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CLIMATIC ATLAS OF THE ARCTIC SEAS 2004: Part I. Database of the Barents, Kara, Laptev, and White Seas - Oceanography and Marine Biology

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CLIMATIC ATLAS OF THE ARCTIC SEAS 2004:
Part I. Database of the Barents, Kara, Laptev, and White Seas - Oceanography and Marine Biology

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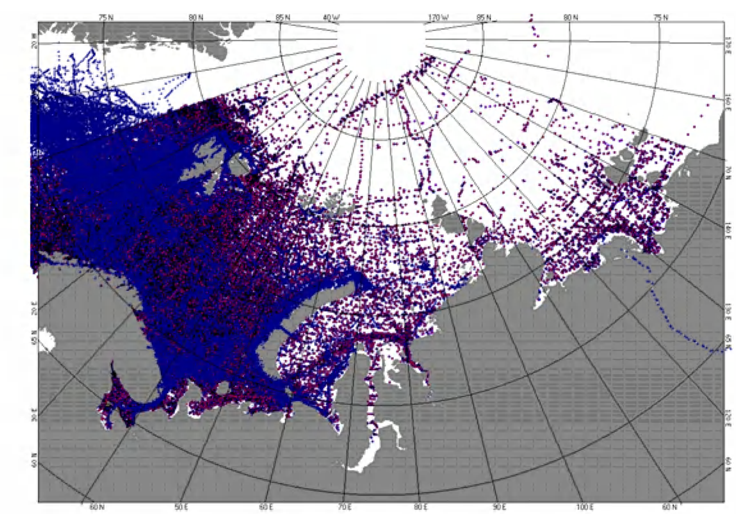
Настоящая работа выполнена в рамках:	The present work is prepared within the framework of:
- проектов “Спасение и архивация глобальных океанографических данных” (GODAR) и “База данных Мирового океана”, одобренных Межгосударственной океанографической комиссией (IOC) ЮНЕСКО	- “Global Oceanographic Data Archaeology and Rescue” (GODAR) and “World Ocean Database” projects endorsed by the Intergovernmental Oceanographic Commission (IOC) UNESCO
- Меморандума о взаимопонимании между Российской академией наук и Национальной администрацией по океану и атмосфере Министерства коммерции Соединенных Штатов Америки о сотрудничестве в области Мирового океана и полярных регионов	- Memorandum of Understanding between the National Oceanic and Atmospheric Administration of the Department of Commerce of the United States of America and the Russian Academy of Sciences of the Russian Federation on Cooperation in the Area of the World Oceans and Polar Regions

DATABASE

Time period: 1810-2001
Number of stations: 433,179



Region	Num. of stations
Barents Sea:	219,077
Norwegian Sea:	160,512
White Sea:	20,348
Central Arctic:	13,870
Kara Sea:	13,591
Laptev Sea:	5,781
Country	**Num. of stations**
Russia:	178,356
Norway:	122,593
Unknown:	54,386
USA:	36,469
United Kingdoms:	17,426
Germany:	6,648
Poland:	2,740
Holland:	1,242
Canada:	1,226
Sweden:	383
Japan:	340
Finland:	221
Iceland:	177
France:	164

Атлас и данные, на которых он основан подготовлены для международного распространения без ограничений на DVD диске, согласно принципов Мирового центра данных Международного совета научных объединений и Межгосударственной океанографической комиссии ЮНЕСКО.

The Atlas and associated data are being distributed internationally without restriction via DVD disk, in accordance with the principles of the World Data Center System of the International Council of Scientific Unions and the UNESCO Intergovernmental Oceanographic Commission.

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Russia 1870
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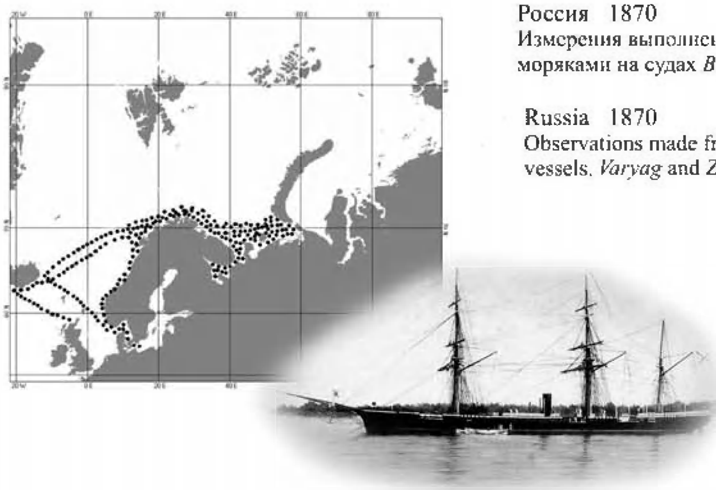
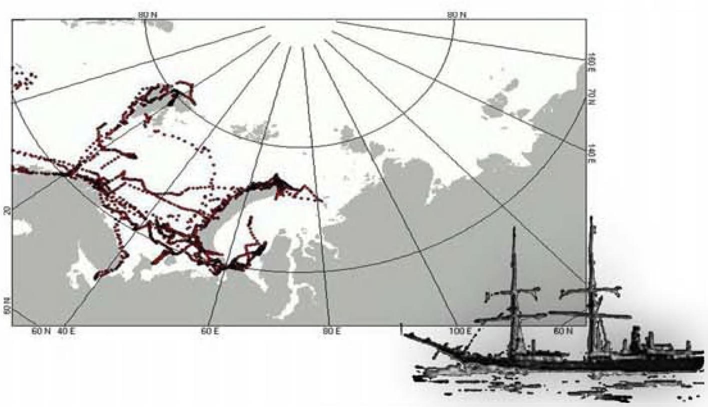


Норвегия 1871
Измерения выполнены на зверобойных судах

Norway 1871
Observations made from hunting vessels



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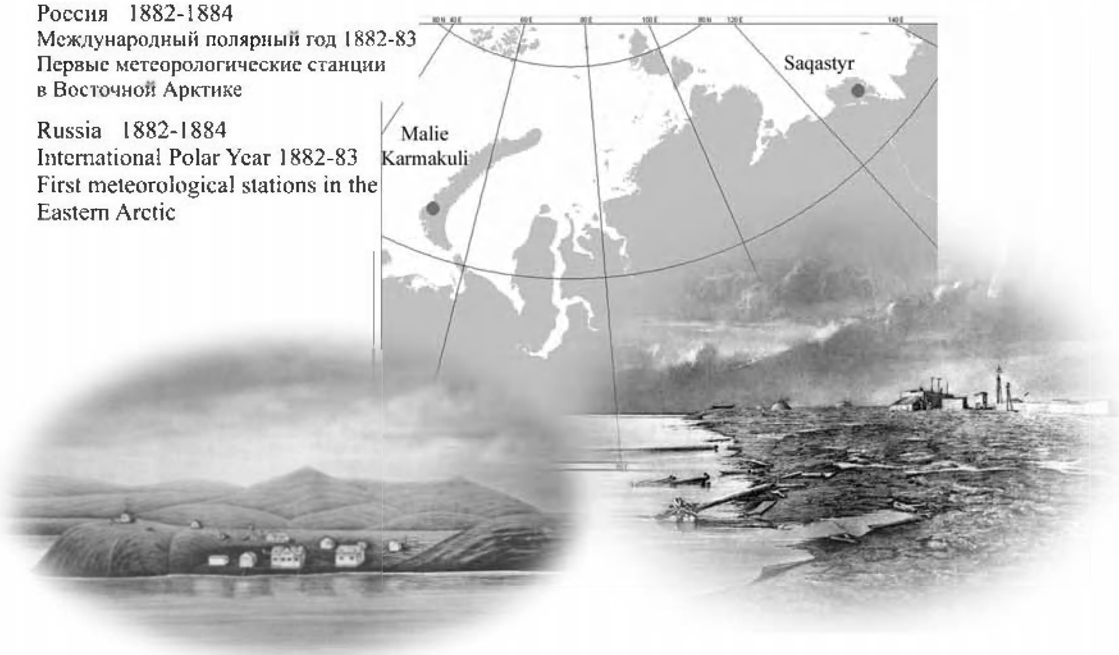

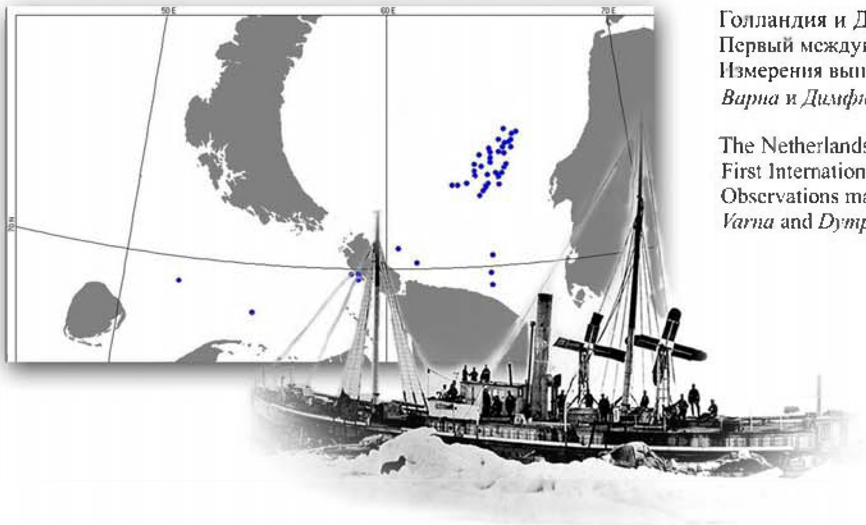

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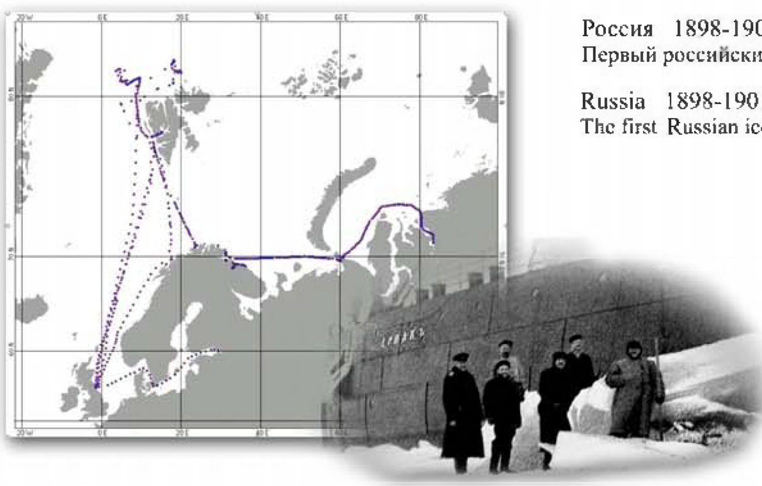

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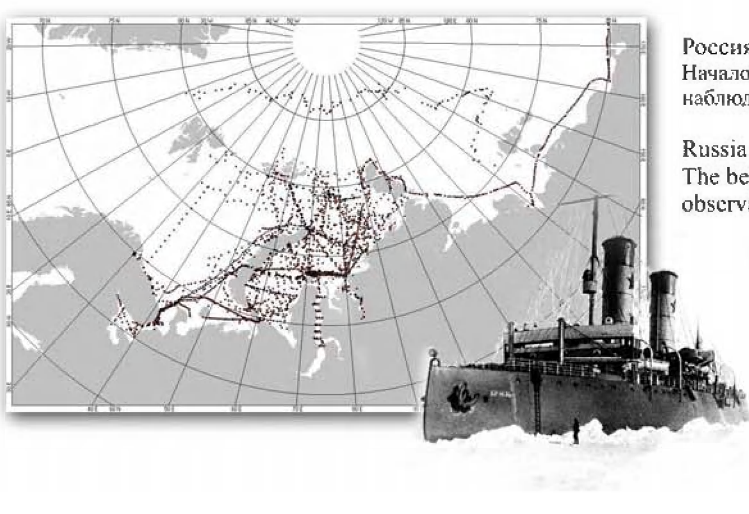

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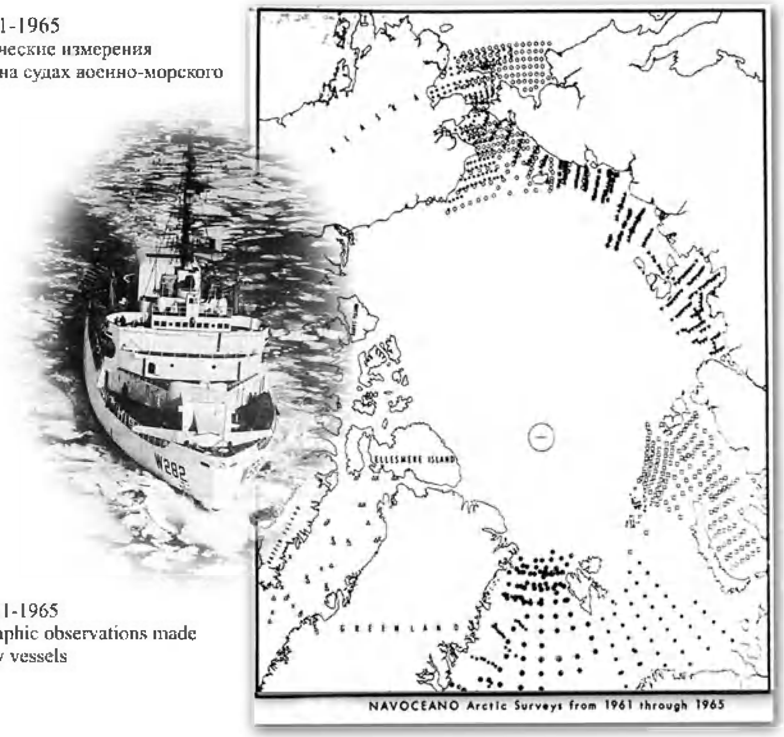

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ACKNOWLEDGEMENT

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We are grateful to the NOAA Central Library (Silver Spring, MD, USA), the Slavic and Baltic Branches of the New York Public Library (USA), the New York Museum of Natural History Library (USA), the Dartmouth College Library (Hanover, NH, USA), the Slavic Library (Helsinki, Finland), and the public libraries of Moscow, Murmansk, and St. Petersburg (Russian Federation), which have served as important sources of data for this product.

We appreciate the assistance of the staff of the Murmansk Marine Biological Institute (MMBI) and the NOAA Ocean Climate Laboratory during the creation of the database, and we wish to thank Valentina Suvorova-Harlowe (Yanuta) for translating this product from Russian into English.

We would like to express special gratitude to Torgny Vinje, Norwegian Polar Institute, who provided us with the observational results obtained by Norwegian ships during the period 1867-1912.

ABSTRACT

This Atlas presents primary data on meteorology, oceanography, and hydrobiology from the Barents, Kara, Laptev, and White Seas, which were collected by scientists from different countries during the period 1810-2001. The data format that we use in the electronic (DVD) part of the atlas allows one to quantitatively access information for oceanographic variables as well as plankton, benthos, fish, sea birds, and marine mammals. The data are divided into one-degree squares with monthly climatic characteristics calculated for every square, which were used to plot monthly climatological charts of temperature and salinity. Access to the primary data is carried out through a graphical interface presented in the shape of a geographical chart. The Atlas also includes, in electronic format, selected copies of rare books and articles about the history of Arctic exploration and climate studies as well as photos and drawings, which provide information about the people and nature of the northern polar latitudes throughout the past two centuries.

1. INTRODUCTION

The natural resources of the Barents, Kara, Laptev, and White Seas are rich and diverse. For many decades, they have supported an enormous and lucrative fishing industry, and today this region continues to be a zone of intensive navigation by providing cargo transportation between the cities of Europe, Asia, and the Far East. In addition, the petroleum sector is actively exploring potential oil and gas fields for development. Consequently, the exploitation of natural resources in this region makes it necessary to study a broad range of environmental issues, among which is a priority to better understand the impact on these resources due to changes in climate. This is even more crucial since the Arctic is inhabited by a variety of human populations, many of whom derive their livelihood from the resources in the Arctic, and it boasts terrestrial and marine ecosystems that do not exist anywhere else.

Climate studies of the Arctic have resulted in a large number of publications that describe various changes taking place within this region and which document and explain sources of variability in the Arctic climate system. However, because this has been an area of chronically poor data coverage, the ability to quantify high-latitude climate variability on interannual to inter-decadal temporal scales has been limited. Thus, this product will provide a more comprehensive series of oceanographic and biological observations in the Barents, White, Kara, and Laptev Seas, which can be used for long-term global change monitoring.

2. HISTORY OF OCEANOGRAPHIC INVESTIGATIONS IN THE ARCTIC

Systematic studies of the Barents, White, Kara, and Laptev Seas started in the second half of the 19^{th} century. These studies were initiated to search for a fast and reliable way to deliver cargo between the ports of Europe, Russia, Asia, and America. Germany, Norway, France, the Netherlands, England, Russia, USA, and other countries sent their ships to the Arctic for scientific and commercial objectives. It is beyond the scope of this discussion to provide a comprehensive review of Arctic exploration, and the reader is directed to the "Electronic Library," which provides partial and full texts of books that go into much more detail. However, it is appropriate to briefly consider the basic events in the history of studies of these seas.

The first half of the 19^{th} century was a period of intensive trade of marine and terrestrial animals found near Spitsbergen and the western part of the Kara Sea. Hundreds of ships from different countries took part in this trade. It was aboard an English whaleboat in April 19, 1810, that the first oceanographic measurements were made by William Scoresby at 76°16' N, 9°00' E in the Arctic, both at the surface and at depth. This data is included in the1871 publication by Piterman *et al.*, the full text of which appears in the "Electronic Library" section. The same publication contains meteorological and ocean-surface temperature data collected during the first German Arctic expedition (1868-1970) in the northeastern part of the Norwegian Sea and northwestern part of the Barents Sea.

At present, there is a considerable amount of sea-surface temperature and meteorological data for the Kara and Barents Seas covering the period of 1867-1912. This is the result of carefully prepared ship logs by the captains of Norwegian commercial ships which utilized the Northeast Passage. The section for "Database/Cruises" on the DVD contains data from 168 Norwegian cruises.

Efforts to pass through the Northeast Passage and establish this as a viable trade route began in the 1590s with expeditions by Willem Barents. The next attempt was not until 1734-43, when Vitus Bering explored the Siberian coast as part of the Great Nordic Expedition. Julius Von Payer, in an Austrian-Hungarian expedition in 1872-74, also attempted to sail through the Northeast Passage, but this expedition ended at Novaya Zemlya when ice trapped his ship.

In 1875-76, the Swedish researcher, A.E. Nordenskiöld, aboard the ships *Pröven* and *Eemer,* was the first to sail from Europe to the mouth of the Ob River in order to prove the possibility of cargo transportation from Europe to Siberia. In 1877, the first Russian cargo cruiser, *Utrennyaya Zarya,* sailed from the Yenisey River to St. Petersburg via the Kara and Barents Seas. In 1878-79, with better preparations, Nordenskiöld left aboard the *Vega* and successfully traversed across the Barents Sea to the Pacific via the Kara Sea. During the cruises in the Barents and Kara Seas on the *Pröven, Eemer,* and *Vega*, meteorological observations and oceanographic measurements at both the surface of the water and at depth were conducted.

With the discovery of the Northeast Passage in the late 1870s and until 1936, regular commercial transport between Europe and across the Barents and Kara Seas took place. This is described in more detail by Khmiznikov in 1937, available in the "Electronic Library" section of the DVD. During this period, forecasts of ice conditions for the Barents and Kara Seas were of critical importance. The cost of ship and cargo insurance reflects the realities of forecasting ice conditions in the Barents and Kara Seas: in 1914, insurance costs were 6%-8% of the total expeditionary budget; in 1929 – 0.8% - 2.25% (Wieze, 1934; full text of this book is available in the "Electronic Library" section of the DVD).

In 1879, Britain and The Netherlands explored the Barents and Kara Seas with expeditions conducted aboard the *Isbjörn* and the *W. Barents*, respectively, the latter performing meteorological observations and water-temperature measurements. From 1880-84, The Netherlands again used the *W. Barents* to conduct hydrological surveys over a considerable part of the Barents Sea.

In 1882, the First International Polar Year (IPY I) commenced. It was organized at the initiative of Karl Weyprecht, the leader of the Austro-Hungarian expedition aboard the *Tegetthoff* to study Franz Josef Land in 1872-1874. The goal of IPY I was to organize an Arctic network of polar stations to conduct meteorological and magnetic observations on a regular basis. Twelve countries took part in IPY I, and they established 15 meteorological stations. Russia established meteorological stations at Malye Karmakuly, on Novaya Zemlya, and Sagatyr, located at the mouth of the Lena River (see the "Photo Gallery" section). In Siberia, there was a shortage of meteorological stations, so The Netherlands and Denmark established stations on Dickson Island and at Cape Chelyuskin (on the Taimyr Peninsula), respectively.

The Netherlands sent the ship, *Varna,* to establish a meteorological station on Dickson Island. During the entire month of August 1882, the *Varna* tried to penetrate the ice-covered Kara Sea. By the end of August 1882, she became trapped by ice in the Kara Sea, and while she drifted, deep-sea temperature and density measurements were performed (Snellen, 1910; see the full text of this book in the "Electronic Library" section).

While the *Varna* was drifting in the Kara Sea, the Danish steamship, *Dijmphna,* was sent to build a meteorological station on the Taimyr Peninsula. Unfortunately, the *Dijmphna* also became entrapped by ice, and it drifted together with the *Varna* (see "Photo Gallery"). The *Varna* sank in the Barents Sea on 24 July 1883, but not before the crew was able to escape to the nearby *Dijmphna.* Soon after, the crew of the *Varna* left the *Dijmphna* and headed out on the ice to make their way to Novaya Zemlya, taking along three sleds and four small boats. Near Yugorsky Shar, the crew met the ship, *Nordenskiöld*, which delivered them to Norway. The *Dijmphna* was liberated from the ice in the middle of September 1883; and in October, she arrived back in Norway.

In 1893, the *Fram* expedition, led by F. Nansen, conducted meteorological and hydrological observations in the Barents and Kara Seas. In the same year, N. Knippovitch conducted a series of hydrological observations in the Barents Sea. From 1898-1914, motivated to further explore the North, Russia organized two large expeditions in the Barents, White, and Kara Seas. These expeditions, aboard the *Andrey Pervozvanny, Pakhtusov,* and *Pomor*, collected meteorological and hydrobiological data.

In 1898, the Russian icebreaker, *Yermak,* set forth into the Barents Sea with the goal of reaching the North Pole. Although the *Yermak* was unable to fulfill this mission, it proved that icebreakers were able to overcome ice-covered seas that are inaccessible to regular ships. During the *Yermak* voyage, meteorological and hydrobiological data were collected (Makarov, 1901).

In 1905 and 1907, a French-sponsored expedition on the Danish ship, *Belgica*, engaged in hydrological and hydrobiological studies in the Barents and Kara Seas. In the "Electronic Library" section, there is a full report of the 1907 expedition, including the meteorological data and sea-surface temperature measurements.

The Russian polar researcher, V. Rusanov, set out in 1912 on the small boat, *Hercules*, with the intention of studying the Kara Sea. He began his journey from Archangel on 12 August 1912, but he disappeared and his fortune remains unknown. The ship, *Eclipse,* was sent to search for Rusanov's expedition. During its passage from the Barents to the Kara Sea, the *Eclipse* expedition carried out meteorological observations and sea-surface temperature measurements (Trzemestskiy, 1917). The full text of the report on this expedition is in the "Electronic Library" section.

Studies of the White Sea for navigation purposes started in the 17th century. The first charts containing data on ice conditions were published by the Russian Navy in the mid-18th century. In 1881, a biological station was established on the Solovetsky Islands, and regular hydrobiological studies commenced for this region. In 1899, the station moved from the Solovetsky Islands to the Yekaterininsky Harbor in the Kola Bay, located in the southern part of the Barents Sea. At that time, the station officially became the Murmansk Marine Biological Station (MMBI). In the "Electronic Library" section, the full text of Deryugin's description of hydrobiological studies (Deryugin, 1906) conducted by the MMBI during 1899-1905 is available.

In the mid-1930s, a system of measuring along standard transects in the White Sea was adopted. Even today, these transects are used to conduct hydrological surveys; during World War II, there was no abatement in the hydrological studies along these transects. On the DVD, there are temperature and salinity profiles for the period 1941-1945.

During the 1950s, the Zoological Institute of the Russian Academy of Sciences established a biological station in the Kandalaksha Bay in the White Sea. Since 1961 and up to the present, measurements are taken every ten days at one location. These include water temperature and salinity at 0, 5, 10, 15, 25, 50, and 65 m. In 1963, in addition to temperature and salinity measurements, observations of zooplankton began, which have also been collected every ten days. This data has been used to document marine environmental effects on zooplankton development in this region (Berger *et al.*, 2003).

The Laptev Sea was difficult to reach due to its distance from both the Atlantic and Pacific Oceans. However, Vitus Bering, Hariton Laptev, Dmitry Ovtsin, and others were among the first the first to reach this area during the Great North Expedition that was conducted from 1734-42, during which the entire Siberian coast was surveyed and documented. In the 1820s, the Ust-Yana expedition, led by Pyotr Anzhu, succeeded in conducting a hydrographic survey of the Laptev Sea coast between the Olenyok and Indigirka rivers, and he also mapped the New Siberian Islands.

In 1900, the Russian Academy of Sciences equipped Eduard Toll for an expedition aboard the ship, *Zarya,* to study the Novosibirsk Islands in the Laptev Sea. This expedition collected hydrobiological data that has been partially published.

In the early 20th century, the Russian Government began to study the problem of promoting regular voyages from the Barents Sea to the Pacific Ocean. Two icebreakers, *Taimyr* and *Vaigach,* were built for this purpose. During the period 1911-1915, these icebreakers made several voyages from Vladivostok to the west via the Bering Strait during which a wide spectrum of oceanographic and hydrobiological studies was conducted (Transehe, 1925. In the section, "Bathymetry" on the DVD, there is a chart of the *Taimyr* and *Vaigach* voyages). Most of the data from these expeditions is not yet published.

In 1918, although he was unable to reach the North Pole, Roald Amundsen did succeed in sailing as far east as Cape Chelyuskin, on the Taimyr Peninsula, where he over wintered. The next year, Amundsen continued his journey eastward and became only the second person to sail through the Northeast Passage.

In the 1920s, efforts to study the northern regions of the European and Asian parts of the Soviet Union began. For this purpose, the Government of the Soviet Union provided significant funds. A portion of these funds was used to build a network of meteorological stations along the ship route, from the Atlantic Ocean to America and Asia via the Bering Strait. Formerly known as the Northeast Passage, this route became identified as the Northern Sea Route. In the 1920s, building commenced on icebreakers and ice-class transport ships that would be able to penetrate the ice-encrusted seas. At the same time the number of scientific expeditions to the seas of the eastern sector of the Arctic increased. During the Second International Polar Year, 1932-33, the Soviet Union organized over ten expeditions that conducted studies from the Bering Sea to the Greenland Sea. During these expeditions, substantial amounts of meteorological, oceanographic, and hydrobiological data were collected. Part of this material is included in this database as well as contained in publications by Markhayev *et al*., 2003, Lappo *et al*., 2003.

After World War II, a new stage began in studying the Arctic seas due to an increased interest in exploring fishery resources of the Barents and White Seas, oil and gas mining in the Barents and Kara Seas, and providing safe navigation along the Northern Sea Route. In this period, a variety of platforms were utilized to study the Arctic seas: scientific stations on floating ice fields (Romanov, *et.al.,* 1997), airplanes (Konstantinov *et al*., 2000), and atomic icebreakers (Matishov *et al*., 2000).

The oceanographic and hydrobiological data collected up to the present time can be used to solve a wide range of problems in various areas of oceanography, marine biology. The database presented here contains 433,179 stations for the period of 1810 to 2001. All the primary data is on a DVD disk.

3. BATHYMETRY AND SEA-BOTTOM TOPOGRAPHY OF THE BARENTS-KARA SHELF

During the 20th and 21st centuries, great success was achieved in studying complicated events and phenomena that determine the nature of seas and oceans as well as of glacial and periglacial shelves (Matishov, 1980). The dynamics, thermohaline structure, and hydrochemical cycle of polar sea waters are the function of climate, ice conditions, and other natural factors. Of special importance is the shelf topography. When traveling along the troughs, Atlantic and Arctic waters transport and redistribute biogenous, radioactive, and other substances (Matishov, 1984; Zenkevich 1963; Bogorov, 1967; Nikiforov, Shpaiher, 1980; Matishov *et al.*, 1982).

Fridtjof Nansen (1904) was the first to start geomorphologic and oceanographic studies of the Arctic Ocean shelf. P.S. Vinogradov, V.M. Litvin, V.D. Rvachev, G.G. Matishov, and B.S. Senin (Vinogradov, 1964, 1979; Litvin, 1973, 1979; Matishov, 1987; Matishov, Rvachev 1983) contributed much to the bathymetric cartography of the Arctic Ocean bottom. A series of bathymetric charts for the North Atlantic Ocean, Norwegian-Greenland basin, and the Barents, White, and Kara Seas were compiled during the 1950s to 1990s (Matishov, 1984, 1987, 1995). The charts are based on bathymetric plane tables and 200,000-scale Mercator projections, which were compiled using detailed sea-bottom echo-sounding profiles (see “Bathymetry” section on DVD). These charts are mainly from MMBI and the Knipovich Polar Research Institute of Marine Fisheries and Oceanography (PINRO). When compiling bathymetric charts for the Barents-Kara shelf and Franz-Josef Land, the data from sea-bottom seismic profiling was also used.

The Barents Sea bottom has a very diverse topography. The average shelf depth is about 250 m; with a maximum depth ranging 400-500 m. The outer edge of the shelf in the north and west of the Barents Sea stretches along the banks at 200- to 350-meter depths and along the troughs at 400- to 550-meter depths (Atlas, 1967, 1980; Dobrovolsky, Zologin, 1982; Suhovey, 1986). Shallow areas of the shelf (less than 100 m depth) are mainly found in the southeastern part of the Sea, on the narrow coastal strip of the archipelagos, Novaya Zemlya and Spitsbergen, and on the Medvezhinsko-Nadezhdinsk upland. In other regions, only small sections of the sea-bottom – the tops of some banks and ridges – are at depths less than 80-100 m. The deep troughs and vast banks exert control, to a large extent, over vertical and horizontal water circulation.

Among all the shelf-topography forms made by continental ice, typical forms are fjords, edge and cross troughs, and sea-bottom edge glacial formations. Detailed bathymetric charts clearly show a direct connection between the underwater valleys of the coastal shelf to the hydrological network of the continent. Underwater fjords are morphologically dense networks of trough-shaped valleys, which have cut up the rocky sea-bottom over tens and hundreds of meters. Such fjord systems as Porsangen, Lakse, Tana, and Varanger near the northern Norwegian coast are examples of comparatively wide (5-20 km) and deep (150-400 m) underwater fjords. These valleys rectilinearly stretch for 20-100 km from the shore towards the sea.

The edge troughs stretch along the coastal shelf of northern Norway, Spitsbergen, Novaya Zemlya, and Franz Josef Land, representing a system of narrow (5-16 km), shallow (100-200 m), successively located valleys and wide (64 km) troughs (Voronin, East-Novaya Zemlya, South- Novaya Zemlya and North-Novaya Zemlya) with depths of 250-450 m.

It is natural that almost along the entire length of the polar shelf, sub-parallel lateral troughs separate uplands and plateaus from each other. In particular, in the southeast Barents Sea, there is a network of troughs separating Moller Bay and the Gusinoye, as well as North- and South-Kanin Banks. They represent large valleys dissecting stratified and basalt shelf plains.

The deep (300-500 m) troughs, Medvezhinsky, Finmarken, and Zuidkapp, as well as the Central depression, stretch for several hundreds of kilometers reaching a width of 100-200 km. On the slopes of the Central and Novaya-Zemlya upland, trade valleys are connected to each other via little breaks and cracks. The Perseus upland in the north of the Barents Sea is the most dissected. It consists of small, shallow (50-160 m) plateaus-horsts separated by graben-shaped troughs with incision depths of 100-200 m.

On the surface of the Barents Sea shelf, there are large uplifts: Murman, Central, Nordkapp, Medvezhinsk-Nadezhdinsk. They serve as main water divides for all large currents and water mass circulation. The height of these flat-slopey sea-bottom uplifts is comparatively large, sometimes reaching 200-400 m. Their length can be as much as 2-5 hundreds of kilometers and width – 100-200 km. Usually, on terraces predetermined by breaks, flat slopes of these uplifts can reach a 2-4^o steepness.

The high-latitude (80-82^o N) archipelago, Franz Josef Land, represents a complicated system of large (more than 1000 km^2) and small basalt islands with deep-water straits (400-650 m) between them. All large islands are covered with glaciers in the shape of sheets or flat domes like Jackson dome (576 m) on Hooker Island, Vetrenny dome (509 m) on Gram-Bell Island, and Tindal dome (519 m) on Wilczek Land. Above the glaciers, there are rocky peaks like in the Wullerstorf Mountains (670 m) on the Wilczek Land Island.

The complicated system of bathymetric edge and cross troughs of the Barents Sea shelf allows for the flow of warmer and more saline Atlantic waters to penetrate into the high Arctic. Warm waters of the Nordkapp and West Spitsbergen Currents flow in from the west and north along the troughs to the deep area of the Barents Sea and eventually interlock between Franz Josef Land and Novaya Zemlya. There is a high-latitude (72-82^o N) water turnover of Atlantic water masses. Interacting with cold Arctic waters, they form a polar hydro-front (Nikiforov and Shpaiher, 1980). Underwater troughs outline biogeographical boundaries and serve as landmarks for the location of productive zones (Matishov, 1987). The intensity of water circulation as well as salt and heat transport along the sea-bottom valley system depends on inter-annual fluctuations of river runoff and sea-ice formation.

4. CLIMATOLOGY

Based on the data contained in the section "Database" on the DVD, the following climatic fields have been created:

- Mean monthly maps of temperature and salinity distributions for the Barents, White, Kara, and Laptev Seas for the levels 0 m, 25 m, 50 m, 100 m, and 200 m.
- Mean monthly fields of temperature and salinity distributions along five sections (Figure 1) on the Barents, Kara, White, and Laptev Seas.

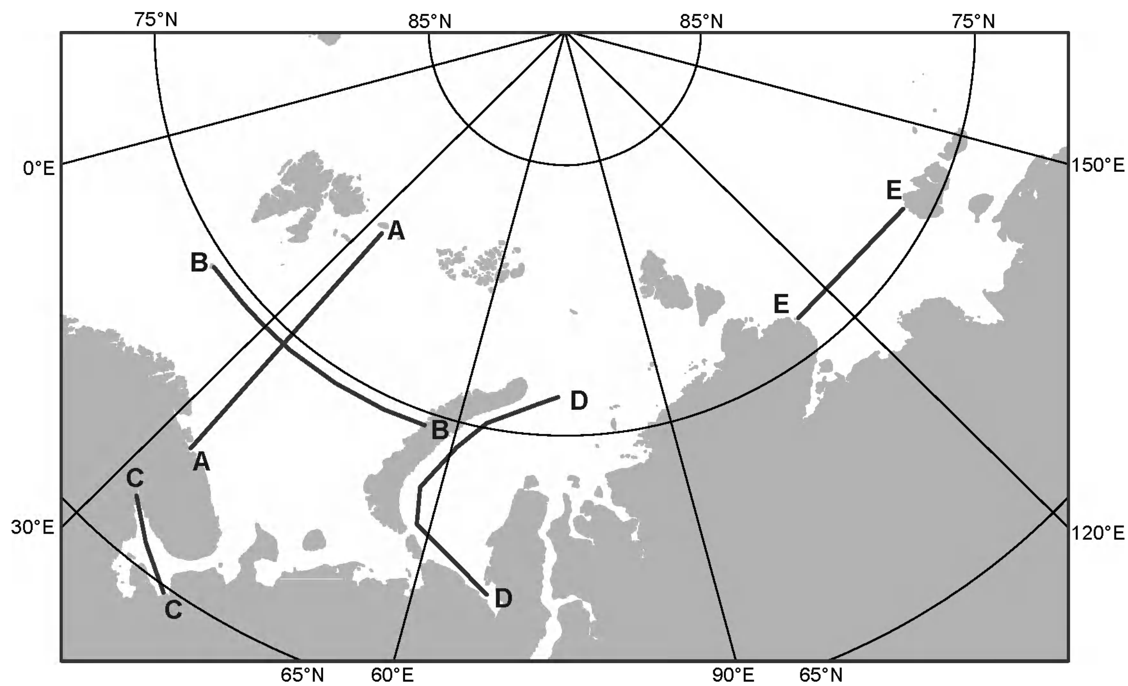


Figure 1. Positions of the sections for which the mean monthly climatic fields of temperature and salinity have been created.

A sample map of sea-surface temperatures in September is shown in Figure 2. On the DVD, in the section "Climatology," there are color maps of mean monthly temperature and salinity fields at the levels 0 m, 25 m, 50 m, 100 m, 200 m for the 5 sections (Figure 2).

The procedure for building climatic fields (an objective data analysis) used in this study corresponds to a scheme proposed by Barnes (1973) and the calculation technique of spatial data distribution and map construction (Levitus and Boyer, 1994). This procedure consists of two stages.

At the first stage, a grid was created in which the Barents, Kara, and Laptev Seas were divided into squares of 50 x 50 km. Temperature and salinity profiles at all points within this grid were assembled for every month and individual year. Data unavailability was marked with a special code.

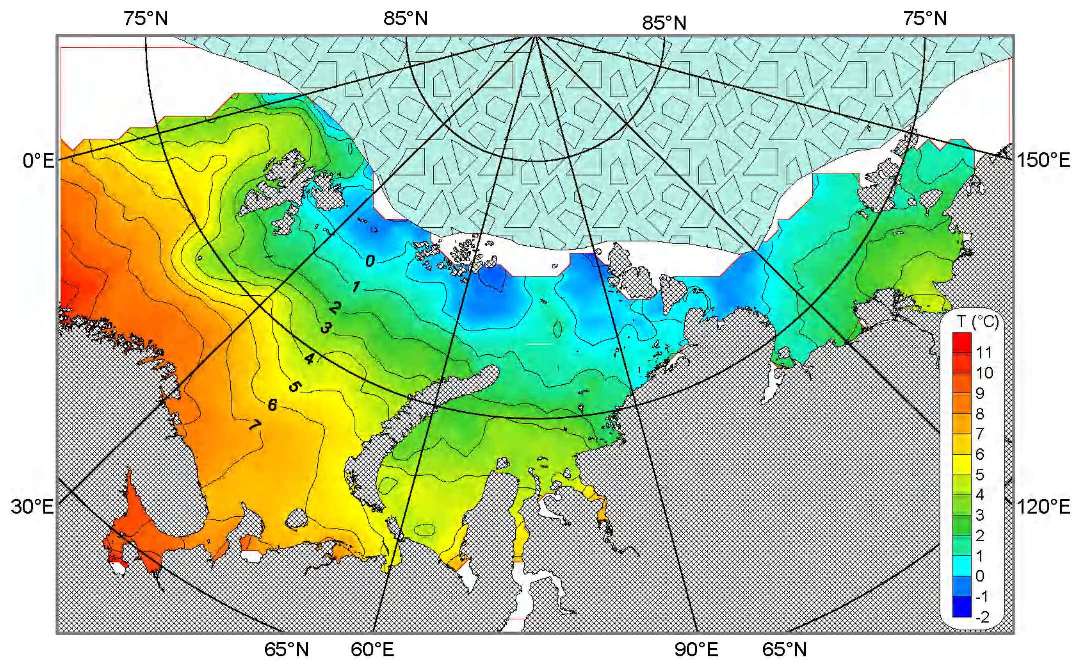


Figure 2. Sea-surface water temperature for September.

At the second stage, calculations were made of mean monthly temperatures and salinities for each of the squares in the grid. Where there was a square with less than four years worth of data, this square was not used to compute the climatology.

When building the climatic fields of temperature and salinity along sections A, B, C, D, and E, data were used that were located within a distance of 50 km on both sides of the section line. The further away the station from the section line, the lesser the effect of temperature and salinity values at this station on calculated climatic characteristics (Golubev and Zuyev, 2003).

The mean monthly distribution maps for temperature and salinity on the surface and at different levels presented on the DVD clearly show an annual cycle of temperature and salinity variations, primarily for the Barents Sea. For this sea, there is a clearly observed annual cycle of air-temperature variations at individual points (Figure 3). In general, for the Barents Sea, in the corresponding time periods, there is a correlation between structures of the fields of air and water temperatures in winter and summer (Figure 4 and 5).

The White, Kara, and Laptev Seas are covered with ice during the winter months, which significantly reduces the amount of data available for these months. Consequently, it is very difficult to determine the annual cycle of temperature and salinity variability in these seas. However, the annual cycle of the ice edge in the Barents, Kara, and Laptev Seas can be used as an indirect proxy to describe these cycles (Figure 6).

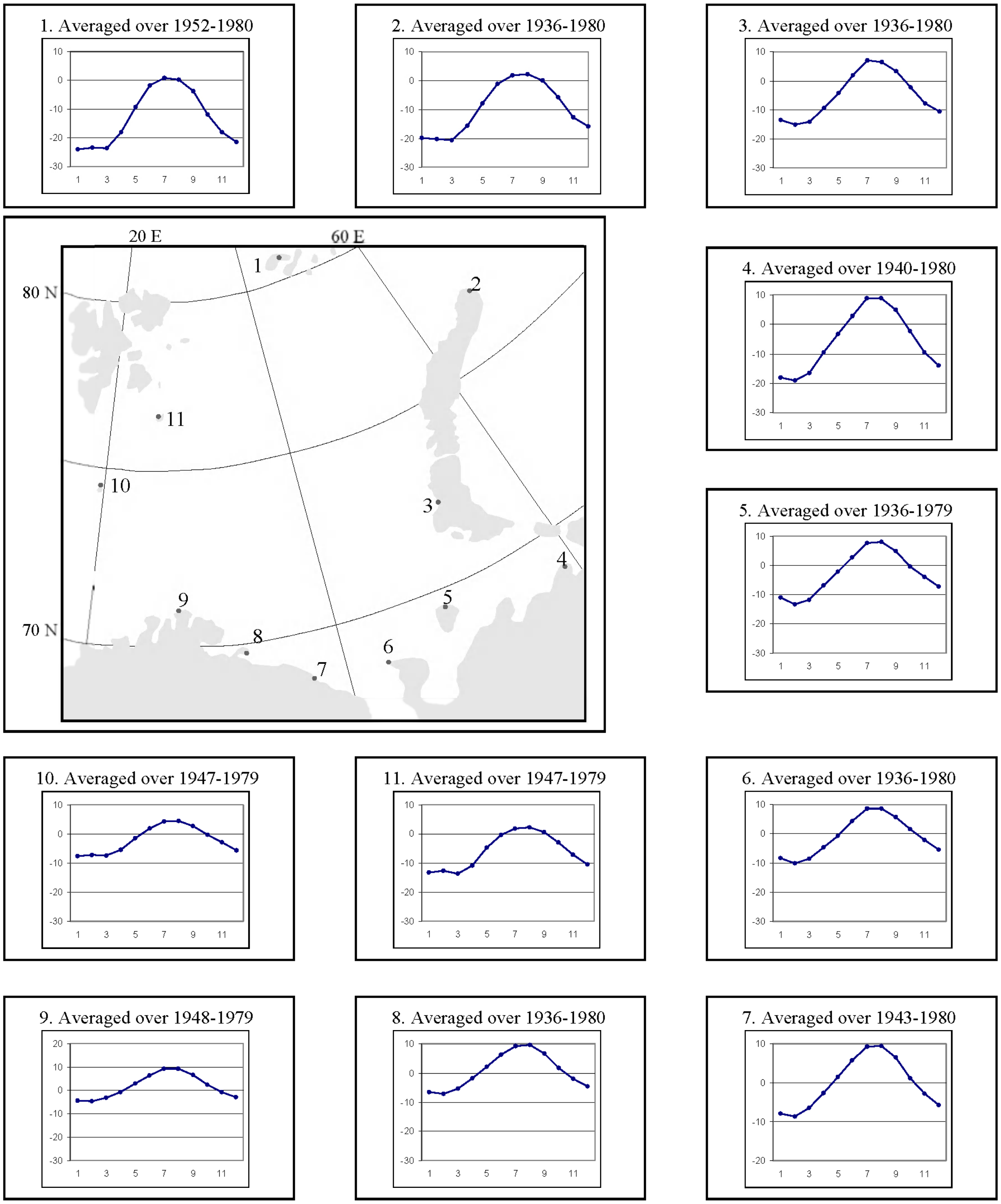
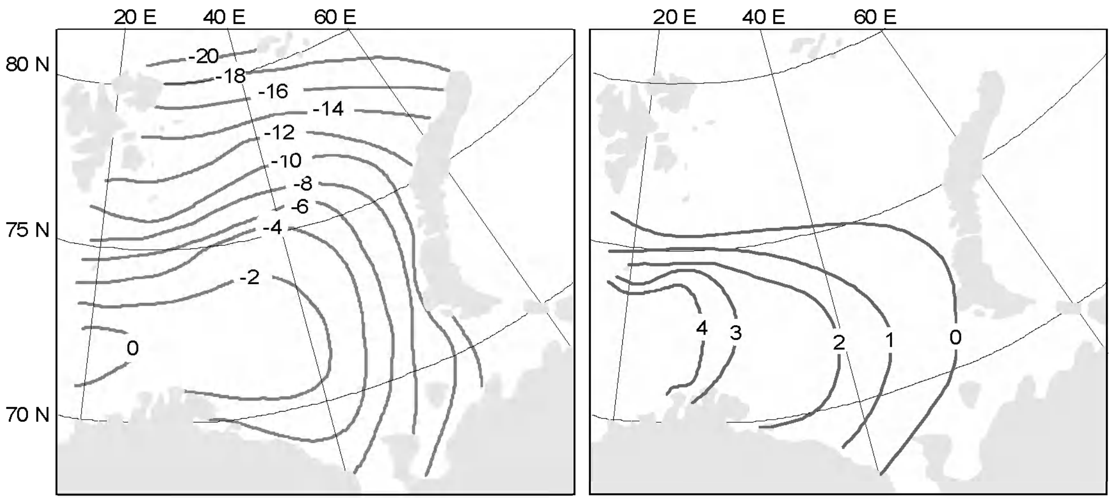
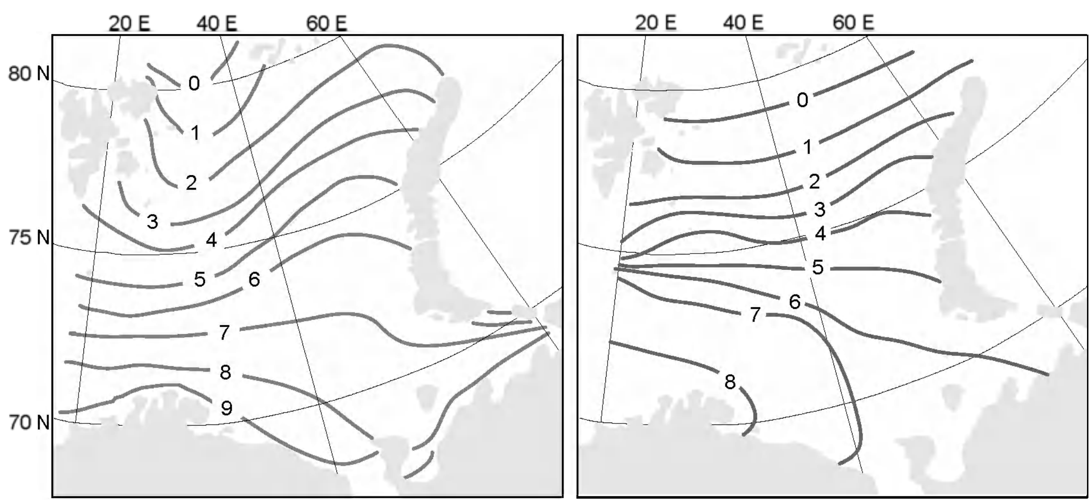


Figure 3. Barents Sea: annual cycle of air temperature (°C) as a function of geographical coordinate.



Air temperature above the sea surface. Temperature of the sea surface.

Figure 4. Climatic fields of air and sea water temperature (°C) during winter.



Air temperature above the sea surface. Temperature of the sea surface.

Figure 5. Climatic fields of air and sea water temperature (°C) during summer.

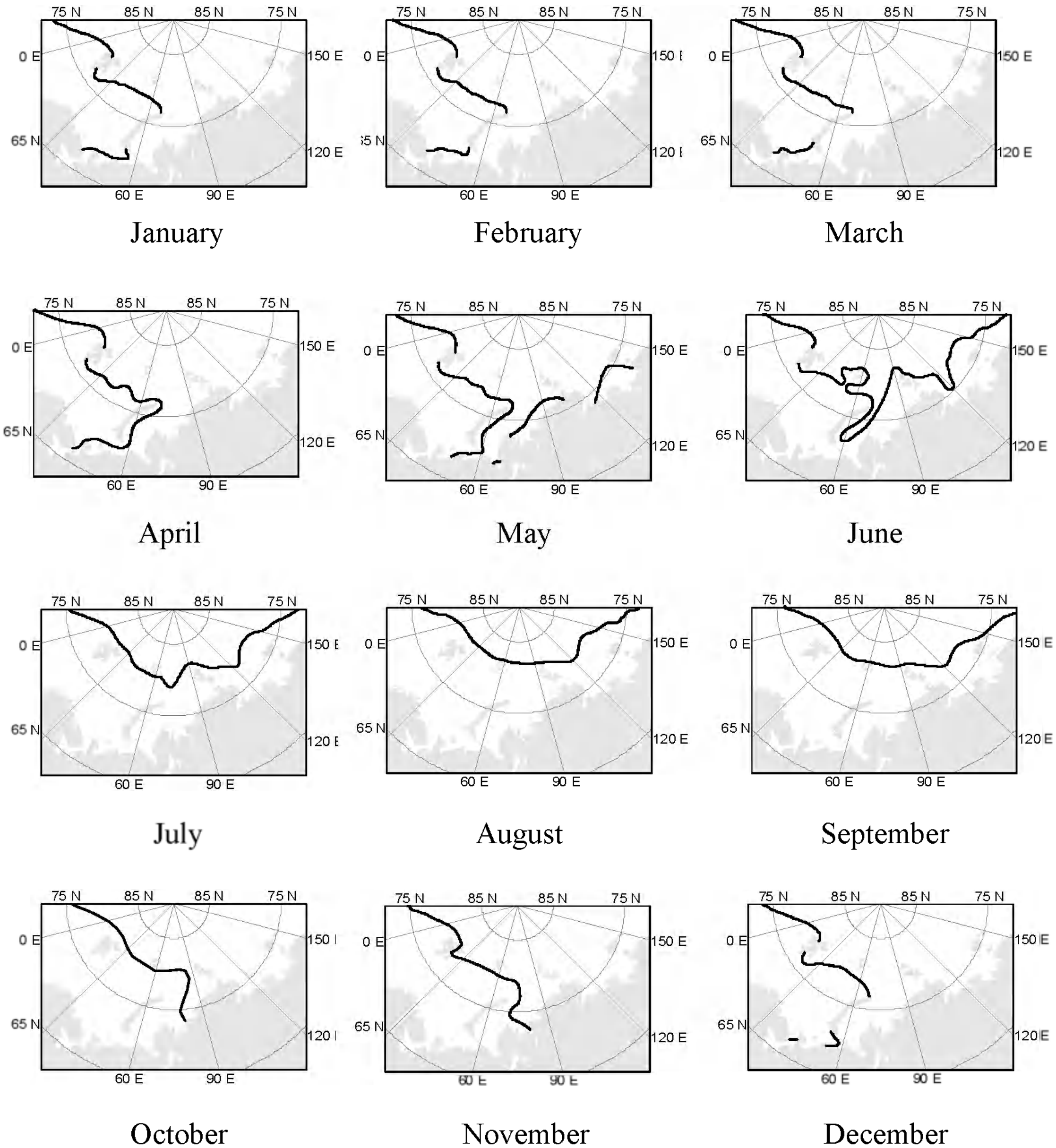


Figure 6. Monthly mean positions of ice edge.

5. DATABASE FOR ECOLOGICAL STUDIES

5.1 Data format

During the expeditions to the Arctic seas, a diverse amount of information was collected. In addition to the traditional meteorological and oceanographic information, cruise reports also contain data on sea mammals, birds, fish, benthos, plankton, geological data, and other information. This information can be used to help provide answers to a wide range of issues; therefore, it is worthwhile to include these other variables into the database. Let us consider the data format.

The current approach for standardizing data is based on the format of parameter descriptions utilized at the Murmansk Marine Biological Institute. This format has a block structure that, with slight changes, is preserved in the data description. This format consists of two blocks: **STATION** and **TYPE.** The block **STATION** has information about the location and time of data collection. The block **TYPE** contains the data consisting of the following elements: **Meteorology, Hydrology, Zooplankton, Phytoplankton, Benthos, Birds, Marine Mammals, Ichthyology, Geology, Paleontology,** etc. The names of the elements indicate the type of the data they contain. On the DVD, in the folder DATA\CODE\, all the code tables can be found. This format is described in more detail in Matishov *et al.* (2000).

When formatting older data, it is often necessary to establish the longitudinal/latitudinal coordinates of the stations since the cruise reports present these in local geographical terms (*e.g.*, 3 miles north of Kildin Island). This is very typical; many expeditions of the late 19th and the first half of the 20th centuries were conducted in the vicinity of the shore, and a mate could easily determine the ship's location in terms of the shore outlines. Establishing the longitudinal - latitudinal coordinates was required for 50-70% of all the stations on these earlier cruises.

The error in determining the ship's location is an integral part of the data-quality assessment. Therefore, the user of this database should know whether the coordinates were created from the qualitative information or they were determined by using instrumental methods. The parameter, COORD DETERM=DESCRIPTION, indicates the method of determining coordinates. If this parameter is empty, the ship's coordinates were determined by instrumental methods. For example, on the DVD, in the file, DOC\Formats\Format1.csv, there is data from three stations. The coordinates of the first station were created from qualitative information. Let us consider examples of presenting different data types.

5.1.1 Plankton

On the DVD, in the file, DOC\Formats\Format2.csv, there are examples of presenting both the quantitative and qualitative data on zooplankton. In the file, DOC\Formats\Format3.csv, quantitative data on phytoplankton are presented. In Matishov *et al.* (2000), there is a detailed description of these formats.

5.1.2. Benthos

The format of the benthos data is identical to that for the plankton data because they contain the same elements: a) describing the methods for data collection and processing; b) determining the taxonomic composition of a sample; c) determining weight and/or numerical characteristics of every taxonomic type. On the DVD, in the file DOC\Formats\Format4.csv, there are qualitative (Station 1) and quantitative (Station 2) data on benthos.

5.1.3. Ichthyology

The results of trawling serve as the basis for the formation of an ichthyology database. Fish caught by a trawl are sorted by species; for every species, X, its percentage in the trawl is determined. Along with this basic information, a biological analysis of 100-300 fish is accomplished. The result of this analysis is the identification of more than twenty parameters characterrizing fish condition such as weight, length, etc. (Karamushko and Alexandrov, 2003; Karamushko, 2002). Ichthyology data can be found on the DVD in the file, DOC\Formats\Format5.csv.

5.1.4. Mammals

Observations of mammals from ships contain information about the ship's location, time, and the number of mammals observed for each species (Mishin, 2002; Matishov *et al.*, 2000; Matishov *et al.*, 2000a). Data on marine mammals is provided on the DVD in the file, DOC\Formats\Format6.csv.

5.1.5. Birds

Let us consider the data format of the observations of birds, which was collected from aircraft (Krasnov *et al.*, 2002; Krasnov and Barrette, 2000). At any discrete moment of time, an airplane location is characterized by its coordinates, altitude, direction (course), and flight speed. The results of visual observations of birds are presented with the list of species, where the numbers for every species are indicated. An example of this data is contained on the DVD in the file, DOC\Formats\Format7.csv.

5.2. Exclusion of duplicates

Our starting database for the White, Barents, Kara, and Laptev Seas included 1,506,481 stations obtained from different sources. Some of the data are outside the region represented in this atlas. These sources included the libraries in Russia, USA, Norway, Finland, and Canada as well as the databases of:

- Murmansk Marine Biological Institute
- World Ocean Database 2001 (Conkright *et al.*, 2002)
- BarKode (Golubev and Zuyev, 1999).
- Oceanographic data (surface marine reports) from Norwegian commercial ships for 1867-1912 were provided by Torgny Vinje (Norwegian Polar Institute).

The probability of obtaining the same data increases repeatedly with this large number of information sources. Therefore, a search and exclusion of duplicates became an essential task. Difficulties in defining duplicates are caused by the fact that a portion of the data arrives not in their original format, but in a slightly processed format, created by an unknown technique. Let us consider a few examples of this data processing.

Example 1. The coordinates of one of the two comparable stations are presented in the original format as degrees, minutes, and seconds. The coordinates of the second station are given in a decimal system, where minutes and seconds are transformed into hundredths or tenths of a degree. In this case, the conversion of the true values of the coordinates can equate to a discrepancy of a few miles. Therefore, we cannot ascertain with 100% confidence that the coordinates of the two stations coincide.

Example 2. For one of the stations, the values of the parameters are presented at the observed levels, where the measurements were actually made. For the other station, they are interpolated to standard levels. The interpolation method is, as a rule, unknown. Therefore, for comparison, the station with observed levels was interpolated to standard levels. As the result, the values of the parameters from the two comparable stations will differ slightly from each other.

Example 3. Every country has its own traditions in choosing units by which oceanographic parameters are measured. When combining data obtained from different countries, it is necessary to convert the data into a unified measurement system. This conversion is, thus, a source of additional uncertainty when comparing data. This is true especially for hydrochemical data.

As a result of these differences in data processing, two primarily similar stations, obtained from different sources, can differ in coordinates, time of measurements at the station, and in the values themselves of the parameters themselves. In addition, the problem of duplicate exclusion becomes increasingly complicated because of the large amount of data to be analyzed.

To identify "near-duplicates" a system of priorities was established: a) sources of information; b) parameters; and c) composition of observations. Among the sources of information that have the highest priority are cruise reports, ship logs, and expedition diaries. Of the lowest priority are sources of information which are *a priori*, i.e. known that the data contained therein were repeatedly transformed and do not contain the entire set of parameters such as vessel name, country code, *etc*. Among the parameters of highest priority are temperature, salinity, and oxygen. Elimination of duplicates and "near-duplicates" stations reduced the number of stations to 433,179.

5.3. Data access

A provision was made to enable the user to access the data via two ways (see section, DATA, on the DVD). The first method provides data access according to the cruises. This category of data includes:

- 186 cruises by the Murmansk Marine Biological Institute during 1952-2001;

- 30 cruises during which scientists of the Murmansk Marine Biological Institute collected ichthyology data;
- 50 cruises sponsored by different institutions during 1870-1963. This data was obtained from various libraries;
- 168 cruises by Norwegian commercial ships during the period 1867 - 1912.

These cruises provide access to 62,453 stations within the Barents, White, Kara, and Laptev Seas.

The second method provides access to the data organized by one-degree squares. The structure of this data access is as follows: First, the entire set of stations is divided into 12 subsets in accordance to the month when the observations were performed. Second, the monthly set of stations is sorted by one-degree squares. In this case, the name of the file indicates the coordinates of a one-degree square and the month. For instance, the name of the file, GN710351.cvs, indicates that it contains the data for January (the last digit in the file name), and the coordinates of the station are within 71-72^{o} N and 035-036^{o} E. To designate months that contain two digits, letters are used: A for October, B for November, and C for December. For instance, the name of the file, GN72135B.cvs, indicates that it contains the data for November, and the coordinates of the station are within 72-73^{o} N and 135-136^{o} E.

For every month, a distribution map of stations is generated that allows a user to access data from a square to which the cursor points. For this purpose, it is necessary to place the cursor on the desired square and right-click on the mouse. All data are presented in the CSV format, which can easily be exported into Excel or another database application.

5.4. Inventory

Figure 7 depicts the main characteristics of the primary data contained in this Atlas. Appendix A presents the data by describing the distribution of the number of stations by month for every individual year for temperature, salinity, oxygen, and plankton, as well as a summary table for all parameters. Appendix B shows maps of station distributions throughout the period between 1810 and 2001 for every individual year. The DVD disk contains monthly climatological maps and sections of temperature and salinity.

Time period:	1810-2001
Number of stations:	**433,179**
January:	16,512
February:	19,621
March:	30,363
April:	34,424
May:	41,612
June:	59,163
July:	47,791
August:	62,710
September:	55,726
October:	29,953
November:	17,620
December:	17,684
Regions	
Barents Sea	219,077
Norwegian Sea:	160,512
White Sea:	20,348
Central Arctic:	13,870
Kara Sea:	13,591
Laptev Sea:	5,781
Countries	
Russia:	178,356
Norway:	122,593
Unknown:	54,386
USA:	36,469
United Kingdoms:	17,426
Germany:	6,648
Poland:	2,740
Holland:	1,242
Canada:	1,226
Sweden:	383
Japan:	340
Finland:	221
Iceland:	177
France:	164

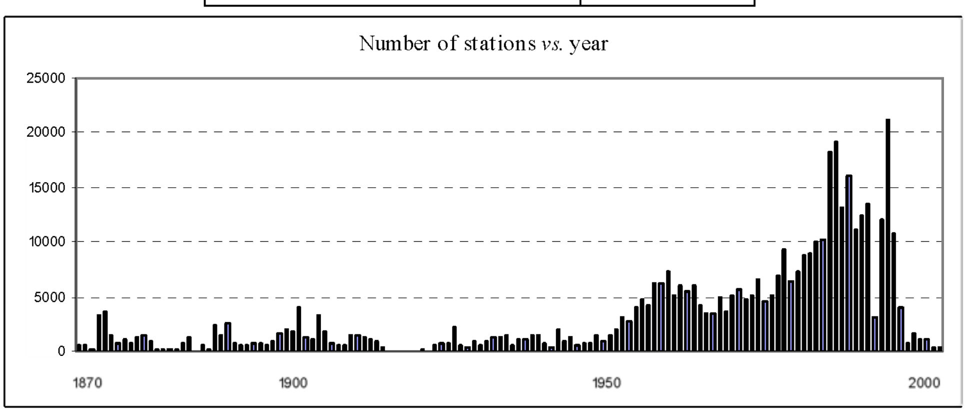


Figure 7. Characteristics of the database.

6. ELECTRONIC BOOKS

This section of the DVD includes electronic versions of various books about the history of Arctic exploration, as well as cruise reports and articles, which contain original data and descriptions of measurement techniques. Most of these publications are considered "rare" books and are, thus, not easily accessible to the public. The quality of some of the text in the PDF files is far from adequate, which is due to imperfect book scanning technology (a digital camera was used). However, the authors considered it appropriate to include these books as they make an important contribution to this Atlas. Below is the list of publications presented in electronic format on the DVD.

1. Benard, C., 1911: La conquete du pole; histoire des missions arctiques depuis les temps les plus recules jusqu'a nos jours: Stations scientifiques, cartographie -- meteorologie. (France)
2. Bogorov, V.G., 1939: Weight and Ecological Features of Macroplankton Organisms of the Barents Sea. (Russia)
3. Bruevitch, S.V., 1931: Hydrochemistry Studies at the State Oceanographic Institute of the USSR in the Barents Sea in 1927-30. (Russia)
4. Bruevitch, S.V., 1960: Hydrochemical Studies of the White Sea. (Russia)
5. Deryugin, K.M., 1924: The Barents Sea along the Kola Meridian. (Russia)
6. Deryugin, K.M., 1925: Exploration of the Barents and White Seas and Novaya Zemlya, 1921-1924. (Russia)
7. Deryugin, K.M., 19XX: History of the Murmansk Marine Biological Station. (Russia)
8. Duc d'Orleans, 1909: La Ravance de la Banquise: Un ete de derive dans la mer ke Kara. (France)
9. Gorbunov, P.. P., M.M. Yermolayev, P.A. Polisadov, R.L. Samoilovitch, V.V. Timonov, 1929: Journal of the Novaya Zemlya Expedition of 1925. (Russia)
10. Khmiznikov, P.K., 1937: Description of Navigation on the Laptev Sea and in the Western Part of the East Siberian Sea: 1878-1935. (Russia)
11. Kreps, E. and N. Verjbinskaya, 1930: Seasonal Changes in the Phosphate and Nitrate Content and Hydrogen Ion Concentration in the Barents Sea. (Russia)
12. Linko, A.K., 1907: Expedition on Scientific and Commercial Studies near the Murman Coast: Studies on Composition and Life of Plankton of the Barents Sea. (Russia)
13. Maidel, B., (date unknown): Report on Studies during the Expedition along the Murman Bank in the Summer of 1870. (Russia)
14. Manteifel, B.P., 1939: Zooplankton of Riparian Waters of West Murman. (Russia)
15. Peterman, A., W. von Freeden, A. Mühry, 1871: Studies on the Eastward and Northward Gulf-Stream Extensions (Germany)
16. Rabot, C. and P. Wittenburg, 1924: The Polar Regions: 1914-1924. (Russia)
17. Rudnev, D. and N. Kulik, 1915: Contributions to the Knowledge of the Northern Sea Route between Europe and the Ob and Yenisey Rivers. (Russia)
18. Samoilovitch, R., 1928: Exploration of Novaya Zemlya and the Barents Sea Performed by the Institute for the Exploration of the North. (Russia)
19. Schultz, B., 1930: Die Hydrographie des Barentsmeeres. (Germany)
20. Snellen, M., 1910: Rapport sur L'Expedition Polaire Neerlandaise qui a Hiverne dans la Mer de Kara en 1882/83. (Holland)
21. Tarbeyev, D., 1940: The Laptev Sea and its Coast. (Russia)

22. Trzhemesky, I., 1917: Hydrometeorological Observations of Hydrographic Expeditions: Observations by Dr. I. Trzhemesky on the Schooner "Eclipse" in 1914-1915 (Russia)
23. U.S. Naval Oceanographic Office, 1969: Oceanographic Survey Results: Kara Sea, Summer and Fall 1965. (USA)
24. Vorobiev, V.I., 1940: The Kara Sea. Izd. Glavsevmorputi (Russia)
25. Wieze, V.Yu., 1934: History of Exploration of the Soviet Arctic: Barents and Kara Seas (Second Complete Edition). (Russia)
26. Willaume-Jantzen, 1889: Observations Meteorologiques de la Dijmphna, Mer de Kara. (Denmark)
27. Zaitsev, G.N., 1967: New Data on Mean Annual Water Temperatures at the Kola Meridian for 1922-44. (Russia)
28. Zhdanko, M.Ye., 18(9)5: Essay of Hydrographic Studies of the Arctic Ocean in the Summer of 1894 (Russia)
29. Zenkevitch, L., 1931: On the Aeration of Bottom Waters through Vertical Circulation. (Russia)

7. PHOTO GALLERY

The books on the history of Arctic studies and the photo archive of the Murmansk Marine Biological Institute served as a source of graphical material for the section "PHOTO GALLERY" on the DVD. Detailed information about all the images is available (see PHOTO GALLERY/Sources of Photos). All material is divided into the following categories:

The First International Polar Year 1882-1883

- Expeditions by The Netherlands and Denmark in the Kara Sea
- Russian meteorological stations in the Barents and Laptev Seas

Ships in the Arctic

Polar Bears in the Barents and Kara Seas

The Kola Peninsula

8. CONTENTS OF THE DVD DISK

The main sections of the DVD are as follows:

- The directory DATA contains the data files.
- The directory DOC contains text files from the section, Documentation.
- The directory HTML contains files that enable the HTML medium to work.
- The directory STAT contains statistics for the one-degree squares.

The key element of this Atlas is the primary data from the Barents, White, Kara, and Laptev Seas. Primary data (433,179 stations for 1810-2001) are on the DVD in CSV format. Access to the information on the DVD occurs via an HTML menu. From this menu, the main sections of the DVD are as follows:

Documentation: This section includes the text of the Atlas in Russian and English.
Bathymetry: This section includes bathymetric maps of the Arctic Seas published during the period 1905-2001.
Inventory: This section contains individual distribution maps of stations for each month for the parameters of temperature, salinity, oxygen, pH, alkalinity, nitrates, phosphates, and silicates.
Database: This section provide access to the primary data and statistics.
Climatology: This section includes monthly climatic fields of temperature and salinity presented as maps and sections.
Electronic Books: This section contains the full text of books, articles, and cruise reports
Photo Gallery: This section contains graphical materials about the Arctic and history of its exploration.
Citation and Authors: This section contains referencing information, list of authers and addresses.

9. SUMMARY AND FUTURE WORK

This Atlas is a continuation of a series of joint work that has been conducted for more than 12 years by Russian and US scientists to create a more comprehensive database from various expeditions to the eastern Arctic Seas. A top priority of this cooperation has been to make the primary data available to the international scientific community without restriction. In the future, it is anticipated that the database will be expanded to include all Arctic seas and that procedures for data quality control will be improved.

10. REFERENCES

Atlas of Lithological-Paleogeographical Maps of the USSR, 1967: V. 4, Moscow: Nauka, 70 pp.

Atlas of the Oceans, Arctic Ocean, 1980: Vol. 3, Leningrad: Ministry of Defense-Navy, 190 pp.

Barnes, S.L., 1973: Mesoscale objective map analysis using weighted time series observations. *NOAA Technical Memorandum ERL* NSSL-62, 60pp

Berger, V. Ja., A.D. Naumov, N.V. Usov, M.A. Zubaha, I. Smolyar, R. Tatusko, S. Levitus, 2003: 36-Year Time Series (1963-1998) of Zooplankton, Temperature, and Salinity in the White Sea. *NOAA Atlas NESDIS 57*, U.S. Gov. Printing Office, Washington, D.C. 352 pp.

Bogorov, V.G., 1967: Biological Transformation and Metabolism in the Ocean. *Oceanology*, 7(5), pp. 839- 859.

Conkright, M.E., J. I. Antonov, O.K. Baranova, T. P. Boyer, H. E. Garcia, R. Gelfeld, D. Johnson, R. A. Locarnini, P. P. Murphy, T. D. O'Brien, I. Smolyar, C. Stephens, 2002: World Ocean Database 2001. Volume 1: Introduction. NOAA Atlas NESDIS 42. S. Levitus, Ed., U.S. Gov. Printing Office, Washington D.C., 160pp.

Derygin, K. M., 1906: Murmansk Marine Biological Station 1899-1905. *Transactions of of the St. Petersburg Society of Naturalists,* Vol. XXXVII, No. 4, 227 pp.

Dobrovolsky, A.D., and B.S. Zalogin, 1982: *Seas of the USSR*. Moscow: MGU, 190 pp.

D'Orleans, Louis Philippe Robert, 1907: *Croisière Océanographique accomplie a bord de la Belgica dans la mer du Grönland*. Brussels: Imprimerie Scientifique Charles Bulens, 568 pp.

D'Orleans, Louis Philippe Robert, 1909: *La Revanche de la Banquise. Un été de dérive dans la mer de Kara Juin-Septembre 1907.* Paris: Librarie Plon, 288+ pp.

Frolov, Yu.S., 1971: *New Fundamental Data on World Ocean Morphology*. Leningrad: Vestnik LGU. Vol. 1. N 6, 85-90 pp.

Golubev, V., and A. Zuyev, 1999: *Barents and Kara Seas Oceanographic Database: BarKode*. Ed. C. Oelke. Oslo: International ACSYS/CLIC Project Office, 215 pp.

Golubev, V., and A. Zuyev, 2003: *Large-Scale Variability of Temperature and Salinity of the Western Barents Sea.* Ed. by K. Pavlov. Technical Report. Murmansk-Tromso: Murmansk Marine Biological Institute and Norwegian Polar Institute, 52 pp.

Khmiznikov, P.K., 1937: *Description of vessel voyages in the Laptev Sea and in the western East Siberian Sea from 1878-1935.* Leningrad: Izd-vo Glavsevmorputi, 180 pp.

Konstantinov, Y.B., and K.I. Grachev, 2000: *High-Latitude Aerial Expeditions "North" (1937, 1941-1993).* Ed. by Sokolov, B.T., St. Petersburg: Gidrometeoizdat, 176 pp.

Krasnov, Yu.V., and R.T. Barrett, 2000: Basic Principles of Organizing the Monitoring of Sea Birds of the Barents Sea. *Russian Ornithology,* Vol. 113, pp. 3-32.

Krasnov, Yu.V., Yu.I. Goryayev, A.A. Shavykin, N.G. Nikolayeva, M.V. Gavrilo, and V.I. Chernook, 2002: *Atlas of Birds of the Pechora Sea: Distribution, Population, Dynamics, Protection Issues.* Apatity, 166 pp.

Karamushko, O.V., 2002: *Modern Studies of Barents Sea Ichthyofauna as the Basis for Preventing Damage of Bioresources. Nature Use in Euro-Arctic Region: Experience of the 20th Century and Prospects.* Apatity: KNC RAN, pp. 193–198.

Karamushko, O.V., and D.I. Alexandrov, 2002: Diversity of Fish Communities of the South-eastern Part of the Barents Sea in the Summer Period. *Ichthyology Issues,* Vol. 43, No 4, pp. 464–468.

Lappo, S., Y. Egorov, M. Virsis, Y. Nalbandov, E. Makovetskaya, L. Virsis, I. Smolyar, S. Levitus, 2003: *History of the Arctic Exploration 2003: Cruise Reports, Data.* CD-ROM, International Ocean Atlas and Information Series, Vol. 8, World Data Center for Oceanography, Silver Spring.

Levitus, S. and T. Boyer, 1994: NOAA ATLAS NESDIS 4. World Ocean Atlas 1994. Vol. 4. Temperature. US Government Printing Office, Washington DC. 118pp.

Litvin, V.M.,1973: Geomorphology of the Bottom of the Norwegian-Greenland Basin. *Problems of Arctic and Antarctic.* Vol. 42, Leningrad: Gidrometeoizdat, pp. 19-27.

Litvin, V.M., 1979: Topography of the Bottom of the Norwegian-Greenland Basin. Topography and Bottom Sediments of the Norwegian-Greenland Basin. *Transactions of PINRO,* Vol. XLII, Murmansk: PINRO, pp. 5-37.

Makarov, S.O., 1901: *Yermak in the Ice.* St. Petersburg, 507 pp.

Markhaseva, E., A. Golikov, T. Agapova, A.Beig, I. Smolyar, 2002: Zooplankton of the Arctic Seas 2002. CD-ROM, *International Ocean Atlas and Information Series, Vol. 6,* World Data Center for Oceanography, Silver Spring.

Matishov G., A. Zuyev, V.Golubev, N. Adrov, V. Slobodin, S. Levitus, I. Smolyar, 1998: Climatic Atlas of the Barents Sea 1998: Temperature, salinity, oxygen. *NOAA Atlas NESDIS 26,* U.S. Gov. Printing Office, Washington D.C., 130 pp

Matishov, G. P., Makarevitch, C. Timofeyev, L. Kuznetsov, N. Druzhkov, V. Larionov, V. Golubev, A. Zuyev, V. Denisov, G.Iliyn, A. Kuznetsov, S. Denisenko, V. Savinov, A.

Shavykin, I. Smolyar, S. Levitus, T. O'Brien, and O. Baranova, 2000: Biological Atlas of the Arctic Seas 2000: Plankton of the Barents and Kara Seas. NOAA Atlas NESDIS 39, U. S. Gov. Printing Office, Washington D.C., 348 pp.

Mishin, V.L., 2002: Modern State and Tendencies of Developing Marine Mammals of the Barents Sea. *Nature Use in Euro-Arctic Region: Experience of the 20th Century and Prospects.* Apatity, KNC RAN, pp. 53-63.

Nansen, F., 1902: *Oceanography of the North Polar Expedition 1893-96: Scientific Results*, 2(9), 1902, 427 pp.

Nikiforov, E.G., and A.O. Shpaikher, 1980: *Features of the Formation of Large-Scale Variations in the Hydrological Cycle of the Arctic Ocean*, Leningrad: Gidrometeoizdat, 269 pp.

Oceanographic Encyclopedia, 1974: Leningrad: Gidrometeoizdat. 631 pp.

Panov, V.V., and A.O. Shpaikher, 1963: Atlantic Water Effects on Some Features of Hydrological Cycle in the Arctic Basin and Adjacent Seas. *Oceanology*, 3(4), pp. 579-590.

Piterman, A., W. Von Freeden, A. Muhry, 1871: *Papers on the Eastern and Northern Extensions of the Gulf Stream,* Washington, D.C.: Government Printing Office, 388 pp.

Romanov, I.P., Y.B. Konstantinov, N.A. Kornilov, 1997: *Drıfting Ice Stations "North Pole" (1937-1991).* St. Peterburg: Gidrometeoizdat, 225 pp.

Sukhovey, V.F. ,1986: *Seas of the World Ocean.* Leningrad: Gidrometeoizdat, pp.211-218.

Snellen, M., 1910: *Rapport sur L'Expedition Polaire Neerlandaise qui a Hiverne dans la Mer de Kara en 1882/83,* Utrecht: J.Van Boekhoven, 141 pp.

Transehe, N.A., 1925: The Siberian Sea Road: The work of the Russian Hydrographical Expedition to the Arctic 1910-1915. *Geographical Review,* Vol. XV, № 3, July, pp. 367-398.

Trzhemesky, I., 1917: *Hydrometeorological Observations of Hydrographic Expeditions: Observations by Dr. I. Trzhemesky on Schooner "Eclipse" in 1914-1915,* Petrograd, 105 pp.

Toporkov, L.G. 1970: Oceanographic Characteristic of the Marginal Seas (Non-Periodic Currents). *Soviet Arctic*, Moscow: Nauka, pp. 173-183.

Vinogradova, P.S., 1964: On Modern Sediments of the Norwegian Sea. *Transactions of PINRO*, Vol. 16, pp. 84-101.

Vinogradova, P.S., 1979: Modern Sediments of the Norwegian-Greenland Basin: Topography and Bottom Sediments of the Norwegian-Greenland Basin, *Transactions of PINRO,* Vol. XLII, Murmansk: PINRO, pp. 38-83.

Wieze, V.Yu., 1934: *History of Exploration of the Soviet Arctic: Barents and Kara Sea (Second Complete Edition)*, Arkhangelsk: Sevkrygiz Publishing House, 210 pp.

Zenkevitch, L.A., 1963: *Biology of USSR Seas*, Moscow: Mysl, 739 pp.

APPENDIX A. Database characteristics

Inventory of all variables

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1810				2									2
1811				1	1								2
1813					1								1
1816					1								1
1817						1							1
1867			196	9	70		112	79	80				546
1868			51	284	204								539
1869			142	37									179
1870			100	246	447	807	832	624	204				3,260
1871			13		164	712	1,035	968	773	64			3,729
1872			5	1	70	326	370	296	201		62	44	1,375
1873	57	90	64	69	134	118	144	142					818
1874			6	33	62	149	291	495	146				1,182
1875			138	102	88		27	185	156	39			735
1876			11	51	181	179	186	186	200	126	120	124	1,364
1877	124	112	142	120	300	217	185	185	28				1,413
1878				1	52	174	188	275	196				886
1879			46	57									103
1880			47	17		3	19	6					92
1881			33	86									119
1882			40	148	68			5	5				266
1883	1	19	101	196	36	138	160	3					654
1884			169	223	226	139	161	167	145				1,230
1885			59										59
1886				7	242	212	70	81	10				622
1887			3	4	72	60	58						197
1888			45	167	541	479	353	374	319	11			2,289
1889		1	114	174	316	228	324	136	86				1,379
1890			58	162	551	595	597	446	232				2,641
1891			27	142	186	163	100	101	85				804
1892			14	144	224	124	4	4					514
1893			48	204	223	75	13	25	5	2	1	1	597
1894			3	132	192	123	149	91	65	7	1		763
1895			13	53	250	210	138	136	1		2	2	805
1896	1	2	2	24	206	139	76	77	25				552
1897		3	86	64	186	179	106	278	34				936
1898			25	84	400	369	235	258	235	3	1		1,610
1899	24	28	53	93	400	616	241	487	86	4	7	1	2,040
1900	7	4	15	17	391	585	292	278	240	10	10	4	1,853
1901	2	14	39	209	717	688	620	1,006	423	93	90	93	3,994
1902	93	84	3	51	203	232	211	322	139	11	8	7	1,364
1903	3	21	2	7	157	249	164	271	170	6	26	14	1,090
1904	115	169	181	118	345	479	416	551	322	135	239	250	3,320
1905	90	84	105	91	254	425	298	259	184		19	3	1,812
1906					218	199	50	170	144	33			814
1907					50	143	134	170	66				563
1908					24	169	95	53	83	39			463
1909				150	261	335	395	275	113		1		1,530
1910			19	120	178	263	363	413	152				1,508
1911				136	229	259	335	170	107				1,236
1912				81	156	265	294	256	112				1,164
1913		7	22	81	107	211	282	147	72				929
1914					66	129	108	1	10				314

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1915							3	24					27
1916					1	1							2
1918								17	23	26	12		78
1919									2				2
1920						4	2						6
1921					10			162	84				256
1922							1	63	12		3	7	86
1923			14	9	2	15	48	340	96		9	3	536
1924					37	53	184	188	206		24	12	704
1925				11	3	117	84	214	228	101	14		772
1926	1	1		1		42	526	987	544	6	32	7	2,147
1927			2		14	103	109	228	147	21	6		630
1928			20	30	41	82	19	116	47	17	1	4	377
1929		26	25	78	60	157	77	89	294	2	36	24	868
1930	6		48	135	38	78	75	87	118	19	12	3	619
1931	1	1	22	174	87	33	188	268	156	53			983
1932			51	56	11	81	136	511	237	151	3	86	1,323
1933	99	82	84	70	163	63	40	273	208	47	19	78	1,226
1934	23	26	85	153	127	172	227	258	391	16	18	18	1,514
1935			60	38	10	91	88	41	72	92	10		502
1936	14	100	117	122	76	78	151	222	111	40	18	71	1,120
1937	28	132	112	114	175	68	95	104	90	66	14	17	1,015
1938	28	70	246	217	173	179	142	49	160	59	86	123	1,532
1939	58	121	136	116	199	382	80	39	129	137	48	16	1,461
1940	32	82	52	49	94	45	146	123	120	13	16	3	775
1941	3	25	39	42	25	52	3	161	57	37			444
1942		1	22	1		80	408	416	616	392	123		2,059
1943		6	15			403	273	190	21	2	46	2	958
1944	3	46	114	5		311	168	200	101	267	46		1,261
1945			39	2		207	44	61	193	12		7	565
1946	7	36	77	39	27	107	102	182	94	77	53	4	805
1947	2	11	10	3	3	204	141	254	73	58	43	15	817
1948		4	50	59	115	273	336	296	82	198	53	23	1,489
1949	10	33	121	40	130	125	155	137	93	58	36	18	956
1950	69	26	183	152	150	161	107	113	130	225	85	21	1,422
1951	23	113	180	282	285	258	105	103	264	225	41	75	1,954
1952	124	50	276	140	123	324	1,424	237	60	117	103	214	3,192
1953	25	87	164	221	238	148	322	462	494	286	119	165	2,731
1954	169	321	335	118	391	615	297	517	606	318	130	174	3,991
1955	221	280	366	359	304	462	769	600	539	270	284	217	4,671
1956	418	65	322	308	250	399	371	508	560	465	174	314	4,154
1957	269	193	534	414	515	356	960	1,060	664	552	290	387	6,194
1958	214	307	519	432	699	600	504	547	654	817	347	497	6,137
1959	447	354	401	818	648	806	973	809	608	724	362	364	7,314
1960	348	310	408	200	315	784	305	678	740	330	390	272	5,080
1961	196	373	655	545	192	524	636	914	774	734	238	246	6,027
1962	373	581	525	328	390	393	340	573	789	450	518	222	5,482
1963	220	184	514	305	246	672	1,030	1,234	416	426	418	369	6,034
1964	209	192	462	304	259	628	398	651	499	286	151	240	4,279
1965	140	106	127	197	243	396	330	469	593	469	263	140	3,473
1966	134	137	162	257	176	577	268	417	857	184	239	63	3,471
1967	291	127	187	236	419	363	239	979	1,083	477	510	67	4,978

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1968	146	129	283	379	491	582	275	458	454	239	108	58	3,602
1969	76	161	105	413	508	1,499	521	611	447	473	173	96	5,083
1970	172	164	293	506	618	850	1,057	748	581	461	141	94	5,685
1971	205	222	349	429	307	146	272	1,070	1,069	474	28	174	4,745
1972	41	132	118	174	323	566	429	908	1,487	550	163	240	5,131
1973	280	300	578	817	450	682	436	866	892	800	111	370	6,582
1974	186	237	321	248	298	650	850	885	411	248	177	112	4,623
1975	152	170	315	457	466	833	284	812	777	455	277	67	5,065
1976	373	296	518	475	612	1,017	613	924	724	462	367	583	6,964
1977	406	504	286	510	836	2,002	734	1,460	691	559	652	667	9,307
1978	301	269	444	720	493	562	515	650	1,012	726	417	362	6,471
1979	487	346	695	359	586	1,276	613	829	1,310	513	132	234	7,380
1980	524	259	944	835	1,463	699	608	1,364	1,127	490	182	246	8,741
1981	445	392	557	1,342	1,263	474	630	1,425	1,199	899	141	175	8,942
1982	394	568	1,498	1,142	1,599	571	869	1,145	949	438	542	359	10,074
1983	715	832	884	937	1,216	687	1,423	898	1,200	917	232	285	10,226
1984	612	601	1,327	1,086	1,699	2,696	2,308	3,742	1,923	852	353	1,052	18,251
1985	808	894	1,654	2,285	2,854	1,472	1,170	1,607	3,046	1,249	1,091	1,025	19,155
1986	704	870	818	1,718	806	697	1,250	1,423	1,637	1,127	896	1,275	13,221
1987	768	783	1,090	1,355	882	1,416	1,040	1,940	3,694	1,064	998	1,074	16,104
1988	641	869	696	1,063	1,179	980	918	1,451	1,350	807	552	562	11,068
1989	520	726	909	1,175	1,181	952	826	1,611	1,375	1,424	787	947	12,433
1990	838	1,504	1,077	1,111	1,584	1,741	861	1,238	1,374	980	591	546	13,445
1991	106	106	141	262	108	365	532	544	444	253	85	85	3,031
1992	64	493	1,187	1,172	780	890	1,090	2,088	1,119	1,303	1,036	842	12,064
1993	700	825	1,185	944	706	9,538	1,570	1,656	1,802	995	623	577	21,121
1994	553	804	894	770	631	1,067	909	1,485	1,865	917	439	366	10,700
1995	476	644	546	36	268	344	379	774	319	108	42	4	3,940
1996	21	6	11	72	79	76	120	140	101	62	14	21	723
1997		21	51	99	228	365	493	81	181	16	38	3	1,576
1998	33	43	267	69	38	99	185	146	179	45	74		1,178
1999	21	76	70	48	109	69	195	45	150	117	80	31	1,011
2000	8	46	82	18	36	42	37	26	48	25	48	21	437
2001	14	82	49	19	1	20	119	37					341
Total	**16,512**	**19,621**	**30,363**	**34,424**	**41,612**	**59,163**	**47,791**	**62,710**	**55,726**	**29,953**	**17,620**	**17,684**	**433,179**

Inventory of temperature stations

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1810				3									3
1811				1	1								2
1813					1								1
1816					1								1
1817						1							1
1867			42	1									43
1869			5	1									6
1870			33	90	314	657	705	597	200				2,596
1871			4		120	641	960	848	712	63			3,348
1872			5	1	25	295	334	294	197		62	39	1,252
1873	42	89	64	69	134	112	141	142					793
1874			3	29	58	114	226	381	81				892
1875			138	101	68		27	183	129	28			674
1876			11	44	156	166	182	176	188	124	120	4	1,171
1877					155	121	175	175	26				652
1878					44	143	159	270	196				812
1879			46	57									103
1880			6			3	19	6					34
1882								5	5				10
1883	1	19	80	73	12	138	160	3					486
1884			128	115	207	139	161	167	140				1,057
1885			59										59
1886				7	242	207	70	81	10				617
1887			3	4	72	60	58						197
1888			45	166	520	359	336	370	284	8			2,088
1889		1	114	174	287	225	301	135	86				1,323
1890			34	103	482	591	596	446	227				2,479
1891			26	141	186	163	100	101	85				802
1892			2	98	183	124	4	4					415
1893				1	1	13	13	25	5	2	1	1	62
1894				132	192	123	149	91	65	7	1		760
1895				53	250	143	88	40	1		2	2	579
1896	1	2		4	187	139	76	77	25				511
1897		3	86	64	186	179	106	278	34				936
1898			25	84	400	369	235	257	235	3	1		1,609
1899	24	28	53	92	387	610	229	439	85	4	7	1	1,959
1900	7	4	6	17	371	553	258	261	240	10	10	4	1,741
1901	2	14	39	209	655	676	619	1,005	415	93	90	93	3,910
1902	82	84	3	51	191	211	207	322	139	11	8	7	1,316
1903	3	20	2	7	157	249	163	270	170	6	26	14	1,087
1904	115	167	181	114	341	475	415	545	322	134	151	158	3,118
1905	2	1	13	1	183	338	290	258	184		19	3	1,292
1906					212	199	50	170	144	33			808
1907					50	139	134	170	66				559
1908					24	169	94	53	83	25			448
1909				150	261	333	394	274	111		1		1,524
1910			19	120	178	263	363	413	152				1,508
1911				136	229	259	335	170	107				1,236
1912				81	156	265	294	253	97				1,146
1913		7	22	81	107	211	269	145	62				904
1914					66	128	108	1					303
1916					1	1							2
1918								17	23	26	12		78
1919									2				2
1920						4	2						6

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1921					10			158	81				249
1922								63	12		3	7	86
1923			14	9	2	15	48	164	91		9	3	355
1924					37	53	184	187	206		24	12	703
1925				11	3	117	84	210	227	101	14		767
1926	1	1		1		42	522	987	544	6	32	7	2,143
1927			2		14	103	109	228	147	21	6		630
1928			19	30	41	82	19	116	46	17	1	4	375
1929		26	25	78	60	157	77	89	294	2	36	24	868
1930	6		48	135	38	78	75	87	117	19	12	3	618
1931	1	1	22	174	87	33	188	268	156	53			983
1932			51	56	11	81	136	508	237	150	3	86	1,319
1933	99	82	84	70	163	63	40	273	208	47	19	78	1,226
1934	23	26	85	152	127	171	227	257	389	16	18	18	1,509
1935			60	38	10	91	88	41	72	92	10		502
1936	14	100	117	122	75	78	151	178	90	33	18	71	1,047
1937	28	132	112	112	175	68	95	104	90	66	14	17	1,013
1938	28	70	246	217	170	179	140	49	160	59	86	123	1,527
1939	58	121	136	116	197	380	78	36	126	133	48	16	1,445
1940	32	82	52	49	94	45	146	123	120	13	16	3	775
1941	3	25	39	42	25	52	3	161	57	37			444
1942		1	22	1		80	407	411	612	392	123		2,049
1943		6	15			403	271	190	21	2	46	2	956
1944	3	46	114	4		310	168	199	100	262	46		1,252
1945			39	2		207	44	61	193	12		7	565
1946	7	36	77	39	27	107	102	182	94	76	53	4	804
1947	2	11	10	3	3	203	141	254	73	58	43	15	816
1948		4	50	59	115	272	336	294	80	198	53	23	1,484
1949	10	33	121	40	130	125	155	137	93	58	36	18	956
1950	69	26	183	152	150	160	107	113	130	224	85	21	1,420
1951	23	112	180	282	285	258	105	103	264	225	41	75	1,953
1952	124	50	273	140	123	324	1,423	236	60	78	40	199	3,070
1953	25	87	147	193	234	148	322	432	492	286	119	165	2,650
1954	164	321	314	102	387	578	204	517	563	280	107	141	3,678
1955	205	113	361	298	218	340	675	572	511	263	284	205	4,045
1956	393	64	321	308	218	389	345	478	506	411	124	288	3,845
1957	225	162	509	325	428	332	926	993	657	516	274	387	5,734
1958	176	287	517	397	613	560	490	545	654	816	347	497	5,899
1959	447	352	401	747	568	696	928	762	518	651	362	363	6,795
1960	348	310	408	200	315	784	278	675	740	330	390	272	5,050
1961	196	373	655	545	192	521	604	914	774	734	238	246	5,992
1962	373	581	525	328	390	393	327	573	789	442	518	222	5,461
1963	220	184	514	305	246	672	1,023	1,231	413	426	418	369	6,021
1964	209	191	462	304	259	626	390	649	499	274	151	239	4,253
1965	140	106	127	197	242	395	327	467	593	468	263	140	3,465
1966	134	137	160	256	174	576	268	417	857	184	239	63	3,465
1967	291	127	187	232	412	357	231	969	1,071	475	510	67	4,929
1968	146	129	269	355	474	566	263	456	454	238	108	58	3,516
1969	76	161	105	413	508	1,494	521	611	444	471	173	96	5,073
1970	172	164	285	463	556	791	999	702	535	409	139	94	5,309
1971	205	220	349	429	305	146	272	1,070	1,067	474	28	174	4,739
1972	41	132	118	156	323	565	429	908	1,487	550	162	240	5,111
1973	280	300	578	817	450	676	383	841	892	799	111	370	6,497
1974	186	237	321	247	298	650	793	882	411	248	177	112	4,562
1975	152	170	315	456	466	833	284	808	777	454	277	67	5,059
1976	373	296	516	472	611	1,016	611	924	724	461	366	583	6,953
1977	406	503	286	509	836	2,002	734	1,459	691	559	652	666	9,303
1978	301	269	442	720	492	562	515	648	1,011	726	417	362	6,465

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1979	487	346	695	359	583	1,274	613	829	1,310	513	132	233	7,374
1980	524	259	944	835	1,463	699	606	1,360	1,124	490	182	246	8,732
1981	445	392	556	1,342	1,262	474	630	1,425	1,198	899	141	174	8,938
1982	394	568	1,482	1,142	1,598	571	868	1,143	949	438	541	359	10,053
1983	715	832	883	936	1,216	687	1,422	898	1,199	917	232	285	10,222
1984	612	600	1,327	1,086	1,698	2,696	2,308	3,741	1,922	852	353	1,048	18,243
1985	808	893	1,654	2,285	2,849	1,470	1,167	1,607	3,045	1,249	1,087	1,019	19,133
1986	704	856	806	1,712	803	696	1,250	1,422	1,635	1,127	896	1,275	13,182
1987	768	783	1,090	1,354	878	1,401	1,032	1,931	3,693	1,063	997	1,074	16,064
1988	641	869	694	1,050	1,173	973	918	1,451	1,349	807	550	560	11,035
1989	520	714	903	1,168	1,170	942	826	1,608	1,372	1,423	785	947	12,378
1990	838	1,501	1,074	1,111	1,581	1,735	861	1,238	1,374	978	591	545	13,427
1991	106	106	140	262	108	364	510	443	433	253	85	85	2,895
1992	64	487	1,115	1,104	718	791	1,007	2,003	1,041	1,247	992	810	11,379
1993	700	796	1,124	889	646	9,465	1,528	1,611	1,746	934	599	557	20,595
1994	552	796	884	735	604	1,036	897	1,421	1,826	880	427	362	10,420
1995	475	621	528	36	268	269	377	766	289	108	42	3	3,782
1996	20	6	10	70	78	76	94	140	101	31	13	20	659
1997		20	51	94	188	298	375	81	166	16	38	3	1,330
1998	33	43	265	69	37	91	185	146	179	29	74		1,151
1999	21	64	70	48	109	69	189	37	149	103	48	3	910
2000	4	34	53	2	3	17	4	1	1	22	29	1	171
2001	11	55	49	17	1	20	82	37					272
Total	**16,136**	**19,047**	**29,082**	**32,289**	**39,474**	**57,427**	**46,166**	**61,227**	**54,754**	**29,351**	**17,234**	**17,257**	**419,444**

Inventory of salinity stations

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1876-96				1	1	2	2	5					11
1897		3	2	1			29	216					251
1898						6	17	17	16	1			57
1899	18	23	31	27	4	66	22	166					357
1900					2		3	55	33	4	10	2	109
1901	2	14	37	16	45	47	113	98	10				382
1902					7	20	20	149	22	11	8	6	243
1903	2	21	2	7	21	17	14	129	78	6	26	14	337
1904	9	42	38	12	27	33	52	124	46	2	23	16	424
1905	1		12	1		10	19	7	3		17	3	73
1906					42		26	64	24				156
1907								3	2				5
1908							1	1	1				3
1909											1		1
1910						28	24	18	12				82
1911								1					1
1912							37	97	7				141
1913		7	22	37	11	59	129	1					266
1914								1					1
1918								17	23	26	12		78
1919									2				2
1921					10			150	75				235
1922							1	61	12				74
1923			3	9	2	15	41	165	26				261
1924					37	53	184	181	199		24		678
1925				8	3	114	84	209	217	99	14		748
1926	1	1		1		38	514	977	478	6	32	7	2,055
1927			2		13	102	108	225	135	21	4		610
1928			20	30	41	82	19	108	45	17		4	366
1929		24	25	76	42	157	73	88	254	2	36	10	787
1930			42	116	37	78	75	87	115	19	12	3	584
1931	1	1	21	173	76	33	188	268	155	44			960
1932			51	56	10	81	136	492	198	145	3	86	1,258
1933	98	82	83	70	163	62	40	239	191	36	19	78	1,161
1934	23	26	85	152	127	172	225	258	389	15	18	18	1,508
1935			60	38	10	90	74	41	71	92	10		486
1936	8	76	88	110	61	53	146	178	77	33	14	56	900
1937	19	106	90	100	168	68	78	79	79	66	5	17	875
1938	24	43	224	190	139	133	110	39	160	39	46	106	1,253
1939	36	102	109	86	154	300	72	36	121	114	46	11	1,187
1940	12	53	29	25	78	36	135	119	100	13	11	3	614
1941	3	12	17	10	20	20	3	160	57	37			339
1942		1	22	1		80	407	415	614	392	123		2,055
1943		6	15			278	226	190	21	2	46	2	786
1944	3	46	89	4		264	138	193	89	260	46		1,132
1945			27			151	38	60	169	4			449
1946		36	77	31	4	87	88	181	82	77	11	2	676
1947	2	11	6	3	3	200	137	250	73	45	33	15	778
1948		4	44	57	100	201	248	280	79	194	51	23	1,281
1949	10	26	121	40	126	92	146	100	93	46	36	18	854
1950	36	25	132	152	107	88	48	67	107	136	35	21	954

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1951	23	63	119	270	128	159	72	28	84	105	34	31	1,116
1952	40	44	205	50	90	137	258	155	53	46	40	67	1,185
1953	25	75	84	149	155	143	155	363	403	184	56	43	1,835
1954	48	65	173	102	222	424	289	251	530	160	40	80	2,384
1955	102	113	288	244	203	188	295	400	296	233	230	171	2,763
1956	221	61	279	278	176	187	255	281	394	391	129	206	2,858
1957	214	159	449	298	302	223	661	759	531	334	175	258	4,363
1958	148	249	411	365	504	444	447	456	544	671	310	468	5,017
1959	419	347	393	700	558	620	857	686	434	541	316	344	6,215
1960	342	309	402	192	315	727	207	566	638	253	365	258	4,574
1961	196	373	644	542	192	510	584	830	731	687	238	233	5,760
1962	340	579	514	327	375	346	311	478	703	355	457	215	5,000
1963	131	92	459	280	246	647	756	550	261	337	395	369	4,523
1964	208	191	461	304	258	598	344	535	394	206	97	204	3,800
1965	105	104	127	191	193	367	256	353	513	332	192	139	2,872
1966	130	129	159	256	160	551	87	309	559	87	161	17	2,605
1967	164	102	187	181	369	317	228	912	984	470	504	67	4,485
1968	107	106	235	343	325	472	197	417	396	219	100	57	2,974
1969	60	136	86	398	450	958	213	529	371	417	156	50	3,824
1970	148	123	279	444	545	604	491	630	442	308	136	82	4,232
1971	184	130	271	389	282	122	214	424	467	311	25	173	2,992
1972	14	102	68	100	213	344	307	228	356	391	69	194	2,386
1973	257	275	527	752	386	610	202	597	708	265	51	268	4,898
1974	106	141	190	80	82	398	322	383	156	197	35	43	2,133
1975	77	84	255	232	335	527	227	667	529	353	112	24	3,422
1976	315	250	430	419	414	903	457	681	539	399	267	295	5,369
1977	318	357	182	355	285	937	613	725	617	470	496	493	5,848
1978	217	138	293	547	290	449	305	519	860	640	326	184	4,768
1979	314	243	648	324	286	818	480	432	1,171	395	86	185	5,382
1980	494	223	656	538	1,224	589	521	1,015	936	428	113	190	6,927
1981	376	336	402	1,060	1,124	409	333	1,080	831	763	70	78	6,862
1982	378	456	760	1,082	1,403	415	667	887	831	342	470	284	7,975
1983	604	765	698	877	1,114	585	1,206	732	1,007	720	184	175	8,667
1984	482	510	870	986	1,585	2,404	1,622	2,755	1,450	722	226	428	14,040
1985	624	723	1,489	2,148	2,233	729	504	896	1,545	596	391	173	12,051
1986	157	200	102	908	307	129	435	434	444	587	336	808	4,847
1987	219	363	523	417	257	504	229	792	1,509	385	335	626	6,159
1988	179	228	227	521	164	108	239	360	239	600	211	245	3,321
1989	509	484	687	820	620	405	558	1,125	1,135	805	423	738	8,309
1990	738	1,366	815	907	946	1,178	549	689	1,043	857	496	431	10,015
1991	1	15	103	204	93	307	405	262	292	225	85	78	2,070
1992	64	283	153	340	120	17	43	340	58	198	160	92	1,868
1993	144	126	119	188	110	8,673	818	821	749	420	58	37	12,263
1994	90	387	457	386	168	379	276	631	1,166	296	35	41	4,312
1995	147	97	33	25	256	263	362	747	269	69	1	1	2,270
1996	1	1	1	44	44	49	86	128	16	48	10	10	438
1997		13	41	90	188	298	375	77	164	3	38		1,287
1998	32	39	123	63	36	91	170	134	179	29	40		936
1999	21	58	61	41	88	69	189	35	148	94	42	3	849
2000	1	11	32	2	3	17	4	2	1	22	2	1	98
2001	9	38	17	17	1	20	82						184
Total	**10,551**	**12,653**	**18,813**	**22,416**	**22,114**	**34,784**	**24,053**	**35,151**	**33,436**	**19,970**	**10,096**	**10,178**	**254,215**

Inventory of oxygen stations

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1893								1					1
1902								3					3
1904		1	2	1	10	2		14	1				31
1905											3	3	6
1906							2	18					20
1921					7			27	10				44
1923				2	1	1	5						9
1924						2	30	27	31				90
1925								4	52	3	1		60
1926								22					22
1927							13	57	21				91
1928			8	15		7	8					2	40
1929			19	45		5	4	13	7		26	8	127
1930			26	37		12		16	10				101
1931			4	50		4	38	49	38	5			188
1932			23	34	5	34	31	62	59	27	2		277
1933	10	22	28	29	85	13	23	43	42	11			306
1934			13	55	53	63	44	86	81	6	3	11	415
1935			26	17		38	25	4	14	61	10		195
1936	6	51	67	53	28	21		1	13				240
1937	9	18	46	46	113	7							239
1938		30	94	94	34	42	17	12	37	16	19	64	459
1939	33	68	68	69	85	142	9	11		59	4	3	551
1940	11	28	19	18	62	18	14	18	7	9	7	3	214
1941	3	5	11	9	11	38	3		7				87
1942							14						14
1944	2	15	25	1				17					60
1945									18				18
1946		17	37	18			1	10	14	31	5	2	135
1947	2	2	3	2	2	3	2	3					19
1948			19	12	28	81	10	50	3	6	5	1	215
1949	1	2	47	4	32	13	37	40	20				196
1950			30	37	32	42	37	5	26	27	5		241
1951		19	5	2	31	47	42	3	44	27	6	3	229
1952		5	47		10	75	37	31	3	10	17	19	254
1953	4	16	32	64	65	75	48	34	38	49	30	17	472
1954	21	18	44	65	34	67	31	52	88	47	20	63	550
1955	15	44	47	73	31	83	52	83	32	53	17	14	544
1956	33	9	31	55	10	54	25	50	51	54	27	25	424
1957	19	21	18	31	38	70	64	84	23	14	3	8	393
1958	10	19	34	120	106	129	64	90	103	150		7	832
1959	49	34	16	160	91	53	16	78	93	89	43	6	728
1960	5	4	63	20	14	65	42	71	73	29	11		397
1961	17	4	8	54	4	164	62	7	81	119	14		534
1962	13	1	17	50	16	64	8	69	91	142	22		493
1963	8		3	4	17	20	5	117	54	85	15	17	345
1964	35	24	82	109	19	62	46	78	45	31	13	9	553
1965	1	6	10	66	91	101	52	46	140	73	107	60	753
1966	40	41	44	84	42	104	31	58	176	33	58	15	726
1967	16	38	39	42	64	100	58	227	172	103	52	24	935

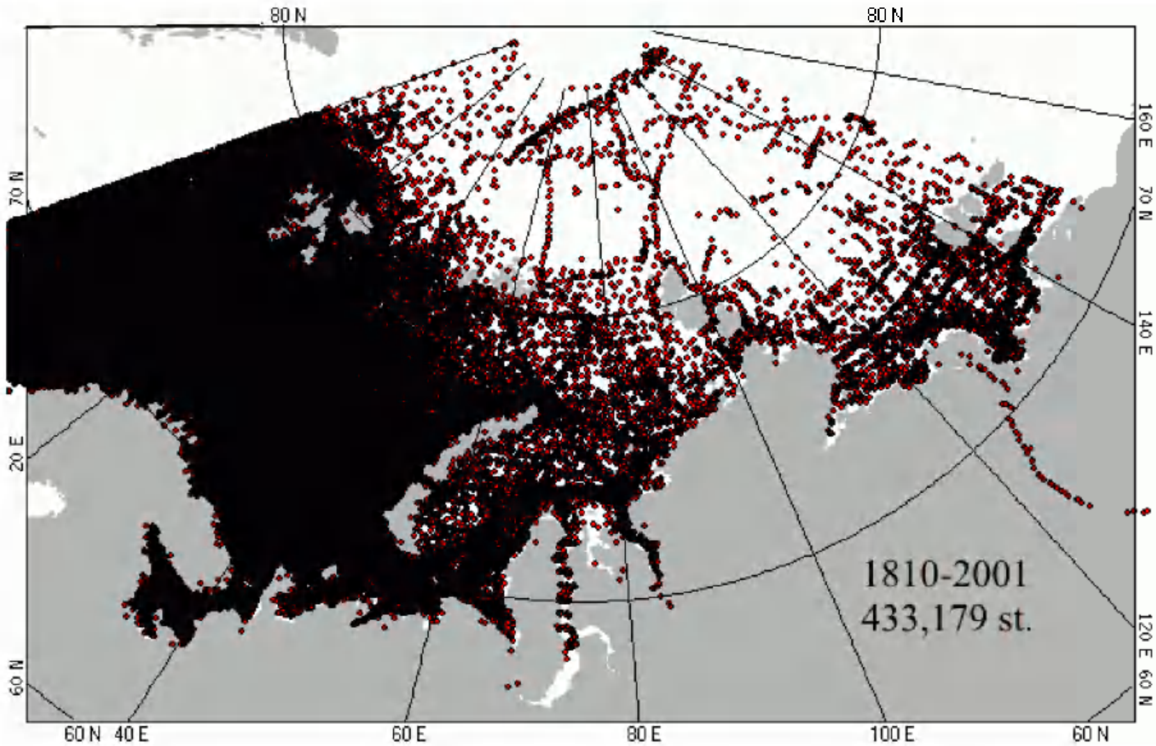
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1968	60	51	80	137	111	254	86	44	38	42	16	10	929
1969	17	22	31	82	58	182	36	119	76	129	115	8	875
1970	118	77	171	70	82	200	70	158	81	165	27	14	1,233
1971	79	113	190	308	200	39	63	115	129	170	12	145	1,563
1972	3	69	41	34	106	142	92	91	132	65	13	96	884
1973	100	40	224	161	189	263	81	283	139	139	17	7	1,643
1974	45	47	86	7	67	215	23	106	34	57	1	4	692
1975	33	1	167	146	257	290	123	109	251	166	50	1	1,594
1976	91	21	130	144	150	285	47	87	28	52	10	17	1,062
1977	53	64	7	39	64	223	100	185	26	113	23	16	913
1978	32	17	38	60	78	170	92	163	102	89	16	18	875
1979	38	53	56	76	51	212	32	97	76	69	67	14	841
1980	64	26	33	69	179	160	125	20	46	168	29	21	940
1981	29	41	22	60	52	125	18	96	58	185	39	51	776
1982	21	33	91	26	99	147	99	113	112	39	127	80	987
1983	59	29	49	82	43	52	21	12	111	251	47	31	787
1984	18	37	4	33	24	55	59	194	94	80	67	21	686
1985	32	27	9	28	55	42	23	3	78	206	2	3	508
1986	72	42	2	68	18	42	67	33	91	186	133	64	818
1987	94	109	9	24	61	98	99	113	150	172	38	19	986
1988	21	42	41	104	45	4	3	146	55	124	68	10	663
1989	40	9	89	37	24	55	50	73	63	193	26	21	680
1990	35	19	9	28	4	92	46	35	55	158	25		506
1991		13	60	63	20	81	84	52	44	117	24	25	583
1992		22	37	43	15		24			99	64	47	351
1993		12	8		16	37	39	16	36	32			196
1994		10			13	17	37	58	122				257
1995			17		40		47	133	31	65			333
1996							6	20			2	4	32
1997		7	3		17		28	2	41				98
1998			22					20	52	17			111
1999									33	5			38
2001							69						69
Total	**1,517**	**1,615**	**2,881**	**3,576**	**3,409**	**5,403**	**2,839**	**4,487**	**4,202**	**4,722**	**1,603**	**1,131**	**37,385**

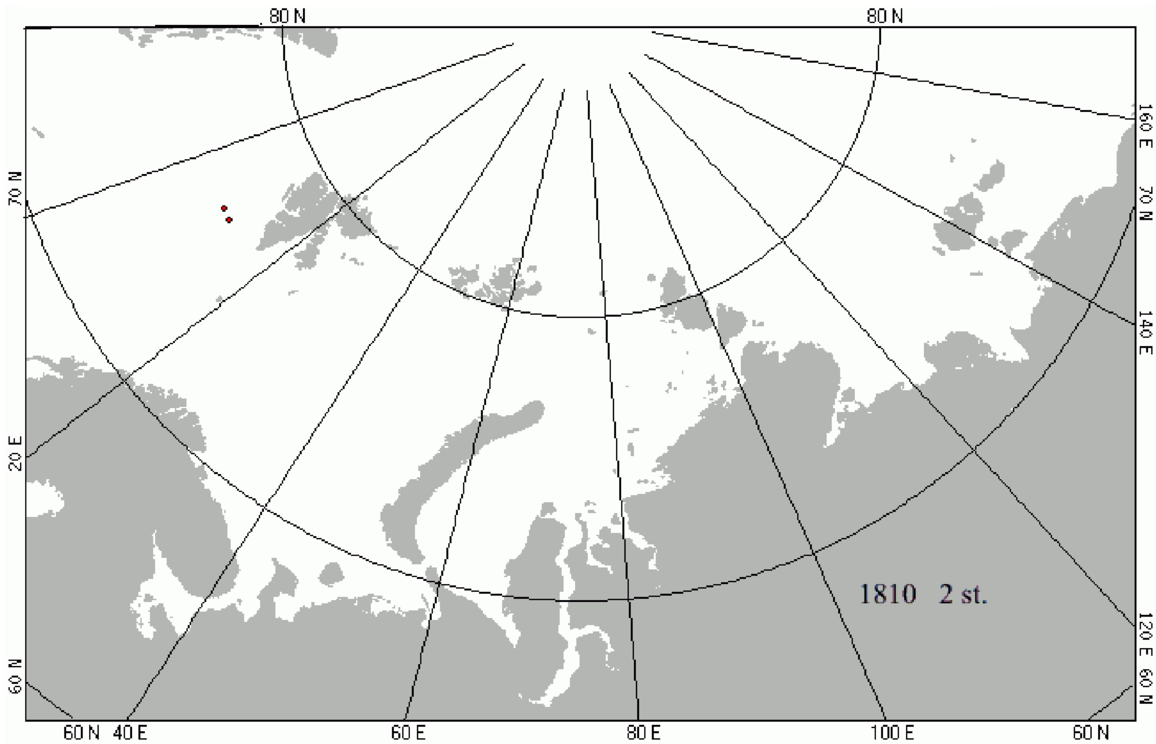
Inventory of plankton stations

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1913								2	10				12
1914									10				10
1915							3	24					27
1921					5			12					17
1925								15	4				19
1927								14	2				16
1929								11	3				14
1930								11	9				20
1931									15				15
1932								5	6	8			19
1936								77	34	12			123
1938							1						1
1939						2	2	3	3	4			14

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1952										51	75	16	142
1953	3	14	34	81	10		27	30	22	15	16	12	264
1954	10		41	33	24	72	21	10	90	51	29	74	455
1955	20	210	10	120	109	158	101	41	55	15		14	853
1956	50	16	32	15	42	5	69	57	58	86	63	35	528
1957	48	54	44	114	108	24	34	90	6	43	16	5	586
1958	44	32		41	152	68	56	41		7		6	447
1959	36	31		159	88	120	51	84	160	117			846
1960							31						31
1962										54			54
1963							10	35	5	2	2	1	55
1964	2	2	3	4	2	1	4	2	3	2	3	2	30
1965	1	1	3	3	3	3	2	4	1	4	2	1	28
1966		2	3	4	3	2	3	3	3	1	3	1	28
1967	2	2	4	6	9	9	11	13	15	5	3	2	81
1968	1	3	18	26	18	18	16	3	3	3	1	1	111
1969	1		2	4	3	2	4	3	2	4	1	1	27
1970	1	1	8	45	64	61	61	48	47	55	3	1	395
1971	1	1	1	3	3	3	3	3	3				21
1972				18			2	3	3	2			28
1973					3	3	55	27	3	3	1		95
1974	1	1		1	1	2	4	3	3	3	1	1	21
1975	1	1	1	1	1	3	4	3	2	4	1	1	23
1976	1	1	1	1	1	3	4	3	3	3	3		24
1977		1	1	2		4	3	4	3	3	3	1	25
1978	1	1		1	2	3	3	3	3	2	3	2	25
1979	1	1	1	1	3	2	4	3	2	4	3	1	26
1980		2	2	3	2	3	3	3	2	3	1		24
1981		1	1		1	3	2	8	27	3	2	2	50
1982			1	2	2	10	10	3	3	3	2		36
1983		1	1	2	2	3	3	2	3	4			21
1984	1		2	3	3	3	7	3	2	4	1	13	42
1985		2	1	21	3	3	3	3	3	3	15	24	81
1986	1	22	14	11	27	32	6	3	3	3	1	1	124
1987	3	4	7	8	7	33	12	10	4	4	1		93
1988	1	1	22	41	4	4	3	19	3	3	4	1	106
1989	12	5	7	41	31	32	40	44	6	4	1		223
1990	1	1	5	4	2	3	3	3	2	4	1		29
1991	1	2	1	1	2	15	33	104	14	3	1		177
1992		16		1		2	28	3	30	4	1		85
1993					2	74	34	13	22	2	2		149
1994			5	5	5	30	31	29	9	6	1		121
1995					15	3	19	27	2	4	1	1	72
1996	1	1	7	33	23	10	40	19	3	3	1	1	142
1997		1		39	13	71	127	3	18	3	1		276
1998		32	1	28	4	15	3	3	3	34	2		125
1999		29	23				6	23	16	45	7	8	157
2000	8	45	9	3	4	20	4	3	32	3	5	7	143
2001	7	55		4	1		84	37					188
Total	**261**	**595**	**317**	**933**	**807**	**937**	**1,090**	**1,055**	**798**	**708**	**283**	**236**	**8,020**

APPENDIX B. Data distribution plots of all variables

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140 E
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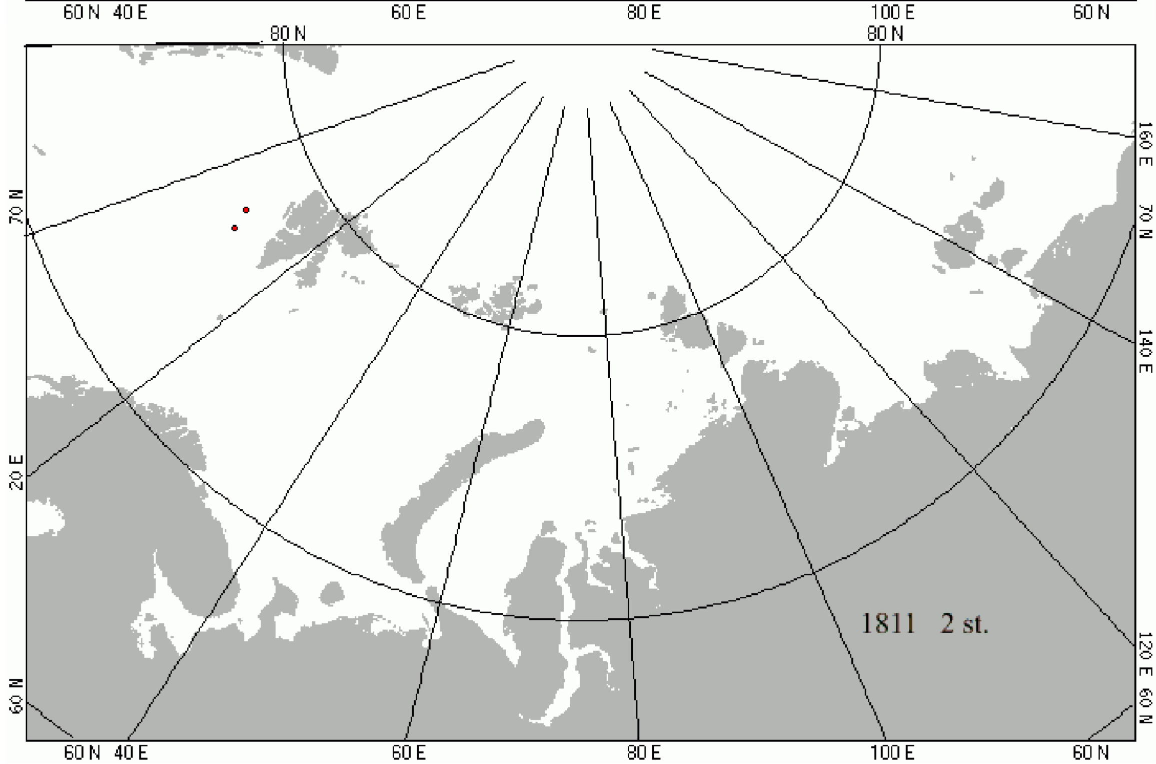
60 N
40 E
60 E
80 E
100 E
60 N
1810 2 st.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60 N
40 E
60 E
80 E
100 E
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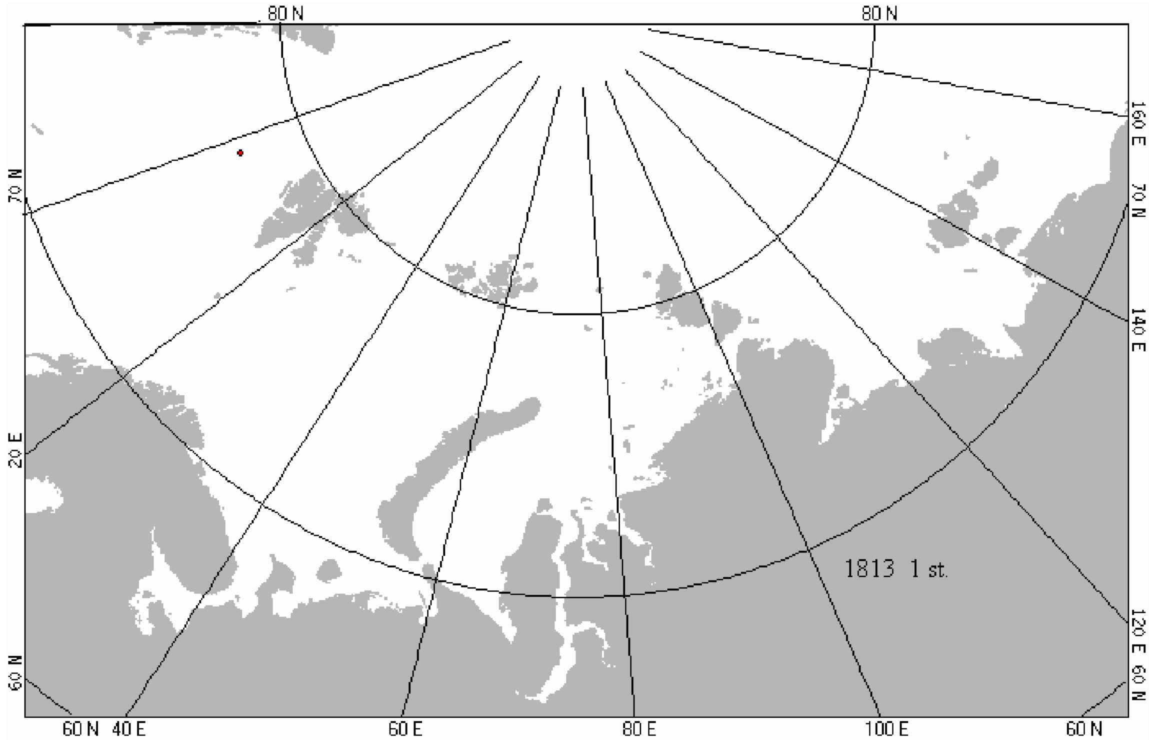
1811 2 st.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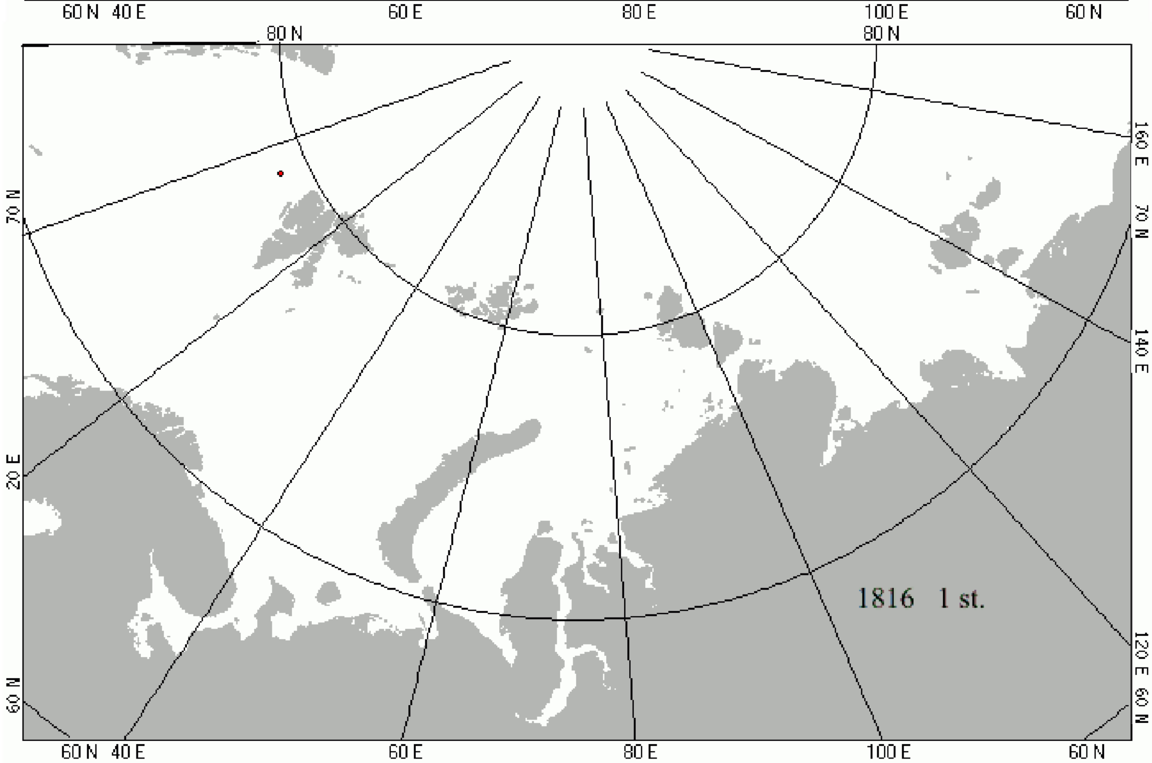
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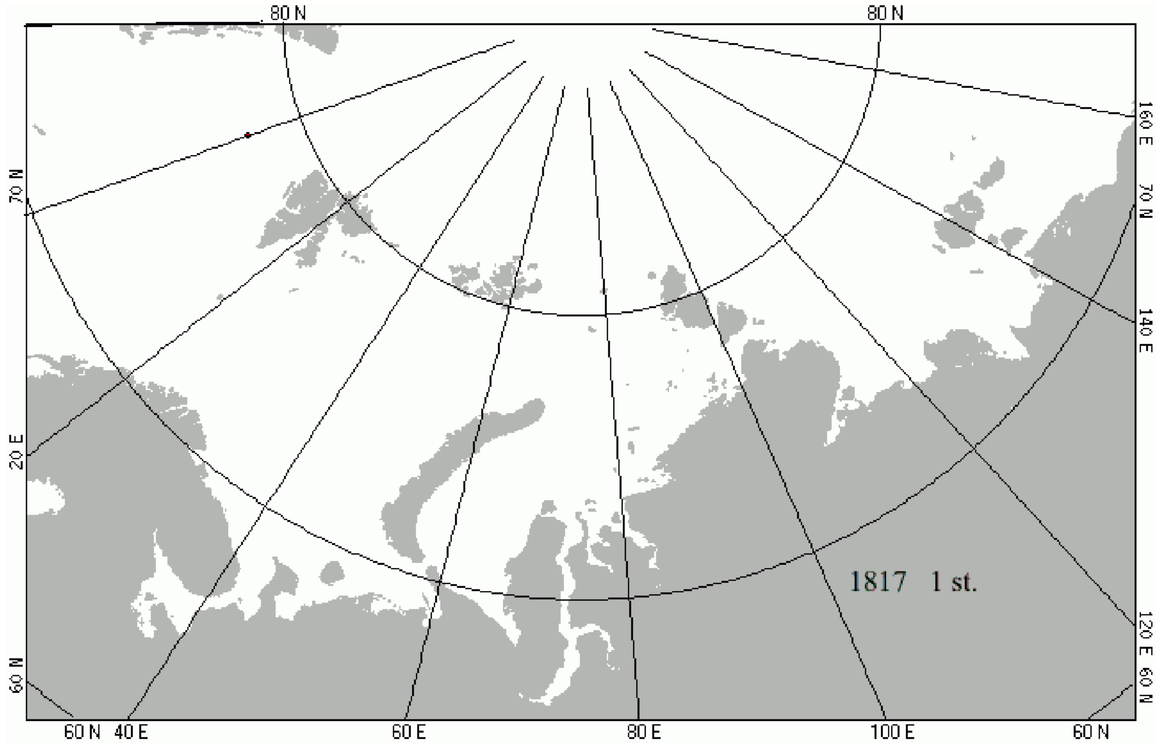
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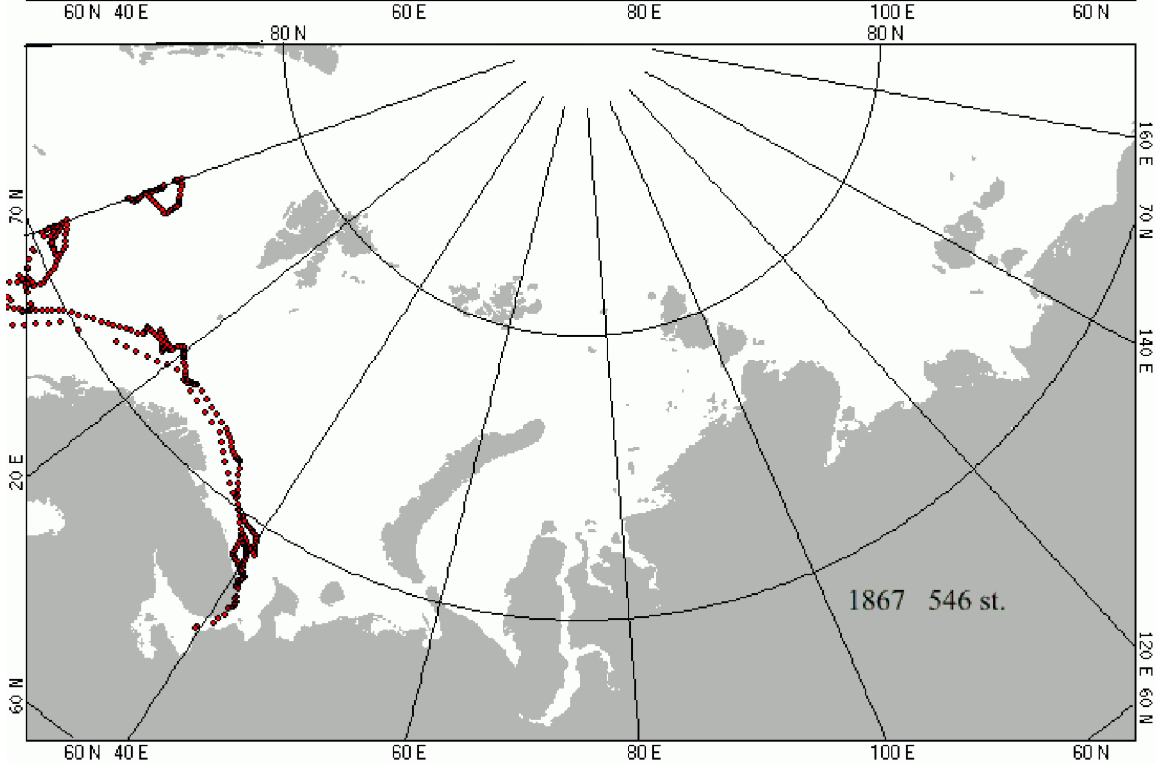
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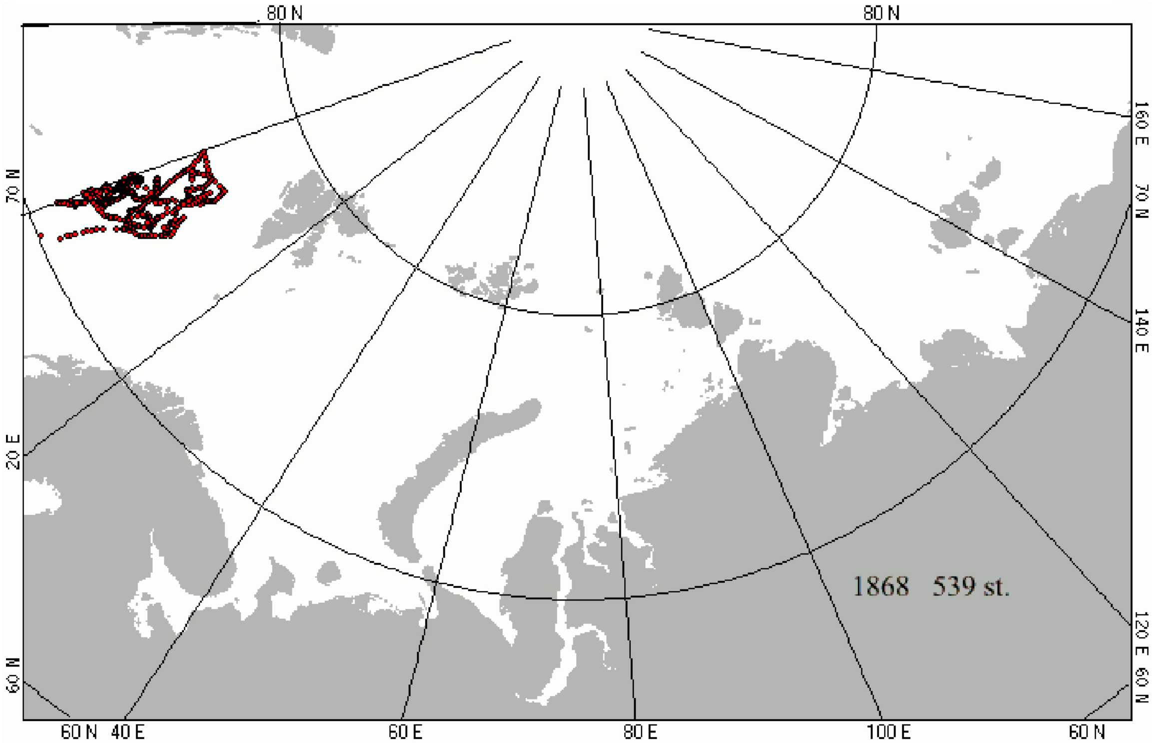
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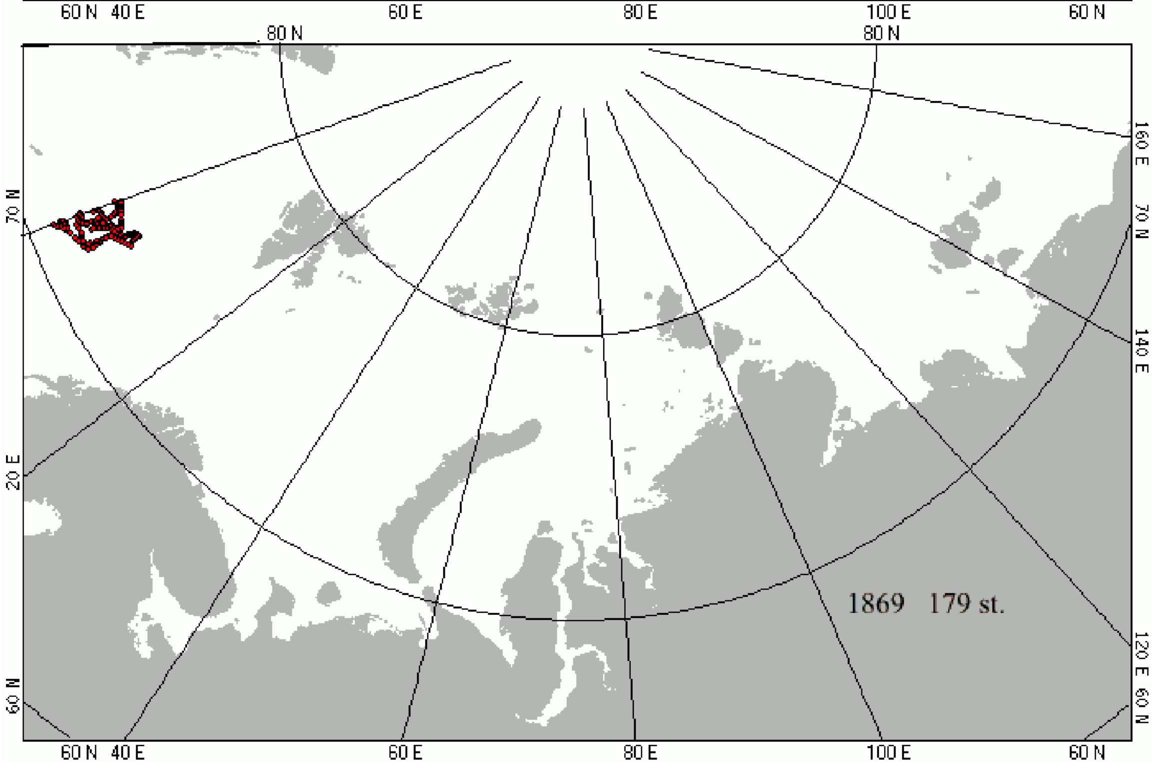
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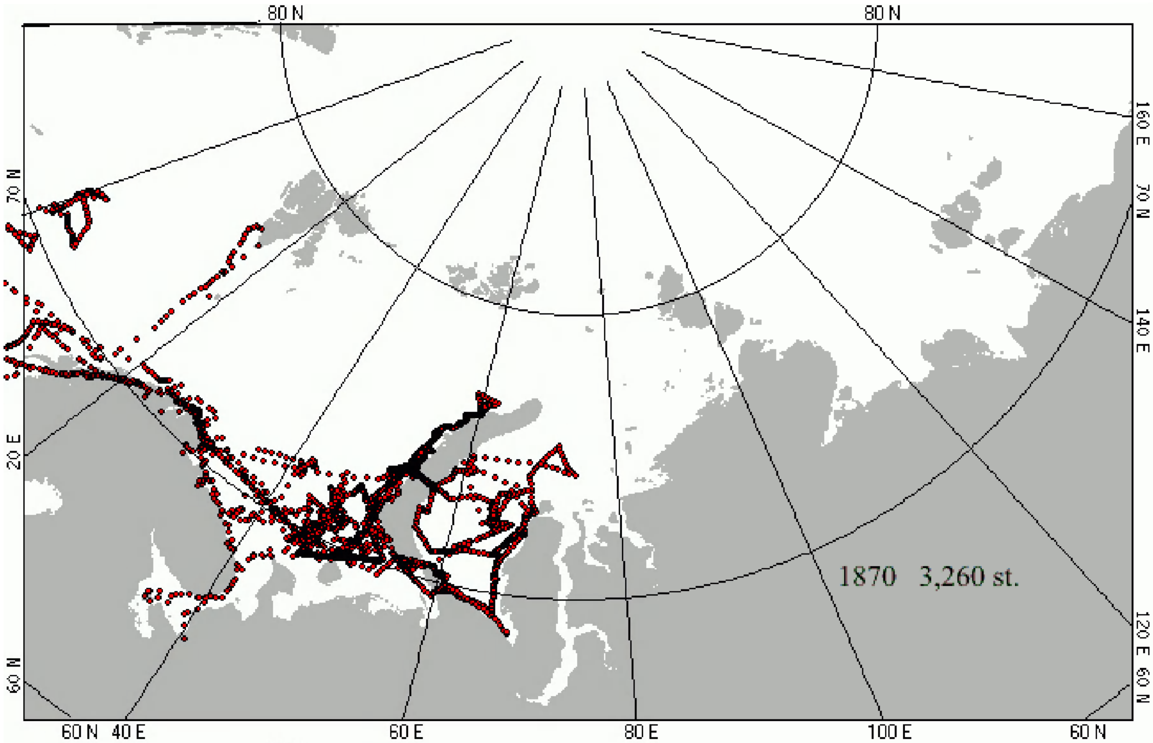
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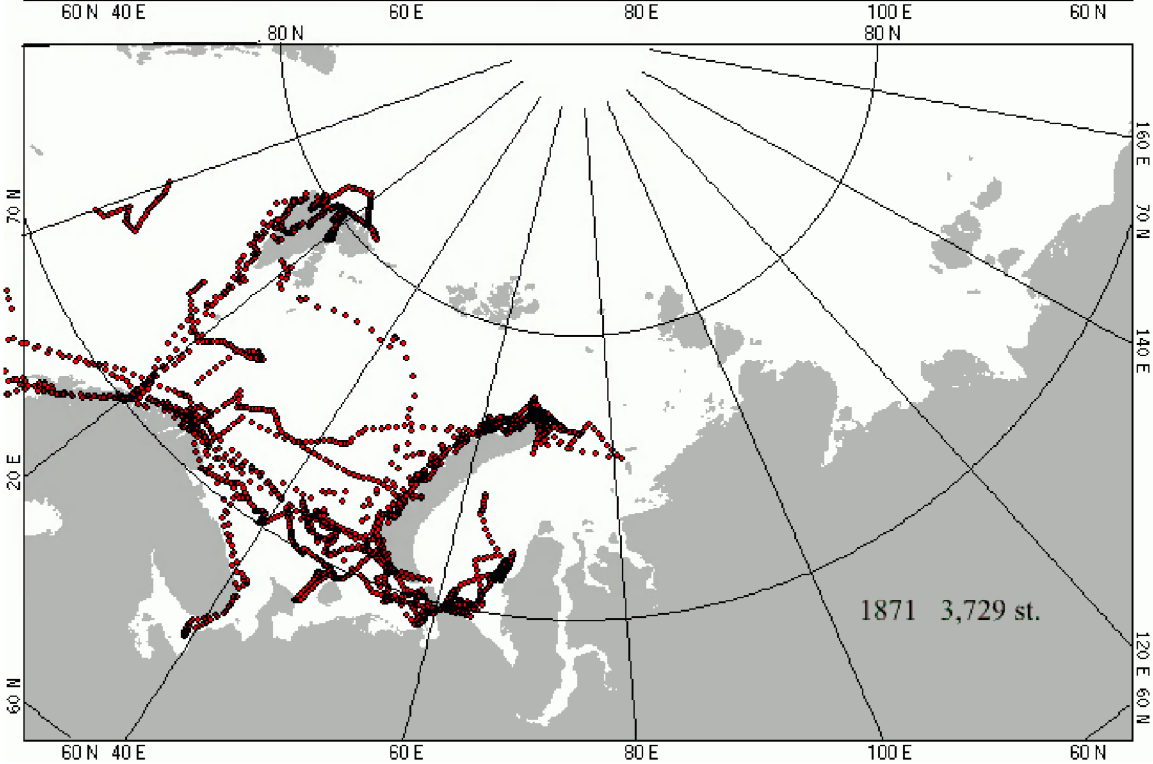
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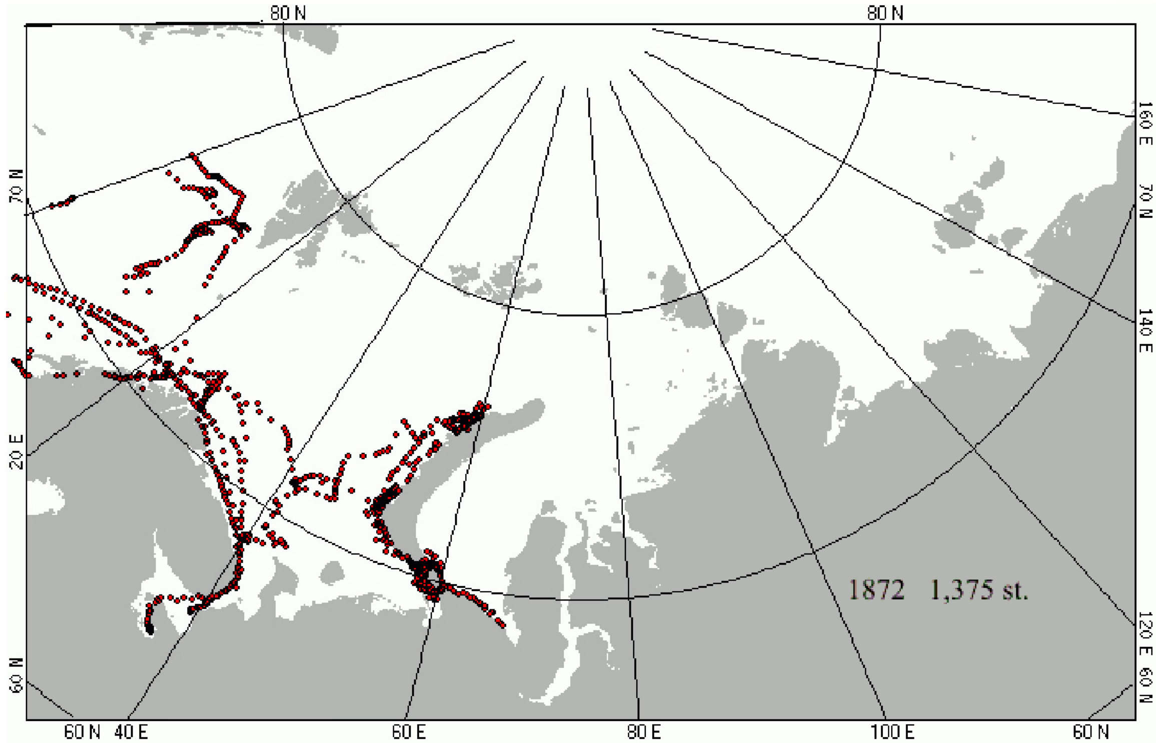
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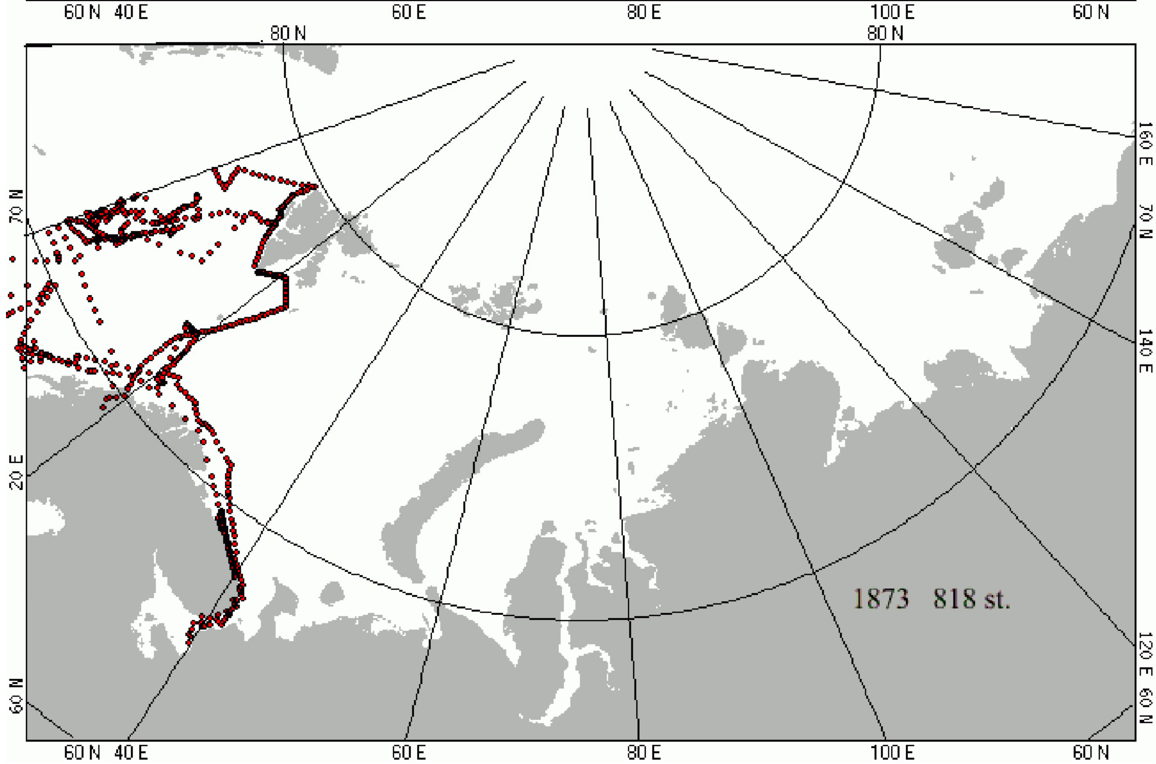
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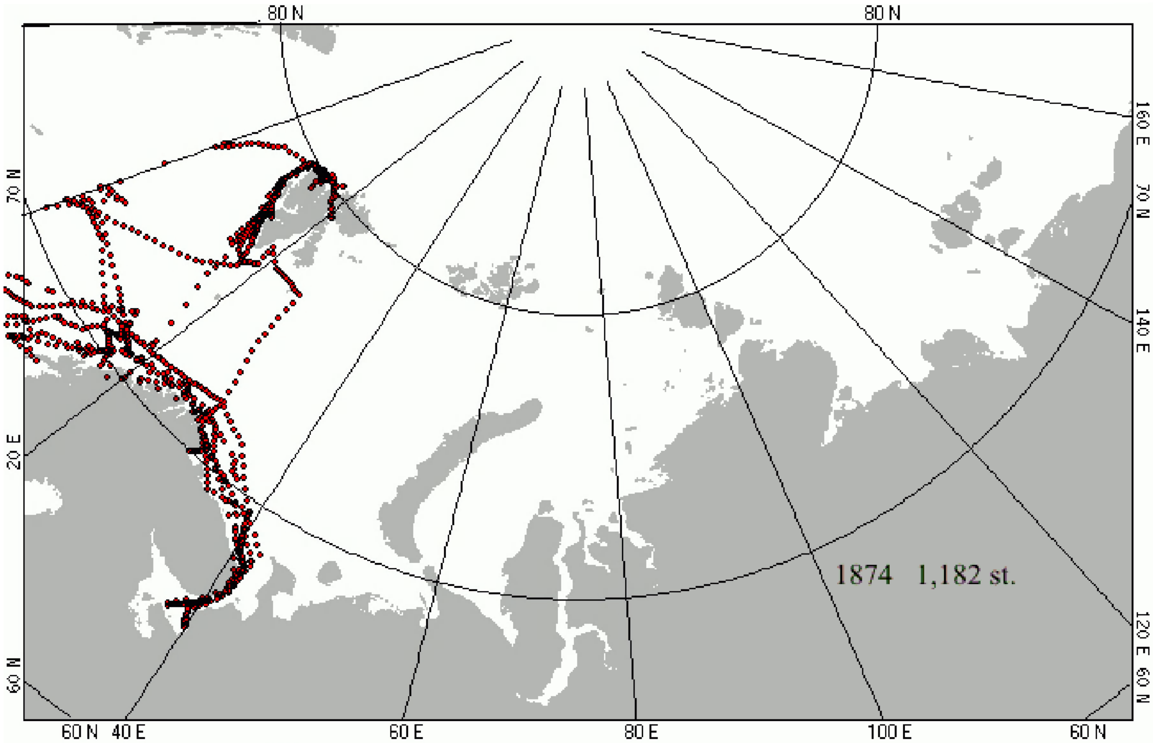
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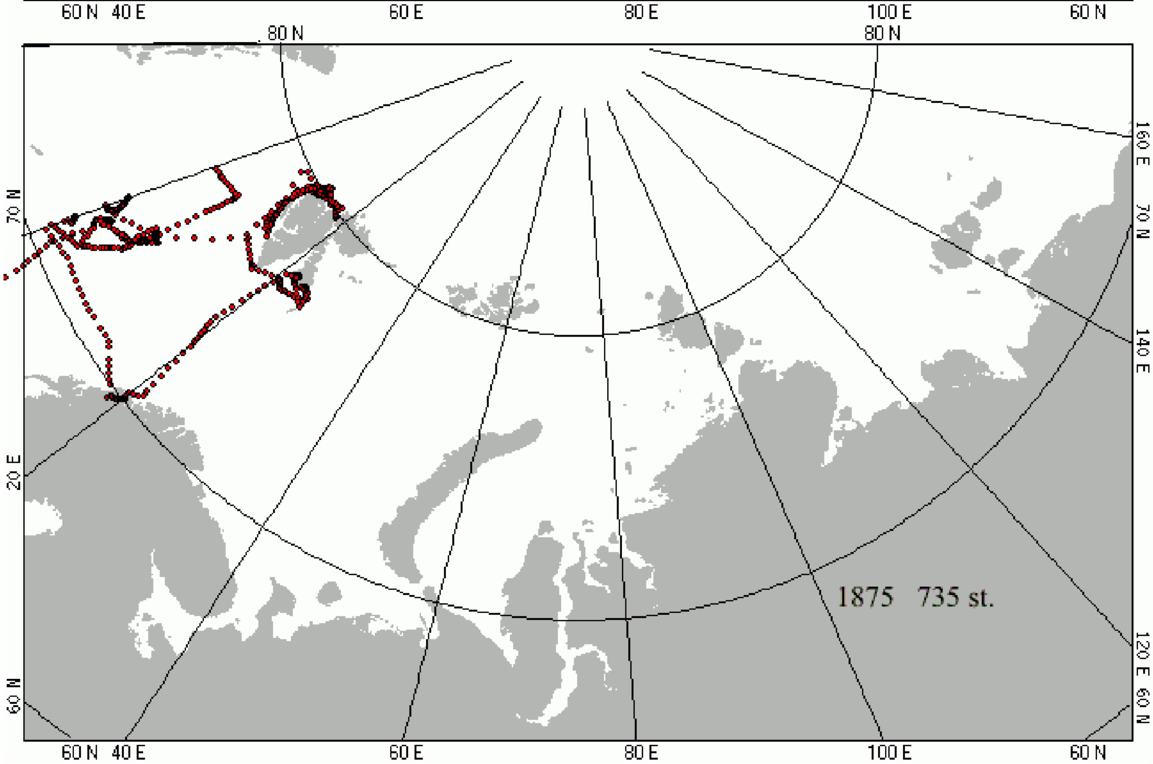
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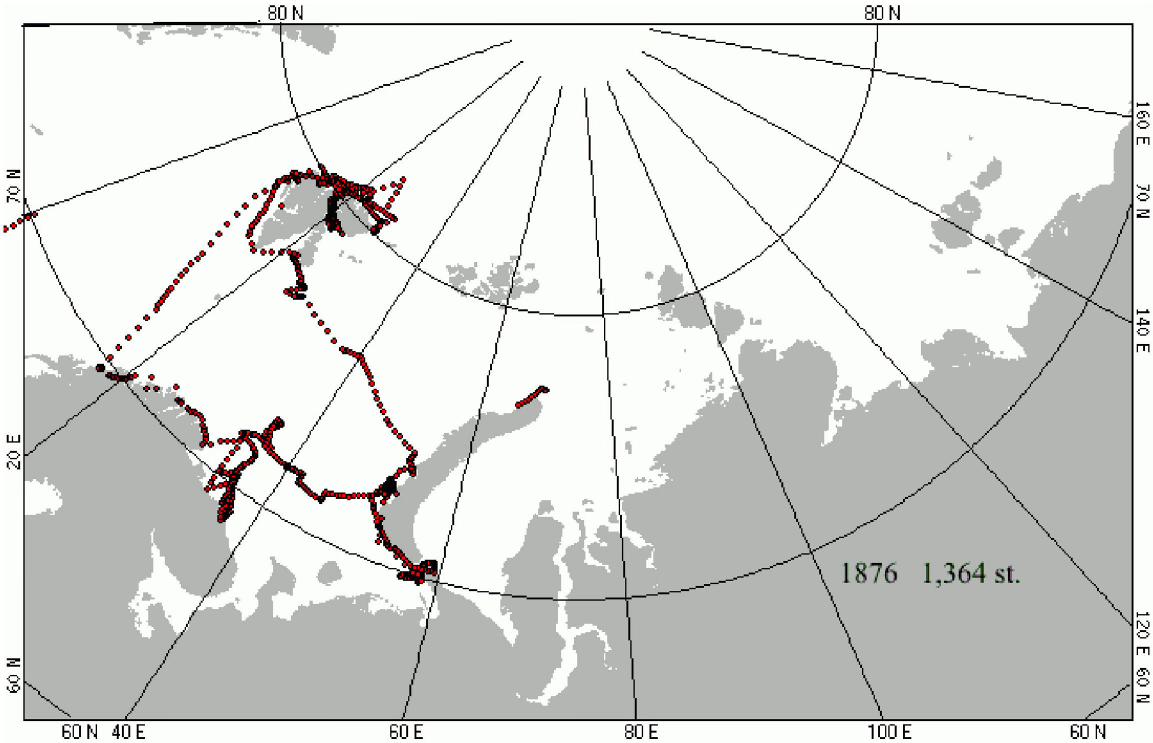
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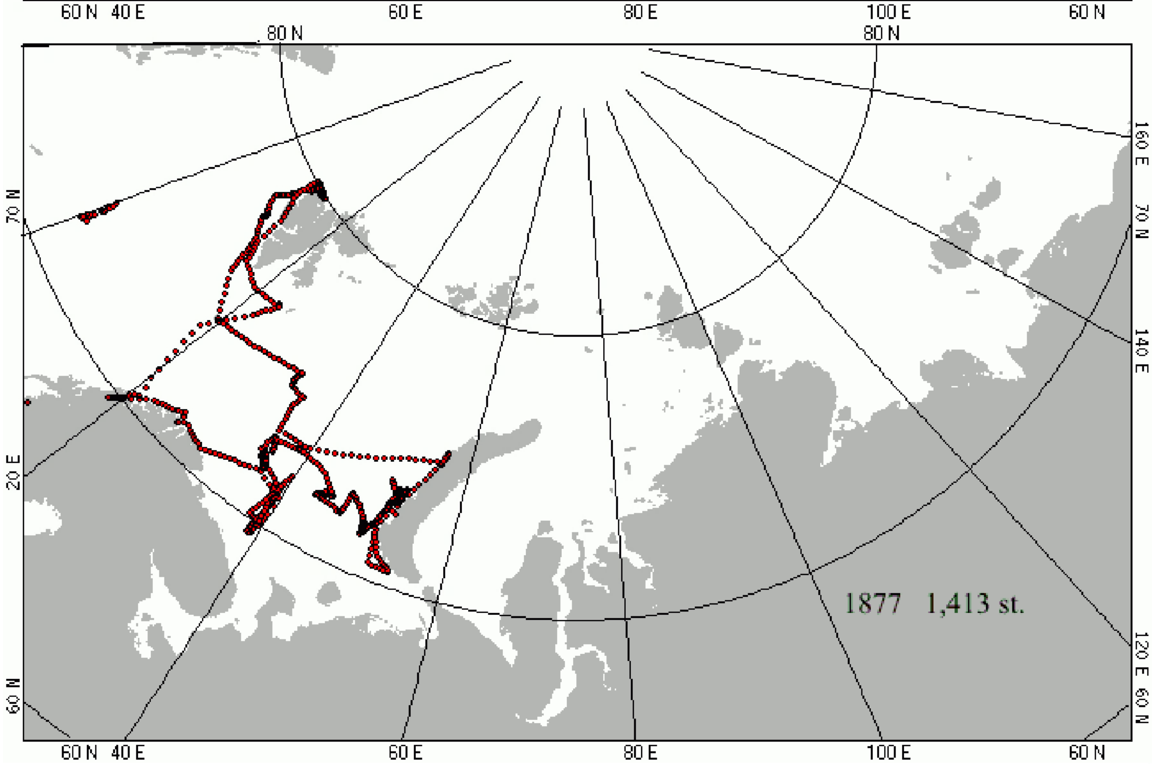
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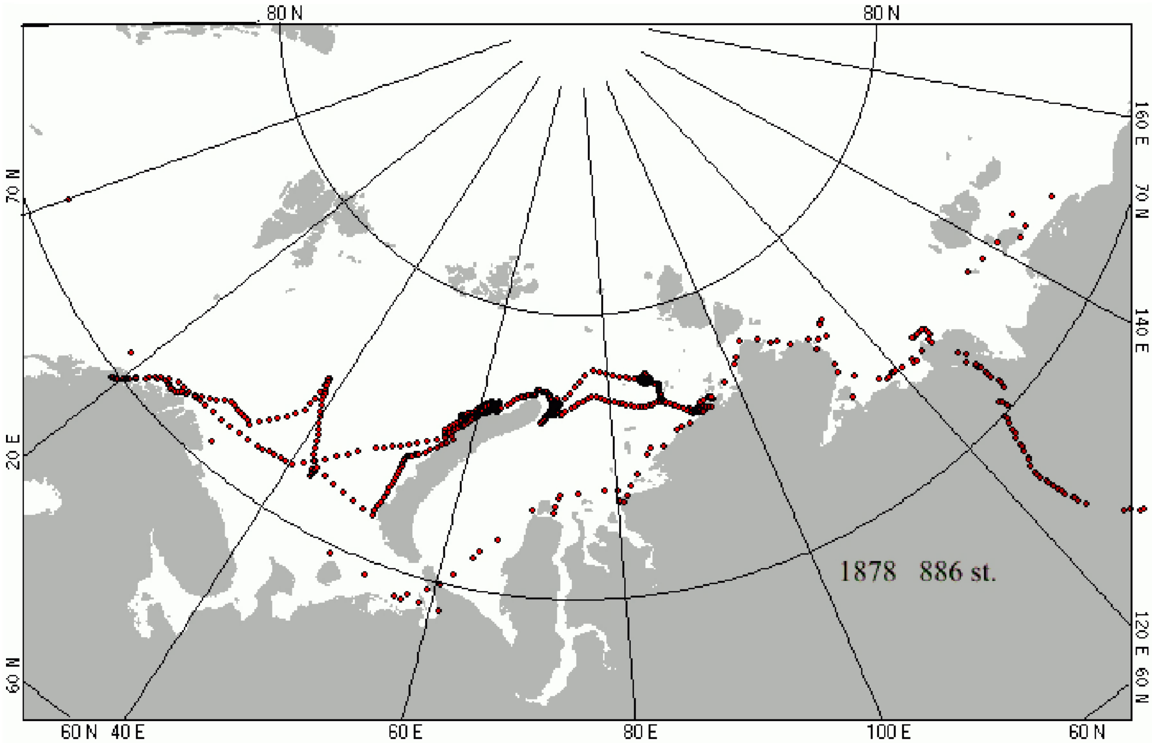
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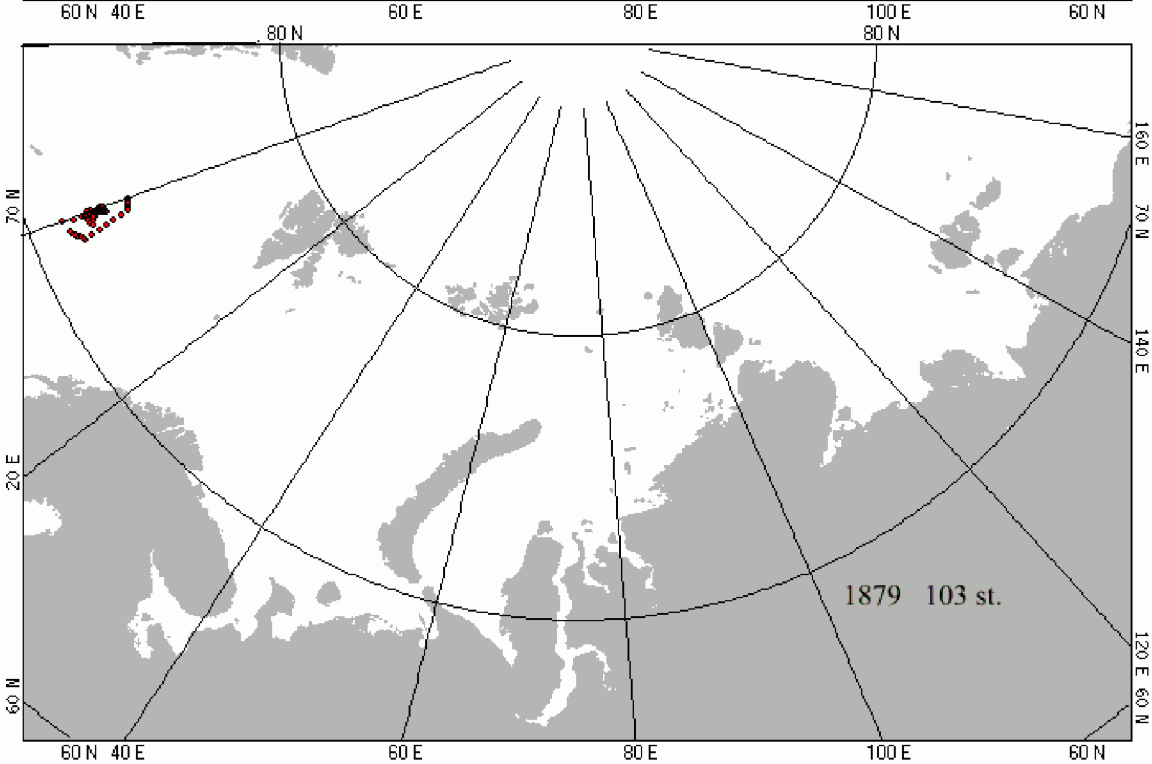
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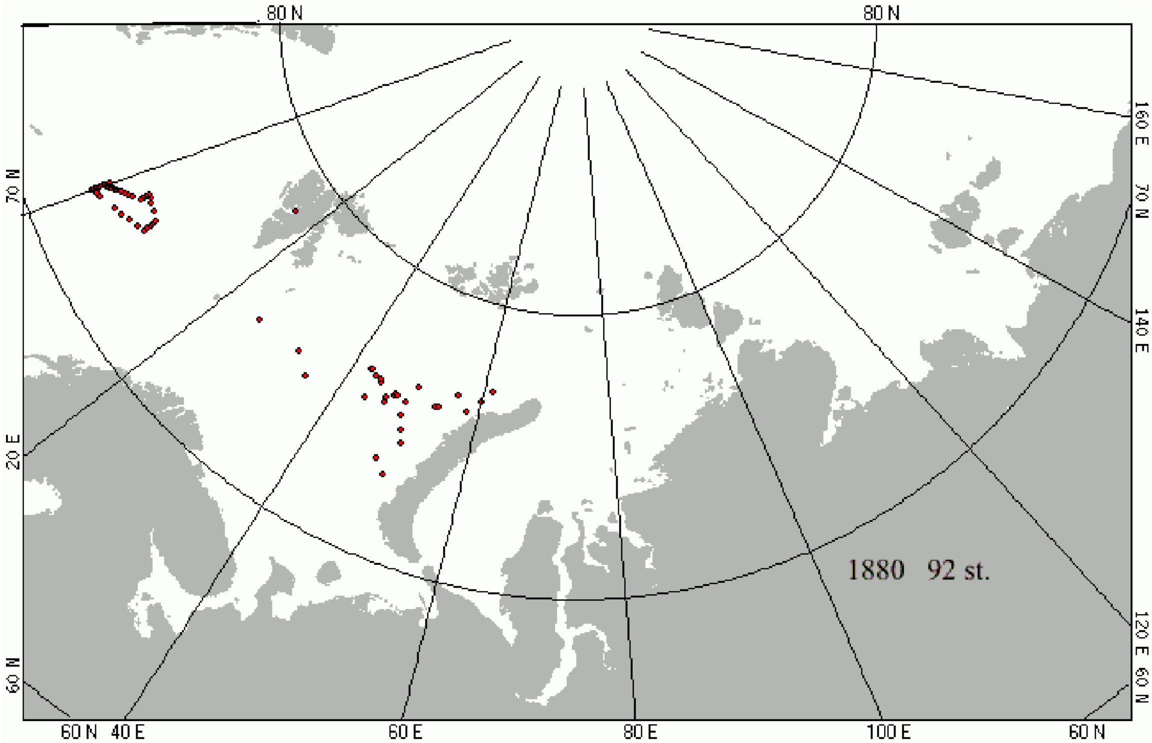
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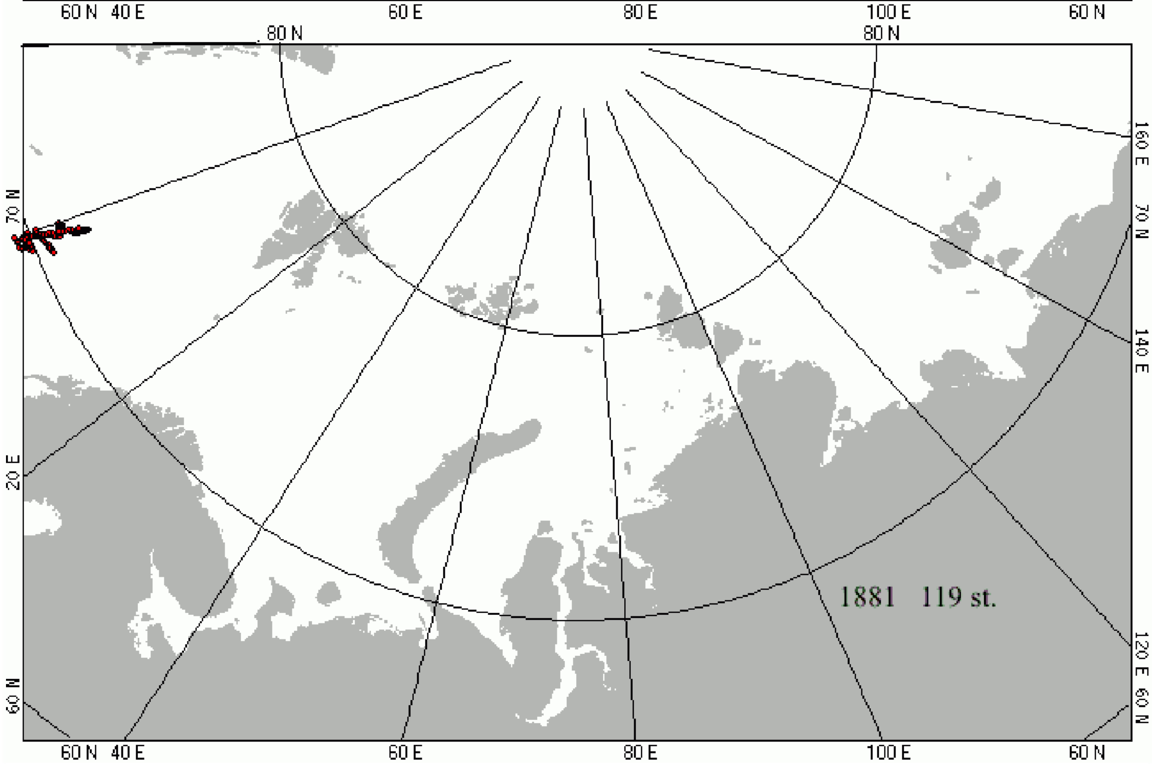
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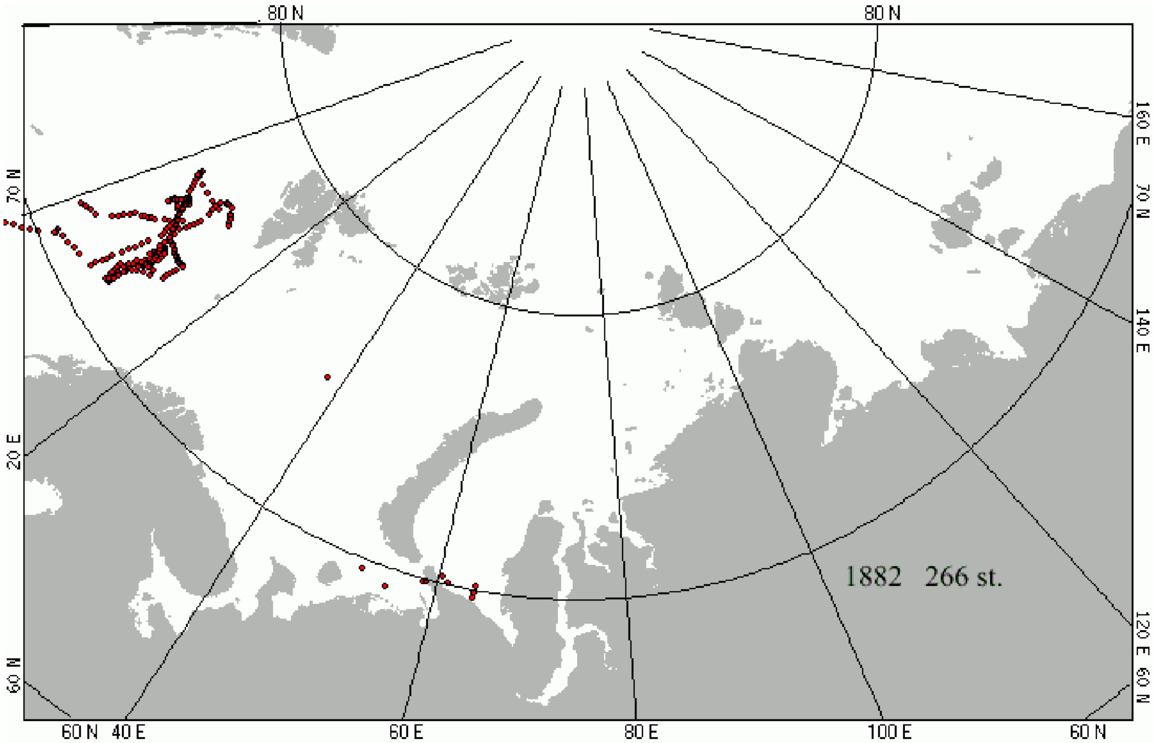
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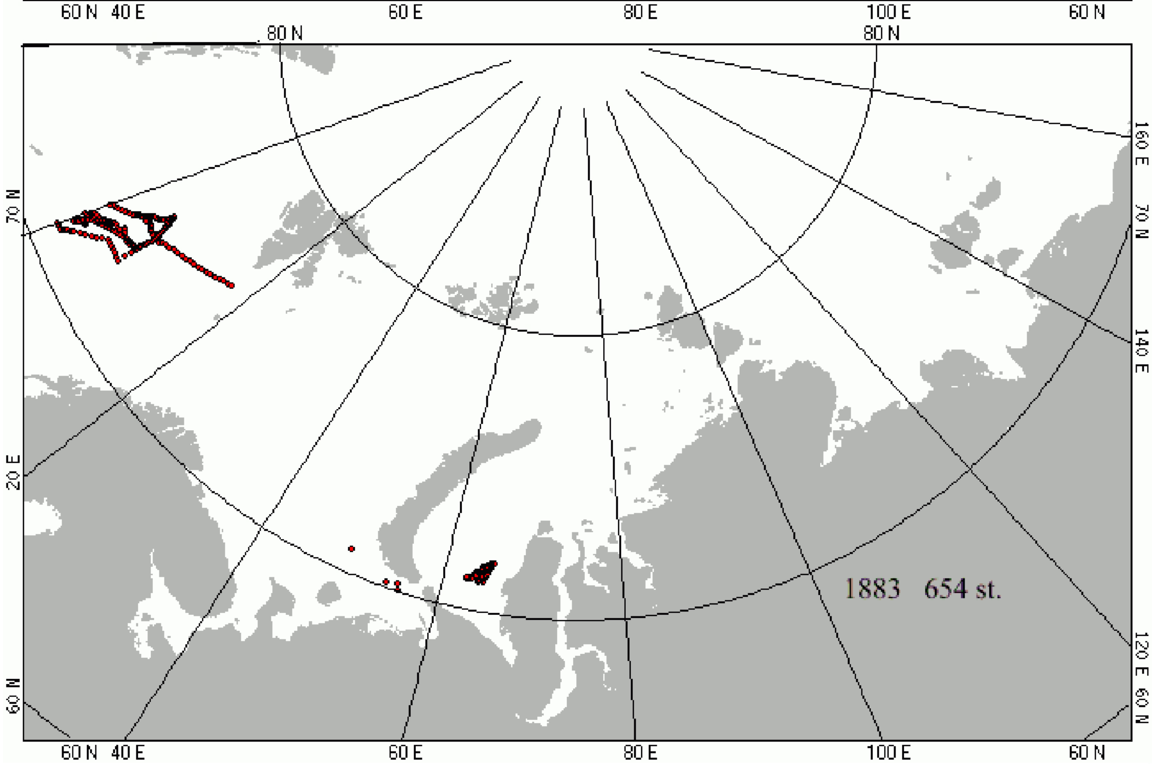
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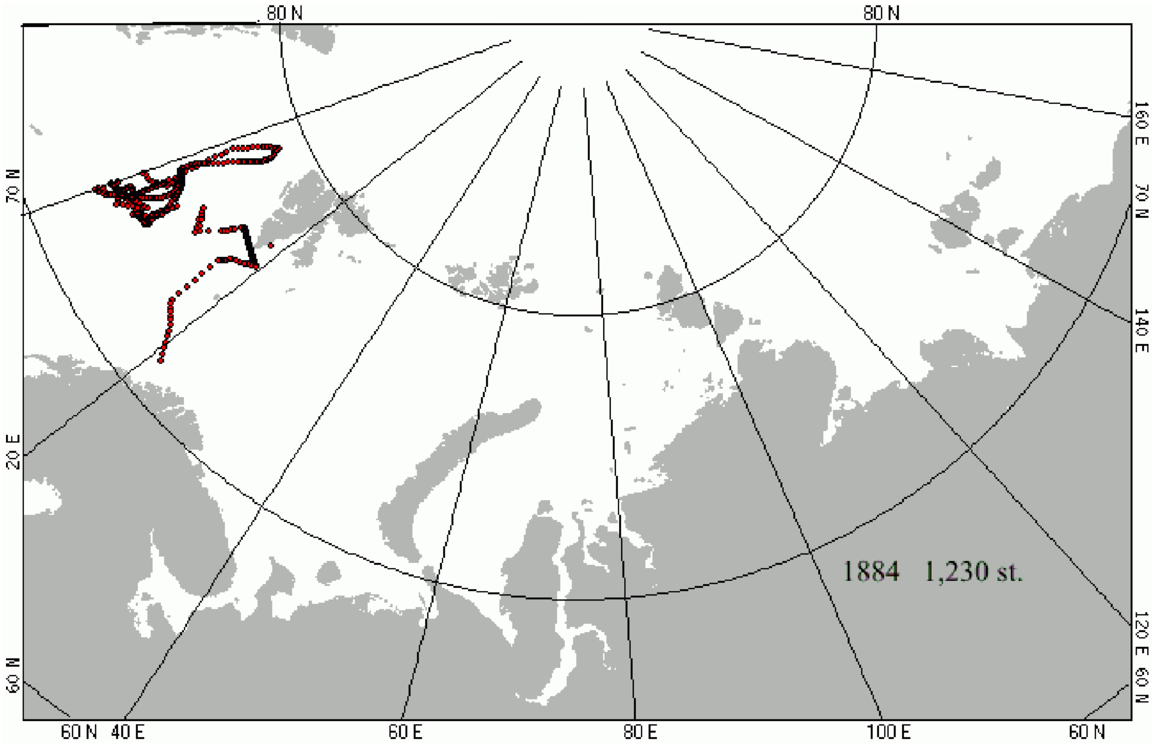
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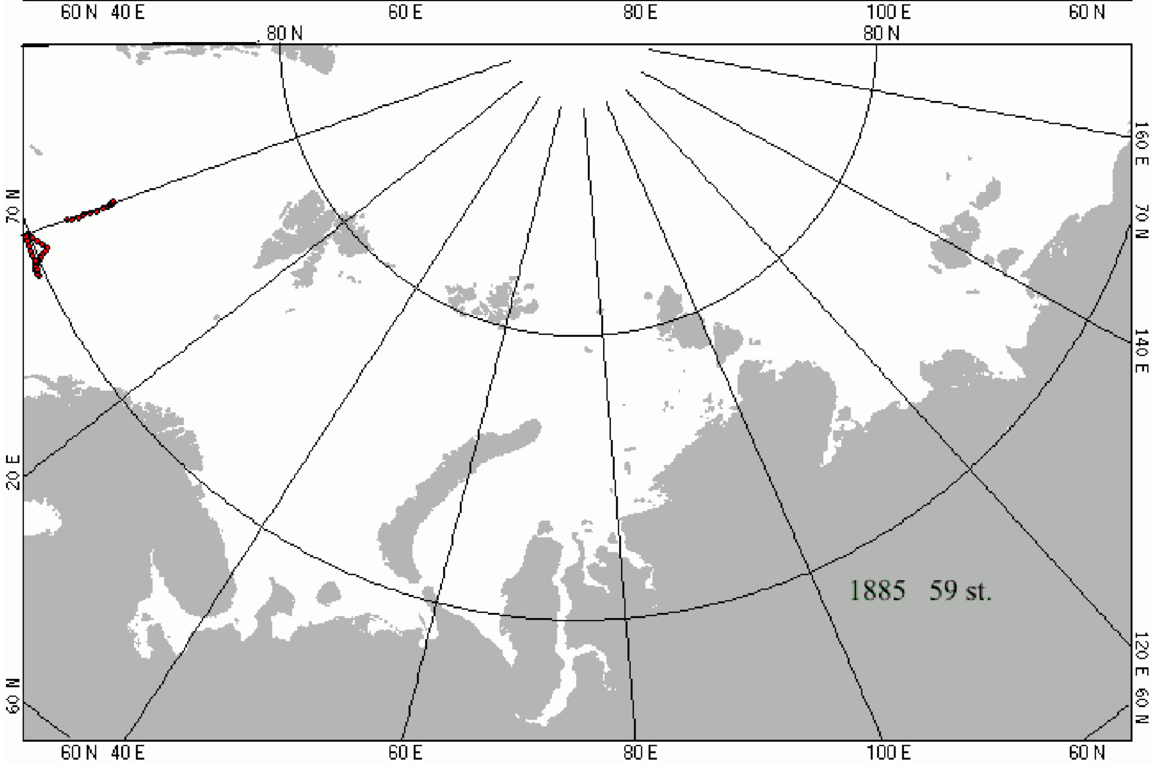
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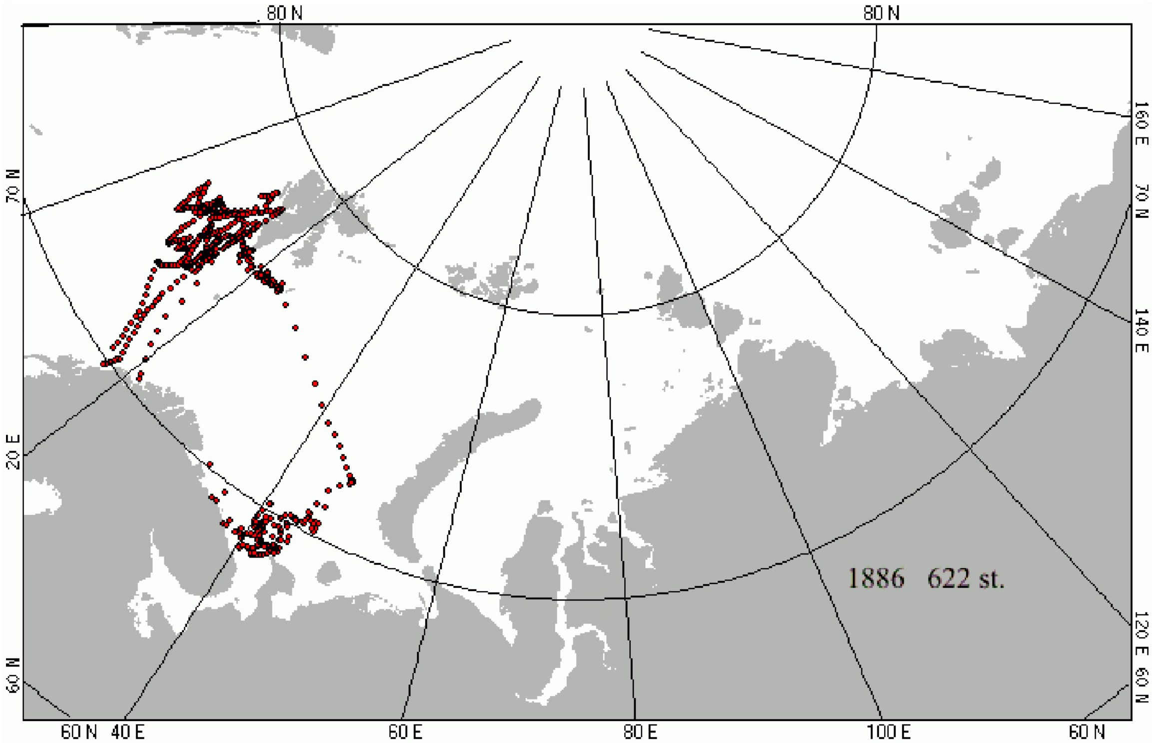
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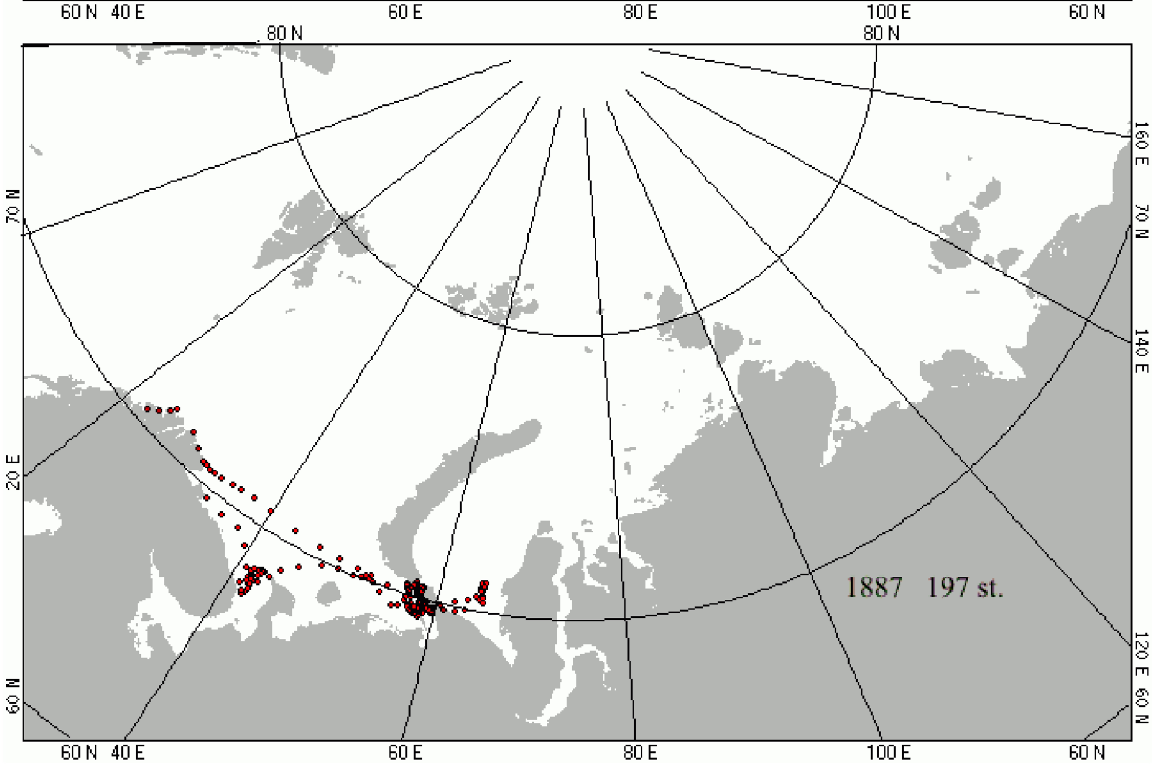
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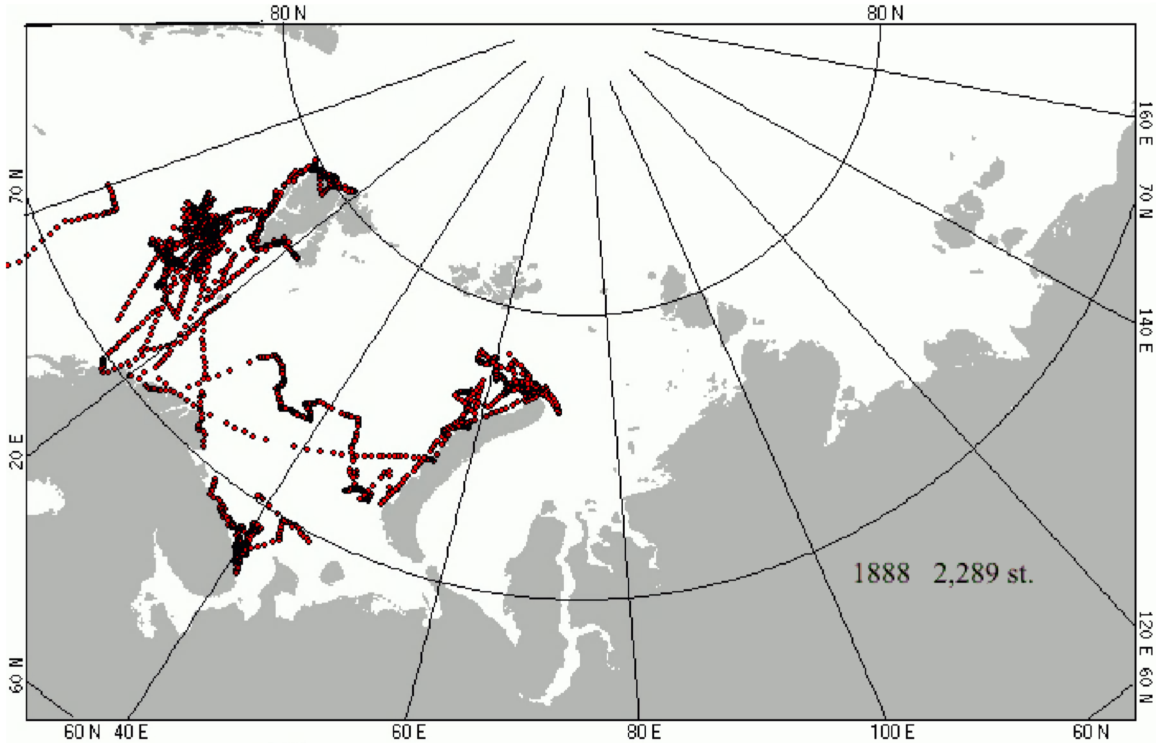
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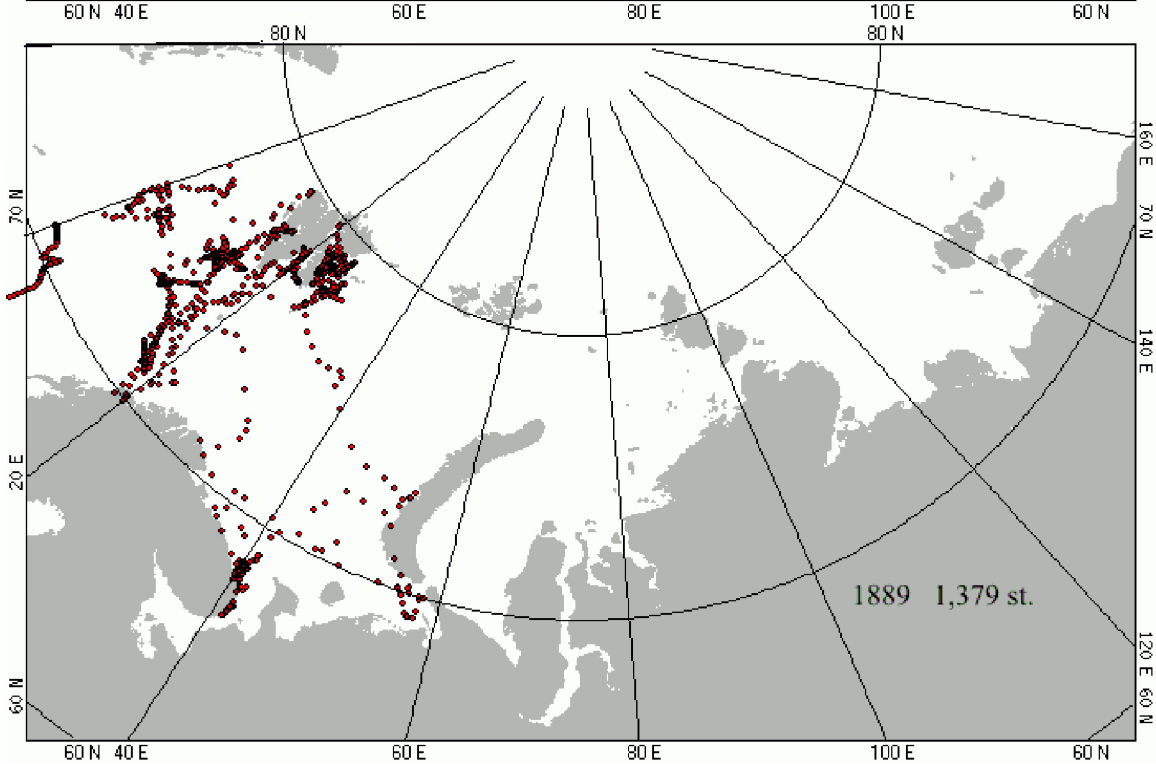
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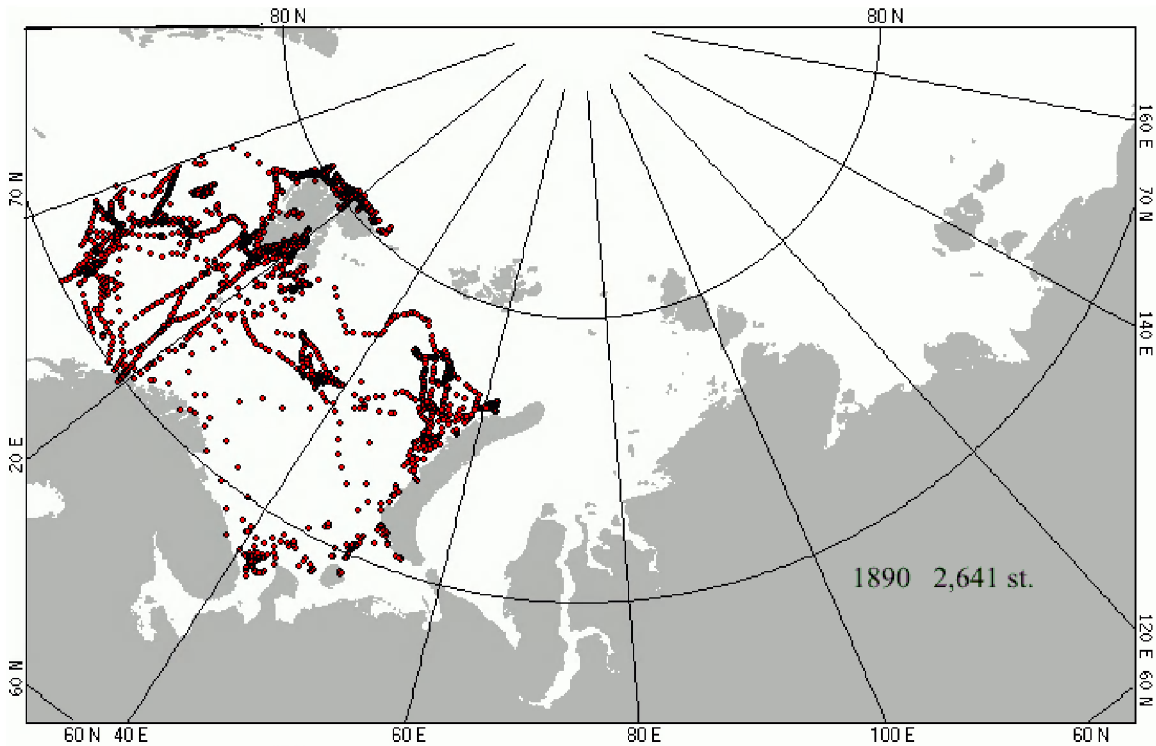
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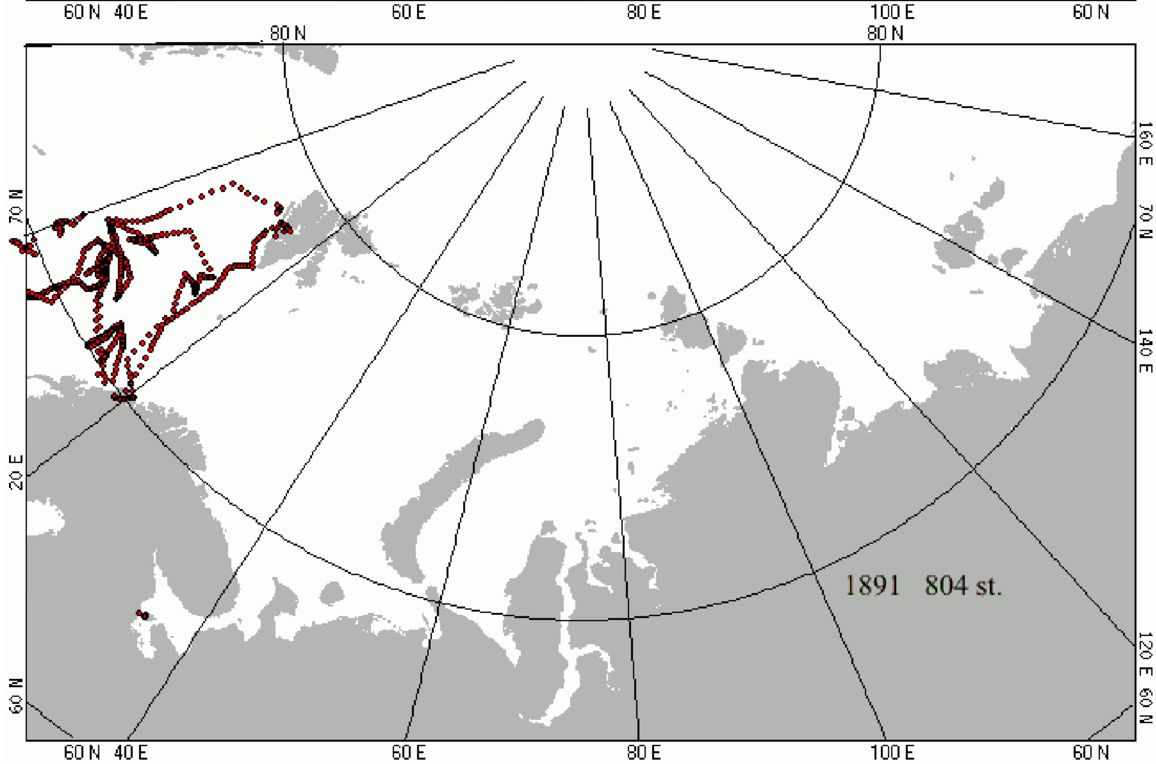
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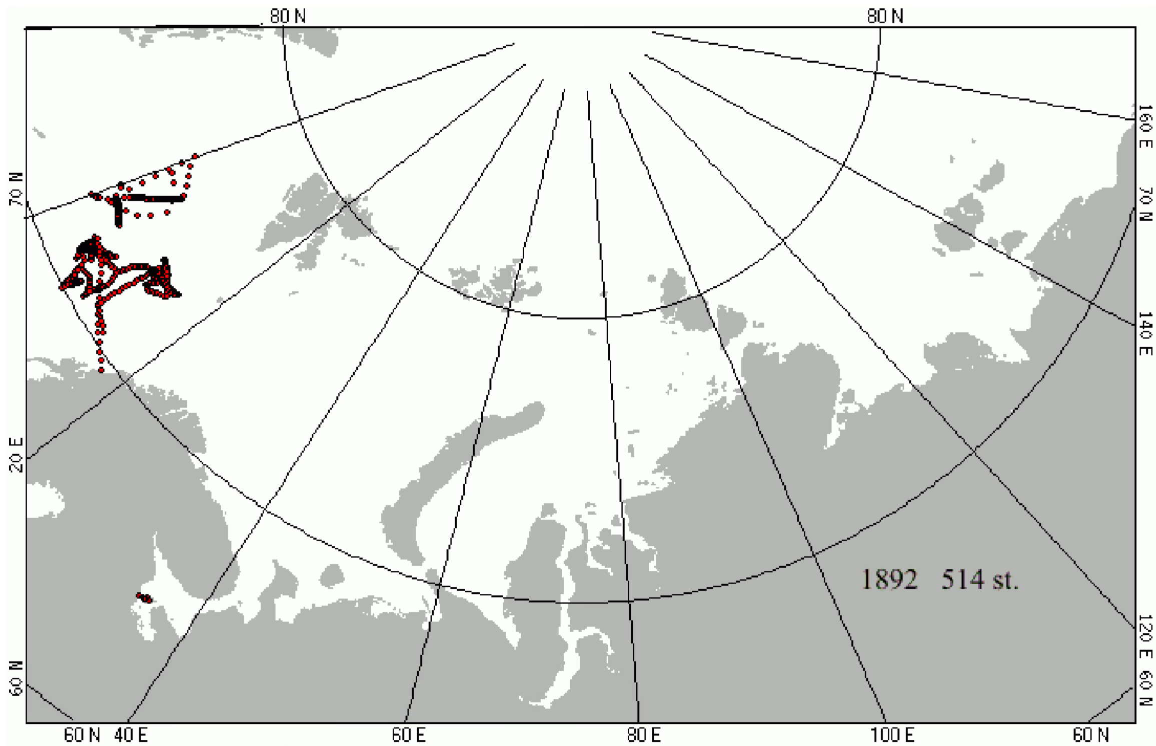
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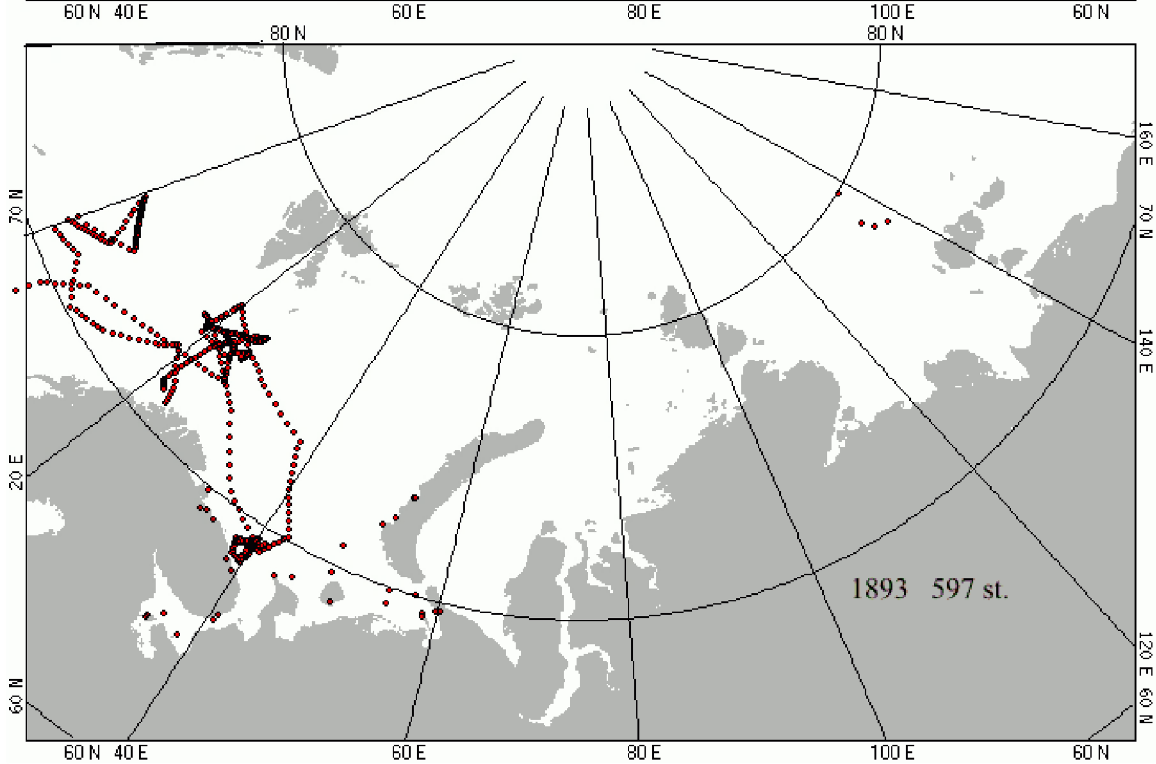
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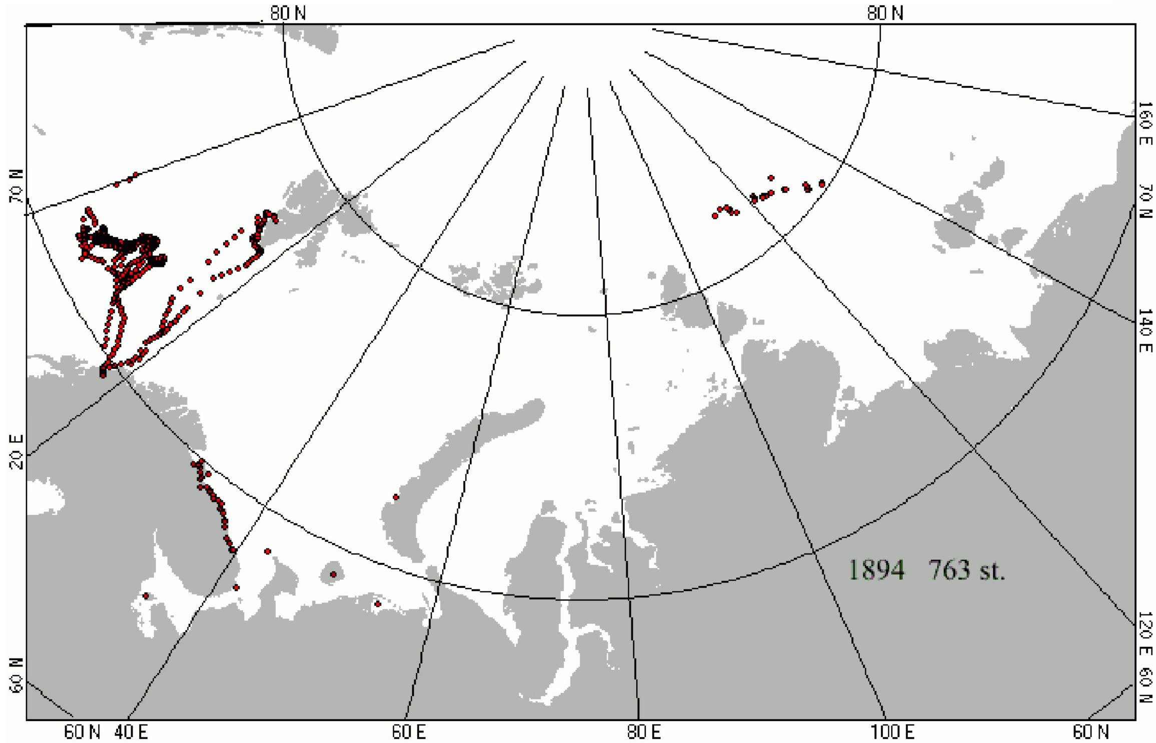
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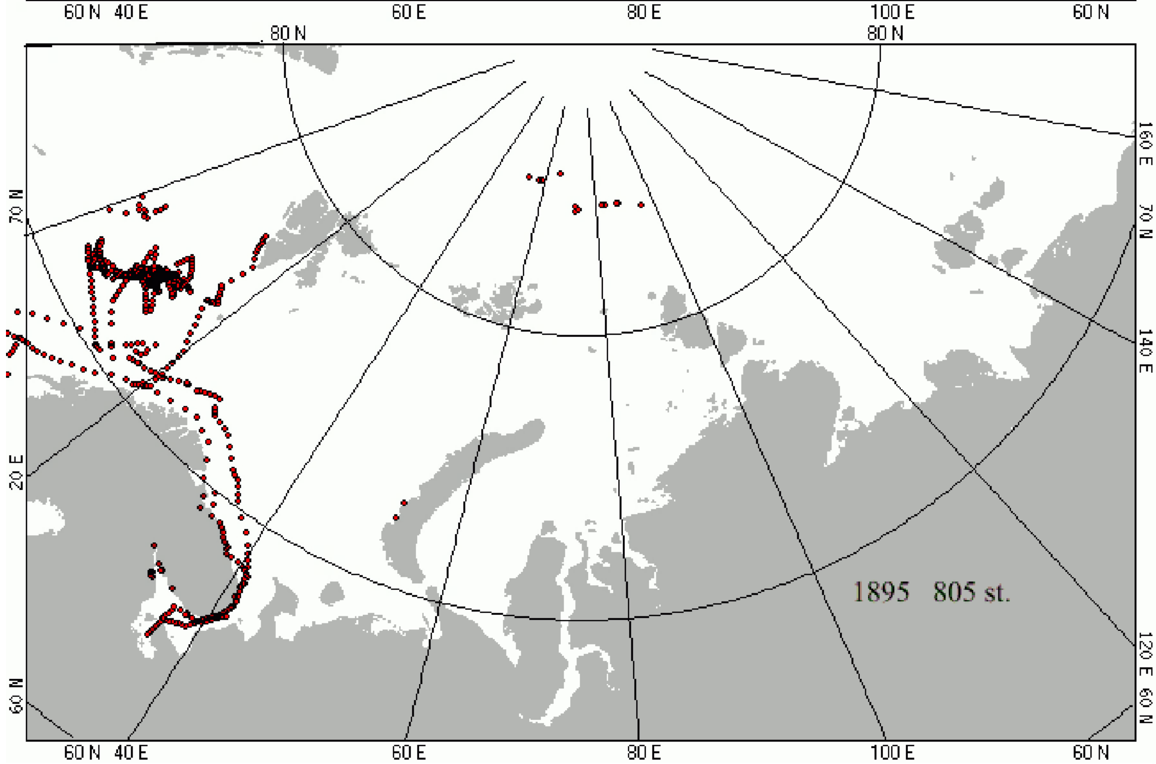
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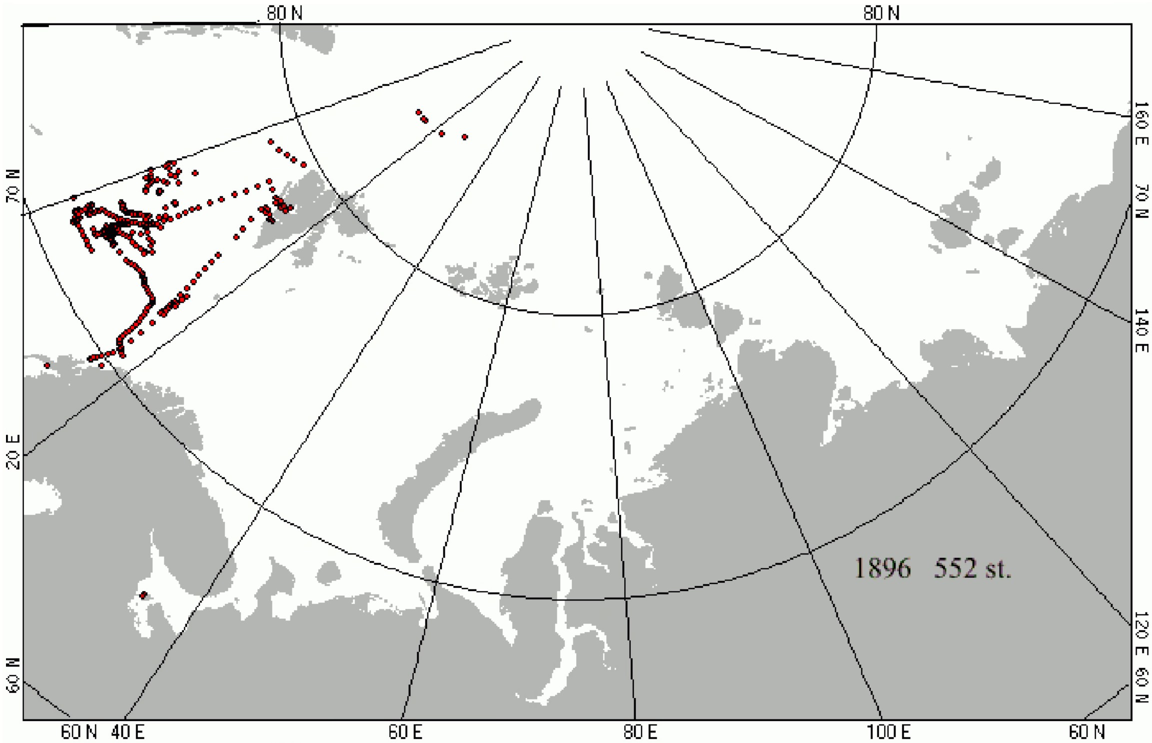
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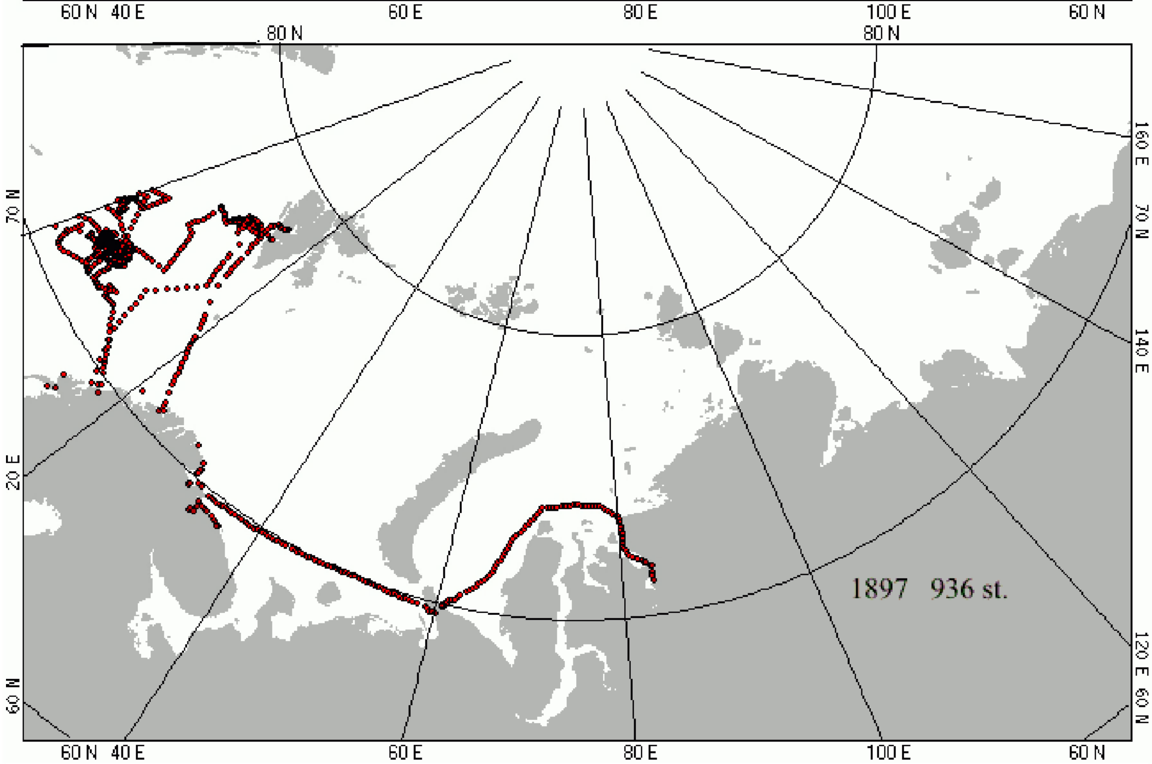
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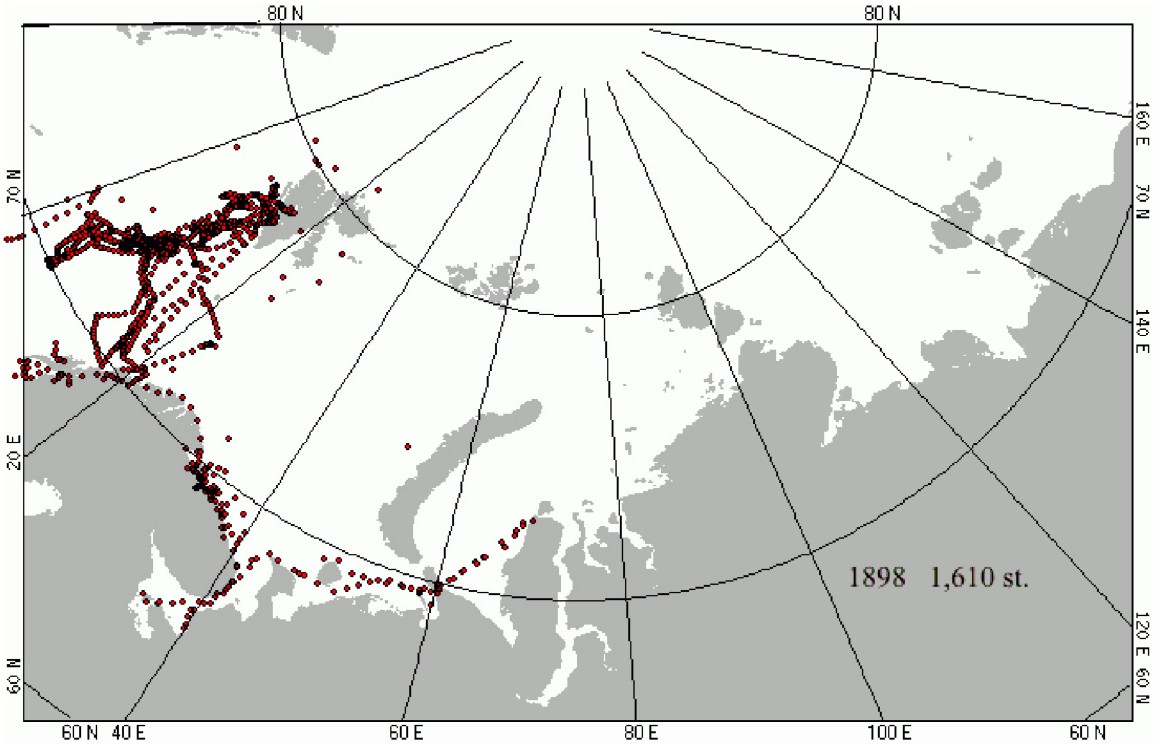
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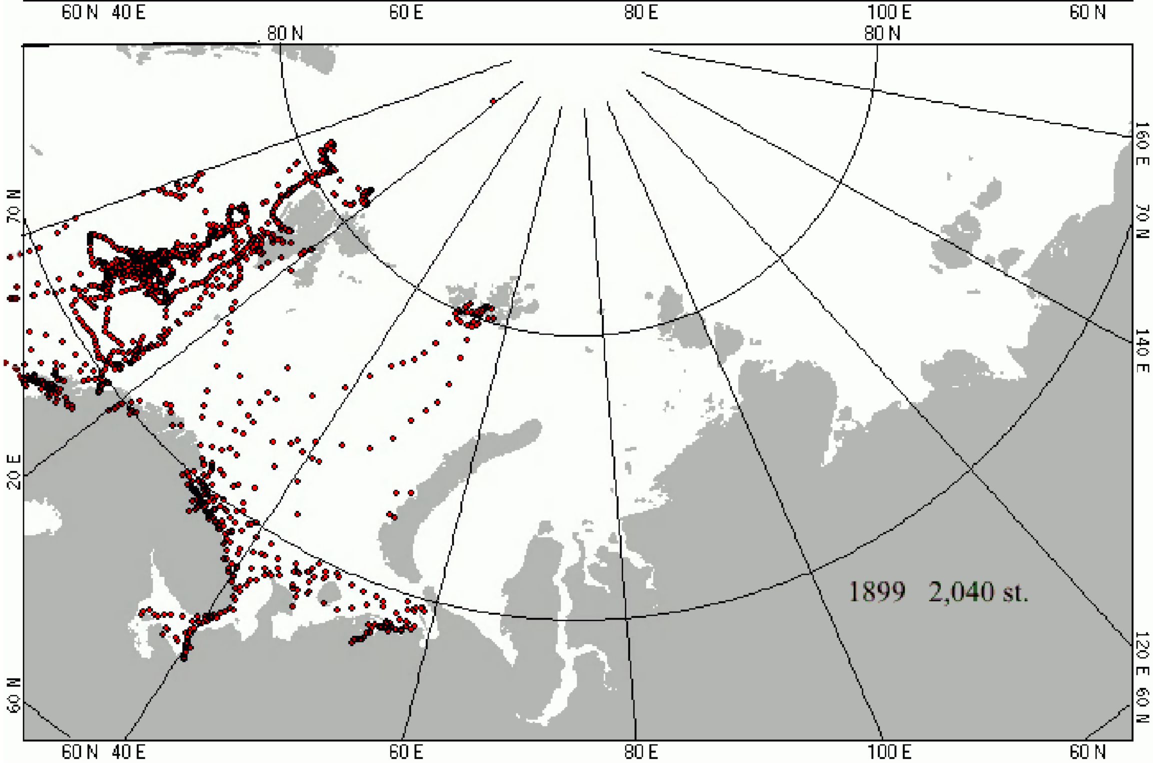
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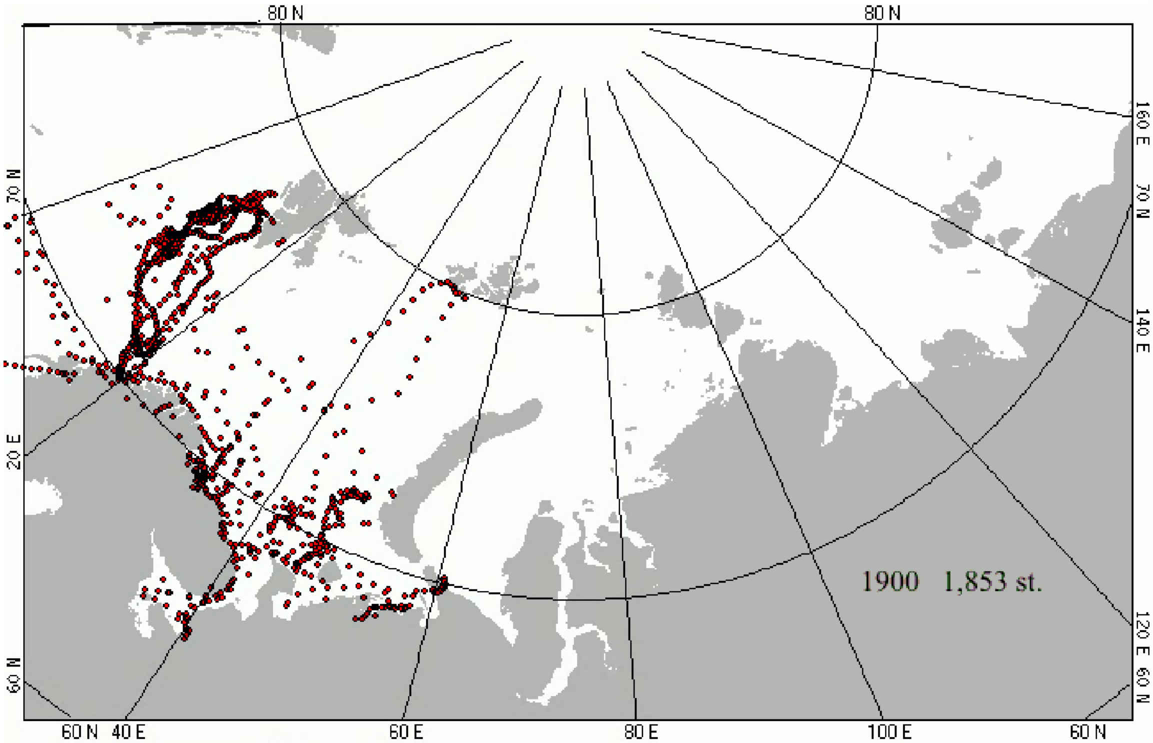
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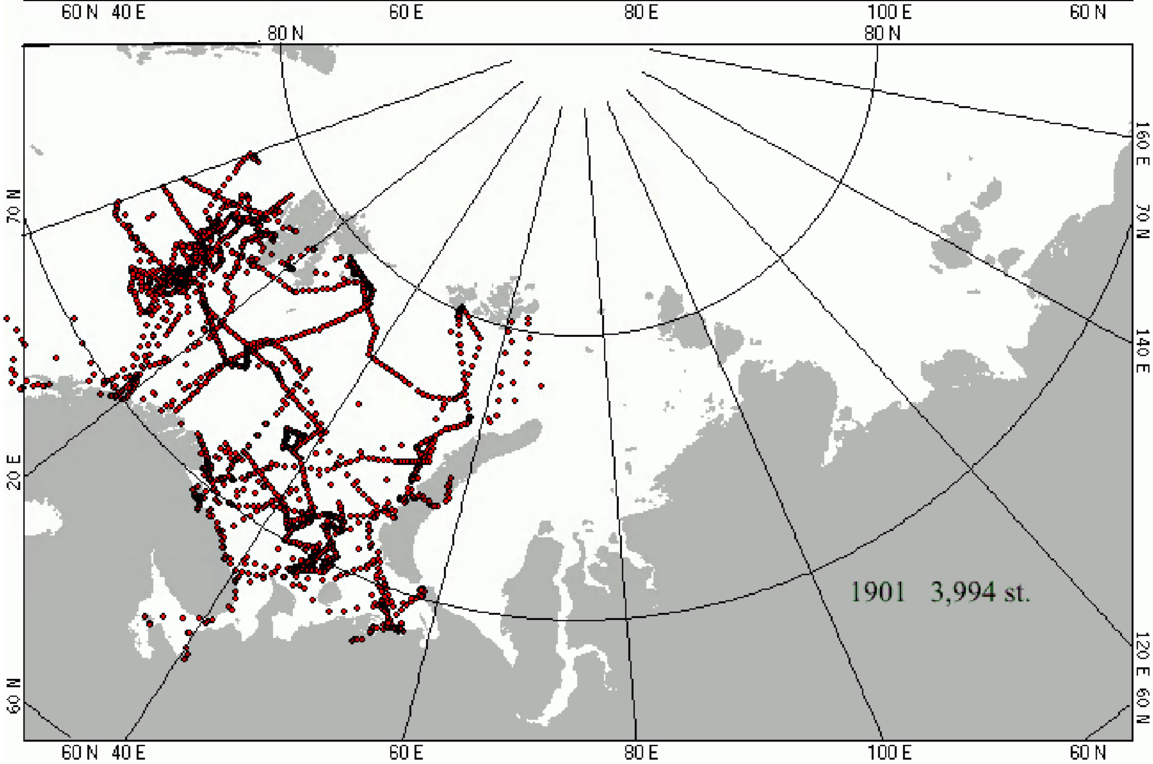
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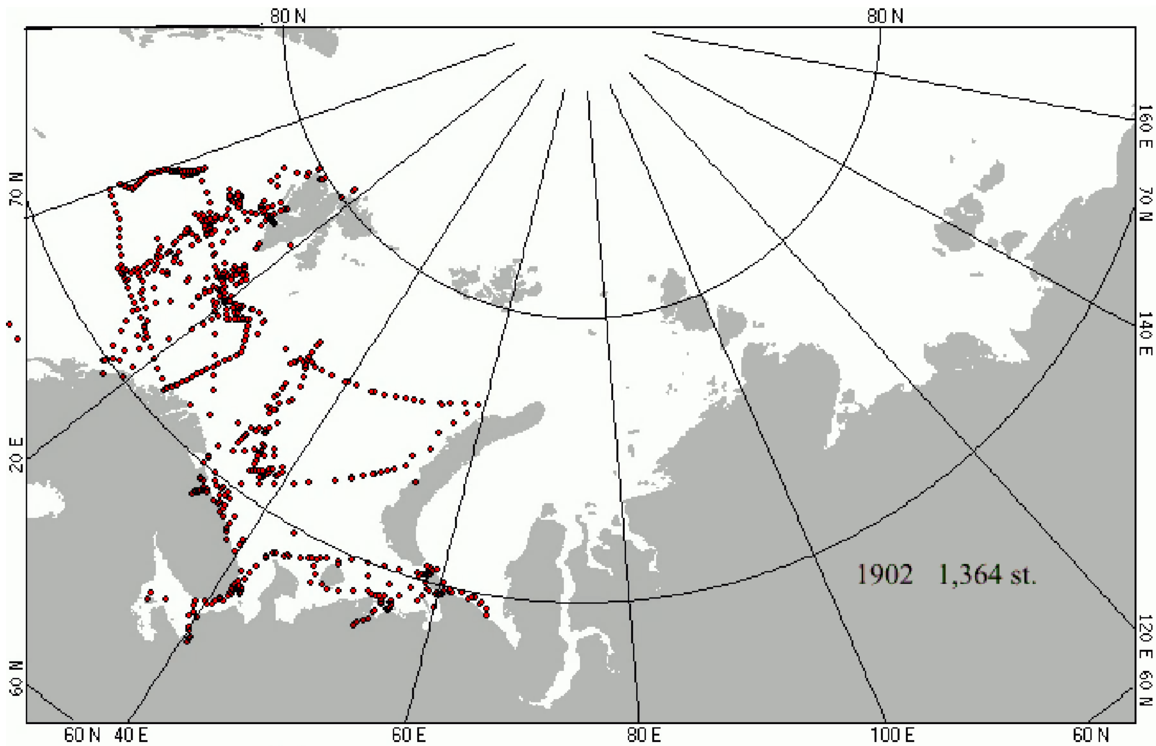

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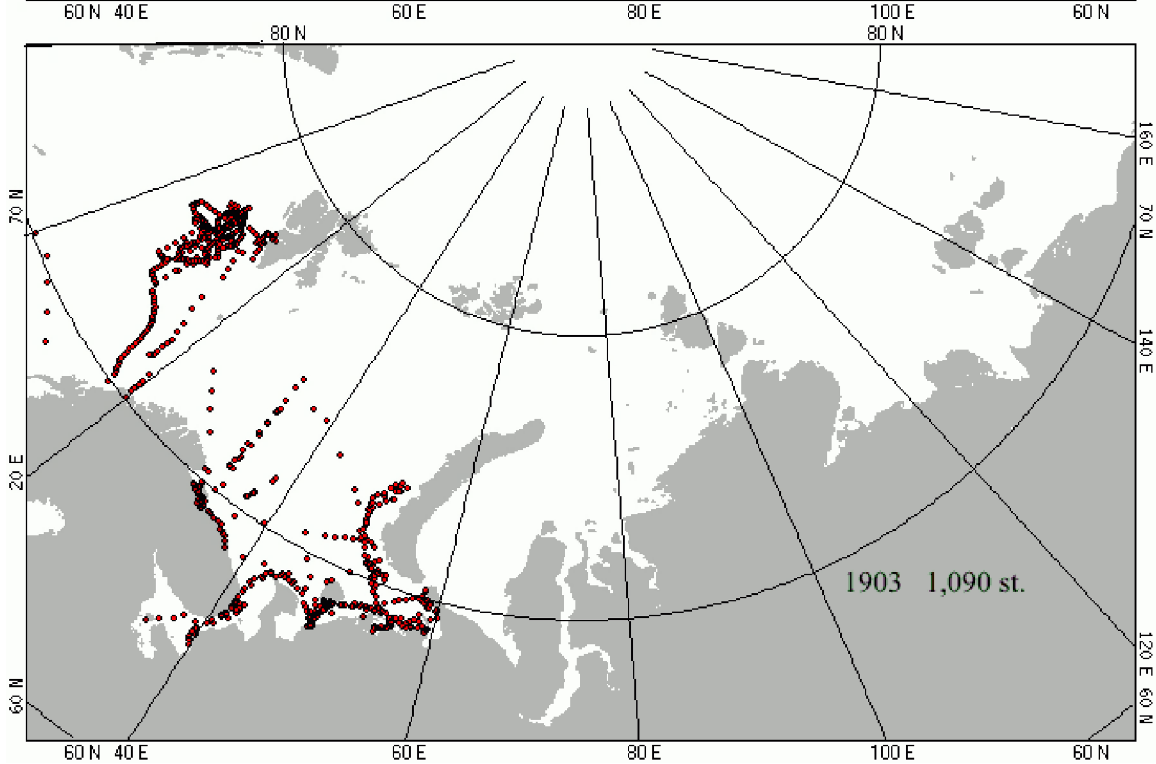

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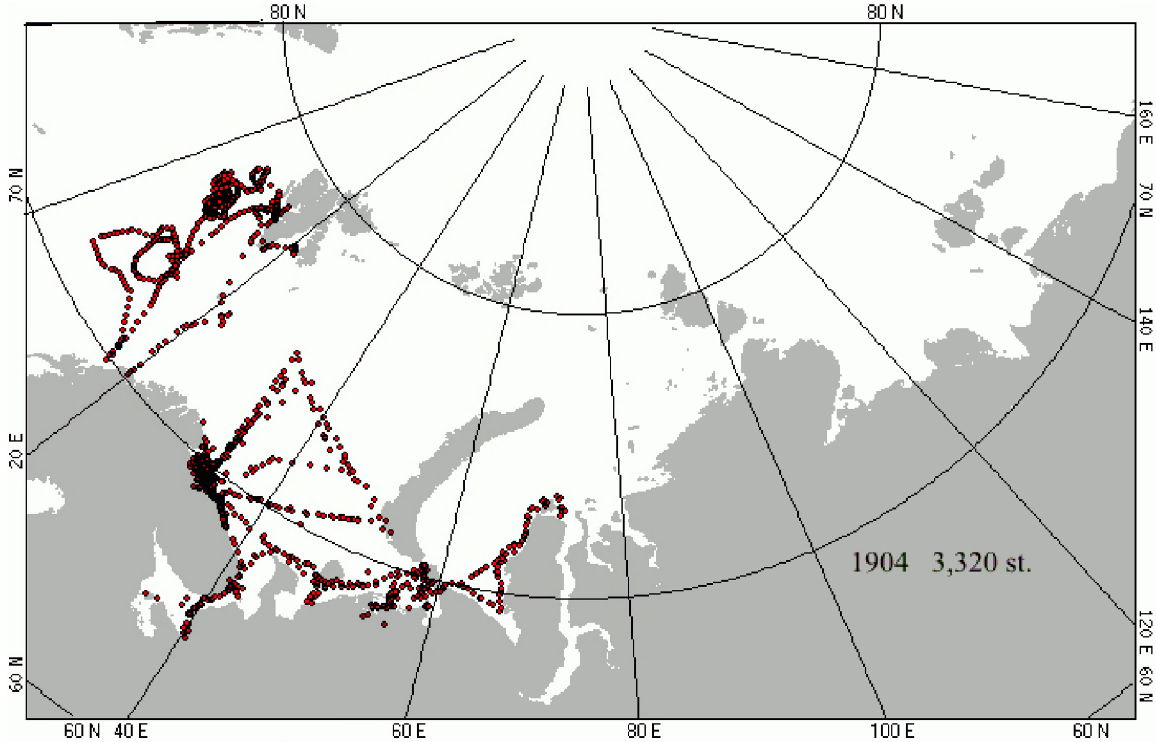
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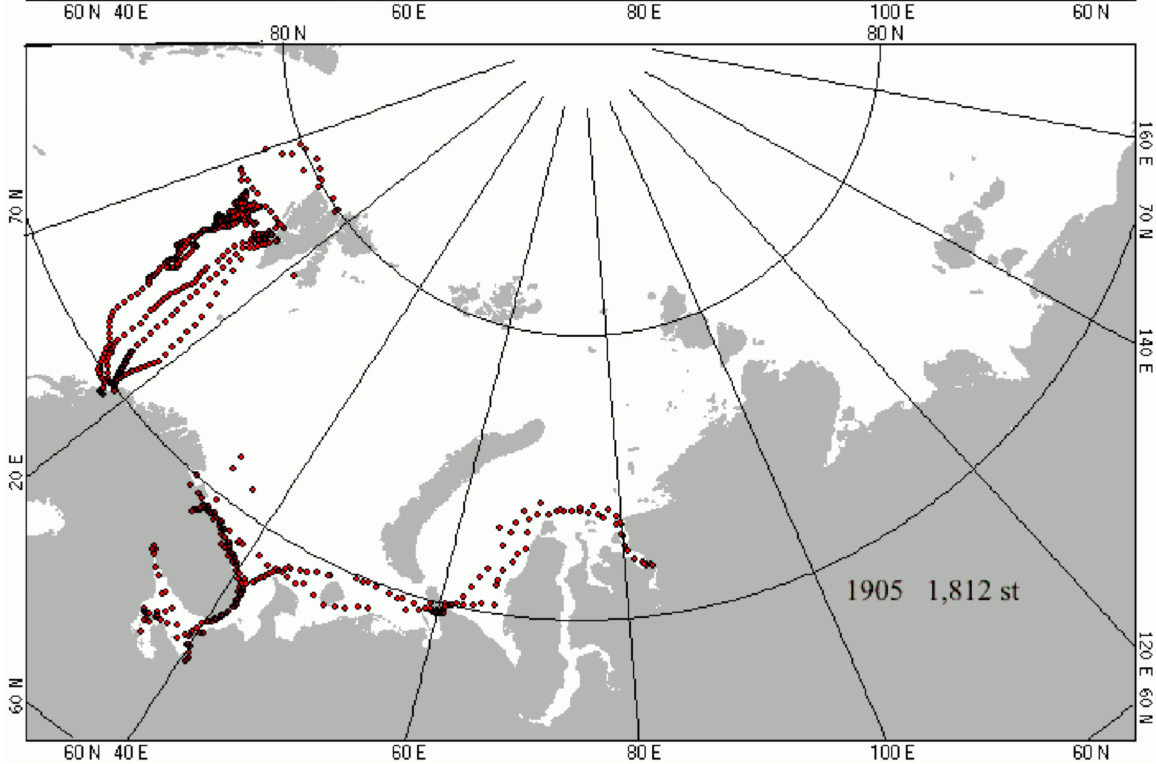
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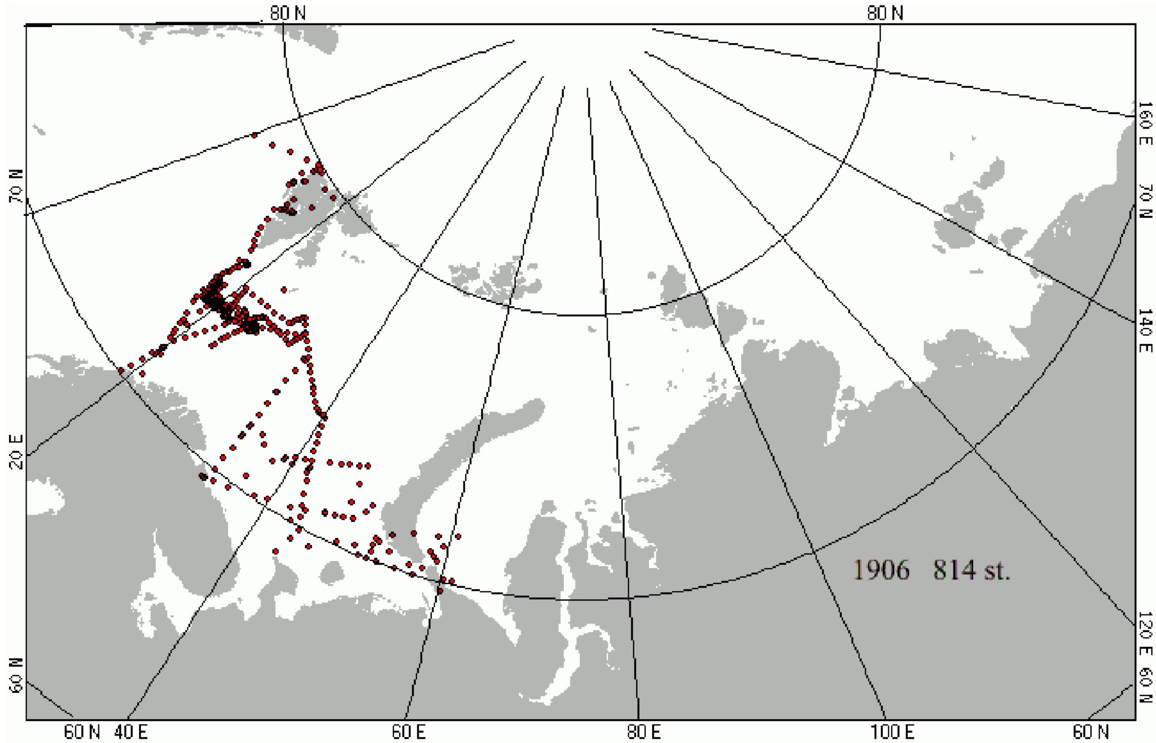
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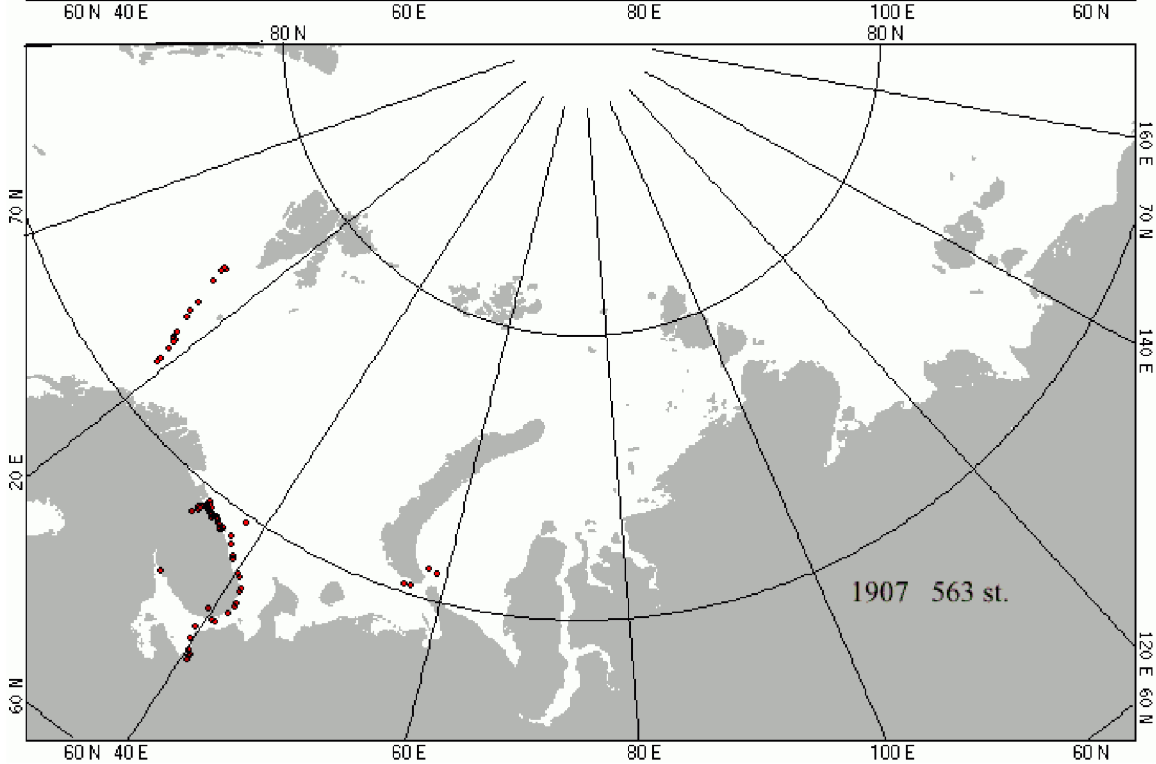
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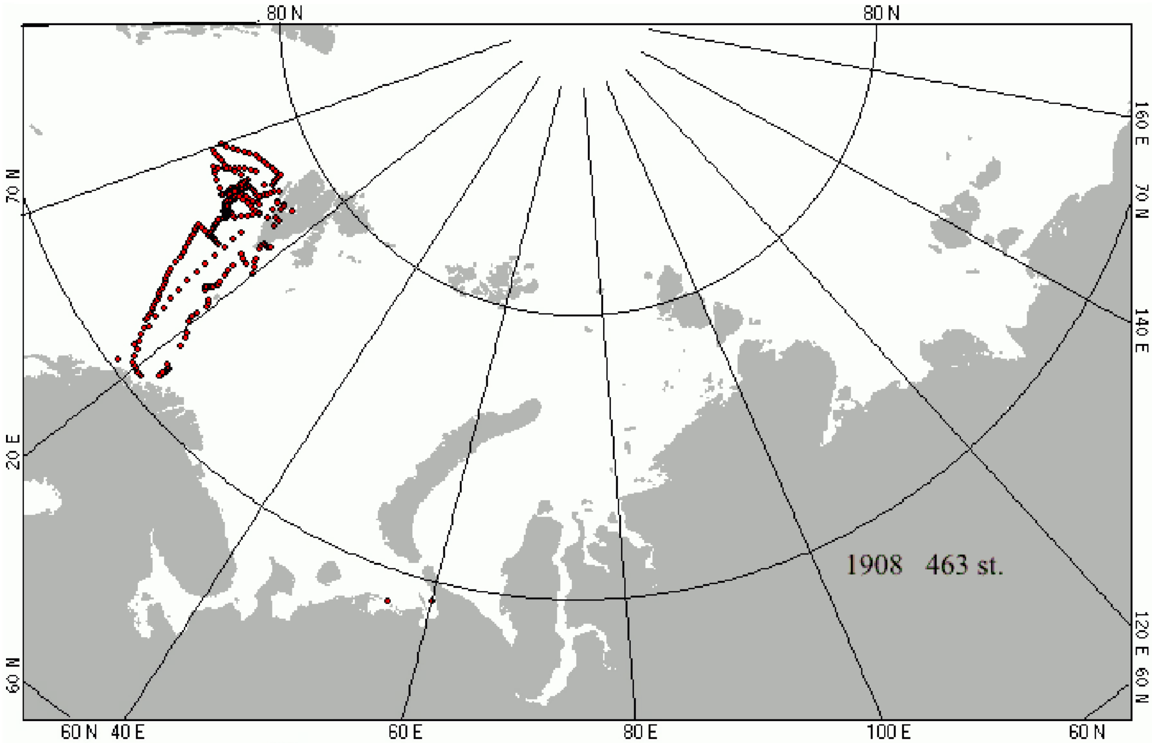
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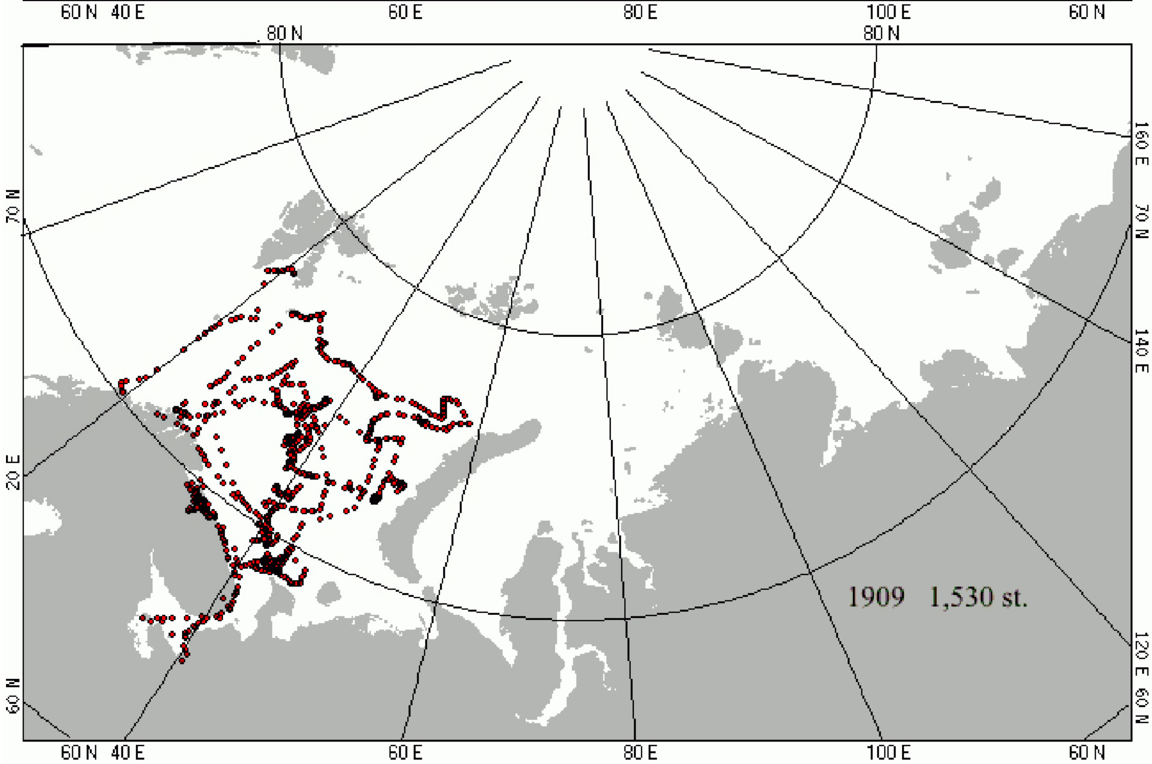
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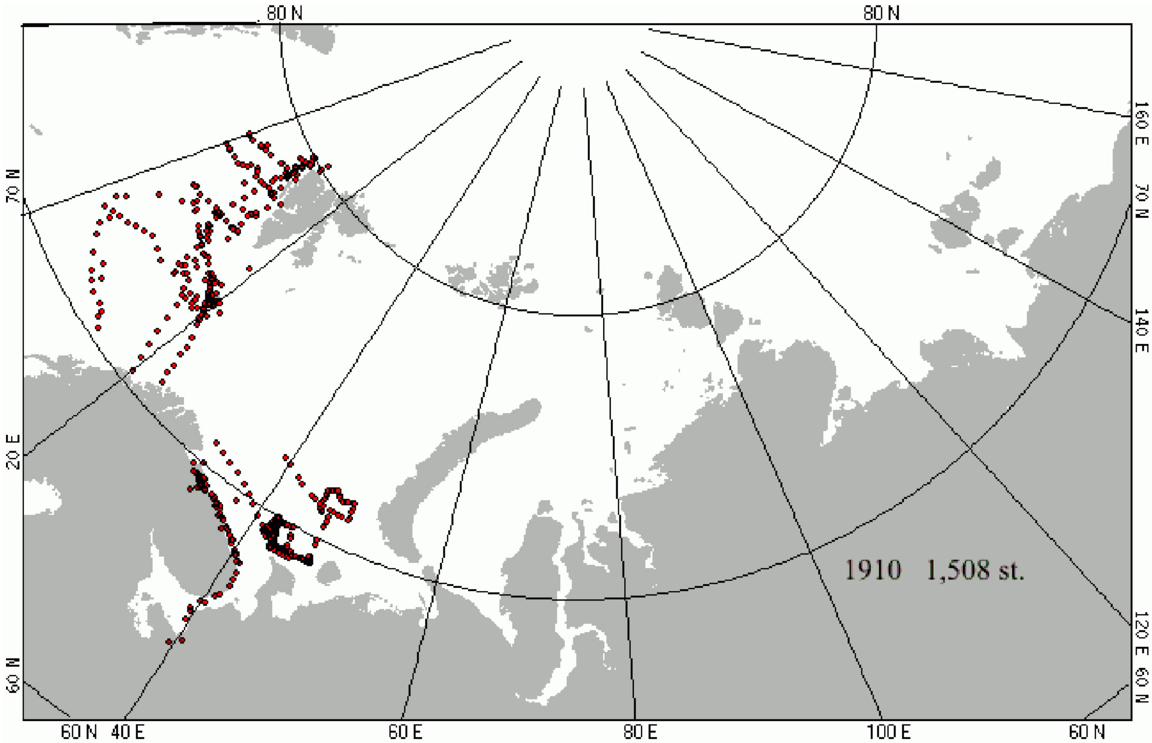
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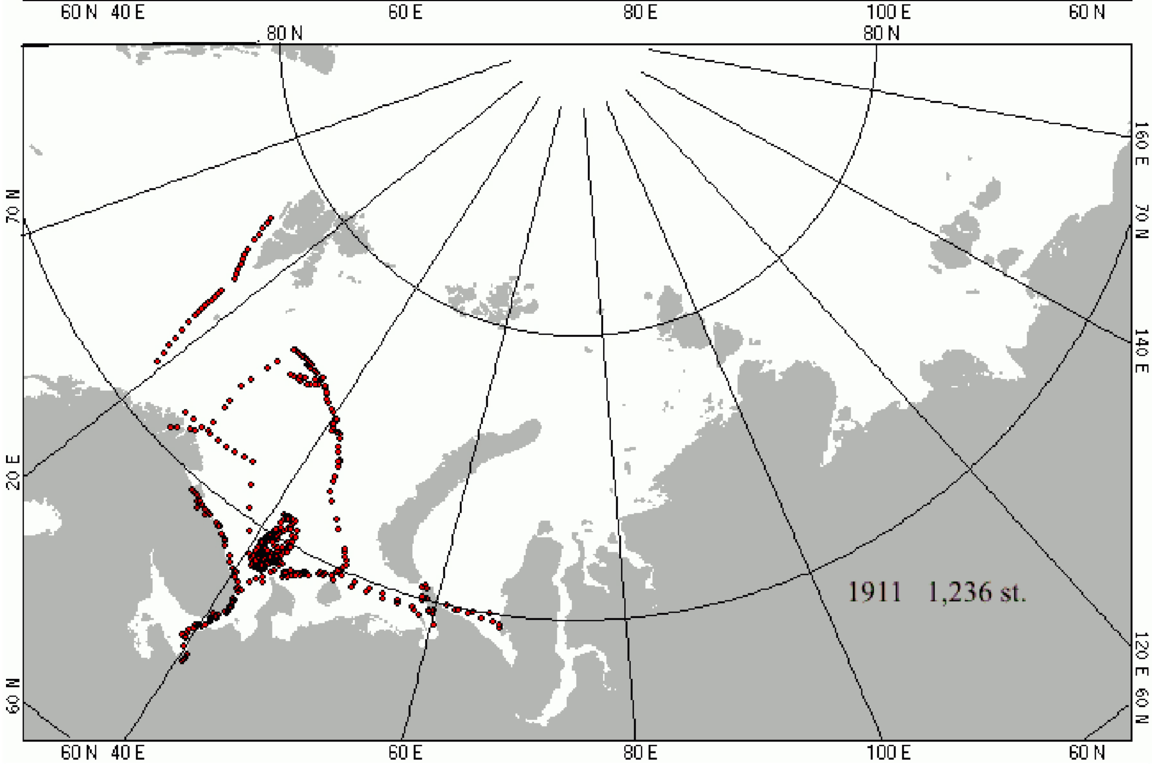
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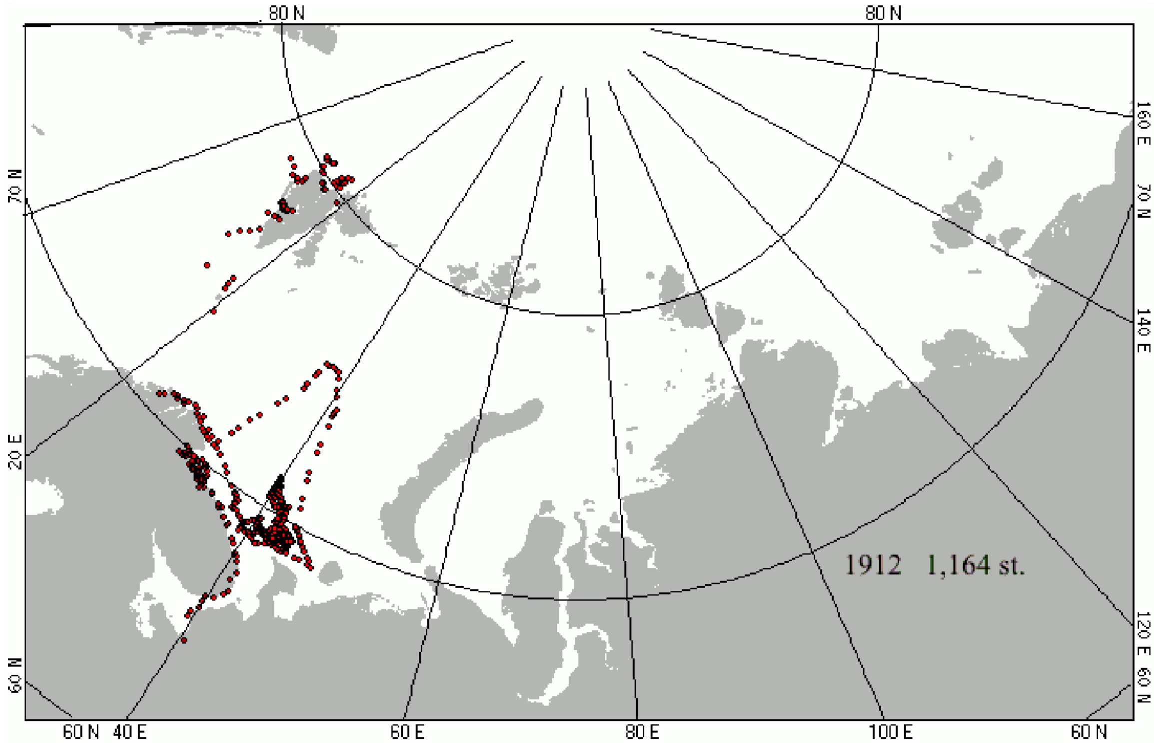
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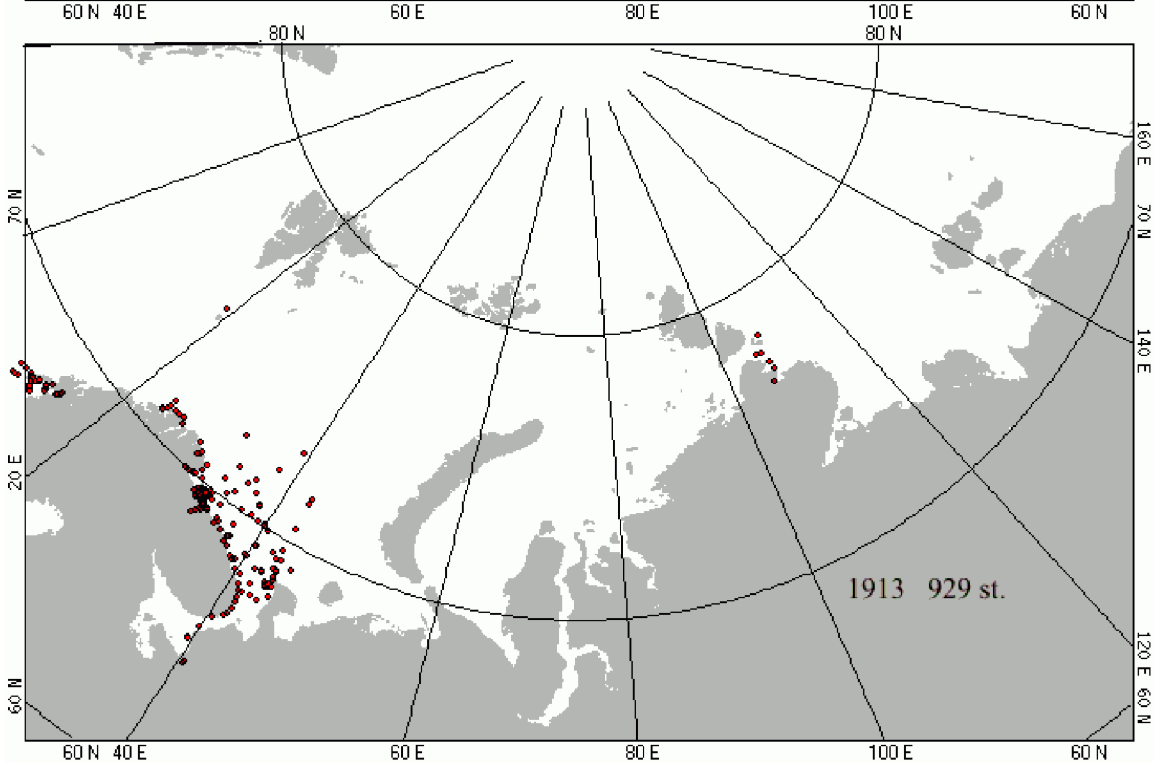
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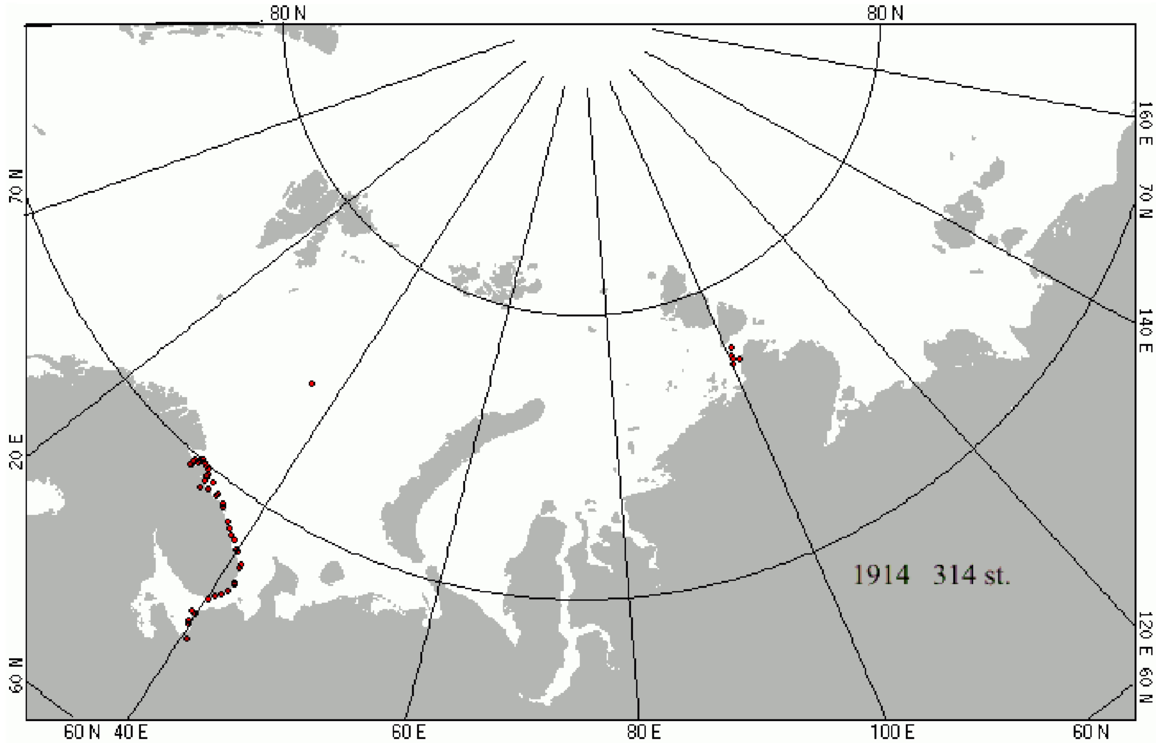
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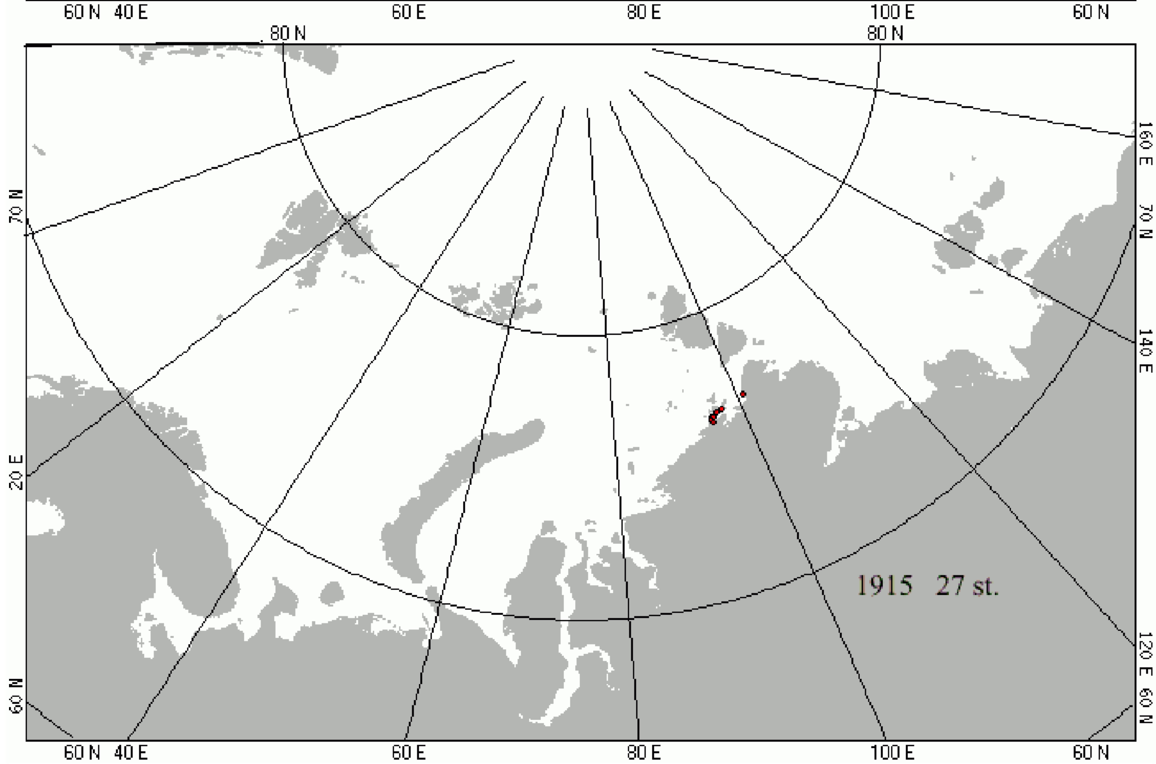
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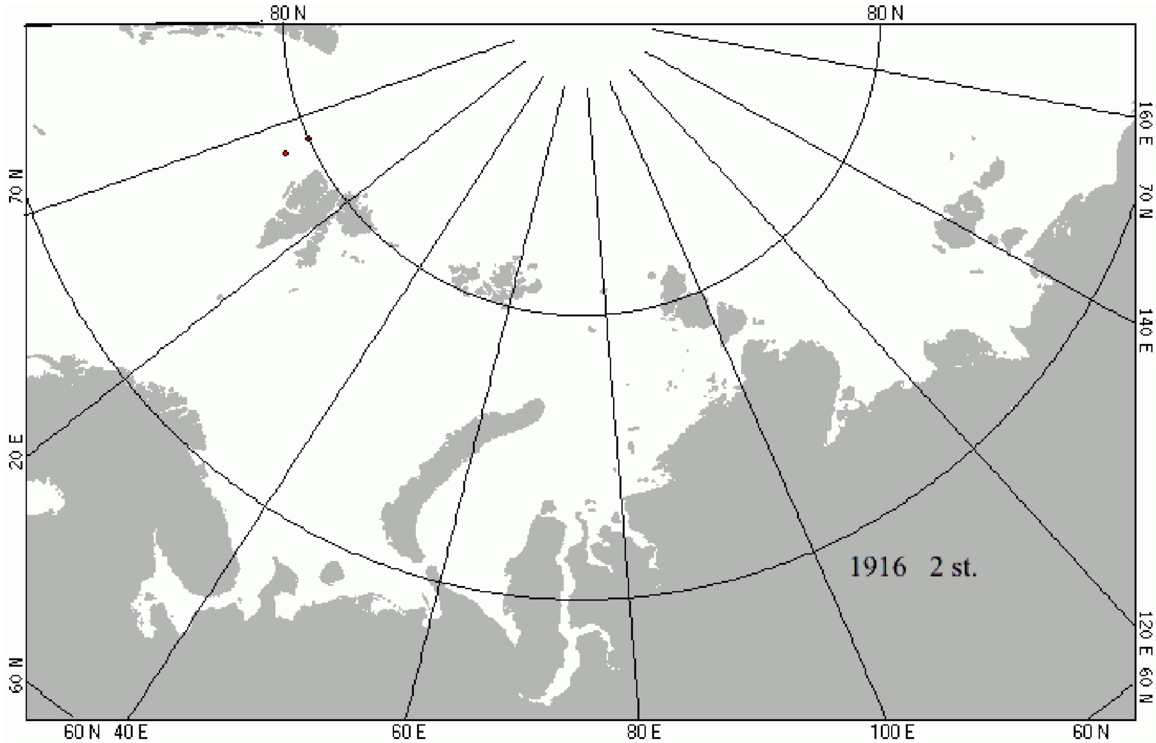
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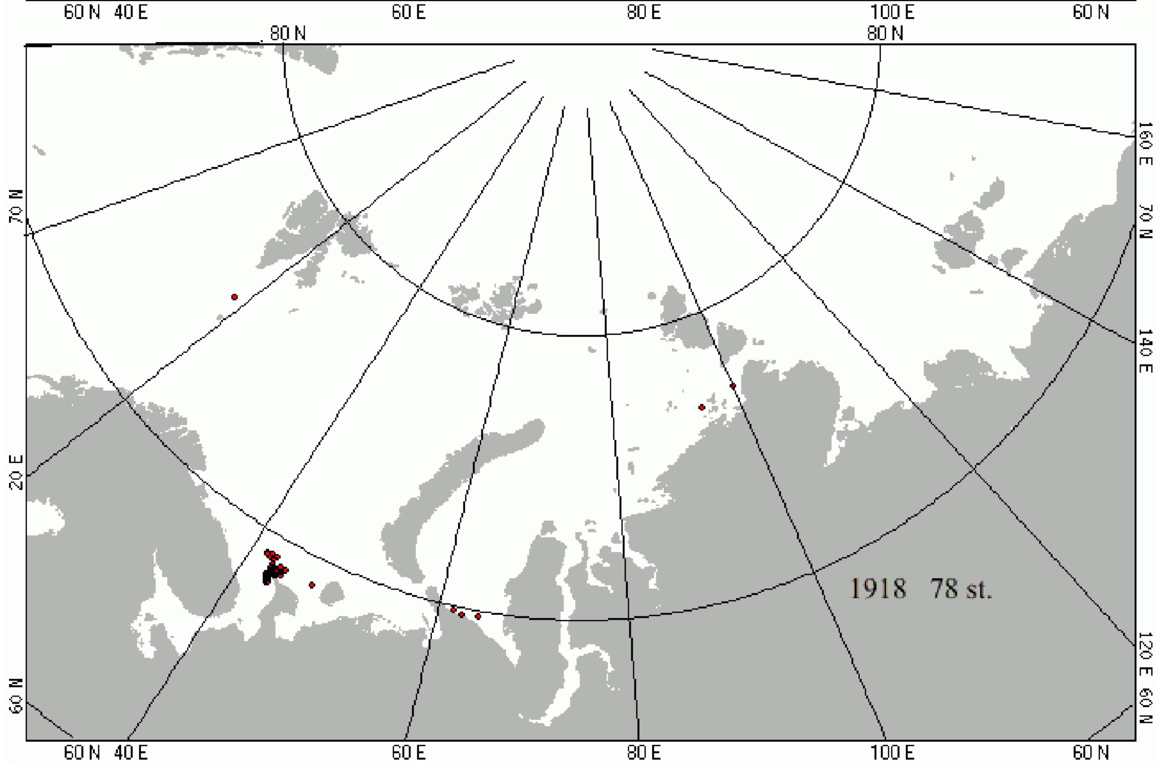
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60 N
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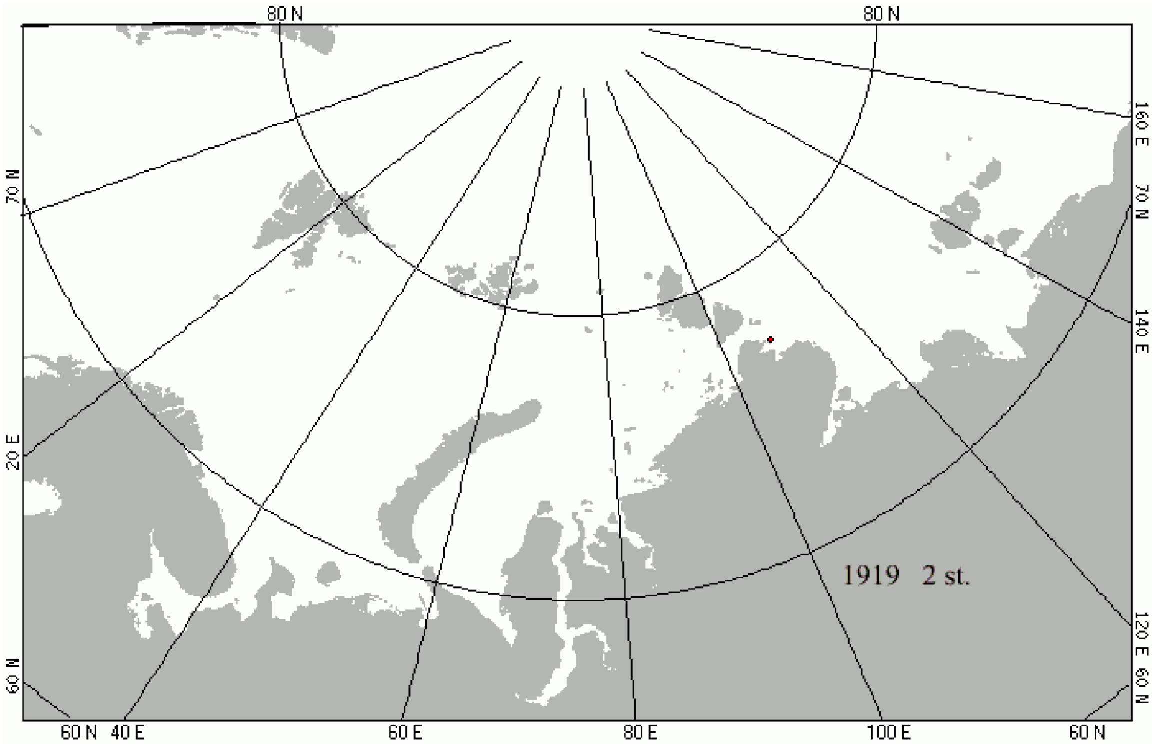
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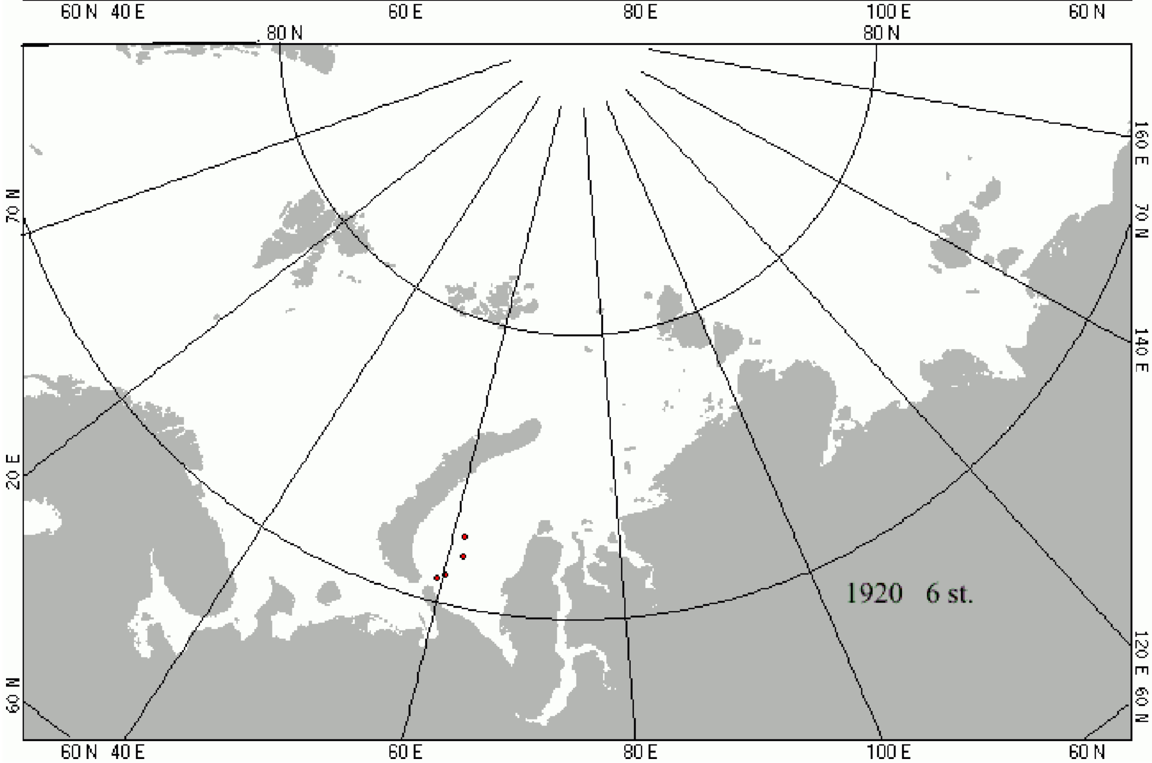
60 N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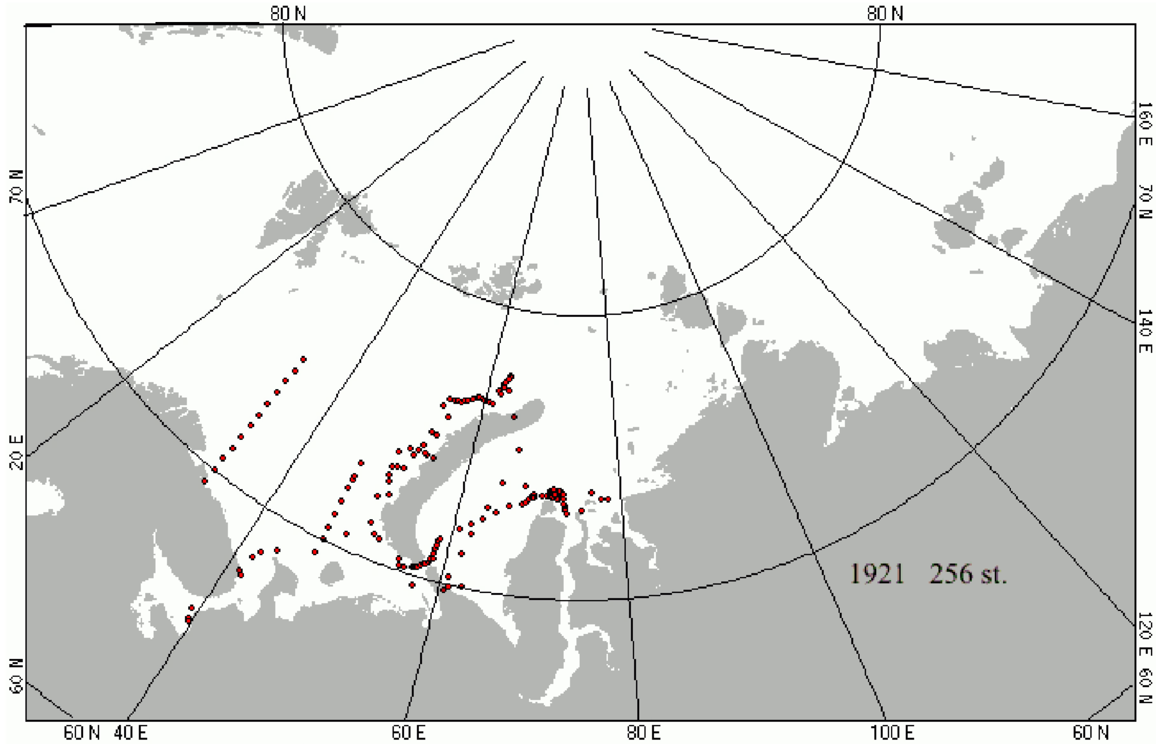
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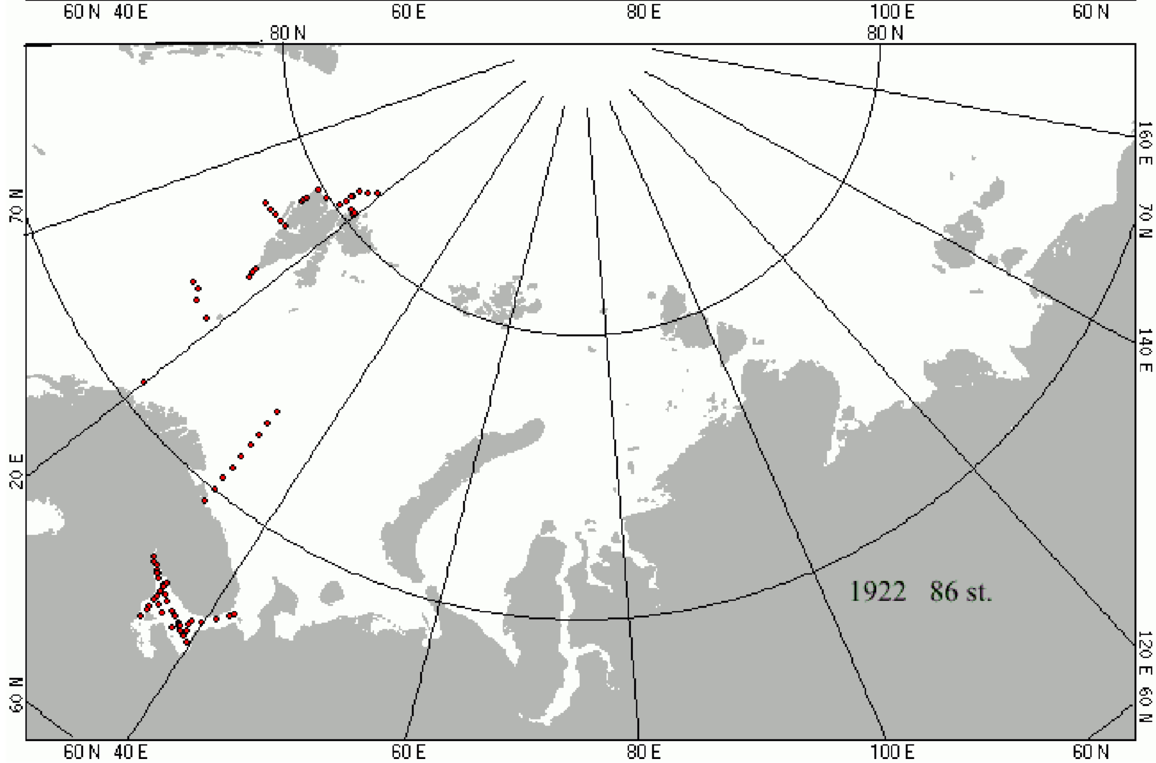
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1922 86 st.
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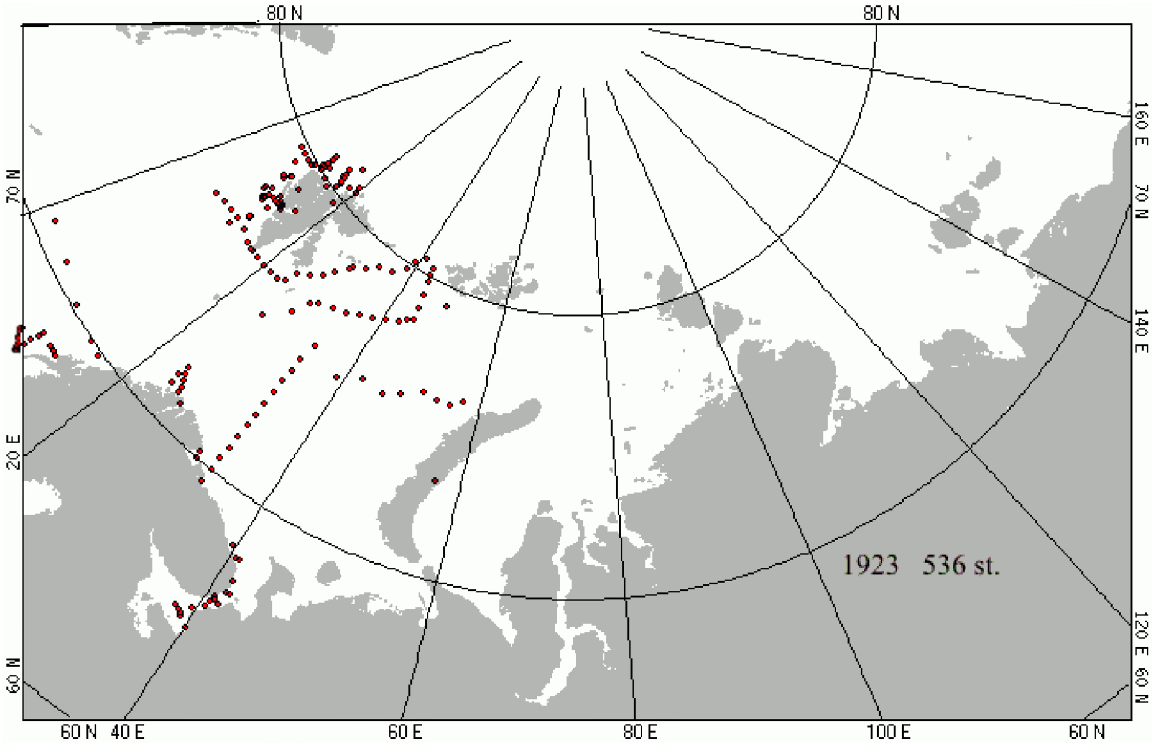
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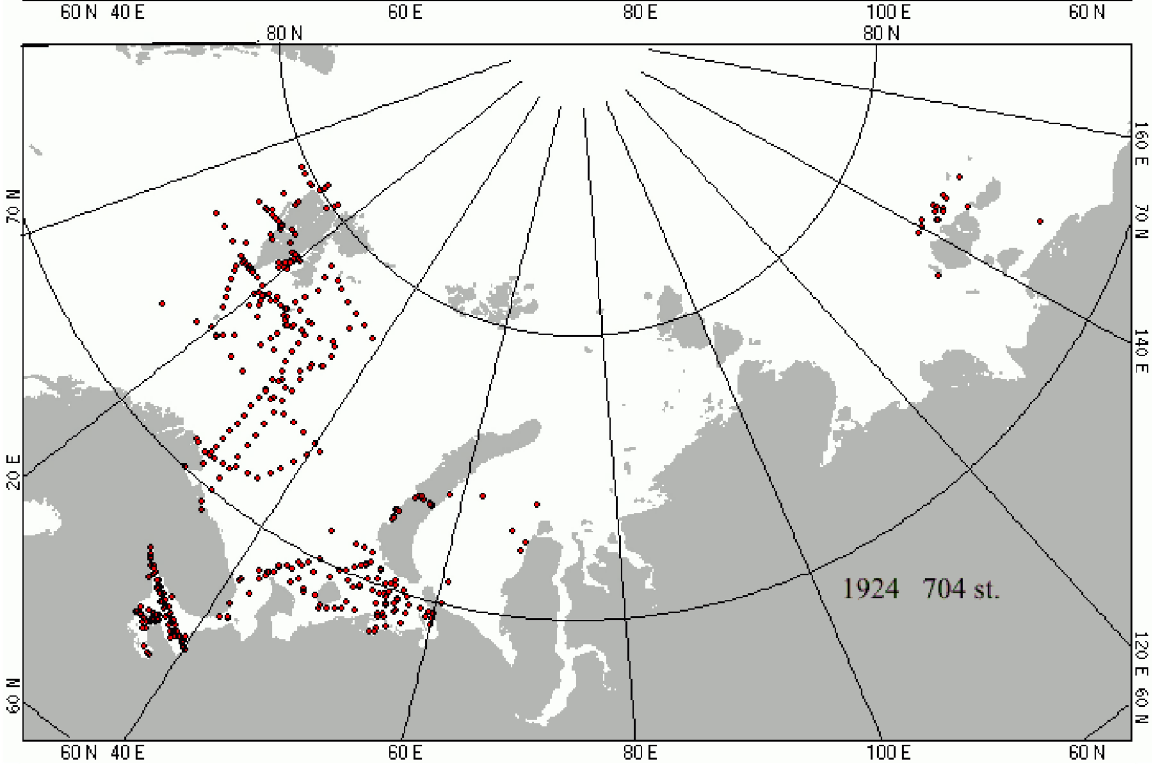
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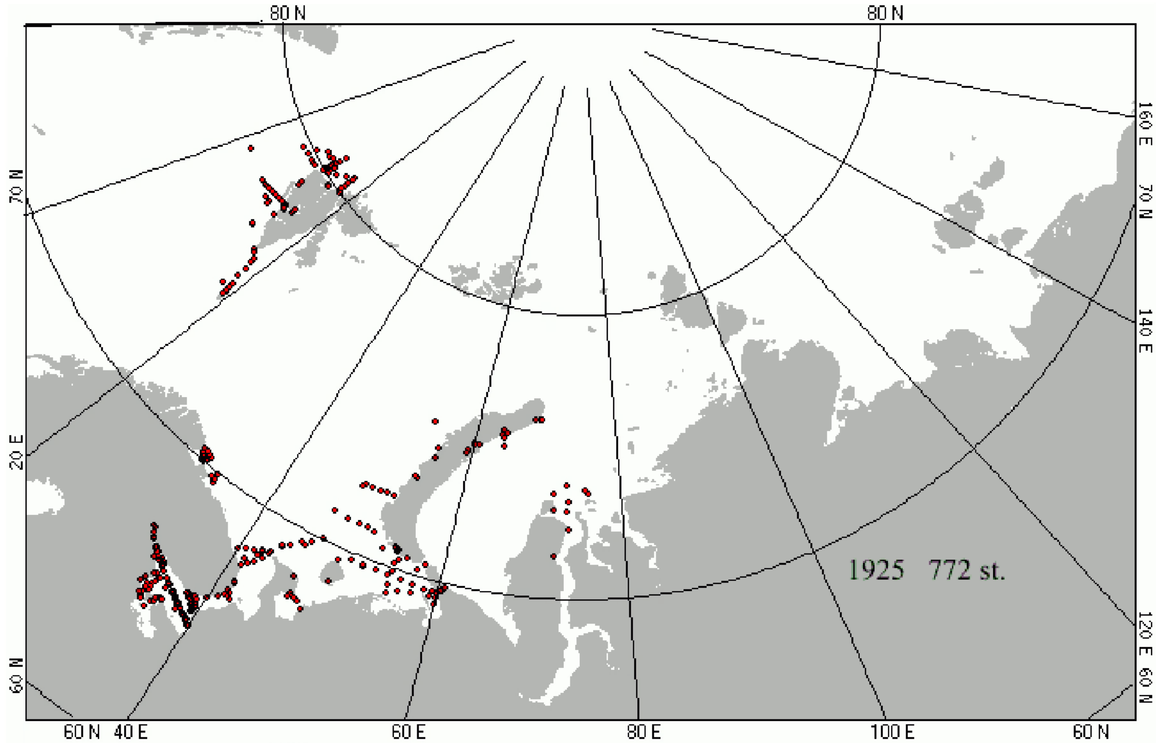
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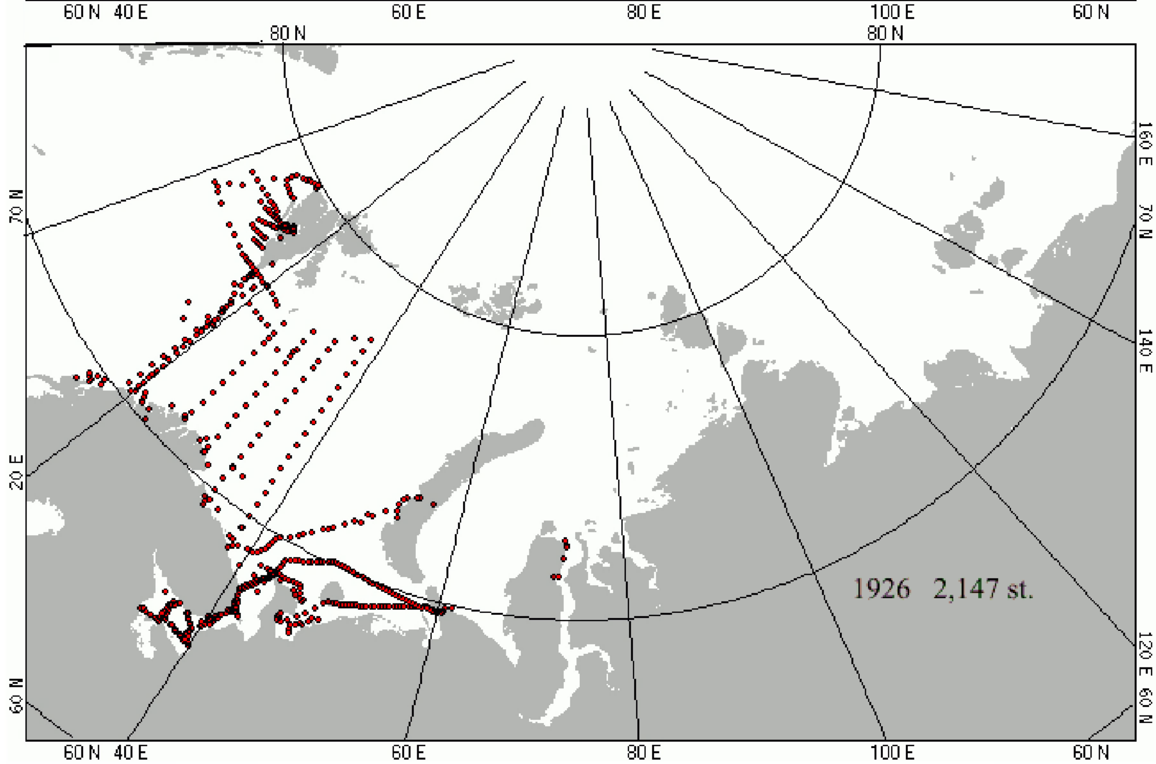
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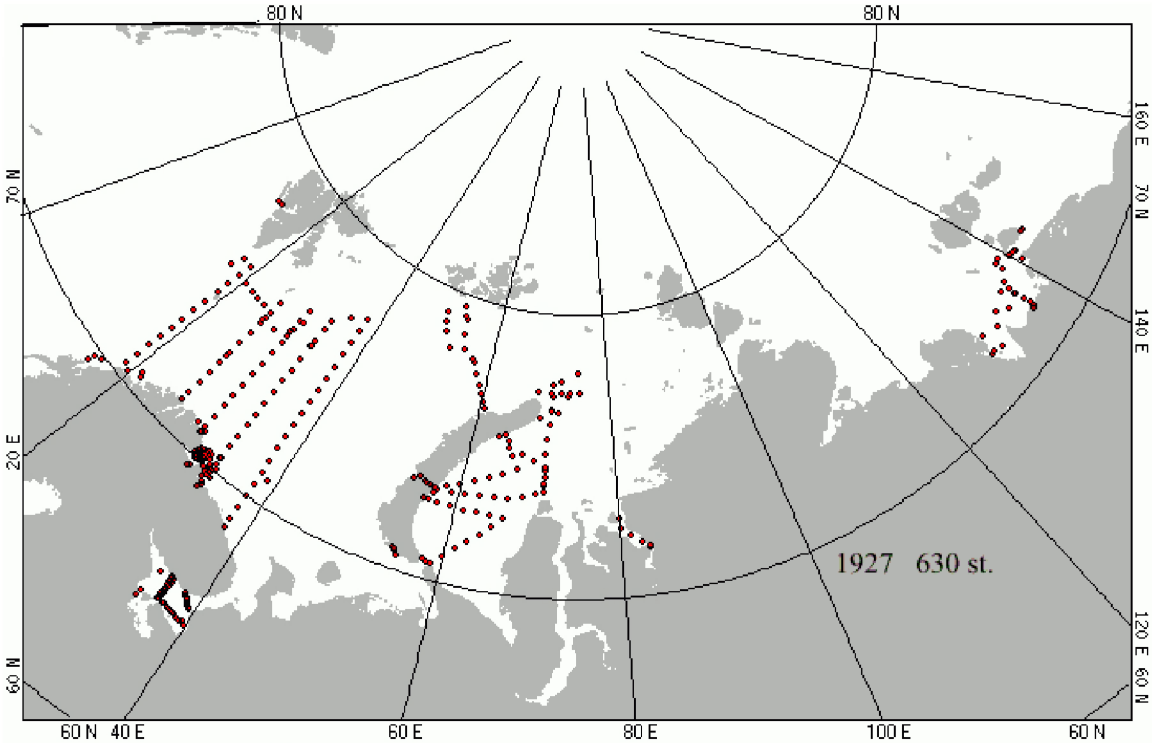

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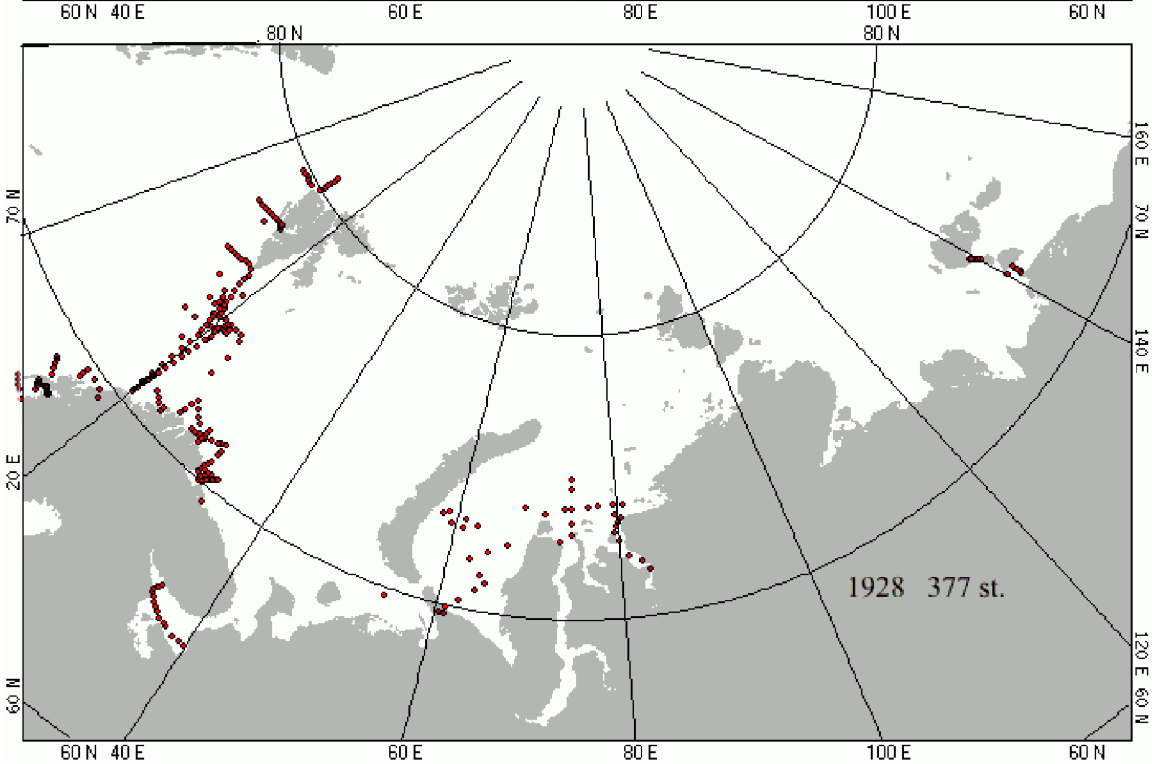

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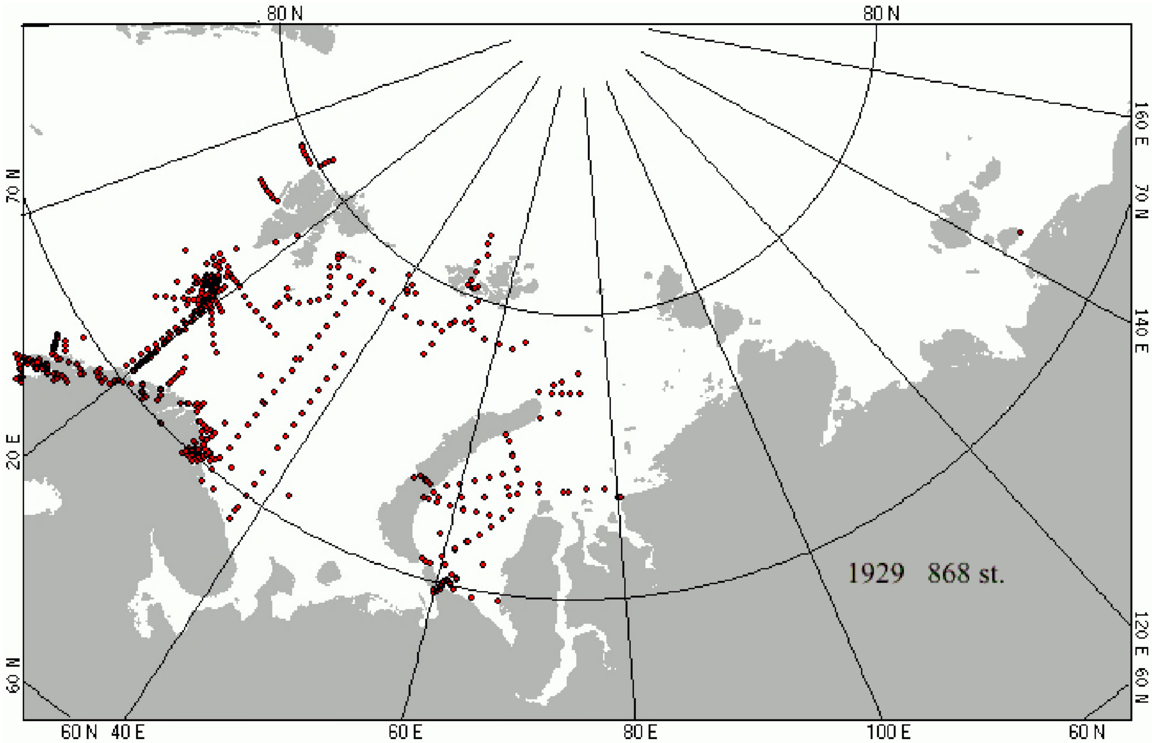
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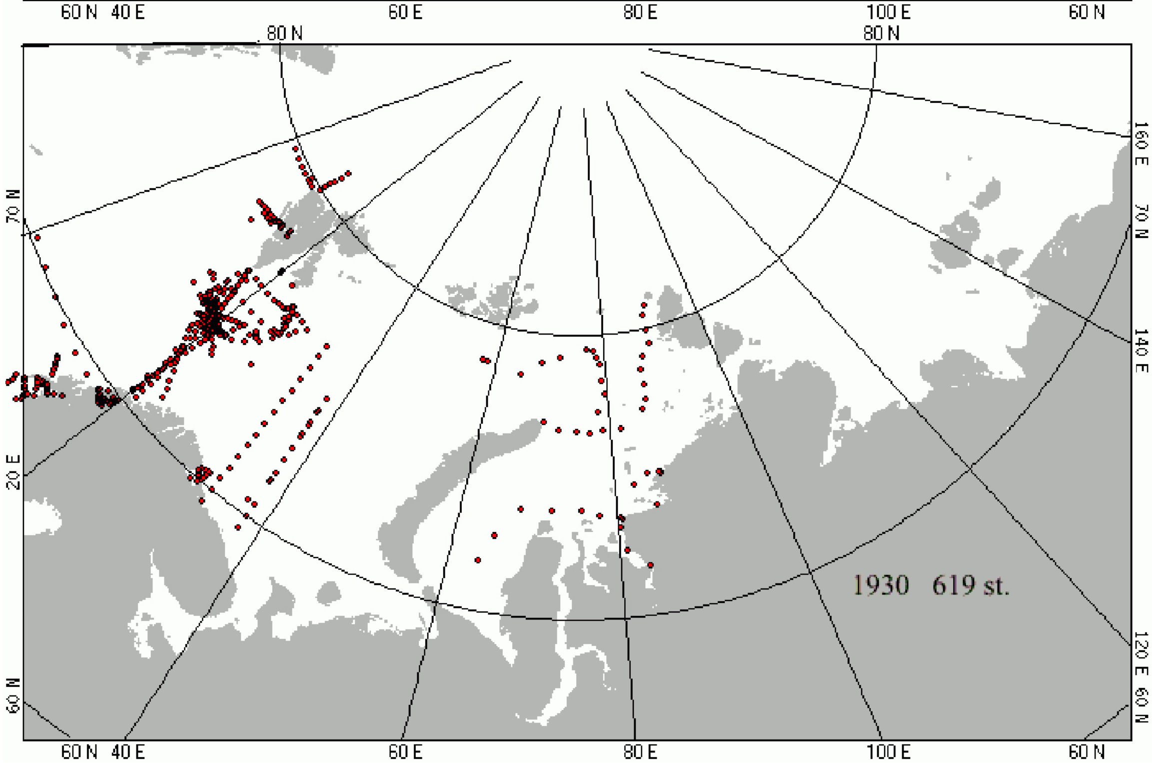
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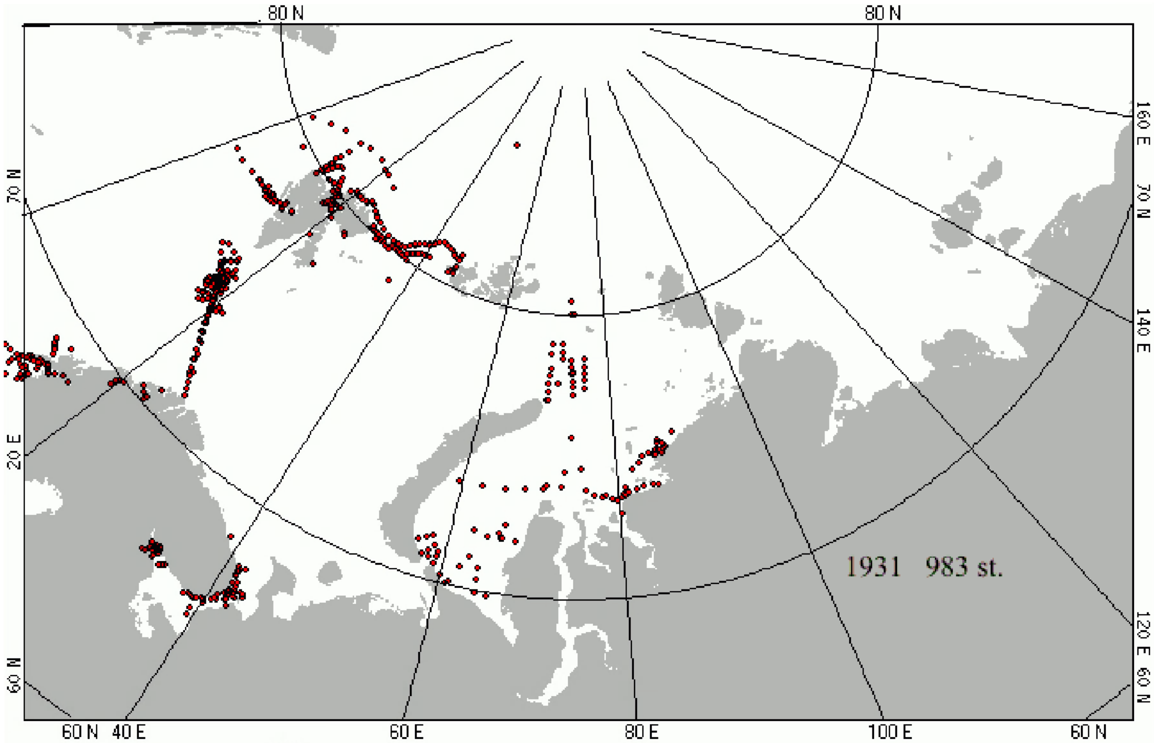
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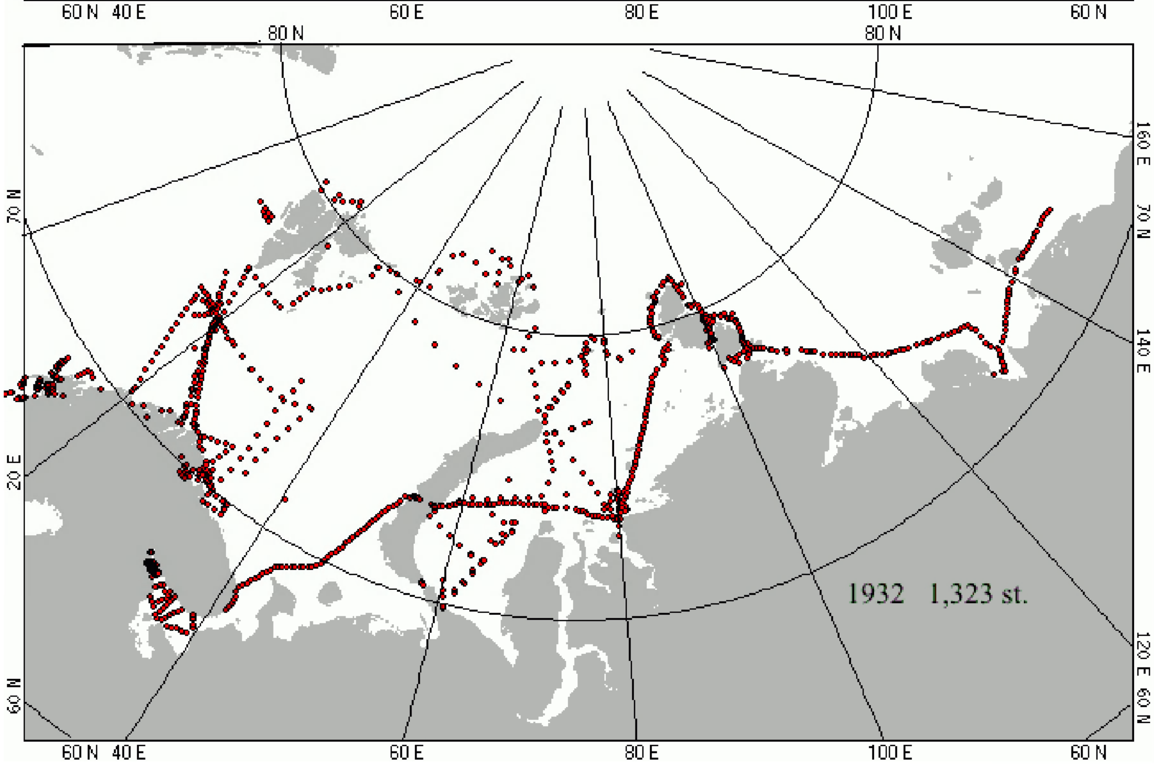
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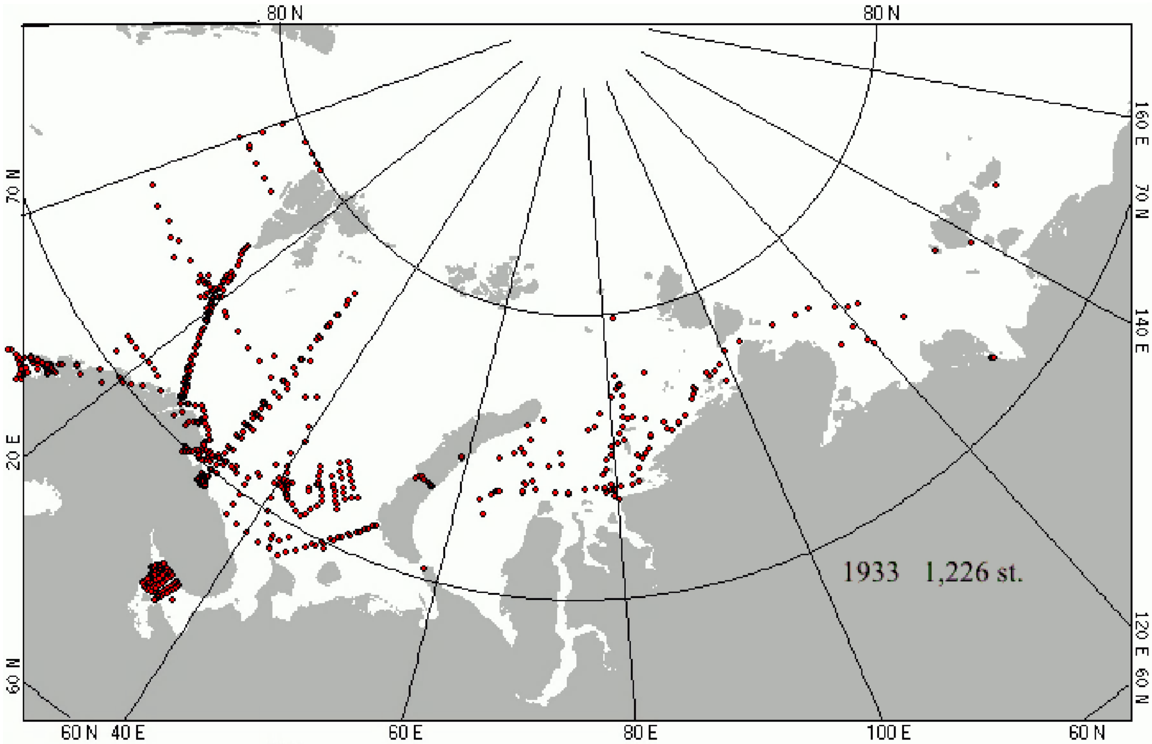
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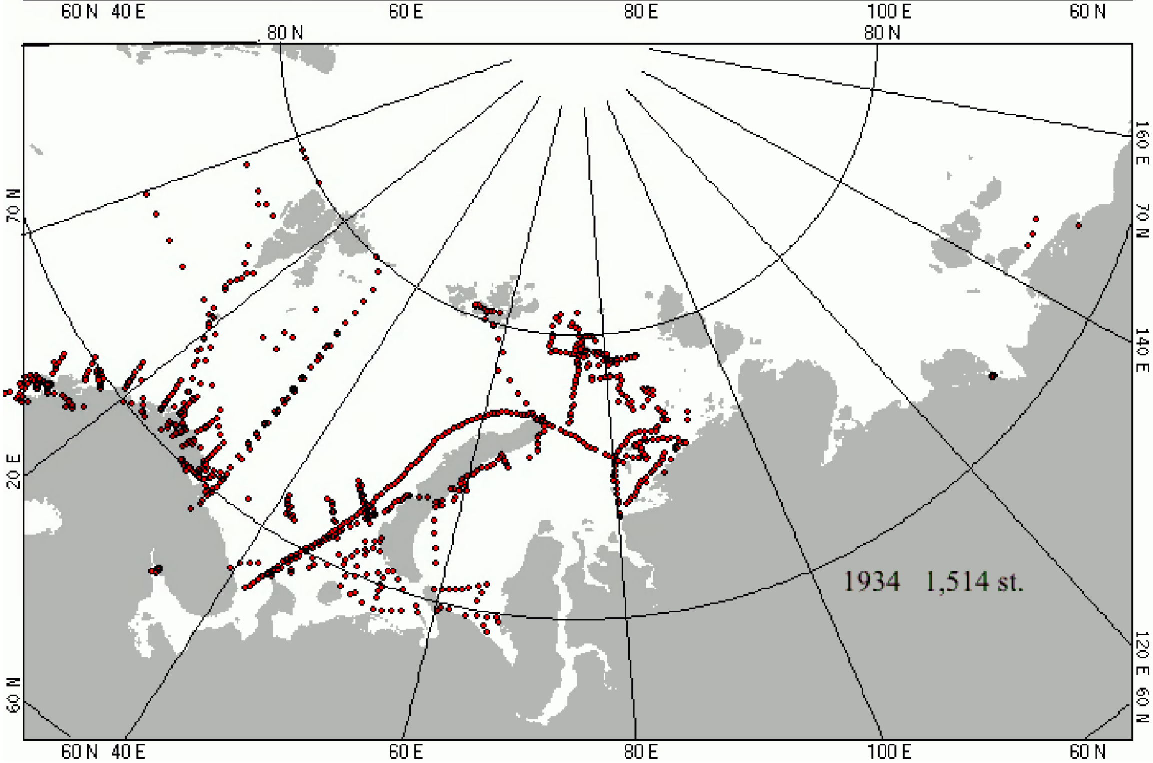
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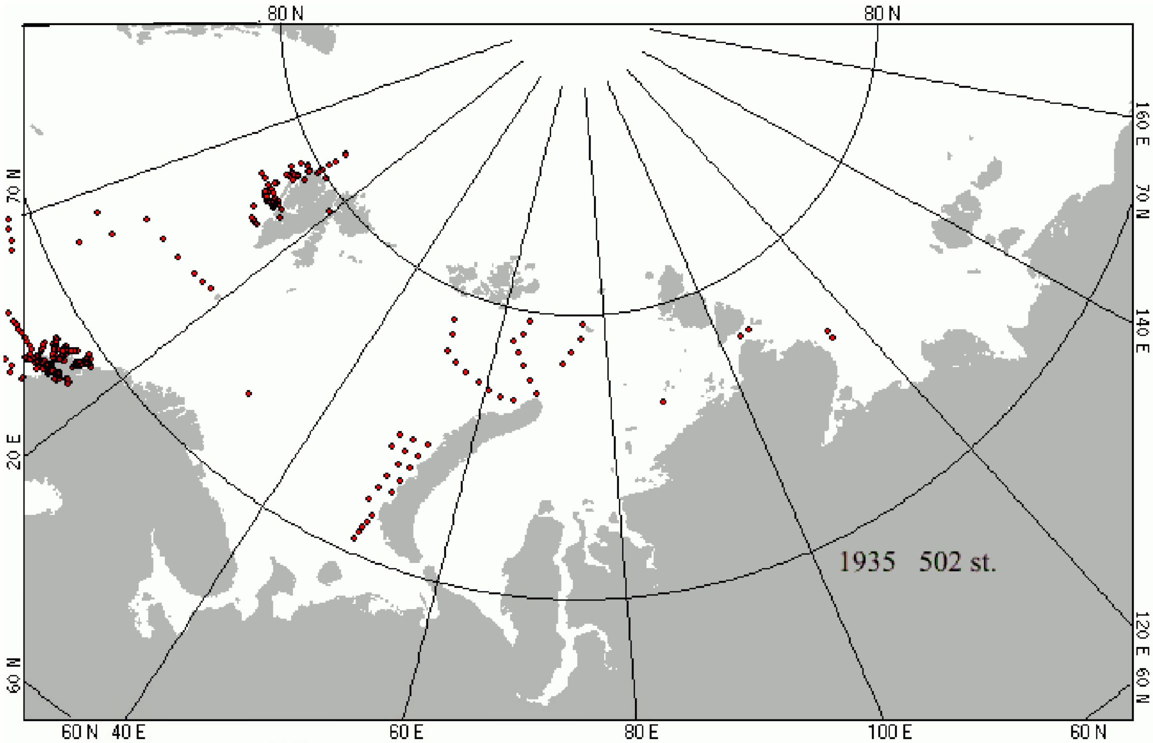
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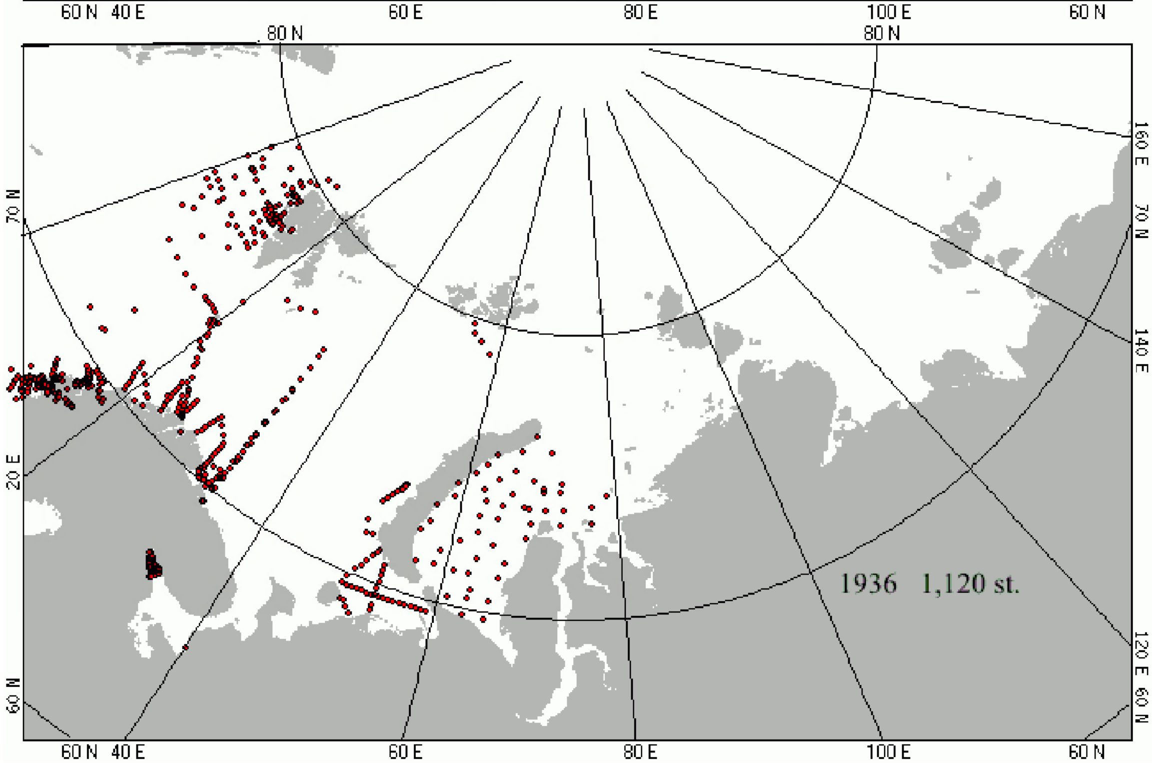
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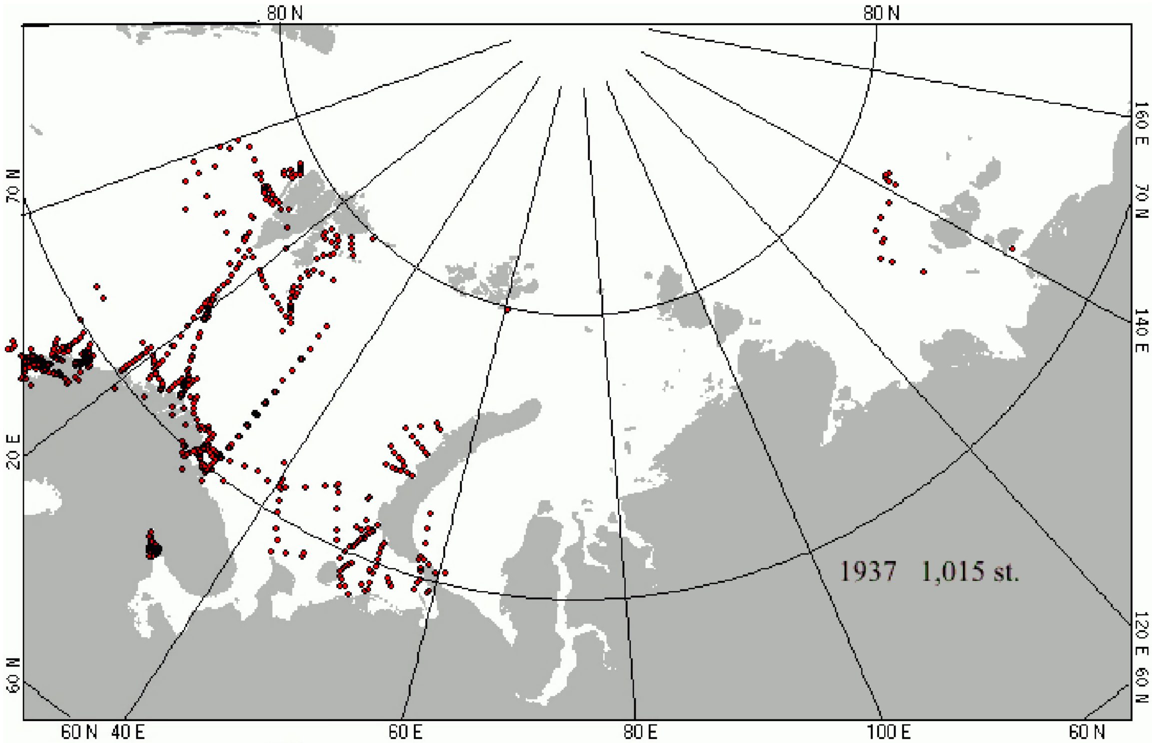
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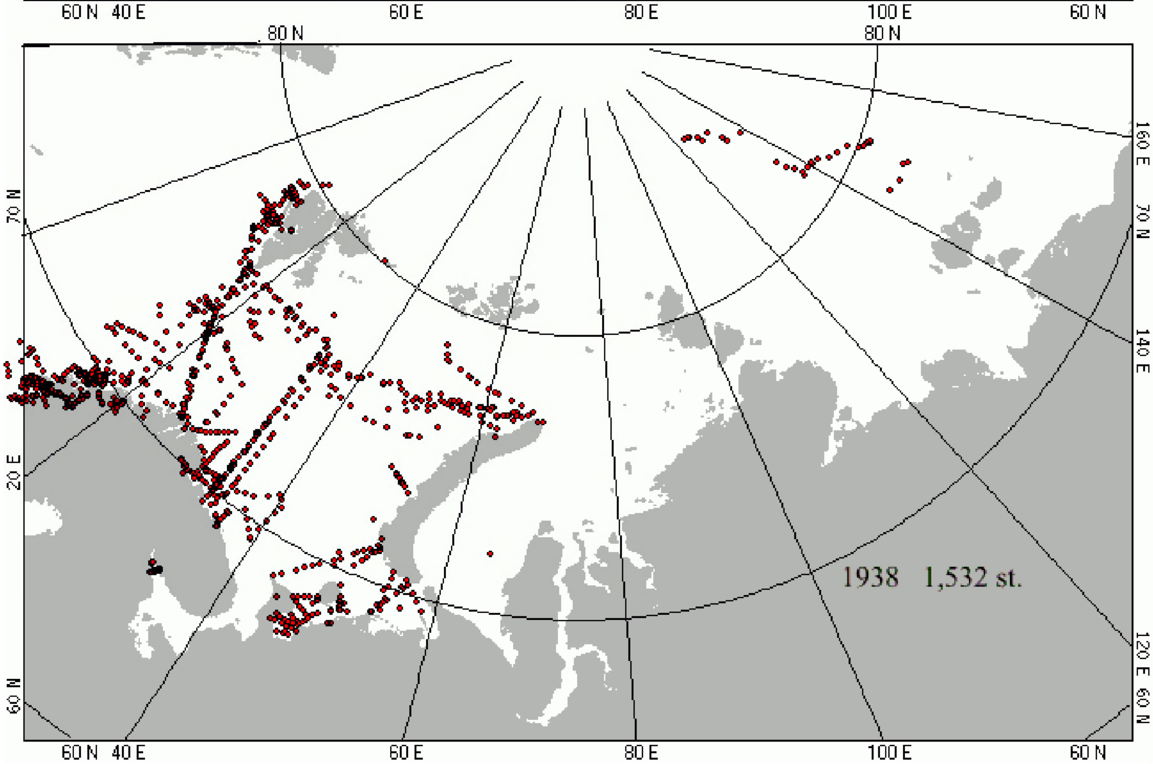
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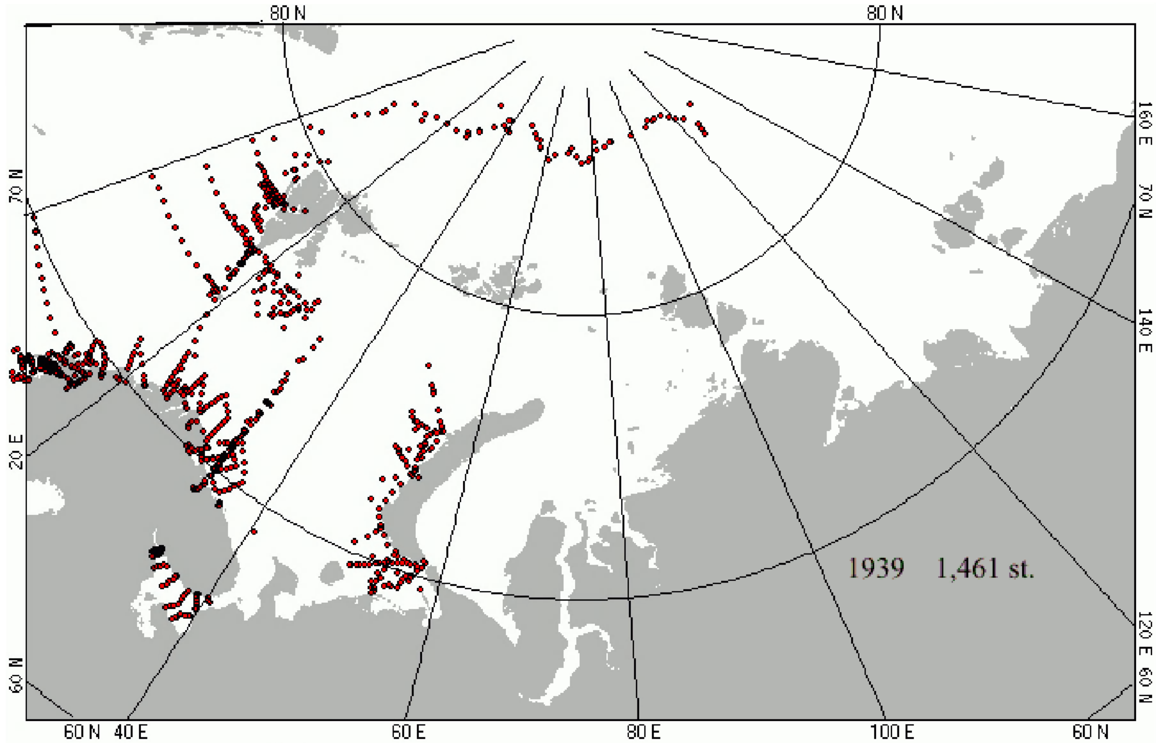
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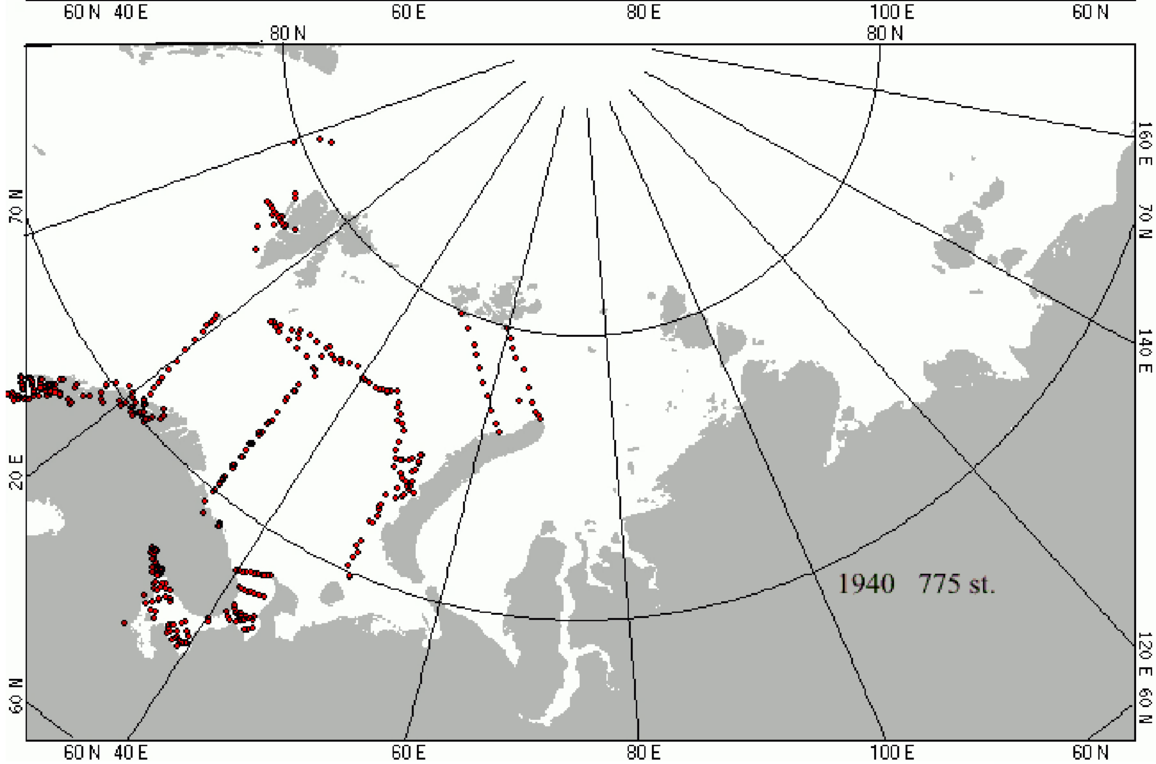
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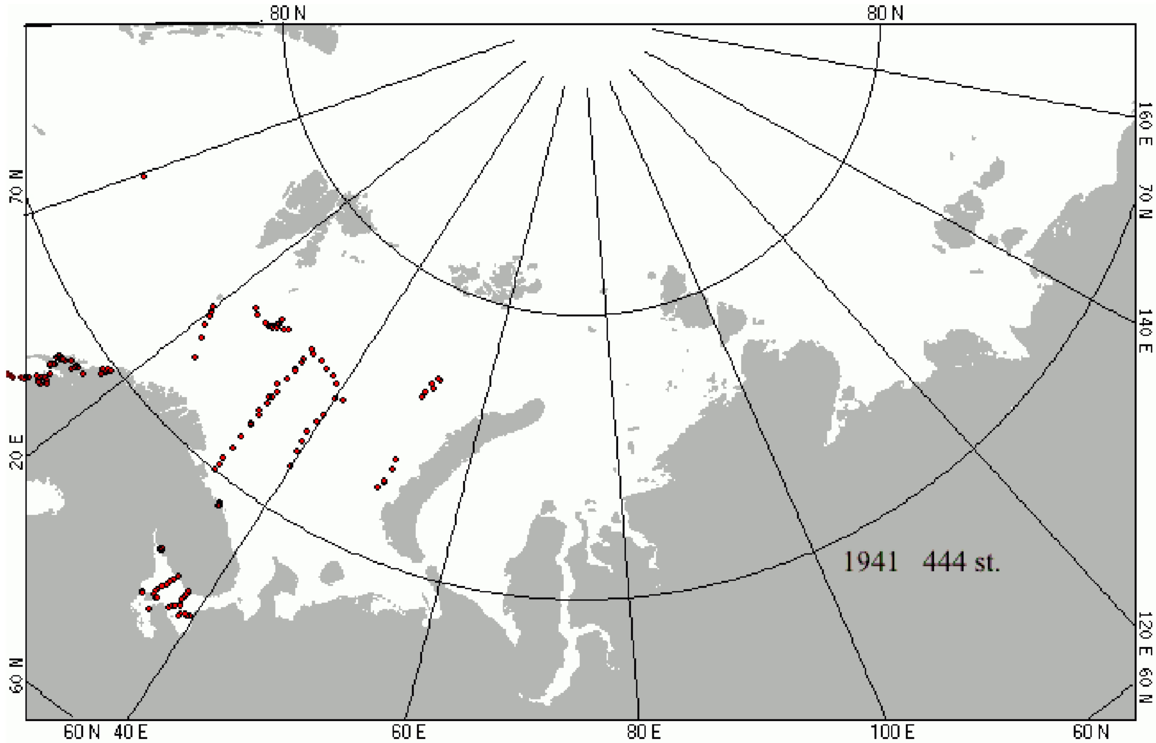
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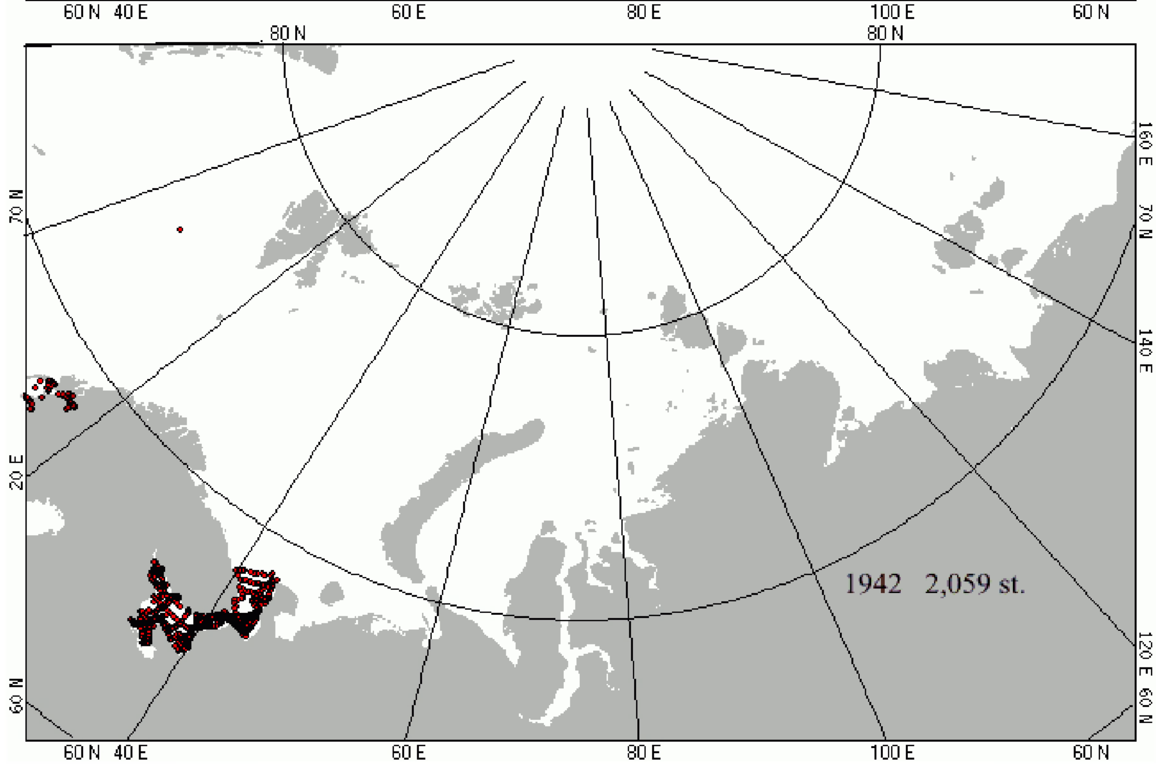
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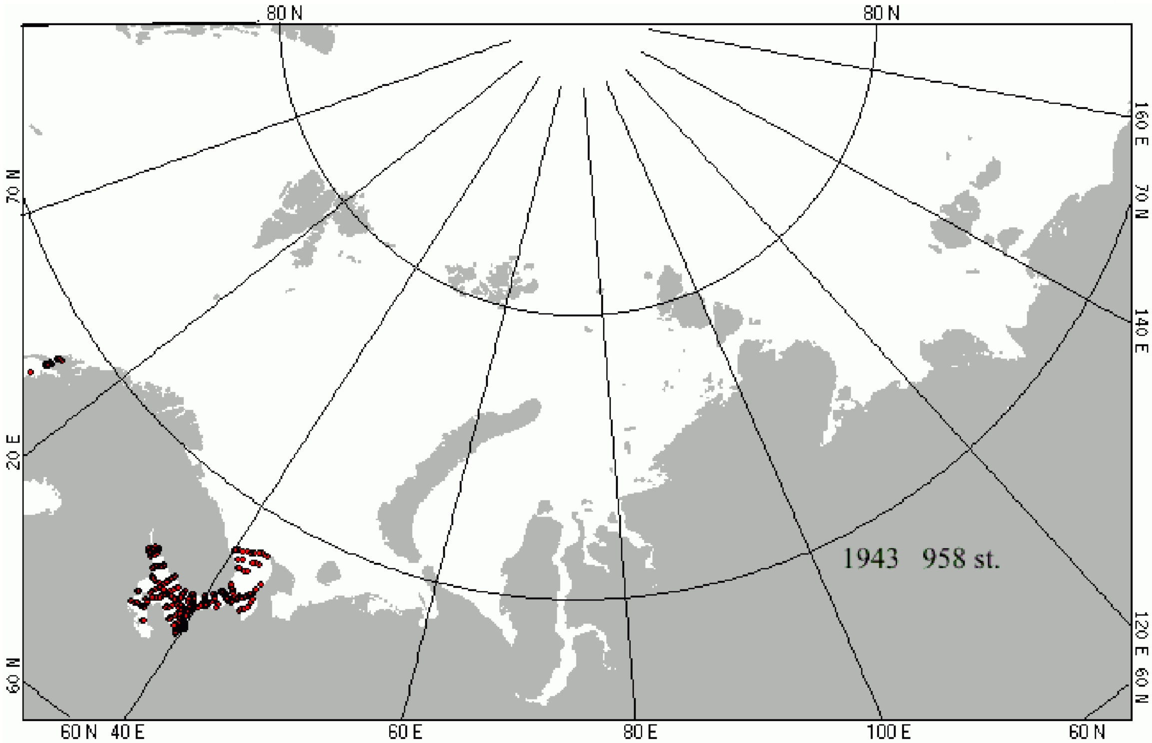
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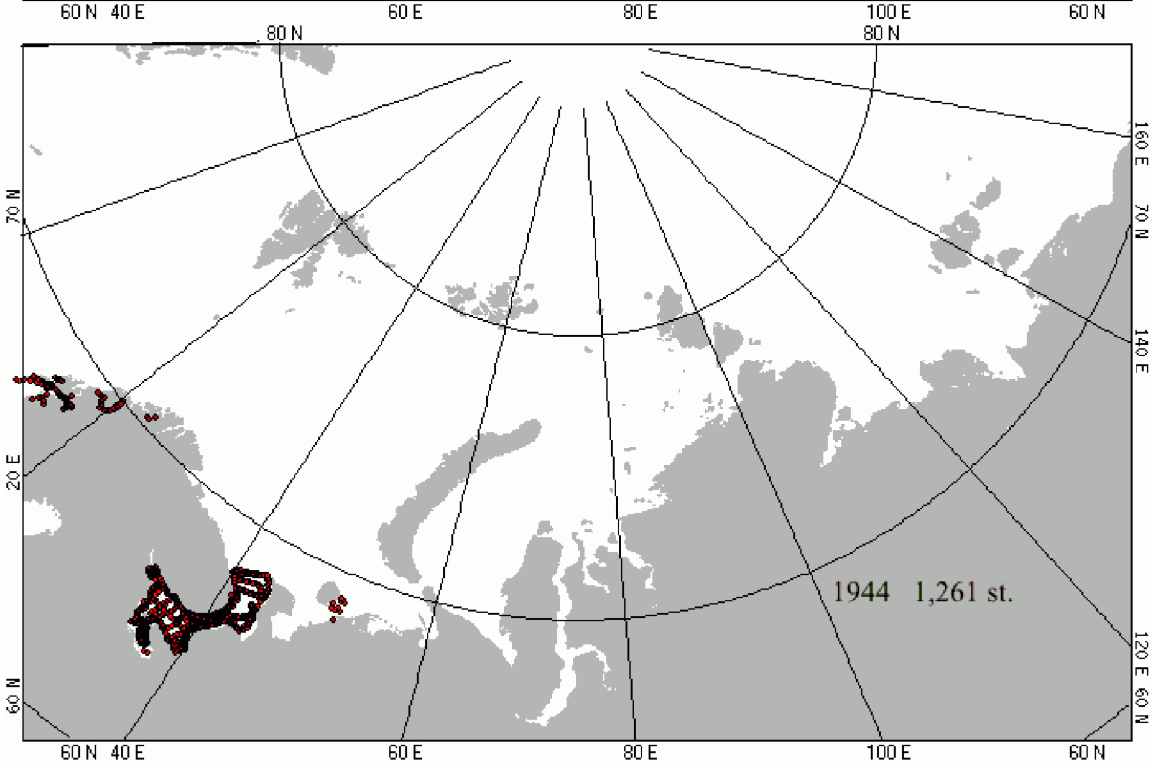
60 N
1943 958 st.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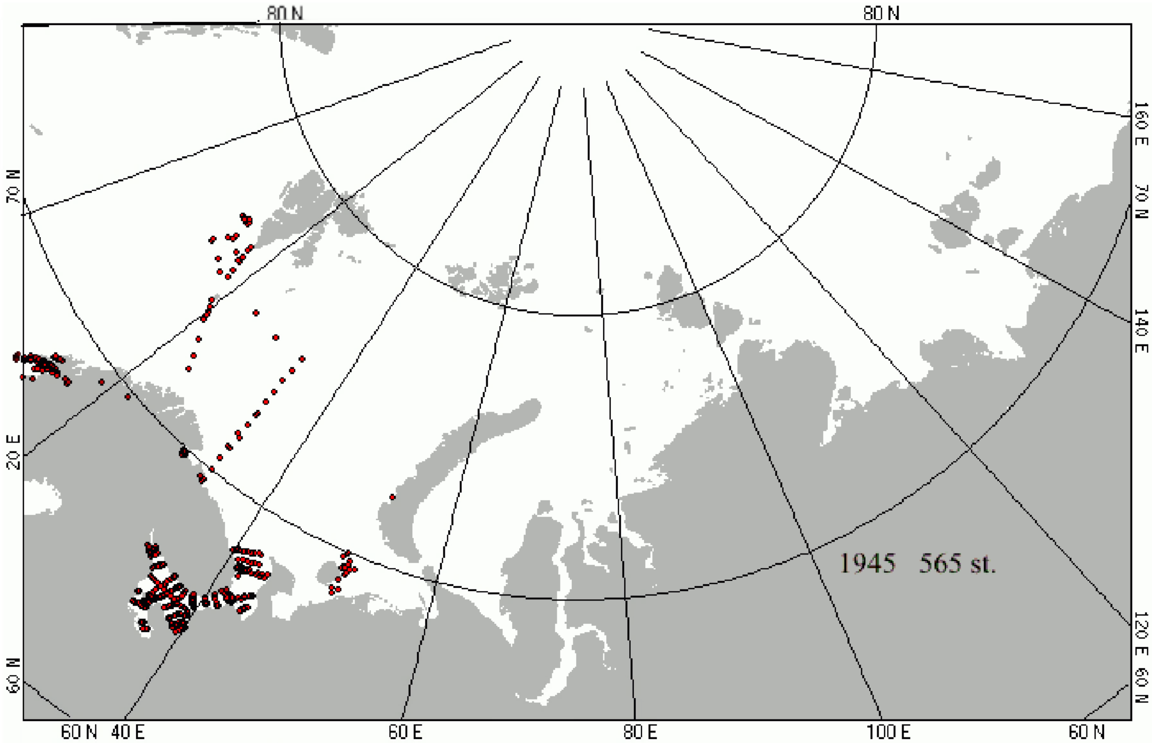
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100 E
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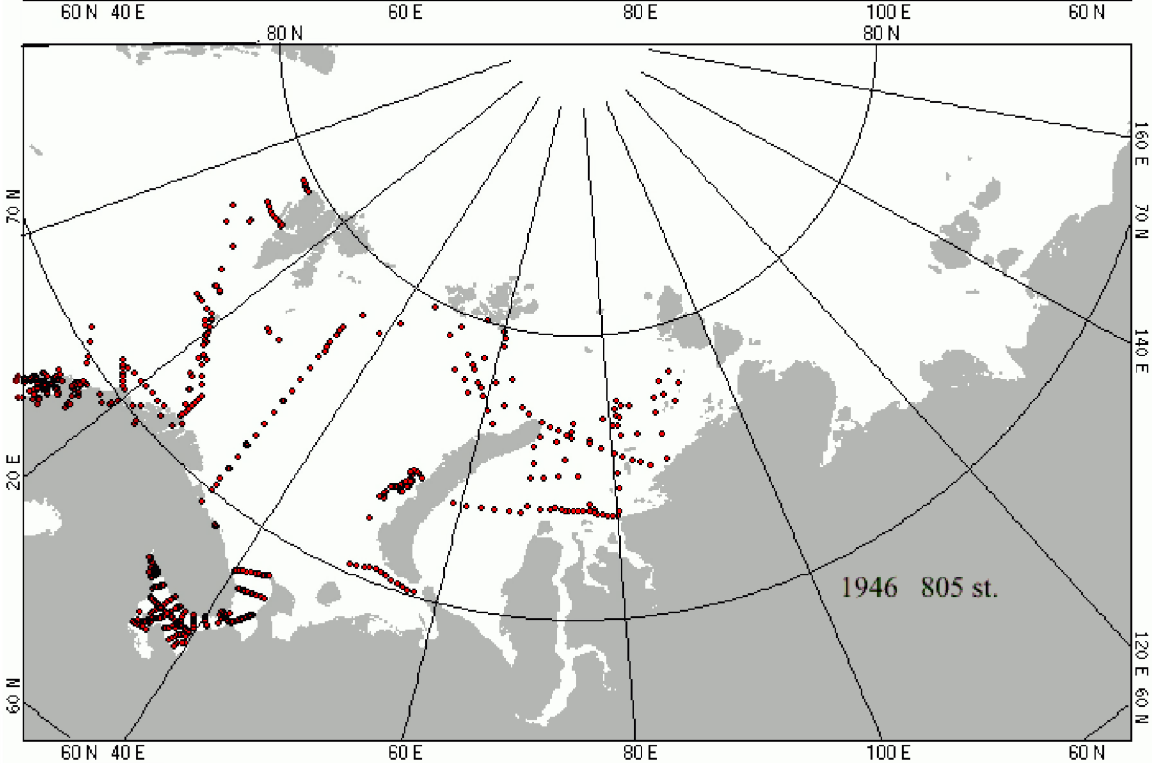
1945 565 st.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60 E
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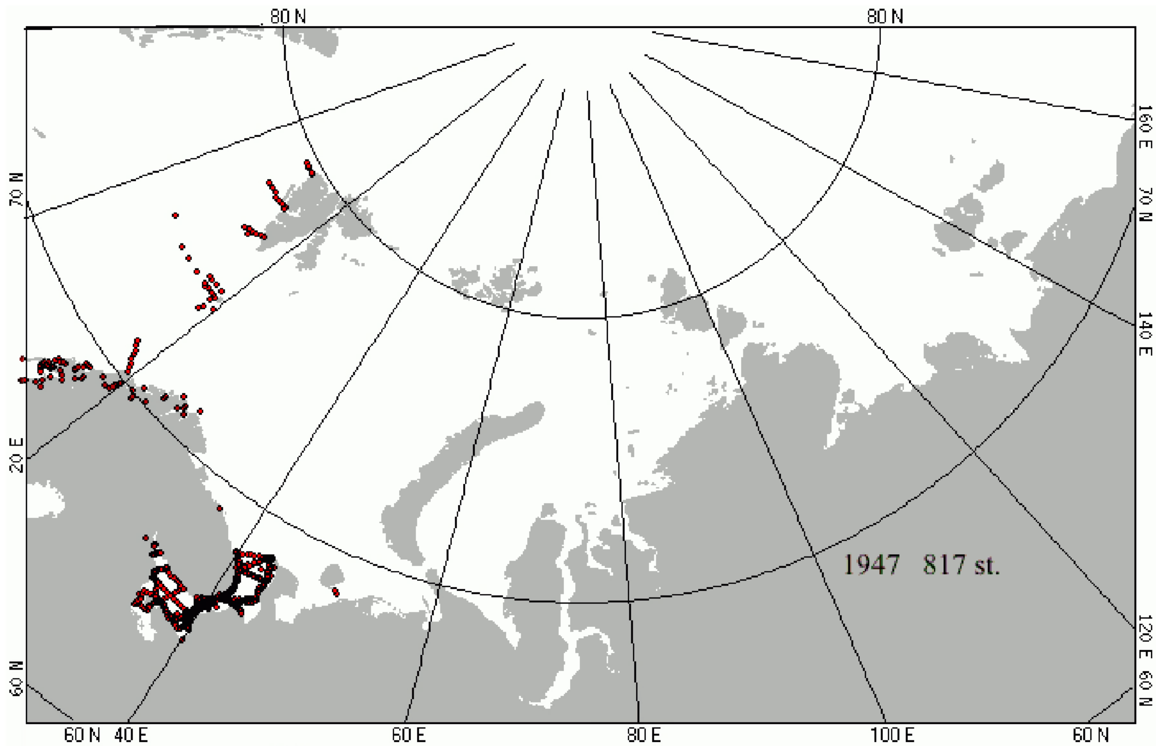
100 E
60 N
1946 805 st.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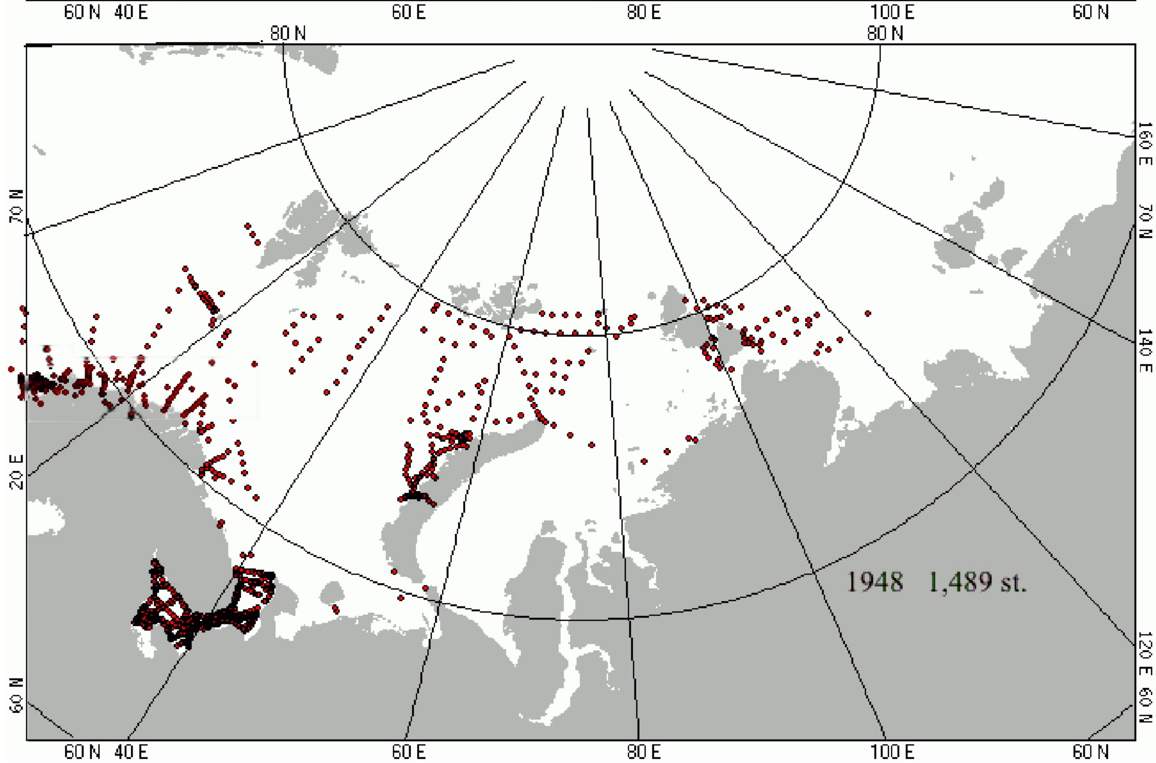
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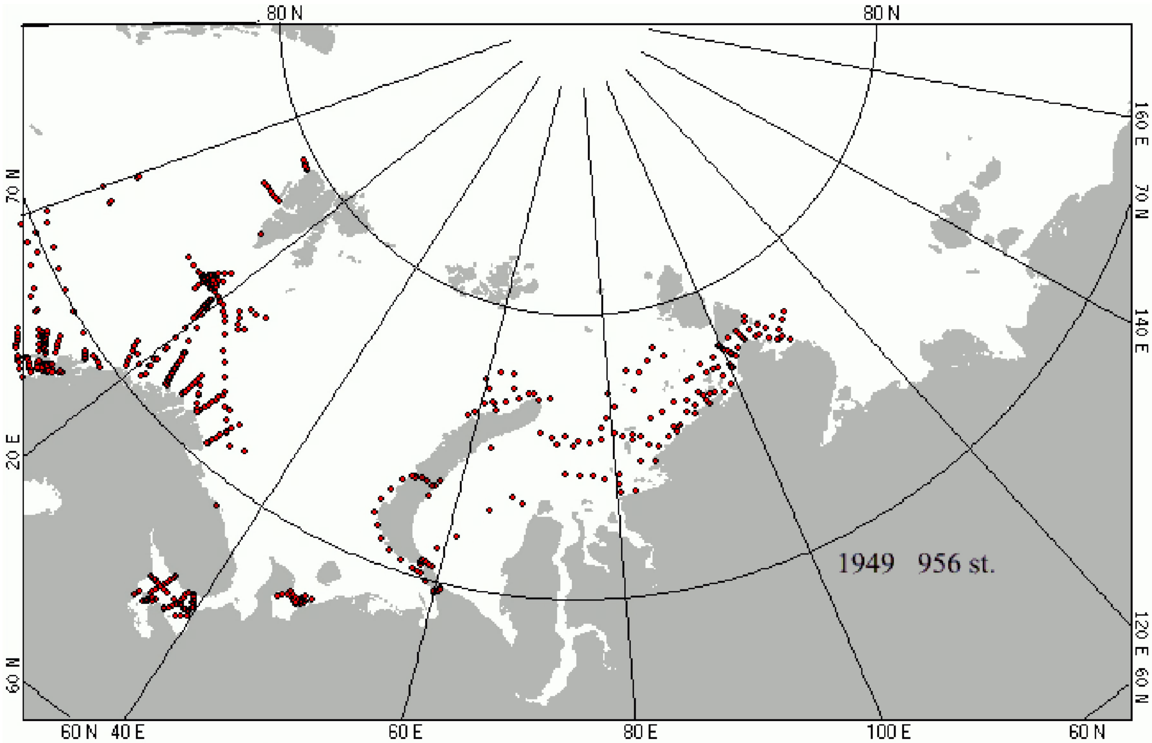
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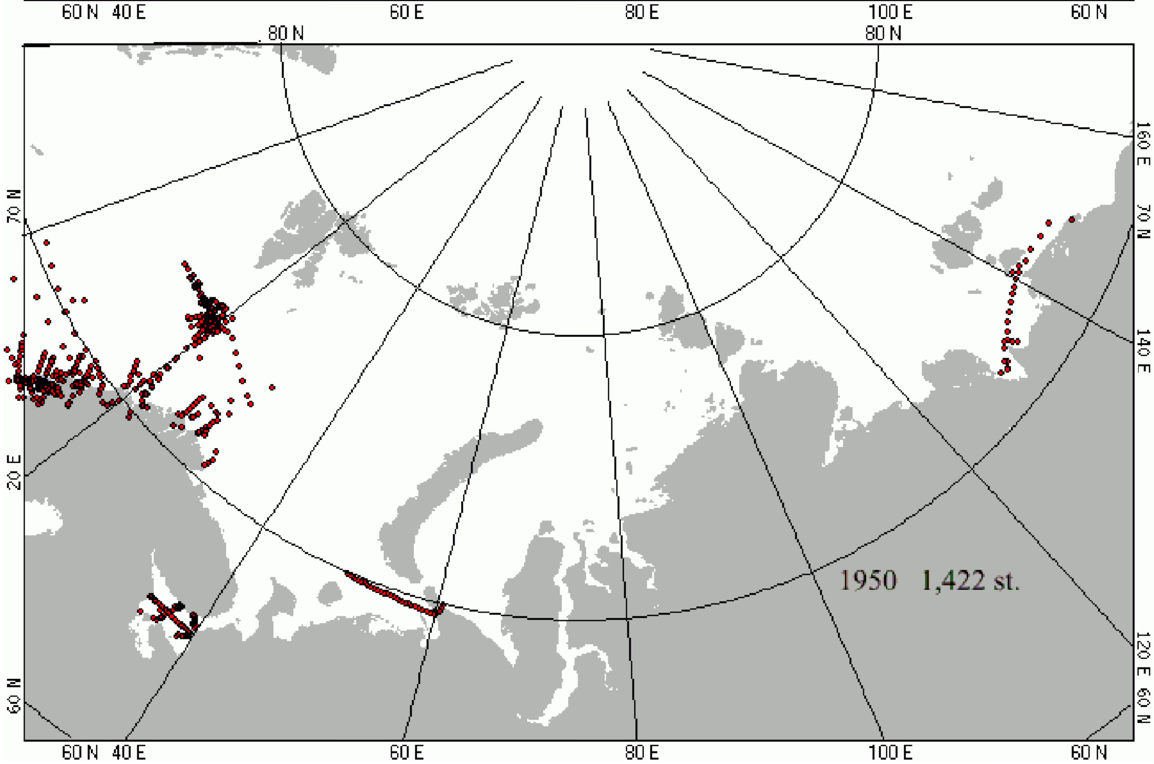
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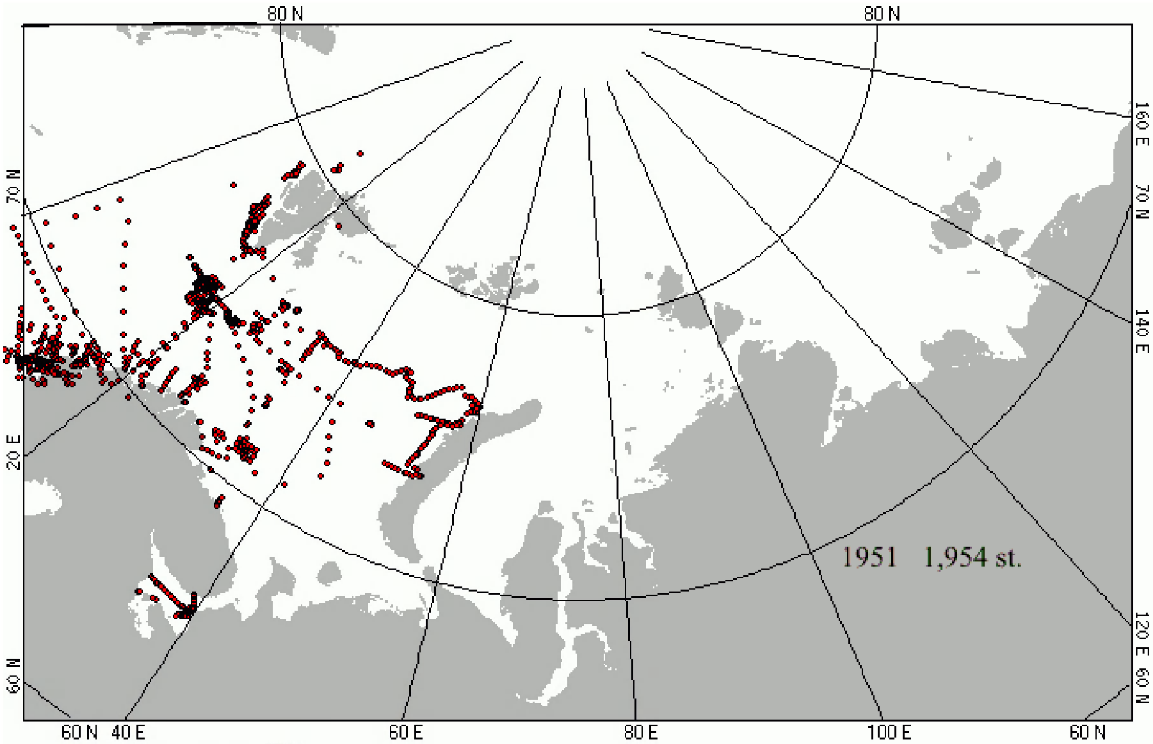
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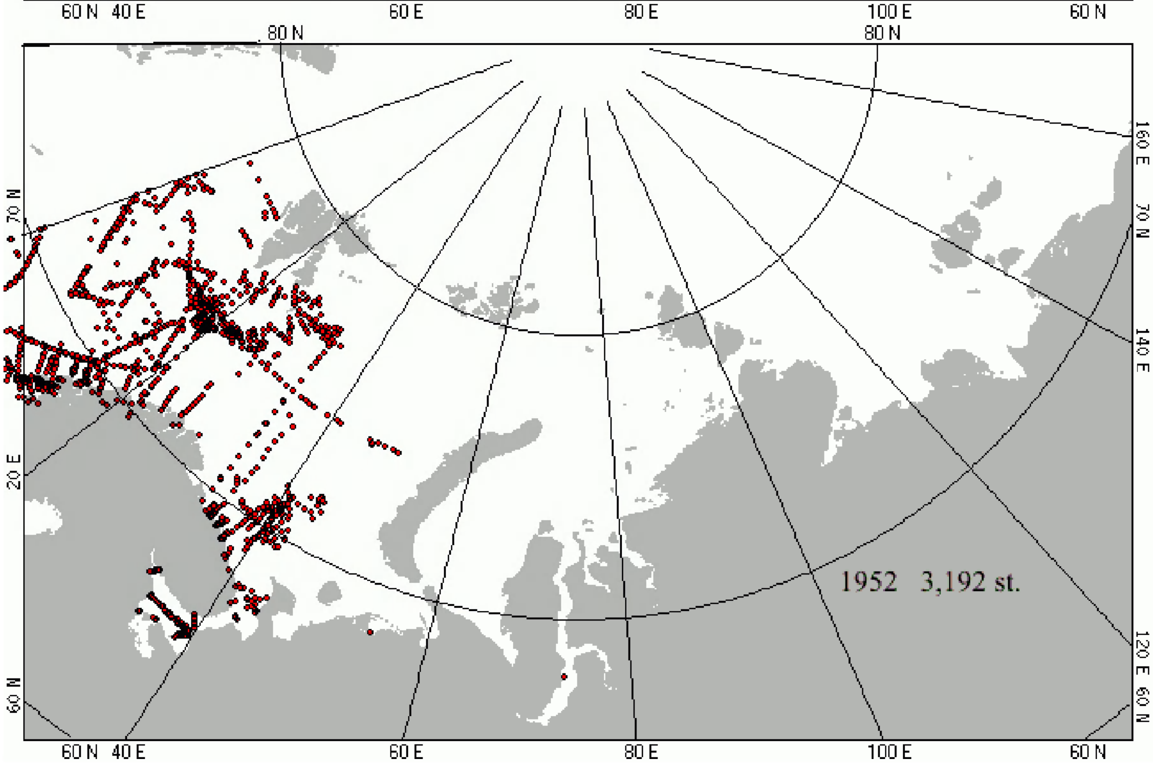
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60 E
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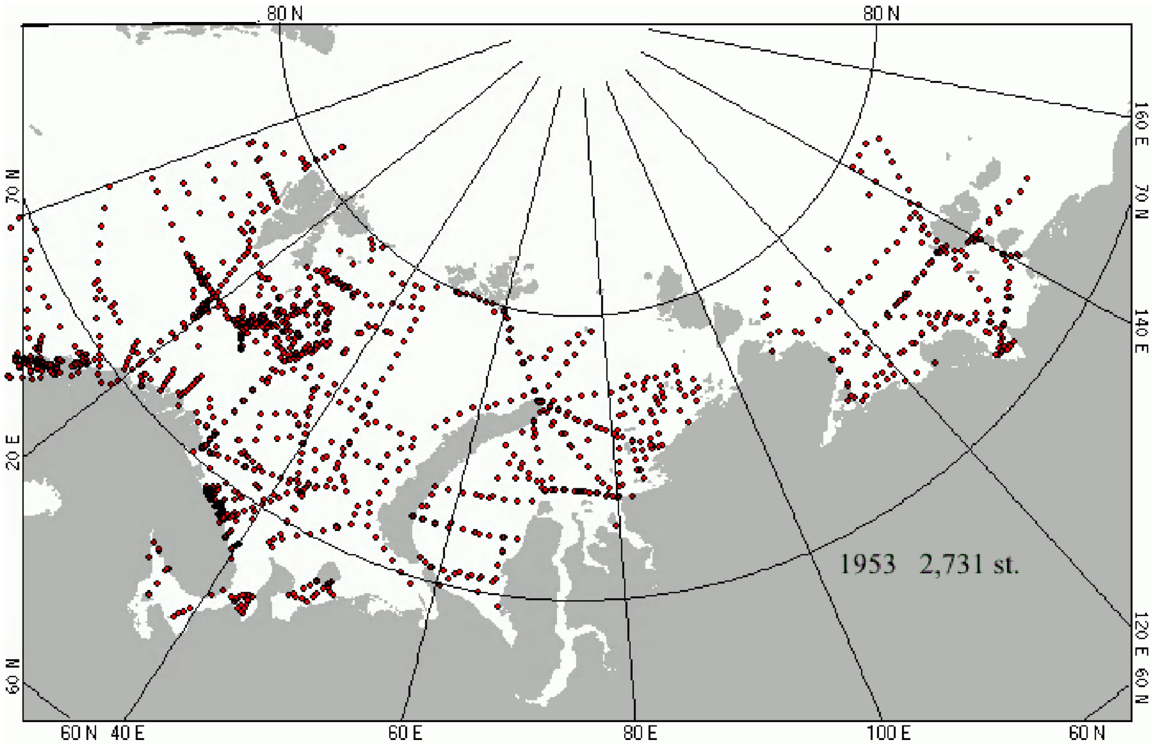
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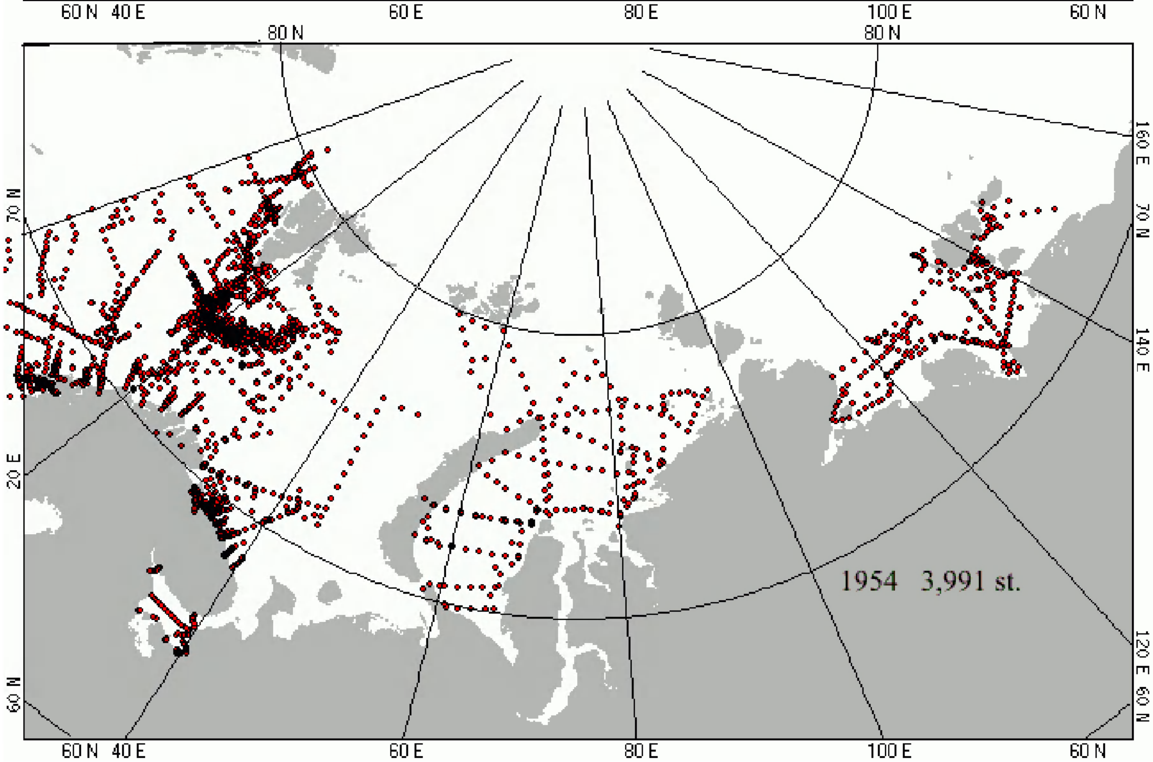
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1954 3,991 st.
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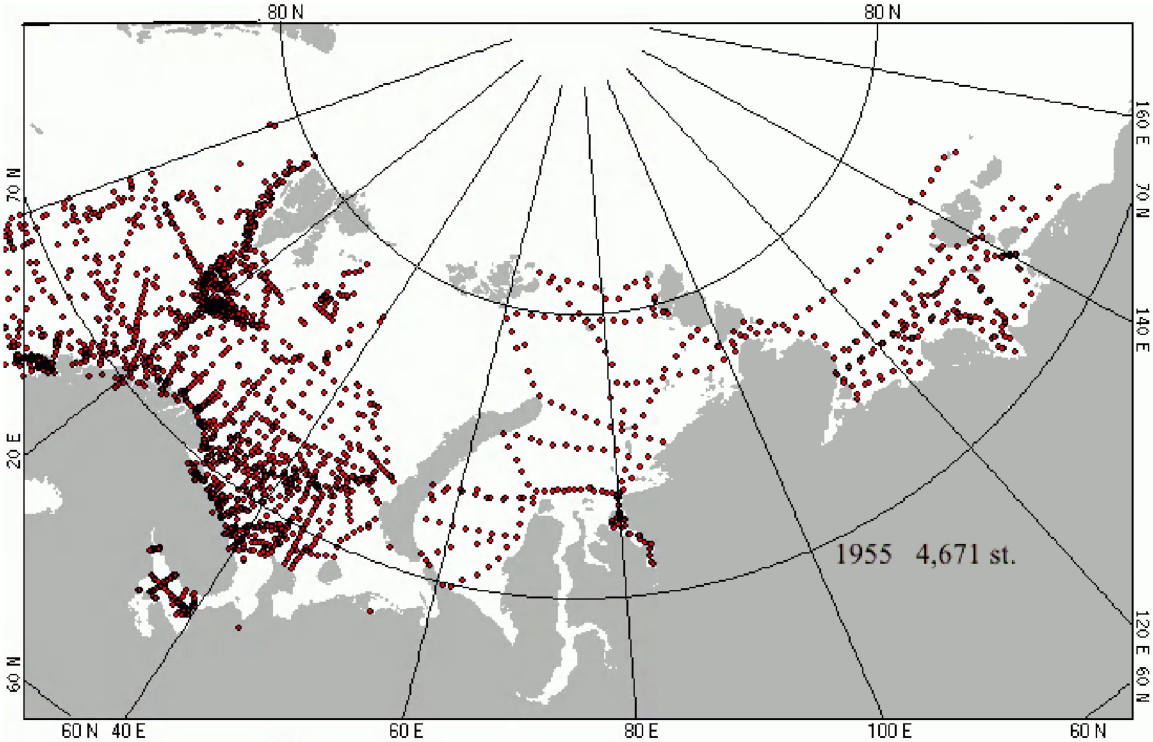

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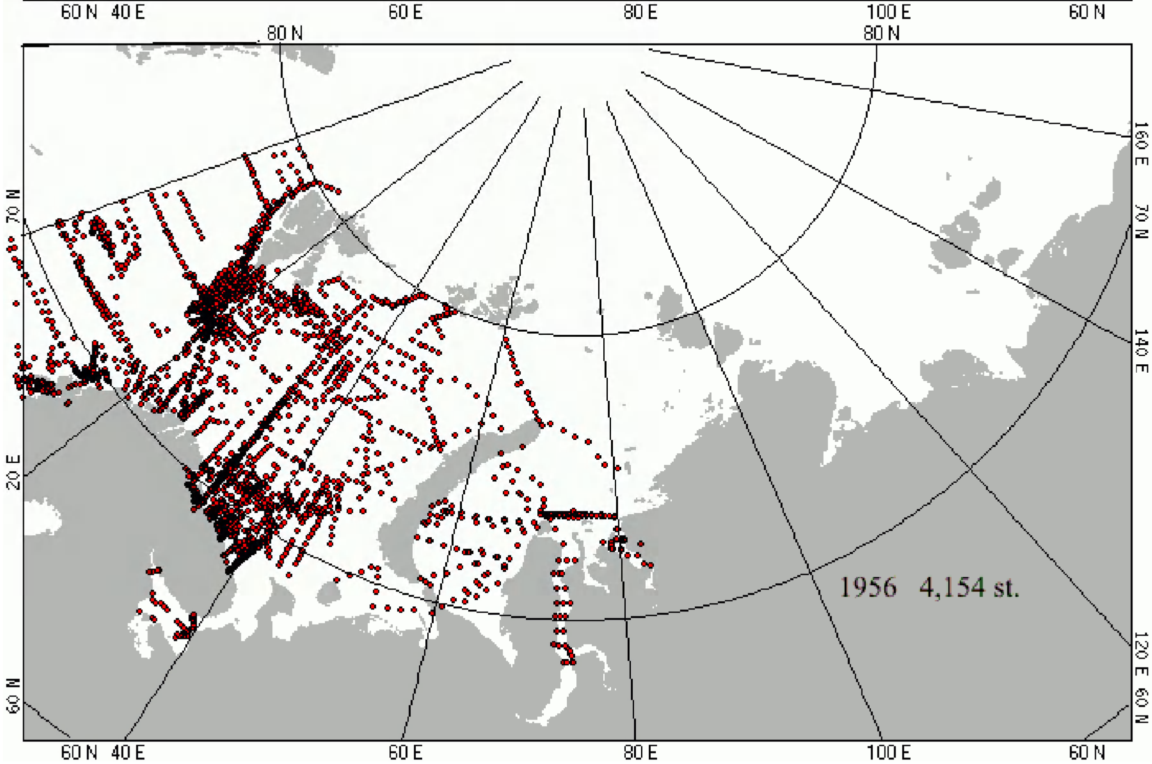

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1956 4,154 st.
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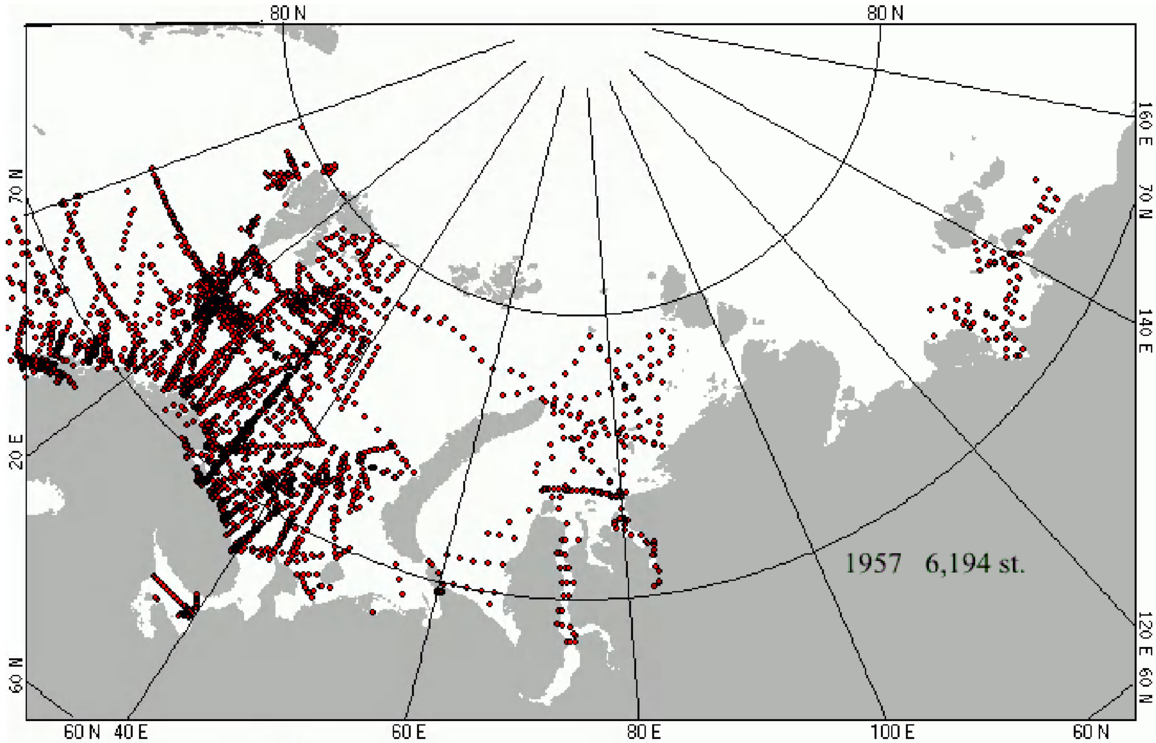
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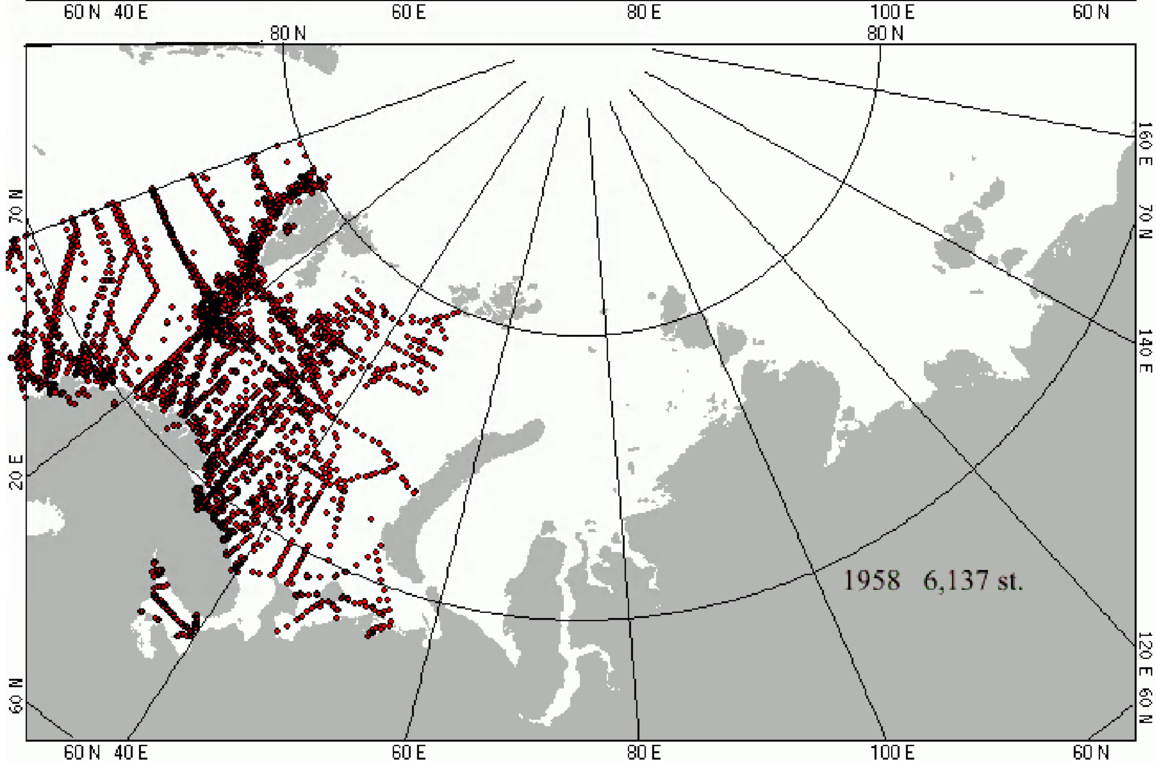
1957 6,194 st.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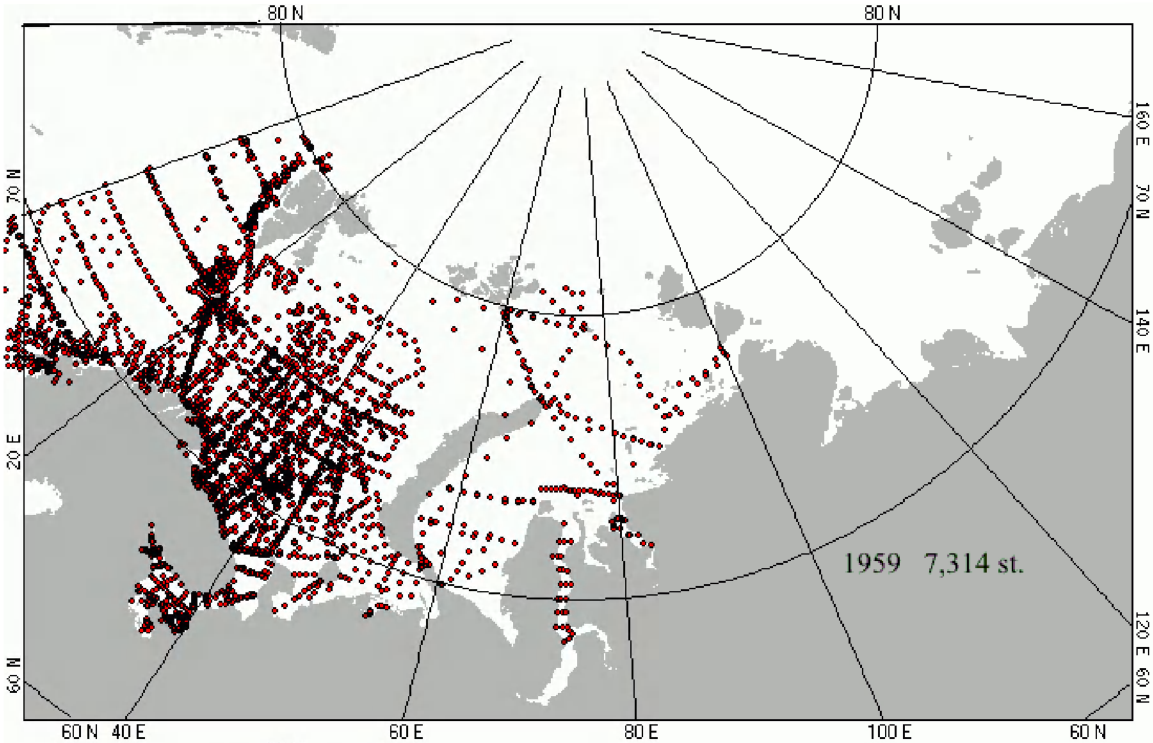
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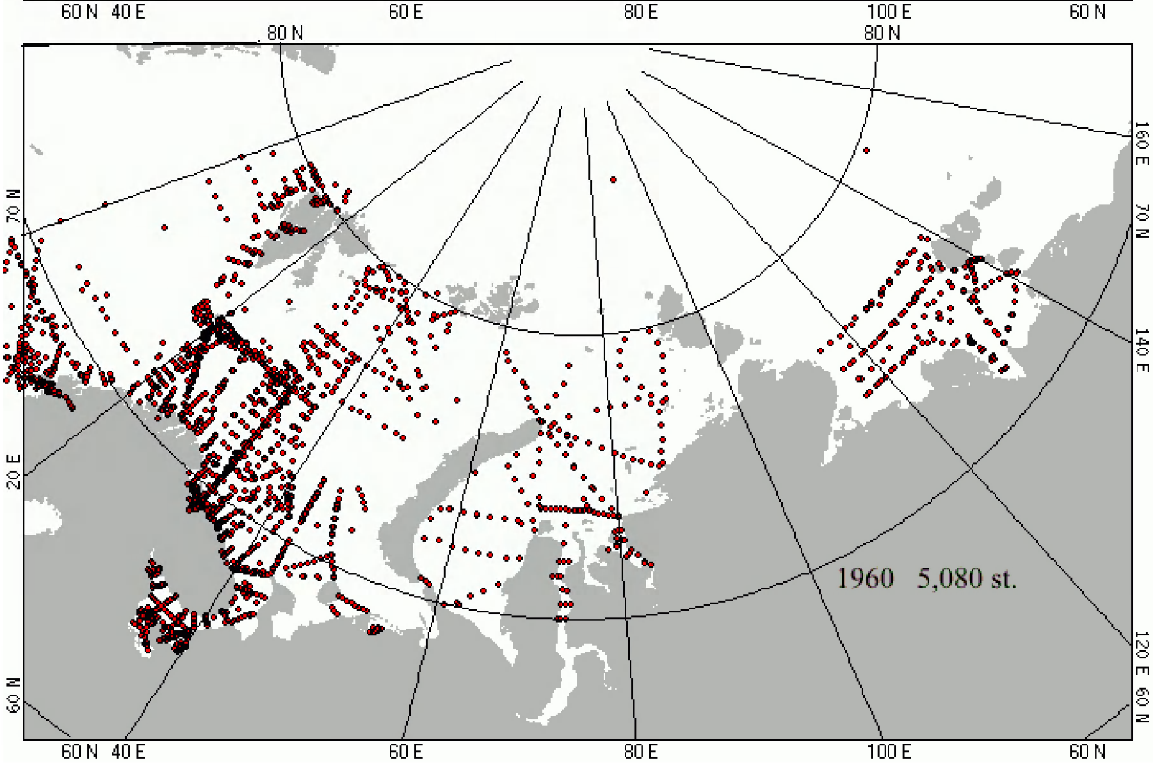
1959 7,314 st.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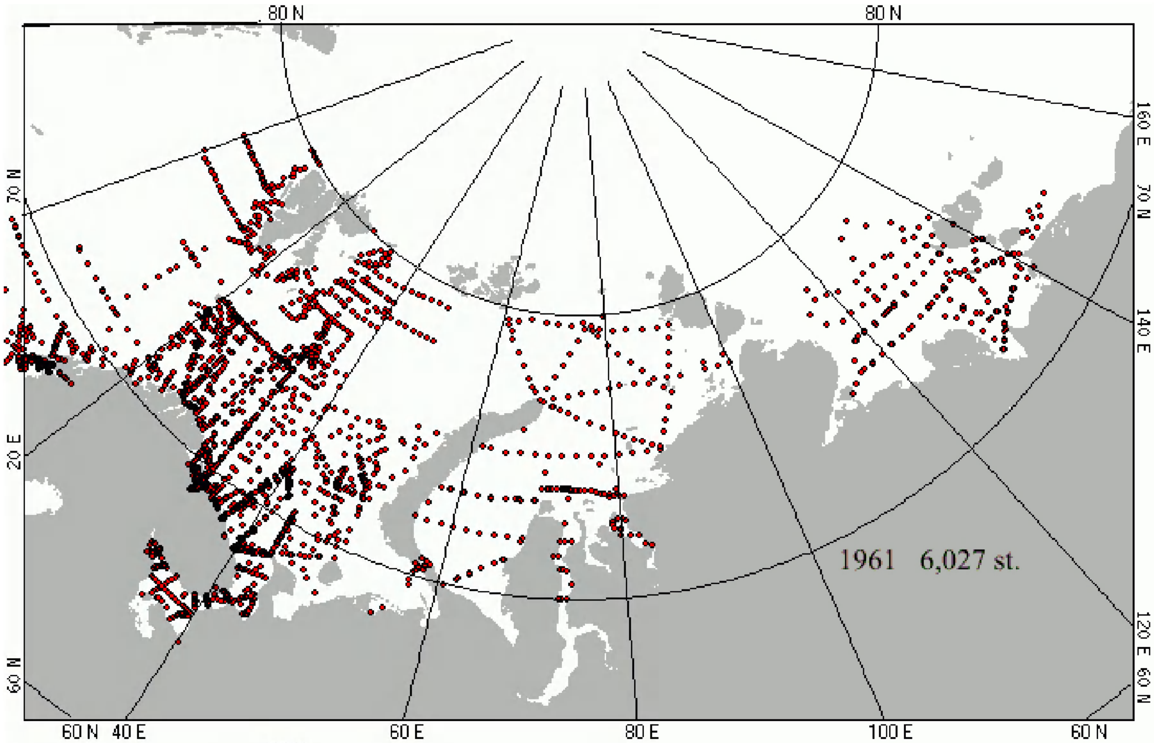
1960 5,080 st.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1961 6,027 st.
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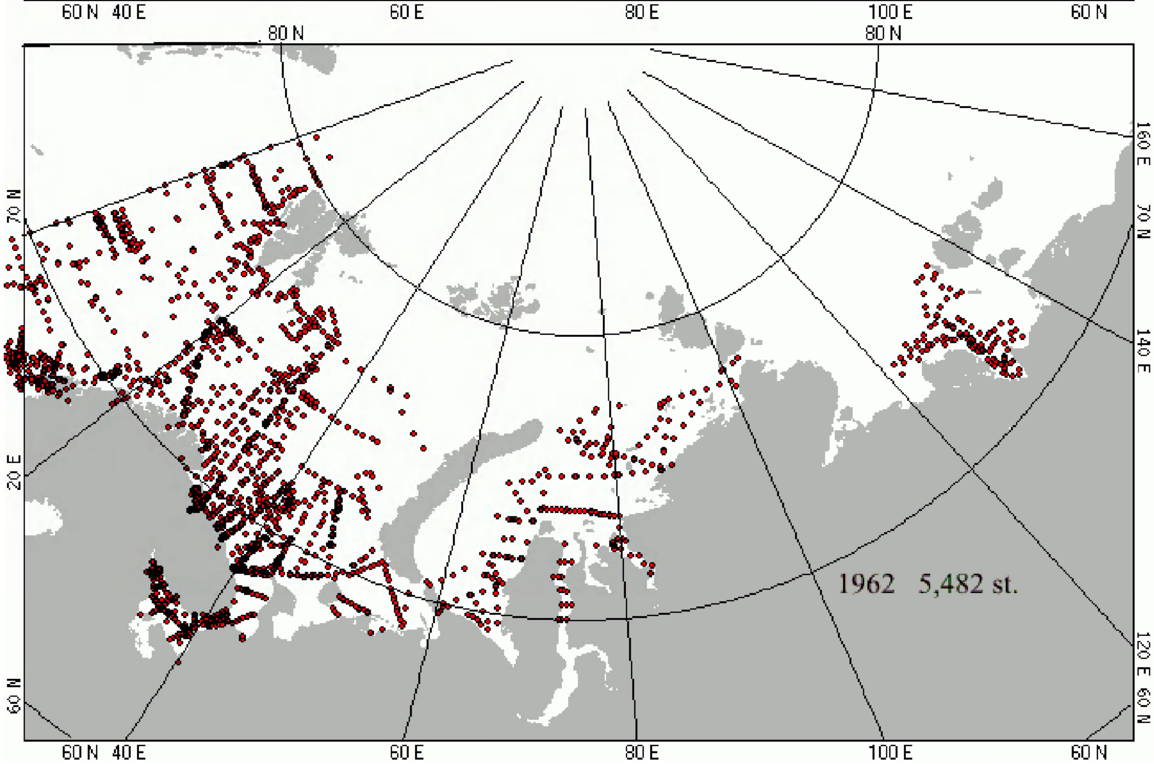
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1962 5,482 st.
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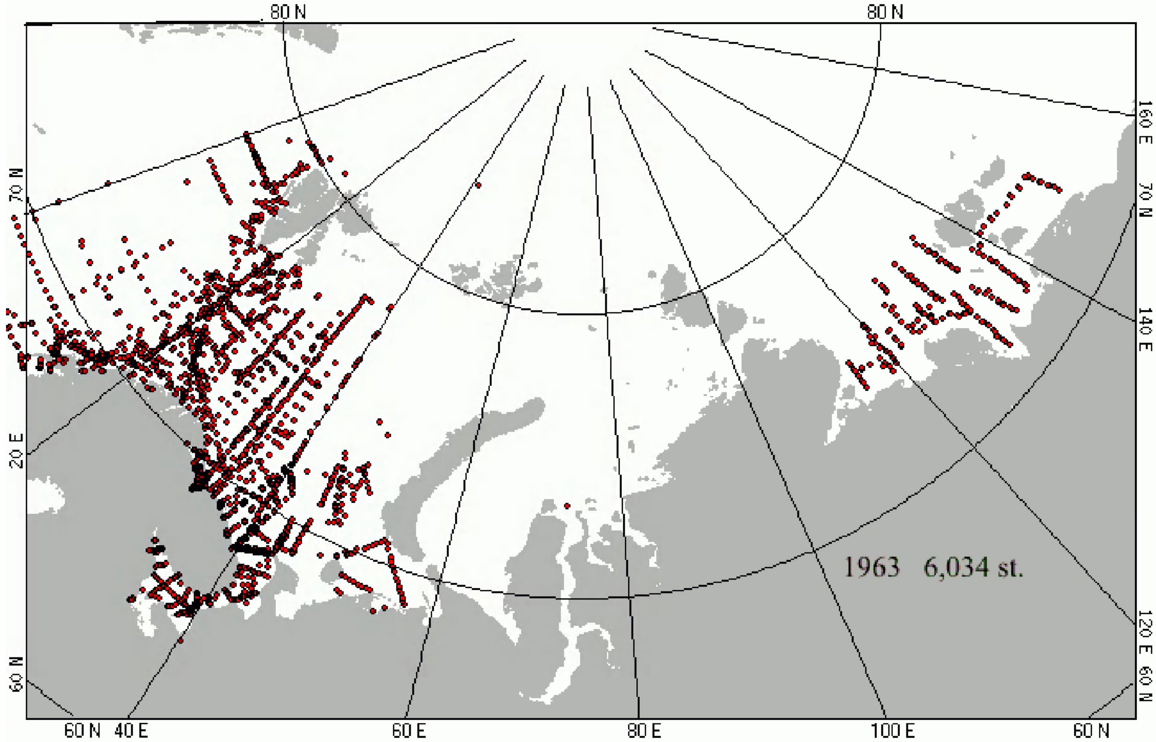
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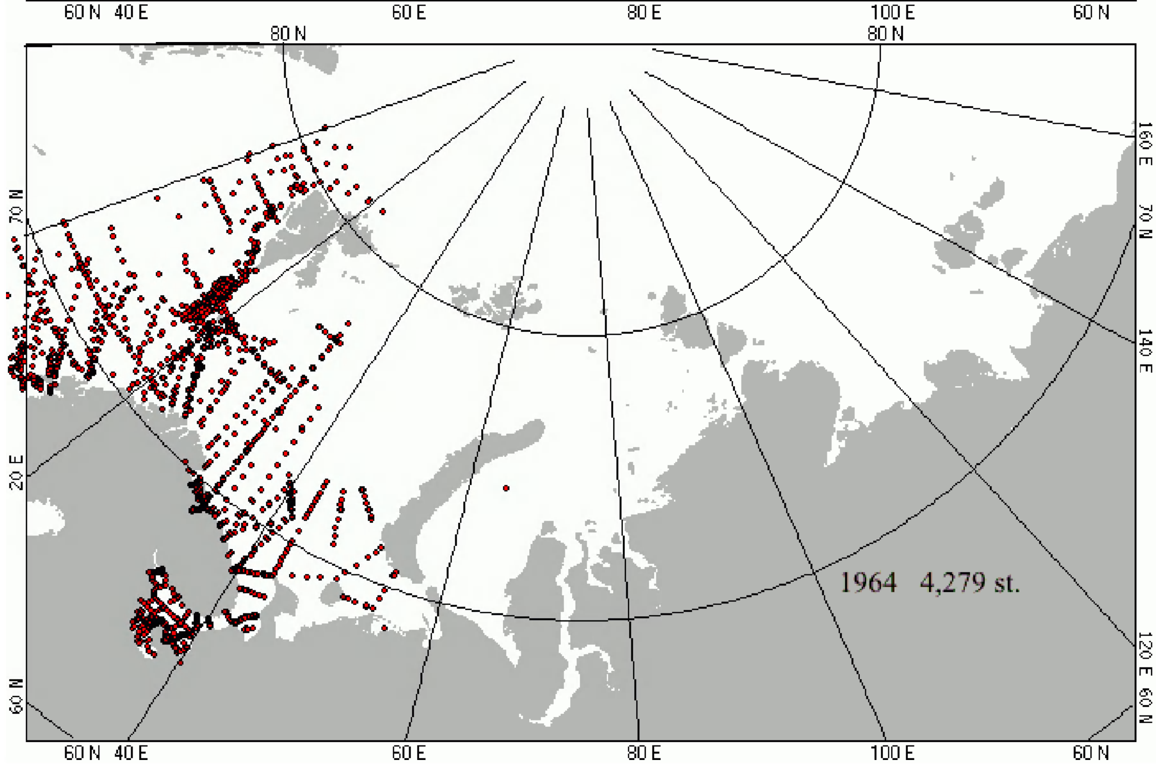
1963 6,034 st.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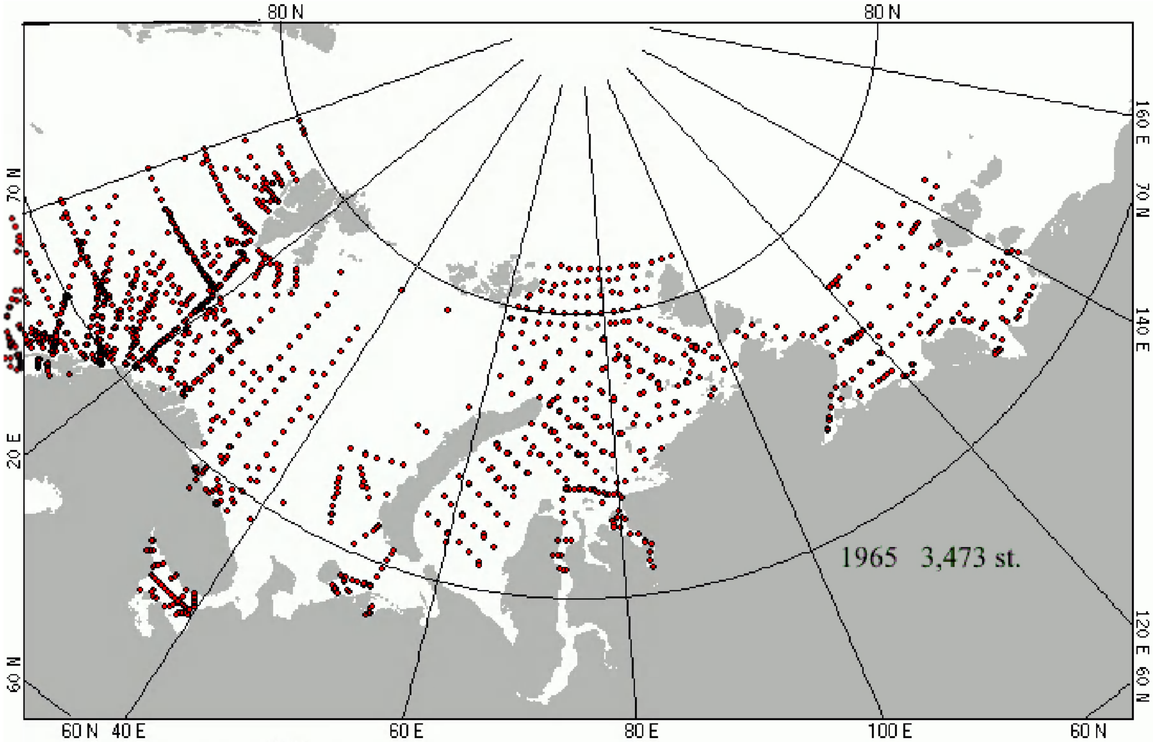
1964 4,279 st.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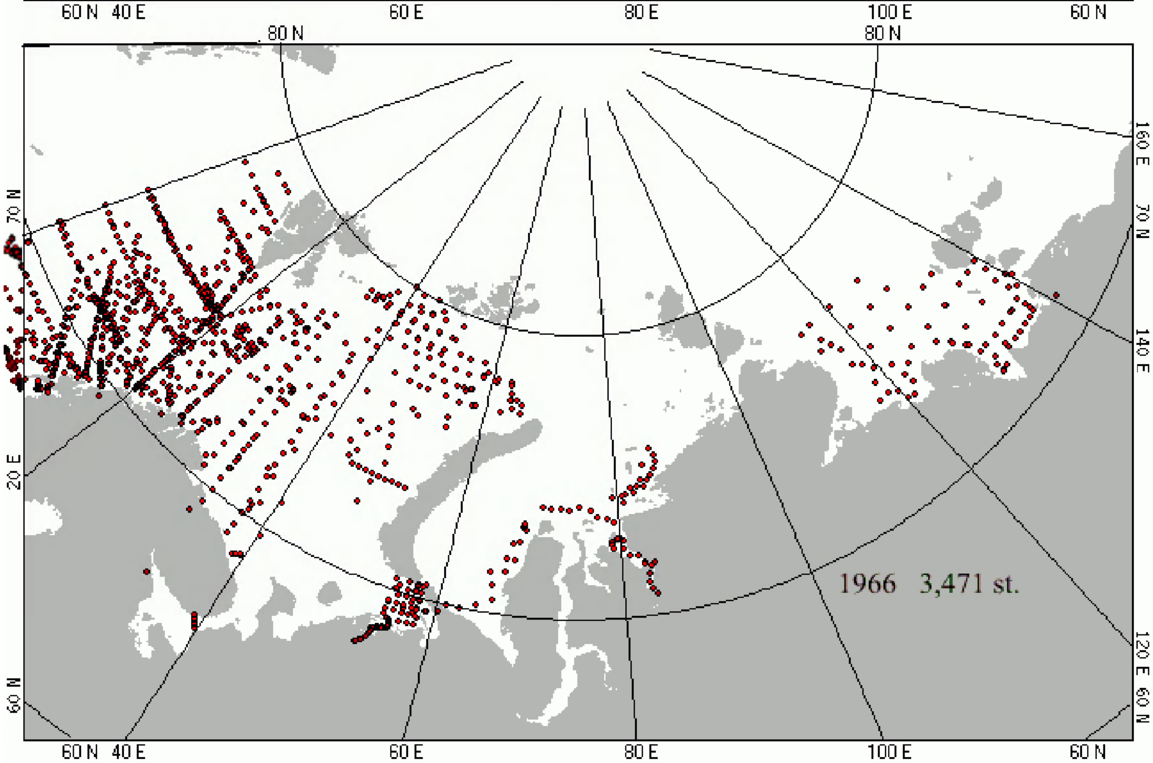
1965 3,473 st.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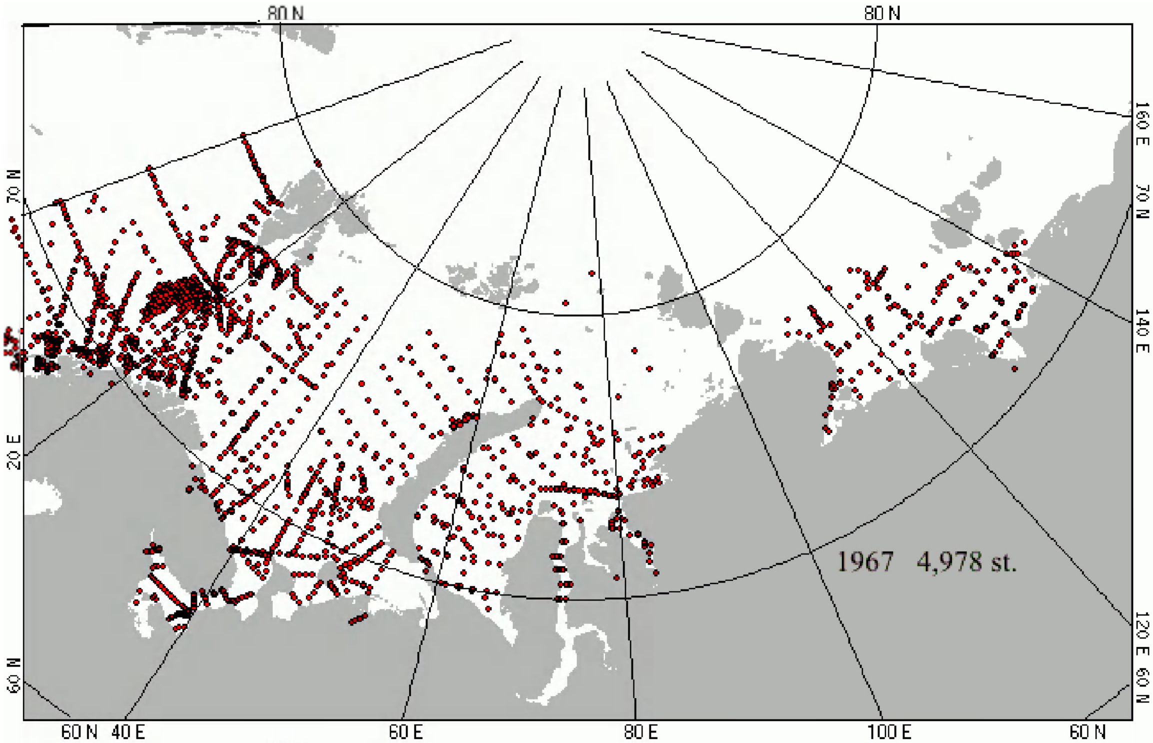
1966 3,471 st.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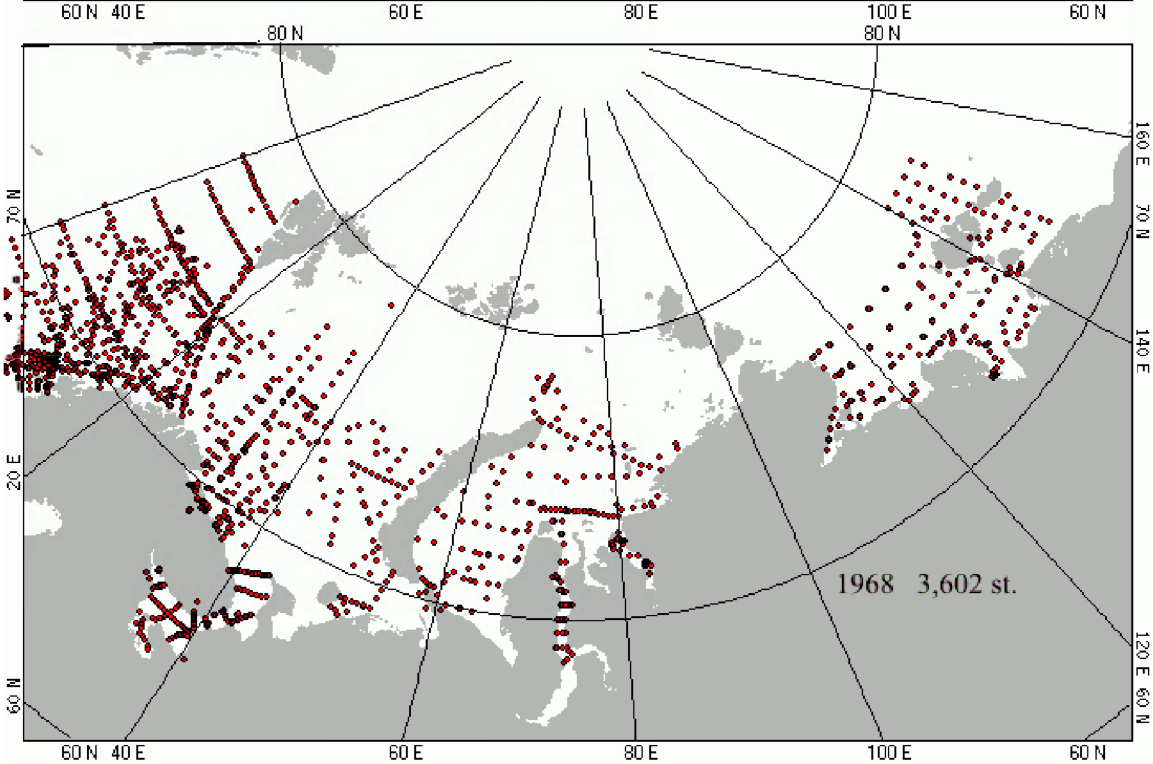
1967 4,978 st.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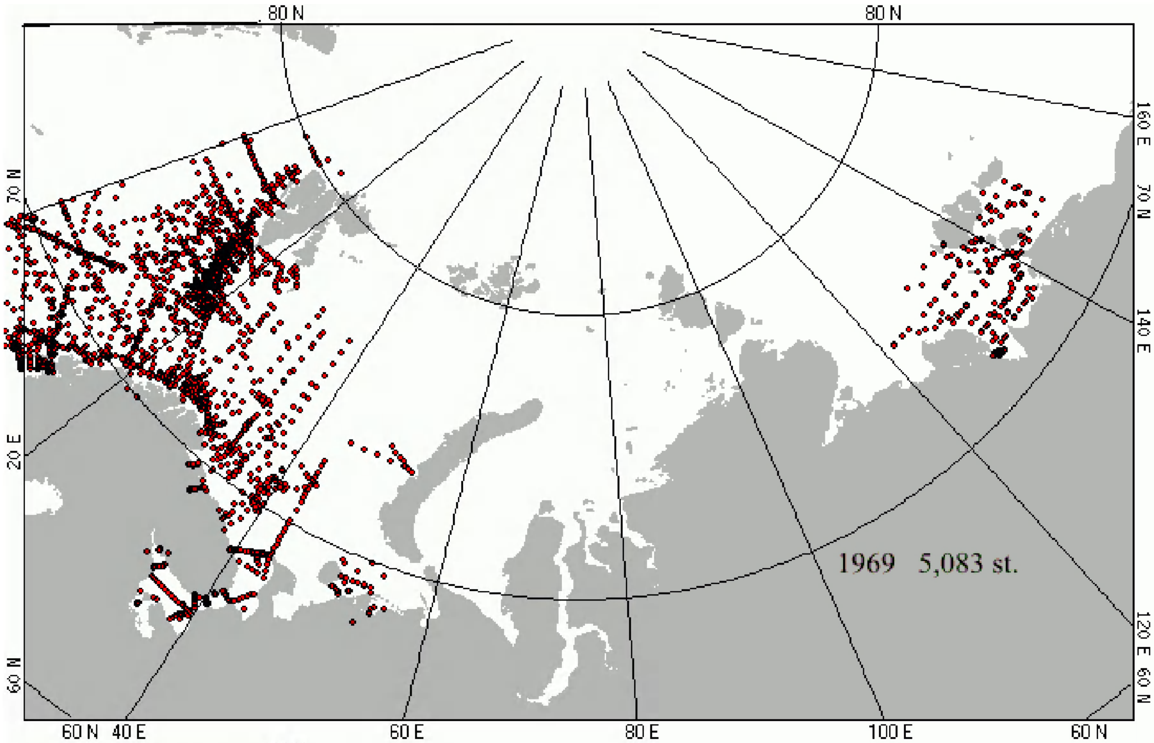
1968 3,602 st.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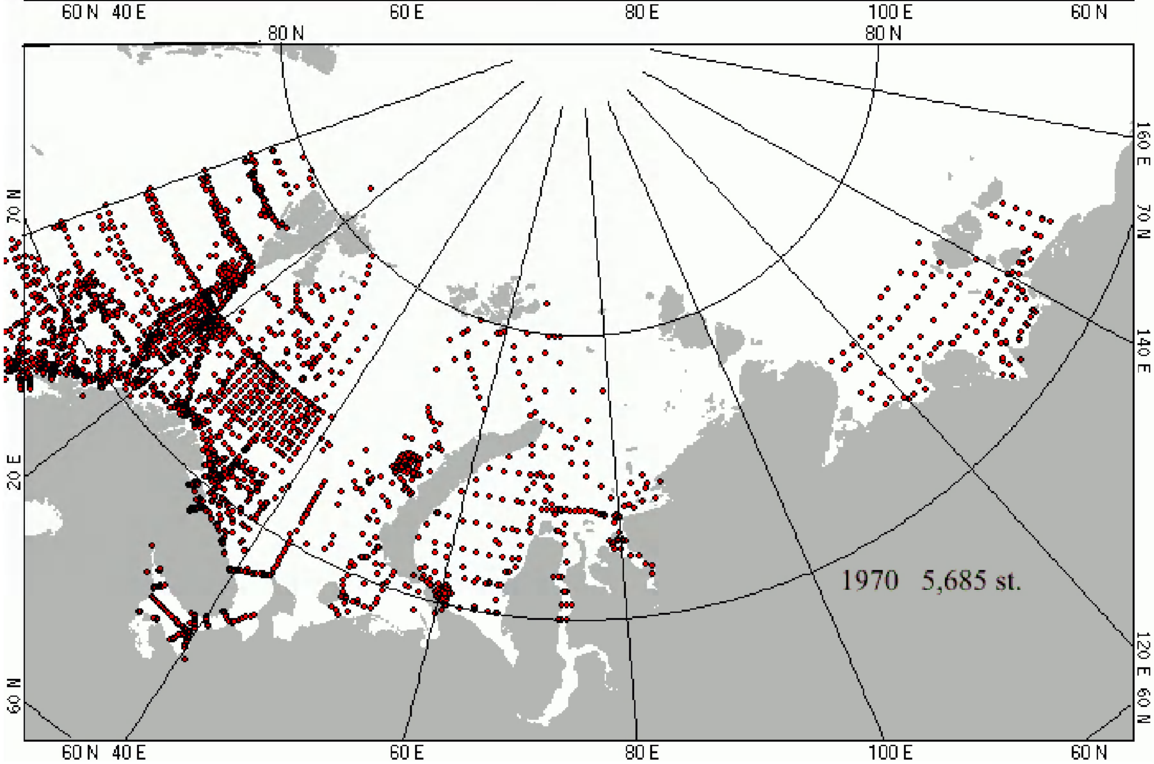
1969 5,083 st.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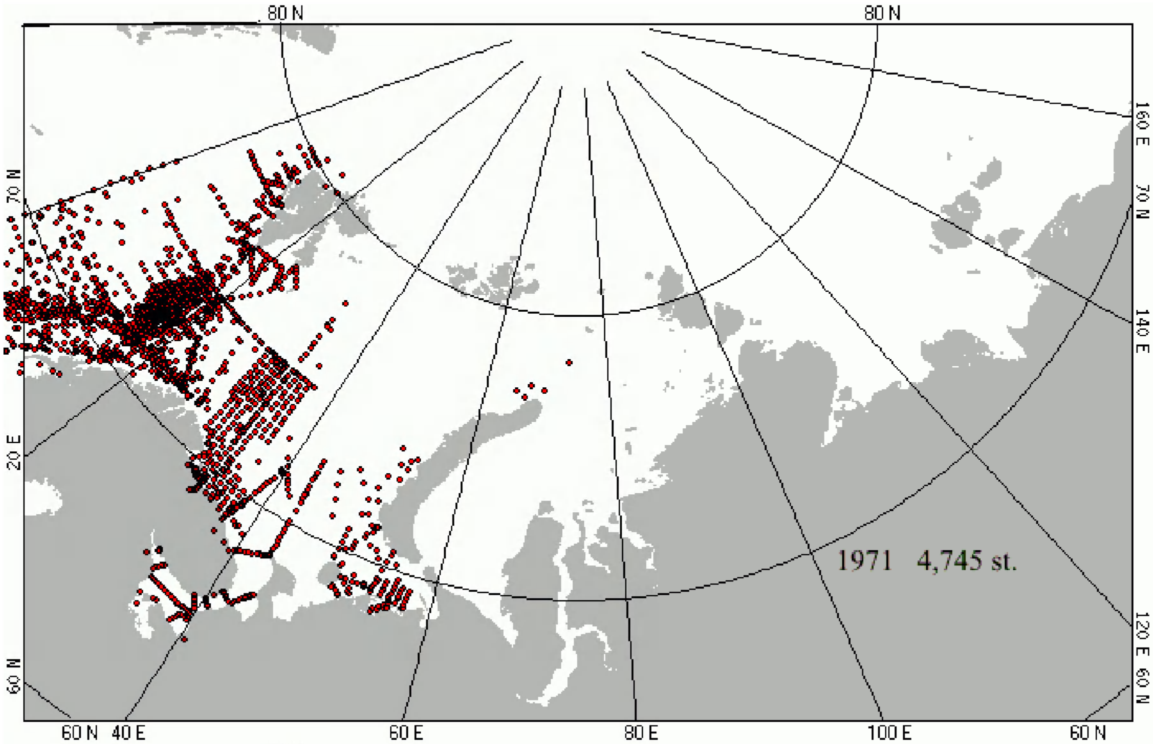
1970 5,685 st.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1971 4,745 st.
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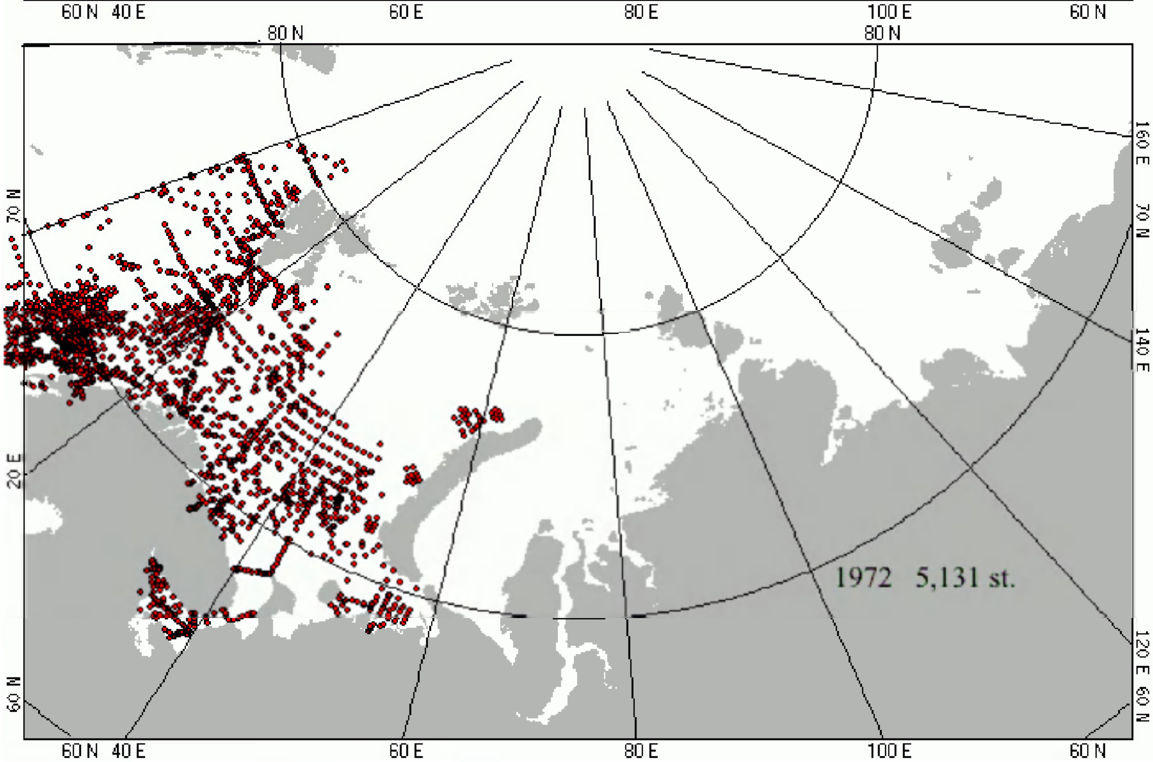
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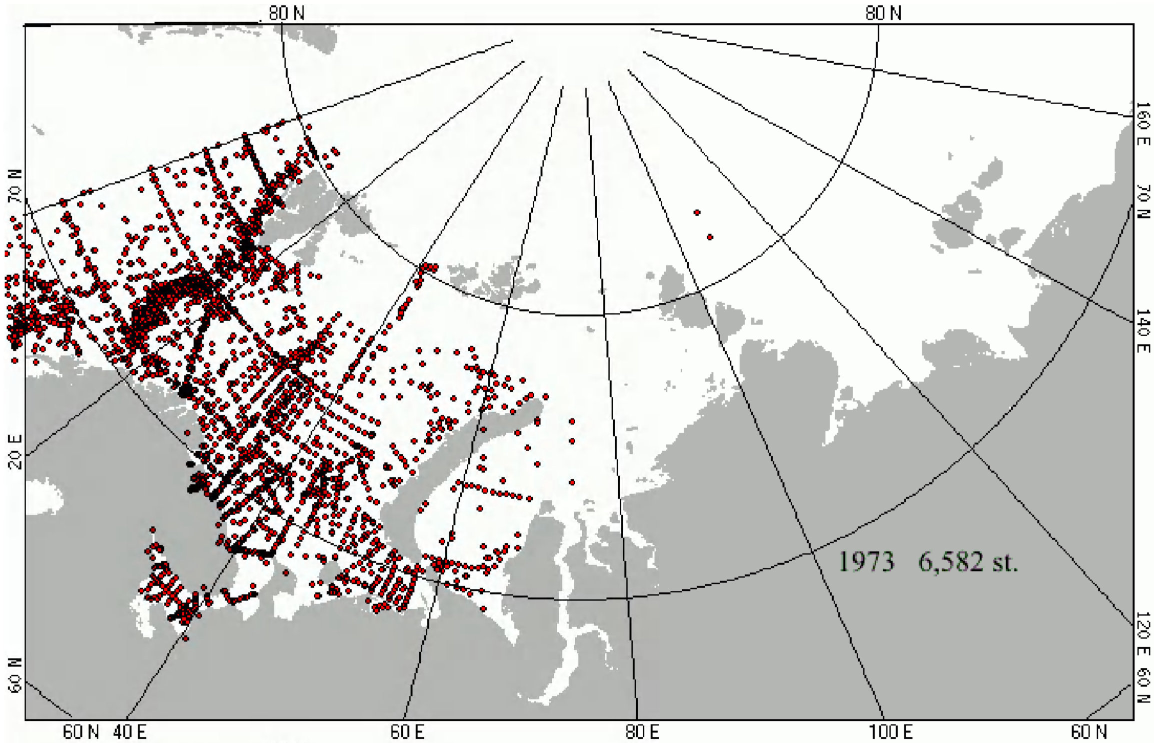
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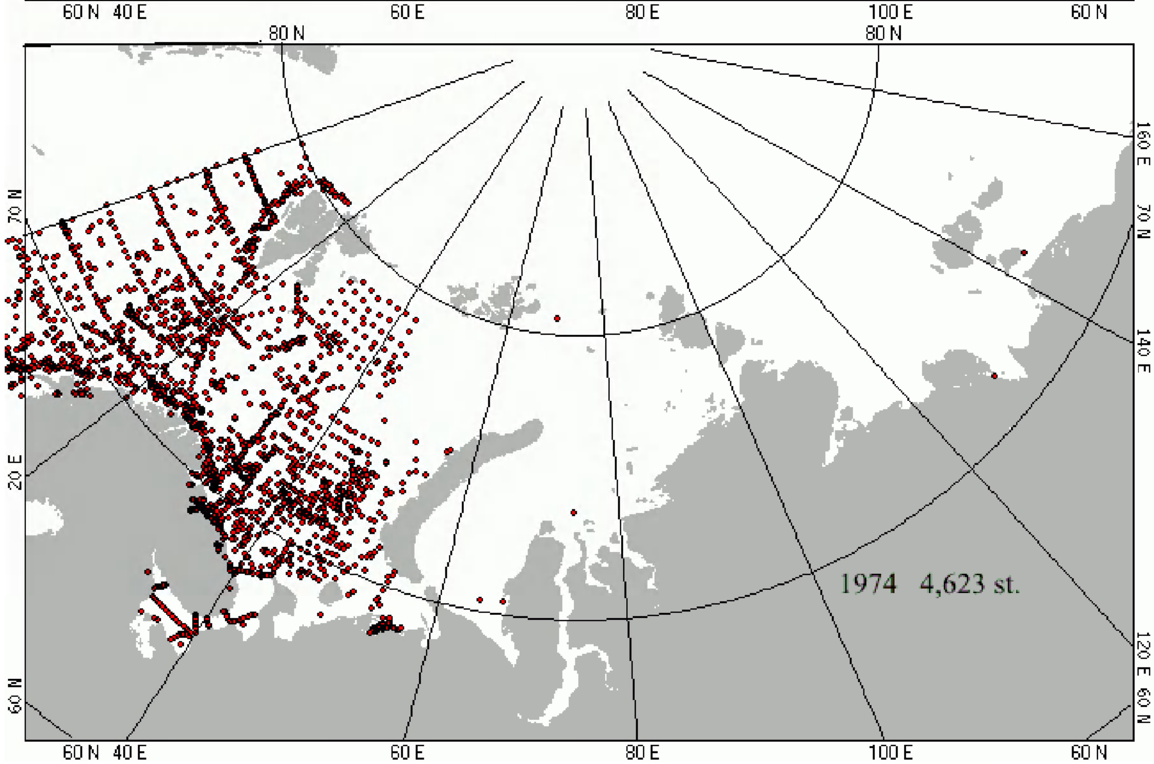
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1974 4,623 st.
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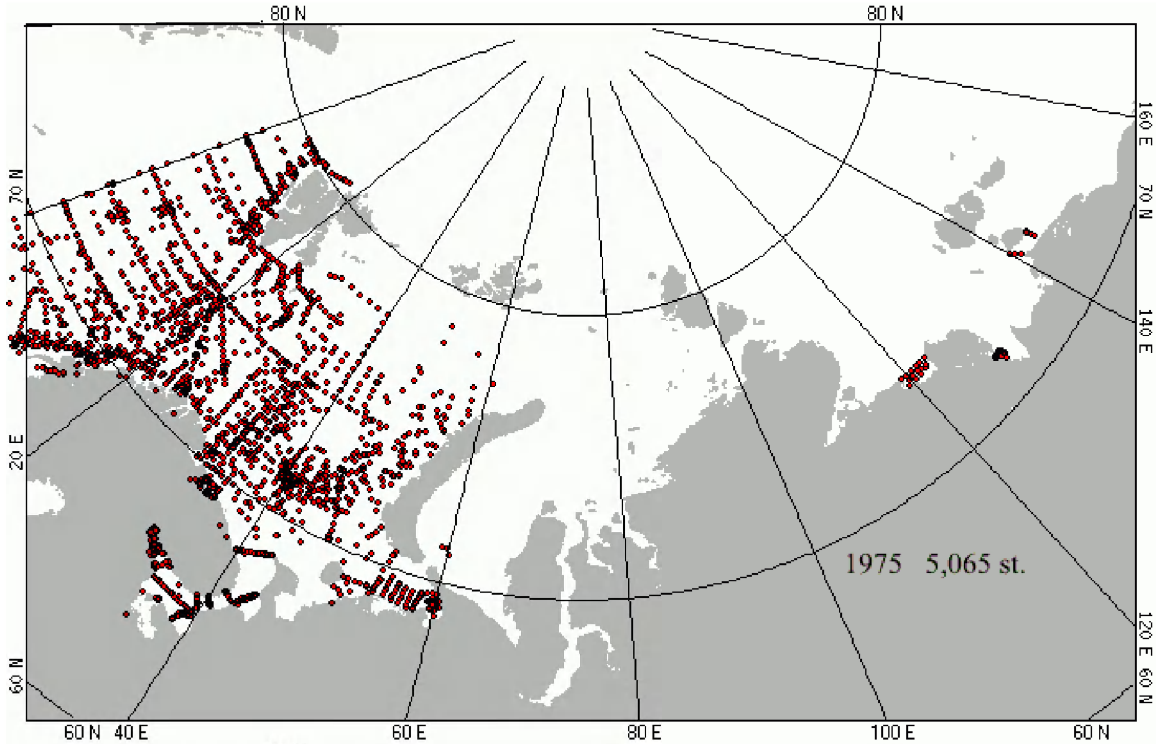
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1975 5,065 st.
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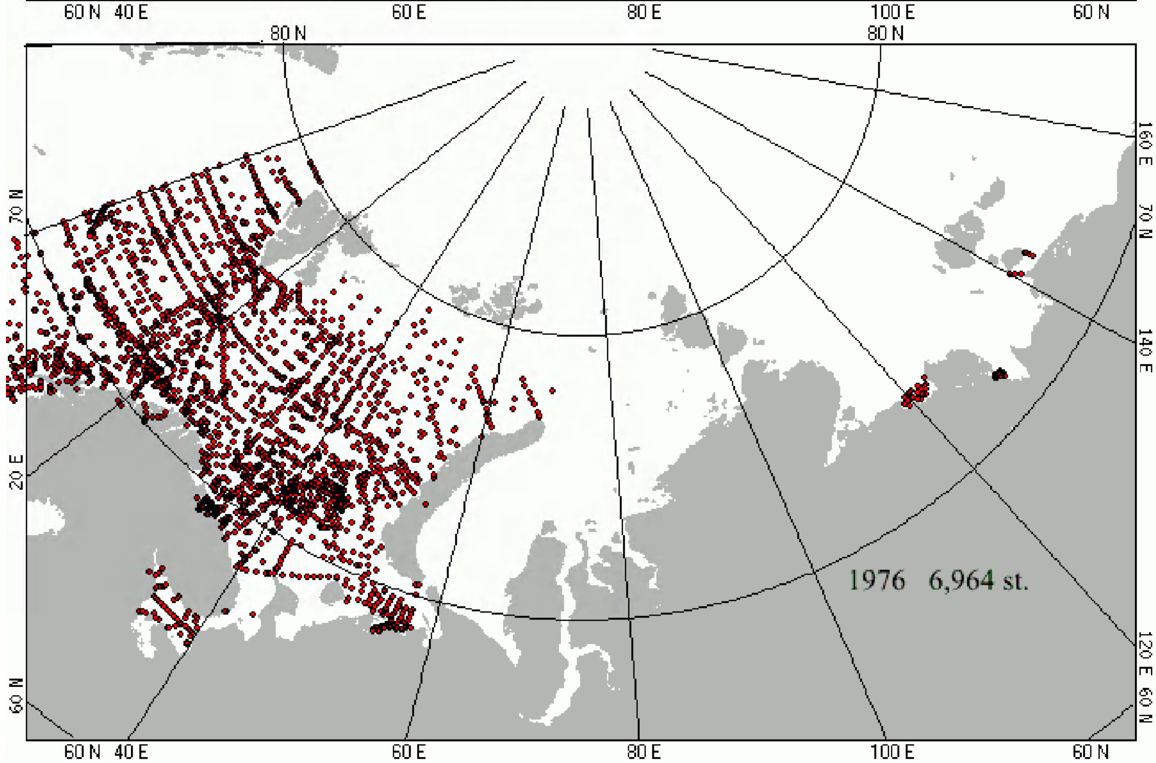
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1976 6,964 st.
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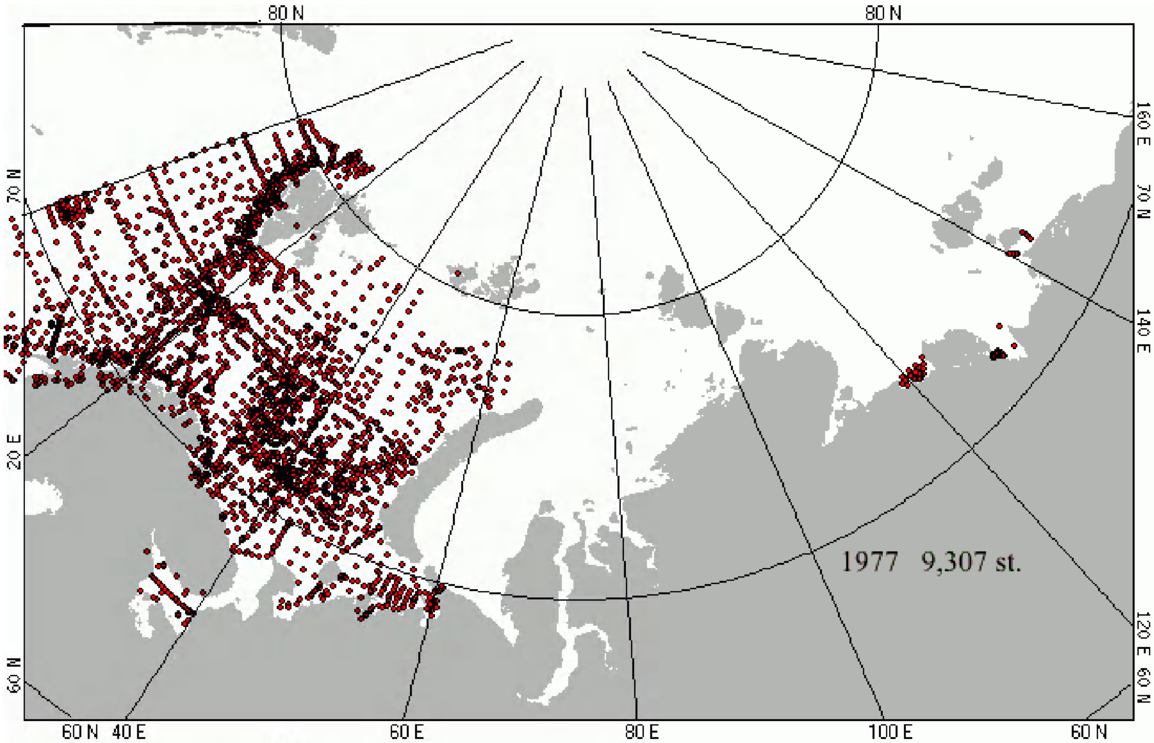
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1977 9,307 st.
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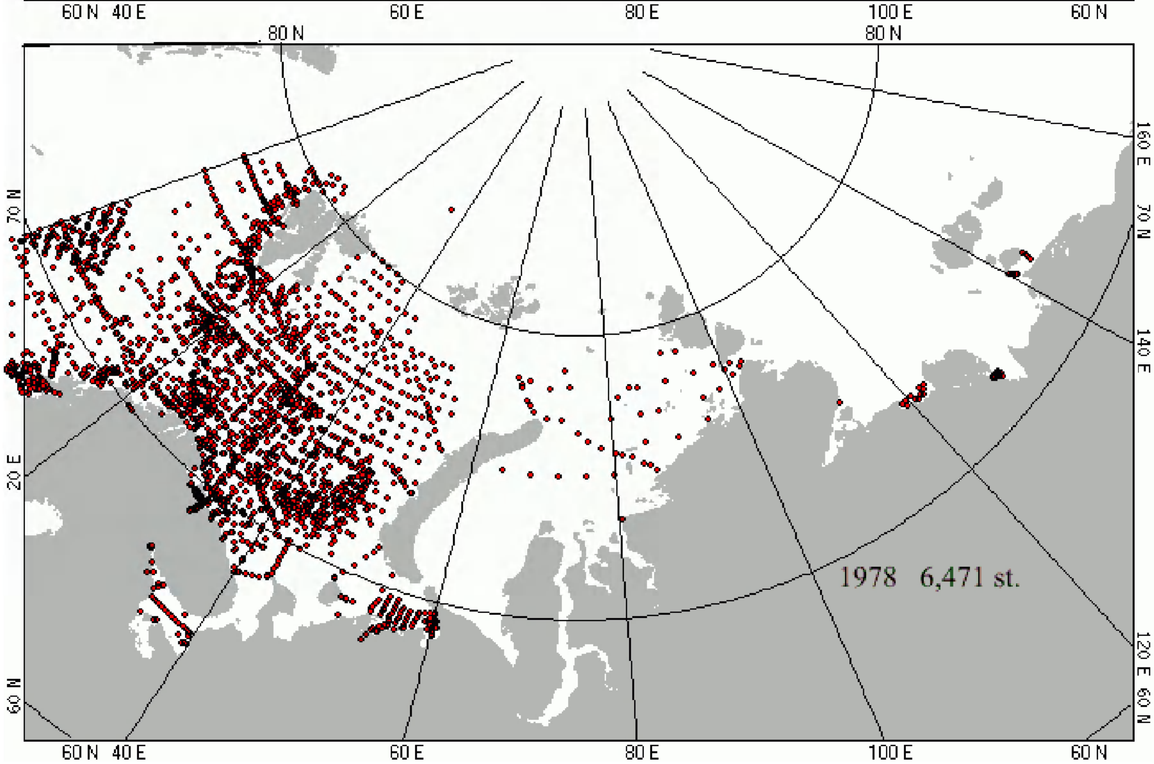
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1978 6,471 st.
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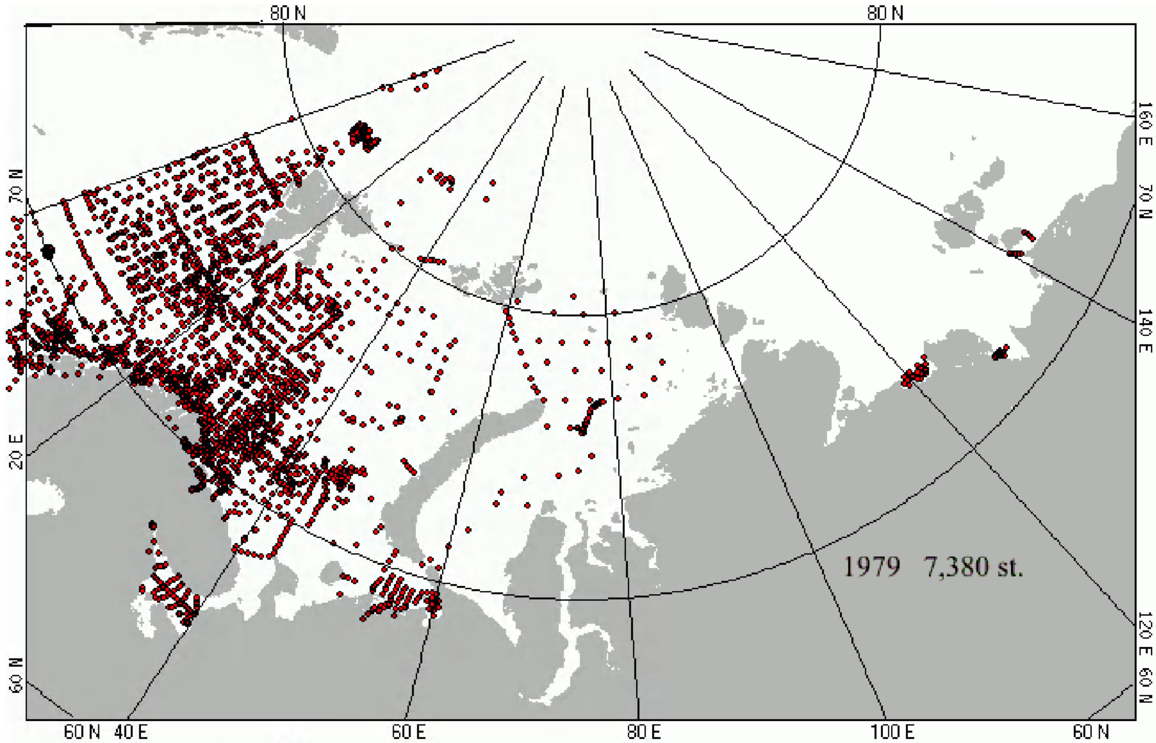
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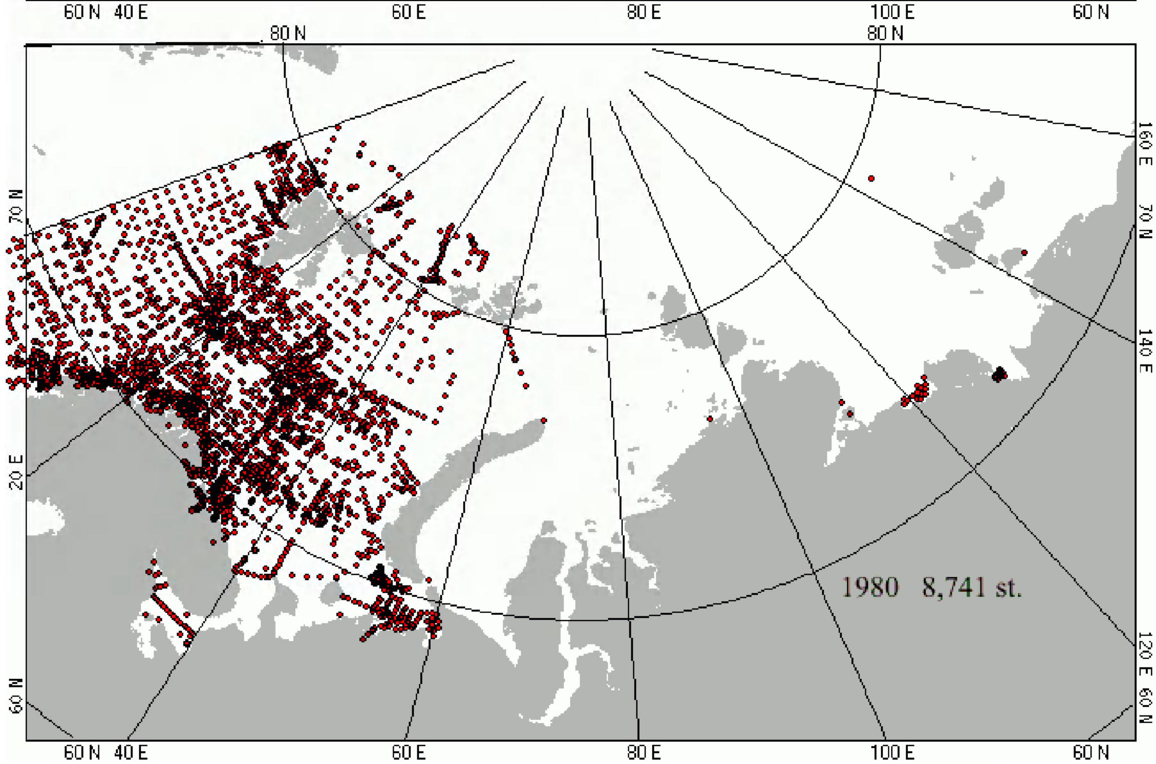
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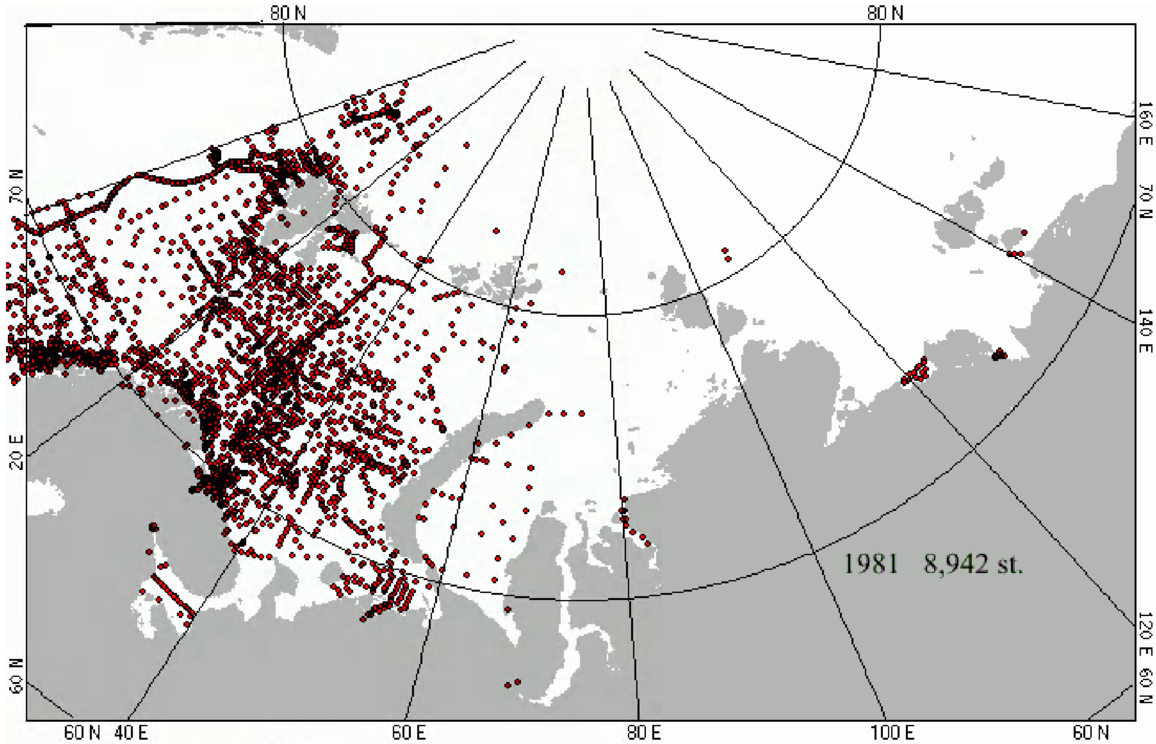
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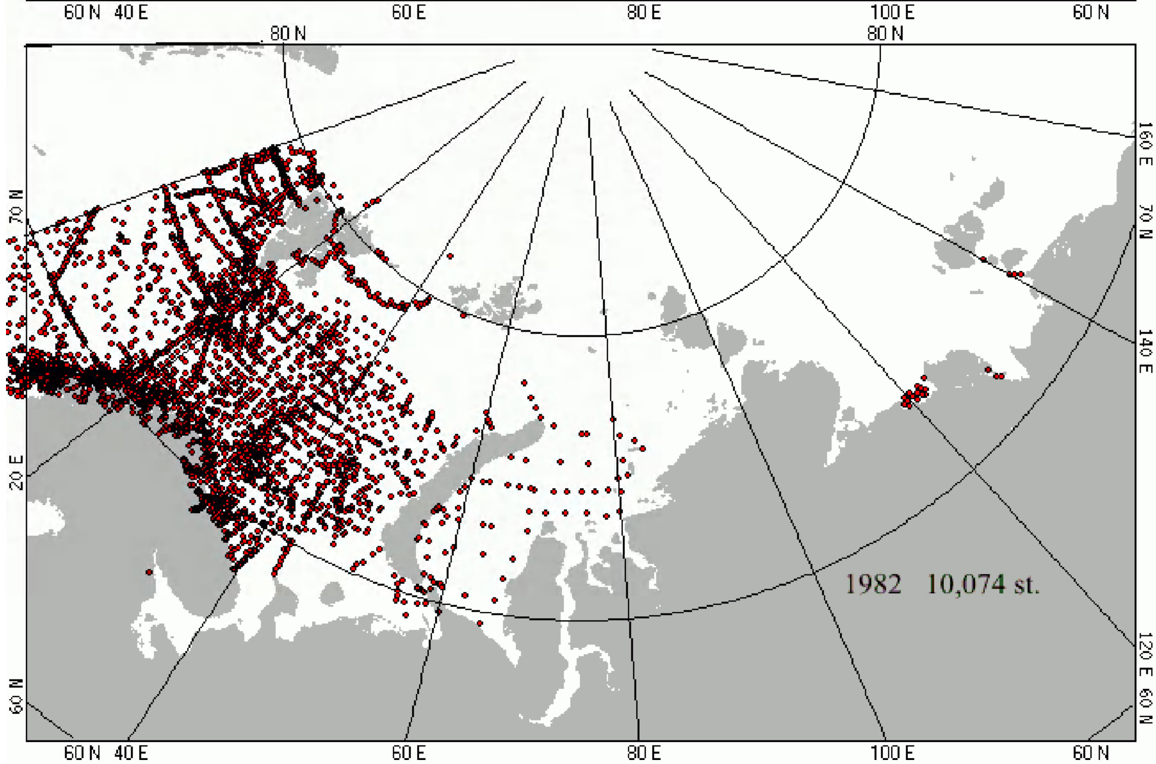
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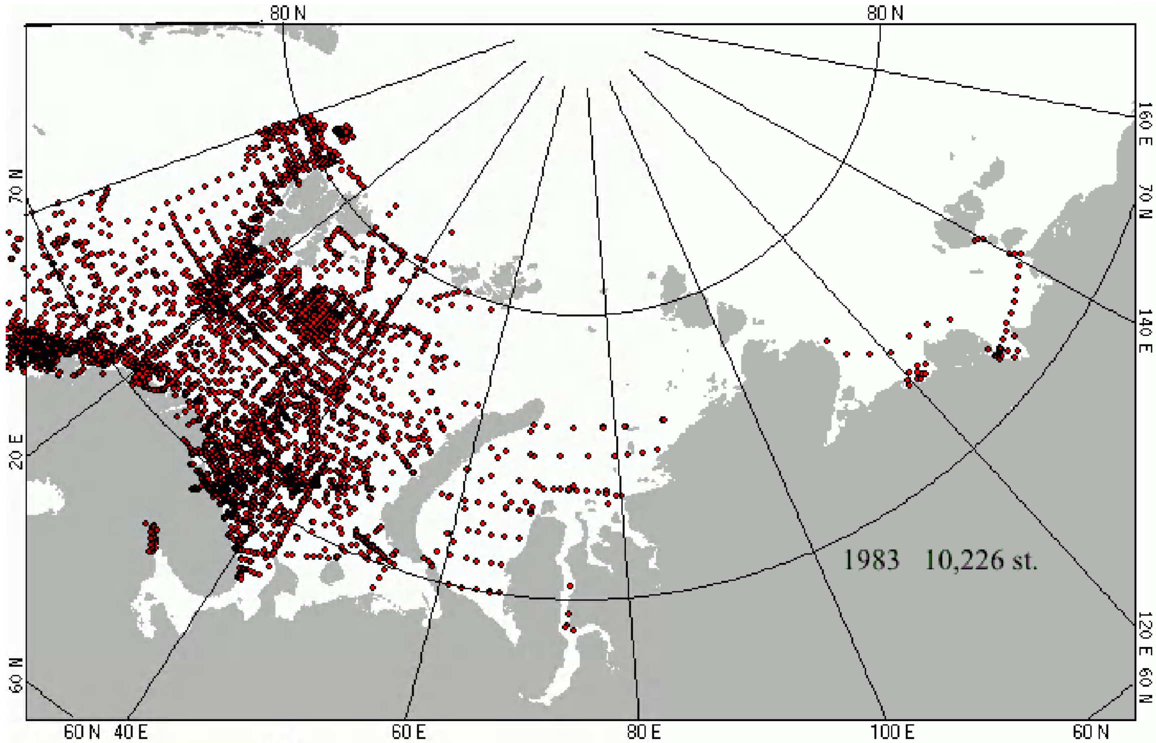
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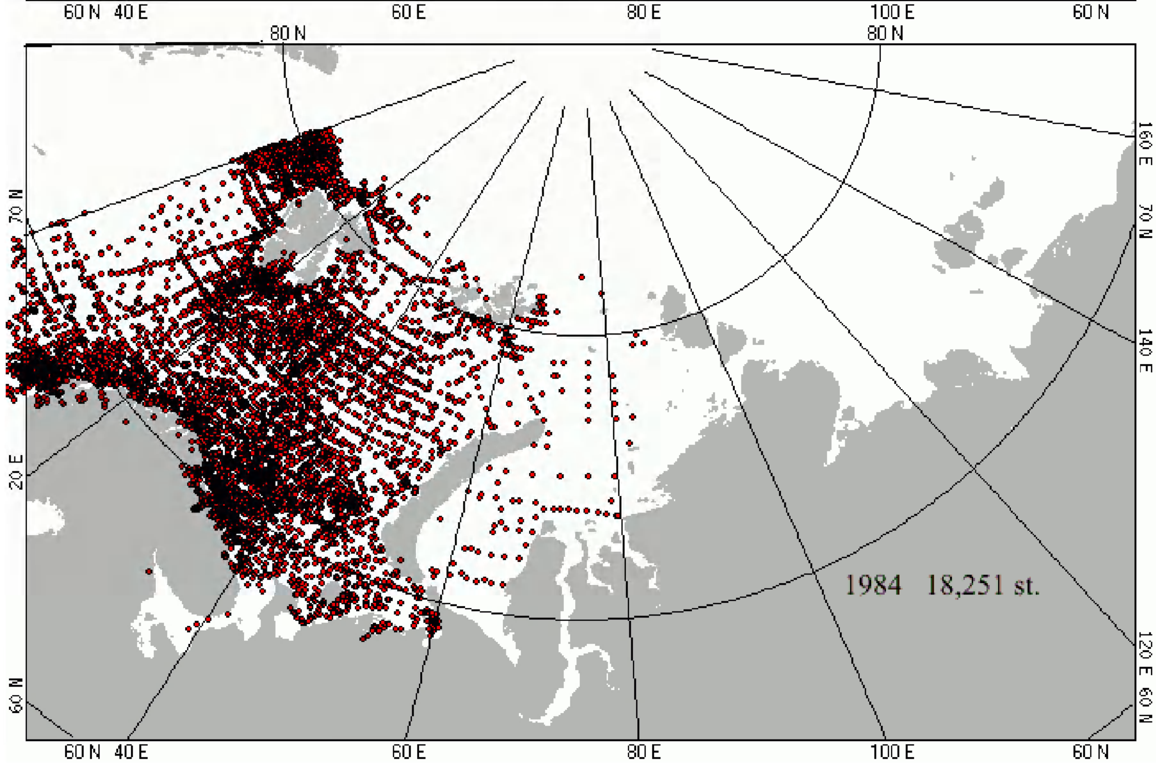
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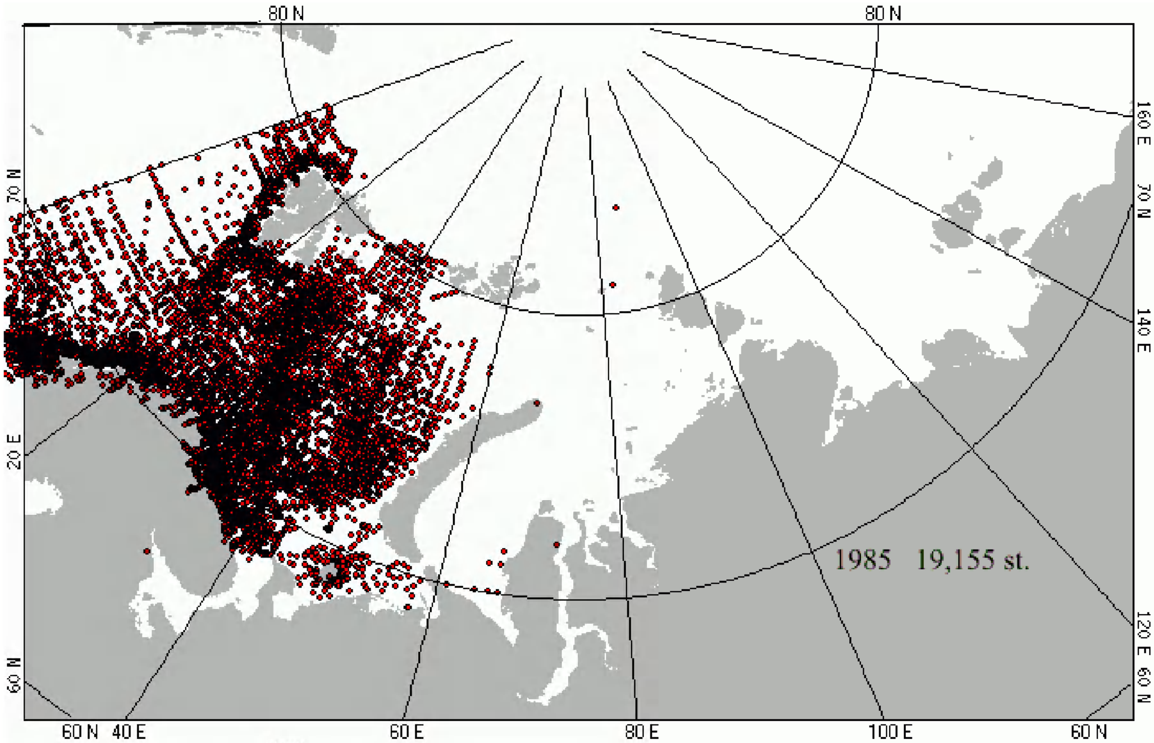
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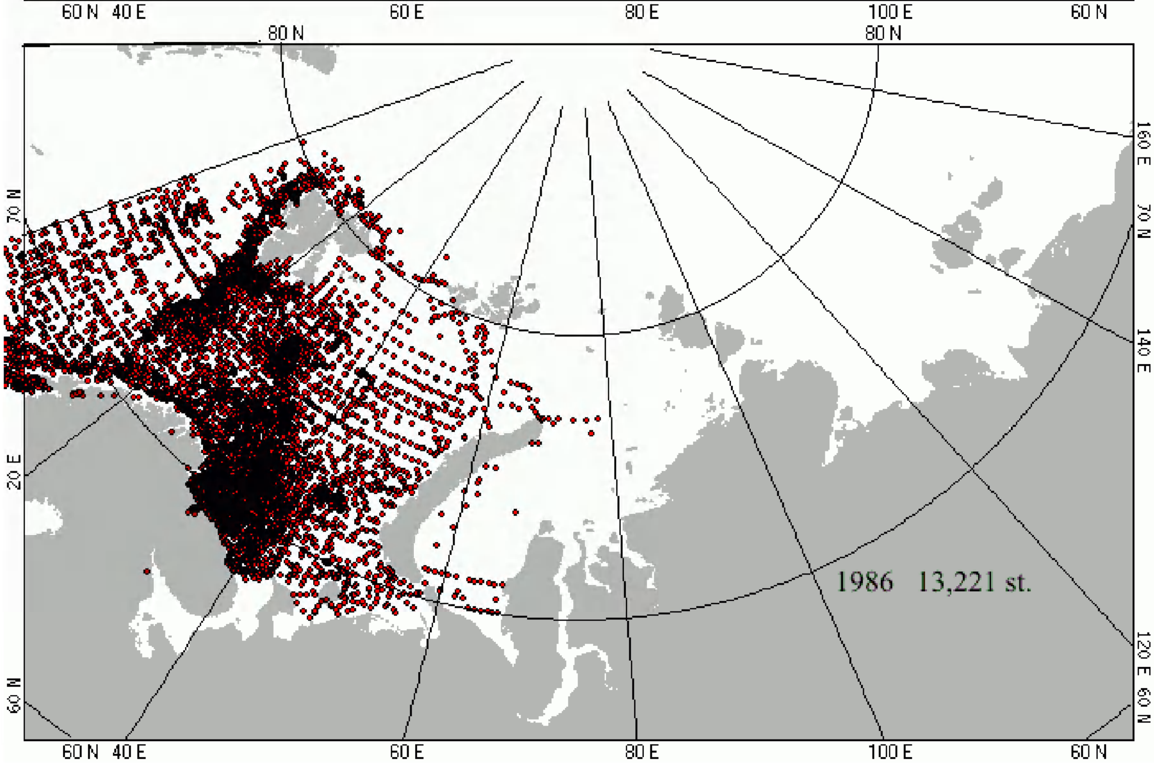
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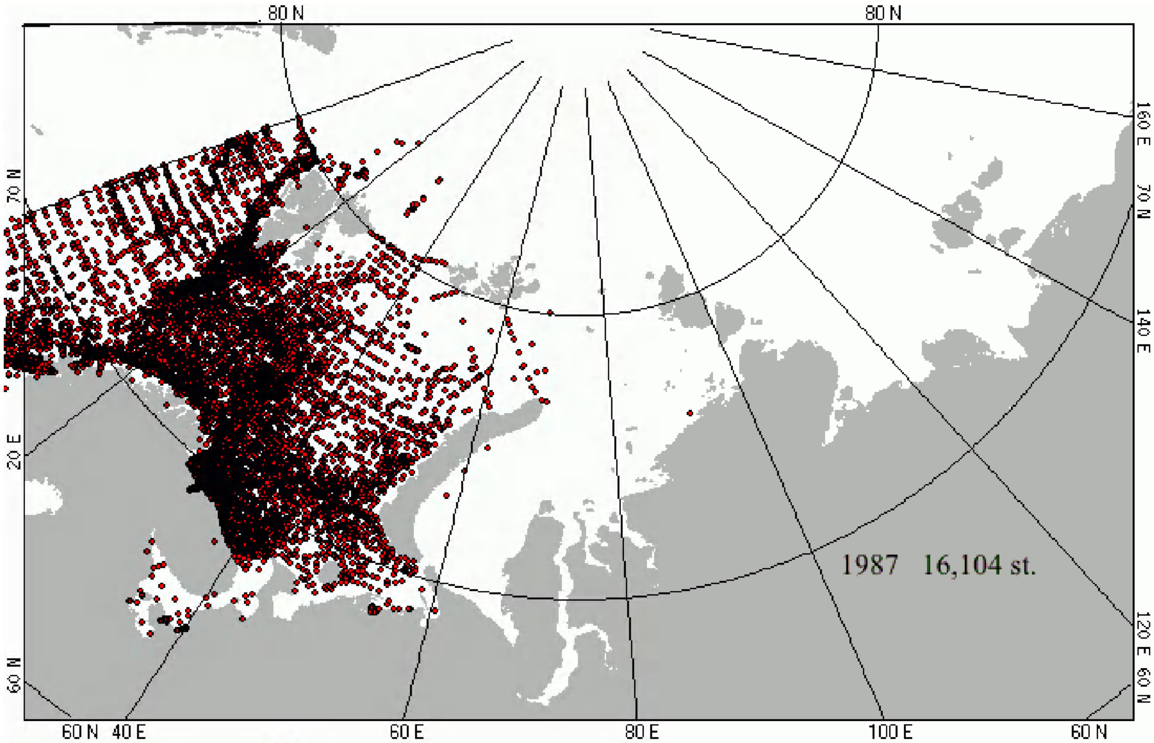
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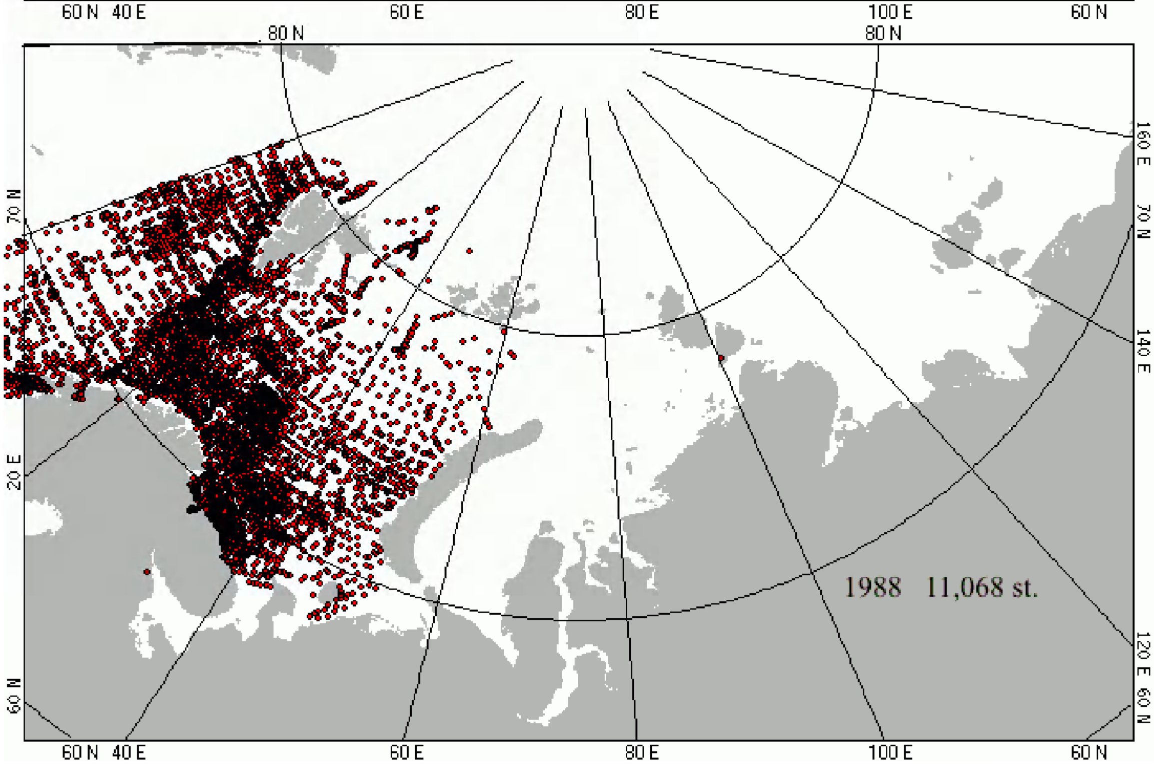
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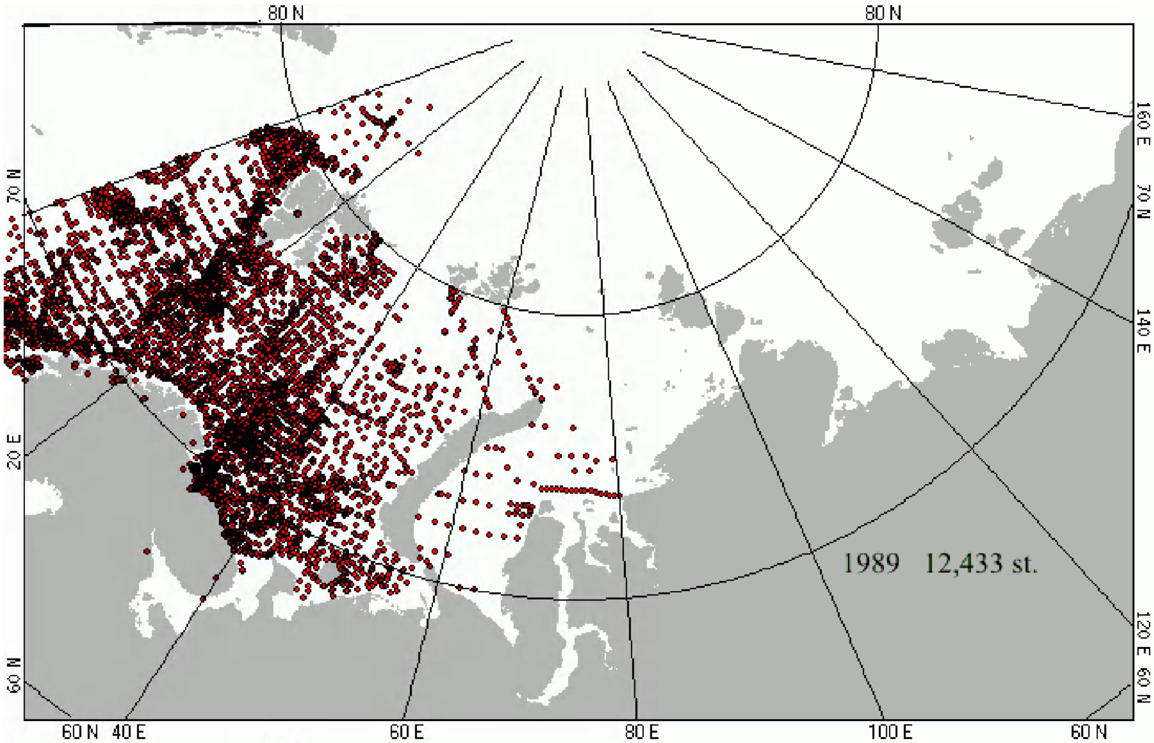
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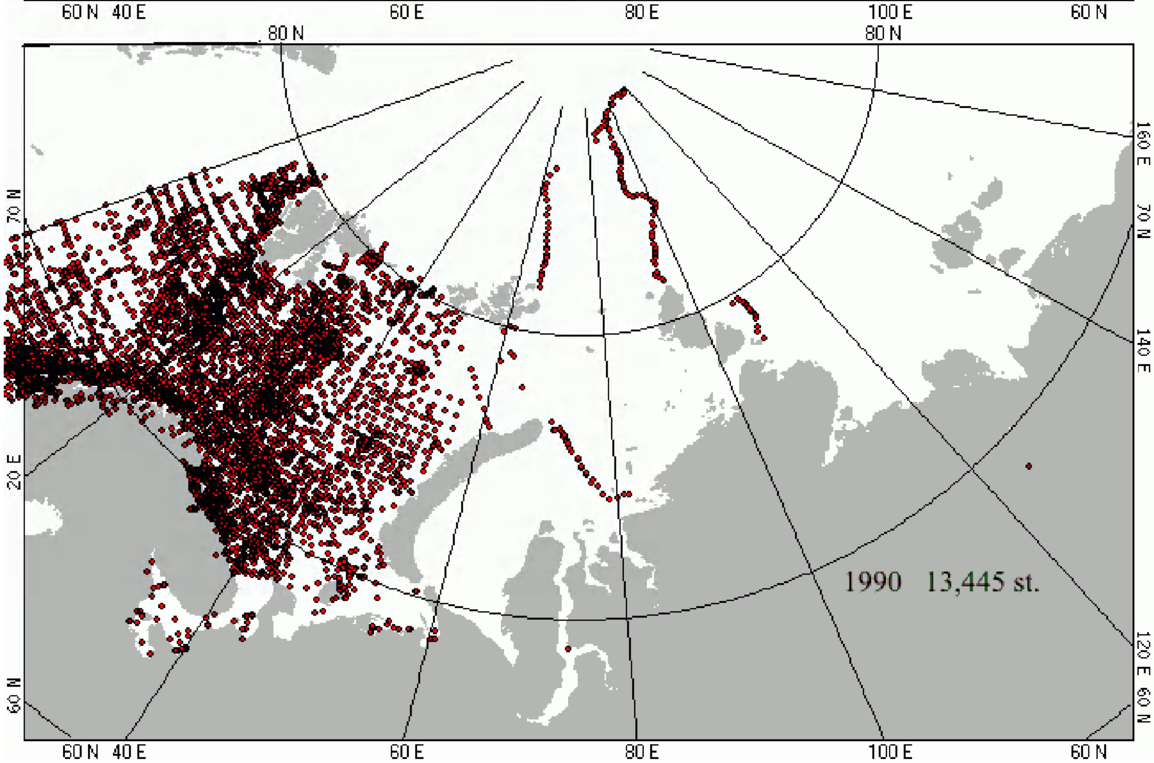
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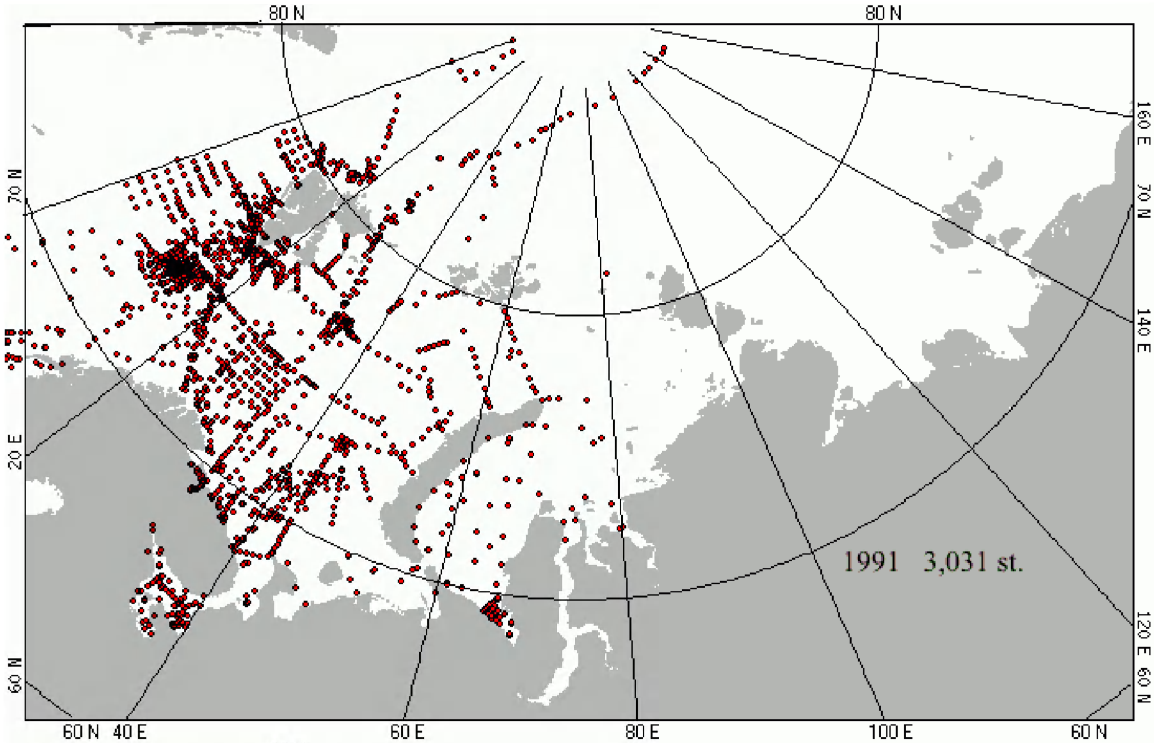
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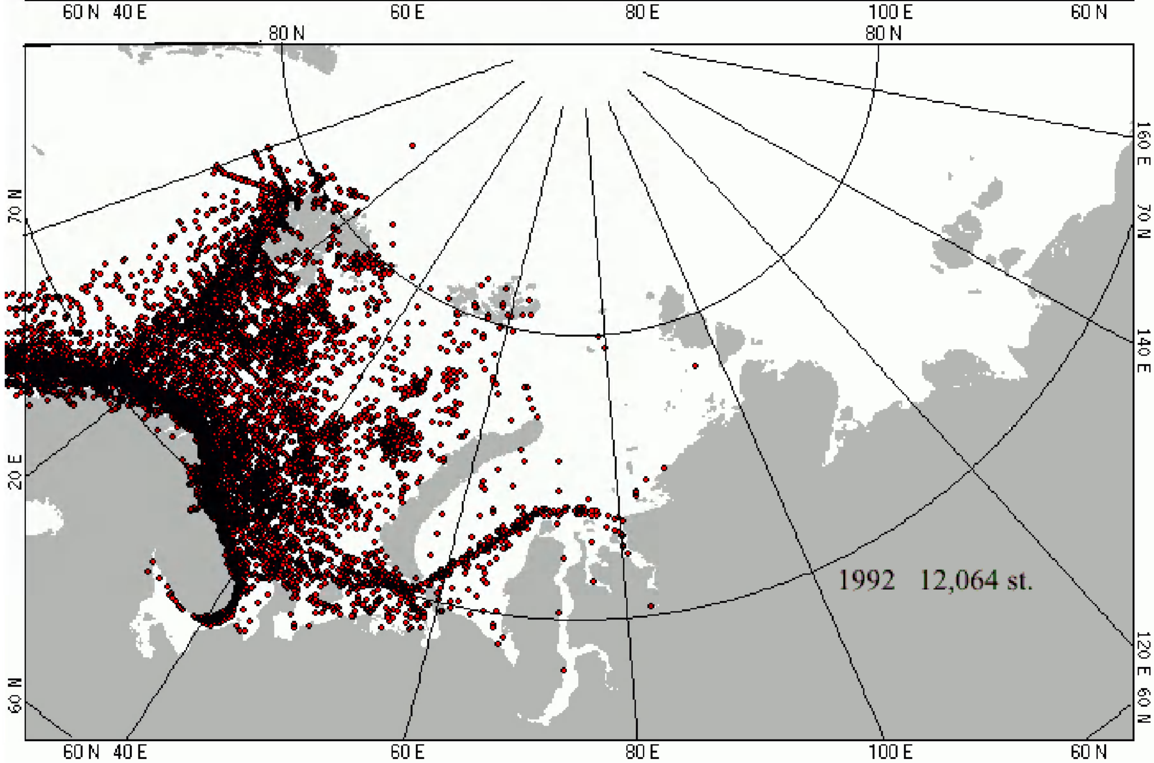
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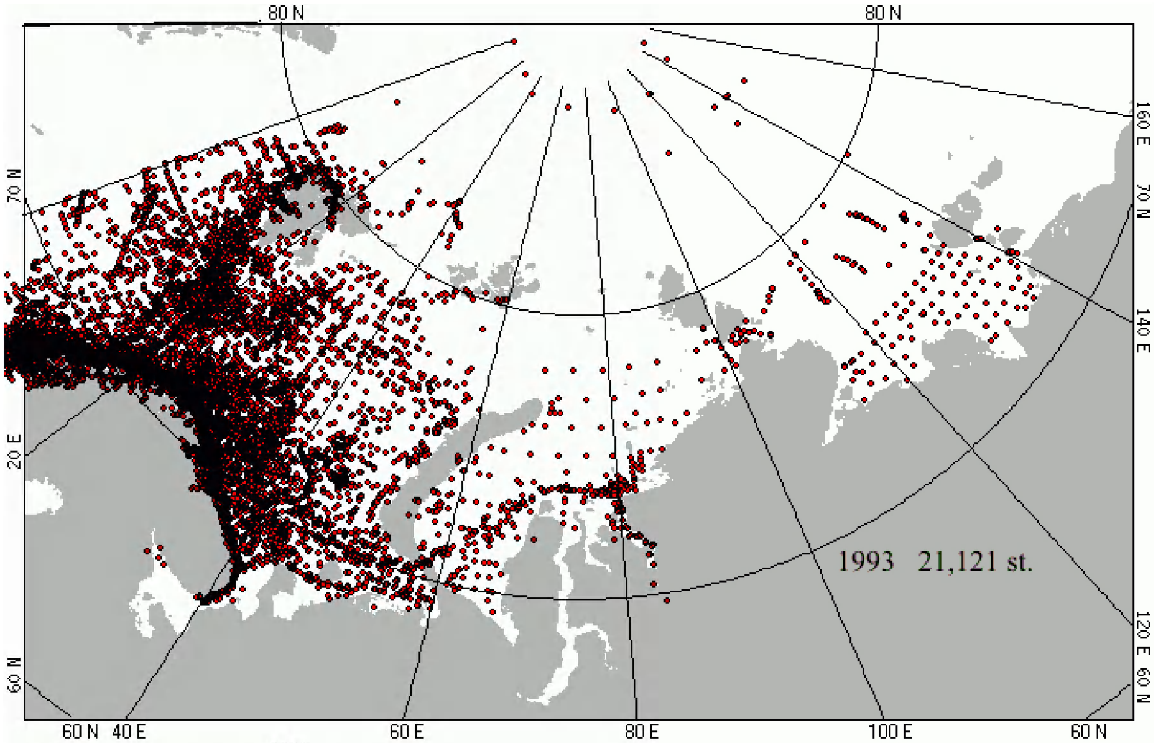
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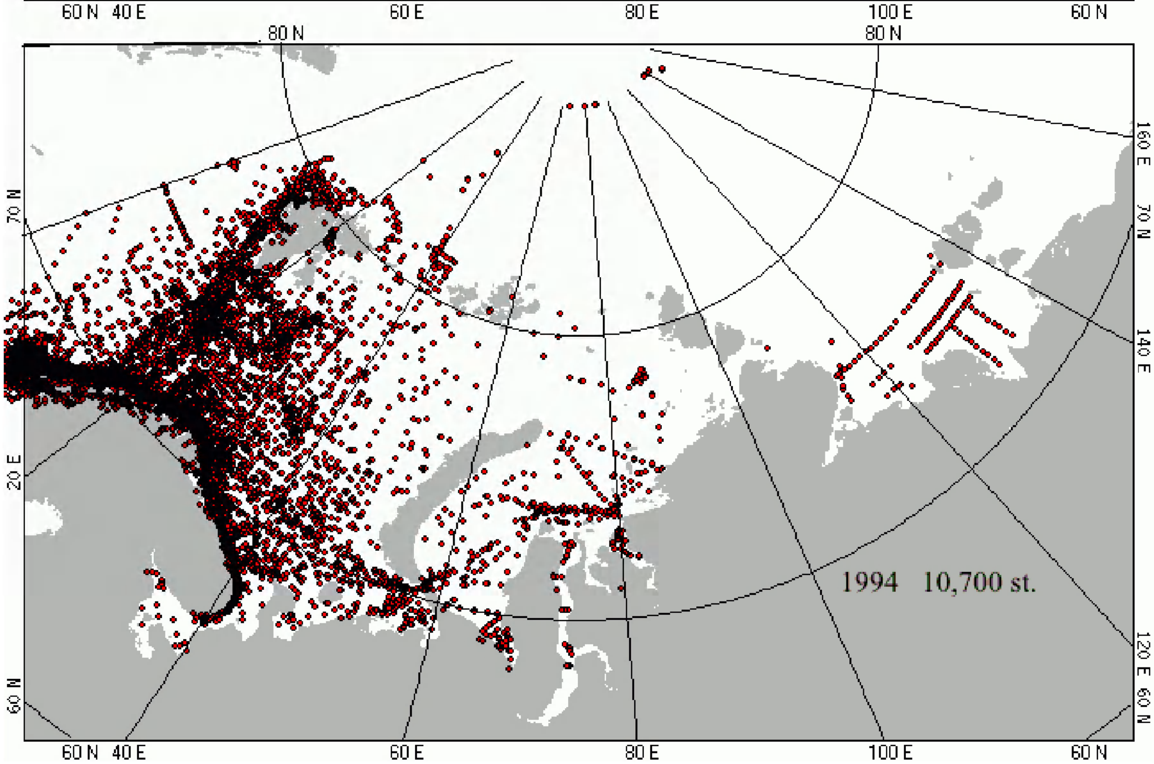
1993 21,121 st.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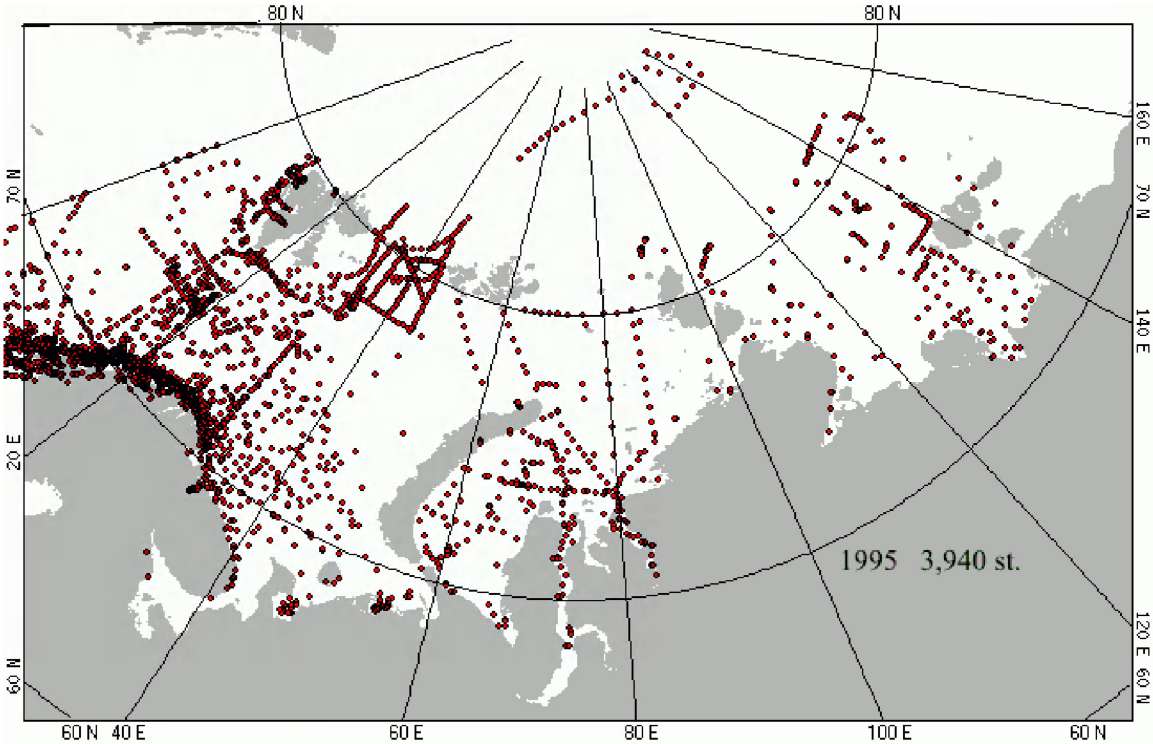
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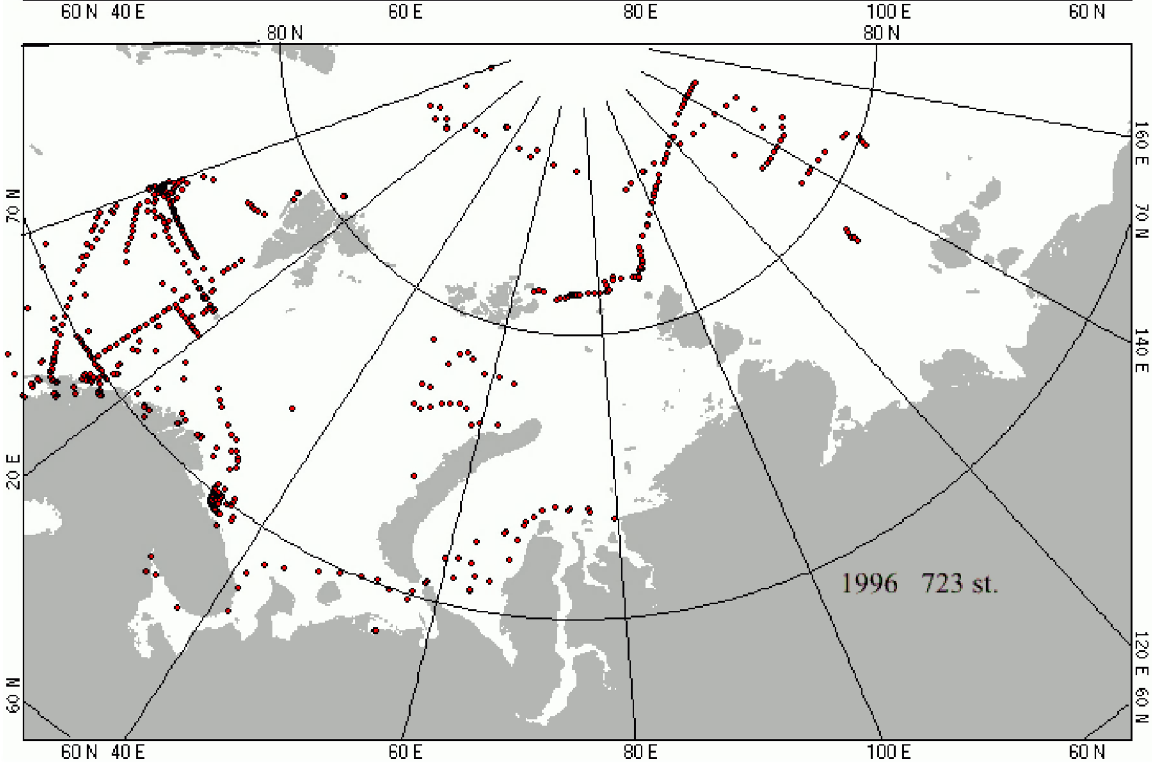
1995 3,940 st.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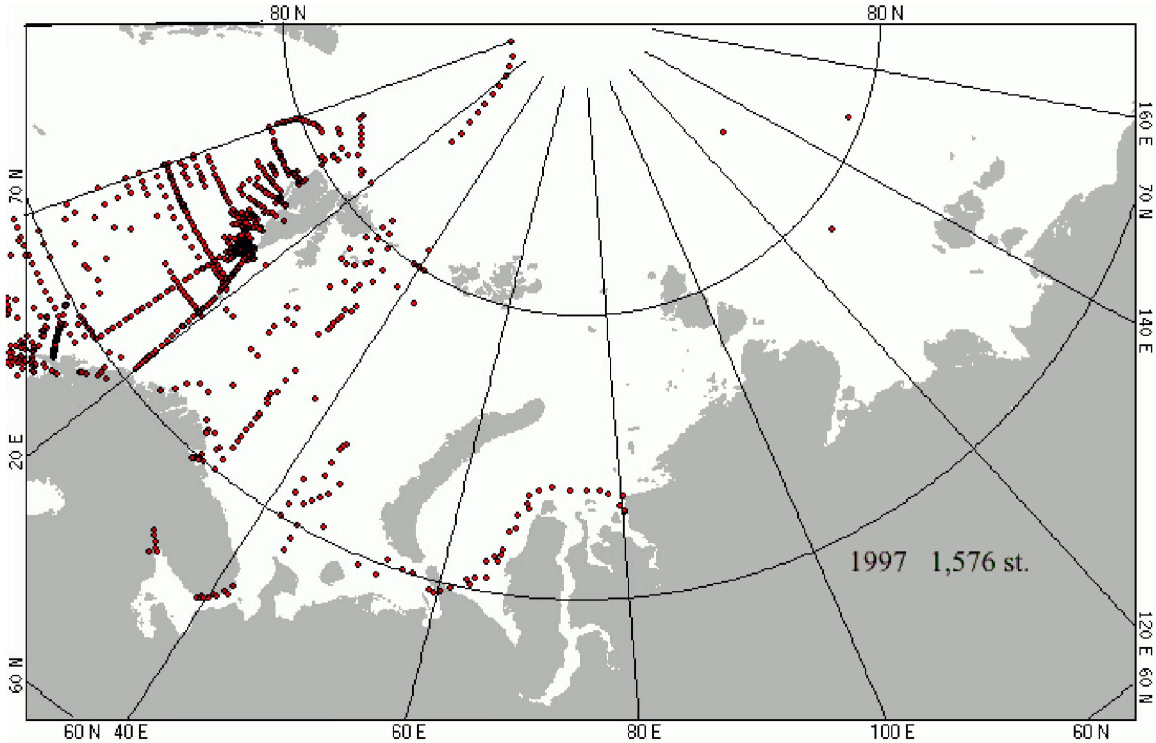
1996 723 st.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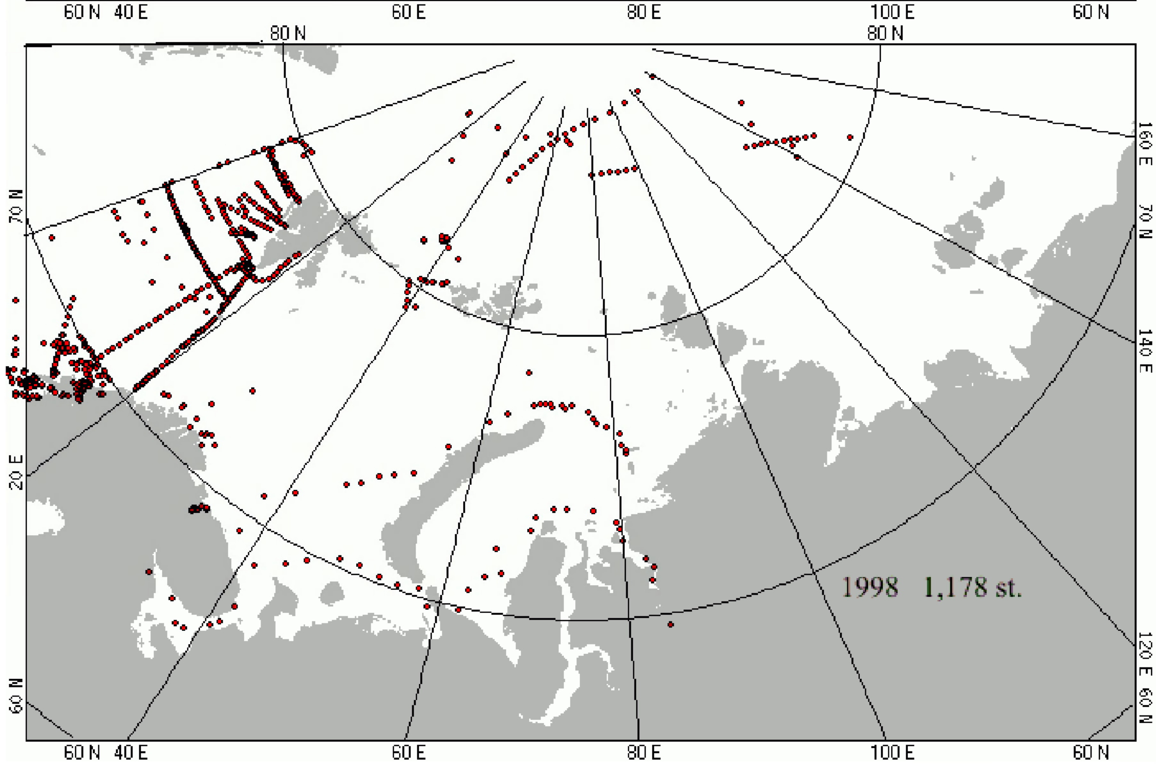
1997 1,576 st.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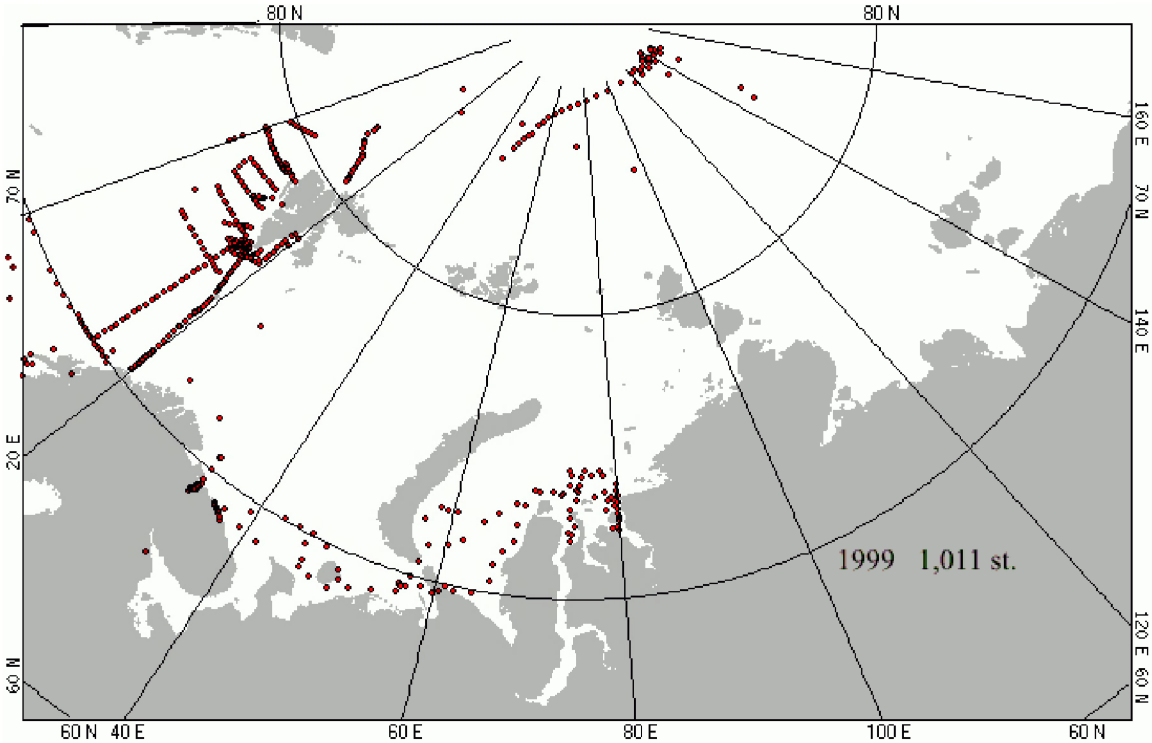
1998 1,178 st.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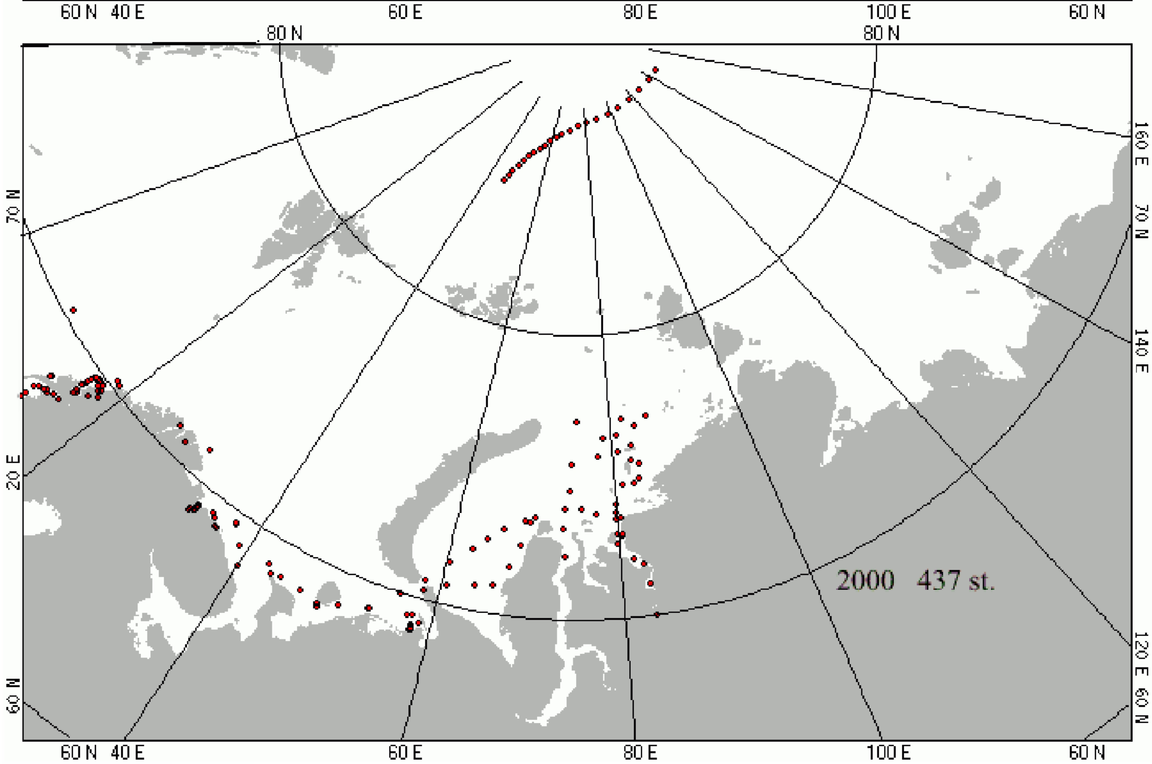
60 N
1999 1,011 st.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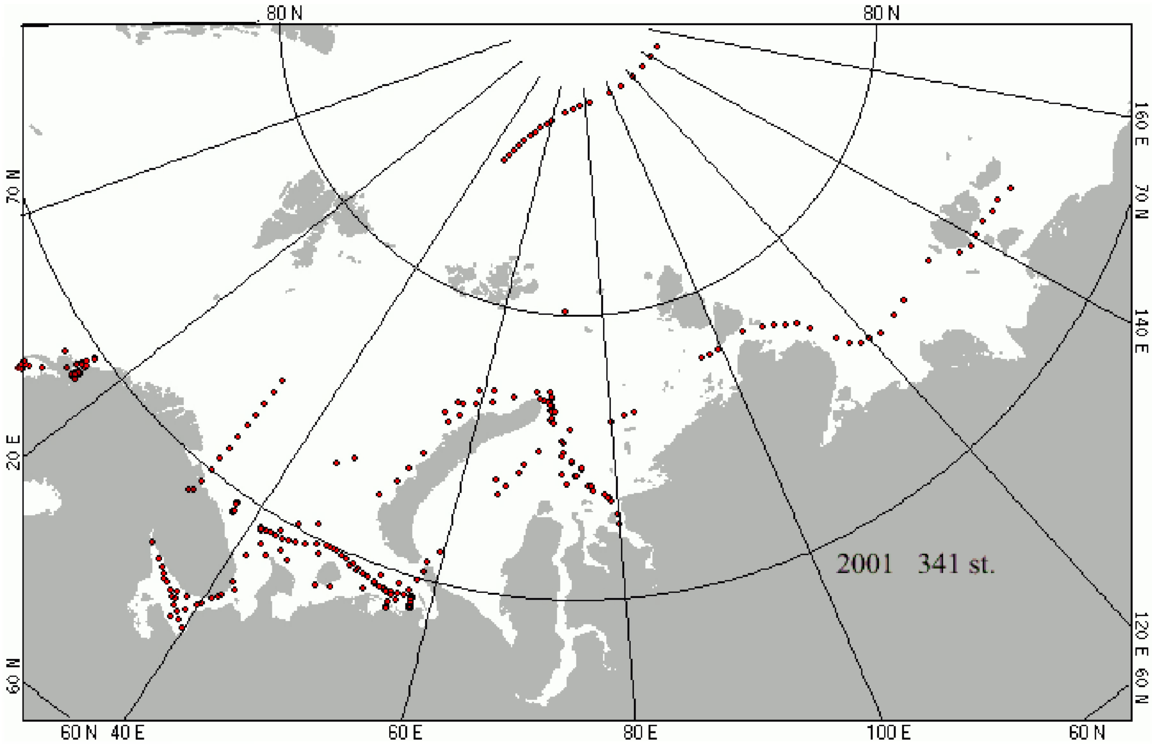
2000 437 st.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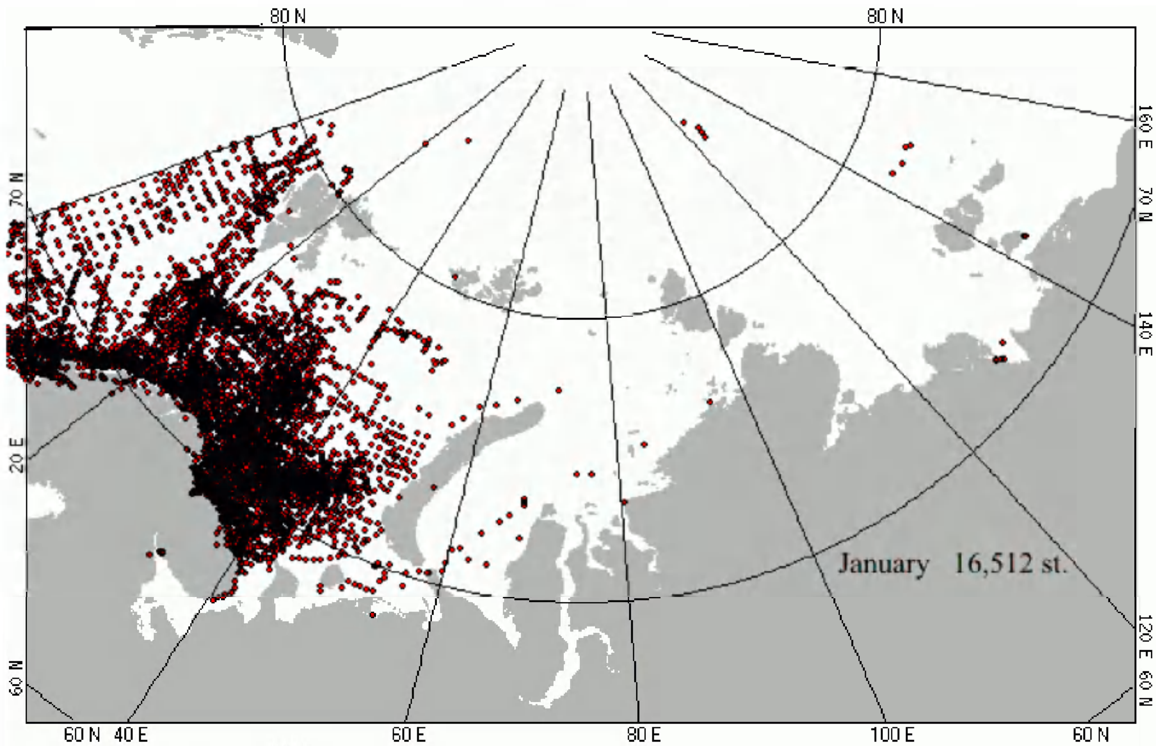
2001 341 st.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January 16,512 st.
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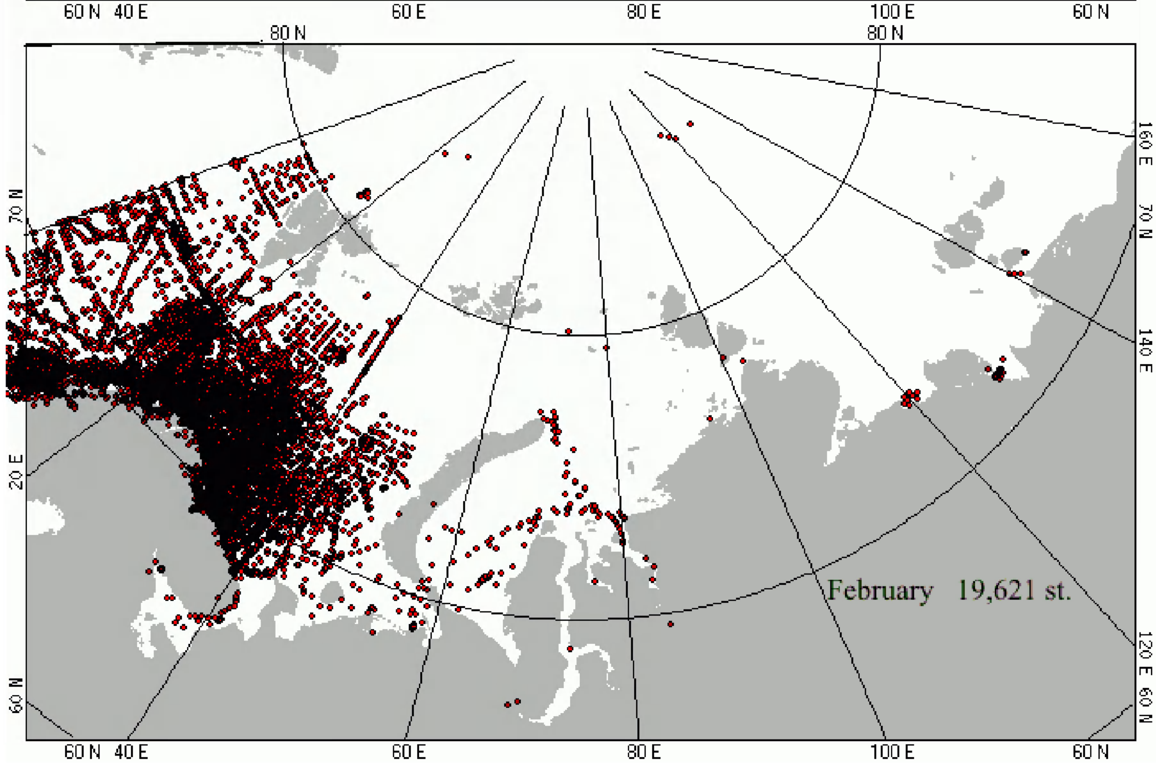
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February 19,621 st.
120 E
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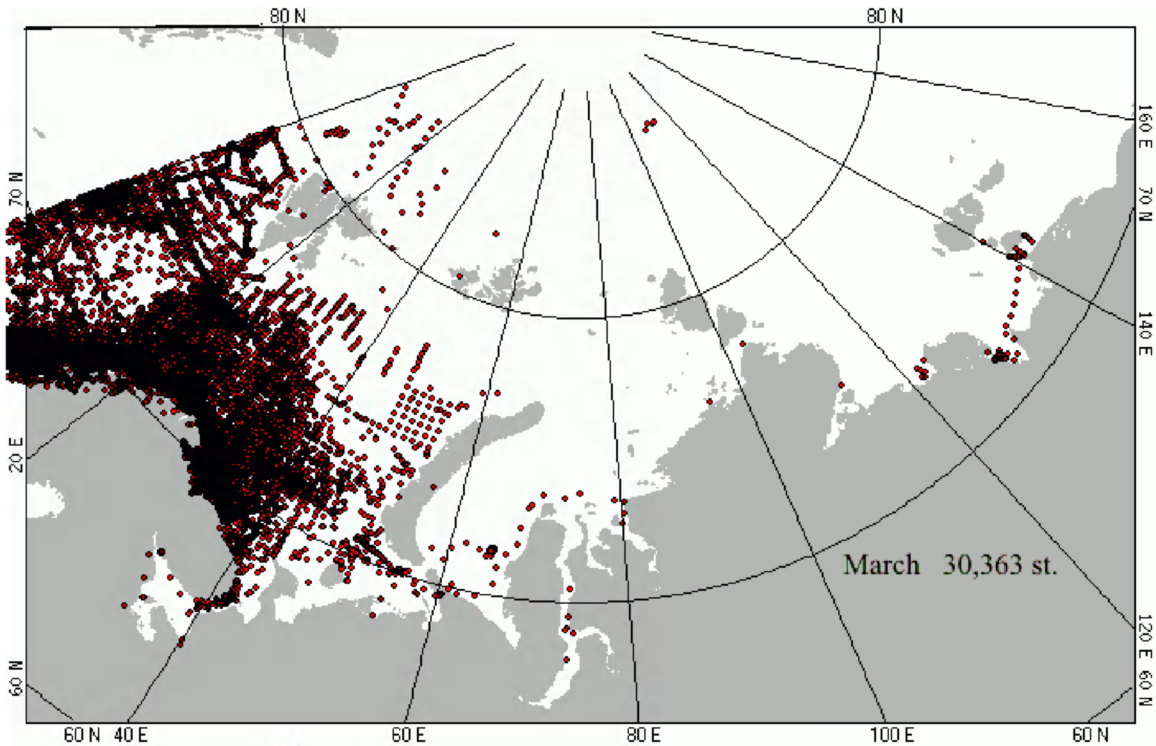
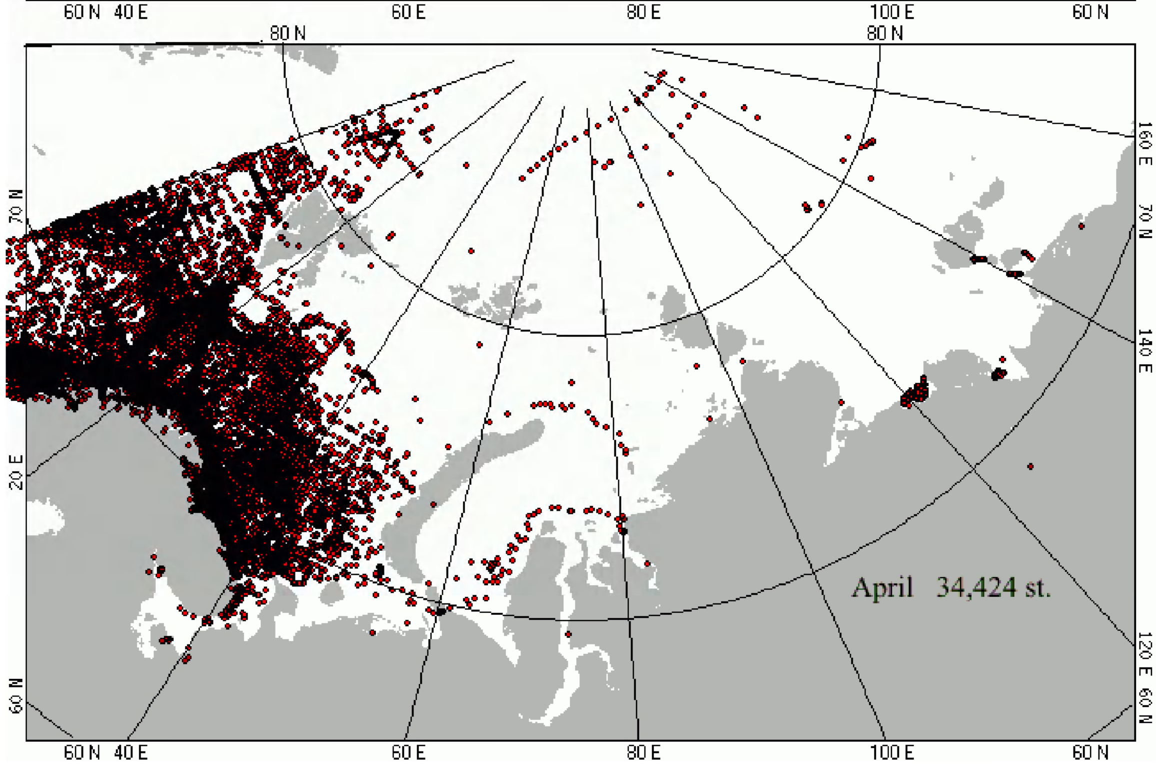
60 N
60 N
40 E
60 E
80 E
100 E
60 N


80 N
80 N
160 E
70 N
70 N
140 E
20 E
March 30,363 st.
120 E
60 N
60 N
60 N
40 E
60 E
80 E
100 E
60 N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80 N
160 E
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140 E
20 E
April 34,424 st.
120 E
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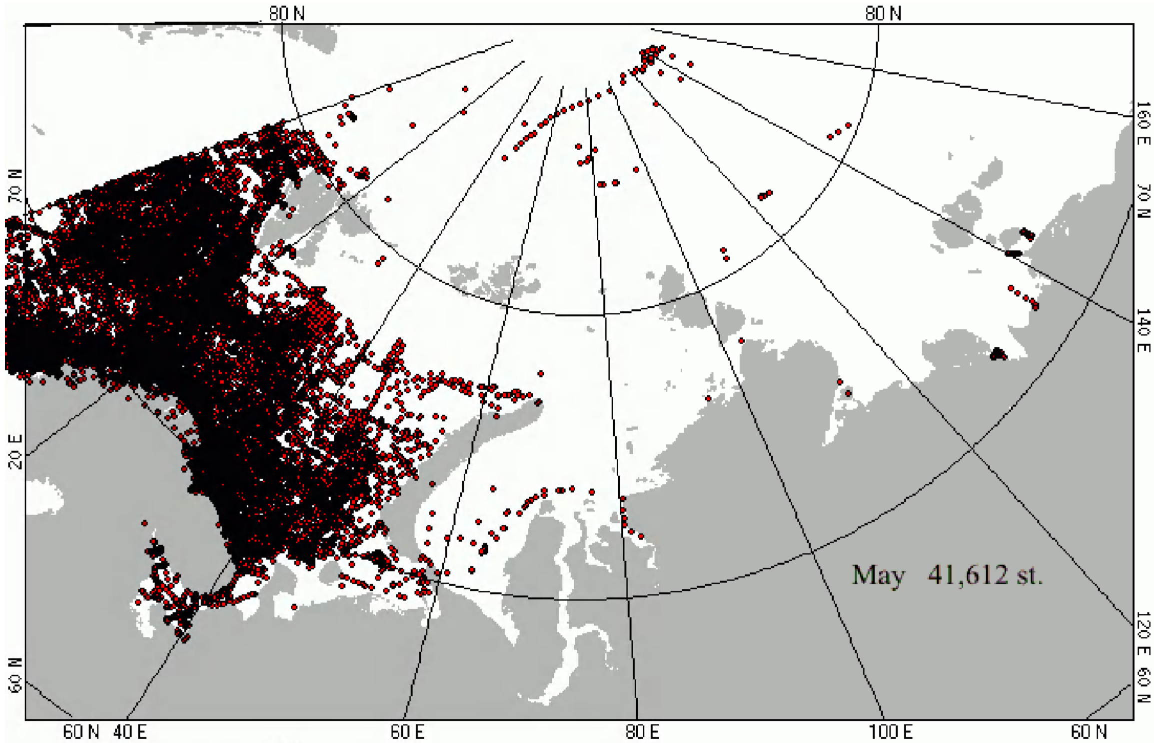
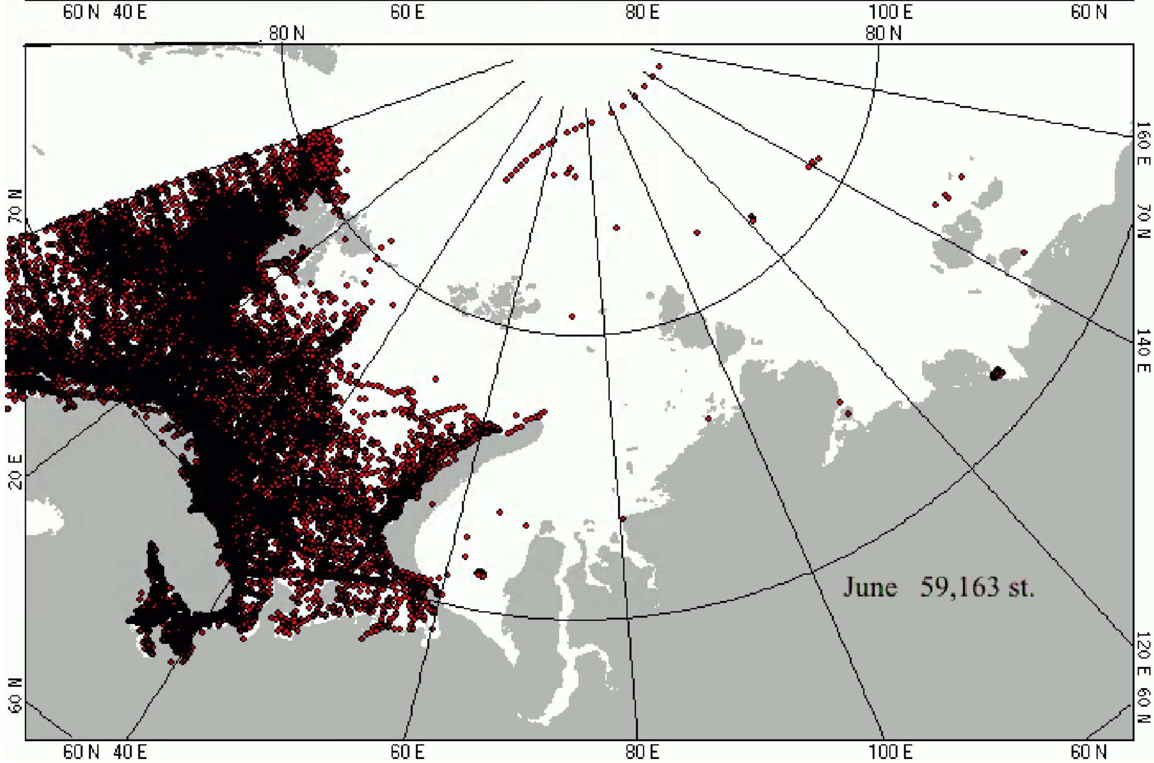
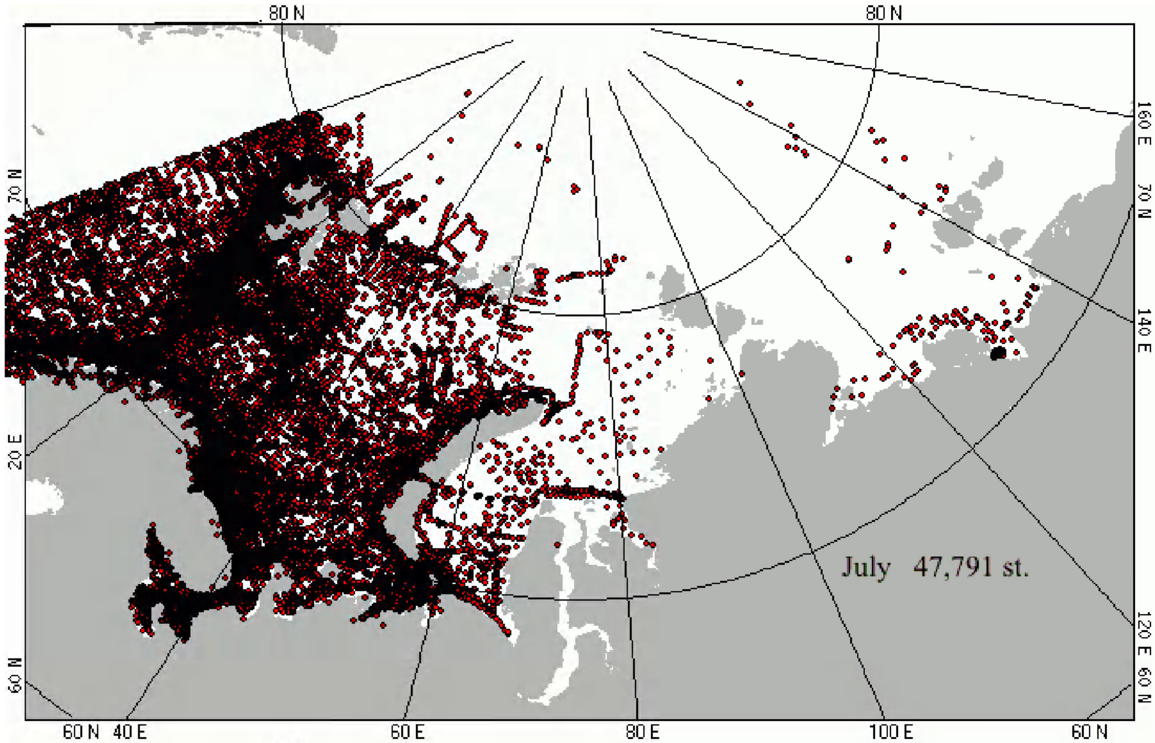
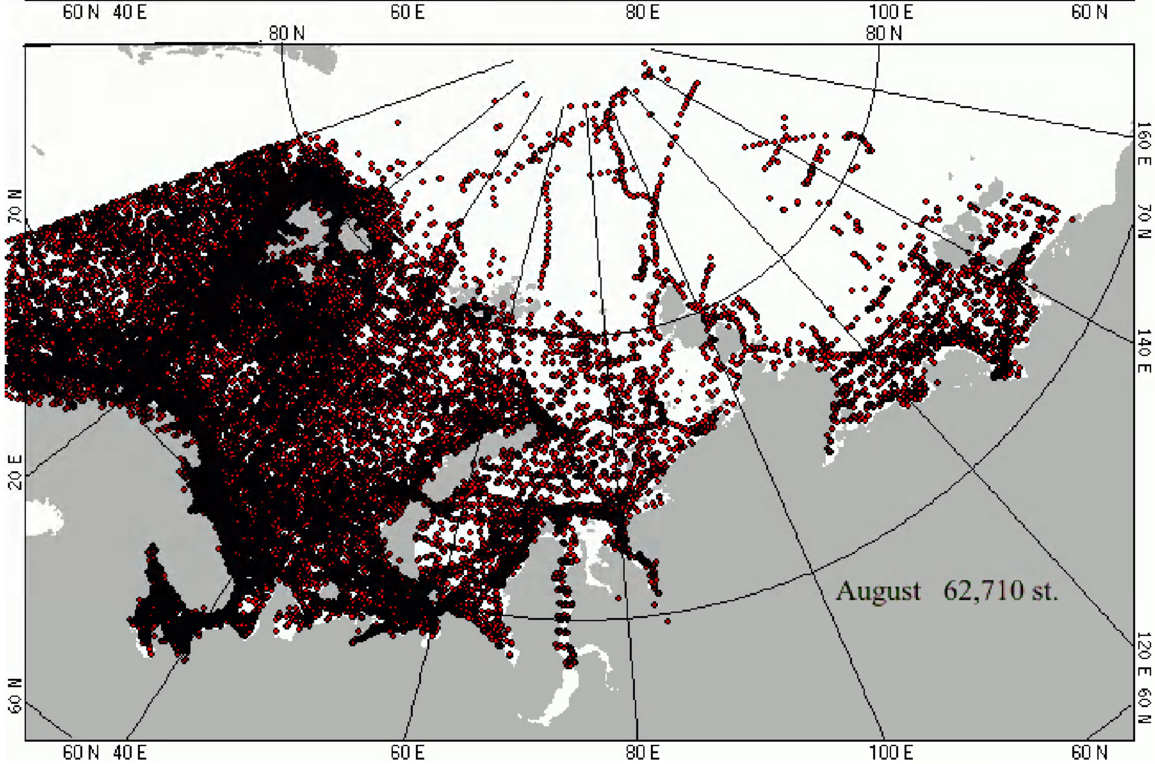
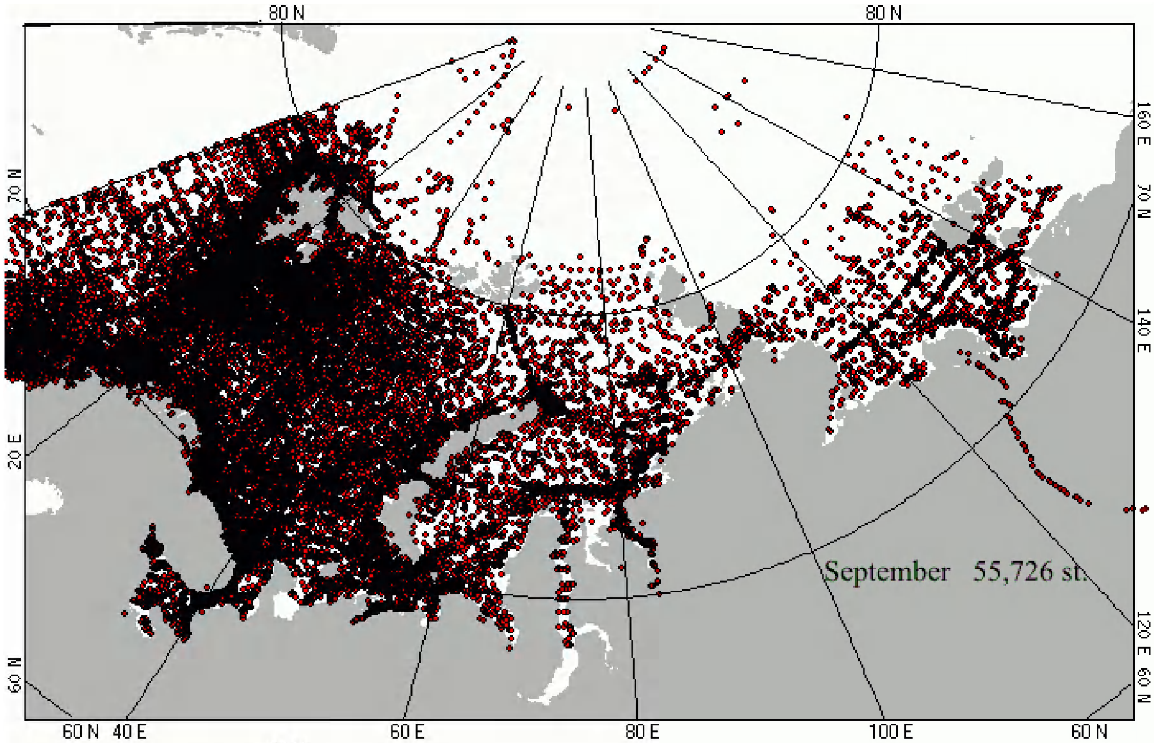
60 N
40 E
60 E
80 E
100 E
60 N

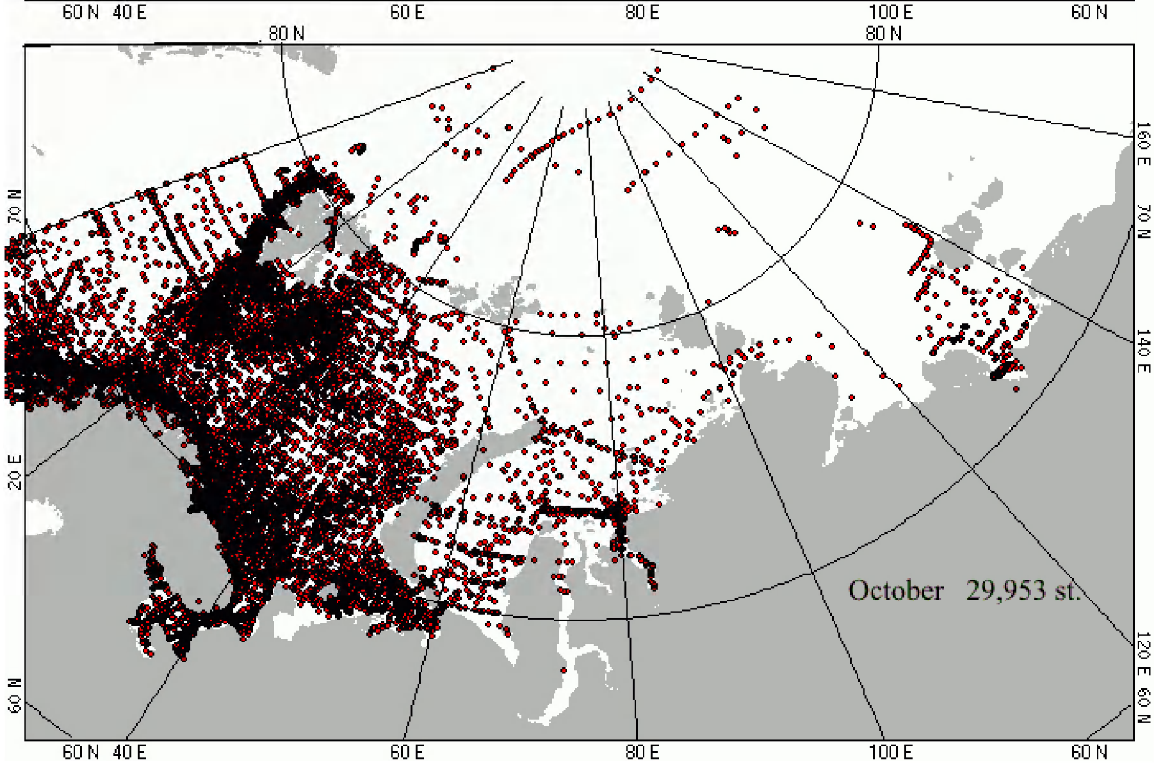

80 N
80 N
160 E
70 N
70 N
140 E
20 E
May 41,612 st.
120 E
60 N
60 N
60 N 40 E
60 E
80 E
100 E
60 N

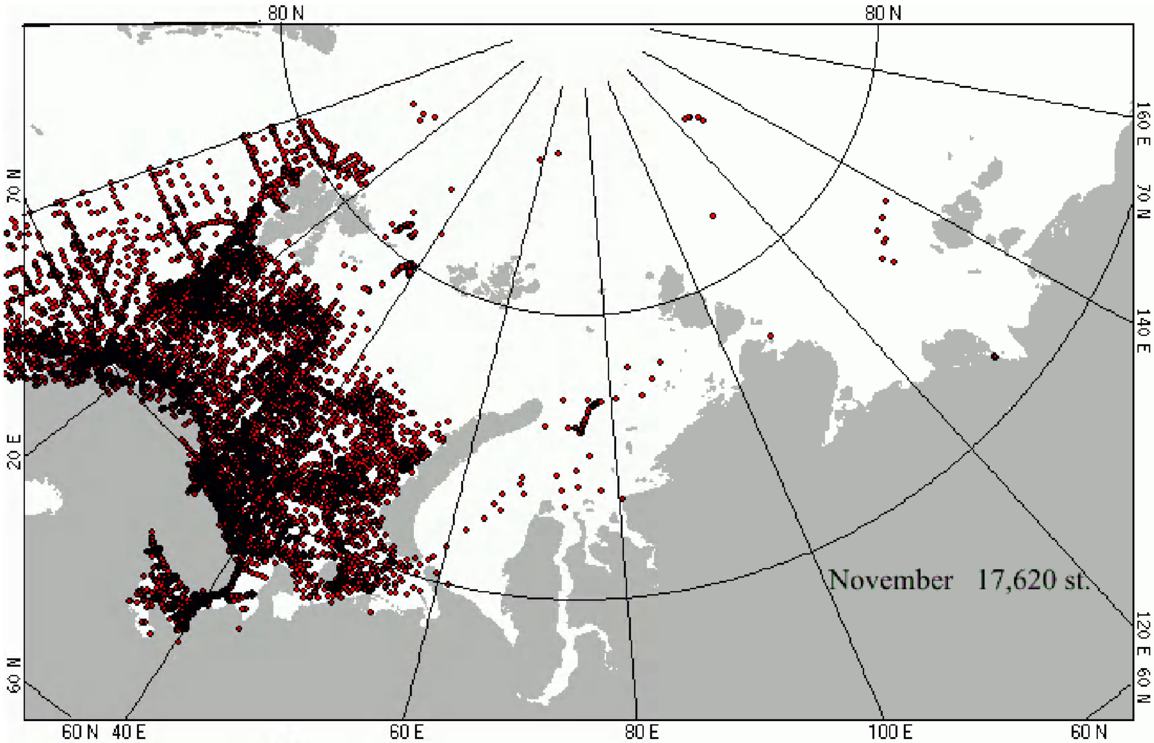

80 N
80 N
160 E
70 N
70 N
140 E
20 E
June 59,163 st.
120 E
60 N
60 N
60 N 40 E
60 E
80 E
100 E
60 N

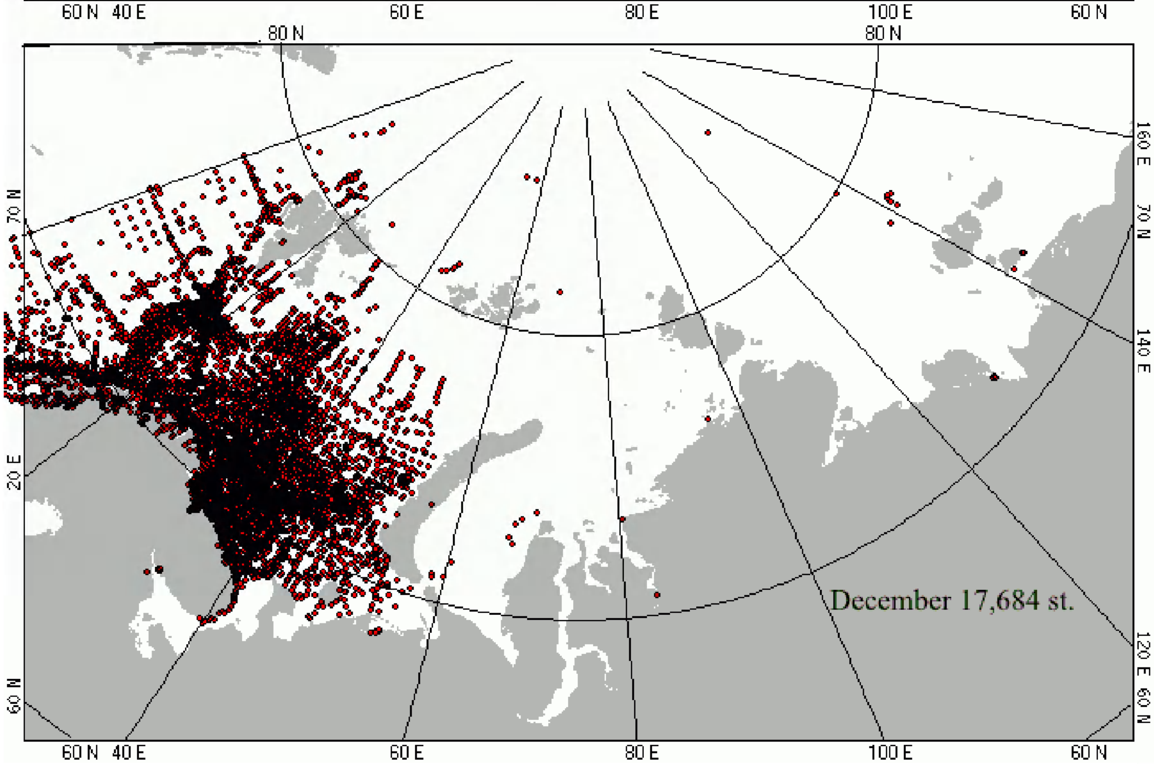

80 N
80 N
160 E
70 N
70 N
140 E
20 E
July 47,791 st.
120 E
60 N
60 N
60 N
40 E
60 E
80 E
100 E
60 N


80 N
80 N
160 E
70 N
70 N
140 E
20 E
August 62,710 st.
120 E
60 N
60 N
60 N
40 E
60 E
80 E
100 E
60 N


80 N
80 N
160 E
70 N
70 N
140 E
20 E
September 55,726 st.
120 E
60 N
60 N
60 N
40 E
60 E
80 E
100 E
60 N


80 N
80 N
160 E
70 N
70 N
140 E
20 E
October 29,953 st.
120 E
60 N
60 N
60 N
40 E
60 E
80 E
100 E
60 N


80 N
80 N
160 E
70 N
140 E
120 E
60 N
70 N
20 E
60 N
60 N
40 E
60 E
80 E
100 E
60 N
November 17,620 st.


80 N
80 N
160 E
70 N
140 E
120 E
60 N
70 N
20 E
60 N
60 N
40 E
60 E
80 E
100 E
60 N
December 17,684 st.

World Data Center for Oceanography, Silver Spring
Ocean Climate Laboratory, NODC/NESDIS/NOAA

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