GEOLOGIC EVIDENCE OF THE CAUSE OF GLOBAL WARMING AND COOLING

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ABSTRACT

As shown in the Greenland GISP2 ice cores, late Pleistocene abrupt temperature fluctuations occurred in only 20–100 years, clearly not caused by atmospheric CO_2 because they occurred thousands of years before atmospheric CO_2 levels began to rise. Global temperature curves show a cool reversal from ~1950 to ~1977), inferring that global temperatures then were not driven by atmospheric CO_2. Solar irradiance curves almost exactly match the global temperature curve and satellite data suggest that the earth has received increased solar radiation over the past 25 years, coinciding with the present 25–year warm cycle. If the cycles continue as in the past, the current warm cycle should end soon, and global warming should abate, rather than increase, in the next 25-30 years. Using these data as a basis, the coming century should experience a cooler climate from ~2006 to ~2035, a warmer period (probably warmer than the 1977–2005 warm period) from ~2035 to ~2065, followed by another cooler period from ~2065 to about the end of the century. The coming decades will test this prediction.

INTRODUCTION

The present global warming and discovery of abrupt climate changes in the geologic record have pushed climate changes into the forefront of scientific inquiry with a great deal at stake for human population. However, without unequivocal, "smoking gun," cause-and-effect evidence that CO2 was the cause of global warming from 1977 to 1998, and despite the media blitz over the 2007 IPCC report, the report provides no tangible physical evidence that CO_2 is *causing* global warming. It *assumes* CO_2 is the cause and computer model simulations are all based on that assumption.

Global warming over the past century, the latter part of which was coincident with rise in atmospheric carbon dioxide levels, has led to dire predictions for the coming century and controversy among scientists about the cause of the warming.

but to point out some interesting relationships between present global warming and isotopic fingerprints from ice cores and recurrent glacial advance and retreat cycles recently and in the geologic past.

IS GLOBAL WARMING REAL?

Little doubt remains that global temperatures have risen during the past several centuries. Temperatures have risen approximately 1° C (1.8° F) per century since the coldest part of the Little Ice Age ~400 years ago, but the rise has not been linear. Global temperatures have warmed and cooled in 25-35 year cycles, well before atmospheric CO_2 began to rise significantly.

Two episodes of global warming and two episodes of global cooling occurred during the twentieth century (Figure 1). The global warming and cooling was somewhat more pronounced in the Northern Hemisphere than the global average because of the greater land mass area in the

Northern Hemisphere. Overall, temperatures rose about 0.8 °C (1.4° F) during the century, which is about the rate of warming per century since the Little Ice Age.

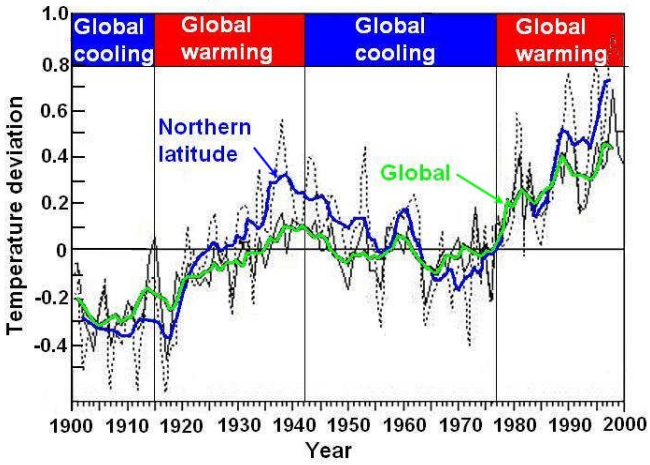

Figure 1. Global and Northern Hemisphere temperatures 1900 to 2000.

1880 to 1915 cool period. Global climatic cooling set in about 1880 lasted until about 1915. Glaciers advanced, some nearly to terminal positions reached during the Little Ice Age about 400 years ago. Many cold temperature records in North America were set during this period. Temperatures reached a low point about 1890, rose slightly about 1910, and by about 1915, began to warm.

1915 to 1945 warm period. Global temperatures rose steadily in the 1920s, 1930s, and early 1940s. By the mid 1940s, global temperatures were about 0.5 °C (0.9° F) warmer than they had been at the turn of the century (Figure 1). More high temperature records for the century were recorded in the 1930s than in any other decade of the 20th century (Figure 2).

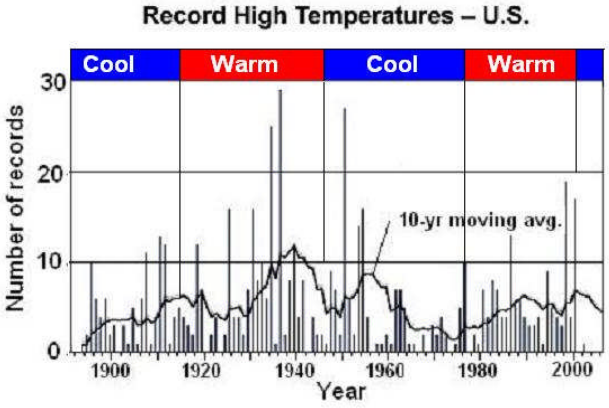

Figure 2. Record high temperatures in the U.S. during the 20th century. Note that the greatest number of high temperatures were recorded in the 1930s.

Temperatures in the 1930s in the Arctic and Greenland were warmer than at present and rates of warming were higher, warming 4°C (7° F) in two decades. Greenland temperatures generally followed the global temperature pattern, warming in the 1920s, 1930s, and early 1940s, cooling until about 1977, and then rising again until the turn of the century. The average rate of warming from 1920 to 1930 was considerably higher than from 1980-2005 despite the fact that the 1920-

1930 warming occurred before CO_2 could be a factor. Temperatures in Greenland during the Medieval Warm Period (900-1300 AD) were generally warmer than today.

1945 to 1977 cool period. Global temperatures in the Northern Hemisphere dropped about 0.5° C (0.9° F) from the mid-1940s until 1977 and temperatures globally cooled about 0.2° C (0.4° F) (Fig. 1). Many of the world's glaciers advanced during this time, and recovered a good deal of the ice lost during the 1915–1945 warm period. However, cooling during this period was not as deep as in the preceding cool period (1880 to 1915).

1977 to 1998 warm period. The global cooling that prevailed from 1945 to 1977 ended abruptly in 1977 when both the Pacific and Atlantic Oceans shifted from their warm mode to their cool mode and global temperatures began to rise, initiating two decades of global warming (Fig. 1). 1977 has been called the year of the "Great Pacific Climate Shift" (Fig. 3).

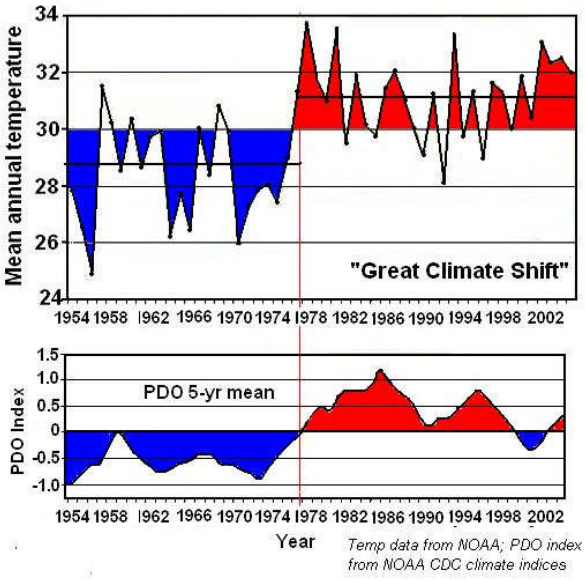

Figure 3. Mean annual temperatures for Anchorge, Fairbanks, and Nome (upper graph) and Pacific Decadal Oscillation Index (PDO) (lower graph) reflecting Pacific sea surface temperatures. The sudden switch from cool to warm PDO caused the "Great Climate Shift" in 1977 that initiated the latest global warming period.

The abruptness of the shift in Pacific sea surface temperatures and corresponding change from global cooling to global warming in 1977 is highly significant and strongly suggests a cause-and-effect relationship. The rise of atmospheric CO_2, which accelerated after 1945 shows no sudden change that could account for the "Great Climate Shift."

The global warming from 1977 to 1998 has received much attention in the news media and represents the period now popularly called "global warming". Previously, warming during the entire 20th century was referred to as the time of "global warming" but when it became apparent that increasing atmospheric CO_2 could not explain warming and cooling prior to 1977, advocates of CO_2 as the cause of the warming restricted what is now labeled as "global warming" to the post-1977 warming.

Distinction between 'global warming skeptics' and 'skeptics of CO_2 as the cause of global warming'

During the intense media coverage of the 2007 IPCC report and Al Gore's film "Inconvenient Truth," scientists who rejected CO2 as the cause of global warming were labeled "global warming deniers" by Gore and others, implying that if a person didn't believe in CO_2 as the cause of global warming, that person also denied the warming itself. Although that certainly was not correct and was an unfair characterization, CO_2 skeptics were nonetheless ridiculed as "*global warming deniers*." The difference between a 'CO_2 skeptic' and a 'global warming skeptic' is an important distinction. Virtually no one, including CO_2 skeptics, denies global warming over the past 20 years.

RISE OF ATMOSPHERIC CARBON DIOXIDE

Although CO_2 has long been recognized as a greenhouse gas, it makes up only ~0.03% of the atmosphere (Figure 4), far less than water vapor (2-4%), the dominant greenhouse gas. Atmospheric CO_2 levels have risen since 1945 to 0.038%, but the question is whether or not an increase of only 0.008% is enough to cause significant global warming that overshadow natural variation. The answer to this question may be found in the geologic record of global climate changes and changes in atmospheric CO_2.

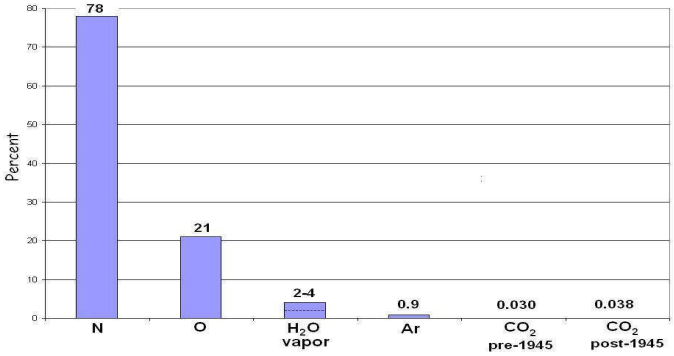

Figure 4. Composition of the atmosphere. CO2 makes up only 0.03% of the atmosphere.

Measurements of CO_2 from air trapped in polar ice cores over tens of thousands of years shows that atmospheric CO_2 concentrations typically vary from about 260 to 285 ppm, averaging about 280 ppm. The ice core records show that CO_2 is low during Pleistocene glaciations and high during interglacial periods. Gore (2007) has claimed that higher CO_2 during interglacial periods indicates that CO_2 is the *cause* of the warmer interglacials. This conclusion is scientifically indefensible because the CO_2 increase ***lagged*** Antarctic deglacial warming by 600 to 800 ± 200 years (Fischer et al., 1999; Caillon et al., 2003).

The high solubility and chemical reactivity of CO_2 permits ready exchange of CO_2 between the atmosphere and oceans. The amount of CO_2 in the oceans is about 50 times greater than in the atmosphere. CO_2 solubility depends on temperature, so changes in sea surface temperature affects CO_2 exchange with the atmosphere. Warming of sea surface water drives CO_2 into the atmosphere, as is seen in spikes in atmospheric CO_2 during strong El Niño years.
Atmospheric CO_2 rose slowly from the mid–1700s to 1945 (Figure 5). Emissions abruptly began to soar in 1945 after World War II) (Figure 6). CO_2 has risen at a fairly constant rate since then, going from about 300 ppm in 1955 to about 385 in 2007.

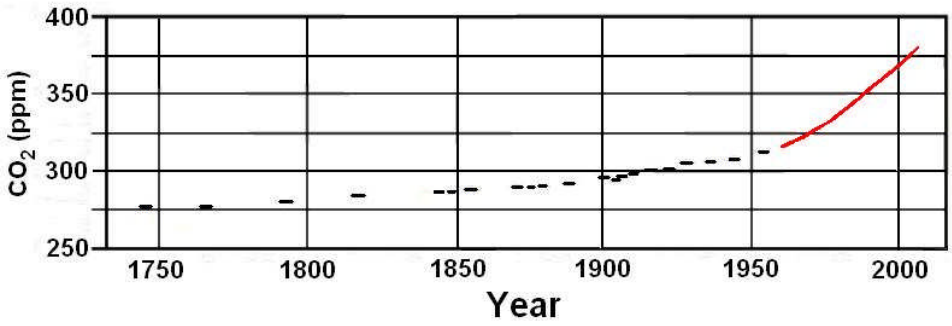

Figure 5. **A**tmospheric CO_2 increased slowly from 1744 until 1945 and then began to soar.

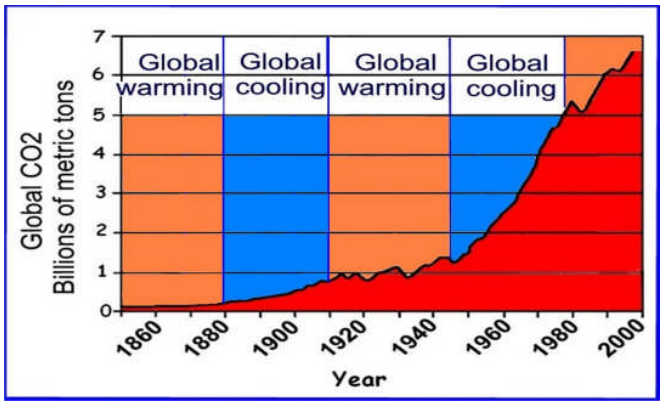

Figure 6. CO_2 emissions from 1850 to 2000. Note that CO_2 emissions were low during the global warming from 1850 to 1880 and rose slowly during the deep global cooling from 1880 to about 1915. Emissions were fairly constant during the strong global warming from 1915 to 1945. While emissions were soaring from 1945 to 1977, the global climate cooled, rather than warmed as it should have if CO_2 was the cause of global warming.

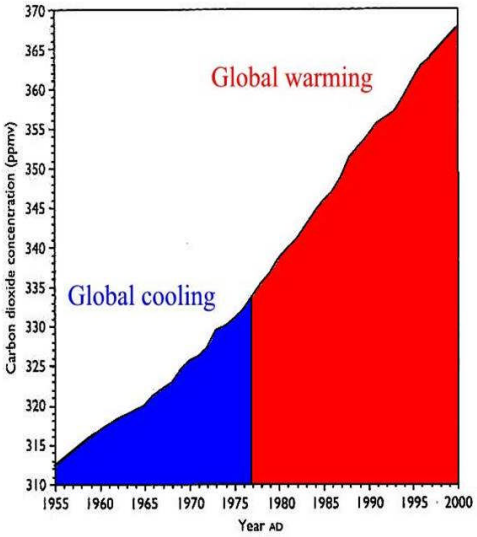

Figure 7. Atmospheric CO_2 from 1955 to 2000. Note that CO_2 rose smoothly without any sign of unusual increase across the 'Great climate shift' from cool to warm in 1977.

Following the 1977 'Great climate shift, global warming persisted until 1998 while CO_2, continued to rise. This is the only physical evidence that connects CO_2, and recent global

warming, but it doesn't prove a cause-and-effect relationship because the rise in global temperature and atmospheric CO_2 could be (and probably was) entirely coincidental.

Global warming from 1890 to 1945 could not be caused by atmospheric CO_2

Atmospheric temperature measurements, glacier fluctuations, and oxygen isotope data from Greenland ice cores all record a cool period from about 1880 to about 1915, reaching a low about 1890 (Figure 8). During this period, global temperatures were about 0.9 ° C (1.6 ° F) cooler than at present. From 1880 to 1890, temperatures dropped 0.35 ° C (0.6° F) in only 10 years. From 1890 to 1900, temperatures rose 0.25 ° C (0.45 ° F) in 10 years, after which temperatures dipped slightly (0.15 ° C (0.3 ° F) until 1910.

From 1915 to 1945, global temperatures rose 0.4 ° C (0.7 ° F), half of the total temperature rise for the past century. As expected, glaciers during this period retreated and, in general, followed the warming climate pattern. All of this occurred before CO_2 emissions began to soar (after 1945) (Figure 6), so at least half of the warming of the past century cannot have been caused by manmade CO_2.

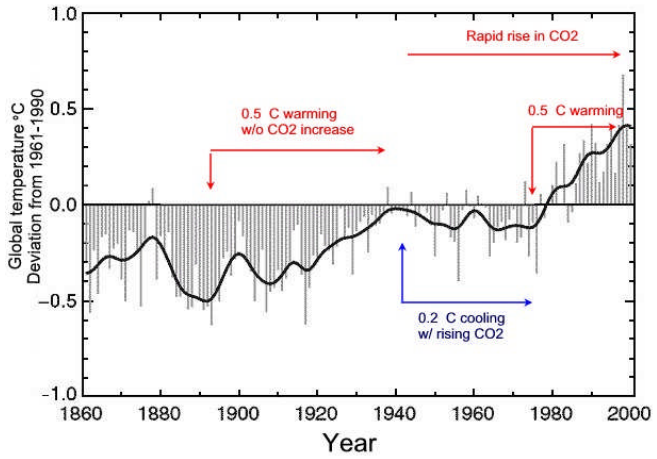

Figure 8. Global cooling during soaring atmospheric CO_2 emissions 1945 to 1977.

Global temperatures began to cool in the 1940's at the point when CO_2 emissions began to soar (Fig. 6). For 30 years thereafter temperatures declined 0.2 ° C (0.4 ° F) globally and 0.5 ° C (0.9 ° F) in the Northern Hemisphere (Figure 5). During this 30 year period (1945–1977), glaciers ceased the recession of the preceding ~30 years and advanced. By 1977, many advancing glaciers had recovered much of the length lost in the previous ~30 years of warming. Many examples of glacial recession during the past century cited in the news media show contrasting terminal positions beginning with the maximum extent at the end of a ~30 year cool period (1915 or 1977) and ending with the minimum extent of the present 30 year warm period (1998). A much better gauge of the effect of climate on glaciers would be to compare glacier terminal positions between the ends of successive cool periods or the ends of successive warm periods.

Figure 6 shows that even though CO_2 emissions soared from 1945 to 1977, global temperature dropped during that 30–year period (Fig. 9). If CO_2 causes global warming, temperature should have risen, rather than declined, strongly suggesting that rising CO_2.does not cause significant global warming. Clearly the climate was driven by natural causes.

Global warming during rising atmospheric CO_2 from 1977 to 1998

In 1977, global temperatures, which had been declining since the late 1940's, abruptly reversed and began to rise. This sudden reversal of climate has been termed "The Great Climate Shift" because it happened so abruptly. Global temperatures rose ~0.5 ° C (0.9 ° F), alpine glaciers have retreated, Arctic sea ice has diminished, melting of the Greenland Ice Sheet has accelerated, and other changes have occurred. The warmest year was 1998, after which global temperatures declined slightly until 2007 when sharp cooling began.

During this time, atmospheric CO_2 has continued to rise, the only period in the past century when global warming and atmospheric CO_2 have risen together. However, this doesn't prove a cause-and-effect relationship—just because two things happen together doesn't prove that one is the cause of the other.

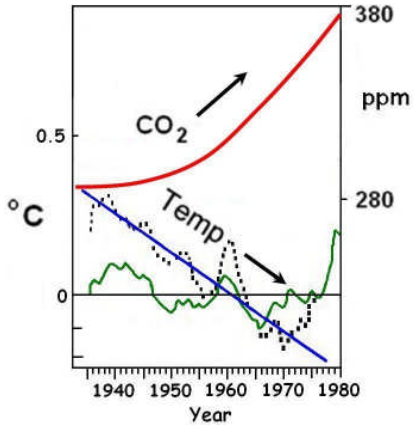

Figure 9. Global cooling during rapid increase in atmospheric CO_2 from 1940 to 1977.

Is Global Warming Caused by Rising CO_2?

No tangible, physical evidence exists that proves a cause–and–effect relationship between global climate changes and atmospheric CO_2. The fact that CO_2 is a greenhouse gas and that CO_2 has increased doesn't prove that CO_2 has caused global warming. As shown by isotope measurements from ice cores in Greenland and Antarctica and by measurements of atmospheric CO_2 during El Nino warming oceans emit more CO_2 into the atmosphere during climatic warming. The ice core records indicate that after the last Ice Age, temperatures rose for about 600–800 years *before* atmospheric CO_2 rose, showing that climatic warming caused CO_2 to rise, not vice versa. No doubt exists that the present high levels of atmospheric CO_2 are the result of human input, but the contribution that it makes to global warming remains to be proven.

LESSONS FROM PAST GLOBAL CLIMATE CHANGES

Proponents of CO_2 as the cause of global warming have stated that never before in the Earth's history of has climate changed as rapidly as in the past century and that proves global warming is being caused by anthropogenic CO_2. Statements such as these are easily refutable by the geologic record. Figure 5 shows temperature changes recorded in the GISP2 ice core from the Greenland Ice Sheet. The global warming experienced during the past century pales into insignificance when compared to the magnitude of at least ten sudden, profound climate reversals over the past 15,000 years (Figure 10).

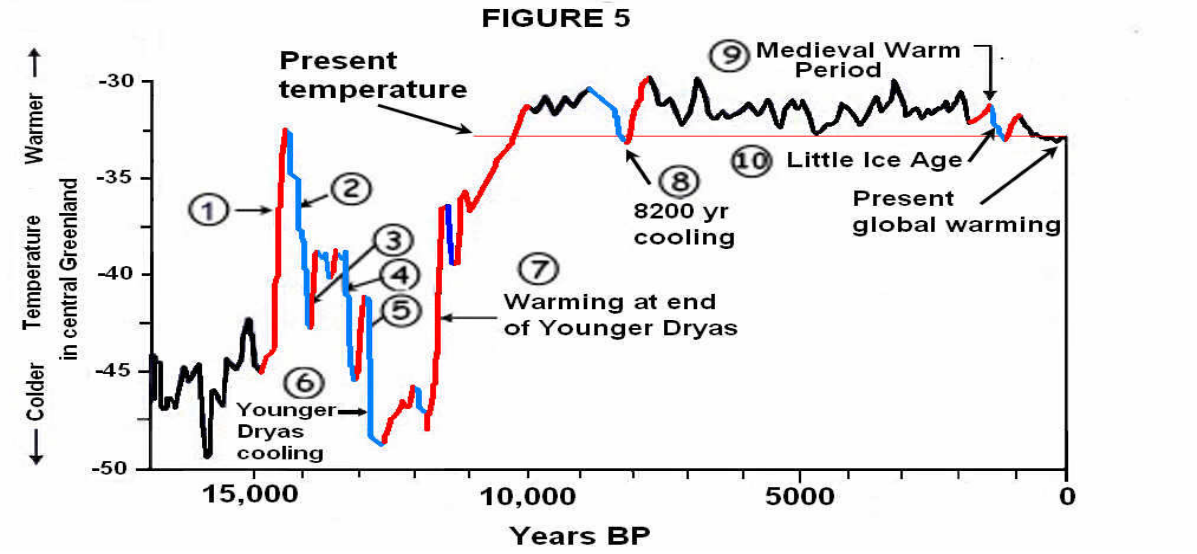

Figure 10. Temperature changes over the past 15,000 years. Red lines represent times of sudden warming, blue lines represent times of rapid cooling. Numbers refer to the events listed below. (Modified from Cuffey and Clow, 1997 and Alley, 2004)

Late Pleistocene abrupt climate changes

The magnitude and timing of past climatic changes are recorded in the isotope data from Greenland and Antarctic ice cores. These data clearly show that abrupt climate changes many times greater than those of the past century have occurred many times in the geologic past. Numbers correspond to the temperature curves on Figure 10.

- 1. About 15,000 yrs ago, a sudden, intense, climatic warming (~12° C; ~21° F) caused dramatic melting of large Ice Age ice sheets that covered Canada and the northern U.S., all of Scandinavia, and much of northern Europe and Russia. Sea level that had been 120 m (~400 ft) lower than present rose quickly and submerged large areas than had been dry land during the Ice Age.
- 2. A few centuries later, temperatures again plummeted (~11° ; ~20° F) and glaciers advanced.
- 3. About 14,000 years ago, global temperatures rose rapidly (~4.5°C; ~8° F) once again and glaciers receded.
- 4. About 13,400 years ago, global temperatures plunged again (~8°C; ~14° F) and glaciers advanced.
- 5. About 13,200 years ago, global temperatures increased rapidly (~5°C; ~9° F) and glaciers receded.
- 6. 12,700 yrs ago global temperatures plunged sharply (~8°C; ~14° F) and a 1000 year period of glacial readvance, the Younger Dryas, began.
- 7. 11,500 yrs ago, global temperatures rose sharply (~12° C; ~21° F), marking the end of the Younger Dryas cold period and the end of the Pleistocene Ice Age.

Early Holocene climate changes

8,200 years ago, the post-Ice Age interglacial period was interrupted by a sudden global cooling (~4° C; ~7° F) that lasted for a few centuries (Figures 10, 11). During this time, alpine glaciers advanced and built moraines. The warming that followed the abrupt cool period was also

abrupt. Neither the abrupt climatic cooling nor the warming that followed was preceded by atmospheric CO_2 changes.

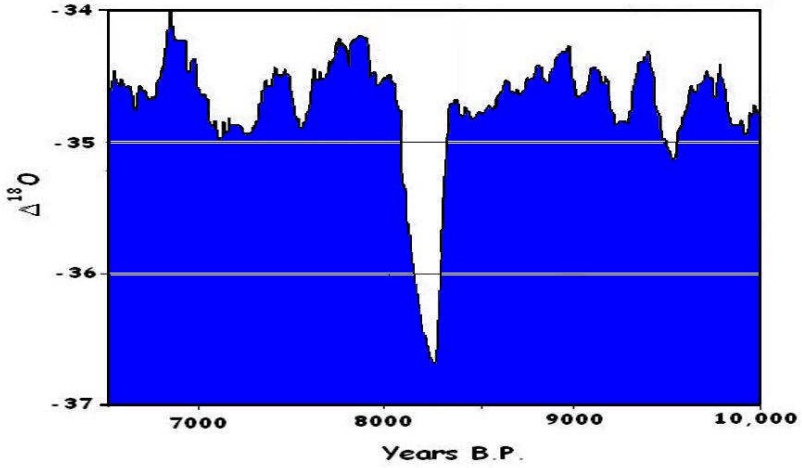

Figure 11. The 8200 sudden climate change, recorded in oxygen isotope ratios in the GISP2 ice core, lasted about 200 years.

Late Holocene climate changes

750 B.C. to 200 B.C. cool period

Prior to the founding of the Roman Empire, Egyptians records show a cool climatic period from about 750 to 450 B.C. and the Romans wrote that the Tiber River froze and snow remained on the ground for long periods (Singer, 2007).

The Roman warm period (200 B.C. to 600 A.D.)

After 100 B.C., Romans wrote of grapes and olives growing farther north in Italy that had been previously possible and of little snow or ice (Singer, 2007).

The Dark Ages cool period (440 A.D. to 900 A.D.)

The Dark Ages were characterized by marked cooling. A particularly puzzling event apparently occurred in 540 A.D. when tree rings suggest greatly retarded growth, the sun appeared dimmed for more than a year, temperatures dropped in Ireland, Great Britain, Siberia, North and South America, fruit didn't ripen, and snow fell in the summer in southern Europe (Baillie in Singer, 2007). In 800 A.D., the Black Sea froze and in 829 A.D. the Nile River froze (Oliver, 1973).

The Medieval Warm Period (900 A.D. to 1300 A.D.)

The Medieval Warm (MWP) Period was a time of warm climate from about 900–1300 AD when global temperatures were apparently somewhat warmer than at present. Its effects were evident in Europe where grain crops flourished, alpine tree lines rose, many new cities arose, and the population more than doubled. The Vikings took advantage of the climatic amelioration to colonize Greenland, and wine grapes were grown as far north as England where growing grapes is now not feasible and about 500 km north of present vineyards in France and Germany. Grapes are presently grown in Germany up to elevations of about 560 meters, but from about 1100 to 1300 A.D., vineyards extended up to 780 meters, implying temperatures warmer by about 1.0 to 1.4° C (Oliver, 1973, Tkachuck, 1983). Wheat and oats were grown around Trondheim, Norway, suggesting climates about warmer one degree C warmer than present (Fagan, 2000).

Elsewhere in the world, prolonged droughts affected the southwestern United States and Alaska warmed. Sediments in Lake Nakatsuna in central Japan record warmer temperatures. Sea surface temperatures in the Sargasso Sea were approximately 1°C warmer than today and the climate in equatorial east Africa was drier from 1000–1270 AD. An ice core from the eastern Antarctic Peninsula shows warmer temperatures during this period.

Oxygen isotope studies in Greenland, Ireland, Germany, Switzerland, Tibet, China, New Zealand, and elsewhere, plus tree-ring data from many sites around the world all confirm the presence of a global Medieval Warm Period. Soon and Baliunas (2003) found that 92% of 112 studies showed physical evidence of the MWP, only two showed no evidence, and 21 of 22 studies in the Southern Hemisphere showed evidence of Medieval warming. Evidence of the MWP at specific sites are summarized in Fagan (2007) and Singer (2007). Thus, evidence that the Medieval Warm Period was a global event is widespread. The IPCC 2nd report (Climate Change 1995) included a graph showing the MWP with warmer temperatures than today and the Little Ice Age with much cooler temperatures.

Despite all of this well-documented physical evidence of the global MWP, the IPCC 3rd report (Climate Change 2001) reassessed the MWP on the basis of tree ring studies by Mann et al. (1998) and concluded that neither the MWP nor the Little Ice Age were global climatic events. Mann's graph (Fig. 12) became known as "the hockey stick" of climate change and was used in the 2001 IPCC report to assert that climate had not changed and led to Gore's 2007 famous assertion that *"Our civilization has never experienced any environmental shift remotely similar to this. Today's climate pattern has existed throughout the entire history of human civilization,"* which is totally absurd as shown by the geologic record.

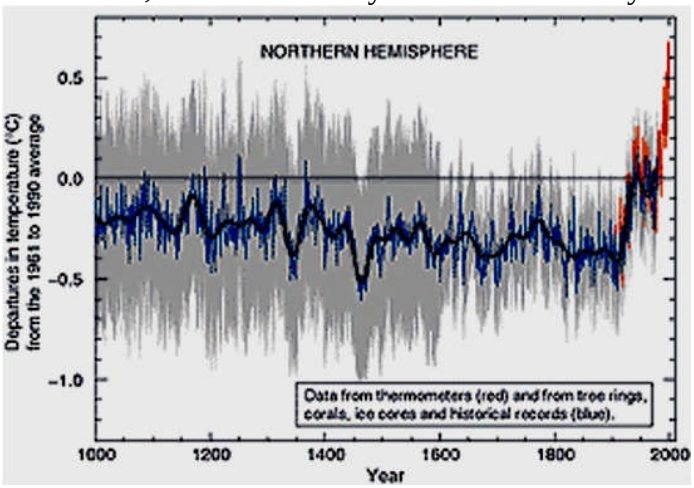

Figure 12. Mann (1998) "hockey stick" graph of temperature change over the past 1000 years

The Mann "hockey stick" was at odds with hundreds of historical and isotope sources, including the Greenland ice core isotope data, sea surface temperatures in the Sargasso Sea sediments (Fig. 13) (Keigwin, 1996), sea surface temperatures derived from sediment cores off Iceland (Fig. 14) (Sicre et al., 2008), and paleo-temperature data other than tree rings (Fig. 15) (Loehle, 2007). McIntrye and McKitrick (2003) evaluated the data in the Mann paper and concluded that the Mann curve was invalid *"due to collation errors, unjustifiable truncation or extrapolation of source data, obsolete data, geographical location errors, incorrect calculation of principal components and other quality control defects."* Thus, the "hockey stick" concept of global climate change is now widely considered invalid and an embarrassment to the IPCC.

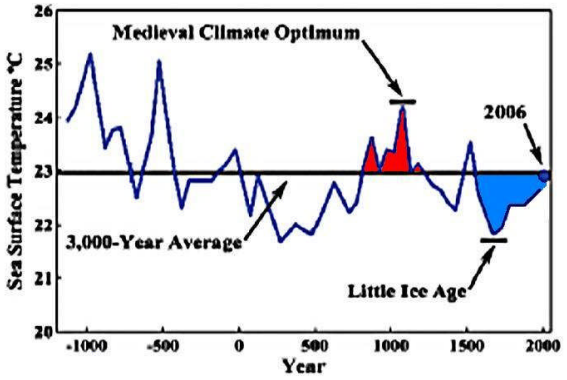

Figure 13. Surface temperatures of the Sargasso Sea reconstructed from isotope ratios in marine organisms (modified from Keigwin, 1996).

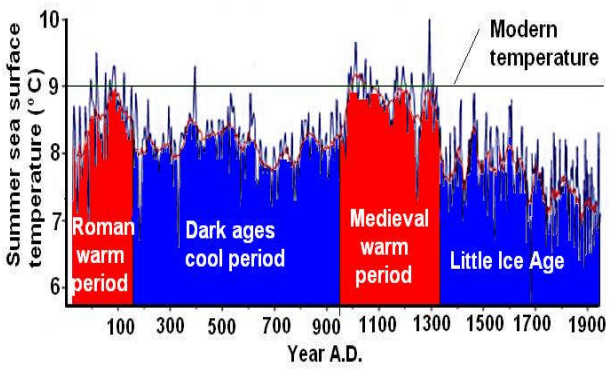

Figure 14 Sea surface temperatures derived from sediment cores off Iceland (modified from Sicre et al., 2008)

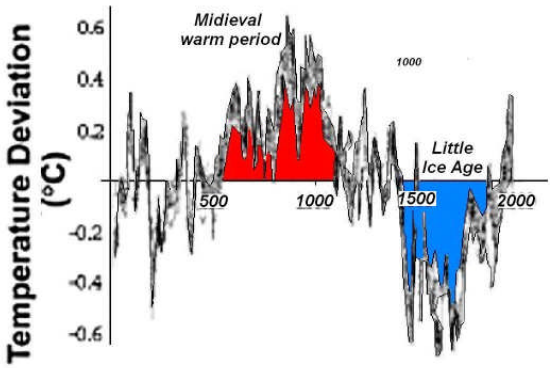

Figure 15. Reconstructed paleo-temperatures without tree ring data (Loehle, 2007)

The Little Ice Age (1300 A.D. to the 20th century)

At the end of the Medieval Warm Period, ~1230 AD, temperatures dropped ~4°C (~7° F) in ~20 years and the cold period that followed is known as the Little Ice Age. The colder climate that ensued for several centuries was devastating. Temperatures of the cold winters and cool, rainy summers were too low for growing of cereal crops, resulting in widespread famine and disease. When temperatures declined during the 30–year cool period from the late 1940's to 1977, Hansen and other climatologists and meteorologists predicted a return to a new Little Ice Age.

During the Little Ice Age, glaciers in Greenland advanced and pack ice extended southward in the North Atlantic. Glaciers expanded worldwide. The population of Europe had become dependent on cereal grains as a food supply during the Medieval Warm Period and when the colder climate, early snows, violent storms, and recurrent flooding swept Europe, massive crop failures occurred. Three years of torrential rains that began in 1315 led to the Great Famine of 1315-1317. The Themes River in London froze over, the growing season was significantly shortened, crops failed repeatedly, and wine production dropped sharply.

Winters during the Little Ice Age were bitterly cold in many parts of the world. Advance of glaciers in the Swiss Alps in the mid–17th century gradually encroached on farms and buried entire villages. The Thames River and canals and rivers of the Netherlands frequently froze over during the winter. New York Harbor froze in the winter of 1780 and people could walk from Manhattan to Staten Island. Sea ice surrounding Iceland extended for miles in every direction,

closing many harbors. The population of Iceland decreased by half and the Viking colonies in Greenland died out in the 1400s because they could no longer grow enough food there. In parts of China, warm weather crops that had been grown for centuries were abandoned. In North America, early European settlers experienced exceptionally severe winters.

In 1609, Galileo perfected the telescope, allowing observation of sun spots. From 1645 to1715, solar activity was extremely low, with some years having no sunspots at all. This period of low sunspot activity, known as the Maunder Minimum, coincided with the thermal low of the Little Ice Age. The Spörer Sunspot Minimum also occurred during a significant cold period of the Little Ice Age. Low solar activity during the Little Ice Age is also shown by changes in the production rates of radiocarbon and ^{10}Be in the upper atmosphere.

Global temperatures have risen about 1° F per century since the Little Ice Age, but the warming has not been continuous. Numerous 25-35 year warm/cool cycles appear in the record of glacial fluctuations and isotope records in Greenland ice cores.

Fluctuations since the Little Ice Age--short-term climate cycles

The global climate has warmed progressively since the LIA, but not at a constant rate. Oscillations between warm and cool periods have occurred in a fairly regular fashion about every 25-35 years (Fig. 16).

Global temperatures have risen about 1° F per century since the cooling of the Little Ice Age, but the warming has not been continuous. Numerous ~30 year warming periods have been interspersed with ~30 year cooling periods (Figure 7). However, each warming period has been slightly warmer than the preceding one and cool period has not been quite as cool as the previous one. For example, the present warm period (1977–2007) is slightly warmer than the 1920–1950 warm period, and the 1947–1977 cool cycle (Figure 1) is not quite as cool as the ~1880–1910 cool period.

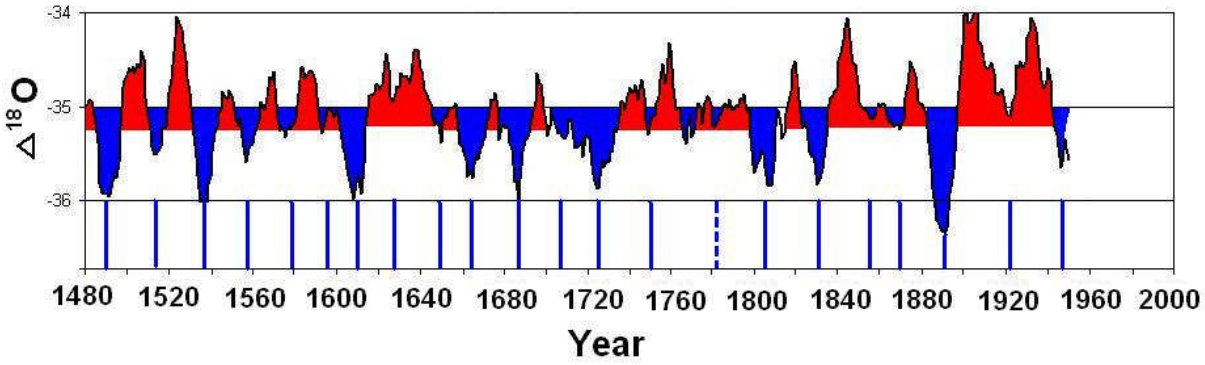

Figure 16. Cyclic warming and cooling trends in the past 500 years (plotted from GISP2 data, Stuiver and Grootes, 2000).

During each warm cycle, glaciers retreated and during each cool cycle, glaciers advanced. However, because each warm cycle was slightly warmer than the previous one and each cool cycle not quite as cool as the previous one, glacier termini have progressively receded upvalley from their Little Ice Age maximums. These relationships are well shown on glaciers on Mt. Baker, Washington where large distinct Little Ice Age moraines mark the glacier termini well below present ice termini. Successively higher moraines upvalley mark progressive advances and stillstands resulting from warm/cool cycles. The later moraines match the observed global climate changes (Fig. 1).

The oldest Little Ice Age moraines have trees growing on them dating back to the 1500's. A buried forest on the Coleman glacier moraine (Figure 8), dated at 680 ± 80 and 740 ± 80 ^{14}C yrs B.P., grew during the Midieval Warm Period atop an older moraine. The forest was buried by a Little Ice Age moraine. Annual rings from trees growing on successively younger moraines upvalley show moraine–building episodes in the 1600's, ~1750, ~1790, ~1850, and ~1890.

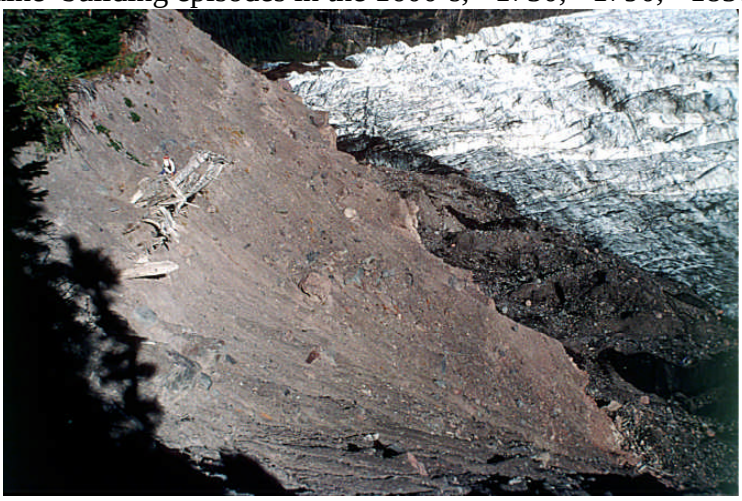

Figure 17. Little Ice Age moraine buring forest that grew during the Medieval Warm Period, Coleman glacier, Mt. Baker, WA.

Ice margins of Mt. Baker glaciers are shown on air photos dating back to 1943 and on some earlier ground and air photos. Glaciers that had been retreating since at least the 1920's advanced during the 1947–1977 cool period to positions downvalley from their 1943 termini. They began to retreat once again at the start of the 1977–2007 warm cycle and present termini of the Easton and Boulder glaciers are about 1500 ft. upvalley from their 1979 positions.

These glacier fluctuations closely follow the global cooling record and indicate that the ~30 yr. warming and cooling cycles seen in the glacial record mimic global climate changes. Thus, pre-historic glacial fluctuations also appear to record global climate changes (Figs. 19, 20).

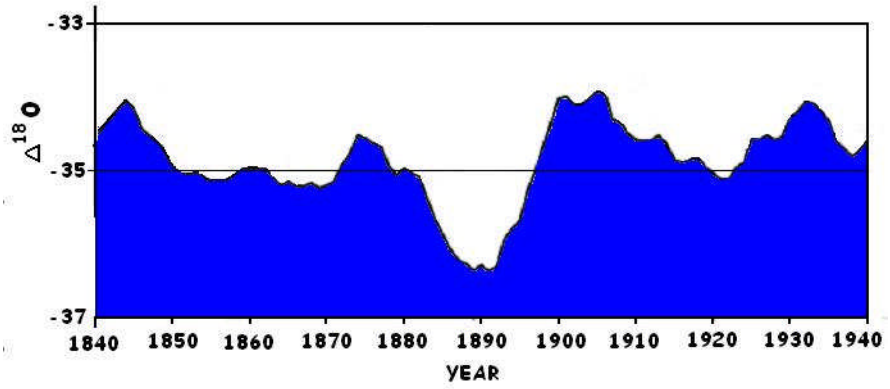

Figure 18. GISP2 oxygen isotope record of the 1875-1900 cool period.

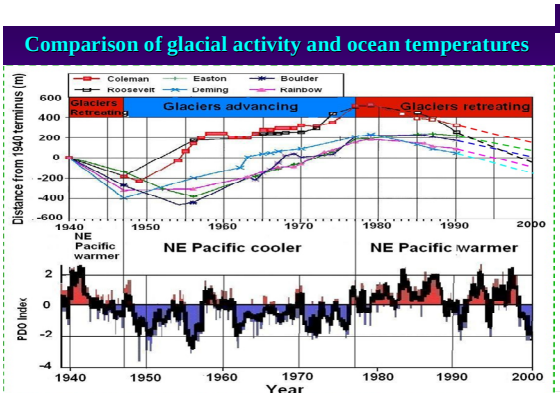

Figure 19. Comparison of advance and retreat of glaciers on Mt. Baker with the Pacific Decadal Oscillation of the NE Pacific Ocean.

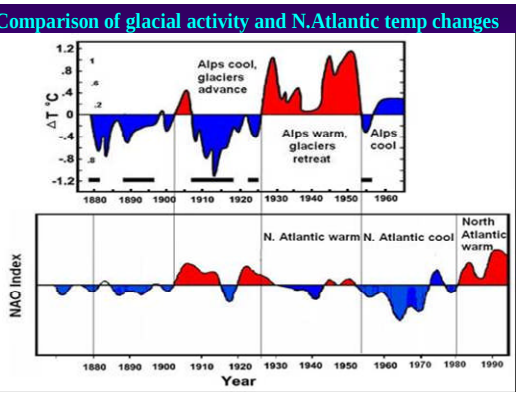

Figure 20. Comparison of advance and retreat of glaciers in the Alps with the North Atlantic Oscillation

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Additional climate changes are recorded in the Greenland ice sheet isotope data. Figure 18 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., nearing the end of the current 30 year warm period. Extending this ongoing record into the future provides an opportunity to predict coming climate changes.

Magnitude and significance of previous global climate changes

All 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. 10), and they took place in as little as 20–100 years. As shown on Figure 10, 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 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, and we are still in the post-1977 warm cycle. 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. If we look at temperature patterns since 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 about 4° C (~7° F). 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 air 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.

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. 21), 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 21). 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.

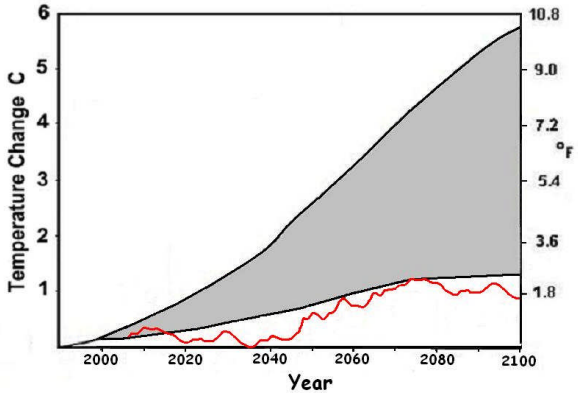

Figure 21. IPCC computer-projected global temperature increase for the coming century.

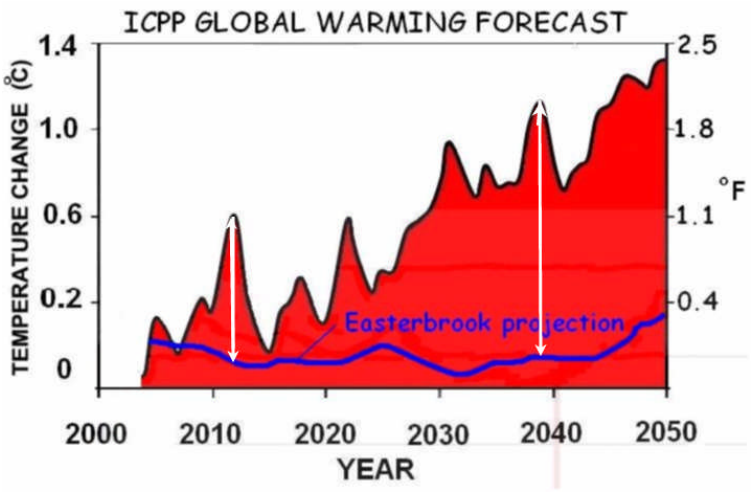

Figure 22. Comparison of IPCC global warming predictions to 2050 and the Easterbrook projection.

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.

Global cooling is here! Evidence for predicting global cooling for the next three decades

Despite no global warming in 10 years and recording setting cold in 2007-2008, the Intergovernmental Panel on Climatic Change (IPCC) and computer modelers who believe that CO_2 is the cause of global warming still predict the Earth is in store for catastrophic warming in this century. IPCC computer models have predicted global warming of 1° F per decade and 5-6° C (10-11° F) by 2100,

which would cause global catastrophe with ramifications for human life, natural habitat, energy and water resources, and food production. 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.

However, records of past climate changes suggest an altogether different scenario for the 21st century. Rather than drastic global warming at a rate of 0.5 ° C (1° F) per decade, historic records of past natural cycles suggest global cooling for the first several decades of the 21st century to about 2030, followed by global warming from about 2030 to about 2060, and renewed global cooling from 2060 to 2090 (Easterbrook, D.J., 2005, 2006a, b, 2007, 2008a, b); Easterbrook and Kovanen, 2000, 2001). Climatic fluctuations over the past several hundred years suggest ~30 year climatic cycles of global warming and cooling, on a general rising trend from the Little Ice Age.

Climatic fluctuations over the past several hundred years suggest ~30 year climatic cycles of global warming and cooling (Figure 3) on a generally rising trend from the Little Ice Age about 500 years ago.

Relationships between glacial fluctuations, the Pacific Decadal Oscillation, and global climate change.

After several decades of studying alpine glacier fluctuations in the North Cascade Range, my research showed a distinct pattern of glacial advances and retreats (the Glacial Decadal Oscillation, GDO) that correlated well with climate records. In 1992, Mantua published the Pacific Decadal Oscillation curve showing warming and cooling of the Pacific Ocean that correlated remarkably well with glacial fluctuations. Both the GDA and the PDO matched global temperature records and were obviously related (Fig. 23). All but the latest 30 years of changes occurred prior to significant CO_2 emissions so they were clearly unrelated to atmospheric CO_2.

The significance of the correlation between the GDO, PDO, and global temperature is that once this connection has been made, climatic changes during the past century can be understood, and the pattern of glacial and climatic fluctuations over the past millennia can be reconstructed. These patterns can then be used to project climatic changes in the future. Using the pattern established for the past several hundred years, in 1998 I projected the temperature curve for the past century into the next century and came up with curve 'A' in Figure 5 as an approximation of what might be in store for the world if the pattern of past climate changes continued. Ironically, that prediction was made in the warmest year of the past three decades and at the acme of the 1977-1998 warm period. At that time, the projected curved indicated global cooling beginning about 2005 ± 3-5 years until about 2030, then renewed warming from about 2030 to about 2060 (unrelated to CO_2—just continuation of the natural cycle), then another cool period from about 2060 to about 2090. This was admittedly an approximation, but it was radically different from the 1° F per decade warming called for by the IPCC. Because the prediction was so different from the IPCC prediction, time would obviously show which projection was ultimately correct.

Now a decade later, the global climate has *not* warmed 1° F as forecast by the IPCC but has cooled slightly until 2007-08 when global temperatures turned sharply downward. In 2008, NASA satellite imagery (Figure 6) confirmed that the Pacific Ocean had switched from the warm mode it had been in since 1977 to its cool mode, similar to that of the 1945-1977 global cooling period. The shift strongly suggests that the next several decades will be cooler, not warmer as predicted by the IPCC.

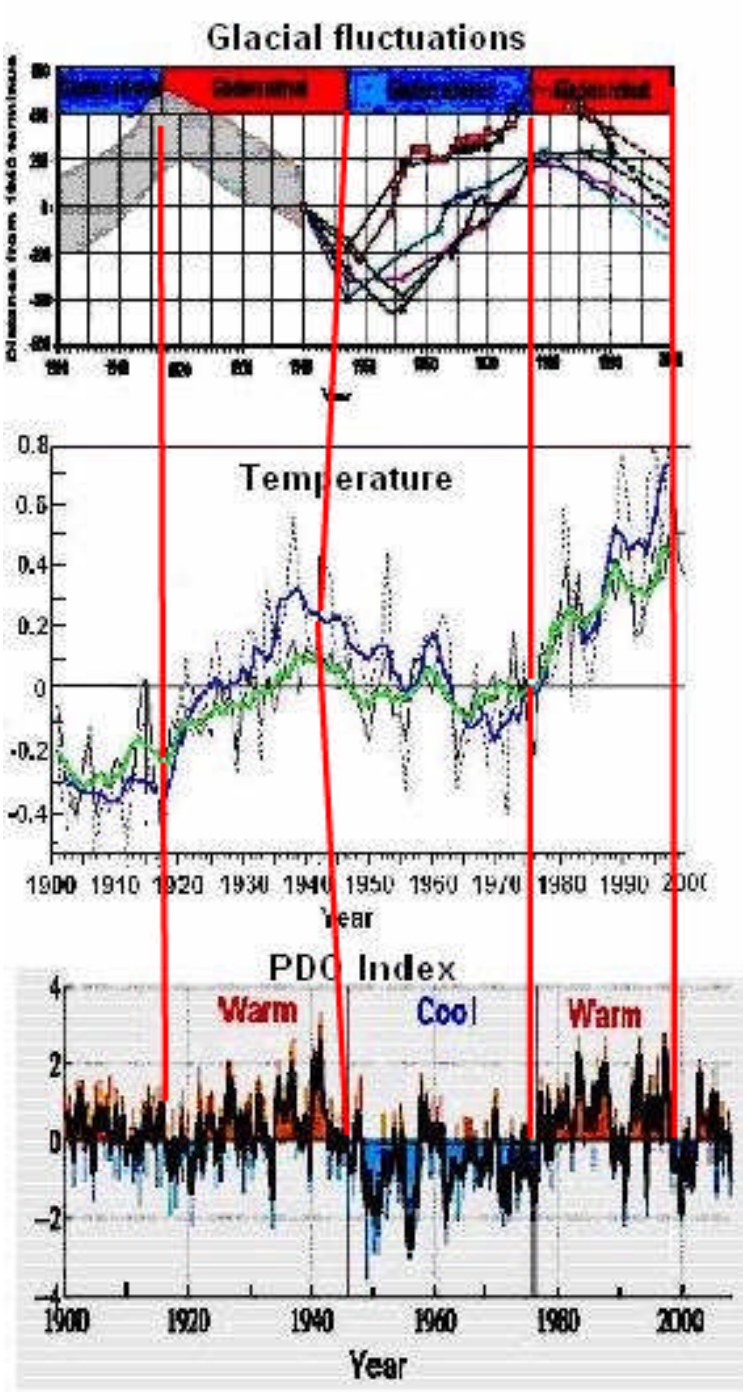

Figure 23. Correspondence of the GDO, PDO, and global temperature variations.

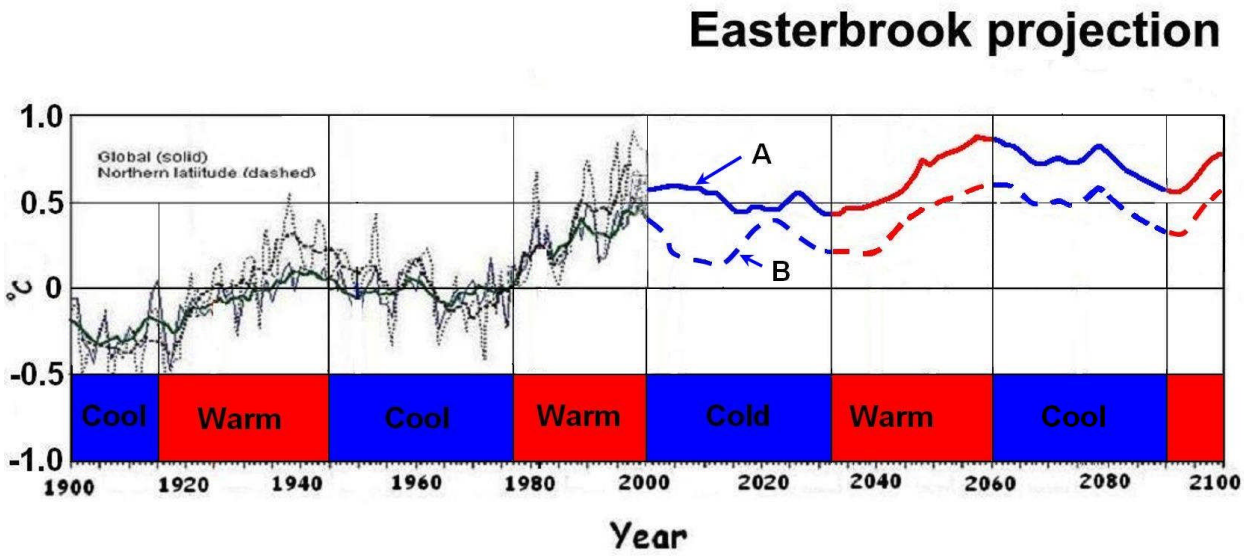

Figure 24. Global temperature projection for the coming century, based on warming/cooling cycles of the past several centuries. 'A' projection based on assuming next cool phase will be similar to the 1945-1977 cool phase. 'B' projection based on assuming next cool phase will be similar to the 1880-1915 cool phase. The predicted warm cycle from 2030 to 2060 is based on projection of the 1977 to 1998 warm phase and the cooling phase from 2060 to 2090 is based on projection of the 1945 to 1977 cool cycle.

Implications of PDO, NAO, GDO, and sun spot cycles for global climate in coming decades

The IPCC prediction of global temperatures, 1° F warmer by 2011 and 2° F by 2038 (Fig. 22), stand little chance of being correct. NASA's imagery showing that the Pacific Decadal Oscillation (PDO) has shifted to its cool phase is right on schedule as predicted by past climate and PDO changes (Easterbrook, 2001, 2006, 2007). The PDO typically lasts 25-30 years and assures North America of cool, wetter climates during its cool phases and warmer, drier climates during its warm phases. The establishment of the cool PDO, together with similar cooling of the North Atlantic Oscillation (NAO), virtually assures several decades of global cooling and the end of the past 30-year warm phase. It also means that the IPCC predictions of catastrophic global warming this century were highly inaccurate.

The switch of PDO cool mode to warm mode in 1977 initiated several decades of global warming. The PDO has now switched from its warm mode (where it had been since 1977) into its cool mode. As shown on the graph above, each time this had happened in the past century, global temperature has followed. The upper map shows cool ocean temperatures in blue (note the North American west coast). The lower diagram shows how the PDO has switched back and forth from warm to cool modes in the past century, each time causing global temperature to follow. Comparisons of historic global climate warming and cooling over the past century with PDO and NAO oscillations, glacial fluctuations, and sun spot activity show strong correlations and provide a solid data base for future climate change projections.

The Pacific Ocean has a warm temperature mode and a cool temperature mode, and in the past century, has switched back forth between these two modes every 25-30 years (known as the Pacific Decadal Oscillation or PDO). In 1977 the Pacific abruptly shifted from its cool mode (where it had been since about 1945) into its warm mode, and this initiated global warming from 1977 to 1998. The correlation between the PDO and global climate is well established. The announcement by NASA's Jet Propulsion Laboratory that the Pacific Decadal Oscillation (PDO) had shifted to its cool phase is right on schedule as predicted by past climate and PDO changes (Easterbrook, 2001, 2006, 2007). The PDO typically lasts 25-30 years and assures North America of cool, wetter climates during its cool phases and warmer, drier climates during its warm phases. The establishment of the cool PDO, together with similar

cooling of the North Atlantic Oscillation (NAO), virtually assures several decades of global cooling and the end of the past 30-year warm phase.

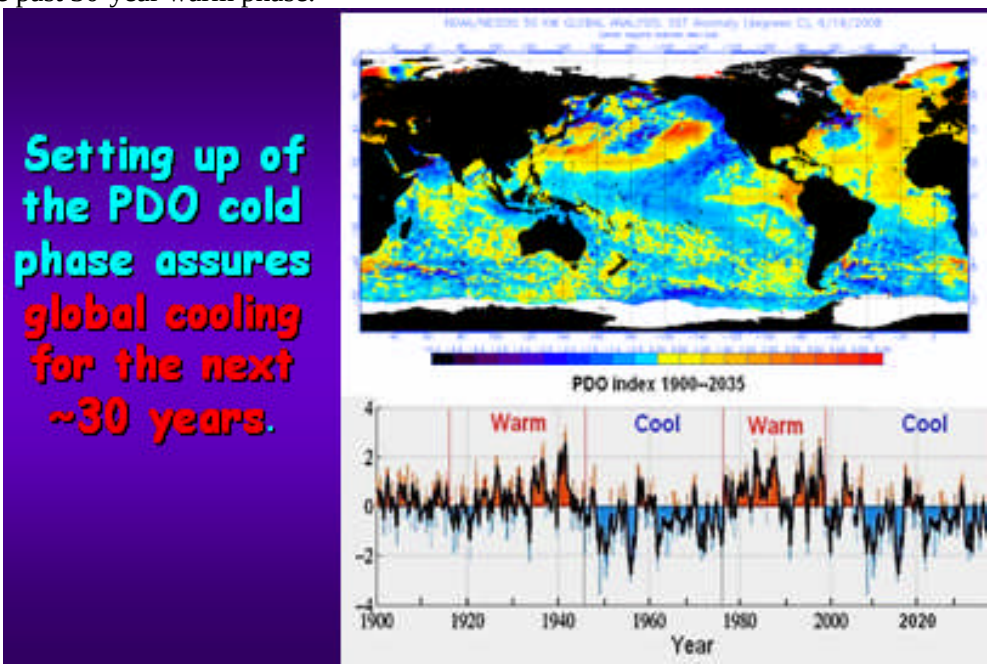

Figure 25. Switch of PDO cool mode to warm mode in 1977 initiated several decades of global warming. The PDO has now switched from its warm mode (where it had been since 1977) into its cool mode. As shown on the graph above, each time this has happened in the past century, global temperature has followed. The upper map shows cool ocean temperatures in blue (note the North American west coast). The lower diagram shows how the PDO has switched back and forth from warm to cool modes in the past century, each time causing global temperature to follow. Projection of the past pattern (right end of graph) assures 30 yrs of global cooling

Comparisons of historic global climate warming and cooling over the past century with PDO and NAO oscillations, glacial fluctuations, and sun spot activity show strong correlations and provide a solid data base for future climate change projections. As shown by the historic pattern of GDOs and PDOs over the past century and by corresponding global warming and cooling, the pattern is part of ongoing warm/cool cycles that last 25-30 years. The global cooling phase from 1880 to 1910, characterized by advance of glaciers worldwide, was followed by a shift to the warm-phase PDO for 30 years, global warming and rapid glacier recession. The cool-phase PDO returned in ~1945 accompanied by global cooling and glacial advance for 30 years. Shift to the warm-phase PDO in 1977 initiated global warming and recession of glaciers that persisted until 1998. Recent establishment of the PDO cool phase appeared right on target and assuming that its effect will be similar to past history, global climates can be expected to cool over the next 25-30 years. The global warming of this century is exactly in phase with the normal climatic pattern of cyclic warming and cooling and we have now switched from a warm phase to a cool phase right at the predicted time.

The ramifications of the global cooling cycle for the next 30 years are far reaching—e.g., failure of crops in critical agricultural areas (it's already happening this year), increasing energy demands, transportation difficulties, and habitat change. All this during which global population will increase from six billion to about nine billion. The real danger in spending trillions of dollars trying to reduce atmospheric CO_2 is that little will be left to deal with the very real problems engendered by global cooling.

CONCLUSIONS

Global warming (i.e, the warming since 1977) is over. The minute increase of anthropogenic CO_2 in the atmosphere (0.008%) was not the cause of the warming—it was a continuation of natural cycles that occurred over the past 500 years.

The PDO cool mode has replaced the warm mode in the Pacific Ocean, virtually assuring us of about 30 years of global cooling, perhaps much deeper than the global cooling from about 1945 to 1977. Just how much cooler the global climate will be during this cool cycle is uncertain. Recent solar changes suggest that it could be fairly severe, perhaps more like the 1880 to 1915 cool cycle than the more moderate 1945-1977 cool cycle. A more drastic cooling, similar to that during the Dalton and Maunder minimums, could plunge the Earth into another Little Ice Age, but only time will tell if that is likely.