The Current Major Interglacial

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Chapter 1. Introduction

Homo sapiens on the Earth have been blessed with a relatively stable climate for the last 10,000 years or so, compared to the climate over the rest of the last 115,000 years of the last Major Ice Age (see Glossary), as shown in Figure 1-1.
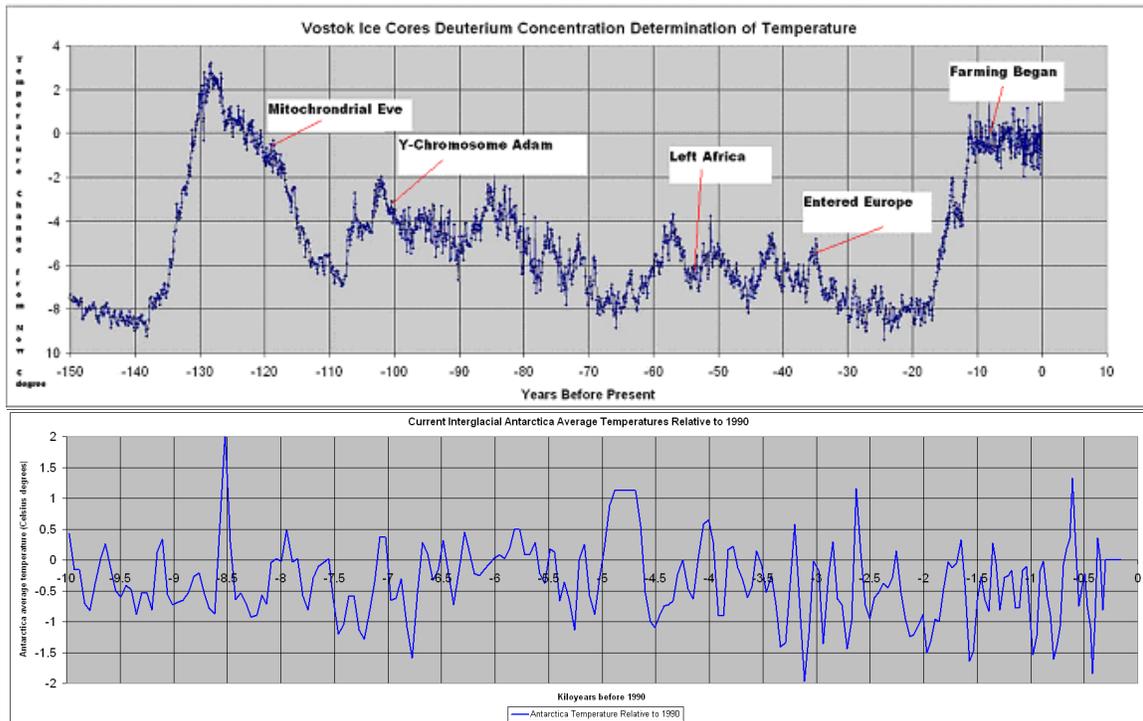
Figure 1-1. Vostok Antarctica temperatures relative to 1990 temperature as measured by deuterium concentration in ice cores (Pettit, 1999). Top: Temperature data from -150 kiloyears before 1990. Also shown are some major events for *Homo sapiens* during the last Major Ice Age. Bottom: Temperatures from -10 kiloyears before 1990 (current Major Interglacial; see Glossary).

From the bottom graph of Figure 1-1 it is seen that, although the temperature was relatively stable compared to the rest of the last Major Ice Age, there were some periods of rapid variation.

Over the last one million years there have been about eight Major Ice ages of about 115 kiloyears duration.

Figure 1-2 shows Vostok Antarctica temperature data and summer insolation at the North Pole for the last four Major Ice Ages and predictions for the next two Major Ice Ages. (North-Pole summer insolation is used because accumulation of ice in the Arctic region is crucial to Major Ice Ages cycles and summer is when the ice can melt.) The temperature data were "tuned" to the insolation calculation, since they lagged excessively at earlier times and the temperature measurements are more prone to error for earlier times (deeper ice cores); thus the calculated lag of temperature to insolation of about 5000 years has been eliminated.
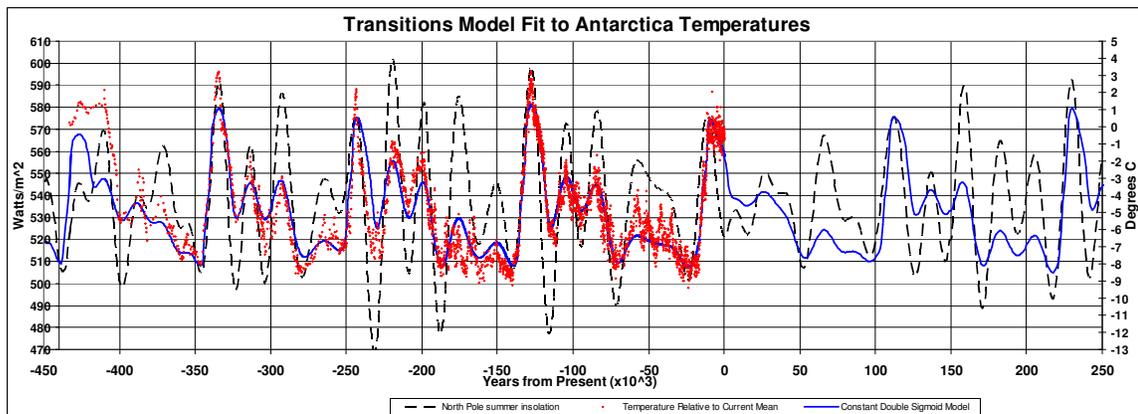
Figure 1-2. Antarctica temperature data (right scale) for 425,000 ybp to the present (present=0 on horizontal scale), which shows four Major Ice Ages of about 115,000-years duration and the five Major Interglacials that bound them. The dashed curve is the precisely calculated solar energy per area that strikes the Earth's upper atmosphere (insolation) (left scale) at the North Pole in the summer. The solid curve is a model fit to the temperature data for four previous Major Ice Ages (Roper, 2004), which is extrapolated into the next two Major Ice Ages up to 250,000 yap. (http://www.roperld.com/science/tempsolinsatc.pdf)

Chapter 2. Antarctica and Greenland Temperatures for the Current Major Interglacial

Figure 2-1 shows Antarctica temperatures relative to 1990 for the current and the last four Major Interglacial periods shifted appropriately for comparison. The last four are shifted in time to make their peaks about the same point in the graph. The last three are much more to be trusted for accuracy than is the fourth one at the end of the ice core at about 425 kiloyears before 1990.
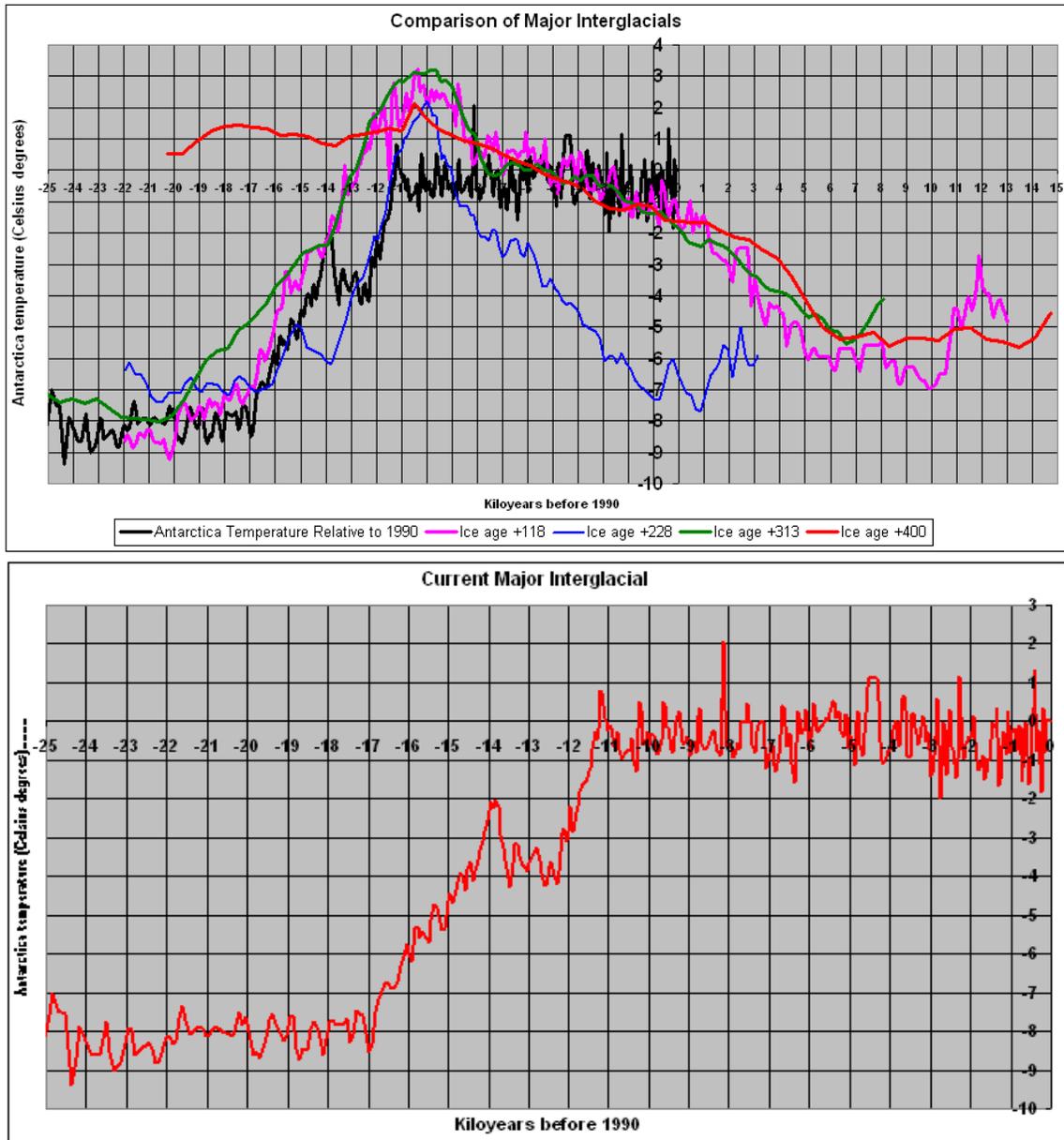
Figure 2-1. Comparison of the last three Major Interglacials with the current Major Interglacial and about 15 kiloyears before them. Antarctica temperatures are relative to 1990 for the current and last four Major Interglacials, which are shifted in time to make their peaks at about the same point in the graph. Top: Comparison. Bottom: Current Major Interglacial and 15 kiloyears before it.

It is clear that the current Major Interglacial is anomalously long and flat compared to the other four Major Interglacials.

The prevailing theory of the rapid rise from a Major Ice Age into a Major Interglacial is that the North Atlantic thermohaline ocean currents (NAOC) (http://en.wikipedia.org/wiki/Thermohaline_circulation) is turned on.

Temperatures in ice cores for Greenland have also been measured, as shown in Figure 2-2.
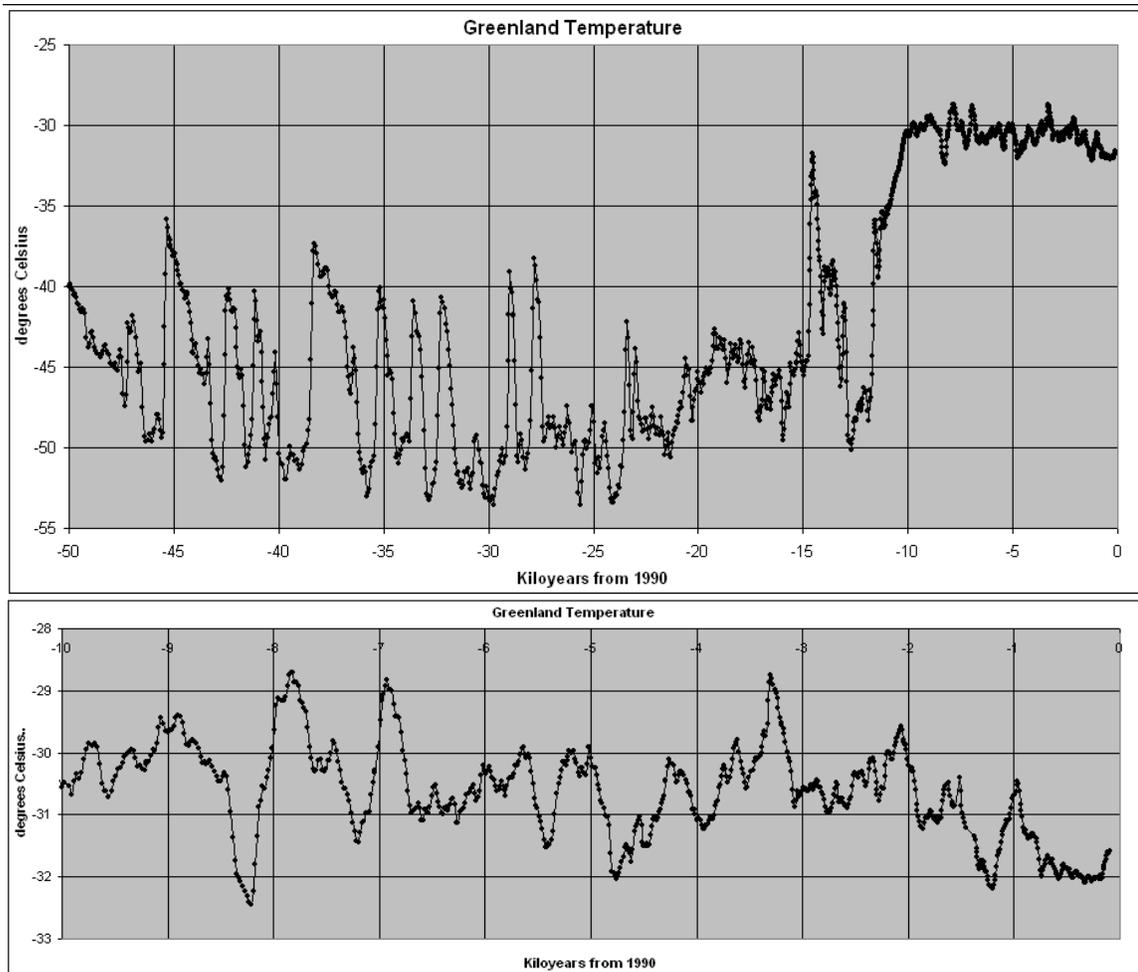
Figure 2-2. Greenland temperatures for the last 50 kiloyears before about 1900 as measured in ice cores. (ftp://ftp.ncdc.noaa.gov/pub/data/paleo/icecore/greenland/summit/gisp2/isotopes/gisp2_temp_accum_alley2000.txt) **Top: Last 50 kiloyears to 1900. Bottom: Last 10 kiloyears to 1900.**

Figure 2-3 compares the Antarctica temperatures relative to about 1990 and the Greenland temperatures relative to about 1900 for the last 50 kiloyears and 10 kiloyears.
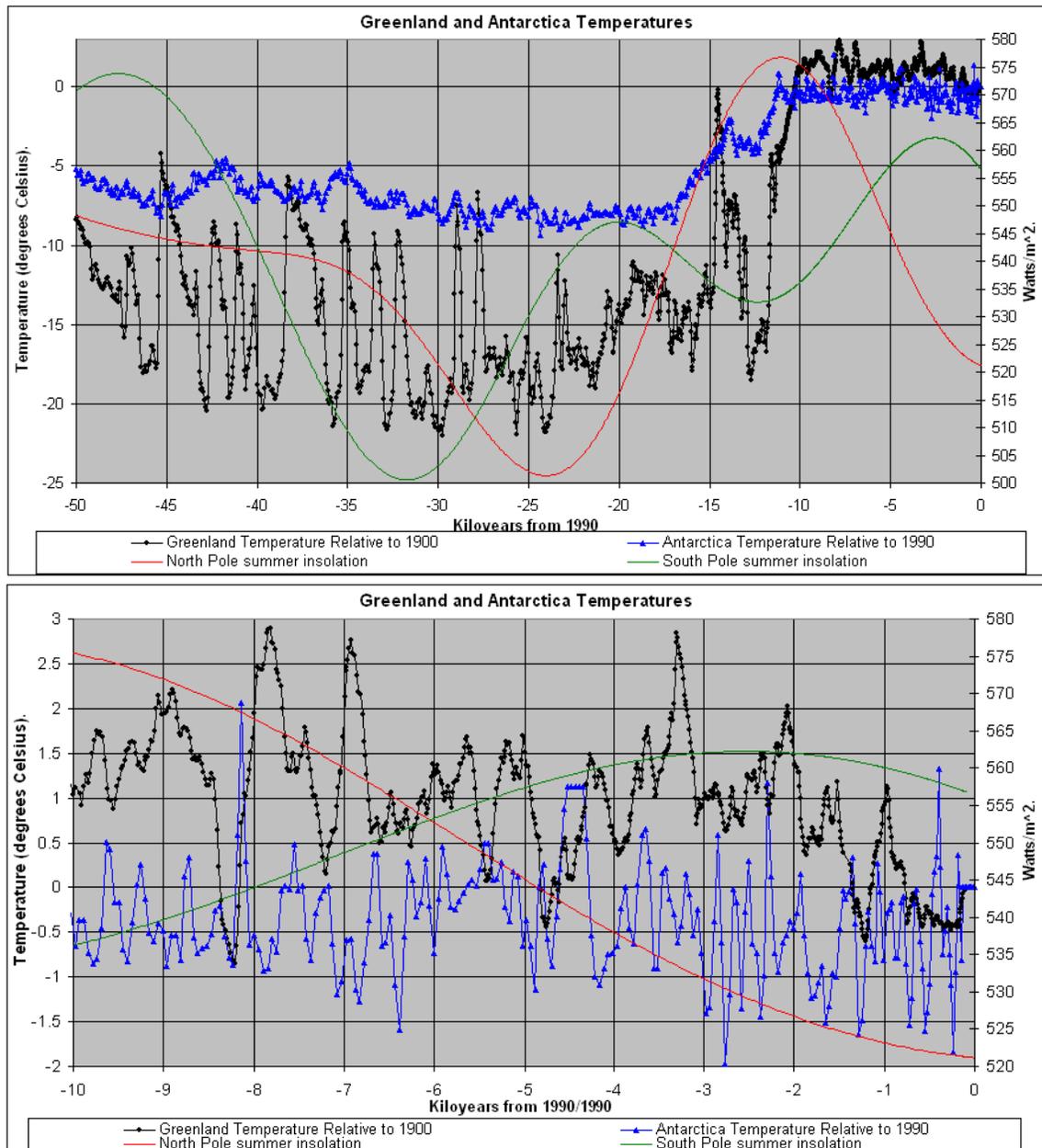
Figure 2-3. Comparison of Antarctica temperatures relative to 1990 and Greenland temperatures relative to 1900. Also shown is the calculated North Pole summer insolation (right scale) (Berger, 1991). Top: Last 50 kiloyears. Bottom: Last 10 kiloyears.

Note that the Greenland temperature differences over the current Major Interglacial are mostly positive compared to 1900 and larger than the Antarctica temperature changes, which are mostly negative relative to 1990. The Greenland temperatures and the Antarctica temperatures have the opposite relationship for the tail end of the last Major Ice Age before the current Major Interglacial. That is, the change from average temperature in the Arctic is much larger negatively than in Antarctica during a Major Ice Age, but the change from average temperature in Antarctica is somewhat smaller positively than the Arctic in a Major Interglacial. A possible theory for this is that the North Atlantic thermohaline ocean currents (NAOC) (See Glossary.) turning on are what cause the rapid transition into a Major Interglacial from the Major Ice Age and that similar, but much smaller, South Atlantic thermohaline ocean currents occur in the Antarctic.

Also, note that the Younger Dryas temperature dip (http://en.wikipedia.org/wiki/Younger_Dryas) between -15 kiloyears and -10 kiloyears was much stronger in Greenland than it was in Antarctica. The prevailing theory for the Younger Dryas temperature dip is that part of the North Atlantic thermohaline ocean currents (NAOC) (See Glossary.) is turned off briefly, probably due to melting ice reducing the saline content of Arctic water. However, usually when that happens Antarctica warms instead of cools (**Houghton, 2004**). Perhaps fresh water was dumped into the Antarctic, also, cutting off a warm current flowing into that region.

An example of Greenland cooling while Antarctica warms is shown at about -8.2 kiloyears in Figure 2-3 when an ice dam that separated Lake Agassiz from the Atlantic Ocean, by way of Hudson Bay and the Labrador Sea, was breached (probably by water flowing under it) and a huge amount of fresh water was dumped into the Atlantic Ocean. See Figure 2-4. (http://pangea.stanford.edu/research/Oceans/GES205/superlakes.pdf) The theory is that the huge amount of fresh water turned of part of the North Atlantic Ocean thermohaline current, thus cooling the Arctic and warming the Antarctic.
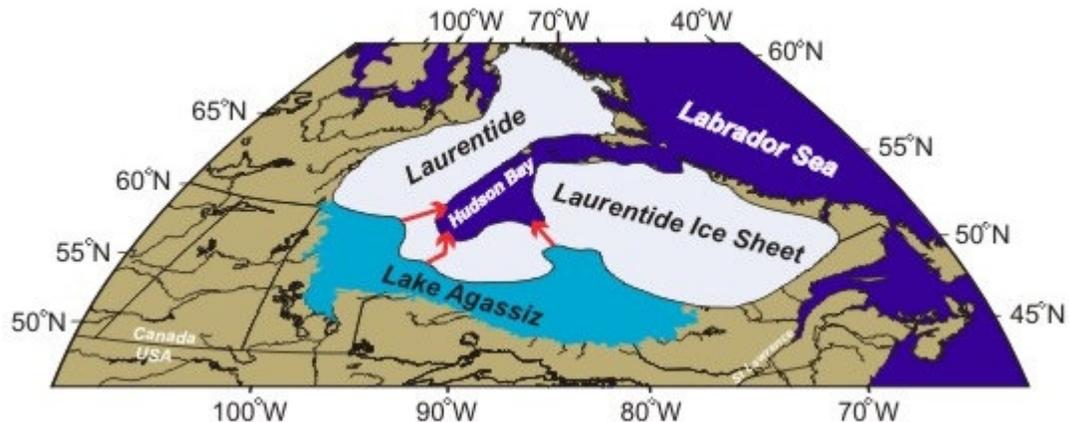
Figure 2-4. Lake Agassiz and three possible points of breaches (red arrows) of the ice dam. (http://pangea.stanford.edu/research/Oceans/GES205/superlakes.pdf)

A close look at the Figure 2-3 hints that a similar event might have occurred between -4.5 kiloyears and -5 kiloyears.

Chapter 3. Fits to the Antarctica and Greenland Temperatures for the Current Major Interglacial

One can fit a series of double hyperbolic tangents, to represent the turning on and off of Earth states, to the temperature data for the current Major Interglacial and the period leading into it.
The mathematical function is:

$$T(t) = C + F \cdot I(t) + \sum_{j=1}^{N} s_j \frac{1}{2} \left[\tanh\left(\frac{t - c_{1j}}{w_{1j}}\right) - \tanh\left(\frac{t - c_{2j}}{w_{2j}}\right) \right]$$

$$= \text{temperature in degrees Celsius,}$$

where $I(t)$ = calculated summer North-Pole insolation at time t in $\frac{Watts}{m^2}$;

DHTF parameters: s_j = strength, c_{Nj} = position, w_{Nj} = width;

and N = number of DHTFs used in the fit.

(DHTF = double hyperbolic tangent = double sigmoid.) The time constant for a fall or a rise is $w/2$.

Table 3-1 gives the parameters for the fit to the Antarctica temperature data and Figure 3-1 shows the fit.

Table 3-1. Parameters for the double-hyperbolic-tangent fit to the Antarctica temperatures.

s	c_1	w_1	c_2	w_2	Insolation Factor	Constant
6.94527	-14.55343	1.75766			0.02019	-18.8125
0.76238	-6.24129	0.50000				
-2.53164	-13.52438	0.11971	-11.57177	0.25589		
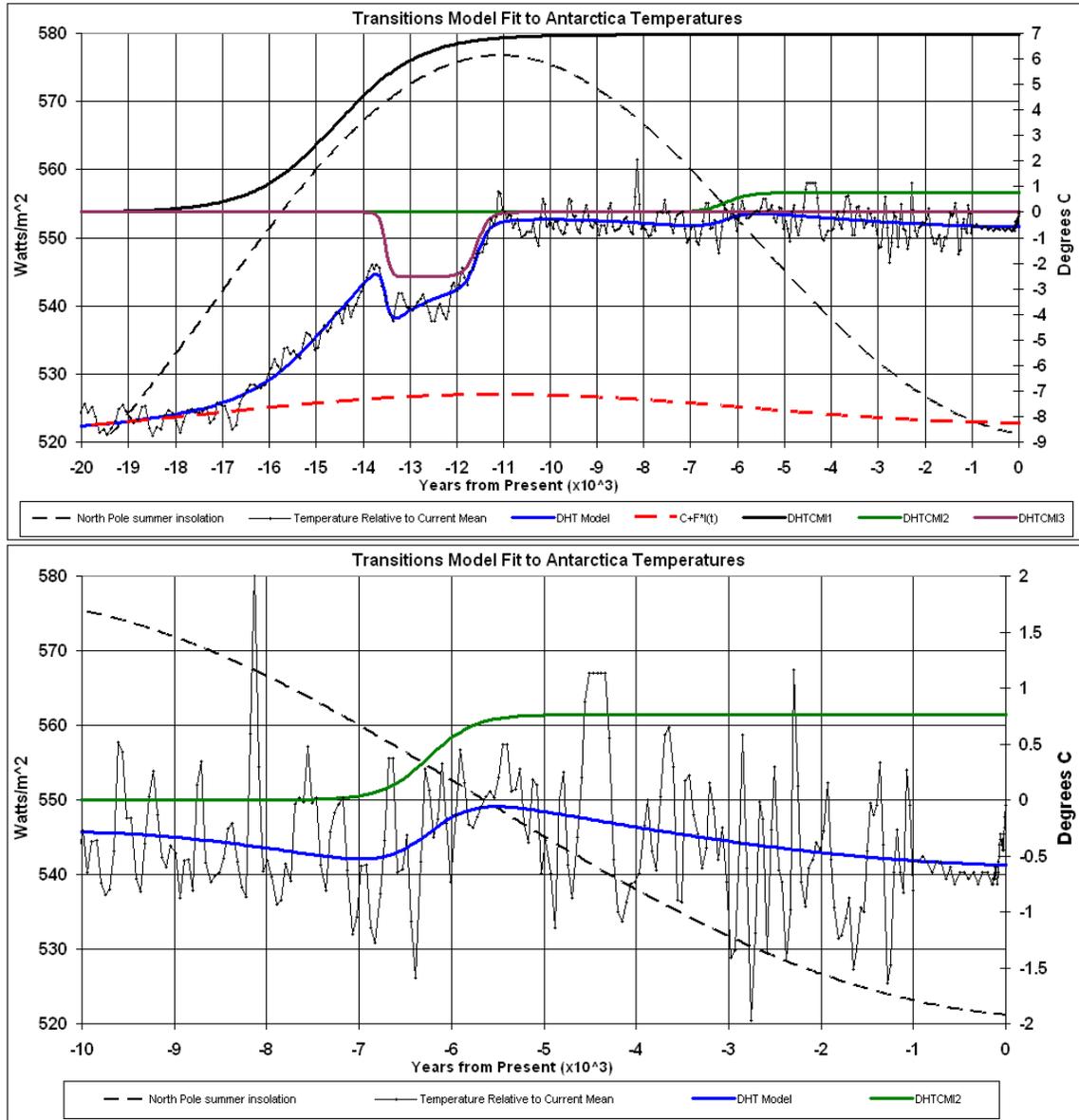
Figure 3-1. Fit of double hyperbolic tangent equation to the Antarctica temperature data. Top: Fit from -20 kiloyears to 1990. Bottom: Fit from -10 kiloyears to 1990.

The time constant for the rapid rise into the current Major Interglacial is 879 years. The time constant for the subsequent fall into the Younger Dryas period is 60 years and the time constant for the rise out of the Younger Dryas period is 128 years.

Table 3-2 gives the parameters for the fit to the Greenland temperature data and Figure 3-2 shows the fit.

Table 3-2. Parameters for the double-hyperbolic-tangent fit to the Greenland temperatures.

| s	c_1	w_1	c_1	w_l	Insolation Factor	Constant
12.088102	-14.68356813	0.04266			0.103093	-69.351
-328.1825	-12.4025245	1.39812	-12.25316394	1.35775		
3.68494	-5.28408	1.96296				
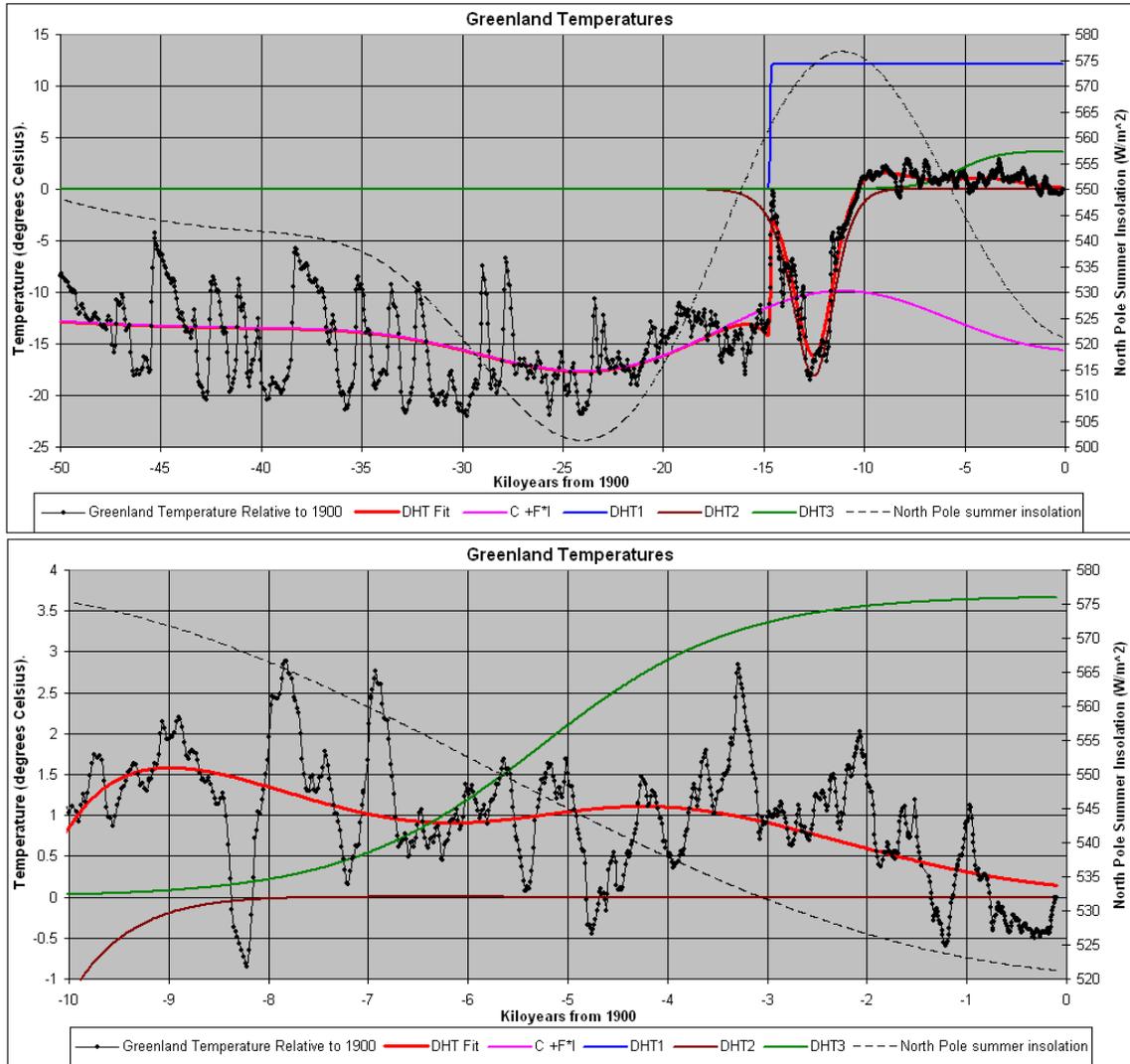
Figure 3-2. Fit of double hyperbolic tangent equation to the Greenland temperature data. Top: Fit from -50 kiloyears to 1990. Bottom: Fit from -10 kiloyears to 1990.

The time constant for the rapid rise into the current Major Interglacial is 21 years. The time constant for the subsequent fall into the Younger Dryas period is 699 years and the time constant for the rise out of the Younger Dryas period is 679 years.

One could interpret the green transition curves in Figure 3-1 and Figure 3-2 as Neolithic Global Warming due to the onset of agriculture dumping carbon dioxide and methane into the upper atmosphere

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(**Ruddiman, 2005**) (http://www.roperld.com/science/HumanFuture.pdf). Whatever the cause is, the time constant for the Greenland rise is 981 years.

Appendix

Several researchers (http://en.wikipedia.org/wiki/Orbital_forcing) have stated that the Current Major Interglacial is exceptionally long because the insolation during it is similar to the very long Third Penultimate Interglacial about 400 kiloyears ago and not just because of anthropogenic global warming due to agriculture, destroying vegetation and burning fossil fuels. Figure A-1 is a test of that claim.
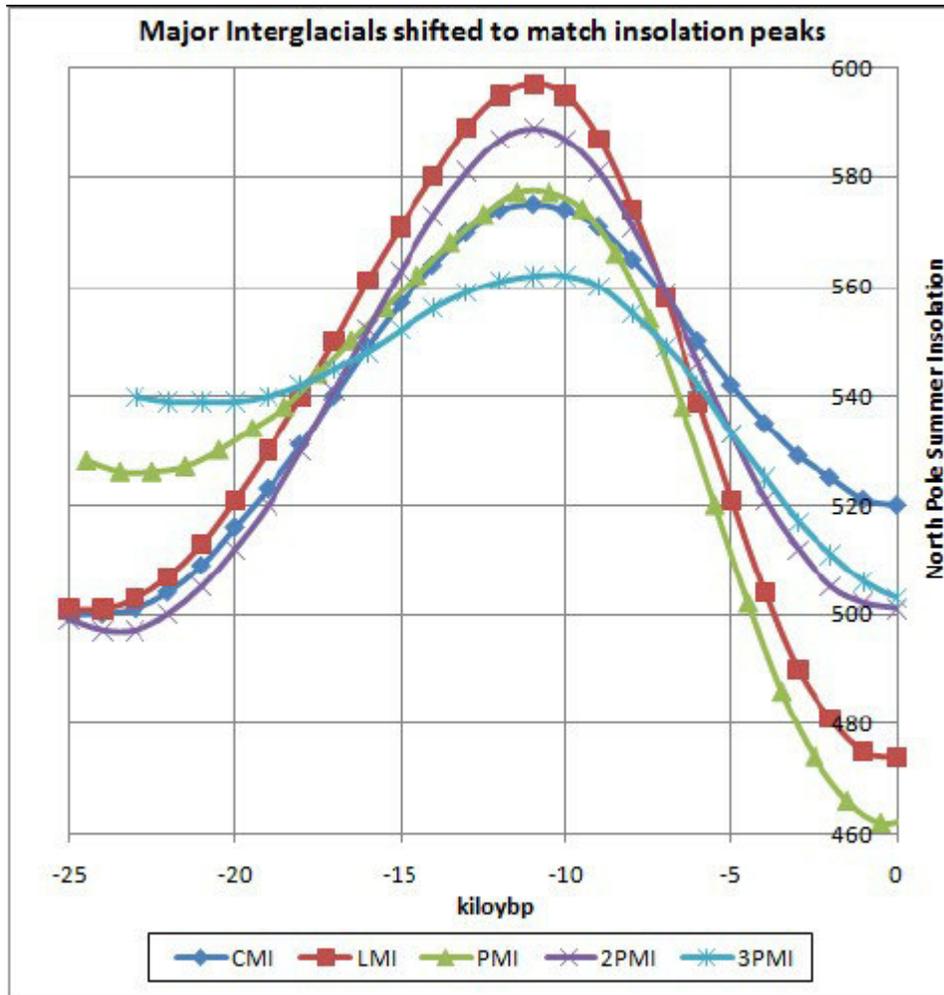
Figure A-1. North-Pole summer insolation for the peaks nearest the Major Interglacial peaks. CMI = Current Major Interglacial; LMI = Last Major Interglacial about 115 kybp; PMI = Penultimate Major Interglacial about 232 kybp; 2PMI = 2nd Penultimate Major Interglacial about 323 kybp; 3PMI = 3rd Penultimate Interglacial about 400 kybp. The earlier four Major Interglacials are shifted to match the CMI at the five peaks.

Note that the 3rd Penultimate Major Interglacial does not appear to be as similar to the Current Major Interglacial as does the 2nd Penultimate Major Interglacial. This can be seen more clearly in Figure A-2.
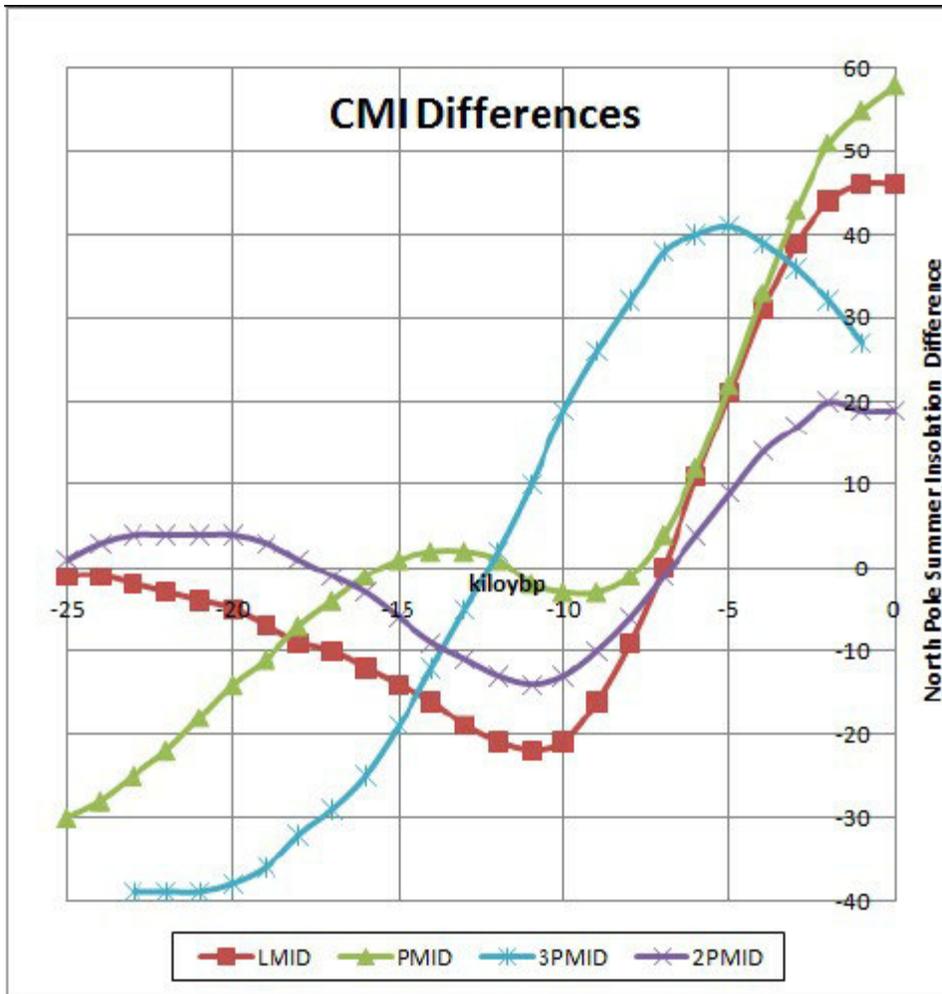
Figure A-2. Difference between the North-Pole summer insolation for the Current Major Interglacial and the three previous Major Interglacials shifted to match the four peaks at the CMI peak.

The difference between the 2nd Penultimate Major Interglacial and the Current Major Interglacial is the smallest over the 25 kiloyears plotted. When the differences are squared and added the results are as shown in Table A-1.

CMI - LMI	CMI - PMI	CMI - 2PMI	CMI - 3PMI
12,158	16,105	2,707	25,157

In fact, the CMI – 3PMI sum-of-squares is the largest of the four. So, without anthropogenic global warming the CMI should be similar to the 3PMI, if solar insolation is the main causative agent.

This implies that, after fossil fuels peak in extraction at least by 2050 (http://www.roperld.com/science/minerals/FossilFuels.htm), the Earth may plunge into the next Major Ice Age of about 100,000 years duration (http://www.roperld.com/science/GlobalWarmingprediction.htm) (http://www.roperld.com/science/Energy_GlobalWarming_IceAge.htm).

Glossary

I capitalize Earth, World and Sun because they are the names of objects. It is long past time when humans must regard the Earth as a special place rather than regarding it as a matrix for unfettered human activity. I capitalize Global Warming, Major Ice Ages and Major Interglacials because they are the names I give well-established scientific concepts.

If the reader needs a definition and discussion of any topic in this book, I recommend trying to find such at http://www.wikipedia.org .

Anthropogenic Global Warming: Global Warming caused by the activities of humans.

Civilization: A society in which the basic needs (shelter, sustenance and meaningful contributing work) of all its members are achieved through cooperation among its members.

Global Warming: The increase of the average temperature of the Earth due to greenhouse gases (carbon dioxide, methane, etc.) being put into the upper atmosphere by geophysical processes or by the activity of humans.

Insolation: Solar energy per time per area (Joules/second/m^2 =Watts/ m^2) that strikes the upper atmosphere.

Little Ice Age/Interglacial: Within the Minor Ice Ages and Minor Interglacials are "Little Ice Ages" and "Little Interglacials" with pseudo-cycles periods of one to two thousand years and amplitudes of about $1C°$ in size. The last Little Ice Age temperature minimum occurred at about 1500-1850 BC.

Major Ice Age: A time interval of about 115 kiloyears duration between two higher-temperature Major Interglacials. The temperature differential between the low point (Glacial Maximum) of a Major Ice Age and the Major Interglacial that follows it is about 9-12 degrees Celsius.

Major Interglacial: A time interval of about 5-15 kiloyears duration when the Earth's temperature is at a high maximum at the edges of Major Ice Ages. The temperature differential between the low point (Glacial Maximum) of a Major Ice Age and the Major Interglacial that follows it is about 9-12 degrees Celsius. The Last Major Interglacial is called the Eemian Interglacial.

Minor Ice Age: Within a Major Ice Age are several "Minor Ice Ages", also called **stadials**, with pseudo-cycle periods of 10,000 to 20,000 years, during which the temperature is about $2C°$ colder than the warm periods (Minor Interglacials).

Minor Interglacial: Within a Major Ice Age are several "Minor Interglacials", also called **interstadials**, with pseudo-cycle periods of 10,000 to 20,000 years, during which the temperature is about $2C°$ warmer than the warm periods (Minor Ice Ages).

Modern Global Warming: Global Warming caused by the activities of humans in the last two hundred years.

Neolithic Global Warming: Global Warming caused by human agriculture putting carbon dioxide (starting about 8,000 ybp) and methane (starting about 5,000 ybp) into the upper atmosphere.

North Atlantic Ocean Current: North Atlantic thermohaline ocean currents (NAOC) due to cold and salty water plunging to lower depths in the Arctic. (http://en.wikipedia.org/wiki/Thermohaline_circulation)

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