# A possible role of the solar inertial motion in climatic changes

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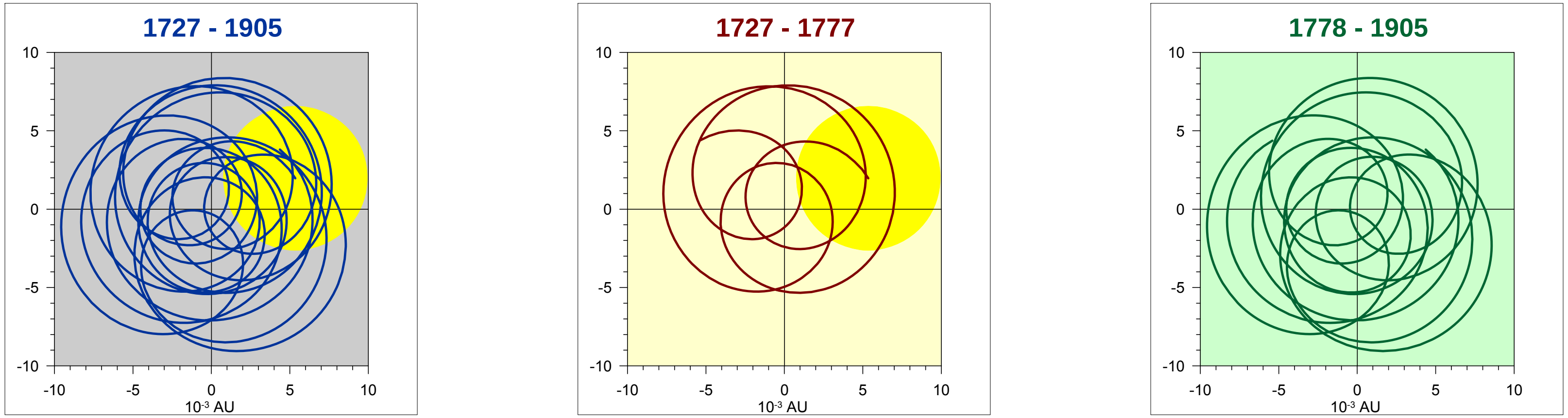
# Solar inertial motion - SIM

Solar inertial motion is the motion of the Sun around the centre of mass of the Solar System due to variable positions of the giant planets (J-Jupiter, S-Saturn, U-Uranus, N-Neptune). The Sun moves inside a circular area which has a diameter of 0.02 AU (= 4.3 solar radii = $3.10^6$ km). The Sun moves with a velocity between 9 and 16 m/s.




Charvátová (1988, 1990, 1997) divided the SIM into two basic types, the ordered ones in a trefoil according to the JS motion order and the other disordered (chaotic).

(Note: the conjunctions of the planets J and S occur once every 19.86 years, with each successive conjunction advancing by 117.3° in a prograde direction.) In case of the ordered trefoil motion, the Sun orbits the centre of mass of the solar system along a loop (arc) about once every 10 years (JS/2).

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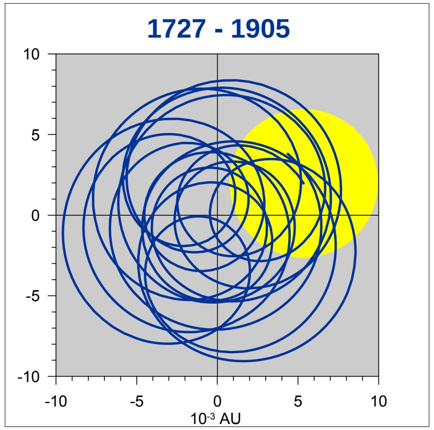
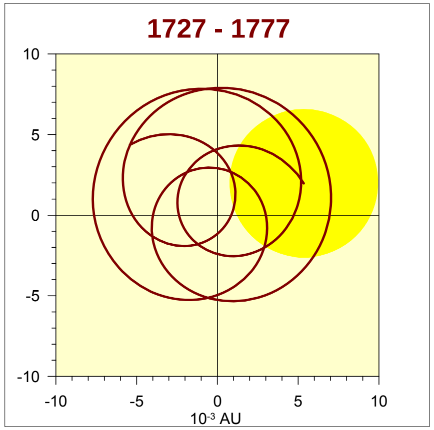
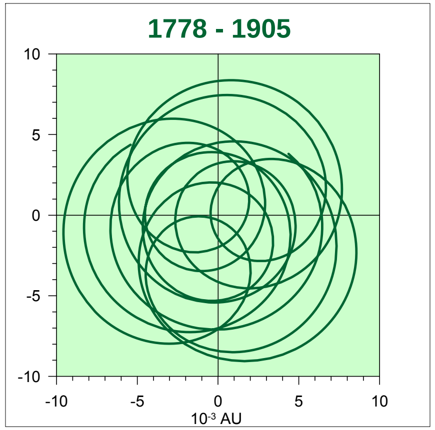


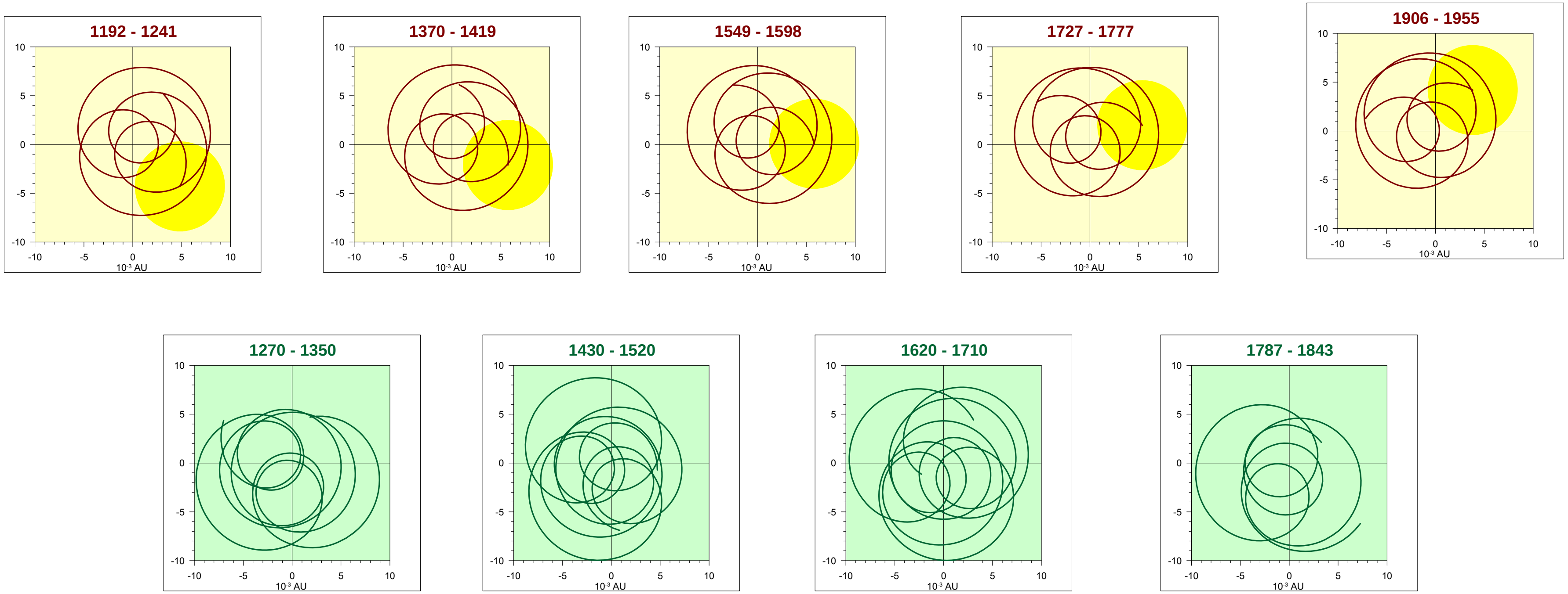




Charvátová, I., The solar motion and the variability of solar activity, Adv. Space Res., 8, 7, 147-150, 1988.
Charvátová, I., On the relation between solar motion and solar activity in the years 1730-1780 and 1910-60, Bull. Astr. Inst. Czech., 41, 200-204, 1990.
Charvátová, I., Solar-terrestrial and climatic variability during the last several millennia in relation to solar inertial motion, J. Coastal Res., 17, 343-354, 1995.
Charvátová, I., Solar motion (main article), in: Encyclopedia of Planetary Sciences, (Eds. J.H. Shirley and R.W. Fairbridge), Chapman and Hall, New York, 748-751, 1997.
Charvátová, I., Can origin of the 2400-year cycle of solar activity be caused by solar inertial motion? Annales Geophysicae, 18, 399-405, 2000.

# Solar inertial motion - SIM

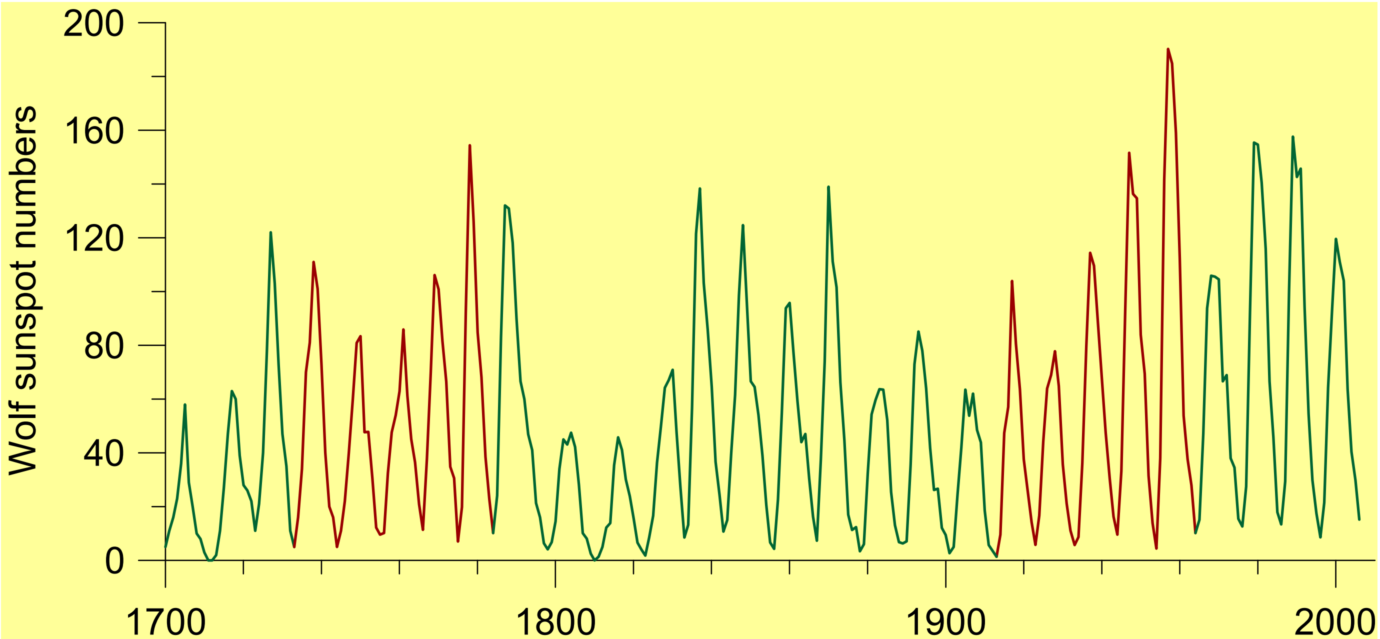
The Sun returns to the ordered trefoil SIM after 178.7 years and this type of motion lasts about 50 years.




The most disordered parts of the SIM correspond with the prolonged minima (Grand decreases) of solar activity, over the last millennium known as the Wolf, Spörer, Maunder and Dalton minima.

# Solar inertial motion and solar activity (observed data)

While the „chaotic“ orbits differ from one another, the ordered (trefoil) orbits are nearly the same. If solar variability is really caused by the SIM, the motion of the Sun along nearly identical orbits should create the same series of sunspot cycles. From 1700 AD to the present, two trefoil intervals occurred: 1727-1777 and 1906-1956 AD.




Sunspot numbers exist from the beginning of the 17th century, but data before 1750 are very uncertain (only yearly values are available there).

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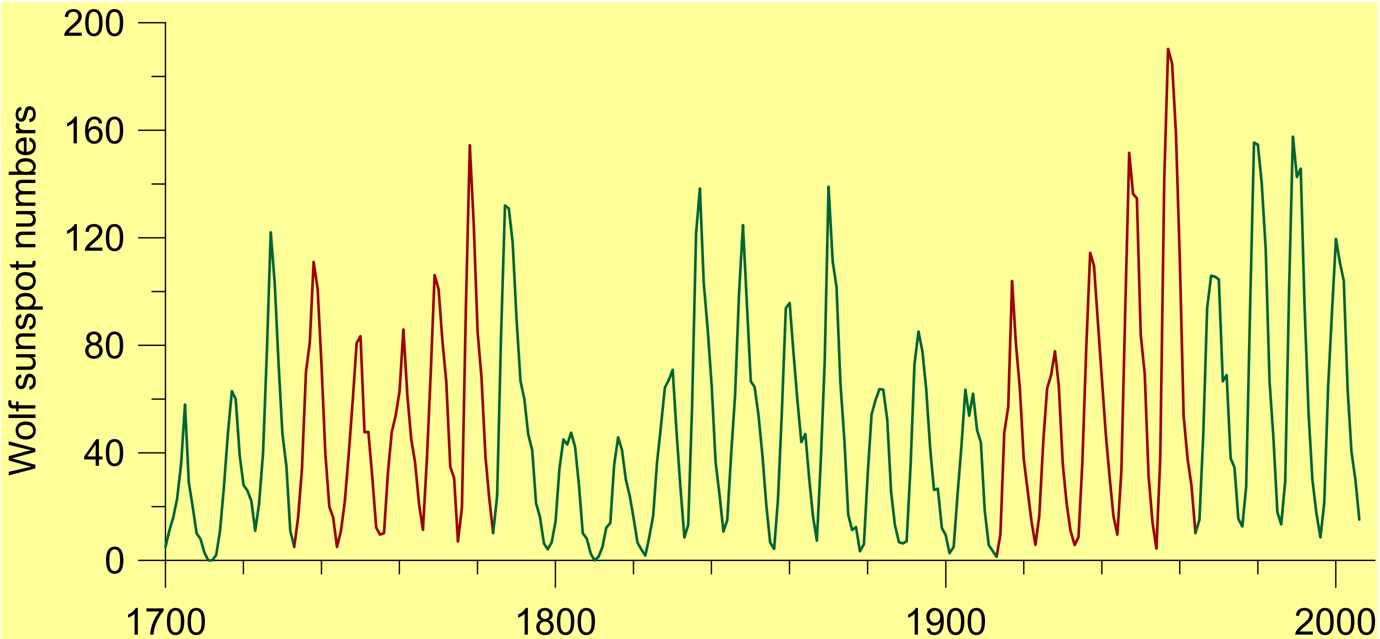


Moving correlation between two groups of five sunspots cycles …

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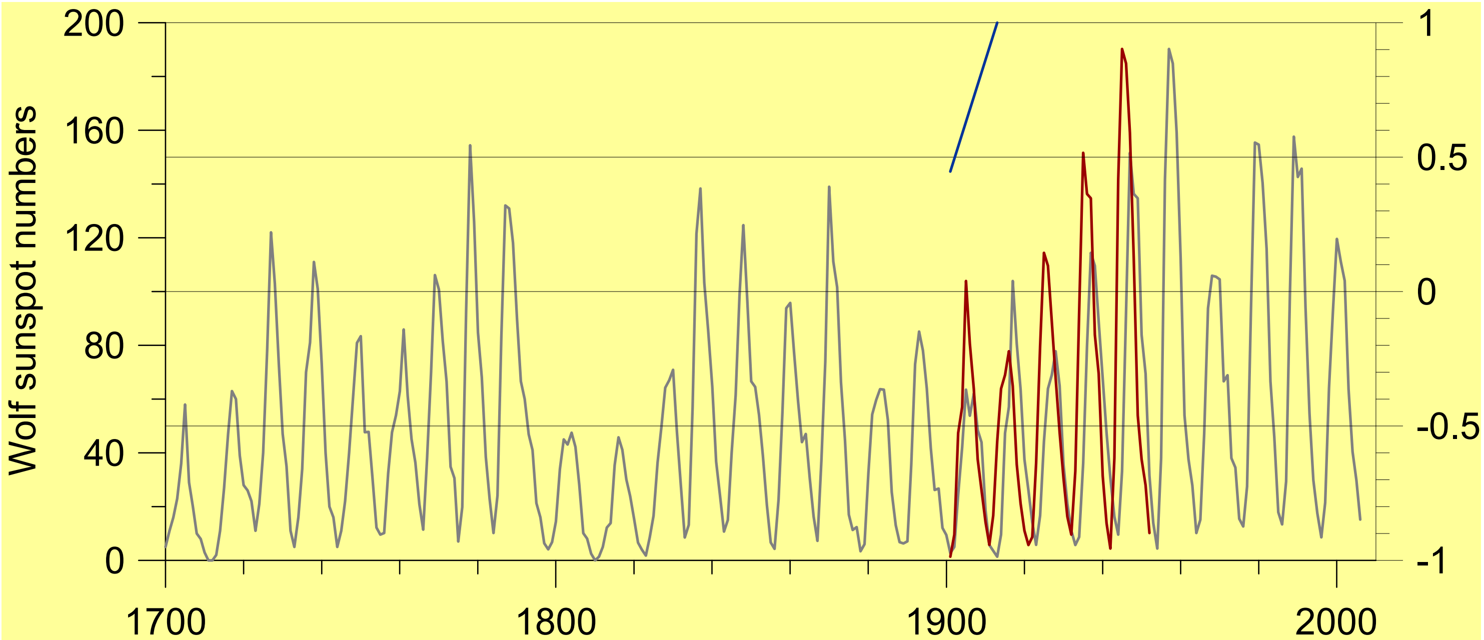


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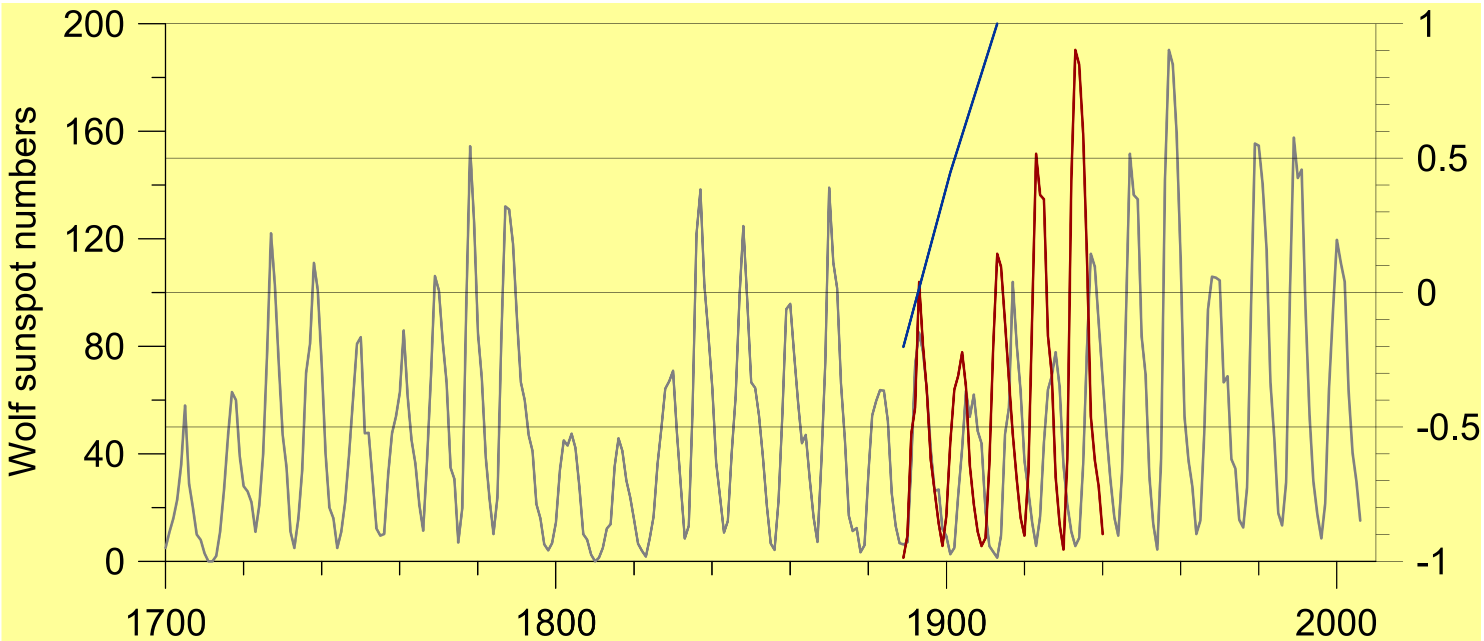


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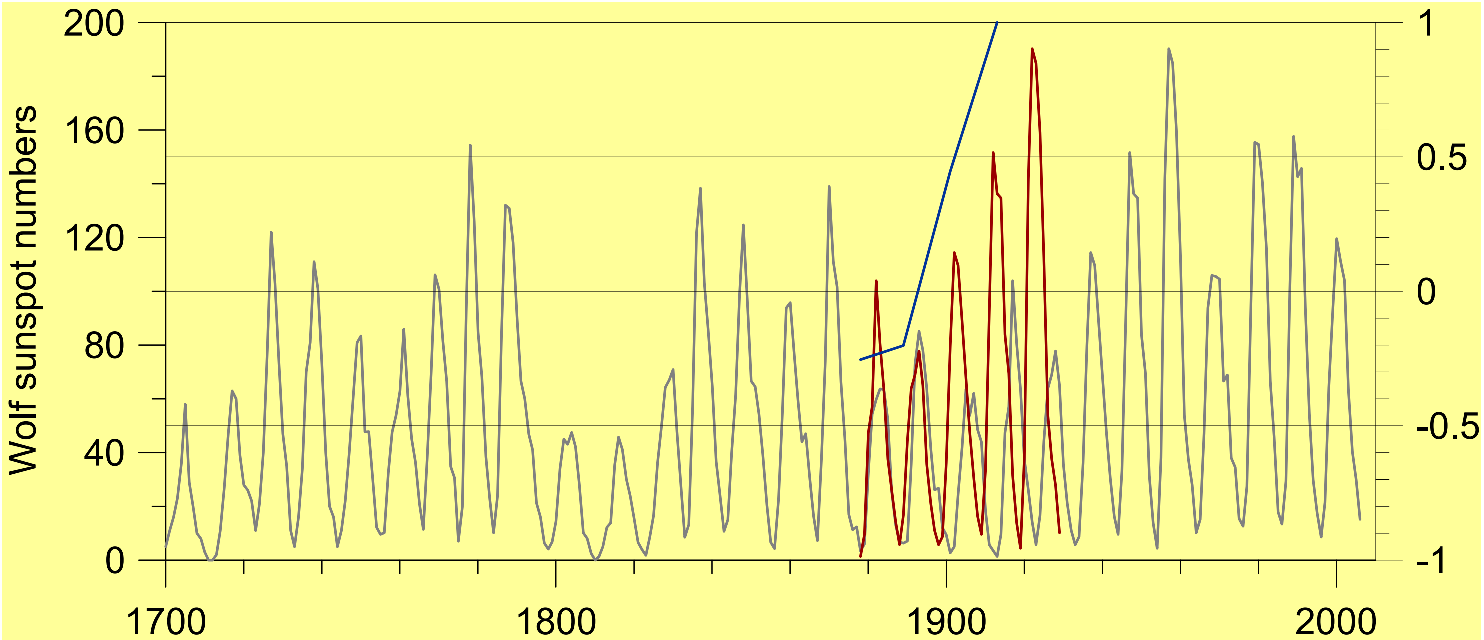


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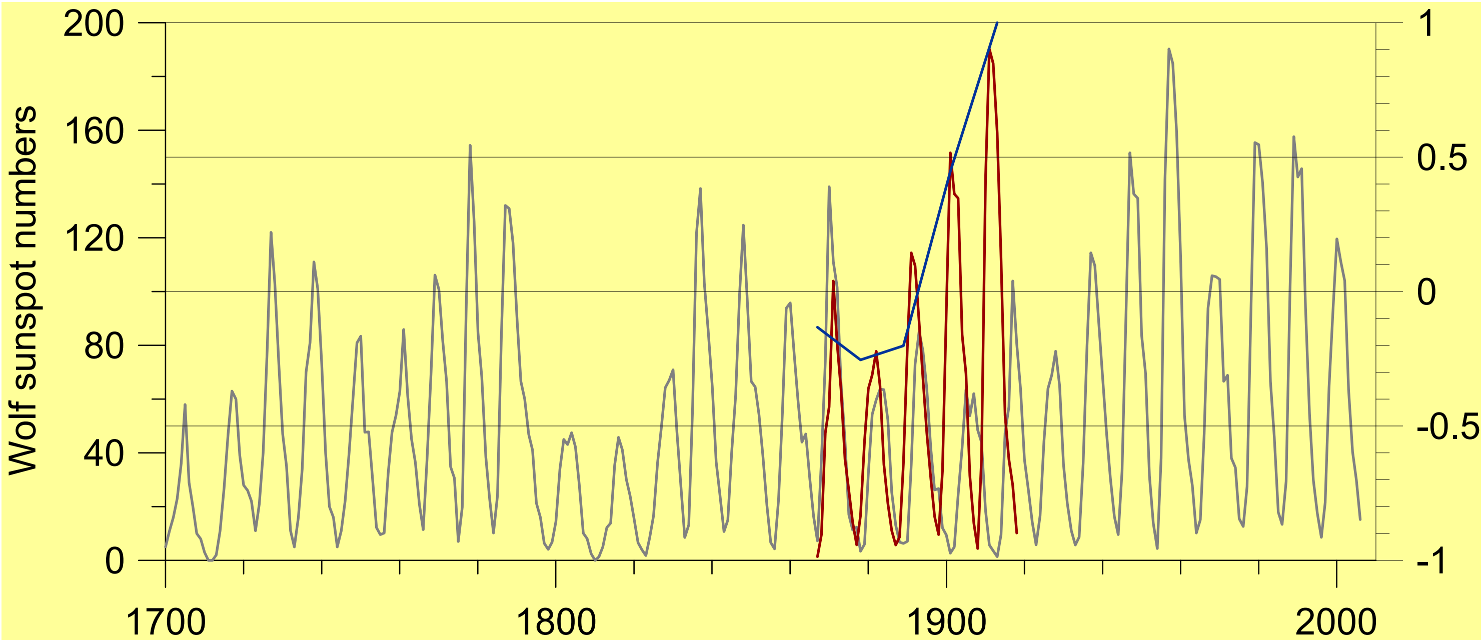


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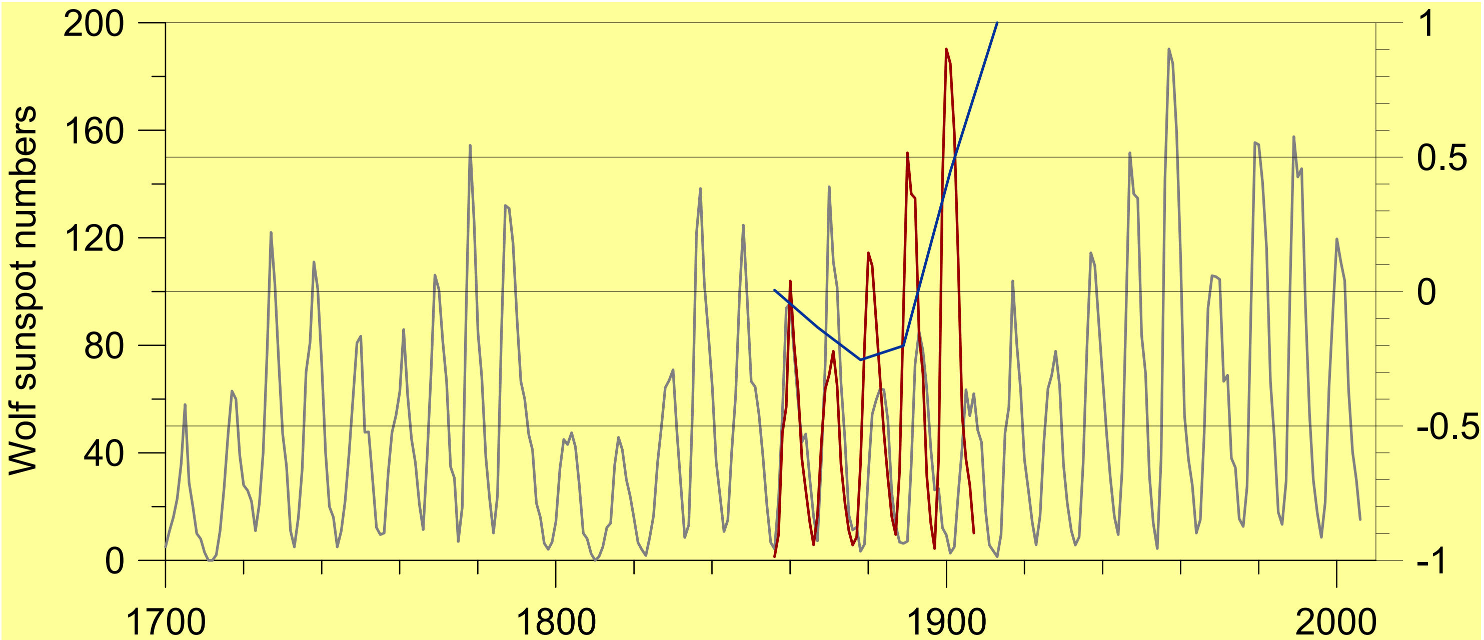


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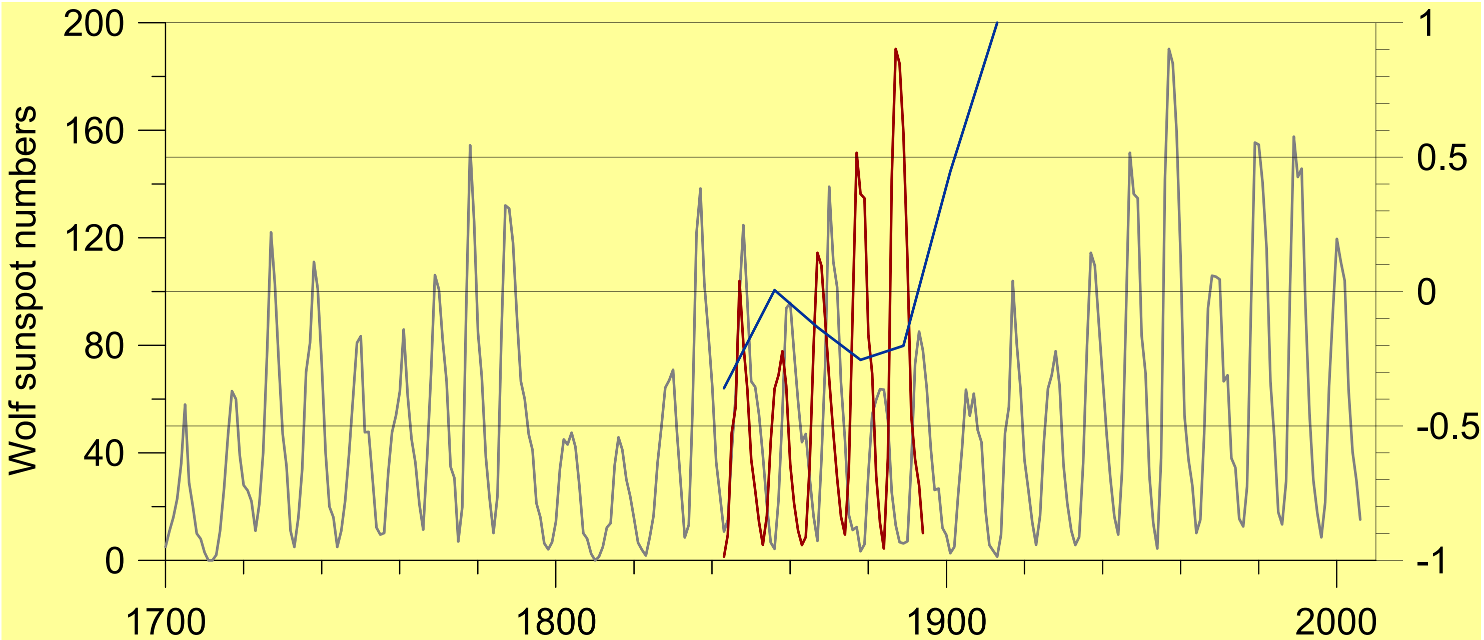


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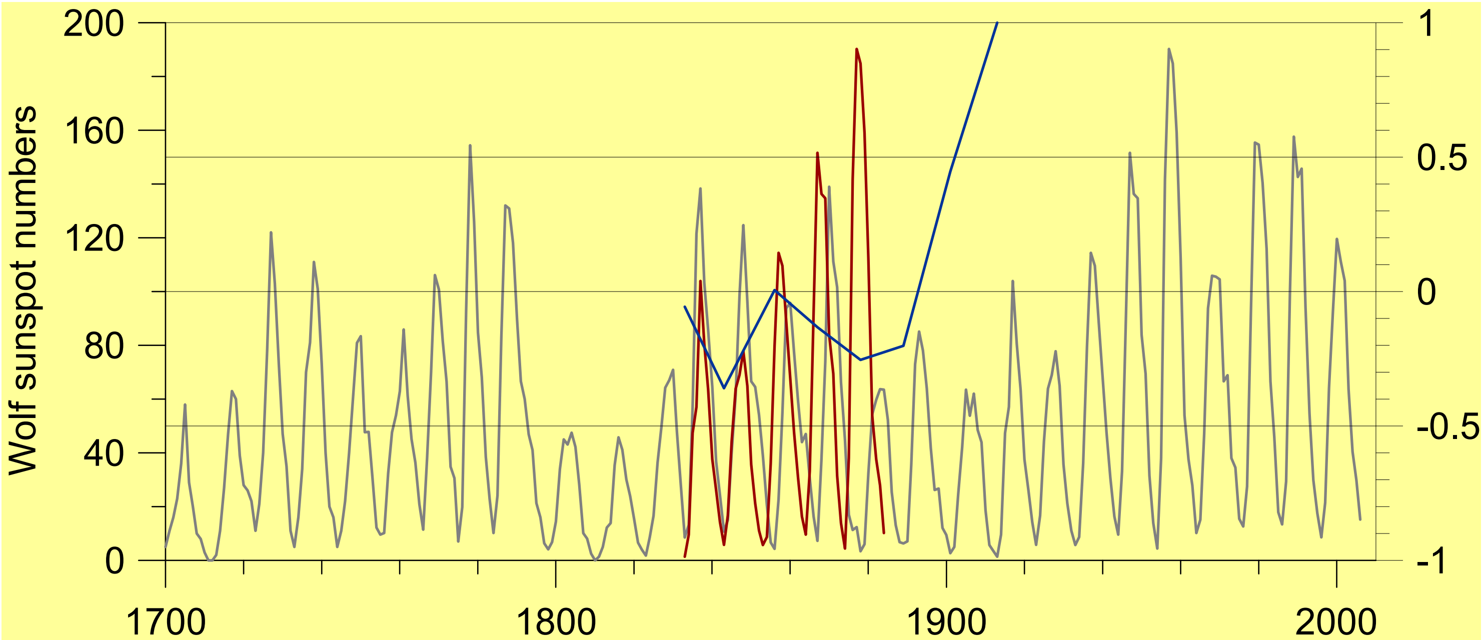


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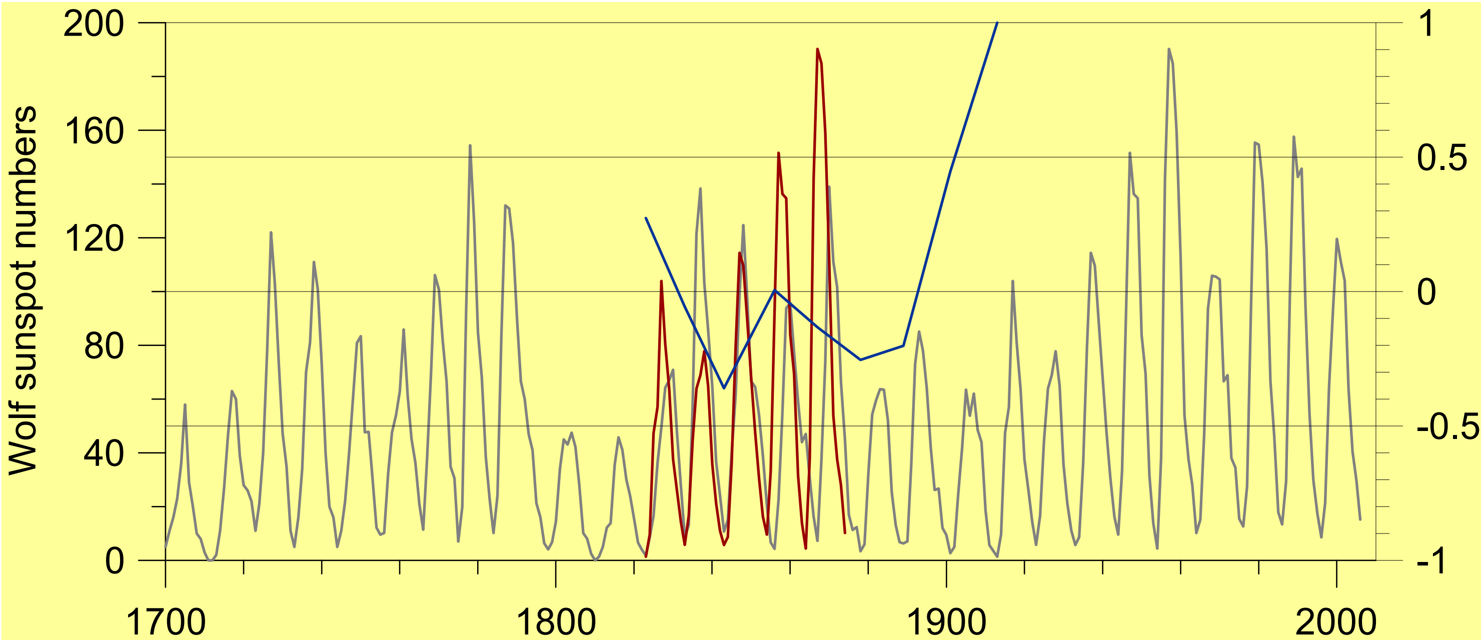


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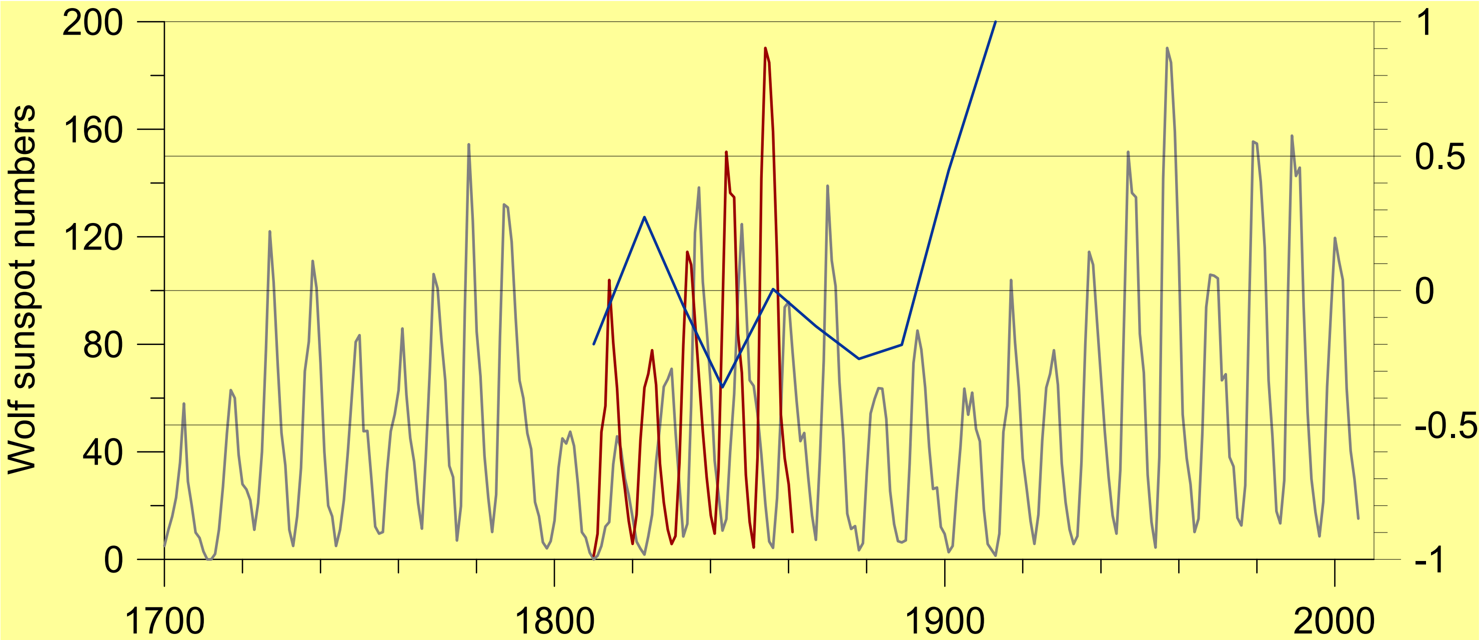


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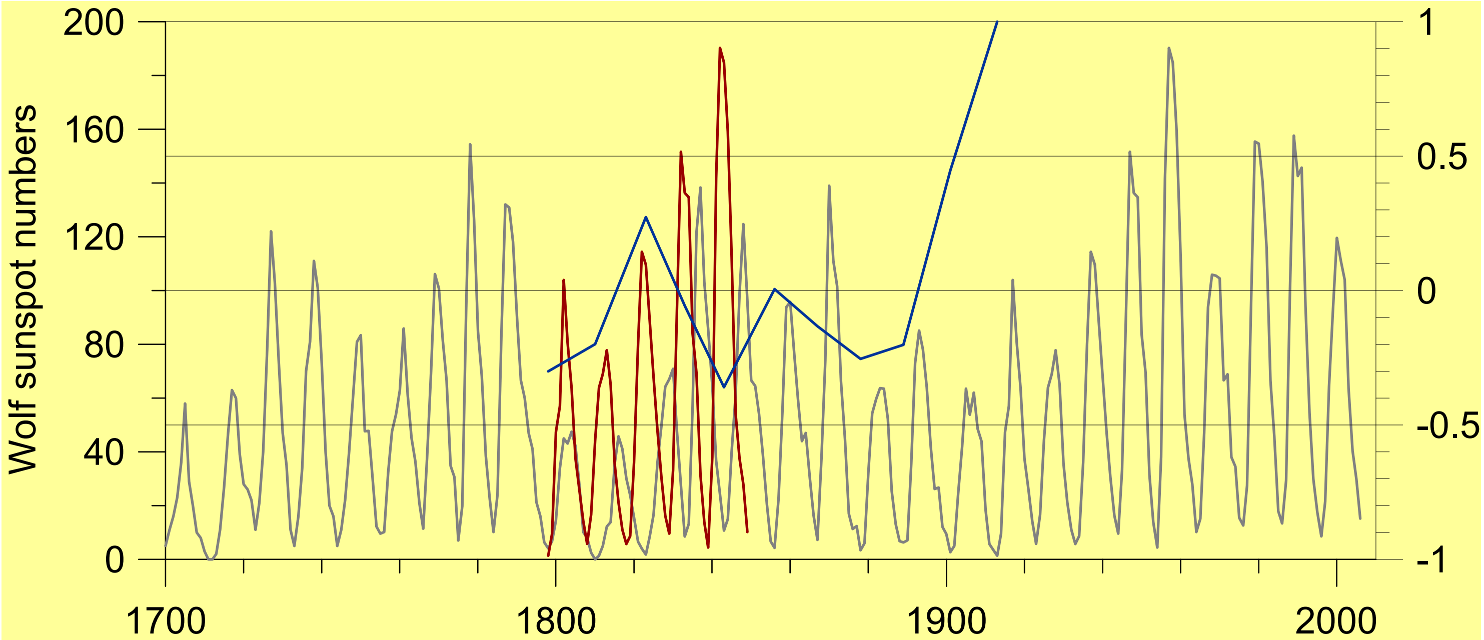


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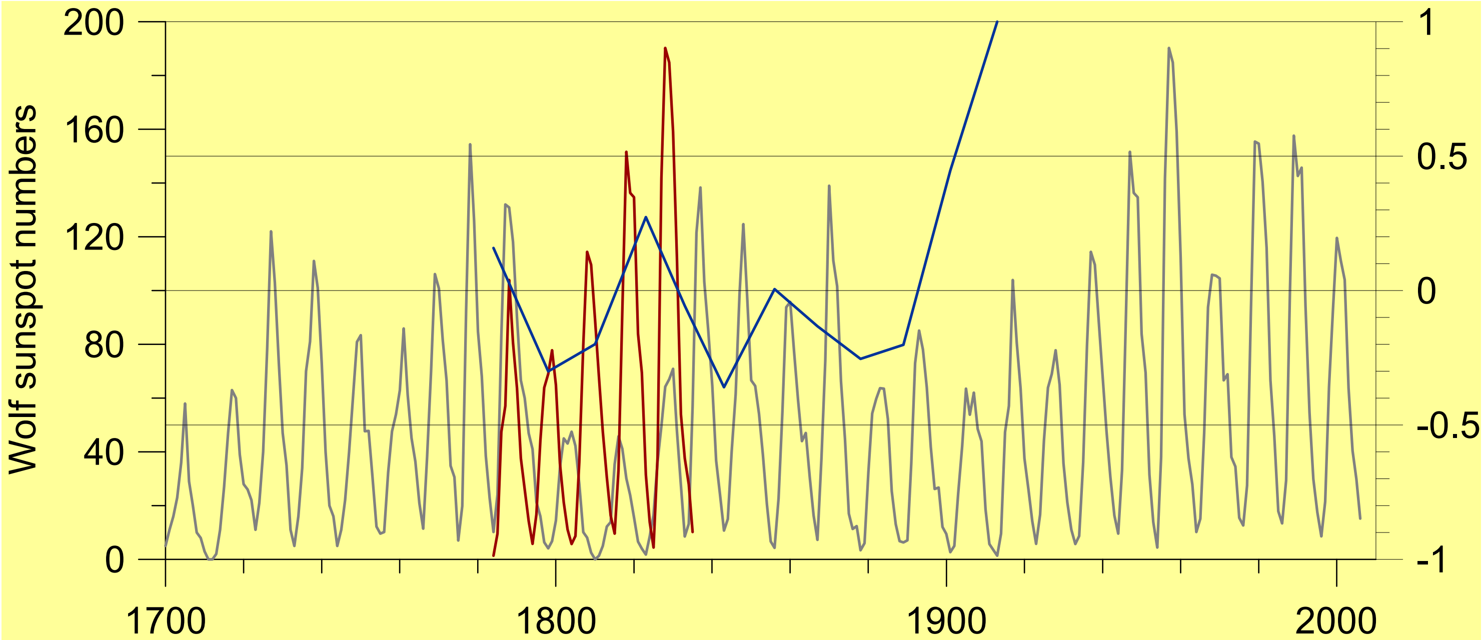


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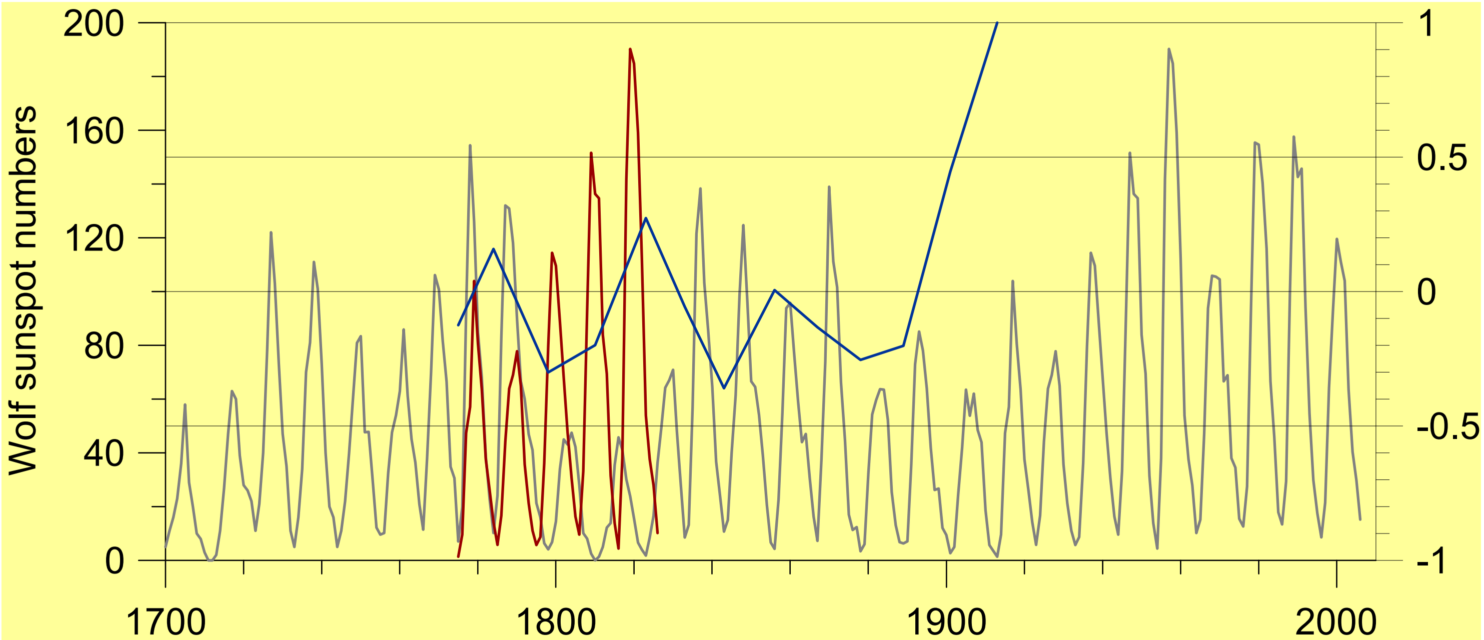


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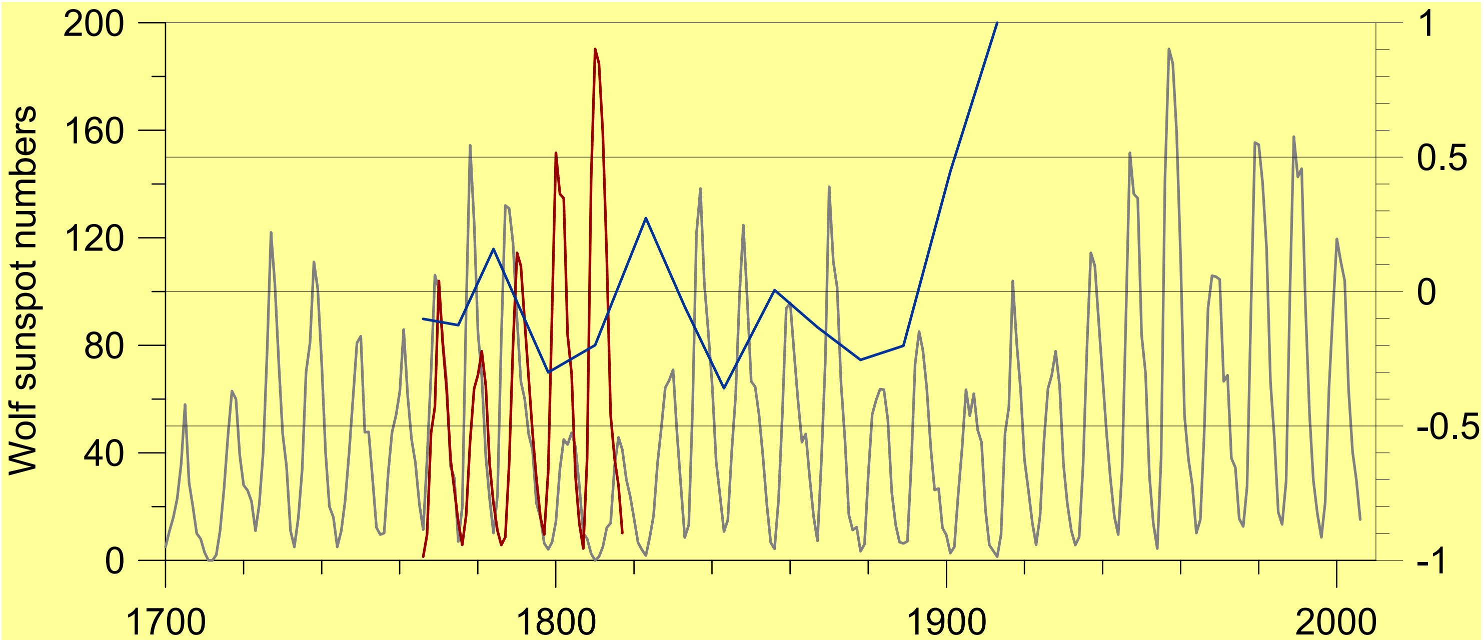


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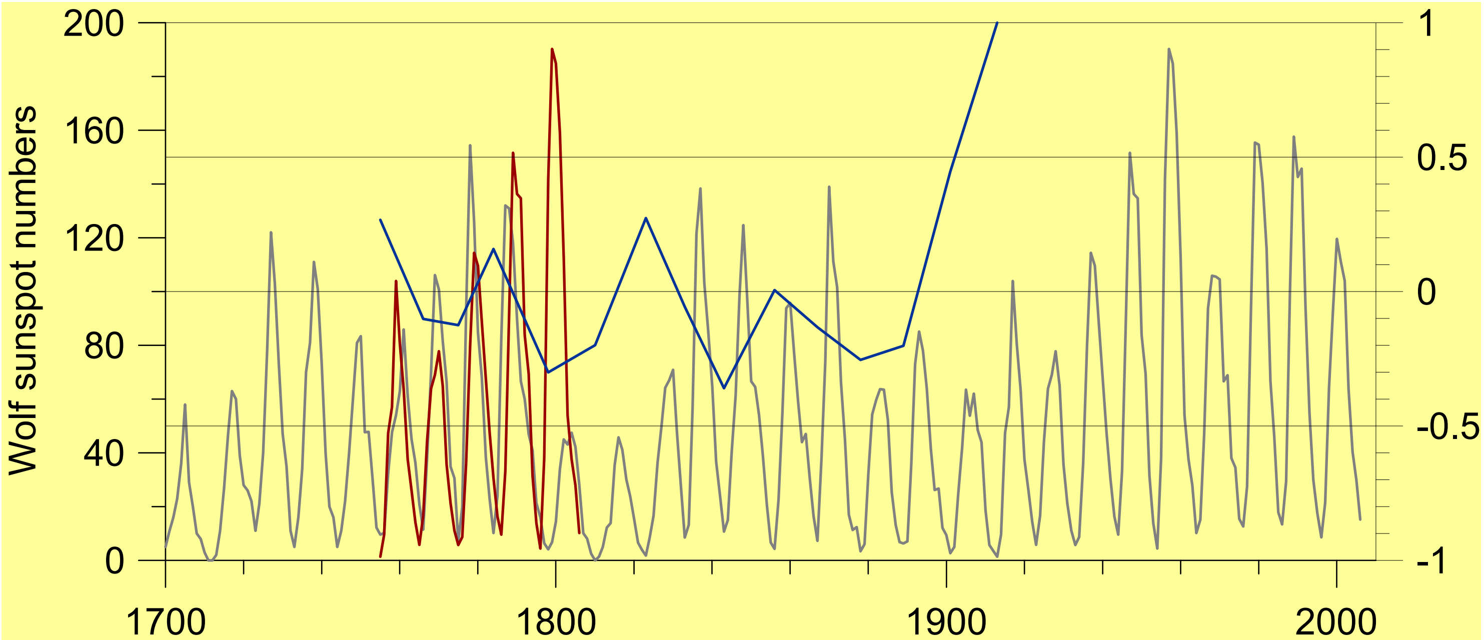


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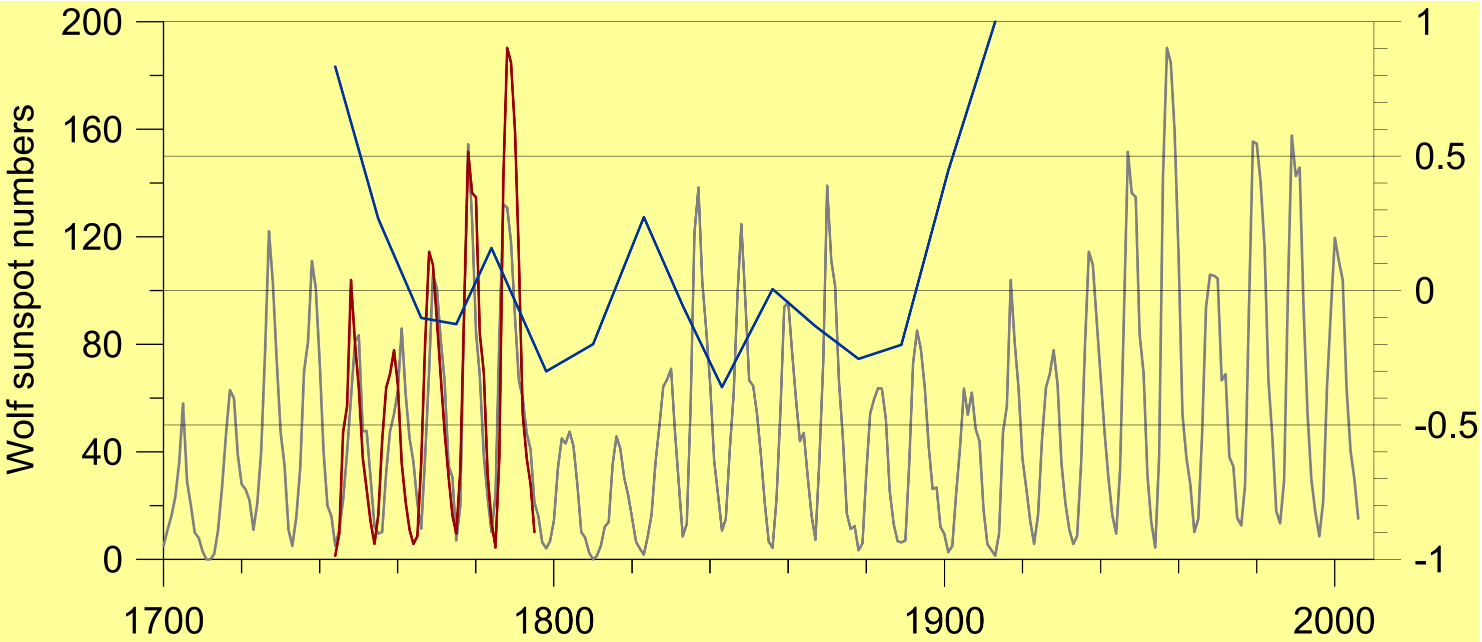


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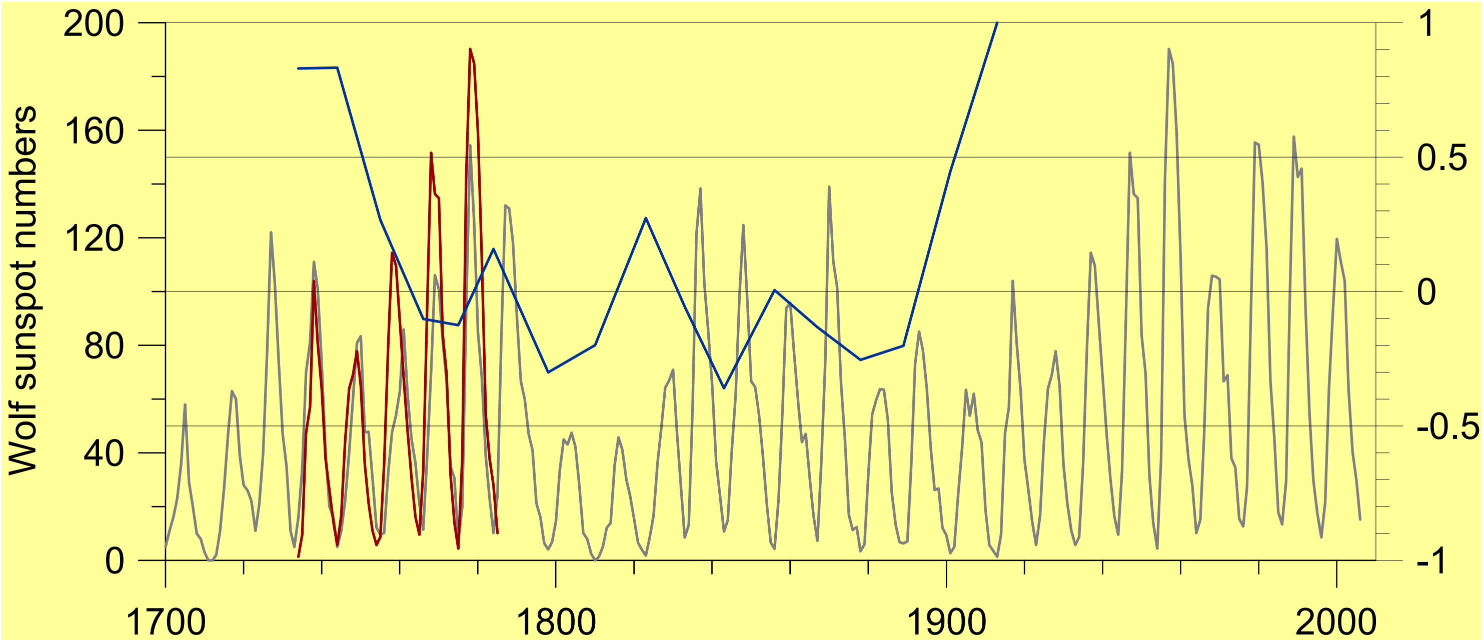


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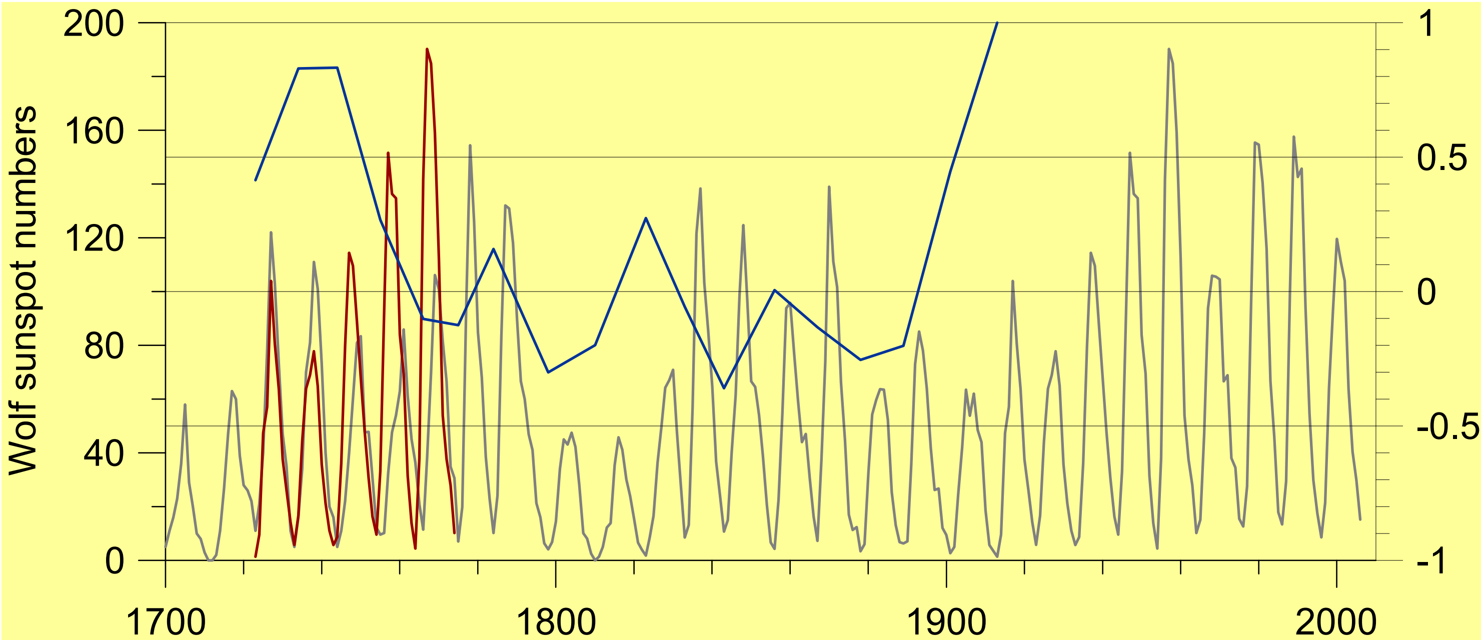


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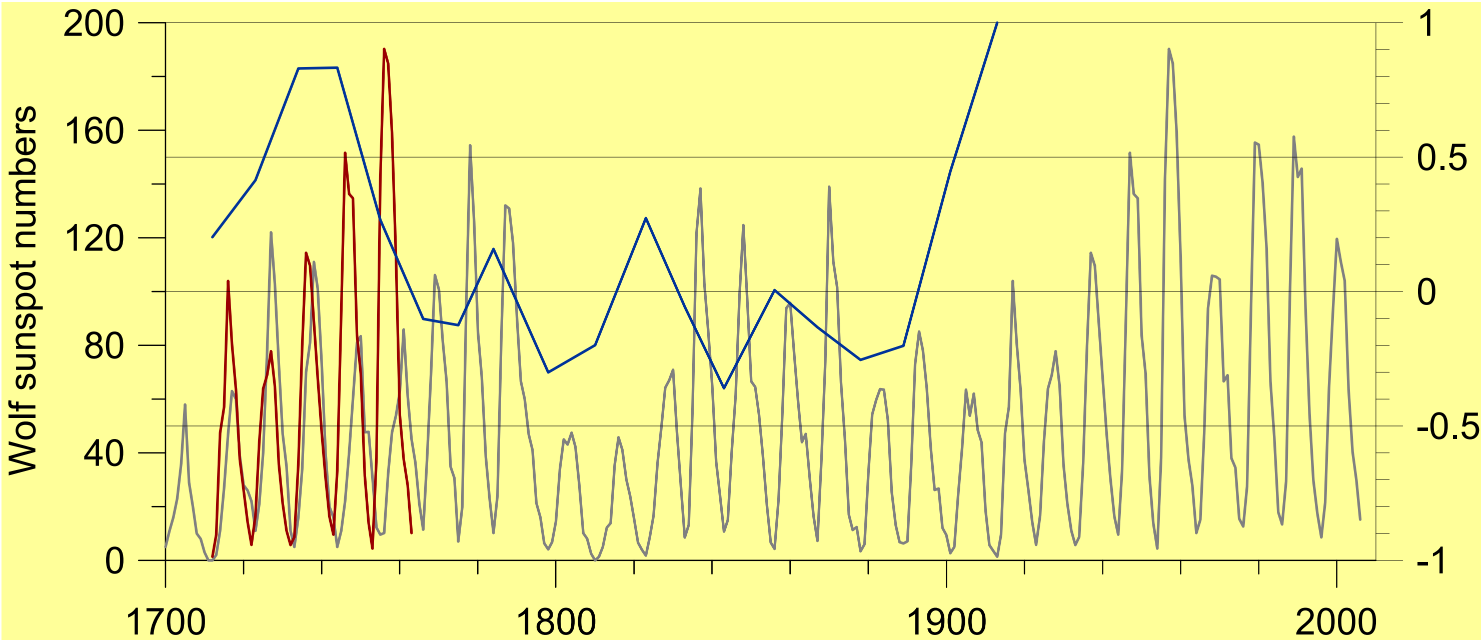


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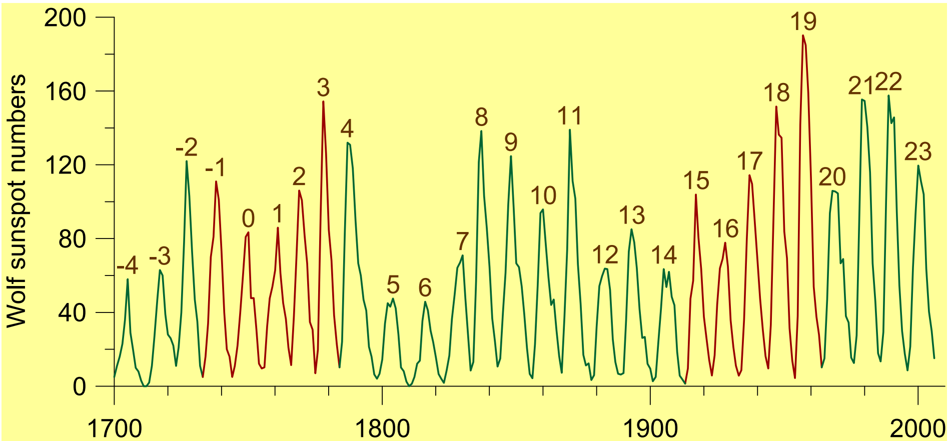
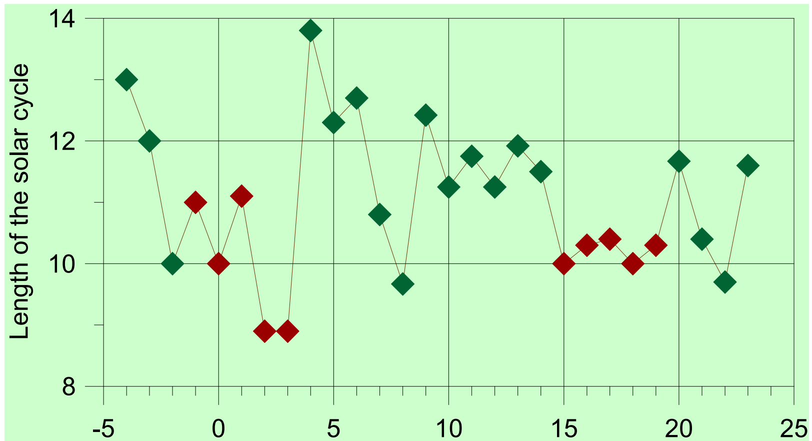
# Solar inertial motion and solar activity (observed data)

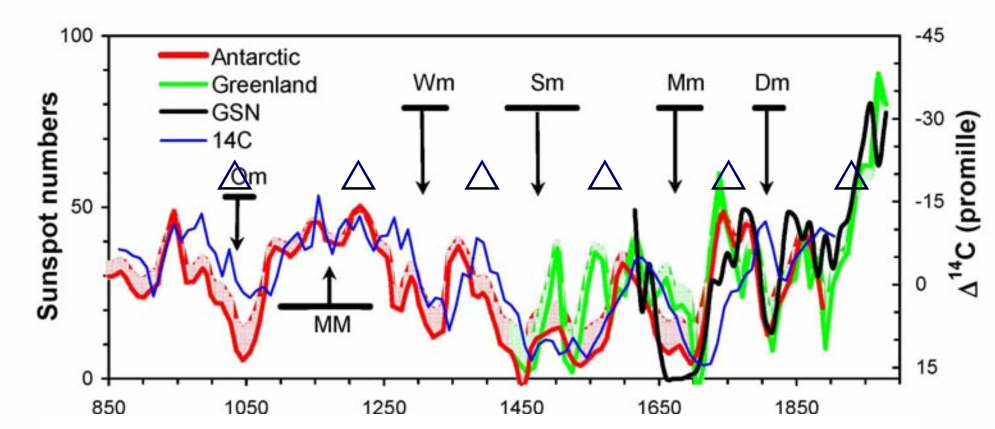
The correlation coefficient between these two series is the only significant (0.81). The lengths of the respective five cycles are nearly constant and equal to 10.1 years, on the average. This value corresponds to the duration of Sun's motion along one loop arc. The length belongs to the most important properties of solar cycles.

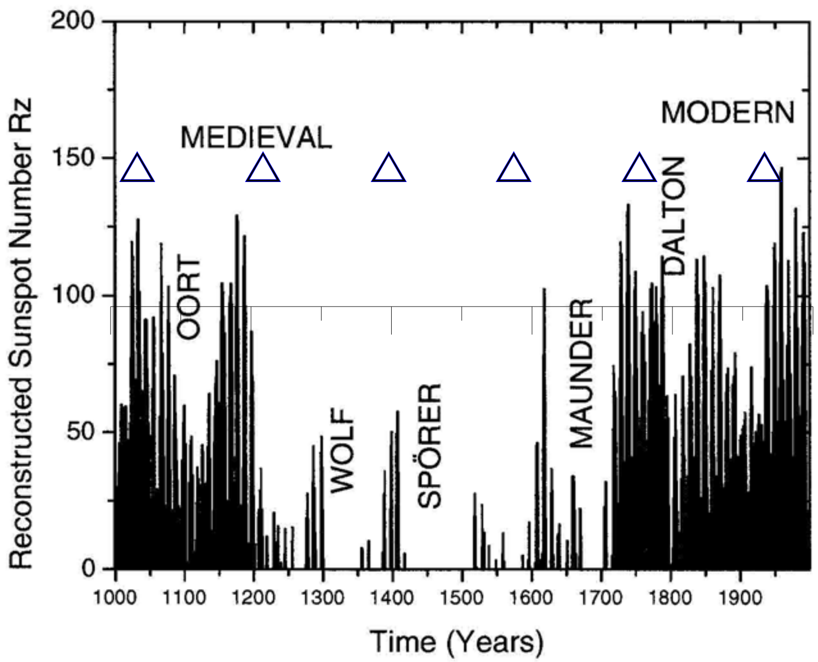



The differences between both the series can be ascribed to substantially lower quality of sunspot data in the 18th century (absence of uniform methodology and poor data coverage).

# Solar inertial motion and solar activity (proxy data)




top: Reconstructions of the sunspot numbers for the last millennium based on $^{10}$Be (red and green lines) and $^{14}$C (blue line) data.

I.G. Usoskin, S.K. Solanki, M. Schüssler, K. Mursula and K. Alanko, Astronomy & Astrophys., 413, 745-751, 2004.

bottom: Reconstruction of the SN derived from spectral analysis of the time series of SN for 1700–1999 .

N.R. Rigozo, E. Echler, L.E.A. Viera and D.J.R. Nordemann, Solar Physics 203, 179–191, 2001.

Blue triangles denote the ordered trefoil intervals. The Wolf, Spörer, Maunder and Dalton minima correspond well with the disordered parts of the SIM. The location of Oort minimum and its relation to SIM will require further investigation.

# Solar inertial motion and temperature (instrumental data)

Charvátová and Střeštík (2004) investigated the time series of surface air temperature from Geneve (1753–1988), Berlin–Tempelhof (1753–1990), Basel (1755–1980), Paris (1757–1990), Praha–Klementinum (1775–1990), Wien (1775–1990), Budapest (1780–1988), and München (1781–1990) and compared their spectra with the spectra of the SIM (the distance between the centre of the Sun and the centre of mass of the solar system).

The spectra were computed for the whole series as well as for the series long 179 years (basic cycle of the solar motion).

I. Charvátová and J. Střeštík, Periodicities between 6 and 16 years in surface air temperature in possible relation to solar inertial motion. JASTP 66, 219-227, 2004.

# Solar inertial motion and temperature (instrumental data)

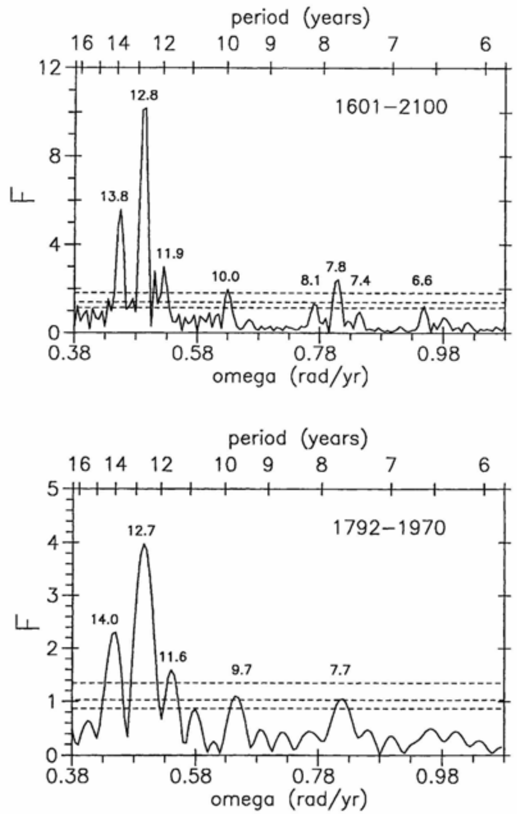



Fig. 3. Top: the Fourier amplitude spectrum of SIM characteristic (here the distance between the centre of the Sun and the centre of mass of the solar system), computed in the time interval 1601–2100. Bottom: the same type of spectra of the same characteristic computed for the 179 years long interval, (1792–1970). The solid horizontal lines represent the confidence levels of 90%, 95%, and 99%.

Fourier amplitude spectrum of the SIM

Power spectra of summarised central European surface air temperature series

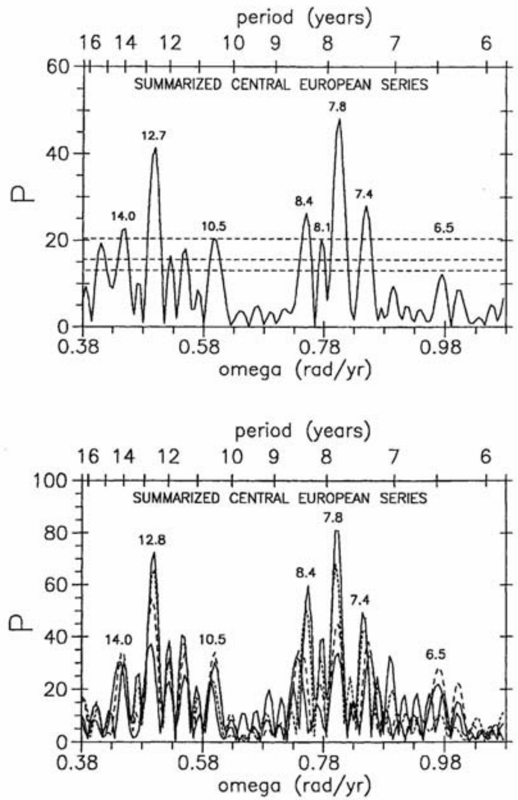
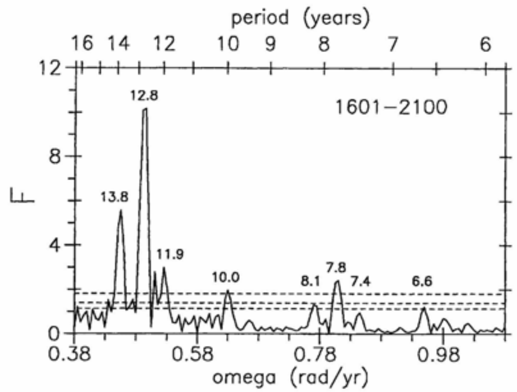
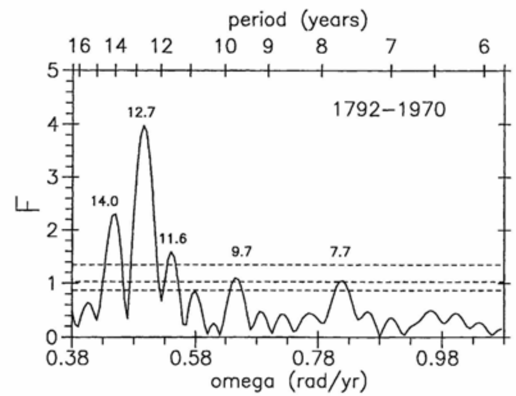



Fig. 4. Top: the power spectrum of summarised central European series (1753–1988). The solid horizontal lines represent the confidence levels of 90%, 95%, and 99%. Bottom: the power spectra computed from the parts of central European series being 179 years long are plotted by solid (1810–1988), long dashed (1792–1970), dashed (1781–1959), and dotted (1775–1953) lines.

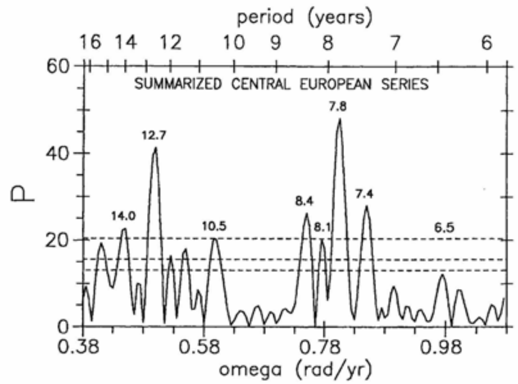
# Solar inertial motion and temperature (instrumental data)

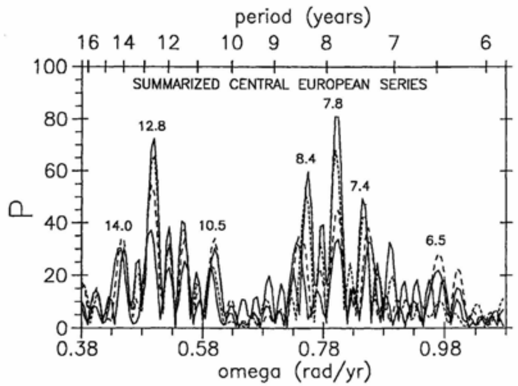



Fourier amplitude spectrum of the SIM

Power spectra of summarised central European surface air temperature series




A similarity between the sets of significant peaks 12.8, 10.4 and 7.8 years in the spectra of surface air temperature and the SIM have been confirmed, especially when computed from the series long 179 years (bottom figures).

# SIM and millennial temperature (proxy data)

There has been considerable recent interest in paleoclimate reconstructions of the temperature history of the last millennium. Juckes et al. (2007) reviewed eleven papers devoted to the reconstructions of past temperature and processed the data using various mathematical and statistical techniques.

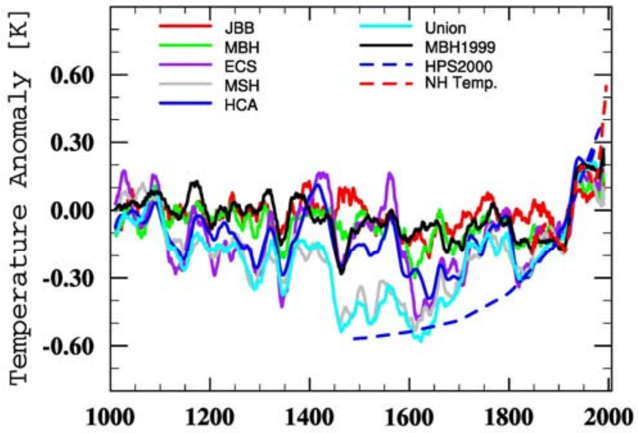



**Fig. 2.** Reconstruction back to AD 1000, calibrated on 1856 to 1980 Northern Hemisphere temperature, using CVM, for a variety of different data collections. The MBH1999 and HPS2000 NH reconstructions and the Jones and Moberg (2003) instrumental data are shown for comparison. Graphs have been smoothed with a 21-year running mean and centred on 1866 to 1970.

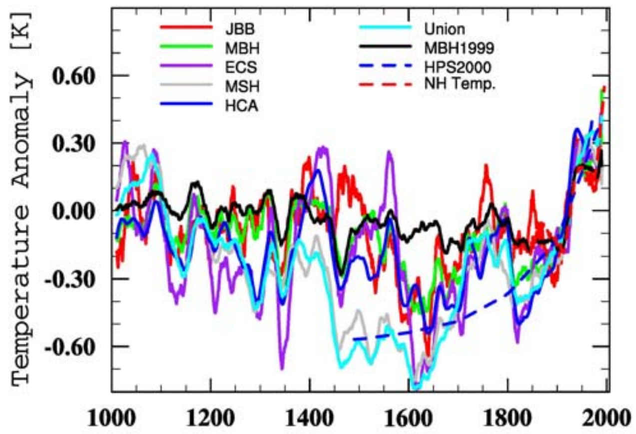
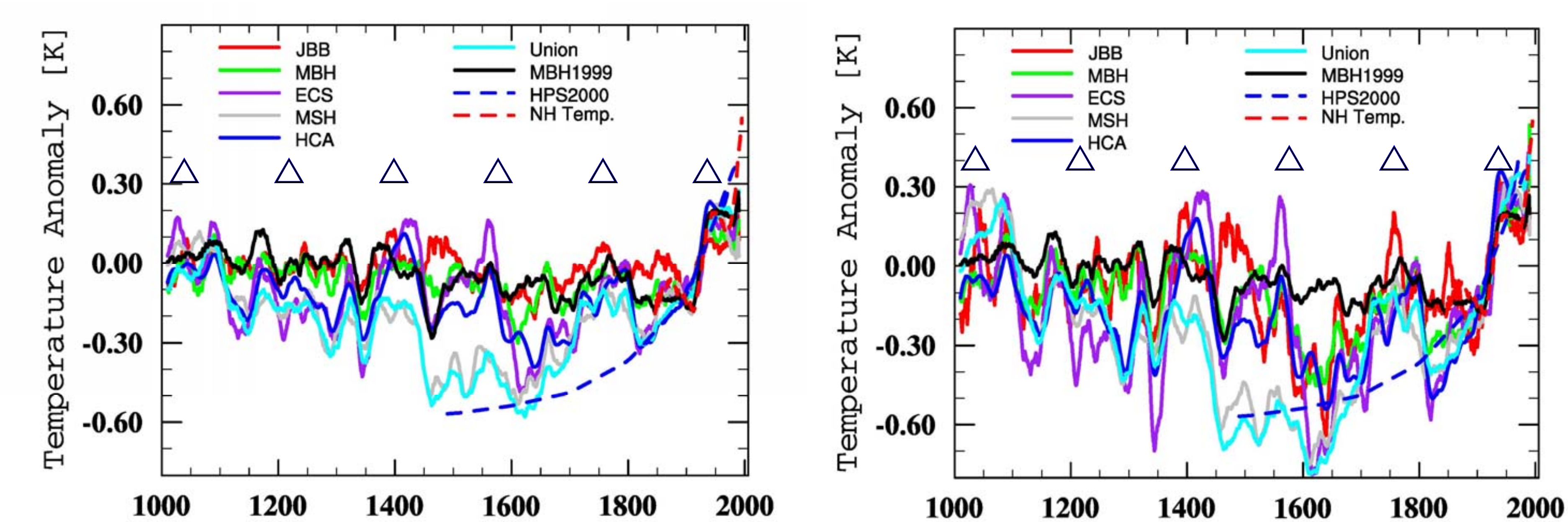



**Fig. 3.** As Fig. 2, except using inverse regression.


M. N. Juckes, M. R. Allen, K. R. Briffa, J. Esper, G. C. Hegerl, A. Moberg, T. J. Osborn, and S. L. Weber, Millennial temperature reconstruction intercomparison and evaluation, Climate of the Past 3, 591-609, 2007.

# SIM and millennial temperature (proxy data)

The trefoil intervals correspond well to the long-term temperature maxima.

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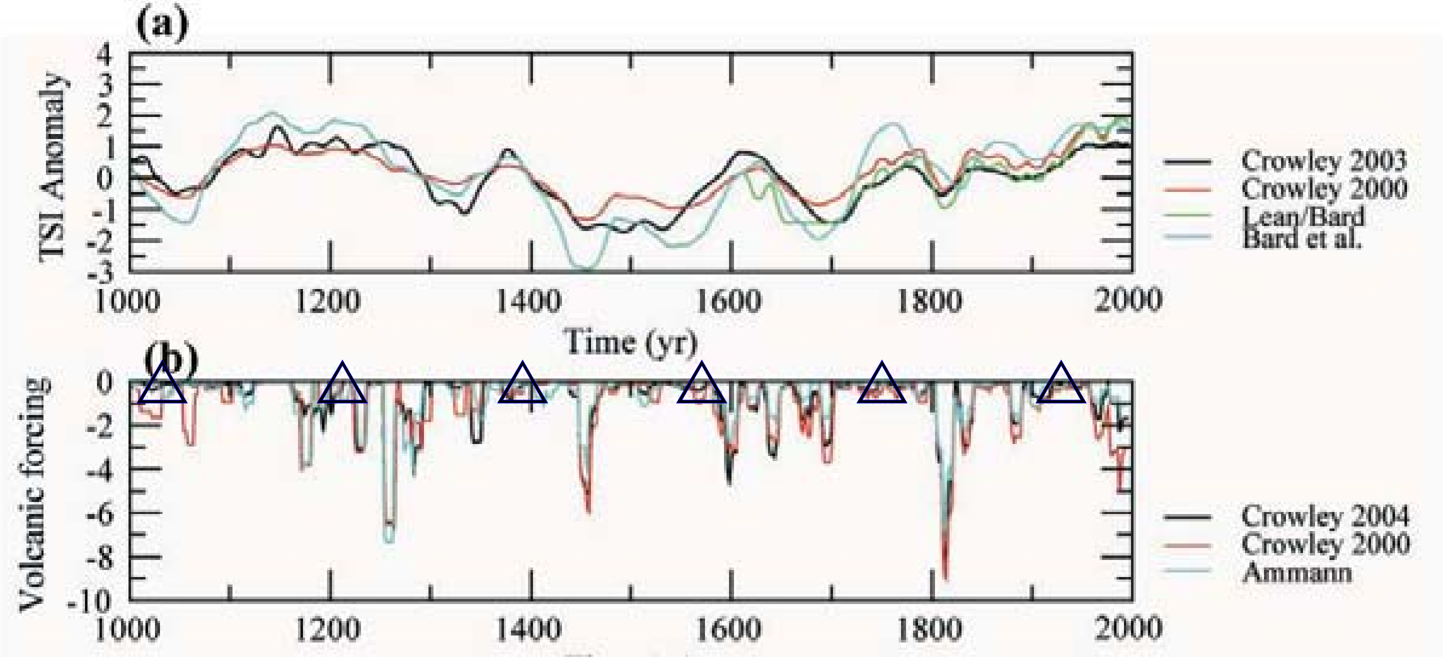
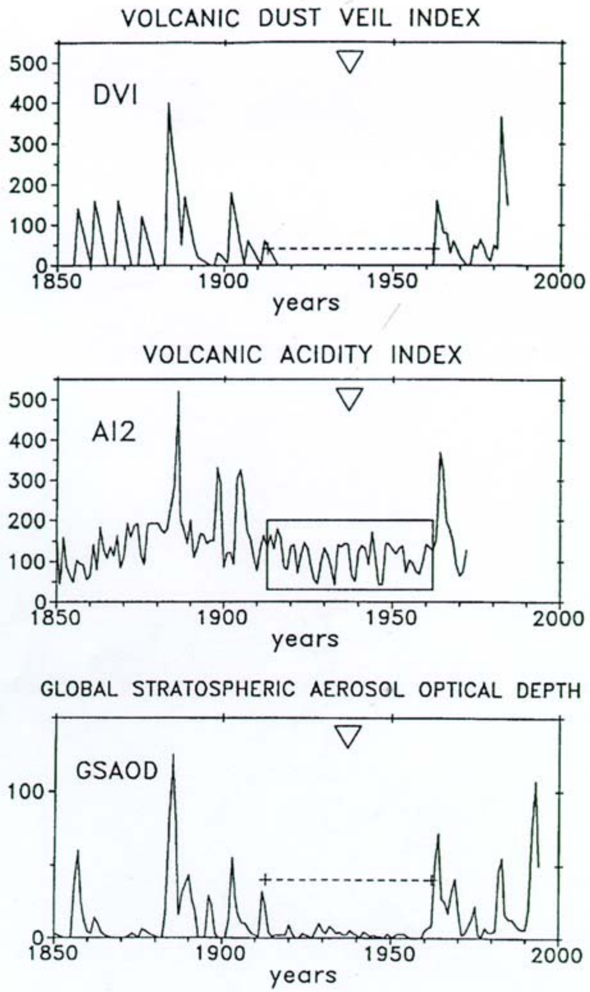
# SIM and volcanic activity

Volcanic activity belongs to the factors that can influence climate variability. Bellow graphs show anomaly of the total solar irradiance and volcanic forcing (W/m2) scaled as an effective changes in the solar irradiance.
There is a low level of volcanic activity in the trefoil intervals.




H. Goosse, O. Arzel, J. Luterbacher, M. E. Mann, H. Renssen, N. Riedwyl, A. Timmermann, E. Xoplaki, and H.Wanner, The origin of the European "Medieval Warm Period", Climate of the Past 2, 99-113, 2006.

# SIM and volcanic activity

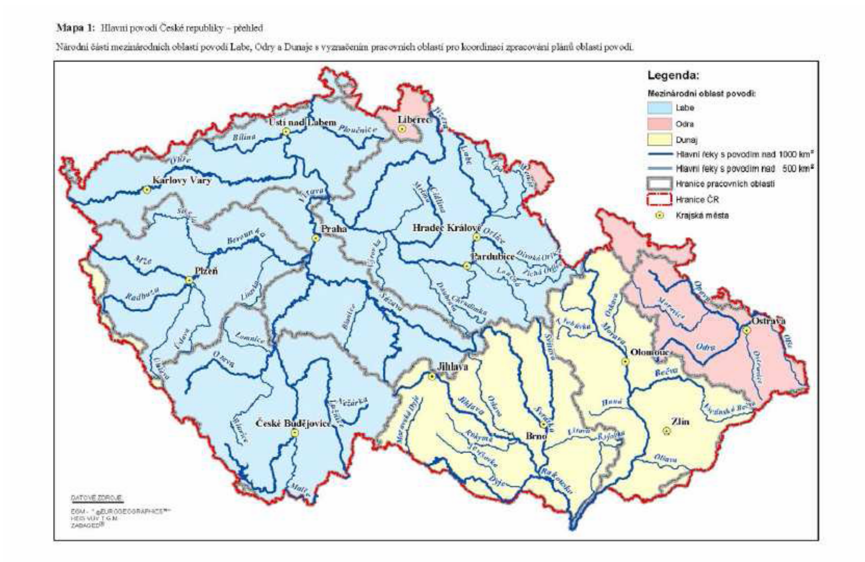



The above results confirm former finding of Charvátová (1997) on the exceptionally low level and stability of volcanic activity during the trefoil interval.

I. Charvátová, Solar-terrestrial and climatic phenomena in relation to solar inertial motion. Surveys in Geophysics 18, 131-146, 1997.

# Solar inertial motion and floods in Bohemia

Recent disastrous floods in the Czech Republic (Moravia 1997, Bohemia 2002) increased the interest of hydrologists in the historical floods. The most reliable data are available from Vltava river basin, because the capital Prague lies on the lower reach of Vltava river.





THE KARLSBRÜCKE AT PRAGUE AFTER THE RECENT FLOOD.—[See Page 799.]

Elleder L.: Variability of seasonality and frequency of disastrous floods in Vltava river basin taken from documentary sources (in Czech), In: Extremal hydrological phenomena in river basins, Workshop 2005.

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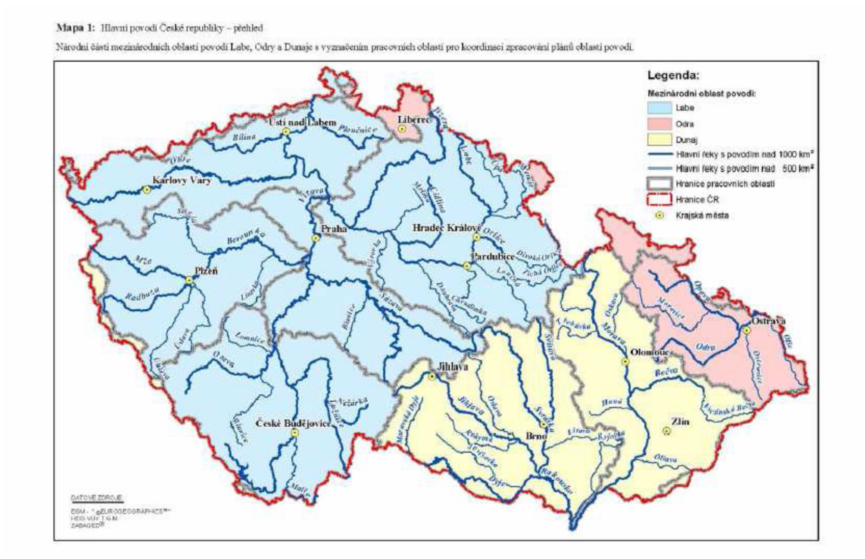



Elleder L.: Variability of seasonality and frequency of disastrous floods in Vltava river basin taken from documentary sources (in Czech), In: Extremal hydrological phenomena in river basins, Workshop 2005.

# Solar inertial motion and floods on the Czech territory

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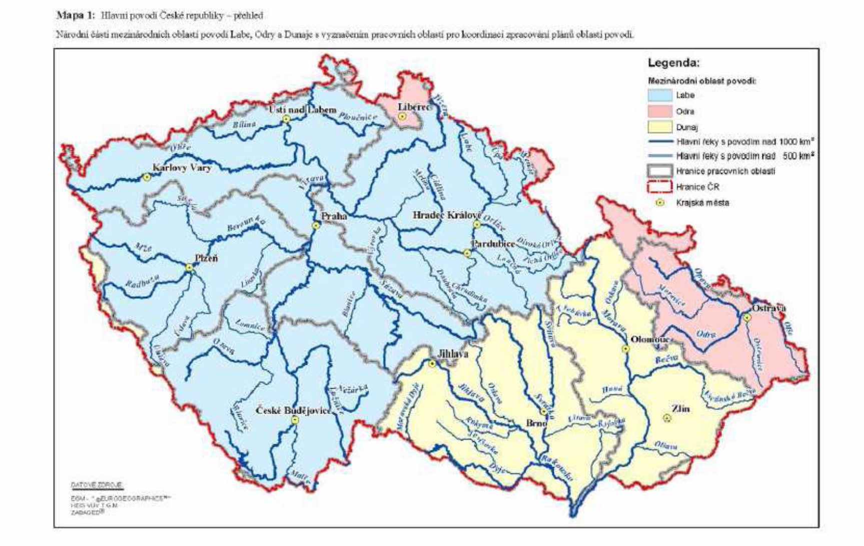
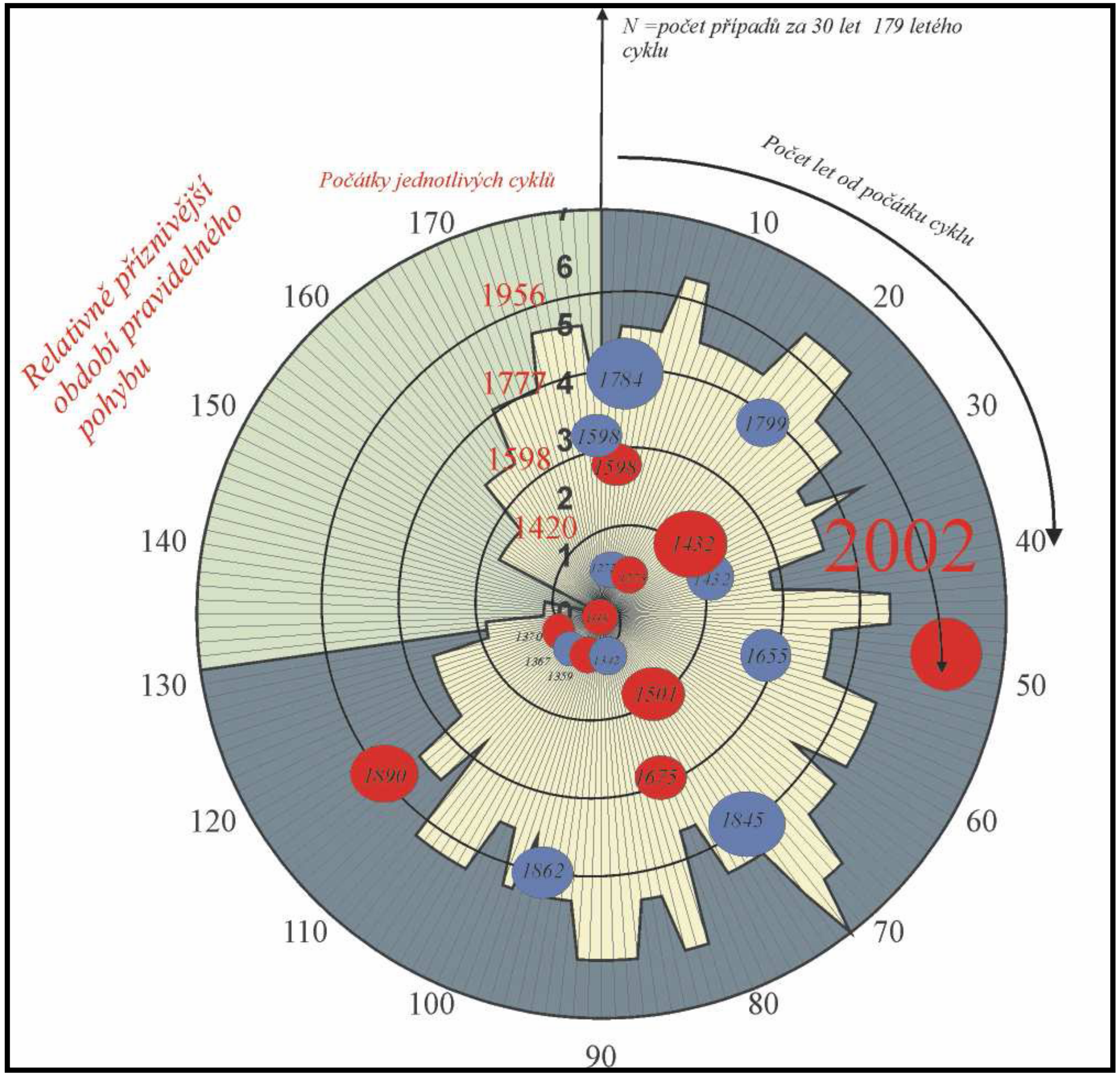




Elleder L.: Variability of seasonality and frequency of disastrous floods in Vltava river basin taken from documentary sources (in Czech), In: Extremal hydrological phenomena in river basins, Workshop 2005.

# Solar inertial motion and floods on the Czech territory




**The great (disastrous) floods recorded in Vltava river basin (Bohemia, Czech Republic) since AD 1000 and their 30 year moving frequency**.

The floods are drawn along the spiral in 179 year cycle. The intervals of the last 50 years without the disastrous floods correspond to the trefoil intervals of the SIM. Summer floods (red) and winter floods (blue) are drawn by the circles. N – number of floods. The figure is taken from Elleder (2005).

# Conclusions

The  results obtained **indicate a primary, controlling role of the SIM in solar-terrestrial and climatic variability.**

The exceptional, stable intervals of the nearly identical trefoils in the SIM  can serve as the supporting bases in searching for mutual relations between the SIM, solar activity, geomagnetic activity, volcanic activity, surface air temperature, etc. This will be in focus of our future research

**The SIM is computable in advance** (celestial mechanics). If  steady mutual relations between the SIM and above phenomena  are gradually found, then predictive assessments of their future behaviours could be established, first of course on the basis of known previous mutual relations (behaviours).

**Proper mechanisms are so far not known.**