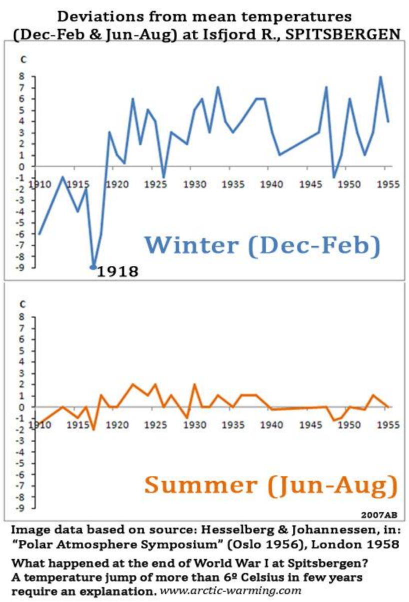
CAN THE "BIG WARMING" AT SPITSBERGEN FROM 1918 to 1940 BE EXPLAINED?

By: Arnd Bernaerts, Germany,

OVERVIEW[1]

Recent conclusion on the arctic warming in the 1920s/1930s:



1. Natural fluctuations are a component of the climatic system (Johannessen et al., 2004);
2. Natural variability is the most likely cause (Bengtsson, et al., 2004);
3. Sun has partly caused the warming (Daly, 2004);
4. The 1930s warm period did not coincide with a positive phase of the NAO (North Atlantic Oscillation) (Polyakov et al., 2004).

The latest IPCC's Summary for Policymakers (IPCC 2007) paid little attention to the previous statements and summarised the 'arctic warming' as it follows:

> *Average Arctic temperatures increased at almost twice the global average rate in the past 100 years. Arctic temperatures have high decadal variability, and a warm period was also observed from 1925 to 1945.*

One century has passed since arctic warming started in the late 1910s, but science is still unable to give a consistent explanation of the warming causes and origins. This investigation attempts to offer clues and explanations about what caused the arctic warming at the beginning of the last century. However, as a Conference paper, it is actually only a brief summary of a more detailed work, which is fully accessible at http://www.arctic-warming.com.

What is up for discussion?

It will be demonstrated that the location and the timing of the first observed arctic warming in the early 20th Century could be identified with high precision. We will prove that the warming phenomenon started at Spitsbergen and, even more that it started within a very short time frame of only a few months, in 1918. Therefore, the most dramatic air temperature increase was recorded in the winter of 1918/19 and lasted in force only until ca. 1922. Over a very short period of time, from the winter of 1915/16 to the winter of 1921/22, winter temperatures

[1] Revised text October 2007

had risen by about 10ºC, never coming back to pre 1918/19 level, but increasing at a lower level until ca. 1940.

In winter 1918/19 the temperatures exploded at the remote island Spitsbergen, laying at the edge between the Northern North Atlantic and the Arctic Ocean. The temperature rise continued until 1939. Why did it happen?
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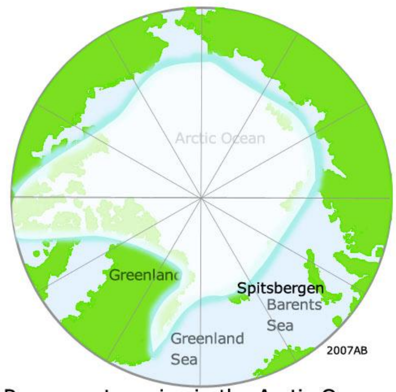

Permanent sea ice in the Arctic Ocean in the early 20th Century
Here for Sept/Oct, usually the period with the minimum of annual sea ice cover
- by approximation only -
The sea areas around Spitsbergen are special. Every winter season sea ice far south from the Arctic Ocean, in even in late summer the ice surrounds Spitsbergen up to ca. 50 %, in April usually ca. 80, and sometimes more.
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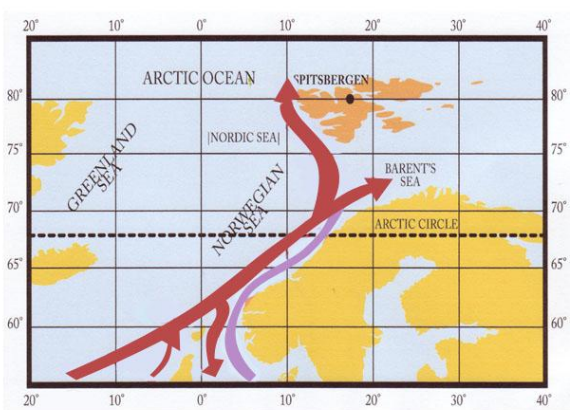
A further highly significant aspect is the Spitsbergen location. On one hand, a substantial part of the water masses reaching Spitsbergen have either passed the West coast of Scotland or came from the North Sea, which might have had dramatic consequences back in 1918. These water areas around Great Britain had been under considerable constraint due to naval warfare during World War I (WWI), whereby the ca. 2000 kilometre distance between the two locations is not a significant one. Oceanic currents carried all the naval battleground water northwards, in the Spitsbergen region, within only a few weeks or a couple of months. Once the ‘composition’ of the battleground seawater structure has changed, it remained so.



If the sea around Spitsbergen is covered with ice between 50 and 90% throughout the year, higher winter temperatures must have had a source that most probably has been coming with warm Atlantic water (‘Gulf Current’).
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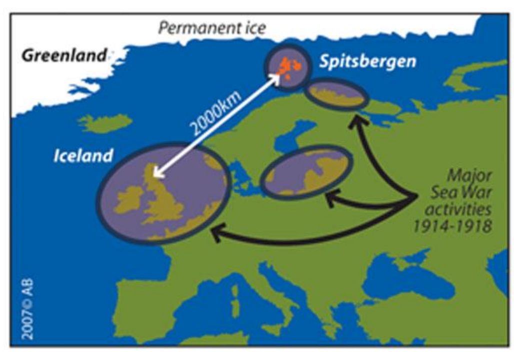

Major Sea War activities 1914-1918 in North Europe
But what could have generated such sudden warming?
No Atlantic water reaches Spitsbergen that has not passed Great Britain and the North Sea, which had been turned ‘upside down’ by naval war for four years.
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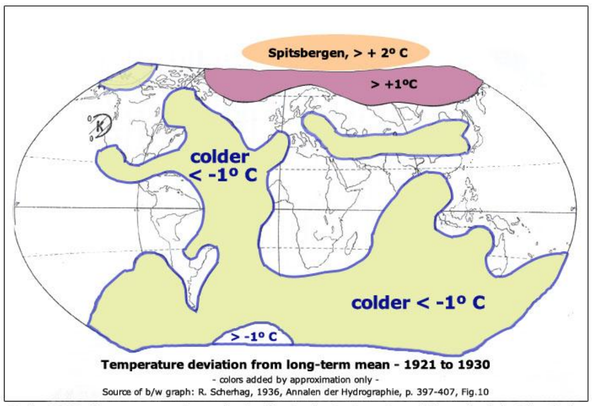
It is important for this investigation to mention that only the winter season is covered: not only because of the fact that only winter temperature recorded a dramatic increase, but because it covers a period during which the sun influence is inexistent for many months, or its direct influence is negligible.

The following investigation will:

- in the first place, establish that the arctic warming location and time can be identified with high precision, namely at Spitsbergen, in the winter of 1918/19; and
- show that naval warfare during WWI is a very serious event which might have caused this phenomenon; and

- that it is up to the scientific community to confirm or to disapprove this *prima facie* evidence.

After all, since meteorological observations began to be recorded, namely over the last 200 years, not one similar phenomenon was ever observed, neither before 1918 nor thereafter. So, no other meteorological event can help us understand the climatic process better than the arctic warming which took place at the end of WWI.



In the 1920s the strong warming took only place in the Arctic region, while south of the Polar Circle the USA experienced a warming until ca. mid 1930s, and Europe until the start or World War II, the end of the year 1939.
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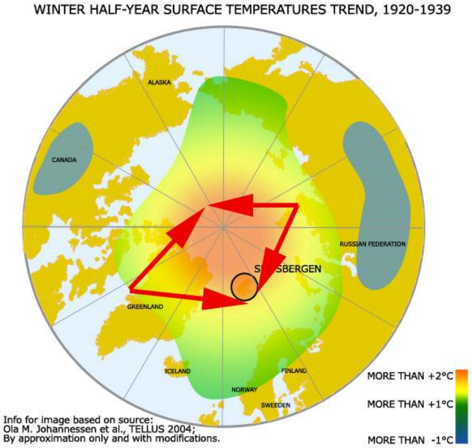
WINTER HALF-YEAR SURFACE TEMPERATURES TREND, 1920-1939



Info for image based on source:
Ola M. Johannessen et al., TELLUS 2004;
By approximation only and with modifications.

The pronounced Arctic warming over two decades (1920-1939) was restricted to an area not larger than ca. 1/3 of the whole Arctic Ocean. 2007AB

The warming did not effected immediately the whole Polar region but was restricted to the area where the North Atlantic and the Arctic Ocean meet which is to note for considering the reasons for the warming.
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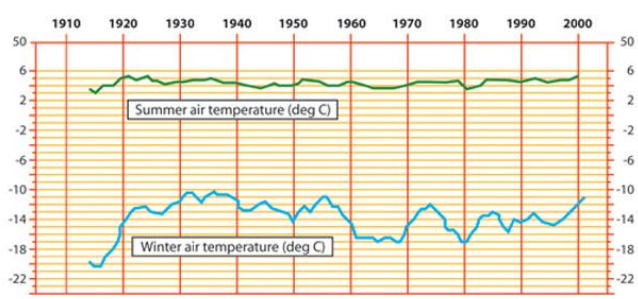
ELABORATION OF SCOPE AND PREVIOUS ANALYSES

Elaboration basis

Until recently, a systematic ocean data collection did not exist, with the exception of the frequent sampling of the sea surface temperatures made by merchant vessels. But these measurements were very random, very selective and very insufficient. Analysing oceanic conditions and changes has to be largely based on air temperature observation. At Spitsbergen, the first permanent temperature data series recording began in 1912. In other places from the Nordic Sea areas, e.g. North Greenland, Jan Mayen, and Bear Island, weather records date from the 1920s. Actually, for the first quarter of the last century, solid data concerning the polar region are limited and rely only on a number of single expeditions and interpretation of secondary observations.



Spitsbergen/Longearbyen
(Source: Uni Svalbard)
The data for the Figure show the extreme difference between summer (above) and winter (below) temperatures, actually more than 10º C in one decade, which requires a heat potential that only the sea could produce.
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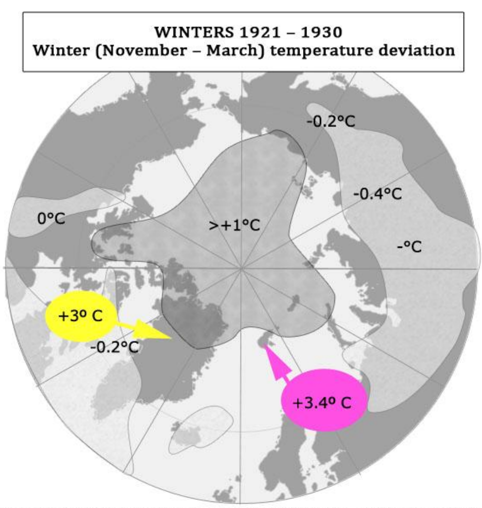
As for the facts concerning temperature development in the high northern hemisphere, the over-proportional rise in the wider polar region is well established and undisputed. The temperature increase is two to three times higher than the global average of the last century. This is well indicated in all temperature graph series available. What these graphs and tables do not indicate clearly enough is the purpose or relevance of the statistical accumulation of data series. The following applications of temperature data are either related to geographical, earth surface or to seasonal issues, as it follows:

Geographical: (A) Local: Spitsbergen, latitude ca. 80 degrees North; (B) Regional: Arctic/Polar region, at least higher than 60º North; (C) Global: Northern Hemisphere; (D) Global: Northern and Southern Hemisphere, whereby this statistical mean can be neglected because it doesn't provide any clue on Spitsbergen warming; or

Earth Surface: (A) Land-based air temperature observation. Concerning air temperature data taken at Spitsbergen, it should be observed that, due to the permanent and extended sea ice-cover, the island is partly similar to an inner continental place. But as the southern flank of the island is open to the sea and the closest continent is almost 1000 km away, this South-Sector is under very strong oceanic influence; (B) Sea-surface air temperatures (SST), which play no important role in this investigation simply because they do not exist in any reasonable number and time for the period in question.

Season or specific months: (A) Seasonal temperatures are of particular interest because Polar Regions at high latitudes are an outstanding example of the considerable impact and influence of the sun decreases in wintertime as far down as the North- and Baltic Sea (both above 50° North). (B) Monthly mean data are a tool equivalent to the seasonal temperature measurement. Their applications make sense in exceptional cases. Spitsbergen is such an exceptional case.

In our research and effort to explain the big warming at Spitsbergen and its causes, air temperatures series play a major part. Focusing on certain aspects such as location and time sequence may reveal the source of the warming.



Data based on source: R. Scherhag, in: Ann.Hydro& Maritim.Met., 1939 (by approximation)
To explain the big warming at Spitsbergen and its causes, air temperatures series play a major part, but due to the permanent and extended sea ice-cover, the Spitsbergen is partly similar to an inner continental place.
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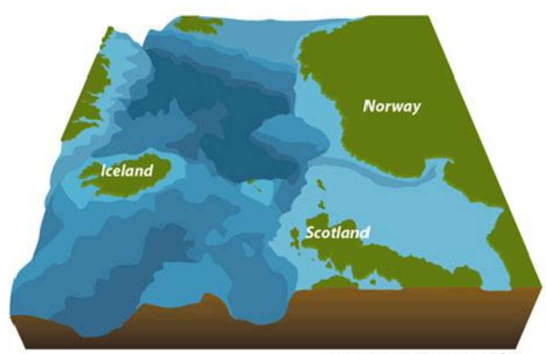

Image concept: Uni Oslo

Warming during winter at Spitsbergen needs either the huge heat reservoir of the Norwegian Sea (3000 m), or the permanent inflow of warm water via Norwegian and West Spitsbergen Current.
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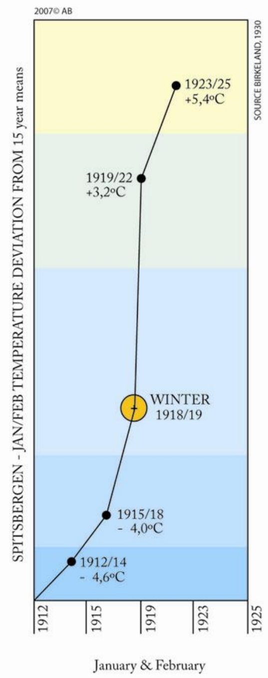
The result of scientific research recently and before WWII



The data B.J. Birkeland published in 1930 resulted in an increase during Jan/Feb. of 10°C between 1912 and 1925.
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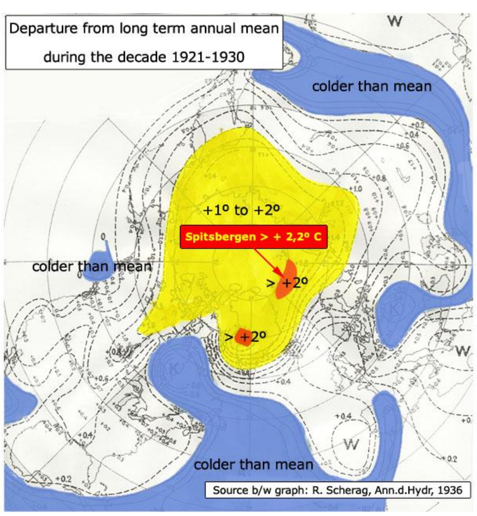
Scientific position when it comes to explaining the phenomenon arctic warming 90 years ago has already been highlighted in the Introduction above. It might therefore be of interest to see to what extent the phenomenon was discussed before WWII.

One of the first scientists who highlighted the extraordinary temperature development at the 'Green Harbour' Spitsbergen station was the Norwegian scientist B.J.Birkeland, in 1930 (op. cit). He was very surprised of what he discovered. He finishes his brief essay with this statement: "In conclusion I would like to stress that the mean deviation results in very high figures, probably the greatest yet known on earth". A couple of years later, in 1936, a number of authors put Birkeland's findings into a wider context.

(A) Johansson (op. cit., 1936) focused his investigation on the relevance of sunspots. Yet, some analytical consideration is nevertheless interesting. For example: (a) In 1919, the statistical means crosses zero-value; or, in other words, all previous years are colder; all later years are warmer; (b) Between 1917 and 1928, the increase during the summer season is of +0.9°C per 10 years, and in winter, of +8.3°C, in February, of +11.0°C; (c) It seems that the changes are coming from the North. (d) Johannsson's main conclusion is that the increased air circulation (15 % higher) between 1896 and 1915 had gradually changed the current and ice conditions, thus altering the borders between the Arctic gulf current climate and the true Arctic climate further north.

(B) Scherhag (op. cit., 1936/8) refers to Birkeland's work from 1930, assuming that all warming analyses have to begin with the observation of the Spitsbergen phenomenon, because only here the temperature increase was measured in the winter of 1918/19 for the first time (Scherhag, 1939); (a) There were increased Gulf Current temperatures, particularly significant in the Barents- and East Greenland Sea. (b) The extraordinary increase of the winter temperatures in Greenland (Scherhag, Nordeuropa, 1936) , was caused by a considerable retreat of the ice border and the prominent increase of the atmospheric circulation (Scherhag, ditto).
(c) Scherhag (op.cit., 1937) states that a thorough research of the temperature changes over the whole northern half of the globe during the period 1921-1930 confirmed that the largest part of the investigated region had been, indeed, considerably warmer during the decade 1921-1930. (d) Scherhag stressed: "such kind of climate changes as could now be observed in Spitsbergen and along the western coast of Greenland were certainly not restricted to a small region but must be global" (Scherhag, 1937). (e) In his subsequent research



The dramatic increase during the 1920s at Spitsbergen is clearly restricted to the Northern North Atlantic.
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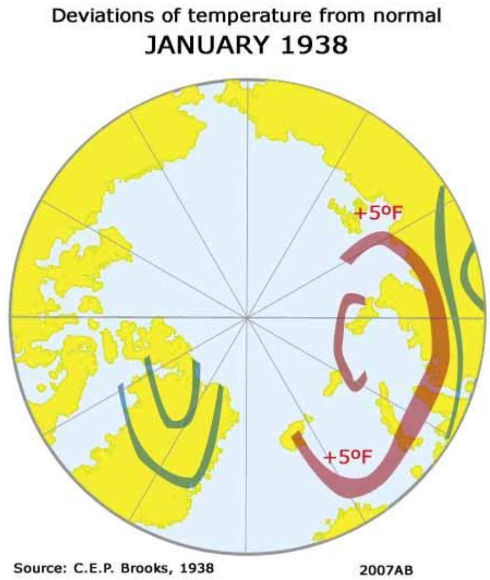
work, Scherhag pays little attention to the natural circumstances from Spitsbergen in the late 1910s, merely acknowledging that the extent of the temperature increase would be, without any doubt, the greatest in the Arctic (Scherhag, 1939).



The Brooks' image covers only January 1938, but the figures are impressive and prove that the warming impulse since winter 1918/19 was sustained and long lasting.
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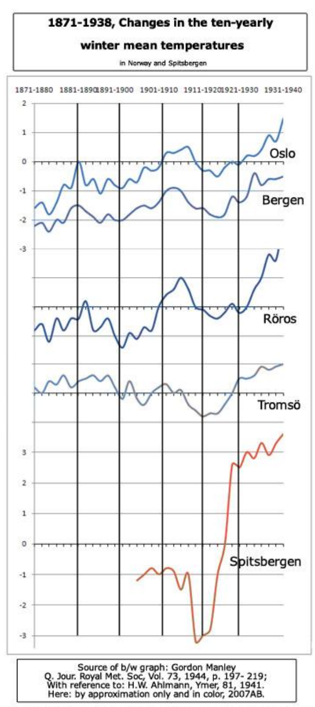
(C) Brooks (op.cit.,1938): (a) The Spitsbergen branch of the North Atlantic Current has greatly increased in strength and the surface layer of cold water in the Arctic Ocean has decreased in thickness from 200 to 100 metres. (b) Attributing the recent period of warm winters to an increase in strength of atmospheric circulation (in reference to Scherhag) only pushes the problem one stage back, because one should still have to account for the change in circulation. (c) It may also be objected that the atmospheric circulation depends on the difference of temperature between low and high latitudes and, hence, should be weakened instead of strengthened by a warming in the arctic. (d) Regardless the mechanism, the rise of temperature did begin prematurely and had a cause, though it is conceivable that it arose spontaneously in the incessant kaleidoscope of temporary pressure distributions.



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 derive from the same source as for Spitsbergen.
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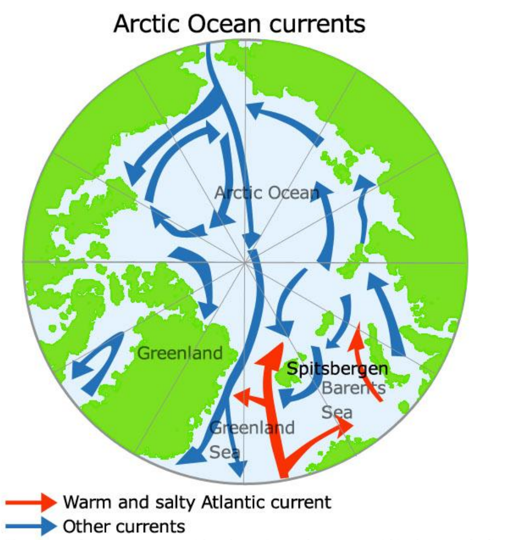
(D) Manley (op. cit., 1944): (a) Temperature in Norway, especially in the North, has certainly risen far more in recent years than at any other time in the last two centuries. (b) A more vigorous atmospheric circulation in the region of the Norwegian Sea would explain the observed facts, namely the recession of the ice-limit, the increased frequency of south-westerly winds, rather than south-easterly, in North Norway, and the consequent marked rise in winter temperatures which has attained its greatest magnitude in the north of the Scandinavian Peninsula.

All pre-WWII papers acknowledge the suddenness of the rise in temperatures in the North Atlantic region since the early 1920s, but pay too little attention to the location of Spitsbergen, an island in the mid of a huge sea area, with sea-ice in the north and at the edge of the Norwegian Sea in the South. However, the great-grandfathers of today's climatologists discussed this matter very seriously and in a way, which is not very different from today.

ANALYSING THE WARMING OF SPITSBERGEN OVER A WIDER REGION

Contributions by sea regions

"Needless to say, a necessary condition for the Arctic warming event to happen depends on the change in the larger scale atmospheric circulation" (Bengtsson, et al., 2004). While a conclusion like the previous one seems to be of little help for the explanation and understanding of the warming in the high North region, a more detailed analysis on first appearance and intensity of temperature changes is required. To this reason, it is to emphasise that, to "warm up" the air of a remote archipelago at 80º North during winter, heat must have been available and injected to the atmosphere between the direction 135º (SE) and 270º (West) of Spitsbergen, which are usually sea ice-free areas throughout the year and belong to the Barents Sea, the Norwegian Sea and the Greenland Sea. The source of the warming was either due to internal processes within the water bodies, or influenced by 'more' warm water coming from the Atlantic Gulf current. The latter came with the Norwegian Current and West Spitsbergen Current, formed by water flowing from the Gulf Current after it had passed the Iceland - Faroe – Scotland line, enhanced by North Sea water, and continental run-off rain and melt water.



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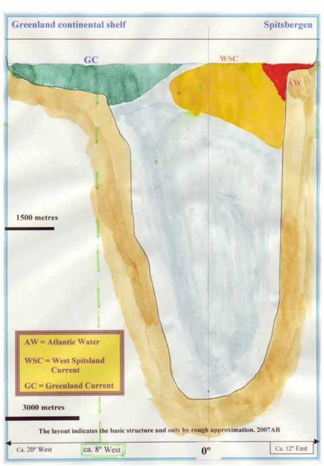
Scenario 1 - A considerable part of the Atlantic water moves via the currents towards the basin of the Arctic Ocean. Actually, due to the high salinity of the Atlantic water and the cooling process, the water becomes very dense and 'falls' over a ridge (with a depth of 600 m below sea level) in the Arctic Basin. Before the Spitsbergen current reaches the ridge, at about 80° North, the water, at a depth of 20 metres, has a salinity of about > 35 per mile and a temperature of up to 7°C (Knies, 1996).



South of the line between Spitsbergen and Greenland the Norwegian Sea is 3000m deep, and uniform cold, except close to the shelf of Spitsbergen with warm water from the South
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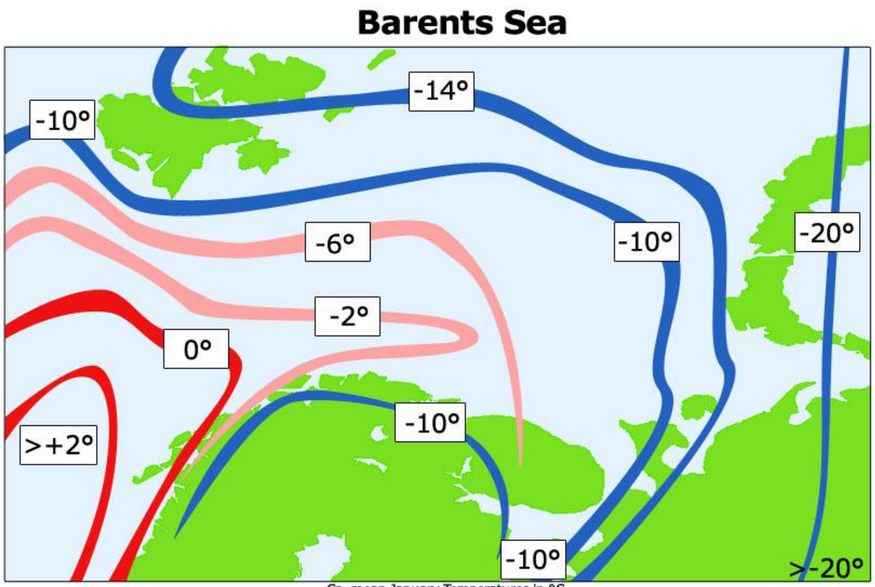
Scenario 2 - The North Cape Current, which supplies the Barents Sea with Atlantic water, may have contributed to the warming in the long run. But, generally speaking, the Atlantic water 'disappears' in the East of the North Cape and Spitsbergen. Instead, a polar water current flows in from NE and partly joins the Spitsbergen Current in the south of Spitsbergen. According to Wagner (op cit., 1940), the mean water temperatures in the Barents Sea increased with +1.8°C from 1912/18 to 1919/28. It is not easy to assess how much the 500 m deep Barents Sea might have contributed to the 'Severe Warming'. Presumably, not very much, especially during 1918, although the Barents Sea ice border retreated significantly since 1919 (Wagner, 1940). After all, a complete renewal of the water body of the Barents Sea is completed at every four years (Schokalsky, 1936). Thus, the Barents Sea would require a permanent water inflow, which could only come from the South, when it is supposed to sustain the warming.



Ca. mean January Temperatures in °C

Could the North Cape Current have carried more warm water? We do not know.
What we know is that at Spitsbergen the temperature jump was extreme in winter 1918/19 at the North Cape not.
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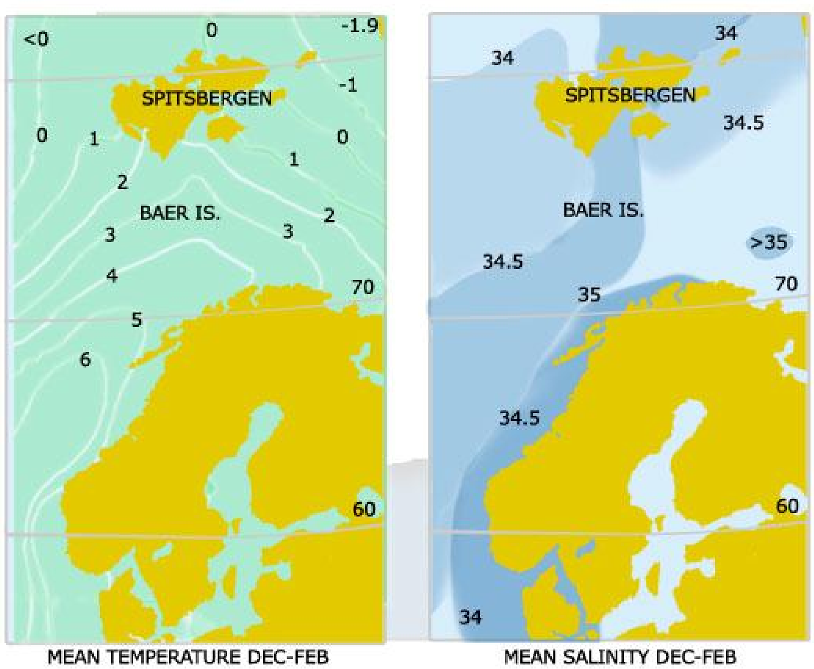

At any time during the year the Barents Sea has a complex balance in temperatures and salinity, particularly during the winter season (here Dec/Feb.), which could have been effected by anthropogenic activities in seas south of it?
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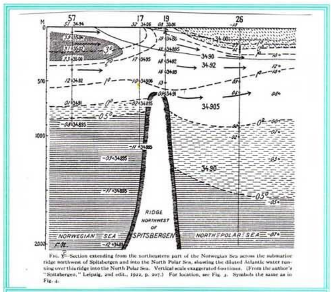
Scenario 3 - At west of Spitsbergen, the seawater has a temperature of 5°C and a salinity of 34.90 to 35.00 mg. A significant part of the warm Atlantic Gulf water that has reached

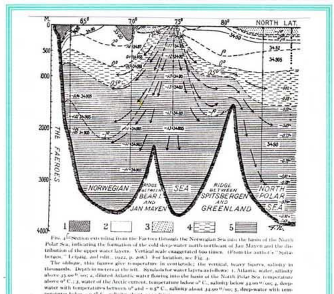


Fridtjof Nansen, 1928, "The Oceanographic Problems of the still unknown Arctic Regions" In: W.L.G. Joerg (ed), Problems of Polar Research, New York, p.3-14 (p.11) American Geographical Society, Special Publication No.7.

Arctic Oceanography - Circulation of the Water – North Polar Sea
Extract from Fridtjof Nansen, 1928*)

As was discovered during the *Fram* expedition of 1893-1896, this sea (North Polar Sea) is covered by a layer, 150 to 200 meters thick, of cold water with temperatures between 0° C and –1,9° C and with a comparatively low salinity owing to the admixture of fresh water, chiefly river water from Siberia, Alaska, and Canada. Below this surface there is a layer, some 600 or 700 meters thick, of warmer and salter water, with temperatures above 0° C and salinities approaching 35 per mille. This is Atlantic water, which is carried into the Arctic Basin chiefly by the small branch of the Atlantic Current ("Gulf Stream") running northwards along the west coast of Spitsbergen. Below this warmer water there is again colder water filling probably the whole basin to the bottom; its temperature is between 0° C and 0,8° and its salinity 34.90 per mille. This cold deep-water originates in the northern part of the Norwegian Sea, north-northeast of Jan Mayen, where it sinks down from the surface, which is cooled by radiation of heat during the winter and spring. The thus cooled water runs into the Arctic Basin across the probable submarine ridge between Spitsbergen and Greenland.

*) F. Nansen, 1928, "The Oceanographic Problems of the still unknown Arctic Regions" In: W.L.G. Joerg (ed), Problems of Polar Research, New York, p.3-14 (p.11) American Geographical Society, Special Publication No.7.



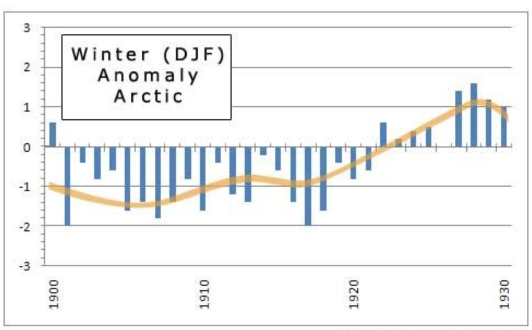
Fridtjof Nansen, 1928, "The Oceanographic Problems of the still unknown Arctic Regions" In: W.L.G. Joerg (ed), Problems of Polar Research, New York, p.3-14 (p.11) American Geographical Society, Special Publication No.7.

Spitsbergen 'turns left' in the south-western direction, at the position of 75-77° North, and flows either as Greenland current down to Newfoundland and back in the Atlantic, or goes down into the huge Greenland Sea Basin with depths of 2,000 metres or more (max. ca. 3,500 m), or circles for some time the surface water layer or the thermocline waters. This water may have contributed to the warming at a later period of time, on a long-term basis.

Scenario 4 – On the fourth place is the Norwegian Sea Basin with depths of 3,000 metres. The whole eastern part of the European North Atlantic – Norwegian Sea - is a reservoir for the Atlantic Gulf water, reaching depths of 800 meters. This large water body has a huge heat retaining capacity. Any increase in temperature, or enlargement of the 'warm water part', or 'functioning', would quickly be reflected in temperatures at Spitsbergen, in Europe or elsewhere in the Northern Hemisphere. In addition, while the deep water of this basin is formed north of Jan Mayen, it can, in exceptional circumstances, warmed up by Atlantic water in case that it had been 'pushed down' to lower depths after passing by the Shetland Islands, Faroe Island and Iceland ridge (approx. 500 m).

Evaluating the *Scenarios*, it can be said that three out of the four possible sea sectors mentioned above may have generated the temperature rise in 1918. For the subsequent climatic change, which took place between 1918 and 1939, the Norwegian Sea must have been the major, if not the only contributor, either due to its own heat storage capacity, or by a sustained supply of warm Gulf current water, respectively both of them.

The warming event in detail



Source: IPCC-region

The IPCC acknowledges an Artic warming twice the global average rate (Report 2007), but assumes a period from 1925-1945.

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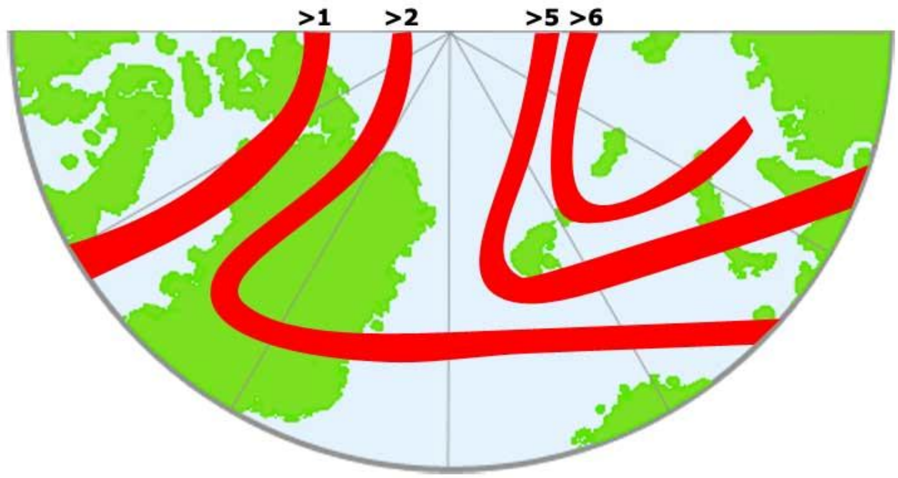
Arctic Ocean. According to Johannessen et al. 2004, the most pronounced warming area from 1920-1939 covered a region from the East coast of North Greenland (60º West) to Severnaya Zemlya Island (100º East), with distances of about 1200 km each. Comparing the location and the extent of this warming area within the wider Polar region, a substantial distinction can be made. The pronounced warming area covers only about 1/3rd of the Arctic area, namely the northern parts of the Greenland Sea, Norwegian Sea and Barents Sea as well.

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 (Scherhag, 25 Jahr, 1936), which indicates that temperature had increased with more than + 3ºC from 1921 to1930. The warming of the East of Greenland, after 1920, could be possibly related to the findings of Bjerknes (Bjerkness, 1959), in 1958, sustaining that the Labrador Current had shown a brisk upward trend, starting as late as 1920. It is certain that a substantial warming of Greenland took place after WWI. One can also be sure that the warming period of Greenland was limited to about one decade. The indicated period of time in question is from 1920 to 1930/32. Bjerkness (op. cit, 1959) assessed seawater temperature data in the North Atlantic as it follows: "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, but essentially, it lasted only from 1920 to 1930 in Greenland waters".



Winter temperature difference 1921-1930 minus 1911-1920
Data info source: H.H. Lamp; in: "The Arctic Ocean" (1982), Fig.7.10a.
- By approximation only - 2007AB

The location of warming in the 1920s is according H.H. Lamp's graph of 1982 Spitsbergen (+ 5°), from where the West-wind transport the heat of the sea current further East.

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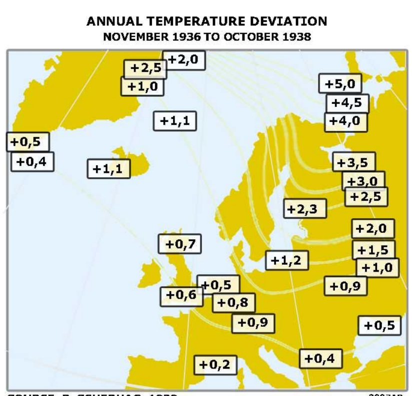

Autumn 1938 was the warmest, together with 1772, 2000 and 2006, in the last 500 years. The warming in North Europe was particularly pronounced.

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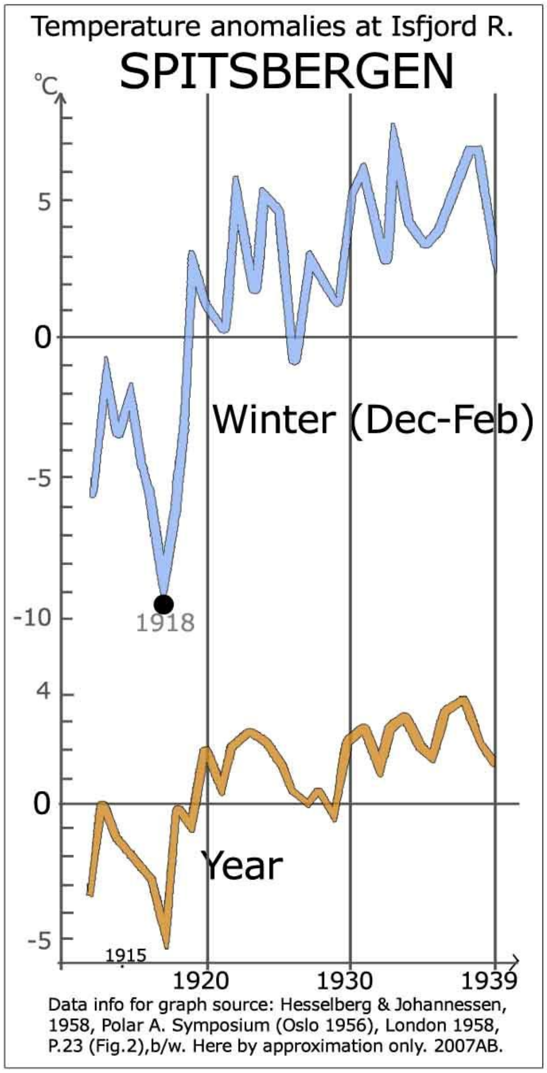
Europe. The warming trend after WWI is different from Greenland because temperatures had increased only very slowly but steadily from the winter of 1918/19 until the winter of 1939/40. It went so far that autumn 1938 was the warmest, together with 1772, 2000 and 2006, in the last 500 years (Xoplaki, 2006). Summer temperatures also rose substantially by 1ºC. Actually, autumnal temperature rises in the 1930s were local and observed in Scandinavia and western part of maritime Russia only (Polyako, 2004). 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.

Is Spitsbergen the only heating-up spot?

If one asks whether the heating-up spot is to be found at Spitsbergen, we would certainly answer 'yes'; information supplied previously sustain this affirmative answer. If one reviews the January/February temperature difference between the winters of 1913/14 and of 1919/20 (ca. + 15ºC), or from the winter of 1916/17 to the winter of 1919/20 (ca. + 22ºC), the results are not only extraordinary, but they reveal that the 'shift' took place in 1918, respectively in the winter of 1918/19. This is emphasised by the comparison between the data recorded since

1912, before WWI ended (ca. – 4.3ºC), and thereafter (ca. +3.8 ºC), including the winter of 1925/26.



The difference between the deviation on a yearly and seasonal level requires an explanation.

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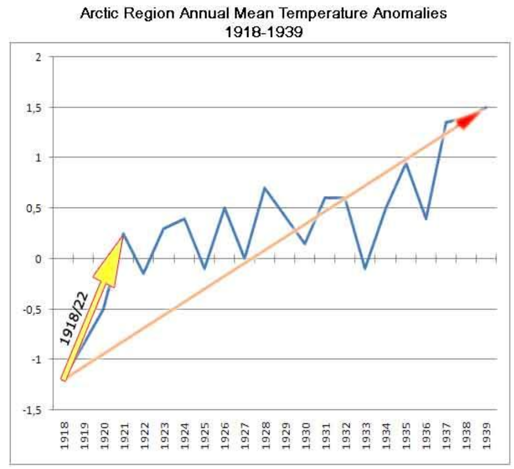

The outstanding warming-up phenomenon can be located with precision at Spitsbergen, and the exact timing is within a range of a few months.

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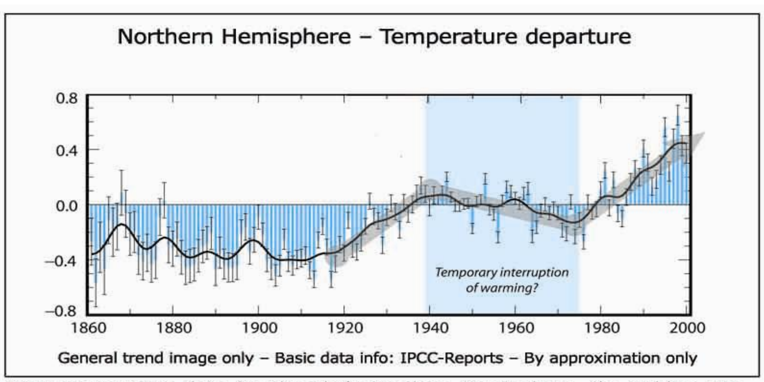
It had been also observed that seawater temperatures had reached unusual values: +7ºC to 8ºC at the West coast of Spitsbergen in the summer of 1918 (Weikmann, 1942). During the winter of 1918/19, there had been considerable temperature variations. There were long periods in November and December 1918 with temperatures close to zero degrees (approx. 26 days with less than 5°C), 4 days with temperatures above zero in November and 7 days in December. In January 1919, the temperatures did not reach –5°C for 14 days, and five days were frost-free. With monthly averages of minus 7.5°C and plus 8°C, the sea must have transferred a lot of heat into the air. However, during February–April 1919, the temperatures were well below the average, with a large ice-cover far out into the sea. But that did not affect the significant warming, which started a few months earlier.



Even summarizing data for the whole Northern Hemisphere, the sudden rise at the end of WWI is significant.

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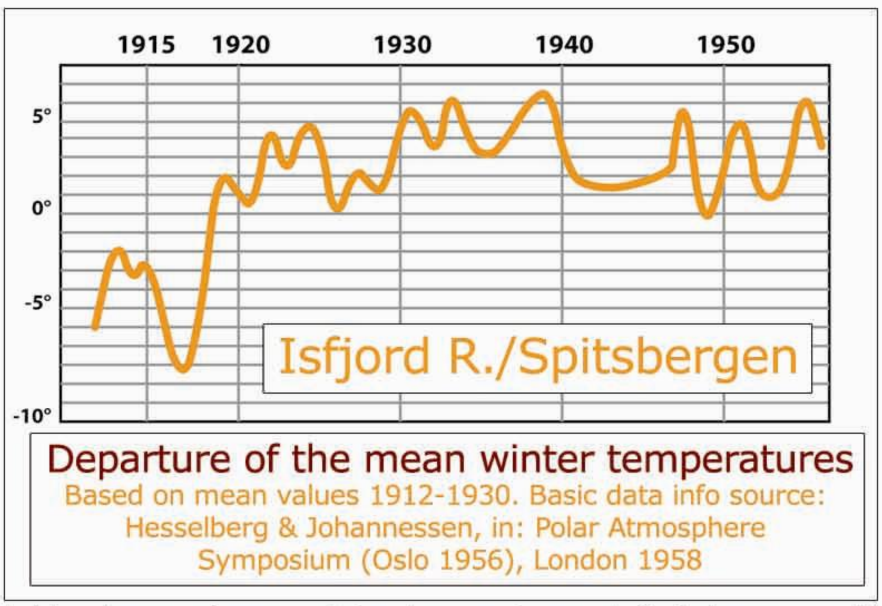
All information and every aspect confirm that an outstanding warming-up phenomenon can be located with precision at Spitsbergen, and the exact timing is within a range of a few months. Such a precise date cannot be provided for any other global location since records have been taken. As there was no 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.

WHAT CAUSED THE ARCTIC-SPITSBERGEN WARMING?

The probable forcing mechanism of the warming

After having established the location and time-period for the sudden Arctic warming, the most interesting question to be answered is: what has or may have triggered this climatic phenomenon? Neither Johannessen et al. (Johannessen, 2004), who recently assumed that the warming in the early part of the 20th century was probably a natural phenomenon, nor Bengtsson et al.(Bengtsson, 2004), who asserted that this climatic anomaly was probably a result of the influx of warmer water into the Barents Sea, can be of much help. Closer to the core issue came Polyakov et al. (Polyakov, 2004), with the conclusion:



A big change of mean winter temperatures at Spitsbergen could not have come from an influx of warmer water into the Barents Sea, or an increase of air circulation, but generated at the edge to the Arctic Ocean.

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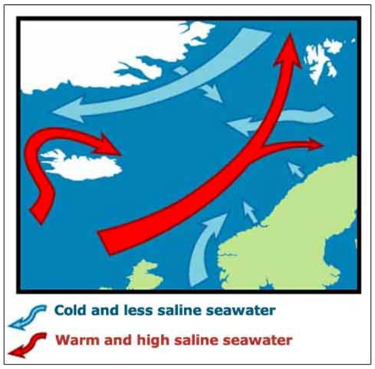
- This variability appears to originate in the North Atlantic and is likely to be induced by slow changes in the oceanic thermohaline circulation.
- However, SAT records demonstrate stronger multi-decadal variability in the polar region than at lower latitudes.
- This may suggest that the origin of the variability may lie in the complex interactions between the Arctic and the North Atlantic.

Although all three research papers come up with a ‘conclusion’, none of them realises that the results offer no consistent explanation at all. C.E.P. Brooks (op. cit, 1938) has already expressed his disagreement with regard to R. Scherhag’s assertion, made in 1936, that an increase of atmospheric circulation was the cause of the Spitsbergen warming, that this pushes the problem one stage back because one should still have to account for the change in circulation.

Polyakov et al. notion that the variability might have been induced *"by slow changes in oceanic thermohaline circulation"* also neglects completely the fact that there must have been a very sudden and dramatic change in the oceanic interior.



The West Spitsbergen Current transports warm waters into the Arctic Ocean, and the East Greenland Current transports very cold fresh water and sea ice southwards.
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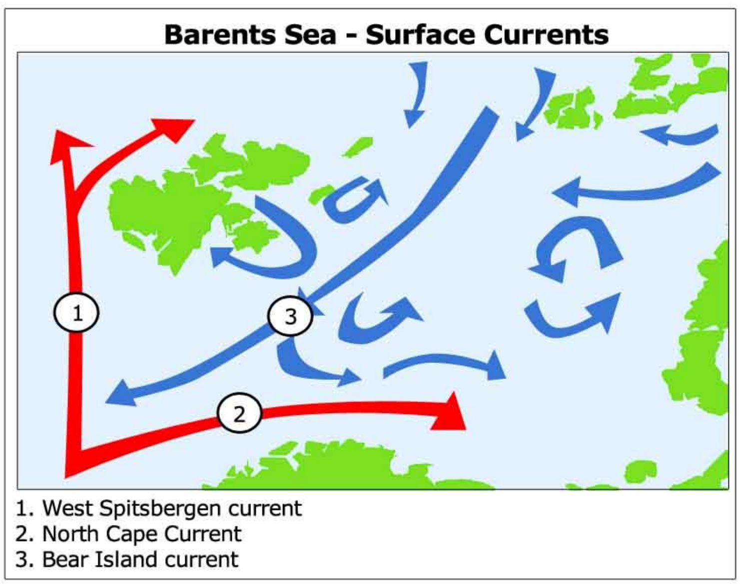
It is also difficult to agree with the affirmation sustaining that the *"variability may lie in the complex interactions between the Arctic and the North Atlantic".* The problem derives particularly from the word "interactions" because the overriding relation between the two oceans is the one-way transport of warm water to the Arctic basin. The West Spitsbergen Current transports warm Atlantic waters to north, through the Fram Strait into the Arctic Ocean, and, in the opposite direction, the East Greenland Current transports very cold fresh water and sea ice southwards. Actually, the higher any interaction at the time period in question, the less significant would have been the warming up of Spitsbergen.



The Barents Sea is in average less than 300m deep. It used to be ice covered by 2/3 in winter. The water body is exchanged over a four-year period. On its own it cannot sustain a longer warming period.
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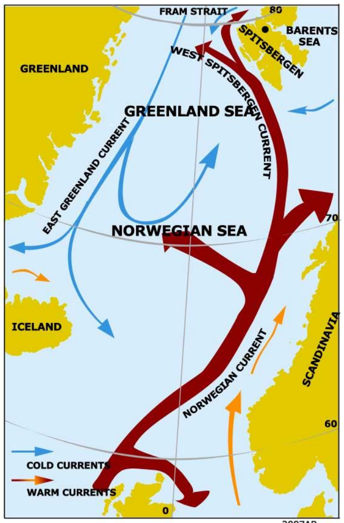
Finally, it should be stressed that the sudden warming phenomenon was definitely not generated in the sea areas from the North-West, North and North-East of Spitsbergen (80˚ N) for the simple reason that they had been permanently covered in sea ice, which at least would have prevented a very sudden air temperature jump during the winter season of 1918/19, and the subsequent winters until ca.1922.

Oceanic potential – Oceanic impact

What is still open for the discussion is the source of the winter warming from Spitsbergen, respectively the role the Norwegian- and Spitsbergen Current played. When the Spitsbergen Current reaches the shelf of Spitsbergen (ca. 79°N), it splits in two and passes the West and



At Spitsbergen arrives very warm and saline water in a very cold environment.
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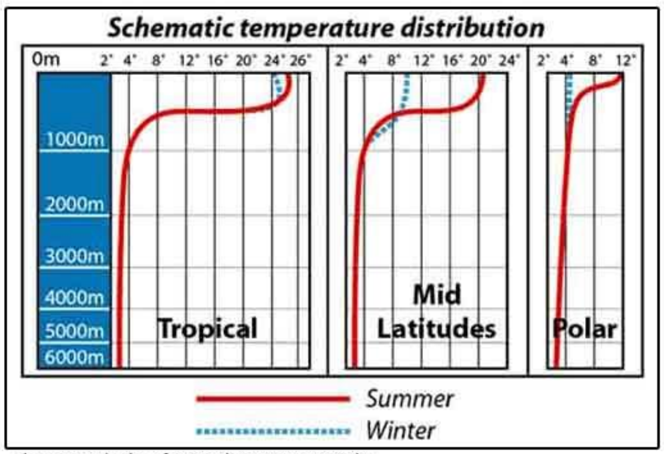
the East of Spitsbergen, to sink, eventually, into the Arctic Basis. The incoming water is relatively warm (6 to 8°C) and salty (35.1 to 35.3%) and has a mean speed of ca. 30 cm/sec^{-1}.

After having reached the Spitsbergen region, the warm current goes through a series of highly complex processes. As no ocean observing systems were in place in the late 1910s, any theoretical analysis would hardly bring any relevant results because there are too many components involved in the transformation process of the warm Atlantic water into cold Arctic Ocean water. At the sea surface, major components are air temperature, wind, waves, sea ice, ice motion and rain- or melt-water. Below the sea surface, there are only two components, which might represent overriding forces on ocean dynamics: seawater temperature and its degree of salinity. Density, the third major component, becomes a significant factor only at much greater depths.



The principal rules of ocean dynamics are simple:
_Warm water is lighter than cold water.
_Salty water is heavier than less saline water.
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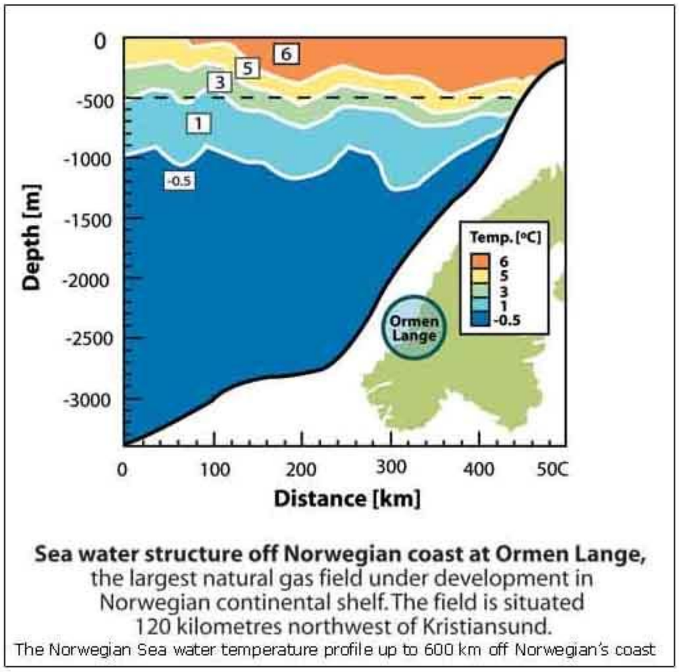
While the water temperature and the salinity for internal oceanic dynamics is generating forces in every ocean water around the globe, the matter is particular crucial with regard to the Spitsbergen Current. There is no other place as 'sensitive' as this one. Very warm and saline water arrives in a very cold environment. Nevertheless, the principal rules of ocean dynamics are simple:

- Warm water is lighter than cold water.
- Salty water is heavier than less saline water.

These two components allow uncountable variations and the sea areas around Spitsbergen have an increased range of variability.

Finally, we have to take into account the 'capacity' issue and the fact that the warming at Spitsbergen was the most pronounced during the winter. In winter, the importance of the ocean role for the supply of the atmosphere with heat becomes much more obvious. And here it comes in discussion the capacity issue. In average, a sea surface layer of mere three metres holds the same heat as an entire air column of 10,000 metres. One can explain it with a 'one-degree-image'. If 1° of heat is taken out of the upper three-metre of the sea surface layer, the entire atmosphere above warms up with one-degree. This is a relation which stresses out the importance of the transfer of the warm Atlantic water into the Polar region.



The image location is only 500 km north of the North Sea with a complex temperature structure in the upper 500m surface layer.
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One need only to pay attention to the interesting ice-cover charts for April 1918 and 1919, which show that towards the end of the winter season the open sea area is reduced to a small percentage of about 10-20%. The section from were high winter temperatures could have only been released from an open sea area is the SW-sector of Spitsbergen, and that is the section where the West Spitsbergen Current transports the warm and saline Atlantic water towards the permanently ice-covered Arctic Basin.

The ice-free sea area during winter 1918/19 from which the big Spitsbergen warming must have been generated

The sudden warming could have been caused only by either the warm Atlantic water or a big change in the 'dynamics' of the water body of the Nordic Sea.
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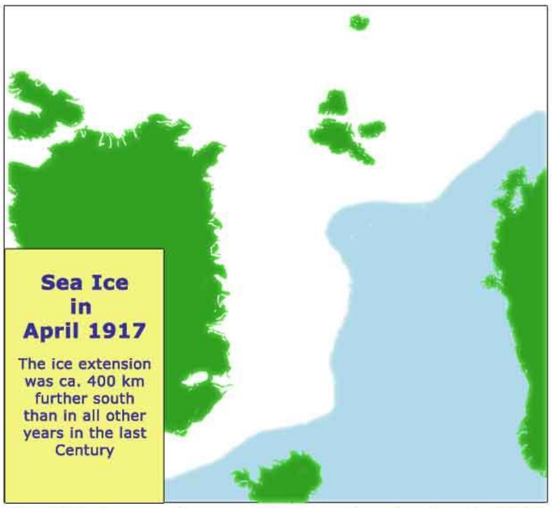
The sudden warming at Spitsbergen after the winter of 1918/19 could have been caused only by one distinct force: the sea, which, in this case, needed an additional forcing mechanism, namely either the warm Atlantic water or a big change in the 'dynamics' of the water body of the Nordic Sea. It could clearly be indicated that the sea areas around Spitsbergen in combination with the West Spitsbergen Current flowing into the Arctic Basin had been the sole driving force of the sudden Arctic warming in the early 20th century.

CAN WWII HAVE CAUSED THE SPITSBERGEN WARMING?

Which are the potential forces available?

Around the winter of 1918/19, nature had run its normal course. No 'natural' event, as asserted by Johannessen et al (op. cit, 2004), which could have affected the natural commons, had been observed around Spitsbergen or at a global level. There was no significant earthquake, no eruption of a forceful volcano, no tsunami, no sunspots, and no big meteorite fell on the continent or into the sea. As previous analysis showed it, there was no hot spot in the atmosphere, from which warm air could have been transferred to Spitsbergen, causing a very pronounced warming and sustaining the phenomenon for such a long time. In so far, the only conclusion is that the sea areas around Spitsbergen must have undergone dramatic changes in a very sudden and unexpected manner.



The third year in war the sea ice in April 1917 was the most extended during the whole 20th Century. Did naval war do it?
Did the subsequent melting change the flow of the Spitsbergen Current within the next ca.18 months?
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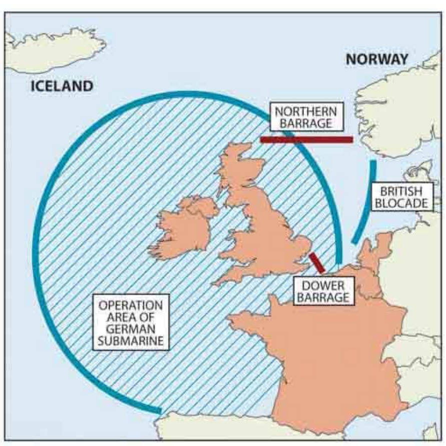
It is furthermore evident that the Spitsbergen event was, in the common sense of the word, 'unnatural', as science has never recorded a similar situation again. To quote Birkeland once again, this rise had been probably the greatest yet known on earth. As there was no extraordinary event in the space, in the atmosphere or in the common ocean behaviour observed which might have caused this special phenomenon, it is reasonable to think about a causational force never experienced before: the First World War. Highly destructive forces had been fighting in the air, on land and at sea, in Europe, from August 1914 until November 1918, when the big warming at Spitsbergen began to manifest itself.

Naval War, a force to recon



Huge water masses in Western Europe seas were churned upside-down. The Norwegian Current transports these water masses northwards, to Spitsbergen.
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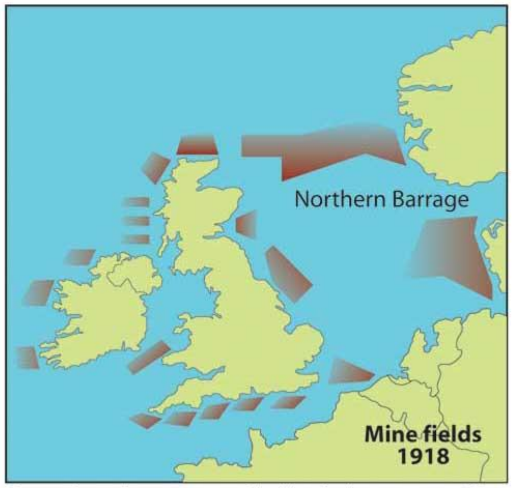
WWI had destructive effects on men and on the environment, but nothing changed the commons of nature as much as the naval war did. This notion derives from understanding that the oceans, together with the sun, determine the status of the atmosphere on a short, medium or long term. The author of this paper has suggested and discussed this matter in a number of publications since 1992 (Bernaerts). The impact of naval warfare on the ocean environment is in so far unique because it includes two principal aspects: one which is destructive to men, ships, and materials, and another one which is changing the temperature and salinity structure of the seas, where naval activities have taken place.

The second aspect is certainly not the only one, which might have had a significant impact on the interior of the seas in question, but it is, presumably, the most important one. Particularly sea surface layers of 50 metres depth and shallow seas (like the North Sea) are highly complex entities, always under permanent change due to season, wind, rain, river water, melt water, ice, and so on. Huge water masses in Western Europe seas were churned upside-down. The Norwegian Current transports these water masses northwards, to Spitsbergen. The temperature and salinity structure of the water had certainly changed its composition.



Sea mines became available in large quantity since summer 1916 and about 200.000 were placed, 80.000 at the outlet of the North Sea.
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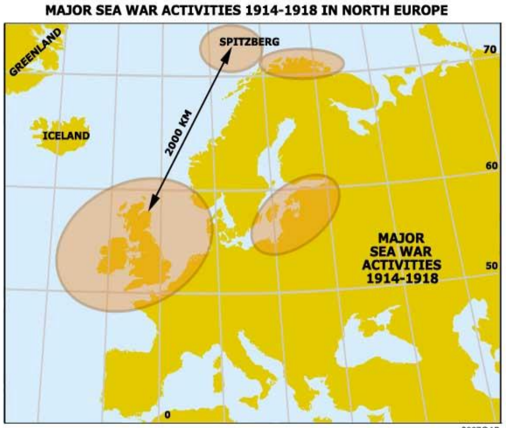
How close was the naval war to Spitsbergen?

Naval war during WWI was highly concentrated in the seas around Great Britain. The distance between Spitsbergen and the main naval battleground was of about 2000 km. But this distance is not very significant in this case. The currents moving through the Norwegian Sea and along the Norwegian coast consist of water from the Gulf Current, from continental rain/melt water, and water from the North Sea.

MAJOR SEA WAR ACTIVITIES 1914-1918 IN NORTH EUROPE



The transport of surface water into the high North can be accomplished within a couple of weeks or several months.
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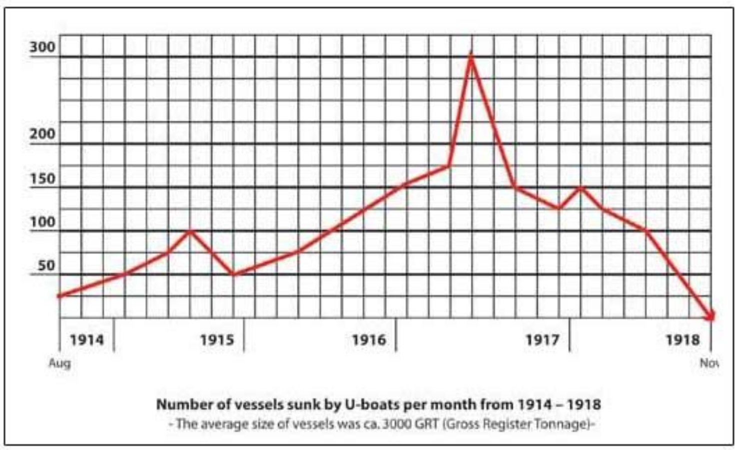
- The branch of the North Atlantic Current has temperatures exceeding 6°C and salinity greater than 35. Norwegian Coastal Current flows closer to the coast of Norway in the upper 50-100 m of the water column with lower temperatures than the Atlantic branch and low-salinity water, less than 34.8.
- The average speed of the coastal current is in the range of 0,7 to 1 km/hour (max. 115 cm/s), while the speed of the Atlantic Gulf water further off the coast is in the range of 0,7 to 2,2 km/hour (max. 85 cm/s), and even under northeast wind condition, the average speed is calculated with 1 km/h.

While the Atlantic branch current needs some time to cover the distance between Scotland/Shetland Is. and Spitsbergen (ca. 1500km), the transport of surface water into the high North can be accomplished within a couple of weeks or several months. All mentioned timing illustrates perfectly the 'connection' between WWI and Spitsbergen warming, as it will be further explained.

Forcing potential of naval war during WWI

Timing and ship losses. Although WWI started in August 1914, naval war began in earnest only two years later, when a series of new weapons were put in use: sea mines, depth charges, new sub-marines, and airplanes. By then naval warfare had reached a destruction stage to which no one might have thought of only two years earlier. The situation became dramatic when U-boats destroyed more ships than Britain could build in early 1917. In April 1917, the same total rate of the previous annual rate of 1916, ca. 850,000 tons, was destroyed by U-boats. In April 1917, Britain together with the Allies lost 10 vessels every day. During the year of 1917, U-boats alone sank 6,200,000 tons, which means about 4000 ships, and, during the war months of 1918, another 2,500,000 ship tonnage. The total loss of the Allies ship tonnage during WWI is of about 12,000,000 tons, namely 5,200 vessels. The total loss of the Allies together with the Axis naval vessels (battle ships, cruisers, destroyers, sub-marines, and other naval ships) amounted to 650, respectively 1,200,000 tons.



Number of vessels sunk by U-boats per month from 1914 – 1918
- The average size of vessels was ca. 3000 GRT (Gross Register Tonnage)-

Although WWI started in August 1914, naval war began in earnest only two years later, when a series of new weapons were put in use: sea mines, depth charges, new sub-marines, and airplanes.

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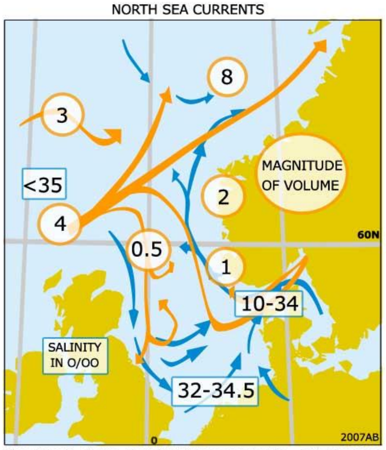
NORTH SEA CURRENTS



The image shows usual water movements, but the seas in Western Europe were 'churned and turned' by naval war for many months.

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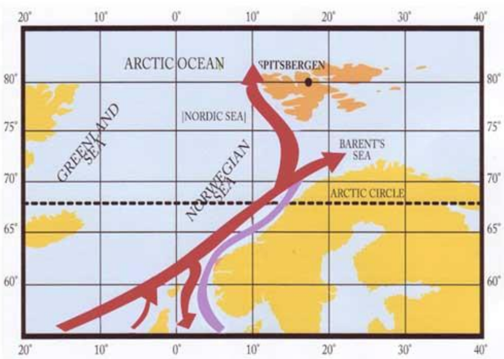
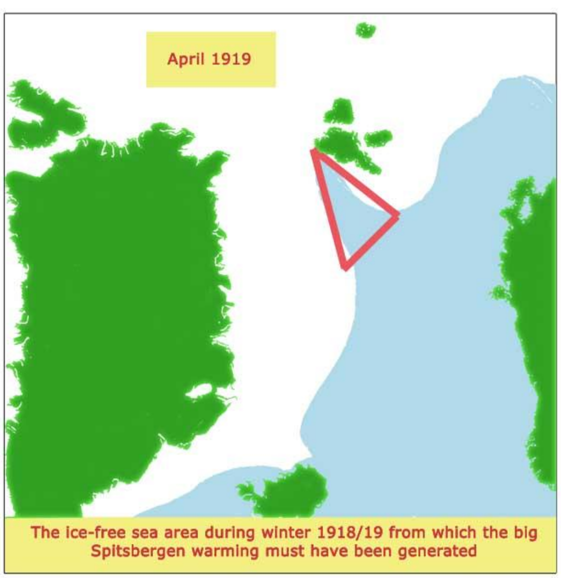
A weapon scenario churning the seas. The weapon scenario employed since 1916 is too complex to make a full assessment. Many figures are even impossible to quantify. The air force, for example, went through a great development. Airplanes were increasingly used in bombing and attacking missions over the sea. But it would be a mere speculation to try to indicate the number of bombs, which fell and exploded above or under the sea surface. We can say the same for the torpedoes activated or for the depth charges dropped upon the submarines, certainly many ten thousands of them. More detailed information is available about the sea mines. Sea mines were planted massively in the water column as soon as they became available since 1916. A total of about 200,000 sea mines had been deployed. Of much



powerful effect in churning the sea on a huge scale were those ships known under the name of minesweepers, which navigated the seas day and night to find and destroy the mines. Britain alone had more than 700 operational minesweepers; the Germans came close, too.

Churning the sea. War matters are usually quantified on the basis of costs and destruction caused to soldiers, population, buildings, industries, material, etc. Whether the water masses of a sea body have been turned up side down has never been of any interest. But that has happened on a grand scale. While in many cases seawater may have remained unchanged, temperature and salinity structure over a range of one metre to many dozen metres of surface water was always altered by any naval activity, whether there were weapons, sunken ships or mines planed or swept. Naval war at the magnitude of WWI means that many thousands of vessels navigated in defence-, combat-, or training missions, day and night. Battle ships had a draft of ten metres and could travel at a speed of 30 knots/hour (ca. 60 km/h). In addition, the wide range of other impacts should be at least mentioned. Most ships that were sunk transported a variety of cargo, and all of them had equipment and provisions on board. The total number could be somewhere in the range of 10-15 millions tonnes. It has been never quantified how much cargo and provisions surfaced and travelled with the currents towards the Arctic region and how the sea and sea-ice interacted with all that stuff - a matter that should not be ignored outright.



The naval war from1914 to 1918 can be considered as the most comprehensive single event. The coincident is prima facie evidence that naval war could have caused the warming.
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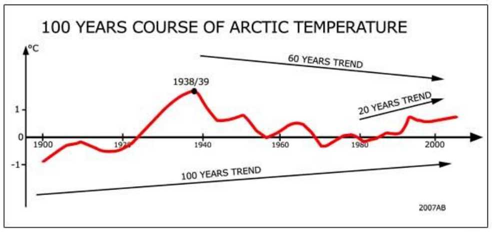
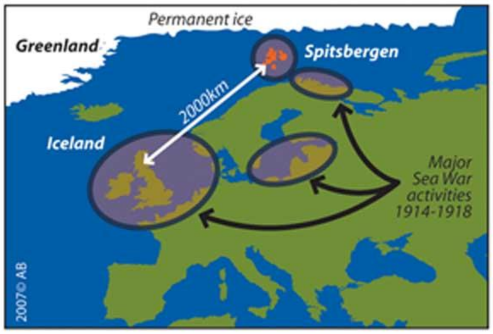
The connection between naval war and Arctic warming

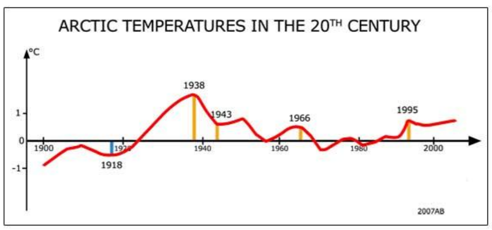
The naval war from1914 to 1918 can be considered as the most comprehensive single event in the late 1910s that has altered the common sea body structure around Great Britain through a huge variety of activities and means. In previous sections, we have proved that an extraordinary warming phenomenon took place at Spitsbergen. These two events are strongly connected by the timing of each event and by the current system linking the two locations. No other coincidence of such a close relation has ever been observed before or after WWI. The coincident is *prima facie* evidence that naval war could have caused the warming.

CONCLUSION





Major Sea War activities 1914-1918 in North Europe



To many climate scientists the Arctic warming remains "*one of the most puzzling climate anomalies of the 20th century*" (Bengtsson, et al., 2004). Yet, the phenomenon discussed here is not as puzzling as claimed. This investigation could establish that only the seas in the realm of Spitsbergen could have generated the sudden increase of the observed air-temperatures, and indicate the precise time period, namely the winter of 1918/19. This timing stands in extremely close relation with the naval war activities in Europe.

The investigation could furthermore demonstrate that there is a high possibility of a connection between the Arctic warming and the naval war in Europe from 1914 to 1918, due to the fact that the seawater current system and the war activities had torn sea areas literally to the front garden of the Spitsbergen region. Had the naval war of WWI occurred in the Spitsbergen area at a similar magnitude to that from the sea waters around Great Britain, no one would have ever questioned the interconnection between the Arctic Warming and the naval war, if not proven otherwise.

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