The Past and Future of Climate

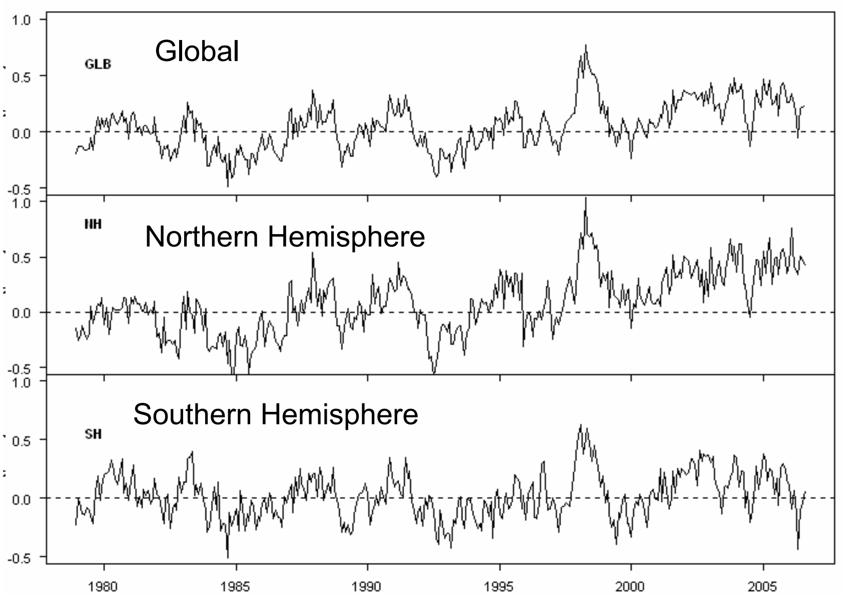
David Archibald **June, 2007**

In this presentation, I will put forward a prediction of climate to 2030 that differs from most in the public domain. It is a prediction of imminent cooling. And it is a prediction that you will be able to check up on every day.

I am going to start off by looking at the near term temperature record, and then go back successively further in time, looking at the range of temperatures in the historic record and then the geological record. Then we will examine the role of the Sun in changing climate, and following that the contribution of anthropogenic warming from carbon dioxide.

I will finish up combining a solar-driven prediction and the anthropogenic contribution to make a prediction of climate to 2030.

The 28 years of High Quality Satellite Data

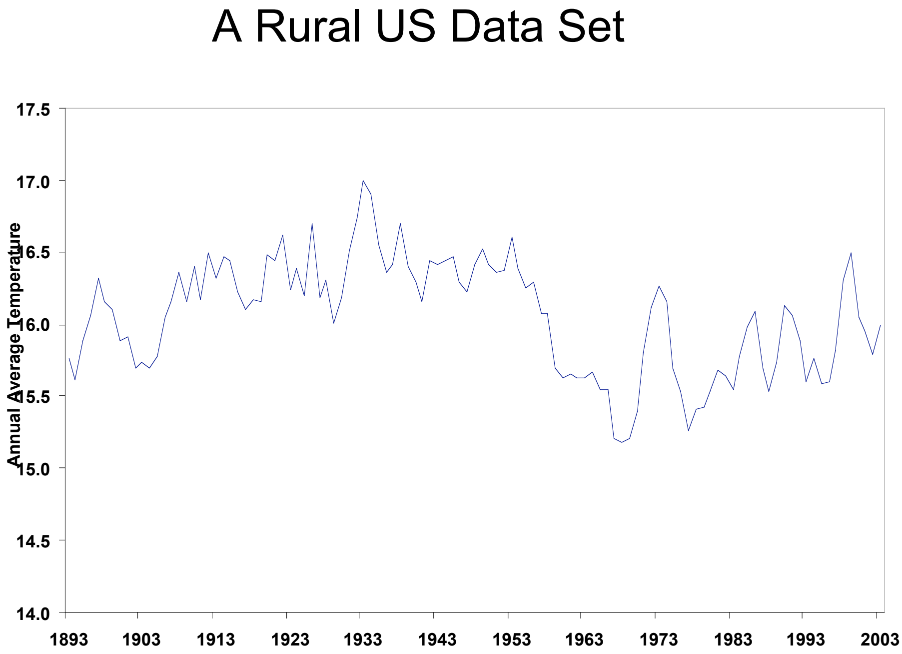


The Southern Hemisphere is the same temperature it was 28 years ago, the Northern Hemisphere has warmed slightly.

Figure 1: The Satellite Temperature Record

The satellite record is the highest quality temperature data series in the climate record. It shows that the temperature of the Southern Hemisphere has been flat, with a slight increase in the Northern Hemisphere. Note the El Nino peak in 1998.

If it doesn’t feel hotter than it was in 1980, it is because it isn’t hotter than it was in 1980.



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)

Figure 2: A Rural US Data Set

Most rural temperature records in the United States were set in the 1930s and 1940s. Greenland had its highest recorded temperatures in the 1930s and has been cooler since.

That is why it is possible to select a number of rural US temperature records and come up with a reconstruction that shows that it is cooler now than it was seventy years ago. The hottest year to date in the United States was 1936.

The 1.5° temperature decline from the late 1950s to the mid-70s was due to a weak solar cycle 20 after a strong solar cycle 19.

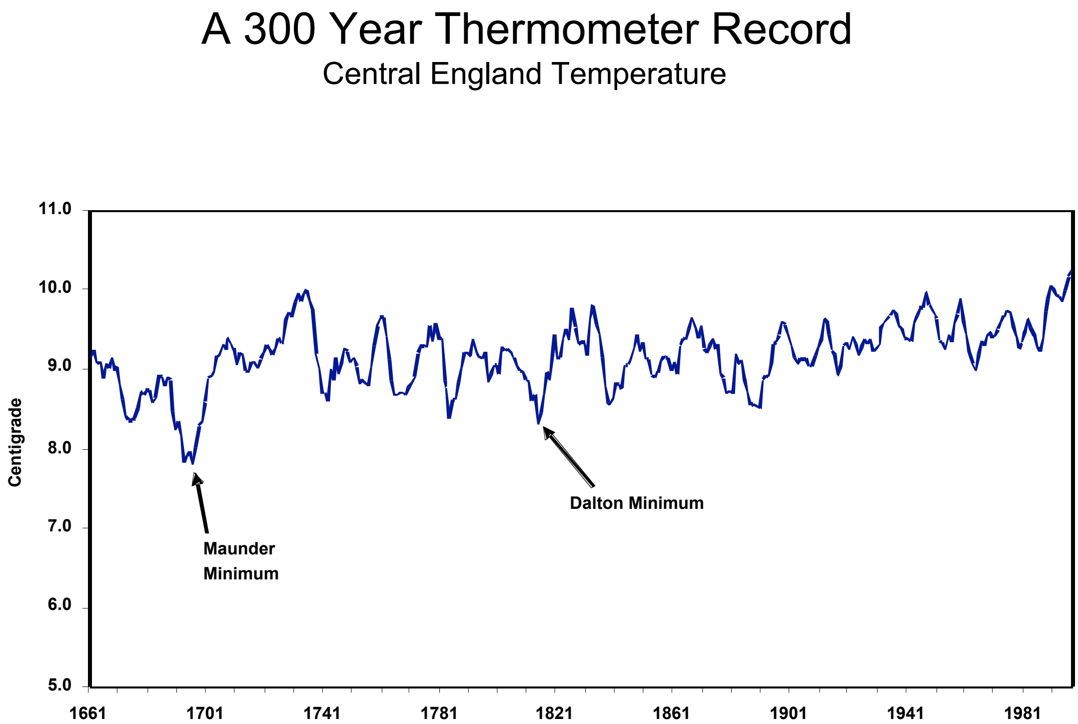


Figure 3: The Central England Temperature Record

After the invention of thermometers, temperature records started to be kept. This is one of the longest temperature series, and is actually an amalgamation of a number of sites. The recent record has been contaminated by the urban heat island effect.

A number of interesting things can be seen in this record, including the depths of the Little Ice Age in the late 17th century when the Thames regularly froze over, and the Dalton Minimum which was the last time the Thames froze over in the City of London. It last froze over upstream at Oxford in 1963.

The warm period in the 1930s and 1940s was seen in the shorter US rural data set and the rise to the El Nino in 1998. What is also interesting is the 2.2° temperature rise from 7.8° in 1696 to 10.0° in 1732. This is a 2.2° rise is 36 years. By comparison, the world has seen a 0.6° rise over the 100 years of the 20th century.

That temperature rise in the early 18th century was four times as large and three times as fast as the rise in the 20th century. The significance of this is that the world can experience very rapid temperature swings all due to natural causes.

The temperature peak of 10° wasn't reached again until 1947.

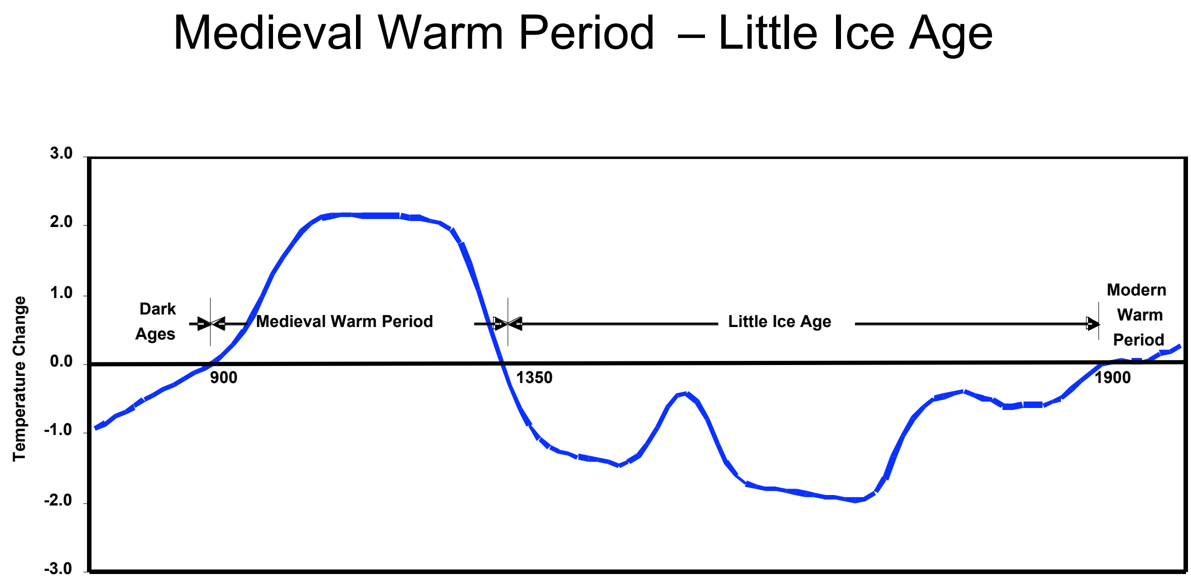


Figure 4: Medieval Warm Period – Little Ice Age

To reconstruct climate prior to thermometer records, isotope ratios and tree ring widths are used. This graph shows the Medieval Warm Period and Little Ice Age. The peak of the Medieval Warm Period was 2° warmer than today and the Little Ice Age 2° colder at its worst. The total range is 4° centigrade.

The warming over the 20th century was 0.6 degrees by comparison. This recent warming has melted ice on some high passes in the Swiss Alps, uncovering artifacts from the Medieval Warm Period and the prior Roman Warm Period.

IPCC Chart

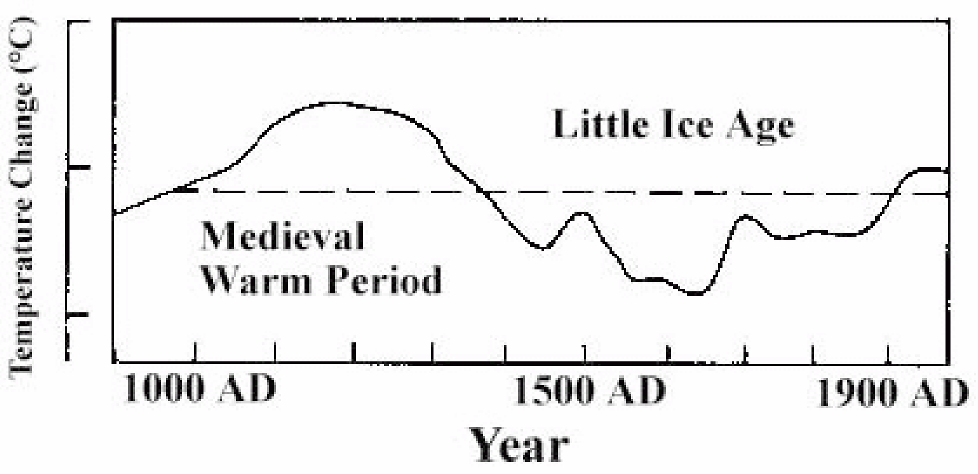
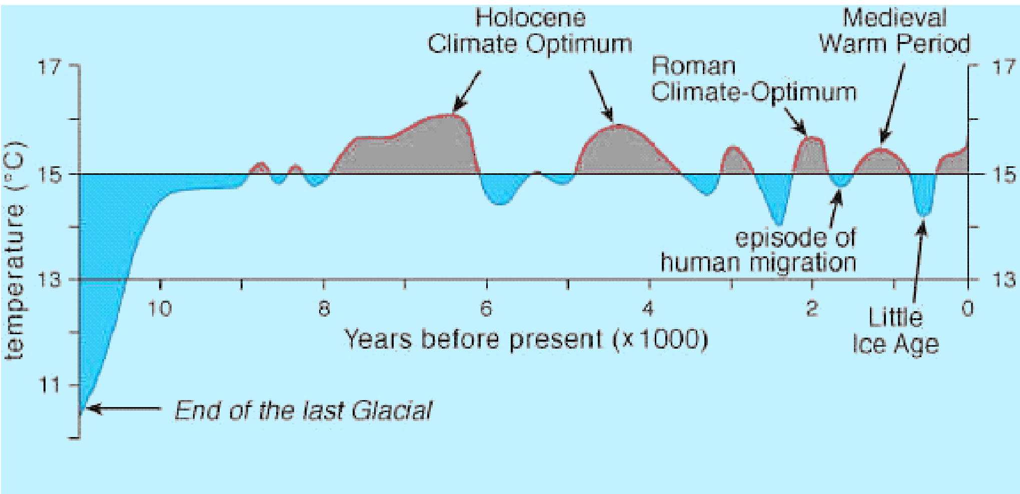


Figure 5: 1990 IPCC Chart of the Medieval Warm Period – Little Ice Age

The previous graph is derived from this graph produced in the 1990 report of the Intergovernmental Panel on Climate Change. The Medieval Warm Period has become inconvenient to the IPCC, so they haven't mentioned it since.

The Holocene Optimum



Average near-surface temperatures of the northern hemispere during the past 11.000 years (after Dansgaard et al., 1969, and Schönwiese, 1995)

Figure 6: The Holocene Optimum

It was warmer again not long after the last ice age ended. Sea level was 2 metres higher than it is today. Since the Holocene Optimum, we have been in long term temperature decline at about 0.25° per thousand years.

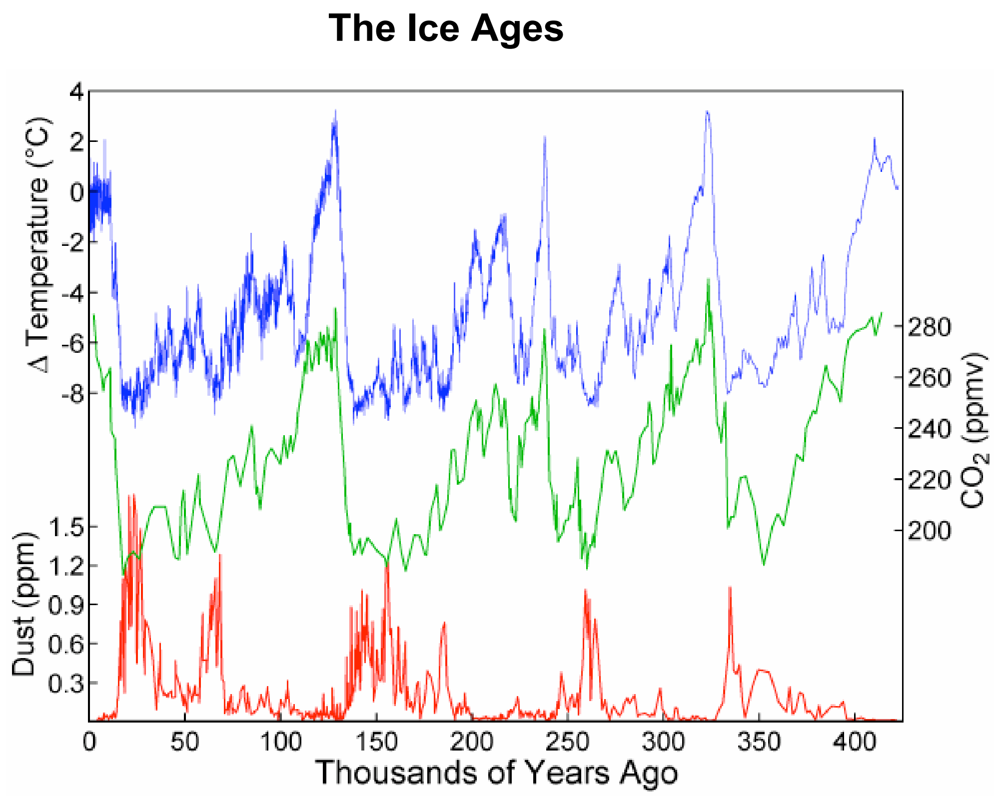


Figure 7: The Last Four Ice Ages

The last three million years have seen extreme fluctuations in temperature at mid to high latitudes. This graph shows the last 400,000 years of data. The temperature range from top to bottom is 10° centigrade. Note that the carbon dioxide level lags temperature by about 800 years.

Also interesting is the amount of dust. Colder is drier and warmer is wetter, generally. Large areas of Australia are covered by sand dunes that formed in these ice ages and are now stabilised by vegetation.

We are currently in an interglacial that has lasted 10,000 years to date. You can see from this graph that interglacials are usually much shorter than that, so the next ice age is overdue.

Ice Ages – The Longer Term Record

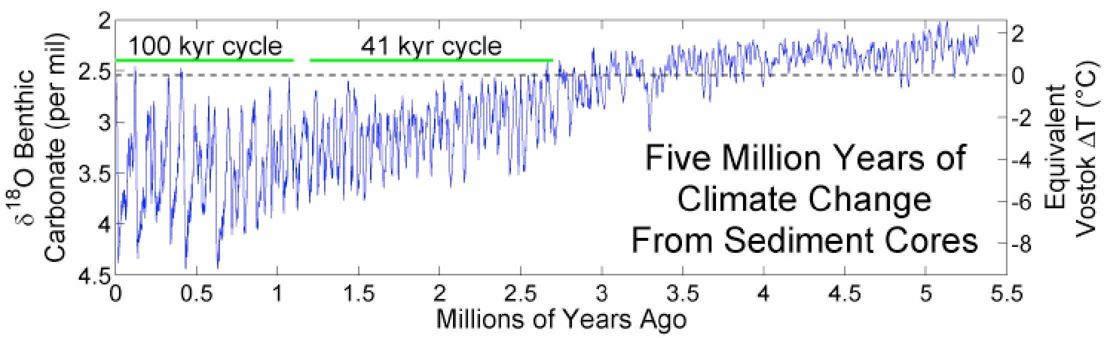


Figure 8: Ice Ages over the last 5.5 million years

Ice ages started about 3 million years ago, initially with a 41,000 year cycle and then with a 100,000 year cycle.

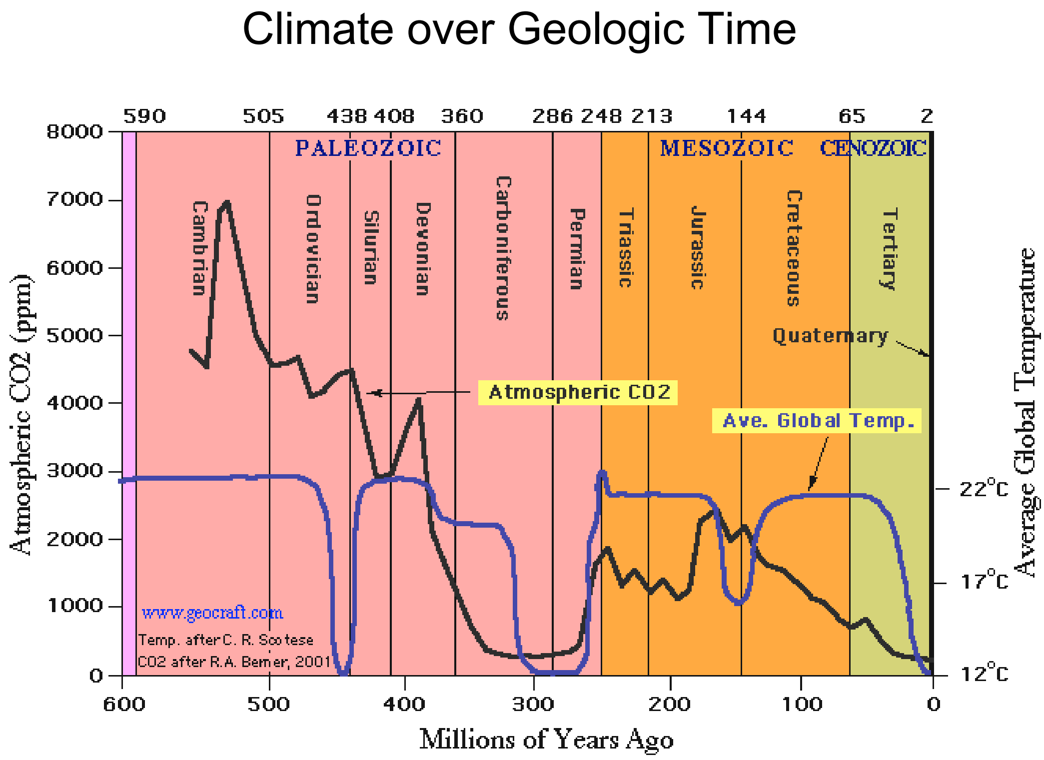


Figure 9: Climate over Geologic Time

For most of the last 600 million years, the Earth's climate has been steady at an average temperature of 22°, apart from periods of ice ages. Ice ages have occurred roughly 140 million years apart, driven by the Sun's position in the spiral arms of the Milky Way galaxy.

What this graph shows is there is no correlation in the geologic record between atmospheric carbon dioxide and global temperature. The Earth went into an ice age 450 million years ago despite a level of atmospheric carbon dioxide that is ten times what it is today. 150 million years ago, atmospheric carbon dioxide levels were five times what they are today, but that didn't stop a Cretaceous-aged glaciation.

Later in this presentation we will see why carbon dioxide would not be expected to have had any influence on global temperature over geologic time.

Before we leave this graph, I should mention that the proponents of Anthropogenic Global Warming state that higher atmospheric carbon dioxide levels will cause the oceans to become more acidic which will kill off coral reefs and other types of marine life. Coral reefs first formed back in the Devonian period when atmospheric carbon dioxide levels were ten times what they are today.

The Solar Driver

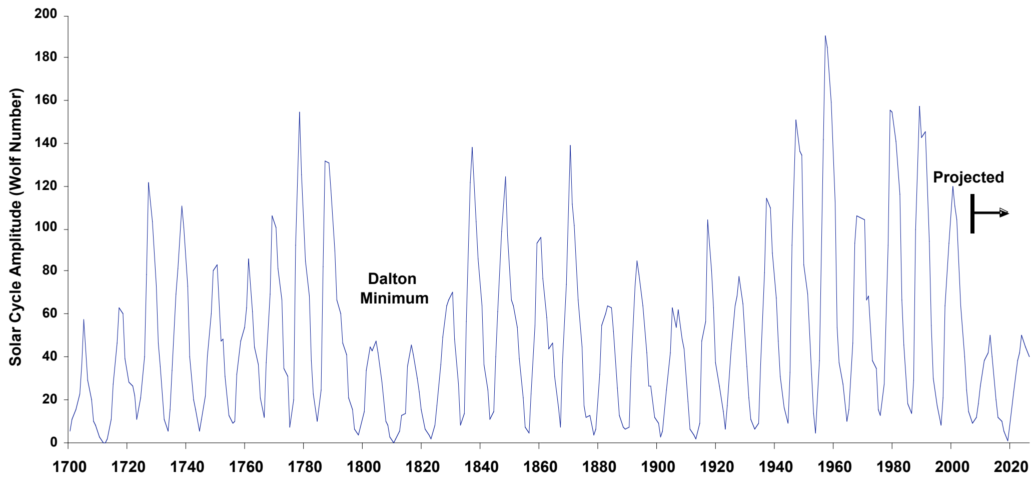


Figure 10: Sunspot Cycles 1700 - 2030

The energy that stops the Earth from looking like Pluto comes from the Sun, and the level of this energy does change. This graph is of sunspot cycles since 1700. The average length of a sunspot cycle is 10.7 years. The Dalton Minimum is a period of lower temperatures from 1796 to 1820 caused by the low amplitude of solar cycles 4 and 5.

We are currently near the end of solar cycle 23. When solar cycle 23 ends is very important, as we will see in the next few graphs.

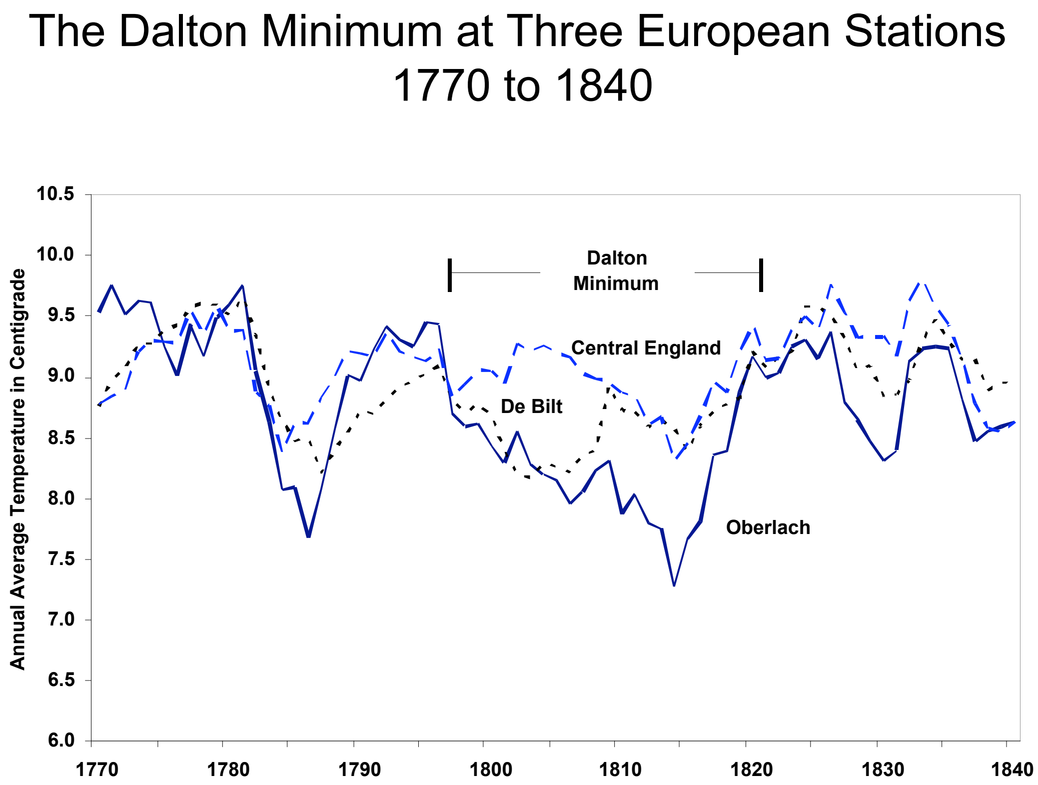


Figure 11: The Dalton Minimum in Europe

This graph shows the temperature response to solar cycles 5 and 6 at three European stations. There was a 2° decline at Oberlach in Germany over that period.

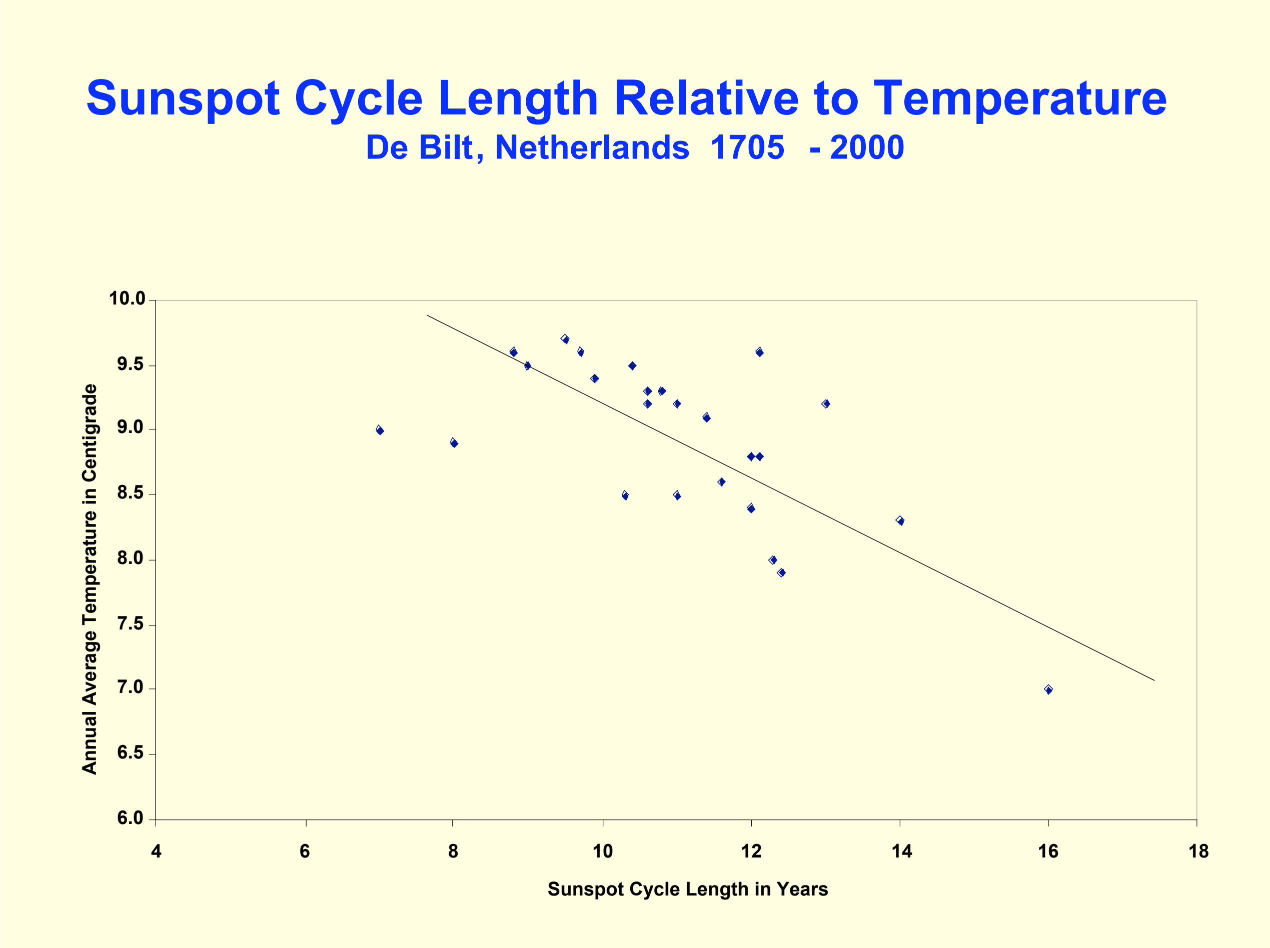


Figure 12: Sunspot Cycle Length Relative to Temperature – De Bilt

There is a better correlation between temperature and solar cycle length, rather than with solar cycle amplitude. I produced this graph using data from De Bilt in the Netherlands. The slope of the line is 0.6 degrees centigrade per year of solar cycle length. The average length of a solar cycle over the last few hundred years is 10.7 years.

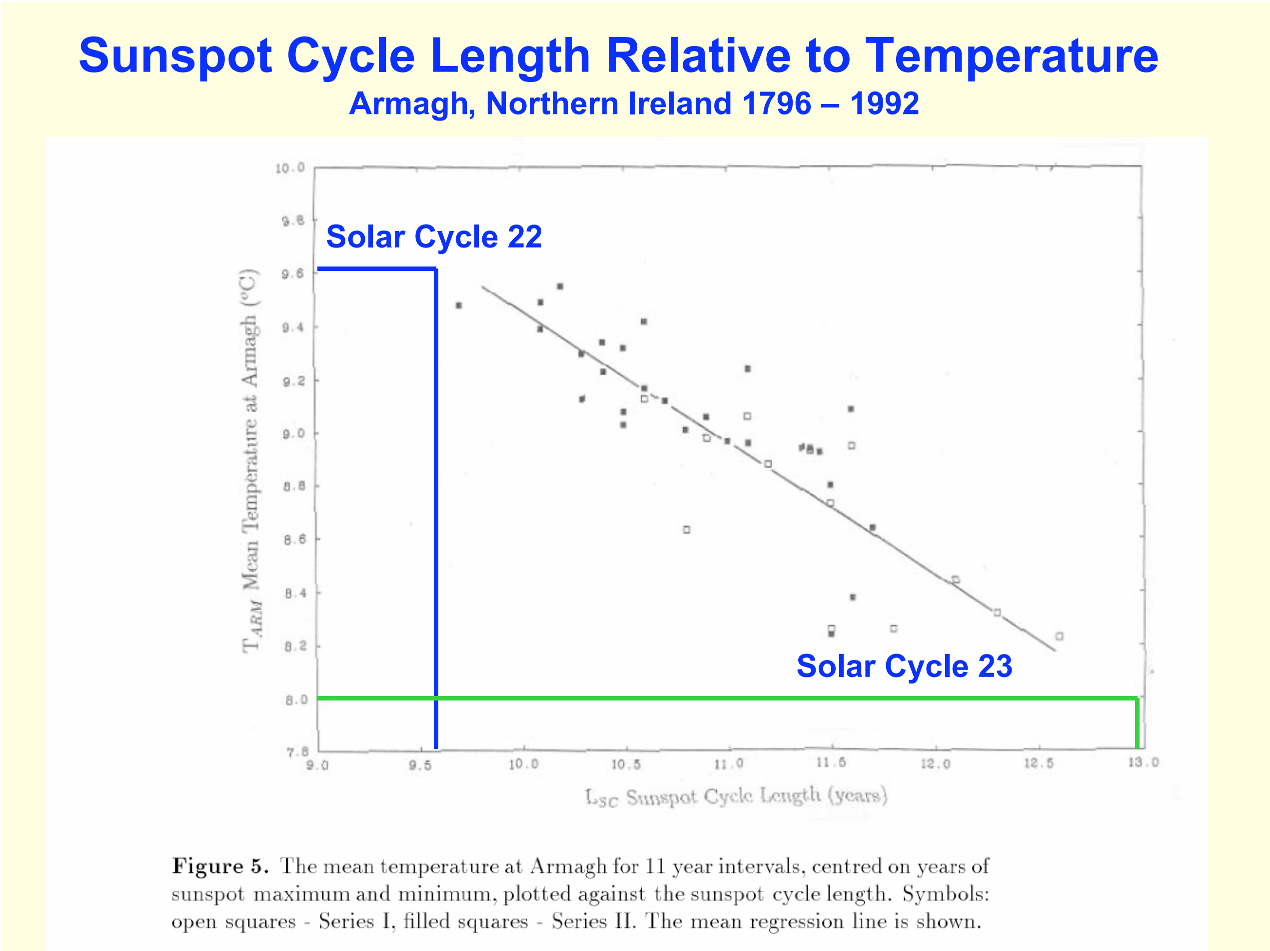


Figure 13: Sunspot Cycle Length Relative to Temperature – Armagh

A strong relationship between solar cycle length and temperature is seen in other data sets. This is a figure from a 1996 paper by Butler and Johnson of the Armagh observatory. The slope of the line is half a degree centigrade per one year change in solar cycle length, which amounts to 1.4 thousands of a degree per day.

Let's assume that the relationship demonstrated in nearly 200 years of Armagh data, and 300 years of De Bilt data, is valid today. I have plotted on top of the original figure solar cycle 22, which was 9.6 years long. Solar cycle 23 hasn't finished yet. If it was an average cycle length of 10.7 years, it would have finished in January 2007. It is now mid-2007. As we haven't seen the first sunspot from solar cycle 24 yet, solar cycle 23 will be at least 12 years long. If it is 12 years long, it follows that the temperature at Armagh will be 1.2 degrees lower.

If solar cycle 24 is as weak as a number of solar physicists are predicting, then solar cycle 23 is likely to be 13 years long, or longer. Solar cycle 4, preceding the Dalton Minimum, was 13.6 years long.

I have plotted on this figure what a 13 year long solar cycle 23 would look like. It would result in a 1.6 degree decline in temperature. This effect is upon us right now. In a few short years, we will have a reversal of the warming of the 20th century.

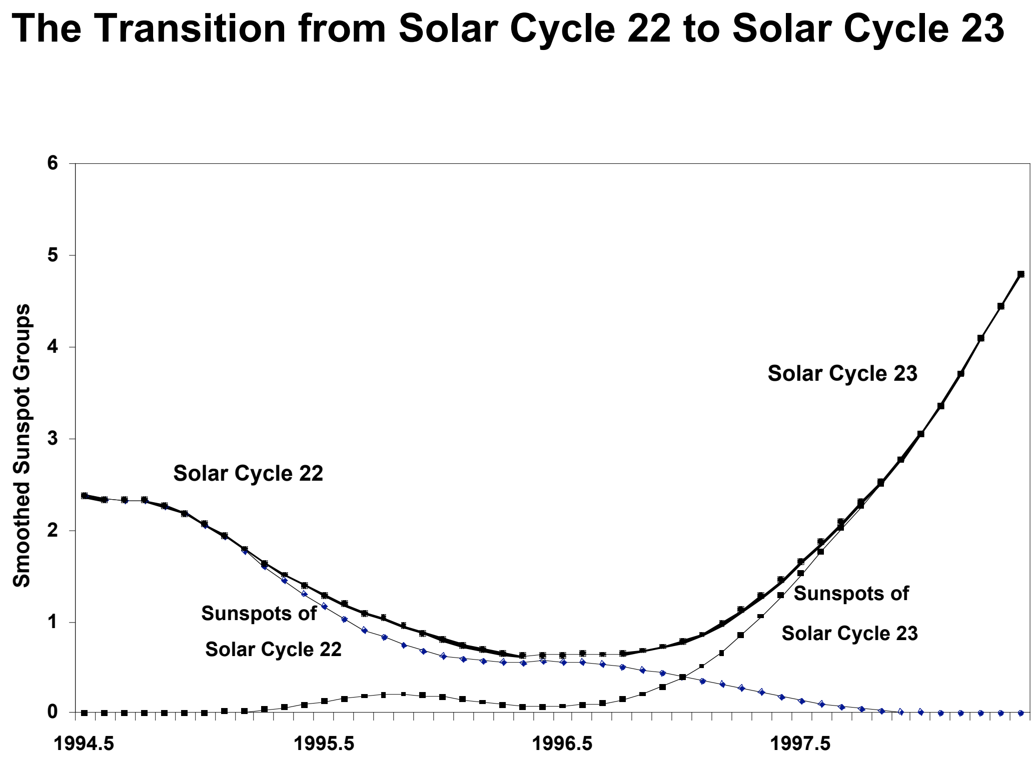


Figure 14: The Transition from Solar Cycle 22 to Solar Cycle 23

This graph shows the transition of one sunspot cycle to the next, using the example of the solar cycle 22 to solar cycle 23 transition.

The sun reverses magnetic polarity with each solar cycle, and sunspots of the new cycle start forming before the old cycle has completely died off. The average length of a solar cycle is 10.7 years. Solar Cycle 23 started in May 1996, rising to a peak of 120.9 in April 2000. For Solar Cycle 23 to be of average length, Solar Cycle 24 should have started in January 2007.

The first sunspots of a new solar cycle appear usually at more than 20° latitude on the Sun's surface. According to the last couple of solar cycles, the first sunspots appear twelve to twenty months prior to the start of the new cycle. Apart from a few spotless magnetic dipoles, there have not been any reversed polarity sunspots with a latitude of more than 20° to the date of this paper. This means that Solar Cycle 24 is at least one year away, or the observational rule is wrong.

Large solar cycles usually arrive early and small solar cycles late. If the observation rule regarding the relationship between first sunspot of the new solar cycle and timing of solar minimum holds, then Solar Cycle 23 will be at least twelve years long. It also follows that the longer the delay to the month of solar minimum, the weaker the amplitude of Solar Cycle 24 is likely to be.

Solar cycle 4, which preceded the Dalton Minimum, was 13.6 years long.

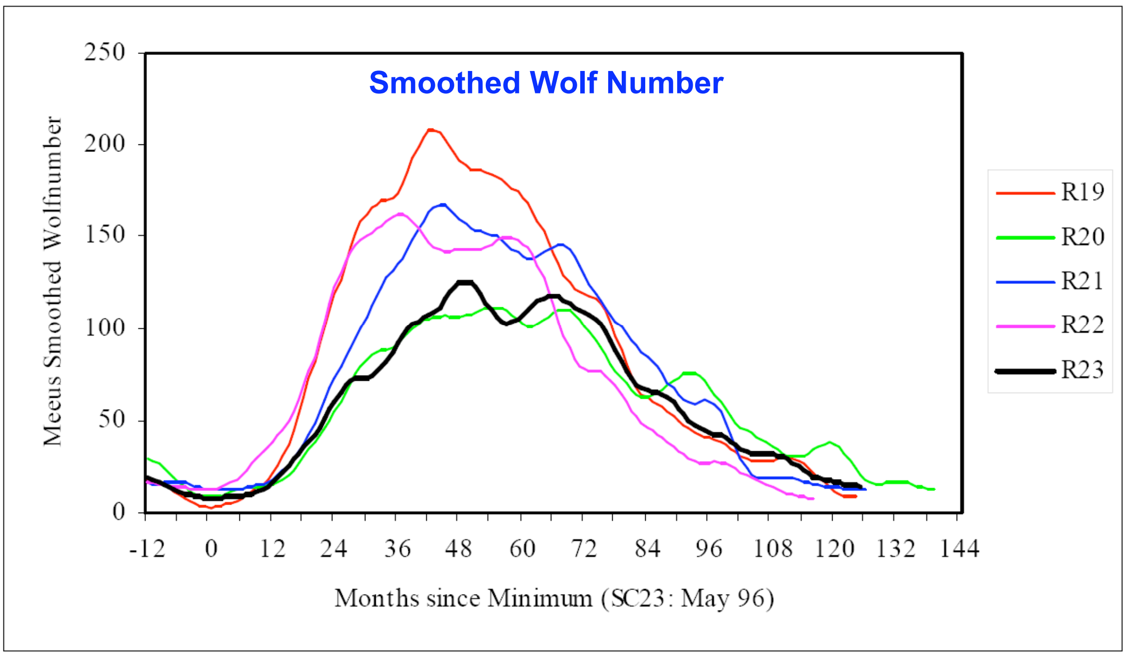
I said at the beginning of this presentation that you can check up on my prediction of imminent cooling every day. And you can do that thanks to amateur radio enthusiasts. They need an active sun with a lot of solar wind to get long distance propagation. A good amateur radio website is www.solarcycle24.com. It updates every six minutes.

By my calculations, every day's delay in the onset of solar cycle 24 will lower the average temperature over that cycle by 1.4 thousandths of a degree centigrade. We are already delayed by a year so that will translate to a 0.5° decline.

Also by my calculations, a 1 ppm increase in atmospheric carbon dioxide increases temperature by one thousandth of a degree. So it only takes two days' delay in the onset of Solar Cycle 24 to offset the increased temperature due to one year's emissions of carbon dioxide.

If Solar Cycle 23 is the same length as Solar Cycle 4, the solar cycle that preceded the Dalton Minimum, then solar minimum won't be reached until November 2010, and we may not see sunspots from Solar Cycle 24 until November 2009.

Every day's delay until the first sunspots of Solar Cycle 24 will mean that the Earth's climate will be harsher in the second decade of the 21st century.



Source: Jan Janssens, Belgian Solar Section

Figure 15: Progression of Solar Cycles 19 - 23

This graph shows the progression of the five last cycles. Solar cycles rise much faster than they fall. Longer cycles are weaker, and solar cycle 20, which is the green line, is longer than the others. This is the solar cycle that caused the 70s cooling scare.

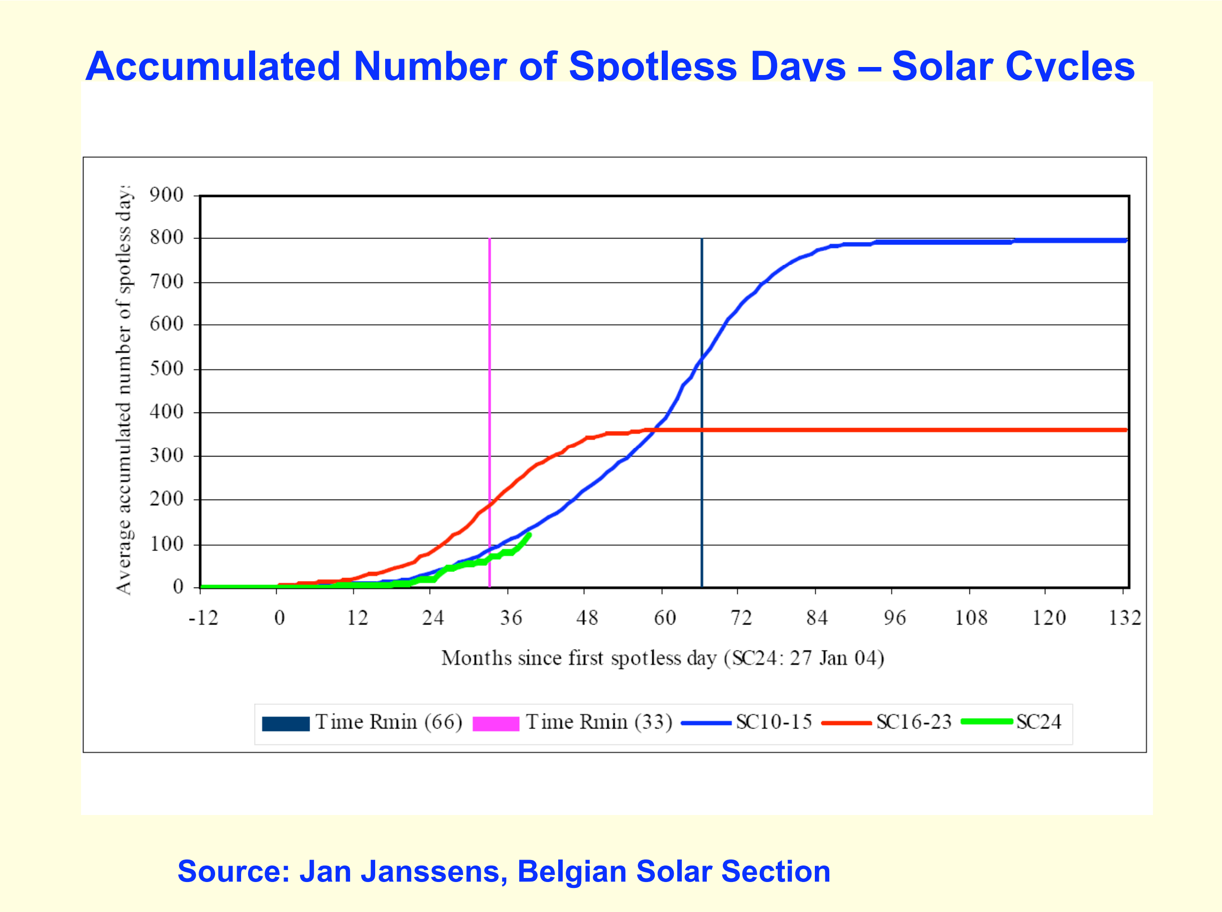


Figure 16: Accumulated Number of Spotless Days

This graph is another pointer that we are heading back to the weak solar cycles of the 19th century, with 19th century type winters to accompany them.

Solar cycles 10 to 15, from 1860 to 1917, had an average of 66 months from the first spotless day to solar cycle minimum. This was a time of considerable glacial advance in the European Alps. Since then, solar cycles have averaged half that at 33 months from first spotless day to solar cycle minimum.

So far, solar cycle 24 is plotting on the 19th century line. With the first spotless day on 27th January, 2004, and if the 66 month observation holds, then solar minimum will be on or about July 2009. This would make solar cycle 23 thirteen years long.

NASA's Solar Minimum Prediction

- **March, 2008** (±6 months)
  - Marks the end of Cycle 23 and start of Cycle 24
  - The length of Cycle 23 will then be 11.75 years
- due to the absence of expected signatures of minimum -like conditions in March, 2007
  - no high-latitude sunspots yet observed with the Cycle 24 polarity
  - the large scale corona has not yet relaxed to a simple dipole
  - the heliospheric current sheet has not yet flattened
  - activity measures, *e.g.* cosmic ray flux, radio flux, and sunspot number, have not yet reached typical solar minimum values

Released on 25th April, 2007

NASA really don't know, but as they are supposed to know, they have to say something.

Source: http://www.sec.noaa.gov/SolarCycle/SC24/Biesecker.ppt

Figure 17: NASA's Solar Minimum Prediction

NASA are supposed to know about solar cycles. They have hedged their bets by making two predictions about the amplitude of solar cycle 24, straddling the solar cycle 23 result. The predictions are 140 and 90.

I have included this graph because it has NASA stating that the expected signatures of solar cycle minimum have not been seen yet.

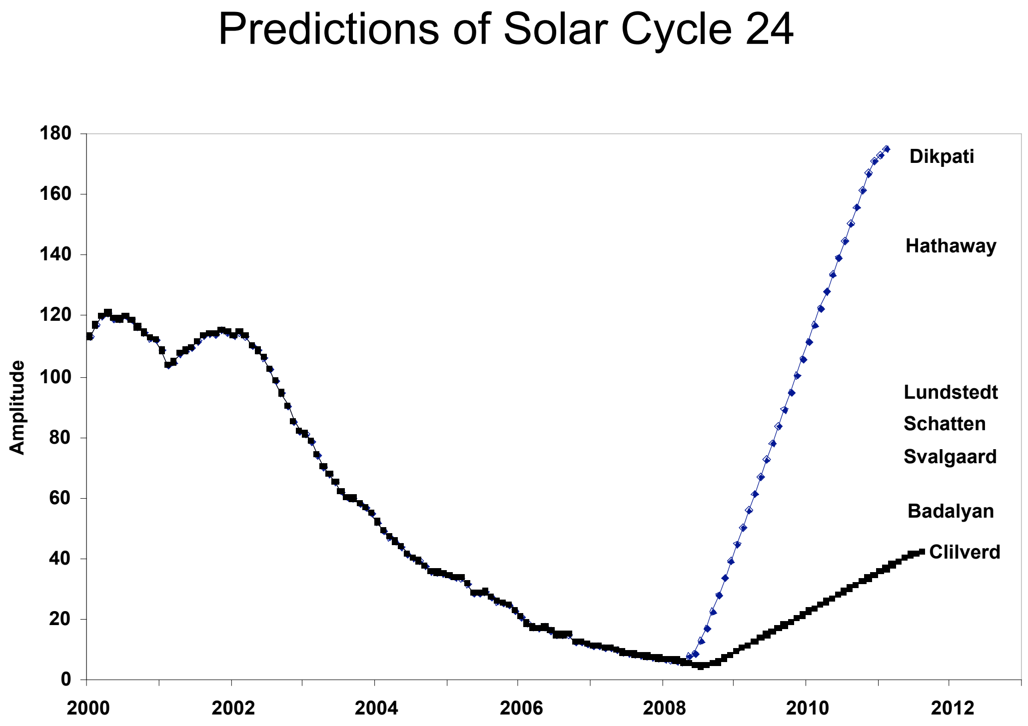


Figure 18: Predictions of Solar Cycle 24

This is a very significant graph. There are currently some 24 published prediction of the amplitude of solar cycle 24. I have chosen seven of these to illustrate the current range of predictions. All of these predictions are by well regarded researchers. The significance comes from the fact that the highest prediction will result in a temperature some 2° higher than the temperature from the lowest prediction.

If the lowest prediction is borne out, this will have a large and negative effect on Canadian grain production, for example, and on all high latitude agricultural production. The experience from the Dalton Minimum was that the winters were longer and harder. And this effect will be on us very soon.

The Solar Dynamo Index

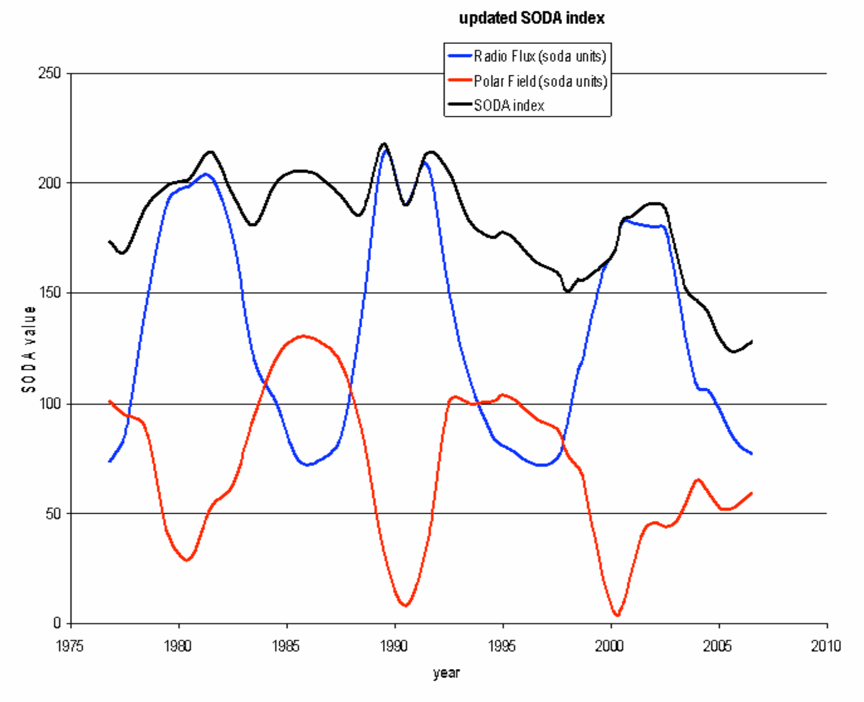


Figure 19: The Solar Dynamo Index 1975 - 2006

This is the basis of Ken Schatten's prediction. The red line is the strength of the polar magnetic fields on the Sun and the blue line is the strength of the toroidal magnetic fields. During a sunspot cycle, polar magnetic fields are converted to toroidal magnetic fields and back again. Sunspots form from the toroidal magnetic fields breaking through to the Sun's surface. The black line sums the polar and toroidal magnetic field strengths. This has been in downtrend since the early 1990s.

This downtrend means that there is much less magnetic force available to make sunspots, so solar cycle 24 will be much weaker than solar cycle 23.

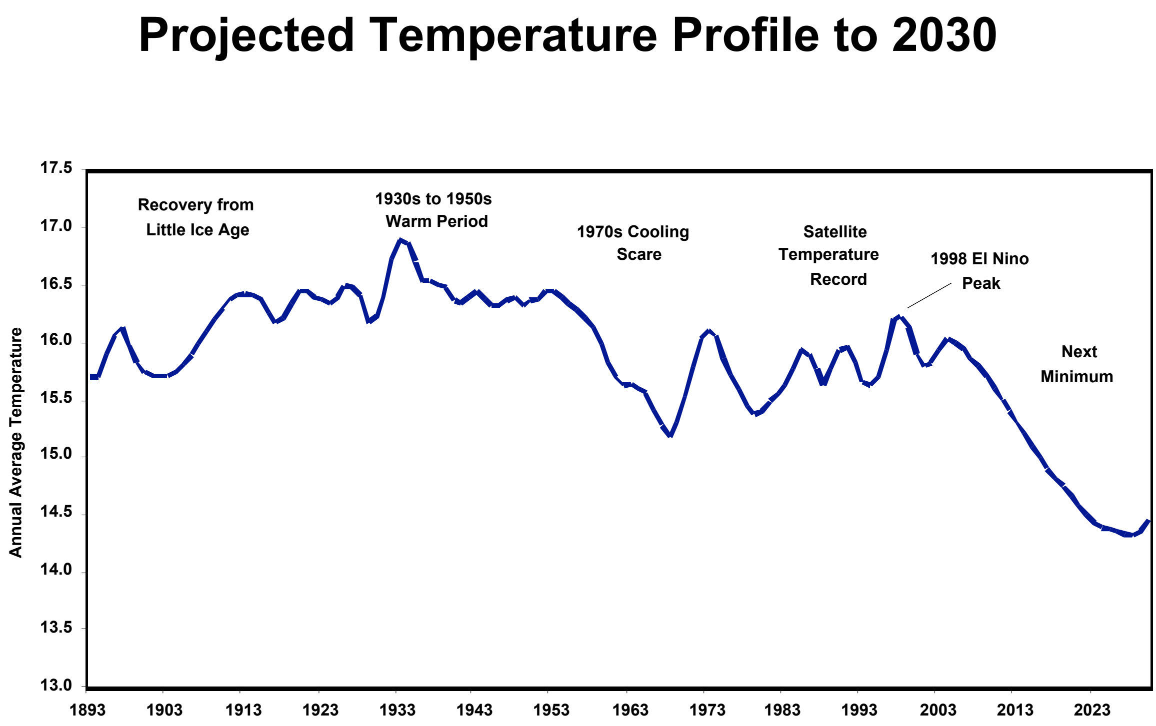


Figure 20: Projected Temperature Profile to 2030

Combining the rural US data set we saw earlier and the project temperature response to weak solar cycles 24 and 25, this graph shows the expected decline to 2030.

The temperature decline will be as steep as that of the 1970s cooling scare, but will go on for longer.

Another Dalton Minimum, or Worse?

"The surprising result of these long-range predictions is 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."

K.H.Schatten and W.K.Tobiska , 34th Solar Physics Division Meeting, June 2003, American Astronomical Society

Figure 21: Potential for another Maunder Minimum

It can get worse than a repeat of the Dalton Minimum. Ken Schatten is the solar physicist with the best track record in predicting solar cycles.

His work suggests a return to the advancing glaciers and delayed spring snow melt of the Little Ice Age, for an indeterminate period.

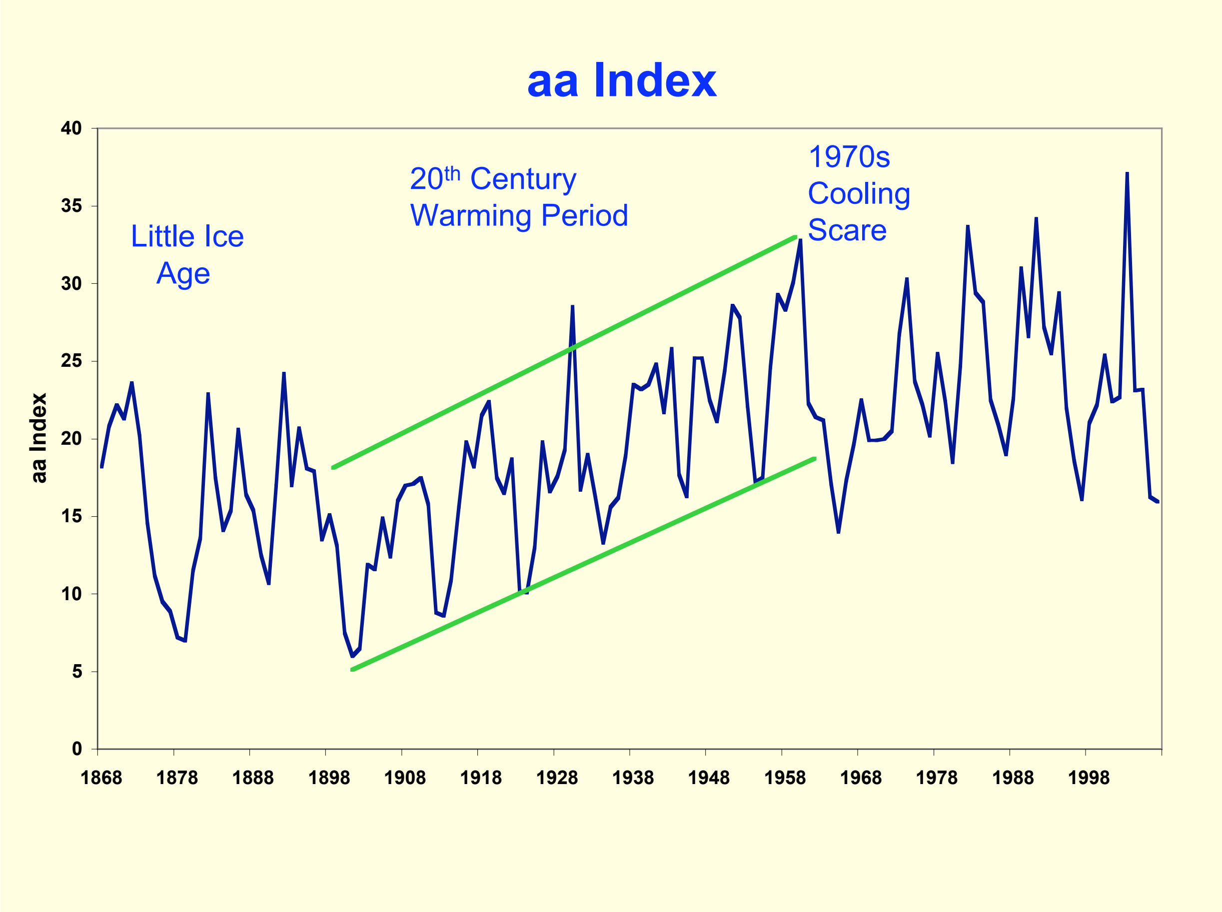


Figure 22: aa Index

I would be doing you a disservice if I left you with the impression that sunspots and solar cycles were the only manifestations of varying solar activity.

This is a graph of the aa Index, which is generated by the solar coronal magnetic field strength. The aa Index was first measured in 1868 when the Earth was still in the Little Ice Age.

The long term increase in the aa Index in the 20th century is seen and corresponds to the warming of the 20th century. The 70s cooling scare corresponds to a break in the uptrend of the aa Index. Post that, the record is flat corresponding to the satellite temperature record.

What is of interest is what is happening right now. 2006 and 2007 are two years of low values as opposed to the normal one year over the past three cycles, and we are still two years off solar minimum.

In the fullness of time, it might be demonstrated that the aa Index is more important than solar cycle amplitude in predicting the Earth's climate, but solar physicists don't predict aa Index and they do predict solar cycle amplitude.

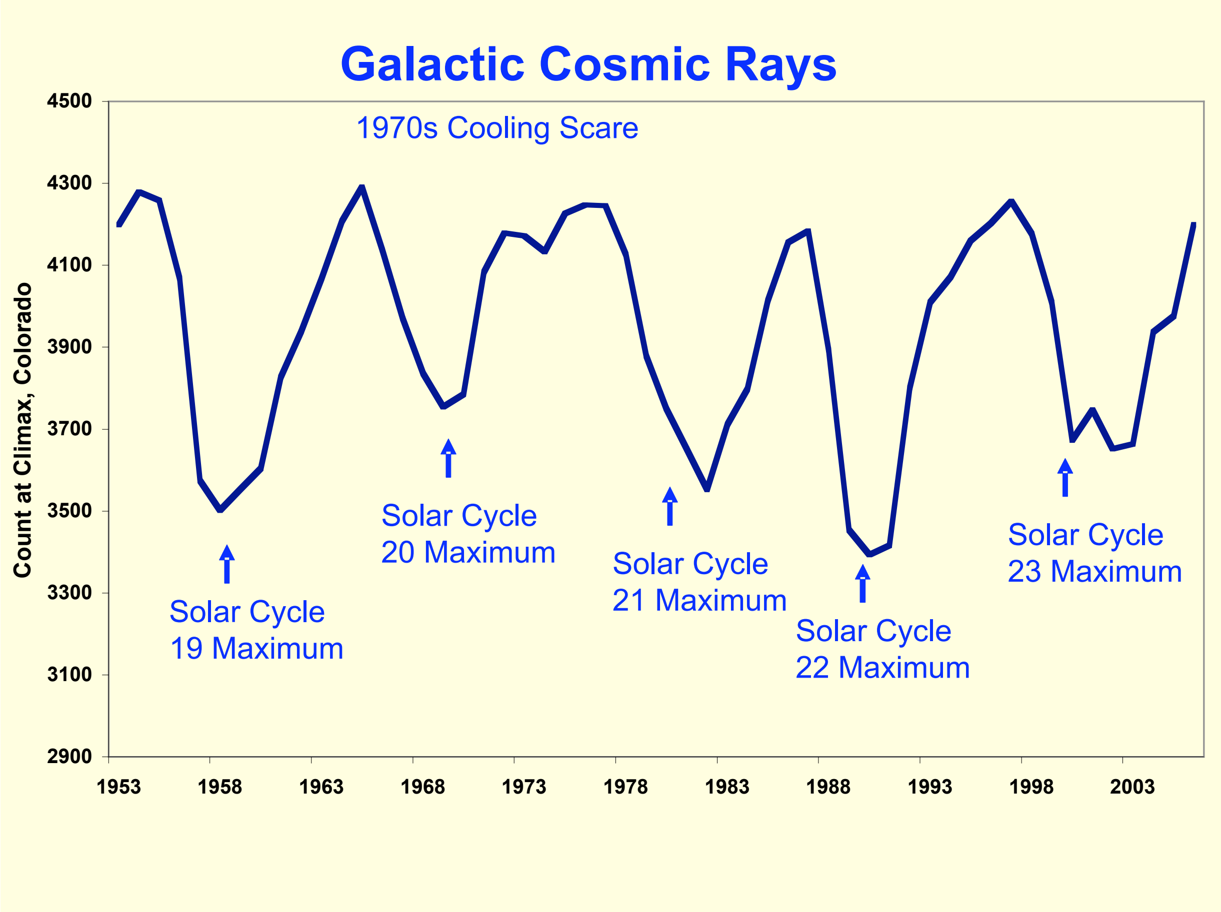


Figure 23: Galactic Cosmic Rays

One Earthly manifestation of the changing geomagnetic index is the galactic cosmic ray count. This is the count at Boulder, Colorado since measurements were first made in 1953.

A strong geomagnetic index deflects galactic cosmic rays from the inner part of the solar system.

Work by Danish researchers has demonstrated a connection between galactic cosmic rays and low level cloud formation. Clouds have an albedo of 60, and thus are more reflective than ocean or ground. The more clouds there are, the more reflective the Earth is, and the lower the temperature. This theory also explains why Antarctica has cooled since the early 1980s. Snow and ice has an albedo of 80, and thus is more reflective than clouds. Less cloud over Antarctica makes it colder.

The 1970s cooling scare coincided with a higher count at solar cycle maximum and an extended period of higher annual counts at the following minimum.

The galactic cosmic ray and low level cloud connection is powerful enough to do anything required of it.

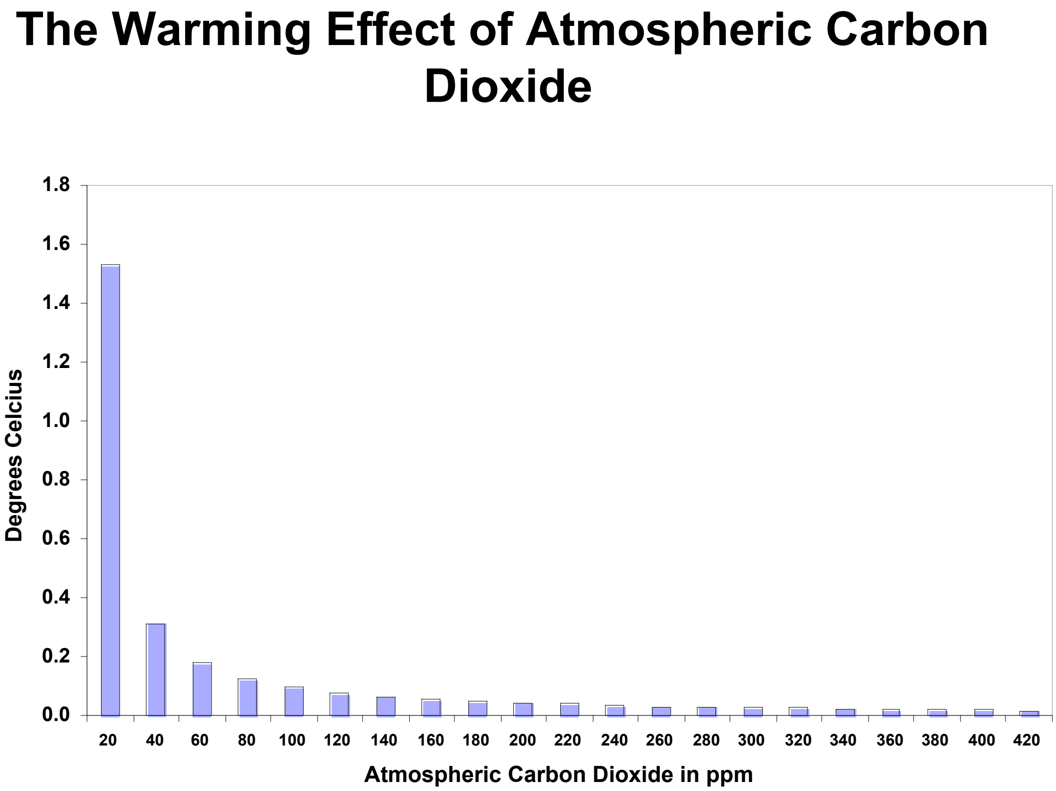


Figure 24: The Warming Effect of Carbon Dioxide

Anthropogenic warming is real, it is also miniscule. Using the MODTRAN facility maintained by the University of Chicago, the relationship between atmospheric carbon dioxide content and increase in average global atmospheric temperature is shown in this graph.

The effect of carbon dioxide on temperature is logarithmic and thus climate sensitivity decreases with increasing concentration. The first 20 ppm of carbon dioxide has a greater temperature effect than the next 400 ppm. The rate of annual increase in atmospheric carbon dioxide over the last 30 years has averaged 1.7 ppm.

From the current level of 380 ppm, it is projected to rise to 420 ppm by 2030. The projected 40 ppm increase reduces emission from the stratosphere to space from 279.6 watts/m2 to 279.2 watts/m2.

Using the temperature response demonstrated by Idso (1998) of 0.1°C per watt/m2, this difference of 0.4 watts/m2 equates to an increase in atmospheric temperature of 0.04°C. Increasing the carbon dioxide content by a further 200 ppm to 620 ppm, projected by 2150, results in a further 0.16°C increase in atmospheric temperature.

Since the beginning of the Industrial Revolution, increased atmospheric carbon dioxide has increased the temperature of the atmosphere by 0.1°.

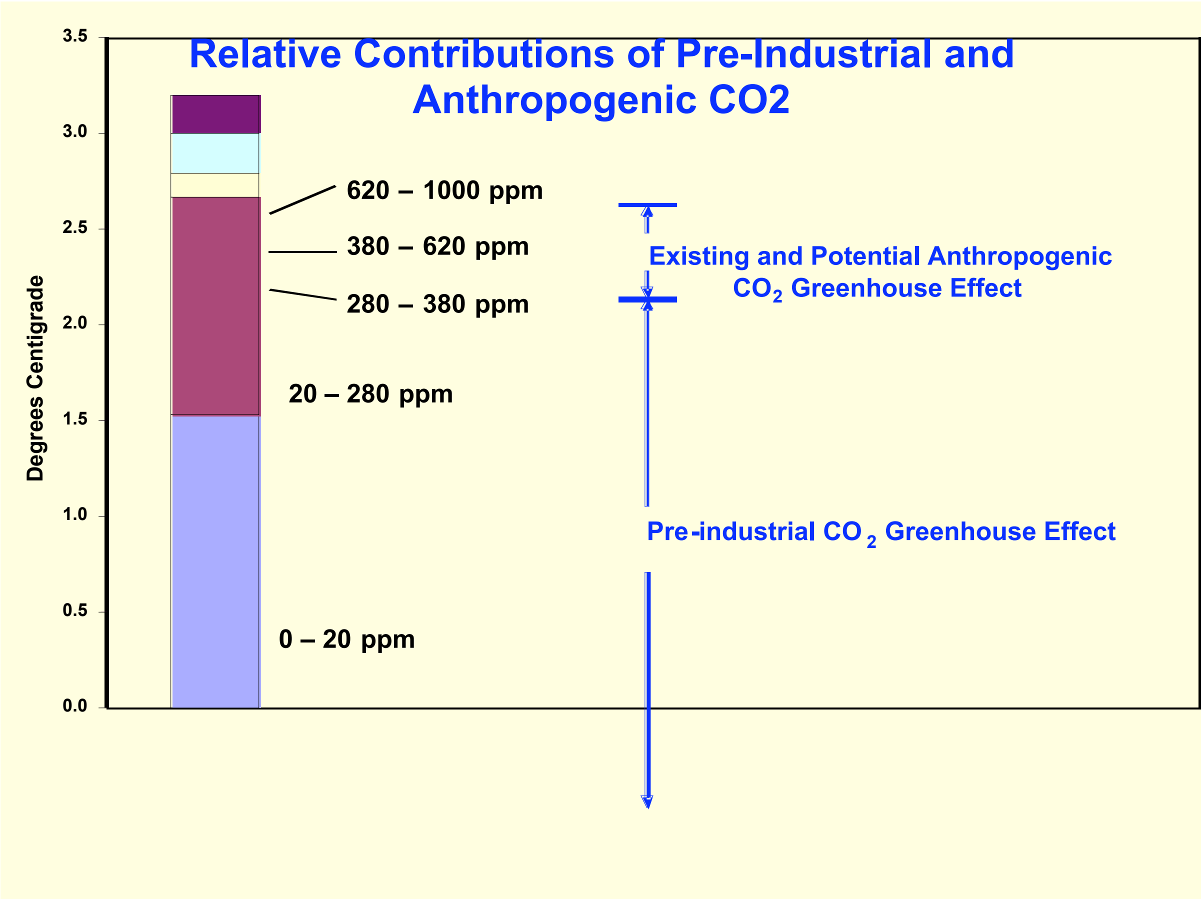


Figure 25: Relative Contributions of Pre-Industrial and Anthropogenic CO2

This graph takes the data from the previous slide, illustrating the logarithmic effect, and condenses it down to one bar. Anthropogenic carbon dioxide is calculated to have contributed 0.1 of a degree to date.

The entire anthropogenic effect is good for about 0.4 degrees.

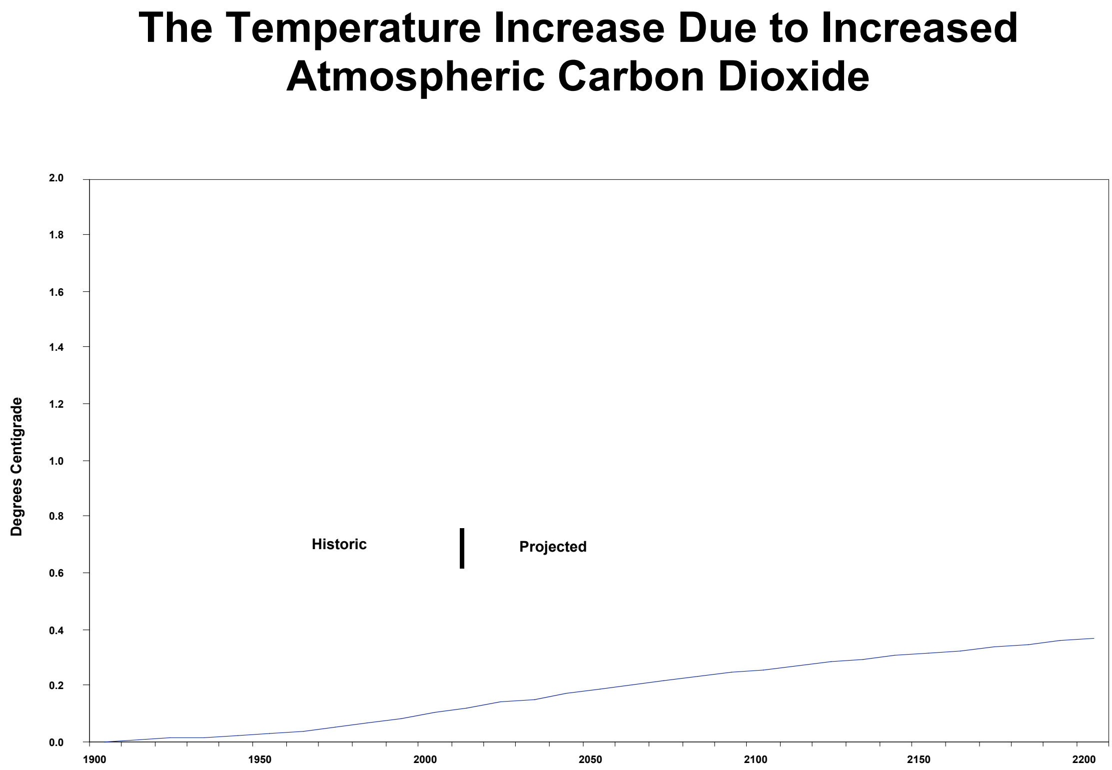


Figure 26: Atmospheric Temperature Increase due to Carbon Dioxide 1900 - 2200

This graph shows the calculated contribution of the carbon dioxide effect to atmospheric temperature over the three hundred years from 1900 to 2200.

It has been 0.1° to date and over the next two hundred years will amount to 0.4° in total. It is scaled against the 2° temperature range experienced in the 20th century. The graph assumes that atmospheric carbon dioxide will continue to increase at 1.7 parts per million per annum.

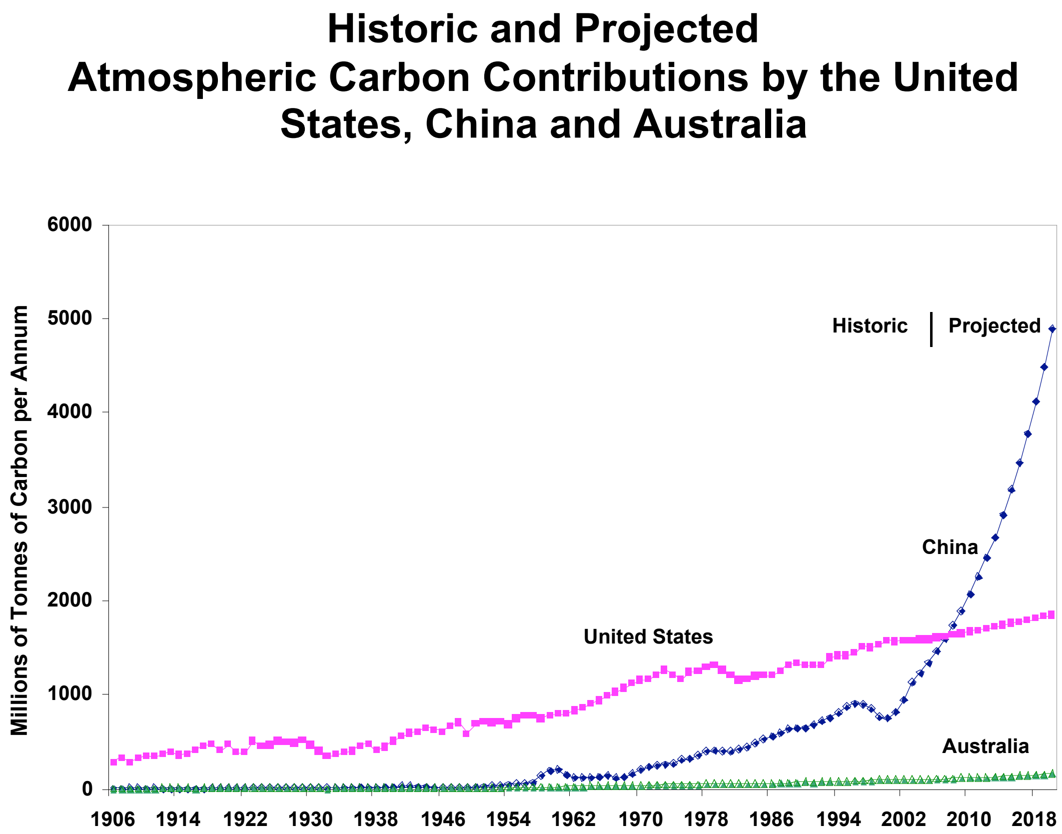


Figure 27: Historic and Projected Atmospheric Carbon Contributions by the United States, China and Australia

The projected increase is likely to be brought forward if Chinese economic expansion continues for the next ten years at the same rate that it has demonstrated over the last ten years. This graph shows emissions of carbon to the atmosphere by the United States, Australia and China, with historic data to 2005 and a projection to 2020.

Chinese emissions will overtake US emissions in 2009, and then double from the current level by 2016. Per capita emissions by the three countries will be equivalent by 2020.

The Anthropogenic Contribution

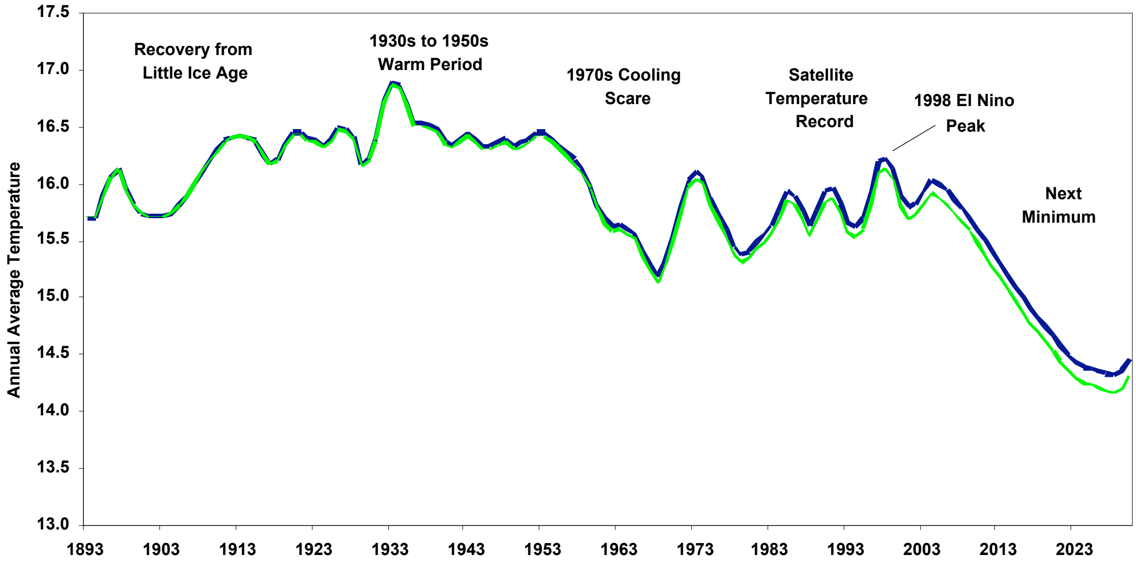
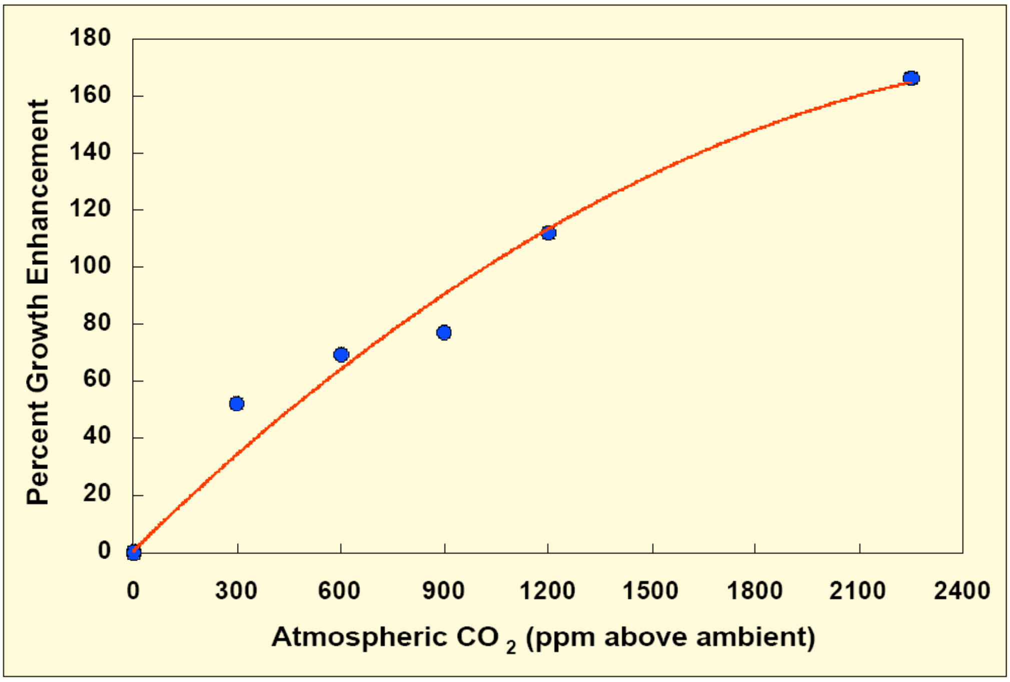


Figure 28: Calculated Anthropogenic Contribution to Atmospheric Temperature 1893 - 2030

This graph shows what the temperature would be with, and without, the warming from anthropogenic carbon dioxide. The anthropogenic effect is able to be calculated, though it is very small relative to natural variation.



Mean plant growth response to atmospheric CO_2 enrichment. Adapted from

Figure 29: Plant Growth Enhancement Relative to Atmospheric Carbon Dioxide

Carbon dioxide is not even a little bit bad. It is wholly beneficial.

This graph from a recent Idso paper shows plant growth response to atmospheric carbon dioxide enrichment. The 100 ppm carbon dioxide increase since the beginning of industrialisation has been responsible for an average increase in plant growth rate of 15% odd.

The 50% increase in plant growth rate due to a 300 ppm increase in atmospheric carbon dioxide can be expected about the middle of the next century. What a wonderful time that will be.

Average Growth Enhancement due to a 300 ppm increase in atmospheric carbon dioxide

C_3 Cereals	49%
C_4 Cereals	20%
Fruits and Melons	24%
Legumes	44%
Roots and Tubers	48%
Vegetables	37%

Source: Idso May 2007

Figure 30: Carbon Dioxide Growth Enhancement by Plant Type

A 300 ppm increase in atmospheric carbon dioxide is something that we can only dream about, but some future generation will get these sort of benefits from the current industrious burrowing of the Chinese in their coal mines.

C3 cereals include wheat and C4 cereals include maize.

Stressed relative to unstressed plant response

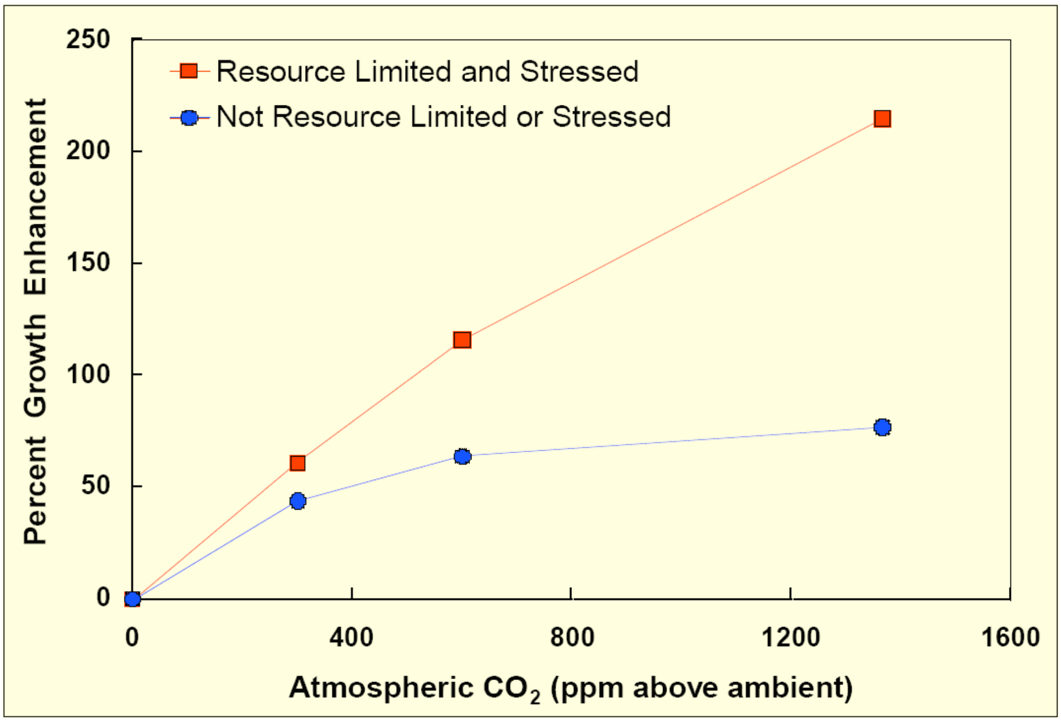


Figure 31: Stressed Relative to Unstressed Plant Response

The news gets even better for Australia. This is a dry continent and our plants spend a lot of their lives being water-stressed. In a world of higher atmospheric carbon dioxide, our crops will use less water per unit of carbon dioxide uptake. It's not all good news. We will need this increase in agricultural productivity to offset the colder weather coming.

It also follows that if the industrialised countries of the world wanted to be caring and sharing towards the third world, the best thing that could be done for the third world is to increase atmospheric carbon dioxide levels. Who would want to deny the third world such a wonderful benefit?

Summary

1. **The Sun drives climate change and it will be colder next decade by 2.0 degrees centigrade.**

2. **The anthropogenic carbon dioxide effect is real, minuscule and too small to be measured.**

3. **Higher atmospheric carbon dioxide levels will boost agricultural production.**

4. **Increased atmospheric carbon dioxide is wholly beneficial.**

Figure 32: Summary

What I have shown in this presentation is that carbon dioxide is largely irrelevant to the Earth's climate. The carbon dioxide that Mankind will put into the atmosphere over the next few hundred years will offset a couple of millenia of post-Holocene Optimum cooling before we plunge into the next ice age. In the near term, the Earth will experience a significant cooling due to a quieter Sun.

There are no deleterious consequences of higher atmospheric carbon dioxide levels. Higher atmospheric carbon dioxide levels are wholly beneficial.

Anthropogenic Global Warming is so minuscule that the effect cannot be measured from year to year, and even from generation to generation.

Our generation has bathed in the warm glow of a benign, giving Sun, but the next will suffer a Sun that is less giving, and the Earth will be less fruitful.

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