# The Solar Cycle Clock

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## Summary

Modern observations and research have given us to a given us a great deal of knowledge and understanding of the behaviour of the Sun and the underlying processes. And yet there is still no generally accepted explanation of why, even after sometimes significant excursions, the length of the SC has averaged close to eleven years over extended periods of time.

This note continues to argue that the long term timing of the solar cycle, or Schwab cycle (SC), is controlled by the tidal influences of the planets Venus, Earth and Jupiter.

## Introduction

In a previous study (1), it was found that the tidal effects of Venus, Earth and Jupiter produced a cycle with an average period of 11.03 years, which appeared to define the true long term SC. That conclusion was based on the analysis of calculations using the Index proposed by Hung (2009) (2), and while it seemed a valid result, was possibly questionable because it was based on a derived Index giving equal weight to the effect of each planet rather than direct calculations with correct weighting. Also, the conclusions were based primarily on detailed analysis of under two hundred years of data, with only spot checking of some earlier periods.

This study seeks to overcome those limitations using the simple first-principles methods described in the next section, including extending the period covered from 1500 to 2050. The primary objective is to establish if there is a strong enough correlation between the planetary tidal forces and observed solar activity to affirm the basic conclusions of the earlier study, and thus warrant acceptance as a hypothesis for further investigation.

## Methods

The resultant tidal force vector (TFV) from the planets Venus. Earth and Jupiter was calculated from the basic tidal formula, for the period from 1500 to 2050. The mechanism or mechanisms by which the primary TFV may affect the Sun is assumed to be by modulating the velocity of the horizontal flows on the surface of the Sun. However, while that concept is simple, analysis is expected to be very complex. This is referred to in more detail in the discussion below. In this study the resultant TFV is therefore considered to be a proxy for the final integrated effect. Although it is recognised that orbital eccentricities and inclination may also affect how tidal forces affect the Sun, it is assumed here that they are small enough to be initially disregarded. Mercury is not included at this stage. Although the tidal force caused by Mercury is about the same as that of the Earth, the short orbital period, and thus the shorter times for which it's tidal force acts in one direction, is assumed to reduce the effect through the assumed mechanism.

The magnitude of the tidal force vector was plotted on a time scale from 1500 to 2050, in segments of fifty years. Smooth curves drawn through the high points spaced at 3.24422 year intervals appear as five sinusoidal curves, which are arbitrarily numbered 1-5 starting from the first peak after 1900.

Note that the orbital data used is given to at least eight significant digits, and the calculations were run to eight decimal places, but calculated values quoted here are generally rounded down to five or six digit accuracy. Consequently, small differences may occur between rounded values.

Observed SC data from 1700 to the present was obtained from SIDC. SC data for the period from 1500 to 1700 is not available from direct observation, but monthly data reconstructed from auroral observations and other sources was obtained from Letfus (1993) (3), for the 1500 to 1700 period. The monthly sunspot data with even numbered cycles reversed is plotted on the same time scales as the tidal plots.

The plots for the four fifty year periods from 1850 to 2050 are shown in Figures 1a to 1d. These are described and analysed in the following section.

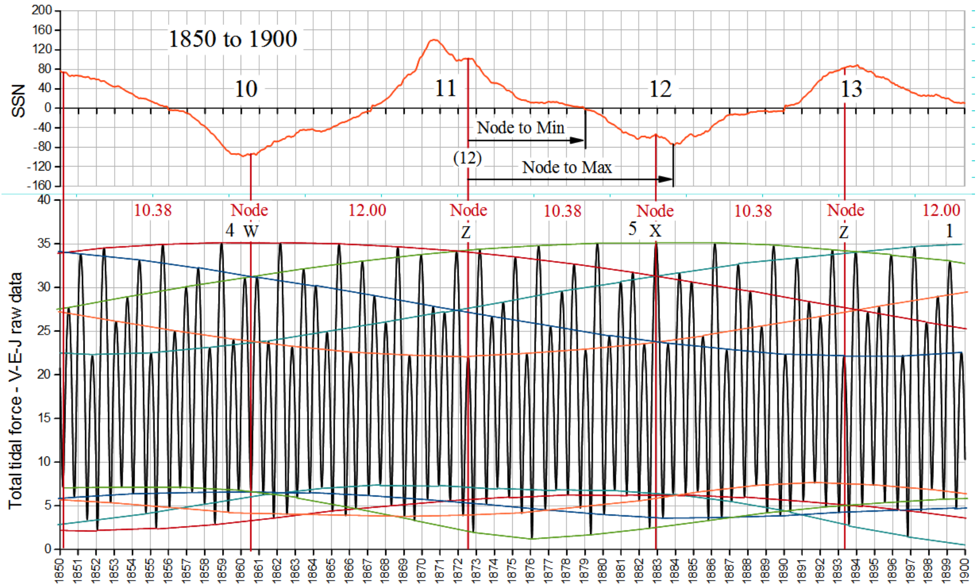

Figure 1a

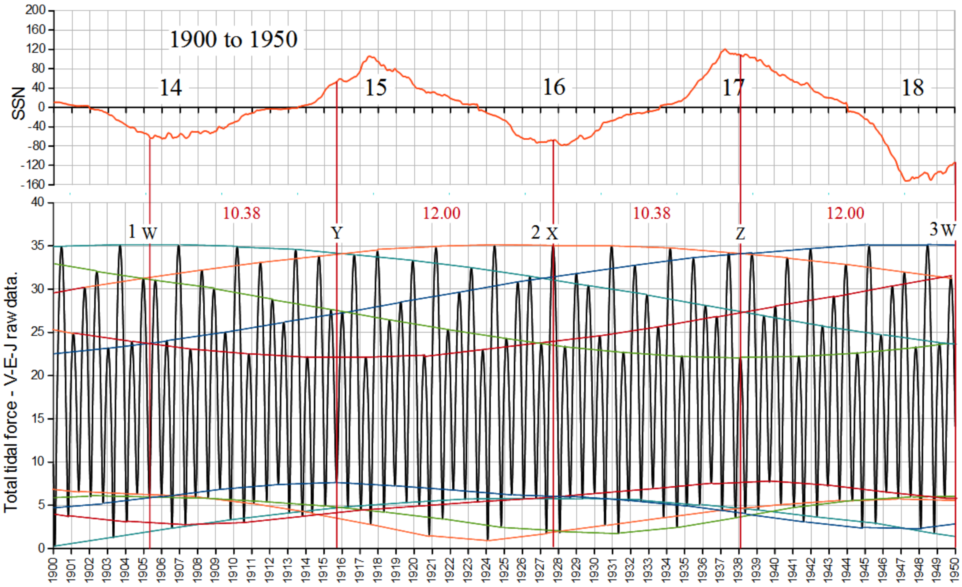

Figure 1b

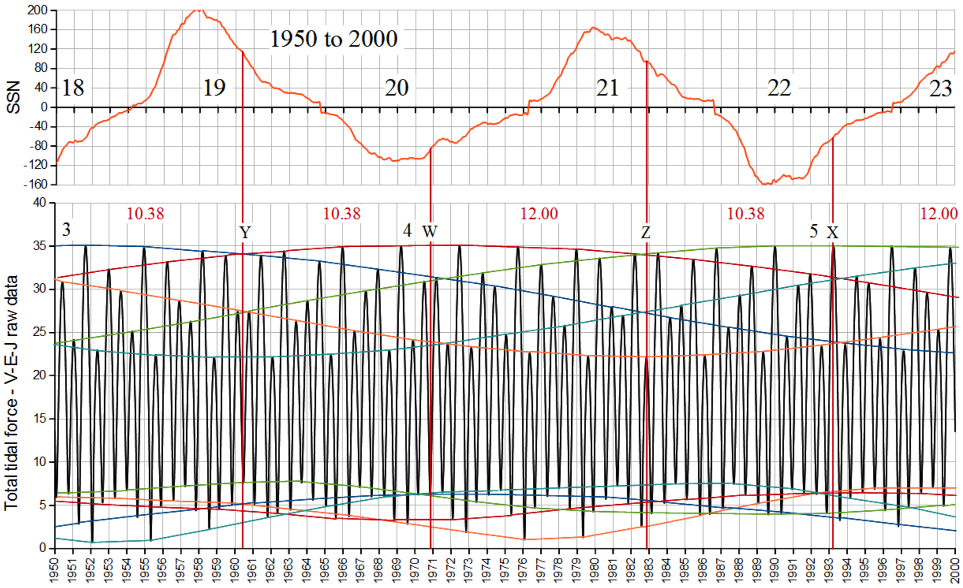

Figure 1c

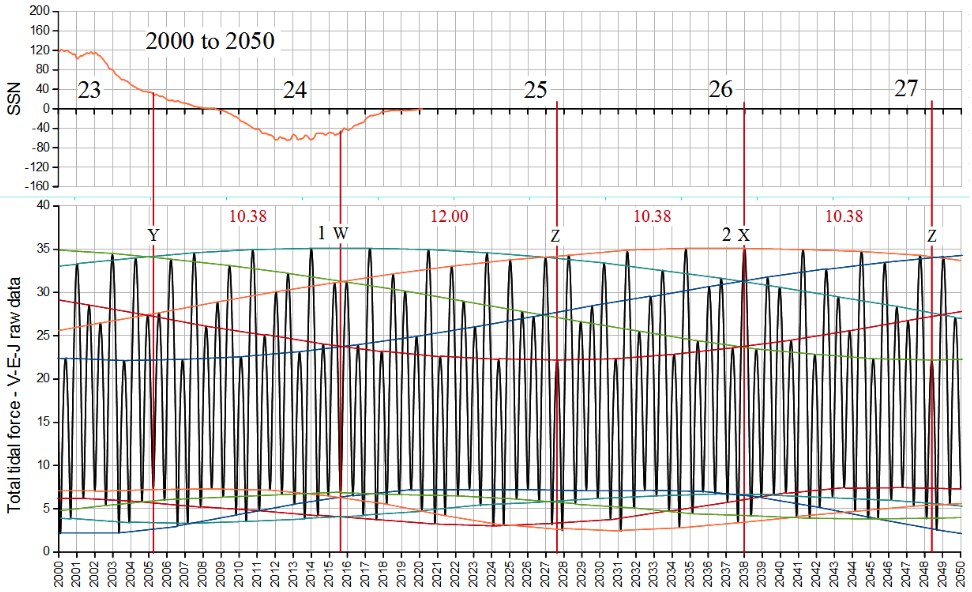

Figure 1d

## Results

There are a number of fundamental characteristics of the TFV illustrated by Figures 1a to 1d, some of which appear to be highly significant:-

1. The shortest cycles in the plot have a period of 0.64885 years, which is the synodic period of Venus and Jupiter.
2. The intermediate peaks forming the five long waves have a constant period of 3.24422 years, exactly five times the V-J synodic period.
3. The five long waves all have a period of 110.304 years, which is exactly 34 x 3.24422
4. The average spacing of the five long waves is 110.304/5 = 22.0608 years.
5. There are ten periods marked out by the peaks of the 110 year waves and the points at which they cross, which are marked by red lines, hereafter referred to as nodes. These appear to vary very slightly in length (which may be an artefact of plotting), but over the full 1500 to 2050 time scale, covering 50 cycles, clearly have an average period of 11.0304 years.
6. Close to each of the 110 yr. period nodes, there are characteristically symmetrical patterns in the 0.6488 periods. Those close to the long wave peaks are designated W and X, and those close to the cross over points Y and Z. The patterns tend to alternate, but sometimes occur in succession. Different sequences in the alignment of the planets occur at around each of these points.
7. The periods between the nodes marked by the red lines are either 10.3815 or 12.0037 years long, designated $q_1$ and $q_2$ respectively.
   We find that $q_1$ = 16 x 0.64885;
   $q_2$ = ~11 x 1.09208 yrs., the J-E synodic,
   and also $q_2$ = (37/2) x 0.64885.
   (Note: ~11 => 10.9916)
8. Between 1500 and 2050, $q_1$ and $q_2$ occur in the ratio of 3:2, and mostly in groups of five such that 3 x $q_1$ + 2 x $q_2$ = 55.152 years, exactly half the long wave period. I have dubbed this grouping of periods a Quintet cycle. The average of the $q_1$ and $q_2$ periods, both in each Quintet group and over the full period, is also 11.0304 years. It is noted that the 3 x $q_1$ and 2 x $q_2$ periods do not occur in any particular sequence within the 55.152 year periods.

Assuming that the planetary tidal forces from V-E-J provide the primary timing for the SC, these calculations directly imply that the long term average length of the SC is 11.0304 years. Similarly the long term average of the Hale cycle becomes 22.0608 years.

The actual average SC length over the full set of observed and reconstructed periods, from cycles -22 to 23, covering 46 cycles from 1501.5 to 2008.9, is indeed 11.03 years. Also, analysis of the distribution of SC lengths over time shows prominent peaks in occurrence at 10.4 and 12.0 years.

This set of characteristic cycles in the tidal forces exerted on the Sun provide an accurate framework against which to assess possible correlations with the observed and reconstructed features of the SC.

We see from Figures 1a to 1d that all solar $R_{max}$ dates are aligned at or close to the nodal points of the 110.3 year waves. More particularly, all odd numbered positive $R_{max}$ dates are closely associated with the nodes at the high points of the waves, and all even numbered negative $R_{max}$ dates are closely associated with the nodes at the intermediate crossover. These associations are consistent back to 1500. They are particularly relevant as the most likely basis for the Gnevyshef-Ohl Rule, which states that the sum of the sunspots occurring within positive numbered cycles is mostly less than the sum in the following odd numbered cycle. Altogether, these observations are highly significant because they imply a correlation over the >500 year period covered of 100%, and so are analysed in more detail.

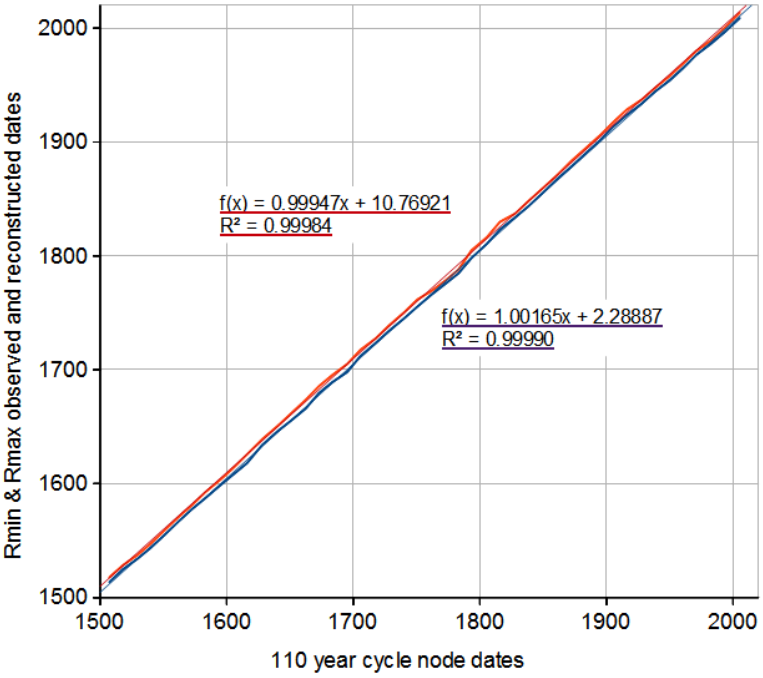

Figure 2.

Figure 2. is a cross plot of the dates defined by the nodal points preceding each solar cycle, set at regular 11.0304 intervals, vs. the observed and reconstructed solar $R_{min}$ and $R_{max}$ dates. The $R^2$ values of 0.9999 and 0.9998 respectively again demonstrate an almost perfect correlation of the observed dates with the regular 11.0304 year period in the resultant tidal forces from Venus, Earth and Jupiter. This is quite definitely not a matter of chance. With such close correlations, it is logical to assume we can now use the nodal dates from the full 1500 to 2050 plots as reference points for further analysis of the relationships between solar events within each cycle.

Figures 3.,& 5. show a number of these relationships.

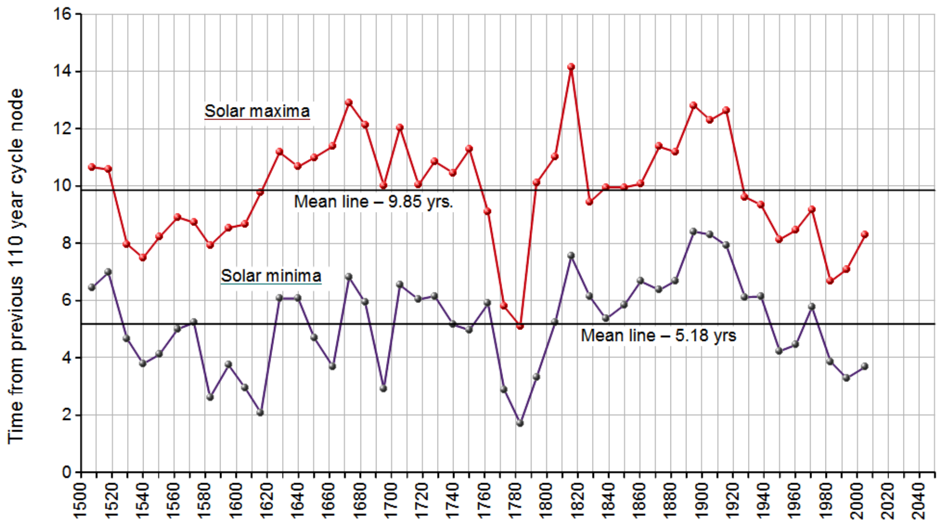

Figure 3. Times at which solar minima and maxima occur after the previous node date of the 110 year cycle.

The time of the tidal node before the SC under consideration has been used for the analysis in Figures 3. & 5.. This is consistent with a number of studies that show that solar activity in cycle n appears to be associated with events around the maximum of cycle n-1.

In Figure 3., the times of $R_{min}$ and $R_{max}$ are seen to fluctuate about a mean line by +3.12/-3.48 and +4.29/-4.74 respectively, with no visually detectable trend. (There may be small trends, but in such a short and irregular series, with higher start and lower end values, it is unlikely they would be reliable indicators.) They appear to vary at random in relation to the nodes, but the absence of any significant trend can be taken as further confirmation of the high correlation between observed or reconstructed dates in relation to the timing reference dates shown in Figure 2. Another test of the validity of the correlation would be to assume that instead of using the tidal node timing dates, which average 11.03 years over the long term, we were to use node dates based on a regular 11.10 year period, which is around the most commonly accepted SC length. That would create a difference over the study period of 47 cycles of:(11.10 - 11.03) x 47 = 3.29 years, enough to introduce a significant trend, which seems inconsistent with observations.

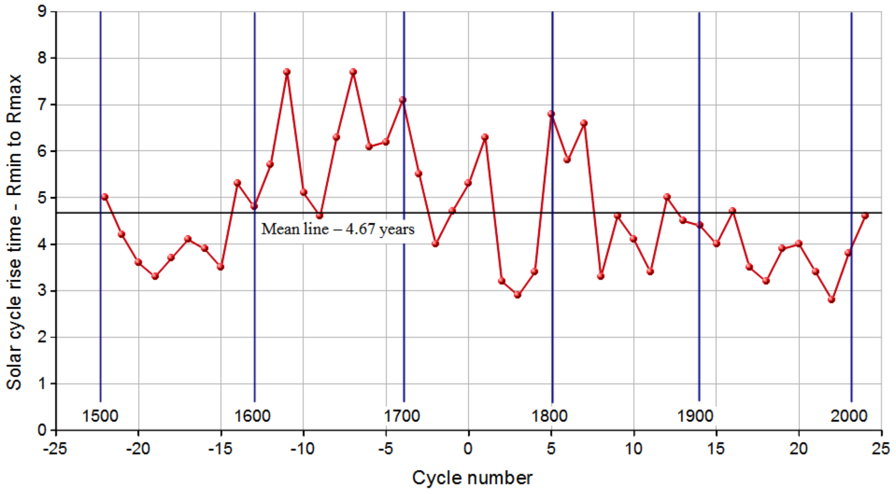

Figure 4. Individual solar cycle rise times.

From 1700 until the present, the plot in Figure 4 is essentially the same as the many published plots of rise times. Inclusion of the reconstructed values from 1500 to1700 provides us with the opportunity to observe that the behaviour of the Sun in the twentieth century was very much like that in the sixteenth. Also, we can see the longer and slower rise times associated with the low solar activity in the seventeenth and early nineteenth centuries, during the Maunder and Dalton minimum periods respectively. Overall, this pattern again appears to be rather random. There do not appear to be regular continuing cyclic variations on any time scale.

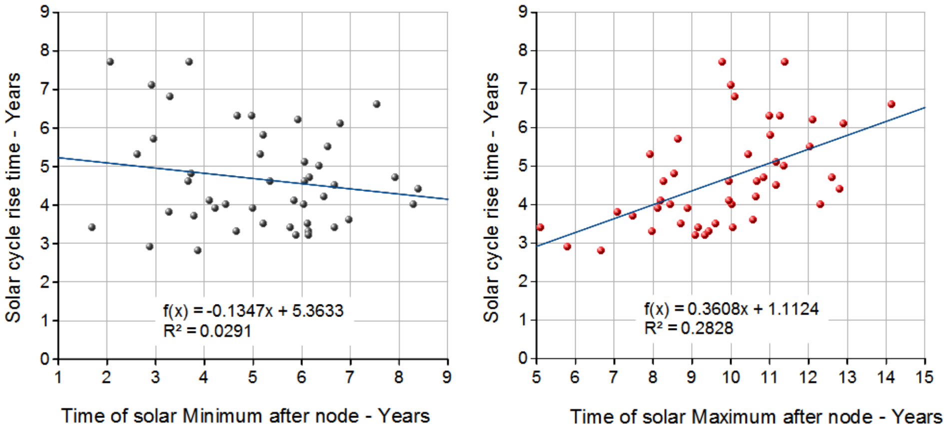

Figure 5. Cross plots of solar cycle rise times vs. the times of $R_{min}$ and $R_{max}$ after the previous 110 year cycle node.

The individual solar cycle rise times shown in Figure 4. appear to roughly track the times of $R_{min}$ and $R_{max}$ in relation to the previous node, however Figure 5. reveals that there is no significant correlation between solar rise times and the time at which $R_{min}$ occurs after the tidal node. An $R^2$ value of only 0.029 implies that the different rise times actually occur at random in relation to the 11.03 year periods. Hence the very irregular plot in Figure 4., which looks somewhat like a random walk. Thus solar rise times are not a direct function of the time by which the SC may occur earlier or later in relation to the timing reference dates, so we must conclude that rise times and the length of the solar cycle cannot be predicted simply by the timing of $R_{min}$. On the other hand, with an $R^2$ value of 0.283, the rise time does appear to correlate a little with the time of $R_{max}$ after the previous tidal node, implying some degree of influence from the tidal action of the planets on the rate of rise and hence the timing of $R_{max}$. That would also be consistent with the conclusions from various studies that the magnitude of $R_{max}$ .in a cycle is a function of events shortly after $R_{max}$ in the preceding cycle.

## Discussion and conclusions

We must observe two important caveats when discussing how planetary tides may affect solar activity. The first caveat is that planetary tidal tides are too weak in relation to the gravitational force at the surface to cause more than a few mm. vertical displacement of the surface. This acknowledged fact is the reason why suggestions that the planets could affect solar activity were flatly dismissed for so long. That thinking completely ignored the possible effects of horizontal components. The second caveat is that planetary tides do not directly affect the phenomena described by theories on the solar dynamo. The solar dynamo is clearly the primary driver of events in the Sun. However, evidence suggest that tidal effects can influence both the timing and magnitude of solar activity.

In the introduction, reference was made to the assumption that the mechanism by which the primary TFV can affect solar activity is a modulation of the velocity of the horizontal flows on the surface. There is an observed meridional flow on the surface from the equator towards the poles. Variations in the velocity of the meridional surface flow are observed to occur within SC's and over the longer term. Velocities occurring in one SC are seen to correlate well with the number of sunspots in the following SC. Further, the horizontal components of the TFV are large enough to significantly affect the velocity of the meridional flow during the time of a SC. The solar dynamo and the sequence of events within a SC have been studied extensively and in great detail by many over the past few decades, and rather than try to make a brief summary here, I refer to work done by Katya Georgieva et.al.(4) (5), in particular: Solar dynamo and geomagnetic activity (2010) (4). These contain very clear explanations of the events in the SC giving rise to the meridional surface flow and the events leading to the variations in sunspot numbers, with extensive supporting references.

The results derived here show that the occurrence of events in the Sun are closely synchronised with periodic variations in the tidal forces exerted on the Sun by the planets Venus, Earth and Jupiter. This synchronisation will have taken millions of years to evolve and become firmly established in the present configuration, but appears to have been stable during the current era.

What can be regarded as the clock timing of the SC is seen to be maintained by the synodic periods of Jupiter-Venus and Jupiter-Earth, as detailed in Items 7. and 8. in the results section above. The 10.3815 an 12.0037 periods in the planetary tidal forces appear to be fundamental in controlling the length of the Schwab and Hale cycles over periods of centuries. Figure 3. shows that the dates of $R_{min}$ and $R_{max}$ are, on at least century time scales, constrained in relation to the nodal dates defined by the tidal forces of V-E-J. The apparently random cycle-to-cycle variations in relation to the nodes can largely be attributed to accountable variations in the meridional velocity at the surface, and the prevailing level of diffusivity. It has also been shown that the alternating high and low nodes are the most likely driver of the differential between positive and negative numbered SCs described by the Gnevyshef-Ohl Rule.

However, while this study establishes the underlying forces causing the SC to be synchronised with the the motion of the planets, it does not provide us with any obvious means of determining the actual times of $R_{min}$ or $R_{max}$.

Mercury plays a definite role in the planetary tidal effects on the Sun, but after a brief look at plots with Mercury included, it was decided to focus first on the effects of Venus, Earth and Jupiter, for direct comparison with the earlier work (1). The results of this current work will make it easier to understand and appreciate the particular and significant role played by Mercury when it is included.

## References:-

(1) Martin, R., 2009. Relations Between Solar Activity and Solar Tides caused by the Planets Defined, http://www.climatestop.com/SolarTidalInfluencesofVEJ_W01.pdf

(2) Hung, Ching-Cheh, 2007. Apparent Relations Between Solar Activity and Solar Tides Caused by the Planets, NASA/TM-2007-14817.

(3) Letfus, V., Solar Activity in the Sixteenth and Seventeenth Centuries, *Solar Physics* **145**: 377-388, 1993.

(4) Georgieva, Katya, Kirov, Boian, 2010, Solar dynamo and geomagnetic activity, arxiv:1003.2533 (pdf)

(5) Georgieva, K., et al, Planetary tidal effects on solar activity, http://www.climatestop.com/KGeorgieva_Pulkovo2009.pdf