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Climatic Conditions Around Greenland – 1993

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Abstract

Air temperature anomalies and sea ice cover during 1993 around Greenland indicated that the early-1990s experienced similar anomalous cold environmental conditions to those experienced during the beginning of the 1970s and 1980s. Similar to the last decade, and the year 1992, cold air masses contributed to the extreme conditions off West Greenland during the first quarter of 1993. March conditions revealed a cold air mass centred around the town of Egedesminde. Temperature anomalies were less than –8K, influencing the entire Davis Strait/Labrador Sea region. Only around Iceland, positive air temperature anomalies were encountered. The warmest month in the Northwest Atlantic region during 1993 was October. In contrast to the west coast, the east coast of Greenland showed different climatic conditions during 1993. Under the regime of the anomalous cold air temperatures, the surface layer of the ocean was cooled, and sea ice formed to a larger extent than normal. The ice did not leave Cape Farewell before mid-August, and it returned in December. During October ice returned to the areas off East Greenland. Analysis of year-mean air temperature time series from Nuuk/West Greenland revealed that the cooling process, as observed since the late-1960s, was still persistent. Subsurface autumn temperature observations indicated slightly above normal temperatures (+0.4K) for the 0–200 m layer compared with the 1963–93 mean. In the 0–50 m surface layer temperature, anomalies were about +1K. This may have resulted from the warm air temperature conditions during September and October in the West Greenland area. Warming was greatest in the 0–50 m layer off Cape Desolation where the anomaly was about 2K above the autumn 1983–93 mean. Off East Greenland, at Angmagssalik, thermal conditions were below normal during most of the first half of 1993, and above normal from September onwards. This was reflected in warming of the subsurface layer 0–200 m, which amounted to +0.9K, for the Gauss Bank Section and +0.26K for the Discord Section of the 1981–93 mean.

Key words: Climate, environment, ice, Greenland, salinity, standard sections, temperature

Introduction

This paper is the second in a series which was started in 1993, which provides an overview of environmental conditions around Greenland. The data used in this paper, deal with air temperatures, distribution of sea ice, and subsurface hydrographic observations. The latter data originated from the 1993 oceanographic observations performed by the Federal Republic of Germany annual groundfish survey in the area off West and East Greenland.

Materials and Methods

Data on the atmospheric climate of Greenland 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) were collected by the Danish Meteorological Institute. Whereas the data set at Nuuk was supplied by the Danish Meteorological Institute in Copenhagen, the latter data sets were taken from Anon. (1993). Ice charts were constructed from the National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce, satellite ice charts. The progression of the approximate location of the ice edge was initially prepared as a computer simulation (Stein, unpublished data, available as computer diskettes), and depicted in this paper in selected representative figures. The temperature anomaly maps for the Northwest Atlantic were also taken from Anon. (1993). These temperature anomaly maps were also prepared as computer simulations (Stein, unpublished data, available as computer diskettes). Sub-surface ocean data were available from German measurements for the West and for the East Greenland area.

Results

Air temperature and sea ice anomaly during 1993

Northwest Atlantic. Generally, air temperature over the Northwest Atlantic was in the normal range with anomaly values below –3K up to above +2K. Extreme values were, however, encountered at Southwest Greenland (Fig. 1, 2), while on a larger geographic scale it was noted that parts of the USA, in Eastern Canada and Southern Greenland experienced very cold conditions. It was relatively quite warm over the European Polar regions. Over the Atlantic/European Polar regions the distribution of

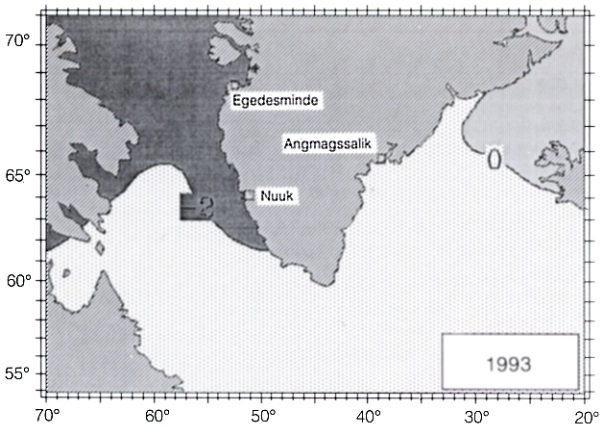

Fig. 1. Mean air temperature anomalies over the Northwest Atlantic, 1993.

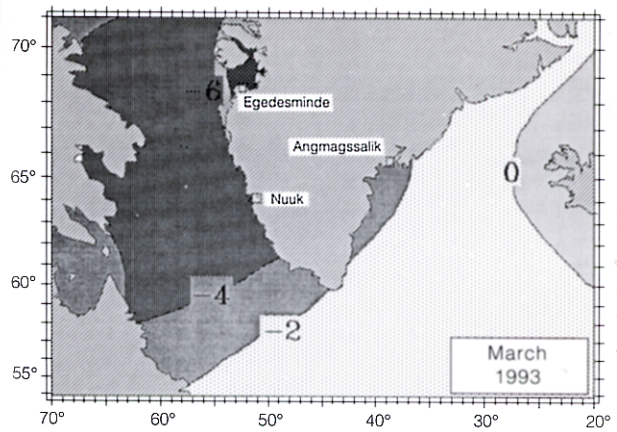

Fig. 2. Mean air temperature anomalies over the Northwest Atlantic, March, 1993.

air temperature anomalies was very similar to those of the year 1992 (Stein, 1995; Henning, 1994). Two examples taken from the 1993 annual series showed the extreme nature of air temperature anomaly over the Northwest Atlantic during 1993: (a) March conditions revealed a cold air mass centred over the town of Egedesminde (Fig. 2), with temperature anomalies less than –8K. This air mass was observed to influence the entire Davis Strait/Labrador Sea region with only the area around Iceland where positive air temperature anomalies were encountered. (b) The warmest month in the Northwest Atlantic region during 1993 was October. Except for the western part of the Labrador Sea and a small region off East Greenland, positive anomalies ranging from 0K to +2K in the Irminger and Labrador Sea, as well as in the Davis Strait (Fig. 3) were observed.

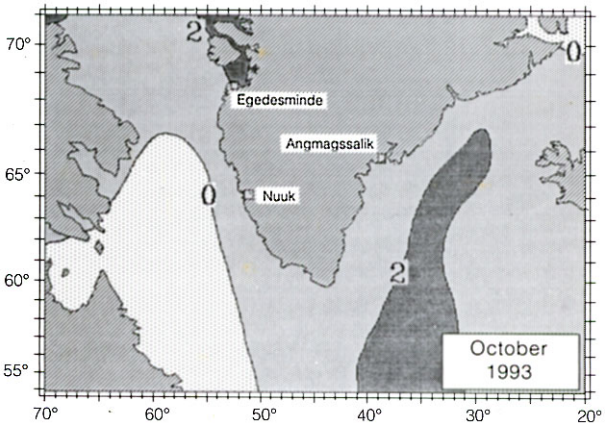

Fig. 3. Mean air temperature anomalies over the Northwest Atlantic, October, 1993.

Air temperatures and climatic means

The annual air temperature curves of Egedesminde, Nuuk and Angmagssalik were compared to the climatic means available from Anon. (1993). On the West Greenland side, the 1993 temperature curves revealed the anomalous conditions during the first quarter of the year which amounted to less than –25°C at Egedesminde (March), and less than –15°C at Nuuk (January). Except for part of the summer months and October, the entire temperature curves were below the mean (Fig. 4 and 5). Off East Greenland, at Angmagssalik, thermal conditions were below normal during most of the first half of 1993, however, in contrast to the west coast of Greenland, they were above normal from September onwards (Fig. 6).

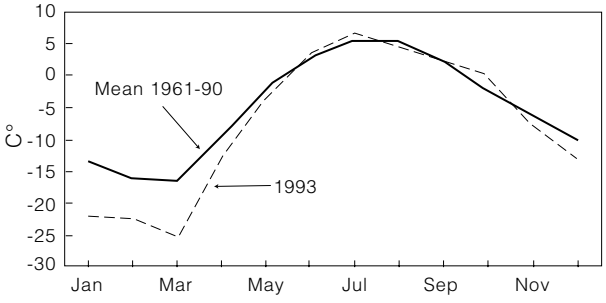

Fig. 4. Monthly mean temperature at Egedesminde during 1993 and climatic mean (1961–90).

Climatic variability off West Greenland

The air temperature time series of Nuuk revealed interannual and long-term variability of the climate at West Greenland (Fig. 7). The year-mean temperature anomaly for 1993 showed near-record low values which were in the range of the early-1980s anomalies. The long-term variability of the climate is indicated by the thick curve in Fig. 7. As

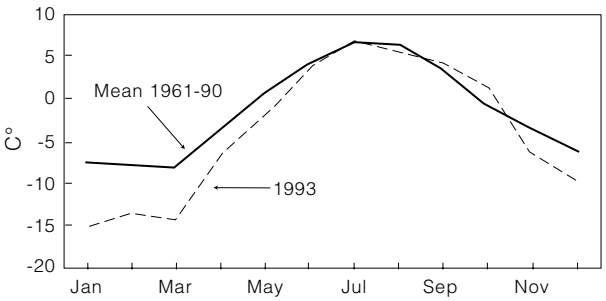

Fig. 5. Monthly mean temperature at Nuuk during 1993 and climatic means (1961–90).

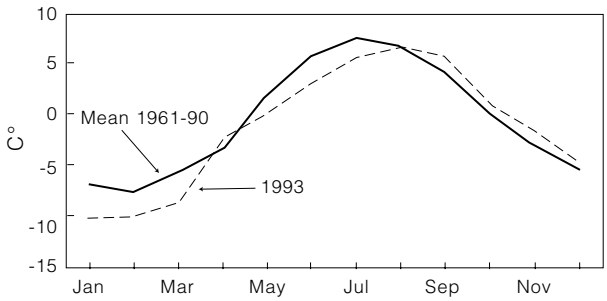

Fig. 6. Monthly mean temperature at Angmagssalik during 1992 and climatic mean (1961–90).

shown by Stein (1995) the low frequency change of air temperature has shown a downward trend since the late-1960s.

Ice conditions in the Northwest Atlantic

As in 1992, ice cover around Greenland persisted to be anomalous during 1993. The months January to March were characterized by extreme ice cover. Especially during late-March (24 March), the worst ice conditions were encountered off southwest Greenland. In the north off Baffin Island, anomalous ice cover was encountered from mid-August to mid-September (22 September). At Cape Farewell, the ice left late, not before August, 11 August, and returned early off East Greenland, during autumn. The ice returned to the Cape Farewell around mid-December (15 December). The two extremes of the 1993 ice cover are given in Fig. 8 and 9. During March, nearly the entire coast of Greenland was covered with ice. The areas normally ice free during March, are dark shaded in Fig. 8. Ice free conditions in the Irminger and Labrador Sea and in the Davis Strait were observed during October (Fig. 9). Off East Greenland, however, formation of new ice was already visible.

Subsurface observations off Greenland

West Greenland. Location of Standard Oceanographic Sections, as performed by RV *Walther Herwig* during the annual groundfish survey around Greenland, are given in Fig. 10. Off West Greenland, two of the NAFO Standard Oceanographic Sections (Stein, MS 1988) were performed, viz the Fylla Bank Section and the Cape Desolation Section. Time series analysis of the temperature and salinity data along both sections are given in Fig. 11–17, with Fig. 11–13 showing the thermohaline history of the Fylla Bank station 4 during the past thirty years (no observations during autumn 1992). Results of three different layers are given: the near surface layer 0–50 m where most of the short-term variability happens (Stein and Buch, MS 1985), the seasonal variable surface layer 0–200 m, and the Irminger layer 200–300 m which denotes the depth of major influence of the Irminger Current on the waters off West Greenland (Stein, 1993).

From the Cape Desolation Section, results of station 3 are displayed in Fig. 14 and 15. Recognizing this is only a short and scanty time series from the deep water sections (Stein and Wegner, 1990), the data show the interannual variation during autumn in the near surface layer (0–50 m), and the Irminger layer (200–300 m).

East Greenland. Off East Greenland three of the national Standard Oceanographic Sections were performed (Fig. 10). The Gauss Bank Section crosses the southward flowing current system influenced by the East Greenland and the Irminger Currents (Stein, 1993). The thermal history of the past decade is given for stations 4 and 5 of the section (Fig. 16, 17). Downstream of the Gauss Bank, the Discord Section crosses the East Greenland and Irminger Currents before they turn around the Cape Farewell and flow northward. Anomaly time series for temperature is given in Fig. 18.

Discussion

The zonal mean of air temperature anomalies for the area 85°N to 5°N, and 120°W to 70°E (about 37% of the northern hemisphere) was +0.07K for the year 1993. For 1992 a value of –0.12K was calculated (Henning, 1994). These 2 years still reveal an anomalous cold situation for more than a third of the northern hemisphere compared to the years 1990 and 1991 (+0.45K and +0.35K). Henning (1994) concluded that the June 1991 eruption of the Volcano Pinatubo at Luzon, Philippines, might be the cause for this long-term cooling process in the northern hemisphere.

The negative air temperature anomalies over the Davis Strait/Labrador Sea during spring 1993 led to anomalous ice formation off West Greenland. The cooling signal was largest on the West Greenland side, as documented by the annual climatic curves

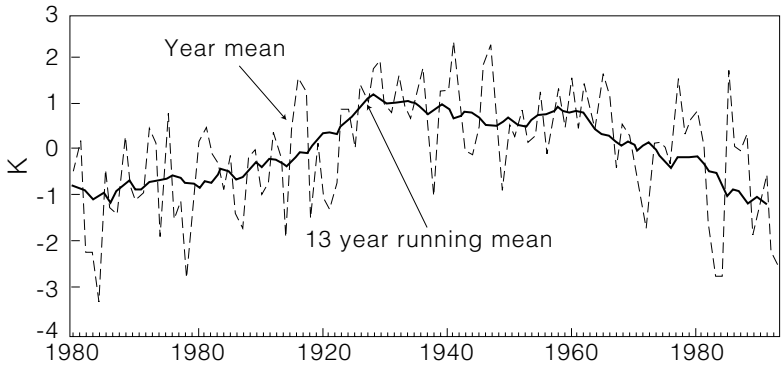

Fig. 7. Time series of annual mean air temperature anomalies at Nuuk (1880–1993) and 13 year running mean.

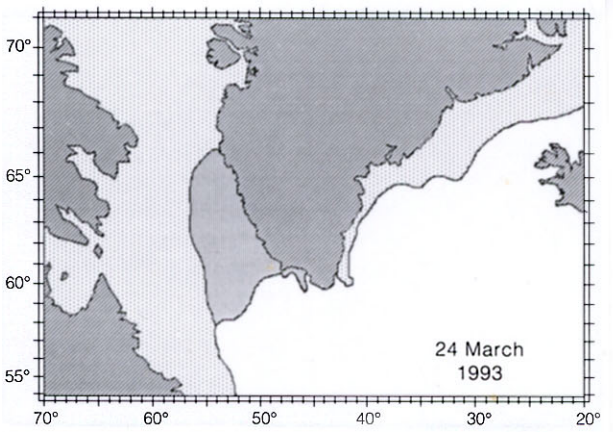

Fig. 8. Ice edge during 24 March 1993; dark shaded areas indicate anomalous extent of ice edge during the month of March.

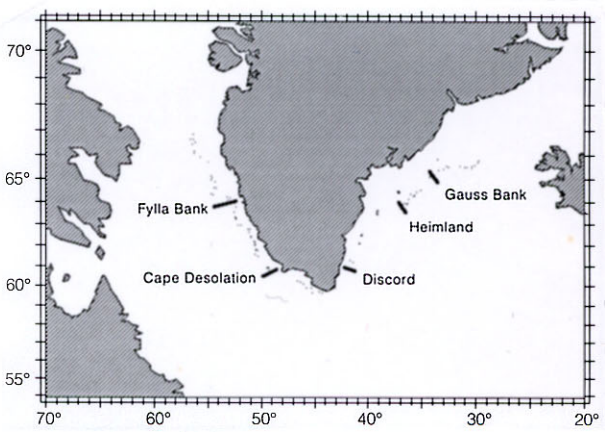

Fig. 10. Location of international/national Standard Oceanographic Sections off West and East Greenland referred to in the paper.

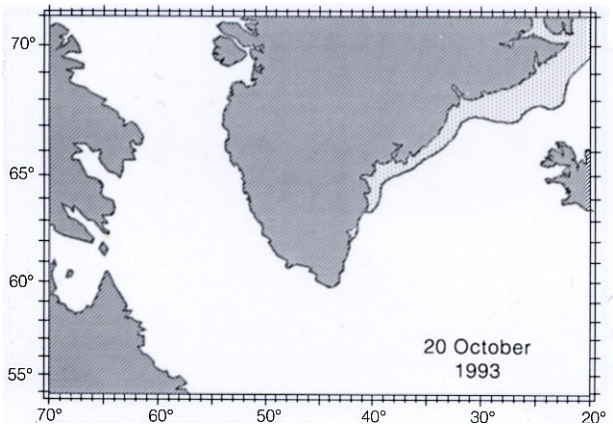

Fig. 9. Ice edge during 20 October 1993.

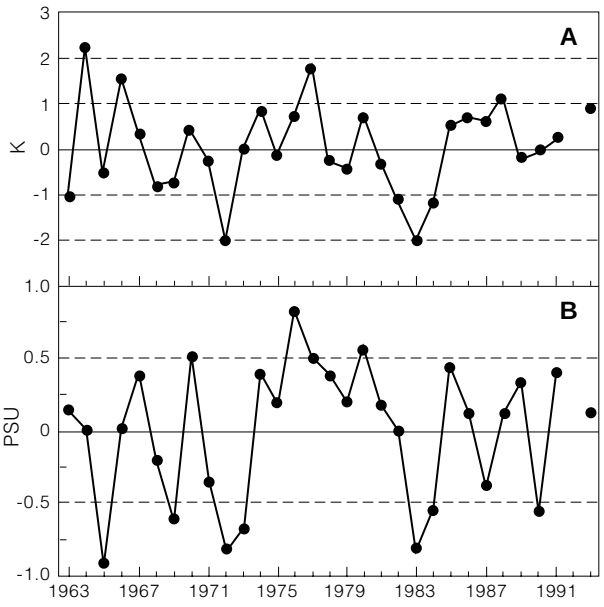

Fig. 11. Fylla Bank Station 4: temperature anomaly (**A**) and salinity (**B**) anomaly 0–50 m during autumn 1963–93.

of Egedesminde and Nuuk. During the first quarter of the year, air temperatures at these sites were well below normal (Fig. 4 and 5). During spring, thermal conditions improved and both cities experienced

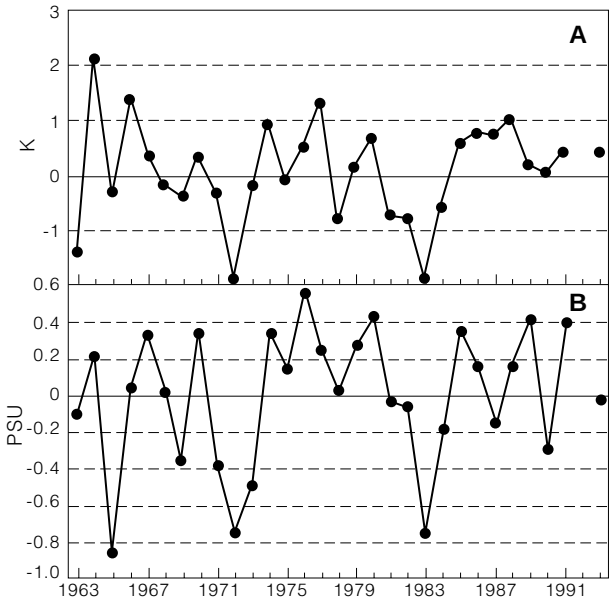

Fig. 12. Fylla Bank Station 4: temperature anomaly (**A**) and salinity (**B**) anomaly 0–200 m during autumn 1963–93.

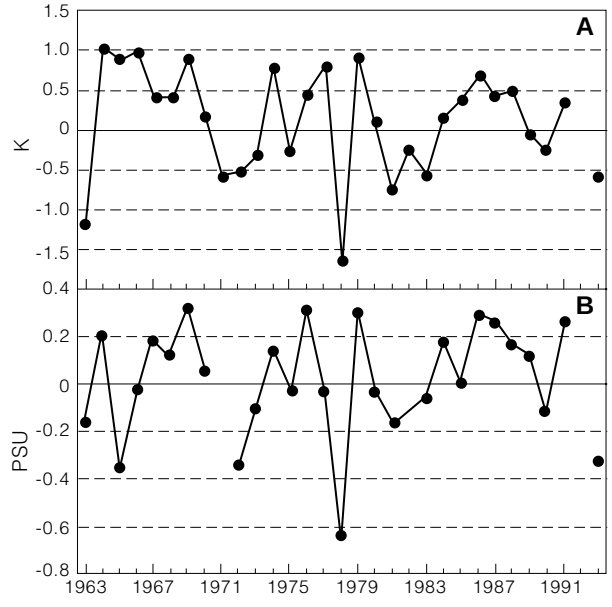

Fig. 13. Fylla Bank Station 4: temperature anomaly (**A**) and salinity (**B**) anomaly 200–300 m (Irminger layer) during autumn 1963–93.

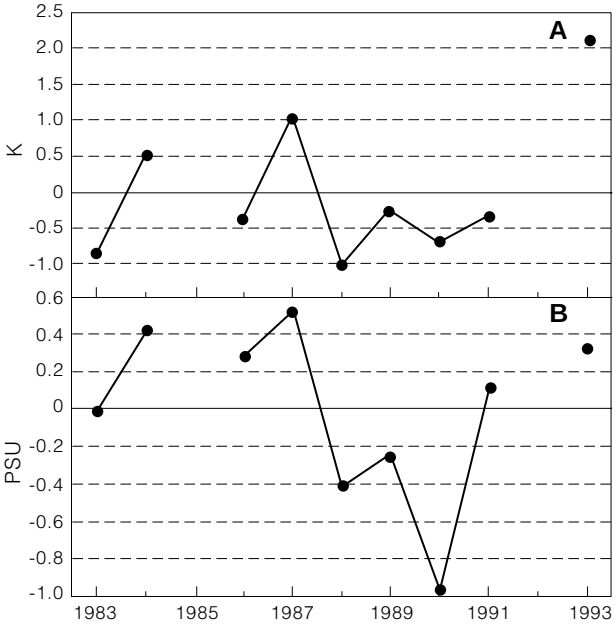

Fig. 14. Cape Desolation Station 3: temperature anomaly (**A**) and salinity anomaly (**B**) 0–50 m during autumn 1983–93.

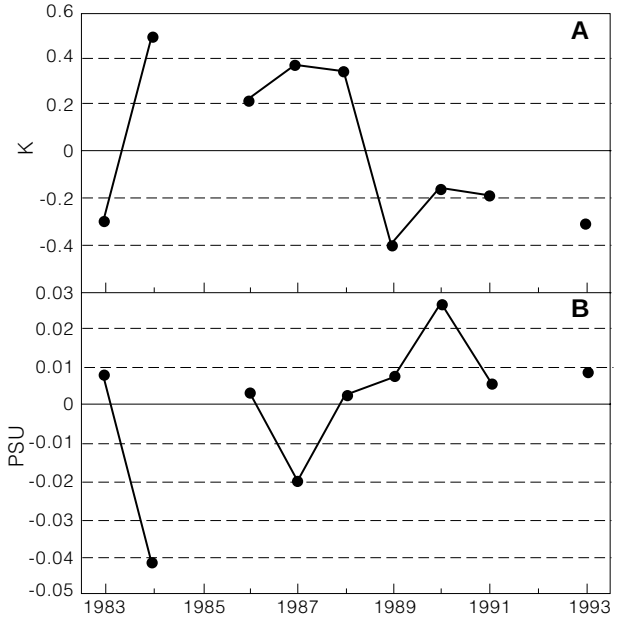

Fig. 15. Cape Desolation Station 3: temperature anomaly (**A**) and salinity anomaly (**B**) 200–300 m (Irminger layer) during autumn 1983–93.

normal climatic conditions. Largest positive deviations were encountered in October, whereas November and December were colder than normal. Similar to the West Greenland sites, Angmagssalik on the East Greenland coast experienced an anomalous first quarter of the year 1993 (Fig. 6). Spring and summer temperatures were below normal, and from about August the thermal conditions were above normal.

In the climatic curve of Nuuk/West Greenland, anomalous cold years were observed about every 10 years (Stein, 1993). After the cold early-1980s, 1983 and 1984 were among the coldest in over 100

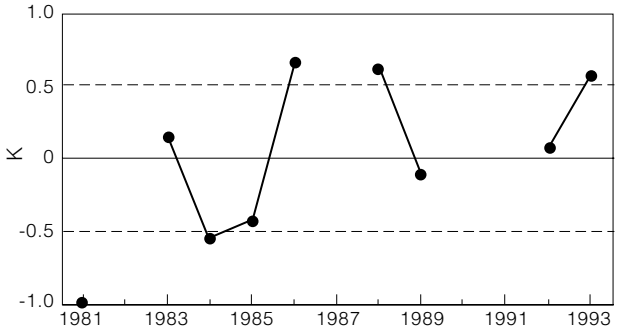

Fig. 16. Gauss Bank Station 5: temperature anomaly 0–200 m during autumn 1981–93.

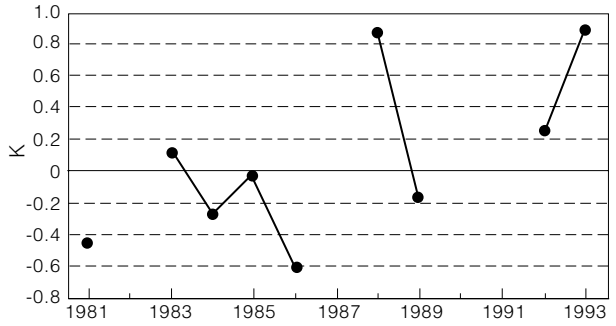

Fig. 17. Gauss Bank Station 4: temperature anomaly 0–200 m during autumn 1981–93.

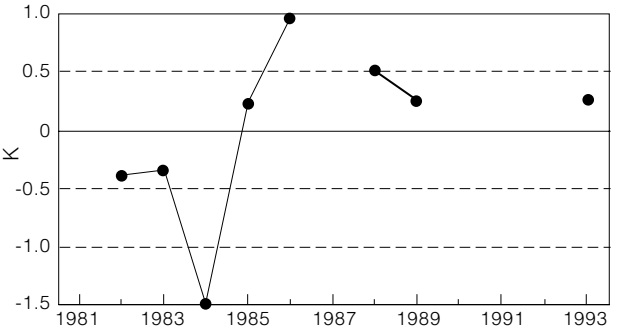

Fig. 18. Discord Bank Station 4: temperature anomaly 0–200 m during autumn 1981–93.

years of record, the early-1990s (1992 and 1993) once again showed similar negative anomalies. From the annual mean of –1.4°C they deviated by –2.2 and –2.4, while the early-1980s anomalies amounted to –2.7. The cold conditions seem to have been maintained at West Greenland. The pattern seemed to continue, since the January and February 1994 air temperatures were also below normal (–8.2°C to –8.9°C, which is –0.7 to –1.1, below the climatic mean of 1961–90).

The subsurface observations off West Greenland indicated warming in the near surface layer 0–50 m. This might have been the influence of the warm air temperature conditions during September and October on the upper ocean layer (Stein and Buch, 1991). In contrast to the upper layer and the 0–200 m layer (Fig. 12), the Irminger layer (200–300 m) indicated cooling and dilution in the range of the early-1980s. Figure 12A and B, and 13A and B indicate consistency of the thermohaline events at Fylla Bank station 4, with intermediate warming periods characterized by higher than normal salinities, i.e. presence of saline Irminger Water, whereas the cold events were accompanied by dilution of the water layers. At station 3 of the Cape Desolation Section, similar results for the thermohaline properties in the upper water column were observed. Here a cooling trend has been visible in the Irminger layer since 1988, which has been accompanied by a decrease in salinity from 1990 onwards (Fig. 14, 15). Similar results were reported by Buch (MS 1994), and the presence of diluted Irminger Water with salinities slightly above 34.85 PSU has been indicated as far north as the Lille Hellefiske Section (Stein, MS 1988).

Off East Greenland, a comparative study of the data collected along the Gauss Bank Section during autumn since 1981 indicated thermal anomalies at the outer station were warmer than normal. Temperature anomalies were 0.6K for the upper 200 m in 1993 at station 5, and 0.9K at station 4 which is the next station to the west of it. The 200–300 m layer of these stations also indicated changes. At station 4 the temperature anomaly varied between –0.12K and 0.16K while at the outer station changes ranging from –0.56K (1985) to 0.40K (1989) were encountered. The warm climatic conditions (as discussed above) favoured warming of the surface layer. Although rather scanty, the Discord Bank data also showed warmer than normal conditions (0.25K) for 1993.

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