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Climatic Conditions Around Greenland – 1994

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Abstract

Based on air temperature data from three sites off West and East Greenland, the annual variability of climate is shown. Mean monthly air temperature data from Nuuk/West Greenland revealed the long-term interannual changes of air temperature anomalies. It is shown that on the seasonal basis, variation of mean amplitudes differed most when considering winter (JFM) and summer (JAS) data sub-sets. As a consequence of warm summer and autumn air temperatures, the sea ice cover was less extensive than in previous years of this decade. Subsurface observations on Fylla Bank/West Greenland, indicated that during the past 30 years cold and diluted events occurred simultaneously. This pointed at the advective influence of the East Greenland Current component on the water mass properties of the West Greenland Bank and slope area. The vertical magnitude of the influence of this Polar Water extended to 150–200 m. Warmer than normal subsurface conditions were attributed to a northerly extension of the North Atlantic Current.

Key words: Climate, currents, East Greenland, ice, temperature salinity, West Greenland

Introduction

The climate at West Greenland has undergone very marked changes (Buch and Stein, 1989; Stein and Messtorff, 1990). These climatic changes in the West Greenland area are in part due to variations of the main ocean current components of the West Greenland Current system, and the air temperature variations. Periods of warm water temperatures correlate with air temperature as demonstrated by Stein and Buch (1991). The necessity of collecting oceanographic data at comparable standard stations has been demonstrated recently (Stein, MS 1990). As an example of systematic sampling and reporting on the results in the Northwest Atlantic, the publications by Drinkwater and Trites (1993), and Drinkwater *et al*. (1994) might be taken. Similarly, a closer view at the climatic conditions of the Greenland area is deemed necessary. Started as a project during 1993, this paper continues the series which provides an annual overview on environmental conditions around Greenland. The data used in the context of this paper deal with data on air temperatures, the distribution of sea ice and subsurface observations. The latter data originate from oceanographic observations performed at Standard Oceanographic Stations by the Federal Republic of Germany during the 1994 annual groundfish survey in the area off West and East Greenland (Stein, MS 1988). It has been shown that the availability of long-term time series enables a better view on the variability of the ocean conditions, especially when correlating variability in the biota and the environment (Stein and Lloret, 1995).

In this paper the available climatic data for 1994 off Greenland are presented. To enable a closer view on thermohaline conditions off West Greenland, isopleth diagrams from Fylla Bank are presented and discussed.

Data and Methods

Data on the atmospheric climate off Greenland were sampled by the Danish Meteorological Institute at Nuuk (64°11'N, 51°44.5'W), Egedesminde (68°42.5'N, 52°53'W) and Angmagssalik (65°36'N, 37°40'W). Whereas the first data set was mutually supplied by the Danish Meteorological Institute in Copenhagen and the Seewetteramt, Hamburg, the latter data sets were taken from Anon. (MS 1994). The climatic mean to which the air temperature anomaly charts (Fig. 1) are referenced is 1961–90. Ice charts were constructed from National Ocean and Atmospheric Administration (NOAA) satellite ice charts. Anomalies of the ice edge are referenced to sea ice normals as displayed by Buch and Stein (1989). The approximate location of the ice edge is given in the selected figures and is compiled in a computer slide show held by the author. The temperature anomaly maps for the Northwest Atlantic were also taken from Anon. (1994). Presently, only the ice charts are available as computer slide shows from the author upon request. Subsurface ocean data are available from German measurements for the West Greenland area. For graphical display of isopleth diagrams and sections the SURFER Software (Version 4) was used.

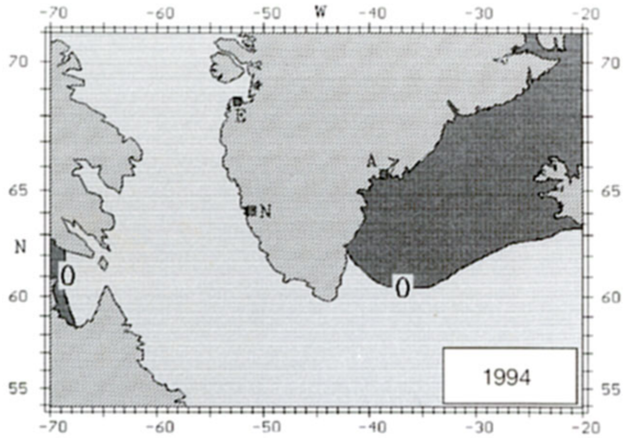

Fig. 1. Mean air temperature anomalies over the Northwest Atlantic during 1994 (E = Egedesminde, N = Nuuk, A = Angmagssalik).

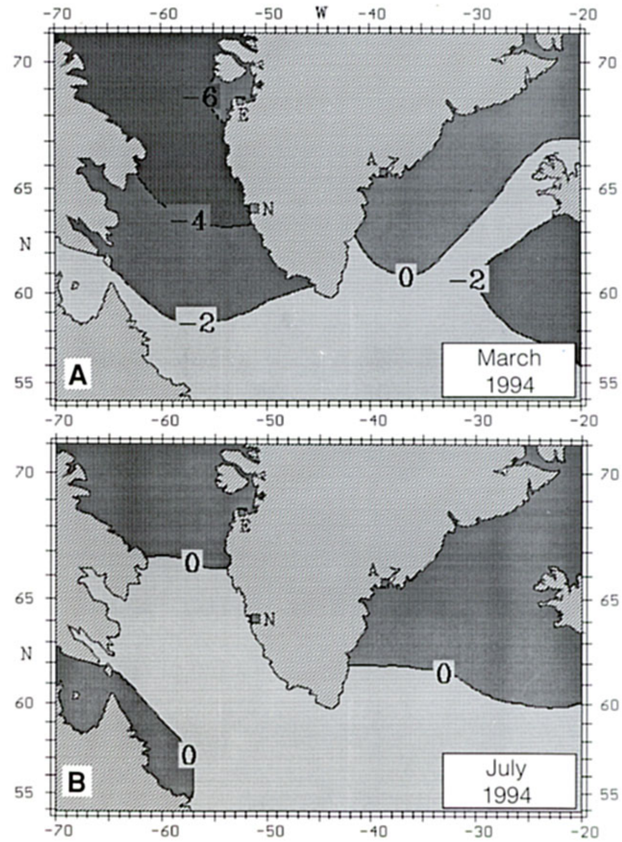

Fig. 2. Mean air temperature anomalies over the Northwest Atlantic during (**A**) March, 1994; and (**B**) July, 1994 (E = Egedesminde, N = Nuuk, A = Angmagssalik).

Results

Air temperature and sea ice anomaly during 1994

Northwest Atlantic. As in previous years (Stein, 1995a, b), air temperatures over West Greenland during the first quarter of 1994 were colder than normal. Especially the month of March (Fig. 2a) showed the typical cold air mass centered over the town of Egedesminde. Anomalies at this site were less than 6K. Warmer than normal conditions were encountered in the month of July at Egedesminde and Angmagssalik, whereas Nuuk had summer temperatures below normal (Fig. 2b).

Air temperatures and climatic means

Mean monthly air temperatures at the three selected sites of the Greenlandic coast varied from about -15°C to +5°C at Egedesminde, -7.5°C to +7°C at Nuuk, and -7.5°C to +7.5°C at Angmagssalik (Fig. 3–5). Although Nuuk and Angmagssalik had about the same mean conditions, year-to-year changes, as well as seasonal changes differed significantly from West to East Greenland. Colder than normal conditions during January to March at the west coast, contrasted with a colder than normal January, a warmer than normal February, and an about normal March at the east coast. From April onwards, Egedesminde air temperatures were above or at mean conditions until December when winter cooling started. An outlook for 1995 indicates winter air temperatures even colder than the 1994 conditions. January to March revealed temperatures around -22°C. Nuuk experienced a colder than normal summer during 1994, a normal autumn, and winter cooling from December onwards. Similar to Egedesminde, Nuuk air temperatures during January to March 1995 were well below the 1994 conditions. At Angmagssalik about normal air temperatures were encountered from February to September. October and December were well below

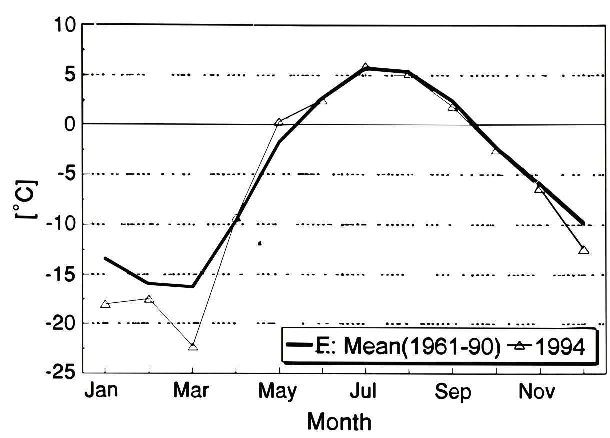

Fig. 3. Monthly mean air temperature at Egedesminde during 1994 and climatic mean (1961–90).

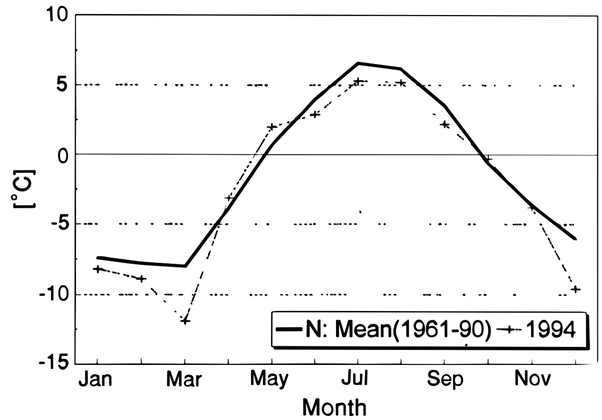

Fig. 4. Monthly mean air temperature at Nuuk during 1994 and climatic mean (1961–90).

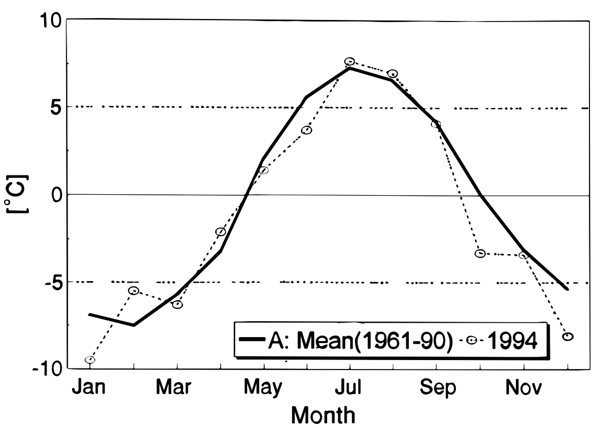

Fig. 5. Monthly mean air temperature at Angmagssalik during 1994 and climatic mean (1961–90).

normal, whereas November was about normal. During the first quarter of 1995, air temperatures were colder than during 1994.

Climatic variability off West Greenland

After the cold years 1992 and 1993, 1994 indicated an increase of the annual mean air temperature. Climatic conditions at Nuuk were, however, still well below normal (Fig. 6). As indicated by Stein (1995a), the low frequency variation as given by the thick line in Fig. 6, points at longer than decadal variations of the mean air temperatures at Nuuk. Splitting of the air temperature anomalies data set in four monthly subsets, the means of January–March (JFM), April–June (AMJ), July–September (JAS), and October–December (OND) revealed different amplitudes of warming and cooling, as well as different low frequency variations (Fig. 7a–d). Largest variation in air temperatures was observed during the winter season, ranging from -2K to +2K (Fig. 7a), variability during summer (JAS, Fig. 7c) was smallest. Steep downward trends after the warm period between the 1920s and 1960s were visible in the first two seasons (Fig. 7a, b), and a surprisingly long warm period which extended far into the 1980s was encountered in the autumn data (OND, Fig. 7d). The warm periods in the seasonally split data sets were from 1918 to 1975 (JFM), from 1919 to 1964 (AMJ), 1918 to 1965 (JAS) and 1917 to 1985 (OND). With the exception of the autumn season, the warm period data were in the range of previously published data (Hovgard and Buch, 1990; Stein, 1995a,b).

Ice conditions in the Northwest Atlantic

Two examples of sea ice conditions during 1994 are given in Fig. 8 and 9. The largest extension of the ice edge was encountered during February with anomalous presence of ice in the vicinity of Nuuk and in Julianehaab Bight/Southwest Greenland (Fig. 8). As visible from the individual ice maps which are plotted on 14 day intervals (see Data and Methods), the year 1994 was a warm year as concerns sea ice distribution around Greenland. Unusual cover of sea ice was observed during mid July at Cape Farewell, and during the first half of August around Baffin Island. Ice-free conditions were observed between mid-September and mid-October when ice started to form again off East Greenland and around Baffin Island.

Subsurface observations off West Greenland

Thermohaline conditions along the Fylla Bank Section (Stein, MS 1988) are given in Fig. 10a and 10b. The vertical field of temperature revealed warm conditions in the depth range between 100 m and 200 m, with temperatures around 6°C. The temperature and salinity properties of the Fylla Bank Section are given for standard depth data in Fig. 11. Temperature and salinity anomalies for Fylla Bank Station 4 are given in Fig. 12 and 13 for the depth ranges 0–50 m, 0–200 m and 200–300 m. Based on standard depth data, the temporal variation between 1963 and 1994 (autumn) of thermohaline changes of the upper 300 m at Station 4 of the Fylla Bank Section are displayed in Fig. 14 and 15.

Discussion

Generally, near surface mean air temperature anomalies were about 0.4K warmer than normal for the area 85°N to 5°N and 110°W to 70°E (Anon., 1995). From 1990 to 1994 these means amounted to +0.45K, +0.35K, -0.12K, +0.07K and 0.38K. The 1992 conditions were influenced by the Pinatubo-Effect (Henning, 1994). Changes to positive anomalies occurred mainly over large areas of

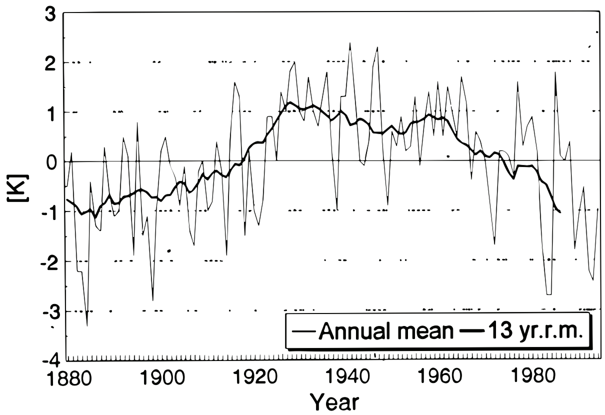

Fig. 6. Time series of annual mean air temperature anomalies at Nuuk (1880–1994, rel. 1876–1994) and 13-year running mean.

North America, United Kingdom, the Iberian Peninsula/Morocco and Eastern Europe. Increasing warming tendencies which surmounted the 1993 anomalies, were encountered over Northern to Southern Europe and Northwest Africa. Except for the region off East Greenland (Fig. 1), air temperatures over the Northwest Atlantic were colder than normal. The negative anomalies over Baffin Bay/ Davis Strait and Greenland, however, weakened as compared to previous years.

At Greenland, air temperature conditions during 1994 were similar to 1992 and 1993 as concerns the cold winter. From April onwards, however, temperatures increased to above normal conditions (Fig. 3 to 5), and led to mostly warmer than normal summer temperatures. This gave rise to fairly good sea ice conditions. From 27 April 1994 onwards, the west coast of Greenland was ice free, a month later Disko Bight was open. Anomalous ice conditions were encountered at Cape Farewell during June and July.

Comparison of monthly mean air temperature time series at Nuuk indicated different amplitudes of warming/cooling when considered on quarter year basis. Winter (JFM) amplitudes ranged from -2K to +2K, and summer (JAS) amplitudes ranged from -0.5K to +1K. The analysis revealed a surprisingly long warm period, which extended far into the 1980s when considering the autumn data (OND, Fig. 7d).

Warm water off West Greenland might be derived by two ways (Buch, 1994): from the Irminger Current component of the West Greenland Current system, and from the northern part of the North Atlantic Current. The latter water mass originates from

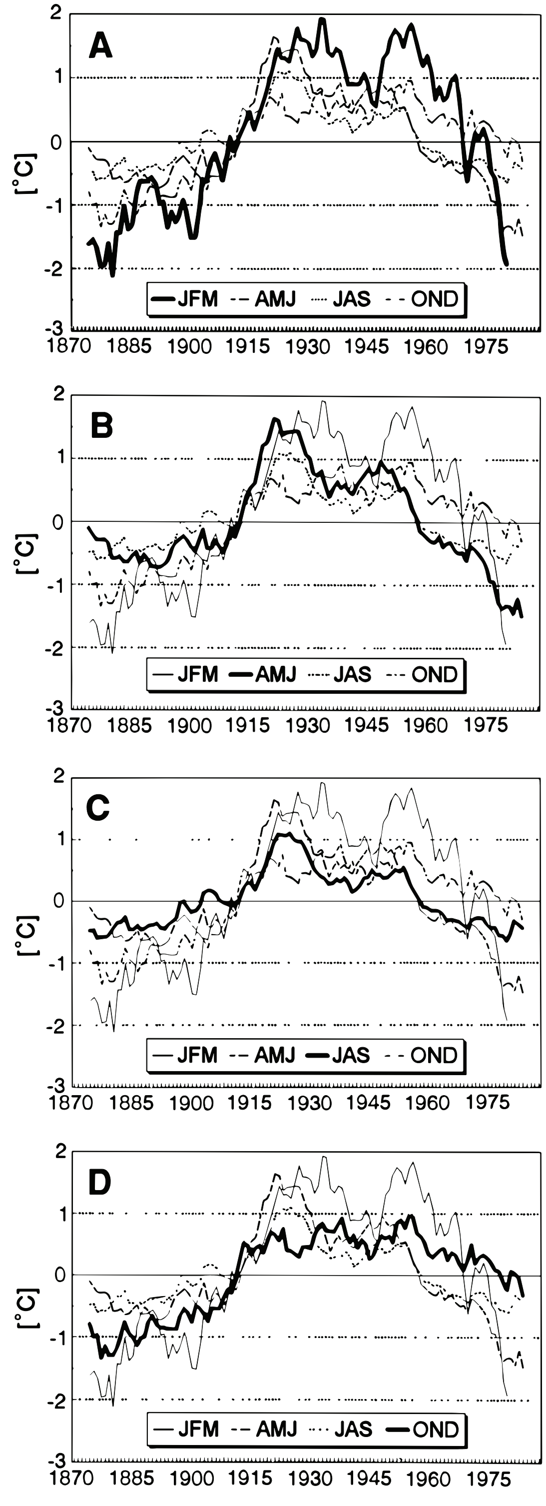

Fig. 7. Time series of three monthly mean air temperature anomalies at Nuuk (1880–94, rel. 1876–1994)

(**A**) January, February, March (JFM),
(**B**) April, May, June (AMJ),
(**C**) July, August, September (JAS),
(**D**) October, November, December (OND).

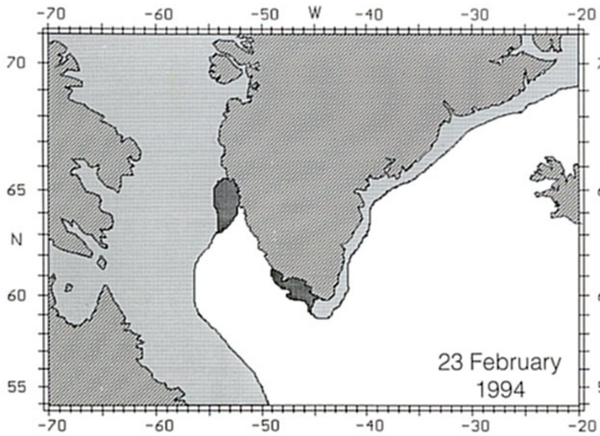

Fig. 8. Ice edge during 23 February 1994; dark shaded areas indicate anomalous extent of ice edge during the month of February.

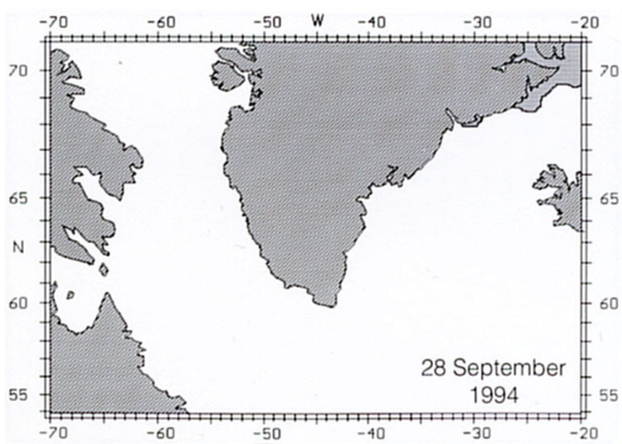

Fig. 9. Ice edge during 28 September 1994.

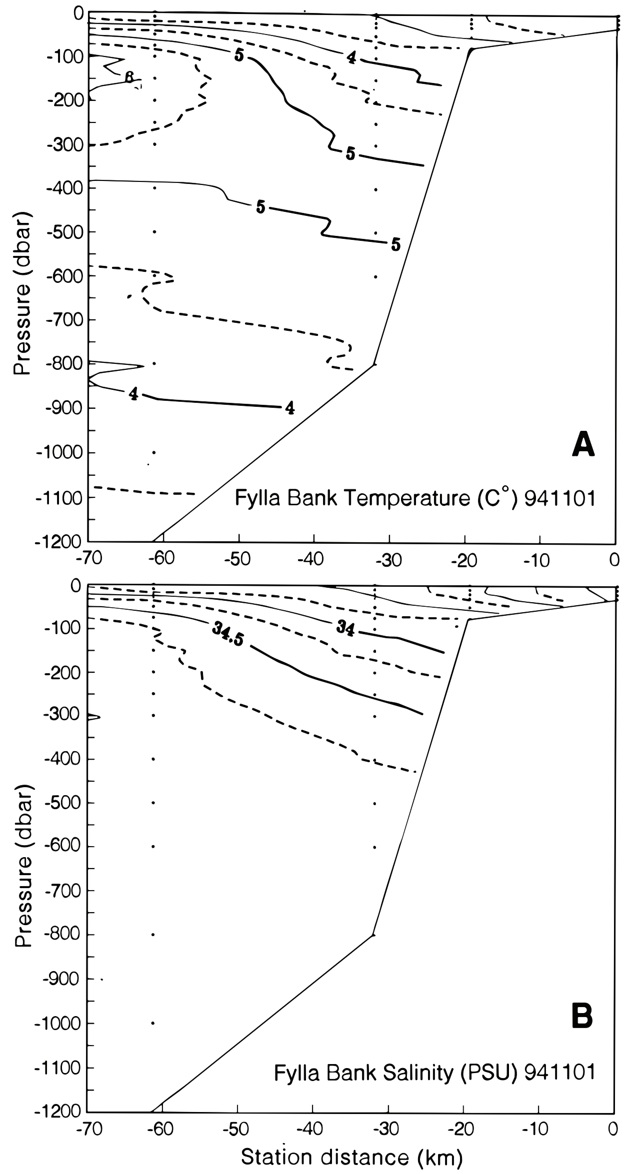

Fig. 10. Vertical distribution of temperature (a) and salinity (b) along the Fylla Bank Section during 1 November 1994.

the area south to southwest of Cape Farewell and has temperatures above 4.5°C, and salinities between 34.5 and 34.9 PSU. This water mass was observed during autumn off the shelf slope of the West Greenland banks at depths below 100 m (Fig. 10a).

Thermohaline conditions during autumn 1994 indicated positive anomalies which were largest in the near surface layer (0–50 m, Fig. 12 and 13). After the very cold year 1992, the years 1993 and 1994 may indicate an intermediate warming, as anticipated recently by Stein (1995). Isopleth diagrams of temperature and salinity (Fig. 14 and 15) revealed cooling and intermediate warming at Station 4 of the Fylla Bank section throughout the last thirty years. The data showed that cooling was accompanied by a tremendous dilution of the water column, with the depth of the signal being the same for both temperature and salinity parameters. Since these events were concurrent, it is suggested that the mode of formation must be of advective nature. In contrast to previous discussions, the coincidence of cold and diluted events point at changes due to the East Greenland Current component. It suggests a larger influence on the thermohaline properties at Fylla Bank during autumn than anticipated (e.g. Buch and Stein, 1989; Stein and Buch, 1991). Taking the autumn temperature and salinity characteristics of East Greenland Polar Water (3–5°C, <34.4

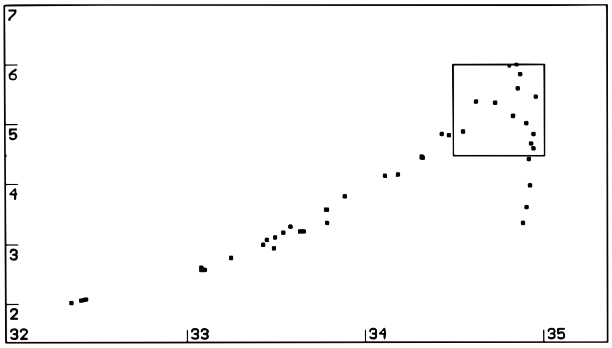

Fig. 11. TS-diagram of Fylla Bank Section (Standard depth data are used).

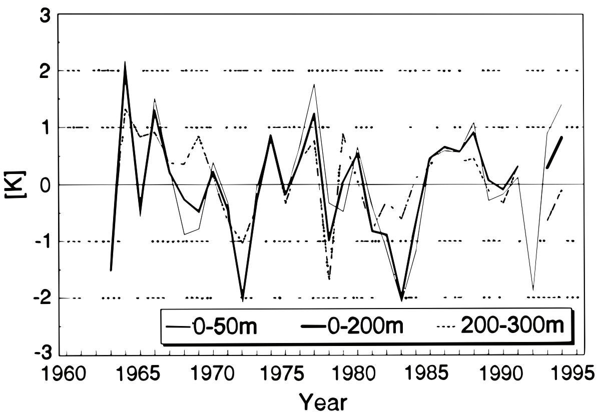

Fig. 12. Fylla Bank Station 4: temperature anomaly 0–50 m, 0–200 m, 200–300 m.

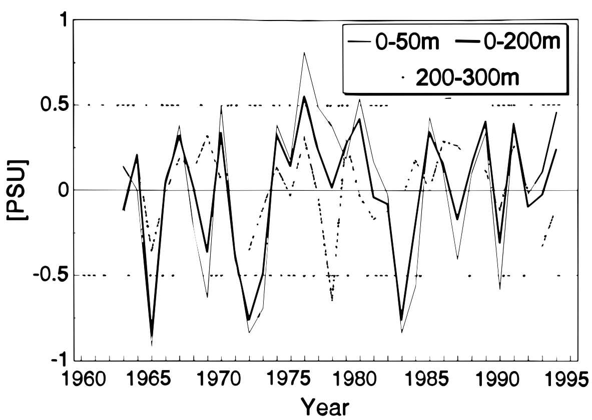

Fig. 13. Fylla Bank Station 4: salinity anomaly 0–50 m, 0–200 m, 200–300 m.

PSU; Buch, 1994), the 34.25 PSU isoline in Fig. 15 roughly delineates the lower boundary of this water

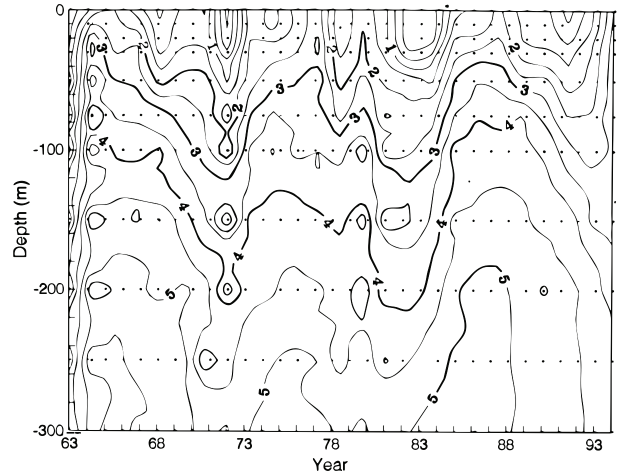

Fig. 14. Fylla Bank Station 4: isopleth diagram of temperature, depth, year.

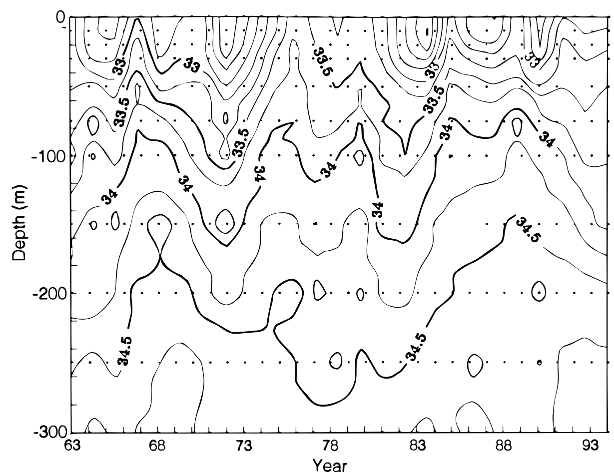

Fig. 15. Fylla Bank Station 4: isopleth diagram of salinity, depth, year.

mass at Fylla Bank Station 4 throughout the past thirty years. The vertical extension of this Polar Water varied between 150 m and 200 m.

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