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Sunspots and Global Warming

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November 2003

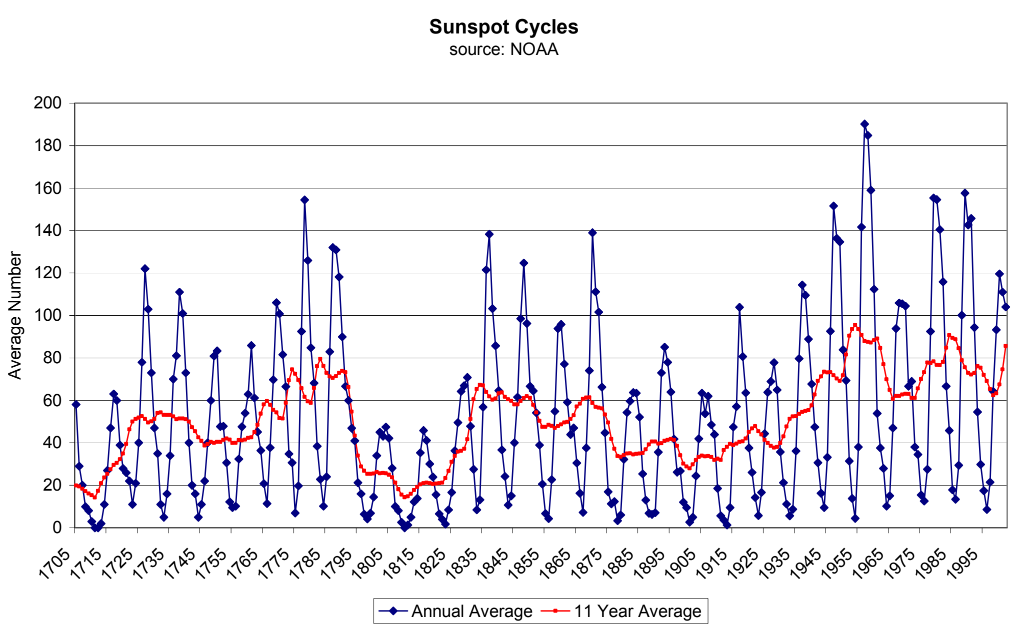
There is a statistically significant correlation between the amplitude of the sunspot cycle and the temperature of the atmosphere. This relationship is nowhere near enough to explain the warming that has been observed over the past century, but it does explain some important features of the temperature record. This has implications for the future of global warming.

Sunspots and the Sunspot Cycle

Sunspots are dark spots on the surface of the sun and their number changes over a cycle of nearly 11 years. They occur when a concentrated portion of the solar magnetic field pokes through the surface. This field slows energy from entering the sunspot region causing them to appear darker than the surrounding regions, although they are still quite bright. Mass ejections and solar flares are large explosions on the sun's surface which occur near sunspots. These increase the incidence of auroras and disrupt power grids and radio transmissions.

The sunspot record extends back to the early 1700's (Chart 1). While the 11 year cycle is evident, so too is the fact that cycles vary in amplitude. There were very few sunspots during the early 1800's, there was a dip in the late 1800's, followed by a strong rise from the 1940's. The cycle with the biggest recorded amplitude peaked in 1957.

Chart 1



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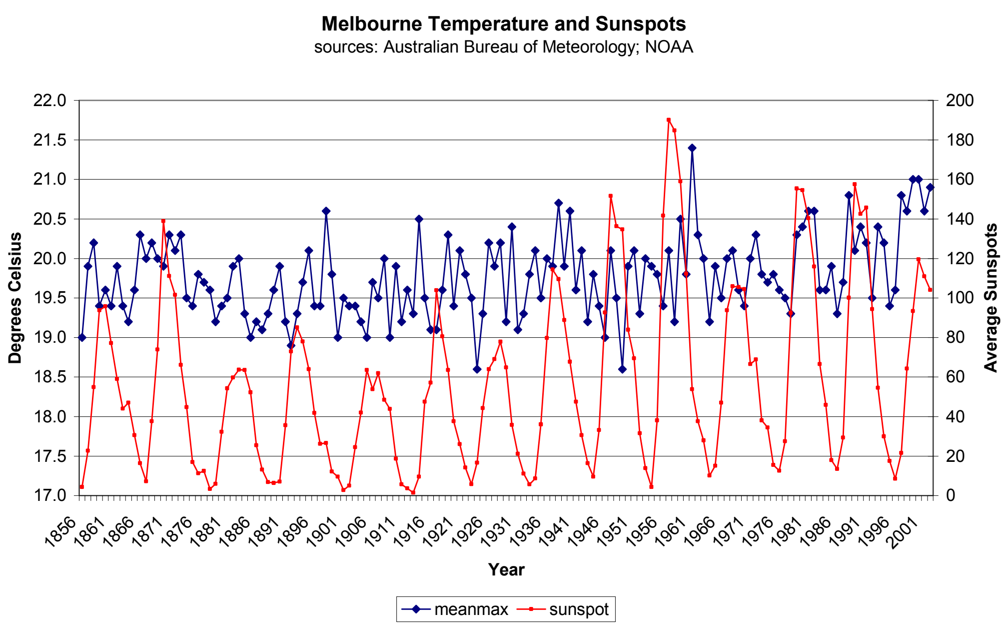
Sunspots and Temperature

Correlation analysis of temperature and the number of sunspots shows a statistically significant relationship. Temperature data for Melbourne, Australia, extends back to 1856 and that data, together with the sunspot data is shown in Chart 2. Visually, there appears to be a relationship. There were lower temperatures in the late 1800's, when the number of sunspots was low and there were high temperatures at the peaks of the last three cycles.

Regression analysis shows that there is a statistically significant relationship. The temperature rises by an average of 0.37 degrees Celsius for every 100 sunspots (the t-value is 4.1 and the probability that this result could occur by chance is less than 0.0001). The sunspot data explains 10.3% of the variance in the temperature data, so other factors are very influential too.

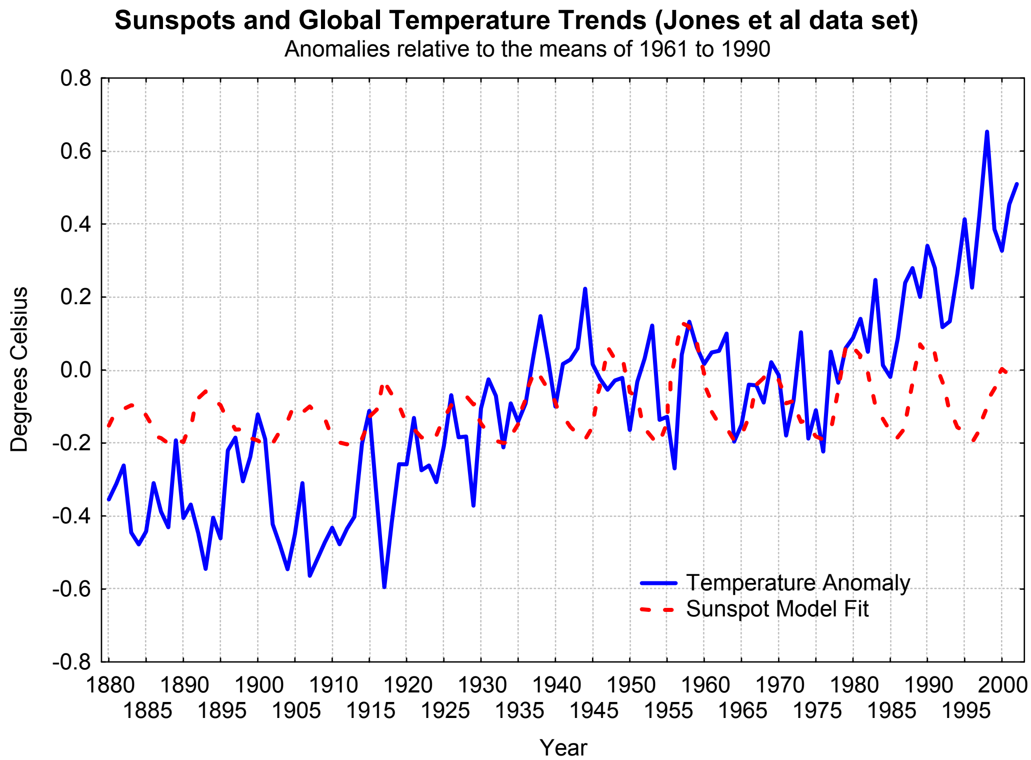
Chart 2



Turning to the global temperature record[1], there is a statistically significant relationship between sunspot numbers and temperature over the period 1880 to 2002. The temperature rises by an average of 0.18 degrees Celsius for each 100 sunspots (the t-value is 3.8 and the probability that this is due to chance is less than 0.0005). The proportion of the variance explained is 10.6%, so other factors are very influential too.

The model fit is shown in Chart 3.

Chart 3



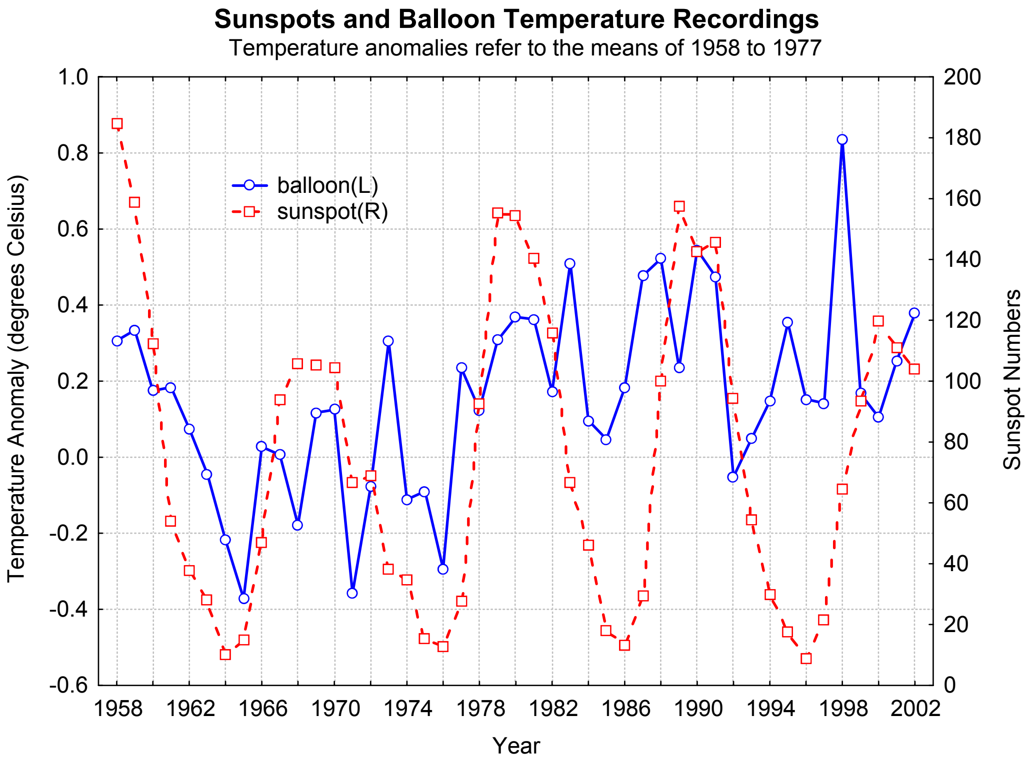
Clearly, variations in the sunspot cycle do not explain all the warming that has been observed since 1880. There have been two periods of warming that cannot be explained by the sunspot cycle:

1. Between 1915 and 1930, the temperature lifted by about 0.2 degrees Celsius;
2. Between 1985 and 2002, the temperature lifted by about 0.4 degrees Celsius.

The sunspot numbers at least partially explain the cooling between the mid-1950's and the mid-1970's. This is important in connection with the other global temperature data – the balloon data[2] and the satellite data[3].

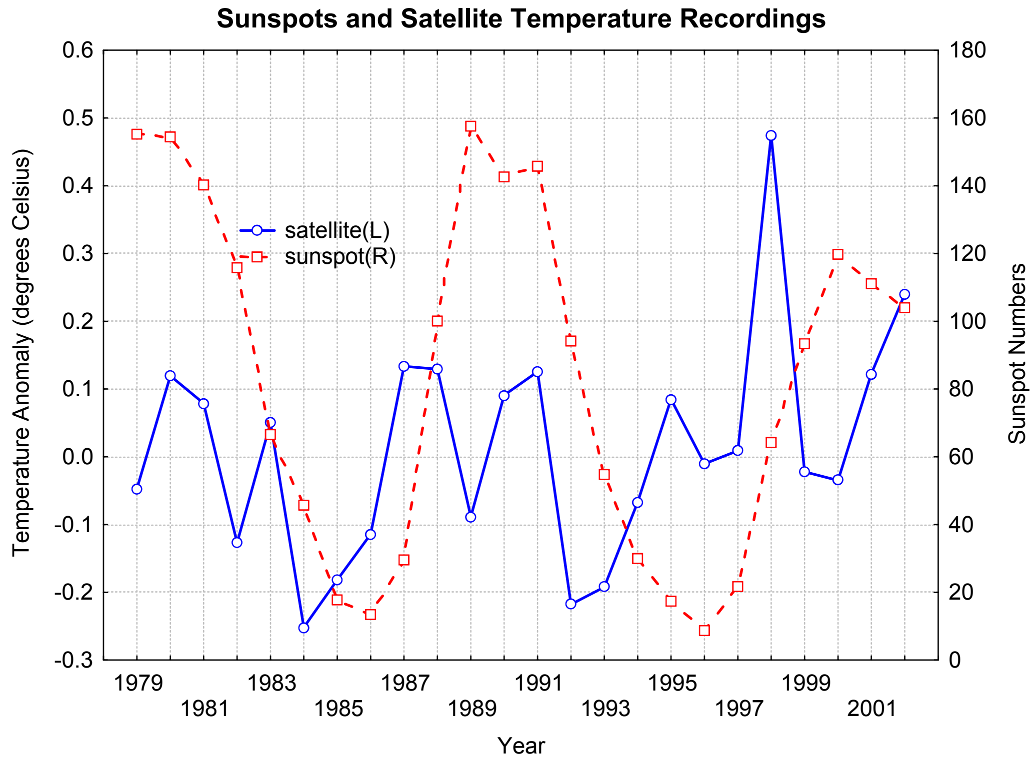
The balloon data commenced in 1958 and is shown in Chart 4. This data has a statistically significant upward trend of 0.8 degrees Celsius per century. For the period 1965 to 2001, the trend is 1.2 degrees per century. The start of the balloon data coincided with the peak of the biggest sunspot cycle recorded and the early decline in the balloon readings coincides with the decline from this sunspot peak. This factor alone would have dropped the temperature by 0.32 degrees, about half the observed amount.

Chart 4



The satellite data commenced in 1979 and is shown in Chart 5. The satellite data set shows no significant upward trend over the period that data is available, from 1979 to 2002 and especially over the period from 1979 to 1997 – although there is a statistically significant upward trend of 1.5 degrees per century between 1984 and 2002. Despite this source of data having the shortest time series of the three sets of temperature data, the lack of an upward trend has led to some analysts doubting the accuracy of other two. However, it is highly likely that the satellite data now supports the conclusion that global temperatures are rising. It almost certainly does **not** support the case that there is **no** global warming. For details, see our paper at www.healingforests.com/satellite.pdf.

Chart 5



There was a peak in the sunspot cycle in 1979, just when the satellite record began, and the trough was in 1986. This coincides with the early decline recorded by the satellites. This factor alone would have dropped the temperature by 0.26 degrees – almost exactly the amount observed.

Note that despite the most recent sunspot cycle having a lower maximum than the earlier two, the satellite temperature recordings have the highest temperatures at this time (1998 and 2002).

The Physical Process

How do sunspots heat the earth's atmosphere? The change in visible radiation from the sun during any one solar cycle is less than one half of one percent and scientists believe that this is not enough to explain the observed temperature variation. According to research by University of Buffalo scientists[4], published in Geophysical Research Letters, sunspot activity modulates cosmic rays and these have a strong influence because of their impact on cloud cover.

Other suggestions have been proposed. For example, researchers at NASA Goddard Institute for Space Studies[5] suggest that upper stratospheric ozone changes may amplify solar cycle irradiance changes.

Clearly, further research is needed to fully understand the physical process with confidence. However, we can be confident about the significance of the relationship. And we can be sure that temperature changes on earth don't affect sunspot activity. The remaining possibility is that another phenomenon influences both sunspot activity and atmospheric temperatures on earth.

Some Implications of these Findings

Understanding the contribution of the sunspot cycle and variations in its amplitude is important because it helps to explain some of the variations in temperature records. The residual variation is due to several factors including increased greenhouse gas concentrations. The more that natural factors can be identified and quantified, the better estimate we will have of the human induced residual.

As the sun is currently passing the peak of a cycle, the trough of which will be around 2006, the apparent rate of warming of the atmosphere may slow. This could lead to some complacency and increased skepticism about global warming. The lead-up to the next peak, due in about 2012, is likely to bring an apparent acceleration in global warming.

The commencement of the temperature recordings from both balloons and satellites commenced at peaks of (different) sunspot cycles. Thus, in their early years these records show declining temperatures. This has been seized upon by global warming skeptics as "proof" that there is no global warming. As the length of these time series of temperature recordings increases, the relative importance of these early readings will decline and we will be better able to gauge the true rate of warming.

The cooling that occurred in the surface recordings between the late 1950's and the mid-1970's is clearly due, at least in part, to the sunspot cycle and variations in its amplitude. This cooling has also led to doubts about the existence of global warming, but it can now be explained by sunspots and falling concentrations of sulphur dioxide in the atmosphere.

References

1. Jones, P. D., Parker, D. E., Osborn, T. J. and Briffa, K. R. 1999. Global and hemispheric temperature anomalies – land and marine instrument records. In *Trends: A Compendium of Data on Global Change*. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Ok Ridge, TN, USA.

2. Angell, J.K. 1999. Global, hemispheric, and zonal temperature deviations derived from radiosonde records. In: *Trends: A Compendium of Data on Global Change*. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, TN, USA.

3. Christy, J.R., Spencer, R.W., and Braswell. 2000. MSU Tropospheric Temperatures: Dataset Construction and Radiosonde Comparisons. *Journal of Atmospheric and Oceanic Research* **17**: 1153-1170.

4. M. Ram, with M. Stolz and G. Koenig. Eleven year cycle of dust concentration variability observed in the dust profile of the GISP2 ice core from central Greenland: Possible solar cycle connection. *Geophys. Res. Letters* 24, No. 19, 2359-2362 (1997).

5. BALACHANDRADN N.K., D. RIND, P. LONERGAN, and D.T. SHINDELL 1999. Effects of solar cycle variability on the lower stratosphere and the troposphere. *J. Geophys. Res.* **104**, 27321-27339.