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The Circumstances of the Arctic Warming in the early 20th Century

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Abstract:

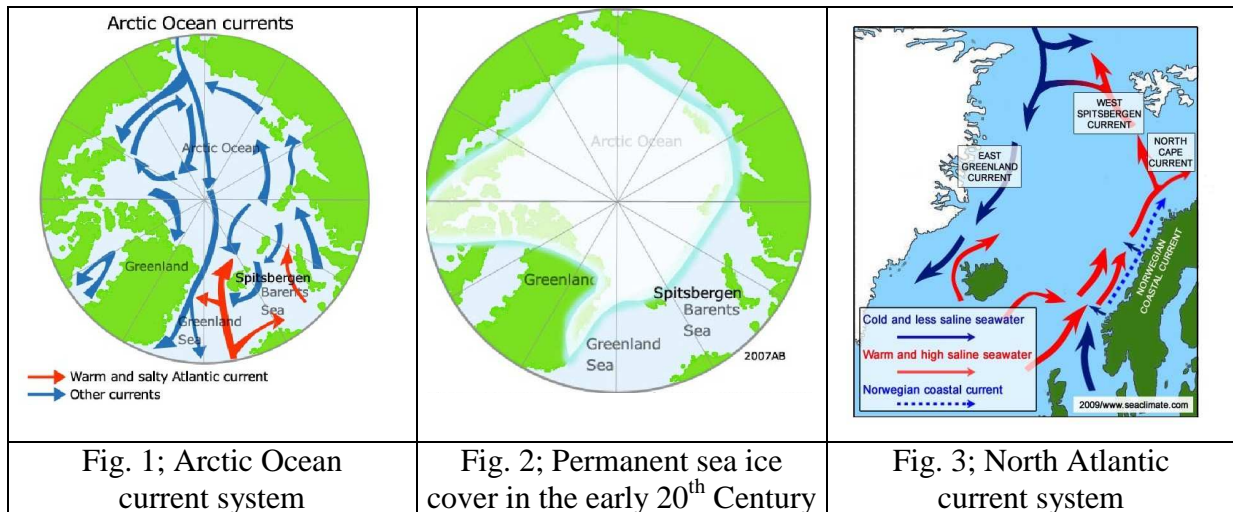
The Arctic has a crucial role in the world's climatic system, and global warming may have an amplifying effect. The recently observed thinning of the sea ice has alerted scientists and policy makers alike. That was quite different when a similar warming occurred 90 years ago, which is still regarded as one of the most puzzling climatic event during the last century. That needs not to be, if the situation is being viewed from an oceanic perspective, together with the fact that the winter air temperatures in the higher Northern Hemisphere are greatly influenced by the ocean, particularly in the North Atlantic, which is partly free of sea ice up to the Fram Strait. Here also ends the West Spitsbergen Current, a current which supplies the Arctic Ocean with warm and saline Atlantic water. Already back in 1920s air temperature observation showed a strong warming at Spitsbergen during the winter season. By analyzing the winter temperature profile of five coastal stations it can be demonstrated that the climatic shift at the end of the 1910s had been closest to Spitsbergen, allowing the conclusion that circumstances related to the West Spitsbergen Current have caused the early Arctic warming almost a century ago.

Introduction

The Arctic is an ocean. By the Fram Strait at about 80° North, between Greenland and Spitsbergen, it is connected with the Atlantic, which serves as a major gate for the supply of warm and saline water to the Arctic Ocean, which is coming with the West Spitsbergen Current. The subject of the paper is whether the warming in the early 20th Century has been caused here.

The term "circumstances" implies the observation or influence of "existing conditions". Here the use of the term shall mean the presentation of circumstances which rectify to draw certain conclusions concerning the period of Arctic warming in the early 20th Century on how it started and how it shaped up. The paper will cover both aspects, but with a clear priority for

the circumstances around the year 1919 when the warming started. The method of investigation will be explained in the second section of the paper, based on a general picture that will be presented first of all. The third section is about the “circumstances” which will analyze temperature records in the Northern North Atlantic realm that may provide clues concerning the location, the timing, and the likely source of the warming event, and thereon discuss the information.

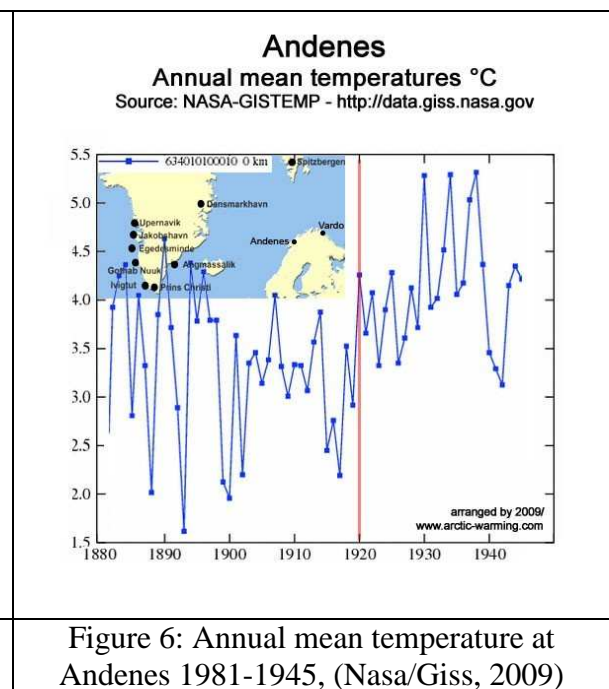
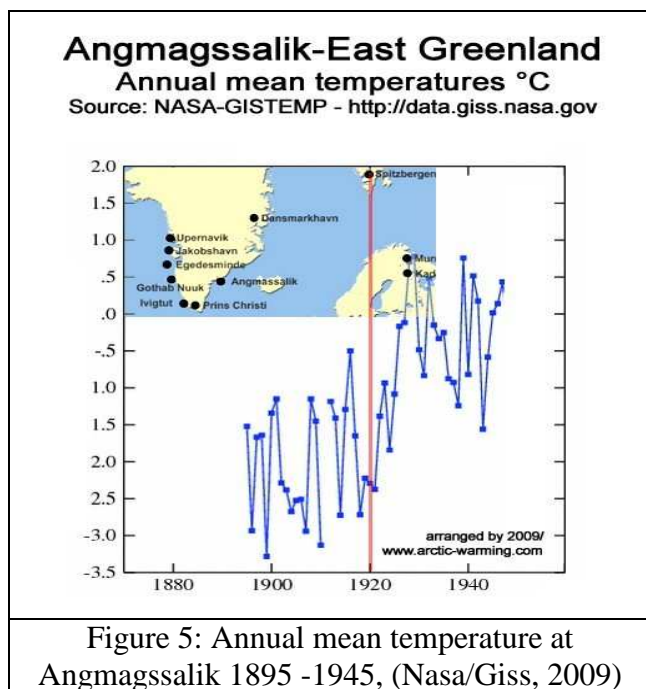
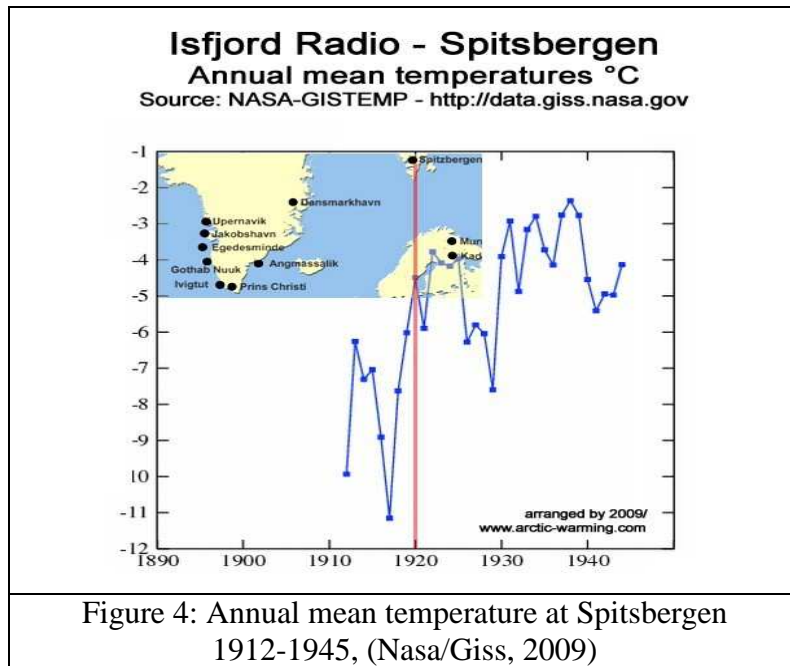


Arctic warming now and then

Overview

Nowadays the polar region is often mentioned, because the Arctic is currently experiencing a rapid warming with a dramatic loss of Arctic sea ice, which could be due to a combination of a global warming signal and fortuitous phasing of intrinsic climate patterns (Overland, 2008:289). The rapid warming is likely to be anthropogenic (IPCC, 2007b:83, 86). According to Serreze et al.: “Rises in surface air temperature (SAT) in response to increasing concentrations of greenhouse gases are expected to be amplified in northern high latitudes, with warming most pronounced over the Arctic Ocean owing to the loss of sea ice“, (Serreze, 2004). A recent U.S. government report concluded that the “temperature change in the Arctic is happening at a greater rate than at other places in the Northern Hemisphere and that the ice cover in the Arctic began to diminish in the late 19th century and this shrinkage has accelerated during the last several decades (US Geological Survey, 2009:486, 6). But the recent warming is the second during the last 100 years. The last IPCC report refers to a warm period from 1925 to 1945 (IPCC, 2007a:7), while an earlier report mentions a warming around the years 1920-1940 (IPCC, 1990:215). More to the point is the finding by Polyakov et al. that concludes: the warming during the 1920s –1930s was very fast in spring, autumn and winter, but much weaker and slower in the summer, while the period between 1918 and 1922 displays exceptional rapid winter warming (Polyakov, 2003:2072). Nevertheless the authors assume: that the complicated nature of the Arctic temperature and pressure variations is making the understanding of possible causes of the variability, and evaluation of the anthropogenic warming effect most difficult” (Polyakov, 2003:2076).

The general situation from the late 1910s to the 1940s is well illustrated by the annual temperature records from Spitsbergen, Angmagssalik, and Andenes (Fig. 4 to 6). They indicate a shift of the mean temperature level of approximately 1.5 to 3 degrees between the decade prior and after 1920, and that the period with an increased mean lasted until about 1940.



How is the EAW explained today

Although 90 years have passed since the earlier Arctic Warming (EAW) commenced, it seems that the issue is still one of the most puzzling climatic anomalies of the 20th century (Bengtsson, 2004:4055), and there are many questions not answered yet. Instead the matter is often sidelined by regarding it as:

- Natural variability is the most likely cause (Bengtsson, 2004:4045);
- We theorize that the Arctic warming in the 1920s/1930s was due to natural fluctuations internal to the climate system (Johannessen, 2004:341)
- The temperature anomalies are due primarily to natural variability in the weather system (Overland, 2008:81).

Such notions explain too little. The matter becomes even more critical if claimed without sufficient prove, for example: That the past 100 years are significant for the changeover of a climate system dominated by natural forcing to a climate system dominated by anthropogenic influences, as done recently by S. Brönnimann et al., while admitting that “Our understanding of the climate mechanisms operating in the Arctic on different timescales is still limited”. (Brönnimann, 2008: 3, 20) Is it helpful to dramatize the shrinking sea ice during a recent time period, if one is not fully aware of what happened in the early years of the last century?

Actually, few but sufficient air temperature data are available since long time. The paper will use them to show that the early warming was initiated and sustained over two decades by the West Spitsbergen Current, a branch of the Gulf Current in the North Atlantic. Naming the sea as the cause of the Arctic warming from 1919-1939 could help to understand better the current situation in the Arctic.

How was the EAW primarily recognized

On the 2nd of November 1922, The Washington Post published the following story: “Arctic Ocean Getting Warm; Seals Vanish, and Icebergs Melt”. The corresponding report in the Monthly Weather Review of November 1922 (Ifft, 1922:589) had also stated that the ice conditions in the Northern North Atlantic were exceptional; in fact, so little ice has never before been noted. Few years later the Spitsbergen data were published with the accompanying text saying that it is “Probably the greatest yet known temperature rise on earth (Birkeland, 1930:236). One of the first to investigate the EAW was R. Scherhag with two papers in 1936. The first he called “A remarkable climatic change across Northern Europe” (Eine bemerkenswerte Klimaänderung über Nordeuropa”) (Scherhag, 1936a:96), while the second draws the attention to the change of temperatures and atmospheric circulation during the previous 15 years since 1920, (Scherhag, 1936b:397).

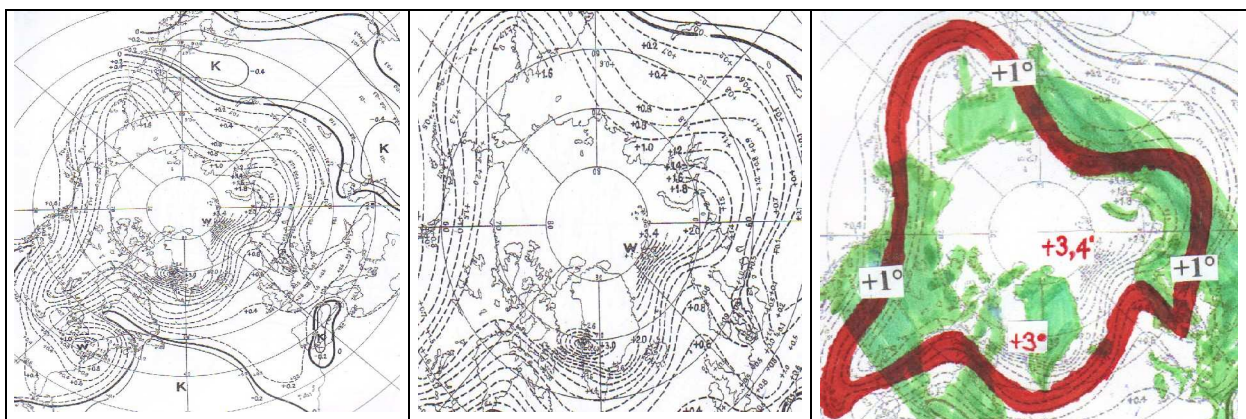


Figure 7a;

Figure 7b

Figure 7c

North Pole and Northern Hemisphere: The three images are of the same origin and concern the deviation from average of the November to March temperatures from 1921-1930 (Scherhag, 1936:Tafel 58)

From thereon the subject received considerable attention until the breakout of World War II. For example, after R. Scherhag had attributed the warming to a change in atmospheric circulation, his American colleague C.E.P. Brooks objected by saying:

“Attributing the recent period of warm winters to an increase in the strength of the atmospheric circulation only pushes the problem one stage further back, for we should still have to account for the change in circulation” (Brooks, 1938:30),

while explaining the general situation as follows:

“In recent years attention is being directed more and more towards a problem which may possibly prove of great significance in human affairs, the rise of temperature in the northern hemisphere, and especially in the Arctic regions. (Brooks, 1938:29)

The sea was practically only mentioned once by a Russian scientist informing the Royal Scottish Geographical Society in Edinburgh, on the 30th of January 1935:

“The branch of the North Atlantic Current which enters it by way of the edge of the continental shelf around Spitsbergen has evidently been increased in volume, and has introduced a body of warm water so great, that the surface layer of cold water which was 200 meters thick in Nansen’s time, has now been reduced to less than 100 meters in thickness“. (Schokalsky, 1936:77),

The WWII ended the lively discussion. As at the same time not only the exceptional warming in the Arctic ended, but actually the Northern Hemisphere went through a global cooling for three decades, the EAW was a non-issue for more than 50 years, only returning back on the agenda with the debate on global warming, and when the Arctic summer sea ice started to diminish significantly in the 1990s.

Scope and method of investing “Circumstances”

The EAW offers a unique opportunity to confine the analysis to two aspects concerning the warming from 1919-1939, namely with regard to the annual season and geographical localization.

Winter air temperature

Due to the lack of any sufficient sea surface temperature data (SST), the investigation will assess the warming conditions only by the use of surface air temperatures (SAT). It will furthermore confine the investigation to the winter season for two reasons.

- Only the winter seasons from 1919 to 1939 show a strong warming, while the increase during the summer periods is only modest.
- The direct influence of the sun can be neglected during the winter season. The sea, as far as not covered by sea ice is getting a dominating role during the sunless winter season.

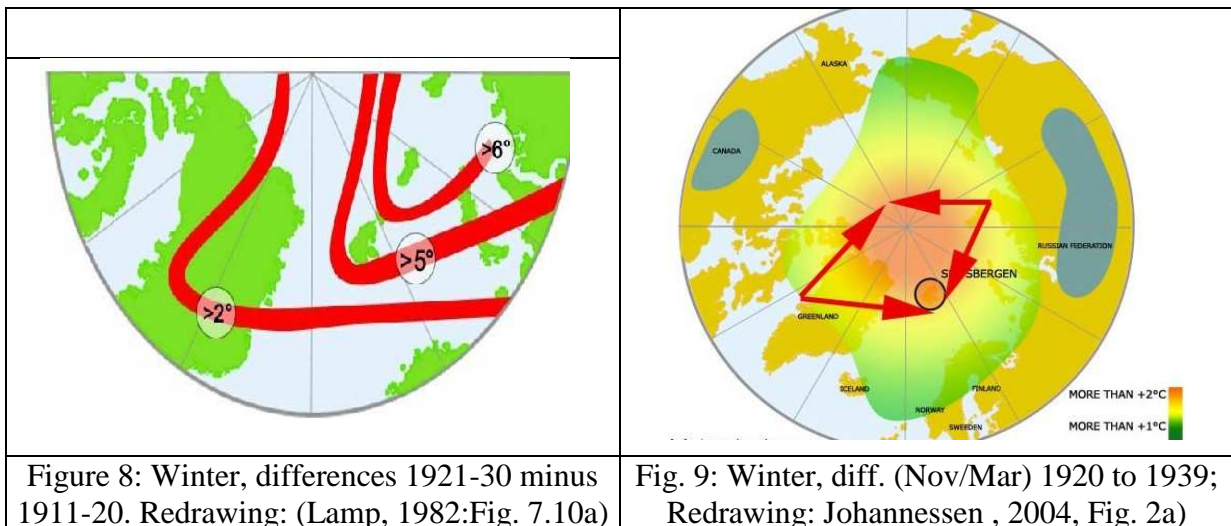
The reduced influence of the sun during the winter season is the pre-eminent factor. Instead, in the northern part, north of Iceland and the Shetland Islands, the ocean is providing the bulk of heat to the atmosphere. After all, higher temperatures must have been generated by something; either the rise had been observed in the location, or at another place, which could be identified, from where the heat had been transported to the place of measurement. For this purpose some coastal stations, in close reach to the sea, will be analyzed with regard to the timing and values of changes observed. Significant difference diversions, delays may rectify drawing not only the conclusion that the EAW generated in the North Atlantic, but also that it was generated by the West Spitsbergen Current.

The core period for the investigation are the years around 1918/1919 when the warming started. The suddenness of the shift could be one of the key indicators for the mechanism of the change. However as the number of stations eligible for such investigation is very limited, it seems advisable to present at first the EAW period from 1919 to 1939, so that the analysis of individual stations is seen in the wider context of the period.

Showing that the cause of warming had been due to the sea could possibly even answer the question concerning the “change in air circulation” (see above: Scherhag & Brooks), or the question a Russian scientist raised ten years ago: Why are the maximum climate fluctuations confined to the Atlantic sector of the Arctic?” (Zakharov, 1997:71). A higher heat release from the sea will inevitably influence the winter temperature and the atmospheric circulation, locally and in a wider region.

Geographical localization

It is furthermore reasonable to choose the region where the Arctic Ocean and the Atlantic meet, as it is acknowledged since the 1930s that the center of the warming had been here, as the material by Scherhag shows (Fig. 7a-c). Even more recent research confirm that the warming occurred during winter close to the Fram Strait and the pick was in the wider region of Spitsbergen, with a varying intensity from south-west Greenland to the Russian Island, Severnaya Zemlya, at 80°N and 100° East; see Figure 8 for the 1920s, and Figure 9 for two decades from 1920 to 1939.

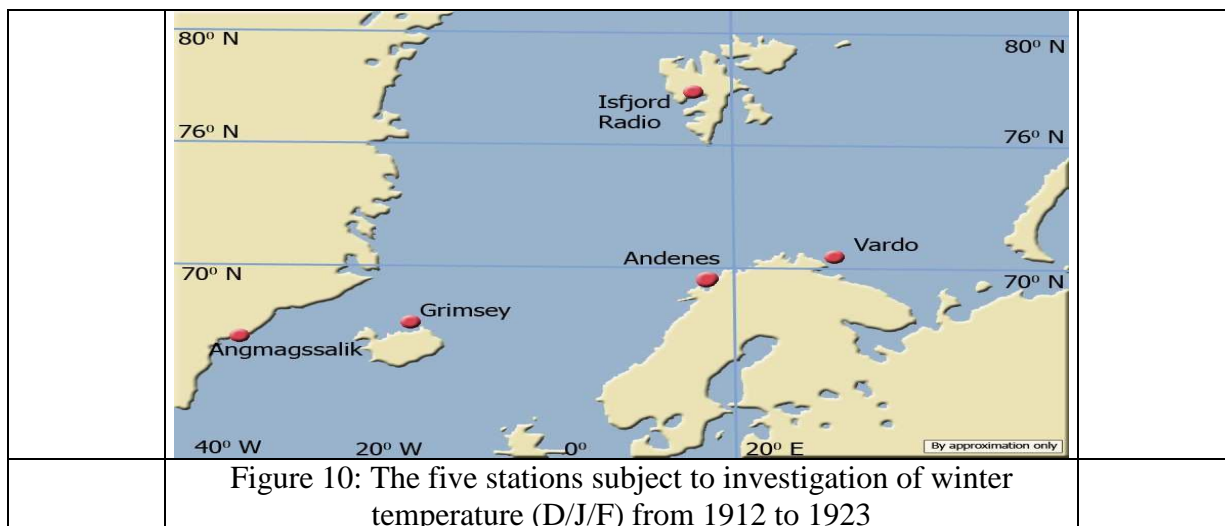


Furthermore, due to the fact that the Arctic Ocean used to be covered by sea ice one hundred years ago (Fig.2), a substantial increase of the air temperature during the winter season could not have been generated in ice covered areas, which makes it virtually impossible to transfer a great amount of heat from sea to the atmosphere within a short period of time. This is practically only available off Spitsbergen, with the most northern sea ice free area during the winter season. (Fig.11) On the other hand the lack of sufficient temperature data from the North Pole restricts the scope as well. Practically, north of app. 76°N only the Spitsbergen record since the 1910s is available, which start in 1912. (Fig.4)

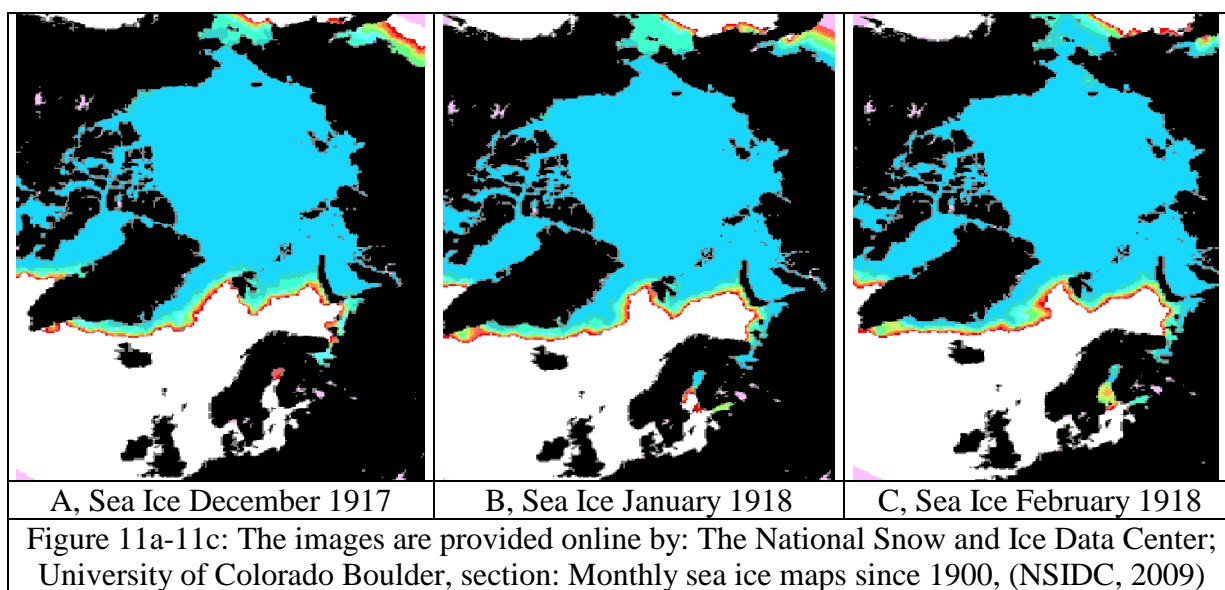
The Circumstances of the EAW

The selection of stations

In the Northern North Atlantic there are about one dozen stations which have a record covering the period prior the 1910s, some since 1880, provided online by NASA/GISS (Goddard Institute for Space Studies) by annual record plots, as reproduced in Figure 4-6, and “monthly data as text” (Nasa/Giss,2009) As it would not necessarily enhance the analysis if all available data records are presented, five representative stations have been selected for the Northern North Atlantic region, namely two from the western part (Greenland and Iceland), two the eastern part (Norway), and the Isfjord Radio station on Spitsbergen. See: Figure 10



Although all stations are close to the sea, they are not necessarily close to open water, due to very different sea ice conditions. This is particularly the case with regard to the eastern coast of Greenland where a current is moving cold water from the Arctic southwards. The maximum sea ice extend usually appears in April and may vary considerably from year to year. Insofar the sea ice conditions during winter 1917/18 (Fig. 11a-c) reflect an average situation.



The annual temperature trend from 1919 to 1939

On first view the annual record of the stations presented (Fig. 4 to Fig. 6) seem to be quite identical. Prior to the year 1920 all stations have a lower level of temperatures over the years shown than thereafter. At a second glance one can observe that prior to 1920 the lowest annual value differs between west and east of the North Atlantic. In the former it is 1918 and in the latter it is 1917. After these years all stations, except Angmagssalik, observe an increase of the values, which is very pronounced at the eastern stations, with a first maximum in 1920. At Grimsey the increase is modest. At Angmagssalik the value for 1920 is actually lower than in 1919. However, the increase of the annual values for two decades at all stations is not very impressive.

The temperature during the winter 1912 – 1923

The following Figures 12 to 16 show the combined figure for the winter months January, February and the previous December (D-J-F).

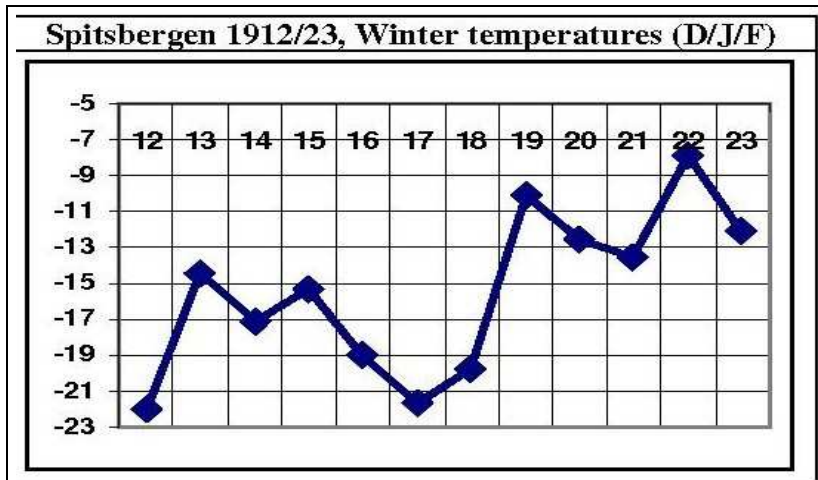


Figure 12; Spitsbergen – Isfjord Radio – winter temperatures (D/J/F) 1912 to 1923 (Nasa/Giss, 2009)

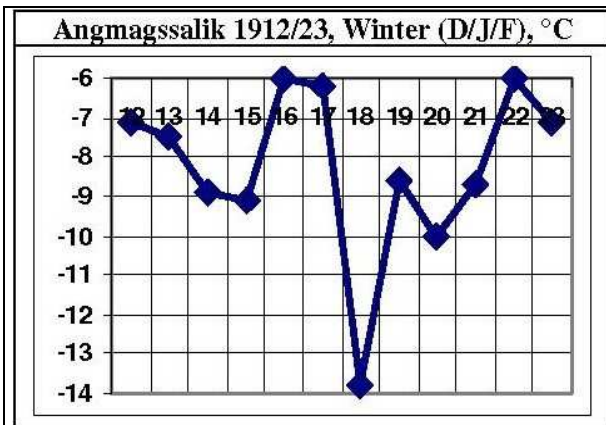


Figure 13; Angmagssalik, Temperatures (D/J/F) 1912 to 1923 (Nasa/Giss, 2009)

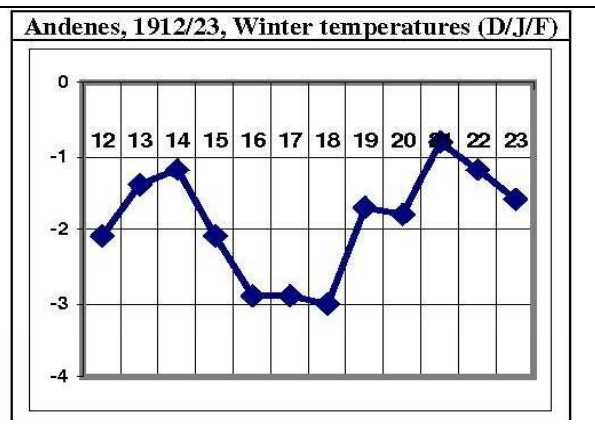


Figure 14; Andenes, Temperatures (D/J/F) 1912 to 1923 (Nasa/Giss, 2009)

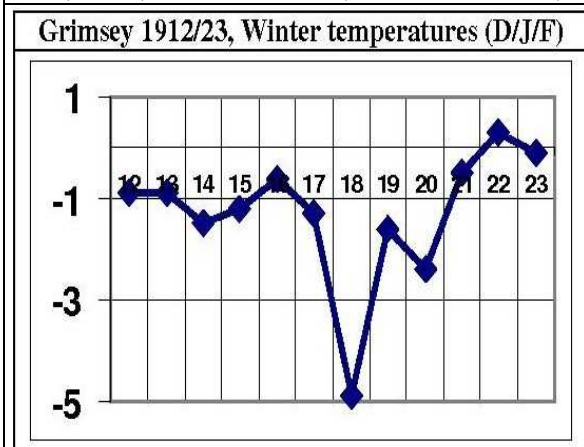


Figure 15; Grimsey, Temperatures (D/J/F) 1912 to 1923 (Nasa/Giss, 2009)

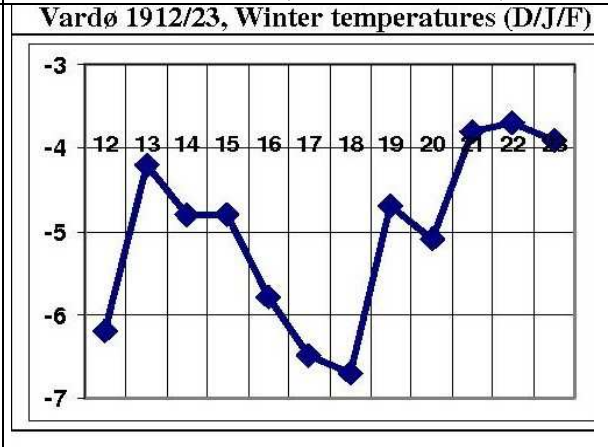


Figure 16; Vardø, Temperatures (D/J/F) 1912 to 1923 (Nasa/Giss, 2009)

Which are the general observations that can be made (without Spitsbergen)?

- At the Norwegian stations, there was, prior 1919, a longer period of cooling since about 1914.
- At the stations Angmagssalik and Grimsey the period from 1912 to 1917 remained in a moderate band, with only one big exception, in 1918. (see below).

Table 1: Winter temperatures from 1912 to 1923 at five stations (see. Fig.9)

Angmagssalik Greenland: 66°N, 38°W				Grimsey Iceland : 66.5°N, 18.0°W				Spitsbergen Isfjord R. 78°N,14°E				Andenes Norway : 69°N, 16°E				Vardø Norway: 70.4°N, 31.1°E			
YEAR	JAN	FEB	D-J-F	YEAR	JAN	FEB	D-J-F	YEAR	JAN	FEB	D-J-F	YEAR	JAN	FEB	D-J-F	YEAR	JAN	FEB	D-J-F
1912	-4.9	-10.6	-7.1	1912	0.3	-3.5	-0.9	1912	-21.4	-24.1	-22.0	1912	-2.7	-5.1	-2.1	1912	-7.0	-10.0	-6.2
1913	-7.3	-8.0	-7.5	1913	-0.7	-1.0	-0.9	1913	-14.0	-18.5	-14.4	1913	-1.5	-1.3	-1.4	1913	-3.4	-5.3	-4.2
1914	-5.1	-12.3	-8.9	1914	0.1	-3.8	-1.5	1914	-20.0	-19.9	-17.1	1914	-1.2	-1.1	-1.2	1914	-6.2	-4.8	-4.8
1915	-7.1	-12.8	-9.1	1915	-0.7	-2.3	-1.2	1915	-12.5	-17.3	-15.3	1915	-2.6	-3.5	-2.1	1915	-5.5	-6.0	-4.8
1916	-6.5	-6.7	-6.0	1916	-0.3	0.3	-0.6	1916	-21.6	-14.7	-19.0	1916	-1.2	-1.2	-2.9	1916	-5.3	-4.5	-5.8
1917	-2.5	-5.8	-6.2	1917	0.5	-0.6	-1.3	1917	-20.4	-25.3	-21.7	1917	-2.0	-4.2	-2.9	1917	-6.0	-9.2	-6.5
1918	-14.8	-13.0	-13.8	1918	999	-4.9	-4.9	1918	-24.4	-17.2	-19.8	1918	-5.1	-1.6	-3.0	1918	-9.5	-5.8	-6.7
1919	-4.1	-14.9	-8.6	1919	-0.3	-3.5	-1.6	1919	-5.7	-19.7	-10.1	1919	-0.4	-4.1	-1.7	1919	-4.1	-7.0	-4.7
1920	-10.9	-13.0	-10.0	1920	-3.5	-2.7	-2.4	1920	-10.5	-15.4	-12.5	1920	-1.5	-0.9	-1.8	1920	-6.2	-4.3	-5.1
1921	-10.9	-6.2	-8.7	1921	-3.9	1.5	-0.5	1921	-15.1	-16.7	-13.5	1921	-2.8	-0.9	-0.8	1921	-5.4	-4.8	-3.8
1922	-4.6	-6.7	-6.0	1922	0.9	1.1	0.3	1922	-3.8	-9.9	-7.9	1922	-1.7	-1.4	-1.2	1922	-4.2	-3.8	-3.7
1923	-11.5	-5.9	-7.1	1923	-2.3	0.5	-0.1	1923	-11.0	-12.0	-12.1	1923	-0.6	-2.1	-1.6	1923	-2.7	-4.6	-3.9

What is particularly significant regarding the Spitsbergen data?

- A much higher range of temperature variations (10°C between 1918 and 1919) towards the other stations (e.g. Vardø ca. 2°C).
- In January 1919 the mean was as low as -5.7°C, while the pervious years had been well below -20°C (except 1915, -12.5°; and 1913, -14°C). From thereon the January mean got warmer (e.g. in 1922, -3.8°; and 1933, -2.3°). The following table shows that the other stations are quite distinct from Spitsbergen in this respect.
- **Table 2; A comparison of the January 1919 with the years 1916 to 1918 at five stations (Fig. 9).**

Spitsbergen	Angmagssalik	Grimsey	Andenes	Vardø
1916 -21.6	1916 -6.5	1916 -0.3	1916 -1.2	1916 -5.3
1917 -20.4	1917 -2.5	1917 0.5	1917 -2.0	1917 -6.0
1918 -24.4	1918 -14.8	1918 (999)	1918 -5.1	1918 -9.5
1919 -5.7	1919 -4.1	1919 -0.3	1919 -0.4	1919 -4.1

The low D-J-F 1918 month figure at Angmagssalik and Grimsey

While the time period from 1912 to 1917 corresponds largely with the data from 1920 to 1923, the 1918 value with -13.8°C is surprising and unique in the data record since 1895. The previous coldest winter 1896 was -11°C. The enormous temperature variation at these stations in 1918 is confirmed by three other Iceland stations. For example, with regard to Reykjavik, the D-J-F figure is for the years: 1917 (-0.3°); 1918 (-3.5°); 1919 (-0.8°), and 1920 (-2.5°), showing the next negative figure only ten years later in 1931 (-0.3°). However, any correlation with the start of the arctic warming seems remote. Here we can only guess that the low temperature had been supported by a temporary and regional change of sea surface temperatures, which might have been enhanced by colder water in the Northern North Atlantic that had also bought colder conditions to the Norwegian stations and Spitsbergen over the brief period of time from about 1914 to 1918.

Spitsbergen compared with Andenes and Vardø

On first glance, the temperature trend at the three stations looks as if there is little to comment. The general trend is quite comparable, although it is noticeable that the cooling

phase prior 1920 had ended at Spitsbergen in 1918, and one year later at Andenes and Vardø, in 1919.

Furthermore the figure value of changes is remarkable different. Although it seems to be a very modest aspect, with regard to the prevailing sea current system in the region, presumably it is of considerable relevance. Actually, all three locations are directly connected to the warm North Atlantic Gulf Currents. Along the coast of Andenes is the Norwegian Current, which separates here into the West Spitsbergen Current carrying warm water northwards to the Arctic Ocean, and the North Cape Current moving eastwards with warm water for the Barents Sea. As all three stations are in a very close distance to the warm water currents mentioned, the huge difference in the change of temperature is remarkable. Furthermore, the distance between Spitsbergen and the two continental stations is with less than 1,000 kilometers, not only quite modest, but due to the considerable speed of the currents, the water needs from Andenes to Vardø, and Spitsbergen only a few weeks. Insofar one could have expected a much less difference between the north and the south, a matter which will be raised in the next section again.

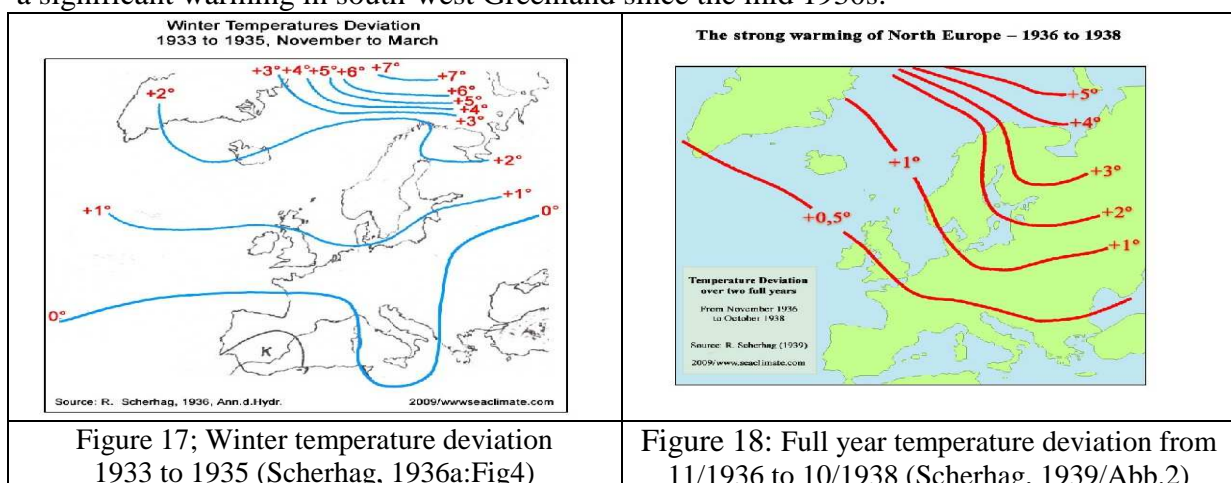
The situation at the West Coast of Greenland

One Scherhag figure (Fig. 7) indicated that there was a warming at the South-West coast of Greenland from 1920 to 1930 as well. The station Godthab Nuuk, which is representative for few other West Coast stations, shows a temperature shift starting with the year 1923 (Table 3). The succeeding two years, 1921 and 1922, had been below the previous average.

**Table 3; Godthab Nuuk, West-Greenland (64°N, 52°W),
Winter temperature (D-J-F) 1912-1941; Source: NASA/Giss.**

YEAR	D-J-F	YEAR	D-J-F	YEAR	D-J-F	YEAR	D-J-F	YEAR	D-J-F
1912	-7.7	1918	-9.0	1924	-6.0	1930	-9.0	1936	-3.9
1913	-8.0	1919	-8.2	1925	-11.2	1931	-6.3	1937	-10.2
1914	-10.9	1920	-8.9	1926	-4.9	1932	-7.1	1938	-8.4
1915	-10.7	1921	-10.3	1927	-6.7	1933	-8.2	1939	-7.8
1916	-6.5	1922	-11.7	1928	-7.2	1934	-7.9	1940	-4.7
1917	-2.9	1923	-7.2	1929	-3.7	1935	-8.0	1941	-4.2

The warming period since 1923 is modest and rather short, lasting only until the early 1930s. Two further figures published by Scherhag, here redrawn (Figure 17 and 18); do not indicate a significant warming in south-west Greenland since the mid 1930s.



The situation in the east of Vardø

Concerning the full time period in question, from the late 1910s to 1940, it is not easy to assess the situation during the initial years of the period, while a substantial warming during

the 1930s is well established for many decades. With reference to the Scherhag figure (Fig.7) the 1920s indicate only a modest rise of the winter temperature, which can be attributed to the increase at Spitsbergen and Greenland and carried from there with the Jet-Stream eastwards to Severnaya Zemlya Island and beyond. This explanation is not sufficient for the strong warming in the east of Spitsbergen during the 1930s, which is not only confirmed by the Scherhag figure (Fig. 17 & 18), but also by Figure 8 which is based on an image published by H.H. Lamp in 1982. The strong warming since the mid 1920s was presumably enhanced by Atlantic water that had entered the Arctic Ocean, and moved eastwards along the continental shelf in the Nansen Basin. Due to observation by Polyakov et al. that a sea water anomaly would need app. 4 to 5 years to reach the Laptev slope (Polyakov, 2005:1), which is immediately east of Severnaya Zemlya Island. However, it can not be excluded, that an impulse came also by the North Cape Current via Barents Sea and Kara Sea. As there is no indication what so ever, that any heating potentials had been in this region prior the warming at Spitsbergen, the issue is here not further scrutinized.

Discussion

The basis for discussing the matter is the widely acknowledge fact that the center of the Arctic warming in the early 20th Century was Spitsbergen, covering a region from south-west Greenland to the Russian Island Severnaya Zemlya. This was at least the situation in the initial phase. It is therefore possible to concentrate fully on the circumstances of the warming, with regards to when and why.

There is no information available about a region or location with a substantial or noticeable heating potential from where the rise of winter temperature at Spitsbergen could have been evoked at the end of the 1910s. That applies for the Northern Hemisphere in general as well as for the North Atlantic in particular. Although all investigated stations have registered a warming after 1919, but in no case, earlier than at Spitsbergen. At the Greenland/Iceland stations the change in winter temperature was modest and manifested only after 1920. With regard to the station in the very north of Norway, the increase from 1918 to 1919 by 1.5° to 2.5° hardly permit to call this a heating potential, when at the same time the rise at Spitsbergen was 10°C. That may already serve as a first indication that a change in air circulation, as claimed by Scherhag (see above) is a rather weak argument. Furthermore, after 1919, the temperatures at Andenes and Vardø, between 1920 and 1923, (Fig. 14 & 15 and Fig. 6) leave little room for the anticipation that heat could have been transferred from here to the north. At Andenes the rise lasts only until 1921 and the figures are lower in the next two years. At Vardø the figures are neutral, while Spitsbergen records his highest figure in 1923. However not the trend during the initial years, but the fact that the trend at Spitsbergen did not limped behind Andenes and Vardø is remarkable, and that the heating potential and the continental stations was in no way excessive. The higher temperatures have also not been generated in Europe; see Figures: 8, 9, 17 and 18. This can be a clear indication that the volume of warm Atlantic water traveling northwards with the Norwegian Current did not increased during the time period in question. Actually some time ago the IPCC (IPCC, 1990: 228) noted:

“Stronger westerlies over the Atlantic do not, therefore, account for the Arctic warming of the 1920s and 1930s on their own: in fact they preceded it by 20 years.”

As the source that caused the Arctic warming in the early 20th Century must be placed in the north of Iceland and Scandinavia, only the sea between Andenes and Spitsbergen remain. As Norwegian Sea could not have generated extra heat during the winter season without heat

supply from elsewhere, the Arctic warming since 1919 is the result of changes in the system of the West Spitsbergen Current. But how did it come about? As the matter had never been investigated, finding a complete answer looked bleak only few years ago. But could that change in the near future if one takes notice of what Dmitrenko et al. said about their assessment of the current situation in the Arctic last year, May 2008, of which we reproduce an excerpt here without any further comment:

“We document through the analysis of 2002-2005 observational data the recent Atlantic Water (AW) warming along the Siberian continental margin due to several AW warm impulses that penetrated into the Arctic Ocean through Fram Strait in 1999-2000. The AW temperature record from our long-term monitoring site in the northern Laptev Sea shows several events of rapid AW temperature increase totaling 0.8°C in February-August 2004. We hypothesize the along-margin spreading of this warmer anomaly has disrupted the downstream thermal equilibrium of the late 1990s to earlier 2000s.” (Dmitrenko, 2008:Abstract);

Despite the great shortcomings in knowledge about the way the Spitsbergen Current changed during the first decades of the last century; one aspect may provide a hint, namely the suddenness. All presented temperature plots record a fairly modest variation, before it came to a very brief cooling around 1916 to 1918, after which a very brisk temperature rise occurred at all stations. The rise between 1918 and 1923 actually resulted in a shift of level. The annual temperature figure for three stations (Fig. 4 to 6) demonstrate very clearly that the level before 1920 was significant lower than after 1920. This sudden shift gives the observation by Schokalsky (see above) special weight, whereby the thickness of the cold sea surface layer of 200m in Nansen’s time (about 1893-1896) has been found reduced to less than 100 meters in thickness about 40 years later. This would release more heat to the atmosphere. But as mentioned already, the warming prior 1920 was very modest, which could mean that the status of the surface layer had been fairly constant. This consequently allows the conclusion that the thinning of the cold surface layer came very suddenly and during a brief time frame, from 1918 to 1923. Already in 1922 The Washington Post could report: “Arctic Ocean Getting Warm; Seals Vanish and Icebergs Melt”.

Under the prevailing circumstances as elaborated here it seems rectified to account the change in circulation as source for the warming as claimed by R. Scherhag (see above), to the same source that generated significant warmer air temperatures at Andenes, Vardø, and Spitsbergen. It would be the account Brooks had asked for (see above).

CONCLUSION

The sudden warming of the Arctic in the early 20th Century is presumably not as puzzling as elsewhere assumed if investigated on three parameters, namely winter temperature observation in the region, the prevailing sea ice conditions, and the impact the sea has on air temperatures at high latitudes during the sunless winter season. The observed temperature profile at several representative coastal stations in the Northern North Atlantic, indicate that the most northern station on Spitsbergen observed the change into a warmer stage first and most pronounced. As this change came with an unknown suddenness, and the temperature increase had evidently not been carried from outside the Arctic Ocean and Northern North Atlantic into the Spitsbergen region, the source of the warming is the West Spitsbergen Current, which must have seen a substantial system shift within a very short period of time. Particularly the explosion of the temperatures and showing up in the subsequent winters until 1940 leave little room for any other option. The circumstances of the Arctic warming since

the winter 1918/19 are ocean related in general, and the West Spitsbergen Current in particular. How the shift came about so suddenly is not to be answered here, but the observation published by J. Schokalsky in 1936, that “the surface layer of cold water which was 200 meters thick in Nansen’s time, has now been reduced to less than 100 meters in thickness“, could have happened over a time period of 2-3 dozen years, but also within a period of several months. The sudden thinning of the sea surface layer in the high North could be an interesting starting point to bring more light in the early Arctic warming.

More about the EAW at: <http://www.arctic-heats-up.com/>

Bengtsson, L., Semenov, V.A., and Johannessen, O.M. (2004), “The Early Twentieth-Century Warming in the Arctic—A Possible Mechanism”, *Journal of Climate*, Vol. 17, pp. 4045-4057.

Birkeland, B.J. (1930), „Temperaturvariationen auf Spitzbergen“, *Meteorologische Zeitschrift*, Vol.47, pp. 234-236.

Brooks, C.E.P., (1938); “The Warming Arctic”, *The Meteorological Magazine*, Vol.73, pp.29-32.

Brönnimann, S., Ewen, T., Luterbacher, J., Diaz, H. F., Stolarski, R. S. and Neu, U. (2008) “A Focus on the Climate During the Past 100 Years”; Springer, Dordrecht.

Dmitrenko, I. A., Polyakov, I. V., Kirillov, S. A., Timokhov, L. A., Frolov, I. E., Sokolov, V. T., Simmons, H. L., Ivanov, V. V. and Walsh, D. (2008); „Toward a warmer Arctic Ocean: Spreading of the early 21st century Atlantic Water warm anomaly along the Eurasian Basin margins“, *Journal of Geophysical Research*, 113, C05023, doi:10.1029/2007JC004158. Abstract, viewed 26 May 2009, <http://www.agu.org/pubs/crossref/2008/2007JC004158.shtml>

Ifft, G.N. (1922), “The Changing Arctic”, *Monthly Weather Review*, Vol.50, p.589.

IPCC (1990); Houghton, J.T., Jenkins, G.J., Ephraums, J.J. (ed); „*Climate Change –The IPCC Scientific Assessment*“, Cambridge University Press, Cambridge.

IPPC (2007a); „A report of Working Group I of the Intergovernmental Panel on Climate Change, Summary for Policymakers“, pp. 1-18, viewed 25 May 2009, <http://www.ipcc.ch/> .

IPPC (2007b); „A report of Working Group I of the Intergovernmental Panel on Climate Change, Technical Summary“, pp. 21-91, viewed 20 May 2009, <http://www.ipcc.ch/> .

Johannessen, O.M., Bengtsson, L., Miles, M.W., Kuzmina, S.I., Semenov, V.A., Alekseev, G.V., Nagurnyi, A.P., Zakharov, V.F., Bobylev, L., Pettersson, L.H., Hasselmann, K., and Cattle, H.P. (2004); „Arctic climate change – Observed and modeled temperature and sea ice variability“, *Tellus*, 56A, pp. 328 –341, Corr., pp. 559-560.

Lamp, H.H. (1982); „The Climate Environment of the Arctic Ocean“, in: Louis Rey (ed), „The Arctic Ocean“, Macmillian Press, London, pp. 135 – 161 (Fig. 7.10a).

Nasa/Giss, (2009); GISS (Goddard Institute for Space Studies) Surface Temperature Analysis; GISS Website Curator: [Robert B. Schmunk](#) ; Responsible NASA Official: [James E. Hansen](#); at: http://data.giss.nasa.gov/gistemp/station_data/ ; viewed April/May 2009

NSIDC (2009) The National Snow and Ice Data Center; University of Colorado Boulder, Monthly sea ice maps since 1900, viewed 15 May 2009, <http://polar.ncep.noaa.gov/seaice/climatology/months.html>

Overland, J.E. (2008); „Arctic change: multiple observations and recent understanding“, *Weather*, Vol.61, pp.78-83.

Polyakov, I.V., Bekryaev, R.V.; Alekseev, G.V., Bhatt, U.S., Colony, R.L., Johnson, M.A., Makshtas, A.P. and Walsh, D. (2003); „Variability and trends of air temperature and pressure in the maritime Arctic, 1875 – 2000“; *Journal of Climate*, Vol.16, pp. 2067-2077.

Polyakov, I.V., Beszczynska, A., Carmack, E.C, Dmitrenko, I.A., Fahrbach, E., Frolov, I.E., Gerdes, R., Hansen, E., Holfort, J., Ivanov, V.V., Johnson, M.A., Karcher, M., Kauker, F., Morison, J., Orvik, K.A., Schauer, U., Simmons, H.L., Skagseth, Ø., Sokolov, V.T., Steele, M., Timokhov, L.A., Walsh, D. and Walsh, J.E.; (2005), „One more step toward a warmer Arctic“; *Geophysical Research Letters*, 32, L17605, doi:10.1029/2005GL023740.

Scherhag, R. (1936a) ‘Eine bemerkenswerte Klimaveränderung über Nordeuropa’; *Annalen der Hydrographie und Maritimen Meteorologie*, Vol.64, pp. 96-100.

Scherhag, R. (1936b); “Die Zunahme der atmosphärischen Zirkulation in den letzten 25 Jahren”; *Annalen der Hydrographie und Maritimen Meteorologie*, Vol.64, p. 397-407 (Fig. 7)

Scherhag, R (1939) „Die Erwärmung des Polargebiets“; *Annalen der Hydrographie und Maritimen Meteorologie*, Vol.67, pp. 57-67.

Schokalsky, J. (1936); “Recent Russian researches in the Arctic Sea and the in mountains of Central Asia”, *The Scottish Geographical Magazine*, Vol. 52, pp. 73-84.

Serreze, M.C. and Francis, J.A., (2006), “The Arctic Amplification Debate” , *Climatic Change*, Vol.76, pp. 241-264.

U.S. Geological Survey (2009), „Past Climate Variability and Change in the Arctic and at High Latitudes“, 533 pages, viewed 15 May 2006, <http://downloads.climate-science.gov/sap/sap1-2/sap1-2-final-report-all.pdf>

Zakharov, V.F. (1997), “Sea ice in the climate system”, World Climate Research Programme/Arctic Climate System Study WMO/TD-No. 782, 80 pp.