SOLAR CURRENT FEEDBACK

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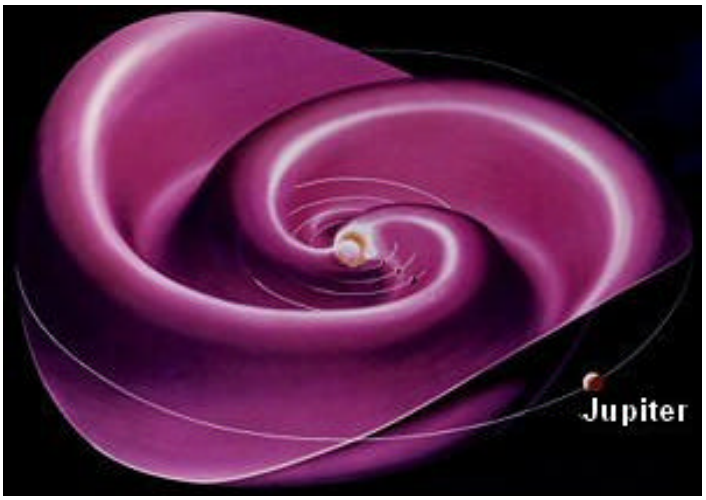
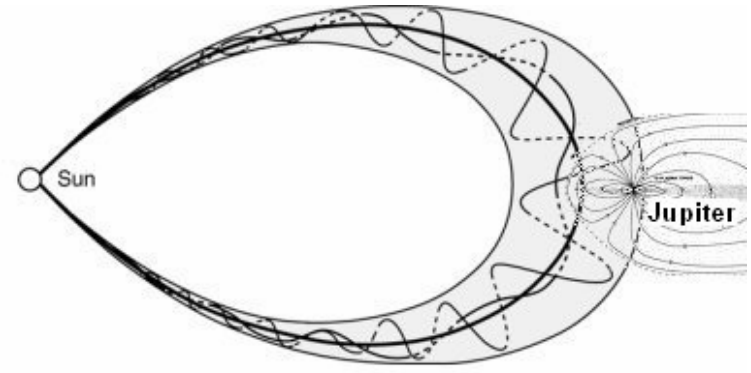
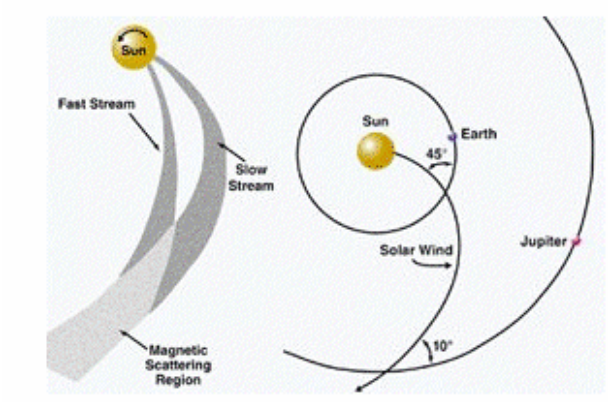
The Sun is the generator of the heliospheric current made of charged particles which extends to the limits of the heliosphere, forming a closed circuit. It flows in three-dimensional plane (known as the heliospheric current sheet. The Sun's rotation has effect of warping of the heliospheric current sheet into shape of a spiral. The electric current in the heliospheric current sheet is directed radially inward, the circuit being closed by outward currents aligned with the Sun's magnetic field in the solar polar regions. The total current in the circuit is on the order of 3×10^9. This current is polarised so the return leg splits into two and closes the circuit above the Sun's surface.



The heliospheric current interacts with planetary magnetospheres. By definition a planet's magnetosphere should have same orbital parameters as the planet itself. A magnetosphere is not sphere at all, being hugely distorted by the solar wind. Due to its size, shape and position a magnetosphere cannot directly influence the Sun's magnetic behavior, but there is a possibility of an indirect influence through modulation of the heliospheric current resulting in a feedback.

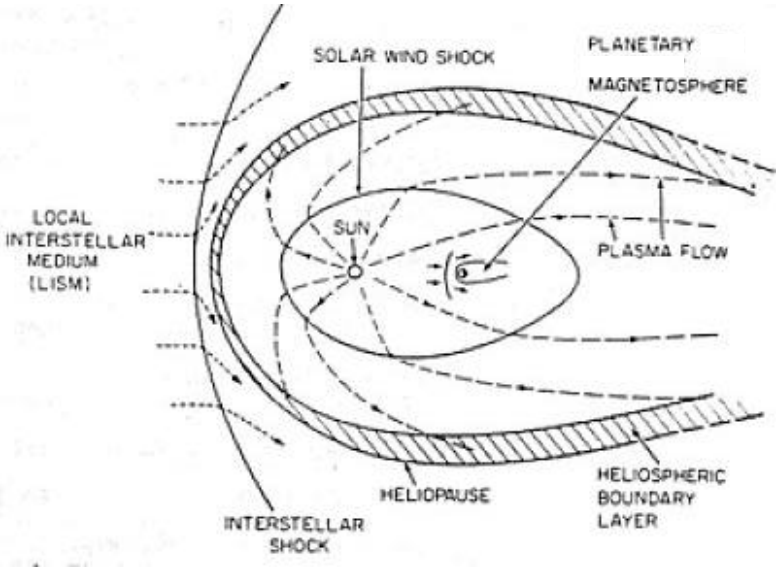


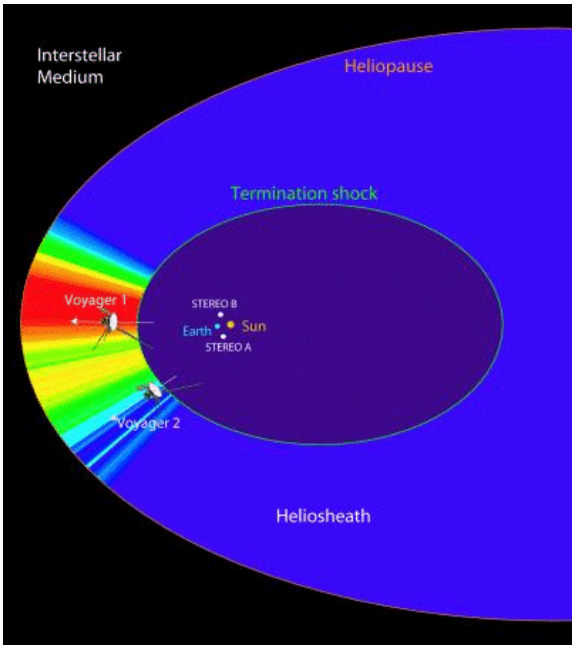
The heliospheric current continuously interacts with the planetary magnetospheres. It could be ascertained that considerable amount of energy is extracted from the current by the impacted magnetosphere: through magnetic reconnection or some other way, also magnetosphere traps some of the charged particles .



The amount of energy extracted out from the heliospheric current by a particular magnetosphere may not vary greatly along its orbital path (if heliosphere was homogenous in all directions), except in the case when two planets line up producing 'magnetospheric eclipse'. In such case heliospheric current will change, hence modulation.

The heliosphere is not homogenous in all directions, it is distorted by galactic magnetic field created by the presence of cosmic rays. The strength of solar magnetic field varies considerably at the head side. As individual magnetospheres enter this particular area then their contribution to the overall feedback (mainly provided by Jupiter) will vary.





The effect will be strongest with the outer planets (Jupiter onwards), while it is likely by the time effect reaches 1AU (Earth), possibly drops to negligible values. It is also obvious that the outer regions of the Jupiter's magnetosphere (which extends up to 10 AU, as far as Saturn's orbit) may have significant effect on the contribution to its own feedback.

It has been recently discovered that this particular area is prone to incursion by strong of cosmic rays and does not abruptly stop at the termination shock but most likely extend much closer to the centre of the solar system, which again may significant effect on the possible feedback as the major magnetospheres enter the area.

Existence of this inhomogeneous area of the heliosphere, may be reason for inability to precisely define SSN extremities to spatial Jupiter- Saturn relationship.

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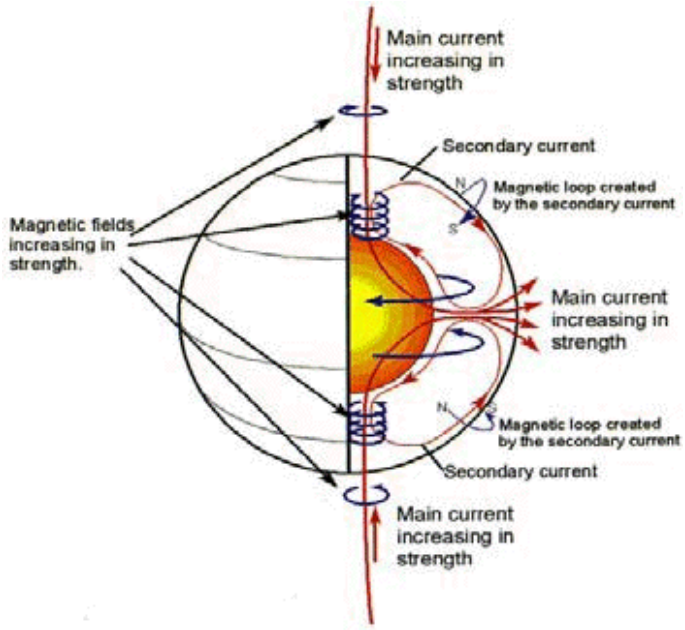
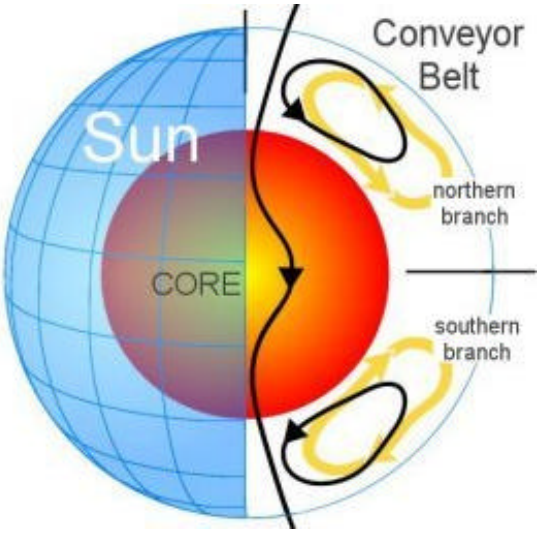


The solar current feedback in return modulates the Sun's surface magnetic activity. Return leg of the solar current splits into two parts according to the polarity, then each splinter of the current affects appropriate hemisphere independently giving possibility of two cycles running in parallel one in each hemisphere.

Let's consider the main current oscillating between two DC values as a result of being modulated by load from planetary magnetospheres. As the current increases (positive gradient of change) the magnetic field generated by it will also change (note N and S hemispheres will have different polarity). The increasing magnetic field will induce secondary currents, which in turn will create own magnetic loops that energize sunspots. When the main current approaches its maximum, its gradient will fall to zero i.e. no change, no primary magnetic field induction, no secondary currents, no SS magnetic loops. Falling main current (negative gradient of change) will induce magnetic field of opposite polarity, changing direction of the secondary current circuits, and therefore polarity of SS magnetic loops. Rising main current is responsible for magnetic polarity of say even cycles, while falling current would be then for the odd cycles.

Plasma is ionized electrically conductive gas so it responds strongly to electromagnetic fields. Movement of plasma constitutes electric current. Now compare secondary currents to NASA's conveyor belts as in

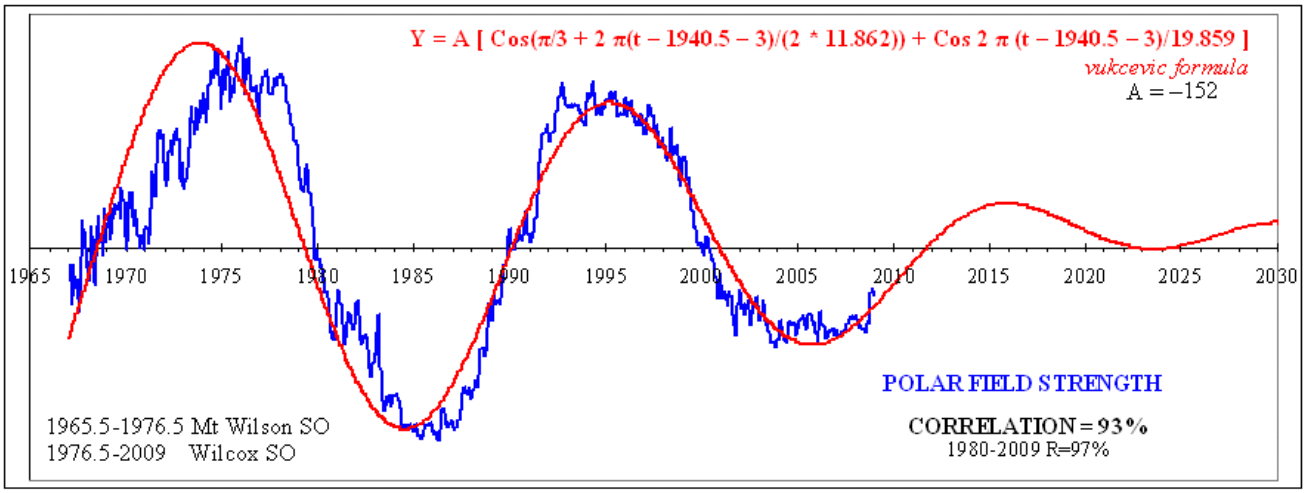


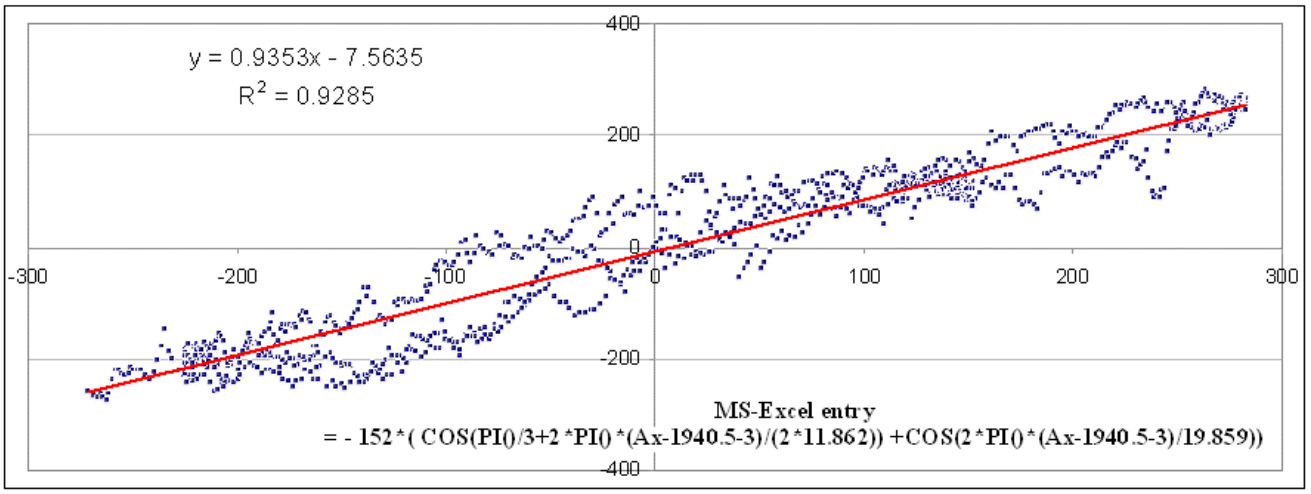
that

Number of eminent solar experts believes that the strength of polar magnetic fields at the time of SC minimum, is a precursor of intensity of the next cycle. According to the data from two solar observatories (Mount Wilson and Wilcox) over the last 40 years, the strength of the polar fields has been steadily declining, at current minimum it is at its lowest value recorded. This indicates that next cycle is going to be low, further more; decline is going to continue for at least next 2-3 cycles (projected probability more than 90%).

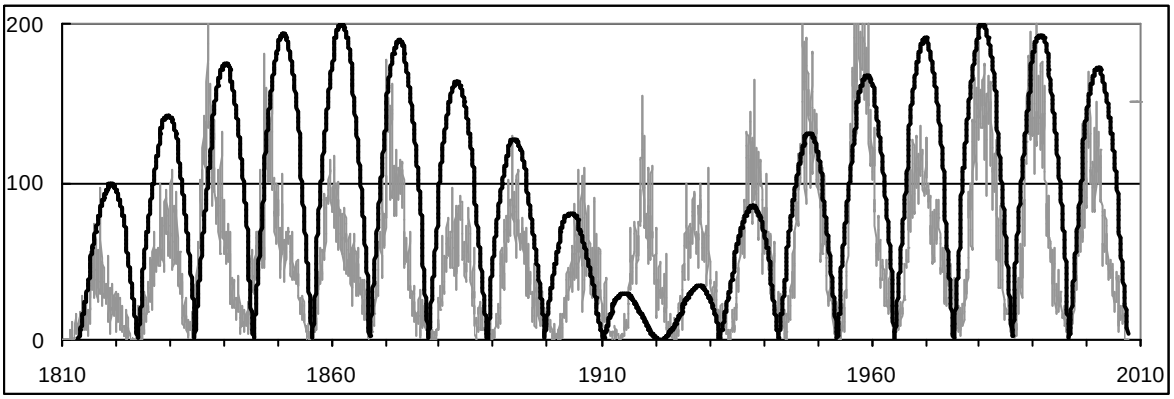
By employing orbital properties of the two major planets with the largest magnetospheres of the Solar system, as in the equation below, a high degree of correlation is achieved with the Sun's polar fields oscillations as demonstrated by its graphic representation

$$\mathbf{Y = A\ [\ Cos(p/3 + 2\ p(t - 1941.5 - 3)/(2 * 11.862)) + Cos\ 2\ p\ (t - 1941.5 - 3)/19.859\ ]}$$





Using 'rectified' version of the above equation with a 3 - 4 year delay (average rise time of a sunspot cycle) then a good approximation of solar cycle activity for last 200 years can be obtained.



Y = 100 abs[Cos(2 p/3 + 2 p (t-1941)/(2 * 11.862)) + Cos 2 p (t-1941)/19.859]

11.862 years – Jupiter sidereal period ;

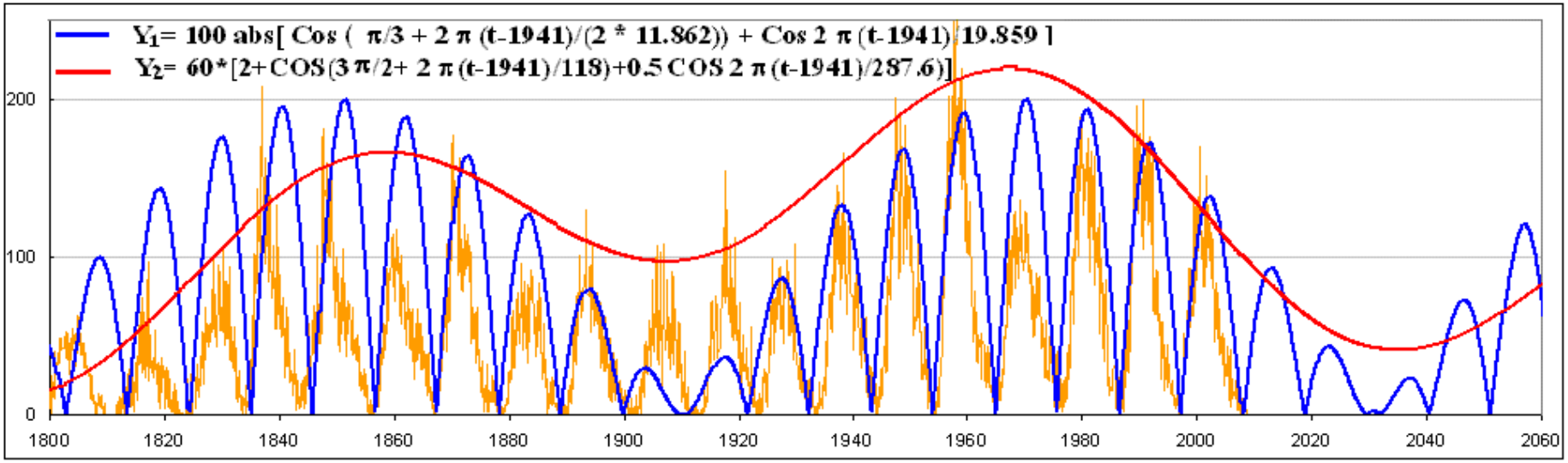
19.859 years – Jupiter-Saturn synodic period ;

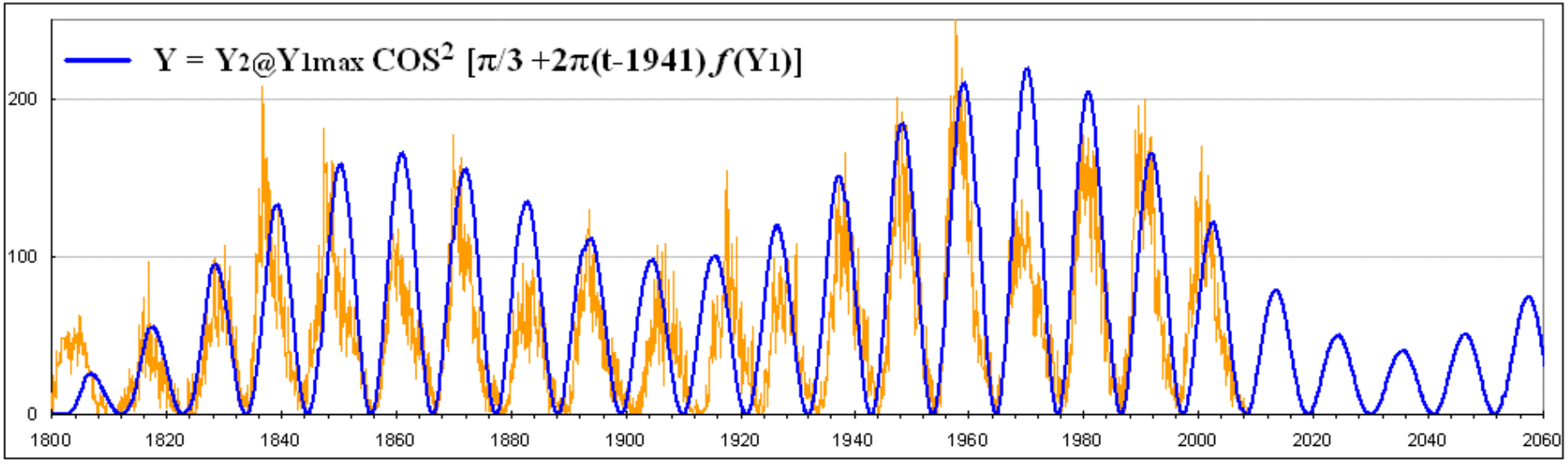
2π/3(120º) – sequential angular shift of Jupiter-Saturn synodic periods ;

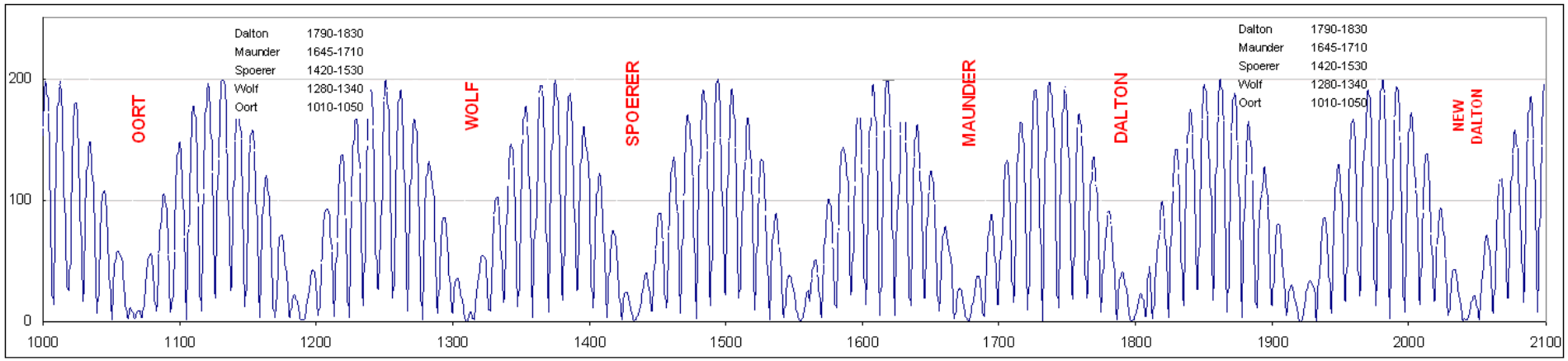
1941 – factor synchronizing horizontal phase.

Possible variability in the curvature of the current sheet spiral, the intensity of the Jupiter's and Saturn's magnetic field strength as well as inclination of their magnetic poles would affect amount of energy taken by their magnetospheres is reflected in variations of the sunspot periodicity and intensity.
Amplitude envelope, past history and some other aspects of the solar activity can be approximated by using above equation with sub-harmonics of the frequencies corresponding to the periods quoted above.

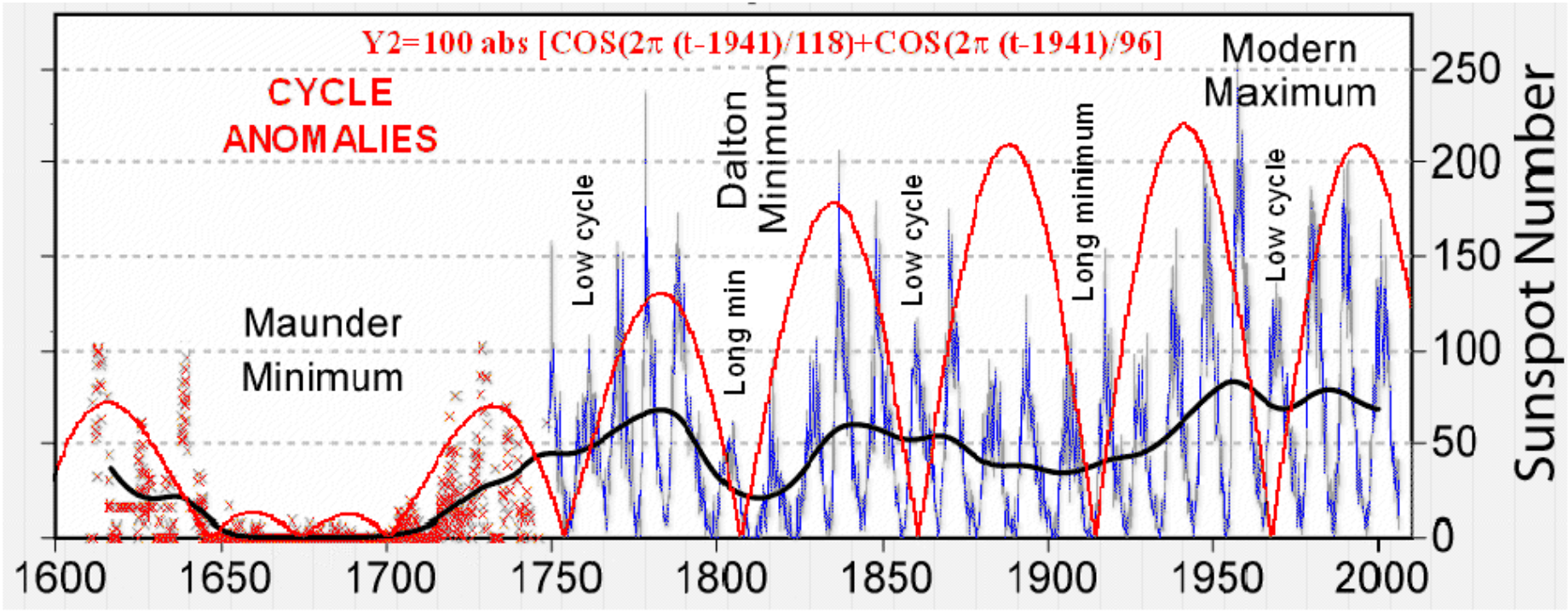
More charts follow on subsequent pages:


Y1= 100 abs[Cos (π/3 + 2 π (t-1941)/(2 * 11.862)) + Cos 2 π (t-1941) 19.859]
Y2= 60*[2+COS(3 π/2+ 2 π (t-1941)/118)+0.5 COS 2 π (t-1941)/287.6)]
200
100
0
1800
1820
1840
1860
1880
1900
1920
1940
1960
1980
2000
2020
2040
2060


Y = Y2@Y1max COS2 [π/3 +2π(t-1941) f(Y1)]
200
100
0
1800
1820
1840
1860
1880
1900
1920
1940
1960
1980
2000
2020
2040
2060



$$Y = 100\ \mathrm{abs}\left[\ \cos(2\pi/4 + 2\pi\,(t-1941)/(2 * 11.862)) + \cos 2\pi\,(t-1941)/19.859\ \right]$$



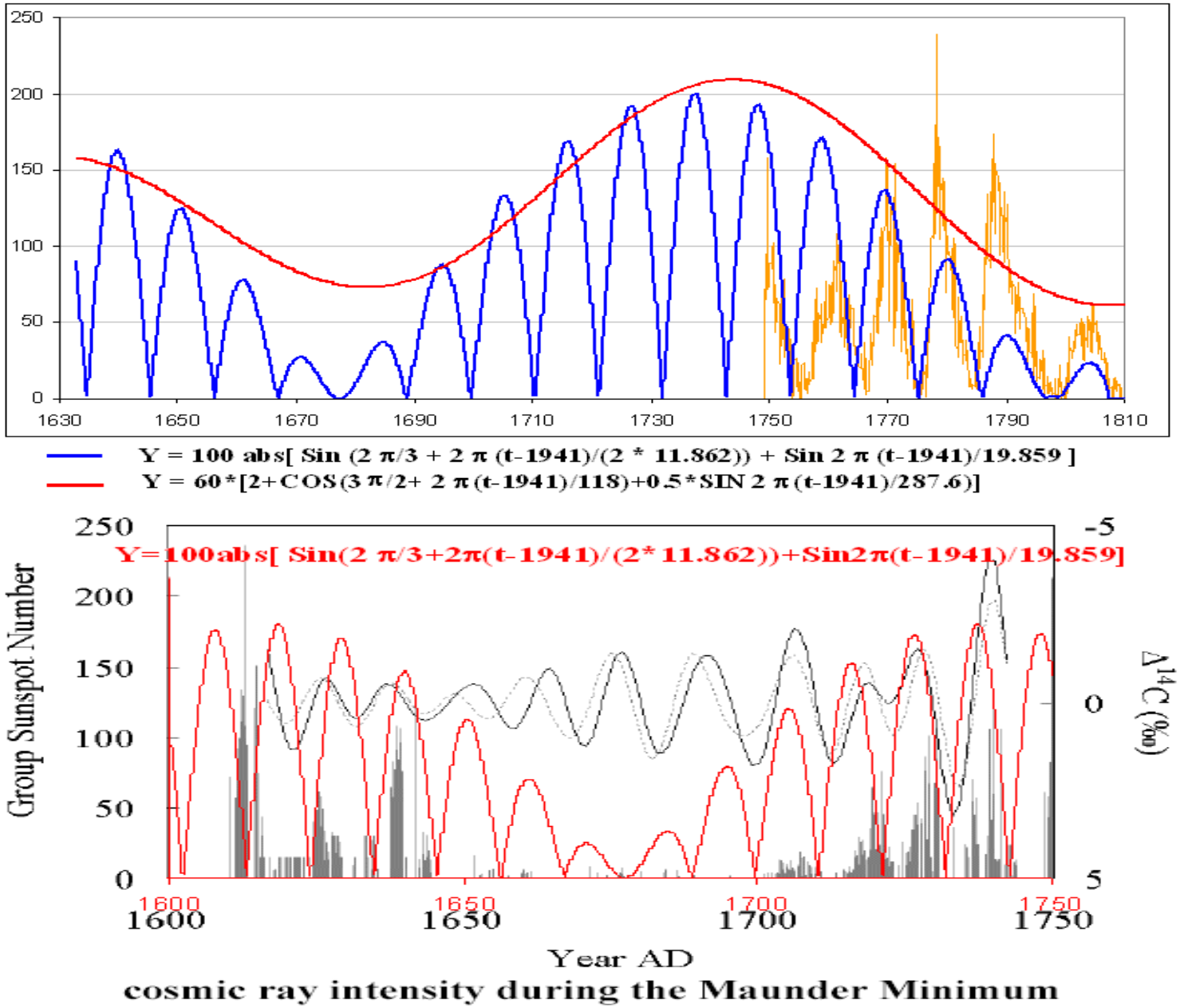
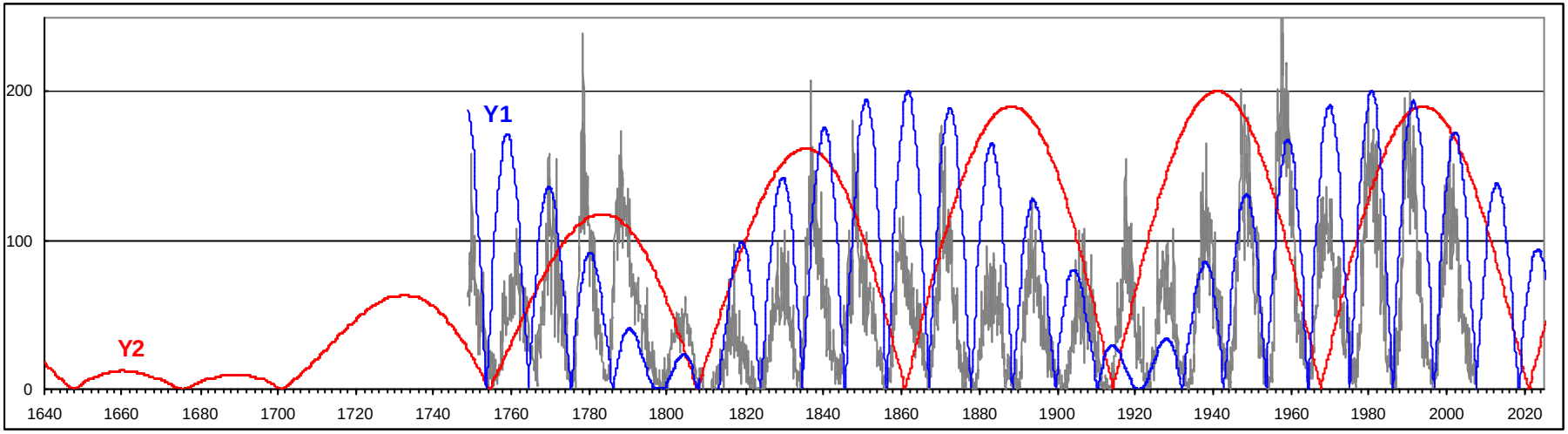


Figure 2. Monthly group sunspot activity and the band-pass filtered carbon-14 records with the bandwidth of 10-18 years. Not that the carbon-14 data are plotted inversely. The time-lag in the carbon cycle has been also taken into account. The solid curve shows the band-pass filtered carbon-14 data obtained by this study (dots in Figure 1), and the dotted curve shows the band-pass filtered carbon-14 data (circles in Figure 1) obtained by Stuiver et al. (1998).



Sunspot cycle periodicity and Maunder minimum functions against historic sunspot record

Y1 Zero or near zero values of the sunspot cycle periodicity curve indicate the Sunspot minima
Y2 Zero or near zero values of the Maunder minimum curve indicate reduced activity (1650 -1700 1810, 1861, 1968) or extended minima (1811, 1913).

General form equation

Y=100abs(Cos(2π (t-To)/T1)+Cos(2π (t-To)/T2))

Particular equations

Y1=100 abs (COS(2π (t-To)/JS)+COS(2 π/3+2p(t-To)/2J))

Y2=100 abs (COS(2π (t-To)/4S)+COS(2π (t-To)/(J+U))

For Y1 pre 1813 use Sin instead Cos function

J –11.862 years – Jupiter sidereal period
JS –19.859 years – Jupiter-Saturn synodic period
S – 29.657 – Saturn sidereal period
2 π/3 (120º) – sequential angular shift of Jupiter-Saturn synodic periods
1941 – phase synchronizing factor (JSU year)
U - 84.02 years - Uranus sidereal period

To reproduce for MS Excel entry use
=100*ABS(COS(2*PI()*(Ax-1941)/19.859)+COS(2*PI()/3+2*PI()*(Ax-1941)/23.724))
=100*ABS(COS(2*PI()*(Ax-1941)/118.628)+COS(2*PI()*(Ax-1941)/ 95.882))

Mathematics is the poetry of logical ideas , it is the silent language of reason .

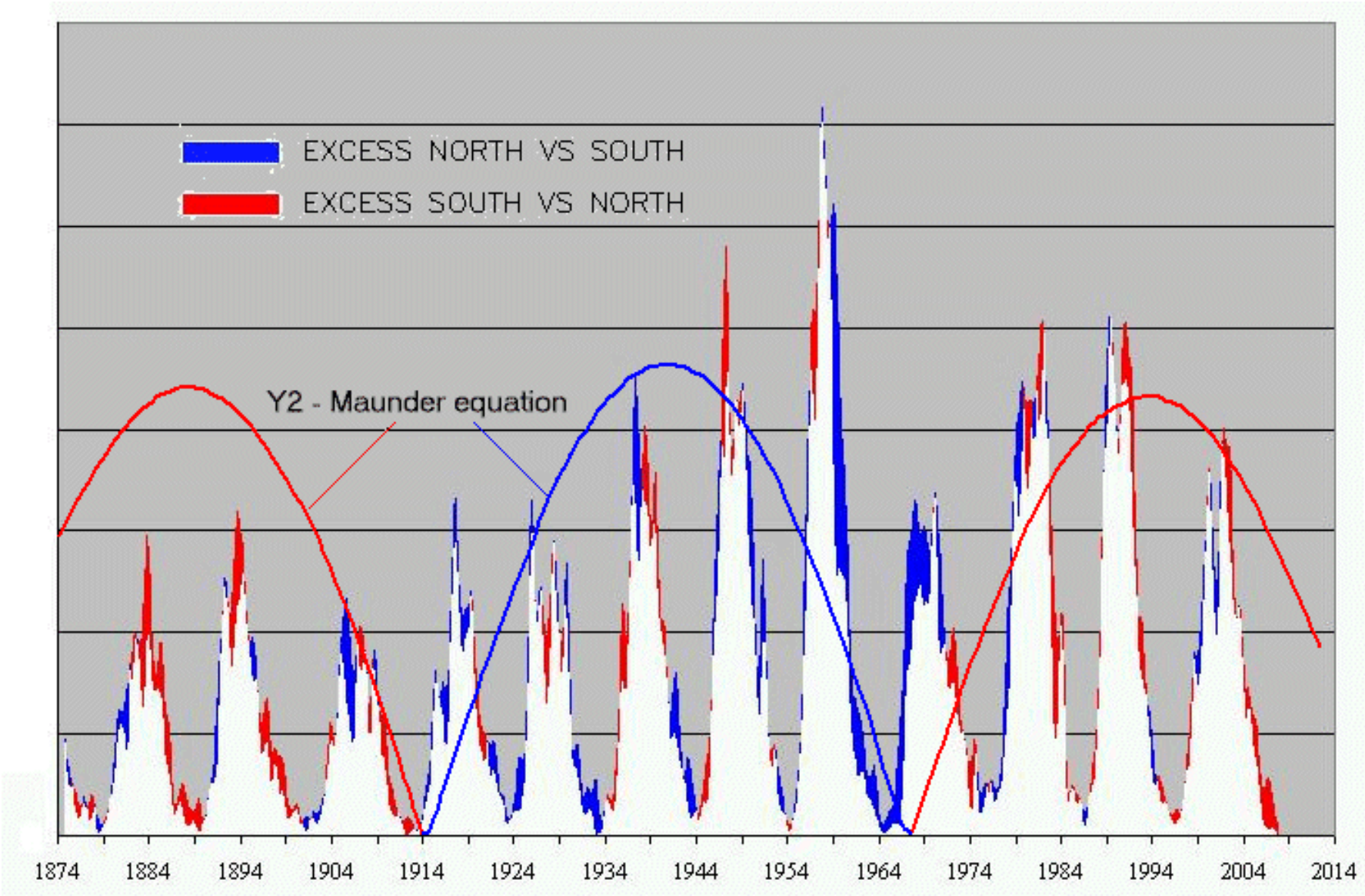
The purpose of the graph is to demonstrate a possible link between solar periodic activity and orbital properties of the major

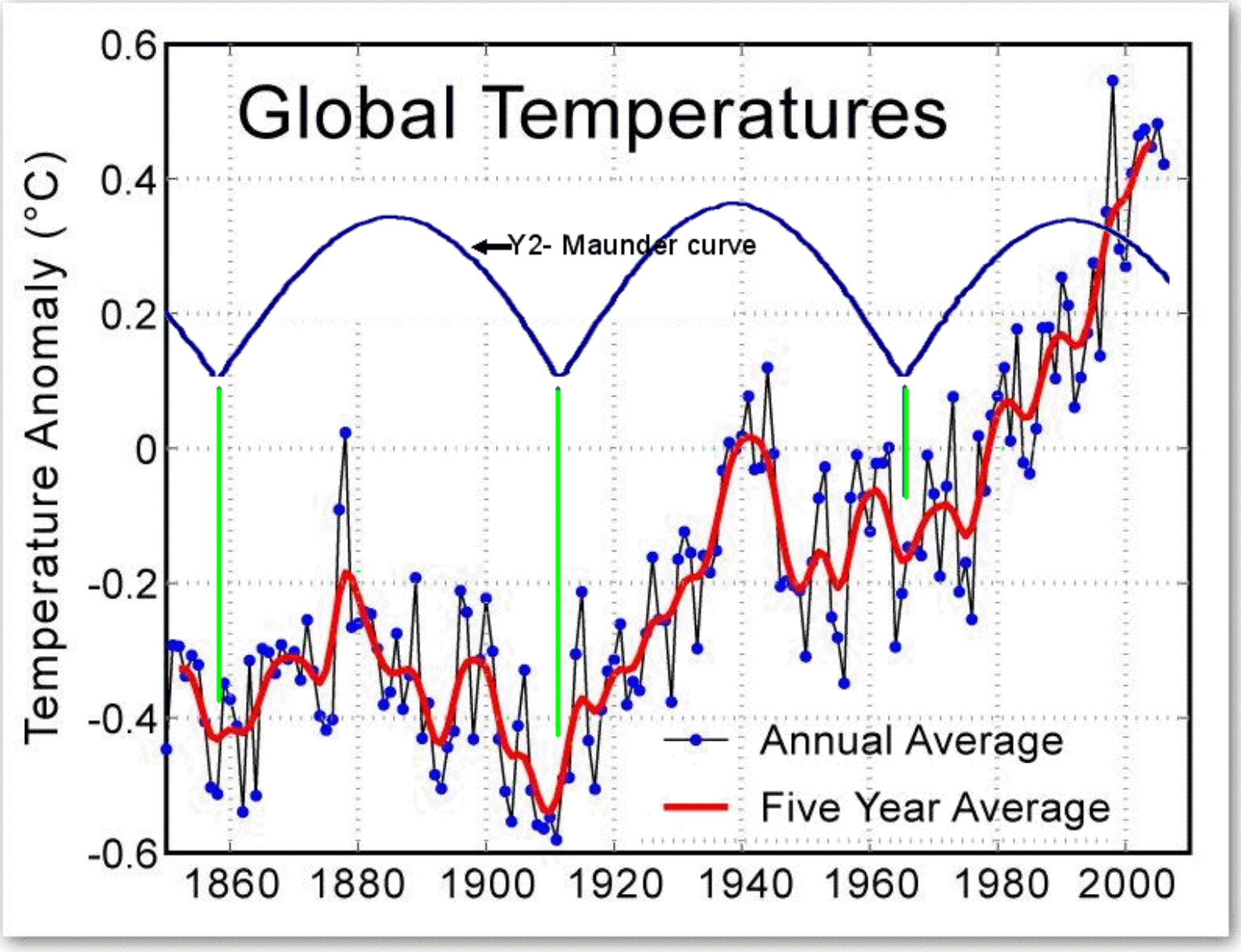
planets i.e. Jupiter and Saturn. This is I believe achieved via a feedback as a result of energy exchange between heliospheric current and planetary magnetospheres. In past numerous attempts were made to explain the effect by simply attributing it to the gravitational forces alone, and a small minority still believes it to be the case.

• If the Sun is an oscillating system (either synchronized or modulated by an outside factor) than its behavior should be possible to express in simple mathematical terms. As in an ordinary electric or mechanical oscillating circuits single general equation (Y) should cover number of resonant frequency ranges (in this case periods)
• Introducing into the general equation Jupiter and Jupiter-Saturn periods gives the first particular equation (Y1). This is blue line in the diagram. Note of warning: here is demonstrated periodicity correlation, and by simply choosing as nominal amplitude 100, the equation just happens, in some cases, to coincide with SC maxima (the correlation with the amplitude is not point of the exercise).
• Number of authors in past have suggested that SC beside 11 year period has a number of other much longer ones. Both, oscillating and modulation processes always contain higher harmonics, sub-harmonics, side-band frequencies etc. If a particular combination of J & S periods is introduced in the general equation and plotted against SS record then result is red line, the second particular equation (Y2) which happens to mimic Maunder minimum. Zeros values of Y2 point to Dalton minimum, as well as pick out number of occasions when a particular solar cycle was reduced in its amplitude in relation to the neighboring once (this is a property also observed with both mechanical and electronic oscillating circuits).
It is important to state that the null or near null points of the equations are the significant ones, in mathematical terms both components of either equation are nearly equal in value but have opposite signs... Note of warning: It is not aim of any of the above to negate in any way whatsoever current understanding how SS are generated or dispute any of SS or SC measured or observed properties. It is to point out that there is a possibility of SS generation being either synchronized or modulated by outside factors as outlined above.

N/S excess

Maunder equation Y2 is shown as a 'rectified' (using abs prefix for calculations), in reality it is a curve oscillating around time (x) axis. To the N/S excess graph (see graph below) is added appropriate fraction of Y2 curve (thin read line), with its proper representation (dotted line coloured in blue and read). It is obvious that this line is in synchronism with the change in N/S excess. The actual changeover takes some 2-3 years later than indicated by Y2 curve. Reason for this, I believe is the difference in time of alignment of J/S magnetospheres, which is governed by the variable curvature of the heliospheric current spiral (distance J-S=5AU), while precise astronomical values are used for calculating Y2 curve. This could be a coincidence, but if it is not than it is of fundamental significance. There are two cycles running in parallel.


EXCESS NORTH VS SOUTH
EXCESS SOUTH VS NORTH
Y2 - Maunder equation
1874
1884
1894
1904
1914
1924
1934
1944
1954
1964
1974
1984
1994
2004
2014



Fraction of Maunder curve (Y2) plotted against Global temperature chart

ACKNOWLEDGMENTS AND REFERENCES