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What's Going On With the Arctic?

by George Taylor

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What's Going On With The Arctic?*

George H. Taylor
June 6, 2005

Jeff Kueter: Good afternoon everyone. Thank you for coming to the latest installation of the George Marshall Institute's Washington Roundtable on Science and Public Policy. The Roundtable is a continuing series in which prominent scientists are invited to discuss issues of importance to the Institute, in this case, climate change in the Arctic. George Taylor's talk is particularly pertinent, because at long last, the Arctic Climate Impact Assessment (ACIA) is releasing its detailed reports. They have been doing so over the last month or so and I understand that the final report will be out in July. The summary came out with great fanfare last December and generated considerable attention and press coverage, but we knew very little about the actual substance of that report. A great number of people have been looking at trends in the Arctic, trying to piece together what exactly is going on in that critical region of the world, and they noticed discrepancies between what they were seeing and what was reported by the ACIA.

George Taylor is here today to talk to us about that region and give some insights on temperature trends, ice and other fascinating topics. George is a certified consulting meteorologist. He has been active in meteorology and climatology studies since the 1970s. Since 1989 he has served as the state climatologist for Oregon and is a faculty member at Oregon State University.

George Taylor: Good afternoon. It is a pleasure to be here. It is hot here today; I understand it got hot very quickly. Well, it turns out that on this date in 1925, Washington and Philadelphia both recorded 100°. This is the earliest record of 100° temperatures in these cities – a little weather trivia for you. I have been studying climate for a long time, having been involved in the field since 1971. As state climatologist for Oregon, my main focus is climate trends in the Northwest. An important part of my job involves studying cause-and-effect relationships between factors, such as human influence and climate change. In addition to this important task, my research involves other areas such as climate mapping. Presently I am working on a rather large comprehensive research paper on Arctic climate,

* The views expressed by the author are solely those of the author and may not represent those of any institution with which he is affiliated.

an invited paper for the *Climate Research Journal*. Much of what I will share with you is from that research.

My motivation here really comes from one of the books in the Bible. There is a book called Ecclesiastes in the Old Testament traditionally written by Solomon, who was reputed to be the wisest man who ever lived. I think the Book of Ecclesiastes is science inquiry at the best. Basically the book tells of Solomon's observations as he journeyed throughout the world. His observations, which are often preceded by the statement "This have I seen" are followed by a conclusion. The focus of my presentation is scientific evidence from observed record, sometimes from actual measurements and sometimes from things like tree rings or similar artifacts used to examine long-term climate change. My conclusions, like Solomon's, are based on observation. With this in mind, let's begin.

How many of you feel you know a little bit about climate science? How many of you know a lot about climate science? How many of you do, but you are afraid to admit it? I am going to assume that you know at least a little bit about it; my explanation will not to be too technical. I have a lot of charts and graphs, many of which I will go through quickly. Don't be intimidated by them; I only want you to get an idea of trends. Most climatologists examine the past to predict the future. In contrast to this, some predict climate by using computer models designed to simulate conditions and relationships between parameters. I tend to use relationships that we discovered in the past to predict the future.

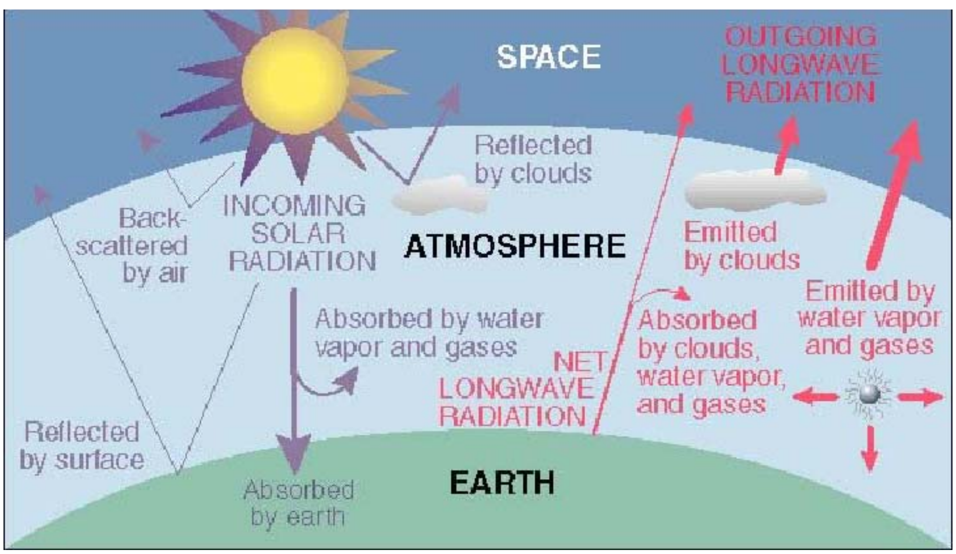


Figure 1

One important relationship is the natural greenhouse effect that is essential for life on earth. There are certain gases which allow sunlight to pass through them, but which absorb heat that is released from the surface. Without that natural effect, the earth would be about 60°F cooler than it is, and clearly life as we know it would not exist. For instance, Chesapeake Bay would be covered with ice without the greenhouse effect. Figure 1 depicts the greenhouse effect and the role played by long-wave radiation (heat), which is absorbed by water vapor and gases. Water vapor is by far the most significant greenhouse gas; it accounts for over 95% of the greenhouse effect. Carbon dioxide and methane are the next most important greenhouse gases. Scientists agree on several points regarding the greenhouse gas carbon dioxide: it is responsible for contributing only a few percent of the greenhouse effect; it is increasing in the atmosphere; most people believe as a result of fossil fuel emissions; and all things being equal, an increase in CO_2 should cause an increase in temperature. This brings us to the real question at issue: how much of a temperature increase is caused by an increase in CO_2?

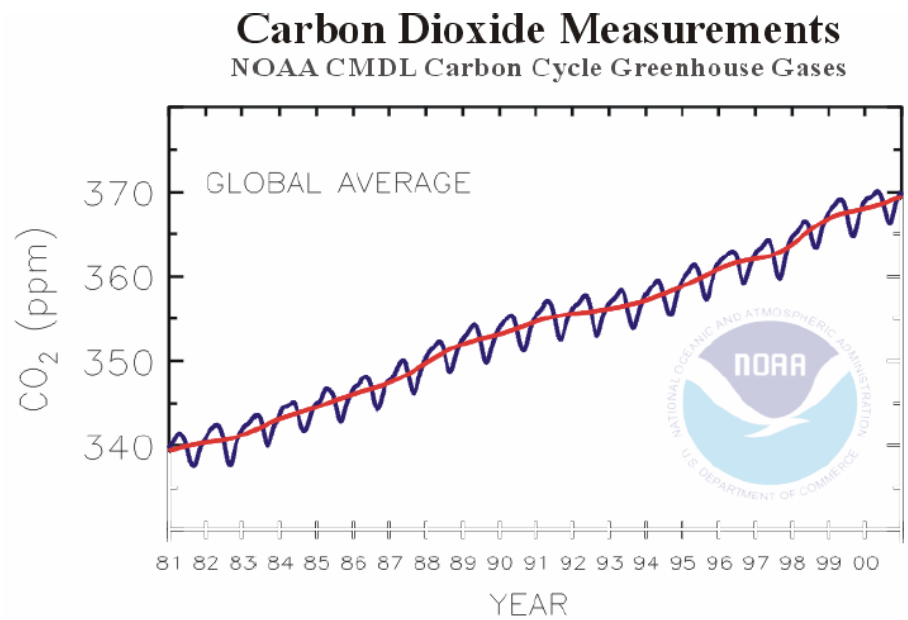


Figure 2

Figure 2 shows a steady rise in CO_2. The presented data goes back to 1981, although the actual measurements taken at Mauna Loa go back to the late 1950s. Regardless of the timescale, there is a pronounced seasonal cycle. During the Northern Hemisphere, summer plants are very active, absorbing a great deal of CO_2. Photosynthesis requires CO_2, sunlight, and water. During the Northern Hemisphere summer, there is an absorption of CO_2 that is released again in the winter.

According to greenhouse physics, a change in greenhouse gases would be most noticeable in its effect on the temperatures of a polar region winter night. So truly the Arctic is the place to look for evidence of global warming; some people call it the canary in the coalmine. Here are the reasons why the Arctic is where we should be looking to see if climate change is really happening: on the average, there is about 2% water vapor in the atmosphere. Right now the CO_2 concentration is about 375 parts per million (ppm), which means there is almost one hundred times as much water vapor as there is CO_2. In most places on earth, as heat is released from the surface, there is enough water vapor to absorb the heat that is given off. So from a greenhouse standpoint the CO_2 concentration really doesn't matter except when the air is really dry. CO_2 is well distributed throughout the atmosphere, but water vapor is not. The unique properties of water play an important role in water vapor distribution and behavior. When air gets very cold its capacity to hold water vapor goes way down. Very cold air holds only a small amount of water vapor. Thus, the driest air on the planet is the coldest air that is found in the polar regions in the winter at night. During those times when there is almost no water vapor, the relative effect of CO_2 on temperature is much greater. Its effect may be even greater than the effects of water vapor; therefore it is the dry Arctic air, the coldest air on Earth, that we examine for effects of enhanced CO_2.

In November the preliminary first report of the Arctic Climate Impact Assessment was released. A few comments from the report follow:

1. Arctic climate is warming rapidly and much larger changes are projected.

2. Annual average arctic temperature has increased at almost twice the rate as that of the rest of the world over the past few decades, with some variations across the region.

3. Additional evidence of artic warming comes from widespread melting of glaciers and sea ice, and a shortening of the snow season.

There are certain "buzz words" that I want you to notice. "Over the past few decades" is one.

The following statements are from Chapter 2 "Arctic Climate – Past and Present" in the pre-release that just came out.

> "Because of the scarcity of data prior to 1945, it is very difficult to say whether the Arctic as a whole was as warm in the 1930s and 1940s as it was during the 1990s."

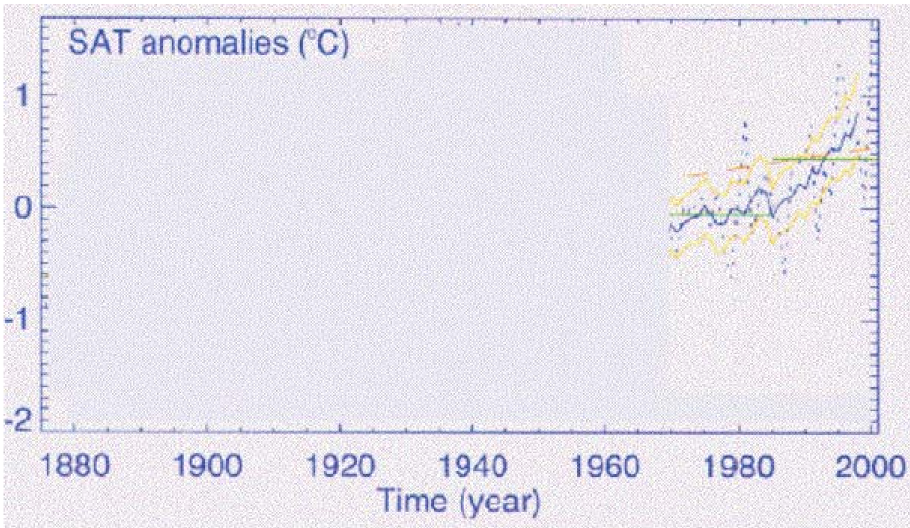
This statement focuses on the last several decades with little attention to earlier periods of record. I think exclusion of earlier records is an oversight because

> "Over the past 40 years, the arctic warming trend was about 0.04°C/yr (0.4°C/decade) compared to a trend of 0.025 °C/yr for the lower latitudes."

Although the Arctic is warming a lot faster than the rest of the world, which according to greenhouse physics should be happening, it is important to consider

> "A related question (which) is whether the warming in the Arctic is enhanced relative to that of the globe (i.e., polar amplification). For example, Polyakov et al. (2002) concluded that observed trends in the Arctic over the entire 20th century did not show polar amplification. A number of studies (e.g., Comiso, 2003; Thompson and Wallace, 1998) suggested that much of the recent warming resulted from changes in atmospheric circulation; Serreze et al. (2000), however, noted that the changes in circulation were "not inconsistent" with anthropogenic forcing."

Chapter 2 quotes a number of scientists. Polyakov, whom I also refer to extensively, says that he did not show polar amplification: "I am not seeing any enhanced effects of CO_2 in the polar regions." The studies of other climate scientists indicate that changes in atmospheric circulation are responsible for the changes, although Mark Serreze is quoted as saying the results of his modeling study indicate "Changes in circulation were 'not inconsistent' with anthropogenic forcing." It is important to realize he is not saying they are caused by it, just that they are not inconsistent.



Polyakov, I, et al., 2002. Trends and Variations in Arctic Climate Systems. EOS, Transactions, American Geophysical Union, Vol. 83, 547-548.

Figure 3

Recently in parts of the Arctic, temperatures have risen. Figure 3 is a 30-year record from Polyakov's paper in the AGU showing a rise in temperatures in the last thirty years. This is what the ACIA has focused on, a rise in temperature over the last thirty years. I will show you the rest of the story, hidden on the left of the graph, as we continue our discussion.

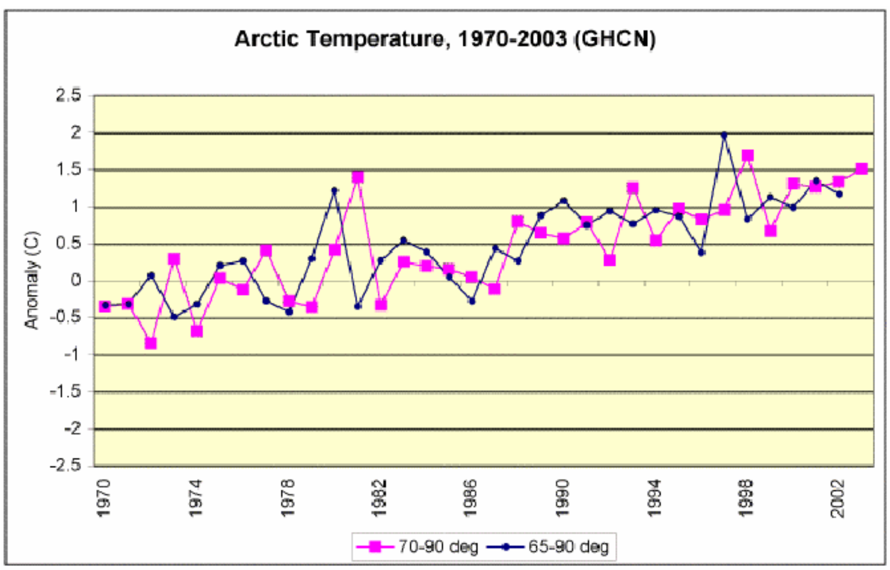


Figure 4

Regardless of whether you examine 70° to 90° or 65° to 90°, warming is evident over the last thirty years (Figure 4). Conclusions, however, depend on how the Arctic area is defined. The debate on this geographic definition is longstanding and continues today.

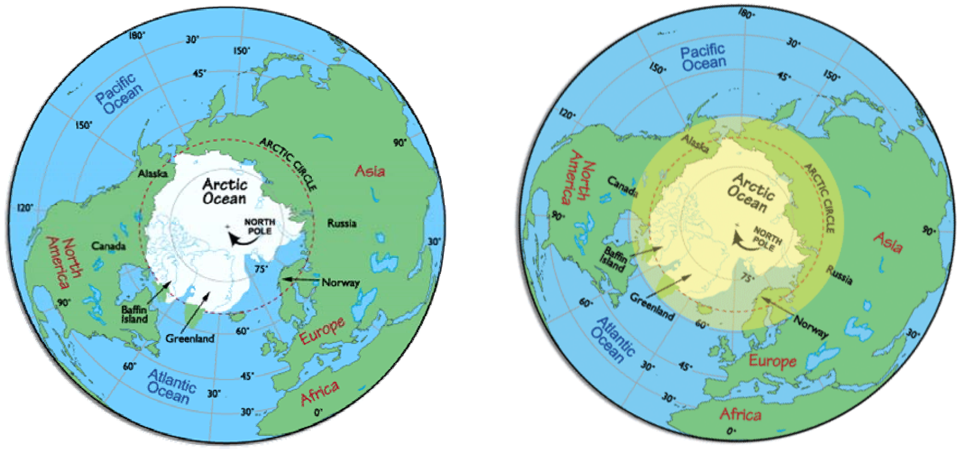


Figure 5

The Arctic Climate Impact Assessment uses a unique definition of the Arctic. The white area (Figure 5 left) shows the extent of the typical winter ice cap. Most scientists use the Arctic Circle to define Arctic regions. This definition makes it easy to label the Arctic by identifying all area north of 66.66°; it includes quite a large area of Northern Siberia, about half of Greenland and just little bits of North America. The ACIA definition uses 60°, as the Arctic boundary (Figure 5 right). This definition includes much more area below the Arctic Circle, including all of Greenland. most of Scandinavia, a very large part of continental Asia with large areas of Siberia and quite a bit of northern North America as well.

Ray Pryzbylak, of the Nicholas Copernicus University in Poland, is a renowned Arctic researcher. He says, “There is no agreed southern border to the Arctic. The three most widely used criteria are astronomical, climatological and botanical.” He really comes down hard on scientists that take the easy way out: “It is surprising that contemporary climatologists very rarely use the climatic criterion to define the limits of the Arctic. The most generally adopted climatic criterion is the 10°C isotherm of the warmest month."[1] In other words, only areas that don't get as high as 50°F in the summer should be considered to be in the Arctic.

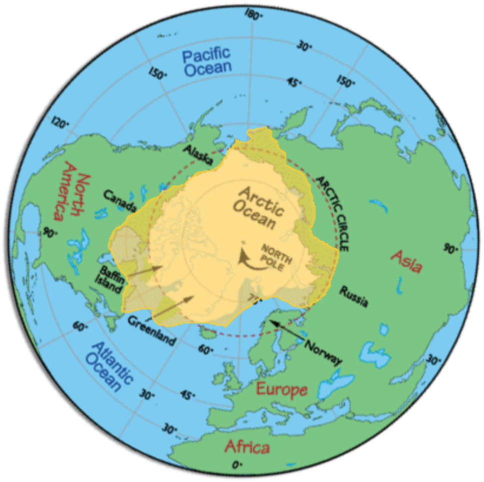
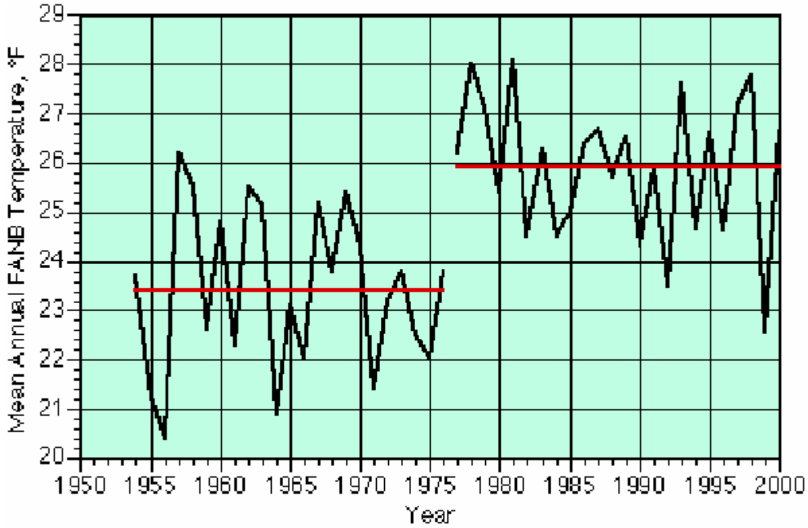


Figure 6

Figure 6 defines Pryzbylak's Arctic: all of Greenland, North America clear down to Hudson's Bay, not very much of Siberia and none of Scandinavia. This is a consistent region with both similar climate and vegetation.

Let's go back and look at what happened in the last hundred years. We will start with Alaska. Just about every climate station in Alaska reports a dramatic temperature increase in 1976. This climate shift, now called the Great Pacific Climate Shift, happened in a one-year period. In political conversation sometimes the phrase "regime shift" is used, and climate scientists apply that phrase here. Due to a climate phenomenon known as the Pacific Decadal Oscillation (PDO), the shift affected areas throughout the world. Alaska, however, experienced the most dramatic effect. Figure 7 shows the temperature in Fairbanks. Prior to 1976, the temperatures jumped up and down, but the average was around 23°F. Then after 1976, they jumped about 2.5°. There was another apparent shift in 1998. Since then data from all climate stations in Alaska indicate that summers have been warm, but the winters have been very, very cold, so it looks like we are beginning to see a temperature drop.

[1] Pryzbylak, R., 2000. Temporal and spatial variation of surface air temperature over the period of instrumental observations in the Arctic. *International Journal of Climatology*, 20, 587-614.



Mean Annual Temperature, average of Fairbanks, Anchorage, Nome and Barrow, Alaska. Red horizontal lines are averages for 1954-76 and 1977-94.

Figure 7

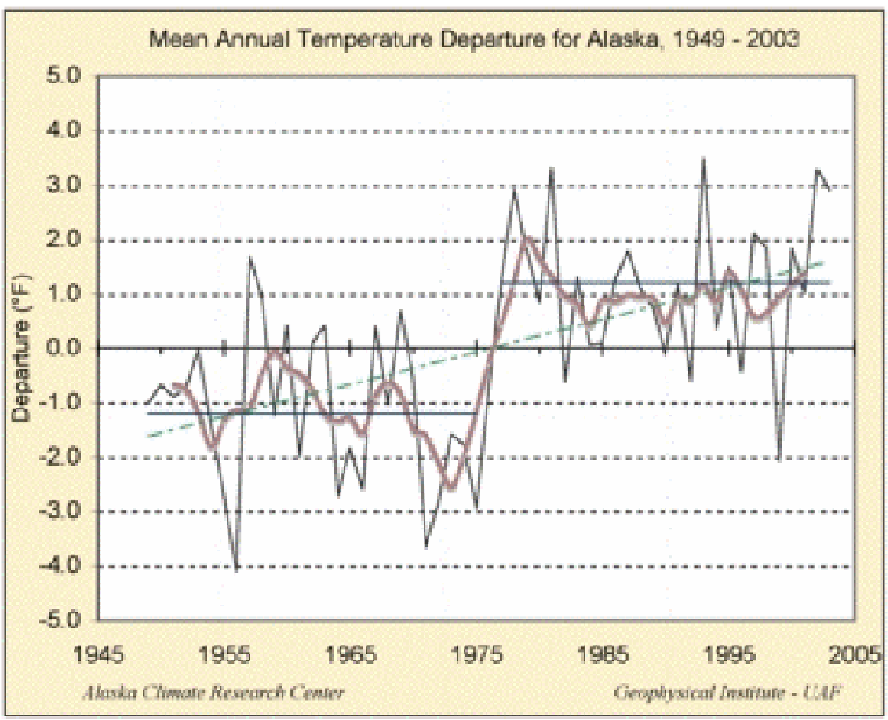


Figure 8

Taking another look at the data, let's really simplify things by drawing a straight green line through the data (Figure 8). Many climate people linearize the data in this manner stating "The trend since 1945 is upward." Please note that the trend on the left side of the graph is flat and the trend on the right side is flat. This is called a time series, with the time along the x-axis. Although with this kind of time series, many take the quick and dirty approach of assigning a straight-line trend, it is important to realize that interpretation of such linearization depends greatly on the starting and ending points. With this in mind, here is what the Alaska Climate Research Center reported

> "[S]ince 1977 no additional warming has occurred in Alaska with the exception of Barrow and a few other locations. In 1976, a stepwise shift appears in the temperature data, which corresponds to a phase shift of the Pacific Decadal Oscillation from a negative phase to a positive phase."

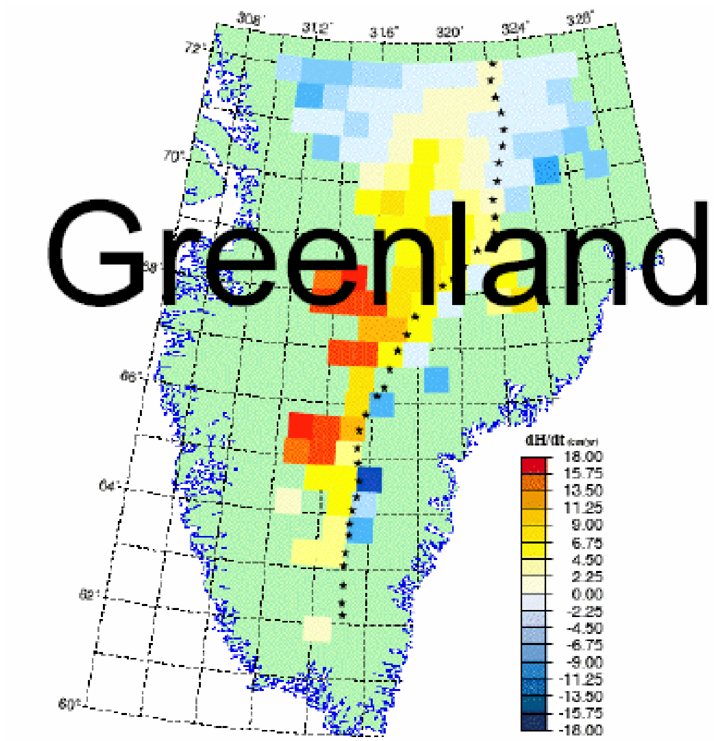


Fig. 1. Spatial distribution of elevation change from 1978 to 1988 showing large variations in *dH/dt* values. The approximate location of the ice divide is indicated by the series of stars. A spatial average yields a growth rate of 2.0 ± 0.5 cm/year.

Figure 9

Moving eastward, let's consider Greenland. There is more ice in Greenland than in any other part of the world, aside from Antarctica. Greenland is often included in climate change studies because if Greenland were to melt, sea levels would rise significantly. An examination of data provided by Davis reveals trends in the Greenland ice cap and an interesting anomaly involving aspect and height. On the east side of the cap, there was a reduction in height, as shown in blue on Figure 9. (The white area on the figure depicts areas of essentially no change in ice volume). However, on the west side there was a notable increase in the ice cap's size. Still, the media is concerned that Greenland is melting and sea level is increasing or will increase. In actuality, the data indicate that Greenland ice has been getting deeper and thicker. The trend is an increase of about 2 cm per year, which isn't very much, but it indicates growth and cooler temperatures rather than melting due to warming.

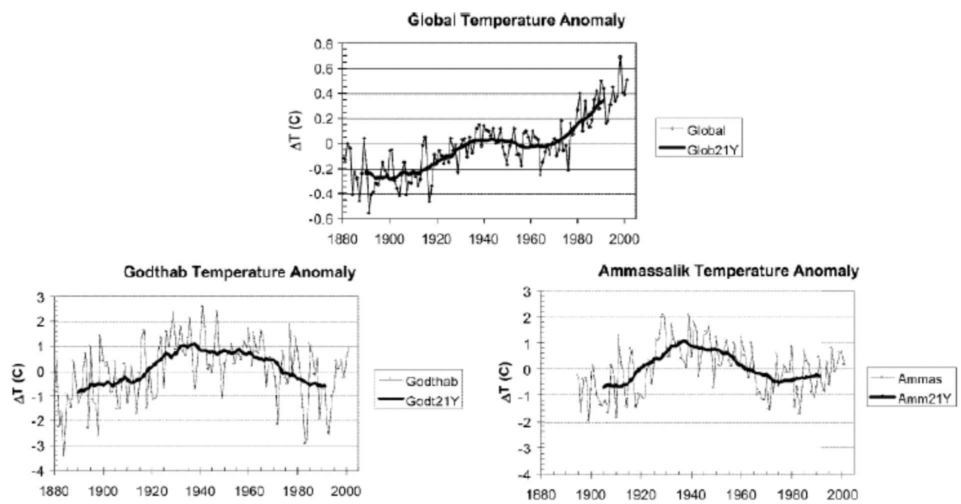


Figure 10

In reference to temperature, the top chart in Figure 10 shows global temperature change. The data from Phil Jones' group in East Anglia University in England shows a steep upward temperature trend over the past thirty years. I could make a few comments about this chart, but I am not going to bother. According to this group, global temperatures are increasing at a high rate of change. And even though the Arctic Impact group states that Arctic temperatures are going up even faster, actual Greenland temperatures do not substantiate claims. Greenland temperatures peaked in about 1940 and have been declining ever since. The lower two charts on Figure 11 show data from west and east Greenland temperature stations and the general trend throughout Greenland has been similar; the temperatures have actually been going down rather than going up.

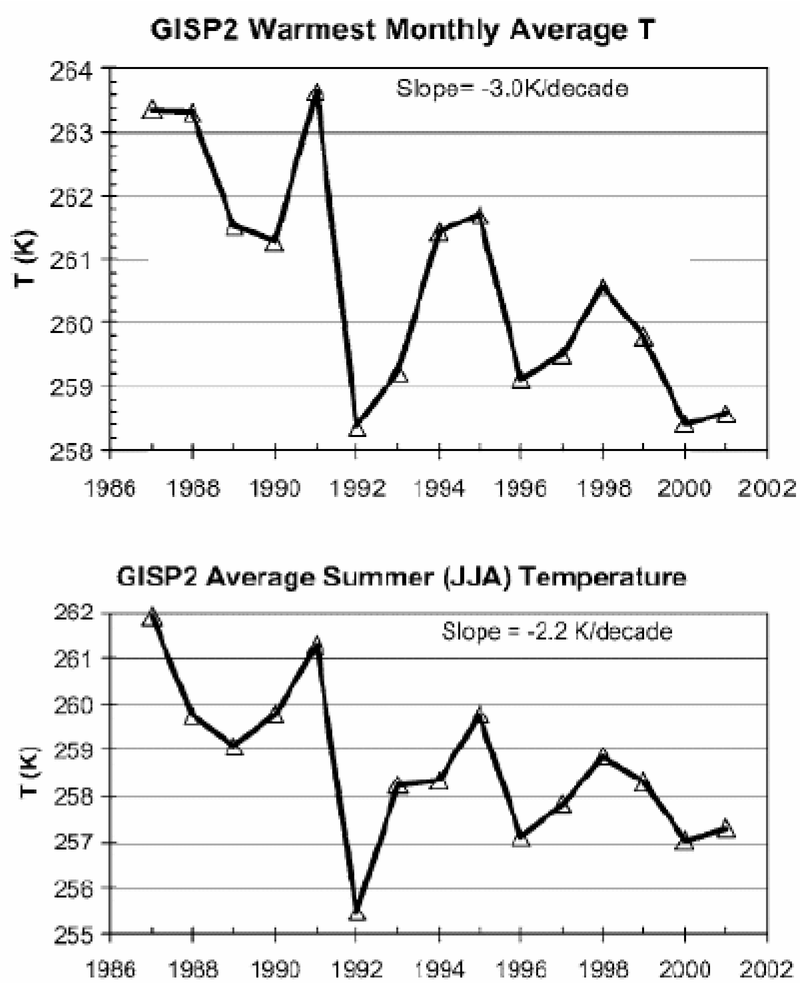


Figure 11

Figure 11 is from another researcher, Chylek, who used all the experimental stations in Greenland to look at the warmest monthly temperature, and the average summer temperature. He examined these parameters because of their influence on melting ice. Since 1986, both have decreased.

Figure 12 depicts information from a Greenland glacier study by Mackintosh. In about 1780, the glaciers really shrank, then they grew, and then they shrank through about 1950. Since 1950 they have been growing. I am afraid maybe sea levels will go down instead of going up, if this continues!

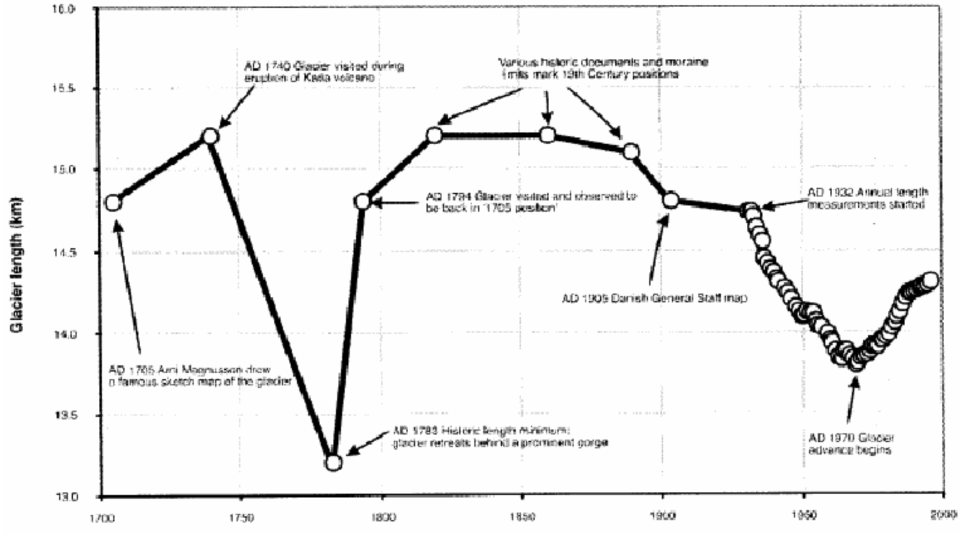


Figure 12

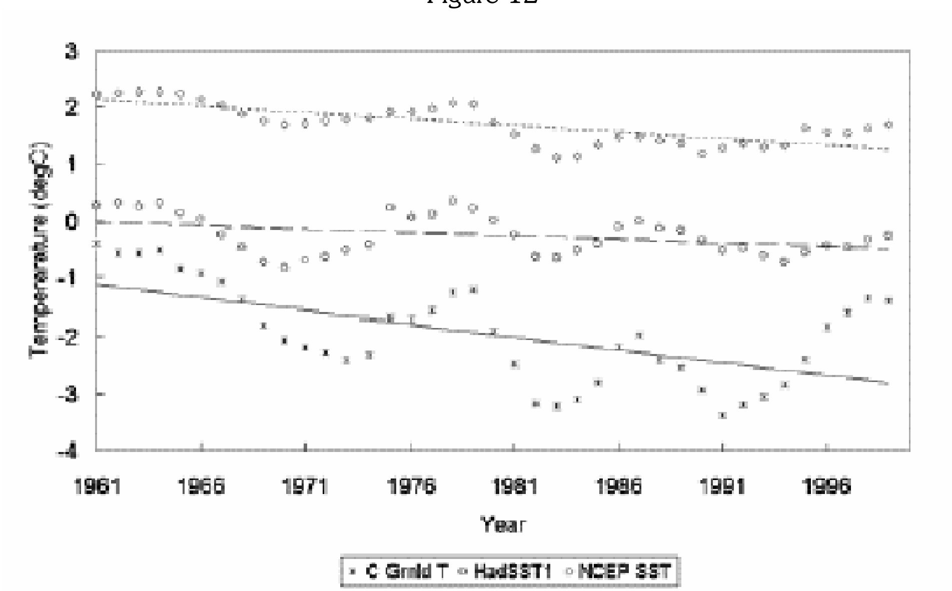


Figure 3. Composite Greenland temperature (CGT) and sea-surface temperatures [Hadley Centre (HadSST1) & US National Centers for Environmental Prediction (NCEP)] off SW Greenland, all 5-yr. running means, with trend lines.

Figure 13

Figure 13 shows how the composite Greenland temperature and sea surface temperature have decreased,

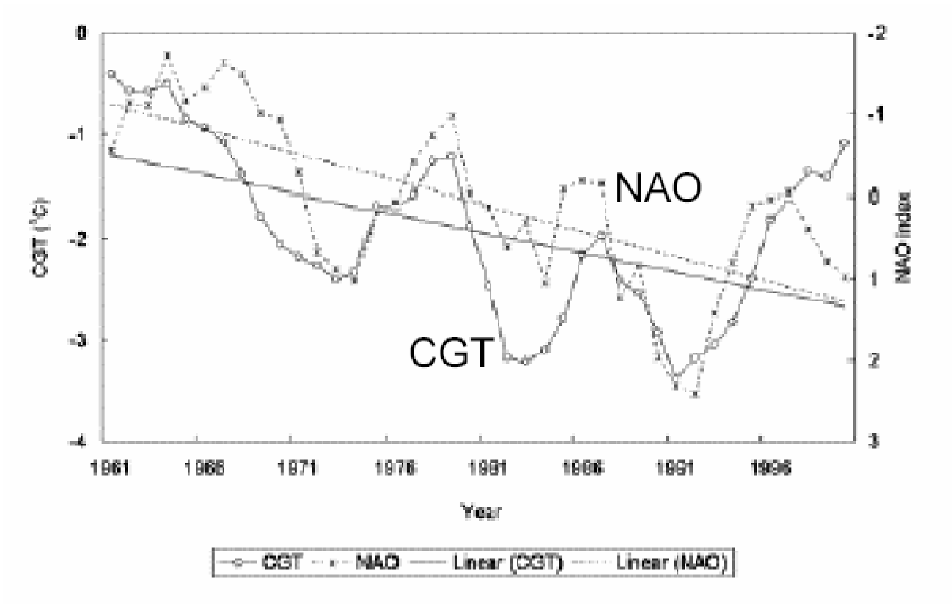


Figure 4. Comparison of Composite Greenland Temperature (CGT) and North Atlantic Oscillation (NAO) index (5-yr. running means with trend lines).

Figure 14

Hanna compared Greenland temperatures with a thing called the North Atlantic Oscillation (NAO). For a long time the Pacific got all the press with El Niño and the Southern Oscillation. It turns out that the Atlantic is important, too, globally as well as in the Greenland and East Coast areas. Figure 14 shows the ups and downs of Greenland temperature, with a general downward trend since 1961 that correlates strongly with the NAO. The NAO is probably the causative factor as it affects many natural parameters.

Figure 15 shows the temperatures in Siberia dating back to 1940, from Naurzbaev. 1940 was a very warm period. Since then there was a decline in temperature and recently there has been an upward swing. (It is important to note, that the data used by Dr. Naurzbaev is more representative of the natural state because it is from rural stations in northern Siberia, locations removed from the heat effect of cities.) While it is warmer than it was thirty years ago, the warmest temperatures in the last seventy years in Siberia occurred in 1940.

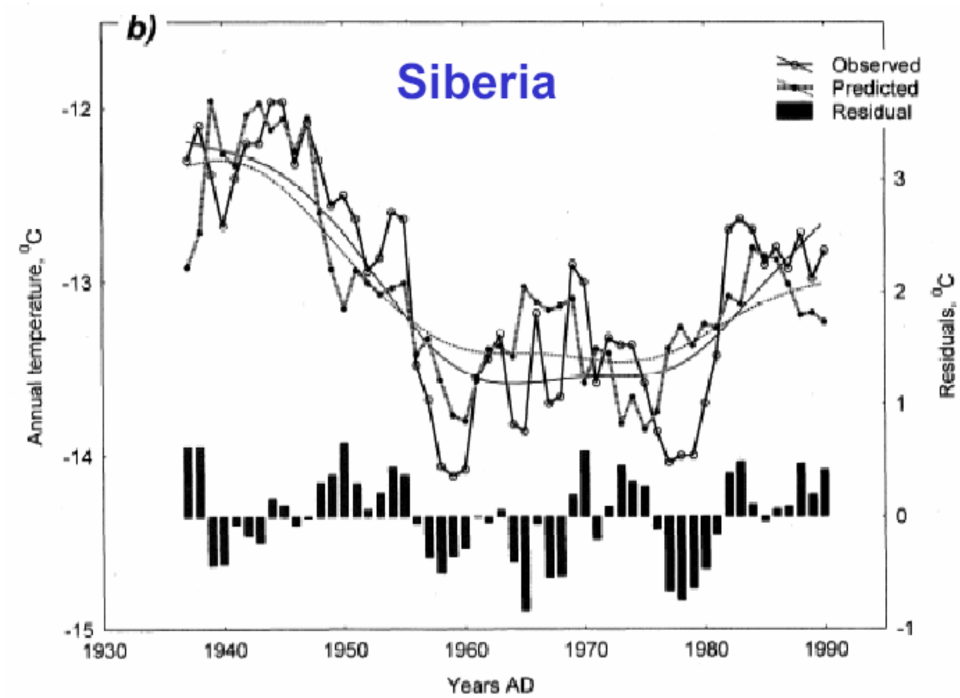


Figure 15

Ray Pryzbylak, whom I mentioned earlier, made this statement several times. I think he wanted us to pay attention.

> "…the second phase of contemporary warming (after 1975) that is common in most parts of the world appears to be very weakly expressed or even absent in the Arctic."[2]

In the same article, he also talks about climate models. There are many people who trust climate models. I tend to trust the data.

> "[R]easons for the current deficiencies of climate models concerning the description of the Arctic climate:
>
> (i) The models show inadequacies in the parameterization of physical processes.

[2] Pryzbylak, R., 2000.

> (ii) The present GCMs … have not captured different mesoscale phenomena.
>
> (iii) Errors in the Arctic large-scale dynamics can arise from problems that are a consequence of the insufficient description of low-latitude processes."

He says, "[T]here exists an agreement in estimating temperature tendencies prior to 1950." The ACIA said we can't look at temperatures prior to 1970 because there isn't enough data. Pryzbylak says no; there is data and agreement on interpretation:

> "Practically all (old and new) of the papers which cover this time period concentrate on the analysis of the significant warming which occurred in the Arctic from 1920 to about 1940. Estimates of the areal average Arctic temperature trend in the second half of the 20th century are inconsistent."

He goes on to say

> "The second phase of contemporary global warming in the Arctic is either very weakly marked or even not seen at all. For example, the mean rate of warming in the last 5-year period in the Arctic was 2–3 times lower than for the globe as a whole.
>
> In the Arctic, the highest temperatures since the beginning of instrumental observation occurred clearly in the 1930s. Moreover, it has been shown that even in the 1950s the temperature was higher than in the last 10 years."

Figure 16 shows some of Pryzbylak's data. The point here is that interpretation, and hence conclusion, depends on the period/range you are considering. If you start at 70°, there is warming by 1940, followed by cooling, and then a bit of warming. If you start at 65°, pretty much the same conclusion is drawn. However, if you begin at 60°, the curve flattens out. And although you still see the peak around 1940, followed by cooling and a little bit of warming, it appears warmer. Lastly we consider the Jones group Northern Hemisphere data showing unprecedented high temperatures in recent years.

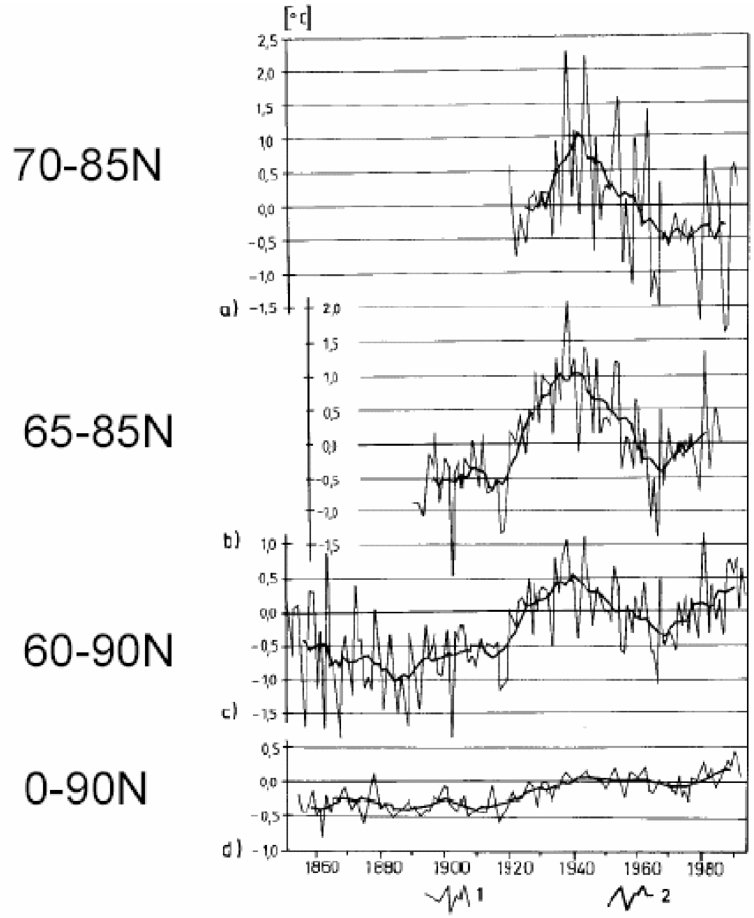


Figure 2. Year-to-year course of the annual (1, solid line) and 5-year running (2, heavy solid line) mean anomalies of air temperature for the zones (after Przybylak, 1996a): (a) 70°N–85°N (after Dmitriev, 1994); (b) 65°N–85°N (after Alekseev and Svyashchennikov, 1991); (c) 60°N–90°N (after Jones, 1995, personal communication); (d) 0°N–90°N (after Jones, 1994)

Figure 16

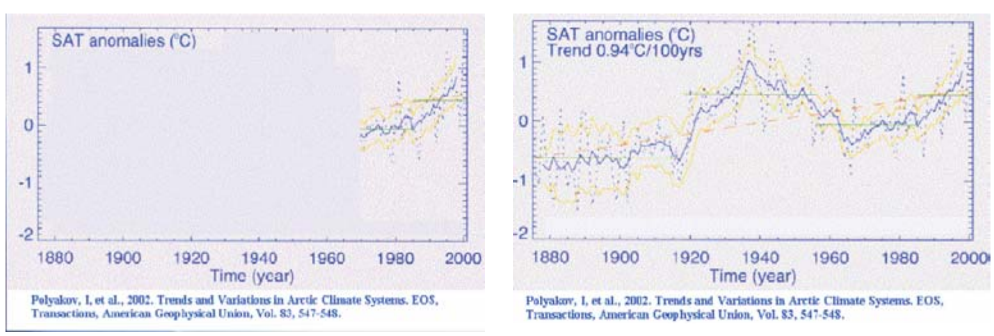


Figure 17

The chart on the left of Figure 17 shows some of Polyakov's data. The data indicate that there has been warming over the last thirty years, but the whole record, which is on the right-hand side, tells another story.

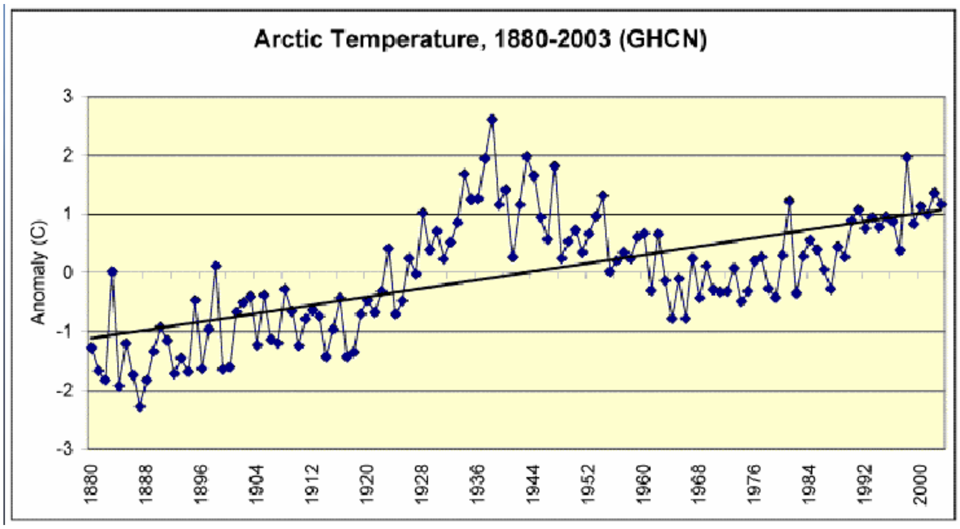


Figure 18

Examination of the data indicates warming in the late 1930s and early 1940s (Figure 18). According to most researchers, the warmest single year in the Arctic was 1937 and the warmest decade was the 1930s, after which time temperatures declined before beginning a warming trend that continues today. As mentioned earlier, interpretation depends on which part of the record is examined; you get a different result if you look at the entire period of record.

The real greenhouse enhancement began during World War II. There has been a steady increase in CO_2, we think, since then. So if CO_2 played a major role, we would expect warming to start earlier. Some factor/parameter(s) other than CO_2 must be involved.

Here is what Polyakov says:

> "In contrast to the global and hemispheric temperature rise, the high-latitude temperature was higher in the late 1930s through the early 1940s than in recent decades."

Again, a lot of people will take the data and assign a straight line to it. Yes, over the last 125 years, there has been a rise in Arctic temperatures of about 2°C.

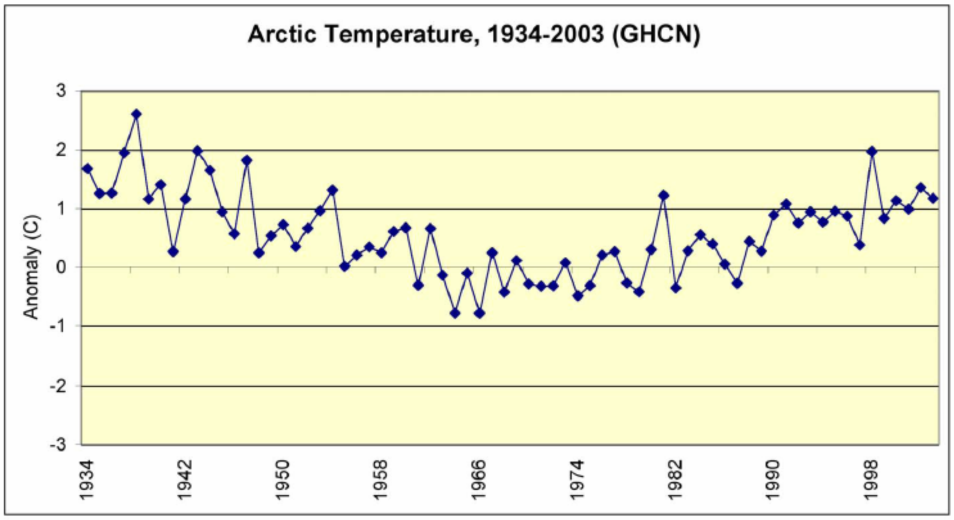


Figure 19

Note that if you begin in 1934, the trend indicates a decrease (Figure 19). So again, assigning a straight line to a time series is a very dangerous thing to do. Data interpretation requires judicious examination of record rather than supporting a preconceived outcome through discretionary choice. Here is what Polyakov[3] says in one of his articles:

> "We examine arctic variability using long-term records of SAT from the maritime Arctic poleward of 62°N, fast-ice thickness from five locations off the Siberian coast, and ice extent in arctic marginal seas.
>
> Arctic variability is dominated by multi-decadal fluctuations. Incomplete sampling of these fluctuations results in highly variable arctic surface-air temperature (SAT) trends."

Then he says something twice. I really think he wants us to pay attention.

[3] Polyakov, I.V., Alekseev, G.V., Bekryaev, R.V., Bhatt, U., Colony, R.L., Johnson, M.A., Karklin, V.P., Makshtas, A.P., Walsh, D. and Yulin A.V. 2002. Observationally based assessment of polar amplification of global warming. *Geophysical Research Letters* 29: 10.1029/2001GL011111.

"Arctic and northern hemispheric air-temperature trends during the 20th century (when multi-decadal variability had little net effect on computed trends) are similar, and do not support the predicted polar amplification of global warming.

If long-term trends are accepted as a valid measure of climate change, then the SAT and ice data do not support the proposed polar amplification of global warming."

Igor Polyakov is arguably the most experienced Arctic researcher. Why is this statement here?

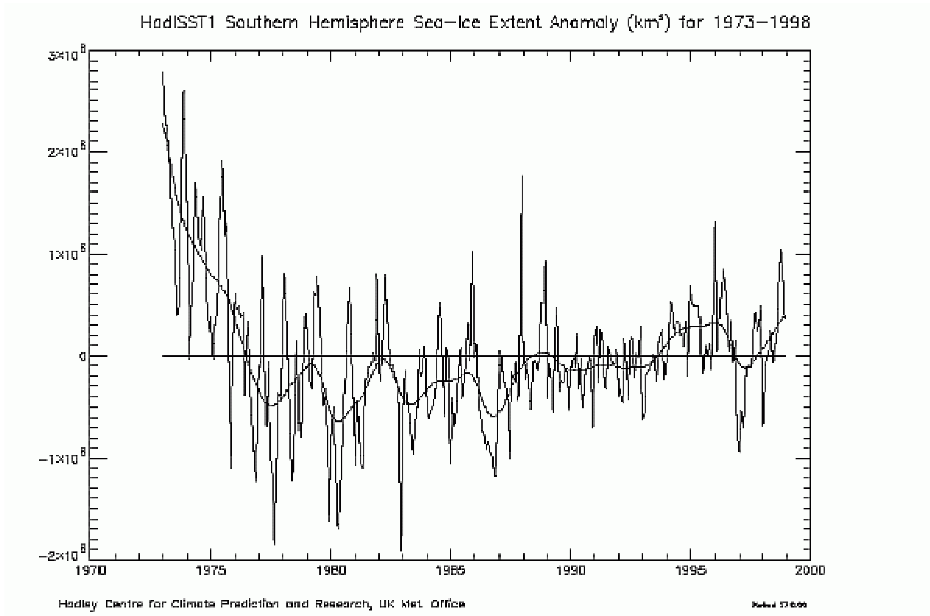


Fig. 2.16: Monthly Antarctic sea-ice extent anomalies, relative to 1973-1996. The data are a blend of National Ice Center (NIC) chart-derived data (Knight, 1984)), Goddard Space Flight Center satellite passive-microwave (Scanning Multichannel Microwave Radiometer (SMMR) and Special Sensor Microwave/Imager (SSM/I)) derived data (Cavalieri *et al*, 1997)) and National Centers for Environmental Prediction satellite passive-microwave derived data (Grumbine, 1996)).

Figure 20

I wasn't going to talk about the Antarctic, but in the mid-1970s, during the Pacific Climate Shift, there was a large reduction in Arctic sea ice. Since then it has been growing and the Antarctic has been cooling (Figure 20).

Let's go back farther in time. Climate people like to go back as far as they can. Although we have one hundred or so years of actual observations, we have other types of information that we can use to examine climate patterns of the past. These proxy indicators include ice cores, tree rings, sediments, and various other artifacts useful in estimating what has happened in the past. Information from such data allow for estimations reaching back thousands or even millions of years.

The ACIA pre-release, Chapter 2 "Arctic Climate – Past and Present" was actually balanced, and very well written. I think most climatologists would agree with many of the statements. However, there are some statements that are a little puzzling. They say

> "Natural climate variability in the Arctic over the past two million years has been large. In particular, the past 20,000-year period is now known to have been highly unstable and prone to rapid changes, especially temperature increases that occurred rapidly (within a few decades or less)."

They see that in the record. Yet not long after, they say

> "The climate of the Arctic is changing … These climate changes are consistent with projections of climate change by global climate models forced with increasing atmospheric GHG concentrations, but definitive attribution is not yet possible."

And yet they continue

> "Following the sudden end of the Younger Dryas [about 12,000 years ago], the Arctic entered several thousand years of conditions that were warmer and probably moister than today."

> "There is an abundance of evidence from the Arctic that summer temperatures have decreased over approximately the past 3500 years."

And again, although data support these statements , they go on to say

> "Two modeling studies have shown the importance of anthropogenic forcing over the past half century for modeling the arctic climate."

> "It is suggested strongly that whereas the earlier warming was natural internal climate-system variability, the recent SAT (surface air temperature) changes are a response to anthropogenic forcing."

The last statement is made without supportive evidence. It rest solely on their belief in models.

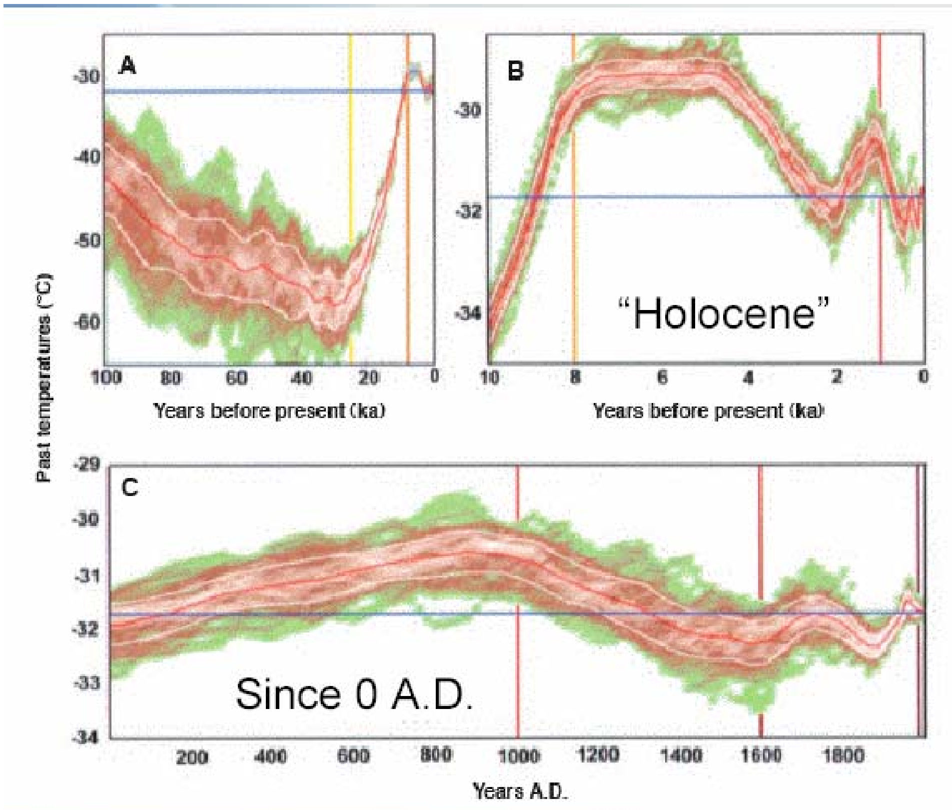


Figure 21

Now let's take a look at what happened in the past. Dahl-Jensen did a study that goes back 100,000 years. Figure 21 shows the last 100,000 years. The data shows general cooling during the Ice Age, which terminated about 15,000 years ago. Following which time temperatures rose before decreasing. Let's focus on the last 10,000 years, the period refered to as the Holocene. During this time there is a warming that peaks about 5,000 - 6,000 years ago, followed by a decrease and another increase about 1,000 years ago. This is followed by a decrease and then a bit of an increase until present time. The last 2,000 years looks like this: there is a general rise until about 1000 AD during the period known as the Medieval Climate Optimum or Medieval Warm Period, followed by a cooling generally known as the Little Ice Age, followed by a brief warming around the late 1700s, followed by another cooling trend, and finally the recent warming followed by a slight decline. The recent warming that peaks at 1940 is based on Arctic deposits, taken mostly in northern Greenland.

Another researcher, Harris, says

> "Arctic variability is dominated by multi-decadal fluctuations. Incomplete sampling of these fluctuations results in highly variable arctic surface-air temperature (SAT) trends."[4]

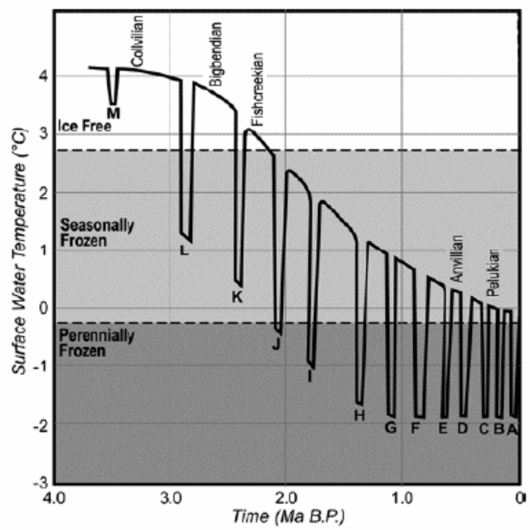


Figure 2 Inferred changes in water temperature along the Arctic coast of western North America

Figure 22

Harris' chart in Figure 22 provides information about the last four million years. The data shows a general decline in temperatures and an

[4] Harris, Stuart A., 2005. Thermal history of the Arctic Ocean environs adjacent to North America during the last 3.5 Ma and a possible mechanism for the cause of the cold events (major glaciations and permafrost events). Progress in Physical Geography 29, 2 (2005) pp. 218–237.

increase in the amount of ice. Areas once free of ice became perennially frozen.

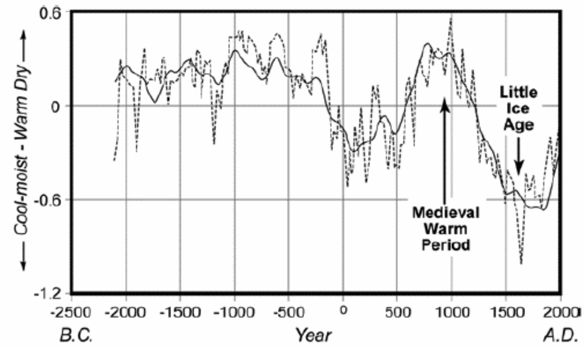


Figure 5 Comparison of theoretical cycles with actual data from Campbell *et al.* (1998). The heavy line represents the results of the interaction of the 23 708-year Milankovitch and eight intermediate term (1500- to 280-year) periodicities. The light line represents the actual Pine Lake medium grain-size record, believed by Campbell *et al.* (1998) to represent temperature fluctuations

Figure 23

The information presented by Harris in Figure 23 goes back to 2500 BC. The temperature pattern is warm, warm, warm, cool around 1 AD, warming during the Medieval Warm Period, followed by cooling during the Little Ice Age, and then a warming trend. This general pattern appears repeatedly in the literature. It is pretty much the consensus among scientists that temperatures were warm followed by a cool period, which was followed by a warmer period. In other words, it is warmer now than it was, but it was warmer prior to the cold period.

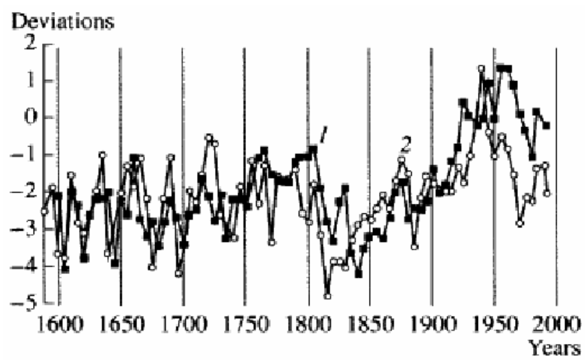


Fig. 2. Comparison of long-term temperature variations based on (*1*) data from [1] and (*2*) a series of tree-ring records for the subarctic region of Asia.

Figure 24

Figure 24 shows another example of climate change periodicity. Vagonov, a Russian researcher, examined tree ring data back to 1600 and found the same trend: a warming period that peaks in the 1940s followed by temperature decline.

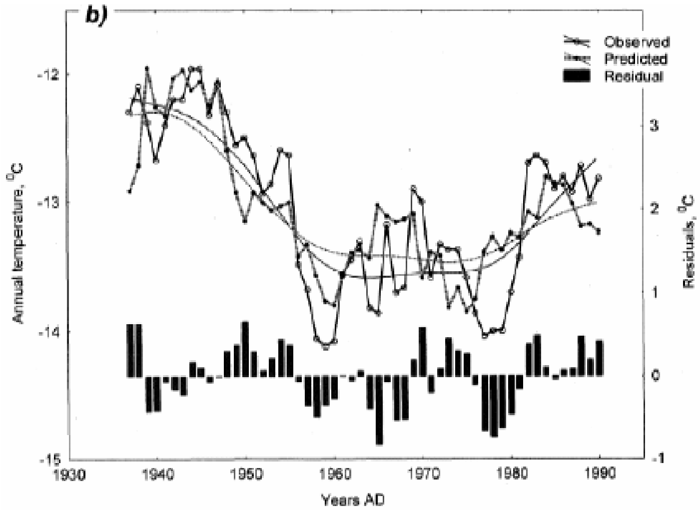


Figure 25

Dr. Naurzbaev discovered the same climatic trend (Figure 25). He states, "the warmest periods over the last two millennia in this region were clearly in the third, tenth to twelfth and during the twentieth centuries." The first two were warmer than those of the last century. Twentieth century temperatures appeared to peak around 1940. Repeatedly data reveal that the same climatic story is told across the globe.

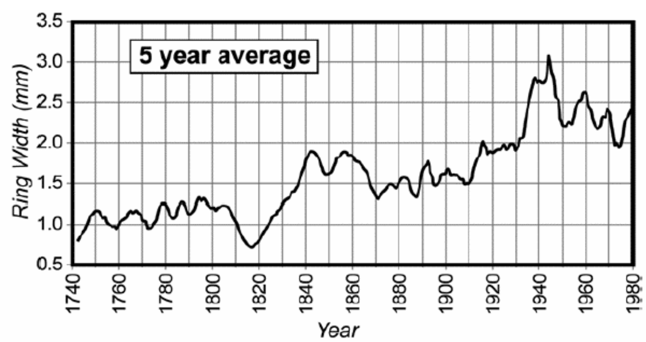


Figure 7 Variations in tree-ring widths from 123 trees in the Slims River valley, SW Yukon Territory. The data have been smoothed by using a five-year running mean *Source*: Allen (1972).

Figure 26

Figure 26 is a summary from Harris' study including a five-year average based on tree ring data from the 1740s. Notice that the Little Ice Age is followed by a warming that peaks in 1940 and has declined since.

"This have I seen" from the research:

1. The warmest period in the Holocene occurred 5000+ years ago.
2. The Medieval Warm Period was likely warmer than it is now. We are not seeing unprecedented temperatures.
3. Temperatures in the 1930s-early 40s were warmer than now.
4. These observations are inconsistent with what is expected during enhanced greenhouse warming

We are not seeing unprecedented temperatures; we are actually seeing declines in temperatures in many places compared to seventy years ago.

So if greenhouse gases aren't responsible, what could possibly be causing this climate change? Quite a few things.

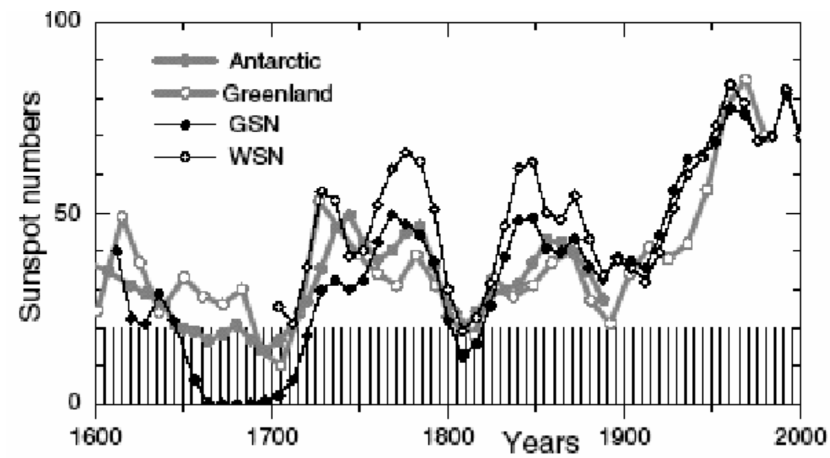


Figure 27

Figure 27 depicts a 400-year reconstruction of solar activity based on beryllium-10 isotopes from icebergs. Notice it was very cold in the 1700s during a time of very little solar activity. The cold period, which was a time when solar radiation was not intense, was followed by a warmer period, then a colder period before it really began to warm again in about 1900 as solar activity increased. Temperatures then dropped before increasing again. It appears that solar activity is a factor in temperature change. Presently we are in a very active solar period and there is reason to believe it is influencing climate. In fact, its role shows up clearly in climate data.

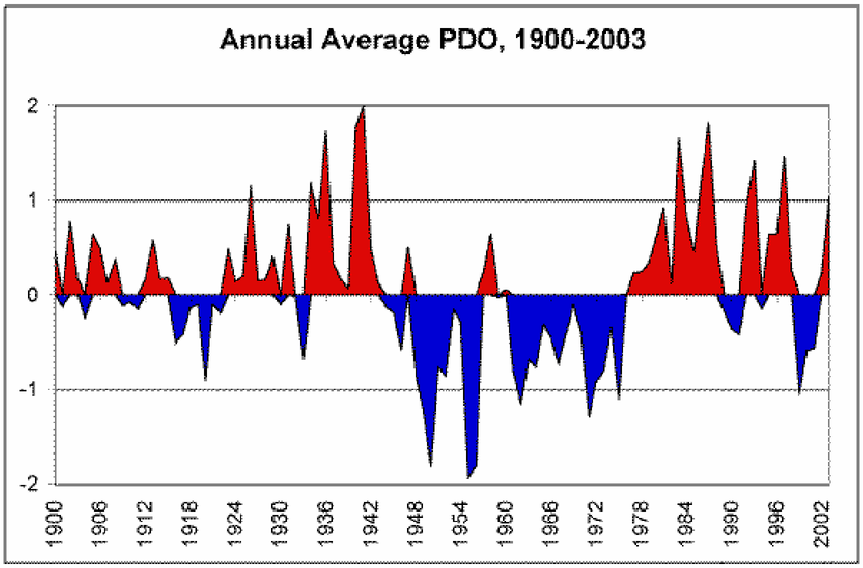


Figure 28

The Pacific Ocean affects climate around the world, especially around the Pacific Rim. The Pacific Decadal Oscillation (PDO) is an indication of ocean temperatures in the Pacific. In Figure 28, the red periods coincide with El Niño, during which time overall Pacific Ocean temperatures tend to rise and the entire planet is warmed. The blue represents what we call logging conditions, which are cooler Pacific temperatures. During this time the plant generally experiences cooler conditions overall. Notice the peak of El Niño activity in the 1930s and early 1940s, which is followed by a cool decade before the 1976 shift to a warmer regime when temperatures globally warmed up.

Arctic climate shows good correlation with these trends (Figure 29). The PDO are the vertical lines and Arctic temperatures are the dots. Temperatures peaked at the time the PDO was really cranking in the late 1930s and early 1940s, falling when the PDO changed before rising again. The PDO appears to be causative mechanism in temperature change.

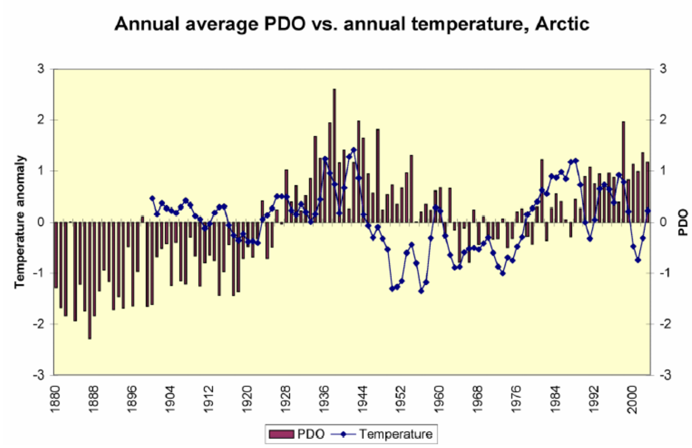


Figure 29

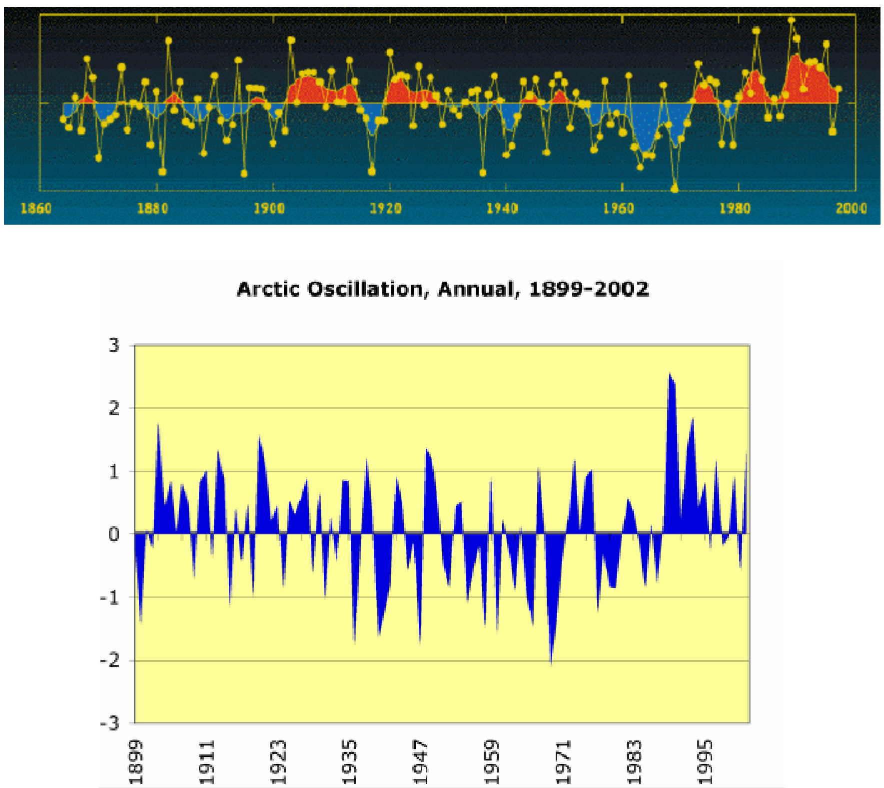


Figure 30

Other mechanisms like the North Atlantic Oscillation and the Arctic Oscillation appear to work in tandem with the PDO (Figures 30 top and bottom). Taking in to account changes in solar radiation, the Pacific, the Atlantic, and circulation over the Arctic, we can explain much of the variability seen past and present in climate without considering greenhouse gases.

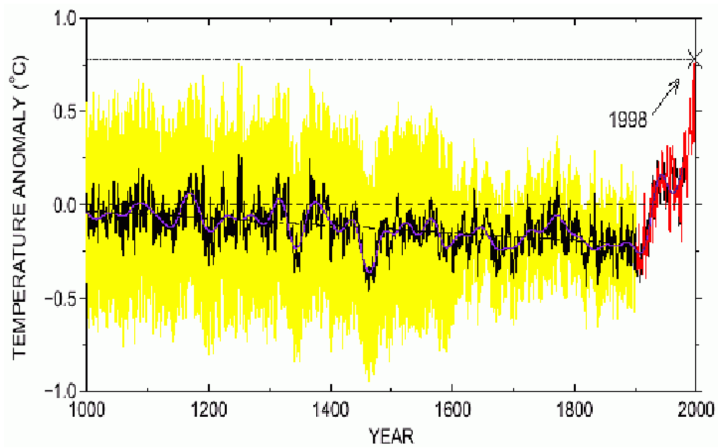


Figure 31

Now let's play a little hockey. Michael Mann's temperature chart depicting the last 1,000 years garnered a lot of attention and was used in the 2001 Intergovernmental Panel on Climate Change (IPCC) report. Based on mostly tree ring studies, Mann et al. concluded that although there had been a slight decline in temperature, there was not much temperature change in the Northern hemisphere from 1000 AD until about 1900. This period was followed by a dramatic temperature rise over the instrumental records (Figure 31). Therefore, what we are seeing are unprecedented high temperatures and since the real change is human activity, then these unprecedented temperatures are therefore due to human activity. That was the train of thought.

The Mann analysis represented a significant departure from what historical climatologists had said had been going on. Figure 32 is from the first IPCC report in 1990. This is pretty much what climatologists agreed to. There was a warm period a thousand years ago, the Medieval Warm Period, there was a cooling period known as the Little Ice Age and then a warm up, but the temperatures were still somewhat lower than they were in medieval times. I have shown you a dozen charts which show the same pattern in the Arctic and we see it in mid-latitudes; we see it all over. Michael Mann's report really flew in the face of that. Nonetheless, it was adopted immediately.

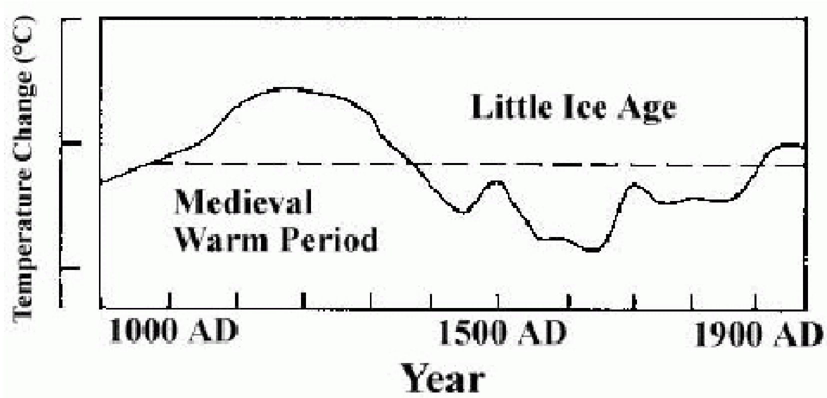


Figure 32

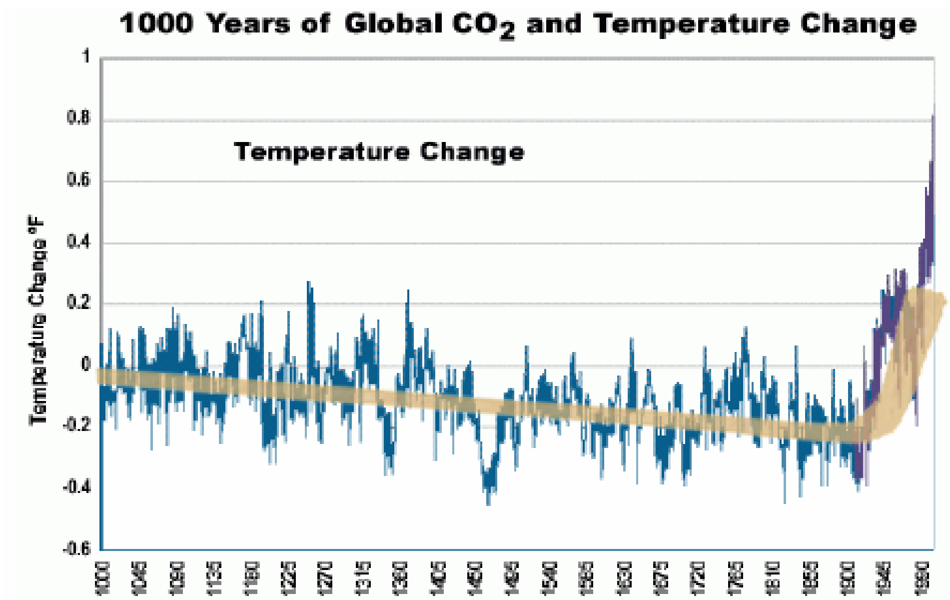


Figure 33

Figure 33 is from the U.S. National Assessment, without the error bars. People noticed that this was shaped a lot like a hockey stick, so it is referred to as the hockey stick. In the last year and a half, there have been three journal articles which have suggested (or proven, in the words of some people) that this is not valid.

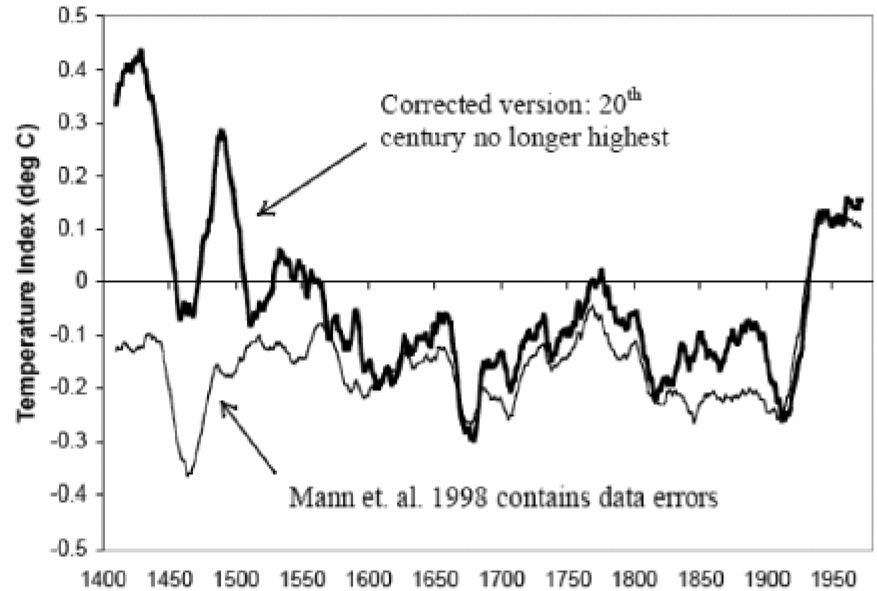


Figure 34

One of the journal articles is by McIntyre and McKitrick. They found fault with the way he had done his statistical calculations of his complicated kinds of mathematical statistical things. They used his actual data and corrected his statistics. Figure 34 shows their results. Temperatures were warmer at the beginning of the record, then they got cooler, and in the last 150 years have warmed, but it was warmer early in the record than it is now.

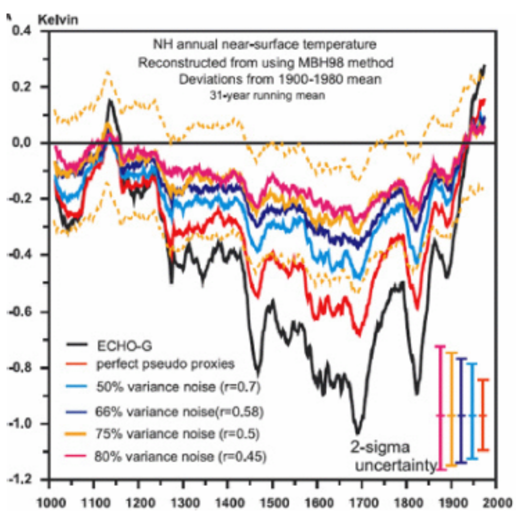


Figure 35

Hans von Storch and colleagues did the same thing with different assumptions (Figure 35). Pardon the busy-ness of this graph, but generally, the right-hand side shows where we are now, with the Little Ice Age around 1700 and the Medieval Warm Period around 1000, showing temperatures comparable to current conditions. Again, this is a return to the tried-and-true that climatologists had assumed for a long time.

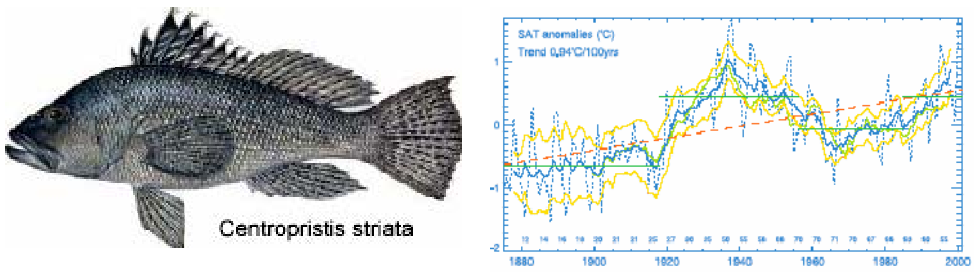


Figure 36

The hockey stick has taken on kind of a life of its own in repetition. When I look at these data, I see fish, specifically Centropristis striata, also known as black sea bass. When I look at the black sea bass, I think it looks like climate data (Figure 36)!

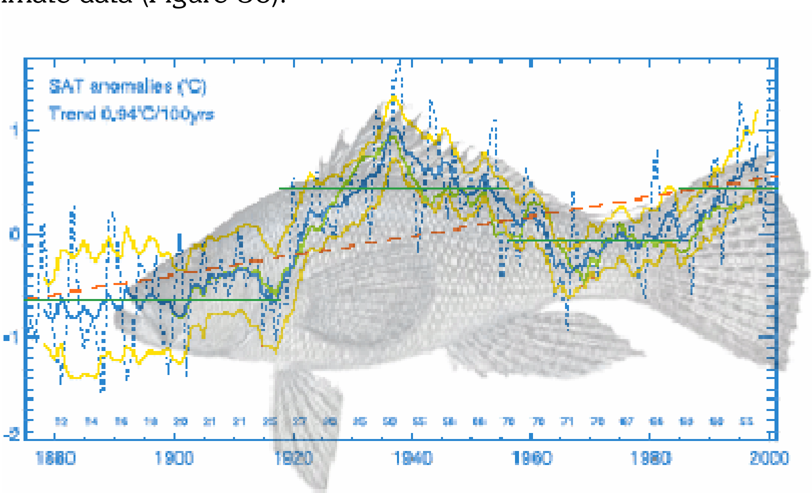


Figure 37

Figure 37 shows Igor Polyakov's chart of Arctic temperatures back to 1880 superimposed on the fish. There it is – there is a black sea bass in the data!

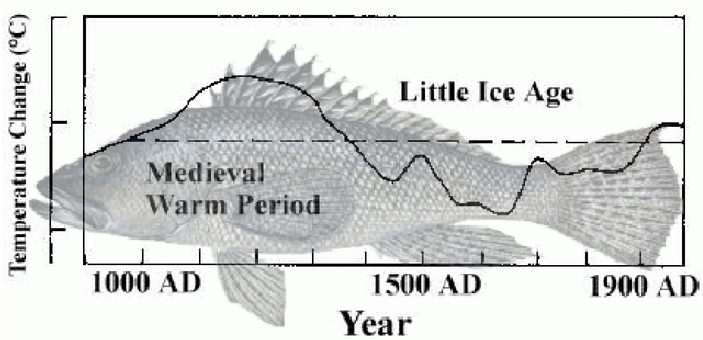


Figure 38

Figure 38 comes from the IPCC. Do you see the fish? We need to be thinking fish instead of hockey sticks.

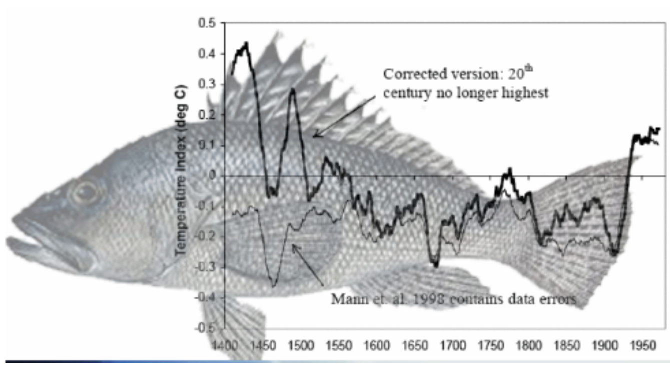


Figure 39

Figure 39 shows McKitrick's data. McKitrick only went back to 1400 so he ended in the middle of the dorsal fin.

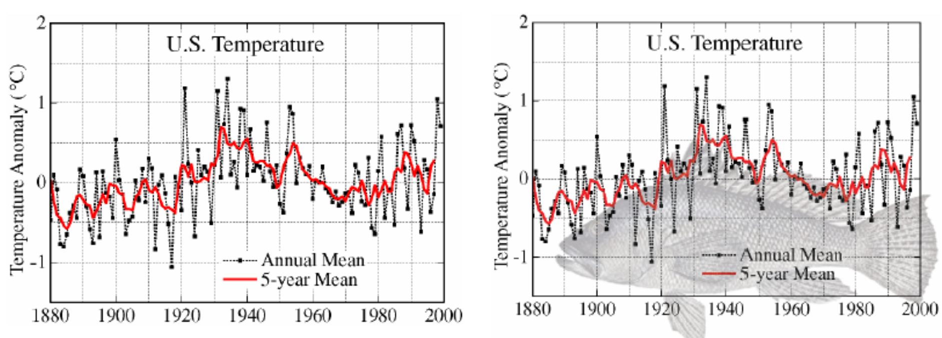


Figure 40

Did you know that the warmest year in the United States was 1934? Did you know that the warmest decade in the U.S. was the 1930s? Well, it is true. Did you know there is a fish in there? Figure 40 shows the fish. There is the dorsal fin in 1934 and now we are in the tailfin area.

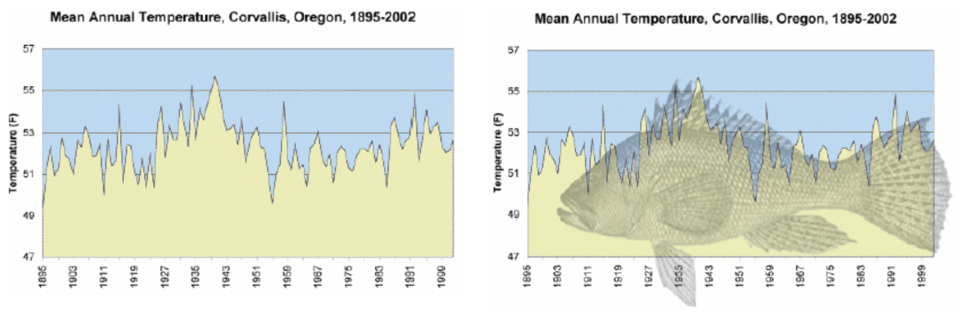


Figure 41

Figure 41 shows data from my hometown, Corvallis, Oregon. Nice town; it is where Oregon State University is, which is where I work. We have a nice station in a rural area surrounded by grass, so it is very representative of temperatures. The warmest year in Corvallis was 1939, the second warmest year was 1934, and the warmest decade was the 1930s. Then it cooled off and in recent decades it has warmed up. You know, it looks like that Arctic chart; and it looks like the U.S. chart. We see this same kind of a diagram repeatedly in the data, whether it is Arctic or mid-latitude or what have you.

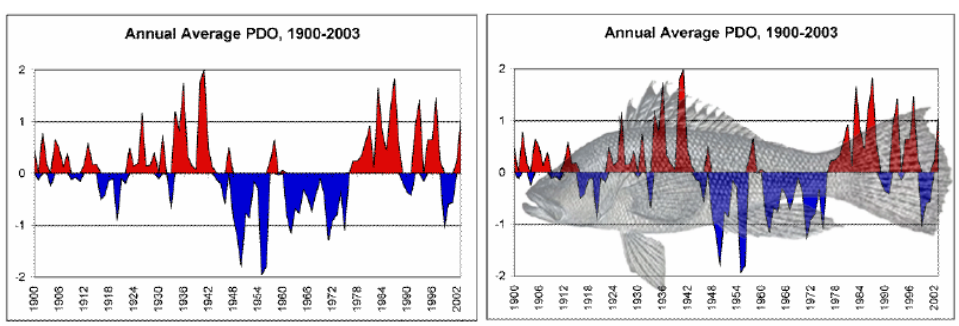


Figure 42

There is a fish even in the PDO (Figure 42). It is not quite as fishy as some of the others, but there is a fish in there as well.

Let's look to the future. But think fish. There are actually climate people that will stick their necks out and predict what is going to happen in the future. Figure 44 shows one of the predictions.

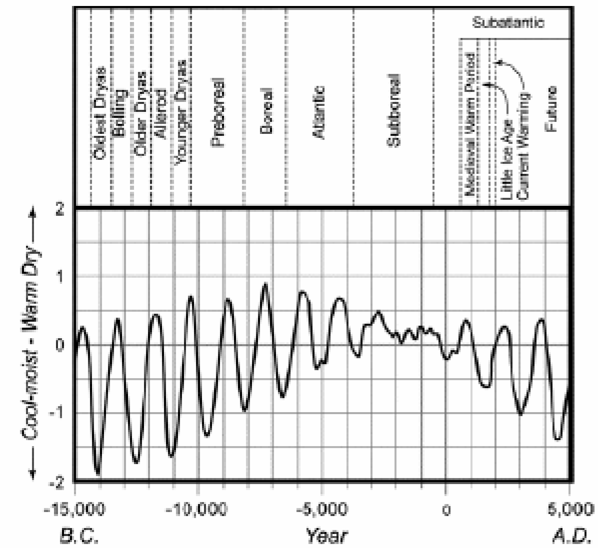


Figure 6 The two strongest periodicities of the Pine Lake record plus the 23 708-year Milankovitch periodicity compared with the European palaeoclimate chronology for the last 15 ka. Note that it predicts cooling in the coming centuries

Figure 43

Most of the people who look at long-term trends, geophysicists, the geologists, the astronomers say they see a lot of cyclical changes due to changes in 200-year sun cycle and other kinds of things. Here we are right now in the general trend; the next 5,000 years will be downward (Figure 43). So this is my foolproof prediction for the next 5,000 years. It will get a lot colder in 5,000 years. And if I am wrong, you can fire me.

My bottom line:

1. Arctic temperatures have varied significantly in the past. I think everybody agrees with that.

2. Most researchers that I have seen believe that the warmest period of the last 100 years in the Arctic (and the US, and in Oregon, and in Corvallis) was the 1930s-early 1940s, before the greenhouse enhancement kicked off.

3. Natural variations, I believe, dominate the climate system. I believe that the human component, which probably exists, is quite small compared to natural variations.

4. Models and climate history give us different answers concerning Arctic climate. I prefer trusting the data. I am active in the national state climatologists association, the American Association of State Climatologists. Most of my fellow state climatologists feel the same way I do about the relative natural versus human component, but most of us look at data. We evaluate current conditions in view of what has happened in the past, rather than drawing models. Most of us feel the same way.

5. I suggest we stop playing hockey and go fishing instead!

Thank you for your attention.

Questions and answers.

Question: For natural variability, what are main components? The sun and ocean currents?

Taylor: Geologists consider four orders of scale in terms of time. The biggest, which is on billions of years, deals with the geometry of the solar system. There is another scale on tens of millions of years, which has to do with the continents and so on; then there is another scale on hundreds of thousands of years, which includes things like the Milankovitch cycles and orbital variations; and then there is the short-term, perhaps tens of thousands of years, which have a different set of variables. This includes changes in the Pacific Ocean, the Atlantic Ocean, the so-called global thermohaline circulation, solar variations, greenhouse enhancement and so on. It is really hard to say which of those is dominant. In the case of the sun, a lot of research is still going on, but we know there is an 11-year sunspot cycle, a 20- to 27-year solar magnetic field cycle, and longer ones. There is a 210-year solar cycle that is very strong and we seem to have longer ones than that. We have 11-year cycles, 27-year cycles and cycles of a few hundred years; all of which are in some way superimposed on each other. Sometimes they are additive and sometimes they cancel each other out. On top of that we have changes in circulation and so on. In short, we have this really messy record that we believe is strongly influenced by the cyclical mechanisms that we cannot possibly model. So I think the short answer is that we really don't know. An excellent way to do significant climate research is to study the effects of these overlapping cycles of different lengths and try to determine their relative magnitudes. Many scientists feel that the solar variability is the biggest one, but as far as which of those cycles is the strongest, I don't think you can really get too much agreement. Good question, though; thanks for asking.

Question: Today the *Washington Post* has an article "Siberian Lakes Disappearing." It says that using satellite photos of 1972 to 1988, researchers found large lakes had declined by more than 11% and that the lakes could disappear altogether if these trends continue. My question may be more cultural than scientific here, but how is your message being received when the *Washington Post* has a story like this and when *Science* magazine publishes a study that says that there is a 100% unanimous consent that man is causing catastrophic global warming? Where do you see your message and the scientific data you presented going in our media and our culture today?

Taylor: It is really easy to take a phenomenon or a data point for a limited amount of time and make a statement about it; I could probably spend the whole afternoon trying to refute it using actual data. Many times it is harder to disprove something than it is to prove it in the first place. You can find anecdotal information that will support just about anything. People have accused me of cherry-picking information as well: "Taylor, all you are doing is picking the studies that support what you believe in and you are ignoring all the other ones." My answer is that I am not really ignoring all the other ones, but what bugs me is that people say that climate science is settled, that we already know the answers, and that humans are a big problem. I am saying that there are pieces of information which seem to disprove the statement that the human influence is tremendously high. Now in this field, unfortunately, science and politics have been enmeshed and when that happens I think science really suffers. I try very hard to document what I do and to be objective. I recognize that I am not perfectly objective and that I am a product of my experience and my world view and so on, but I really try hard to read information from both sides and to learn from it. When it comes to this particular thing, the Siberian lakes are disappearing, one might think that is because precipitation has changed. There is a very large lake in Russia called the Aral Sea which is disappearing because they have dammed the rivers that flow into the Sea and have basically destroyed it on the ground. I would want to investigate some of the other human induced changes before blaming it on greenhouse gases.

Question: I was at a conference last week in which Professor Steven Warren of the University of Washington asserted that measurements show that the thickness of the ice in the Arctic had been reduced by half over the course of the last few decades. Are you saying that that assertion is factually incorrect or are you saying that it is caused by phenomena other than anthropogenic warming?

Taylor: When it comes to Arctic ice, some researchers have said there is a diminution of Arctic ice in the last thirty years or so and there is certainly evidence that parts of the Arctic have warmed up in the last thirty years, as Igor Polyakov showed. That is possible, based on a warming of summertime temperatures. Many researchers, including Dr. Warren's colleague Mike Wallace at the University of Washington, have said that the main cause of changes in Arctic ice thickness is variability in winds caused by changes in the Arctic Oscillation. There seem to be periods in the Arctic Oscillation where winds flip-flop: some periods when winds blow primarily from Asia over towards Alaska and other periods when they blow back the other way. So a lot depends on where the measurements are taken. So to take a record from a limited number of years in a few different places that are actually hard to measure because there is no land, to base data mostly on satellite measurements and some marine measurements and then to make a blanket statement is, I think, probably a bit of a stretch. It may be happening, it may be attributable to the averaging period that he is looking at and it may be do to something entirely different from temperatures.

Question: Actually two points. The British Prime Minister is in the country this week and he has taken the unprecedented step of inviting twenty senators to the British Embassy to get together and talk about trying to change the United States policy on Kyoto specifically, on the basis that the UK's position. You know, the Prime Minister has tried to walk Sir David King's statement about climate change being "the greatest threat facing mankind" back a little bit. Apparently nuclear power, hydroelectric power and mono-cultural trees are a greater threat and terrorism is *not* a greater threat, in the British formulation. What would you say to Mr. Blair about the scientific advisors in the U.K. other than Sir David King?

Taylor: I would say that there are plenty of climate scientists in Britain and other places that have a different point of view than Sir David King. I would also say that Kyoto itself is really not going to accomplish anything in terms of reducing global temperatures. That has been agreed to by just about every climate scientist. Tom Wigley of the U.S., one of the premier climate scientists working for the Global Change Program, had estimated that if Kyoto were adopted and adhered to by the countries of the world, the net reduction in temperature over the next fifty years would be less than a tenth of a degree Celsius, which means you couldn't measure it. Several scientists including Jerry Mahlman in the U.S. said, "Well, Kyoto is just a start. What we need is thirty more Kyotos." My response would be that Kyoto is not going to accomplish anything in terms of climate impacts. Certainly it would have a significant financial impact. So I would probably take it to that point.

In response to your earlier question, there was a report by Naomi Oreskes a while ago in *Science* who did a literature search on climate change and said that every scientist that she found agreed with the IPCC. I think that's laughable. There are hundreds and hundreds of journal articles which have a different point of view on climate change than the one that says that it is happening, it is because of people, and we are all in trouble. Climate science is not settled, by any means. There are plenty of folks, including most of the state climatologists, who agree otherwise.

Question: If you are using the Arctic study as a benchmark for a lot of your conclusions, is the definition being used of the Arctic area that you are studying a dynamic model, in that it is contingent on temperature? Is it just a latitude line on the globe or is it based on areas that are defined by a certain temperature range? If the temperature actually fluctuates, does that definition of the Arctic change with those temperature fluctuations?

Taylor: If you take all the stations that are within that box or polygon or whatever it is and average them year by year, some of them are going to be warmer than others. There is going to be a spatial variation much of the time. But over the span of the time, that will somewhat even out. The reason for using a benchmark like a 50-degree temperature in the summer is that it is summer temperatures that tend to melt the ice, not the winter temperatures. So by having a consistent summertime average temperature, you are looking at the area whose boundaries have an equal chance, over the long term, of melting in those kinds of summer conditions. By going down to 60° north, you have a very sizable area in Siberia that is ice-free for much of the year. It is very cold in the winter, but it has very warm summers. So I think you are in a more consistent geographic area if you use something like temperature.

Question: So if an area started to show consistently higher temperatures in the summer, would that area be knocked off your definition for the Arctic?

Taylor: No, you are sticking with a single definition and if there were a large area that began having warmer temperatures, then that would tend to affect the entire area. Now there are charts that show it area by area, geographically, within that big box. So it is not just a matter of looking at only one number average for the whole box. They are actually looking at individual stations as well. Time did not permit me to get into that.

Question: Later this month, the working groups from the Arctic Council will be meeting with the explicit goal of determining what to do next, as far as the Arctic Climate Initiative. What is your recommendation for the working groups?

Taylor: I am not sure I can give a recommendation for the working groups. My recommendation for the Arctic Climate Impact Assessment is to continue studying this. It is an important phenomenon. But I think there is a large contingent of viewpoints that are not represented in the group and I think it would be great to have people of the stature of Igor Polyakov or Ray Pryzbylak who are involved in that. There are many names that don't show up in that. Their work is quoted, but it does not seem to be given the same weight as some of the other kinds of information. So I think it has become somewhat skewed.

Question: I would like to follow up on that. Could you discuss the data in the Arctic Climate Impact Assessment versus the modeling? When they first rolled it out, I noticed that everybody who talked about it said they moved very quickly from the data to "and our models show that this trend will continue." I wonder if there is some disagreement, as you have indicated in your own analysis, among the team itself, between the data people and the model people. Sir David King has picked up on the idea that Greenland is going to melt and raise the sea level twenty feet. Then if you read further in the interviews, he said, "Well, it will be a thousand years or so before that happens."

Taylor: I think I mentioned that there is a very different pattern to the report when they talk about the long-term climate trends. My assessment is that the parts of the chapter that talk about the millennial scale and beyond are very even handed, quite accurate and I would say not very controversial. There are then summary conclusions that seem to be attached to that that say "but the models say such-and-such." They state that they only go back to the 1970s because there aren't enough observations available earlier. Polyakov used a number of stations for his analysis. The number of stations peaked in the early 1970s but there are many stations in the 1940s and 1950s; it really only drops off once you get back in the 1920s. There is not a big significant difference between the mid-1930s and mid-1980s as far as the number of data points available. I certainly don't want to accuse people of not being objective, but sometimes when I look at people's analyses – when, for example, they take only thirty years of data – I sometimes wonder if they had not turned the scientific principles around backwards. We are supposed to start with a hypothesis and then look at information that would either prove or disprove that. I think many scientists have fallen into the trap of making up their minds and then finding information that would tend to prove that. I am not going to mention names; I am sure people accuse me of doing the same thing. But it is easy to fall into that trap. That is why I think we need a variety of viewpoints and scientists involved in this issue, so that one side doesn't co-opt this whole thing and start adding conclusions that probably do not belong.

Question: Do the locations have any impact on the average of the data? I mean, are the stations spatially representative or do they skew?

Taylor: To obtain the average, they take this area over the point measurements and they superimpose a grid on it and then for each grid cell they come up with an estimate based on a weighting of the stations around it. So it is more or less objective. Certainly taking out a really important station can affect a rather large area. Polyakov's data began at 62° north; he used a circle. Since the ACIA used 60° rather than 62°, one might say this is probably very similar to what the ACIA would have gotten if they had gone back a hundred years, using the same data.

Question: To follow up on that, I think McIntyre and McKitrick have plotted a fairly appreciable drop in the number of Russian measuring stations about the time the Soviets underwent political turmoil. And suddenly we had the hottest decade in history.

Taylor: Yes, there was a big drop-off in the number of worldwide reporting stations in the early 1980s. They peaked in the early 1980s and went down about the time that the global temperatures started to go up. So there is a very uneven record there. In many parts of the world, there were more stations in the past than there are now.

Question: Early in your presentation, you mentioned nighttime temperatures. One of the predictions of warming theory is that there would be more warming in the Arctic at night.

Taylor: The data say that the daytime and nighttime temperatures have been pretty much been following the same trend. They are not separated from each other. So the general trend of average temperatures applies to both daytime and nighttime temperatures.

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