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Bathymetric and Bottom Temperatures GIS of the Barents and Kara Seas

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Abstract The Arctic shelf is the most important link in the climatic kitchen of our planet: here, under the influence of the flow of the great Siberian rivers, a layer of freshened water is formed, blocking access to the surface of relatively warm saline waters of the North Atlantic origin, which prevents the melting of the ice cover of the Arctic basin Thus, the processes occurring in the relatively small size of the Arctic region, are able to change the state of the planetary scale system. Such active attention to this problem is associated with the development of offshore oil and gas fields. Permafrost established under the bottom of the Arctic seas occurs at a distance of up to 120 km from the coast, at a depth of several tens of meters. The temperature of the sea day is an important characteristic in assessing the state and direction of the evolution of sub-permafrost. To solve the part of this problem we tried to make bathymetric and temperature GIS of costal and offshore permafrost in Barents and Kara Seas. The GIS is based on the sea depth, temperature, and salinity of sea water collected by the marine organizations of Russia, the USA, England, Germany, Norway and Poland for the Barents and Kara Sea regions from 1898 to 1998. From all sources in the areas of the Barents and Kara Seas, more than 1,000,000 oceanographic stations were selected for processing. These maps are only the part of the GIS project.
Keywords: Barents Sea; Bottom temperature; GIS; Kara Sea; subsea permafrost

1. Introduction

The Arctic shelf is the most important link in the climatic kitchen of our planet: here, under the influence of the flow of the great Siberian rivers, a layer of freshened water is formed, blocking access to the surface of relatively warm saline waters of the North Atlantic origin, which prevents the melting of the ice cover of the Arctic basin. In the autumn-winter period, the shelf waters are the source of young ice, which are eventually transferred through the Fram Strait and further to the North Atlantic. Thus, the processes occurring in the relatively small size of the Arctic region, are able to change the state of the planetary scale system. Such active attention to this problem is associated with the

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development of offshore oil and gas fields. The possibility of the long-term existence of the sub-permafrost cryolithozone is due to the constantly negative temperature of the bottom layers of sea water in most of the territory of the Arctic seas (Soviet Arctic, M: Science, 1970).

The temperature regime of Arctic waters has been studied in some detail (Chekhov, 1972). It has been established that permafrost under the bottom of the Arctic seas occurs at a distance of up to 120 km from the coast, at a depth of several tens of meters (Hunter, 1976). The temperature of the sea day is an important characteristic in assessing the state and direction of the evolution of sub-permafrost.

2. Materials and methods

To determine the temperature of the seabed and estimate the trends of the evolution of the sub-permafrost, a GIS was developed for the Barents and Kara Seas. The GIS is based on the sea depth, temperature, and salinity of sea water collected by the marine organizations of Russia, the USA, England, Germany, Norway and Poland for the Barents and Kara Sea regions from 1898 to 1998. From all sources in the areas of the Barents and Kara Seas, more than 1,000,000 oceanographic stations were selected for processing (Matishov, 1998).

The existing system of international collection and exchange of information involves the repeated inclusion of the same data in arrays obtained from different sources. In addition, even in the data of one source, duplication is obviously possible. The matter is complicated by the fact that in different formats and databases the same information can be stored in different forms, with different losses and of different quality. For example, in some information bases there is no information on the time of the implementation of oceanographic stations. In others, there is no information on related meteorological and hydrochemical observations. Thirdly - geographic coordinates are not specified in degrees, minutes and seconds, but in degrees with an accuracy of hundredths, which leads to additional errors associated with the rounding of the coordinate values. It is also possible deliberate duplication of data within a single source. Given this circumstance, a search and exclusion of duplicate stations was conducted. During subsequent processing, the data were checked for coincidence of coordinates with an accuracy of 0.5 min. latitude and longitude, and the temperature is accurate to 0.001oC. For ease of use of the information database, all observed parameters are interpolated to nine standard horizons 0, 25, 50, 100, 150, 200, 250, 300 m and the bottom. The distance from the bottom to the bottom horizon is set within five meters. In the absence of such a horizon, the data on it is interpolated.

Processing was carried out in stages. The data from various sources were originally presented in various formats and structured with translation into accepted units of measurement. Values deliberately exceeding the possible range of variability of the observed parameters are excluded: for temperature the limits are set from -2,00 to 35,00^{o}C, and for a maximum depth of less than 9990 m (Barents, 1990).

A check was performed to get data into the sample area. The data falling on land were rejected. At this stage, the depth of the station and the last horizon at which the

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observations were made was checked. The minimum and maximum depth values were determined by the 9 closest to the design point sites of the bathymetric map (Shirokov, 2012).

On the basis of the entire array of materials and the processed database, working versions of the bottom temperature maps of the Barents and Kara seas were created. Maps are based on interpolation of about 500,000 points (Figure 1,2).

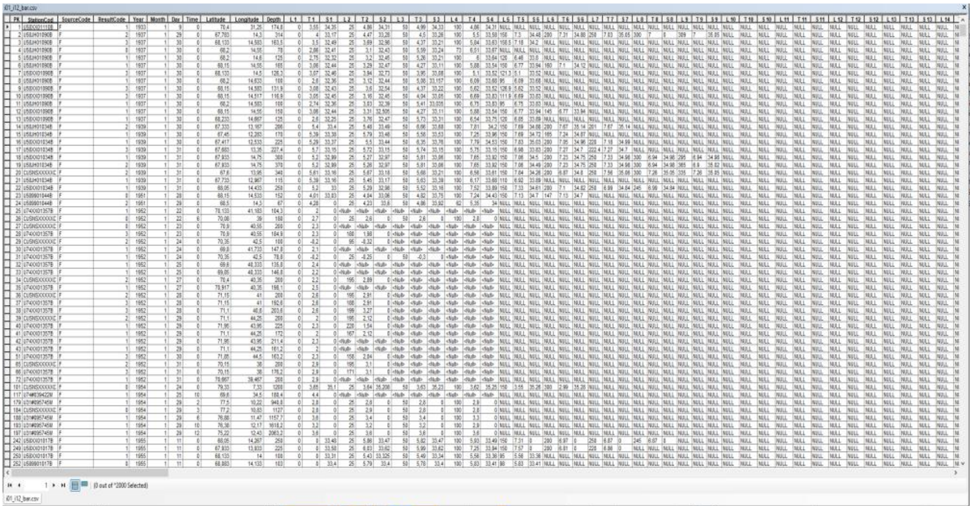

Figure1. Sea bottom temperature data base

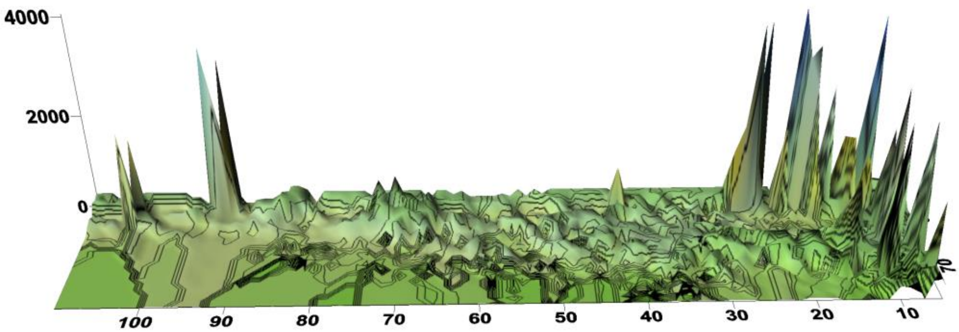

Figure 2. Relief based on our database of Barents and Kara Seas

Next, an array of data is selected that contains information only about the temperatures of the seabed. The spatial distribution of averages for 1900-1998 has been calculated. seabed temperatures and a map of seabed temperatures has been constructed.

3. Results

The constructed map of seabed temperatures is supposed to be used as one of the GIS layers characterizing the distribution conditions and the state of sub-permafrost. The primary analysis of the spatial distribution of the temperatures of the seabed and sub-subsurface frozen rocks shows that for almost the entire territory of the southeastern Barents Sea, within which there are sub-substated permafrost, its accelerated degradation is observed. Here, the bottom temperature reaches 3°C and higher. Accelerated degradation of the subabergeal permafrost is also characteristic of the Kara Sea bays, the Baydaratskaya, Ob and Gydan lips and the Yenisei Gulf. For these regions of the Kara Sea, the seabed also has a positive temperature. In the rest of the Kara Sea, the subabergeal permafrost is most likely in a quasi-equilibrium state. The temperature of the seabed here has negative values close to the thawing temperature of saline frozen soils (Figure 3).

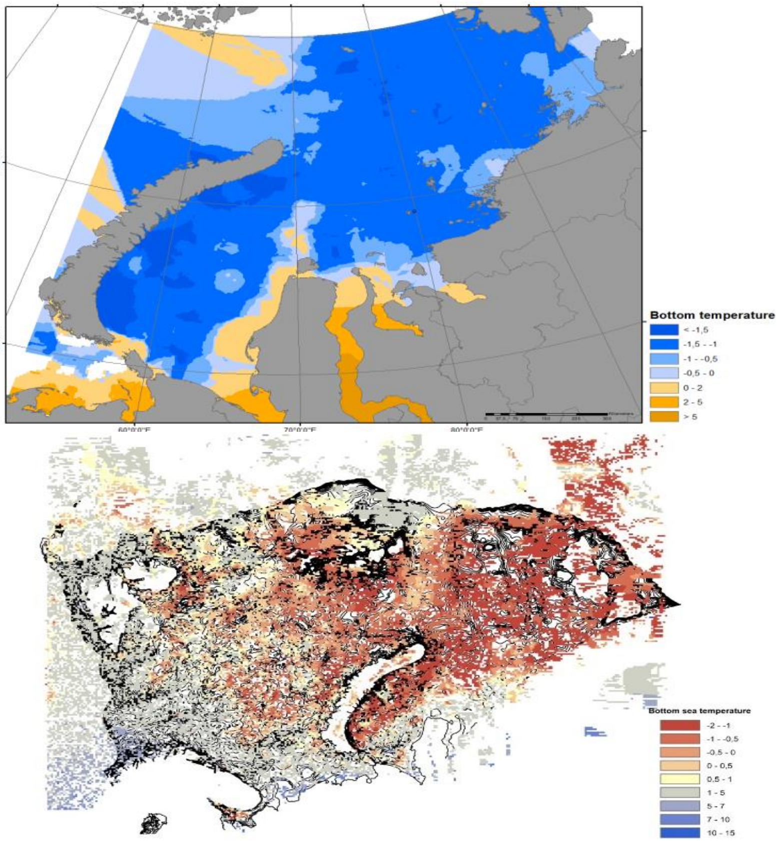

Figure 3. Models of water bottom temperature Barents and Kara seas

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To assess changes in the seabed temperature over time, two key regions were selected with the maximum amount of data on the seabed temperature over the entire observation period - the South-Eastern Barents Sea and the Malygin Strait in the Kara Sea. For these plots, diagrams of the seafloor temperature have been plotted over decades, and trends have been calculated. As an example, Figure 4 shows the changes in sea bottom temperature and the age-old trend in the southeast part of the Barents Sea.

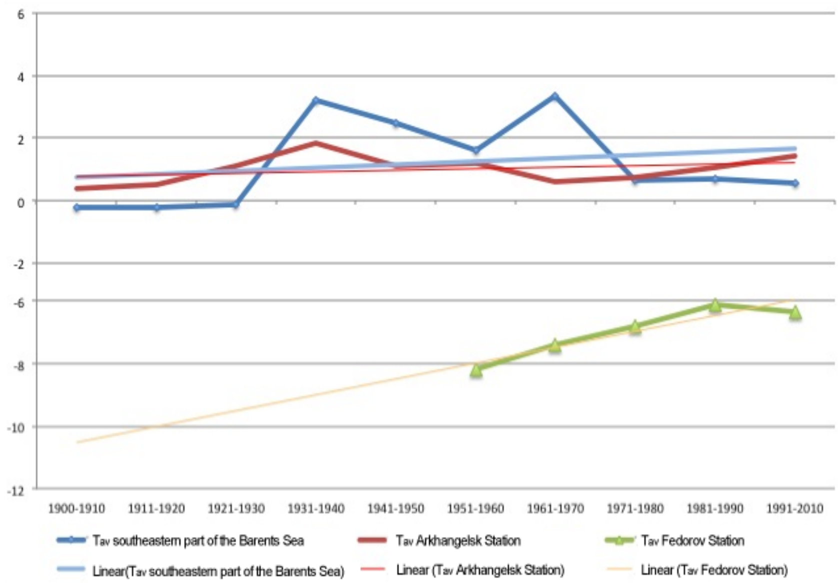

Figure 4. Secular variations of bottom temperatures in southeastern Barents Sea and air temperatures from Arkhangelsk and Fedorov weather stations.

For comparison, diagrams of changes in air temperature are plotted for base weather stations for these sites.

From 1900 to 1998, the temperature of the seabed of the southeastern Barents Sea increased by about 0.4°C. In the Malygin Strait (Kara Sea), over the same period, the temperature increase was 0.2°C. The reason for the increase in the seabed temperature is the increase in air temperature and, possibly, an additional influx of warm Atlantic waters into the Arctic Ocean (Figure 5).

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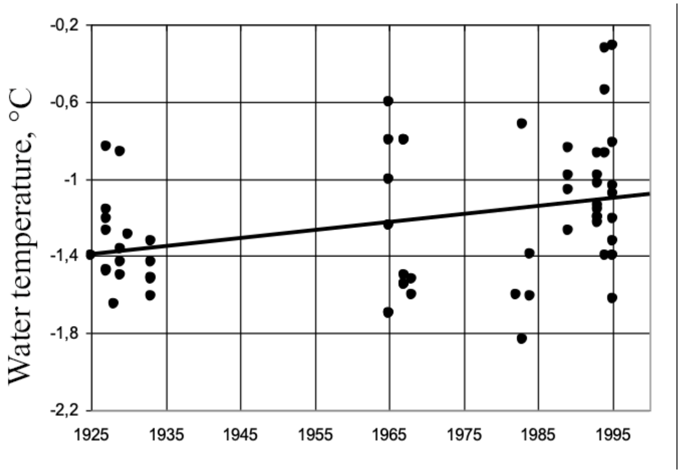

Figure 5. The secular change in the temperature of the bottom layer of water in the Strait of Malygina. A straight line - the trend.

To create a GIS solved the following tasks:

- A method for controlling oceanographic data was developed and implemented in software.
- Selected data on temperature and salinity of the bottom layer of seawater; bathymetric data for the Barents and Kara Seas. It is assumed that the bottom temperature is equal to the temperature of the bottom water layer.
- A GIS was developed that includes more than 300 thousand data on temperature and salinity of the water of the Barents and Kara Seas (1988–2005) (Fig. 1).
- 2D and 3D models of the distribution of bottom temperatures in the Barents and Kara Sea were built based on the terrain (Fig. 2).
- Maps of the space-time distribution of the bottom temperature and salinity of water were created, allowing to compare the fields of these temperatures (Fig. 3).
- Two key regions were selected in which sub-subsurface frozen rocks are present, with the maximum amount of data, and a secular change in the spatial distribution of averages for 1900–1998 estimated. bottom temperatures in the Barents and Kara Seas.
- Changes in the bottom temperatures of the Barents and Kara Seas were detected.
- Charts of bottom temperature changes by decades were constructed, and trends and air temperature change diagrams were calculated for the base weather stations for these sites (Fig. 4).
- Created maps of the spatial distribution of temperature seafloor Barents and Kara Seas, the example of two model regions - East part of the Barents Sea and west of the Strait Malygina found in the Kara Sea temperature of sea bottom increase by 0.4 and 0.2 ° C, respectively. The reasons for the rise of the sea bottom temperature

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are increasing air temperature and, possibly, the additional inflow of warm Atlantic waters into the Arctic Ocean (Fig. 5).
The obtained data can be used for qualitative assessments and modeling of changes in the state of sub-permafrost.

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