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Environmental Overview in the Northern Atlantic Area – With Emphasis on Greenland

by

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Abstract

Air temperature anomalies and sea ice cover around Greenland during the early nineties indicate that at the beginning of the present decade similar anomalous cold environmental conditions are experienced in the Northwest Atlantic region than during the beginning of the seventies and eighties. It is shown that, similar to the last decade, cold air masses centered over the town of Egedesminde contribute to the extreme conditions off West Greenland during late winter/early spring. In contrast to the west coast, the east coast of Greenland showed different climatic conditions during 1992 and 1993. Under the regime of the anomalous cold air temperatures the surface layer of the ocean is cooled and sea ice formed to a larger extent than normal. Subsurface temperature observations on Fylla Bank/West Greenland indicate close correlation with air temperature variation. The climatic curves of Nuuk, Egedesminde, and Angmagssalik indicate warming and return to normal conditions during the year 1994. It would appear that this warming points at a **similar intermediate warming** as encountered **during** the **seventies** and **eighties**. This intermediate warming must, however, not necessarily indicate the end of the general cooling in this area as observed since the late sixties. Recent XBT-measurements of the vertical thermal field (0-750m) of the North Atlantic Ocean between Cape Farewell and the waters west off the British Isles, along 60°N, reveal no changes in the thermal properties when compared to historical observations during 1955.

SYMPOSIUM ON ANOMALOUS OCEANOGRAPHIC CONDITIONS

Introduction

There is evidence of global climatic changes (**HOUGHTON, 1991**) which are of different magnitude and sign, depending on latitude and region. Climatic models predict regional cooling, e.g. in the arcto Canadian and Greenland region, they indicate warming in the Siberian region (**MIKOLAJEWICZ et al., 1990**). As concerns the Northwest Atlantic region, time series of sea ice cover and air temperatures indicate considerable increase of duration and extension of sea ice and cooling trends of air temperatures on both sides of the Davis Strait/Labrador Sea (**DRINKWATER et al., 1994**). Potential impact of climatic changes in the Northwest Atlantic on fish stocks and fishery has been discussed recently (**STEIN, 1991**). Changes on decadal scales seem to play an important role in the North Atlantic region (**ANON., 1992**). Among these changes the influence of a salinity anomaly travelling along the North Atlantic circulation since the late sixties, the "Great Salinity Anomaly" (**DICKSON et al., 1988**), is thought to have sensible influences on recruitment of certain cod stocks (**CUSHING, 1990; MERTZ and MYERS, 1994**).

The present paper collates information on variability on decadal scales since the beginning of this century (sea surface temperature anomalies of North Atlantic regions), air temperature and subsurface ocean temperature variation during the last forty years off West Greenland, and air temperature and sea ice anomalies of the Northwest Atlantic during the early nineties with reference to the climatic mean 1961-1990. In a separate chapter, the paper gives information on thermal properties in the upper layer (0-750m) of the North Atlantic Ocean between Cape Farewell and Scotland.

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, the latter data sets are taken from **ANON. (1992a, 1993).** The Nuuk air temperature anomaly time series as displayed in **Fig. 1**, was referenced to the actual climatic mean (1961-1990). Ice charts were constructed from NOAA satellite ice charts. They give the approximate position of the ice edge for the annotated date. Anomalous ice cover, indicated by dark shading in **Figs. 7** and **8**, is related to mean ice conditions as given in **BUCH** and **STEIN (1989)** The temperature anomaly maps for the Northwest Atlantic were also taken from **ANON. (1992a, 1993)**. These temperature maps give air temperature anomalies relative to the 1961-1990 climatic mean. Both the ice charts and the temperature anomaly maps, are available from the author on request as computer slide shows. Sub-surface ocean data are available from Danish observations (June temperature data from Fylla Bank/West Greenland, **BUCH pers. comm.**) and from German measurements (November temperature data from Fylla Bank/West Greenland, and XBT-transects along 60°N across the Atlantic). XBT (Deep Blue) probes were launched every three hours after leaving Cape Farewell. Thus, about every 30 nautical miles a vertical temperature profile was obtained and transmitted via METEOSAT to the German Hydrographic Office. Data analysis and plotting of vertical sections was done there using the technique as described by **SY and ULRICH (1994)**. Sea surface temperature (SST) anomalies were mutually supplied by the former ICES Hydrographer Jens Smed. The data were transformed into computer readable format. The data were smoothed by a 25 year running mean. Results are displayed for areas A1, B, D, L, M, N (**Fig. 15a**, redrawn from **SMED, 1965**).

Results

Air Temperature Anomalies over the North Atlantic and Greenland

Similar to the last two decades, at the beginning of this decade anomalous low temperatures were encountered at West Greenland (**Fig. 1**). Although not being at record low values as during 1983 and 1984, the year mean data indicate near record low values for the years 1992 and 1993. These climatic conditions are quite in contrast to the fifties and sixties when positive temperature anomalies prevailed at West Greenland.

Mean air temperature conditions for the North Atlantic west of 20°W during 1992 and 1993 are outlined in **Figs. 2** and **3**. In both years negative temperature anomalies were observed to the west and south of Iceland, off Labrador and Greenland. During 1992, year mean temperature anomalies were below -3K in the Egedesminde region. February and March were the coldest months in these years with temperature anomalies below -10K (February 1992 at Egedesminde, **Fig. 4**) and below -8K (March 1993 at Egedesminde, **Fig. 5**). March 1994 air temperature anomaly distribution reveals similar conditions as during March 1993 for the West Greenland area (**Fig. 6**).

Distribution of Sea Ice

As a consequence of the anomalous cold air temperatures around Greenland during 1992 and 1993, the distribution of sea ice in the area was also anomalous. Two examples are given, they show the situation during the mid of July (**Figs. 7** and **8**): Ice was still present off Labrador and north of Baffin Island, as well as at Cape Farewell (July 15, 1992). A year later, a tremendous tongue of sea ice was covering the Cape Farewell region and stretched out to the northwest off West Greenland as far as Nuuk. At the western side of Davis Strait, north of Baffin Island, unusual coverage of sea ice was encountered on July 14, 1993.

Subsurface Temperature Distribution at Fylla Bank/West Greenland

Annual values of temperature anomaly on top of Fylla Bank (June data) and at the slope (November data) are given in **Figs. 9** and **10**. A five year running mean is superimposed on the annual curves. The data are referenced to the mean of the entire time series, whereas the data from the top of the bank are referred to the 1951-1980 climatic mean. Similar to the air temperature time series of Nuuk (**Fig. 1**), the water temperatures on top of Fylla Bank (40m of water column), reveal the cold events during 1969, 1970 and 1972, during 1983, and during 1991. The temperature anomaly data on the slope of the bank, at station 4 (**STEIN, 1988**), represent mean anomaly values of the upper 200m of the water column. Anomalous cold events were observed during 1972 and 1983.

Thermal properties of the North Atlantic along 60°N

During eastbound crossings of the North Atlantic, FRV "Walther Herwig" performed regular surveys of the upper ocean thermal field (0-750m) since 1989. **Figs. 11** to **13** show the vertical thermal fields during October, November and December. For comparison results from published data are displayed in **Figs. 14a** and **14b**. These data are May/June and October observations, done by FRV "Anton Dohrn" in 1955 (**DIETRICH et al., 1961**). To illustrate the temporal variation of thermal properties of the North Atlantic throughout most of this century, sea surface temperature anomalies from West Greenland to the west of the British Isles are given (**Fig. 15**) for the belt between 55°N and 60°N. Unfortunately, this time series was abandoned from 1975 onwards.

Discussion

After extremely cold years at the beginning of the previous two decades of the seventies and eighties, there was warming or return to normal conditions during the second half of these two decades with the exception of 1989 which was nearly 2K below the mean (**Fig. 16**). The early nineties seem to follow this trend. The climatic curve for Nuuk (**Fig. 17a**) shows that March is the coldest month on average of the climatic mean (1961-1990). During the early nineties, February 1992 was the coldest month. The present year (1994) was near normal during January, February, but anomalous cold during March. April to August data of this year are near to normal. Egedesminde air temperature data reveal a climatic curve similar to Nuuk (**Fig. 17b**). February 1992 was the coldest month on record (below -25°C mean temperature), followed by March 1993 with -25°C. The year 1994 indicates the return to normal climatic conditions, except for the month of March which was well below the norm. On the East Greenland side, at Angmagssalik, the typical cold spring conditions were not encountered (**Fig. 17c**). After 1993 being the coldest year, the 1994 conditions show near normal climatic conditions. The years two and three of the eighties and nineties (**Fig. 16**) indicate similar trends. Cooling in both years was strongest in February and March. This might reflect similar meteorological conditions in those years. The air temperature anomaly maps of February 1992, March 1993 and also March 1994 indicate a cold air mass centered over the town of Egedesminde (**Figs. 4, 5** and **6**). As discussed by **BUCH and STEIN (1989)**, a comparable meteorological situation was observed during the early eighties: cold arctic air masses were kept over Davis Strait for about two months. This resulted in cooling of the oceanic surface layer and led to the anomalous formation of sea ice.

A completely different situation in air temperatures at Nuuk was encountered during the fifties and sixties. Except for a minor negative deviation in 1956 and 1967, these decades were characterized by anomalous warm conditions (**Fig. 18**).

The warm conditions of the fifties and sixties are well reflected in the thermal conditions of the water column on top of Fylla Bank (**Fig. 9**). When air temperatures decreased at the end of the sixties, the first significant drop in water temperatures was observed during the beginning of

the seventies. Warming in the middle of the seventies and eighties did also influence the thermal conditions on Fylla Bank. From 1989 throughout the early nineties colder than normal ocean temperatures were observed. According to **BUCH (pers. comm.)** during the 1993 measurements in June, the surface layer at all stations off West Greenland was dominated by the inflow of cold, relatively fresh polar water.

The SST- anomalies of the North Atlantic areas given in **Fig. 15**, reveal a general warming of the surface waters between 55°N and 60°N which started in the twenties. Warming was most pronounced in area A1 (West Greenland, **Fig. 15a**). At the end of the sixties cooling of the surface waters occurred in all areas except for area N. At the same time cooling started off West Greenland in the air temperatures at Nuuk (**Fig. 1**), and the subsurface observations on Fylla Bank (**Fig. 9**). Subsurface observations on the thermal properties of these areas reveal a completely different picture. Measurements done by FRV "Anton Dohrn" during 1955, and by FRV "Walther Herwig" nearly forty years later, reveals about the same thermal conditions during October (**Figs. 11** and **14b**). The topographic influence of the Mid Atlantic Ridge on the distribution of water masses is similarly mapped during both observations (9 to 16 October 1955 and 22 to 25 October 1993). Doming of the isotherms to the west of the ridge (**Fig. 14b**) shows the Irminger Sea thermal properties: a deep reaching, nearly homogenous water mass below the upper thermocline. The upper 1000m of the water column east of the ridge comprise the waters of the North Atlantic Current, structured during the preceeding summer. A tongue of warm summer surface water stretches to the west with temperatures being well above 10°C. Both features and the same thermal properties were found during 1989, even with the tilting isothermes above the Mid Atlantic Ridge. **Figs. 12** and **13** elucidate the gradual decrease of thermal structure east of the Ridge when winter is approaching. The December observations (**Fig. 13**) show vertical convection within the upper 750m west off the British Isles: a nearly homogenous water mass.

The two comparable observations, made in 1955 and 1989, are too scarce to draw climatic conclusions. These examples express, however, what Global Climatic models take into account: **no warming in this part of the North Atlantic, but cooling in the Labrador/West Greenland area**. The climatic curves of Nuuk, Egedesminde, and Angmagssalik (**Figs. 17a-c**) indicate warming and return to normal conditions during the year 1994. It would appear that this warming points at a **similar intermediate warming** as encountered **during** the **seventies** and **eighties** (c.f. **Figs. 1** and **9**), as indicated by **STEIN (1993)**: "*Considering the shorter period variability (3.8 years), however, there is a probability for intermediate warming periods like in the mid-seventies and mid-eighties. Similar to the last two decades, these intermediate warming periods can raise mean air temperatures to above normal levels, e.g. during the mid-nineties.*" This intermediate warming must, however, not necessarily indicate the end of the general cooling in this area as observed since the late sixties.

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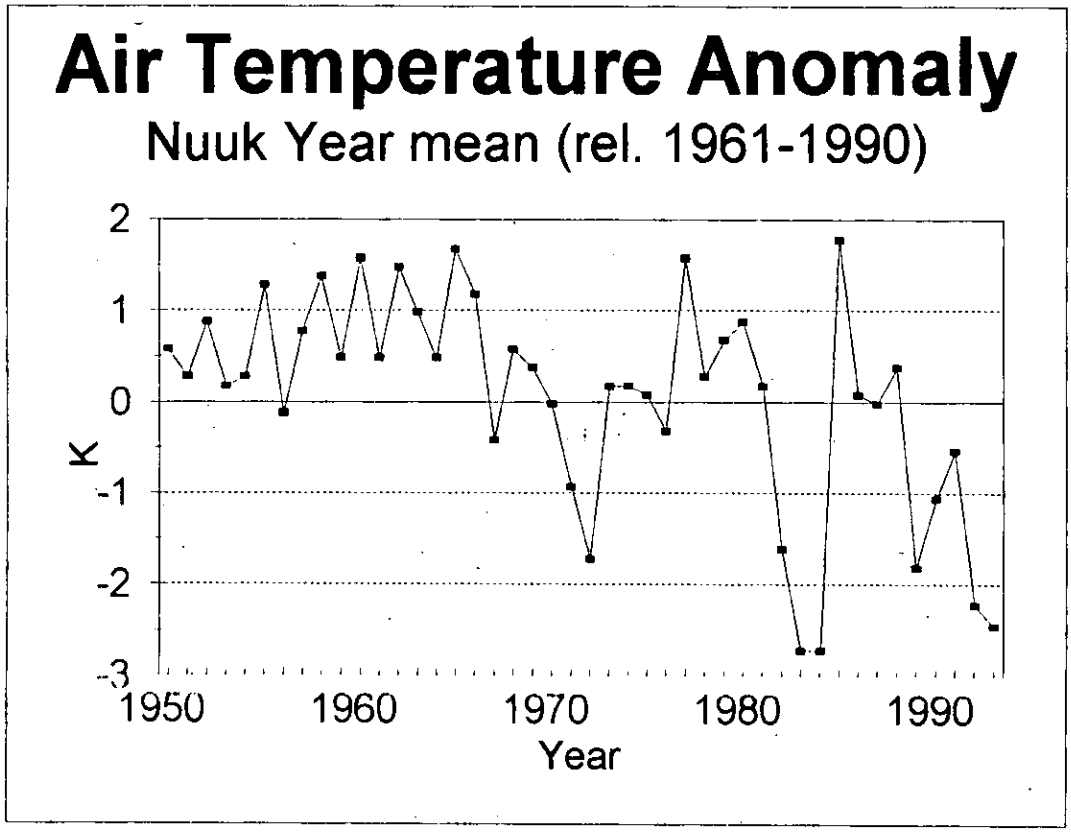

Fig. 1 Air temperature anomaly for year mean data at Nuuk, 1950-1993 (rel. to the climatic mean 1961-1990)

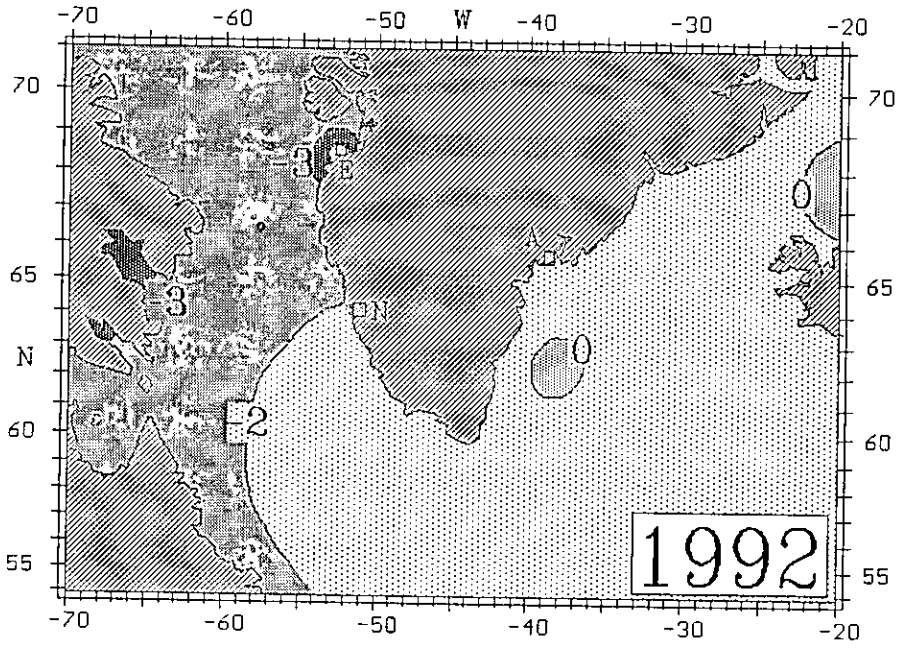

Fig. 2 Mean air temperature anomalies over the Northwest Atlantic during 1992 (data are given rel. to the climatic mean 1961-1990; E=Egedesminde, N=Nuuk, A=Angmagssalik)

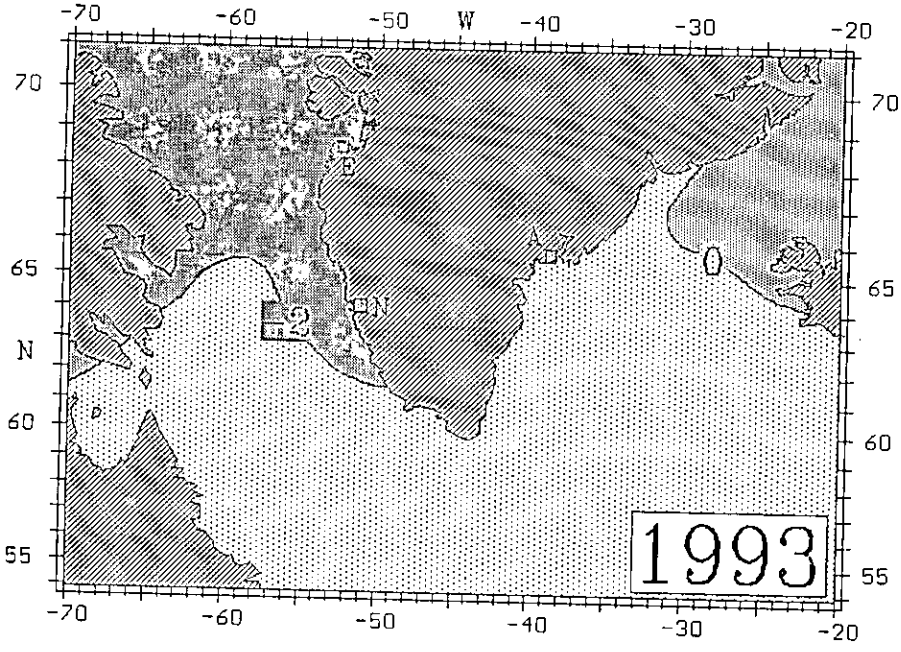

Fig. 3 Mean air temperature anomalies over the Northwest Atlantic during 1993 (data are given rel. to the climatic mean 1961-1990)

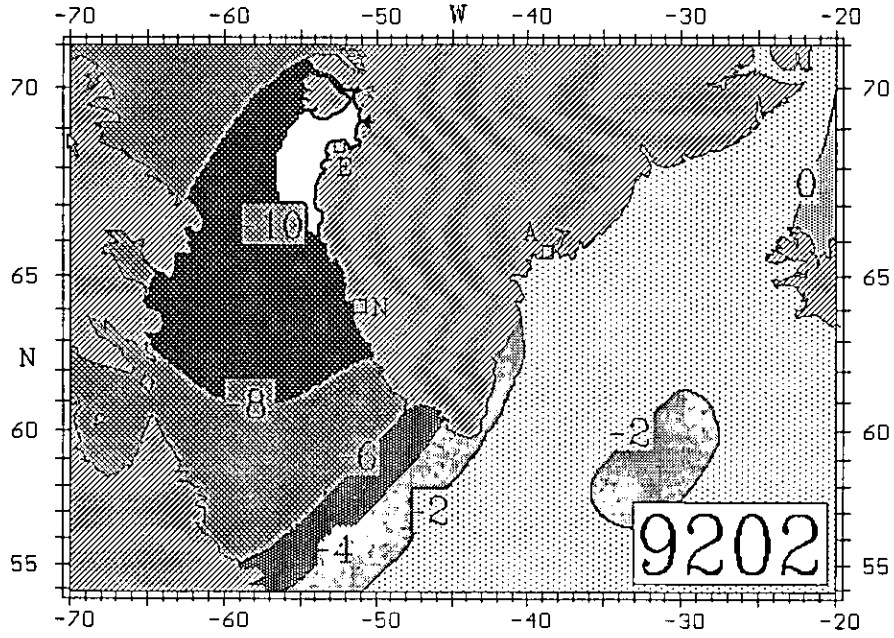

Fig. 4 Mean air temperature anomalies over the Northwest Atlantic during February 1992 (data are given rel. to the climatic mean 1961-1990)

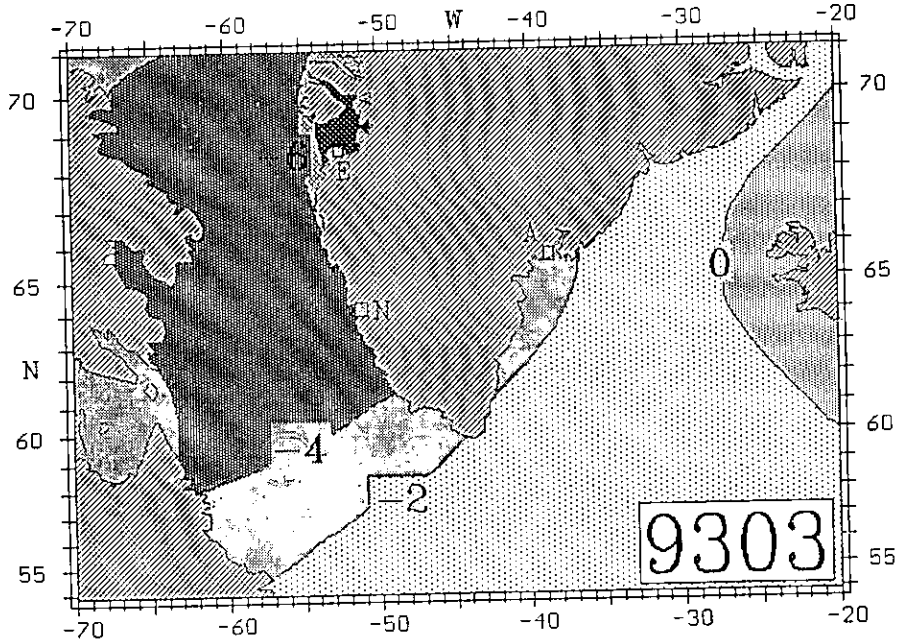

Fig. 5 Mean air temperature anomalies over the Northwest Atlantic during March 1993 (data are given rel. to the climatic mean 1961-1990)

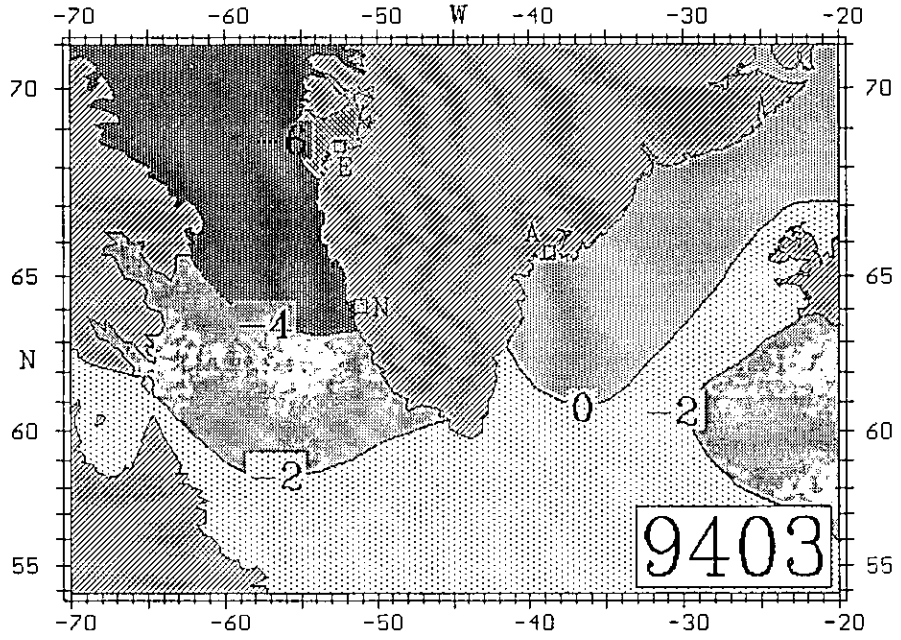

Fig. 6 Mean air temperature anomalies over the Northwest Atlantic during March 1994 (data are given rel. to the climatic mean 1961-1990)

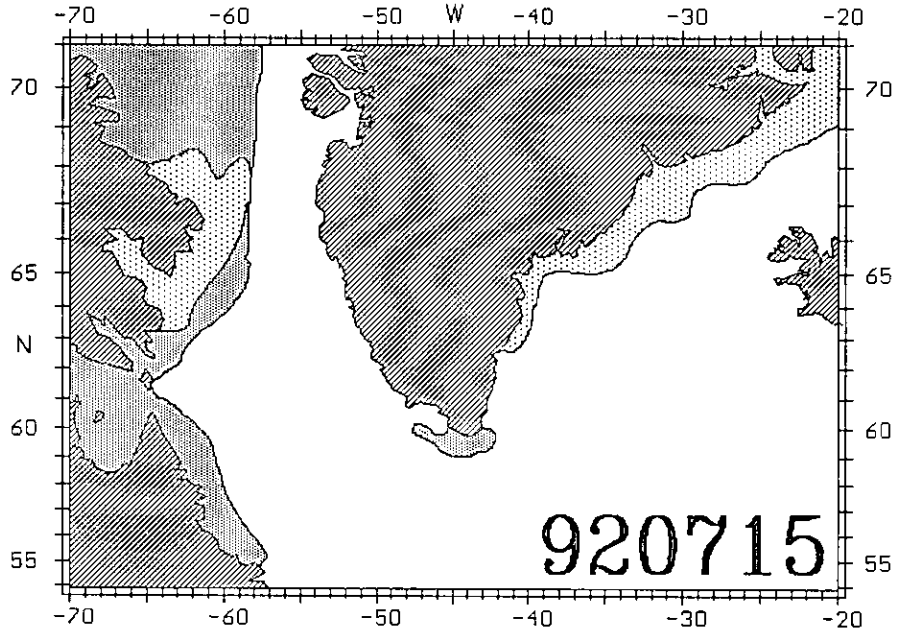

Fig. 7 Location of ice edge on July 15, 1992 (dark shaded areas denote anomalous ice cover for the given month)

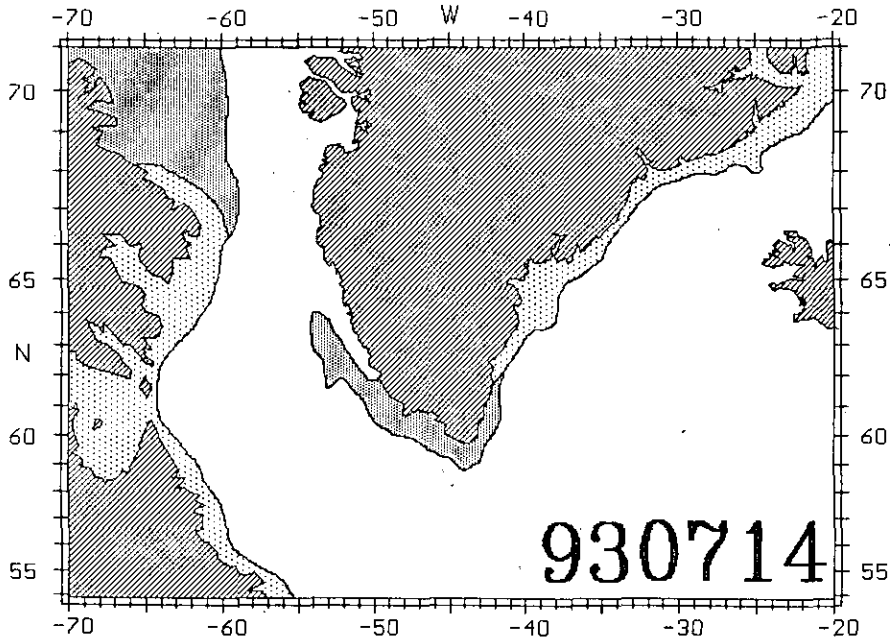

Fig. 8 Location of ice edge on July 14, 1993 (dark shaded areas denote anomalous ice cover for the given month)

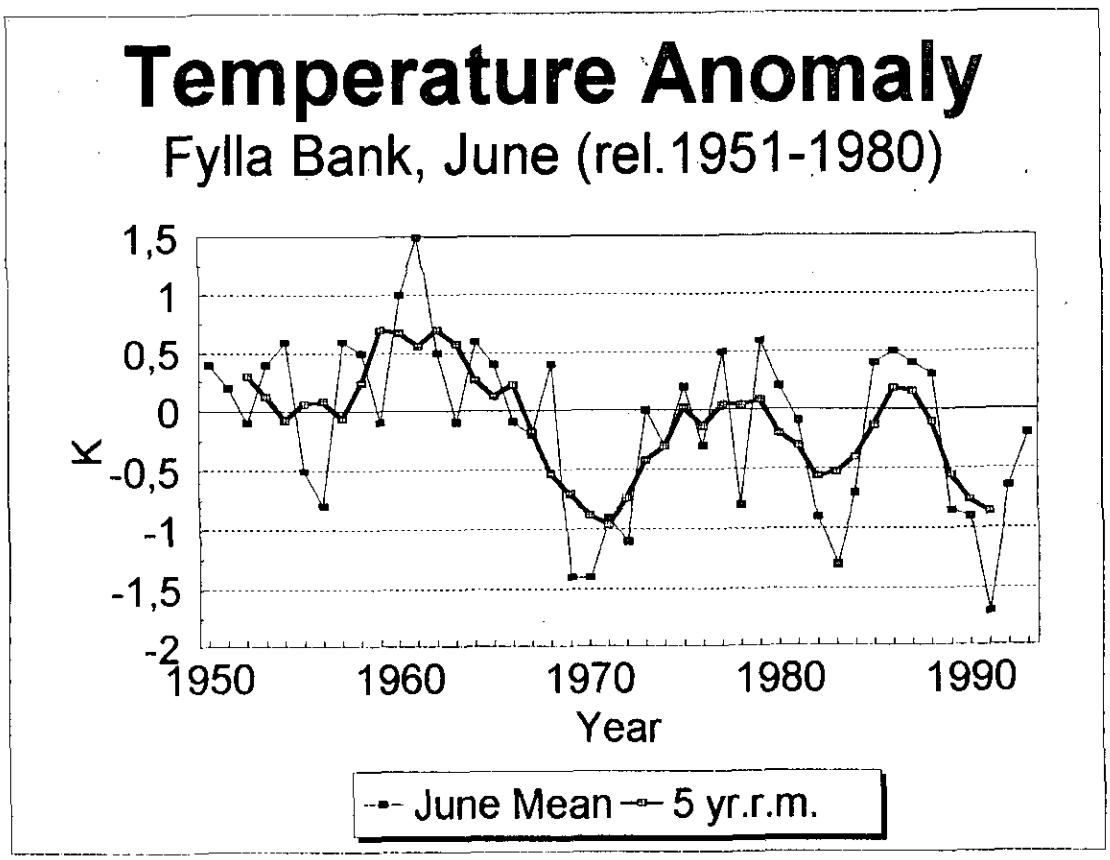

Fig. 9 Mean temperature anomaly on top of Fylla Bank (0-40m) during June (rel. to the mean 1951-1980) and 5 year running mean of the anomaly data

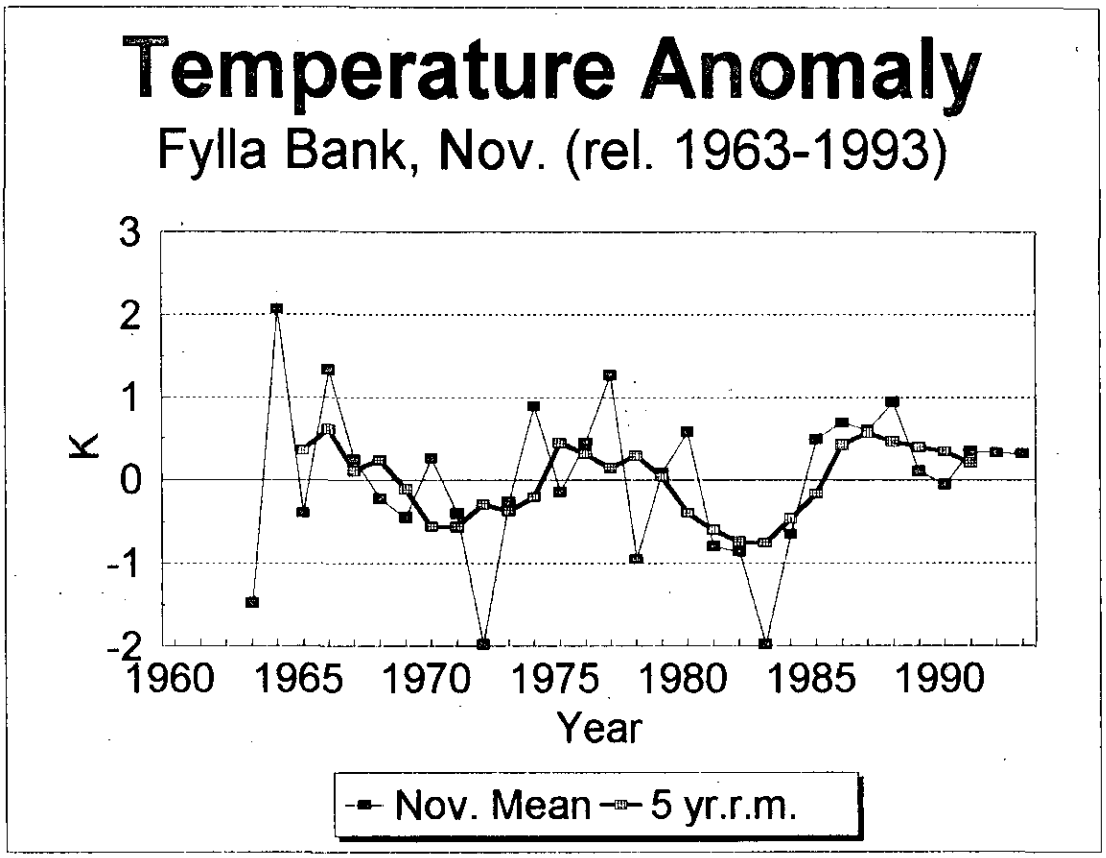

Fig. 10 Mean temperature anomaly at the slope of Fylla Bank (0-200m) during November (rel. to the mean 1963-1993) and 5 year running mean of the anomaly data

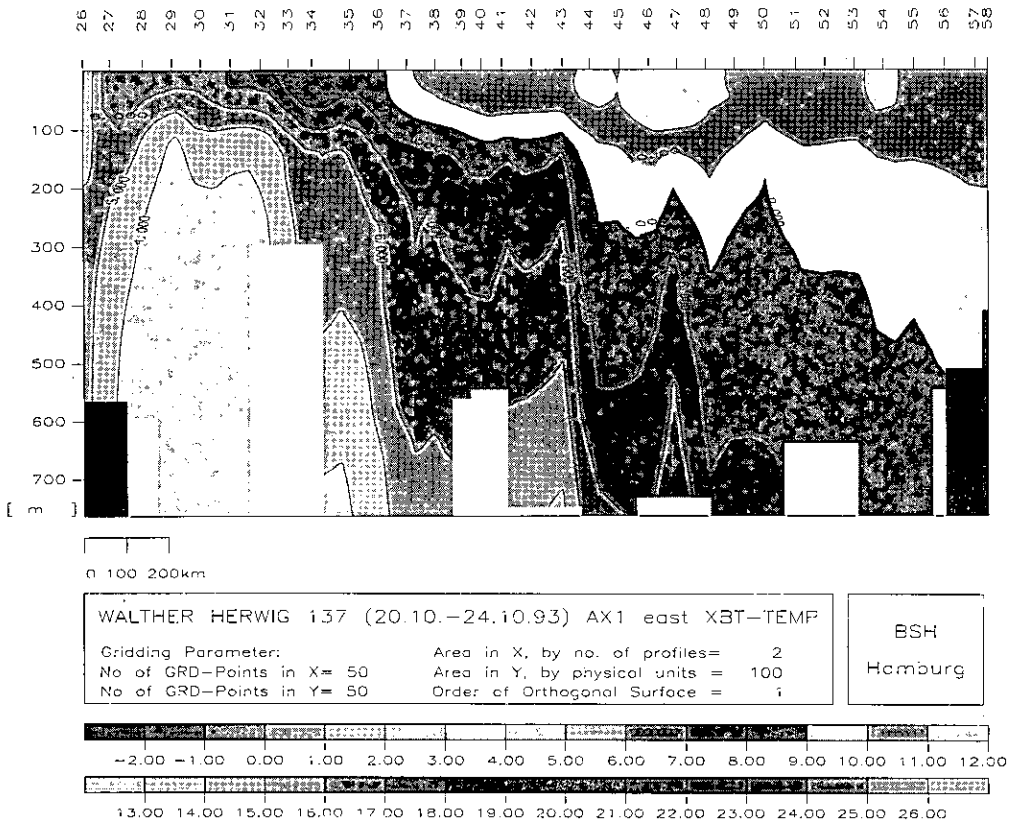

Fig. 11 Upper ocean thermal field of the North Atlantic along 60°N between Cape Farewell and the British Isles (October 20 to 24, 1993)

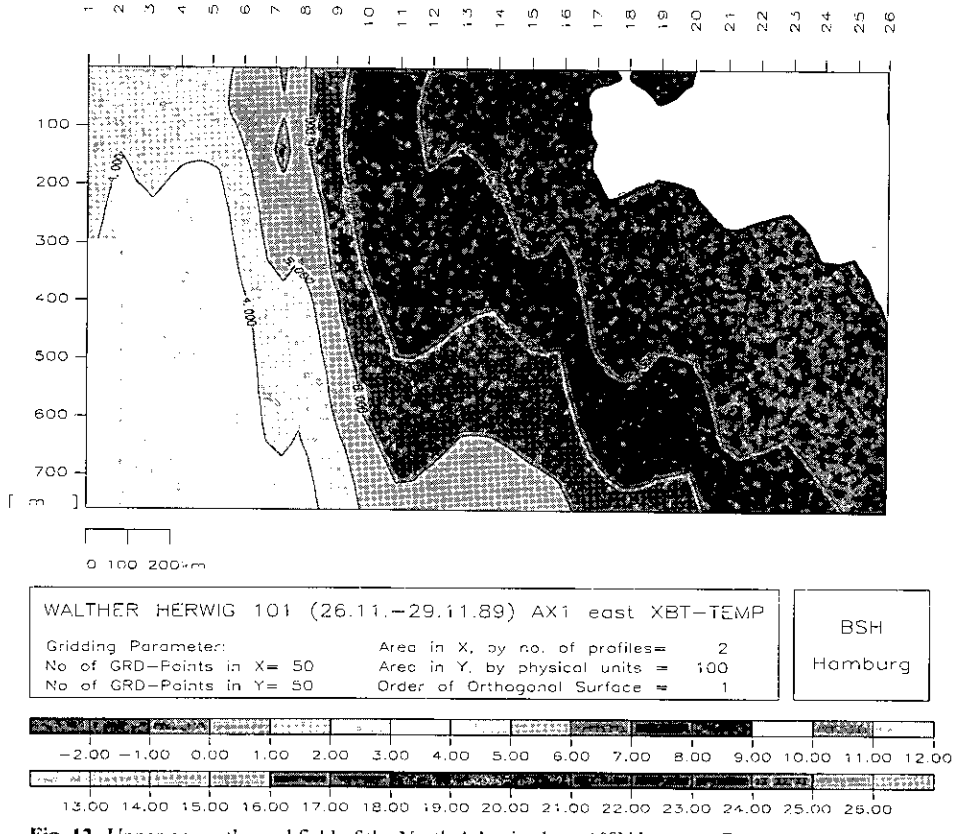

Fig. 12 Upper ocean thermal field of the North Atlantic along 60°N between Cape Farewell and the British Isles (November 26 to 29, 1989)

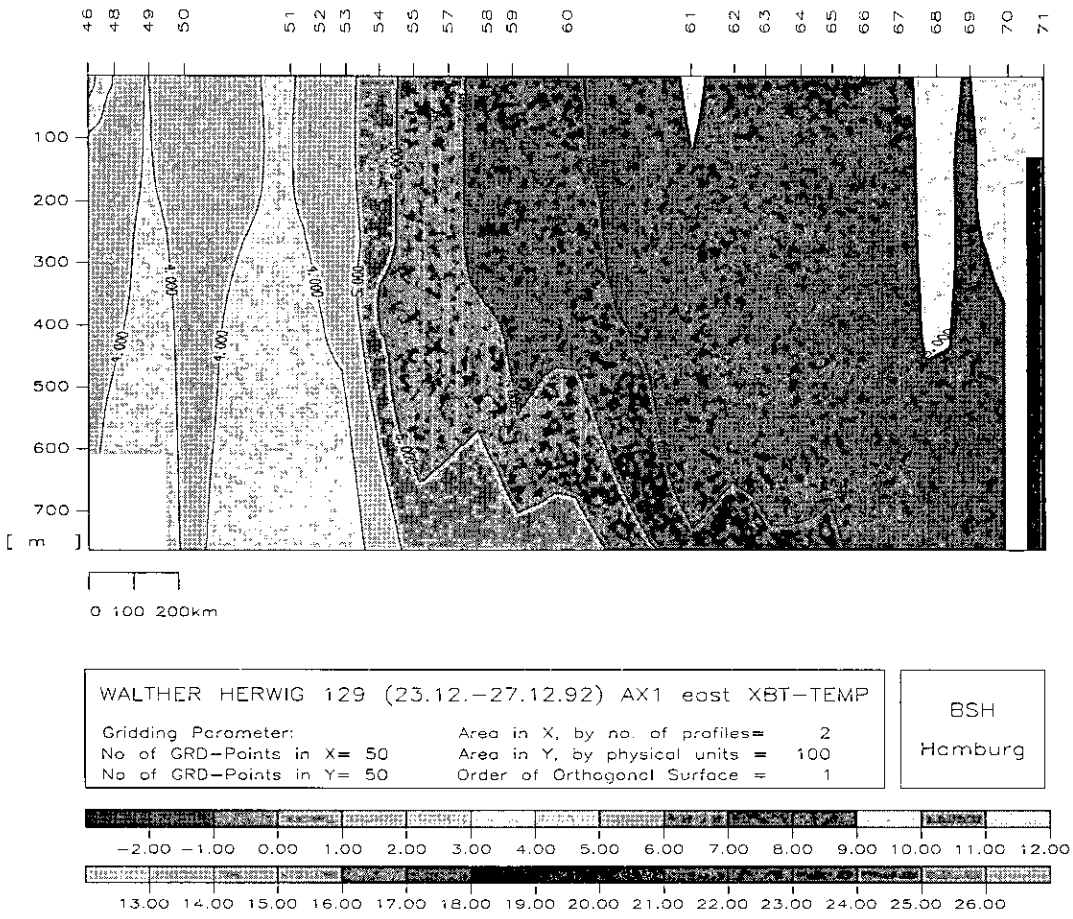

Fig. 13 Upper ocean thermal field of the North Atlantic along 60°N between Cape Farewell and the British Isles (December 23 to 27, 1992)

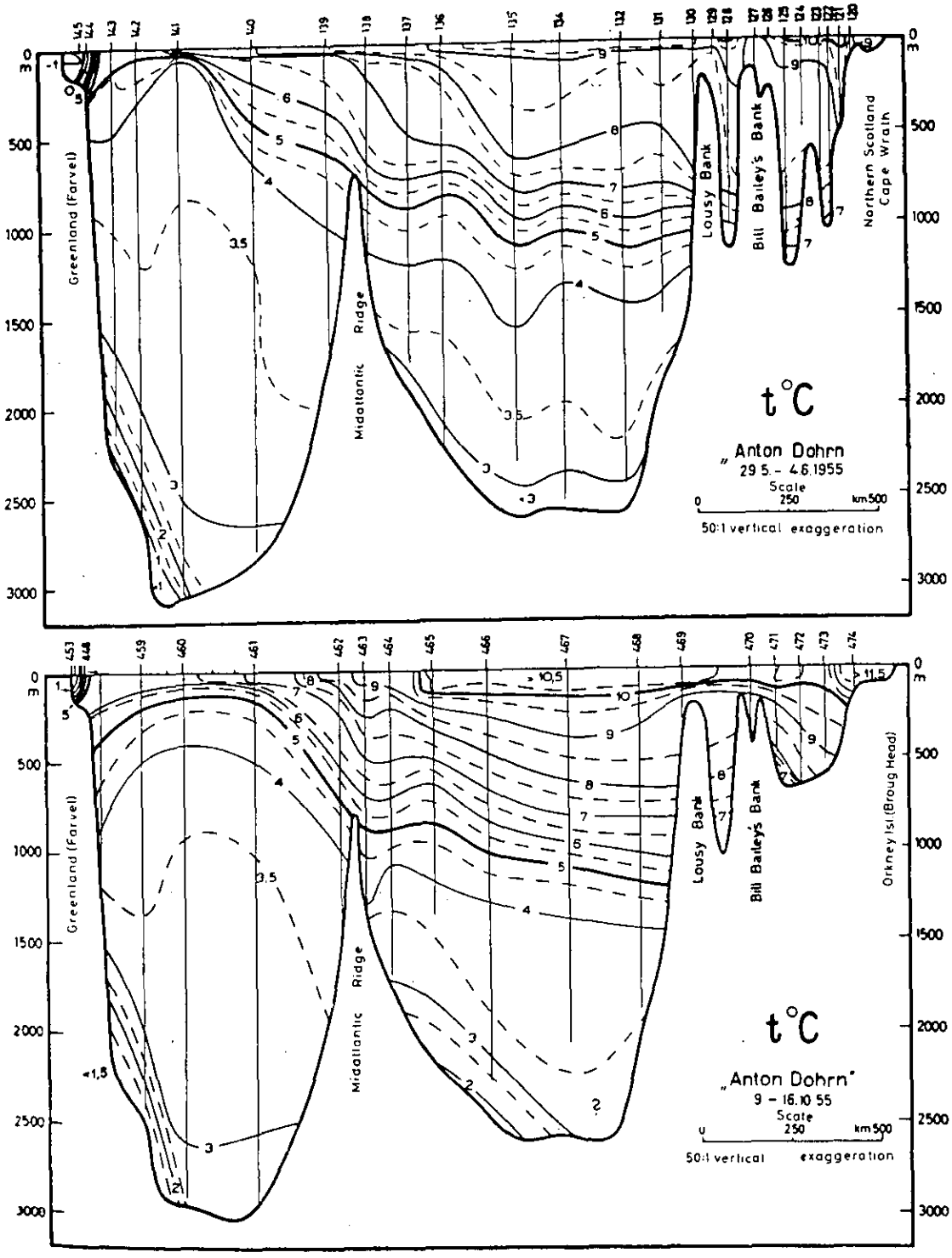

Fig. 14a Upper ocean thermal field of the North Atlantic along 60°N between Cape Farewell and the British Isles (May 29 to June 4, 1955)

Fig. 14b Upper ocean thermal field of the North Atlantic along 60°N between Cape Farewell and the British Isles (October 9 to 16, 1955)

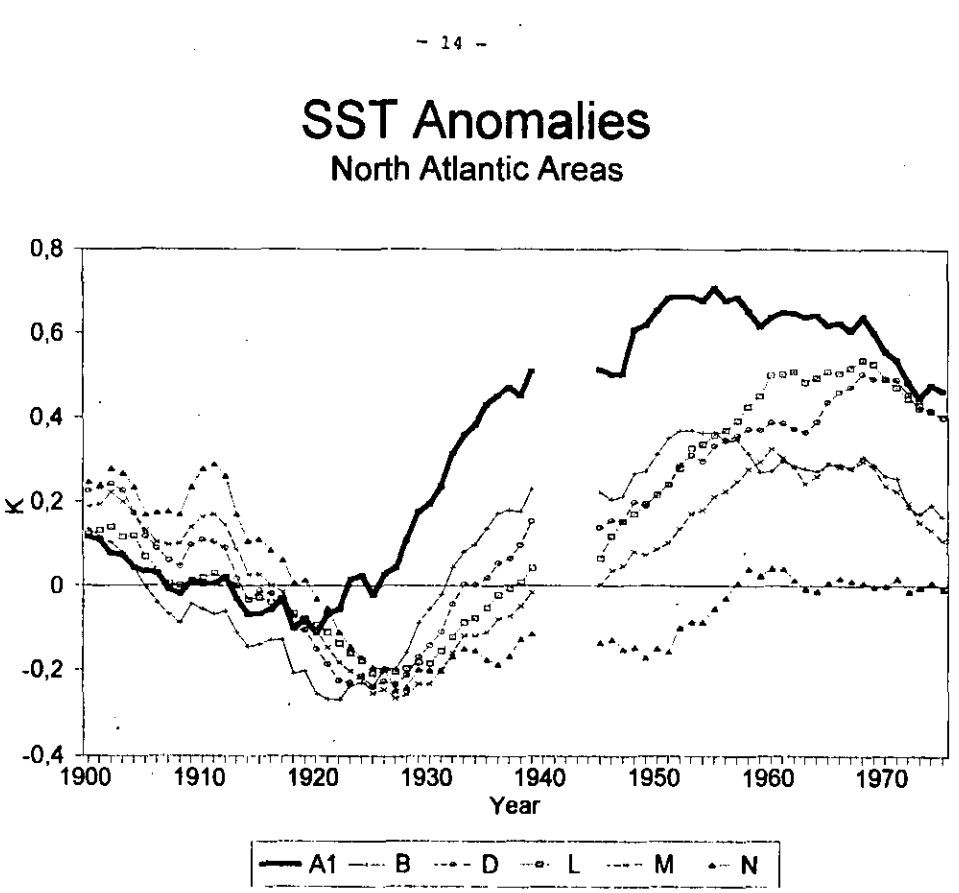

Fig. 15 Sea surface temperature anomalies of North Atlantic areas denoted in Fig. 15a (data are smoothed by a 25 year running mean)

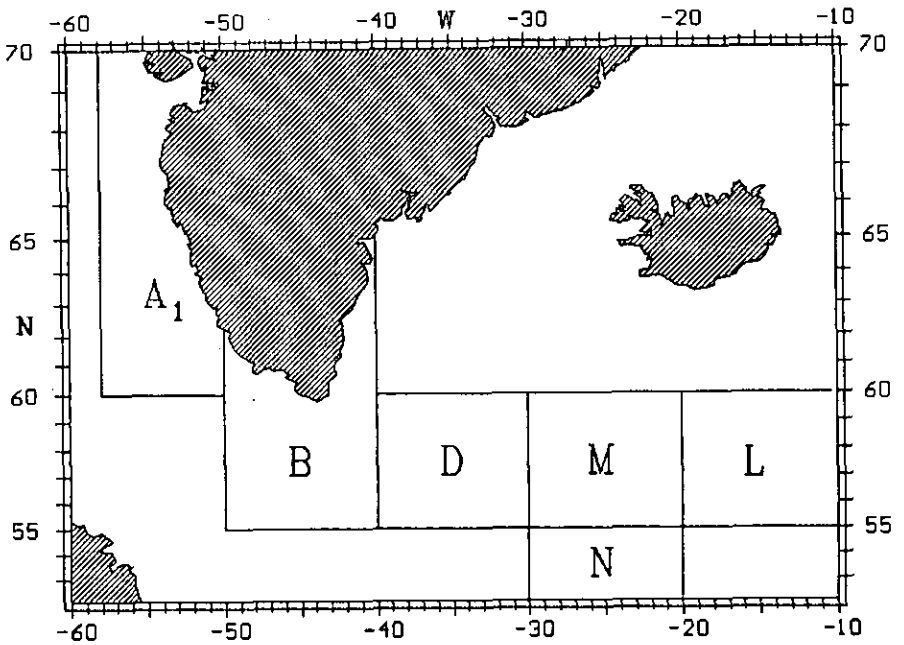

Fig. 15a North Atlantic areas as given by SMED, 1965

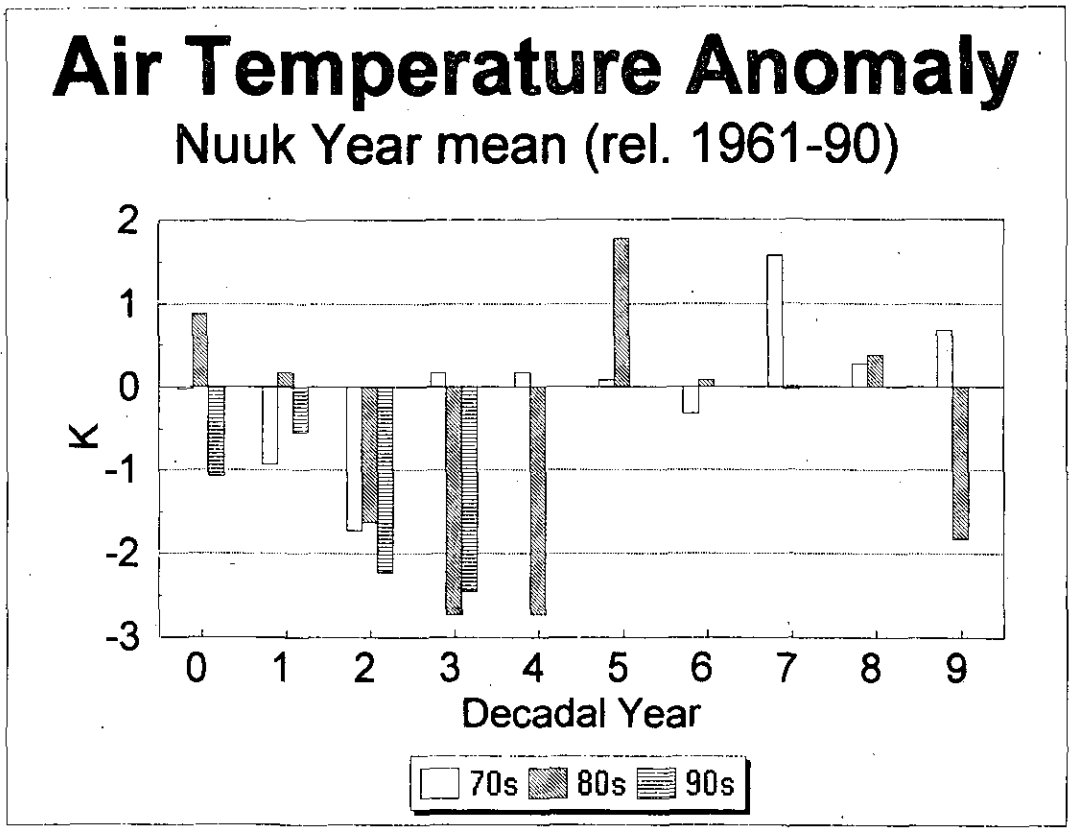

Fig. 16 Composite of decadal air temperature anomalies at Nuuk (rel. to the climatic mean 1961 - 1990) for the decades of the seventies, eighties and nineties

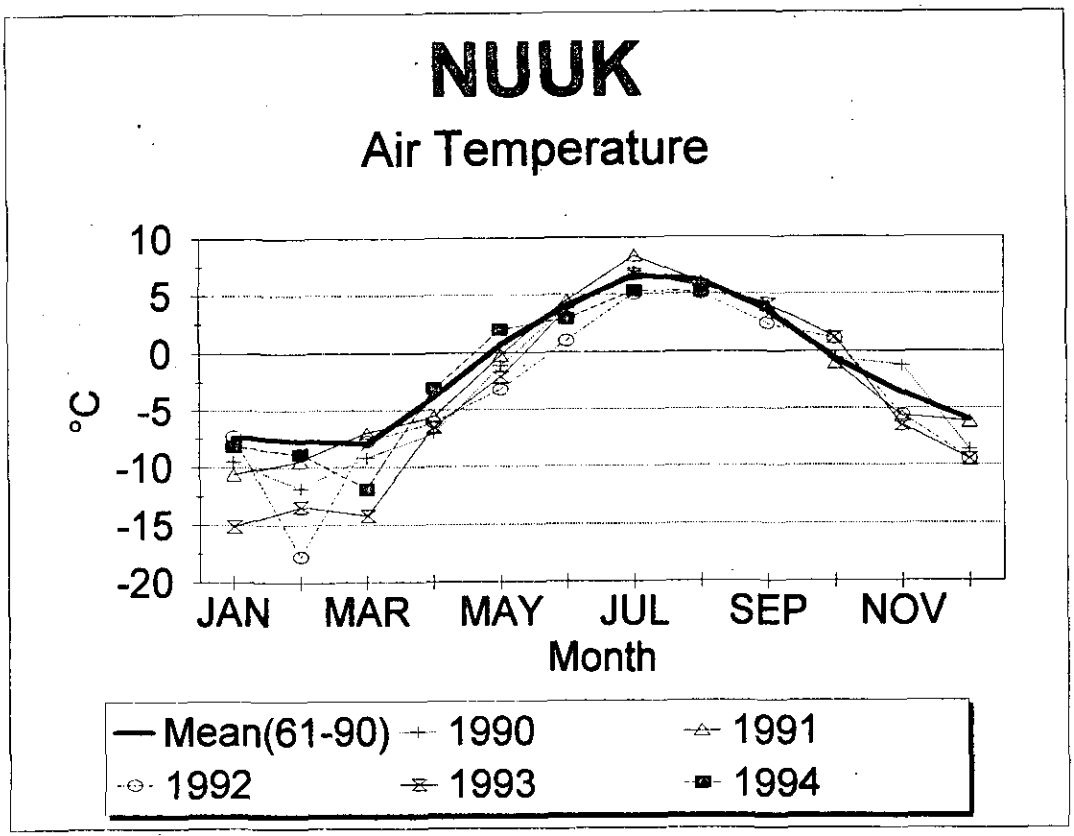

Fig. 17a Climatic mean monthly air temperature curve for Nuuk (1961-1990) and climatic curves for the early nineties

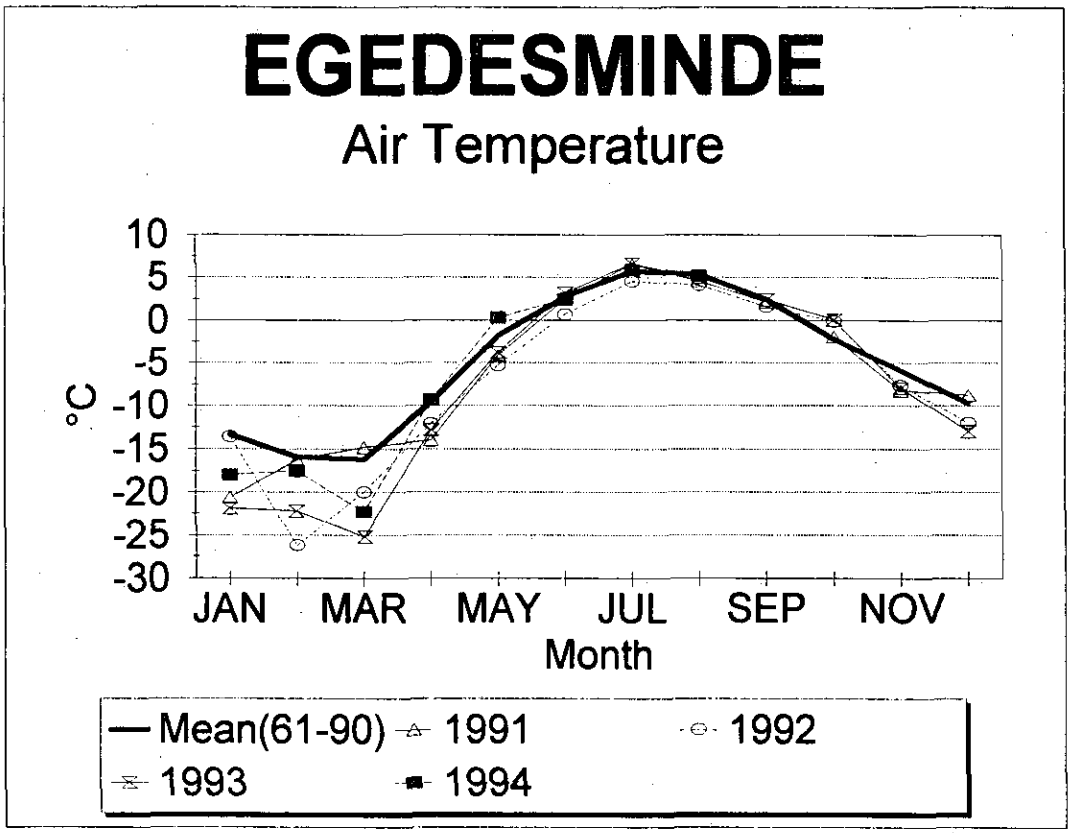

Fig. 17b Climatic mean monthly air temperature curve for Egedesminde (1961-1990) and climatic curves for the early nineties

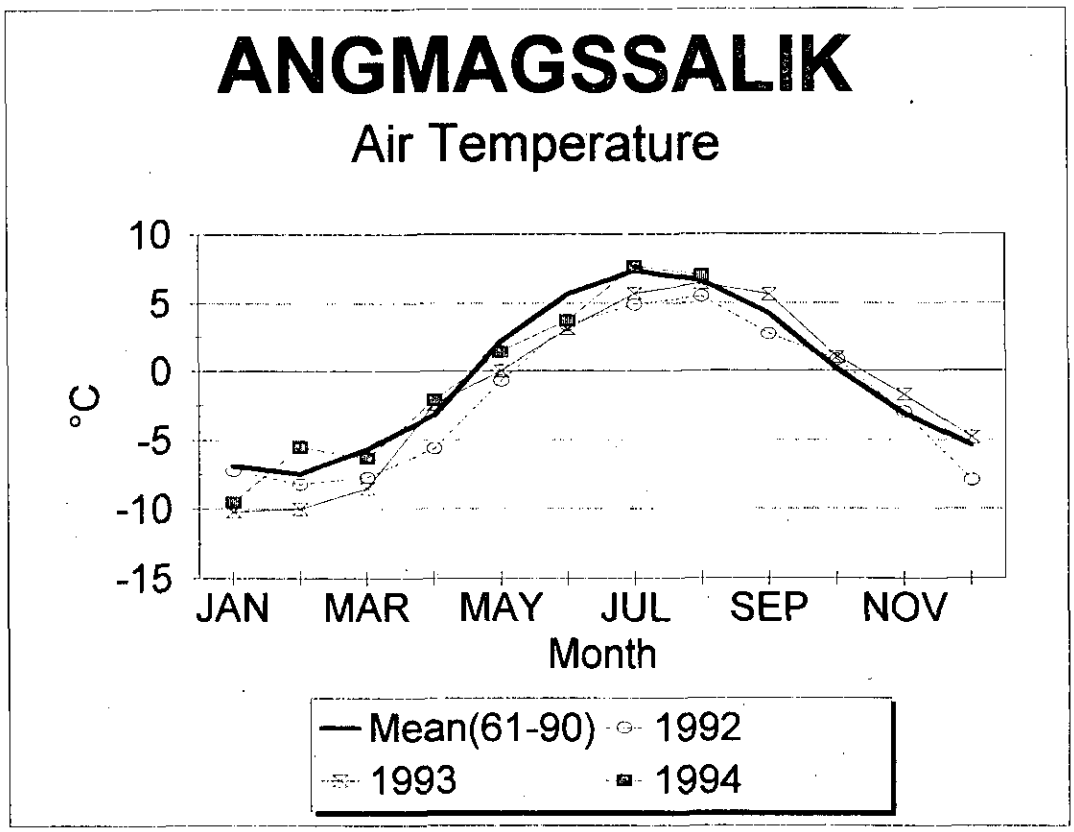

Fig. 17c Climatic mean monthly air temperature curve for Angmagssalik (1961-1990) and climatic curves for the early nineties

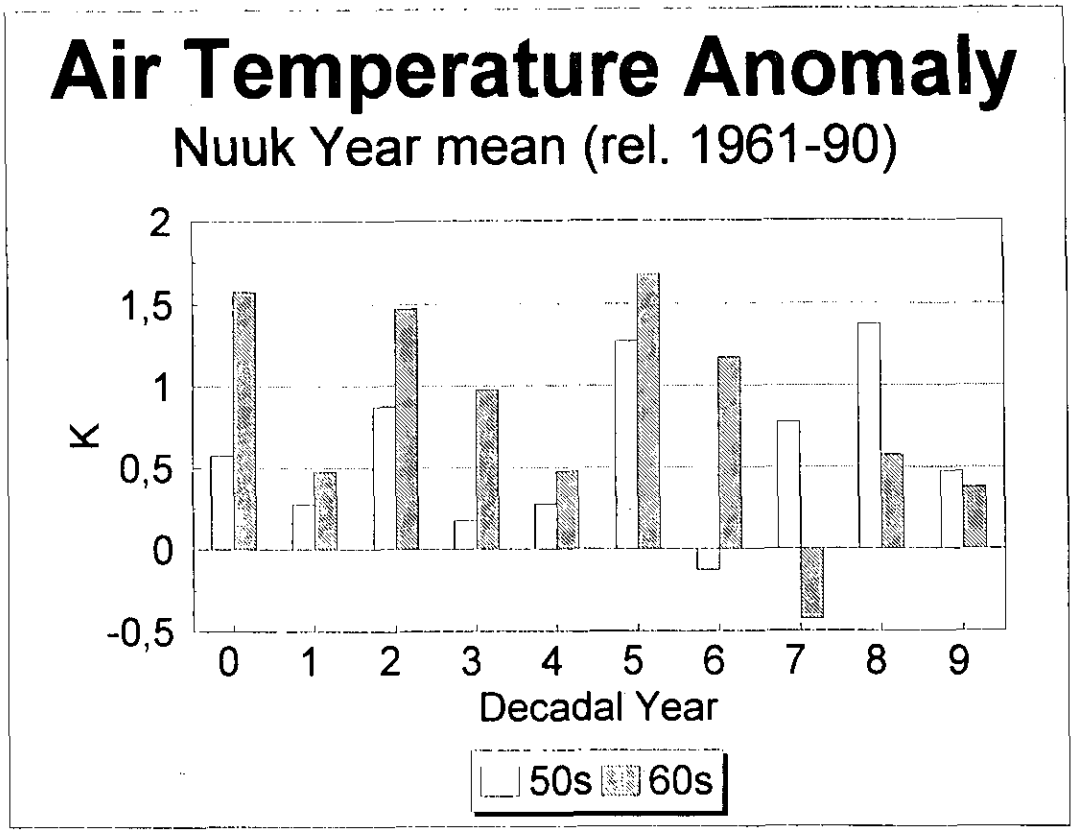

Fig. 18 Composite of decadal air temperature anomalies at Nuuk (rel. to the climatic mean 1961 - 1990) for the decades of the fifties and sixties