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Is the Earth still recovering from the "Little Ice Age"?
A possible cause of global warming

– an updated version –

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There seems to be a roughly linear increase of the temperature of about 0.5°C/100 years (~1°F/100 years) from about 1800, or even much earlier, to the present. This value may be compared with what the IPCC scientists consider the manmade effect of 0.6 - 0.7°C/100 years. This linear warming trend is likely to be a natural change. One possible cause of the linear increase may be that the Earth is still recovering from the Little Ice Age. This trend should be subtracted from the temperature data during the last 100 years in estimating the manmade effect. Thus, there is a possibility that only a fraction of the present warming trend may be attributed to the greenhouse effect resulting from human activities. This conclusion is contrary to the IPCC (2007) Report (p. 10), which states that "most" of the present warming is due to the greenhouse effect. It is urgent that natural changes be correctly identified and removed accurately from the presently on-going changes in order to find the contribution of the greenhouse effect.

There are many documents that suggest that the period between 1500 and 1900 was relatively cool; the River Thames was frequently frozen in the later part of the 17th century (Lamb, 1982). Stories of the exploration of the Northwest Passage also hint that sea ice conditions in northern Canada in the latter part of the 1800s were much worse than conditions today; it is now possible to cruise the passage without much assistance by icebreakers. Although there is some doubt about the exact timing of the "Little Ice Age," it is possible to infer that the period between 1500 and 1900 was relatively cool in many parts of the world (cf. Lamb, 1982; Gribbin (ed.), 1978; Crowley and North, 1991; Burroughs, 2001; Serreze and Barry, 2005).

Climate change during the last 100 years or so has been intensely discussed over the last few decades. However, it is important to recognize that as far as the *basic* global warming data for this period are concerned, all we have is what is illustrated in the top of the diagram of Figure 1. The IPCC Reports state that the global average temperature increased about 0.6°C - 0.7°C (~1°F) during the last 100 years. Their interpretation may be illustrated in the middle graph of Figure 1, as both the temperature and the amount of CO_2 in the air have increased during the last 100 years or so. Further, it is well known that CO_2 causes the greenhouse effect, so that it is natural to *hypothesize* that CO_2 is one of the causes of the present warming trend. Nevertheless, it is not appropriate to tacitly assume that the 0.6°C - 0.7°C rise is mostly due to the manmade effect without carefully examining the contributions of natural changes.

Indeed, there is so far no definitive proof that "most" of the present warming is due to the greenhouse effect, as is stated in the recently published IPCC Report (2007). In fact, the relationship between air temperature and CO_2 is not simple. For example, the temperature had a cooling trend from 1940 to about 1975, in spite of the fact that atmospheric CO_2 began to increase rapidly in about 1940, as can be seen in Figures 1 and 2. It is not possible to determine the percentage contribution of the greenhouse effect that is a direct result of human activities, unless (and until) natural causes can be identified and subtracted from the present warming trend.

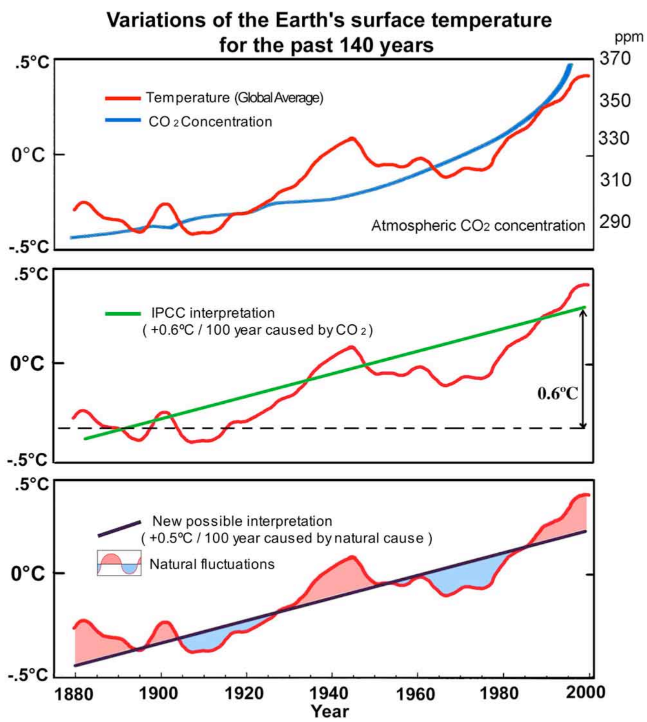

Figure 1: The top graph is the basic data on global warming; the middle graph is the IPCC's interpretation that the 0.6°C (or 1°F) increase is caused by the greenhouse effect; the bottom graph is another interpretation, suggesting that a large fraction of the 0.6°C - 0.7°C rise is due to natural changes.

As another interpretation, in the bottom graph of Figure 1, it is assumed that there was an almost linear increase of natural temperature rise of 0.5°C/100 years, which is superposed by fluctuations, such as multi-decadal oscillations. The difference between the second and third diagrams is that the IPCC Report assumes that the warming trend is mostly due to human activities, while the latter assumes that a large fraction of the warming trend is due to natural causes. Actually, there are many other ways to interpret the temperature changes than what is shown in the bottom graph of Figure 1.

It is somewhat surprising that there has, so far, been no debate on such, and many other interpretation and possibilities. Indeed, it is doubtful that the IPCC conclusion of "most" is the consensus of 2500 experts in climatology. The greenhouse effect is a hypothesis to be proven. At this stage in the development of modeling and simulation, however, one can test the hypothesis only qualitatively, not quantitatively by global climate models (GCMs), because they are adjusted or "tuned" to reproduce the 0.6°C - 0.7°C rise. This point will be discussed later.

Figure 2 shows both the global average temperature and the temperature from stations widely distributed along the coast of the Arctic Ocean (blue) during the last 100 years or so (Polyakov et al., 2002). One can see that the magnitude of temperature changes is significantly larger in the Arctic. A similar result was shown in the ACIA Report (2004); see p. 23. In particular, fluctuations, including multi-decadal oscillations, are greatly "amplified" in the Arctic. There occurred two major fluctuations, one between 1920 and 1975, and one after 1975. The arctic data indicates that the two fluctuations in the global average data should not be ignored as minor fluctuations.

Indeed, it is crucial to investigate the nature of the temperature rise between 1920-1940 and the one after 1975. As the Figure 1 (top graph) and Figure 2 show, CO_2 in the atmosphere began to increase rapidly after 1940, when the temperature decreased from 1940 to 1975. Thus, the large fluctuation between 1920 and 1975 can be considered to be a natural change, until proven otherwise. Therefore, unless the difference between the two changes can be understood, it is not possible to say tacitly that the rise after 1975 is mostly caused by the greenhouse effect. There is nothing wrong to suspect that the rise after 1975 contains a significant natural component.

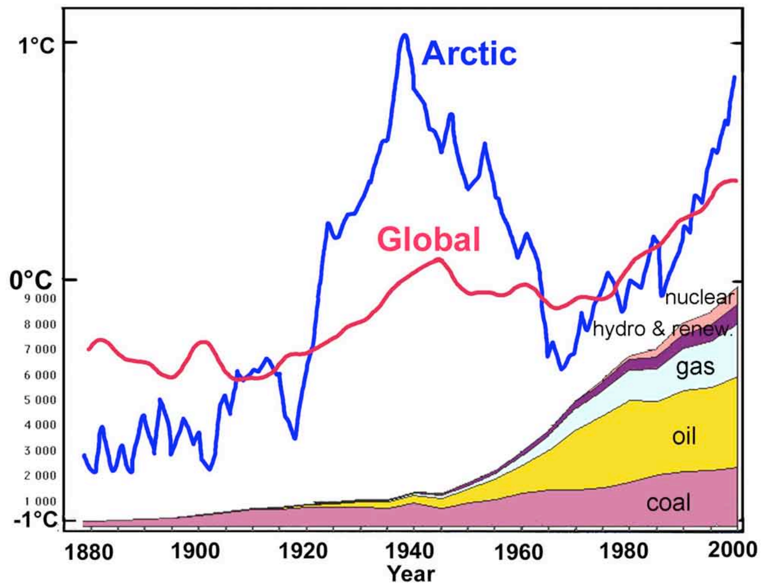

Figure 2: Red – global average change (IPCC Reports). Blue – data from stations along the coastline of the Arctic Ocean (Polyakov et al., 2002). The figure shows also the amount of various sources of energy used during the last century; gas, oil, and coal all release CO_2.

In this note, we examine first the possibility of the case shown in the bottom graph of Figure 1 and then the nature of the fluctuations.

1. Linear Increase

The basis for drawing a linear line in the bottom graph in Figure 1 cannot be justified without additional data. Fortunately, Fritzsche et al. (2006) obtained ice cores from Severnaya Zemlya, an island in the Arctic Ocean, and made the $\delta^{18}O$ analysis. Their results are reproduced here as Figure 3a. It shows the $\delta^{18}O$ data at the top. It is possible to observe that an almost linear change is evident from about 1800 to the present in the ice core record; the red linear line is added by the present author; large fluctuations are also indicated as "natural changes" also by the author, since it is unlikely that CO_2 caused any major temperature fluctuations before 1940.

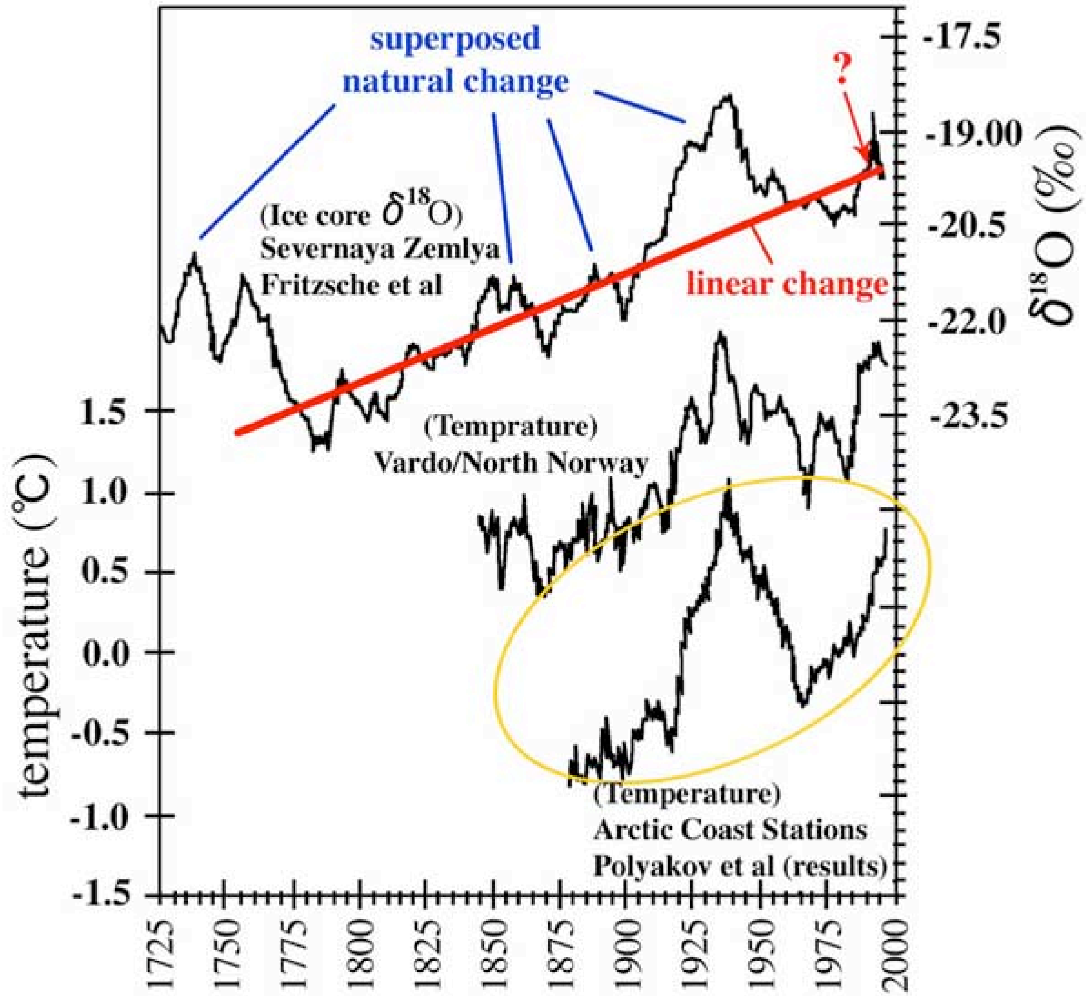

Figure 3a: Late Halocene ice core record from Akademii Nauk Ice Cap, Severnaya Zemlya, Russian Arctic, together with temperature records at Vardo, Norway, and along the artic coast stations (Polyakov et al., 2002), the last one is the same as the blue curve in Figure 2 (D. Fritzsche et al., 2006).

Their figure shows also a thermometer record from Vardo in Northern Norway. The bottom graph is the same as the "Arctic" one of Figure 2. The credibility of the ice core record is supported by the similarity with the Norwegian temperature record and the data by Polyakov et al. (2002), or vice versa.

Figure 3b shows ice core data from Quelccaya, Peru, and Dunde, China, comparing them with decadal temperature departures in the Northern Hemisphere. One can infer a quasi-linear trend in both data, in addition to various fluctuating components.

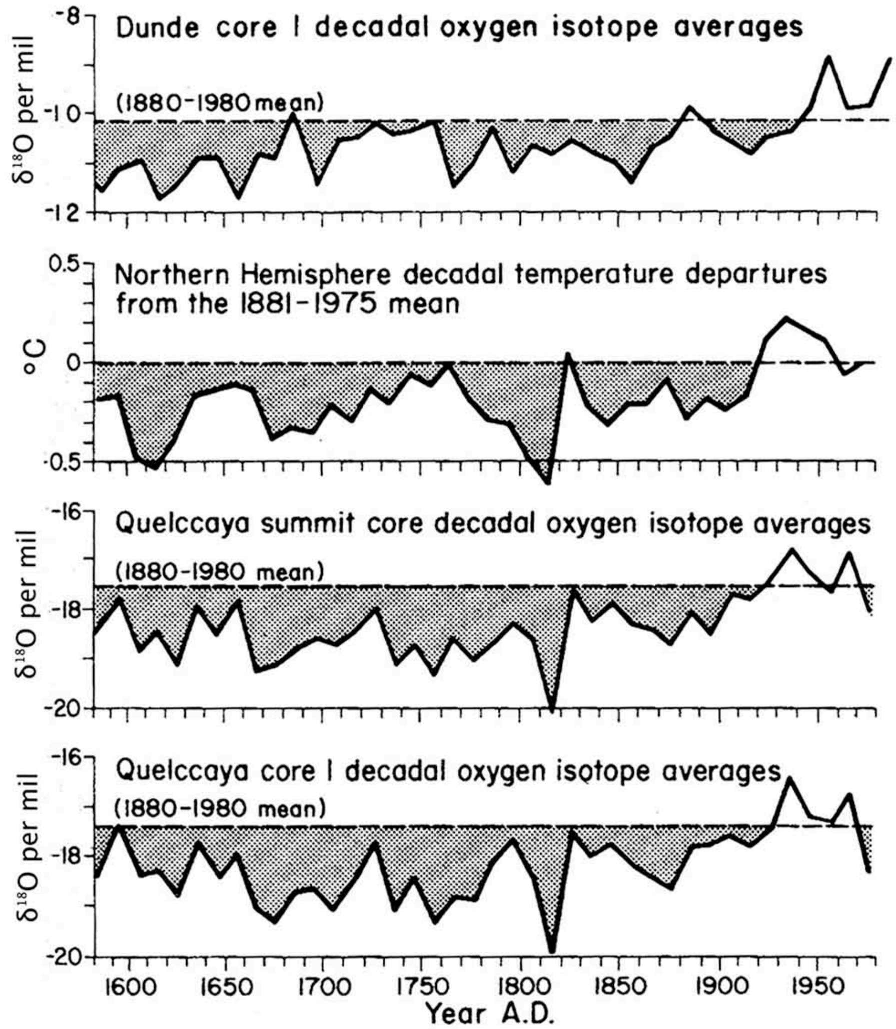

Figure 3b Decadal temperature departures (from 1881-1975) in the Northern Hemisphere from 1580 A.D. to 1975 (second) compared with decadal average δ^{18}O values for both the Dunde, China, D-1 core (top) and Quelccaya, Peru, ice cores (third and fourth). The dashed line is the 1881-1980 A.D. mean for the δ^{18}O records (L.G. Thompson, 1992).

The ACIA Report (2004) took the *average* of 100-year records as the baseline (their figure on page 23), namely, a line parallel to the horizontal axis, with the average value as the zero (base) line. However, the above ice-core records show that such a practice is not appropriate. There is clearly a linear increase of temperature from about 1800 or much earlier. Similar linear trends can be inferred in the Norwegian data and the data by Polyakov et al. (2002) in Figure 3a. There are several other supporting studies that suggest that there has been a linear change from about 1800 or earlier. For example, Figures 4, 5, 6, 7, and 8 suggest a roughly linear change of temperature from the earliest recordings by Burroughs (2001), Tarand and Nordli (2001), and van Egelen et al. (2001). The trend lines and curves were drawn by the quoted authors, not by the present author.

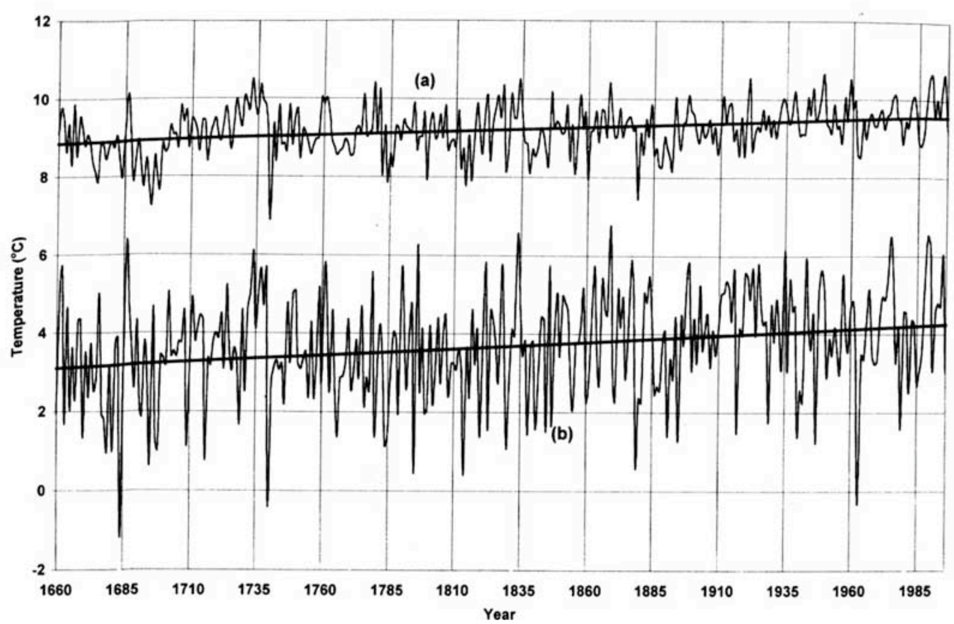

Figure 4: The linear trends for the temperature of central England over the period 1660-1996 for (a) the annual data, and (b) the winter months (December to February), show a marked warming. In both cases, this warming is significant, but although the temperature rise is greater in winter, this trend is less significant because the variance from year to year is correspondingly greater (L.D. Burroughs, 2001).

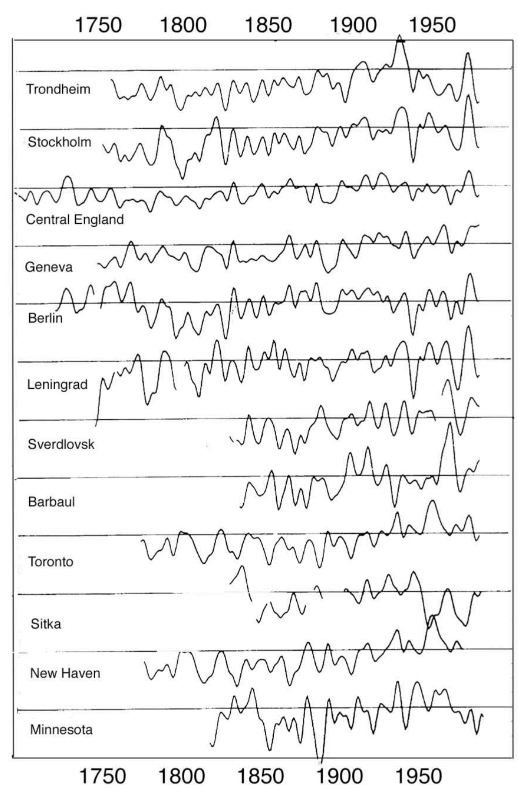

Figure 5: Temperature change at a number of stations in the world (P.D. Jones and R.S. Braley, 1992).

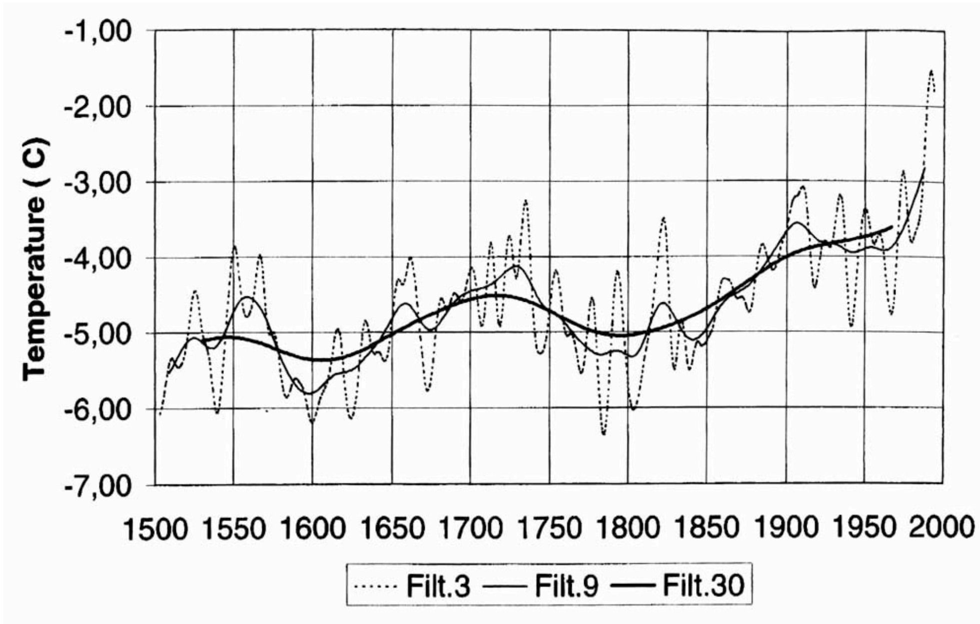

Figure 6: Winter temperature (December-March) at Tallinn since 1500, which are based on ice break-up dates in Tallinn port. The series is smoothed by Gaussian filters of 3, 9, and 30 years as standard deviations in the Gaussian distribution (A.N. Tarand and P.Ø. Nordli, 2001).

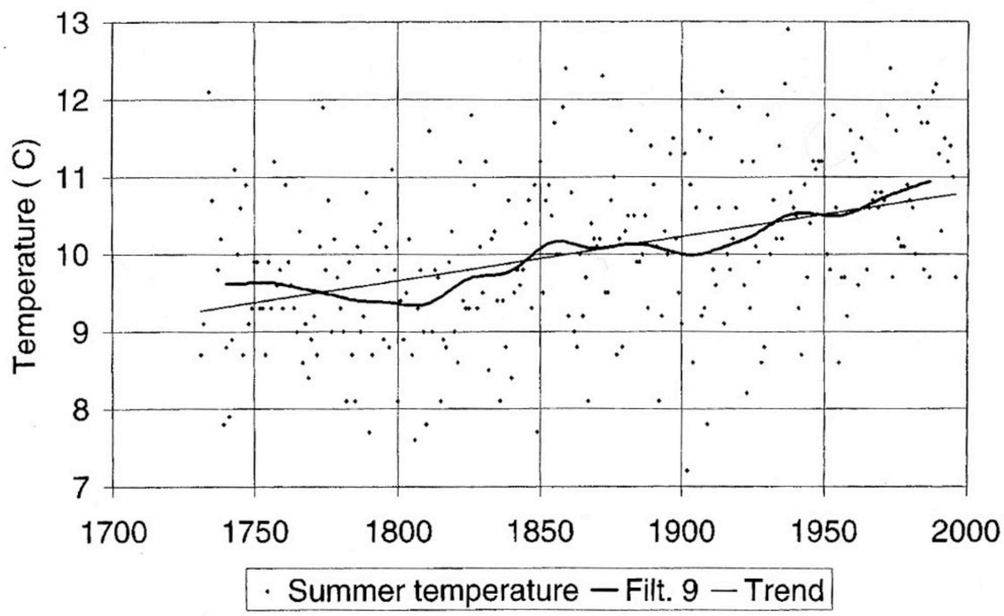

Figure 7: Summer temperature (April to July) for Tallinn, which is based on ice break-up and rye harvest data and of instrumental observations. To ease the study of variations on a timescale of approximately 30 hours, the observations are smoothed by a Gaussian filter with standard deviation of 9 years in its distribution (curve). A trend line for the whole period is also shown (A.N. Tarand and P.Ø. Nordli, 2001).

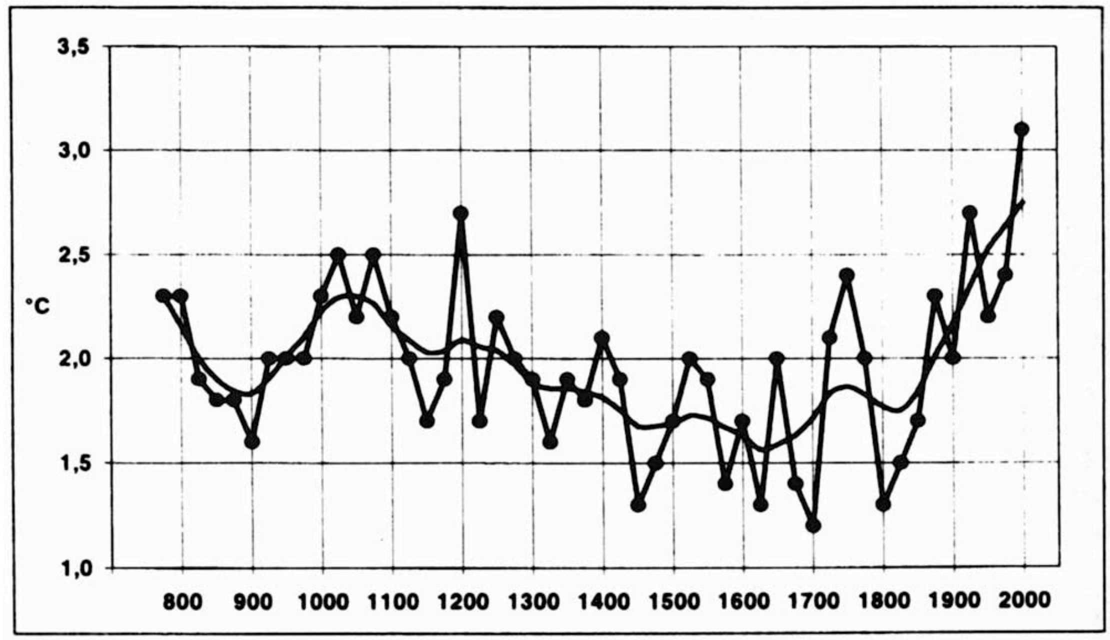

Figure 8: 25-year mean winter (DJF) temperature at De Bilt (A.F.V. van Engelen, J. Buisman and F. Ijnsen, 2001). This figure includes a longer period data than Figures 4, 5, and 6.

There is further supporting evidence of a continuous climate change from about 1800. Figure 9a shows that the southern edge of sea ice in the Norwegian Sea has been continuously receding from about 1800 to the present. Further, there is a possibility that the present receding is related to an intense inflow of warm North Atlantic water (Polyakov et al., 2002); this phenomenon is known as the North Atlantic Oscillation (NAO), which is a natural phenomenon (Figure 9b). Further, Figures 10a and 10b show examples of glaciers in Alaska and New Zealand, respectively, which have been receding from the time of the earliest records. There are a large number of similar records from the European Alps and elsewhere (Grove, 1988). Therefore, it can be assumed that many glaciers advanced during the Little Ice Age and have been receding since then. Thus, the retreat is not something that began only in recent years.

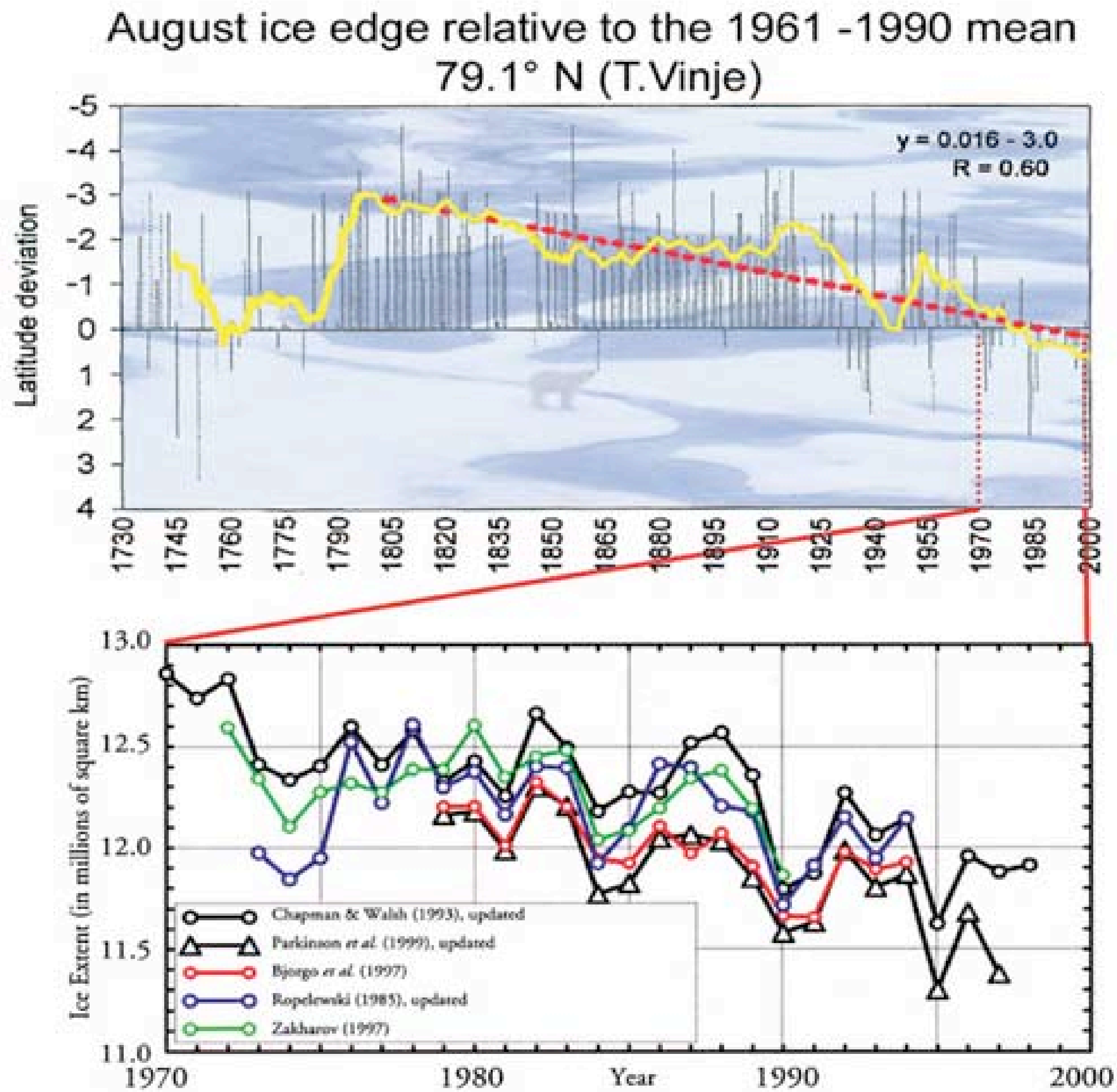

Figure 9a: Upper, retreat of sea ice in the Norwegian Sea (T. Vinje, 2001). Lower, satellite data corresponding to the period between 1970 and 1998 are shown.

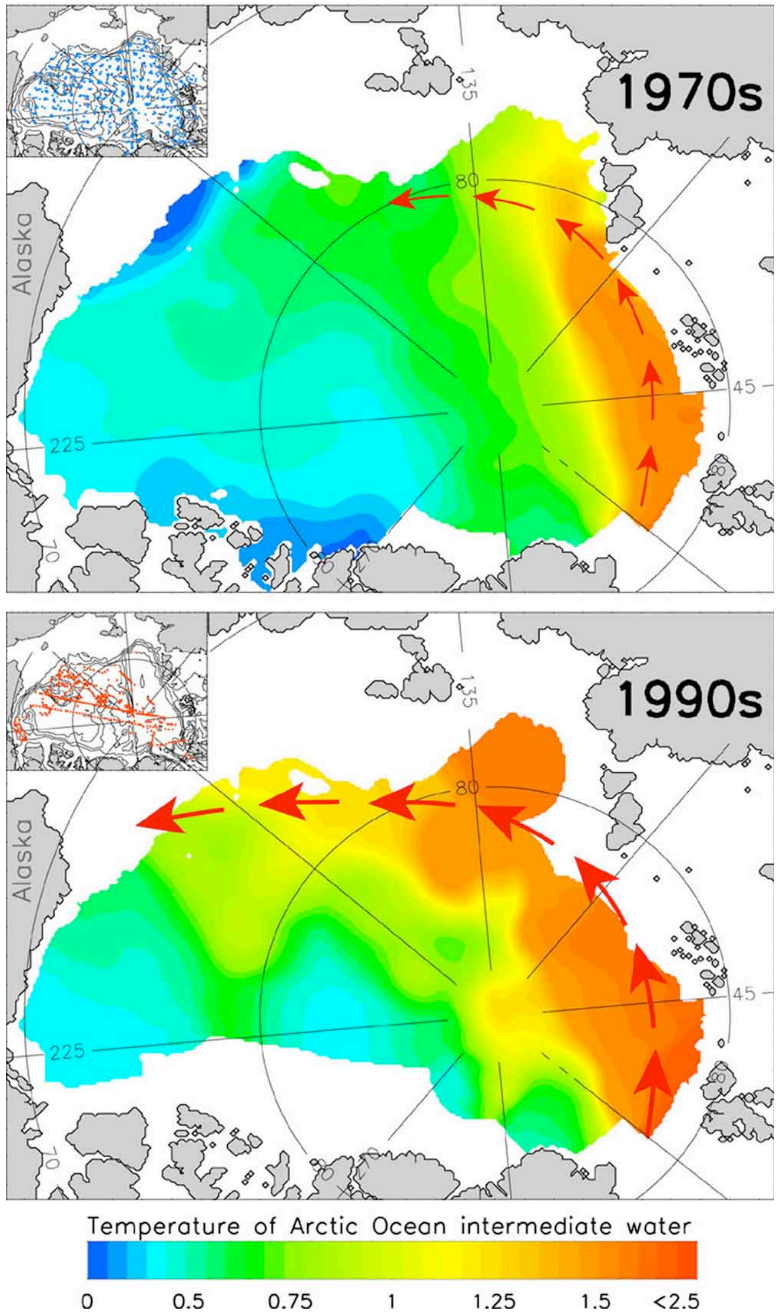

Figure 9b: Inflow of warm North Atlantic water into the Arctic Ocean (I. Polyakov, 2006).

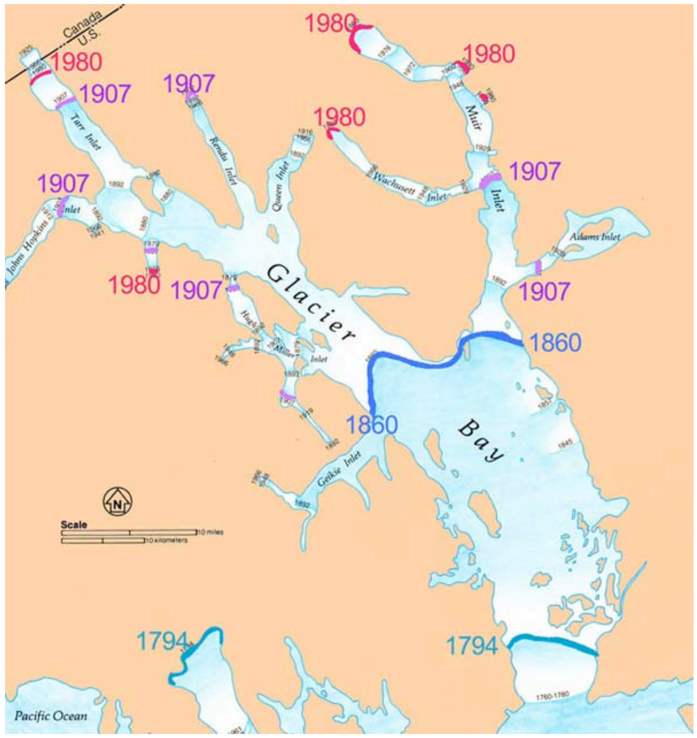

Figure 10a: Retreat of glaciers in Glacier Bay (*Alaska Geographic*, 1993).

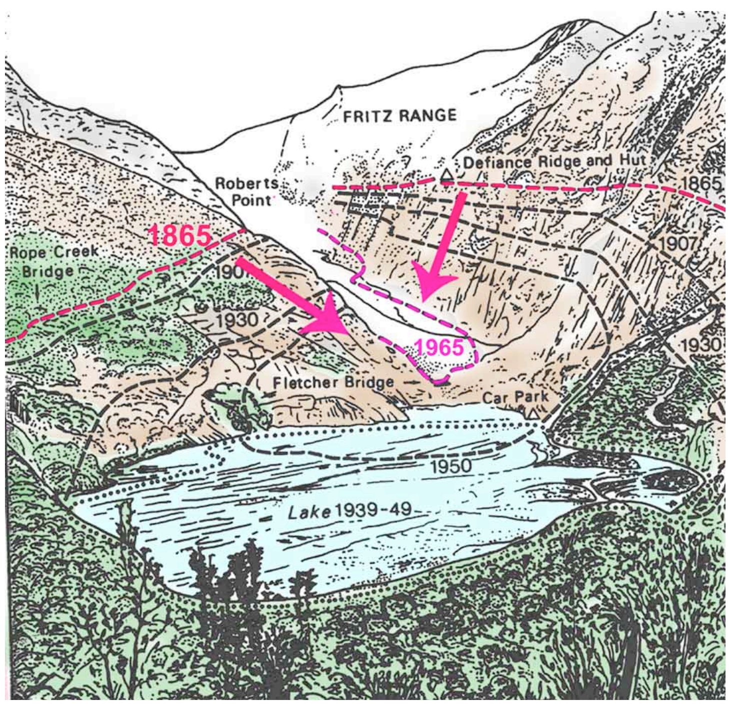

Figure 10b: Retreat of the Franz Josef Glacier in New Zealand (J.M. Grove, 1988); the coloring is added by the present author for emphasis.

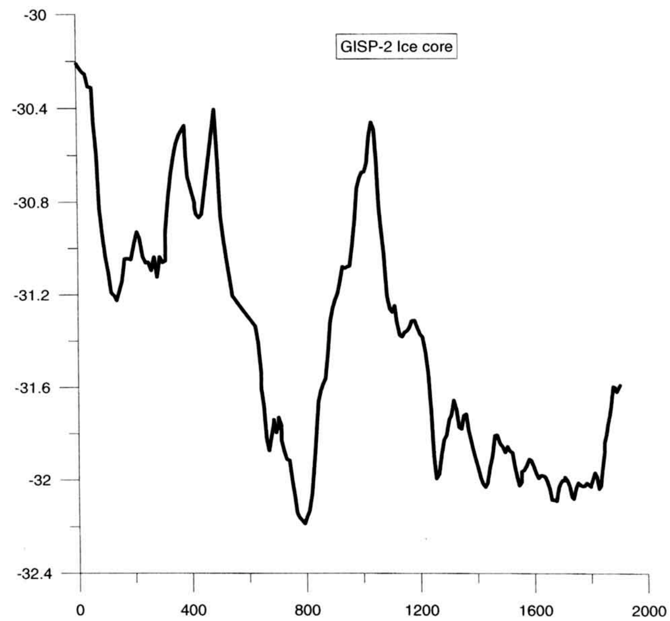

Figure 11: Ice core temperature at the GISP-2 site in Greenland (R.B. Alley, 2000).

The fact that an almost linear change has been progressing, without a distinct change of slope, from as early as 1800 or even earlier (about 1660, even before the Industrial Revolution), suggests that the linear change is a natural change. As shown at the top graph of Figure 1 and also Figure 2, a rapid increase of CO_2 began only after 1940.

As far as the gradient of the linear change is concerned, it can roughly be estimated to be about 0.5°C/100 years based on Figures 3a, 3b, 4, 5, 6, and 7. *It is very interesting to recognize that this gradient is almost comparable with the IPCC's estimate of 0.6°C - 0.7°C/100 years.* Since the maximum decrease of temperature during the Little Ice Age is estimated to be about 0.5°C (Wilson et al., 2000) – 1.5°C (Crowley and North, 1991; Grove, 2005), it is worthwhile to speculate that the Earth is still recovering from it. Another possibility is that the Earth is experiencing a new warming trend of unknown causes. Yet, another possible additional cause may be changes in solar output (cf. Soon, 2005; Scafetta and West, 2006), which we did not investigate in this note.

Therefore, the linear change, which is likely to be a natural change, should be subtracted from the top graph of Figure 1 in order to identify and estimate the greenhouse effect.

However, it is not intended here to make an accurate estimate of the gradient of the linear change. It is beyond the scope of this note. It is a task of climatologists. There is a great uncertainty in obtaining early data corresponding to the accuracy of the top graph of Figure 1 in terms of the geographic distribution of the stations, seasons, etc. Here, I emphasize only that a significant part of the 0.6°C - 0.7°C increase during the last 100 years includes natural changes, contrary to the statement by the IPCC Report (2007), so that natural changes must be subtracted before estimating manmade effects.

At this point, we encounter one of the fundamental problems in climatology and also meteorology. Is there any definitive evidence to conclude that the Little Ice Age ended by 1900? Permafrost that formed during the Little Ice Age still exists around Fairbanks, although it is thawing (Romanovsky, 2006). More fundamentally, how can we determine the "normal" or "standard" temperature from which deviations (warming or cooling) are considered to be abnormal? At this time, there is no reference level to conclude that the Little Ice Age was over by about 1900. The problem is that the "normal" and "standard" depend on the chosen period and the length of the period. Figure 11 shows the ice core temperature at the GISP-2 site in Greenland (Allen, 2000). One can recognize at least that the Earth experienced a cool period during the last few hundred years. Furthermore, there were large fluctuations of temperature in the past, which are obviously natural changes, so that there is a possibility that the Earth is experiencing a new warming trend after recovering from the Little Ice Age.

Further, the IPCC Report (2007) states that the present high temperature is "unusual" except for about 130,000 years ago (p. 10). However, if we examine the temperatures during all the other interglacial periods (240,000, 330,000, 400,000 years ago), each interglacial period was warmer than the present one. Thus, it could be said that the present interglacial period was abnormally a cool one. In fact, even during the present interglacial period, the temperature was a little warmer than the present one for a few thousand years at its beginning (cf. Wilson et al., 2000). It seems that there are unjustifiable efforts on the part of IPCC to stress that the present warming is very unusual.

2. How Linear is the Linear Change?

It is reasonable to expect that the linear change is only a rough first approximation. An accurate examination is expected to show deviations from the linear trend, if the greenhouse effect is significant, namely an upward deviation from the linear change after 1940. As mentioned earlier, this is a task of climatologists. This may be hard to examine because the linear change is superposed by large fluctuations.

In this respect, it is interesting to note a recent study of sea level changes (Holgate, 2007); it is shown in Figure 12. Although the data covers only the period after 1907, it is sufficient to examine any indication of accelerated increase of sea level after 1940. The sea level change should reflect the expected changes associated with the thermal expansion of seawater and glacier melting changes during the last half century that were warned in the IPCC Reports. Figure 12 shows that there is no clear indication of an accelerated increase of sea level after 1940, even if some individual glaciers in the world show accelerated receding. In fact, comparing the slope between 1907-1960 and 1960-2000, there is even slightly less increase in the latter period. During the period of his study, Holgate (2007) noted that the rate of sea level rise was about 1.7 mm/year.

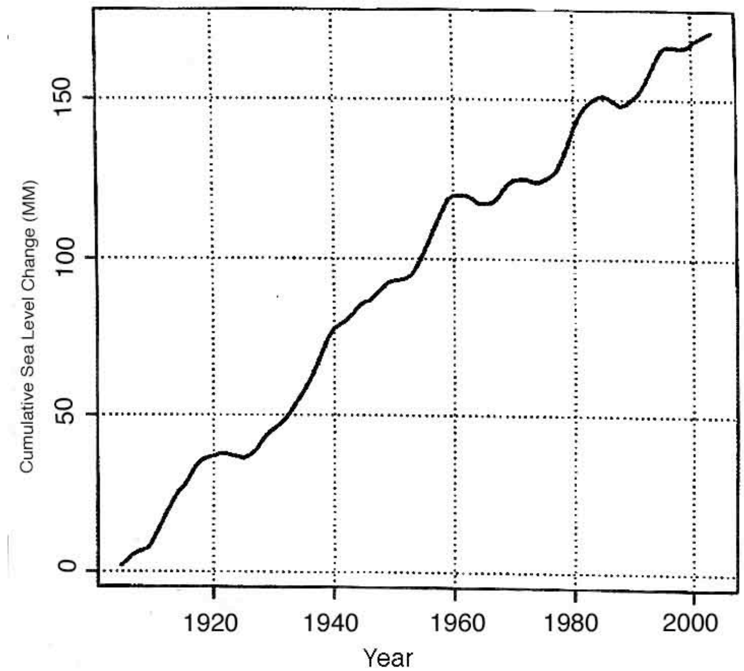

Figure 12: The mean sea level record from the nine tide gauges over the period 1904-2003 based on the decadal trend values for 1907-1999. The sea level curve here is the integral of the rates (Holgate, 2007).

3. Fluctuations

As shown in Figure 2, two prominent fluctuations occurred during the last 100 years. The first one was a temperature rise from 1920 to 1940 and the subsequent decrease from 1940 to about 1975 (Figures 1 and 2). The second one is the present rise after 1975. As stated earlier, it is crucial to examine if both rises are due to the same, similar, or entirely different causes. Until some study can provide convincing results on this problem, we should not claim that the rise after 1975 is mostly due to the greenhouse effect as the IPCC Report did.

It is interesting to note from the original paper from Jones (1988, 1994) that the first temperature change from 1920 to 1975 occurred only in the Northern Hemisphere. Further, it occurred in high latitudes above 50° in latitude (Serreze and Francis, 2006). The present rise after 1975 is also confined to the Northern Hemisphere, and is not apparent in the Southern Hemisphere; there may be a problem due to the lack of stations in the Southern Hemisphere, but the Antarctic shows a cooling trend during 1986-2005 (Figure 13).

Thus, it is not accurate to claim that the two changes are a truly *global* phenomenon, even if *averaging* the data from both hemispheres can provide Figure 1. Since the greenhouse effect is supposed to be global, the two prominent changes (1920-40 and after 1975) may be considered to be regional changes. Thus, there is a possibility that both increases are natural changes, unless it can be shown definitely that such regional changes are caused by the greenhouse effect. Further, the two changes are not obvious in the Southern Hemisphere (Jones, 1988). If this would indeed be the case, it may not be very difficult, after all, to remove the two prominent fluctuations from the changes during the last 100 years. Using data from stations below 50° latitude, fluctuations above and below the linear change can also be regarded as natural changes, as a *very rough* first approximation. One important question is how much of the rise after 1975 is "contaminated" by natural changes.

It is important to note that the present global warming after 1975 is not uniform over the Earth. Although a single number, namely +0.6°C - 0.7°C/100 years, is used in discussing global warming, the geographic distribution of "warming" is quite complex. The upper part of Figure 13 shows the "warming" pattern during the last half of the last century, from about 1950 to about 2000 (Hansen et al., 2005). One can see that the most prominent change occurred in Siberia, Alaska, and Canada, namely in the continental arctic. There is no doubt that such a prominent change contributed to the global average change in Figures 1 and 2. In the continental arctic, the warming rate was several times more than the global average of 0.6°C/100 years (0.6°C/2=0.3°C/50 years). It may be also noted that cooling was in progress in Greenland over the same time period.

It is of great interest to ask if GCMs can reproduce this geographic distribution of the observed changes shown in the upper part of Figure 13, since they "can" reproduce the 0.6°C - 0.7°C/100 years rise. Thus, we asked the IPCC arctic group (consisting of 14 sub-groups headed by V. Kattsov) to "hindcast" geographic distribution of the temperature change during the last half of the last century. To "hindcast" means to ask whether a model can produce results that match the known observations of the past; if a model can do this at least qualitatively, we can be much more confident that the model is reliable for predicting future conditions. Their results are compiled by Bill Chapman, of the University of Illinois, and are shown in the right side of Figure 14a. The left side of the figure is taken from the ACIA Report (2004), which shows a similar trend as that of the upper part of Figure 13, namely the prominent warming in the continental arctic and cooling in Greenland. This comparison was undertaken in an attempt to reduce differences between them, because both are expected to be similar, but imperfect.

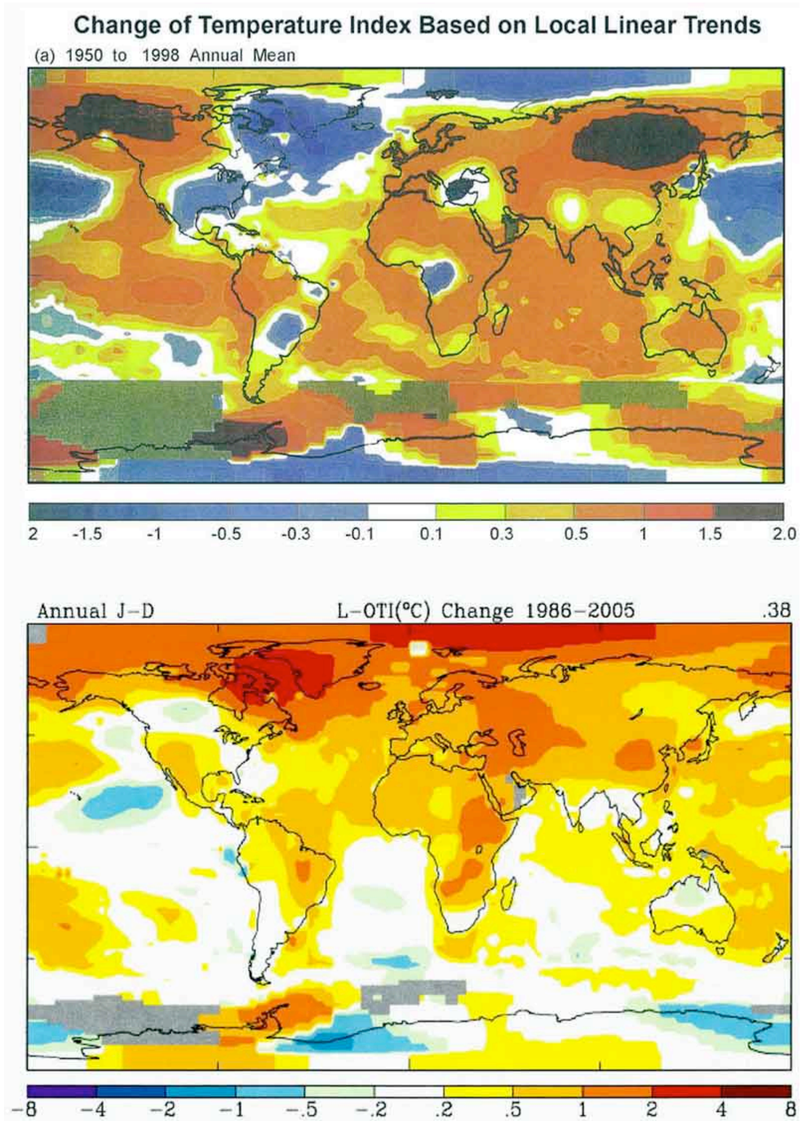

Figure 13: Upper – the geographic distribution of temperature change between 1950 and 1998 (Hansen et al., 2005). Lower – the geographic distribution of temperature change between 1986 and 2005 (Hansen, 2006).

We were surprised at the difference between the two diagrams in Figure 14a. If both were reasonably accurate, they should look alike. Ideally, the pattern of change modeled by the GCMs should be identical or very similar to the pattern seen in the measured data. We assumed that the present GCMs would reproduce the observed pattern with at least reasonable fidelity. However, we found that there was no resemblance at all, even qualitatively.

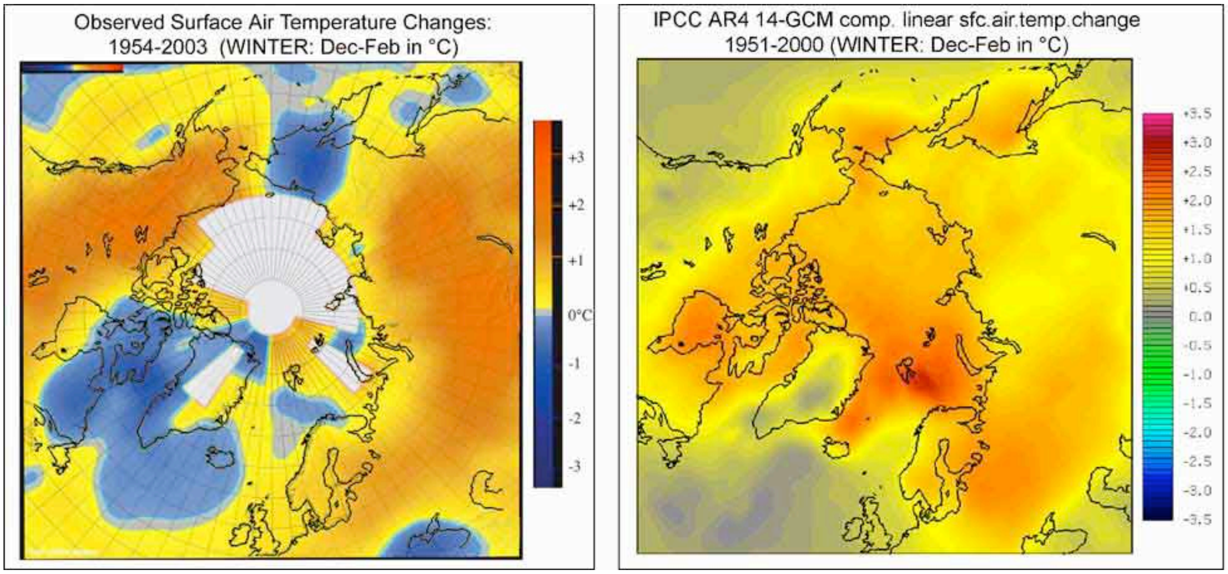

Figure 14a: Comparison of the observed distribution of temperature changes (ACIA, 2004) and the simulation (hindcasting) by the IPCC arctic group (Chapman 2005).

Our first reaction to this surprising result was that GCMs are still not advanced enough for hindcasting. However, this possibility is inconceivable, because the increase of CO_2 measured in the past is correctly used in the hindcasting, and everything we know is included in the computation. The IPCC arctic group's result is the best result based on our present knowledge. In fact, they can reproduce the 0.6°C - 0.7°C increase during the last hundred years. If the greenhouse effect caused the warming, it should be reproducible to some extent by these models, even if the reproduction is not perfect.

It took a week or so before we began to realize another possibility of this discrepancy: If 14 GCMs cannot reproduce prominent warming in the continental arctic, perhaps much of this warming is not caused by the greenhouse effect at all. That is to say, because it is not caused by the greenhouse effect, the warming of the continental arctic cannot be reproduced at least qualitatively by our GCMs. How do we examine that possibility?

If the prominent warming in the continental arctic (Figure 13, upper, and Figure 14a, left) is due to the greenhouse effect, the prominent trend should continue after 2000. That is, we should observe an amplification of continental arctic warming in this century that will be even greater than the amplification that was observed during the last half of the last century, because the amount of CO_2 continues to increase at an exponential rate. Thus, we examined the warming trend during just the last 20 years or so, provided by Hansen (2006). To our surprise, the prominent continental arctic warming almost disappeared in those results; the Arctic warmed at a rate about like that of the rest of the world, while Greenland showed a strong warming (the lower part of Figure 13), instead of cooling during the last half of the last century. Actually, in Fairbanks, the temperature shows a cooling trend between 1977 and 2001, as can be seen in Figure 14b (Hartman and Wendler, 2005). Therefore, our conclusion at the present time is that much of the prominent continental arctic warming and cooling in Greenland during the last half of the last century is due to natural changes, perhaps to multi-decadal oscillations like Arctic

Oscillation, the Pacific Decadal Oscillation, and the El Niño. This trend is shown schematically in the bottom graph of Figure 1 as positive and negative fluctuations. If this would indeed be the case, the IPCC Report is incorrect again in stating that the warming after 1975 is particularly caused by the greenhouse effect. If the fluctuation are only of positive changes, the linear slope in the third graph may be about 0.4°C/100 years. Again, this is a task of climatologists to clarify.

In this connection, it might be added that permafrost temperatures has stopped rising during the last several years (Richter-Menge et al., 2006); see Figure 15. The amount of CH_4 has ceased to increase from about 2000. It is puzzling why they do not show an accelerated increase if their increase before 2000 was due to the greenhouse effect; they may be temporal fluctuations.

4. Summary

From the data provided in the earlier sections, it is quite obvious that the temperature change during the last 100 years or so includes significant natural changes, both the linear change and fluctuations. It is very puzzling that the IPCC Reports states that it is mostly due to the greenhouse effect. Further, unfortunately, computers are already incorrectly "taught" or "tuned" that the 0.6°C - 0.7°C/100 years rise during the last hundred years is caused by the greenhouse effect, so that their results cannot be used as proof of the greenhouse effect and thus cannot predict accurately the degree of future warming.

It is suggested here that the linear change may be due to the fact that the Earth is slowly recovering from the Little Ice Age or in the period of a new warming.

Regardless of the cause of the Little Ice Age, it is urgent that natural changes should be correctly identified and removed accurately from the present on-going changes in order to find the contribution of the greenhouse effect. Only then will an accurate prediction of future temperature changes become possible.

One lesson here is that it is not possible to study climate change without long-term data. This is understandable from the fact that it is not possible to draw the linear line in the bottom graph of Figure 1 without the data shown in Figures 3a, 3b, 4, 5, 6, 7, and 8.

It is very easy to discredit the results of the traditional climate change studies (Figures 4, 5, 6, 7, and 8) in terms of accuracy. However, this is what climatologists must face. In some sense, *inaccurate data (compared with modern data) during the last few hundred years are more important than accurate satellite data after 1970 in our study of global warming*. Unfortunately, at this time, many studies are focused only on climate change after 1975, because satellite data have become so readily available. A study of climate change based on satellite data is a sort of "instant" climatology. It is puzzling why the causes of the rise between 1930 and 1940 have not been studied. Chylek et al. (2006) reported that present changes of the Greenland ice sheet is less than what was observed during the 1920-1940 period.

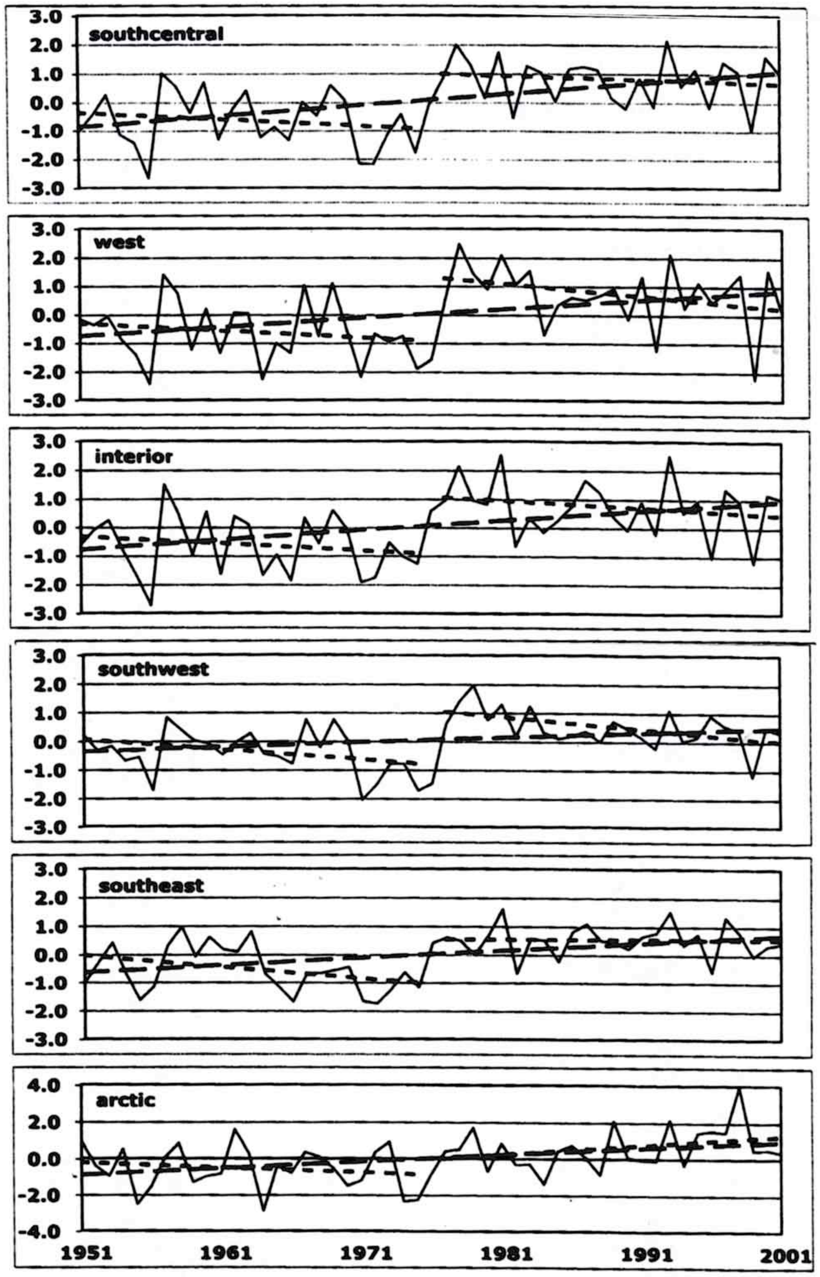

Figure 14b shows the transition from the declining period (1940-1975) to the rising period after 1975. The transition is a step-function-like change, unlike the Greenland effect. Further, after a step-function-like increase, the trend appears to be negative, which is inconsistent with what Figure 13 shows (B. Hartmann and G. Wendler, 2005).

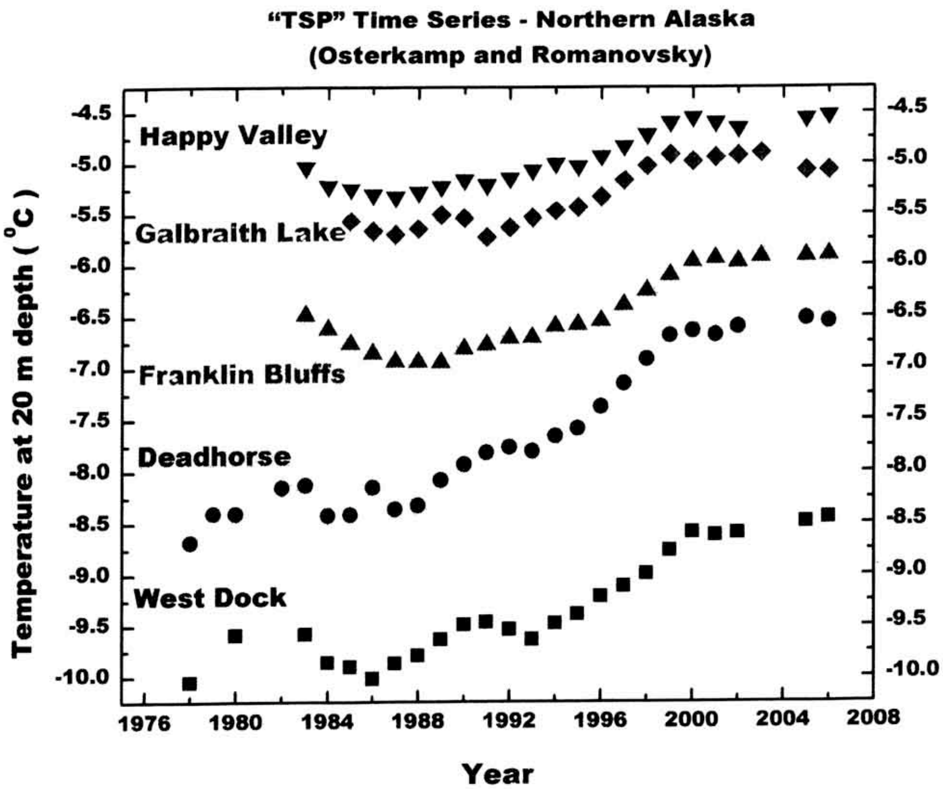

Figure 15 Permafrost temperature variations in Northern Alaska from 1976 to 2006. Note that the increasing temperature from about 1988 stopped in about 2000 (Richter-Menge et al., 2006).

5. *Conclusion:*

I would like to emphasize:

(i) Natural components are important and significant, so that they should not be ignored;
(ii) Two natural changes are identified in this note: a linear increase of about +0.5°C/100 years and fluctuations superposed on the linear change;
(iii) It is insufficient to study climate change based on data from the last 100 years;
(iv) It is difficult to conclude about causes of the rise after 1975 until we can understand the rise from 1920 to 1940;
(v) Because of these deficiencies, the present GCM models cannot prove that the present warming (0.6°C - 0.7°C/100 years) is caused by the greenhouse effect; and thus,
(vi) Future prediction of warming by GCMs is uncertain.

If most of the present rise is caused by the recovery from the Little Ice Age (a natural component) and if the recovery rate does not change during the next 100 years, the rise expected from the year 2000 to 2100 would be 0.5°C. Multi-decadal changes would be either positive or negative in 2100. This rough estimate is based on the recovery rate of 0.5°C/100 years during the last few hundred years. It should be noted that the greenhouse effect shown by GCMs should be carefully re-evaluated, if the present rise (0.6°C - 0.7°C/100 years) is mostly due to natural components, such as those I suggest.

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