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SOLAR CYCLES 24 AND 25 AND PREDICTED CLIMATE RESPONSE

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ABSTRACT
Projections of weak solar maxima for solar cycles 24 and 25 are correlated with the terrestrial climate response to solar cycles over the last three hundred years, derived from a review of the literature. Based on solar maxima of approximately 50 for solar cycles 24 and 25, a global temperature decline of 1.5°C is predicted to 2020, equating to the experience of the Dalton Minimum. To provide a baseline for projecting temperature to the projected maximum of solar cycle 25, data from five rural, continental US stations with data from 1905 to 2003 was averaged and smoothed. The profile indicates that temperatures remain below the average over the first half of the twentieth century.

INTRODUCTION

Brunetti (2003) provided a review of the literature on the solar influence on terrestrial climate. Brunetti reported that C. Piazzi Smyth, in an article submitted to the Royal Society in 1870, was the first to determine an 11 year cycle in temperature, and that this must be induced by the Sun. He also reported that, in 1974, Robert G. Currie published an analysis of climate data from 226 stations distributed over the planet in which he found a periodicity of 10.6 years in many of them. Over the same time interval, the periodicity of sunspots was 10.7 years.

Eddy (1976) analysed C^{14} data and concluded that the sunspot envelope was a good indication of variation of solar eruptive activity. The solar wind varies with the sunspot cycle. Increasing solar flux suppresses galactic cosmic rays which convert N^{14} to C^{14}. Reid (1991) noticed a fair agreement between the sunspot envelope and sea surface temperature.

Friis-Christensen and Lassen (1991), examining data over the period 1850 to 1990, found that length of the solar cycle has a very good match with temperature, and that this correlation is better than that of sunspot number and temperature. That paper concluded by stating, “70–90 year oscillations in global mean temperature are correlated with corresponding oscillations in solar activity. Whereas the solar influence is obvious in the data from the last four centuries, signatures of human activity are not yet distinguishable in the observations.”

Thejll and Lassen (2000) updated that paper and came to the conclusion that the relationship between solar cycle length and temperature broke down after 1975, and that anthropogenic warming is likely to be have been responsible for the departure.

Reichel, Thejll and Lassen (2001) subsequently published a paper showing that "cause-and-effect ordering, in the sense of Granger causality, is present between the smoothed solar cycle length and cycle mean for the Northern Hemisphere land air temperature for the twentieth century, at the 99% significance level. This indicates the existence of a physical mechanism linking solar activity to climate variations".

Amongst other papers linking solar cycle length to climate, Zhou and Butler (1998) found an association between the sunspot cycle length and climate, with wider tree-rings (i.e. more optimal growth conditions) being associated with shorter sunspot cycles. An association between sunspot cycles and human longevity has also been found. Juckett and Rosenburg (1993) reported that children of mothers who were born during peaks in the sunspot cycle were likely to die 2 to 3 years sooner than if their mothers had been born during the sunspot minimum, based on a study of 7,552 members of the US House of Representatives.

Svensmark and Friis-Christensen (1997) showed an association between cloud cover and galactic cosmic rays varying with the solar cycle, with greater cloudiness at lows in the sunspot cycle. The physical relationship is that collisions with galactic cosmic rays provide nucleation sites for water droplets in low level clouds. The Svensmark and Friis-Christianson paper elucidates the link between the sunspot cycle and terrestrial climate response. Recently, Usoskin, Schuessler, Solanki and Mursula (2005) extended the correlation of terrestrial Northern Hemisphere mean surface temperatures and solar activity over time intervals up to nearly 1,800 years.

FORECAST OF SOLAR CYCLES 24 AND 25

Sunspot cycle 23 peaked in April 2000 with a smoothed sunspot number of 120.8. The next minimum is predicted by IPS Radio and Space Services, Australia to be in March 2007 with a value of 8.8.

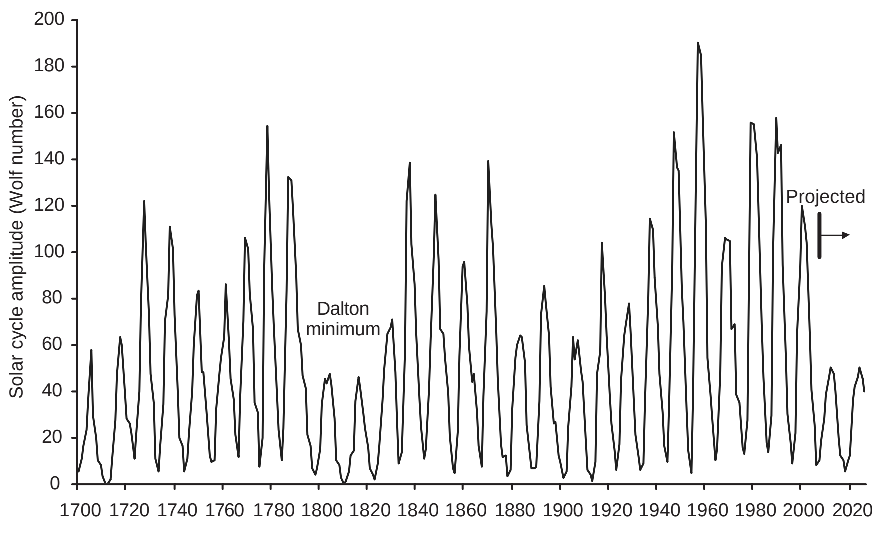

Figure 1: Past Solar Cycles with a Projection of Solar Cycles 24 and 25.

Badalyan, Obridko and Sykora's projection of solar cycle 24 maximum of approximately 50 is shown in figure 1 with solar cycle activity back to the end of the Maunder Minimum. Solar cycle 25 is also expected to be weak. The rise in amplitudes prior to the Dalton Minimum mimics the rise in amplitudes from the late nineteenth century to the end of the twentieth century.

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Amongst other predictions of solar cycle 24, Svalgaard, Cliver and Kamide (2005) predict a solar maximum of 75, which would make it the weakest solar cycle since cycle 14 when the sunspot number peaked at 63.5 in 1905. A longer range prediction is provided by Schatten and Tobiska (2003) who predicted "a rapid decline in solar activity, starting with cycle #24. If this trend continues, we may see the Sun heading towards a "Maunder" type of solar activity minimum – an extensive period of reduced levels of solar activity." Landscheidt (2003) comes to a similar conclusion based on the variable torque applied to the Sun by the movements of the giant planets and their impact on solar eruptive activity.

THE DALTON MINIMUM

A period of two solar cycles with maxima of approximately 50 mimics the Dalton Minimum, which is a period of low temperatures in northern Europe from 1796 to 1820. This was due to very weak solar cycles 5 and 6, which had maxima of 47.5 and 45.8 respectively.

The temperature response to these cycles is illustrated in Figure 2 which shows the temperature profile of three European stations with a continuous record through the Delton Minimum. The Oberlach Station in Germany experienced a2.0° C decline over 20 years

THE RECENT TEMPERATURE RECORD IN NORTH AMERICA

To provide a baseline for projecting temperature to the projected maximum of solar cycle 25 in 2024, data from five, rural, continental US stations with data from 1905 to 2003 was averaged and smoothed. That is shown in Figure 3. Rural stations were chosen so as to eliminate the possibility of contamination by the urban heat island effect. The use of a 98 year long data set precludes the possibility of the data being affected by short term local conditions. The smoothed average annual temperature of the Hawkinsville (32.3N, 83.5W), Glennville (31.3N, 89.1W), Calhoun Research Station (32.5N, 92.3W), Highlands (35.0N, 82.3W) and Talbotton (32.7N, 84.5W) stations is representative of the US temperature profile away from the urban heat island effect over the last 100 years (Data source: NASA GISS)

The temperature profile over the period shows three distinct trends: a relatively stable period from 1905 to 1953 averaging 16.3°C, a relatively steep decline of 1.4°C over the 15 years to 1968 due to a weak solar cycle 20, and then a slight rise to the current day with an average of 15.8°C to 2003. The profile indicates that temperatures

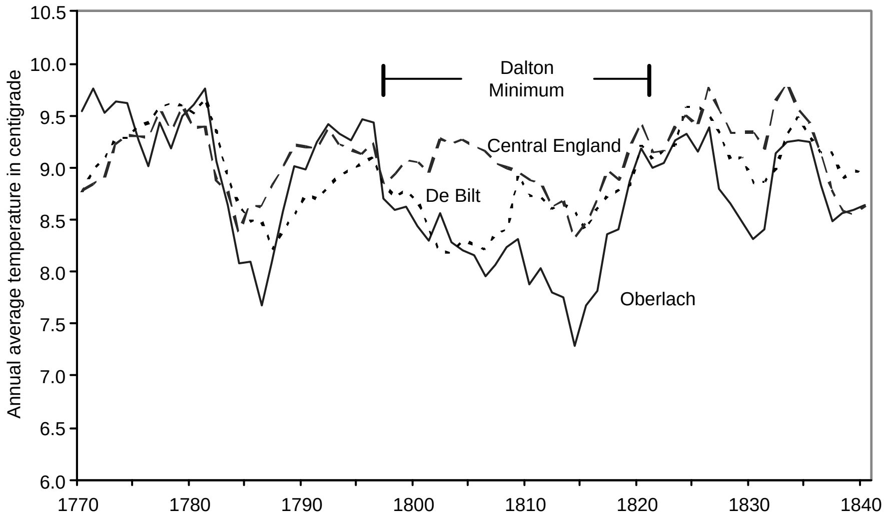

Figure 2: Annual Average Temperatures for Three European Stations 1770–1840.

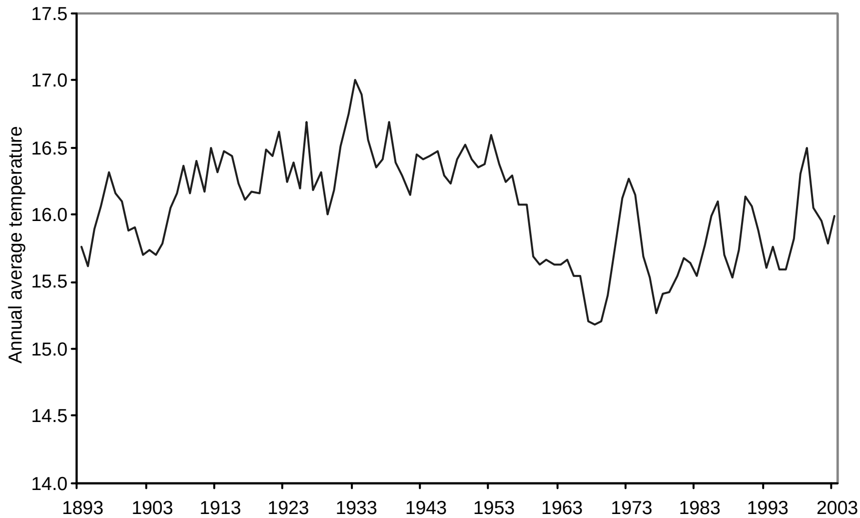

Figure 3: Annual Average Temperature of Five Rural US Stations.

remain below the average over the first half of the twentieth century. The flat profile of the last 20 year period is corroborated by the satellite data over that period, which shows only a very weak rise in the temperature of the lower troposphere.

By comparison with the last data point of Figure 3 of 16° C in 2003, the minimum of solar activity associated with Solar Cycles 24 and 25 is expected to result in a temperature by late next decade of 14.5° C.

PREDICTED TEMPERATURE RESPONSE TO SOLAR CYCLES 24 AND 25

Friis-Christensen and Lassen (1991) found that, over the period 1850 to 1990, the length of the solar cycle correlated better with temperature than with solar cycle amplitude. By expanding the time interval studied to 1705 to 2003, a good correlation of temperature and solar cycle amplitude is evident. This is shown in Figure 4 which demonstrates a correlation between solar cycle amplitude and annual average temperature at de bilt, Netherlands.

The correlation of temperature and solar cycle length is still stronger, as shown in Figure 5.

Based on the projection of amplitudes of about 50 for solar cycles 24 and 25, the correlation in Figure 5 derives a temperature fall of 1.5°C relative to the recent cycles 22 and 23, which had maxima of 157.6 and 119.6 respectively.

CONCLUSION

A number of solar cycle prediction models are forecasting weak solar cycles 24 and 25 equating to a Dalton Minimum, and possibly the beginning of a prolonged period of weak activity equating to a Maunder Minimum. In the former case, a temperature decline of the order of 1.5°C can be expected based on the temperature response to solar cycles 5 and 6. A rural US temperature data set shows that recent and current temperatures remain below the average of the first half of the 20th century.

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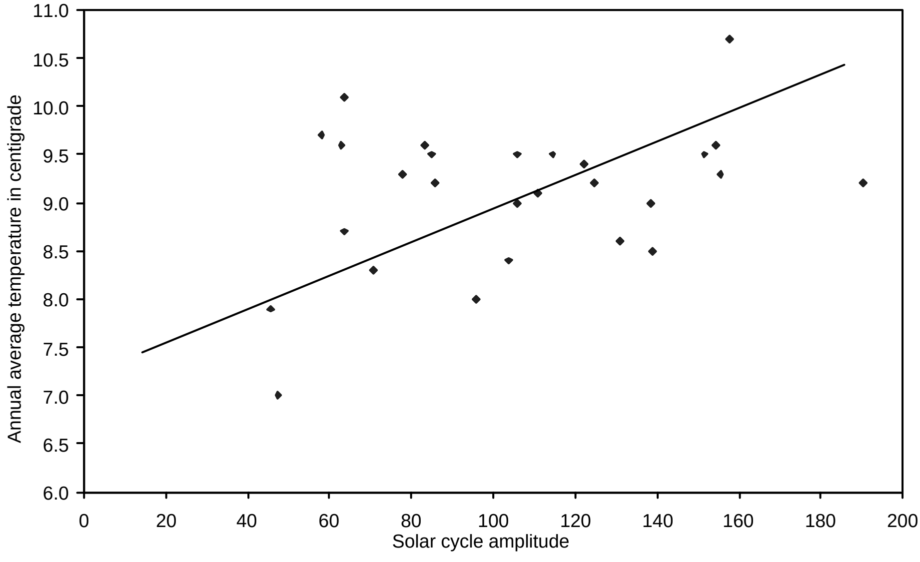

Figure 4: Solar Cycle Amplitude relative to Temperature 1705 to 2000.

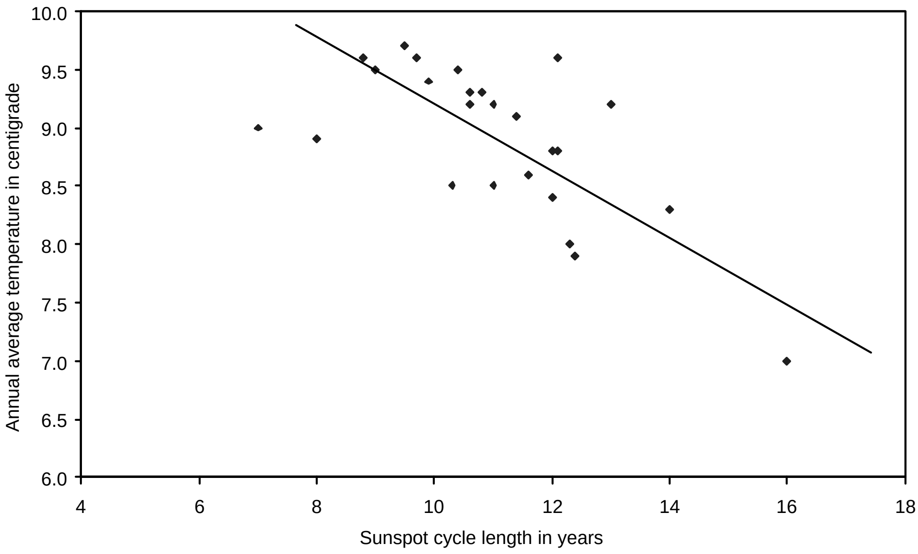

Figure 5: Sunspot Cycle Length relative to Temperature 1705 to 2000.

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