

Chapter 5

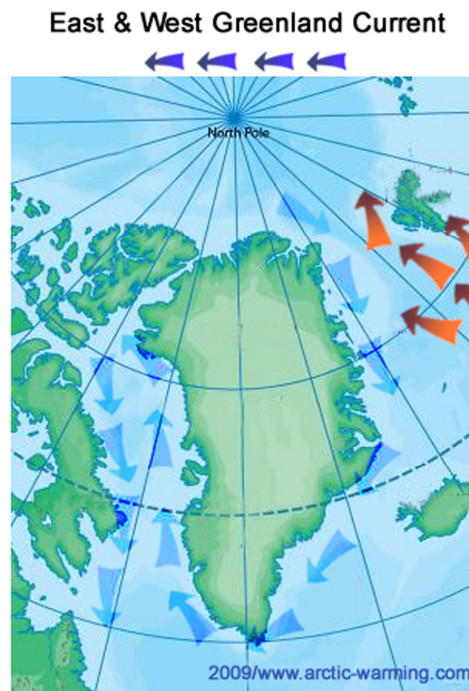
The warming event in details

A. Exceptional temperatures rise

It is said that the Arctic temperatures in the 20th century have been the highest over the past 400 years (Overpeck, 1997). The fact is that until now the global surface air temperature (SAT) have increased by 0.76°C since 1861³¹. This was not a homogenous rise. The air temperatures through the latter part of the 19th century and the early 20th century were relatively cool compared to years since the 1920s, especially after 1925 (Drinkwater, 2006). The increase in the Arctic was two to three times higher than the global mean, particularly during the two decades from 1920 to 1940, whereby the period from 1918 to 1922 displayed an exceptionally rapid winter warming in the circum-Arctic region (Polyakov, 2003). This is emphasized by the observation that annual temperatures from 1920–1940 rose even more markedly than during the post 1970s period (Serreze, 2000).

The proportions of the warming are illustrated in almost every Arctic temperature graphic. The moment the event started to happen can be identified very precisely, January 1919. It was the second month after WWI had ended. Suddenly, Spitsbergen a remote archipelago between the North Cape in Norway and the North Pole had corresponding mean temperatures during January as 2000 km further south in Oslo, mere -5°C. That was a climatic “bang”. It meant that the temperature differences between the two pre and post WWI January were 16° (sixteen) degrees³². Nothing can illustrate the extraordinary jump better than looking at a 10°C difference between the winter temperatures (the mean of D/J/F) seven years before January 1919 (1912-1918), and the seven winters 1919 to 1925. The ability to establish a precise timing is elementary for improving the chance to consider and to reason the circumstances of the event.

Confining the date of the warming-up period to the year 1918 is very precise and important, while describing the warming-up area to “the circum-Arctic region” is rather superficial. On the other hand V.F. Zakharov stated with reference to Russian researcher: “Indicating that while high latitude play a special role in the



³¹ IPCC, 2007, The total temperature increase from 1850 – 1899 to 2001 – 2005 is 0.76 [0.57 to 0.95]°C (Summary for Policymaker, p.4)

³² The January temperature at Spitsbergen : 1917 -20.4; 1918-24.4; (mean: 22.4°C); and 1919 -5.7, 1920 -10.5 (mean: -8.1°C); <http://data.giss.nasa.gov/work/gistemp/STATIONS/tmp.634010050010.1.1/station.txt>

5. The warming event in details

climate changes over the hemisphere, the Atlantic sector plays a special role in these latitudes themselves. This important aspect of spatial structure of polar forcing should not, of course, be omitted when explaining the causes of the present day climate changes” (Zakharov, 1997). This process became pronounced affecting the ecosystem with a general northward movement of fish, due to a dramatic warming of the northern North Atlantic Ocean during the 1920s and 1930s (Drinkwater, 2006). Quite a number of research papers on fishing have mentioned this aspect since the 1930s (e.g. Carruthers, 1941) but remain unspecific concerning details. This is of not too much help if one wants an explanation: what made the northern North Atlantic warming? Meanwhile we have established that Spitsbergen was a hot-spot in this scenario. What we not know yet: Had there been several hot-spots? Became they effective simultaneously or one after the other? Do distant locations and periods of warming or cooling allow conclusions? The starting point is that the changes started in the late 1910s and evidently extreme pronounced at Spitsbergen, and for this reason the northern North Atlantic will be the focal point in our further investigation.

B. Distant warming

Overall, the Earth gains heat at low latitudes by the sun and it loses heat at high latitudes. To balance these gains and losses the heat is transported poleward by the atmosphere and the ocean in comparable proportions. In winter 1918/19 and from thereon a lot of surplus of heat must have been coming from distant places, so that distant and medium of transport matters. This shall be indicated by the term ‘distant warming’, whereby a region or location which is separated from the warming hot-spot Spitsbergen, is within the “reach” of Spitsbergen either by atmospheric air masses, or particularly by the ocean current system. This means practically that all seas and their coastal areas north or in the range of the Arctic Circle could have contributed by ‘distant warming’.

By the ‘core Arctic’ region shall here be understood the Arctic Ocean, respectively the sea space north of 80° North and north of the all continents³³. In addition to the exclusion of the landmasses, it seems that also the Northern Pacific Ocean region can be excluded. Neither has any research in the 1930s, or more recently asserted that the early Arctic warming could have been generated in the Alaska, Siberia and North Pacific sector of the Arctic Ocean. As the Aleutian in the North Pacific are at the latitude of 51° north, that is on the same latitude as London, Kiev, Astana, and Vancouver, the Bering Strait region is not comparable with the situation in the Northern North Atlantic.

The very different oceanic conditions between the two ocean entrances to the Polar Basin are even more significant. The fairly cold and low saline water inflow from North Pacific to the Arctic Ocean is extremely less influential than the warm water masses, which arrive via the Norwegian and Spitsbergen Current at Spitsbergen and flow into the Arctic Basin. The volume of Atlantic water is about eight times higher than the mass transport via the Bering Strait.

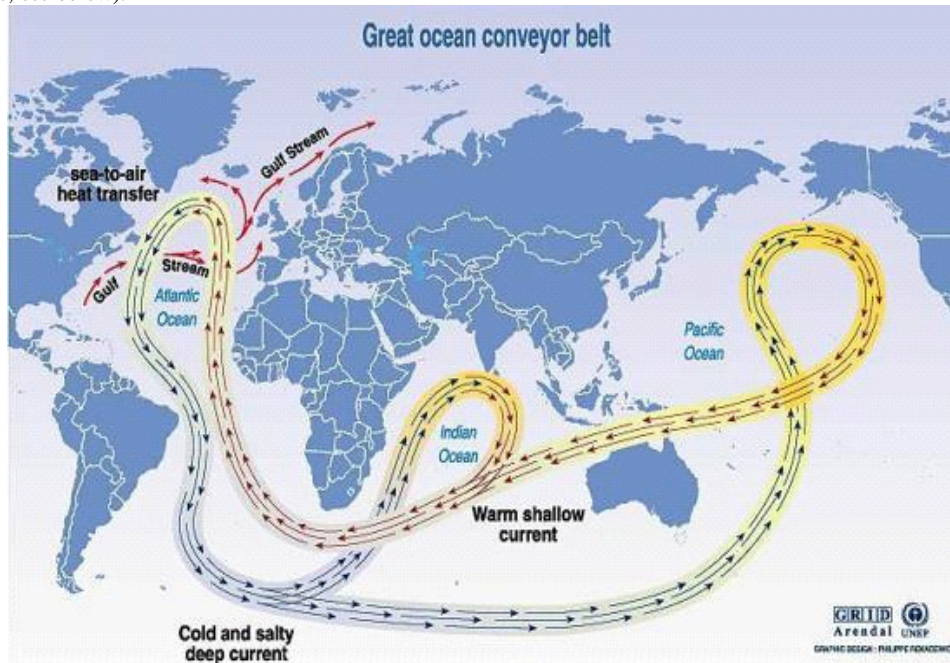
C. Is ocean warming ascertainable?

It would be so helpful if the “most significant regime shift experienced in the North Atlantic in the 20th century”(Drinkwater, 2006) could be analysed with data records from all sea levels ranging from the sea surface (SS) to the bottom of the seas. But there had been nothing comparable to air temperature records.

³³ According the International Hydrographic Organization the Arctic Ocean proper extends well over land and other sea areas, see: http://en.wikipedia.org/wiki/Arctic_Ocean#Geography



The global conveyor belt thermohaline circulation is driven primarily by the formation and sinking of deep water (from around 1500m to the Antarctic bottom water overlying the bottom of the ocean) in the Norwegian Sea. When the strength of the haline forcing increases due to excess precipitation, runoff, or ice melt the conveyor belt will weaken or even shut down. The variability in the strength of the conveyor belt will lead to climate change in Europe and it could also influence in other areas of the global ocean (Source, see below).



Source: Broecker, 1991, in: Climate change 1995, impacts, adaptations and mitigation of climate change: scientific-technical analyses, contribution of working group 2 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge press university, 1996; <http://www.grida.no/publications/vg/climate/page/3085.aspx>

Sources Climate change 1995, Impacts, adaptations and mitigation of climate change: scientific-technical analyses, contribution of working group 2 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge press university, 1996; <http://www.grida.no/publications/vg/climate/page/3085.aspx>

Designer Philippe Rekacewicz, UNEP/GRID-Arendal

REMARK

The map identifies only one region as “sea-to-air heat transfer”, of which the text actually should be further to the East (close or north of Iceland), and the Gulf Stream symbols should pass Spitsbergen in the West. However, the warm water for the Arctic, from all oceans as far away as the North and South Pacific, is coming with the red line as West Spitsbergen Current to the Arctic gate. As this warm salty water reaches the Fram Strait in the West of Spitsbergen, it is able to release enormous heat into the atmosphere, by cooling down. These cool salty waters are now very dense compared to the surrounding waters, and sink to the bottom of the Arctic Ocean, or Nordic Sea. There is virtually no other place in the world where “heat release” and warming of an cold environment could be more effective. Even a water temperature of only one or two degrees are still able to heat the atmosphere. The end of the squeezing out is only reached when the sea water is freezing. Only this heating-spot seems capable to initiate and sustain an explosive temperature rise, and sustain it over a longer period of time.

5. The warming event in details

Even SST are few and often insufficient, respectively do not exist at all. It is therefore virtually impossible to assess the internal warming processes of the Northern Hemisphere seas from 1918 to 1939.

But the case is not hopeless, as it is possible to draw reasonable conclusions from surface air temperature (SAT) records, which are not overwhelmingly available in number but evidently sufficient to establish a reliable picture of what happened above the ocean surface. This means that it is possible to show a statistical trend of SAT in certain regions of location, but partly – and together with some imagination - what actually happened below the sea surface. In this respect it seems reasonable to listen to an advice given by J. W. Sandström soon after World War II:

“The influence of the sea on the weather seems to be of particular interest, seeing that the great specific heat of the sea water influences the atmosphere in a very high degree. The slow variation of the oceanic conditions will probably make it possible to predict the general character of the weather a long time in advance, to foresee the summer in the following winter will be warm or cold, abundant in snow or not, and in the winter if the following summer will be warm and dry or cold and wet.” (Sandström, 1947)

While Sandström wanted to predict weather due to prevailing sea condition, here we are going to analyse the air temperature records in retrospect; which will allow to make conclusions of SST trends. There can be no doubt that any coastal location is considerably influenced by the seasonal and internal conditions of the sea, which is particularly influential at a location as Spitsbergen far away from continental reach.

D. The influential regions

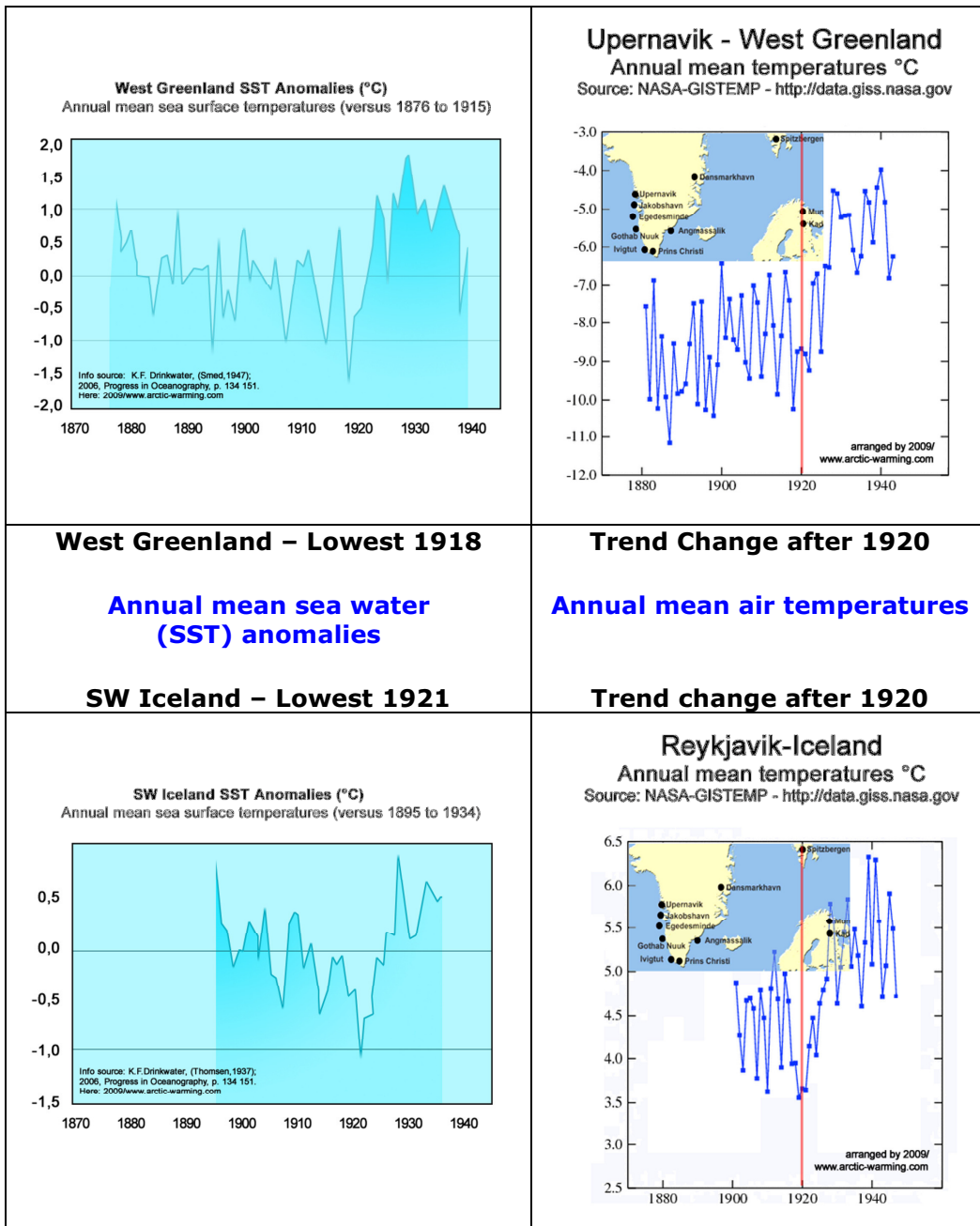
a) Arctic Ocean

During the early years of the last century the Arctic Ocean was almost completely out of reach for the collection of meteorological data series. Neither SST nor SAT records exist. The situation is furthermore complicated by the extensive availability of sea ice, and related to seasonal changes. The maritime influence grossly diminishes, the higher the Arctic Ocean sea ice cover is. Any sea ice free ocean space during the summer season will substantially increase the interchange with the atmosphere (e.g. with regard to its air temperatures, the humidity, and the cyclonic and anti cyclonic conditions). Back in the early part of the last century the meteorology was already well versed with preparing weather charts and drawing climatic relevant conclusions from the material. There is, on one hand, clear indication that the whole Polar region warmed up over the two decades, 1920s and 1930s, more than any other region anywhere in the world. On the other hand, the information available provides little hindsight on the hypothesis questioning whether the observed Arctic warming is the result of “summarized” temperature statistics on a decadal basis, or whether certain particular warming spots could be identified.

Today it is an acknowledged fact that only the part of the Arctic closely connected to the Northern North Atlantic experienced an exceptional temperature rise (Johannessen, 2004). The most pronounced \ warming area from 1920-1939 covered a region from the East coast of North Greenland (60° West) to Severnaya Zemlya Island (100° East)³⁴. This was already observed since the 1930s by a number of researchers (e.g.

³⁴ The distances to Spitsbergen are roughly ca. 1200 km each.

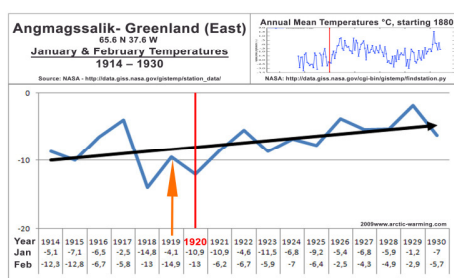
5. The warming event in details



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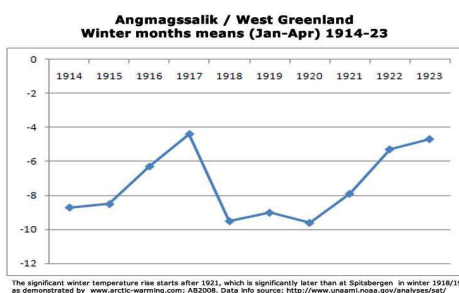
Scherhag, 1939), and again confirmed by H.H. Lamp who noted that “the change of prevailing temperatures seems to be the greatest in the regions affected by changes in the balance between the warm northbound Atlantic water and the cold polar current at the ocean surface in the Norwegian-Barents Sea-East Greenland region” (Lamp, 1982). The fact whether Lamb’s assertion makes sense and would permit the ‘explosion’ of temperatures at Spitsbergen will be discussed later. Comparing the location and the extent of this warming area within the wider Polar region, a substantial distinction can be made. The pronounced warming area covers less than 1/3rd of the Arctic area, but it extends well into the northern parts of the Greenland-, Norwegian-, and Barents Sea.

b) Greenland



It is widely acknowledged that Greenland went through a significant warming-up period. This is well demonstrated in the research work of R. Scherhag, in 1936, which indicates that temperature had increased with more than + 3°C from 1921-1930 (Scherhag, 1936). Our interest is to establish whether the brisk warming at Spitsbergen has any correlation with the observed warming in Greenland. The timing, development, intensity, and duration will be of big help for a better understanding of the Spitsbergen event. The main questions are:

- Where did the warming start at first, or did the warming start at several locations at the same time;
- Can a time gap be identified, and what time delay;
- How significant is the proportion of increase, and
- How long lasted a warming up period.



Although one can argue that each answer to any question needs to be evaluated and discussed in the light of the findings for Spitsbergen, we will discuss the matter in a comprehensive manner due to the fact that older material often raises only single aspects. It is furthermore necessary to be aware that Greenland’s maritime climatology is not necessarily unison but differs between the East and the East Coast.

A start shall be made with the findings of one of the prominent names in meteorology Jacob Bjerknes (1897-1975), according to whom a warming in the East of Greenland occurred after 1920 (Bjerknes, 1959)³⁵. The indicated period of time in question is from 1920 to 1930/32. Bjerknes assessed seawater temperature data in the North Atlantic as it follows:

³⁵ The Bjerknes paper indicates for the same time: “A somewhat similar brisk upward trend, stating as late as 1920, is found in the Labrador current on the Newfoundland Banks in close proximity to the main stem of the Gulf Current. asserted that the Labrador Current in the West of Greenland had shown a brisk upward trend, starting as late as 1920.

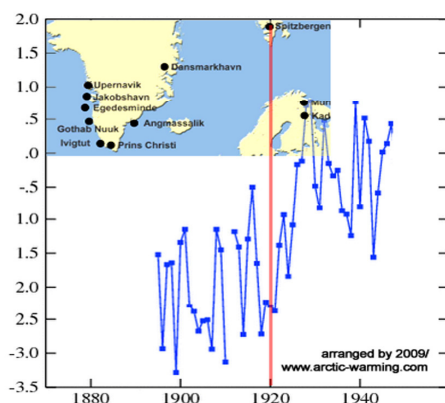
5. The warming event in details

- North of about 57° North the trend in sea temperature has been slightly upwards. Actually this change resulted from a brief but strong upward trend in the 1920s
- The warming of the waters in the far northern Atlantic was much more sudden and short range than farther south.
- Essentially, it lasted only from 1920 to 1930 in Greenland waters. (Bjerkness, 1959).

Thus the general Greenland picture indicates that a substantial warming took place after 1919, but that the warming period was limited to about one dozen years. The Greenland warming rate during the decade 1920-1930, shall have been 50% higher than during the 1995-2005 period. (Chylek, 2006)

Angmagssalik-East Greenland Annual mean temperatures °C

Source: NASA-GISTEMP - <http://data.giss.nasa.gov>



For the East coast of Greenland data information are particularly sparse. Many observation stations were installed only in 1920. For example, at Myggbukta, 73°29'N, 21°34'W, data had been recorded since 1922; whereon the summer average temperature had shown a typical warming trend, which lasted until 1930/39 (Kirch, 1966), while generally winter data indicated a warming trend since 1923, which decreased since the period 1929/38 (Kirch, 1966). It was further reported that the last 'bad ice year' in the Greenland Sea was 1923 (Manley, 1944).

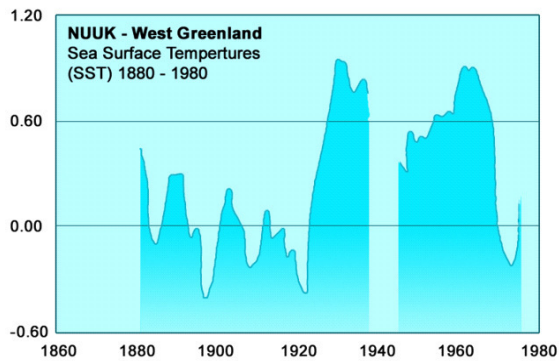
At least one station is available at the East Coast, Angmagssalik at the southeast of Greenland, for which Nasa-Gistemp provides a detailed record since 1880. The data confirm Kirch's analysis. The annual temperature rise did not start before 1922³⁶. Actually, only the change from the cold years 1919-1921 is fairly pronounced with about 1.2° against the two years 1922/23. That can neither be regarded as big, nor sudden, but it is nevertheless noticeable. Any significance diminishes further if reviewed against the temperature data for the months January and February. For the time period 1918-1920 the annual amplitudes do hardly impress with significance. With regard to identifying a trend, it seems that one could identify the year 1920 as the starting point of a rising trend, which would compete with the annual trend within a range of 1-2 years. For timing the warming at the East Coast of Greenland it might also be of help to bring a graphic from the fishing sector. The cod fishing could only increase harvest after the fish population could grow in warmer water and that had been suddenly available after 1920 (Carruthers, 1941). The trend change in the early 1930s is remarkable as well.

In the range of Greenland's West Coast at least four locations offer a longer dating record since the late 19th Century. On one hand the region is of greater interest because the West Greenland Current uses all the way along the West coast up to the northern part of the Baffin Sea before turning south toward Newfoundland. At Jakobshavn it is possible to make at least two observations. The January-February series (1914-1930) has no distinctive change close to 1920, while the annual temperature record does, but it actually became pronounced starting only in 1921/22, and lasting only until ca.1930. That the record does not show a more prominent result for the winter months, could be due to the extent of sea ice during winter time, which made

³⁶ Annual mean temperatures at Angmagssalik (according Nasa-Gistemp): 1919 -2.22; 1920 -2.29; 1921 -2.38; 1922 -1.38; 1923 -0.93, 1924 -1.84; 1925 -1.08, 1926 -0.17; 1927 -0.12



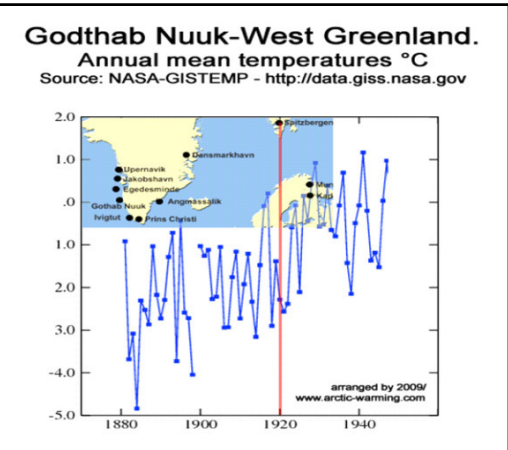
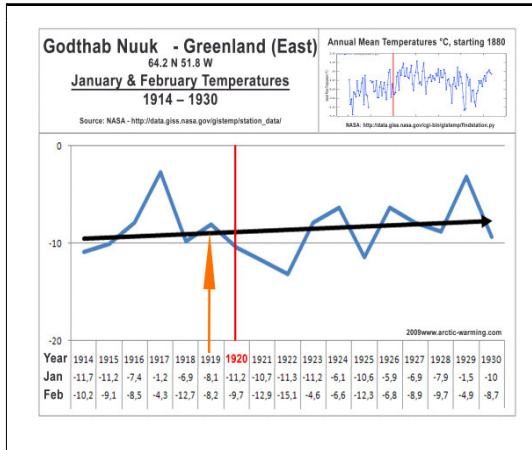
Extract from Abstract: (Nuuk-air temperature graphic added) Greenland and its adjacent waters are located at the northern boundary of the Sub-polar Gyre and thus subject to climatic variations within this gyre. It is suggested that periods characterized by regional shrinkage of warm water masses within the Gyre adversely affect the propagation of gadids from upstream Icelandic waters to Greenlandic waters, and periods of regional dilatation of warm water masses within the Gyre are favourable for developing gadid stocks in Greenlandic waters. Ocean temperatures off West Greenland show a significant upward trend, which is considerably higher than that for the North Atlantic Basin.



Data source: M. Stein (2007), J. Northw. Atl. Fish. Sci. By approximation: 2009www.arctic-warming.com

_____The paper states concerning: **Nuuk air temperature anomalies;** Very cold conditions were seen during the 1880s to 1910s., Warming began around 1920; and presently Nuuk enjoys warm conditions as during the 1926-30 period.

_____The paper states concerning: **Nuuk sea surface temperatures** (see modified M.Stein graphic); the 1890s appeared as a decade with warm SSTs; the first decade of the new century showed shrinking of the Gyre, and only East Greenland waters were warmer than normal during those times; from 1915 onwards, warming increased; and a warm Gyre was seen in the second part of the 1920s.

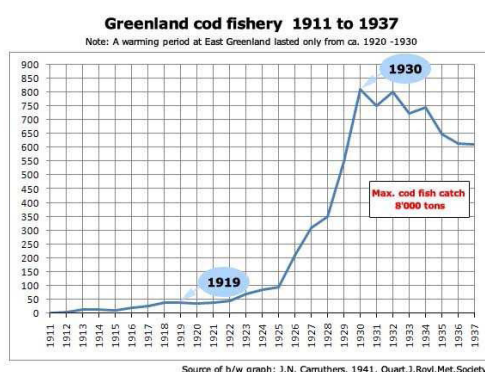


Comment:

_____The series do not show an immediate correlation between the big warming at Spitsbergen during winter 1918/19, but a time lag of about two to three years. The SST increase at about 1922 is remarkable.

_____ The first warming impulse seem to have been coming from the North, while only during the second part of the 1920s a warm Gyre had been observed.

5. The warming event in details



the location more continental, with little or no effect on the air temperatures. A recent research asserted that although the last decade of 1995-2005 was relatively warm, almost all decades within 1915 to 1965 were even warmer at both the south-western (Godthab Nuuk) and the south-eastern (Angmagssalik) coasts of Greenland (Chylek, 2006).

The temperatures at other stations can be discussed in the same manner as done in the case of Angmagssalik that would also lead to the same results. With some confidants one can say that the warming trend did not start before 1920, and did not last longer than the early 1930s.

c) Sub-polar North Atlantic

One way to temper Greenland by the ocean water system is the discussed East and West Greenland Current coming from the North and heavily influenced by very cold but less saline Arctic water. But what about any water coming from the South or Southeast, where the warm Gulf Current, and the Irminger Current, is not very far away. Had the warming of the Arctic been generated in the Gulf of Mexico and spread via the Atlantic Gulf Current to the Arctic? The region is described as sub-polar, and it is practically the only basin through which the heat from the South can be carried by the system of oceanic currents towards the pole because of the open boundary between the Atlantic and the Arctic oceans.

Trend of Average Annual Sea Surface Temperature From 1890/1897 to 1926/1933

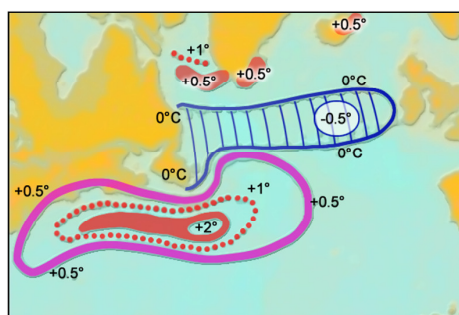


Image data source: J. Bjerknes (1959), ed Bert Bolin; The Atmosphere and the Sea in Motion. Here: 2009/www.arctic-warming.com

R. Scherhag addressed the question already in 1937, and analysed water temperatures in the North Atlantic, with the conclusion that the Gulf Current at source had been warmer during the years 1926-1933 than during the period 1912-1918, and that a similar increase had been observed in the English Channel, albeit smaller, for the time period 1920-1927. (Scherhag, 1937; and 1939):

Twenty years later J.Bjerkness picked up the issue but differentiated the situation. He said (extracts):

- “The warming of the Atlantic waters continues in a tongue extending eastwards from the edge of the Banks (Newfoundland) over the southern European coast.
- Between 50°N and 57°N the trend in the sea temperature has been slightly negative. That is, in fact, the only region within the whole Gulf Stream system where the long range trend of warming fails to show up.
- This belt of negative trend to temperature is traversed by the strongest, farthest left branch of the Gulf Stream system which is heading for Iceland.

5. The warming event in details

- North of about 57°N the trend in sea temperature has been slightly upward. Actually that secular change results from a brief but strong upward trend in the nineteen-twenties which compensates the accumulated effect of a preceding long and slow downward trend.” (Bjerknes, 1959). Note: The southern cape of Greenland, Kapp Farvel, is 60°N.

Bjerknes' analysis and conclusion show that the warming of the water around Greenland's coasts has not been coming and generating from the south, but north of about 57°N. In this respect a further conclusion should be noted:

- From the northern data collection can be seen that the sea surface temperatures near Greenland culminated in the early nineteen thirties, while from Iceland to the British Isles the maximum water temperatures seem to have occurred in the early nineteen forties. Despite the irregular downward trend, following the culmination, the general level of sea surface temperatures remains well above the low recorded in the northern areas around 1920.

Meanwhile it seems undisputed that off south west Iceland significant low SST temperatures had been observed in the early 1920 before a brisk temperatures rise occurred together with the air temperatures with a short delay only (Eythorsson, 1949), and that the Faroe were even later effected, since the early 1930s (Drinkwater, 2006).

In conclusion it seems obvious that the general situation in the middle North Atlantic range did contribute marginally to the warming of Greenland starting in 1920 and ending in the early 1930s. The one decade of Greenland warming has quite obviously been coming from the Northern North Atlantic, the Nordic Sea area. From where if not from the West Spitsbergen Current could a warm water stimulus had been coming from? The short period of one dozen years strongly indicates in this direction.

d) Barents Sea

Although the distance between the entrances to the Barents Sea in the South and in the North are only 1000 km apart, the two locations had had a quite different temperature experience in winter 1918/19 and the subsequent years of the 1920s.

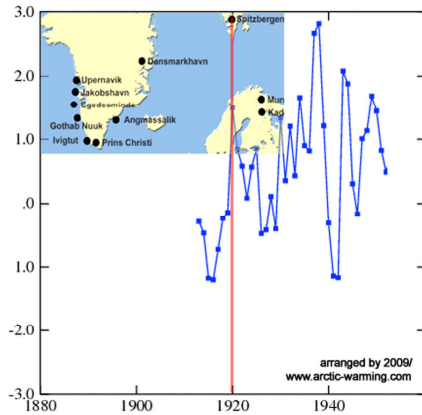
As an example may first serve the Russian record from Kandalsaka near Murmansk. The annual temperature did not show any change between the years 1918 and 1919, but only from 1919 to 1920. This time the increase is significant (+1.5°C) but neither exceptional within the record nor impressive concerning the following years which showed downwards. Concerning the core winter months (J/F), the difference by +2° from 1918 to 1919 is modest. Kandalaska did not experience an extraordinary temperature rise.

The second example is Vardø, in the most north-eastern corner of Norway and close to the North Cape Current, which keeps the sea usually sea ice free³⁷. Here the winter temperatures (D/J/F) actually increased between the years 1918 and 1919 (+2°C), and decreased slightly the following year, with a modest rise until 1930. The annual record is more interesting at least with regard to one aspect, namely the rise between 1919 and 1920, which indicates a general shift. The mean temperature before winter 1918/19 and there after shows a shift from one degree. On the other hand the record shows that the Vardø location could not have

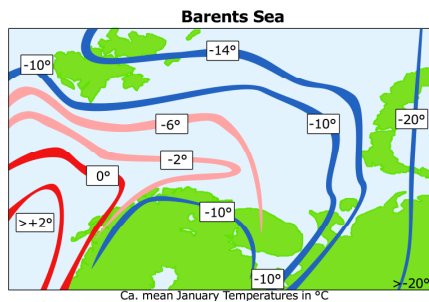
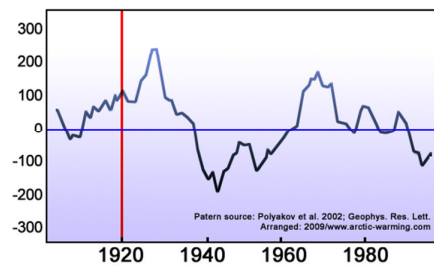
³⁷ See Chapter 7, Special Page; “2009 Question to Bengtsson”

5. The warming event in details

Kandalaksa
Annual mean temperatures °C
Source: NASA-GISTEMP - <http://data.giss.nasa.gov>



KARA SEA - AUGUST - SEA ICE
August ice extent anomalies
six-year running means - by 1000 km²



contributed to the big warming of Spitsbergen in winter 1918/19. The fact that the region did not contribute to the sudden Arctic warming immediately does not necessarily mean that there was not a verifiable contribution over the total warming period until 1940. But one conclusion can already be drawn at this stage, that any detectable influence would be more modest rather than powerful or even decisive. This aspect will be raised again later.

In addition to the remarks in the previous chapter (relative shallowness, inflow of polar sea water, etc), the eastern part of the Barents Sea was usually fully ice covered during the core winter season 90 years ago. Sea ice is rare in the south-western portion of the Barents Sea. In April, however, the sea can be 75 percent ice covered. This extensive ice cover may play an important aspect when looking at special issues. As a matter of fact in the 1920s particularly high temperature had been observed at Franz-Joseph-Land, and at Novaya Zemlya, which require an explanation. However, in this region the increase was only observed since 1927 and 1928, only since than one could speak of “incontestable evidence of a progress warming” (Schokalsky, 1936) in this region.

As the open sea can release much more heat than an ice covered area, one simple explanation may be that the ‘heat’ had been coming with the flow of western wind from Spitsbergen, with its permanent supply with warm Atlantic water, which can transfer its heat to the air due to the sea ice free tongue up high in the North. The usually extent of sea ice here and elsewhere in the north-eastern part of the Barents Sea hardly allows any other explanation, at least for the winter period. Any claim that warm Atlantic water had “managed” to cross the Barents Sea, and remained warm enough to heat these remote Russian islands through the existing sea ice, sounds little convincing and needs to be proved. The distant from Spitsbergen (West coast) to the West coast of Franz-Joseph-Land is ca. 800 km, respectively less than 2000 km to Novaya Zemlya. In particular, such locations as Vardø and Kandalaksa (see above) would have felt if warm Atlantic water had entered the Barents Sea by mass and travelled to that very distant location.

From this region a contribution to the initial warming period can be excluded, and it might be questionable if it is claimed that warming of the Barents Sea and Kara Sea



The paper provides an indication that the annual average (Feb-Jan, 5-year series) at Spitsbergen increased from about 1918/19 to 1921/22 by four degree, but that the trend from the 1930s to the mid 1990s showed a general cooling, contrary to a warming over the whole century. With these facts at hand it seems strange when the paper says:

_____With the IPCC report released during 2007 the scientific community is adding confidence to the relation between global warming and the boost of the greenhouse effect via anthropogenic emissions. Modelling work after the previous IPCC report have shown that the Arctic region is likely to warm up faster than the global average, and that the Arctic may be one of the regions to have the quickest response to global warming.
 _____The reason for this Arctic warming is debated, but was likely an effect of enhanced atmospheric circulation triggered by heat excess in its source region.

LEFT:
Air-temperature
Dec. to Feb.
1917/18=-21,7°C
1918/19=-10,1°C

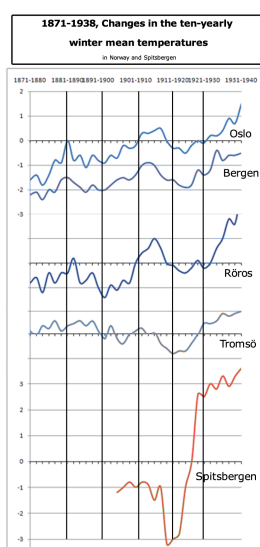
RIGHT:
Annual mean

Pohjola:
 The North Atlantic drift is a powerful contributor of heat into the Nordic Seas and further into the Arctic Ocean, where the northern branch of the drift splits at Svalbard.

How can such a high rise in winter occur when the location is almost enclosed by sea ice?

Pohjola: One of the "hotspots" in this Arctic warming may be Svalbard, due to the fact that this archipelago is positioned right where the Arctic front separates the polar and extra-tropical air and water masses.
Pohjola: How well the Svalbard region senses global climatic variability is exemplified by the much larger warming the archipelago experienced in the 1920–30s event than what was recorded at other North Atlantic/Arctic sites.

5. The warming event in details



The Manley graph from 1944 provides a demonstration of the huge warming difference between e.g. Spitsbergen and Oslo. The temperature rise in Norwegian can but need not be derived from the same source as for Spitsbergen.

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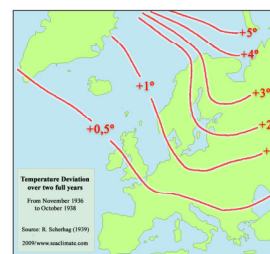
consisted of 2° annually until the mid of the 1920s (Kelly, 1982). Only since 1920 temperature observation was taken at Boar Island, a location roughly half way between the North Cape and Spitsbergen. The recorded winters of 1920 and 1921 (January/February) were significantly colder than the following ones, except for the winter of 1928/29, until the winters of 1939/40 and 1940/41. In so far, the warming of Boar Island started with the winter of 1921/22. The annual means are fairly equal (1° to 3.2°C, between 1920 and 1932), getting warmer only after 1932 until 1939. (Kirch, 1966). Although it is a small temperature increase over a two decade period, the Barents Sea did not contribute in any significant way to the Arctic warming, and at the time of commencement, not at all, respectively only modestly over the subsequent two decade period.

e) Europe

In Europe the temperatures increased only very slowly but steadily since 1920. Although the 'natural climatic system' of continental Europe had definitely not been the source of the Arctic warming during the 1920s and 1930s, a brief introduction will indicate that not necessarily all warming has been coming from the North. However, here we concentrate merely on the correlation between the Arctic warming and warming in Europe since winter 1918/19, while considering any correlation between the Spitsbergen warming with Europe's treatment of its coastal waters due to naval activities during WWI from 1914 to 1918 is discussed later.

A convincing piece of evidence is the data set for Norway, demonstrating that the difference between Spitsbergen and the city of Tromsø, only about 800 km away, is tremendous (Manley, 1944). The shown graphic indicates the slowly advance of rising temperatures at Bergen and Oslo. This could be interpreted as a clear indication that not only one but at least two forces had been at work. This is indirectly confirmed by the observation that the NAO (North Atlantic Oscillation) has weakened during the 1920s and remained weak for the whole period of the warm Arctic anomaly (Bengtsson, 2006). It is obvious that Europe, neither the land nor the sea areas had been in the driving seat, due to the fact that the warming came in creeping pace only. The start of Europe's warming since 1920 had presumably not been noticed in practice by anyone. Even nowadays it seems impossible to establish that there had been any signs available in the late 1910s that an increased warming could be starting soon.

The strong warming of North Europe - 1936 to 1938



However, it happened, but definitely later as at Spitsbergen, and simultaneously in time with Greenland. It lasted until the winter of 1939/40. The warming was so pronounced that autumn 1938 was the warmest, together with 1772, 2000 and 2006, in the last 500 years (Xoplaki, 2006). Summer temperatures also had risen substantially; with 1°C. Autumnal temperature rises in the 1930s were local and observed in Scandinavia and western part of maritime Russia only (Polyakov, 2003). No other continental Northern Hemisphere region experienced a similar rising trend. The United States data records, which had a modest warming until 1933, saw a decrease in temperatures since then. The correlation with Greenland is perfect. In Europe the warming continued for another six years. The air temperatures over North Europe from 1936-1938 indicate that higher temperatures were observed in the Baltic Sea region (Scherhag, 1939).

5. The warming event in details

Although it can be assumed that at the end of the 1930s Europe experienced the highest annual temperatures in several hundred years, it can be questioned whether there had been an exclusive connection between the Arctic warming and the warming in Northern Europe. Iceland got warmer since the mid 1920s (Eythorsson, 1949) and the Faroe in the northwest of Scotland since the early 1930s (Bjerknes, 1956). Therefore, the middle Atlantic seems to have played no significant role in the warming of Europe. Although the warming of Northern Europe between the two World Wars is evident, the main warming impulse came from the North.

E. Spitsbergen as a Heating Spot

If one asks whether the heating-up spot is to be found at Spitsbergen, we would answer: yes. The information supplied sustains this affirmative answer. Nothing demonstrates this better than the data record taken at Spitsbergen since 1912. If one reviews the January/February temperature difference between the winters of 1913/14 and of 1919/20 (ca. + 15°C), or from the winters of 1916-1917 to the winters of 1919-1920 (ca. + 22°C), the results are not only extraordinary, but they reveal that the “shift” took place in 1918, respectively in the winter of 1918/19 (Hesselberg, 1956). This is emphasized by the comparison between the data recorded from 1912, until WWI ended in November 1918 (ca. – 4.3°C), and thereafter (ca. +3.8°C), including the winter of 1925/26.

In the summer of 1918 the seawater temperatures had already reached unusual values: +7°C to +8°C at the West coast of Spitsbergen (Weikmann, 1942). During the winter of 1918/19 the temperatures varied considerably. There were long periods in November and December 1918 with temperatures close to zero degrees, 4 days with temperatures above zero in November and 7 days in December³⁸. In January 1919, the temperatures did not reach –5°C for 14 days, and five days were frost-free. The annual mean (1912-1926) with minus 7.7°C suddenly jumped to an annual average of minus 5.4°C in 1919, representing a plus of 2.3 degree. The corresponding figures provide for January a difference + 8.6°C, which indicates that the sea was able to transfer a lot of heat into the air. However, during February–April 1919, the temperatures were well below the average (ca. -6°C), with a large ice-cover far out into the sea. But that did not affect the significant warming that had started a few months earlier.

F. Summary

The interpretation of the reference material indicates that an outstanding warming-up phenomenon can be located with precision at Spitsbergen, and the exact timing is within a range of a few months, with the core month January 1919. Such a precise date cannot be found for other location. As there was no simultaneous temperature jump during the corresponding time period elsewhere, it is possible to assert with certainty that Spitsbergen represents the first place where the Arctic warming started at the beginning of the 20th century. Therefore the next chapters will subsequently examine: WHY did the “greatest yet known sudden temperature rise on earth” (Birkeland, 1930) presumably occur. After all, the “severe warming” at Spitsbergen in 1918 did not come from “nowhere”, nor did the subsequent ‘climatic change’. The event needs to be explained, either that the sudden change was due to internal dynamics of the sea body, or due to an external force, or a combination of both.

³⁸ Average temperatures (1912-1926) for December minus 14.4°C: in December 1918 minus 7°C.