Chapter 7
Where did the early Arctic Warming originate?

A. Suggested forcing mechanism

a) An introduction with a lecture given in 1935

On the 30th January 1935, the Royal Scottish Geographical Society honoured the President of the Geographical Society of the Soviet Union, Jules Schokalsky, with the Society's Research Medal. In his address he informed the Society that records provide incontestable evidence of a progressive warming of the Arctic Ocean:

> *"The branch of the North Atlantic Current which enters it by way of the edge of the continental shelf round Spitsbergen has evidently been increasing in volume, and has introduced a body of warm water so great, that the surface layer of cold water which was 200 metres thick in Nansen's time, has now been reduced to less than 100 metres in thickness." (Schokalsky, 1936)*

For this investigation it is now time to ask what might have forced the change in the polar realm. In previous chapters the location and time-period for the sudden Arctic warming 90 years ago has been established, which leads to the question what has or may have triggered the event. Neither Johannessen (Johannessen, 2004)., who recently assumed that the warming in the early part of the 20th century was probably a natural phenomenon, nor Bengtsson (Bengtsson, 2004), who asserted that this climatic anomaly was probably a result of the influx of warmer water into the Barents Sea (see below), can be of much help. Closer to the core issue came Polyakov (Polyakov, 2003), with the conclusion:

- *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.*

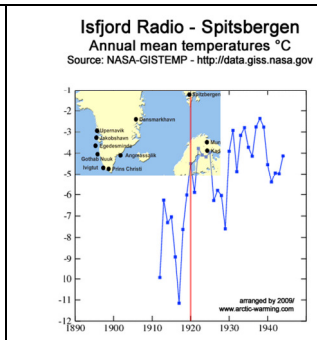
Although all three-research papers come up with a 'conclusion', none of them realises that the results are of little help. As already mentioned in the previous chapter, C.E.P. Brooks (Brooks, 1938) had expressed his disagreement with regard to R. Scherhag's assert on increased atmospheric circulation, as this pushes the problem one stage back because one should still have to account for the change in circulation. Brooks made a thoroughly right diagnosis. All the conclusions which have been previously quoted can be quickly questioned today using Books' comment that he made 70 years ago. What is different from Scherhag's suggestion is the fact that at least two of the quoted opinions make reference to the role that the sea might have played in the warming phenomenon.

7. Where did the early Arctic Warming originate?

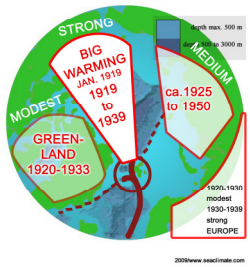


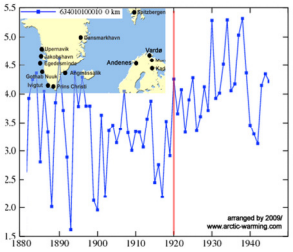
Permanent sea ice in the Arctic Ocean in the early 20th Century

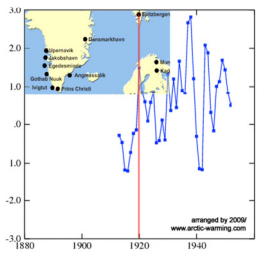
Here for Sept/Oct, usually the period with the minimum of annual sea ice cover - by approximation only -



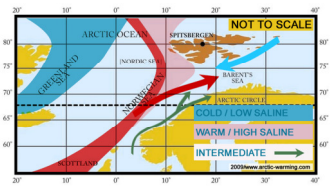


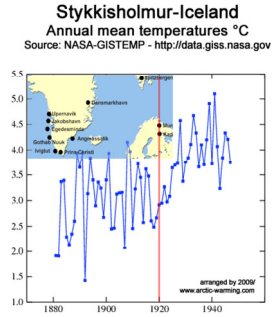




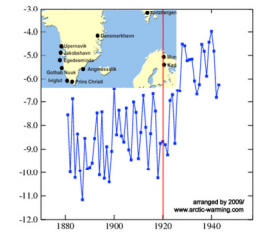


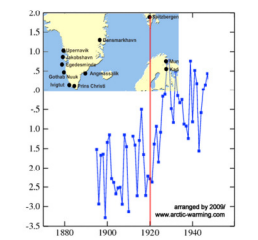












Source: www.arctic-heats-up.com; The Arctic Warming 1919 to 1939; by: Arnd Bernaerts

1982

Aagaard, Knut, (1982),
„The Climate Environment of the Arctic Ocean"
in: Louis Rey, The Arctic Ocean, Comite Arctique International, London, p. 69-81.

Extracts:

____Even the deepest portion of the Arctic Ocean is therefore not isolated from surface events in the seas to the south. The details of the deep lateral exchange are completely conjectural, however: Is the flow large or small? Does it occur in broad bands or slender ribbons? Is it confined to a thins near-bottom sheet, or is it a thick layer? Is it highly variable in time, or is it relative constant?

____We do not know very much about the cause of variability (salt and heat), nor about its consequences.

____So far we have not said anything about what happens to the Atlantic water within the Arctic Ocean. This situation is rather like a black box, for which we may know something about the input function but have neglected the response function. Until we determine the internal circuitry of the box, we shall not be able to make any useful analyses and predictions.

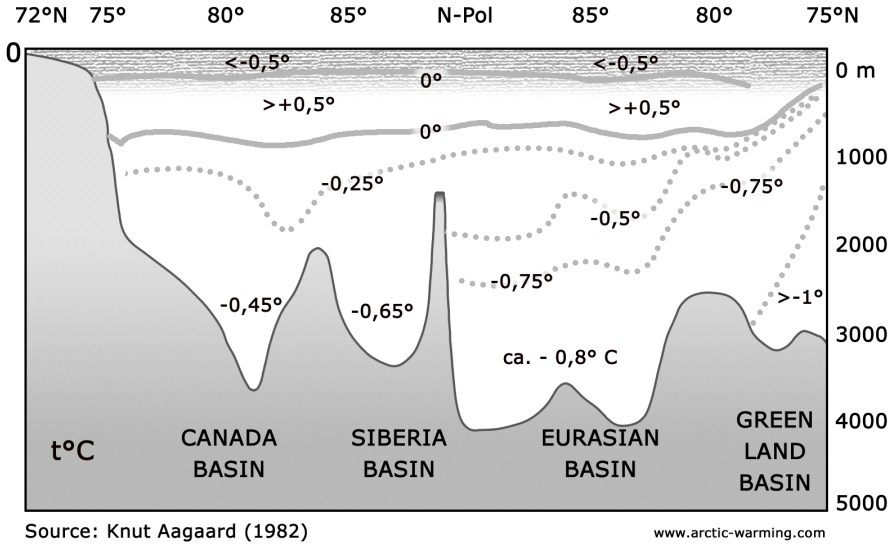
____The consequences of such onshore fluxes of salt and heat are not clear, but what is clear is the events in the north Atlantic can be transmitted years later to the shore of the far Pacific side of the Arctic Ocean.

____It may well be, for example that in the long run the Eskimos in Alaska will care considerably what the European puts into the Irish Sea.

____It is important to point out that we know next to nothing about the deep circulation of the Arctic Ocean.

____A rather direct Atlantic influence is therefore pervasive in the Polar basin, from the shelves to the abyss.

Exploring the fate of the water within the Arctic Ocean is one of the most important tasks we can set ourselves			
Where does it go?	How fast?	How and where and when does it lose its heat & salt?	
In what quantity?	With what variability?	At what rates?	By which mechanisms?



Source: Knut Aagaard (1982)

www.arctic-warming.com

In many respects, the oceanography of the Arctic Ocean is at the point it was in the Atlantic 60 years ago, prior to the great modern oceanographic expeditions.

b) Slow change in ocean circulation – Oceans interaction

It seems that Polyakov et al. (Polyakov, 2003) have missed the identification of the most interesting points, especially when assuming that the variability might have been induced "by slow changes in oceanic thermohaline circulation". This notion neglects completely the fact that there must have been a very sudden and dramatic change in the oceanic interior. The previous analysis demonstrates this fact beyond any doubt. Obviously, the 'big warming' from the winter of 1918/19 could have been caused only by an extremely rapid change, so quickly that it has never been observed since weather and ocean records have begun to be registered, 200 years ago. The statement sustaining that the "variability appears to originate in the North Atlantic" is not very enlightening either, although the location where the "variability appeared" can be very precisely identified as being the island of Spitsbergen.

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 the North, through the Fram Strait into the Arctic Ocean, and, in the opposite direction, the East Greenland Current transports very cold low saline water and sea ice southwards. The features of the two currents are so different that one can consider them, in the widest sense, as very separate entities. While they run in opposite directions, there is inevitable and considerable mixing and interactions going on. But these mixing and interactions cannot be held responsible for the generation of such an extraordinary warming up event. Actually, the higher any interaction at the time period in question, the less significant would have been the warming up of Spitsbergen.

Increased interactions between different currents of the North Atlantic can be excluded. The most prominent currents flowing from South to North (off Norway's coast) and from North to South (off Greenland's coast) are separated by a distance of about 100 to 300 km. There is no claim sustaining that any significant warming, or cooling, or any other relevant change in weather statistics had been observed in the North Atlantic, along the Polar Circle (66° 34' N) or in the south of it, in the winter of 1918/19.

c) The wind induced Arctic warming

As it is still asserted nowadays that the early warming "was associated and presumably initiated by a major increase in the westerly and south-westerly wind, north of Norway, this leading to an enhanced atmospheric and ocean heat transport from the warm North Atlantic Current, through the passage between northern Norway and Spitsbergen, into the Barents Sea" (Bengtsson, 2004), this should raise astonishment. Such a statement needs to be challenged for a number of reasons, primarily for ignoring a principle rule already mentioned: T*he energy that maintains the atmospheric circulation is to a great extent supplied by the ocean* (Sverdrup, 1942). Any list of questions should certainly include such as:

- Where did the wind come from to push warm Atlantic water north-eastwards?
- Has the wind over the Norwegian Sea "access" to the warm North Atlantic water?
- How much water could be pushed by wind into the Barents Sea, respectively how much wind must be available, to increase the flow of water from West to East throughout the Barents Sea?
- How can wind influence the flow in the Barents Sea over the time period in question when the sea is at least partly covered by sea ice?
- If the wind pushed water into the Barents Sea between Norway and Spitsbergen, should there not a simultaneous high rise in temperature at the North Cape as there was at Spitsbergen?

Source: www.arctic-heats-up.com; The Arctic Warming 1919 to 1939; by: Arnd Bernaerts

2004 Questions to Bengtsson et al. paper 2004

Concerning: Enhanced wind driven oceanic inflow into the Barents Sea

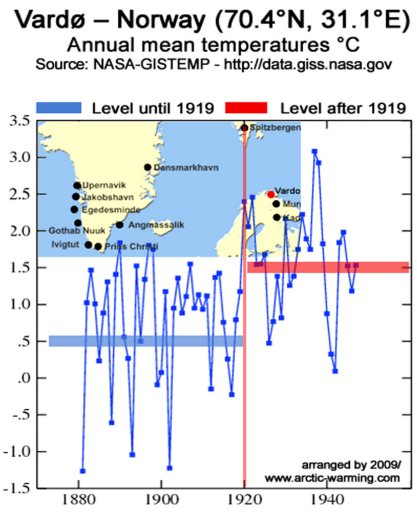
Bengtsson, Lennart (2004), Vladimir A. Semenov, Ola M. Johannessen, The Early Twentieth - Century Warming in the Arctic—A Possible Mechanism, Journal of Climate, page 4045-4057:

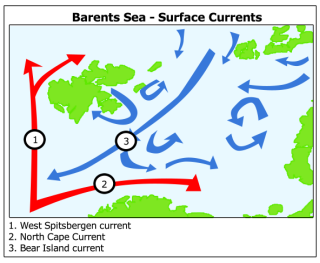
The authors assert that the temperature rise in the Arctic in the early 1920s was caused by enhanced wind driven oceanic inflow into the Barents Sea. The Abstract of the paper summarizes this aspect – inter alias – as follows:

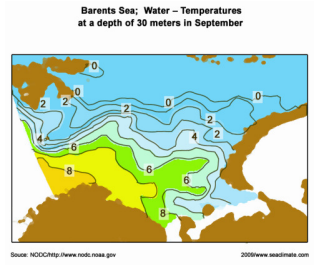
1. The huge warming of the Arctic that started in the early 1920s and lasted for almost two decades.
2. By analyzing similar climate anomalies in the model as occurred in the early 20th century, it was found that the simulated temperature increase in the Arctic was caused by enhanced wind driven oceanic inflow into the Barents Sea with an associated sea ice retreat.
3. Observational data suggest a similar series of events during the early 20th century Arctic warming including increase westerly winds between Spitsbergen and the northernmost Norwegian coast, reduced sea ice and enhanced cyclonic circulation over the Barents Sea.
4. It is interesting to note that the increasing high latitude westerly flow at this time was unrelated to the North Atlantic Oscillation, which at the same time was weakening.

The author's conclusion should be questioned, at least on reasons as follows:

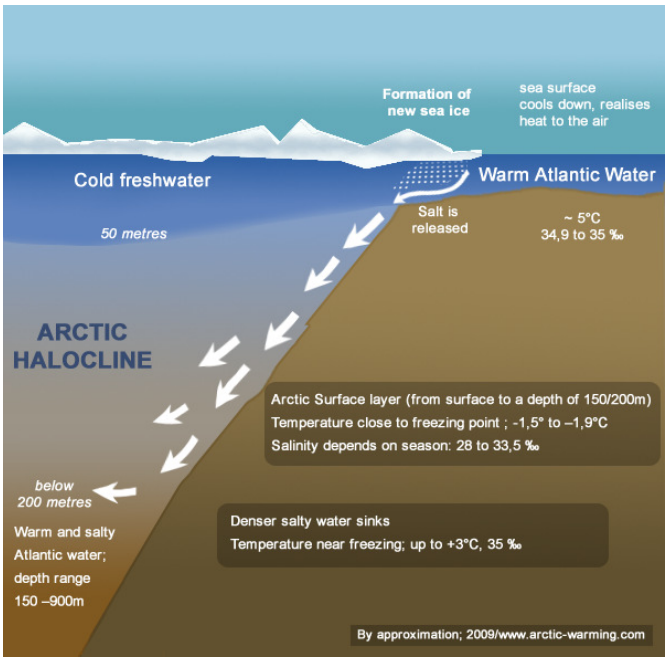
- Was the jump of winter temperature at Spitsbergen from 1919-1923 not by far to high and sudden for having been caused by oceanic inflow to the Barents Sea.
- Is the Barents Sea with a mean depth of 230m not to shallow to 'receive' a substantial amount of warm Atlantic water. See figure on water temperature at 30m depth in August (right – below).
- How can it be explained that the temperature at Spitsbergen exploded, while the rise in Norway was moderate over the years until 1939.
- If the Barents Sea had indeed received a stronger inflow, should the temperature record at Vardø not be substantial higher? (see the Vardø graphic)
- Do the data from Vardø not clearly indicate that there had been a modest system shift around 1919 (see the Vardø-graph, annual mean, indicating the different levels) of about one degree?



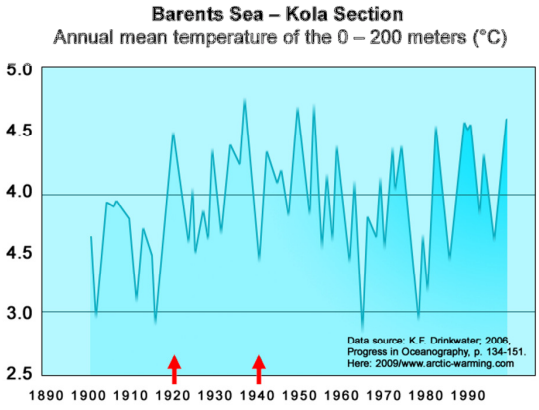




7. Where did the early Arctic Warming originate?



For the validity of the claim the authors (Bengtsson, 2004) should have answered these questions. Some may be not easy to verify, but others are. For example, had the strong warming impulse been generated in the Barents Sea realm, the temperature at Vardø-Norway should have jumped correspondingly to those in Spitsbergen. They didn't. Actually, the temperature record shows (see: Special Page "Questions to Bengtsson") that the temperature-level changed suddenly at about 1919, when the medium of the level prior 1919 was lifted by about one degree in the 1920s.



The optimum penetration of warm water at the 30 metre depth level occurs during the month of August. During winter this penetration is much less, and hardly capable of injecting substantial heat in the atmosphere. Actually some time ago the IPCC (IPCC, 1990) addressed this question quite differently, when saying:

"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."

When nowadays researchers make an opposite claim, at least, they should discuss such

Note — Norwegian & Spitsbergen Current

Extract from:
Berge, Jørgen, (2005) and Geir Johnsen, Frank Nilsen, Bjørn Gulliksen
„Ocean temperature oscillations causing the reappearance of blue mussels in Svalbard after 1,000 years of absence"
http://www.unis.no/40

These current systems transport Atlantic Water (AW), as an extension of the Gulf Stream system, with salinity >34.90 psu and temperature >3°C when it enters the Arctic Ocean. Here it meets the fresher and colder Arctic Water (ArW) with salinity between 34.3-34.8 psu and temperatures below 0°C. The transport time of water masses from Northern Norway (Lofoten / Vesterålen area at ~69°N, see Fig 1) to the shelf areas outside Isfjorden in Svalbard (a distance of approx. 1000 km) is estimated to be between 32-38 days for an average current speed between 0.30-0.35 ms^{-1} (Fig 1B-C). These estimates are based on time series observations of the NwASC and WSC. In terms of inter-annual variability, the annual mean volume transport of AW in the Svinøy section (a site at 62°N used for estimation of water transport by the NwAC) was at an absolute minimum in 2001 and increased to an absolute maximum in 2002.

>>The Norwegian Atlantic Current (NwAC); Norwegian Atlantic Slope Current (NwASC) & West Spitsbergen Current (WSC)<<.

Extract from:
Nilsen, J. Even Ø., (2006) and Eva Falck
"Variations of mixed layer properties in the Norwegian Sea for the period 1948–1999"
Progress In Oceanography, 70, p. 58-90

In the region around Ocean Weather Ship M (OWSM) in the Norwegian Atlantic Current (NwAC) the mixed layer depth varies between ~20 m in summer and ~300 m in winter. The depth of the wintertime mixing here is ultimately restrained by the interface between the Atlantic Water (AW) and the underlying water mass, and in general, the whole column of AW is found to be mixed during winter. In the Lofoten Basin the mean wintertime mixed layer reaches a depth of ~600 m, while the AW fills the basin to a mean depth of ~800 m. The temperature of the mixed layer at OWSM in general varies between 12 °C in summer and 6 °C in winter. Atmospheric heating controls the summer temperatures while the winter temperatures are governed by the advection of heat in the NwAC. Episodic lateral Ekman transports of coastal water facilitated by the shallow summer mixed layer is found important for the seasonal salinity cycle and freshening of the northward flowing AW. Atmospheric freshwater fluxes have no significant influence on the salinity of the AW in the area. (Position of Ocean Weather Ship M (OWSM): 66° North and 2° East)

Extract from:
Joanna Gyory, (2008) and A. J. Mariano, E. H. Ryan.
"The Norwegian & North Cape Currents."
www.oceancurrents.rsmas.miami.edu/atlantic/norwegian

The WSC is the northernmost extension of the Norwegian Atlantic Current. It flows poleward through eastern Fram Strait along the western coast of Spitsbergen. A mainly barotropic current, the WSC appears to be predominantly steered by the bathymetry. It is about 100 km wide and is confined over the continental slope, where it reaches its maximum current speed of 24 to 35 cm s^{-1} at the surface. Because it transports relatively warm (6 to 8°C) and salty (35.1 to 35.3) Atlantic Water, the WSC keeps this area free of ice. At around 79°N the WSC splits in two. The Svalbard branch stays close to the continental shelf of Spitsbergen, flowing north and east and eventually sinking and spreading at intermediate depths.

conclusion, which the IPCC has made in a foregoing IPCC Assessment Report two decades ago. The authors should have also explained their statement that warming in the Arctic region reached its maximum during the period 1935 –1944 and that the strongest warming with more than 2°C occurred in the Kara- and Barents Seas (Bengtsson, 2004). As it stands now it implies that a warmer Barents Sea is responsible for this warming. At least it cannot verify the suddenness of the Arctic warming since 1919. For example:

- It takes about one year for a wave of warmth or of cold to traverse the distance from Kola meridian to Novaya Zemlya. (Schokalsky, 1936)
- The sea ice in the Kara Sea decreased only since about the mid 1920 (see Special Page).
- (Schokalsky, 1936, Notes): *"The other very important piece of work of the SADKO in 1935 consisted in the discovery of the edge of the continental shelf and of the deep furrow west of the Northern Land with saline and warm Atlantic water. This proves that the warm saline waters of the under –current of the Arctic Ocean penetrated to the deeper parts of the North Siberian shelf seas, which thus influenced the ice –condition of these shallow seas.*

The message from this explanation is clear; the warm water came from the interior of the Arctic Ocean, and not via the Barents Sea, which actually means that it entered the Arctic Ocean via the Fram Strait in the West of Spitsbergen. However, the warming of the Kara Sea was definitely later than the big temperature rise at Spitsbergen.

Although Dmitrenko et al. meanwhile published their recent findings:

> *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 totalling 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);*

it is astonishing a bit that the early Arctic warming has never seriously been evaluated in conjunction with the warm Atlantic Water branch before or at the time it enters the Polar Sea.

d) Any other suggestions?

As far as this investigation is aware of, science seems to have not come up with more than the mentioned suggestions on how the natural commons of the Arctic-Atlantic fringe could generate and sustain this sudden warming.

We can therefore conclude this part of investigation, by stressing once again, that the sudden warming phenomenon was definitely not generated in the sea areas from the N-West, North and N-East of Spitsbergen (80˚ N) for the simple reason that they had been permanently covered in sea ice. In winter, the cover could reach 70-100%, in summer, with great variations, around 50%. The sea ice 'shield' reduces to minimum all interaction between sea and air. Ice-covered seawater releases 90% less heat into the atmosphere than the open sea. It is possible that winter temperatures in the ice-covered areas could have increased very slowly

Source: www.arctic-heats-up.com; The Arctic Warming 1919 to 1939; by: Arnd Bernaerts

over decades, but any assumption that such areas could have played a significant role in a dramatic temperature rise of the magnitude of Spitsbergen, is completely unfounded.

All areas situated north of 80° N and south of 66.5°N are excluded from the list of possible contributing factors. East Greenland Current is very cold and the Barents Sea depended completely on warm water supply from the South. Consequently, it is not difficult to confine the forcing of the Arctic warming since the winter of 1918/19 to a spot in the North Atlantic, namely Spitsbergen.

B. Warm Atlantic Water of Spitsbergen

After a lengthily discussion of all options as source for the early warming remains only the West Spitsbergen Current arriving with warm Atlantic Water at the Fram Strait, where it cools down and thereon submerges in the Arctic Basin. The conclusion is rectified by three further parameters, namely the facts:

- That nowhere else arrives so much heat from southerner regions so far North;
- That nowhere else the ocean surface remains usually all year round sea ice free so far in the North;
- That nowhere else in the Polar Regions the sun has no direct influence on the weather and climate over several winter months.

In summary it can be concluded, that nowhere else could such a sudden temperature jump have occurred, together with the observation of a huge difference between summer and winter temperature rise at the time of commencement and over a two decade period. But having nailed down the source of the warming does not say anything about the WHY. Why did the ocean current off Spitsbergen change course. As this shall be discussed in the next Chapter, a brief overview of the "Warm Atlantic Water" shall be given.

This sub-branch of the Atlantic Gulf Current crosses the Norwegian Sea in considerable depth northwards until reaching the high North in the Arctic realm as Spitsbergen Current. Once the shelf of Spitsbergen (ca. 77°N) has been reached, the current splits in two and passes the West and 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}. From thereon 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 at greater depths.

While the water temperature and the salinity for internal oceanic dynamics are generating forces in every ocean water around the globe, the matter is particularly 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:

Source: www.arctic-heats-up.com; The Arctic Warming 1919 to 1939; by: Arnd Bernaerts

- 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.

One needs only to pay attention to the interesting ice-cover charts for April 1918 and 1919 (see e.g. Chapter 2), 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 sudden warming at Spitsbergen after the winter of 1918/19 could have been caused only by a powerful heat resource 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.

Source: www.arctic-heats-up.com; The Arctic Warming 1919 to 1939; by: Arnd Bernaerts