A CRITIQUE ON THE LOCKWOOD/FROHLICH PAPER

IN THE ROYAL SOCIETY PROCEEDINGS

by

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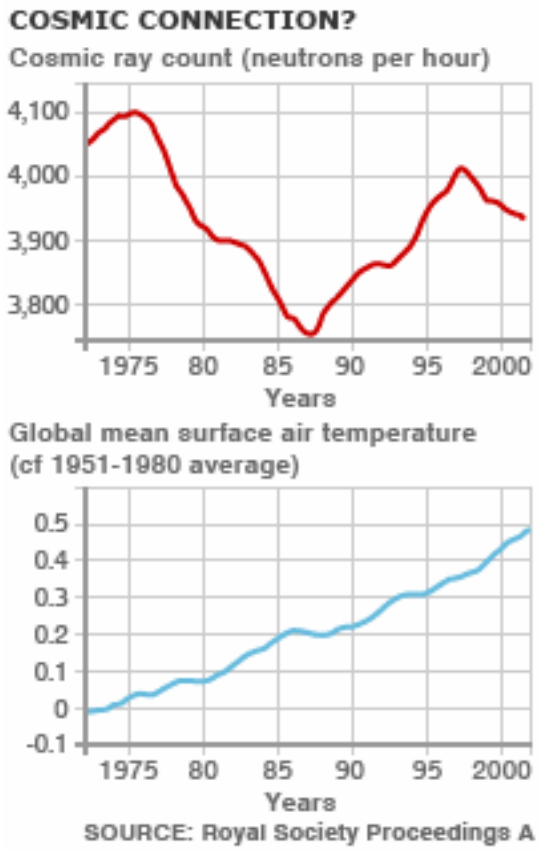
in the Royal Society proceedings

Mike Lockwood and Claus Frohlich published a paper in the Proceedings of the Royal Society which concludes that the Sun could not be responsible for the global temperature rise over the last twenty years. The BBC published a news story[1] on the paper dated July 10, 2007.

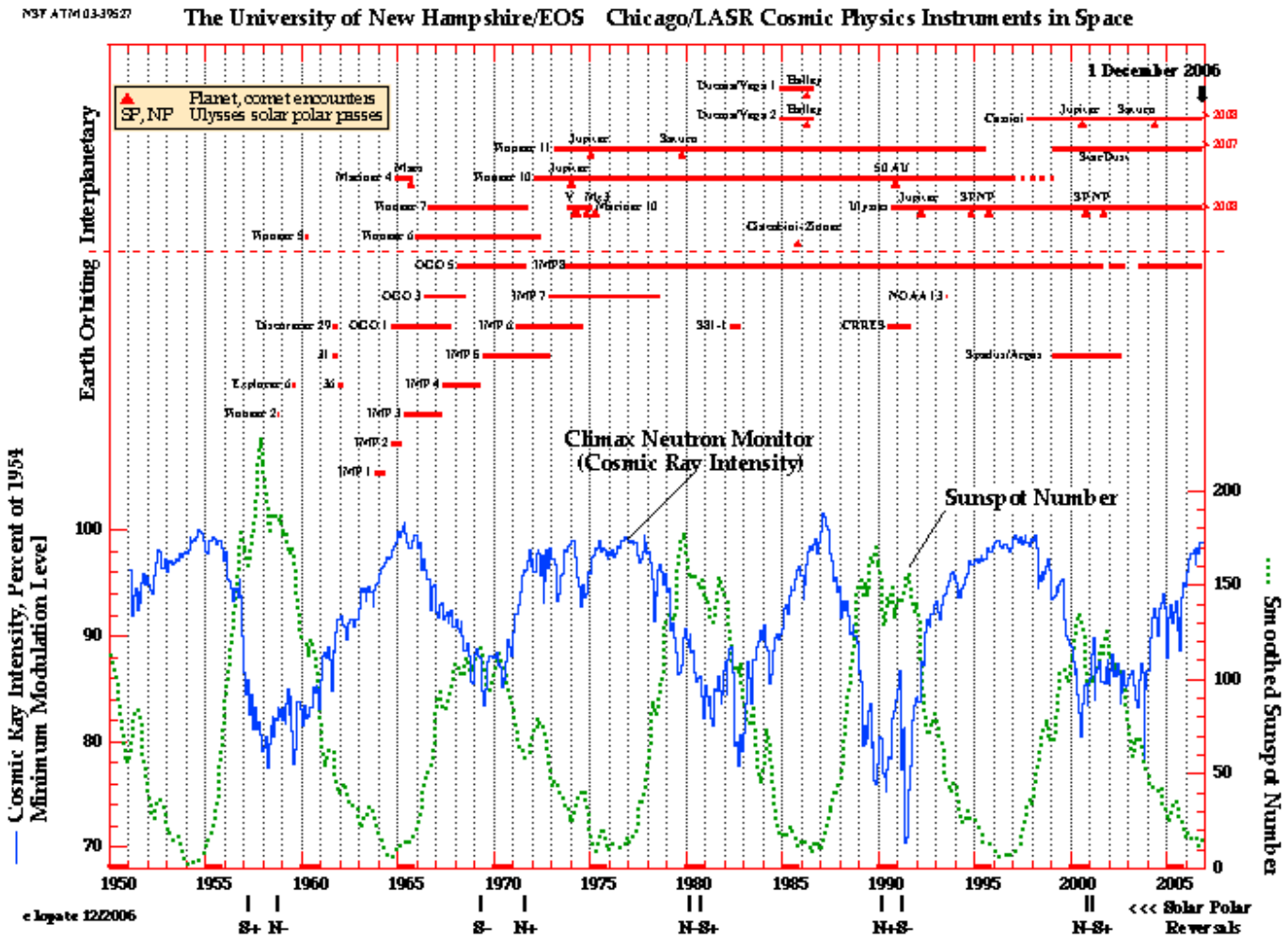
Cosmic rays vary over an 11 year cycle with the sunspot cycle. Dr. Svensmark developed a theory that the Sun is a significant driver of climate change through its effects on the cosmic ray flux and cloud cover. The increased solar wind and magnetic field during times of high sunspot count repels cosmic rays that otherwise would hit the Earth's atmosphere, resulting is less aerosols in the lower atmosphere and thereby reducing low cloud formation. Fewer low clouds allows more solar radiation to reach the Earth's surface causing warming.

The BBC article presents this graphic:

The BBC article is misleading because the graph titled "Cosmic ray count" is not of cosmic rays (neutrons) count at all. It is the result of a mathematical manipulation to eliminate the 11 year cosmic ray cycle. The curve is taken from the Lockwood paper. The actual cosmic ray count from the Climax neutron monitor is shown as the blue curve below.



[1] http://news.bbc.co.uk/2/hi/science/nature/6290228.stm

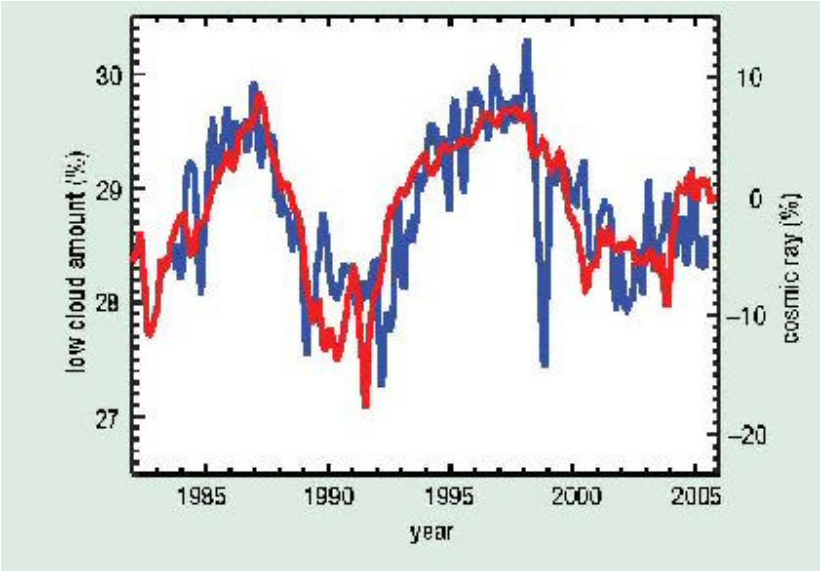


Note that the cosmic ray count shown above is identical to that given in the Svensmark paper shown below. The red curve shown below is the cosmic ray count variation. The blue line shows variations in global cloud cover.

The Lockwood paper is fundamentally flawed for several reasons.

The paper states "Hence, all solar trends since 1987 have been in the opposite direction to those seen or inferred in the majority of the twentieth century—particularly in the first half of that century".

This is not true for cosmic rays which shows very low counts during the 1990-1991 solar maximum; lower counts than the previous three cycles. This would have caused warming during the 1990's.

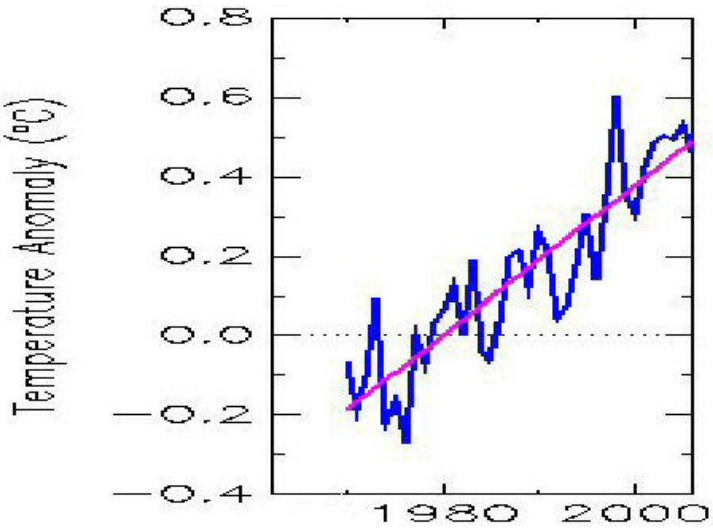


The paper states "The Earth's surface air temperature does not respond to the solar cycle."

This is false; the earth temperature does respond to the solar cycle as confirmed by numerous studies. The 11 year solar cycle is clearly shown in sediment cores[2] obtained from Effington Inlet, Vancouver Island, B.C. by Dr. Tim Patterson, and in records of the Nile River[3], to name just two studies.

The paper continues with "Even a large amplitude modulation would be heavily damped in the global mean temperature record by the long thermal time constants associated with parts of the climate system, in particular the oceans (Wigley & Raper 1990)."

This is true. The oceans act as a hugh climate flywheel, which both smoothes and delays the effects of the climate forcings. Global temperatures do not react strongly to each 11 year cycle, but are smoothed out. Here is the World 1970 - 2006 land and sea-surface temperature data from HadCRUT3 database.



You can clearly see that when the cosmic ray counts are high, there is a temperature drop, 1974-77, 1986-87, 1995-97, and 2004 - 2006. The pink straight line best fit indicates 0.1880 Celsius per decade.

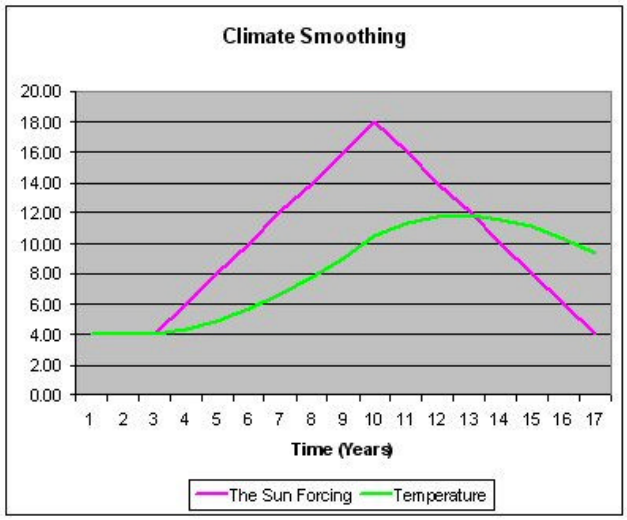
The Lockwood paper manipulates the cosmic ray count data to eliminate the 11 year cycle by extrapolating between the nodes of the cycles. The nodes are points where the top part of the cycle has the same mean as the lower part, approximately the midpoint of each cycle. The result is the "Cosmic ray count" graph shown in the BBC article and reproduced above. Note that this reveals a 22 year cycle. But totally eliminating the 11 year cycle implies that the damping effect of the oceans is near infinite, which would also eliminate a 22 year cycle, or any other cycle length. If the oceans really had a near infinite heat capacity, it would absorb all effects of the Sun and CO_2 changes and global temperatures would not change! Lockwood essentially applies a 100% damping to the 11

[2] http://members.shaw.ca/sch25/FOS/Patterson_Spectral_Analysis.jpg
[3] http://www.jpl.nasa.gov/news/features.cfm?feature=1319

year cycle but 0% damping to the 22 year cycle, which is complete nonsense.

The ocean's flywheel damping effect means that the temperature today is effected by the Suns activity over the last many years. The 2006 global temperature is effected mostly by the 2006 Sun's intensity, but also by the Sun's activity in previous years. Even the Sun's activity 20 years ago has an effect on the current temperature.

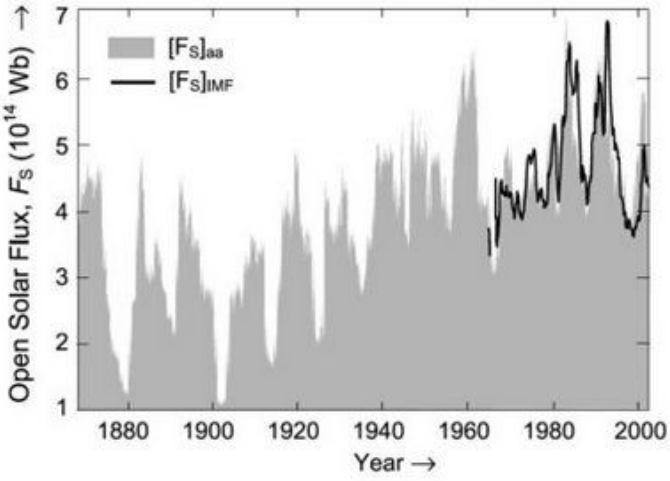
Below is a graph showing a hypothetical increase followed by a decrease in the Sun's forcing, and the resulting temperature change. The graph is only for illustrative purposes to show the climate smoothing and time lag effects on temperature. The units are arbitrary. Here I assume the temperature of a given year is effected by the Sun's forcing over the previous 24 years such that each prior year has 85% of the weighting of the next year.



Note that the temperature continues to rise for several years after the Sun's forcing starts to decrease.

The Lockwood paper falsely assumes that the current Sun activity would have an immediate effect on temperature without a time lag. One should expect a time lag based on the length of the variation cycle. For example, each day the Sun's intensity peaks at noon but daily temperatures peak several hours later. Each year the Sun's intensity peaks at June 21, but July and August are the warmest months in the northern hemisphere.

The 11 year solar cycle causes about a 2 year lag in the temperature variation. The Sun's activity has been increasing though most of the twentieth century and one should expect about a decade of time lag. The graph below from here[4] show the rising solar flux during most of the twentieth century.



Since the cosmic ray count was a minimum in 1991 (the 2001-2002 minimum count was higher) we expect the temperature to increase for about a decade to about 2001 before falling. This is exactly what has happened!

All climatologists should know the the heat capacity of the oceans cause a large time lag in temperature response. The IPCC fourth assessment report includes computer model

[4] http://motls.blogspot.com/2007/07/nir-shaviv-why-is-lockwood-and-frohlich.html

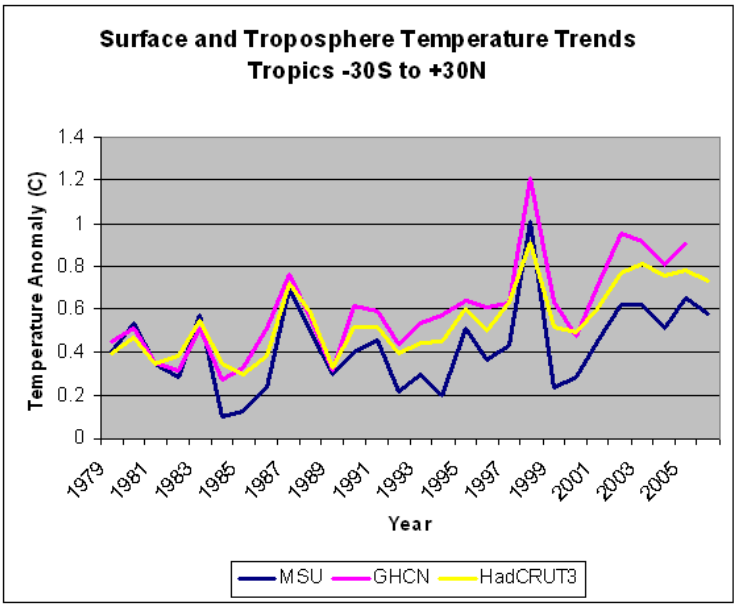
projections that show if the CO_2 concentration is held constant at year 2000 levels, the global temperature will continue to rise over the next two decades. The same effect occurs for Sun activity as CO_2.

Lockwood compares the cosmic ray (with the 11 year cycle removed) to a smoothed surface temperature graph. The Sun's climate forcings should be compared to the actual temperature curves, which show no increase in global temperatures since 2002.

The surface temperatures used by Lockwood are contaminated by the heat island effects and numerous quality control issues related to the individual station measurements and spatial placements. Lockwood should use the MSU (Microwave Sounding Units) satellite data which is truly a global measure of temperatures, as it is the troposphere temperature, and is not contaminated by the heat island effect.

The theory of CO_2 temperature change shows that the enhanced greenhouse effect would increase temperatures faster in the troposphere where temperatures are cold and the water vapour content is low. All the climate models show that the troposphere temperatures should increase faster than the surface temperatures, especially in the tropics.

The graph below shows the temperature in the tropics.



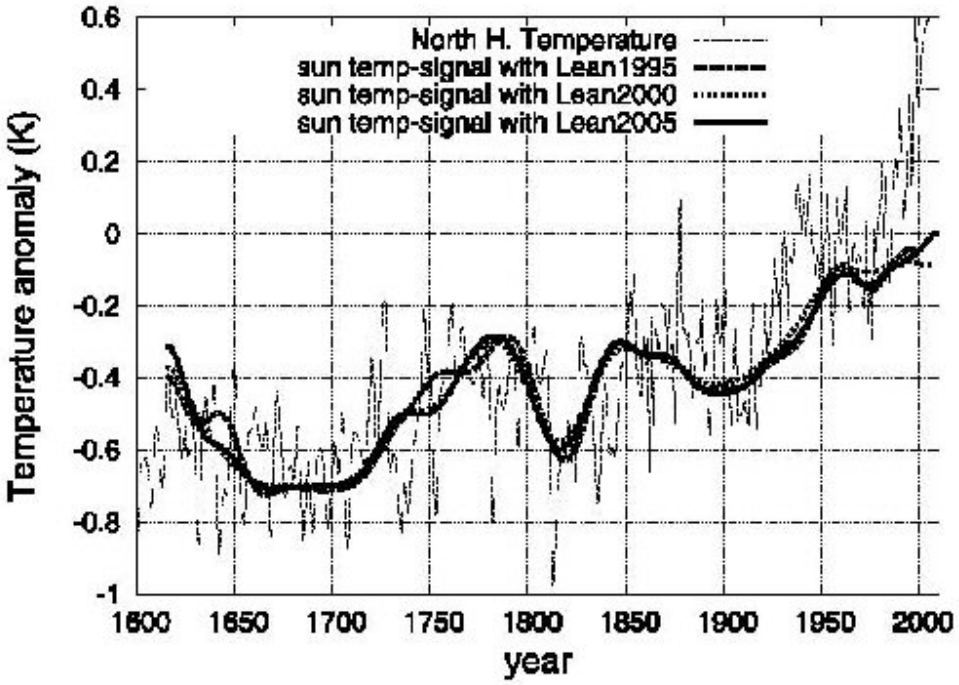
The three curves are scaled so that the average of the first 5 years are the same. The GHCN curve is the land only surface temperature trend. It shows the highest rate of increase because it is contaminated by the heat island effect. The HadCRUT3 curve is the land and sea surface temperature trend. It is lower that the GHCN curve because the sea temperature data does not have any heat island effect. If the Sun had little effect on climate and CO_2 was responsible for the twentieth century temperature rise, both of these curves should show a lower warming trend than the MSU, troposphere temperature, curve! It is illogical to believe that CO_2 is the primary temperature driver and concurrently believe that the surface measurements are accurate.

The Lockwood paper only analysis the last 30 years of data which is too short of a time interval. A system that has 11 year cycles require at least 110 years (10 cycles) of data to obtain meaningful statistical results.

The paper says in the conclusions "... there was a detectable influence of solar variability

in the first half of the twentieth century". The BBC article quote Lockwood "It [the cosmic ray effect] might even have had a significant effect on pre-industrial climate; but you cannot apply it to what we're seeing now, because we're in a completely different ball game." The paper fails to explain what laws of physics have recently changed.

Solar activity correlates well with temperature over longer time scales. The graph below from Scafetta and West of Duke University compares solar proxies with the Northern hemisphere temperature reconstruction by Moberg et al. [2005].



Solar activity can account for at least 50% of the warming since 1900. It is likely that both the Sun/Cosmic rays and CO_2 emissions are affecting climate.

In summary, the Lockwood paper is seriously flawed by:

1. It falsely says the Sun's influence peaked by 1987. The cosmic ray count in 1991 is the lowest it has ever been, causing warming.
2. It falsely says the Earth's temperature does not respond to solar cycles.
3. It eliminates the 11 year solar cycle from the cosmic ray data, but does not smooth any other cycle.
4. It fails to account for the large time lag between the Sun forcings and temperature changes.
5. It uses smoothed surface temperatures rather than actual global satellite temperature data.
6. It analyses too short a time interval
7. It fails to explain why the cosmic ray influence apparently stopped twenty years ago.

This paper is so flawed that it is remarkable that it was published.

My conclusion is that the recent Sun and cosmic ray data is entirely consistent with the position that the Sun is the primary driver of climate change.

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