
# Earth's Temperature: Abrupt Climate Change is Happening Now

The last 23 years have seen the 19 hottest years ever recorded. We have completely and totally broken out of our old climate and have begun the trip into a new climate era. New data from ice core research, high resolution sediment analysis and information obtained from cave formations, fossilized coral, preserved tree rings and organic debris have definitively shown that our Earth's temperature is rising at a rate that is a unprecedented in the last 10,000 years. It is now warmer than at anytime during our current interglacial warm phase, warmer than at any time in the last 100,000 years. This same research, and similar efforts around the globe have shown that increases in greenhouse gasses, primarily caused by man, are to blame. Out Earth's temperature is seemingly out of control. Over the last 5,000 to 6,000 years our climate should have been slowly cooling so that today's temperatures should be 4 to 6 degrees cooler than they actually are.(1) Carbon dioxide and methane, along with temperature, have slowly decreased after a each of the last three climate cycles reached their maximum temperatures following the last three long glacial periods. These periods between glaciated times, or ice ages, generally lasted about 10,000 years, and once started, slowly cooled by 5 or 6 degrees to a trigger point where the temperatures rapidly plunged back into the ice age climate.

Our current interglacial period however is not behaving like all of the rest. Instead of cooling we have been strangely stable, and in the last 150 years have started to warm

significantly. This warming has dramatically increased in the last 20 years and as our atmospheric content of greenhouse gasses is increasing faster than ever before, our temperature is likely to keep on increasing at ever-increasing rates until a climate trigger is flipped and our climate violently swings back towards ice age conditions. Until then, the records just keep piling up.

**Hottest 25 Years Ever Recorded**

| Rank | Year | Degrees above Normal |
|---|---|---|
| 1 | 2005 | 1.044 |
| 2 | 1998 | 1.008 |
| 3 | 2002 | 0.99 |
| 4 | 2003 | 0.936 |
| 5 | 2004 | 0.864 |
| 6 | 2001 | 0.846 |
| 7 | 1997 | 0.72 |
| 8 | 1990 | 0.666 |
| 9 | 1995 | 0.666 |
| 10 | 1999 | 0.594 |
| 11 | 1991 | 0.576 |
| 12 | 2000 | 0.576 |
| 13 | 1988 | 0.54 |
| 14 | 1987 | 0.486 |
| 15 | 1983 | 0.45 |
| 16 | 1994 | 0.45 |
| 17 | 1996 | 0.45 |
| 18 | 1981 | 0.396 |
| 19 | 1944 | 0.342 |
| 20 | 1989 | 0.342 |
| 21 | 1980 | 0.288 |
| 22 | 1992 | 0.252 |
| 23 | 1993 | 0.252 |
| 24 | 1941 | 0.216 |
| 25 | 1953 | 0.216 |

Source: Global Annual Mean Surface Air Temperature Change, Goddard Institute for Space Studies, January 2006.

If it were not for the Super-El Nino of 1998, the top 5 hottest years ever would have occurred in the last 5 years. As it is, the top 9 hottest have occurred in the last 12 and the top 19 hottest have occurred in the last 23 years.(18)

The most devastating heat wave of modern times struck Europe in 2003. All-in-all, over 35,000 people died. Swiss Re estimates the economic damages because of the heat wave at 16 billion US dollars. The casualties listed by country follow:

- France 14,802
- Italy 4,200
- Portugal 1,300
- Spain 4,200
- England 2,045
- Germany 7,000
- Netherlands 1,400
- Belgium 150

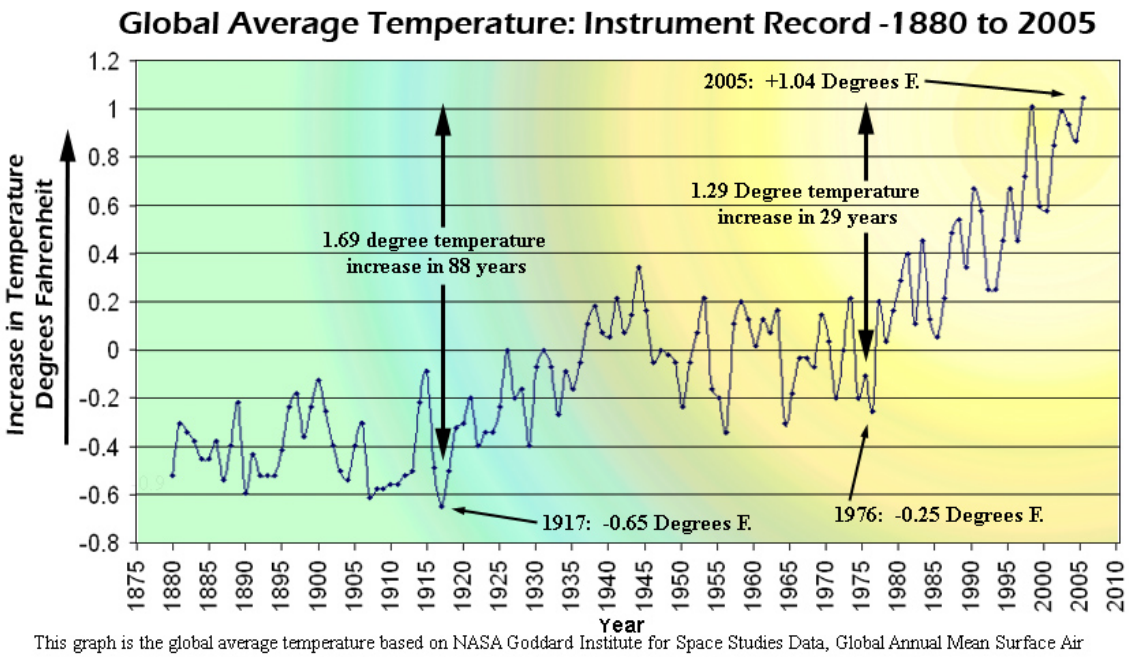
A letter in the Journal Nature in December 2004 by Peter Stott and colleagues has given a 90% confidence level that human influences on our climate had doubled the risk of such a heatwave (6). A paper from Geophysical Research Letters in January 2004 finds that the 2003 European heatwave was more characteristic of something that would happen because of global warming in the latter part of the 21st century (5).

In California in 2005, Death Valley set a new record for consecutive days at or above 125 degrees at seven. Junneau, Alaska beat a record 7 days of 80 degree plus weather set in 1951 with 10 days in 2005. More than 200 daily temperature records in six western states were broken.

The National Interagency Fire Center in Boise Idaho reports that a record 8.6 million acres burned across the U.S. in 2005, the most recorded since 1960. Five of the last ten wildland fire seasons have been in the top 10. As of April 2006, the season is progressing at a record pace with over 2 million acres already burned. Most of those have been in Texas where over 1.5 million acres have burned already this year.

A paper by Lindsay and Zhang, or the Polar Science Center at the University of Washington has found that Arctic sea ice has thinned over 40% since 1987. (7) Two scientists by the names of Rignoti and Kanagaratnamu, from the Jet Propulsion Laboratry at the California Institute of Technology and the Center or Remote Sensing of Ice Sheets at the University of Kansas, revealed in February 2006 that Greenland's ice is moving into the sea twice as fast as previously estimated. This increase in speed is most likely being caused by meltwater penetrating the ice sheet through crevasses and lubricating the base of the ice sheet. The implications of this increase in ice discharge has not been taken into consideration in sea level increase models and other climate models that rely on ocean temperatures and levels and will require that these models be evaluated for accuracy.

Our planet has warmed about 1.7 degrees across the globe in the last 100 years or less. Even though more than half of this rise has taken place in the last 30 years it might seem to be a modest amount of warming. Scientists have been warning of a 1 to 2 degree temperature increase because of global warming over the period of 100 years or more for the last 20 years. Today, more and more scientists are saying that past predictions of climate change were too small and took place over too long of a time span. The following graph shows global average temperature from the thermometer record for the past 125 years.(17) The jagged blue line is the average annual temperature.




This graph is the global average temperature based on NASA Goddard Institute for Space Studies Data, Global Annual Mean Surface Air Temperature Change, updated January 2006. The blue line represents individual annual average global temperature.

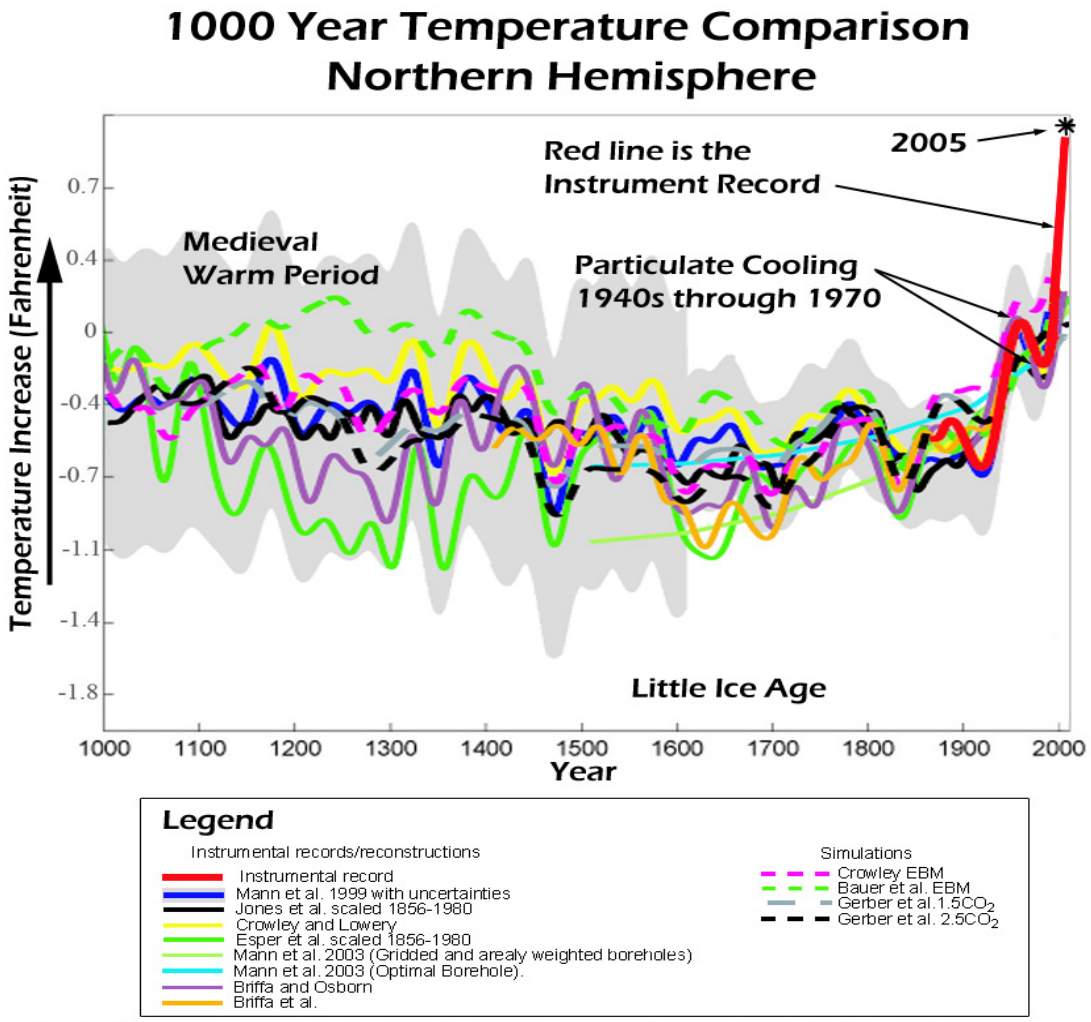
From the teens to the 1940s there was a significant rise in temperature across the globe, then the temperatures leveled off for 30 or more years. This was a period of increased particulate content of the atmosphere from industrial sources and automobiles that gave rise to speculation about man-caused global cooling.(2) The particulates (smog) blocked heat from the sun for 30 years kept the planet from warming. Buy the mid 1970's, most notably in the U.S. clean air laws had significantly improved atmospheric pollution, and the temperature started to rise again. Other factors have helped to accelerate the warming since the mid 70s like the rate of carbon dioxide increases in the atmosphere getting more pronounced and feedback affects from less snow reflection because of reduced global snow cover in winter.

One of the common questions asked about our records of global temperature involves the accuracy of the records. How can we measure the average temperature of the earth so accurately? The data in the chart *Global Average Temperature: Instrument Record - 1880 to 2005* are accurate to a little less than 0.1 degree Fahrenheit plus or minus since 1951. That is, if the chart shows a temperature of -0.22 degrees in 1930 we are 95%

certain that the temperature is between –0.32 and –0.12 degrees. The records have a four times greater error between 1860 and 1950 because of fewer reporting stations and the tendency for the records to be less complete, the accuracy getting better every year up until 1950.(3)

The temperatures shown were all measured with normal thermometers, but at different elevations, in different countries and from ocean going vessels. The higher the elevation, the lower the given temperature, just like in the mountains where the higher in altitude one travels, the colder it becomes. Different countries also estimate average temperatures differently. To make the different temperatures comparable they are all measured according to a standard reference period. In this case that period is 1961 to 1990. All stations are measured as the temperature difference, warmer or colder, from the average of each standard reference period (which is shown as zero in the chart). Much of the data over the oceans comes from mobile ships. This mass of seemingly random data can be assembled and compared to similar data to develop complete weather records for any given point. All of this data is assembled into a grid across the entire globe, with each grid related to all of the other grids according to their place on the globe. Thirty-one data sets from 7,200 different stations were used. In one data set - from the US - 1,200 different stations were used. (3, 4)

The next chart is a little more alarming than the first. It shows the last 1,000 years of temperature across the globe. This last 100 years of temperature change from the previous chart is shown with a little greater perspective - a bigger picture. This graph makes it a little easier to see how stable our climate was over the last millennia, and how rapidly it has begun to change in the last 100 or 150 years. This graph is also one of the more famous pieces of recent climate research and is called the Hockey Stick Graph because of the way that the current increase in temperatures juts out from the long, relatively unchanging historical temperature record like the business end of a hockey stick.(16) The different colored lines are from various data sets including ice cores, ocean sediments and a pollen study. The black line on the far right is the thermometer data.




**Original Source: Jones et. al., On past temperatures and anomalous late-20th century warmth EOS, American Geophysical Union, July 2003 . The various colored lines represent various temperature reconstructions. The instrument record in black has been extended from 2003 to 2005 by the author.**

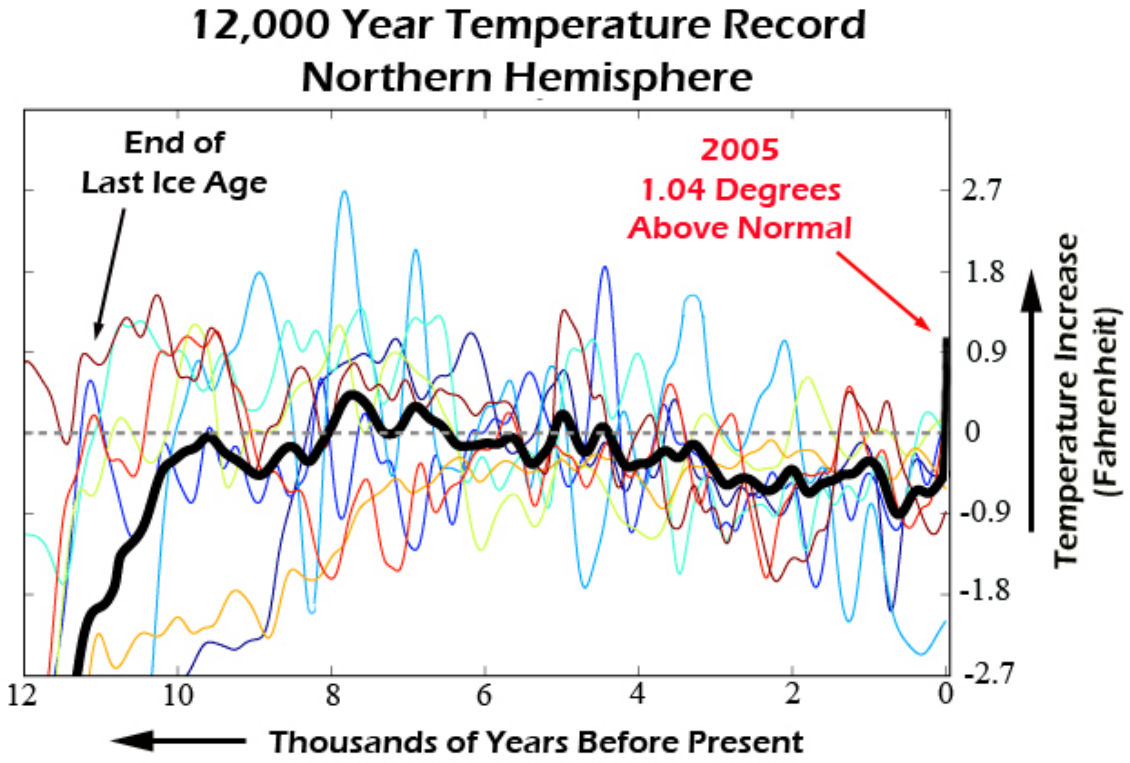
The 1000 Year Temperature Comparison chart , like psychedelic spaghetti, is complicated until you get it in your mouth. All of those different colored lines represent different studies or laboratory analysis or physical records or computer models including; solar influence, carbon dioxide, tree ring time / temperature research, continental borehole research and global surface temperature models. The gray shaded area is the estimated error. The trend is easy to see. Pick the densest area on the chart,

where the most amount of colored lines seem to be drawn. That would be right down the middle of the gray shaded area, right in the middle of the possible error. The most dense area between the lines is representative of the average temperature from many different sources. Averaging all of these different research methods together allows for a higher accuracy result to be obtained, or it can be viewed as another way of lessening the possible error. Notice how the error decreases as time moves closer to the present? The relationship between the abrupt increase in temperature over the last 100 years vs. the relatively gradual changes over the last 1000 years is fairly striking in this image – even if the instrument data record, which is very accurate,. Was not colored bold red. There are a few places in a few of the reconstructions where the climate changed about half as fast as it has over the last 88 years, by half the amount as it has recently, but nothing greater than that.

Our planet's 1.69 degrees of warming in less than a hundred years, when viewed within the perspective of the last 1,000 years, begins to appear significantly out-of-the-ordinary. Our climate was actually undergoing slight cooling until about 1850, a normal part of the last 9 or 10 interglacial warm periods. The year 1850 is the approximate date when historians agree that the Age of the Industrial Revolution began. Coal, oil and wood were needed to fuel the global industrial machine. At this time our society began an accelerated use of carbon as fuel. Records around the globe show a marked increase of carbon in the atmosphere around this time (see the chapter on Our Atmosphere in Trouble). Deforestation and increased livestock numbers compounded the situation, and man-made global warming began. Also in the above graph are two periods called the Little Ice Age and the Medieval Warm Period. The Little Ice Age was a worldwide climate change of less than a degree Fahrenheit. This period of history saw about a 1 degree cooling of the average temperature of our planet and endured crop failures, the decline of civilizations, the Irish Potato Famine and the Black Plague. The Medieval Warm Period, also about a 1 degree shift in temperature, saw the greatest social expansion of our planet's civilization ever recorded. So far this century, we have seen significantly more than a degree of change, and the rate of change is increasing. But will it result in a great sociological expansion?

The next graph shows how stable our temperature has been for the last 12,000 years and gives an even greater impression that our current global warming really is

absolutely no where near normal. During a typical interglacial warm period the temperature slowly cools until a threshold is crossed and the temperature plummets




Data Source: Jones and Mann, Climate over Past Millennia, Reviews of Geophysics, Vol. 42, No. 2 May 2005
Instrument record extended by the author to 2005.

back to ice age cold. The black line is the average of the data sets, a description of each temperature reconstruction is given below.(15) This is another fine example of averaging with accuracy. By combining all of these different data sets, we get a much bigger picture of what the global climate used to look like. We can compare this global picture to our current day global averages much more easily.

Data Sources: 12,000 Year Northern Hemisphere Record:

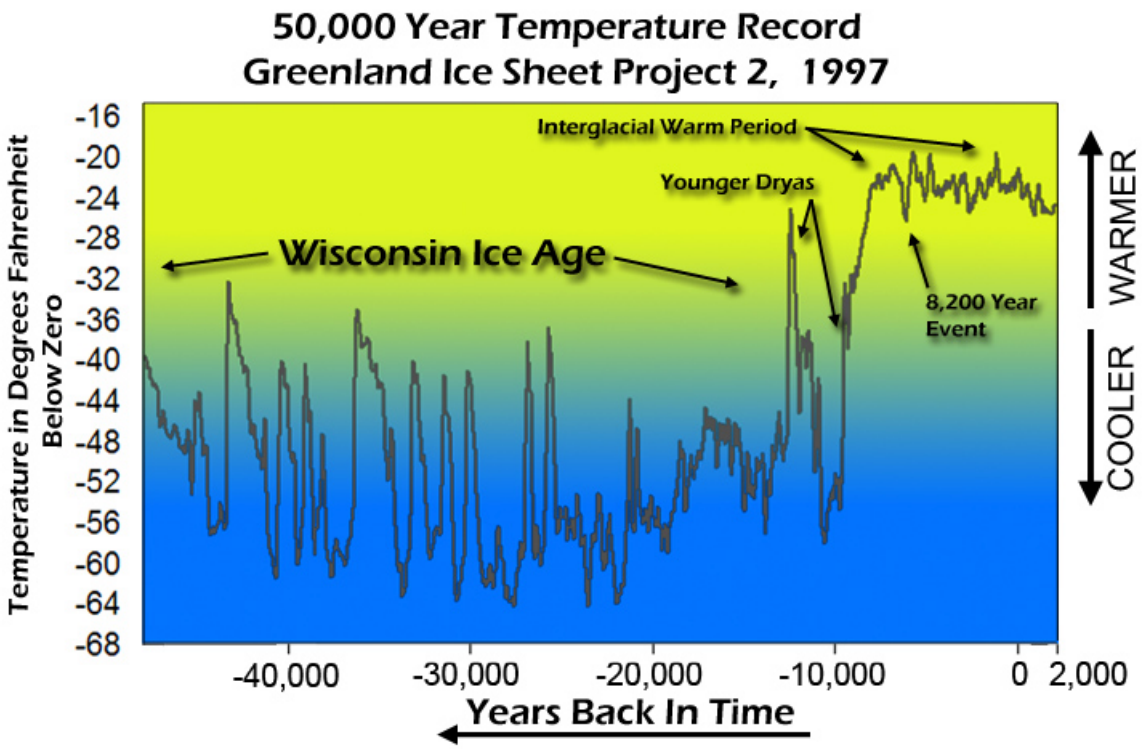
1. **(dark blue)** Sediment core ODP 658, interpreted sea surface temperature, Eastern Tropical Atlantic: Zhao, et. al., National Academy of Sciences, Molecular stratigraphy of cores off northwest Africa: Sea surface temperature history over the last 80 ka. *Paleoceanography*, 1995.

2. **(blue)** Vostok ice core, interpreted paleotemperature, Central Antarctica: Petit et. al., Climate and Atmospheric History of the Past 420,000 years from the Vostok Ice Core, Antarctica. *Nature*, 1999.
3. **(light blue)** GISP2 ice core, interpreted paleotemperature, Greenland: Alley, The Younger Dryas cold interval as viewed from central Greenland. *Quaternary Science Reviews*. 1999.
4. **(green)** Kilimanjaro ice core, $\delta^{18}O$, Eastern Central Africa: Thompson, et.al., Kilimanjaro Ice Core Records: Evidence of Holocene Climate Change in Tropical Africa. *Science*, 2002.
5. **(yellow)** Sediment core PL07-39PC, interpreted sea surface temperature, North Atlantic: Lea, et. al., Synchroneity of tropical and high-latitude Atlantic temperatures over the last glacial termination. *Science*, 2003.
6. **(orange)** Pollen distributions, interpreted temperature, Europe: British Antarctic Society, Davis, et. al., The temperature of Europe during the Holocene reconstructed from pollen data. *Quaternary Science Reviews*, 2003.
7. **(red)** EPICA ice core, interpreted site temperature, Central Antarctica: Stenni, et. al., A late-glacial high-resolution site and source temperature record derived from the EPICA Dome C isotope records (East Antarctica). *Earth and Planetary Science Letters*, 2003.
8. *(dark red) Composite sediment cores, interpreted sea surface temperature, Western Tropical Pacific:* Stott, et. al., Decline of surface temperature and salinity in the western tropical Pacific Ocean in the Holocene epoch. Nature, 2004.

Once again, this 12,000 year graph shows how truly different the last 150 years has been from anything in the last 12,000 years. We have been in one of the most stable climate periods ever seen and now it has ended. Mankind has so polluted the atmosphere of this planet that our future is changed.

The actual future of our planet's climate at this point is unknown. Climate models are well calibrated against historic climate, and are quite capable of simulating our future climate. These models are however, are simulations, and they are based on our climate history. Our atmosphere has been changed by our 6.5 billion person population and climate models have nothing to calibrate against for future scenarios or even greater changes to our atmosphere.

What we do know from recent findings in climate research is that big changes can happen very fast in our climate, and that in general, the bigger and faster the temperature rises, the bigger and faster will be the abrupt change leading to a much cooler climate. The next graph extends the climate record back 50,000 years.




Original Data Source: R. B. Alley, 2004, GISP 2 Ice Core Temperature and Accumulation Data, IGBP PAGES/World Data Center for Paleoclimatology Data Contribution Series #2004-013, NOAA/NGDC Paleoclimatology

Global warming has traditionally been something that happens at a glacial pace. The old theories are now changed because of the discovery of new information. Scientific agreement, on this change in basic theory about our climate, is as well accepted as previous theories on global warming were a decade ago. We now know that our climate can abruptly change more than 20 degrees in less than a lifetime, and sometimes these abrupt changes can occur in only a few of years.

The chart: 50,000 Year Temperature Record – Greenland Ice Sheet Project 2, 1997 is a record from the deep polar ice cap of what the temperature on the Greenland ice sheet was like during the last 50,000 years.(14) This period encompassed the last half of the last ice age (the Wisconsin Ice Age) and our current interglacial warm period. The temperatures were determined from laboratory techniques that analyze atmospheric

gases preserved in the ice. The saw-tooth pattern of the graph shows rising and falling temperatures over time, the peaks being warmer (yellow) and valleys being colder (blue). The scale on the left shows the temperature spread ranging from the coldest of 68 degrees below zero to the warmest of 16 degrees below zero. These abrupt changes of polar temperatures of twenty to thirty degrees cycled back and forth like a yo-yo over several thousand year periods. Much of the temperature changes occurred in only decades, and sometimes even less than a single decade. The chapter Eureka – Startling facts from deep ice goes into more depth about ice records. These abrupt shifts persisted for centuries to millennia. This new climate change theory is very different from previous climate change theories that required centuries to change the temperature by a few degrees. It is this vast difference in climate concepts that is making the new information even more difficult to believe than was the case with global warming theory.

## Not the Climate We Grew Up With

What in the world was going on during our ancient climate? It's not like the ice records are an isolated instance of this sort of thing. Sediment records from across the globe are showing very high similarity to the ice records as are tree rings, cave formations, and coral growth rings. It is a complex climate story that these scientists are unraveling, and the relatively simple explanations of these findings are the central theme of this book. These abrupt changes are not what we were taught, or what has trickled down from academia over the years as public perception of what an ice age is. But that's ok. A lot of things we were taught as a society were found out later to be less accurate than when those items were first discovered. Many theories stood for centuries before new knowledge replaced them with new theories. The entire population of our planet, or anyone who cared at the time, thought the Earth was flat, until a new theory was proposed.

# Glaciation Theory

The theory of glaciation is a good topic to help describe why new theories about the climate of our earth have been so hard to accept. In the late 1700s and early 1800s the

Photo Credit: Ulyses Sherman Grant, 1909 - Holgate and Little Holgate Glaciers: From the online glacier photograph database, Boulder, CO: National Snow and Ice Data Center/World Data Center for Glaciology, Digital media.

first ideas about glaciers and ice movement were being discussed. Before this time there was no idea of the gigantic scope of the Antarctic or Greenland ice sheets. Jens Esmark was among the first in 1824 to associate glaciers with the Fjords of Scandinavia. Jean de Charpentier soon developed theories on how glaciers formed and moved and generally rearranged the environment. Louis Agassiaz first proposed that much of the northern and southern hemispheres had once been covered by massive ice sheets.(10) Glacial theory was difficult for many scientist to agree upon at the time. The common understanding of deposits that were later proven to be from glaciers revolved around geologic disruption by great floods. Geologic flood theory (like the great Biblical Flood) was also emboldened by the presence of fossils in glacial deposits and the interpretation of how those fossils came to be where they were.

Ice sheet theory at the time was virtually non-existent. There were many common theories and much belief in an open polar sea for example. No one had been there; no one knew for sure, it was a theory. It was a theory that was surprisingly widely accepted given what we know today. It was not until 1888 that Fridtjof Nansen, one of

Photo Credit: Bruce Molina, 2004 - Holgate and Little Holgate Glaciers: From the online glacier photograph database, Boulder, C National Snow and Ice Data Center/World Data Center for Glaciology, Digital media.

the greatest polar explorers ever, first crossed the interior of the Greenland ice sheet and proved the theories of Luois Agassiz from 50 years earlier. It took 50 years for scientists to accept the theories of ice sheets. So what about their possible extension into Central Europe and the American Midwest?

John Strong Newberry and Charles Whittlesey, between 1862 and 1870 proposed that the Great Lakes had been formed by ice sheets thousands of feet thick that moved down from the poles in the last ice age, covered everything in their paths and completely changed the face of the planet. Scientist and the public alike were extremely skeptical. In the 1880s discussions of multiple ice ages occurring over long time spans became prevalent. In 1911 a young scientist named Milankovitch began studying what is called the periodicity of ice age cycles. He found, over the next 20

years, that there has been a very distinct ice age cycle of 90,000 years followed by 10,000 years of warmth (interglacial warm periods) that have recurred over the last 1 million years. His theory was based on orbital cycles of the sun and Earth that recur on regular intervals making the earth's tilt and closeness to the sun important for the growth of polar ice.

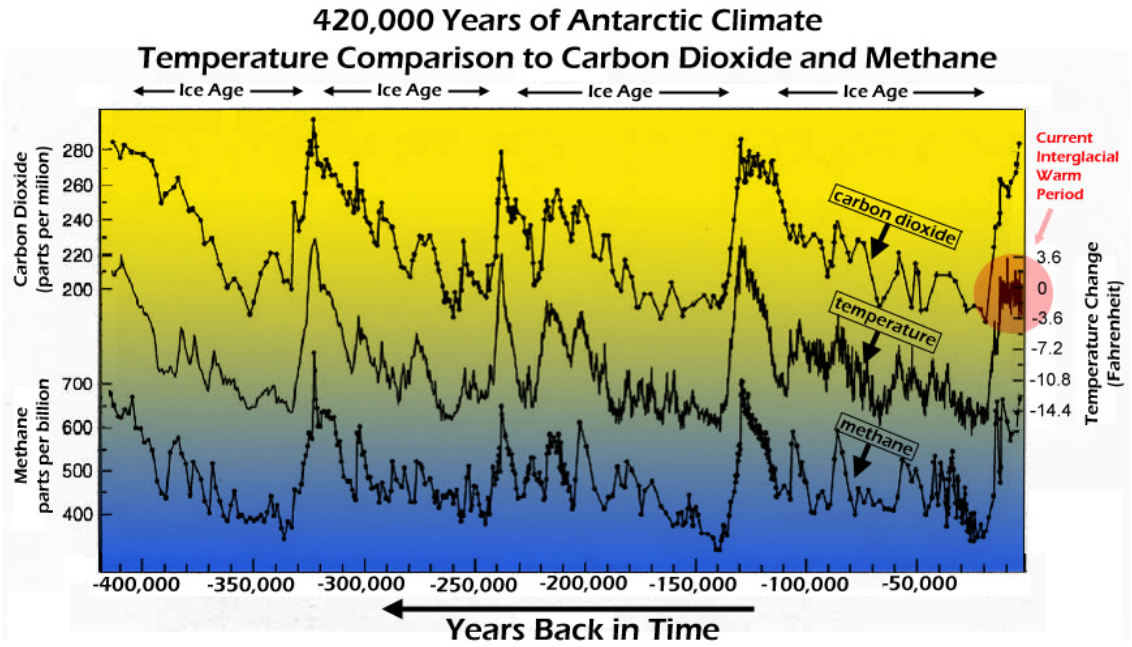
Milankovitch's theories were slow to be accepted until the early 1960s when the first significant ocean sediment core research began to show results that proved the orbital cycles theory. It took 80 years for science to warm up to ice age theory, and another 40 to prove how long ice ages last. Today, a significant majority of the general population has never even heard of abrupt climate change even though scientists started significant research and discussion on the topic in the mid 1970s. In 1993 scientist on the Greenland Ice Core Project drilled two identical ice cores, 20 miles apart that proved the theories of climate change like Fridtjof Nansen proved the theories about ice sheets. So any day now, most folks across the globe should become aware that our climate is not what we always thought it was.

## Four Ice Ages – 420,000 Years of Temperature, Carbon Dioxide and Methane Records

This chart shows three things at once: carbon dioxide, temperature and methane. These data sets come from an ice core at the Russian Antarctic station Vostok. These three things were put together one-on-top-of-the-other to show how they react and interact together over time. The big idea is that when one changes, they all change. When the temperature goes up, so does carbon dioxide and methane. The relationship appears to be simultaneous. Sometimes one or the other comes before or after by a few years or decades, but in general they all work together and none of the three ever change radically without the other two following along like peas in a pod. Temperature can definitely have an effect on methane levels, as the climate warms, more bogs form and release more methane. Carbon dioxide can likewise have an effect on climate– as the carbon dioxide content of the air increases, the greenhouse effect warms the planet.

But nowhere in the record of the last 420,000 years does carbon dioxide depart as radically from temperature and methane as it has done over the last one hundred or one hundred and fifty years.

A little description of the 420,000-year chart will clarify things. Carbon Dioxide ($CO_2$) is the top saw-tooth shaped data set with it's legend from 220 to 280 parts per million located on the top left side of the graphic. Temperature is the next line down with its legend in degrees Fahrenheit on the right, from 3.6 to –14.4 degrees Fahrenheit. This is temperature change, not real temperature. Antarctica's ice sheet is a few degrees colder than the top of the Greenland ice sheet. Winters usually get down to –70 degrees whereas in Greenland the temperature usually only gets down to –60 degrees. Methane




Data Source: Petit, et.al., Climate and atmospheric history of the past 420,000 years from the Vostok ice core, Antarctica, Nature Volume 399, June 1999, NOAA, National Climatic Data Center, Department of Commerce.

is the bottom line with a legend on the bottom left from 400 to 700 parts per billion. There are four ice ages represented in this data. These are shown at the top of the chart for reference, but are most easily identified by the peaks and valleys of the Data representing carbon dioxide, temperature and methane. The highest peaks are the

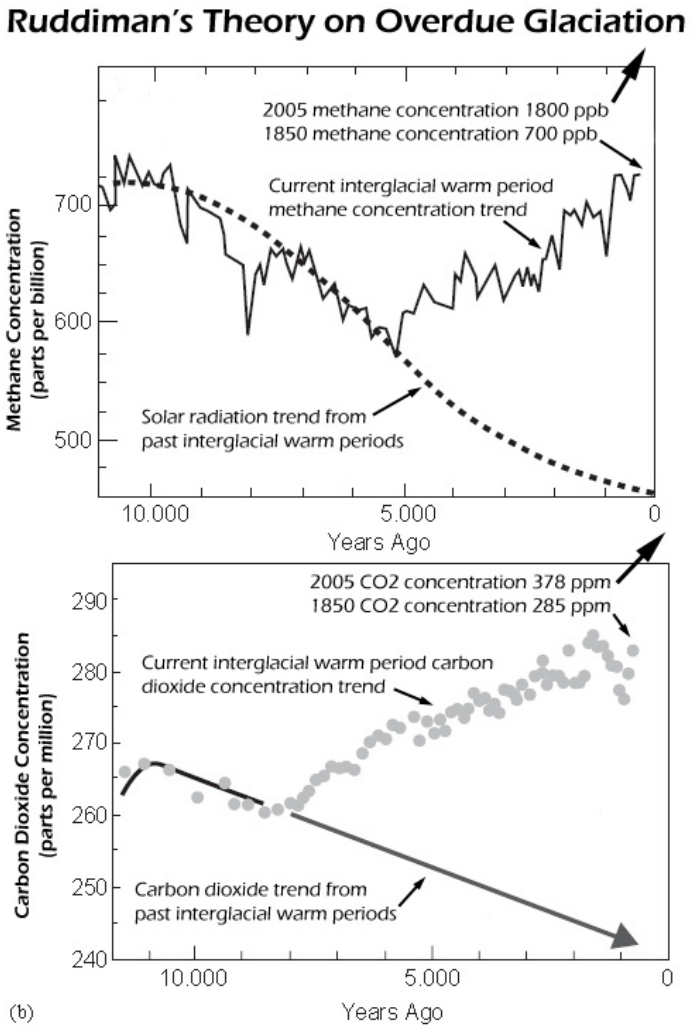
warmest parts of the interglacial warm periods, and the extended low areas or valleys are the depths of the ice ages. Carbon dioxide, methane and temperature all peak at the same time, or the methane and carbon dioxide concentrations in the atmosphere increase and decrease as the temperature increases and decreases.

Our current interglacial warm period is highlighted with a red circle on the right hand side of the chart. This is the same period that has been presented before in this chapter in three previous graphs: the Thermometer Record, the 100-Year Record and the 12,000-year Record. The stability of this warm period is even more striking when shown compared to the three previous interglacial warm periods. Why is this period so different than the rest? The previous three interglacial warm periods, at about 1120,000 years ago, 235,000 and 320,000 years ago all peaked very abruptly then slowly the temperature fell away into the depths of ice age cold. This is represented the best by the interglacial period that happened about 120,000 years ago, the period that that is most like our current interglacial period.

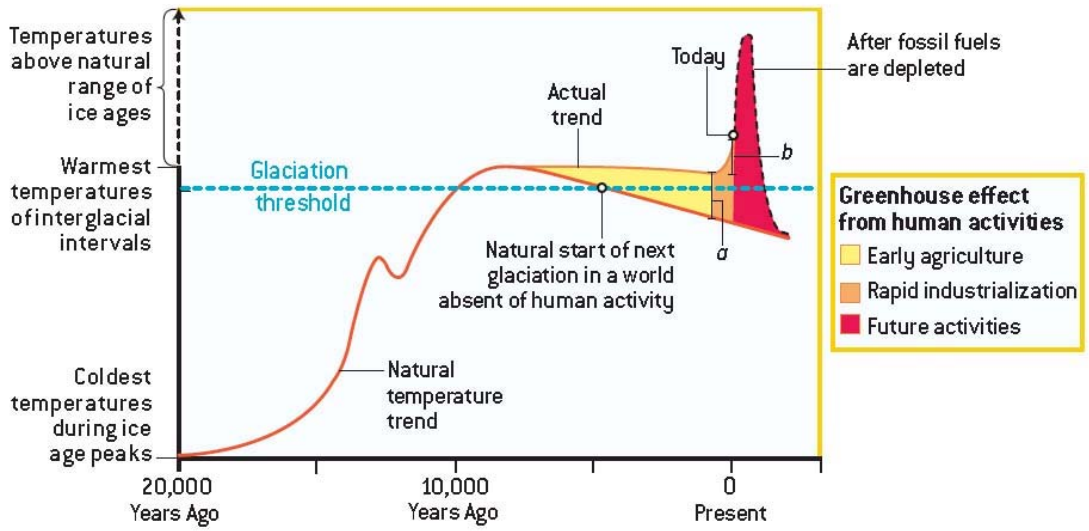
There are several other things to note concerning this information. The overall temperature change between ice age and interglacial periods is significantly smaller in Antarctica than at the North Pole. This is generally assumed to be because the Antarctic land mass, its location in the Southern Ocean and its relationship with the Antarctic Circumpolar Current has a stabilizing effect on the climate there. The continent of Antarctica is situated at nearly the exact bottom of the Earth. Because weather rotates around the pole, it also rotates around Antarctica. This creates a quasi-stable area where the weather varies less than typical climate areas that are constantly having weather systems roll through on their way around the world. Another thing that amplifies the "bottom of the world" affect of Antarctica's location is the circumpolar current. There is no land mass blocking ocean currents from circling around the South Pole in almost a perfect circle. This serves to cut off the Antarctic continent from warm ocean currents that could moderate the climate. The temperature changes less, but the patterns are still there. The 100,000 year long Milankovitch cycles are there and scientist say that there are significant similarities in the smaller abrupt changes within the ice age cycles between Antarctica and the rest of the world as well.

Possibly the most alarming thing that scientists are saying about the results of the study of this ice core comes from a paper published in Nature in 1999 titled: *Climate and atmospheric history of the past 420,000 years from the Vostok ice core, Antarctica.* The authors of this paper say: "Present-day atmospheric burdens of these two important greenhouse gases seem to have been unprecedented during the past 420,000 years."(11)

So while temperatures may not be quite as warm as they were during past interglacial periods, carbon dioxide and methane concentrations have not been this high in 420,000 years. (12, 13)




**These two graphs are from deep ice cores at the Russian Vostok Station in Antarctica. They show how the natural trends towards a colder climate have been interrupted by mankind's manipulation of the planet. The natural solar radiation trend and natural carbon dioxide trend are from previous interglacial warm periods in the Vostock record.**
**Original Source: Ruddiman, et. al., A test of the overdue glaciation hypothesis, Quaternary Science Reviews, Volume 24, 2005.**



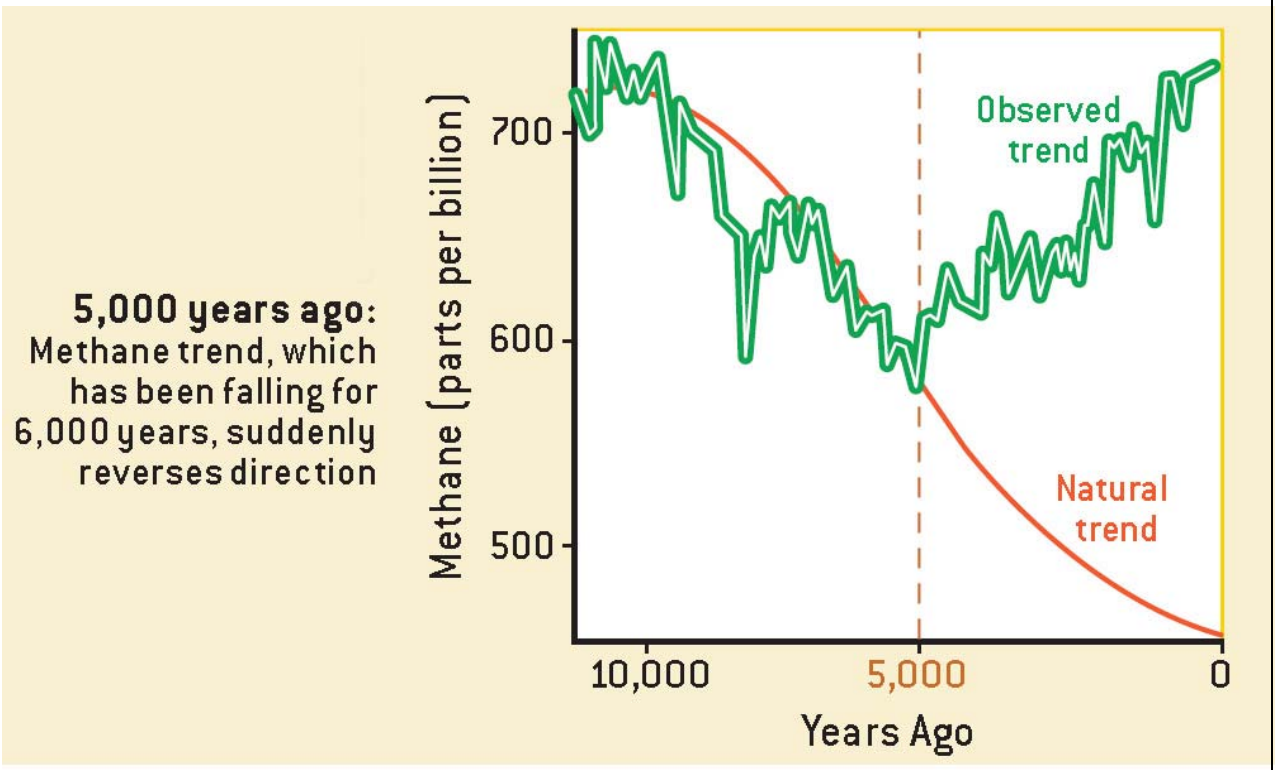

GREENHOUSE EFFECT from human activities has warded off a glaciation that otherwise would have begun about 5,000 years ago. Early human agricultural activities produced enough greenhouse gases to offset most of the natural cooling trend during preindustrial times (*yellow*), warming the planet by an average of almost 0.8 degree Celsius. That early warming effect (*a*) rivals the 0.6 degree Celsius (*b*) warming measured in the past century of rapid industrialization (*orange*). Once most fossil fuels are depleted and the temperature rise caused by greenhouse gases peaks, the earth will cool toward the next glaciation—now thousands of years overdue.

## Ruddiman Hypothesis: Scientific American , March 2005

The Ruddiman Hypothesis (William Ruddiman, The anthropogenic greenhouse era began thousands of years ago, Climatic Change volume 61, 261-293, 2003), is one of the most controversial of theories today. It states that the beginnings of large scale agriculture and forest clearing started 5,000 to 8,000 years ago when the climate should have been in a slow cooling trend into the next ice age. This slow cooling trend has been demonstrated time and again after interglacial warm periods over the last million years. This theory is supported by atmospheric modeling which shows that when CO2 and methane suspected to have been

added to the atmosphere by agriculture is removed, our current temperature should be 2 degrees C cooler than it is. About 11,000 years ago man invented agricultre, About 8,000 years ago he started clearing forests. Rice was domesticated about 7,500 years ago when people in China began flooding lowlands to grow this crop. In England, somewhere around the year 1,000 AD, 90 percent of the forests had been cleared for agriculture. The population density to reach this stage was about 10people per square kilometer. China and India had reached this density 2,000 to 3,000 years ago. Rice paddies began to be constructed around 2,500 years ago, intensifying even further the agricultural activities.

Ruddiman's Carbon dioxide Concentrations (13)




Ruddiman Hypothesis: Scientific American , March 2005

Ruddiman, Stephen J. Vavrus and John E. Kutzbach of the University of Wisconsin–Madison explored this world without CO2 and methane caused by early agriculture with a computer climate model. This model showed that without the human agriculture, our climate would be 2 degrees C or 3.6 degrees F cooler today than it actually is. This is about one third of the way to ice age conditions. Their model also showed, and has been shown by other models as well that temperature changes such as these would have already created the beginnings of new ice sheets across northern latitudes.

(1) Ruddiman, The Anthropogenic Greenhouse Era Began Thousands of Years Ago, Climatic Change, Volume 61, 2003.
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(3) Global Annual Mean Surface Air Temperature Change, NASA Goddard Institute for Space Studies Data, updated January 2006.
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## Holocene Carbon-cycle Dynamics Based on $CO_2$ Trapped in Ice at Taylor Dome, Antarctica

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