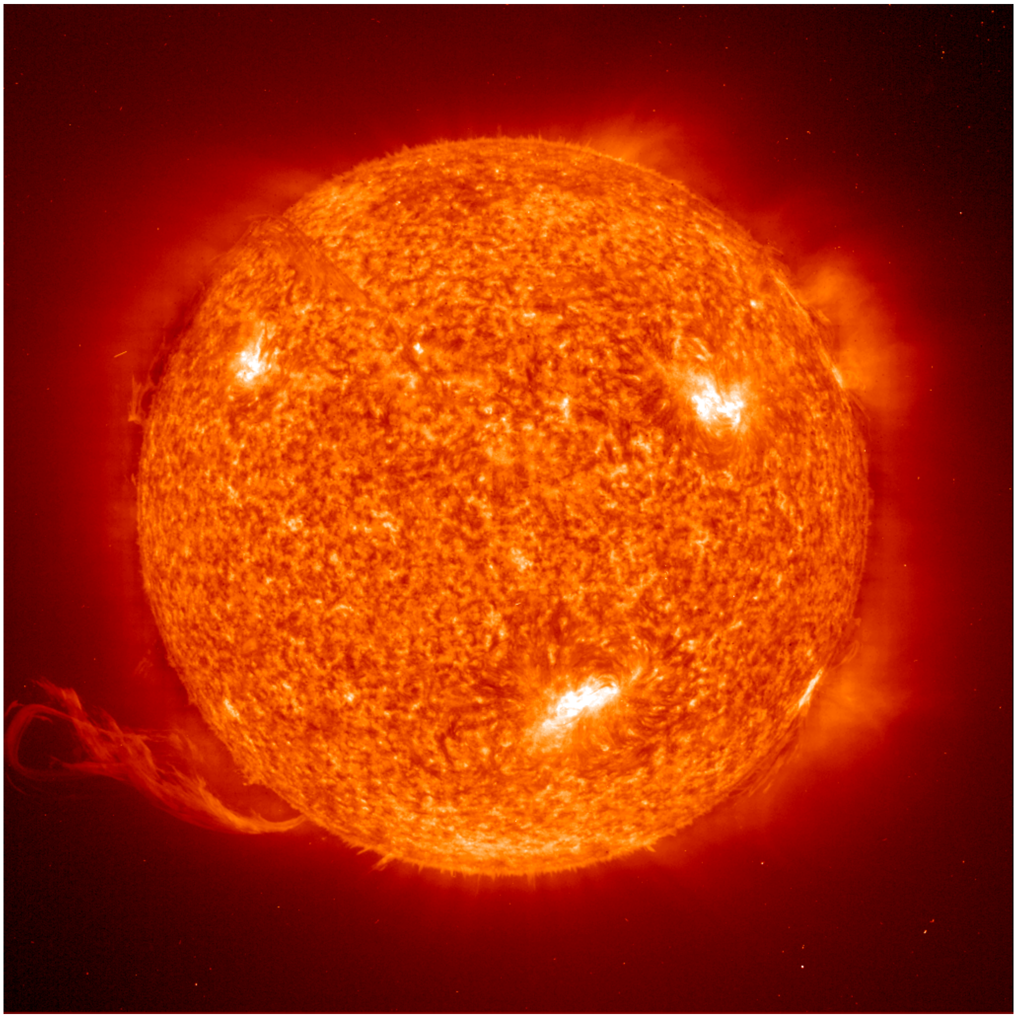
ULTRALONG SOLAR CYCLE 23 AND POSSIBLE CONSEQUENCES

By Joseph D'Aleo, CCM



WHAT ARE SUNSPOTS?

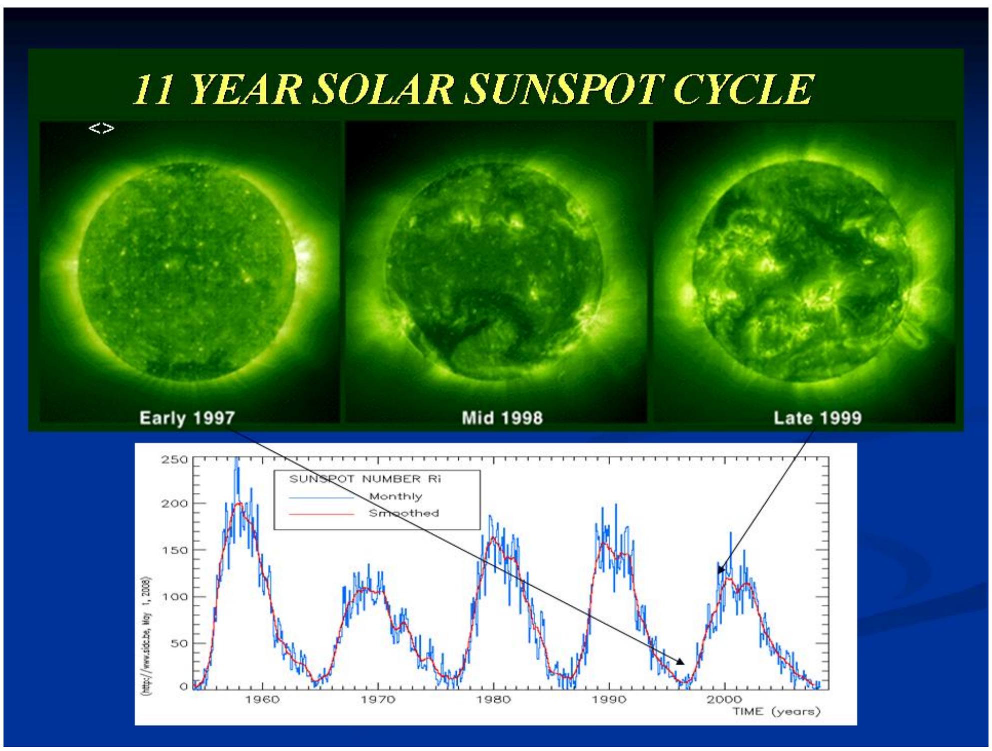
In 1610, shortly after viewing the sun with his new telescope, Galileo Galilei made the first European observations of Sunspots. Daily observations were started at the Zurich Observatory in 1749 and with the addition of other observatories continuous observations were obtained starting in 1849. As a climatologist, I always found it amazing that we have had regular sunspot data far longer than we have had reliable coverage of temperature or precipitation.

Sunspots appear as dark spots on the surface of the Sun. Temperatures in the dark centers of sunspots drop to about 3700 K (compared to 5700 K for the surrounding photosphere). They typically last for several days, although very large ones may live for several weeks.

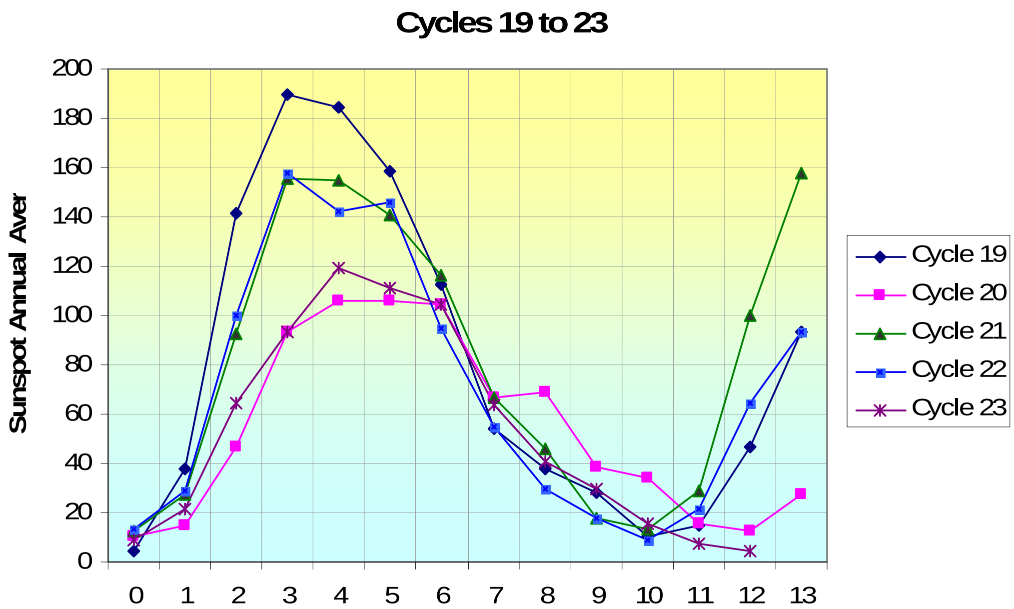
Sunspots are magnetic regions on the Sun with magnetic field strengths thousands of times stronger than the Earth's magnetic field.

Sunspots usually come in groups with two sets of spots. One set will have positive or north magnetic field while the other set will have negative or south magnetic field. The field is strongest in the darker parts of the sunspots - the umbra. The field is weaker and more horizontal in the lighter part - the penumbra. Faculae are bright areas that are usually most easily seen near the limb, or edge, of the solar disk. These are also magnetic areas but the magnetic field is concentrated in much smaller bundles than in sunspots. While the sunspots tend to make the Sun look darker, the faculae make it look brighter. During a sunspot cycle, the faculae actually win out over the sunspots and make the Sun appear slightly (about 0.1%) brighter at sunspot maximum that at sunspot minimum.

The sunspot number is calculated by first counting the number of sunspot groups and then the number of individual sunspots. The "sunspot number" is then given by the sum of the number of individual sunspots and ten times the number of groups. Monthly averages (updated monthly) of the sunspot numbers show that the number of sunspots visible on the sun waxes and wanes with an approximate 11-year cycle, The last five cycles are shown in the diagram below.

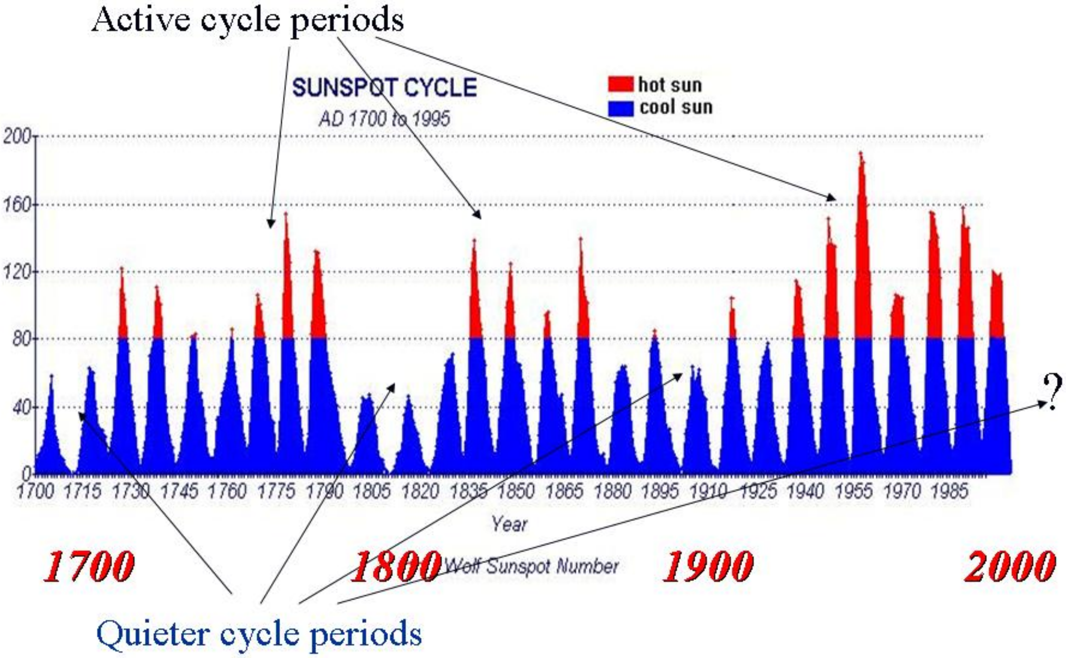


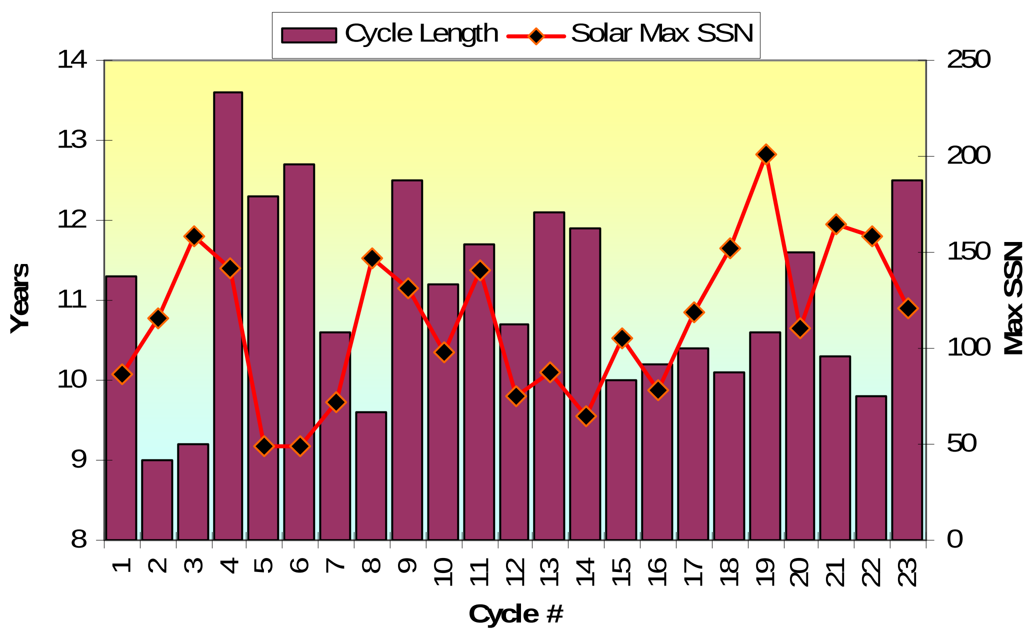
You can see from this diagram that the cycles are not equal in magnitude (110 to 200) or period (9.8 to 12+ years). If you superimpose the five cycles you can see this even more dramatically. The chart has the annual average sunspot number and starts with the year of the solar minimum (lowest sunspot average). You can see that cycles 19, 21, and 22 were higher amplitude and shorter periods (bottoming out in years 9-10 and then rebounding rapidly). Cycles 20 and 23 were less amplified and longer. Cycle 20 lasted about 11.8 years. It appears from the evidence we will present that cycle 23 has not yet bottomed out and thus is at least 12 years long.



Looking back at the full record of sunspot cycles, we can see this general behavior of short active cycles and longer, quiet ones. Successive 11 year cycles are different in their magnetic fields and the 22 year Hale cycle has in the past been related to some phenomena such as drought. Longer term cycles are apparent when you carefully examine the data. Very obvious from the long term plot of the 11 year cycles is the approximate 100 (106) year cycle. There is also a 213 year cycle. The last 213 minimum was in the early 1800s. The turn of each of the last 3 centuries has started with quiet long cycles with mid-century shorter, higher amplitude cycles. The quietest period was in the early 1800s (the Dalton Minimum). The 100 and 200 year minima are due the next decade suggesting a quieter sun ahead.

11 year solar cycles vary in their strength on a longer term on cycles of 22, 53, 88, 106, 213, 429, etc. years



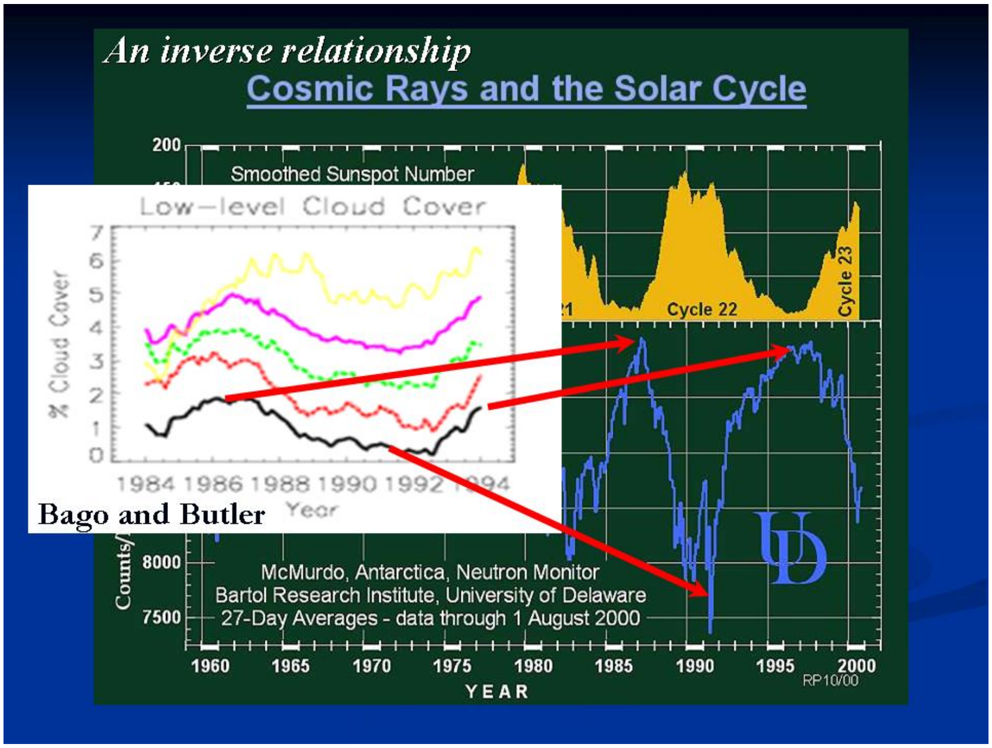


SOLAR CYCLES AND TEMPERATURES

When the sun is more active, it is brighter than when it is quiet. This difference in brightness or irradiance over the 11 year cycle is about 0.1%. The irradiance change though since the little ice age may be as high as 0.4 or 0.5% and has been used to explain the ice age and recovery since. Even on the shorter term, there are other solar factors at play besides simple brightness or irradiance changes.

While irradiance changes just 0.1% over the 11 year cycle, ultraviolet radiation changes 6 to 8% and shorter wavelengths even more. Ultraviolet radiation destroys ozone, an exothermic process which produces warming in the higher atmosphere in low to mid latitudes that works its way down to the middle troposphere in time. Labitzke (2001) has shown statistically significant differences of temperatures in the lower stratosphere into the middle troposphere with the 11 year solar cycle (warmest at max) which she attributes to solar flux induced ultraviolet variance. Shindell et al NASS GISS (1999) showed results from a global climate model including ozone and UV found UV induced stratospheric ozone changes and generated heat that penetrates into the troposphere, in effect confirming Labitzke's findings.

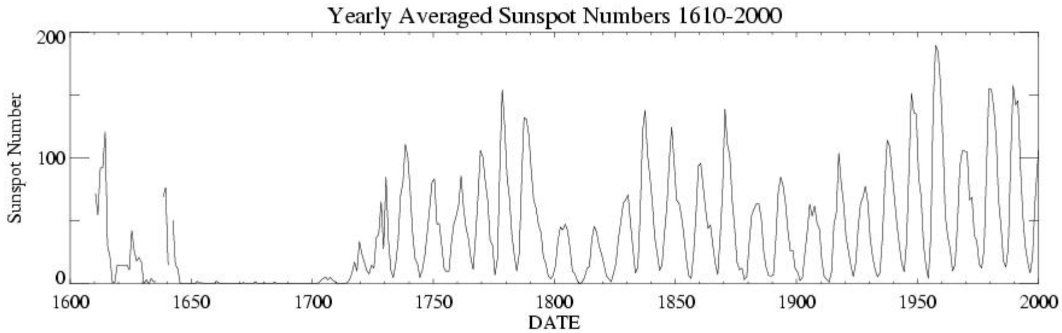
Also an active sun causes a diffusion of cosmic rays, which have a low cloud enhancement effect through ion mediated nucleation. Low clouds reflect radiation and have a net cooling effect. The absence of them during active solar periods means more radiation reaching the surface. Enhanced low cloudiness during solar minima would augment cooling.



These factors magnify the solar irradiance factors acting to enhance warming during active solar periods and diminish it during quiet periods. Scafetta and West (2007) have indicated that Total Solar irradiance as a proxy for the total solar effect could be responsible for well over 50% of the changes since 1900.

MAUNDER MINIMUM

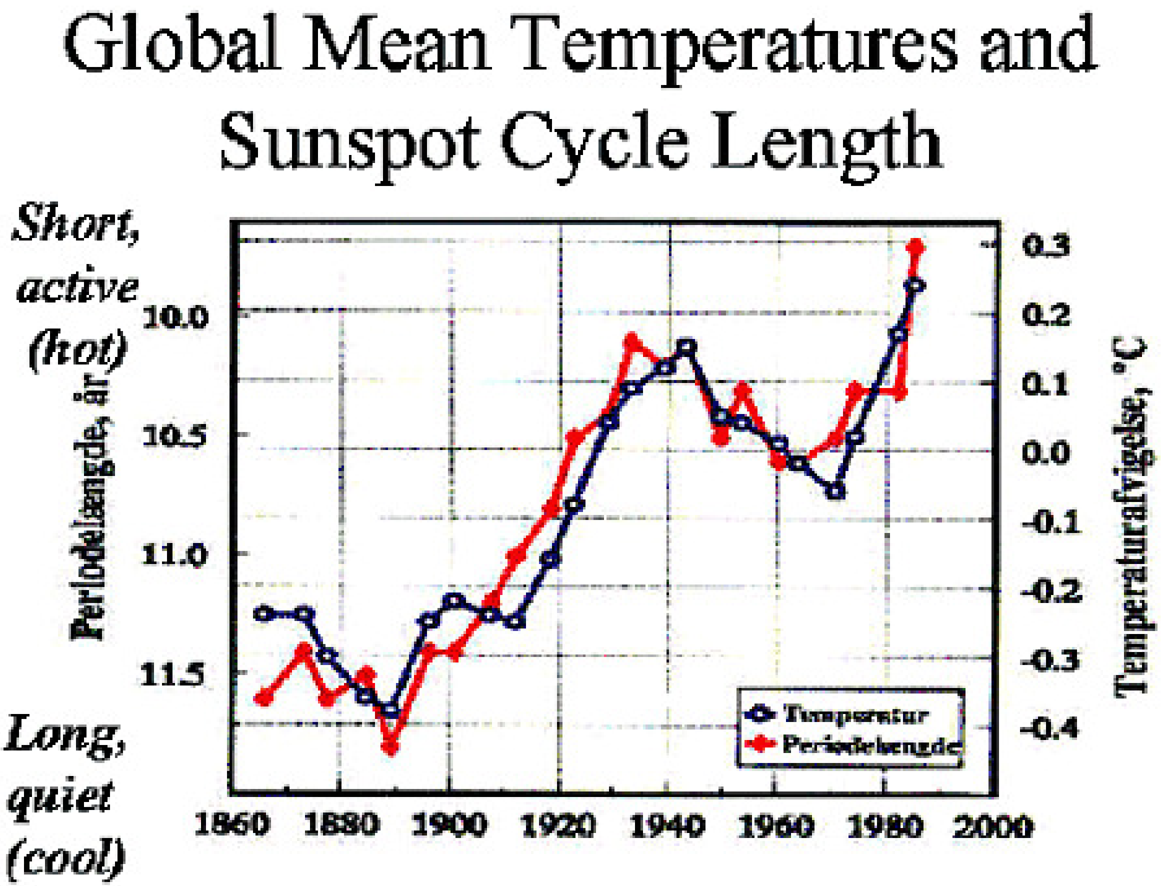
Early records of sunspots indicate that the Sun went through a period of inactivity in the late 17th century. Very few sunspots were seen on the Sun from about 1645 to 1715, a period known as the Maunder Minimum.



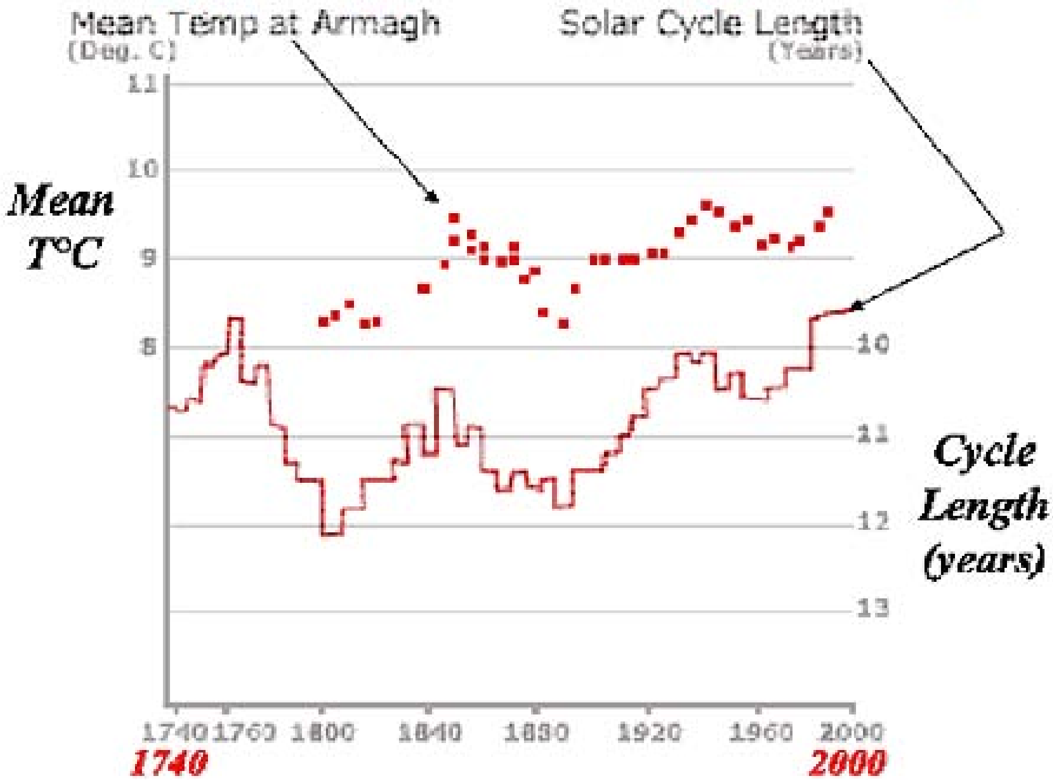
Although the observations were not as extensive as in later years, the sun was in fact well observed during this time and this lack of sunspots is well documented. This period of solar inactivity also corresponds to a climatic period called the "Little Ice Age" when rivers that are normally ice-free froze and snow fields remained year-round at lower altitudes. Shindell here related this cooling to low solar UV radiation and less ozone destruction which he hypothesizes has an effect on the AO/NAO (negative modes). There is evidence that the Sun has had similar periods of inactivity in the more distant past.

SOLAR CYCLE LENGTH AND TEMPERATURES

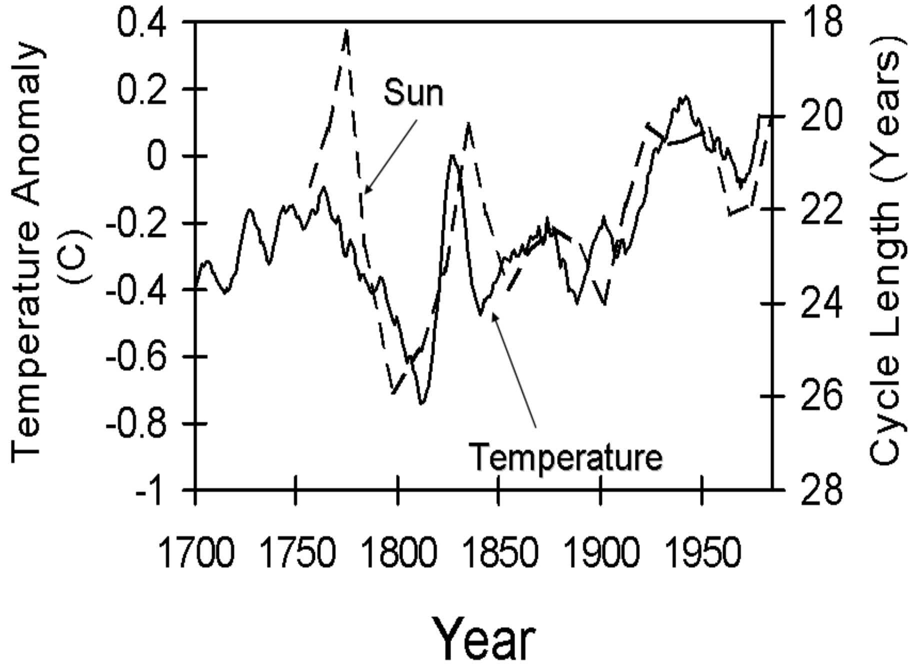
Since the solar cycle length correlates inversely with the magnitude and the magnitude directly with temperatures, it is not surprising that solar cycle length has been shown to correlate very well with temperatures. In an important paper in 1991, Friis-Christensen et al., compared the average temperature in the northern hemisphere with the average solar activity defined through the interval between successive sunspot maxima. Their results are displayed in the figure below:



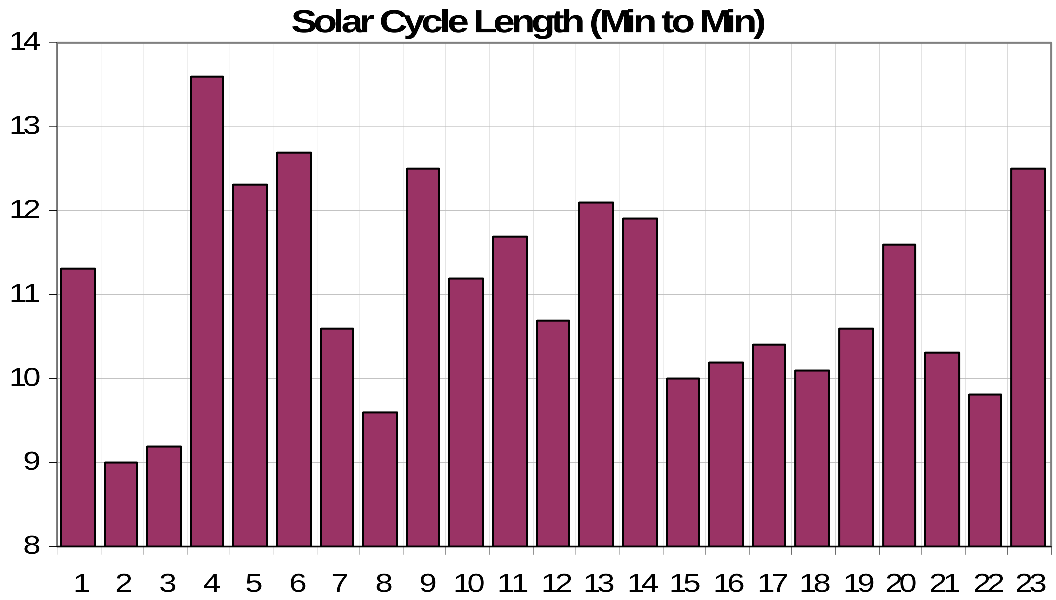
The Armagh Observatory in Ireland has one of the longest continuous record of temperatures and they repeated the analysis and again showed a lock-step relationship.

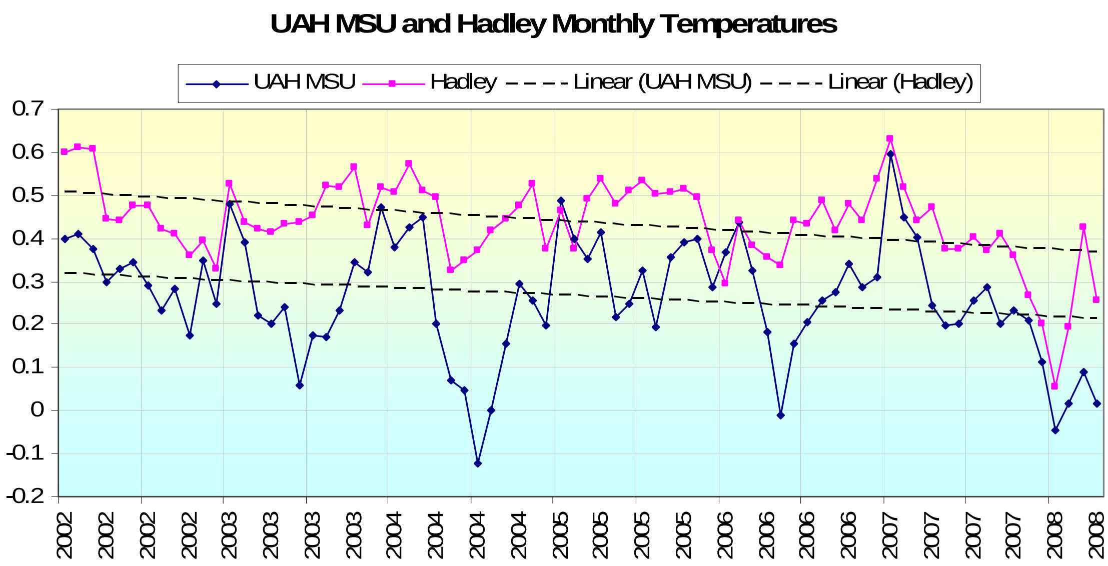


Proxy data has been used to estimate past temperatures and when compared with the solar cycle length shows also this relationship back into the 1700s.



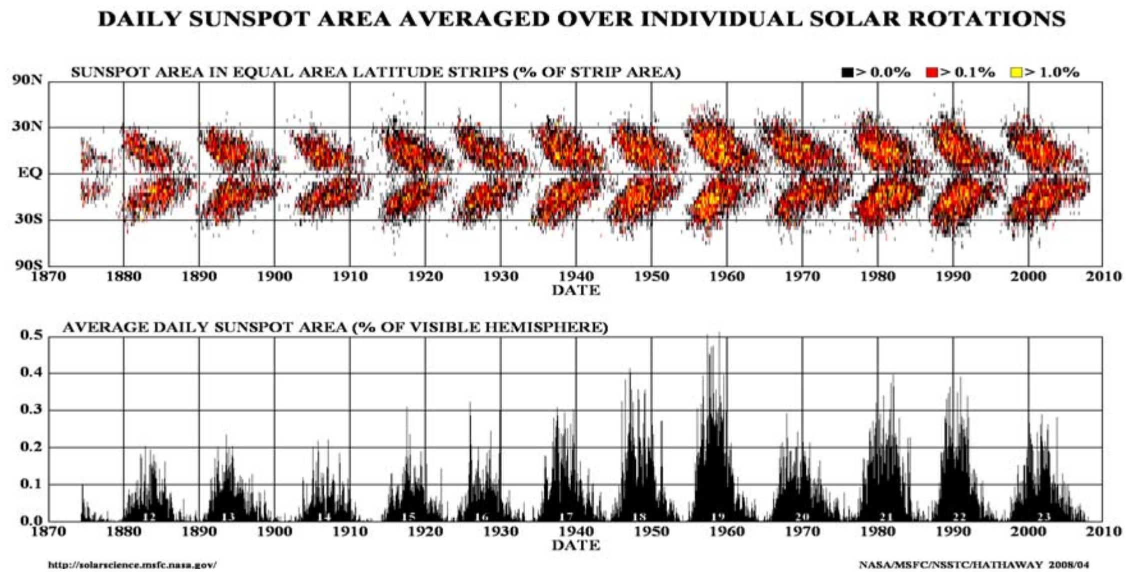
The cycle length of cycle 22 which peaked in 1990 was 9.8 years. Landscheidt has suggested a lag of up to 8 years between solar peaks or troughs and temperatures, which would mean a peak warmth from 1995 to 1998. Global temperatures appear to have peaked in 1998. The current longer quieter cycle 23 may be behind the cooling in the last 7+ years.



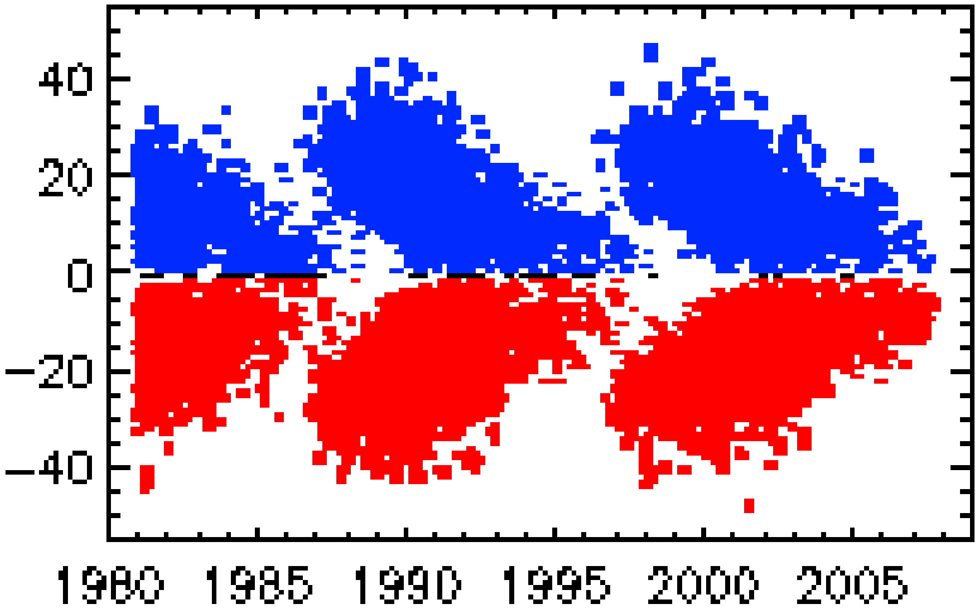


WHERE TO FROM HERE?

Detailed observations of sunspots have been obtained by the Royal Greenwich Observatory since 1874. These observations include information on the sizes and positions of sunspots as well as their numbers. These data show that sunspots do not appear at random over the surface of the sun but are concentrated in two latitude bands on either side of the equator. A butterfly diagram (updated monthly) showing the positions of the spots for each rotation of the sun since May 1874 shows that these bands first form at mid-latitudes, widen, and then move toward the equator as each cycle progresses.

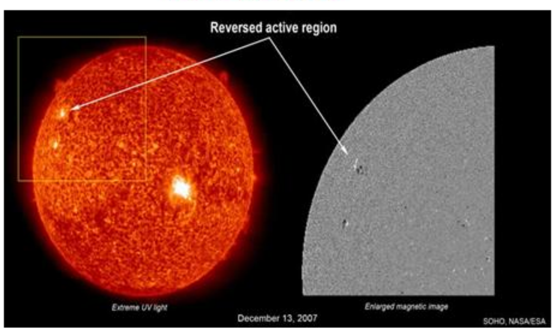


During transitions between cycles, typically the old cycle spots continue even as new cycle spots appear at higher latitude with reverse polarity. Eventually new spots overwhelm the old spots which gradually end. The latest Butterfly Diagram show the old cycle continues with very little in the way of new cycle activity

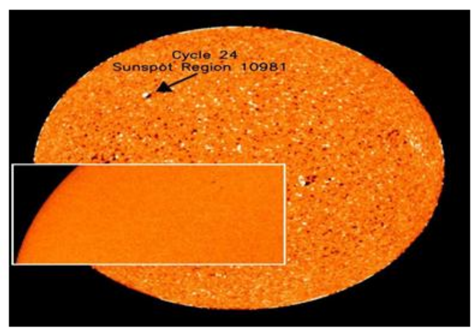


In fact there have been just four spots or pre-spot magnetic activity with characteristics of cycle 24. Meanwhile cycle 23 cycle spots continue.

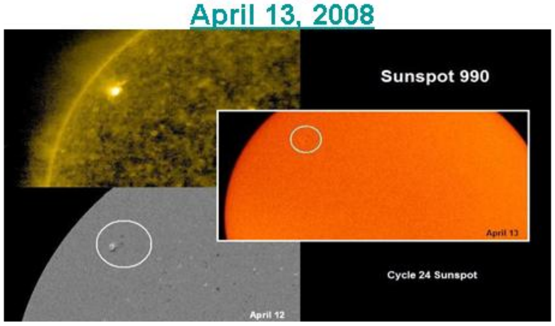
First sign of SC24. Plage Region.
Dec 13, 2007



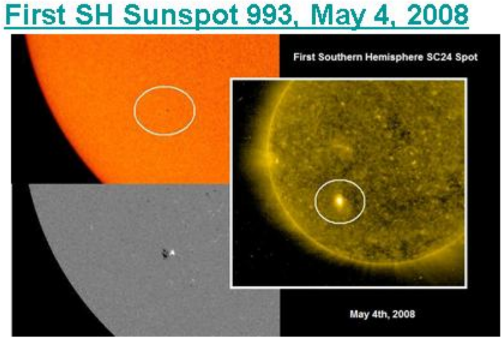
First Cycle 24 Sunspot, 981.
Jan 4, 2008.



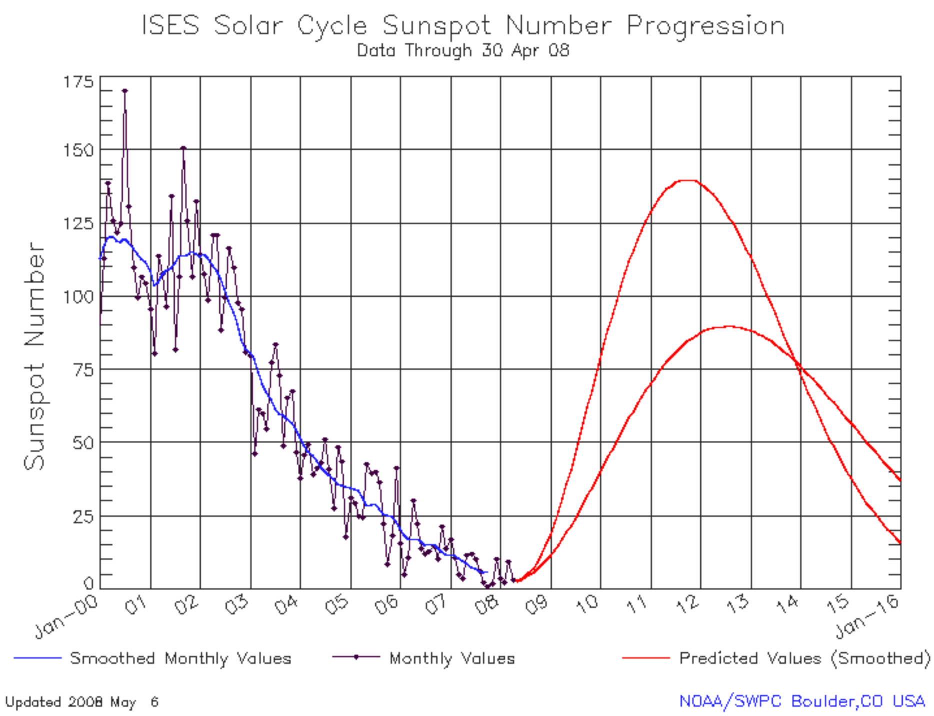
Tiny Sunspot 990.
April 13, 2008



First SH Sunspot 993, May 4, 2008

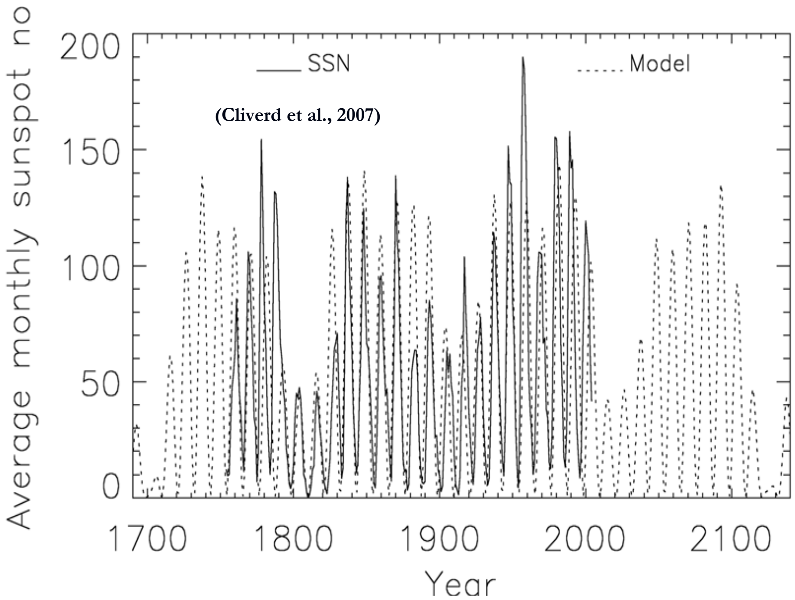


This suggests that cycle 24 may not kick in until later 2008 or even 2009. NASA led forecast team is split on how active and long the next cycle will be. See the latest forecast here.



The best forecast in recent years has been by Ken Schatten (AI Solutions) and Sabatino Sofia (Yale). That forecast requires analysis of conditions at solar minimum and since that has not clearly happened yet it is not available. Schatten has another method he has used and is projecting a quieter (SSN maximum of 80 or less) cycle 24.

Clilverd and others in 2007 did a statistical analysis of the various cycles and used their superimposition to correctly hindcast the past cycles. He projects a cycle max of around 40 for the next two cycles, similar to the Dalton Minimum 200 years ago.



Richard Mackey wrote this paper about Rhodes Fairbridge and the Idea that the Solar System Regulates the Earth's Climate in 2007. His work likewise projects cycle 24 will be quieter than 23 and that 25 and 26 will be very quiet and result in colder decades ahead

A similar finding was made by Archibald who speculates a major cooling ahead that could rival or be worse than the Dalton Minimum. In the hyperlinked paper, he even projects impact on some US locations based on historical trendlines. Such a cooling would of course further call into question the idea that greenhouse gases are behind all the changes in our climate and natural factors are now suddenly unimportant. In our recent stories, we have shown how important ENSO and the multidecadal cycles in the oceans are to temperatures. It is my belief that someday we will find proof that solar changes drive the ocean cycles which drive the land temperatures.

SUMMARY

The sun undergoes cyclical changes that appear to correlate with temperatures. The current cycle 23 appears to be the longest in at least a century and may project to quieter subsequent cycles and cooling temperatures ahead.

REFERENCES:

Clilverd, M. A., E. Clarke, T. Ulich, H. Rishbeth, and M. J. Jarvis (2006), Predicting Solar Cycle 24 and beyond, Space Weather, 4, S09005, doi:10.1029/2005SW000207.

Friis-Christensen, E., and K. Lassen, Length of the solar cycle: An indicator of solar activity closely associated with Climate Science, 254, 698-700, 1991

Labitzke, k., Van Loon, H.: Association Between the 11 Year Solar Cycle , the QBO and the Atmosphere, Part III, Aspects of the Association; Journal of Climate, June 1989, 554-565

Labitzke, K., 2001: The global signal of the 11-year sunspot cycle in the stratosphere. Differences between solar maxima and minima, Meteorol. Zeitschift, 10, 83–90.

Landscheidt, T, (2000). Solar wind near earth, indicator if variations in global temperatures in Vazquez,M. and Schmiedere, E, ed.: The solar cycle and terestrial climate, European Space Agency, Special Publication 463, pp 497-500

Mackey, Richard (2007). Rhodes Fairbridge and the idea that the solar system regulates the Earth's climate: Journal of Coastal Research, Special Issue 50, pp 955-965

Scafetta, N., and B. J. West (2007), Phenomenological reconstructions of the solar signature in the Northern Hemisphere surface temperature records since 1600, J. Geophys. Res., 112, D24S03, doi:10.1029/2007JD008437.

Shindell, D.T., D. Rind, N. Balachandran, J. Lean, and P. Lonergan, (1999). Solar cycle variability, ozone, and climate, Science, 284, 305–308

Shaviv, N. J., (2005). "On Climate Response to Changes in the Cosmic Ray Flux and Radiative Budget", JGR-Space, vol. 110, A08105.'