ACCESS
Arctic Climate Change
Economy and Society

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ACCESS

Arctic Climate Change, Economy and Society

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Contents

1. Introduction

The Arctic has featured the strongest transformation surface warming over the globe during the recent decades, and the temperature increase has been accompanied by a rapid decline in sea ice extent. However, little is known about Arctic sea ice change during the early twentieth century warming (ETCW) (the abbreviation proposed by Wood et al., 2010). during 1920–1940, also a period of a strong surface warming, both globally and in the Arctic.

Meanwhile, in the Russian literature, discussion about warming of the Arctic approximately in 1920 - 1940 arose already in the 30th and quite intensively proceeded up to the end of the 60th after which in the Arctic significantly became cold. In many respects, exactly progress of Russia is connected with relative warming of the Arctic on a establishing of a network of polar observing stations, research and transport ship expeditions, other types of development of the Arctic territories, during preparation, carrying out and continuation of the second international polar year in 1932. Information regarding the ETCW is the part of the Russian university education of the students of the sciences related to Earth. For this reason the author of the present report at, perhaps, first international conference related to modern Arctic warming, gave the report on ETCW (Pisarev, 1997) in the Arctic. Then for the majority of participants of the conference of data that warming of the Arctic and discussion about it already happened, were the real news.

In 20 years as modern warming of the Arctic is investigated there was a series of the modern publications which are specially investigating earlier ETCW (Alekseev et al., 2007, 2009, Bengtsson, Semenov and Johannessen, 2004, Brönnimann, 2009, Divine and Dick, 2006, Johannessen et al.,2004, Overland et al, 2004, Polyakov et al., 2002, 2003, 2004, 2009, Przybylak, 2000, Semenov and Latif , 2012, Wood and Overland, 2010, Wood et al., 2010). That such phenomenon was became now the standard fact. At attentive studying of old publications to the 60th it appeared also that early warming of the Arctic was discussed at all only in publications in Russian, as well as in works of scientists from the Scandinavian countries, Canada, Germany, etc (Ahlmann, 1946, Birkeland, 1930, Brooks 1938, 1949, Ifft, 1922, Dunbar, 1946, Hesselberg and Birkeland, 1940, 1941, 1943, Jensen, 1939, Johannsson, 1936, Lysgaard, 1950, Manley, 1944, Petterssen, 1949, Scherhag 1936a,b,1937, 1939a,b, Wagner, 1940, Willett, 1950).

Studies of the instrumental record, reconstructions of past climates from proxy records and experiments with global climate models confirm that Arctic amplification is a characteristic feature of the climate system. While the instrumental network for the Arctic is temporally inhomogeneous and insufficiently dense to capture some of the details of temperature variability and change, particularly over the ocean, it is abundantly clear that there have been periods of strong Arctic warming or cooling throughout the 20th century.

Despite of the fact that since ETCW of the Artic beginning passed 90 years, despite undertaken by last and modern researchers of effort, the reason and mechanisms of last warming it is impossible to consider received an explanation. And such explanations would be good to be received to reveal common features and distinctions in comparison with modern warming and on this basis with big confidence to interpret features of modern changes in the Arctic. “The Arctic warming from 1920-1940 is one of the most puzzling climatic anomalies of the 20 century” say one publications (for example Bengtsson, et al., 2004). Brönnimann acknowledged also: “Our understanding of the climate mechanism operating in the Arctic on different timescales is still limited” (Brönnimann, 2009). “Arctic temperature anomalies in the 1930s were apparently as large as those in the 1990s and 2000s. There is still considerable discussion of the ultimate causes of the warm temperature anomalies that occurred in the Arctic in the 1920s and 1930s.” - IPCC AR5 Chapter 10.

Understanding the first arctic warming would definitely provide many hindsight for better assessing and handling the entire climate change issue. Another words, is it reasonable and fair to dramatize the shrinking sea ice during a recent time period, for example, if one is not fully aware of what happened in the early years of the last century?

Obviously, characteristics of last warming were based on much smaller volume of natural observations in comparison with the modern period. Even for the most general reasons it is impossible to expect comparable quantity, a spatial covering and quality of observations over a condition of environment for the first and second warming of the Arctic during 20 century. Especially it is important to try to find and mobilize as much as possible observations received as a result of often heroic efforts of the researches in the first half of the 20th century.

In the present report it is made, on the one hand, the audit of the natural data that described the characteristics of the atmosphere, ice and the ocean of the Arctic to the 60th, and with another hand, search and application to the analysis of those observed data which still aren't presented in modern publications related to ETCW. The attention is paid, generally to those data which can be presented in the form of figures and which are received by devices similar to the modern. Such approach reduces our consideration to physical quantities, namely, to temperature and pressure of air, the area of ice and temperature and salinity of water.

The short description of the previous warming as it was described in old publications is given in section 2. Then, in section 3, information that we know is carried out and we can know about changes of temperature and air pressure in the Arctic till 50th years of the last century. Similar information on sea ice is provided in section 4. In the fifth section the natural data characterizing changes of characteristics of sea waters of the Arctic during nearly 100 years are considered. Report conclusions are presented in section 6.

2. Early twentieth century warming as it is presented in publications of the first half of the twentieth century.

Discussion regarding to Arctic warming was started in old Russian scientific literature at 1930. The WWII interrupted the discussion while it was continued later before the nicely end at 1960th. The period of the warming was determined as 1920-1940. The first half of XX century discussion very looked like modern one outwardly and emotionally.

Famous Russian oceanographer, corresponded member of the Russian Academy of Sciences, professor Vize pointed out at 1940 that: "Just now we are witnesses of very noticeable climate change, change which should be considered as the largest fluctuation of climate recorded in meteorological chronicles since the invention of the thermometer (the end of the XVI century). Especially sharply this fluctuation of climate affected in the Arctic where, since 1920, strong warming is observed. For the last 15 — 20 years average annual air temperature was above average long-term size — on Spitsbergen on 2 °, in the Western Greenland on 2,5 °, on Franz-Joseph Land on 3,5 °. These changes of temperature are equivalent to that when places mentioned above moved on 300 km southward." Johannsson's main conclusion when he investigated the atmospheric conditions modern for him, 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 (Johannsson,1936).

Outstanding Russian investigator of the Barents Sea Knipovich stressed at 1938 :" So remarkable changes of the distribution of the marine fauna took place during short period as last fifteen years that, as believed previously, they can happen during the long geological time only". Manley echoes to Knipovich actually: "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" (Manley, 1944).

"Ice conditions were exceptional" pointed out USA consul in Bergen when described the Norwegian department of Commerce expedition to Spitsbergen water at August 1922 (Ifft, 1922). "In fact, so little ice has never before been note!. The expedition all but established a record, sailing as far north its Sl0 29' in ice-free water. This is the farthest north ever reached with modern oceanographic apparatus" (Ifft, 1922). One more notes from the same publication: "……observations of Capt. Martin Ingebrigtsen, who has sailed the eastern Arctic for 54 years past. He **says** that he first noted warmer conditions in 1915, that since that time it has steadily gotten warmer, and that to-day the Arctic of that region is not recognizable as the same re ion of 1865 to 1917" (Ifft, 1922).

Norwegian scientist Birkeland B.J. (Birkeland, 1930) investigated the extraordinary air temperature development at the 'Green Harbour' Spitsbergen station. He finishes his work 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". One more quote – "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).

The pronounced rise in temperature over most of the Subarctic during the 1920s and 1930s was named as "the most spectacular climatic event" (Lysgaard (1950).

The numerous of the publications in Russian related to Arctic warming before 1960[th] were summarized by Vize and Zubov (Vize, 1940, Zubov,1938,1944,1963, Pisarev, 1997) in the following look (together with short remarks from publications in English):

Along with the fluctuations in ice abundance in each individual sea from year to year, in late years a most interesting phenomenon has been observed – a warming of the Arctic, as evidence by a gradual and universal decrease in ice abundance. The main evidence of this general warming of the Arctic are:

Receding of glaciers and "melting away" of islands and retreat of permafrost. All the Greenland glaciers which descend into Northeast Bay and Disko Bay have been receding since approximately the beginning of the century. During the Persey cruise in 1934 Zubov noticed that the glaciers of Jan-Mayen and Spitsbergen were considerably reduced, relative to their sizes adduced in British sailing directions of 1911. Retreat of glaciers was observed al so at Spitsbergen, Franz-Joseph Land, and Novaya Zemlya. The ice bridges between some of Franz-Joseph islands melted. Ii was noted a great decrease in the size of (Jan Mayan and Spitzbergen) glaciers.

Disappearance of the island of Vasilyevsky — the small island to the Laptev Sea, put of fossil ice and sandy-argillaceous deposits, was related to ETCW of the Arctic. This island was last time visited in 1912 by expedition under the command of B. Vilkitsky, executed detailed shooting of the island. The survey vessel Chronometer tried to visit the Vasilyevsky island at 1936. Despite the most careful searches, the vessel wasn't succeeded to find the island. The island disappeared, and on its place there was a bank over which depth of the sea equaled 2,5 m. Nearby located Semenovsky island is threatened, apparently, by the same fate. In 1823 length of this island was 15 km, in 1912 — 5 km, and in 1936 — only 2 km. (Let's say here, that there is no such island on the Arctic maps published after 1970 at least).

Along with a retreating of the Arctic glaciers, it was removed, as it is noted by M. I. Sumgin, the southern border of permafrost as well. The interesting fact is given in this regard by the prof. L. S. Berg. In 1837 when the city of Mezen was visited by A. Shrenk, here at a depth of 2 m the permafrost lay, and in 1933, when Mezen was visited by expedition of Academy of Sciences, here wasn't found permafrost traces absolutely (see links in Vize, 1940, Zubov,1938,1944,1963).

Swedish scientist Ahlmann terms the rapid receding of the Spitzbergen glaciers "catastrophic". The measurements made over glaciers of Iceland, give the same picture. And here balance of ice now the negative (at 1946). For example, supervision in 1935 — 1938 showed that for Hoffelsiokull — one of big glaciers of Iceland — reduction of quantity of ice owing to thawing and evaporation annually exceeds glacier food by a dropping-out precipitation on 94 million m^3 (Ahlmann, 1946). "If warming of the Arctic holds on and in the future, Spitsbergen will at all be freed from an ice cover" decided Vize after analyses of the Ahlmann work (Vize, 1940) "Many old landmarks are so changed as to be unrecognizable. Where formerly great masses of ice were found there are now often moraines, accumulations of earth and stones. At many points where glaciers formely extended far into the sea they have entirely disappeared" American consul at Bergen (Norway) Nicolas Ifft pointed out at 1922 when reported the modern for his time situation on the north of Norway (Ifft, 1922).

Rise of air temperature and others changes of atmosphere. "The Arctic seems to be warming up" published Ifft at 1922 without exact values. He continued: "Reports from fishermen, seal hunters, and explorers who sail the seas about Spitsbergen and the eastern Arctic, all point to a radical change in climatic conditions, and hitherto unheard- of high temperatures in that part of the Earth's surface".(Ifft, 1922).

Changes of Arctic atmosphere related to ETCW widely published in old literature in Russian, English, German, Norwegian. Summarizing these works, it can be stated that there exists an agreement in estimating temperature tendencies prior to 1950. Practically all old (and modern also) of the papers which cover this time period demonstrated of the significant warming which occurred in the Arctic from 1920 to about 1940. The greatest rise of temperature occurred in the Atlantic region. (Scherhag, 1931, 1937, 1939; Hesselberg and Birkeland, 1940, 1941, 1943; Weickmann, 1942; Groissmayer, 1943; Ahlmann, 1948; Lysgaard, 1949; Vize, 1940, Stepanova, 1956; Hesselberg and Johannessen, 1958; Petrov, 1959; Bolotinskaya, 1961; Thomas, 1961; Prik, 1968;)

In case look on Russian publication specially, it have to be noted, that during 1920 -1940 the average temperature of the winter months has steadily increased in the last 10 years in the whole Arctic sector from Greenland to Cape Chelyuskin there has not been a single (negative) anomaly of average annual and monthly winter temperatures, while the positive anomalies have been very high. Since 1920, strong warming was observed in the Arctic. "For the last 15 — 20 years average annual air temperature was above average long-term size — on Spitsbergen on 2 °, in the Western Greenland on 2,5 °, on Franz Joseph's Earth on 3,5 °" (Vize, 1940).

According to old publications in Russian, цarming occurred not only in the Arctic, but also in the most part of the Northern hemisphere lying to the North from tropics. Out of the Arctic warming reached, however, considerably the smaller sizes, than to the North from a polar circle. So for example, in Arkhangelsk average annual air temperature increased for the last 15 — 20 years approximately on 1 °, and almost same size expresses warming in Leningrad.

"If to consider temperature conditions in separate months, it appears that temperature, mainly, cold months whereas temperature of summer changed very little increased. So, for example, on Spitsbergen the average temperature of five coldest months (November — March) in recent years was on 6 — 8 ° above average temperature "long-term size. As the winter and on Franz Joseph's Earth strongly became warmer. Cases when average monthly air temperature in part of the Arctic closest to Atlantic on 10 — 12 ° is higher than norm don't make in recent years a rarity. On the other hand, on islands of the western sector of the Soviet Arctic severe frosts less frequently began to be observed. For example, in Tichaya Bay on Franz -Joseph Land, where polar meteorological station was established at 1929, so far (publication at 1940) the thermometer never showed below — 40°. Meanwhile all expeditions working at this archipelago at the end of the last century and at the beginning of the present (such expeditions was ten), every winter, except for winter of 1896, noted frosts lower than - 40°."Warming of the Arctic represents itself the long process which begun still at the end of the last century and has sharply amplified in the twenties of the current century" reported

Vise in 1939. It is well visible from average air temperatures for January — February — March in Yakobskhaven (the Western Greenland).

Vise and Zubov, as well as others Russian authors, pointed out on existence of stability extreme positive temperature anomalies within the Arctic. For example, in Varde (on Far North of Norway) average annual air temperature since 1918 to the present (publications at 1939 -1944) from year to year is higher than average centenary temperature, except for one only 1926. However and this last year the negative deviation of temperature from norm was expressed by insignificant size in — 0,2 °.

The data testifying to considerable warming of the central Arctic were received during "Sedov's" drift. This icebreaking steamship to a certain extent repeated "Fram's" well-known drift in 1893 — 1896. The air temperature observations of the both expeditions were compared at the end of 1930th. I was fixed, that in all months, except for March, air temperature on "Sedov" in 1938 — 1939 was higher, than on "Fram" in 1894 — 1895. And it in spite of the fact that "Fram's" compared locations steadily have to the South and the West from "Sedov's" corresponding locations. On the average in time from September, 1938 to April, 1939 air temperature around "Sedov's" drift was on 6 ° above the corresponding temperature noted on "Fram".44 years before.

According to old Russian publications, during ETCW of the Arctic the cyclones coming from the North of Atlantic, move in the Arctic and Subarctic region on the trajectories located considerably to the north of those trajectories on which cyclones followed before warming. This shift of cyclonic ways to the North is expressed by many hundreds, even in one thousand kilometers. As a result in the Arctic, and especially in its periphery zone, there was very noticeable change of a wind mode together with warming. For example, in the Yugorsky Strait repeatability of southwest winds during warming of the Arctic increased by 2 — 4 times in comparison with repeatability of these winds during previous period of observations.

To look on “publications not in Russian” again, it have to be noted, that the extraordinary increase of the winter temperatures in Greenland was caused by a considerable retreat of the ice border and the prominent increase of the atmospheric circulation (Scherhag, 1936a). Scherhag stated also, 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 (Scherhag, 1937).

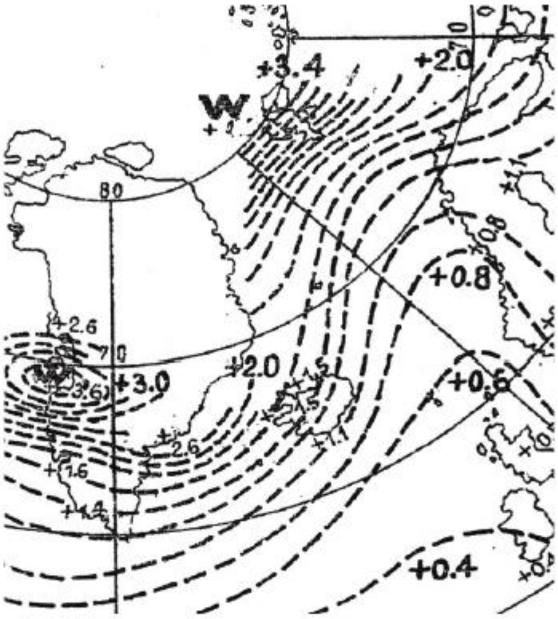

Figure 2.1 Decade 1921-1930. Deviation of winter temperature (Nov-March) from long term mean; (from R. Scherhag, 1936b).

In his book "Climate through the Ages", the meteorologist C.E.P. Brooks (Brooks, 1949) noted that winter temperatures had risen since 1850 in all the north temperate and Arctic regions. Winter temperatures in Spitzbergen, lying at roughly 80°N in the northernmost North Atlantic, rose by 9 °C between 1911–1920 and 1931–1935 compared to only 3 °C between 1851–1900 and 1901–1930 in Western and Central Europe. The especially strong warming around Spitzbergen was attended by Brooks together with regional poleward retreat of the sea ice edge.

It was concluded, that 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 (Manley, 1944). "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" (Manley, 1944).

As part of the Centenary Conference of the Royal Meteorological Society in 1950, Willett (1950) analyzed global temperature trends from the mid-nineteenth century onwards and found that annual and particularly winter temperatures had increased since 1885, especially in northern high latitudes, and referred to this as "the well-known warming which occurred in north polar latitudes". No counterpart was seen in the Southern Hemisphere. Willett invoked changes in atmospheric circulation as an explanation, namely longitudinal displacements of the Siberian polar anticyclone.

Lysgaard (1950) came to similar conclusions and further showed that the sea level pressure gradient in the North Atlantic strengthened during the warming interval. Callendar (1961) noted that the warming trend during preceding decades was significant from the Arctic down to about 45°N, but quite small in most regions below35°N. The temperature difference for 1921–1950 minus 1891–1920 for the latitude zone 60–73°Nwas 0.81 °C compared with 0.39 °C for the band spanning 25–60°N. Callendar discussed possible causes of the warming, including the potential role of back radiation from increasing carbon dioxide concentrations.

Rise in temperature of Atlantic water which enters the Arctic Basin and changes of others water masses. The Russian scientist Jules Schokalsky (President of Russian Geographical Society at that time. A paper read before the Royal Scottish Geographical Society in Edinburgh on the 30th January 1935, on the occasion of the presentation to Professor Schokalsky of the Society's Research Medal.) informed the Royal Scottish Geographical Society in 1935: "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 meters thick in Nansen's time (1895/96), has now been reduced to less than 100 meters in thickness." (Schokalsky, 1936). He pointed out also, that during the memorable voyage of the FRAM (1893-1896), Nansen discovered that the upper layer of the Central Arctic Ocean from 200 to 500 meters in thickness was less saline than the deeper water, and that it had a temperature of –1,0° to –1,9° C, while the deeper layer, from 600 to 700 meters thick, was of oceanic salinity (over 35 per cent.), and had a temperature of +1,2°C (It was Arctic Atlantic water discovering). Five years later, S.O. Makarov, on the ice-breaker Ermak, between Franz Josef Land and Novaya Zemlya, found that the zero temperature occurred at a depth of about 200 meters, and that below this the temperatures rose to +1,1°C. This confirmed Nansen's observations. In 1927 the ship Elding, between Franz Joseph Land and Novaya Zemlya, recorded temperatures of +0,6°C at 100 meters depth. Then, in 1928, the Krasin's observation north of Spitsbergen in lat. 81°47'N revealed a new fact. At 70 meters the water was found to have oceanic salinity of over 35 per cent and a temperature of 4,6°C. Sverdrup's observations in the Nautilus in 1928 confirmed these facts for latitude 82°N. In 1929 the Sedov and the Persey, at almost the same place Makarov chose for his observation in 1901, found the zero isotherm to occurs at the depth of 125 meters instead of 200 meters. Again, in 1931, the Persey, in the same vicinity, found this isotherm at 75 meters, and the Lomonosov, a little farther east, found it from 25 to 40 meters, below which depth the temperature increased to +1,6°C. And finally the Persey in 1934 reaching 81°17'N, north of Spitsbergen, early in September, recorded an air temperature of 12°C and a sea temperature of +5,5°C down to 10 meters (Schokalsky, 1936).

Vize and Zubov also, as well as Shokalsky, took special attention on the Atlantic Current as very important factor of ETCW of the Arctic. Really, being made in the Barents Sea on a meridian of Kola Bay systematic (longer most of the World section named as Kola one now) hydrological section showed, that temperature of the Nord Cape current — one of northern branches of the Atlantic current — for the years from 1920 -1925 to 1940 considerably increased. Professor Zubov calculated the following average water temperatures on this section (between parallels 69,5 ° and 72,5 °N), relating to more thickly water from a surface up to the depth of 200 m for May 1900-1906 – 2.16 and for August 3.94, while for the same months during 1921 – 1936 2.85 and 4.73 correspondently. From these figures it is visible that during the period before ETCW of the Arctic (in this case it is presented for years 1900 — 1906) the water temperature of the Nord Cape current was in May on 0,69 °, and in August on 0,79 ° below, than during warming of the Arctic (1921 — 1936). “At first sight this temperature increase can seem insignificant, however, if to consider a big thermal capacity of water, it will appear that the specified figures speak about very big increase in stocks of heat in waters of the Barents Sea” Vize pointed. “It is possible to give the interesting calculation made by the Norwegian oceanographer Helland-Hansen as an example. It showed that if all mass of the Atlantic water in the Norwegian Sea will be cooled only on 1 °, allocated heat will suffice to heat to 10 ° an air 40 km thick layer over all Europe” (Vize, 1940). Concerning the figures given above for a section on the Kola meridian, N. N. Zubov writes: "It follows from this, that on the average the column of water of the Nord Cape current with a section of 1 cm^2 and 200 m high possesses now a stock of heat 14 000 GCal bigger, than it was at the beginning of the current century” (Zubov, 1938, 1944,1963).

Vize pointed out: ”Change of a wind mode couldn't but affect change of a hydrological mode of the Arctic seas. The southwest part of the Kara Sea in this regard gives an interesting example. In the fall of 1936 in this area made deep-water hydrological observations by “Papanin” and “Professor Vize” research vessels. Extraordinary high temperatures for the Kara Sea were found within the bottom layer .Anything similar here it wasn't observed earlier. In the summer and in the fall the positive temperature were found previously only within the upper layers while water bellow had negative temperature. When hydrologists from "Papanin" and "Professors Vize" delivered the results of observations into in Glavsevmorputi's Hydrographic management, there even doubted correctness of observations. Therefore in 1937 the "Professor Vize" was again sent to southwest part of the Kara Sea to repeat the observations. Thus the same rather high temperatures of water which so confused employees of Hydrographic management were found once again. These temperatures can be very easily explained in connection with warming of the Arctic and sharp increase in repeatability of southwest winds in the southern part of the Kara Sea. The big mass of warm water from the Barents Sea began to be made up through Kara Gate Strait and partly through the Yugorsky Strait due to prevailing wind” (Vize, 1940).

According to Zubov, in the regions adjacent to Spitsbergen and Franz-Joseph Land, the lower boundary of the cold intermediate water layer rose from 150–200 m in the beginning of the century to 75–100 m in 1940–45. Not one station made during the Fram cruise showed Atlantic Waters exceeding a temperature of 1.13°C, but in 1935 (Sadko cruise) Zubov observed Atlantic Water temperatures reaching 2.68°C within the northern most part of the Kara Sea. In 1938 (Sedov trans-Arctic drift) even in the places situated to the north and east of Fram’s drift the temperatures reached 1.8°C. (Zubov 1944,1963).

The first publications demonstrated the un-linear and thus complicated connections between different parameters of the climatic system during the warming trend even were also published at 1940th. The positive relation of the East Greenland Current to the Atlantic inflow to the Arctic Ocean was shown by Berezkin (1937), who reported that an increase in flow in the Atlantic current of the eastern Greenland Sea is accompanied by, or followed very shortly by, an increase in the flow of the Arctic water of the East Greenland Current. There is also, according to Berezkin, a negative relation between the temperature change in the two water bodies. After continuing his speculations he noted, that “increased temperature of the North Cape Current in August of any year is reciprocated by a greater amount of ice in the Greenland Sea in July of the following year.

International group of scientists worked early that 1960th also pointed out a lot of changes within the water masses during the ETCW of the Arctic. “Dr. Hoel reported that he made a section of the Gulf Stream at 81 north latitude and took soundings to a depth of 3,100 meters. These show the Gulf Stream very warm, and it could be traced as a surface current till beyond the 81 parallel (Ifft, 1922) “Sea water at the west coast of Spitsbergen had shown unusual high temperatures in summer 1918”. (Weikmann, 1942). Dunbar suggested that there was evidence, from the study of the West Greenland Current, that the climatic warming of the nineteen twenties and thirties appeared to have reached a peak in the mid-thirties, and that there were indications of a weakening of the Atlantic, or warm water, influence in that region between 1942 and 1944 (Dunbar 1946). “There were increased Atlantic waters temperatures, particularly significant in the Barents- and East Greenland Sea” (Scherhag, 1936b). “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 meters” (Brooks, 1938). “Attributing the recent period of warm winters to an increase in strength of atmospheric circulation only pushes the problem one stage back, because one should still have to account for the change in circulation” (Brooks, 1938). According to Wagner, the mean water temperatures in the Barents Sea increased with +1.8°C from 1912/18 to 1919/28 although the Barents Sea ice border retreated significantly since 1919 (Wagner, 1940).

Decrease in ice abundance and others changes of ice characteristics.

ETCW of the Arctic manifested, according of several Russian publications, in the decreasing of the polar ice. Quantity for the last 20 years (1920 -1940) sharply decreased and everything continues to decrease at 1940th. In the Barents Sea the southern margin of ice was removed to the North approximately on 120 km. Southern part of the Kara Sea (to the south from a parallel of Matochkin Shar strait) over the period 1930 – 1940 in September was absolutely free from ice every year. In time from 1869 to 1928 the probability of a meeting of ice in this part of the Kara Sea was expressed in the first half of September of 30%, i.e. ice was observed every third year on the average. The quantity of ice both in the Greenland Sea and in waters to the West from Greenland decreased. “There were very long observations (begun in the XVIII century) over the sea ice at northern coast of Iceland. At 19 and start of 20 centuries drifting ice quite often approached to these coasts disturbing here to navigation and fishery. For the 1915 - 1935 years ice appeared at Iceland only once (1929) and that in a minute quantity” (Vize, 1940).

There were fixed, that the dates of opening and freezing of coastal areas of the seas and passages of the Russian Arctic changed essentially with ETCW of the Arctic. For example, before warming of the Arctic (i.e. till 1920) the Yugorski Shar Strait finally froze, on the average, on November 24. During warming of the Arctic this date (during 1920 — 1937) falls on January 25, i.e. it was removed for the whole two months (Vize,1940, Zubov,1938,1944,1963).

It was pointed out also, that owing to warming of the Arctic the quantity of the sea ice which annually formed in the Central Arctic Basin by icing of new ice on the bottom of pack ice decreased. On the basis of the observations made on "Sedov" during trans-Arctic drift, there were possible to accept, as a first approximation, that at 1930th, the quantity of the ice which is annually forming in the Arctic Basin owing to freezing of water, on 1500 km ^{3} less, than the corresponding quantity at the beginning of the 20 century (Vize,1940, Zubov,1938,1944,1963).

Noticeable reduction of an ice cover in the Arctic seas, according to several publications in Russian, influenced on tidal fluctuations of the sea level, which amplitude increased (the ice cover moderates this amplitude a little). So, the observations made on Franz Joseph Land and on the island of Dickson, showed, that during ETCW of the Arctic amplitude of tidal fluctuations of sea level increased by 20 — 30%.

The good example of strengthening, in connection with ETCW of the Arctic, speed of the ice drift circulation gives comparison of drift of "Sedov" to "Fram's" drift. "Sedov's" drift happened from January 1 to May 1, 1939 in the general direction on west and south-wes to average speed of 3,6 km per day whereas "Fram's" drift between the same degrees of longitude (127 ° and 81 ° to the East from Greenwich) happened to speed only 2,4 km per day (in the same direction). Speed of circulation increased, thus, in 1939 in comparison with 1894 — 1895 for 50%.

Biological signs of warming of the Arctic. Big changes of the fauna of the Arctic took place in connection with ETCW. Professor N. M. Knipovich was the first within the Russian scientist who paid attention to these facts. He found in the Barents Sea in 1921 such forms of animals which here weren't found earlier. About these remarkable changes of sea fauna Knipovich in wrote in 1930 (cited according to Vize, 1940): "Within only several years — one moment from the geological point of view — there was a noticeable movement to the east rather warm-water forms, and besides both easily mobile fishes, and inactive inhabitants of a bottom. In any fifteen years and even in shorter period there was such change in distribution of representatives of sea fauna what contacts ordinary idea of long geological periods".(Vize, 1940).

Sharply ETCW of the Arctic affected distribution of food fishes. Big shoals of a cod appeared in the last 10 years at the northern island of Novaya Zemlya and at west banks of Spitsbergen. Especially far to the north the cod promoted at west banks of Greenland. In 1929 a cod in a large number caught at the island of Disko (69 ° north), and in 1932 it passed further away to the north — to 71° north. Together with a cod west banks of Greenland had a herring which here wasn't found here earlier. Since 1929 at coast of Greenland the haddock which earlier wasn't coming not so into these waters began to come across.(Vize, 1940, Zubov, 1944, 1963).

“In the north of the Pacific Ocean the last 15 — 20 years also appeared such fishes who here weren't found earlier. So, in 1932 at coast of Alaska the mackerel that earlier wasn't coming to the north of a parallel 48 °25' was caught. (Vize, 1940). "Zones of life are displaced now in the direction to a pole" — Russian professor Berg pointed out. Professor Zubov finded possible to note that "the center of world fishery gradually moves to the Arctic waters, and certainly warming of these waters should attribute it substantially" (Zubov, 1944, 1963).

Some birds who were earlier nesting in Norway, for example, a silvery seagull and the sitting duck began to nest in recent years in Iceland. On the other hand, the white seagull — a typical Arctic bird absolutely disappeared from Iceland. Obviously, with warming of the Arctic, captured and Iceland, this island seemed to a silvery seagull the country too southern. Uspensky stated that 40–50 species of birds moved to the North during 1890–1930. (Vize, 1940).

Jensen (Jensen, 1939) was in charge of investigation into the fisheries of Greenland, beginning in 1908, and was able to follow, and to exploit, the remarkable changes in distribution and abundaonf cteh e seaf auna, notably the Atlantic cod *,* which began in the second decade of the century to move into the West Greenland area from Iceland, and to establish a breeding stock there. By 1917 the cod were to be found in the southwest, in the latitudes of Julianehgb (61° N) and Frederikshlb (62 °N); and by 1919 they had penetrated northward to Godthlb, and by 1927 to Holsteinsborg. By 1931 they were well into Disko Bay, and were found also at Umanak. By 1940 they were known in small numbers at Upernavik (nearly 73° N). During this time, from 1908 to 1940, the temperature in the core of the West Greenland Current had risen by more than *2° C,* which represents an enormous increase in total heat transport. There was a very cold year in 1938, when many codfish were found dead at the surface in various parts of West Greenland, and since the nineteen forties the temperatures, and the cod fishery take, have been declining. The faunal changes were of course general, since what was happening was a migration (Jensen, 1939).

Among the faunal elements concerned, and of special interest, is the Atlantic salmon *,* which since 1960 has been fished commercially in West Greenland waters and in the Labrador Sea (Dunbar, 1946). Of this species Jensen (1939) wrote: “The Salmon was previously only known and only in small numbers at two places, namely, Kapisigdliit n Godthaab Fjord and Amerdlok Fjord near Holsteinsborg. But toward the end of the twenties the observation was made, that in the autumn (October and November) a migration of large salmon takes place in the Sukkertoppen district, though not very near the coast. Later, especially in 1935 and 1936, the salmon occurred in numbers from October and on into December at several places in the Sukkertoppen district, at the dwelling place Ikerasak and in fjords round about as also at the outpost Napassok and the dwelling place Agpamiut. In the autumn of 1935 about *200* of this stately fish were caught at Ikerasak. In September 1936 a number of salmon were caught at Lichtenau, in 1935 in October several salmon were noticed at Fiskenaesset, and in Septem1b9e3r8 a salmon” (Jensen, 1939).

“In Iceland, a country drastically affected by these changes, the avifauna has virtually changed twice: first the arrival of new breeding bird species from Europe during the ETCW, to be followed by the disappearance of these novelties and the establishment of breeding birds from the north” (Watson 1975).

“In Canada there is documentation of northward dispersal of both birds and mammals during the warming period (years 1920-1940 was taken in mind), including moose, red fox and coyote. An interesting discovery some years ago (at start of 197-th ?) was the presence of red fox fleas on arctic foxes in Baffin Island - evidence no doubt of more than just a northward movement of the red fox” (Dunbar, 1976).

Ship navigation. Reduction of the ice cover of the Arctic seas allowed the Russian (Soviet) vessels to get into such areas where any seafarer didn't come earlier. For the first time in the history of navigation the small wooden vessel "Nikolay Knipovich" rounded in 1932 from the North Franz Joseph's Land. In the same year, for the first time also, "Siberiakov" passed to the North from

Severnaya Zemlya. I wasn't less remarkable also 1935 when "Sadko" on clear water passed from the northernmost tip of Novaya Zemlya to Severnaya Zemlya further to the 82.4° north. If to remember that in the summer of 1901 the powerful icebreaker Yermak couldn't reach even the northernmost tip of Novaya Zemlya, it becomes clear, what huge change happened in a condition of ice of the polar seas. In 1938 the same "Yermak" got into the Central Arctic Basin (northward from New Siberian Archipelago) to 83°05' north having set up these a world record of a northern latitude for freely floating vessel (i.e. for the vessel which isn't in ice drift) .(Vize, 1940, Zubov, 1944, 1963).

Let's compare the parameters that were investigated in old literature for ETCW of the Arctic and for modern, started in 1990th, Arctic warming. Let's use the essay topics of the Arctic Report Card for this purpose (http://www.arctic.noaa.gov/reportcard_previous.html). Air Temperature & Circulation, Clouds & Surface Radiation, Greenhouse Gases, Ozone, UV Radiation, Black Carbon are under consideration modern time while only air temperature and circulation and partly surface radiation were investigated before 1960 th for atmosphere. Sea Ice, Wind-driven Ocean Circulation, Ocean Temperature & Salinity, Sea Level, Ocean Acidification are under investigation now for "Sea Ice and Ocean". The same characteristics, with exception of ocean acidification, were investigated previously. For the item "Marine Ecosystems" the ocean biogeophysics, Pacific Arctic Marine Ecology, Barrow Canyon Ecosystem, Sea Ice biota, Primary productivity, Benthic Communities, Seabirds, Murres, Fish and Fisheries, Arctic Char, Marine Mammals, Polar Bears and Whales and Seals are under attention at modern time while previous investigation were essentially narrow. The same limitation of the investigation before the 1950th can be pointed out for "Terrestrial Ecosystem" investigations. The Arctic Wildlife, Caribou and Reindeers, Goose Populations, Shorebirds, Lemmings, Artic Fox, Muskox are investigated specially at modern time while more fragmental investigation took place previously. Arctic Report Card issues present information regarding the Snow, Glaciers and Ice Caps, Greenland, Permafrost, River Discharge, River Biogeochemistry, Lake Ice under the title "Terrestrial Cryosphere". The same types of information, with excluding of River Biogeochemistry, was under scientific interest during the first half of 20 century. It possible fixed, that the general direction of investigation of ETCW and modern Artic warming is practically the same, while many modern investigations have not analogues in ETCW analyses.

3. The search of the additional Russian data to characterize ETCW of the Arctic atmosphere.

The instrumental record of Arctic temperature is brief and geographically sparse. Only five known records (Upernavik: date of start 1874; Jakobshavn: 1874; Godthab: 1876; Ivigtut: 1880; and Angmagssalik: 1895) extend back to the second half of the 19th century. As can be seen, all climatic stations operating during the 19th century were located in Greenland (Przbiak, 2000). The first station was established in Spitsbergen in 1911 (Green Harbour). In the 1920s, the next seven stations came into operation, mainly in the Atlantic region of the Arctic. Following the Second Polar Year (1932:1933) most Russian stations were established, while most Canadian stations were founded after World War II. For this reason, the opinion exists, that the spatial distribution in addition to reliable estimates of air temperature characteristics in the Arctic are only possible for the last 40–50 years (Przbiak, 2000).

The goal of use all atmospheric measurements that were carried out in Arctic to characterize ETCW is very actual because the continuation of the observed data in time or spatial spreading of the observed data can change the result of the investigation even. The good example of such fact is the story with air temperature data used by Polyakov et al., firstly and Johannessen et al. later.

In 2002, Igor Polyakov and colleagues published an analysis of annual surface air temperature anomalies averaged for the region north of 62°N, extending back 125 years (Polyakov et al., 2002). Their record blended measurements from land stations (primarily coastal), the Russian North Pole drifting ice camps, and buoys over the Arctic Ocean. For the final 17 years of the record (1985–2001), the computed trend of approximately 0.6 °C per decade was found to be twice the corresponding value for the Northern Hemisphere as a whole. By sharp contrast, a trend calculated from1920 to present yielded a small Arctic cooling. For the period 1901 to 1997, there was no significant difference between the trend for the Northern Hemisphere as a whole and for the Arctic. Given the lack of enhanced high latitude warming when the trend is computed over the longest possible record, Polyakov and colleagues concluded that there is no Arctic amplification and that the more notable feature of the Arctic is its pronounced low-frequency variability.

This raised a number of questions. Is it valid to dismiss Arctic amplification by focusing only on the long-term trend? Were the results influenced by a bias towards records from land areas, when climate models were suggesting that amplification, when it emerges, will tend to be strongest over the Arctic Ocean? Such questions led Johannessen et al. (2004) to enhance the data set used by Polyakov et al. (2002) by including additional land stations as well as output from the European Centre for Medium-Range Weather Forecasts numerical weather prediction model (starting in 1995) to provide better coverage over the Arctic Ocean. While their analysis captured the major features noted in other studies, namely substantial high latitude warming from about 1920–1940, followed by cooling to about 1970, then renewed warming extending to the end of the record, the recent warming was seen to increase pole ward of the Arctic Coast. This was some of the first evidence of the warming over the Arctic Ocean projected by many climate models.

Published historical meteorological data analyses were checked to found gaps in such type of data presentation. Another words, the question was : “Is it all historical data measured are used while modern analyses of inter annual Arctic atmospheric variability are taking place?” Motivation of search was based on the fact, that three meteorological stations were constructed in Russian Imperia during First International Polar Year at 1882.

Карта станций Первого международного полярного года в Арктике.
1 — Мыс Тордсен, 2 — Боссекоп, 3 — Содапкюля, 4 — Малые Кармакулы, 5 — район дрейфа «Варны» и «Димфны», 6 — Сагастырь, 7 — Мыс Барроу, 8 — Форт Рэй, 9 — Форт Конгер, 10 — Кингуа-Фьорд, 11 — Готхоб, 12 — Ян-Майен

Figure 3.1 Arctic meteorological stations positions (red points) of the all countries-participants of the first International Polar Year 1882-1883.

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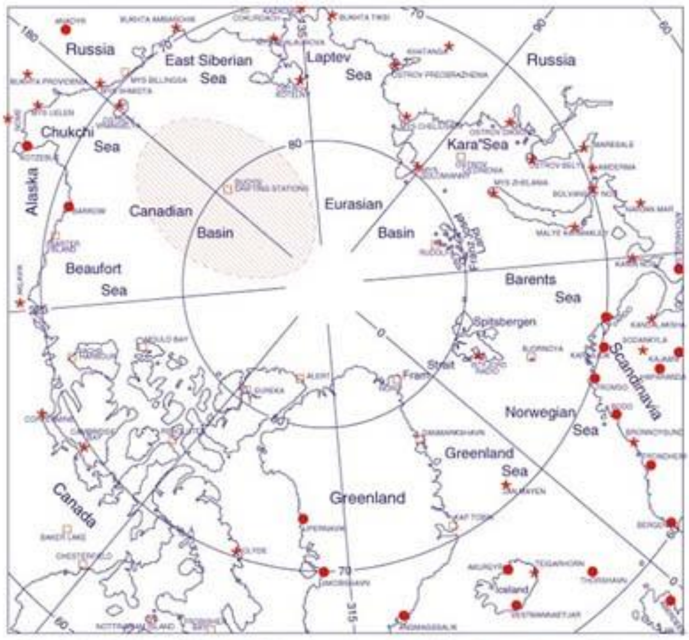


FIG. 1. The locations of SAT and SLP observations. Red circles show stations with $L \geq 100$ yr of observations, red stars represent stations with $65 \leq L < 100$ yr, and red squares indicate stations with $L < 65$ yr. The red cross-hatched oval denotes the region represented by data from the NP manned stations and IABP drifting buoys.

Figure 3.2 The location of the surface air temperature and pressure observations used in Polyakov et al., 2003 investigation. Red circle show stations with duration of measurements logger than 100 years, red stars – between 65 and 100 years, red squares represent the stations with records shorter as 65 years.

It was fixed that for some reasons, the longer most Arctic meteorological data presented in published papers and etc start later that it can be potentially. Looking to fig.3.1 it easy to recognize, that several meteorological stations, namely of the first International Polar Year 1882-1883 ones, started measurements more than 130 years ago (see points with digits 3,4,5 on figures 3.1). Looking on the one of the most exhaustive analyses of the Arctic observed meteorological data variability (see fig,3.2) it is obvious, that full observed records for these stations are not analyzed.

It was determined after searching, that the original meteorological data of the first International Polar Year exist in one archive at Sankt-Petersburg in paper form, while these data are not digitized yet. The estimation of the necessary efforts to digitize the named data within the ACCESS project had the result that there are no enough resources to curry out such big technical work.

4. The search of the additional Russian data to characterize ETCW manifestations in Arctic sea ice.

Published analyses of the historical ice extent data were checked to found possible gaps in such type of data presentation. It was understood before the gaps searching, that estimates of Arctic ice extent, density, volume etc. has been carried out informally and formally for many years by whalers, explorers, indigenous peoples, scientific expeditions and many others. The various data bases used to construct ice conditions prior to and during the period of ETCW as follows:

AARI gridded data, 1930-1990s

Danish Meteorological Institute yearbooks,(DMI)1870s-1960s

ACSYS sea ice databank (North Atlantic ice edges, 1750-1966

National Research Council of Canada (B. Hill), Newfoundland ice extent, 1810-2000

Alaskan ship reports (whaling and others) K. Wood and Bockstoce/Mahoney/Eicken, 1850-early 1900s

HadISST-1 and coordination with new HadISST-2

It was attempt to look critically on first two data source of ice conditions because in old Russian literature essentially prevailed the information regarding the Russian Arctic Seas only and practically no information for others Arctic regions.

Modern (1990th-2013) warming period are characterized in case ice extent charts are under consideration, by several products. The essential part of every products is daily or monthly maps produced by NSIDC. It was fixed also, that direct comparison of the historical and modern charts is difficult because of the different method of the charts construction and different type of observations. The historical monthly charts were constructed based on the several points of visual observations that were carried out during particular month from the rare ships steamed along the Northern Sea Route, for example, and on some near shore meteorological stations, while daily charts were impossible at that time. The visual method to determine the ice margin was very subjective while ships not penetrated into the ice obviously. Modern NSIDC charts constructed daily using the images from space. The unrealistic differences of the ice extent exist sometimes between consecutive days because of difficulties of the interpretation of the signals from space. The monthly ice charts – the main NSIDC ice product, are constructed after averaging of the daily ice charts. The ice margin of the NSIDC products is determined as line separated the regions with less and more 15% ice concentration. The ships that navigated during 1920-1940 and reported ice conditions along their tracks, tried to avoid 15% ice concentration. The determination of the ice margin during 1920-1940 and during 1979-2013, while modern NSIDC ice charts are under consideration, are essentially different therefore. The previous and modern ice extent estimations are also different because the extents determine as areas inside the ice margins. It was fixed the decision that ice extent estimated before and after the era of ice characteristic determinations from the space (at 1979) can be compared qualitatively only, but not as exact digits.

Despite of visually good comparisons between DMI and NSIDC ice product it have to be noted, that actual observations were carried out at August 1938 in that places only where red points exist on map. It means, that real ice margin can situated in any coordinates between the red points (Figure 4.1). The DMI data Coverage is considerably better over Greenland, Iceland, and Spitzbergen than for the rest of the Arctic, and direct observations over the Western Arctic are particularly sparse over the entire period of record. From 1946 to 1956, the ice edge in this region solely reflects annual climatology; the DMI probably did not have access to any data in this region because of the Cold War."

It has to be noted that according to old literature analyses, the Russian scientific expeditions carried out ice observations. One of example of the ice map constructed in 1912 by Georgiy Sedov expeditions on a board of Sviatoy Foka ship presented on figures 4.2. How we can use the ice data obtained within the local region for the imaginations about ice distribution on a large scale obviously demonstrated graph related to Cola Bay (figure 4.3). We can see, that local region can be frozen during both cold and warm integral water temperature of the Barents Sea. It means that interesting, but fragmentary observations, can't serve as indicator of large scale ice cover changes.

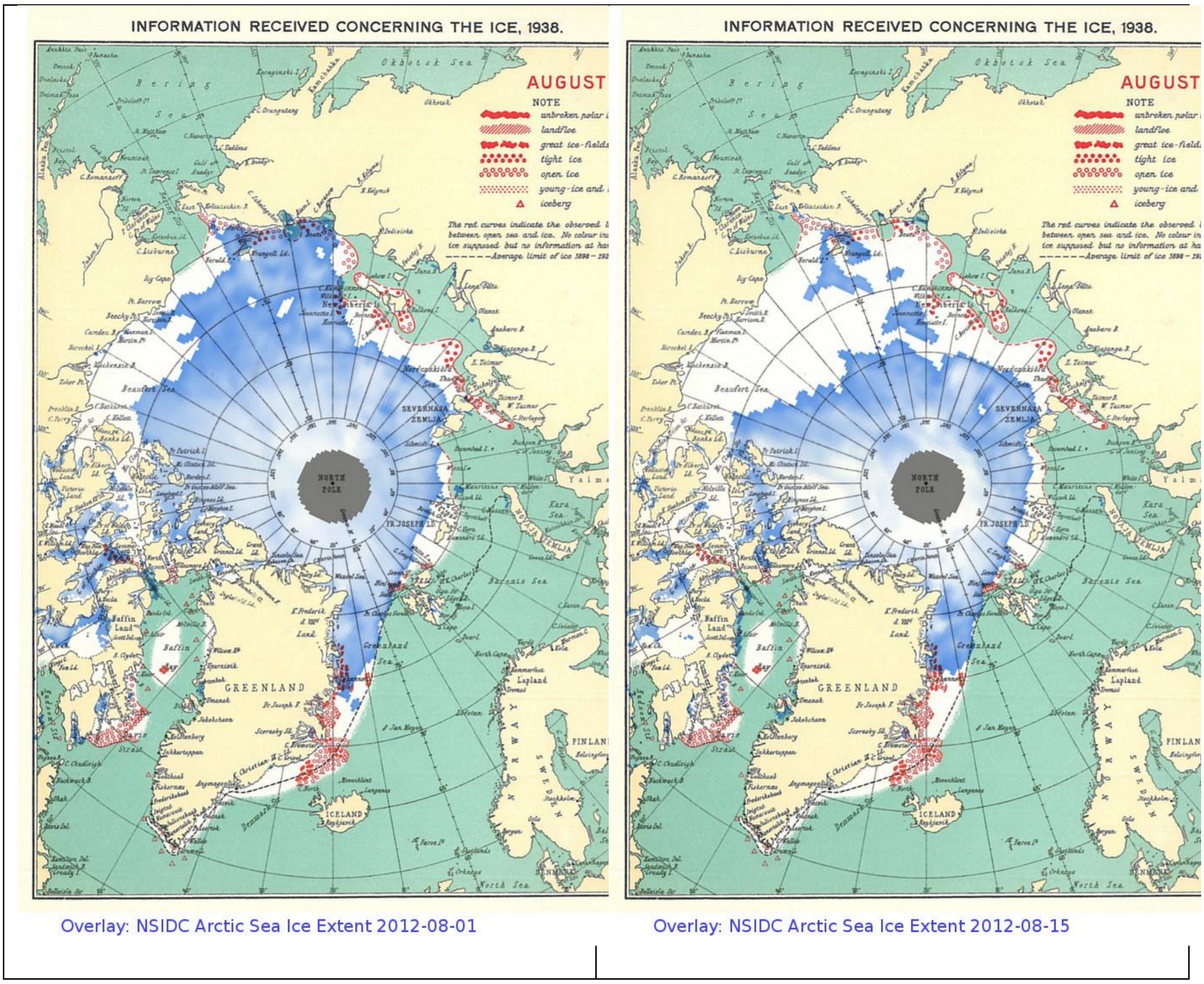


Fig.4.1 Ice charts constructed by Denmark Meteorological Institute for August 1938 in comparison with the ice chart constructed by NSIDC for August 01 2012 (left) and August 15 2012 (right) (overly level, blue color). Note, that red marks on old chart only demonstrate the actual ice observations.

Another "criticism" has to be directed to the original data using while DMI ice maps have constructed. Let's remind about heroic expedition on a board of sailing-motor wooden, 24 meters long, boat Nikolay Knipovich that at August 1932 bended around the Franz-Joseph Land under the leadership of professor N. N. Zubov (figure 4.4). It is impossible to agree with DMI ice margin line in the vicinity of the Franz-Joseph Land for August 1932 (figure 4.5) because the report of the Knipovich' cruise, including photos and maps, exists. The several others checking of the DMI ice maps using the reports of Russian scientific expeditions took place from the second half of 1920th to second half of 1930th supported the idea about non-utilization of many observed data by DMI maps.

Figure 4.2. The ice map that was constructed by Georgiy Sedov expedition (1912-1914) on a board of Sviatoy Foka ship.

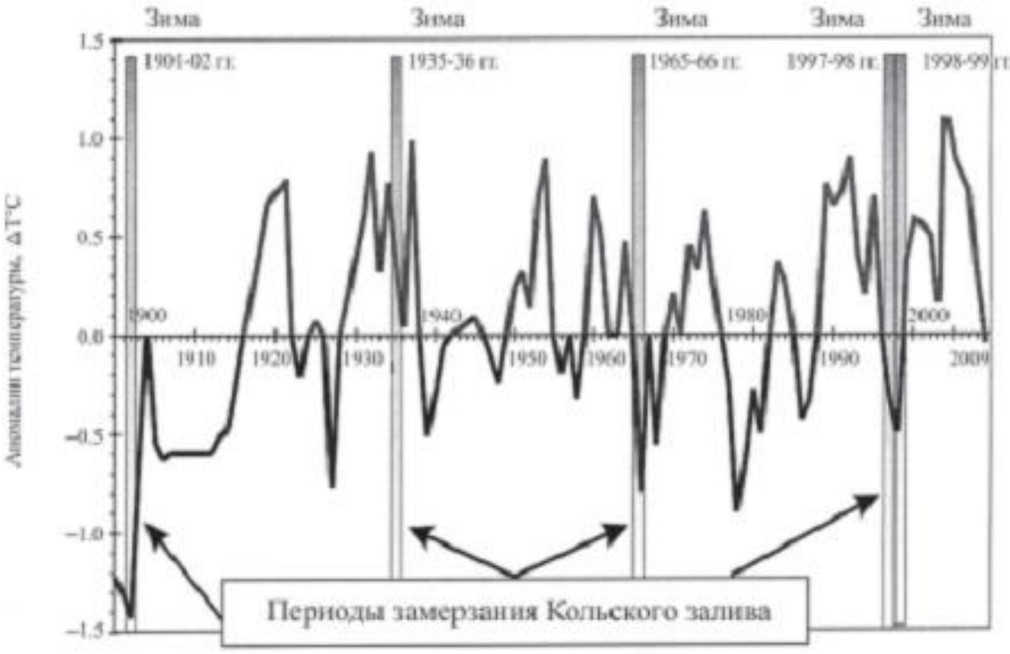


Figure 4.3. The periods of the freezing of the Cola Bay (vertical wide lines) in winter together with integral water temperature anomaly along the Cola Section (that follow through the Barents Sea from the Cola shoe to northern part of the Sea).

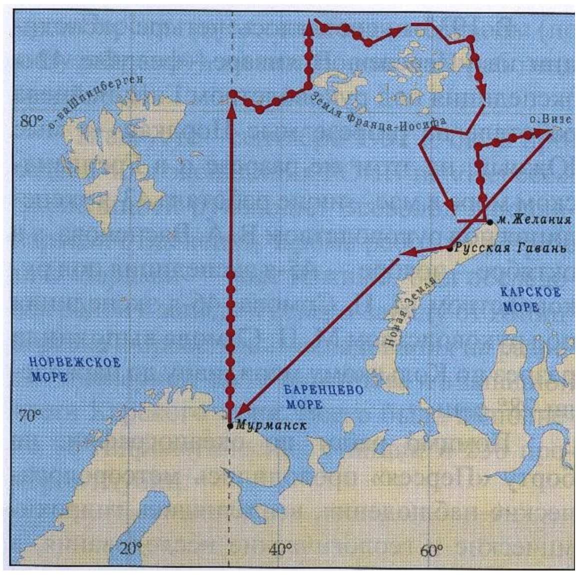


Figure 4.4. The sale-motor boat Nikolay Knipovich (left) and the track of her cruise at August 1932 (right).

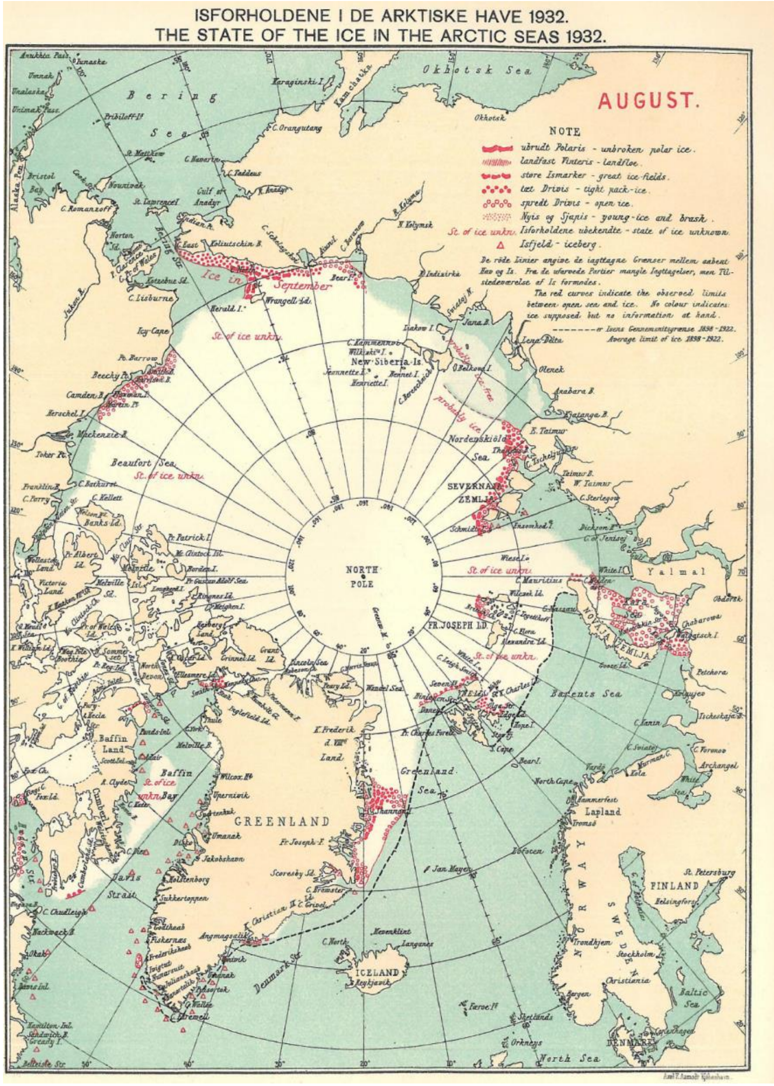


Fig.4.5 Ice chart constructed by Denmark Meteorological Institute for August 1932. Note, that red marks on old chart only demonstrate the actual ice observations.

It well known that more or less regular flights for ice reconnaissance were started in Russian Arctic Seas at 1930th. Example of the map of such air reconnaissance presented in figure 4.6. All such charts and the results of the ice observations from the ships also (Russian generally) have utilized accurately by AARI gridded data, 1930-1990s. Look like there are no the better information to describe ice conditions during ETCW within the Russian Artic Seas at least.

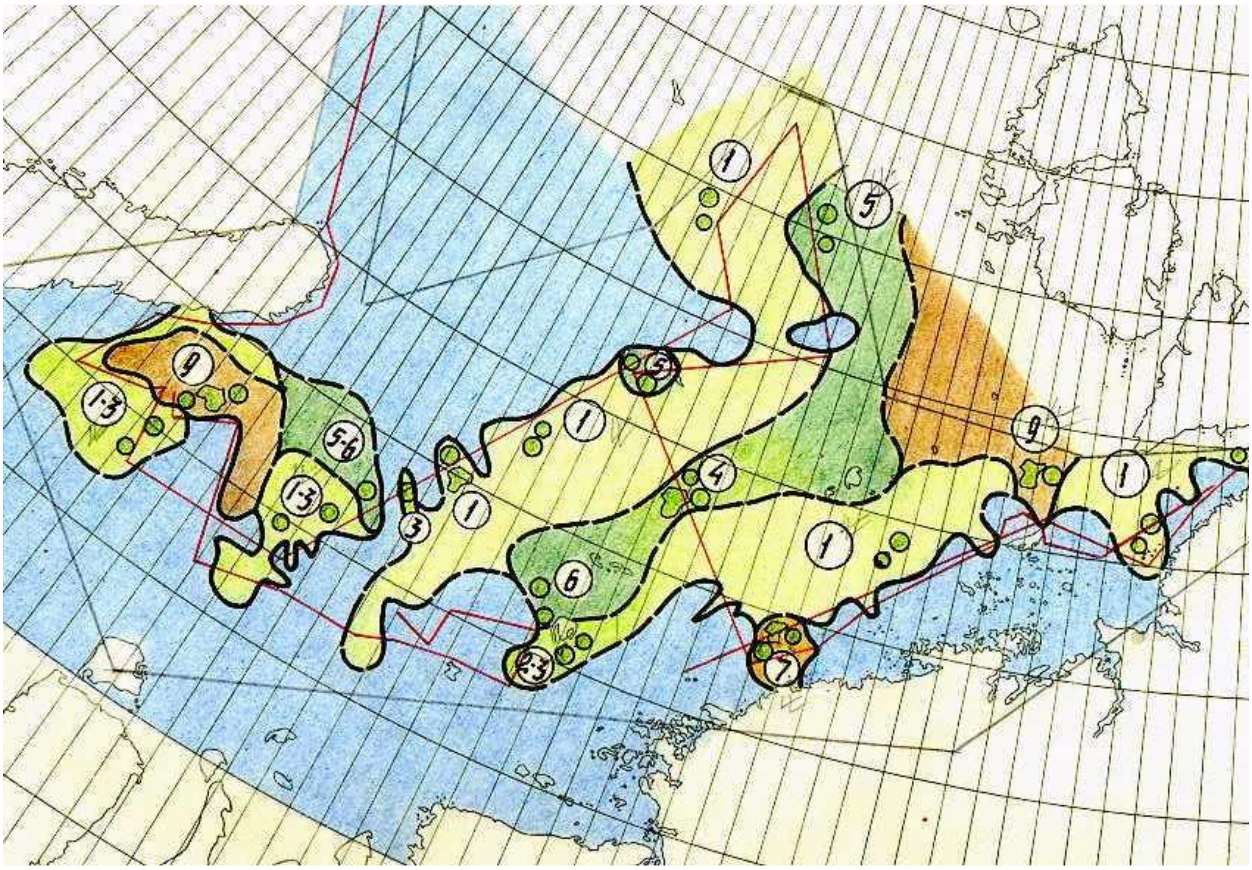


Figure 4.6. Ice map for the Kara Sea at the August of 1933 created on a base of air reconnaissance.

5. The search of the additional Russian data to characterize ETCW manifestations in Arctic waters.

Ocean data archeology was curry out to add the digital data available for investigation of ETCW of the Arctic waters. The well known data bases as into World Ocean Data of National Ocean Data Centre in USA (WOD NODC), Master Ocean Observational Data Sets (MOODS) – the product of USA NAVY, Acrctic Climate System Study project data base for Barents and Kara Seas (BarKode), Climatic Atlas of the Barents Sea 1998, and data of Russian Oceanographic Data Centre served as a base to compare the observed data founded as a table in papers, reports and books with already digitized data. (Matishev et. al., 1998, 2000, 2004). The Moscow' libraries and archives as well as electronic copies of the old publications (Lappo et.all, 2003, Michailov at al., 2002) were used to looking for the ocean data.

Near one hundred old books, papers and reports were checked and 340 stations were digitized for the Eurasian part of the Arctic Ocean deeper than 300 m (fig.5.1). At the same time altogether near

4000 stations were digitized for the Russian Arctic Seas from the same original sources (see examples on figures 5.2, 5.3, 5.4) while the biggest part of this type of data were digitized before the start of the ACCESS project. It is necessary to note, that the famous Fram ocean data exist in WOD without salinity. Altogether 80 stations included previously into known data bases mentioned above were modified therefore.

Newly digitized data were added, after duplication elimination procedure, to local data base of SIO, constructed from several international data bases. The new version of data base of SIO includes 1010 stations for the period 1900 - 1955 within the Eurasian Basin regions deeper 300 m. This data base was used for comparison with the data 1990 – 2010 using such important ocean characteristics as Arctic Atlantic Water temperatures and margins as well as fresh water content above the Atlantic Water. 3350 T,S profiles in the Eurasian Basin that were obtained from CTD (Conductivity Temperature Depth) measurements between the years 1990 and 2010 during ship-borne, submarine and air-borne surveys and manned as well as automated ice drifting platforms were collected also for the Eurasian Basin regions deeper 300 m to compare with the data 1900 – 1955.

It is impossible yet to demonstrate final results of observed data comparison but it is possible to note, that Arctic Atlantic Water was warmer during the 1990 – 2010 comparing with 1920-1940, while it' vertical distribution were comparable for both periods. The preliminary result of fresh water content comparison is that resent time freshening exceed the same during the ETCW. The final result will be after the continuation of the investigations using the comparisons of sparse observed stations of ETCW with EWG climatology to spread the quantity and spatial covering.

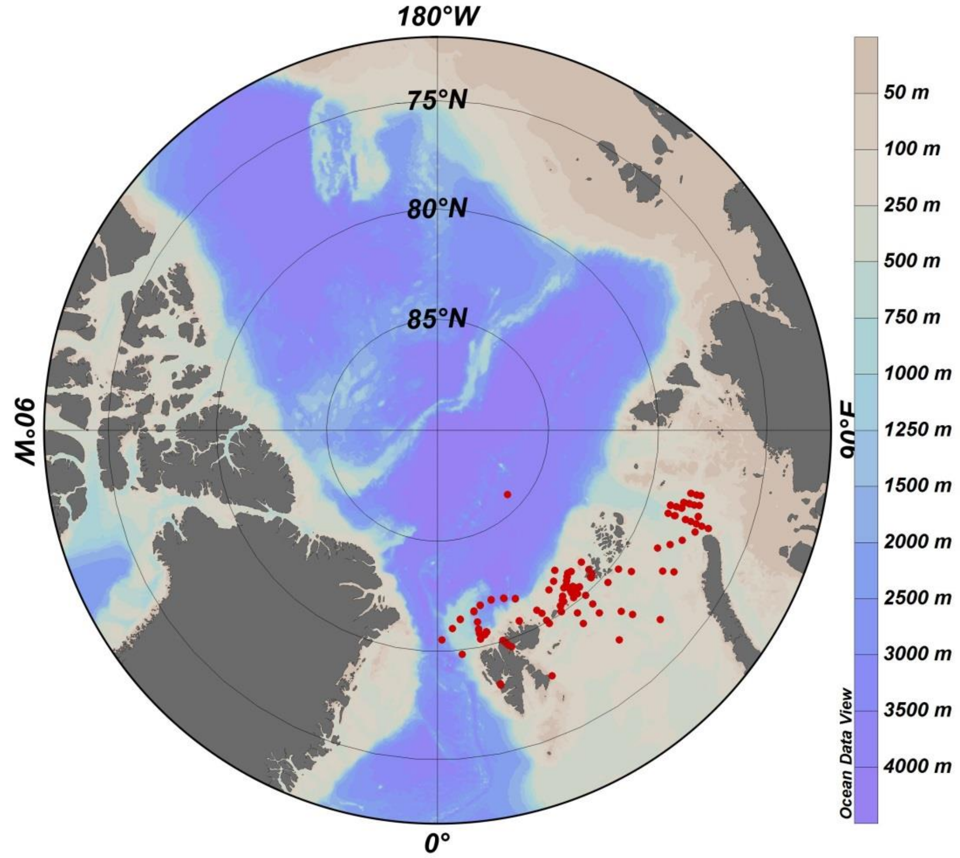
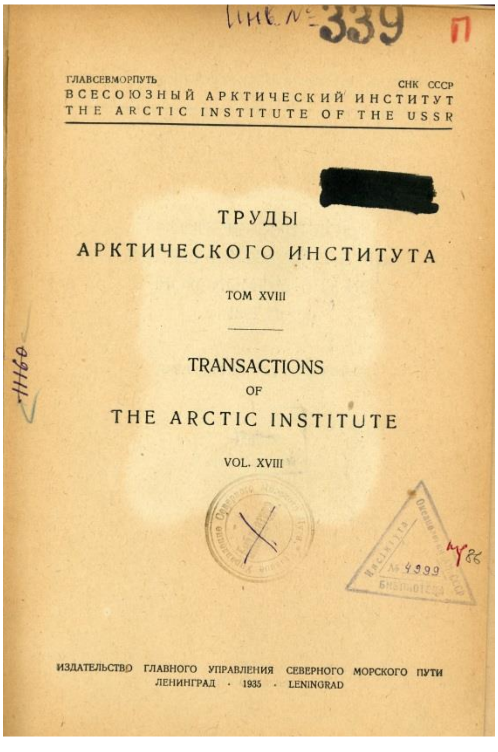


Figure 5.1 Distribution of the stations (red points) that were newly digitized for year 1931.



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ТРУДЫ
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ИЗДАТЕЛЬСТВО ГЛАВНОГО УПРАВЛЕНИЯ СЕВЕРНОГО МОРСКОГО ПУТИ
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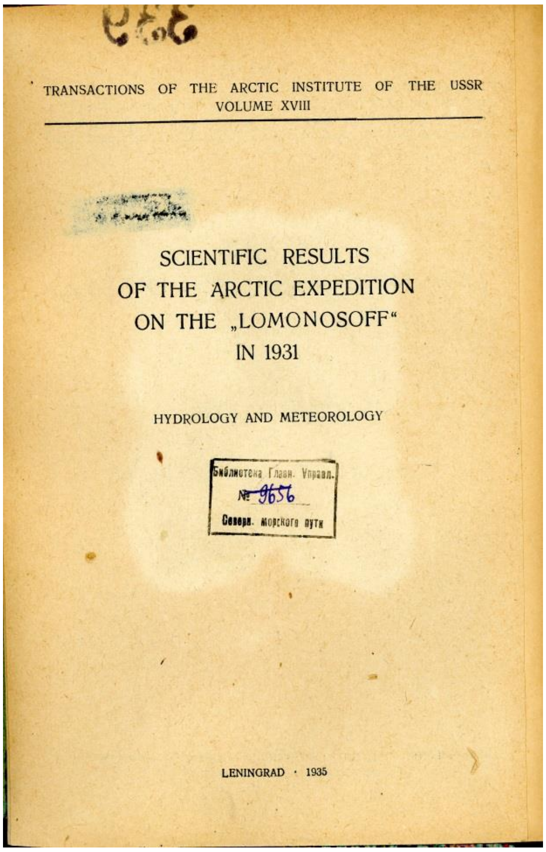
Figures 5.2 Example of the reports from which old ocean data were digitized.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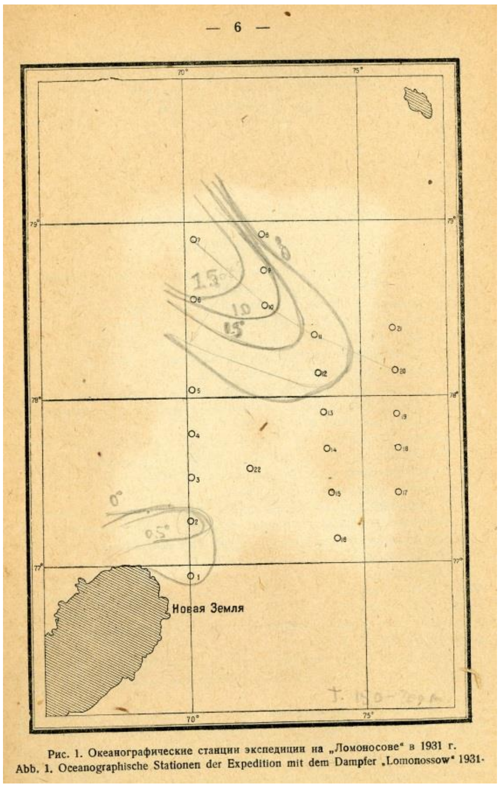
OF THE ARCTIC EXPEDITION
ON THE „LOMONOSOFF"
IN 1931

HYDROLOGY AND METEOROLOGY

LENINGRAD · 1935

Figures 5.3 Example of the reports from which old ocean data were digitized.



Figures 5.4 Example of the reports from which old ocean data were digitized.

6. Conclusion.

After comprehensive analyses of the observed data available within the period 1900-1950 for the Arctic ice cover, air temperature, air pressure, and for the ocean, the last one was determined as the most having obvious lack of digital representation appropriated for the modern investigation of the early twentieth century warming (ETCW) of the Arctic. It was recognized also, that the representations of the characteristics of the Arctic ice and atmosphere during the 1900 – 1950 are under considerations within the several investigations published during the last 10 years. The modern digitized data bases of atmosphere and ice characteristics, according to knowledge regarding the establishing of the Russian Arctic ice and air observations at least, can't be increased in volume practically because most of data have digitized already.

The search of original data of Arctic Ocean expeditions within the hundred old papers, books and reports as well as digitizing of the data was continued during the third ACCESS reporting period to compare the water masses characteristics during the ETCW and 1990 - 2010.

340 temperature and salinity (T,S) stations were "re-open" (had digitized from books, papers and reports in Russian) for the Eurasian Basin regions deeper 300 m (this data are not including into WOD NODC, MOODS or Russian Data Centre Base yet), while near 4000 stations were digitized from the same set of the paper' sources for more shallow regions (this data have included into WOD-online) to characterize 1900-1955. Newly digitized data were added, after duplication elimination procedure, to local data base of SIO, constructed from several international data bases. The new version of data base of SIO includes 1010 stations for the period 1900 - 1955 within the Eurasian Basin regions deeper 300 m. This data base was used for comparison with the data 1990 – 2010 using such important ocean characteristics as Arctic Atlantic Water temperatures and margins as well as fresh water content above the Atlantic Water. 3350 T,S profiles in the Eurasian Basin that were obtained from CTD (Conductivity Temperature Depth) measurements between the years 1990 and 2010 during ship-borne, submarine and air-borne surveys and manned as well as automated ice drifting platforms were collected also for the Eurasian Basin regions deeper 300 m to compare with the data 1900 – 1955.

The traditional, "hand made" methods to compare close (not more than 55 km distance between the coordinates) stations using the maps, vertical profiles, T,S diagrams were used because of sparse spatial and temporal distribution of the observed stations for the period 1900 – 1955. The comparison of every observed station with digital Arctic Ocean EWG climatology characteristics instead of the close stations ones was started (but not finished during the third reporting period yet) to enlarge the quantity and spatial covering of comparisons.

It was fixed, that Arctic Atlantic Water was warmer during the 1990 – 2010 comparing with 1920-1940, while it' vertical distribution were comparable for both periods. The preliminary result of fresh water content comparison is that resent time freshening exceed the same during the ETCW. The final result will be after the continuation of the investigations using the comparisons of sparse observed stations of ETCW with EWG climatology to spread the quantity and spatial covering.

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