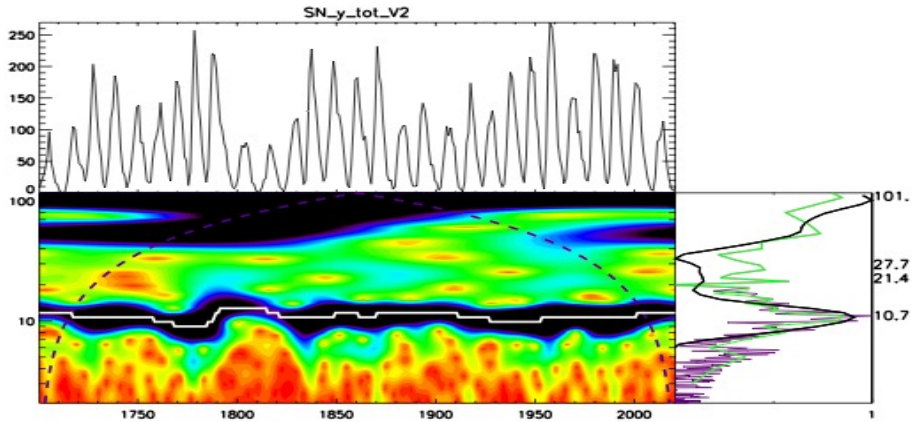
Maunder Grand Solar Minimum



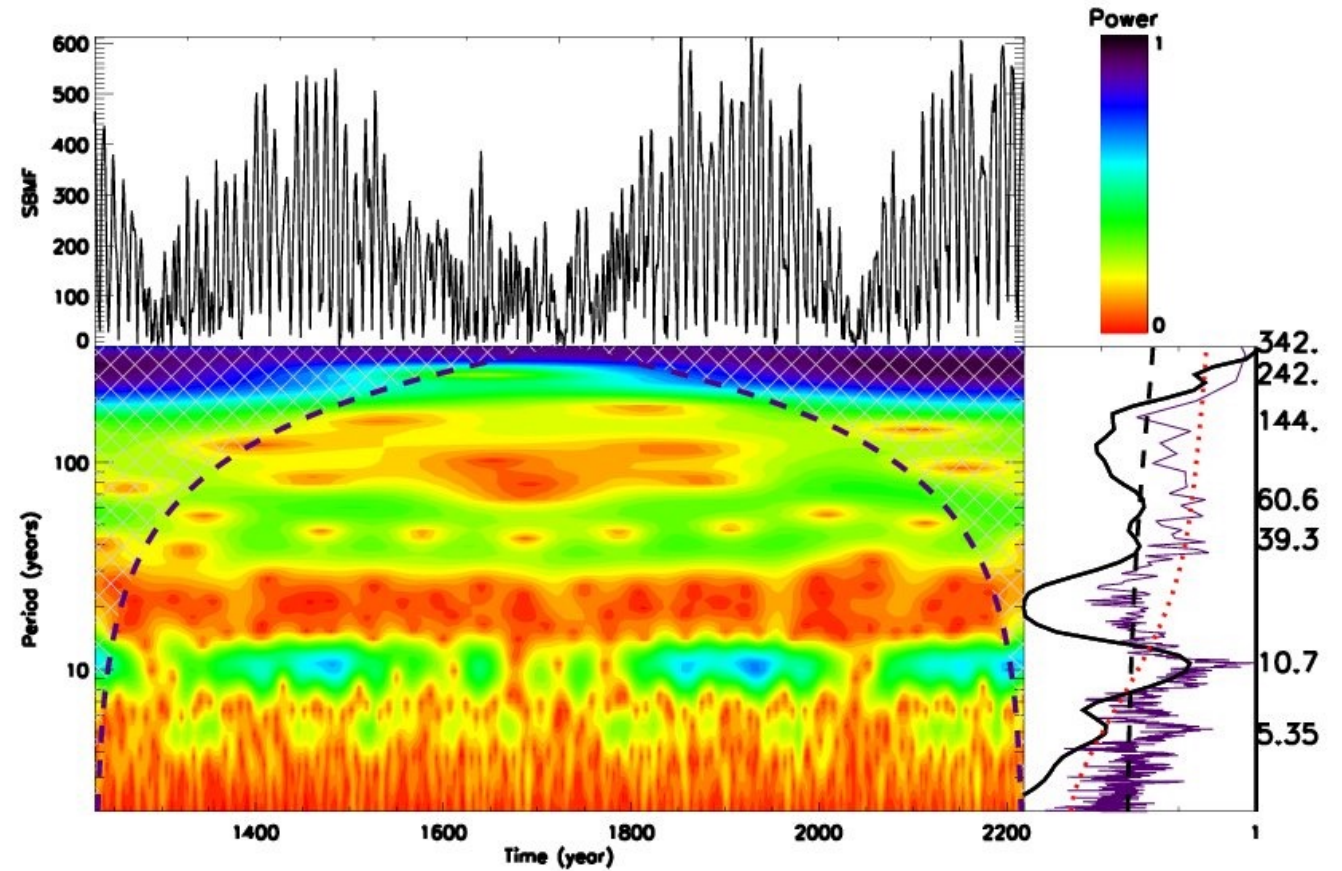
Zharkova et al, 2015, Popova et al, 2018

Wavelet spectral analysis

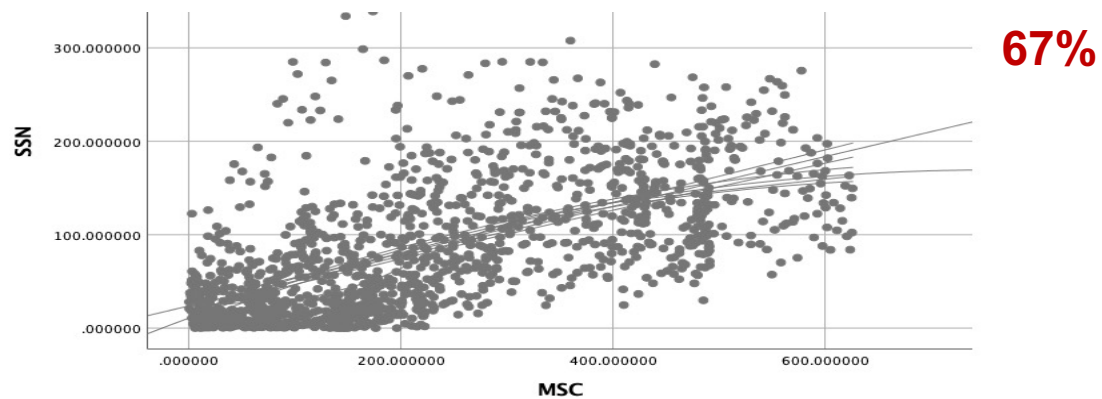
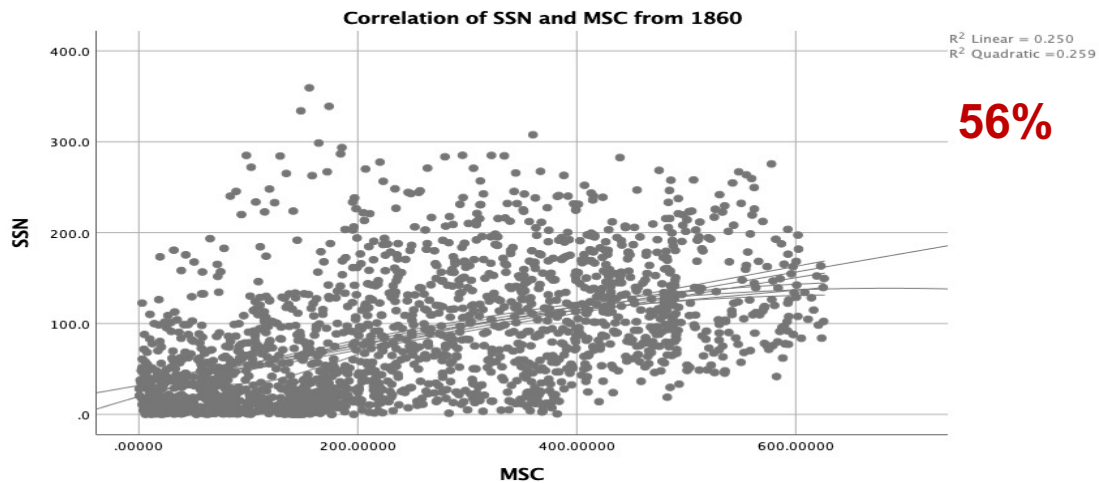
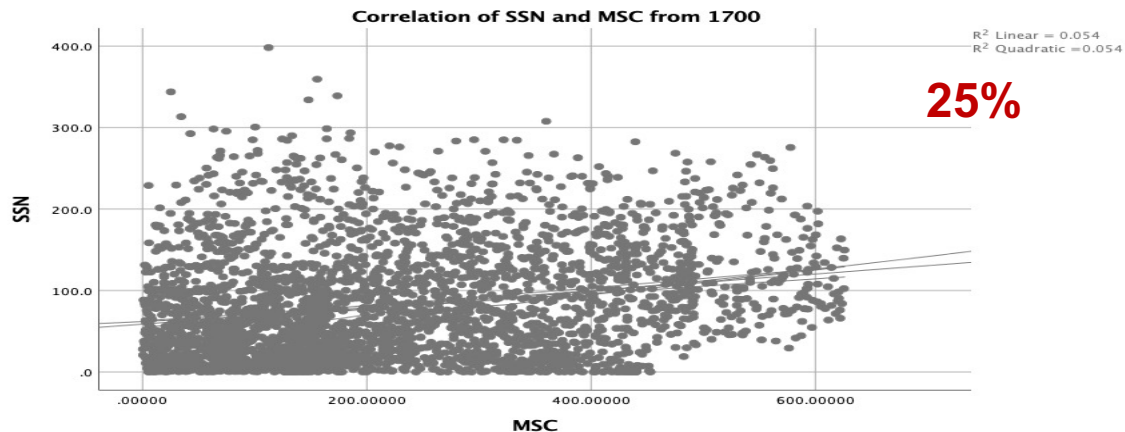
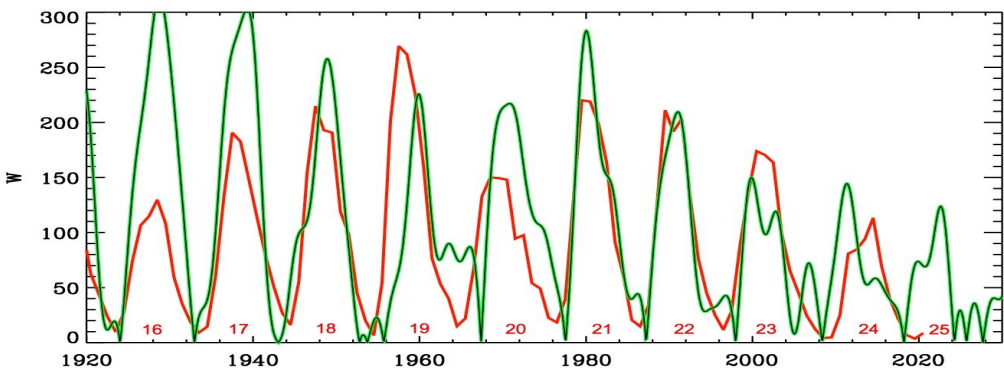
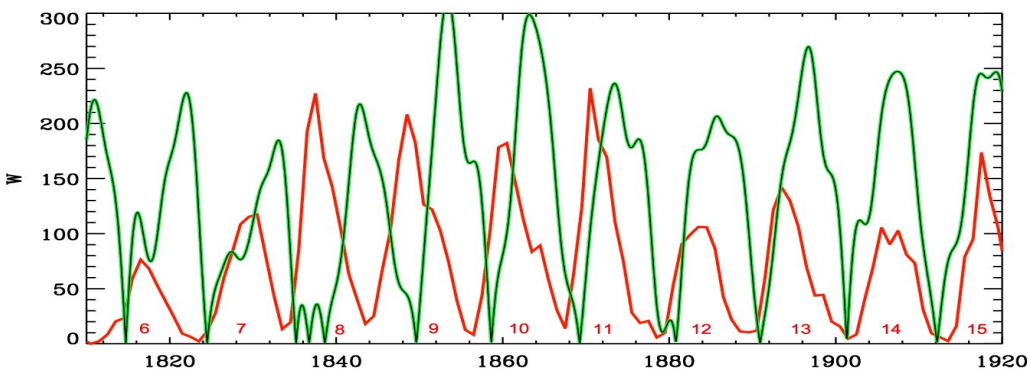
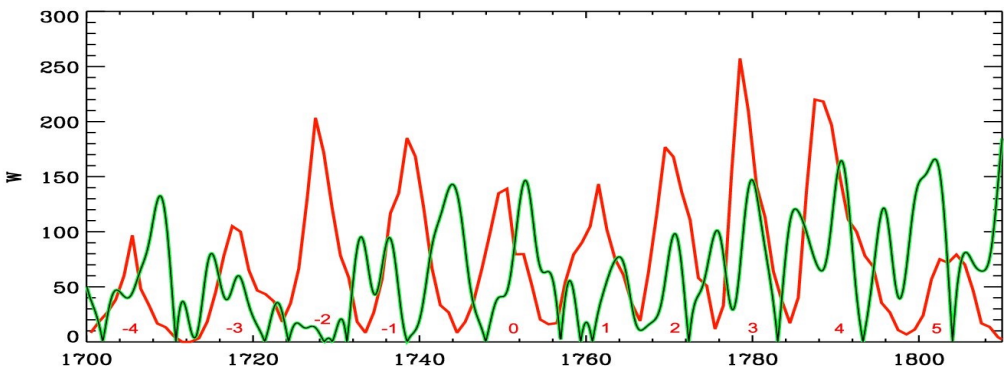
Averaged sunspot numbers



Modulus summary curve of PCs Z15



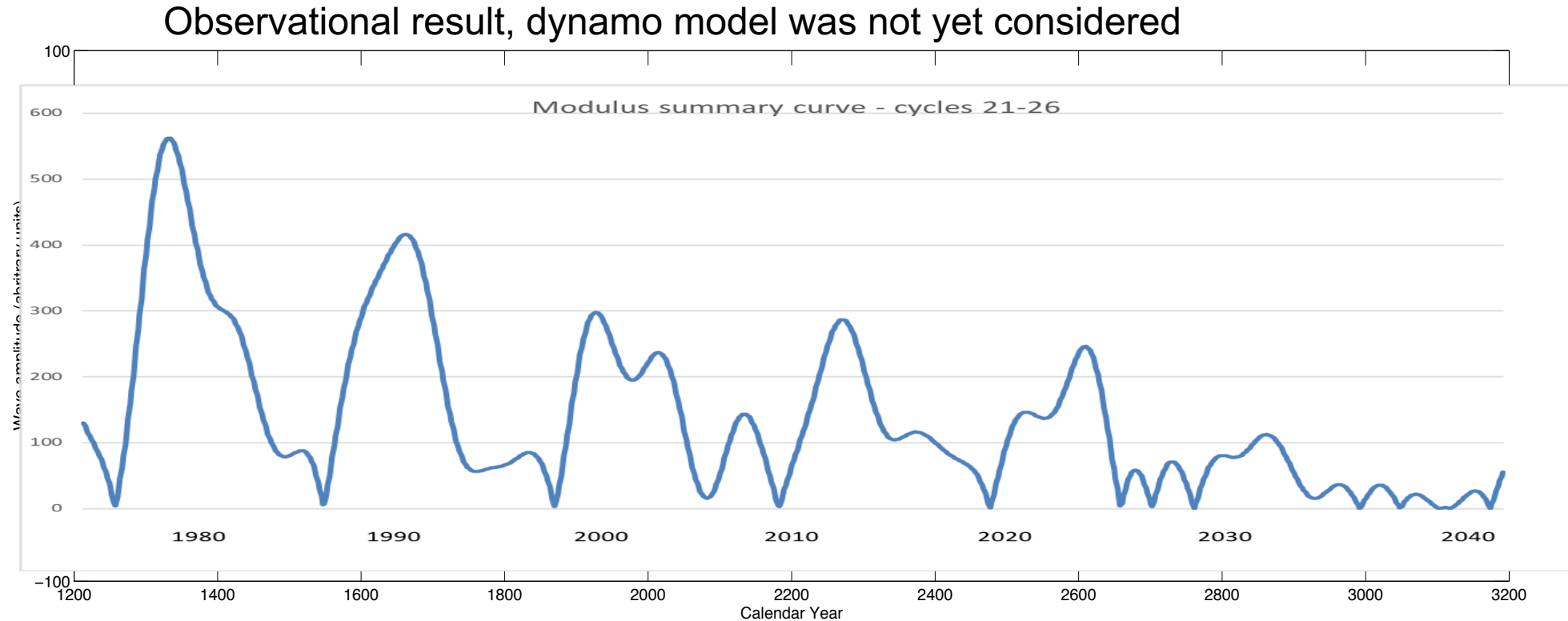
Correlation with SPSS of SSN with MSC



Predicted solar activity in cycles 25-26

(Zharkova et al, 2015, SR

<https://www.nature.com/articles/srep15689>)

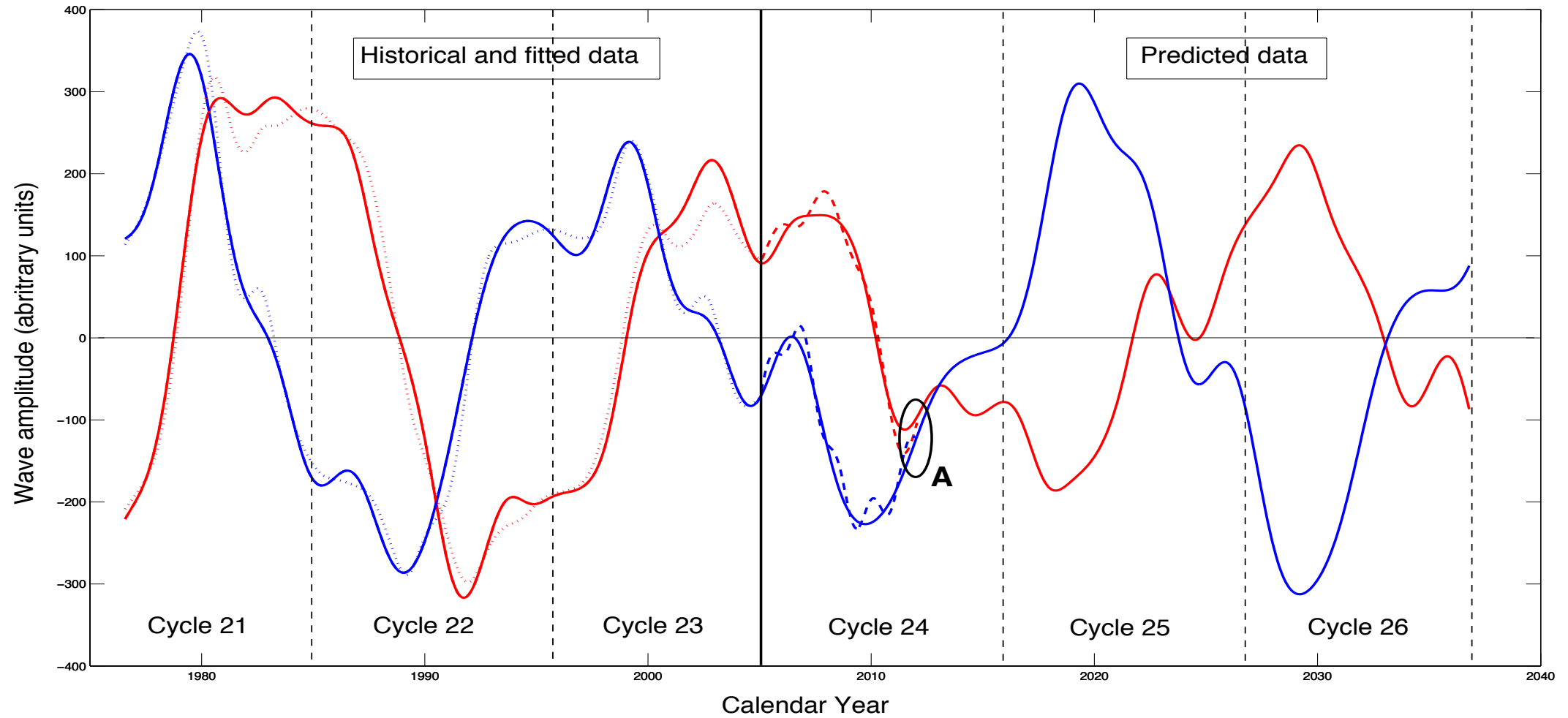


Discovery of grand solar cycles :350-400 years

In addition to 11 year cycles

<https://solargsm.com/solar-activity/> - my webpage

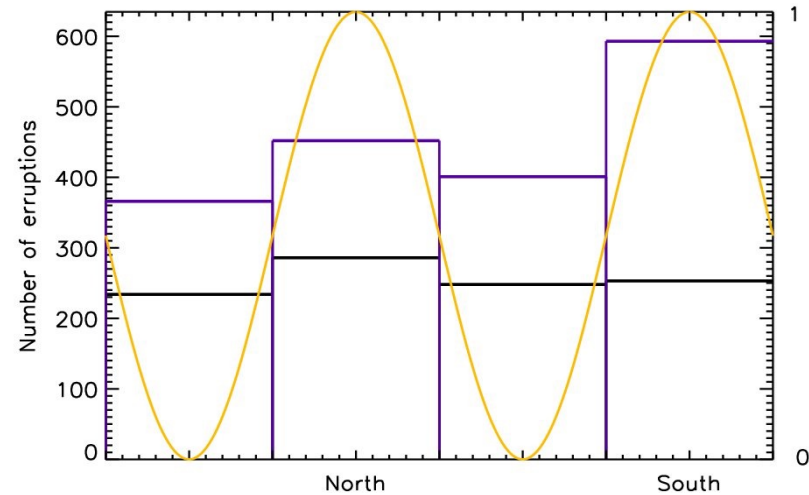
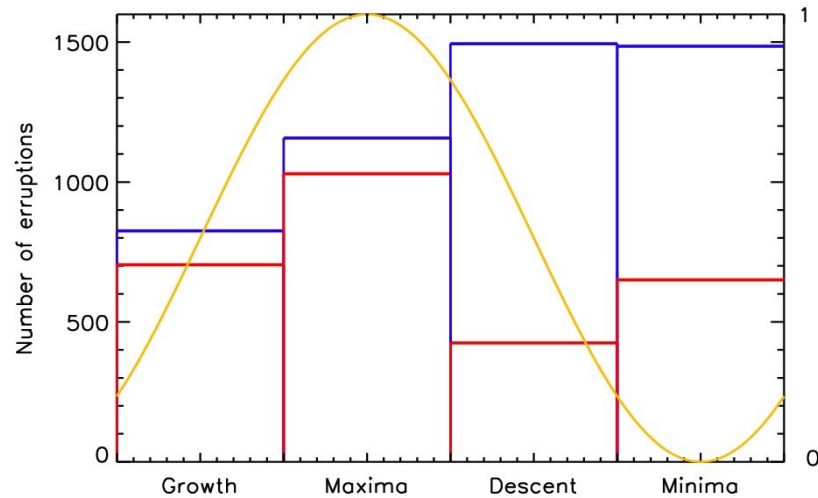
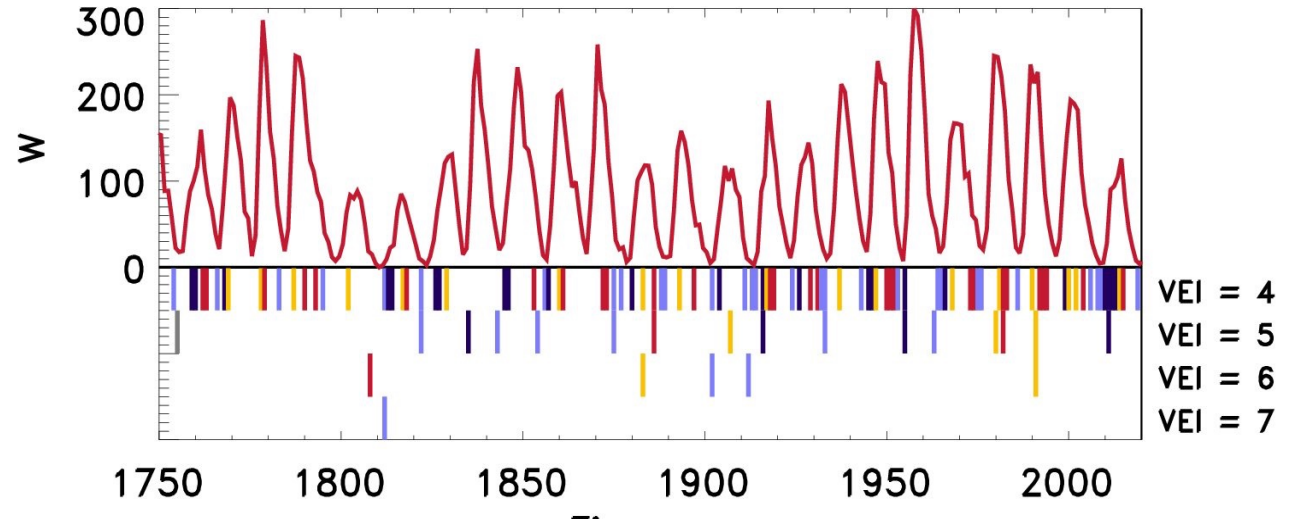
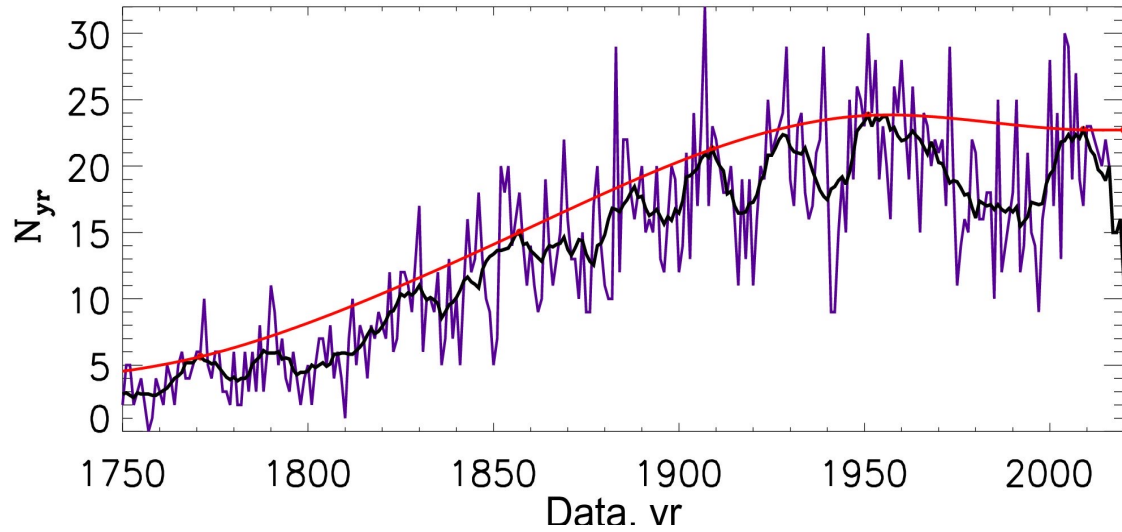
Eigen vectors come in pairs, here are PCs



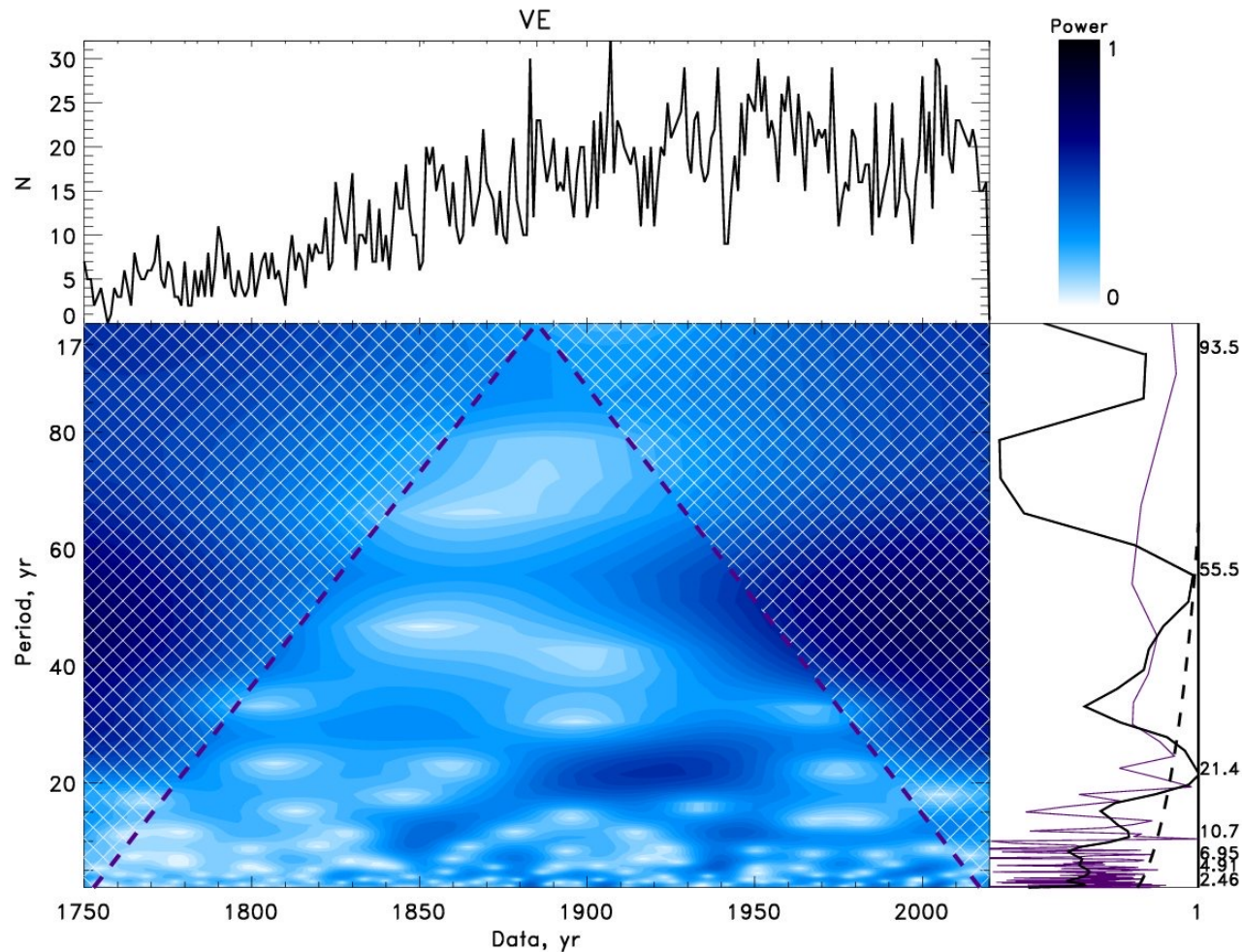
(Shepherd et al, 2014, Zharkova et al, 2015)

<https://solargsm.com/solar-activity/>

Volcanic eruption numbers (top row) and link with SA (left) and magnetic field (right) cycles (bottom row)



Wavelet spectral analysis of VE frequencies



Top plots: Time series of the annual volcanic eruptions in the period of 1750-2020 (top left) with the power bar for the wavelet spectrum (top right).

Bottom plots: The wavelet spectrum with periods (Y-axis) derived from frequencies of volcanic eruptions (bottom left) obtained using the Morlet wavelet.

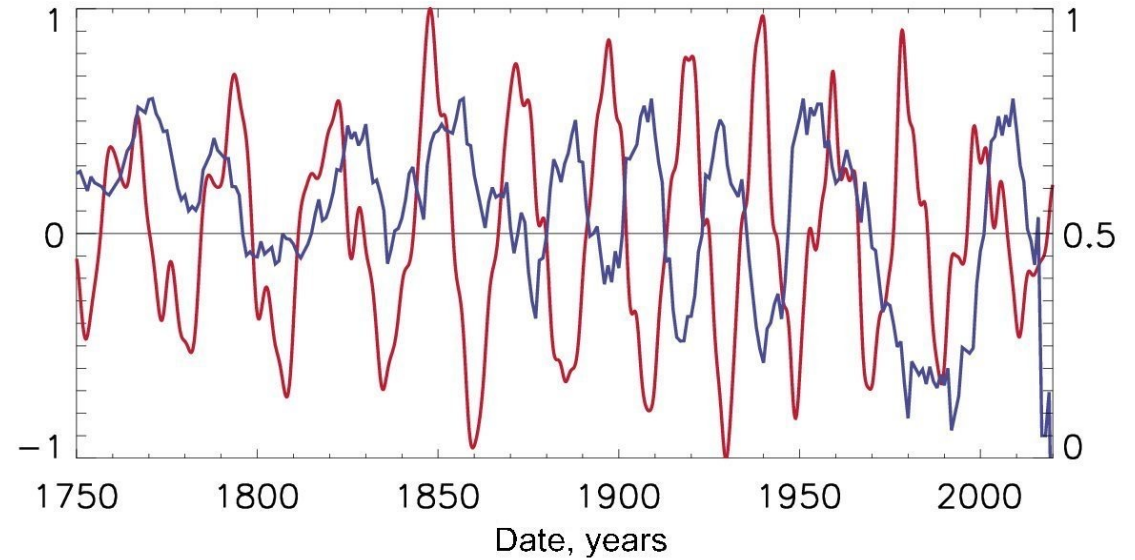
The global wavelet spectrum (the solid black line) and Fourier spectrum (the indigo line) (bottom right).

The Cone of Influence (COI) marked by the black dashed lines

Volcanic activity correlates with SA cycles of southern polarity (Vasilieva and Zharkova, 2022)

Top plot

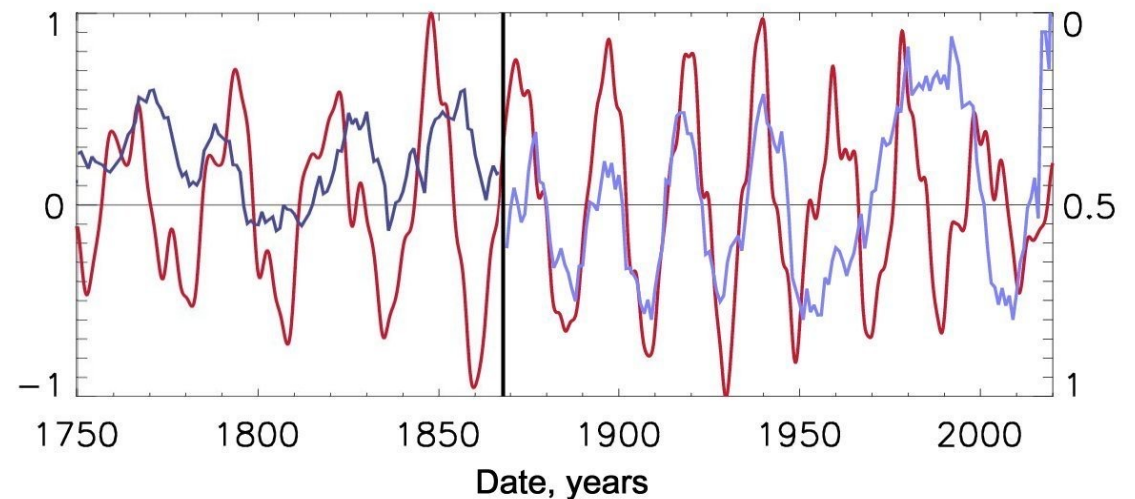
Blue – frequencies of volcanic eruptions
Red - the summary curve of solar background magnetic field. Positive magnitudes – northern polarity, negative - southern polarity.



Bottom plot

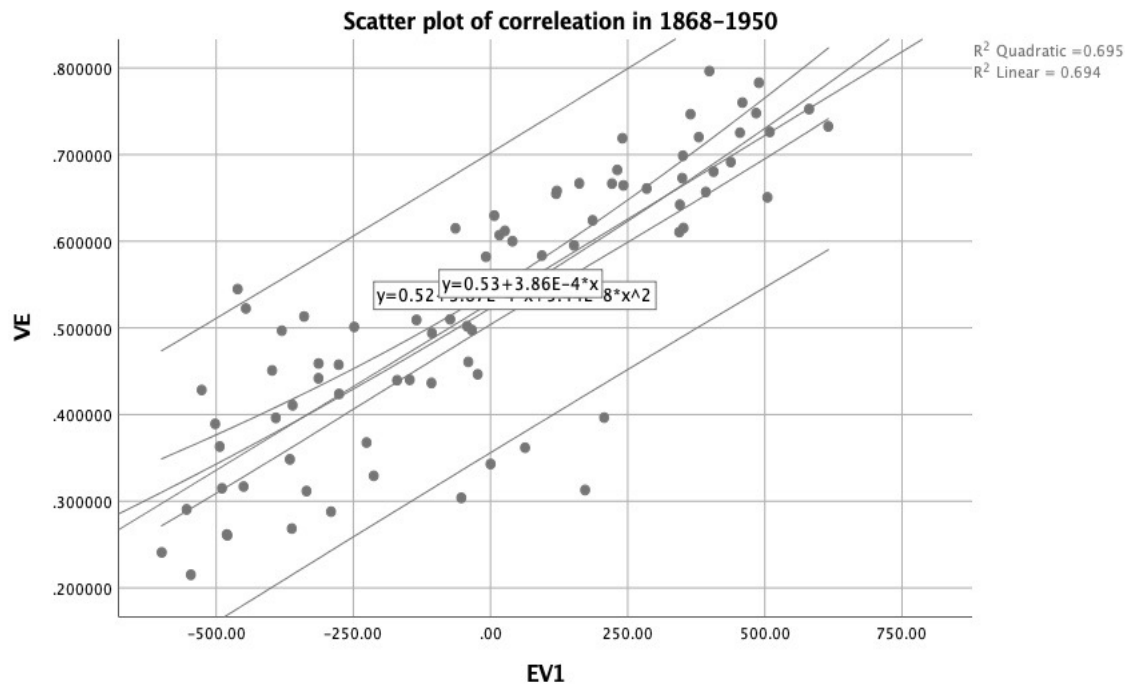
Volcanic eruption frequencies highly (0.84) correlate with the summary curve with southern polarity with a period of 22 years (1860-1950).

Next maximum of volcanic eruptions will occur in cycle 26 (2031-2042).

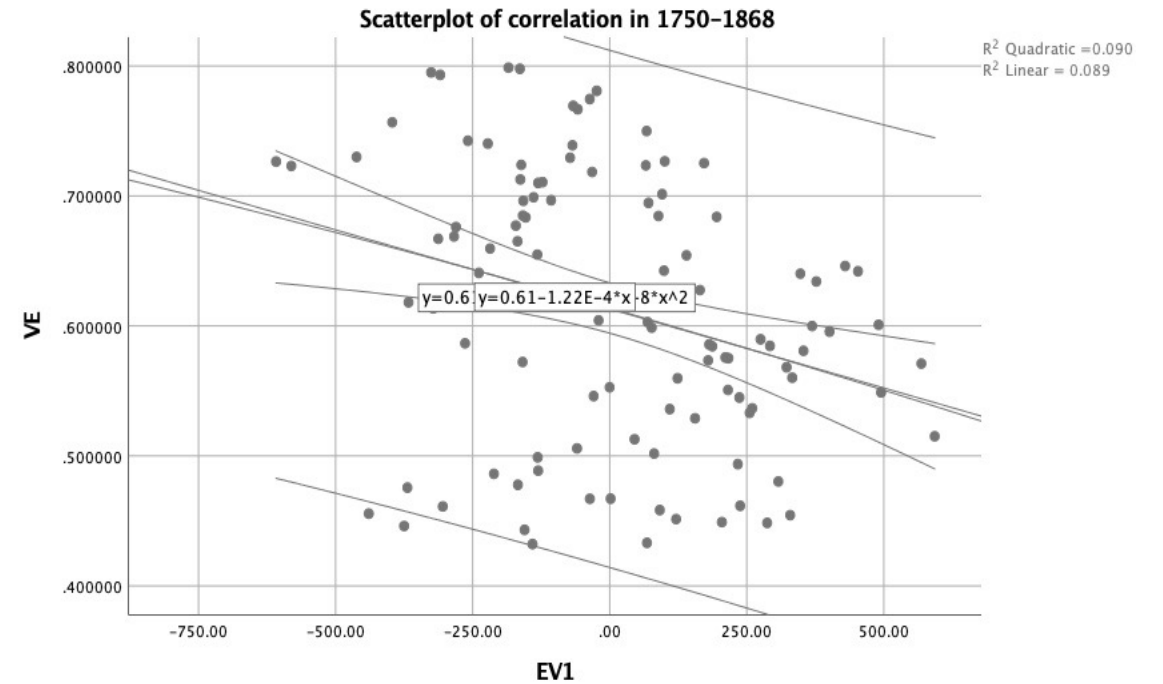


Scatter plots of correlation

of averaged sunspot number SSN and modulus summary curve MSC of eigen vectors of solar magnetic field

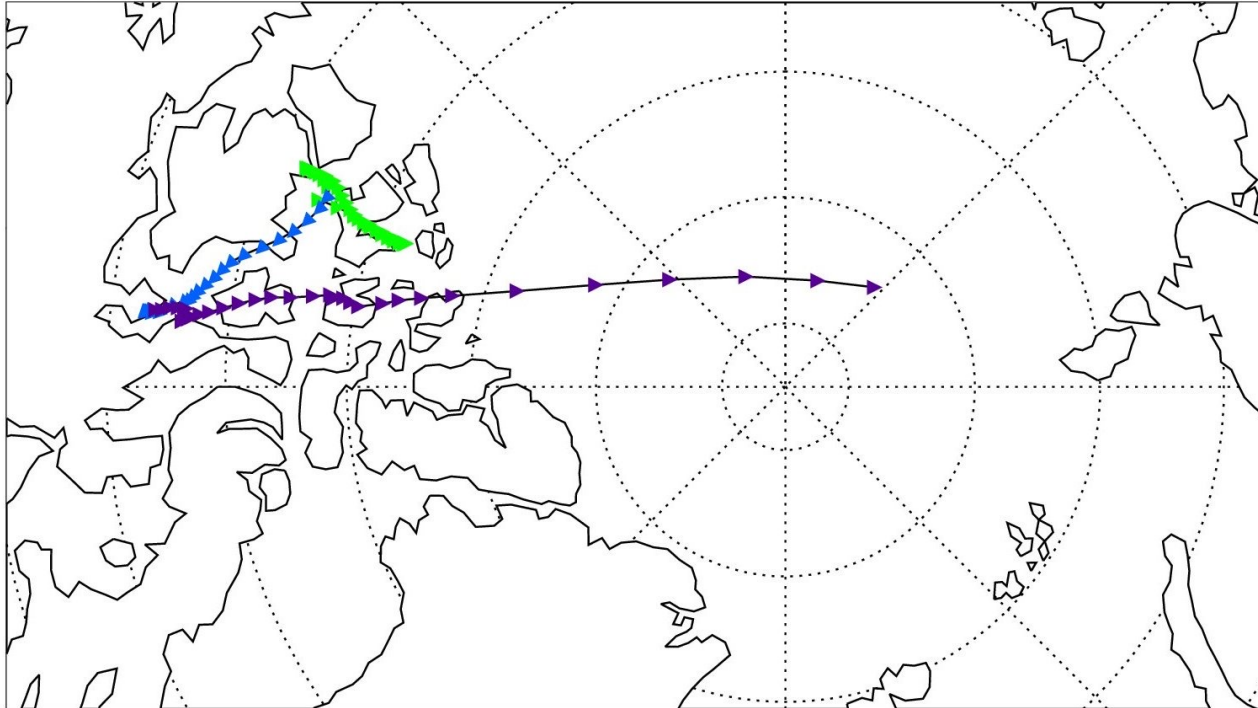


1868-1950 & 1990-2020
Correlation 84%



1750-1868
Correlation -33%

North pole motion in 1590-2025



Reconstructed locations

1590-1750 (green curve),
1750-1860 (blue curve)
1860-2025 (violet curve)

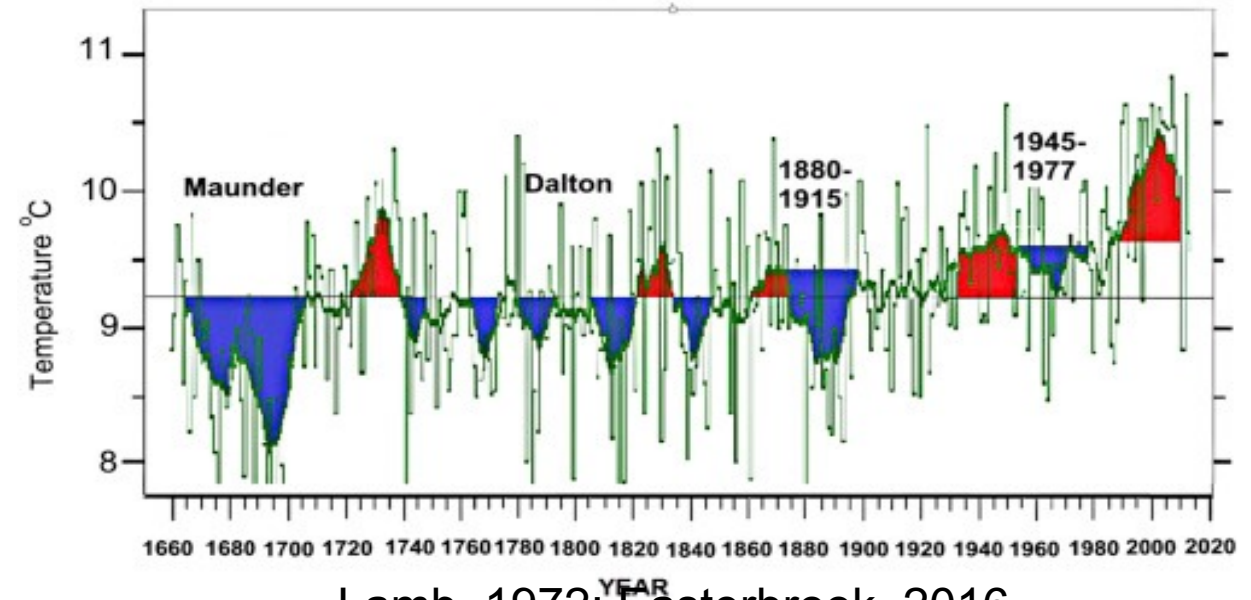
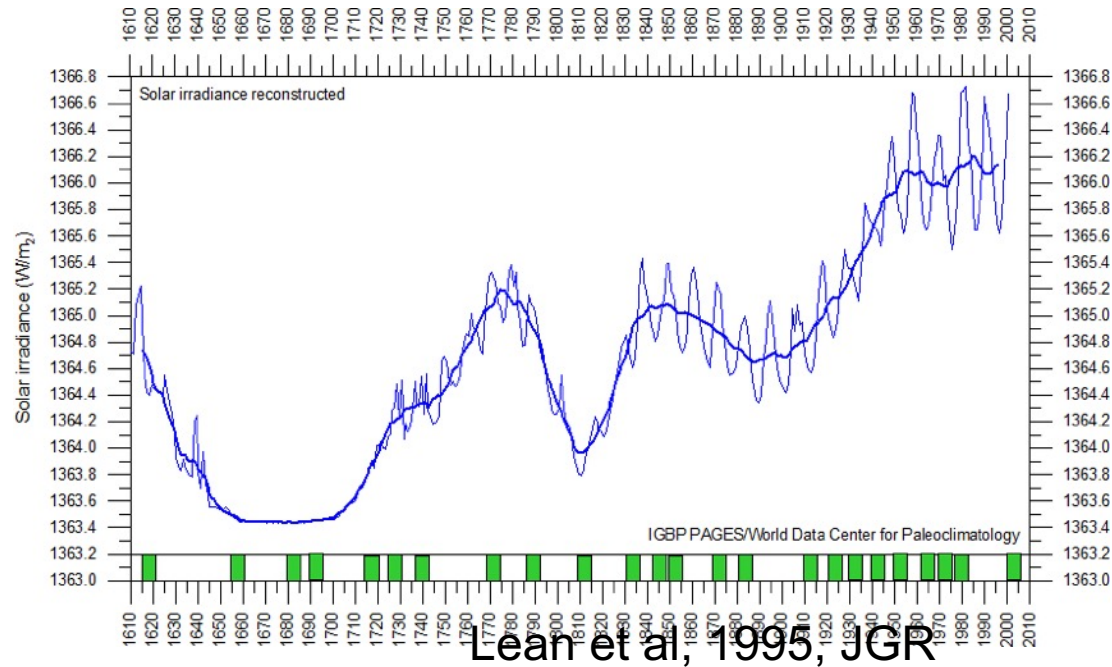
In 1760-1860, the magnetic pole was moving away from its geographic position (see Fig left)

thus reducing the interaction with the solar magnetic field of any polarity

after 1860 it began returning back by rapidly approaching the geographic pole of the Earth

that simplified this interaction with the solar magnetic field.

Solar irradiance and terrestrial temperature during MM

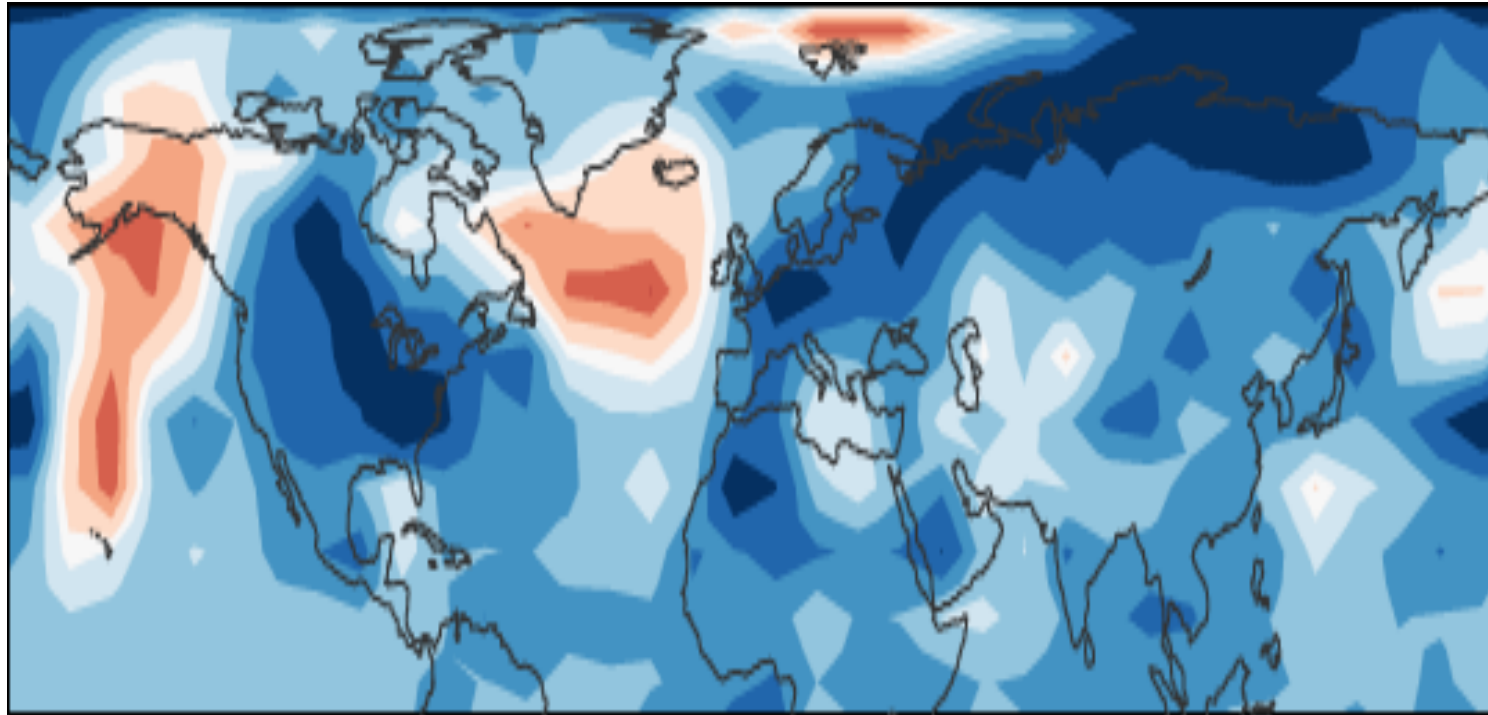


Authors	S, Maunder minimum, W/m ²	S 1990-2000, W/m ²	ΔS from MM, %
Lean et. Al., 1995	1363	1366	0.22
Steinhilber et al, 2012	1364	1366	0.22
Shirley et al., 1990	---	1370	0.51
Wolff and Hickey, 1987	---	1371	0.51
Lee et al., 1995	---	1372	0.51

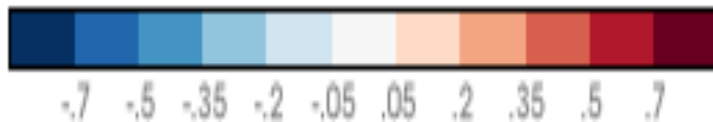
After the TSI data were re-normalized the old data are hardly usable

Temperature restoration during/after MM

(Shindell et al., 2001, Science)



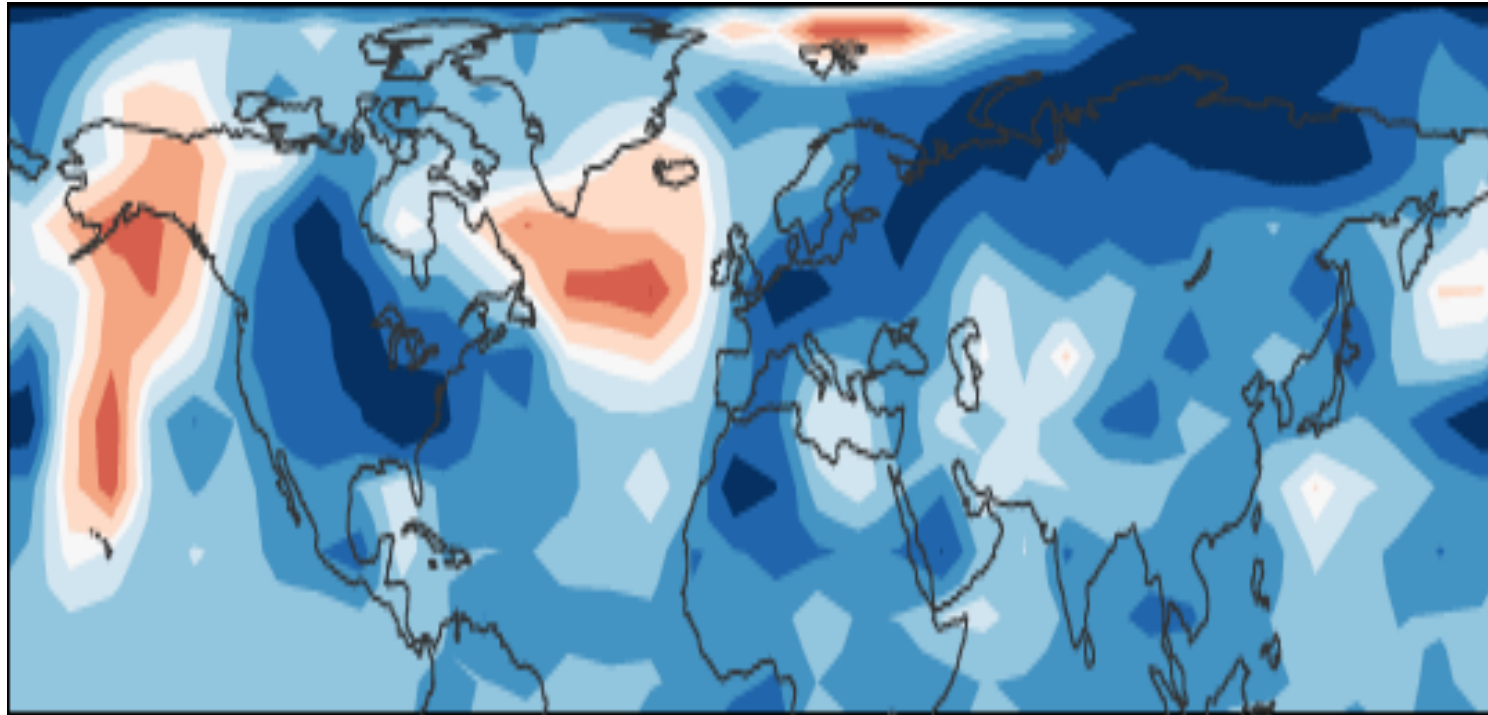
Temperature Change: 1680-1780 (°C)



- The surface temperature of the Earth was reduced all over the Globe
- Europe and North America went into a deep freeze
- Alpine glaciers extended over valley farmland
- Sea ice crept south from the Arctic
- Danube and Thames rivers & canals in the Netherlands froze regularly

Temperature restoration during MM

(Shindell et al., 2001, Science)



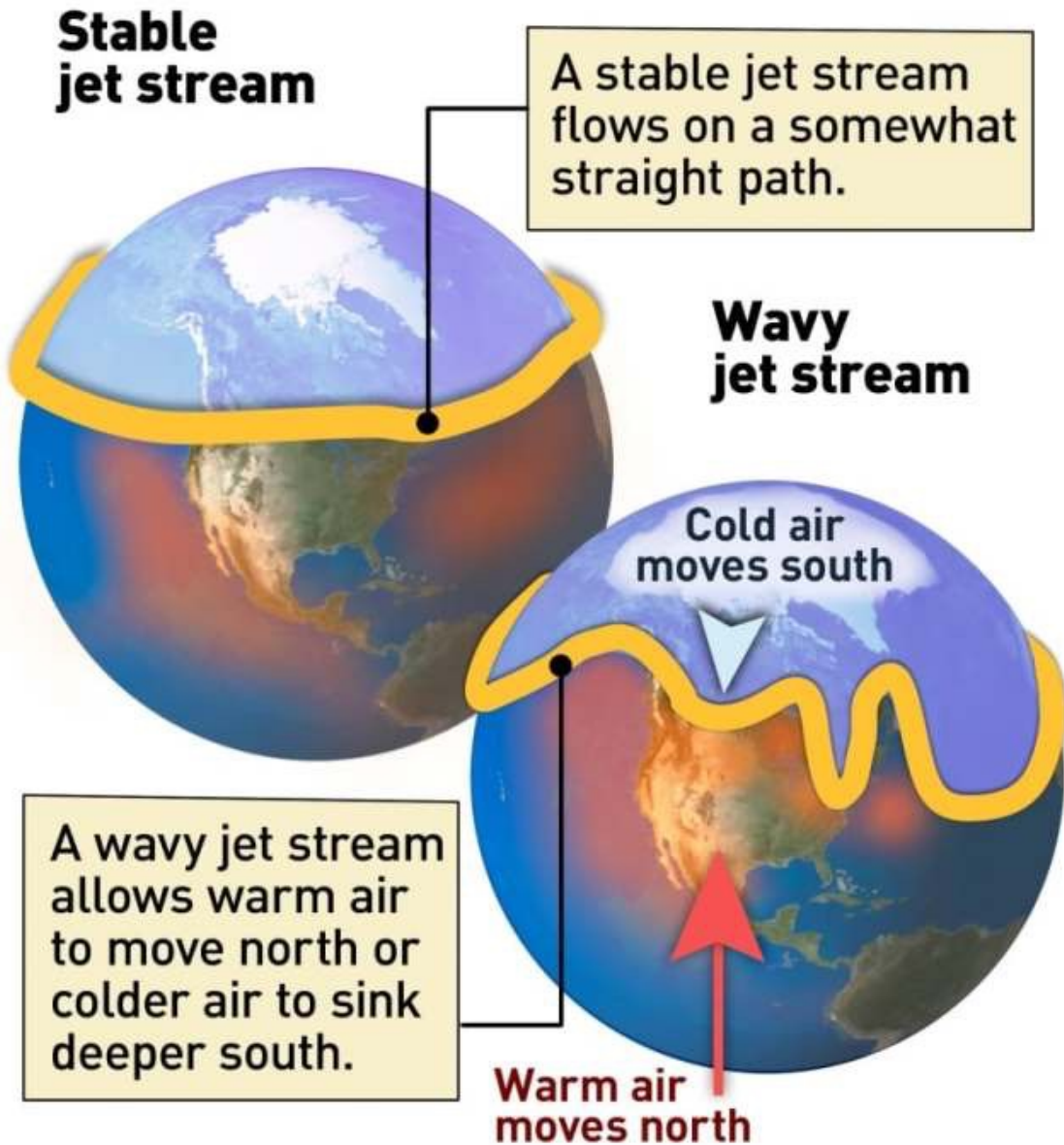
Temperature Change: 1680-1780 (°C)



-0.7 -0.5 -0.35 -0.2 -0.05 0.05 0.2 0.35 0.5 0.7

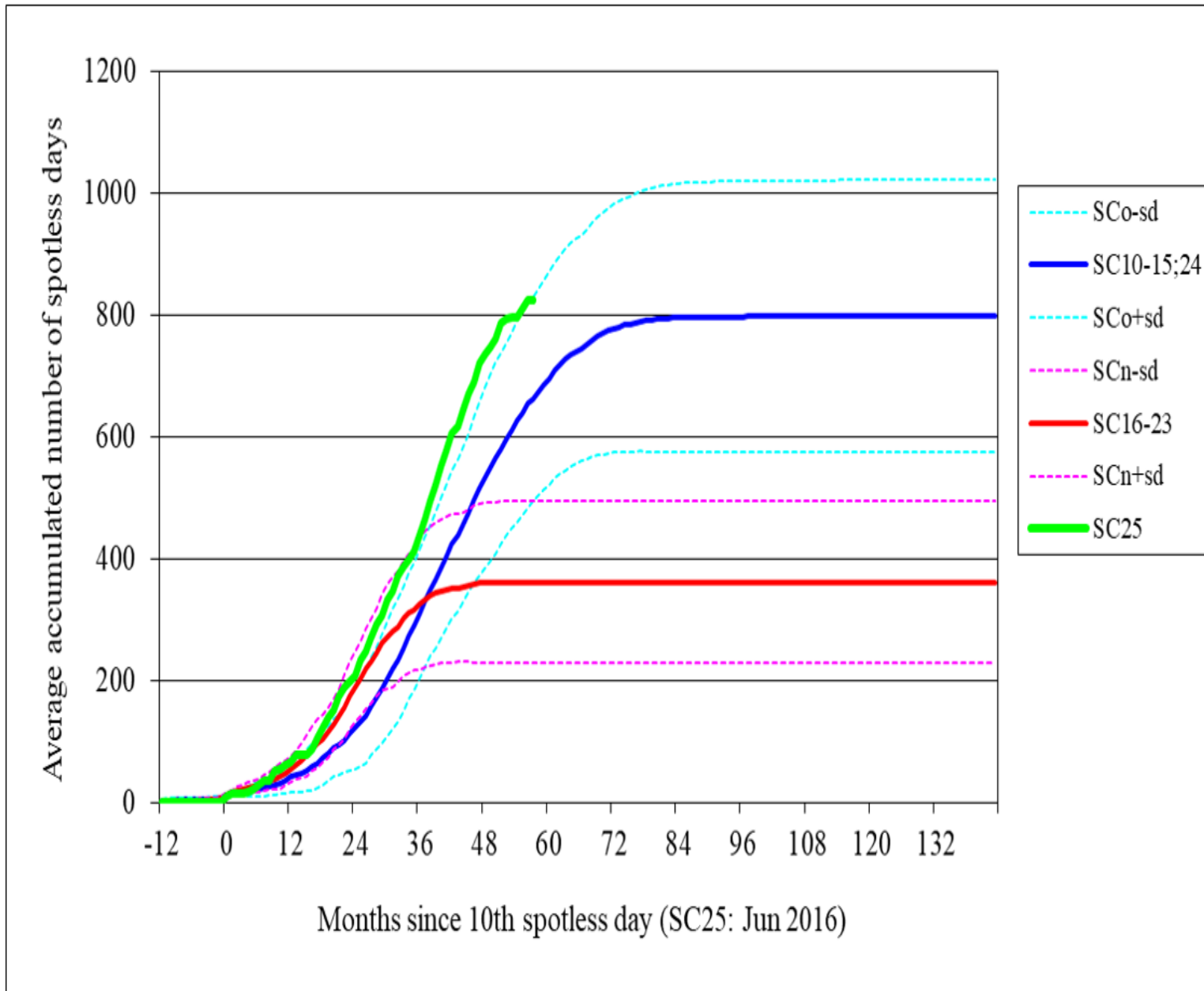
- the drop in the temperature was related to dropped abundances of ozone created by solar ultraviolet light in the stratosphere, the layer of the atmosphere located between 10 and 50 kilometers from the Earth's surface

The Changing Jet Stream



- Less ozone affected planetary atmosphere waves
- They, in turn, caused the giant wiggles in the jet stream as shown in picture on the left
- It kicked the North Atlantic Oscillation (NAO)—the balance between a permanent low-pressure system near Greenland and a permanent high-pressure system to its south—into a negative phase
- that led to Europe to remain unusually cold during the MM

Shindell et al., 2001



- **Cycle 25** (green line) shows a steeper growth of the number of spotless days than any other cycles including the ones during Dalton min (cycles 15 and 24) (blue line)

Modern Grand Solar Minimum 2020-2053

Snow in Carpathian mountains

7, 14 July'19 July –Ukraine, 12 July 2019, 2021-2021 – many examples



- Contrary to the prediction of JAMES HANSEN, 1989: “NEW YORK CITY’S WEST SIDE HIGHWAY WILL BE UNDERWATER BY 2009”
- January 2020 snow and frost -2C was recorded in Amman, Arabia, first in 150 years
- Early snow in Canada in September’ 20, May 21
- Summer snow in south of Australia 2021

Snow in Africa's desert 8 December 2020

<https://twitter.com/GerryAMcG/status/1336420778582138886>



During covid days the Nature retake it initial

Snow blizzards in USA and Canada for 2 weeks in Dec '22 –Jan' 23



Late spring snow
in Australia and NZ
22-30 November '22

(analog of late May
in Northern hemisphere)

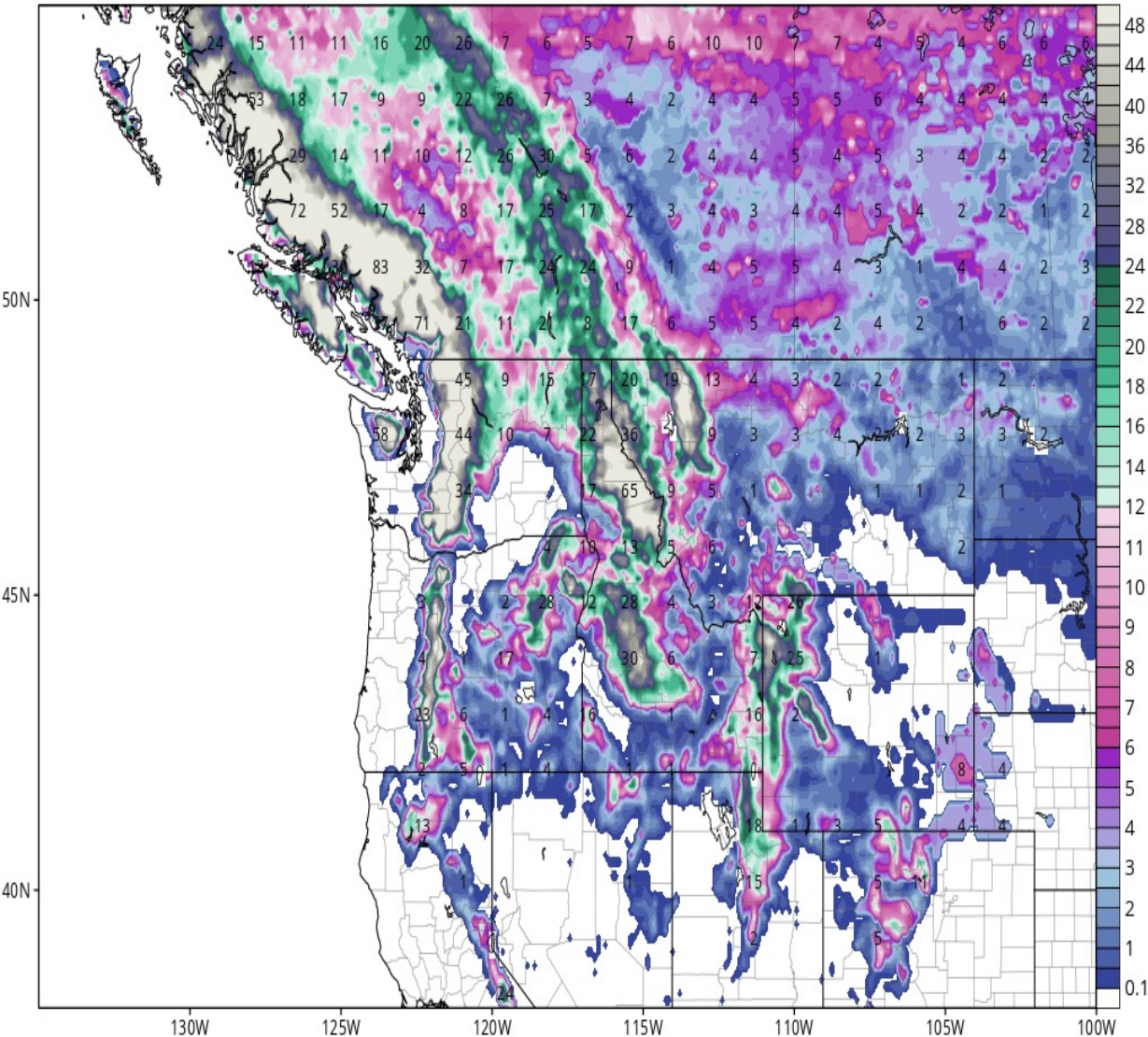


Modern GSM is progressing –November 2020- June 2022

GFS Total Snowfall [*includes sleet*] (inches) (assuming 10:1 snow:liquid ratio)

Init: 00z Nov 11 2020 Forecast Hour: [384] valid at 00z Fri, Nov 27 2020

TROPICALTIDBITS.COM



- UNPRECEDENTED WINTER STORM HITS BRITISH COLUMBIA
- Both NOAA and NASA appear to agree, *if you read between the lines*, with NOAA saying we're entering a ‘full-blown’ Grand Solar Minimum in the late-2020s
- NASA seeing this upcoming solar cycle (25) as “the weakest of the past 200 years”, with the agency correlating previous solar shutdowns to prolonged periods of global cooling here.

HOW ICE SHEET GREW 533,000 SQUARE MILES IN A YEAR

AUGUST 2012



CONTRACTION: This Nasa satellite image shows the ice at the smallest extent on record, with much of the Arctic Ocean uncovered

AUGUST 2013



RECOVERY: Contrary to predictions that the ice would have vanished by this summer, it has actually increased by 29 per cent from last year

Modern Grand Solar Minimum

<https://solargsm.com/solar-activity/>

- To occur in **2020 – 2053**
- This is a unique event in solar-terrestrial connection → will reveal the pros and cons of solar dynamo models
- Decrease of solar magnetic field → big impact ozone reduction, high cloud formation, jet direction changes, cosmic rays increase
- **Increase of volcanic and earthquake activities**
- Effects on the terrestrial temperature via TSI, jets and volcanic activity
- **Shortage of vegetation periods can lead to possible food shortages in 2028-2042**
- Need inter-government efforts to avoid energy and food shortage disasters



Thanks for your attention!