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Climatic Conditions Around Greenland - 1996

by

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Abstract

Based on air temperature data from three sites of West and East Greenland, on ice charts for the area 54°N, 71°N and 20°W, 70°W, and on CTD profile observations around Greenland, the annual variability of climate is shown. Mean monthly air temperature data from Nuuk/West Greenland reveal the long-term interannual changes of air temperature anomalies. The warming trend which was observed during November, December 1995 was maintained into 1996 for about five months. Thus, spring warming of the near surface water layers, especially on the shallow bank areas off West Greenland has been favoured.

As a result of mild air temperatures over most of 1996, sea ice conditions were about normal around Greenland and off eastern Canada. Subsurface observations indicate considerable warming of the 0-200m water layer off West Greenland. The thermal anomaly of this layer amounts to +1.59K, which is the second highest value on record since the warm 1964 event.

The warmer than normal conditions as recorded since November 1995 off East and West Greenland, point at intermediate warming which is characteristic of the second half of the recent decades. The long-term trend of air temperature anomalies off West Greenland points, however, still at cooling, a trend which is persistent since the early 1970s.

As the potential driving mechanism for the intermediate warming in the Labrador Sea area, the sea level air pressure gradient between Iceland and the Azores is identified. The 1996 value of this gradient, the North Atlantic Oscillation (NAO) Index, is strongly negative and this represents the flow of mild air masses from the mid-latitude Atlantic Ocean to the Greenland/Labrador Sea region. Accordingly, air temperature anomalies indicated unusual warming during the month of February which amounted to >2K in the region of Baffin Land, Labrador and Greenland.

Introduction

In a recent study **Newell (1996)** identified a link between sea-ice clearing dates off the coast of Labrador and the Southern Oscillation. He found that in recent decades (1951-1984) low values of the Southern Oscillation Index (SOI) during the September to May period are associated with earlier than normal sea-ice clearing dates in the western Labrador Sea. Conversely, high values of the SOI during the same period lead to later clearing dates. **Newell (1996)** proposes that this relationship is a result of the SOI influencing sea-level pressure patterns over the north-west Atlantic which subsequently influence sea-ice clearing dates off Labrador.

The statistical relationships between various components of the subpolar North Atlantic air-sea-ice climate system were examined by **Wohlleben and Weaver (1995)** in order to investigate potential processes involved in interdecadal climate variability. They found that sea surface temperature anomalies concentrated in the

Labrador Sea region have a strong impact upon atmospheric sea level pressure anomalies over Greenland, which in turn influence the transport of freshwater and ice anomalies out of the Arctic Ocean, via Fram Strait. These freshwater and ice anomalies are advected around the subpolar gyre into the Labrador Sea affecting convection and the formation of Labrador Sea Water. This has an impact upon the transport of North Atlantic Current water into the subpolar gyre and thus, also upon sea surface temperatures in the region.
Wohlleben and Weaver (1995) propose an interdecadal negative feedback loop as an internal source of climate variability within the subpolar North Atlantic. They found time scales for one cycle of this feedback loop to have a period of about 21 years.
Finally, STACFEN recognized during it's June 1996 meeting that the North Atlantic Oscillation (NAO) index which represents the sea level pressure difference between Iceland and the Azores explains largely the hemispheric conditions in the North Atlantic Ocean **(Stein, 1996).**
While recent cooling has occurred in the Labrador Sea region, in the Barents Sea conditions have been very mild. The cause of the negative relationship is suggested to be related to the large-scale atmospheric wind patterns, the NAO. When the NAO index is high, the Icelandic Low strengthens and the northwest winds over the Labrador Sea intensify, carrying cold air further south. This produces more ice and colder temperatures. At the same time over northern Europe the southwest winds intensify carrying warm air masses farther north causing warm conditions to develop in the Barents Sea.

We see from these three examples that climatic conditions around Greenland are largely the product of hemispherical interactions, both in the east-west direction, and in the north-south direction. The link seems to be on a global scale.

Continuation of climatic data analysis is therefore vital for understanding the climatic events recorded around Greenland and in the Labrador Sea. The present paper is the fifth in a series which started with the year 1992, to elucidate relevant climatic issues around Greenland.

Data and Methods

Data on the atmospheric climate of 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 given by the Seewetteramt, Hamburg. The climatic mean which the air temperature anomaly charts are referenced to is 1961-1990. Ice charts were constructed from NOAA satellite ice charts. Anomalies of 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 in a computer slide show. The temperature anomaly maps for the Northwest Atlantic were taken from **Anon. (1996)**. The ice charts and the monthly air temperature anomaly maps are available from the author on request as computer slide shows. Subsurface ocean data are available from German measurements for the West Greenland area.

Results

Air Temperature and Sea Ice Anomaly during 1996

Compared to previous years, climatic conditions changed during the year 1996.

During 1992 to 1995 the pattern of air temperature anomalies between 20°W and 70°W, 54°N and 71°N was very similar in the first quarter of the year, especially during the coldest month of the year. This was February during 1992, and March during 1993, 1994, 1995 (**Stein, 1995; Stein, 1995a; Stein, 1996a, b**). Two examples from this period are given in Figs. 1 and 2. Whereas it was „normal" during the first half of this decade to find a cold air mass centered over the town of Egedesminde (labelled E in Figs. 1, 2) with air temperature anomalies of <10K (1992) and <6K (1995), air temperatures were 2.5 to 4.5K warmer than normal over the Canadian Archipelago and over Greenland during March 1996 (Fig. 3). This situation persisted throughout April when the centre of positive temperature anomalies was situated over South Baffin Land (+6K) and Northeast Greenland (+6.7K). May and June 1996 revealed colder than normal temperatures over the north American continent, over Baffin Land and the West Greenland Sea. July, August and September were warmer than normal in eastern Canada (+3K), and colder than normal off West Greenland. A steep south-north air temperature gradient east off Newfoundland in August 1996 produced a series of strong low pressure systems.
During the last quarter of the year positive air temperature anomalies prevailed in the Labrador Sea region. Positive anomalies over Baffin Island and Labrador persisted from November to December and increased to +6K. Except for Southwest Greenland which was slightly colder than normal, the west and east coast of Greenland encountered warming up to +4K.

Air Temperatures and Climatic Means
In contrast to previous years (**Stein, 1995; Stein, 1995a; Stein, 1996a, b**) the three observation sites at the west coast and east coast of Greenland (Egedesminde, Nuuk and Angmaggsalik, Fig. 4, 5, 6) indicated positive conditions throughout most of the first half of the year. Whereas the previously coldest month March revealed normal temperatures at Egedesminde (-16.4°C, Fig. 4), air temperatures at Nuuk and Angmaggsalik were considerably warmer than normal (-5.4°C at Nuuk and -2.6°C at Angmassalik). Summer months were slightly colder than normal at the west coast of Greenland, however warmer than normal at the east coast (Fig. 6).
The warming trend which was observed during November, December 1995 (**Stein, 1996b**) was maintained into 1996 for about five months. Thus, spring warming of the near surface water layers, especially on the shallow bank areas off West Greenland has been favoured.

Climatic Variability off West Greenland
For the first time since 1988, the 1996 annual mean air temperature anomaly value revealed above normal conditions (+0.6 K, Fig. 7). The decadal presentation of Nuuk mean air temperature anomalies (Fig. 8) indicated warming which was considerably larger than in the previous year. The long-term trend of Nuuk air temperature anomalies (the 13-year running mean as well as the 5-year running mean) was, however, far from returning to warm or even normal conditions (Fig. 7, 9).

Ice Conditions in the Northwest Atlantic
The southernmost location of the ice edge was found in the mid of March (960313, Fig. 10). Except for the anomalous ice cover around Cape Farewell the distribution of sea ice is normal. Nearly ice free conditions were found at the end

of September (960924, Fig. 11) when only at the Baffin Land coast some ice was found. During the last quarter of the year 1996 ice cover around Greenland and off arctic Canada was normal. Only at the beginning of December some new ice formed around Cape Farewell.

Subsurface Observations off West Greenland

Due to time constraints only two Oceanographic Standard Sections could be achieved during the cruise of FRV „Walther Herwig III". These were three stations of the Cape Desolation Section and five stations of the Fylla Bank Section (**Stein, 1988**). Fig. 12, 13 show results from station 4 of the Fylla Bank Section. The temperature and salinity time series are referenced to the 1963-1990 mean. Temperature and salinity indicate positive trends, and the temperature anomaly value is the second highest on record (+1.59K) since the warm 1964 conditions.

Further subsurface observations off East and West Greenland were performed in conjunction with the bottom trawl stations. Results on the thermohaline conditions and water mass properties on the fishing banks are given in a separate paper during the 1997 NAFO Scientific Council Meeting (**Stein, 1997**).

Discussion

As indicated by **Drinkwater et al. (1996)** the NAO index had a high value in 1995, and „it was expected that the air temperatures in the Labrador Sea region should have been colder than in recent years. However, the icelandic Low also shifted eastward reducing its influence over the Labrador Sea below that expected during a typical high NAO index year."

For 1996 the NAO index was -9.8 (dashed line in Fig. 14). Similar values were found at the end of the 1970s, and this represents the flow of mild air masses from the mid-latitude Atlantic Ocean to the Greenland/Labrador Sea region. Accordingly, air temperature anomalies indicated unusual warming during the month of February which amounted to >2K in the region of Baffin Land, Labrador and Greenland.

This had implications on the sea ice distribution in the Labrador Sea which seemed to be normal off the Labrador, Baffin Land and Greenland coast except for some unusual sea ice formation around Cape Farewell in January and February.

In contrast to the early 1980s and 1990s the characteristic feature of the „blocked cold air mass" centered near the city of Egedesminde (Fig. 3 in: **Buch and Stein, 1989**; Fig. 1 in this paper) has disappeared during 1996. This seems to represent large scale changes in the sea level pressure distribution, which, as indicated above, seems to be on the hemispherical or even global scale.

Warmer than normal spring conditions (March, April, May) were the consequence of a warmer than normal winter 1995/1996. Summer was slightly colder at the west coast of Greenland, however warmer at the east coast.

The warmer than normal conditions as recorded since November 1995 off East and West Greenland, point at intermediate warming which is characteristic of the second half of the recent decades. The long-term trend of air temperature anomalies off West Greenland points, however, still at cooling, a trend which is persistent since the early 1970s (c.f. **Stein, 1996b**).

The subsurface observations on the Fylla Bank Station 4 reveal anomalous warm and saline conditions in all water layers from the surface down to 300m depth (Fig. 12, 13). The 200-300m water layer is mostly influenced by the slope trapped warm and saline Irminger component of the West Greenland Current system. As presented in a separate paper (**Stein, 1997**), the thermohaline conditions on the West Greenland fishing banks during autumn 1996 were dominated by this warm, saline water mass.

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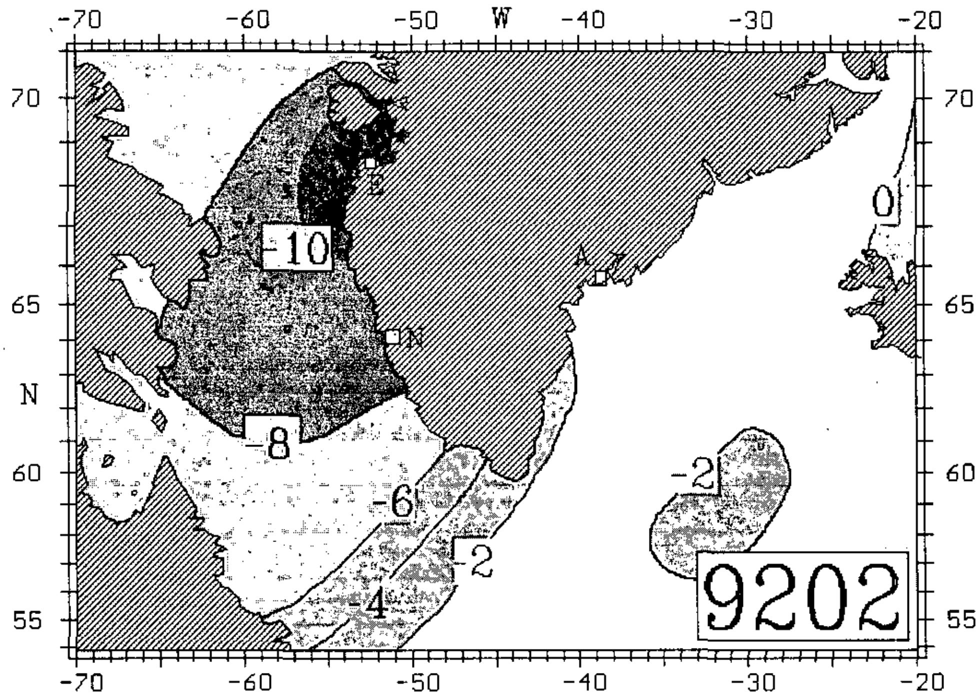

Fig. 1 Mean air temperature anomalies over the Northwest Atlantic during February, 1992 (E=Egedesminde, N=Nuuk, A=Angmagssalik)

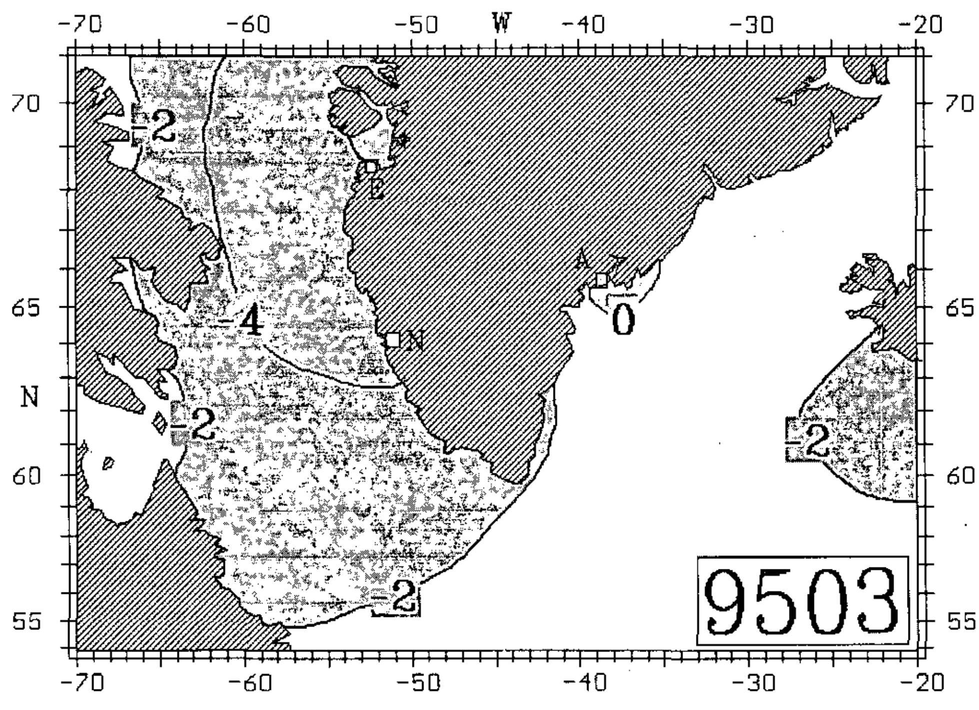

Fig. 2 Mean air temperature anomalies over the Northwest Atlantic during March, 1995 (E=Egedesminde, N=Nuuk, A=Angmagssalik)

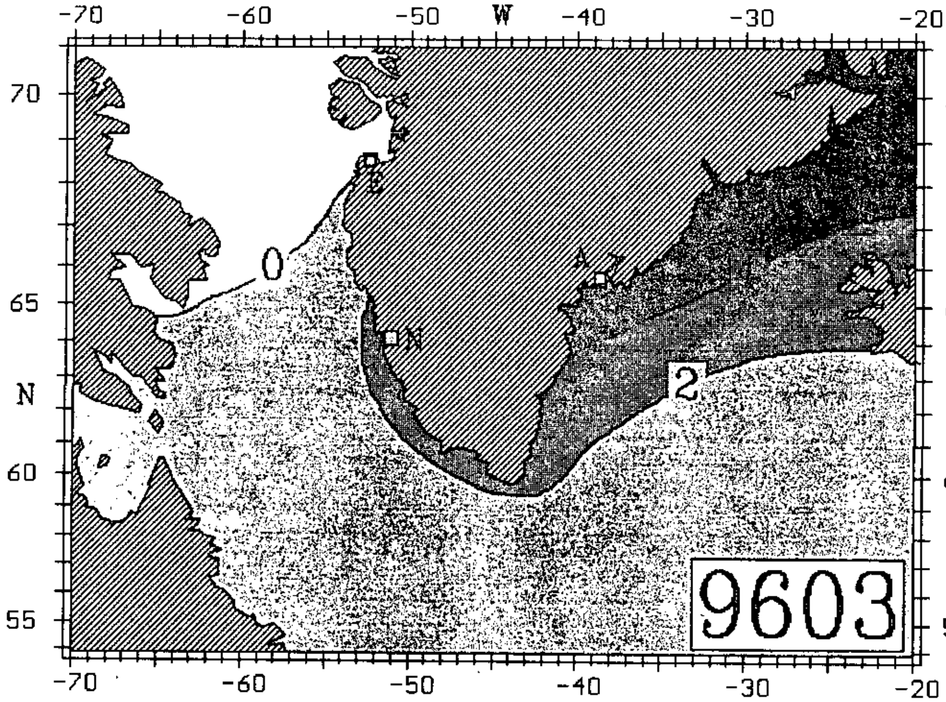

Fig. 3 Mean air temperature anomalies over the Northwest Atlantic during March, 1996 (E=Egedesminde, N=Nuuk, A=Angmagssalik)

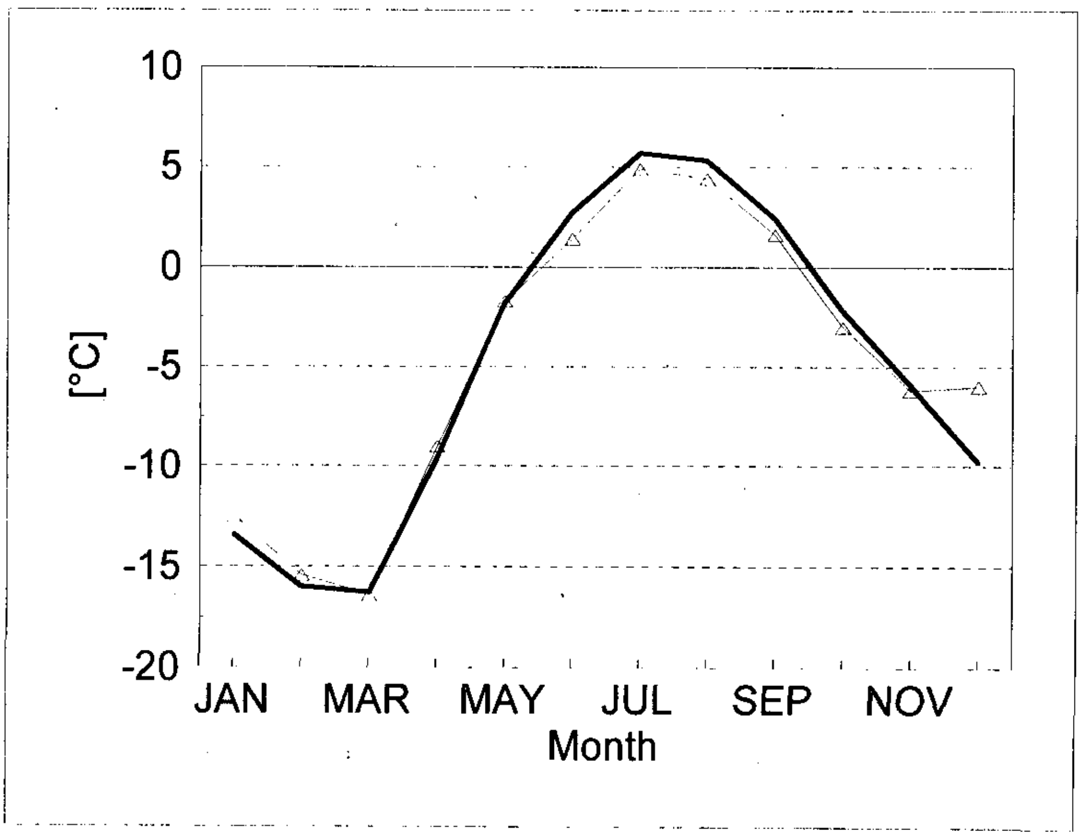

Fig. 4 Monthly mean air temperature at Egedesminde during 1996 and climatic mean (1961-1990)

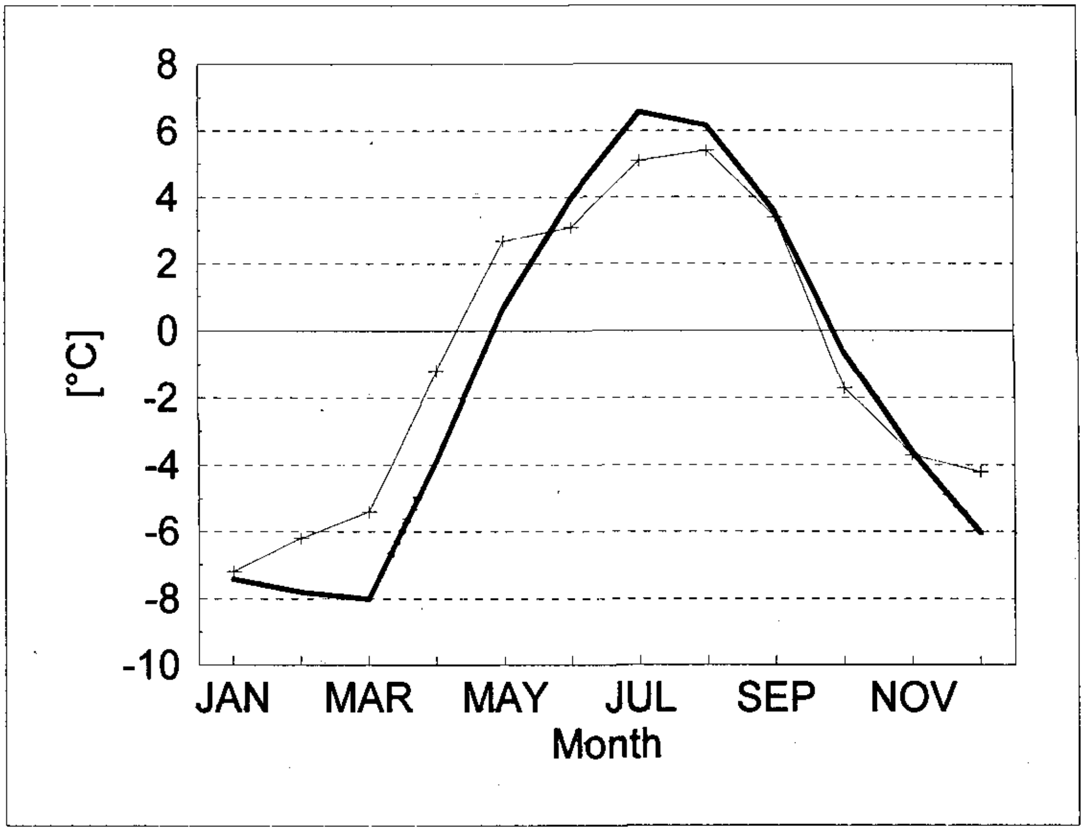

Fig. 5 Monthly mean air temperature at Nuuk during 1996 and climatic mean (1961-1990)

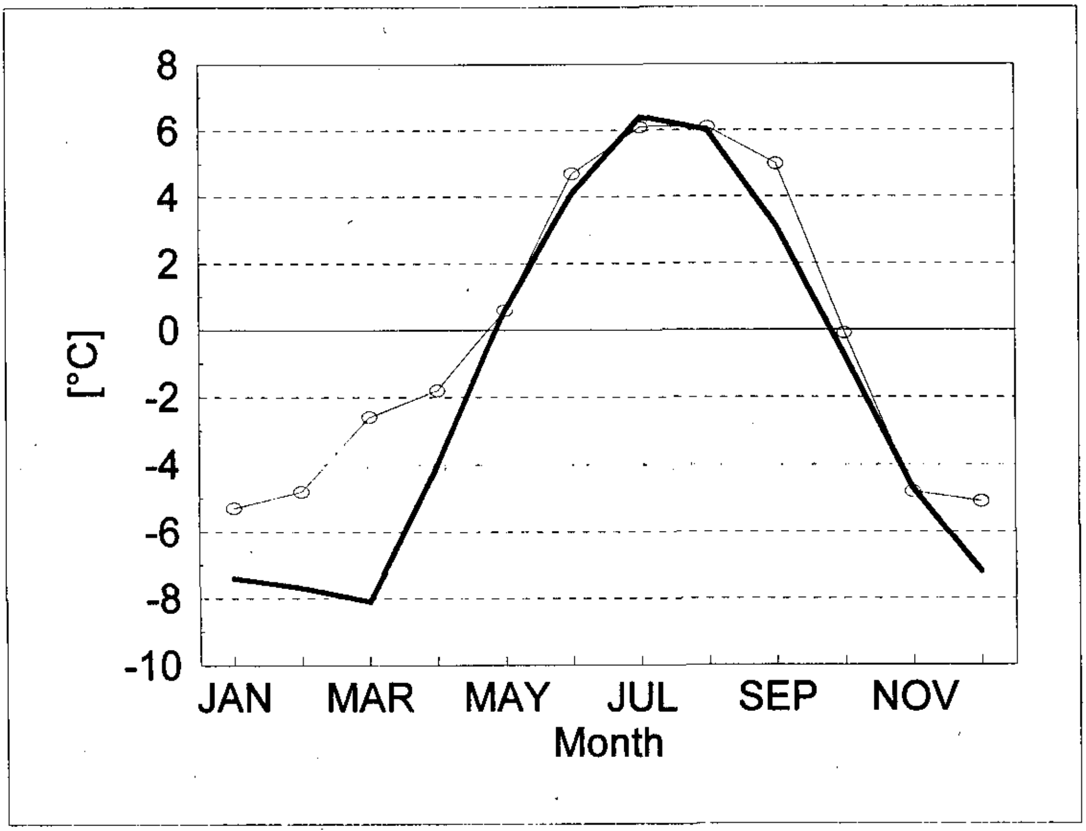

Fig. 6 Monthly mean air temperature at Angmagssalik during 1996 and climatic mean (1961-1990)

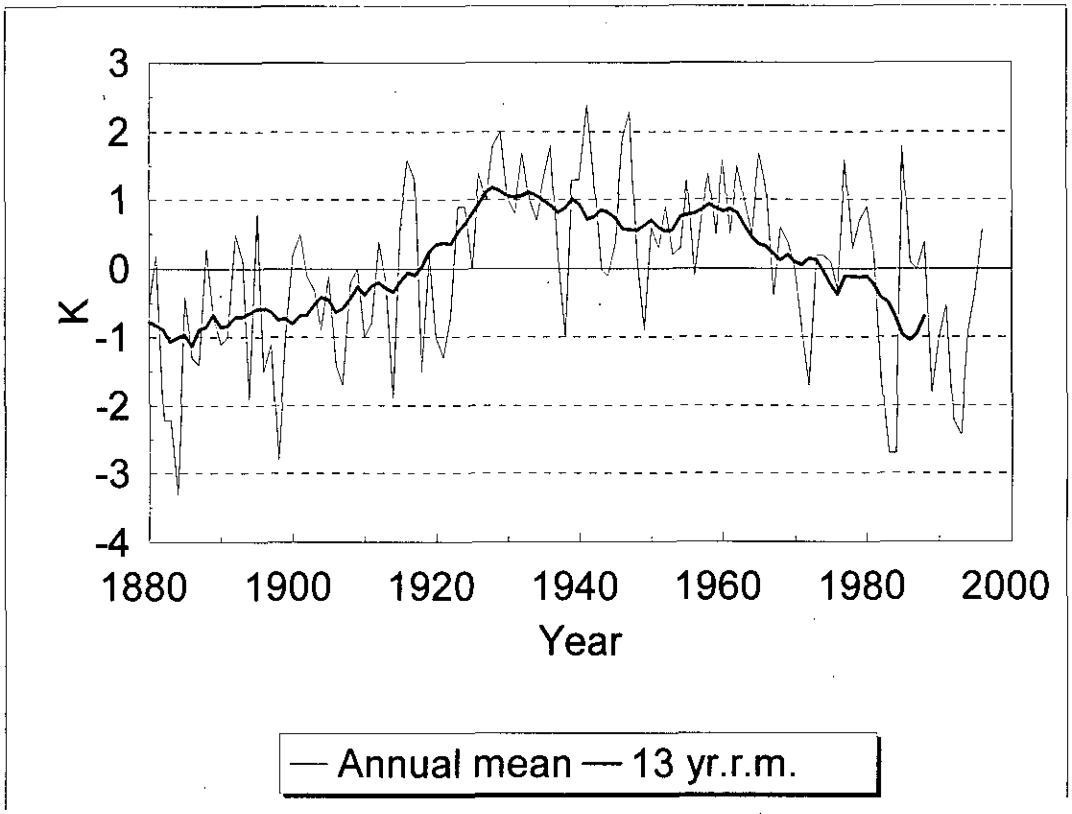

Fig. 7 Time series of annual mean air temperature anomalies at Nuuk (1880-1996, rel. 1876-1990) and 13 year running mean

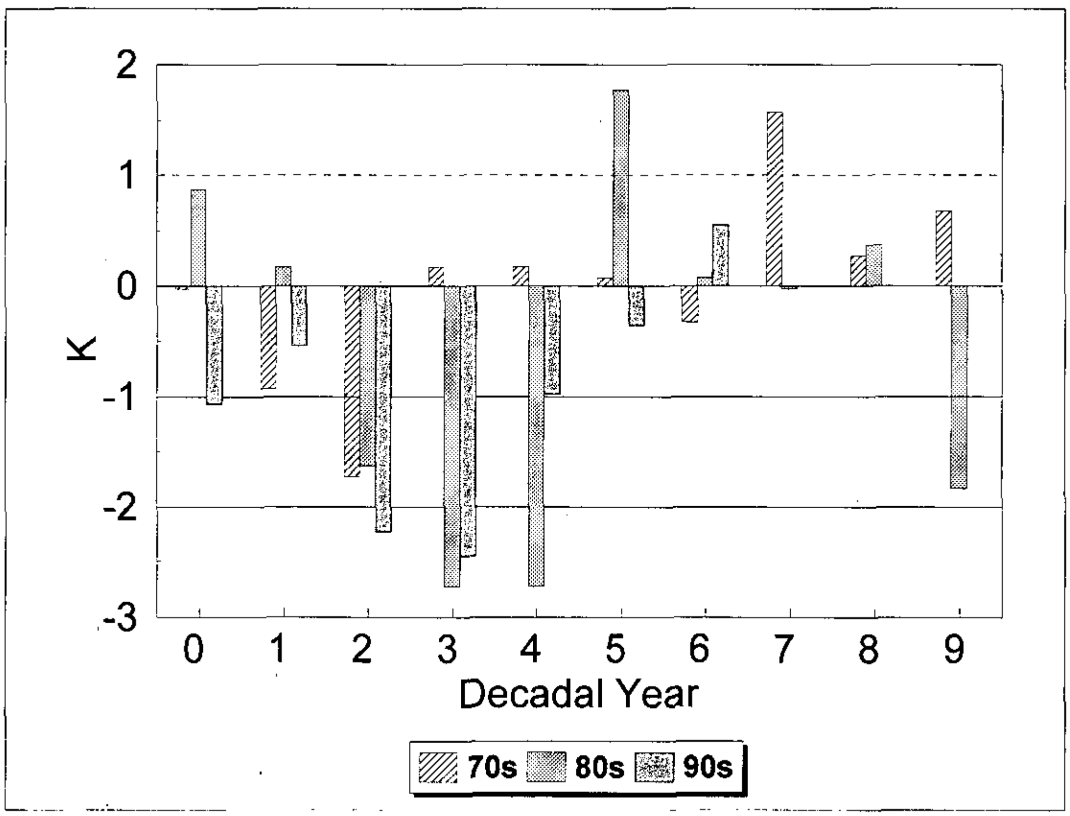

Fig. 8 Composite of decadal air temperature anomalies at Nuuk given relative to the climatic mean of 1961-90 for the decades of the 1970s, 1980s and 1990s

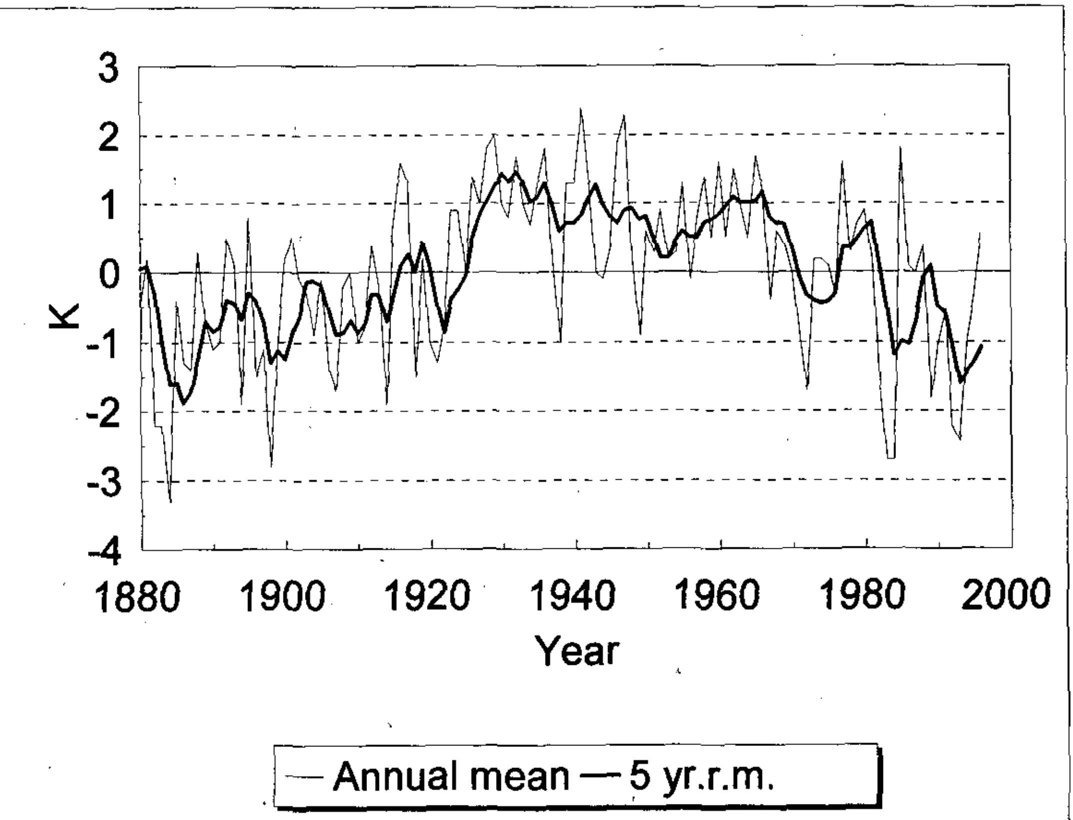

Fig. 9 Time series of annual mean air temperature anomalies at Nuuk (1880-1996, rel. 1876-1996) and 5 year running mean

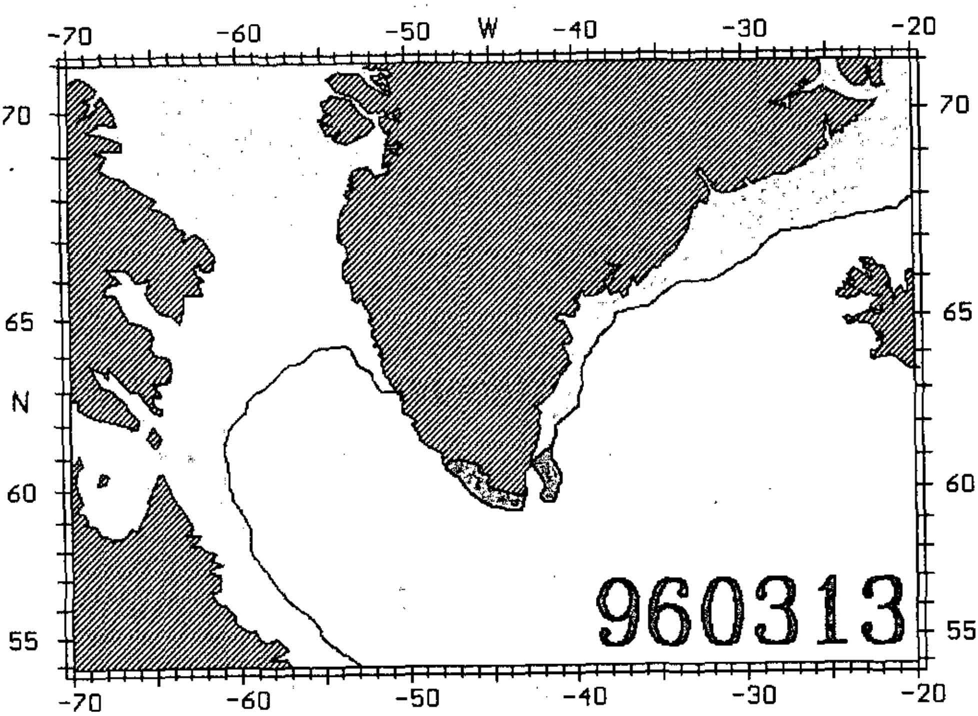

Fig. 10 Ice edge during March 13, 1996; dark shaded areas indicate anomalous extent of ice edge during the month of April

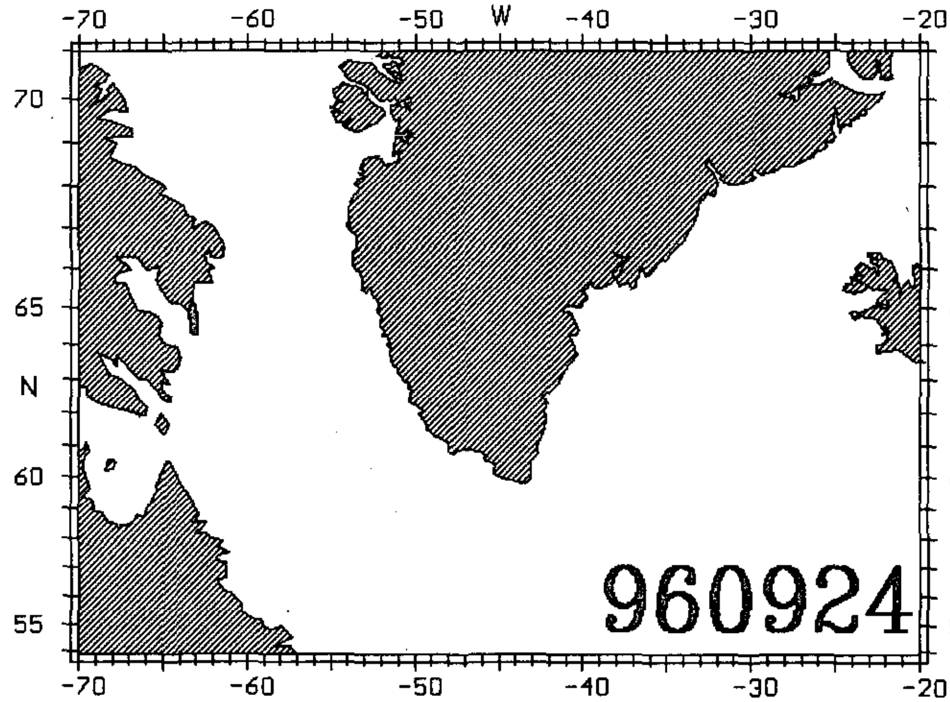

Fig. 11 Ice edge during September 24, 1996; dark shaded areas indicate anomalous extent of ice edge during the month of September

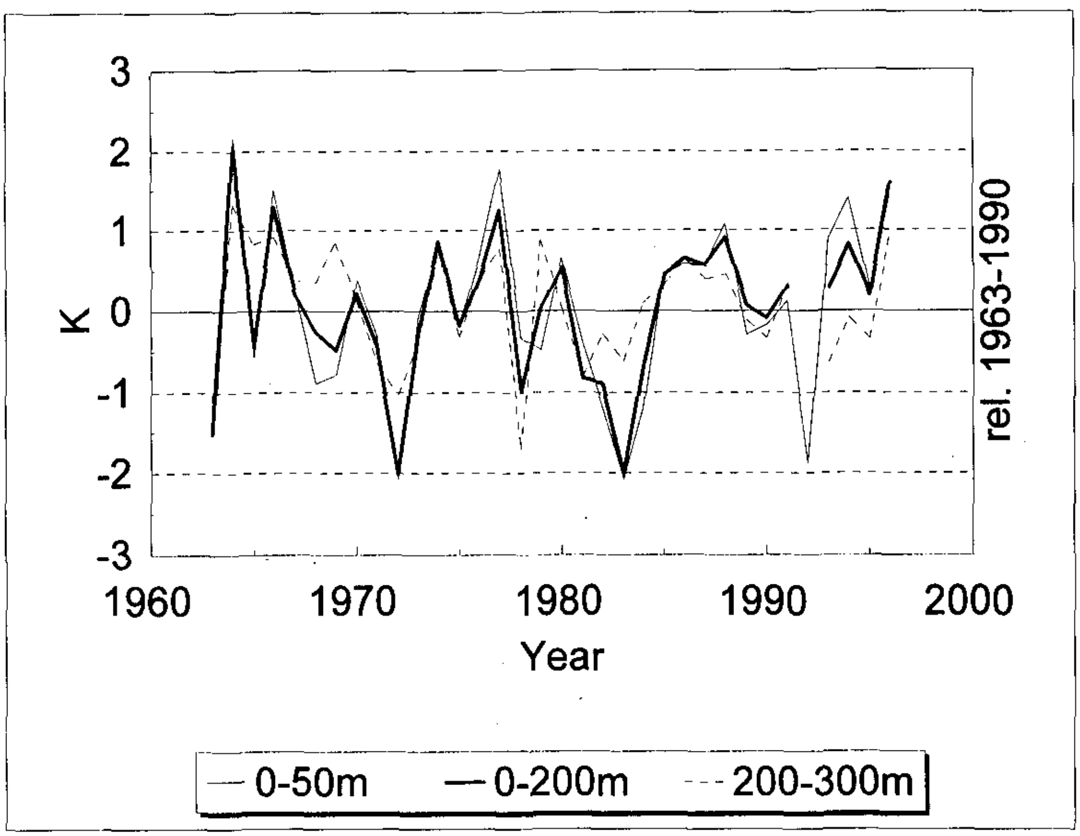

Fig. 12 Time series of temperature at Standard Oceanographic Station 4 of the Fylla Bank Section (1963-1996) for surface layers 0-50m, 0-200m and Irminger Water layer 200-300m

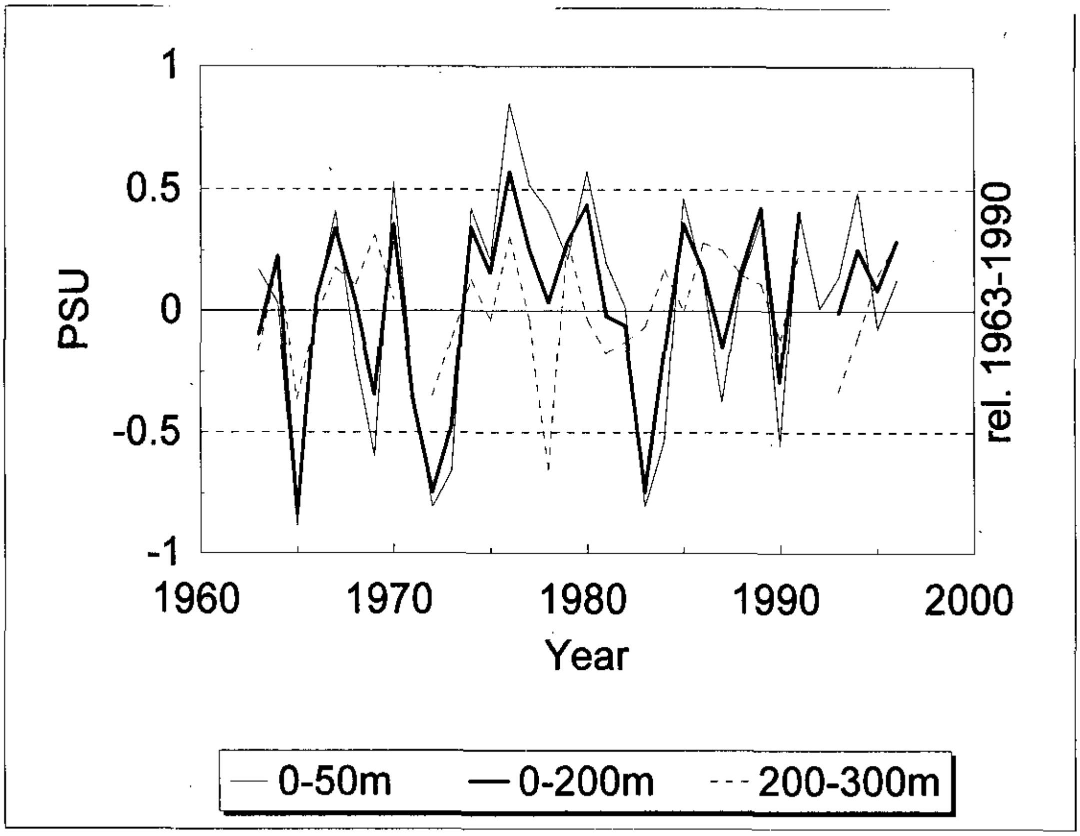

Fig. 13 Time series of salinity at Standard Oceanographic Station 4 of the Fylla Bank Section (1963-1996) for surface layers 0-50m, 0-200m and Irminger Water layer 200-300m

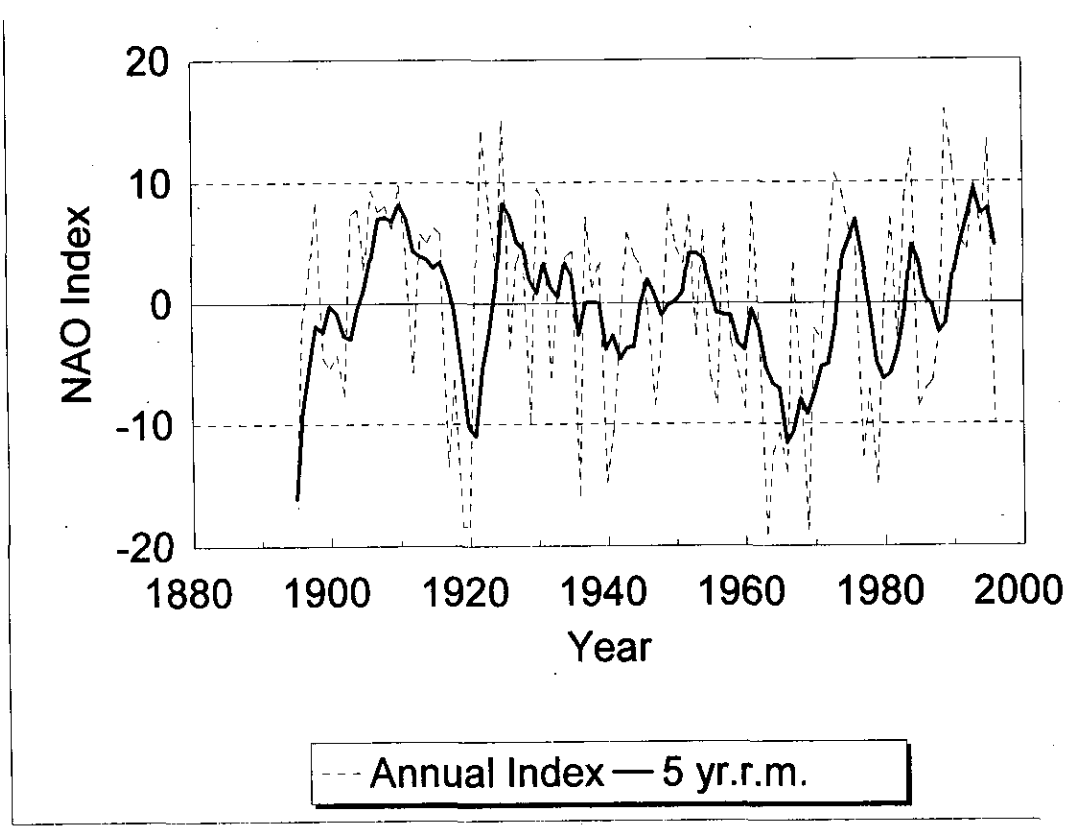

Fig. 14 The North Atlantic Oscillation Index defined as the winter (December, January, February) sea level pressure at Ponta Delgada in the Azores minus Akureyri in Iceland