Sea ice metadata for Billefjorden and Grønfjorden, Svalbard

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Abstract

Description of sea ice conditions in the fjords of Svalbard is crucial for sea transport as well as studies of local climate and climate change. Old observations from the Russian Hydrometeorological stations in the mining settlements Barentsburg (Grønfjorden) and Pyramiden (Billefjorden) have now been digitized. These visual and instrumental observations are archived in the State Archive of Arctic and Antarctic Research Institute (AARI) and Murmansk Branch of the Russian Hydrometeorological Service. In this paper, we bring an overview of the sea ice metadata with few examples of yearly changes in sea ice extent.

Key words: sea ice observation, methods, data, instruments

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Introduction

The Barentsburg meteorological research station ("Hydrometeorological Observatory") was established in August 1932 as an observation site for the Second International Polar Year on Svalbard. The previous location was in the Soviet mining settlement Grumantbyen (1931-1932). Observations were interrupted during a period of the Second World War, between August 1941 and July 1947. The Barentsburg research station still works.

Pyramiden meteorological research station was founded in July 1948 and was closed on May 16th 1957.The official decision was noted in the logbook station (*see* Fig. 1). During its operation period, the station was run by the Arctic Research Observatory in Barentsburg.

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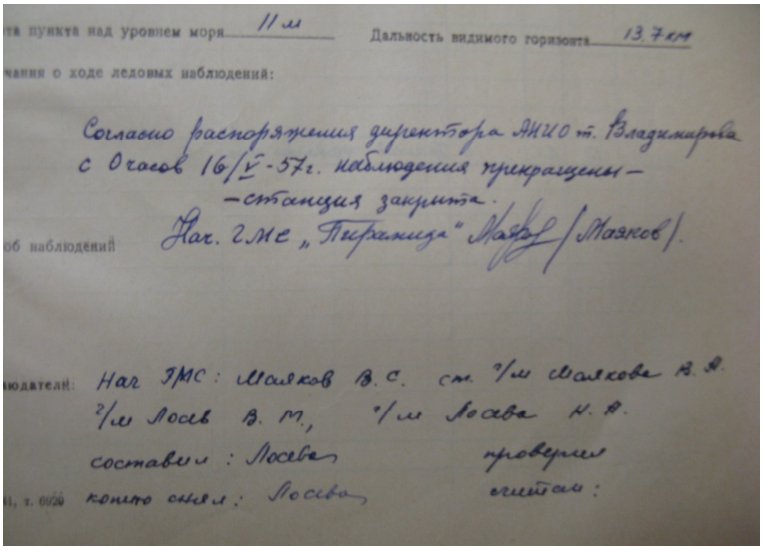

Fig. 1. The entry about closing of Pyramiden meteorological station (photo from AARI archive).

Material and Methods

Russian (Soviet) visual and instrumental observations of sea ice conditions have been carried out in the settlements of Barentsburg (Grønfjorden area) and Pyramiden (Billefjorden area) (Fig. 2).

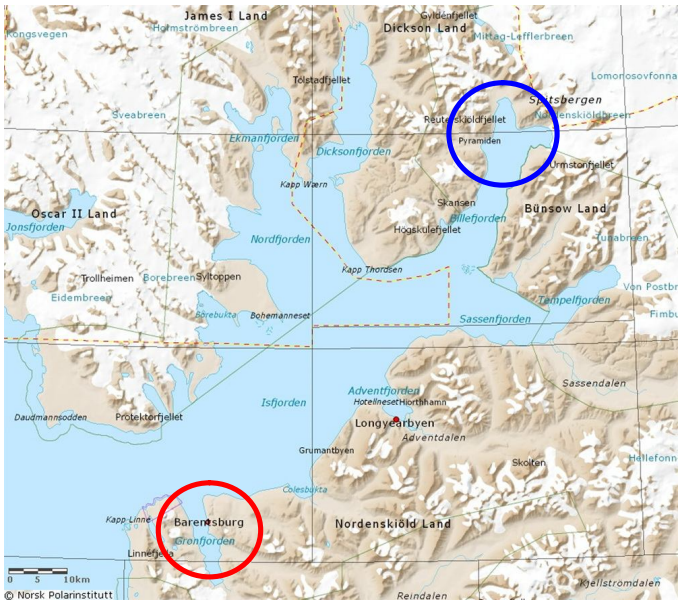

Fig. 2. Map of Isfjorden and the areas for the sea-ice observations (red circle - Barentsburg area, blue - Pyramiden). Map is by courtesy of the Norwegian Polar Institute.

Regular sea ice observations in Pyramiden were carried out from June 1948 to August 1957 and in Barentsburg from 1936 up to present time. Unfortunately, we have not been able to find data for the period prior the Second World War so far. Barentsburg's time-series during 1950-60were found to be inhomogeneous and to contained several gaps. The time-series of highest quality for analyzing the long-term variability of sea-ice conditions were found to be from the mid-1970s.

The first (main) observation site in Barentsburg was located at the roof of the research station building (elevation of about 80 m above sea level). The area of visual observations was oriented (anti-clockwise) from the north-north-west through west to the south. The second (ancillary) site of visual observations was located on the mountain terrace over the Cape Finneset (20 m above sea level). This site was vital for additional observations of ice conditions in the southern part of the fjord (invisible area from Barentsburg). The width of the fast ice was determined in the west direction (*see* Fig. 3).

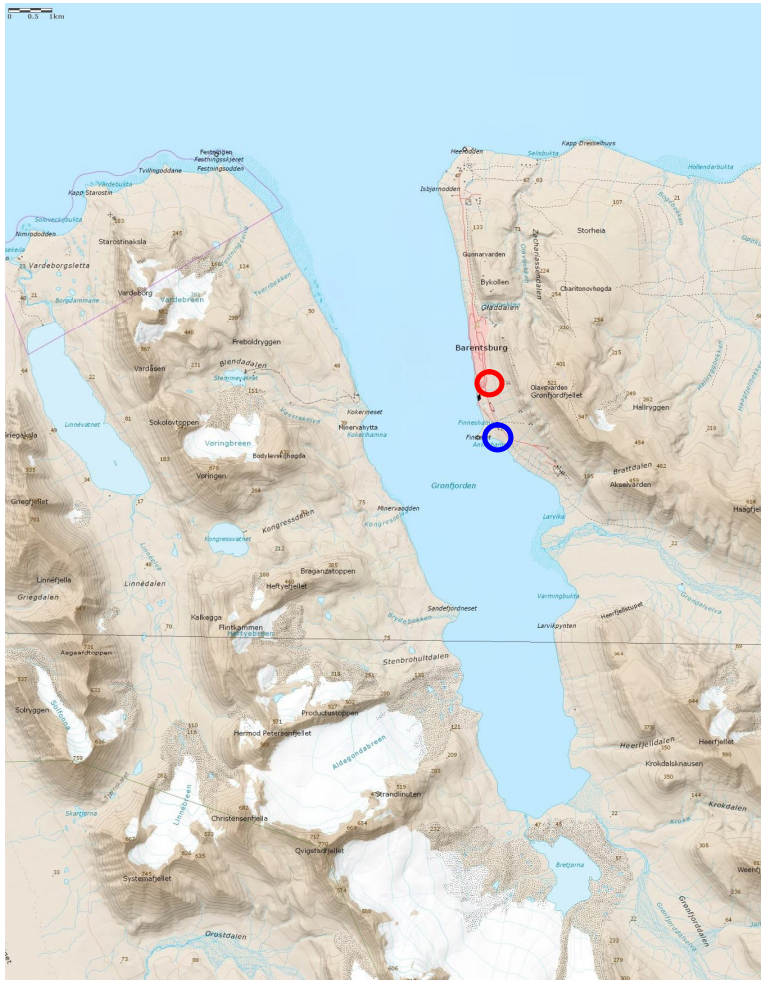

Fig. 3. Sector of visual observations in Grønfjorden Bay (first position - red circle; second position - blue circle).

The first (main) site for instrumental measurements of the thickness of sea ice (fast ice) and snow was located 150 m from the shore in the harbour area of the Barentsburg settlement. The second (additional) site was located ca. 300 m from the shore to get undisturbed observations. The sea ice (land-fast ice) in the harbour area at the first site was sometimes broken and disturbed by vessels moving to or from Barentsburg. A typical example of the fast ice distribution in Grønfjorden is shown on the aerial picture in Fig 4.

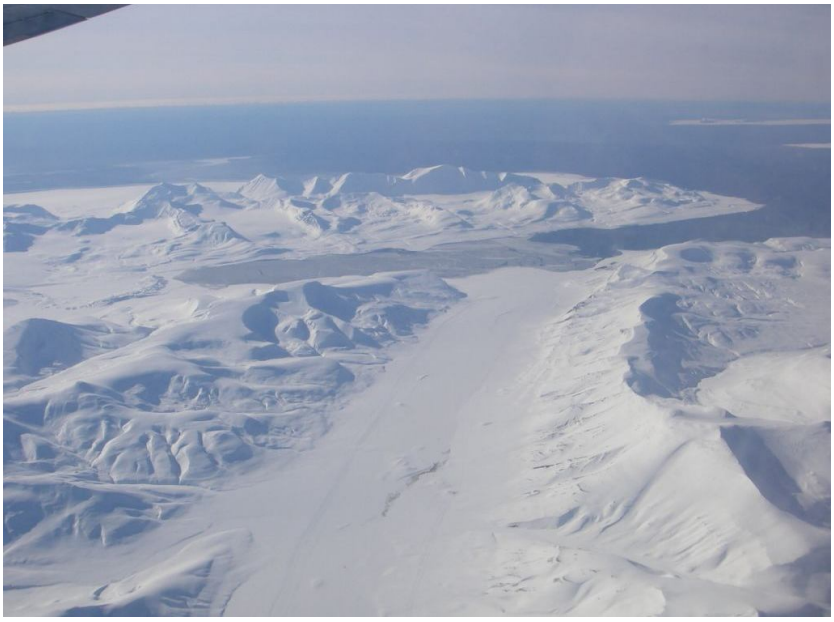

Fig. 4. Panorama towards Grønfjorden and the valley Grøndalen (April 2008, Photo by S. Gerland, NPI).

The first (main) visual observation site in Pyramiden was located on the roof of harbour building (11 m above sea level, 30 m from the shore line). The second site of visual observations was located at the southern slope of the mountain Pyramiden. The sector of visual observation was: east-north-east (Nordenskiöld glacier, Adolf bukta) through south-east to south (Cape Ekholm, Mimer bukta, middle part of Billefjorden). Horizontal visibility was 13.7 km to the south (*see* Fig. 5). The fast ice width was determined in the south-east direction. The site of measuring the thickness of sea ice (fast ice) and snow was located 300 m from the shore (harbour area) to the south-east direction (Mimer bukta area).

For both research stations the time of observation was at the local solar noon (12:00). Carrying out visual observations during the polar night (November-February) were challenging and were not performed if horizontal visibility was less than 500 m (using an artificial light source - projector). For both fjords, after establishment of stable fast ice, the sea ice thickness was measured daily if the ice thickness was less than 20 cm; every second day if the ice thickness was 20-50 cm; and every fifth day if ice thickness was 50-100 cm. Ice thickness was measured in 4 neighboring holes at a distance of 1 m from each other.

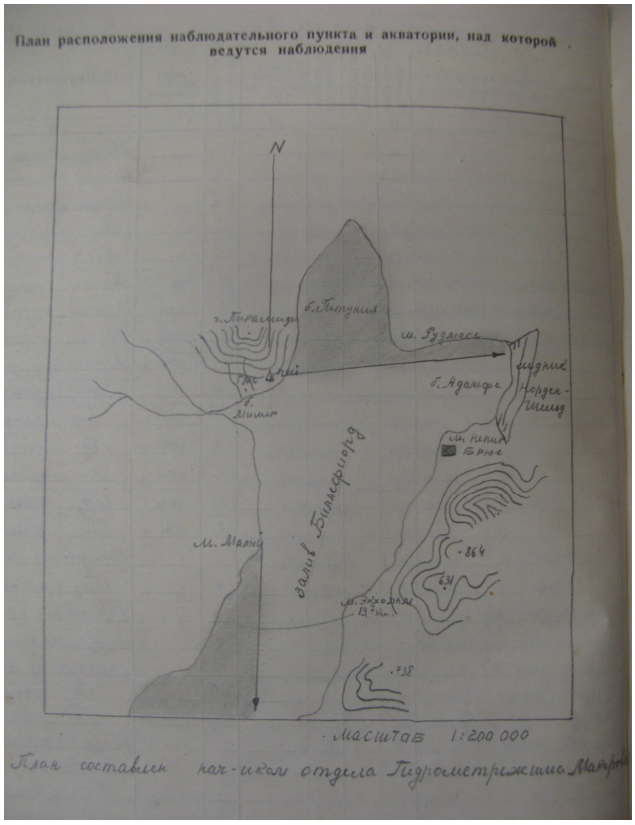

Fig. 5. Sector of visual observation in Billefjorden. Grey background marks invisible area (photo from a hand book from AARI archive).

Results

The visual and instrumental sea ice observations were recorded in special hand books. The official name of these books was: "*Hydrometeorological Table – 2*" (HMT-2). An example of such hand book is shown in Fig. 6.

Results of daily observations of ice cover in the visible areas of Grønfjorden and Billefjorden are found in these tables. The detailed description (definitions and terminology) of ice characteristics is presented below. The "*Overall table*" of main stages of ice conditions throughout the year for a specific parameter of ice observations was compiled at the end of each ice season (period). An example of this table can be seen in Fig. 7. Description (definition) of the main ice phases are also given below.

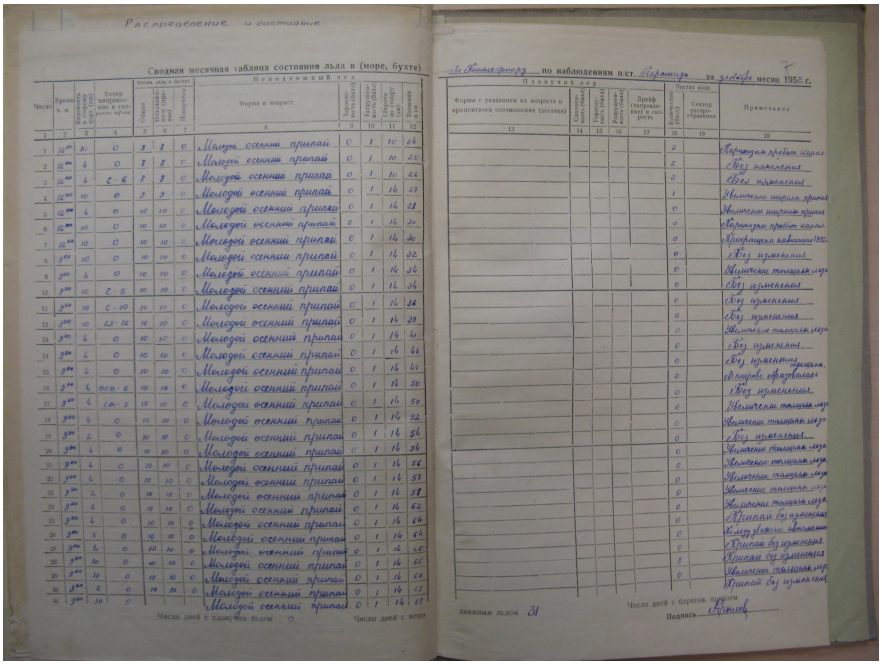

Fig. 6. The hand book for recording of visual and instrumental sea ice observations – HMT-2 (photo from AARI archive, Pyramiden, December 1952).

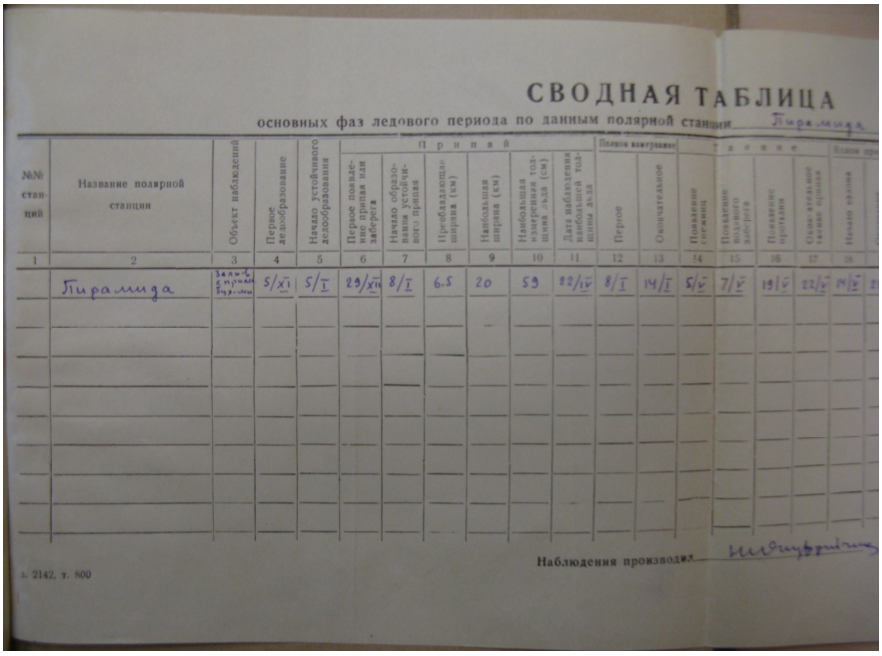

Fig. 7. Overall table of main stages of ice conditions throughout the year (photo from AARI archive).

In this paper and the planned follow-up studies, we will stick to the official international terminology regarding ice terms and definitions (Krutskih 1984, WMO Nomenclature 2014) as well as recommendations and guidelines that are used on Russian polar stations and Arctic marine and aircraft expeditions (Nomenclature of sea ice, and symbols for ice maps 1974, Guidelines for the production of ice airborne reconnaissance 1981 (*see* Table 1, 2).

The following ice characteristics (*see* Table 2) are recorded by an observer using meteorological instruments (air and water thermometers) and special ice equipment (manual or mechanical ice auger, ice rake).

As follows from the Fig. 8 the land-fast ice thickness at Pyramiden area is experiencing significant changes from year to year, indicating about high climatic variability in the period 1948-1957.

We have more representative time series of instrumental observation of the maximum thickness of the fast ice for period 1950-2011 for Barentsburg research station (*see* Fig. 9). We can observe a significant interannual variability in fast ice thickness, but any stable trend is absent.

The short series of parallel observation at research stations "Pyramiden" and "Barentsburg" naturally does not allow for an objective quantitative analysis of the relationship of ice processes and phenomena in different parts of Isfjorden. However, a simple comparison of the maximum thickness of land-fast ice (*see* Table 3) allows us to conclude that more powerful land-fast ice formed in the North-East (inner part of Isfjorden). This is due to more continental climate in Pyramiden area in compare with Barentsburg, and freshened surface waters. Other things being equal, these circumstances provide an earlier onset of ice formation and achieve more significant thickness of land fast ice.

Concluding Remarks

A preliminary digital version of the sea ice data archive collected at the research stations Pyramiden and Barentsburg is located in State Data Archive/Depository of AARI (Saint-Petersburg, Russia) and at MET-Norway (Oslo, Norway). Currently, a joint group of experts from AARI, MET-Norway and Saint-Petersburg State University analyzes seasonal and long-term variability of sea ice characteristics in the Pyramiden and Barentsburg area to assess sea ice conditions in the area prior the beginning of regular satellite observations.

Name of characteristic	Definition
Floating ice	Any form of ice floating in water
Sea ice	Any form of ice which is faced in sea and formed as a result of sea water freezing
Land-fast ice	Sea ice, which is formed and remains stationary coastwise, where it is attached to the shore, ice wall, ice barrier, between bench lands
Young coastal ice	Initial stage of development of stationary ice consisting of nilas or young ice, which width varies from several meters to 100-200 m from coast line
Ice foot	Narrow ice zone attached to the shore, stationary at flow of tide and remaining after the stationary ice turns away
Ice destruction	Ice damage level during process melting, which is estimated visually
Melt pond	Accumulation of melted water on ice, first of all by virtue of snow melting, and during the later stages, also because of ice melting. It is a water-logged spot in the initial stage
Water snow spots	Single wet spots of water-logged snow observed at the snow-covered ice surface in the melting initial period
Thaw holes	Vertical holes in sea ice, formed as a result of subjacent melting (thawing) of ice under melt ponds
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Date of the first ice formation	The day of the first appearance of new/autumn formation of sea ice in the waters of the bay, independently of its type, amount and origin
Date of stable ice formation	The starting day when autumn ice formation goes on at all times before shore ice formation. Here after amount of pure water in the waters of the bay should be less than 10 points (100%)
Date of the first formation of young coastal ice or land-fast ice	The starting day when stationary ice (fast ice of any origin) or young coastal ice is present in the bay
Date of stable land-fast ice formation	The day of fast ice formation, which has held out for not less than one month
Date of the first ice formation	The day of the first appearance of new/autumn formation of sea ice in the waters of the bay, independently of its type, amount and origin
Date of stable ice formation	The starting day when autumn ice formation goes on at all times before shore ice formation. Here after amount of pure water in the waters of the bay should be less than 10 points (100%)
Date of stable land-fast ice formation	The day of fast ice formation, which has held out for not less than one month
Size of stable land-fast ice width	The width of fast ice observed during long time period
Extreme width of land-fast ice	The maximum visible distance to the sea ice edge from the observation site
Date of first appearance of melt ponds	The day when the first signs of destruction of drifting or fast ice, which correspond to appearance of melt ponds, wet ice spots, puddles or lake lets on ice, were recorded
Date of thaw holes appearance	The day of the appearance of the first drifting or fast ice subjacent thawing
Date of spring break start or first land-fast ice twitch	The day of the first partial reduction of the 10-point (100%) fast ice amount or its complete destruction after the period of final full freezing of water object (bay, fjord, *etc.*)
Date of land-fast ice final destruction	The day (last day), when the fast ice was broken over the whole area of the object and was not formed to the end of ice period

Date of final full cleaning from ice	The day when sea became ice free up to the next ice period (ice formation period) or at least for a term of not less than one month
Duration of ice period	The period starting from the date of the first ice formation and finishing by the date of final cleaning of the object (fjord). If there was no final cleaning of the object from ice, ice period is lasting up to the end of the set period of ice observations, *i.e.* till July 31
Amount of days with ice during ice period	The difference (number of days) between total duration of ice period and number of days without ice during the same period
Amount of days without ice during ice period	The number of days during ice period, when 10 points (100%) of pure/open water are observed or amount of stationary ice is less than 1 point (10%)

Table 1. International Sea ice terminology and definition (visual observation or by binocular)

Name of characteristic	Definition
Date of stable air (water) temperature crossing of 0^{o}C	The day after which there is no reverse crossing of average daily temperature values during 30 days for air temperature and 15 days for water temperature
The largest thickness of land-fast ice	The maximal thickness of fast ice in cm according to results of measurements in a fixed point

Table 2. International Sea ice terminology and definition (instrumental observation)

Year	Barentsburg	Pyramiden
1949	No data	129
1950	40	50
1951	107	90
1952	64	142
1953	64	94
1954	Land-fast ice no formed	59
1955	36	93
1956	51	123
1957	25	72
Average values	55	95

Table 3. Maximum thickness (cm) of land-fast ice near Barentsburg and Pyramiden.

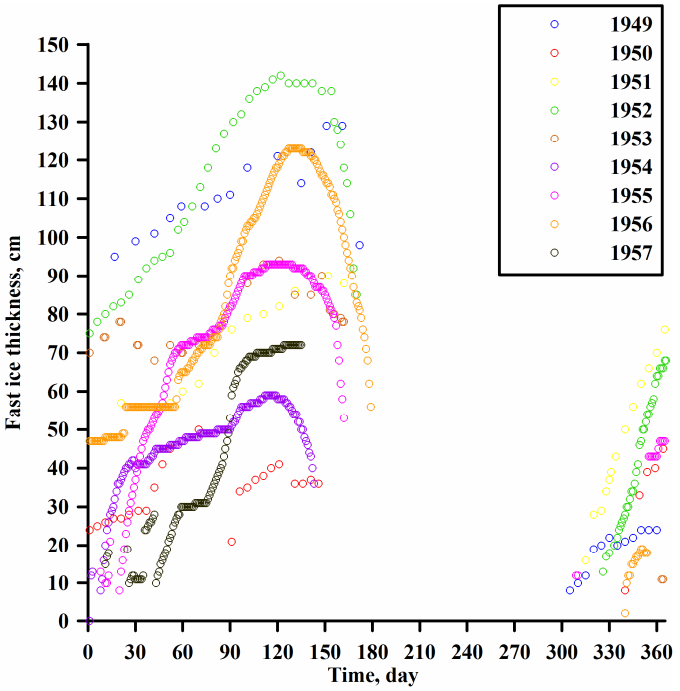

Fig. 8. Seasonal variability of land-fast ice thickness during 1948-1957.

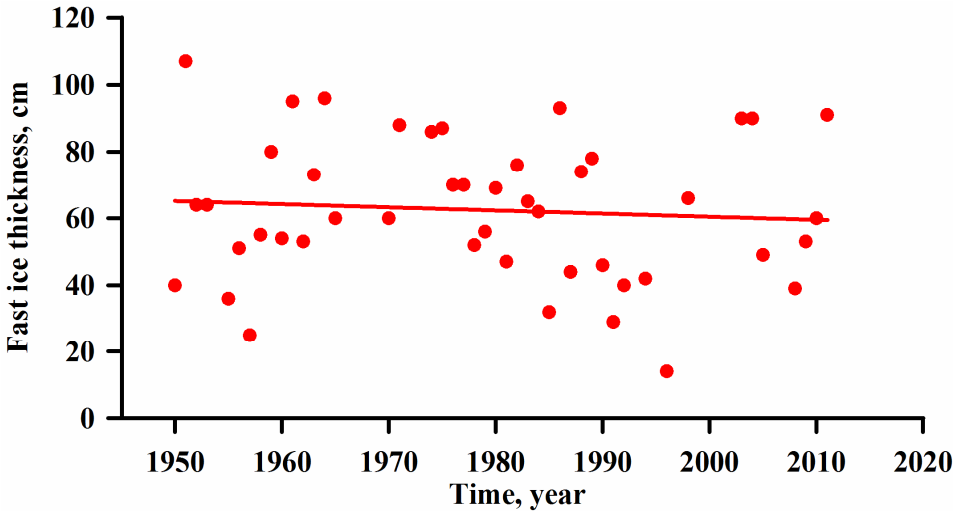

Fig. 9. Long-term variability of the maximum of the fast ice thickness in Grønfjorden (Barentsburg research station).

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