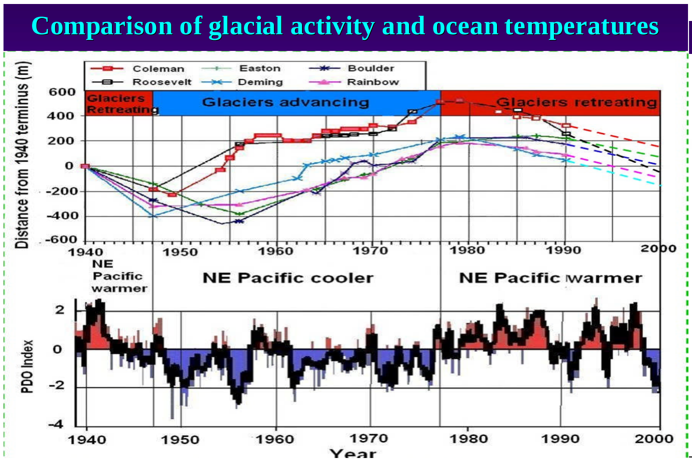


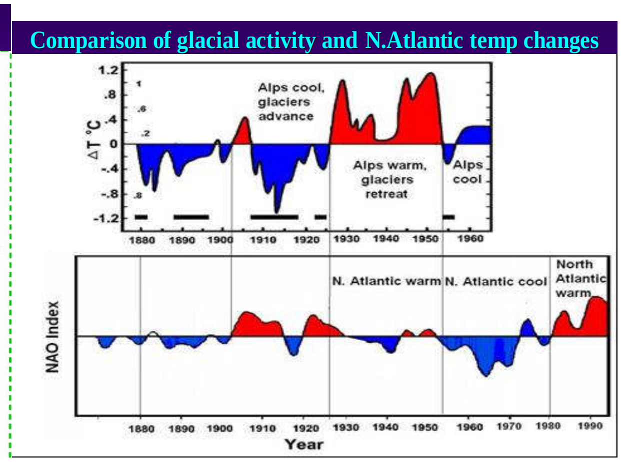


Figure 17A. Comparison of advance and retreat of glaciers on Mt. Baker with the Pacific Decadal Oscillation of the NE Pacific Ocean.

Figure 17B. Comparison of advance and retreat of glaciers in the Alps with the North Atlantic Oscillation.

.

The North Atlantic Oscillation shows patterns very similar to the PDO (Fig. 17B). Glacial advances and retreats in the European Alps correspond to warm and cool phases of the NAO in the same way as glacial advances and retreats in North America correlate with the PDO. All are in phase with observed atmospheric temperature changes over the past century.

Additional climate changes are recorded in the Greenland ice sheet isotope data. Figure 10 shows regular warm/cool cycles of approximately the same duration as the glacial moraine record extending back 500 years.

The importance of the various types of evidence of climate fluctuations is that they show long–standing evidence of cool/warm cycles over many centuries. Adding more recent, observed climatic fluctuations to the earlier records shows that we are now right where we ought to be in this pattern, i.e., at the end of the current 30 year warm period and just entering the next 25-30 year cool phase. Extending this ongoing record into the future provides an opportunity to predict coming climate changes.

MAGNITUDE AND SIGNIFICANCE OF PREVIOUS GLOBAL CLIMATE CHANGES

Most of the global climate changes described above were far more intense (12 to 20 times as intense in some cases) than the global warming of the past century (compare them in Fig. 5), and they took place in as little as 20–100 years. As shown on Figure 5, the global warming of the past century (0.8° C) is virtually insignificant when compared to the magnitude of the earlier global climate changes.

None of these sudden, pre-1977 global climate changes could possibly have been caused by human CO_2 input to the atmosphere because they all took place long before human CO_2 contributions to the atmosphere began. The cause of the ten 'natural' climate changes that occurred earlier could easily have been the same as the cause of present global warming.

If CO_2 is indeed the cause of global warming, then global temperatures should mirror the rise in CO_2. For the past 1000 years, atmospheric CO_2 levels have remained fairly constant at about 280 ppm (parts per million). Atmospheric CO_2 concentrations began to rise during the industrial resolution early in the 20th century. In 1945, atmospheric CO_2 rose sharply. By 1980 it has risen to just under 340 ppm. During this time, however, global temperatures fell about 0.5° C (0.9° F) in the Northern Hemisphere and about 0.2° C (0.4° F) globally (Fig. 3). In 1977, global atmospheric temperatures again reversed suddenly, rising about 0.5° C (0.9° F) above the 1945-1977 cool cycle in 25 years. If CO_2 is the cause of global warming, why did temperatures fall for 30 years while CO_2 was sharply accelerating? Logic dictates that this anomalous cooling cycle during accelerating CO_2 levels must mean either (1) rising CO_2 is ***not*** the ***cause*** of global warming or (2) some process other than rising CO_2 is capable of overriding its effect on global atmospheric warming and CO_2 is inconsequential.

If we look at temperature patterns since the latter part of the Little Ice Age (~1600 to 1860 A.D.), a very similar pattern emerges--25-30 periods of alternating warm and cool temperatures during overall warming from the Little

Ice Age low. These temperature fluctuations took place well before any effect of anthropogenic atmospheric CO_2 and were far greater. About 80% of the CO_2 from human activities was added to the atmosphere after 1940, so the early 20th Century and earlier warming trends had to be natural and the recent trend in surface warming cannot be primarily attributable to human–made greenhouse gases. Thus, CO_2 cannot possibly have been the cause of these climatic changes so why should we suppose that the last few must be? We clearly need to look to causal mechanisms other than rising CO_2 if we are to truly understand global warming.

RECENT GLOBAL COOLING AND PACIFIC DECADAL OSCILLATION (PDO)

COOLING IN THE PACIFIC OCEAN

Global temperatures peaked in 1998 and have not been exceeded since then, despite dire predictions by the IPCC and CO_2 advocates. Instead, the climate cooled slightly from 1998 to 2007 and then cooled dramatically in 2007-2008 (Fig. x). Pacific Ocean temperatures began a cooling phase in 1999 that was briefly interrupted by El Nino in 2005-2006 and dramatic cooling in 2007-2008 appears to be a continuation of a global cooling trend set up by the PDO cool phase (Fig. 18).

The announcement by NASA's Jet Propulsion Laboratory that the Pacific Decadal Oscillation (PDO) had shifted to its cool phase (Fig. 18) is right on schedule as predicted by past climate and PDO changes (Easterbrook, 2001, 2006, 2007). It is <u>*not*</u> an oddity superimposed upon and masking the predicted severe warming by the IPCC.

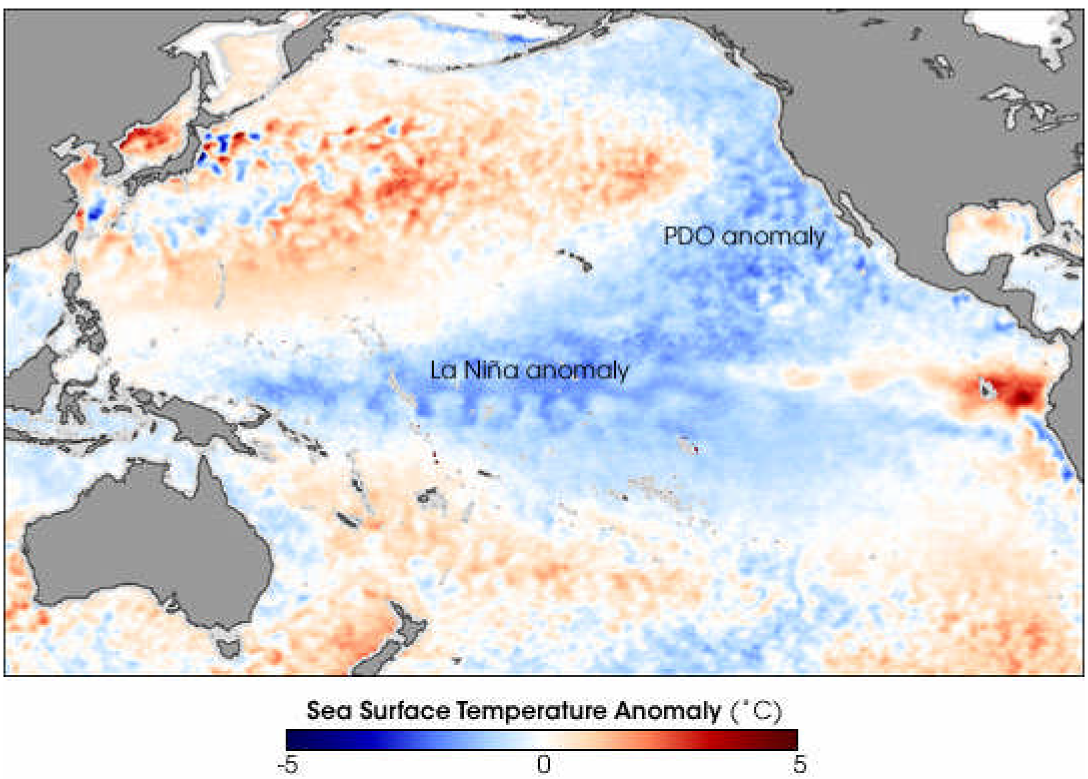


Figure 18. Cooling of the Pacific Ocean and setting up of the PDO. Sea surface temperature anomaly in the Pacific Ocean from April 14–21, 2008. The anomaly compares the recent temperatures measured with an average of data from 1985–1997. Places where the Pacific was cooler than normal are blue, places where temperatures were average are white, and places where the ocean was warmer than normal are red. The cool water anomaly in the center of the image shows the lingering effect of the year-old La Niña.

However, the much broader area of cooler-than-average water off the coast of North America from Alaska (top center) to the equator is a classic feature of the cool phase of the Pacific Decadal Oscillation (PDO). The cool waters wrap in a horseshoe shape around a core of warmer-than-average water. (In the warm phase, the pattern is reversed). Unlike El Niño and La Niña, which may occur every 3 to 7 years and last from 6 to 18 months, the PDO can remain in the same phase for 20 to 30 years. (NASA image by Jesse Allen, AMSR-E data by Chelle Gentemann and Frank Wentz, Remote Sensing Systems. Caption by Rebecca Lindsey, adapted from a press release from NASA JPL).

As shown by the historic pattern of PDOs over the past century (Fig. 2) and by corresponding global warming and cooling, the pattern is part of ongoing warm/cool cycles that last 25-30 years.

CLIMATE CHANGES IN THE COMING CENTURY

IPCC Predictions:

What does the century have in store for global climates? According to the IPCC, Al Gore's recent book, and many computer modelers who believe that CO_2 is the cause of global warming, the Earth is in store for climatic catastrophe later this century. Computer models predict global warming of as much as 5-6° C (10-11° F) (Fig. 4), which would cause massive starvation from crop failures, melting of most of the world's glaciers, sea level rise with drowning of some low-lying islands and coastal cities, and numerous environmental changes. All of this is predicated on the assumption that global warming is caused by increasing atmospheric CO_2 and that CO_2 will continue to rise rapidly.

The Intergovernmental Panel on Climatic Change (IPCC) has projected that in the next century, global warming will continue to rise to catastrophically higher and higher levels (Figure 4). The basis for this prediction is that the IPCC believes that rising atmospheric CO_2 is the cause of global warming and that CO_2 levels will continue to rise in the future, so global temperatures will also continue to rise. Computer models, programmed to calculate rise in global temperatures as a function of $CO_{2,}$ predict that by 2100, atmospheric CO_2 will to rise to 540-970 ppm and global temperature will increase 0.6 °C (1.1° F) by 2010, 1.2° C (2.1° F) by 2038, and up to 10.7°C (19° F) by 2100.

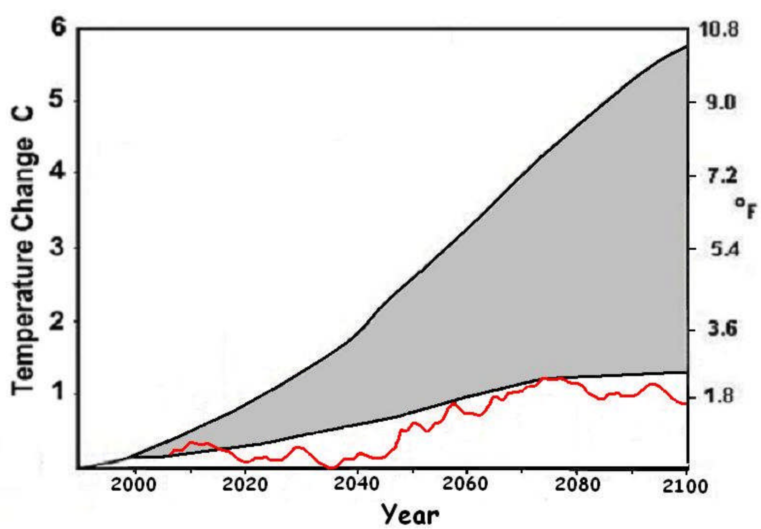


Figure 19. IPCC computer-projected global temperature increase for the coming century. Gray area is the range of IPCC predictions; red line is the Easterbrook projection based on past cyclic climate changes.

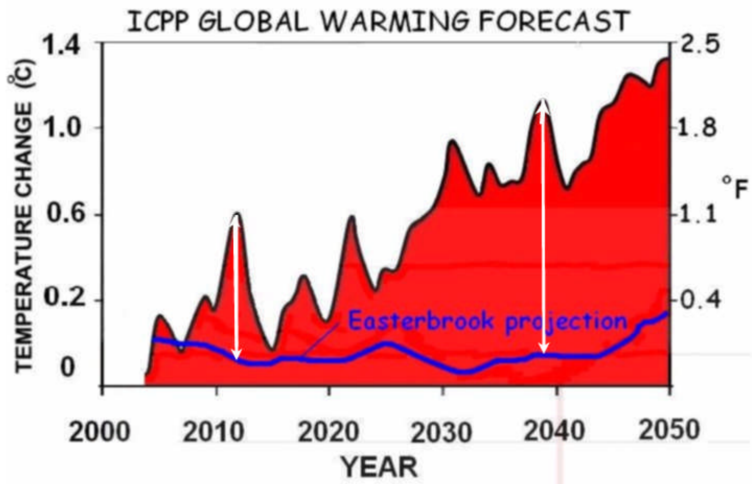


Figure 20. Comparison of IPCC global warming predictions to 2050 and the Easterbrook projection.

The validity of these predictions depends on the assumptions that (1) the cause of global warming is rising CO_2, (2) the rise in CO_2 is caused by anthropogenic fossil fuel emissions and other human activities, and (3) anthropogenic fossil fuel emissions will continue to rise throughout the present century. With so much at stake, verifying the soundness of these assumptions is of critical importance.

The ramifications of such an increase in global warming are far reaching, even catastrophic in some areas. Such a rise of global surface temperatures would have devastating results. The Arctic Ocean would become free of its cover of sea ice, the Greenland ice sheet would diminish rapidly, and alpine glaciers would disappear. Water supply in areas that depend on snowmelt would be severely impacted. Melting of Greenland and Antarctic ice would cause sea level to rise, flooding low coast areas and submerging low coral islands in the oceans. Crops in critical agricultural areas would fail, resulting in widespread starvation of millions of people in agriculturally marginal areas. Wheat/grain belts, such as the mid-continent area of North America, would have to shift northward. Droughts would become increasingly severe in dry areas. Environmental impacts would be severe, resulting in extinction of some species and drastic population decreases in others.

Predictions Based on Past Climate Patterns

Considering all the positive correlations between solar activity and global climate change, what if the cause of global warming is solar, rather than atmospheric CO_2? Then all of the computer models are meaningless and we can look to past natural climatic cycles as a basis for predicting future climate changes. The climatic fluctuations over the past few hundred years suggest ~30 year climatic cycles of global warming and cooling, on a general rising trend from the Little Ice Age cool period. If the trend continues as it has for the past several centuries, global temperatures for the coming century might look like those in Figure 15. Global cooling should begin soon and last until about 2040, then warm again until about 2070, and cooling again to the end of the century. The total increase in global warming from now to the end of the century should be only about 0.4°C, compared to nearly 11°C (maximum) predicted by the IPCC (Fig. 16)

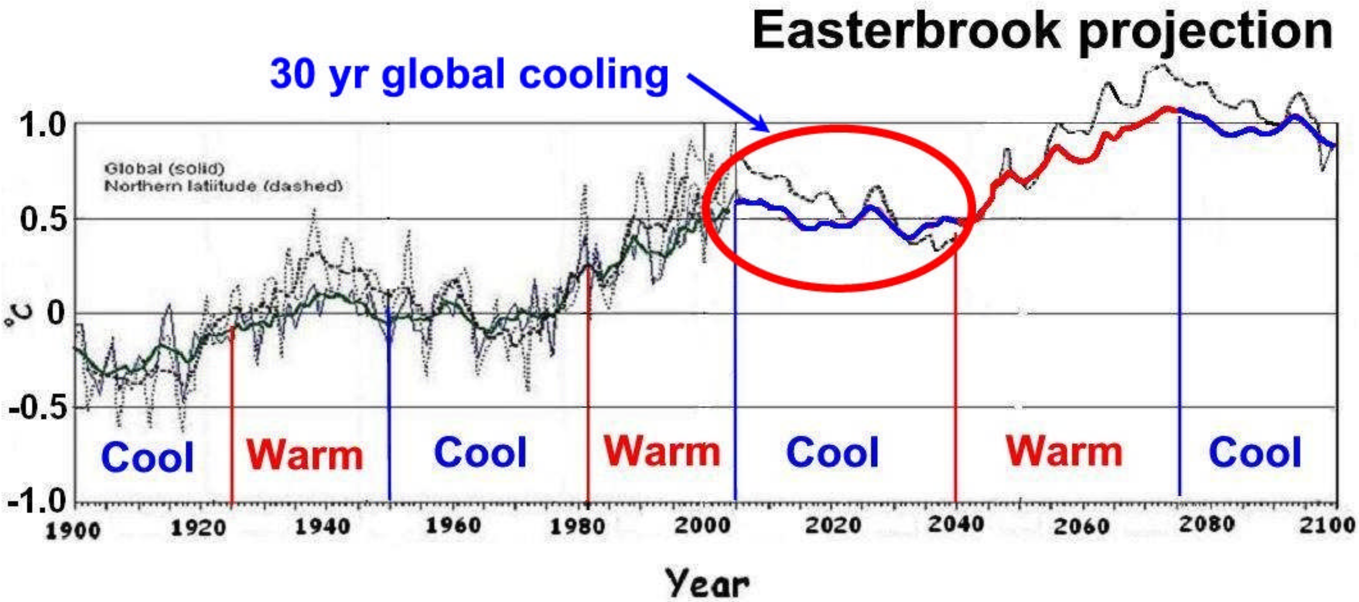


Figure 21. Global temperature projection for the coming century, based on warming/cooling cycles of the past several centuries. The 30-year global cooling prediction was first made in 1998 and reaffirmed in 2001. The recent setting up of the cool phase of the PDO appears to confirm the strong likelihood that the prediction will indeed happen.

SOLAR IRRADIANCE AND GLOBAL CLIMATE CHANGE

The global climate changes described above have coincided with changes in sunspot activity, solar irradiance, and rates of production of ^{14}C and ^{10}Be in the atmosphere by radiation, suggesting that the climate changes are caused by fluctuations in solar activity. A good example of the relationship between solar activity and climate occurred

When Galileo perfected the telescope in 1609, scientists could see sunspots for the first time. They were of such interest that records were kept of the number of sunspots observed, and although perhaps not entirely accurate due to cloudy days, lost records, etc., the records show a remarkable pattern for nearly a century (Fig. 6). From 1600 to 1700 AD, very few sunspots were seen, despite the fact that many scientists with telescopes were looking for them, and reports of aurora borealis were minimal. This interval is known as the Maunder Minimum (E.W. Maunder, 1894; E.E. Maunder, 1922). After 1700 AD, the number of observed sunspots increased sharply from nearly zero to 50–100 (Fig. 6). The Maunder Minimum was preceded by the Sporer Minimum (~1410–1540 AD) and the Wolf Minimum (~1290–1320 AD) (Fig. 7). Each of these periods is characterized by low numbers of sunspots, significant changes in the rate of production of ^{14}C in the atmosphere, and cooler global climates.

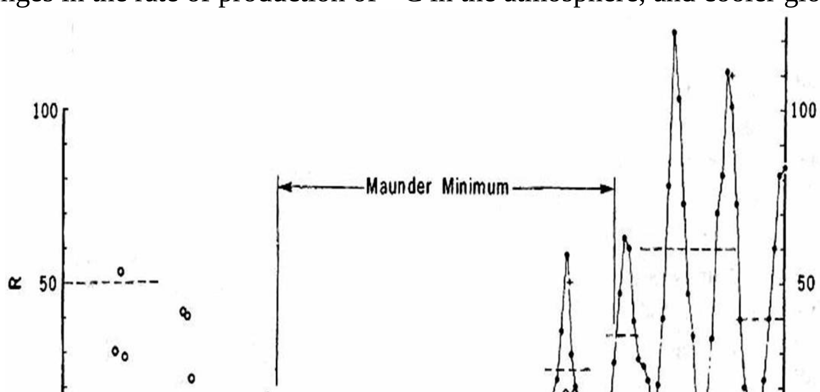


Figure 22. Sunspots during the Little Ice Age. (Modified from Eddy, 1976)

Global temperature change, sunspots, solar irradiance, ^{10}Be and ^{14}C production

Good correlations can now be made between global temperature change, sunspots (Eddy, 1976; Stuiver and Quay, 1980), solar irradiance (Lean, 1989, 1991, 2000, 2001, Lean and Rind, 1998; Lean et al., 1995, 2002), and ^{10}Be (Beer et al., 1994, 1996, 2000) and ^{14}C production (Stuiver, 1961, 1994; Stuiver and Brasiunas, 1991, 1992; Stuiver et al., 1991, 1995) in the atmosphere. ^{10}Be is produced in the upper atmosphere by radiation bombardment of oxygen. Increased radiation results in increased ^{10}Be production. Plots of ^{10}Be production and sunspots (Fig. 8) indicate a good correlation between the two. Thus, ^{10}Be measurements can serve as a proxy for solar activity.

The close correspondence of solar activity to global climate change from 1860 to 1990 is shown in Figure 9. This is in sharp contrast to the lack of correlation of atmospheric CO_2 changes to global warming and cooling prior to 1980.

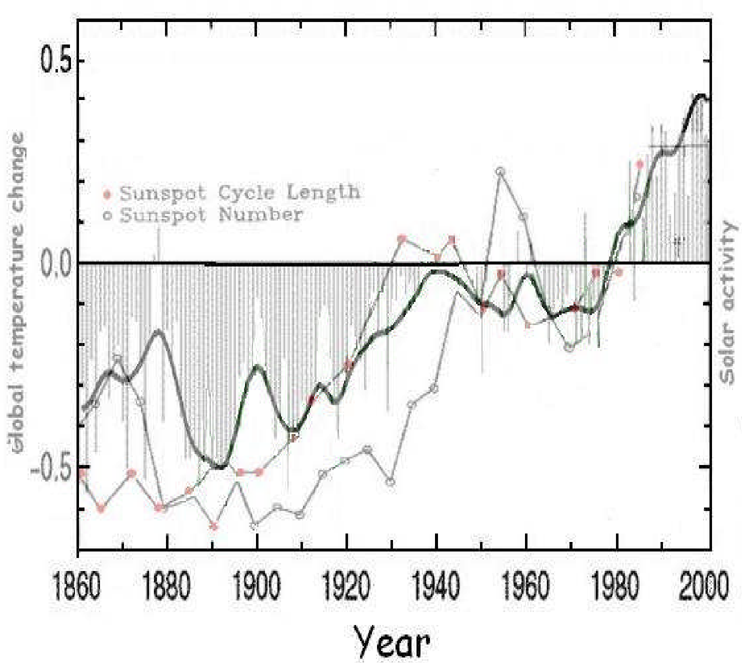


Figure 23. Variation in global warming and cooling with solar activity from 1860 to 1990. Note how closely the trends of the curves follow one another almost exactly. Contrast this with the lack of correlation of CO_2 variation and global temperature shown in Figure 3 and in pre–1980 global temperature changes.

Not only did atmospheric global temperature change with solar activity, but so did sea surface temperatures. Figure 11 shows the close correspondence between sunspot number and sea surface temperature.

A similar relationship between solar irradiance and climate change for the past 400 years is shown in Figure 12. The very low sunspot activity that began about 1600 AD is also marked by a decrease in solar irradiance that heralded the beginning of the Little Ice Age. Solar irradiance also dropped during the Dalton Minimum in the early 1800s. Since then, solar irradiance has risen with an oscillatory pattern (Fig. 12)

Solar irradiance and global temperature (Fig. 13) show the same relationship as solar activity (sunspots) and global temperature (Fig. 10). Solar irradiance from 1750 to 1990 shows almost exactly the same pattern as global warming and cooling over the past 250 years.

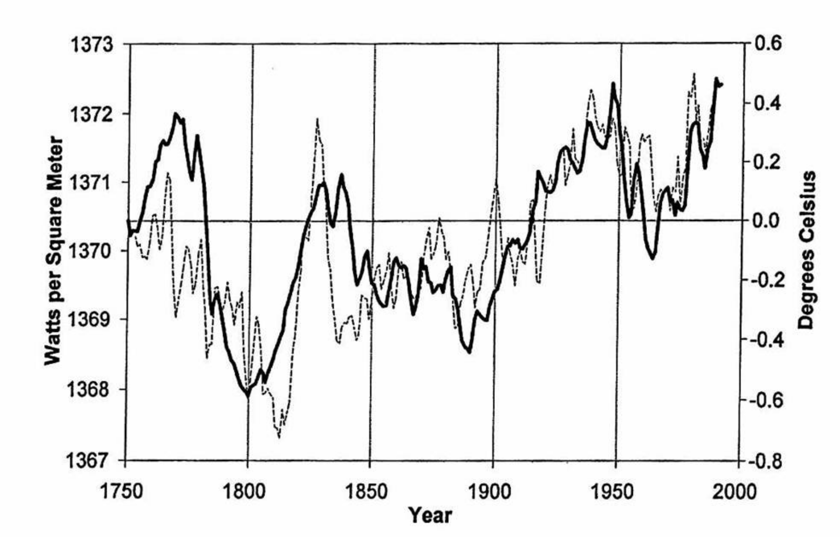
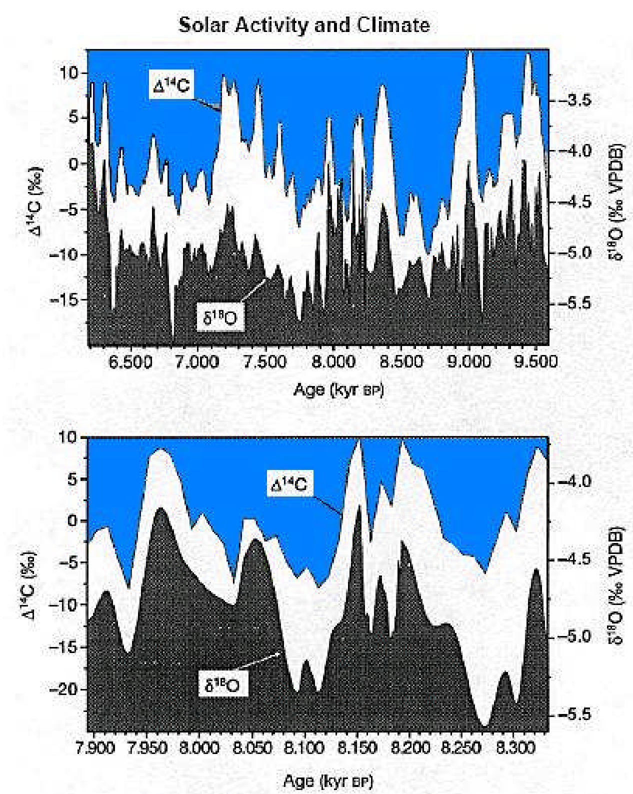


Figure 24. Solar irradiance and global warming and cooling from 1750 to 1990. During this 250 year period, the two curves follow a remarkably similar pattern. (Modified from Hoyt and Schatten, 1997)



Values of carbon-14 (produced by cosmic rays – hence a proxy for solar activity) correlate extremely well with oxygen-18 (climate proxy); data are from a stalagmite in Oman [Neff 2001]. The time interval covers more than 3,000 years, from about 9,600 to 6,200 years before present (BP). The lower graph shows a particularly well-resolved time interval from 8,350 to 7,900 years BP. It would be difficult to explain this detailed correlation except through the modulation of galactic cosmic rays by changes in the solar wind and solar magnetic activity [Singer 1958]. The mechanism whereby cosmic rays influence terrestrial climate is most likely a change in cloudiness, as suggested by Svensmark [2007a, 2007b].

Figure 25. Correlation of temperatures derived from oxygen isotope ratios with production rates of radiocarbon in the upper atmosphere.

The correspondence of global cold periods with solar irradiance and sun spot cycle length is remarkable. Figure 26 shows the close relationship of time of glacial advance with low solar irradiance. Figure 27 shows a comparison of the correlation of solar irradiance and global temperature and the lack of correlation of atmospheric CO_2 and global temperature.

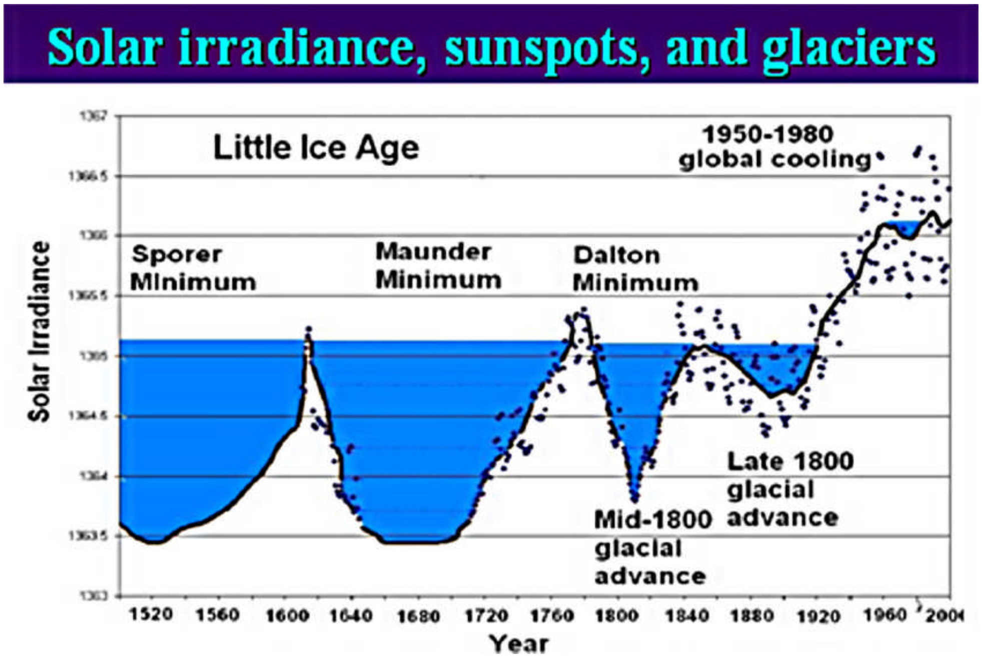


Figure 26. Solar irradiance, sunspots, and glacial fluctuations. Blue areas are times of glacial advances. Note that each period of glacial advance is marked by a time of low solar irradiance, including the 1880 to 1910 and 1945 to 1977 glacial advances during global cool periods. Is the correspondence of the extended length of sun spot cycle 23, recent global cooling, and the setting up of the cool phase of the PDO purely coincidental or is there a cause-and-effect relationship?

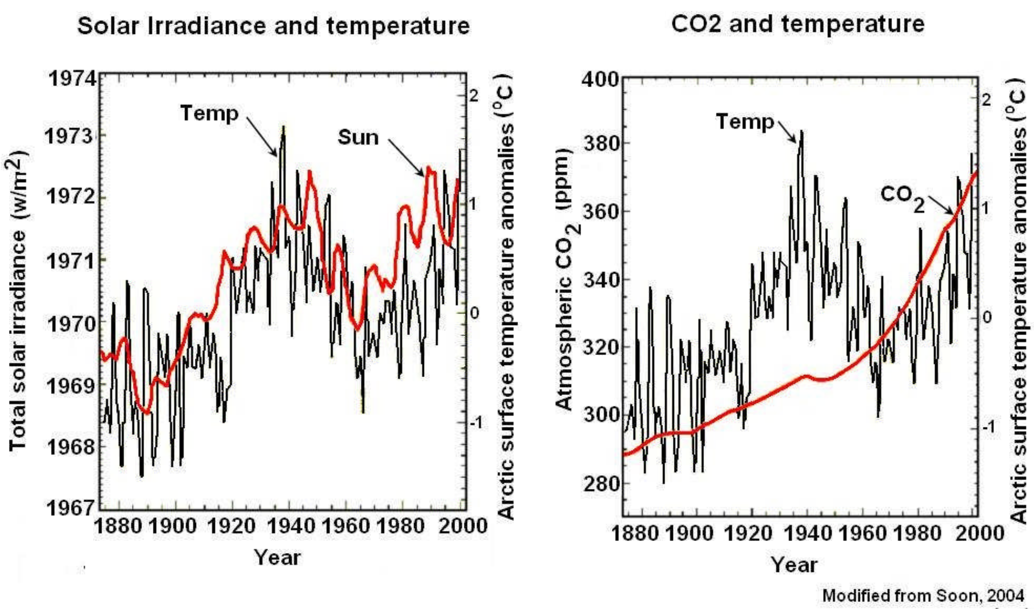


Figure 27. Comparison of the correlation of global temperature with solar irradiance and the lack of correlation with CO_2.

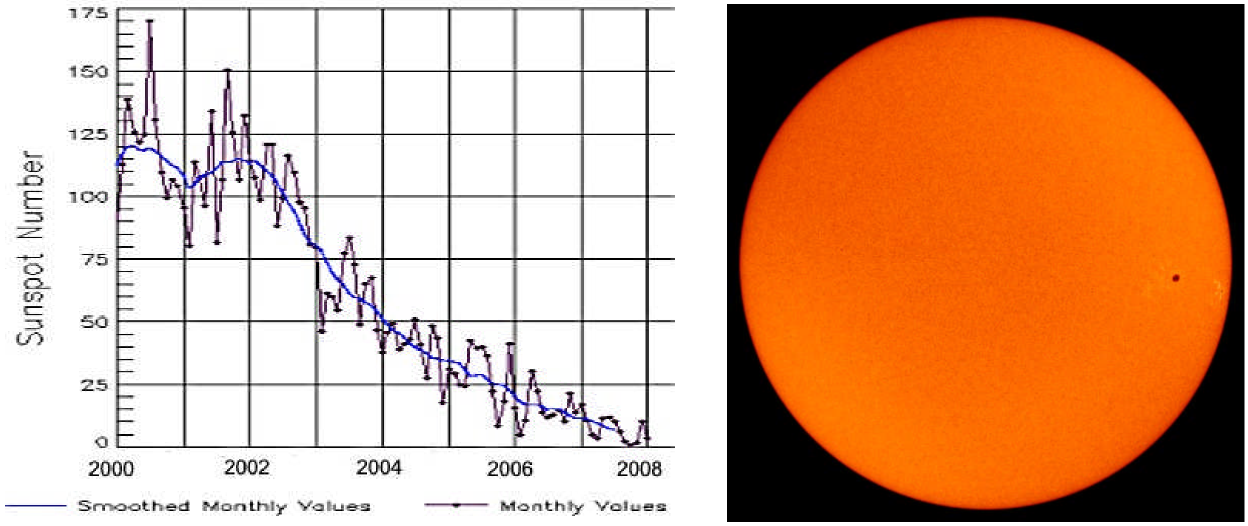


Figure 28. Low sun spot frequency in sun spot cycle 23 is extended beyond the normal length and cycle 24 is overdue. The recent global cooling and setting up of the cool phase of the PDO is reminiscent of solar and climatic conditions at the beginning of the Little Ice Age.