Evidence of a Significant Solar Imprint in Annual Globally Averaged Temperature Trends - Part 2

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Part II

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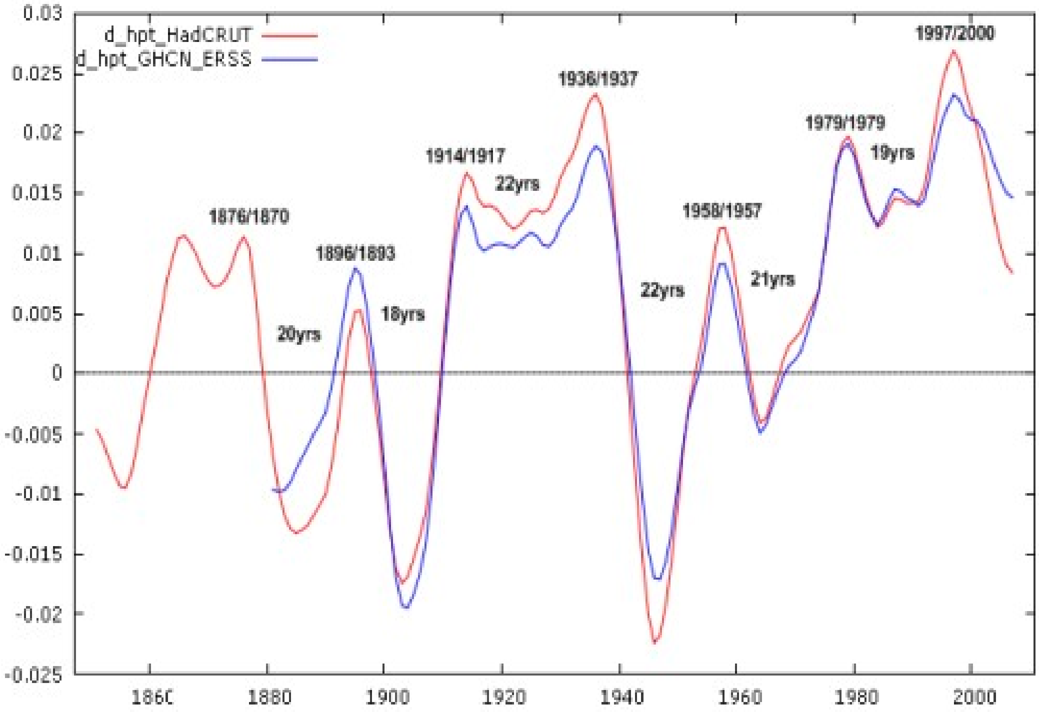
In Part I, we presented evidence of a noticable periodicity in globally averaged temperatures when filtered with Hodrick-Prescott smoothing. Using a default value of lamda of 100, we saw a bidecadal pattern in the rate of change in the smoothed temperature series that appears closely related to 22 year Hale solar cycles. There was also evidence of a longer climate cycle of ~66 years, or three Hale solar cycles, corresponding to slightly higher peaks of cycles 11 to 17 and 17 to 23 shown in Figure 4B. But how much of this is attributable to value of lambda (λ). Here is where lambda (λ) is used in the Hodrick-Prescott filter equation:

$$\min \sum_{t=1}^{T} (y_t - \tau_t)^2 + \lambda \sum_{t=2}^{T-1} \left[(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})\right]^2.$$

The first term of the equation is the sum of the squared deviations $d_t = y_t - \tau_t$ which penalizes the cyclical component. The second term is a multiple λ of the sum of the squares of the trend component's second differences. This second term penalizes variations in the growth rate of the trend component. The larger the value of λ, the higher is the penalty.

For the layman reader, this equation is much like a tunable bandpass filter used in radio communications, where lambda (λ) is the tuning knob used to determine the what band of frequencies are passed and which are excluded. The low frequency component of the HadCRUT surface data (the multidecadal trend) looks almost like a DC signal with a complex AC wave superimposed on it. Tuning the waves with a period we wish to see is the basis for use of this filter in this excercise.

Given an appropriately chosen, positive value of λ, the low frequency trend component will minimize. This can be seen in Figure 2 presented in part I, where the value of lambda was set to 100.



Annual HadCRUTv3 and GHCN-ERSSTv2 globally averaged temperature trends are smoothed with Hodrick-Prescott filtering (lambda=100). Plotted are the first differences of the smoothed series, representing annual rates of change in temperature in the smoothed series. Peaks occur roughly in sync with the 22 year Hale solar cycle for reversal in the Sun's magnetic field. The first number above each peak is the year of the peak in the rate of change in temperature from the smoothed series; the second number is the solar cycle peak. Unusual warming in the 1920's and 1930's, and again in the

[redacted]

Figure 2 - click for a larger image

A lower value of lambda would result in much less smoothing. To test the sensitivity of the findings reported in Part I, we refiltered with a lambda of 7. The results are shown in Figures 3 and 4.

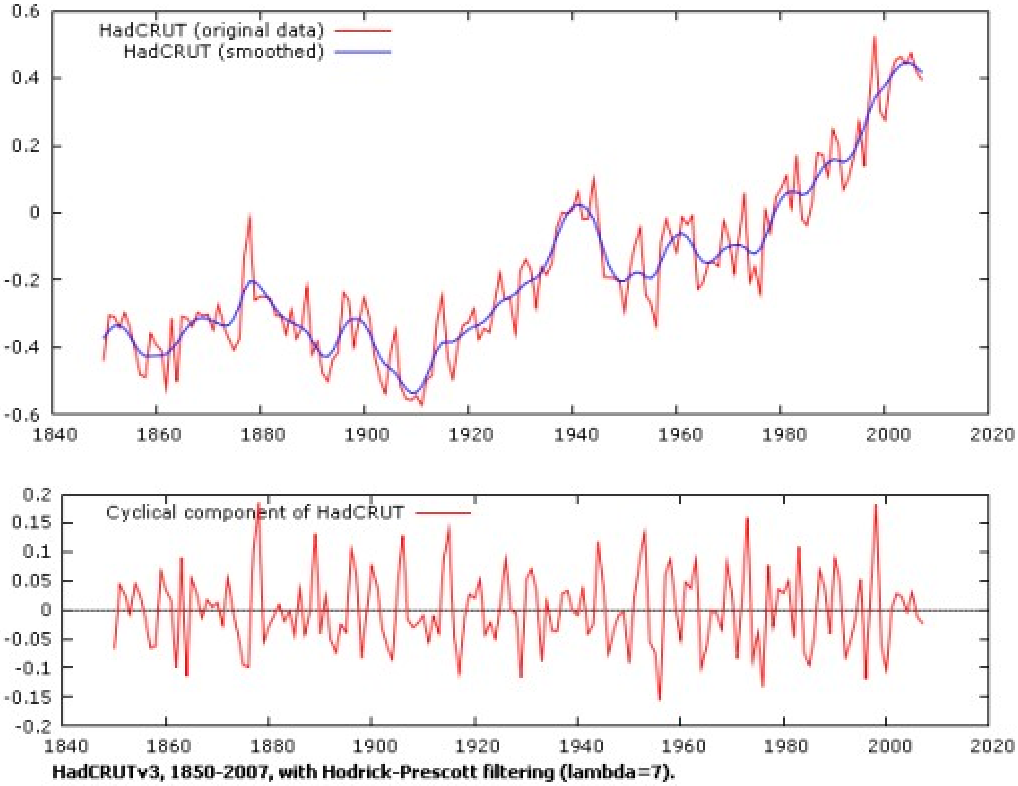
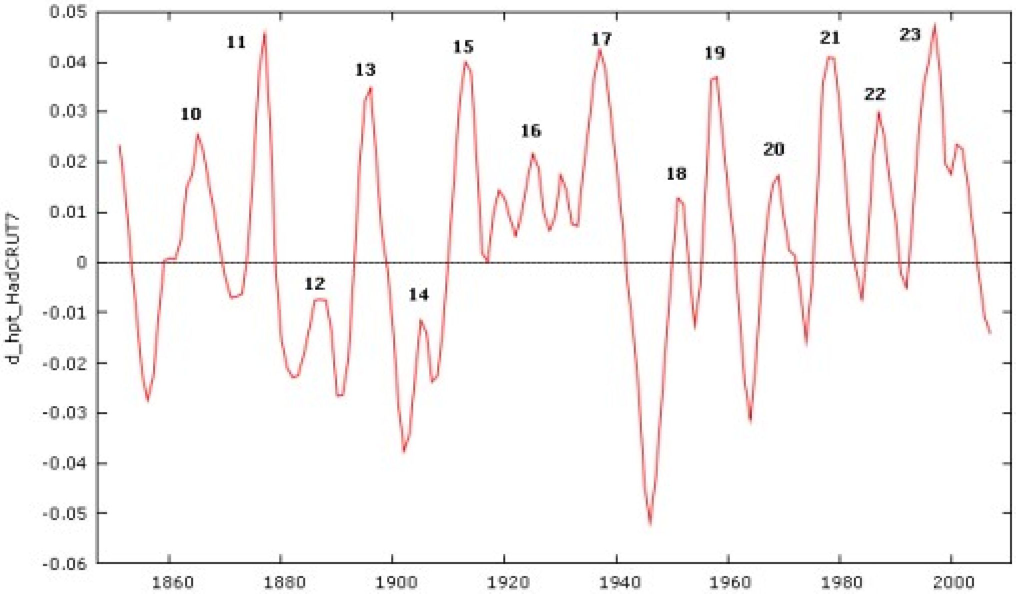


Figure 3 - click for a larger image

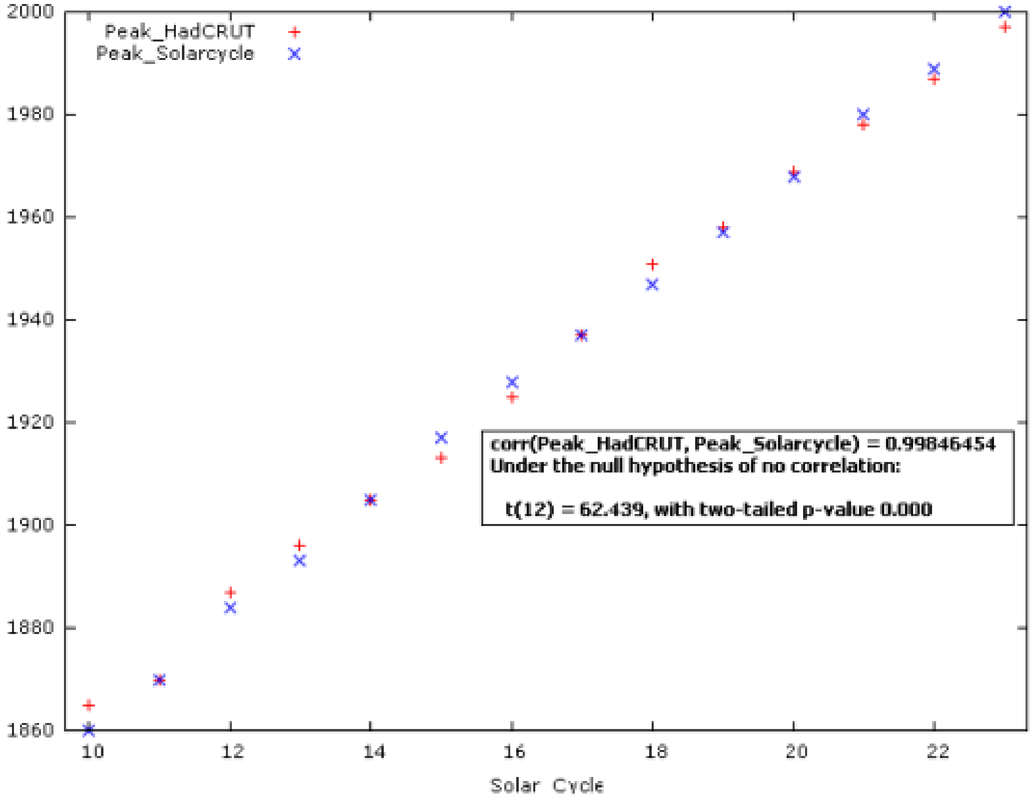
As expected, the smoothed trend line, represented by the blue line in the upper panel of Figure 3, is no longer as smooth as the trend in the upper panel of Figure 1 from Part I. And when we look at the first differences of the less smoothed trend line, shown in Figure 4, they too are no longer as smooth as in Figure 2 from Part I. Nevertheless, in Figure 4, the correlation to the 22 year Hale cycle peaks is still there, and we can now see the 11 year Schwabe cycle as well.



First differences in smoothed HadCRUTv3, Hodrick-Prescott filtering with lambda=7. Peaks in the annual rate of change correspond roughly to solar cycle peaks as indicated by the accompanying solar cycle number.

Figure 4 - click for a larger image

The strong degree of correspondence between the solar cycle peaks and the peak rate of change in the smoothed temperature trend from HadCRUT surface temperature data is seen in Figure 5.



Plot of correspondence between years of peak rate of change in smoothed HadCRUT series, lambda=7, to years of peak in the solar cycle. Blue "x" indicates the year in which the solar cycle peaks, and red "+" indicates the year in which the rate of change in the smoothed HadCRUT series peaks.

Figure 5 - click for a larger image

The pattern in Figure 4, while not as eye-catching, perhaps, as the pattern in Figure 2 is still quite revealing. There is a notable tendency for amplitude of the peak rate of change to alternate between even and odd numbered solar cycles, being higher with the odd numbered solar cycles, and lower in even numbered cycles. This is consistent with a known feature of the Hale cycle in which the 22 year cycle is composed of alternating 11 year phases, referred to as parallel and antiparallel phases, with transitions occurring near solar peaks.

Even cycles lead to an open heliosphere where GCR reaches the earth more easily. Mavromichalaki, et. al. (1997), and Orgutsov, et al. (2003) contend that during solar cycles with positive polarity, the GCR flux is *doubled*. This strongly implicates Galactic Cosmic Ray (GCR) flux in modulating global temperature trends. The lower peak amplitudes for even solar cycles and the higher peak amplitudes for odd solar cycles shown in Figure 4 appears to directly confirm the kind of influence on terrestrial climate postulated by Svensmark in Influence of Cosmic Rays on Earth's Climate (199😎 From the pattern indicated in Figure 4, the implication is that the "warming" of the late 20th century was not so much warming as it was less cooling than in each preceding solar cycle, perhaps relating to the rise in geomagnetic activity.

It is thus notable that at the end of the chart, the rate of change after the peak associated with solar cycle 23 is already in the negative range, and is below the troughs of the preceding two solar cycles. Again, it is purely speculative at this point, but the implication is that the underlying rate of change in globally averaged temperature trends is moderating, and that the core rate of change has turned negative.It is important to understand that the smoothed series, and the implied rates of change from the first differences, in figures 2 and 4, even if they could be projected, are not indications of what the global temperature trend will be.

There is a cyclical component to the change in global temperature that will impose itself over the underlying trend. The cyclical component is probably dominated by terrestrial dynamics, while the smoothed series seems to be evidence of a solar connection. So it is possible for the underlying trend to be declining, or even negative, while actual global temperature increases because of positive cyclical factors. But by design, there is no trend in the cyclical component, so that over time, if the trends indicated in Figures 2 and 4 hold, global warming will moderate, and we may be entering a phase of global cooling.

Some are probably wondering which view of the historical correspondence between globally averaged temperatures and solar cycles is the “correct” one: Figure 2 or 4?

Such a question misconstrues the role of lambda in filtering the data. Here lambda is somewhat like the magnification factor “X” in a telescope or microscope. A low lambda (less smoothing) allows us to “focus in” on the data, and see something we might miss with a high lambda (more smoothing). A high lambda, precisely because it filters out more, is like a macroscopic view which by filtering out lower level patterns in the data, reveals larger, longer lived processes more clearly. Both approaches yield valuable insights. In Figure 2, we don’t see the influence of the Schwabe cycle, just the Hale cycle. In Figure 4, were it not for what we see in Figure 2, we’d probably miss some similarities between solar cycles 15, 16, and 17 and solar cycles 21, 22, and 23.In either case, we are seeing strong evidence of a solar imprint in the globally averaged temperature trend, when filtered to remove short term periodicities, and then differenced to reveal secular trends in the rate of change in the underlying long term tend in globally averaged temperatures.

At one level we see clear evidence of bidecadal oscillations associated with the Hale cycle, and which appear to corroborate the role of GCR’s in modulating terrestrial climate. At the other, in figure 4B, we see a longer periodicity on the order of 60 to 70 years, correspondingly closely to three bidecadal oscillations. If this longer pattern holds, we have just come out of the peak of the longer cycle, and can expect globally average temperature trends to moderate, and increased likelihood of a cooling phase similar that experienced during the mid 20th century.

In Lockwood and Fröhlich 2007 they state: *“Our results show that the observed rapid rise in global mean temperatures seen after 1985 cannot be ascribed to solar variability, whichever of the mechanisms is invoked and no matter how much the solar variation is amplified.”* . Yet, as Figure 5 demonstrates, there is a strong correlation between the solar cycle peaks and the peak rate of change in the smoothed surface temperature trend.

The periodicity revealed in the data, along with the strong correlation of solar cycles to HadCRUT surface data, suggests that the rapid increase in globally averaged temperatures in the second half of 20th century was not unusual, but part of a ~66 year climate cycle that has a long history of influencing terrestrial climate. While the longer cycle itself may be strongly influenced by long term oceanic oscillations, it is ultimately related to bidecadal oscillations that have an origin in impact of solar activity on terrestrial climate.

UPDATE: We have had about half a dozen people replicate from HadCRUT data the signal shown in figure 4 using FFT and traditional filters, and we thank everyone for doing that. We are currently working on a new approach to the correlations shown in figure 5, which can yield different results using alternate statistical methods. A central issue is how to correctly identify the peak of the solar cycle, and we are looking at that more closely. As it stands now, while the Hodrick-Prescott filtering works well and those results in figures 2,3, and 4 have been replicated by others, but the correlation shown in figure 5 is in question when a Rayleigh method is applied, and thus figure 5 is likely incorrect since it does not hold up under that and other statistical tests. There is also an error in the data point for cycle 11. I thank Tamino for pointing these issues out to us.

We are continuing to look at different methods of demonstrating a correlation. Please watch for future posts on the subject.

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