Northwest Atlantic Fisheries Organization

Serial No. N3023

NAFO SCR Doc. 98/36

SCIENTIFIC COUNCIL MEETING - JUNE 1998

Climatic Conditions Around Greenland - 1997

by

M. Stein

Institut für Seefischerei, Palmaille 9, D-22767 Hamburg
Federal Republic of Germany

Abstract

Air temperature time series derived from three sites of Greenland, ice data, subsurface ocean temperature and salinity data, and a time series of the North Atlantic Oscillation (NAO) index are used to characterise the climatic conditions around Greenland during 1997. By means of a simple harmonic model on the climatic variation at Nuuk/West Greenland, it is shown that the present mild climatic conditions represent intermediate warming in the region. This led to below normal sea ice cover, and above normal subsurface ocean temperatures. The oceanographic data acquired at NAFO Standard Oceanographic Station 3 of the Cape Desolation Section reveal a significant drop in the salinity of the upper 300m of the water column, and in the Irminger Water layer (200-300m), as well as an increase of water temperature since 1996. It would appear that this salinity signal is a consequence of a major ice export from the North Polar Sea, and that there is the potential for a new "Great Salinity Anomaly" travelling along the North Atlantic circulation. The winter (DJF) NAO index is negative during winter 1996/97. This favours the flow of mild air masses from the mid-latitude Atlantic Ocean to the Greenland/Labrador Sea region.

Introduction

The North Atlantic Oscillation (NAO) is a large scale alternation of atmospheric mass with centres of action near the Icelandic Low and the Azores High. It is the dominant mode of atmospheric behaviour in the North Atlantic sector throughout the year, although it is most pronounced during winter and accounts for more than one-third of the total variance in sea-level pressure **(Cayan, 1992).** A "high-index" pattern, indicating strong midlatitude westerlies, is characterised by an intense Iceland Low with a strong Azores Ridge to its south, while in the "low-index" case, the signs of these anomaly-cells are reversed.

STACFEN, during it's meetings in 1996 and 1997, recognised that the NAO index explains largely the hemispheric conditions in the North Atlantic Ocean **(Drinkwater et al., 1996; Drinkwater et al., 1997; Stein, 1996; Stein, 1997).** During 1996, a significant change occurred in the large-scale atmospheric circulation pattern. The Icelandic Low which has for over a decade been more intense than the long-term average, weakened. The Bermuda-Azores High also weakened. This resulted in a decline in the NAO index, the single largest annual decrease on record in over 100 years **(Drinkwater et al., 1997).**

The tremendous drop of the winter 1995/96 NAO index to a value of –9.8, and the coldest October 1997 in this century in western Europe, may have led some climatologists to forecast a severe ice winter for the eastern side of the North Atlantic Ocean. *Nature behaved differently:* Cold winter conditions in the Northwest Atlantic region, and a mild winter in western Europe. The NAO index had returned to nearly normal conditions.

Albeit this dramatic failure in forecasting winter conditions, continuation of climatic data analysis and long-term oceanographic data sampling is vital for understanding the climatic events recorded around Greenland and in the Labrador Sea. This is especially important since the characteristic time scale over which atmospheric circulation anomalies develop, is on the order of 8 days, and the atmosphere, with it's short-term memory, therefore provides no means of driving the longer-term variability of the NAO. The ocean, however, with a large heat capacity and long-term memory, may set the pace for the observed interannual variations. Although the atmospheric component of the NAO has been visible since the times of Hans Egede in the 1700's, long-term oceanographic observations are still scarce. They are essential to understanding the oceanic component and what role it may play in modulating the long-term NAO signal.

The present paper is the sixth 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 taken from the INTERNET (http://www.natice.noaa.gov).They originate from NOAA satellite ice observations.

The temperature anomaly data for the Northwest Atlantic were taken from **Anon. (1997)**. Subsurface ocean data are available from German measurements for the West and East Greenland area.

Results

Air Temperature and Climatic means

The positive air temperature conditions as observed during December 1996 at the West Greenland sites, were maintained through to January 1997. In contrast to the year 1996, however, February and March temperatures were again below normal. Air temperature anomalies during the coldest month (February) ranged from –2K to –3K at the west coast of Greenland (**Anon., 1997**). As in the winter of 1996, and as it was normally encountered during the first half of this decade, there was no cold air mass centered over the town of Egedesminde. This may have led to a relatively mild winter with air temperature anomalies of –4K in the Labrador Basin (c.f. the conditions during February 1992 when the equivalent value amounted to –10K and less; **Stein, 1995**).

The annual air temperature curves referred to the climatic means at the three observation sites are given in Figs. 1 to 3. Colder than normal conditions were encountered at the west coast of Greenland from February to April, May and June were warmer than the norm. During July and August air temperature fell slightly below the climatic mean (Egedesminde and Nuuk) to raise above the mean from September onwards. Angmagssalik (Fig. 3) experienced climatic conditions which were about the norm. Only November and December were well above the long-term climatic mean.

Climatic Variability off West Greenland

The annual mean air temperature anomalies indicated positive conditions (+0.1 K, Fig. 4) for the second year in consecution since 1988. The decadal presentation of Nuuk mean air temperature anomalies (Fig. 5) pointed at warming which was considerably less than in the previous year. Compared to the 1970s, year 7 of the 1990s revealed insignificant warming. 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. 4, 6).

Ice Conditions in the Northwest Atlantic

Winter ice conditions were favourable during 1997 off West Greenland. The southernmost location of the ice edge was found in the beginning of March (970303, Fig. 7). There was no ice around Cape Farewell during winter and spring.

Subsurface Observations off West Greenland

Observations on Standard Oceanographic Stations (**Stein, 1988**) were done at the Cape Desolation Section and at the Fylla Bank Section. Figs. 8 and 9 display time series of temperature and salinity at station 3 of the Cape Desolation Section. Thermal conditions in the top 300m of the water column were considerably warmer than in the years previous to 1993 (Fig. 8). Salinity measurements at Cape Desolation Section Station 3 (3000m depth) showed a significant drop in salinity since 1996 in the upper 300m of the water column and in the Irminger Water Layer (200-300m) (Fig. 9). In detail: 1995 (34.925/34.966), 1996 (34.910/34.940), 1997 (34.856/34.904) *); this drop is larger than that one observed 10 years ago: 1988 (34.895 for the 0-300m), 1987 (34.914 for the 200-300m layer).

Further north, at the Fylla Bank Section, the signal is not so clearly visible (both at stations 4 (Fig. 10) and 5 which are 900m and 1300m deep). This might be due to the topography in the south of the Fylla Bank Section, which guides the main flow of the Irminger Water towards the west.

Thermohaline conditions on Fylla Bank Station 4 (Figs. 11, 12) are given for the years 1963 to 1998, relative to the 1963-90 climatological mean. All water layers indicate warmer than normal conditions, salinity shows a decreasing trend, however the 1998 values of the surface layers are near the norm.

*) first value in brackets refers to the 0-300m, second to the 200-300m layer which is the approximate depth of the Irminger Water

Discussion

The normalised mean pressure difference for December 1997 to February 1998 is ***positive*** and the indications are that the March figure will reinforce this positive value. This increase during the 1997/98 winter 'corrects' a temporary reversal in the sign of the NAO during the winter 1996/97. *Hence the long positive phase of the NAO Index during the 1990s decade is therefore now continuing* (**Anon., 1998**).

As discussed by **Stein et al. (1998)**, a negative winter NAO index yields positive environmental conditions for recruitment of cod off Greenland. The 1997 winter NAO index was, however, only slightly negative. This is documented in the negative air temperature anomalies during February and March at Egedesminde and Nuuk (Figs. 1 and 2). Since the February air temperature explains 58% of the mean annual air temperature variability at Nuuk (Figs. 4 to 6), the +0.1K warming for 1997 is no surprise.

A large Salinity Anomaly is seen off West Greenland since 1996 (Fig. 9), following a major ice export during 1994/95 through Fram Strait with an equivalent of diluted water similar to the 1960s (**Meincke, pers. comm.**). Does this drop in salinity refer to a new "Great Salinity Event" which travels around the North Atlantic Current system? Do these climatic events point at a general change in the North Atlantic climate, back to the 1960s?

It would appear that the upward trend in Fig. 4 points at an intermediate warming peak. As indicated by **Stein (1995)** the short period of variation (3.8 years) "*can raise mean air temperatures to above normal levels, e.g. during the mid-1990s*". This intermediate warming around the middle of the decade (dashed curve in Fig. 14 indicates 3.8 year period), and the long-term variation as given by the harmonic model with a period of 108 years **(Stein, 1995)** are composed with the Nuuk year mean temperature anomaly curve from 1965 to 1997 (Fig. 7). As one can see from this figure the model curve (dashed line) correlates fairly good with the year mean curve, and the mid-1990s peak can be explained as intermediate warming and not as a return to warm conditions.

Hence, the model approach points at intermediate warming and not at a general change in the thermal trend. Consequently, the climatic conditions at Egedesminde, Nuuk and Angmagssalik which indicate above normal temperatures (Figs. 1 to 3) for most of the year 1997, vary in the normal range. Also the ice cover represents variation within the norm.

References

Anon., 1997. Der Wetterlotse. Vol. 49, Nr. 33-60; Deutscher Wetterdienst, Seewetteramt, Hamburg.

Anon., 1998. The Annual ICES Ocean Climate Status Summary 1997/1998 (I-OOS Executive Summary). ICES Ocean Hydrography Working Group, 8p.

Cayan, D.R., 1992. Latent and Sensible Heat Flux Anomalies over the Northern Oceans: the connection to Monthly Atmospheric Circulation. J. Climate, 5, 354-369.

Drinkwater, K.F., E. Colbourne, and D. Gilbert 1996. Overview of Environmental Conditions in the Northwest Atlantic in 1995. . NAFO Sci.Coun. Studies, 27: 1-37.

Drinkwater, K.F., E. Colbourne, and D. Gilbert 1997. Overview of Environmental Conditions in the Northwest Atlantic in 1996. NAFO SCR Doc. 97/63: 1-44.

Stein, M. 1988. Revision of list of NAFO standard oceanographic sections and stations. NAFO SCR Doc., No. 1, Serial No. N1432, 9p.

Stein, M. 1995. Climatic Conditions Around Greenland - 1992. NAFO Sci. Coun. Studies, 22: 33-41.

Stein, M. 1996. Conclusions drawn from the climatic issues as presented during the STACFEN Meeting in June 1996. NAFO SCR Doc.96/83; 6 pp.

Stein, M. 1997. Climatic Conditions Around Greenland - 1996. NAFO SCR Doc. 97/4: 1-12.

STEIN, M., J. Lloret, and H.-J. RÄTZ 1998. North Atlantic Oscillation (NAO) Index – Environmental Variability Effects on Marine Fisheries?. NAFO SCR Doc. 98/x: 1-y.

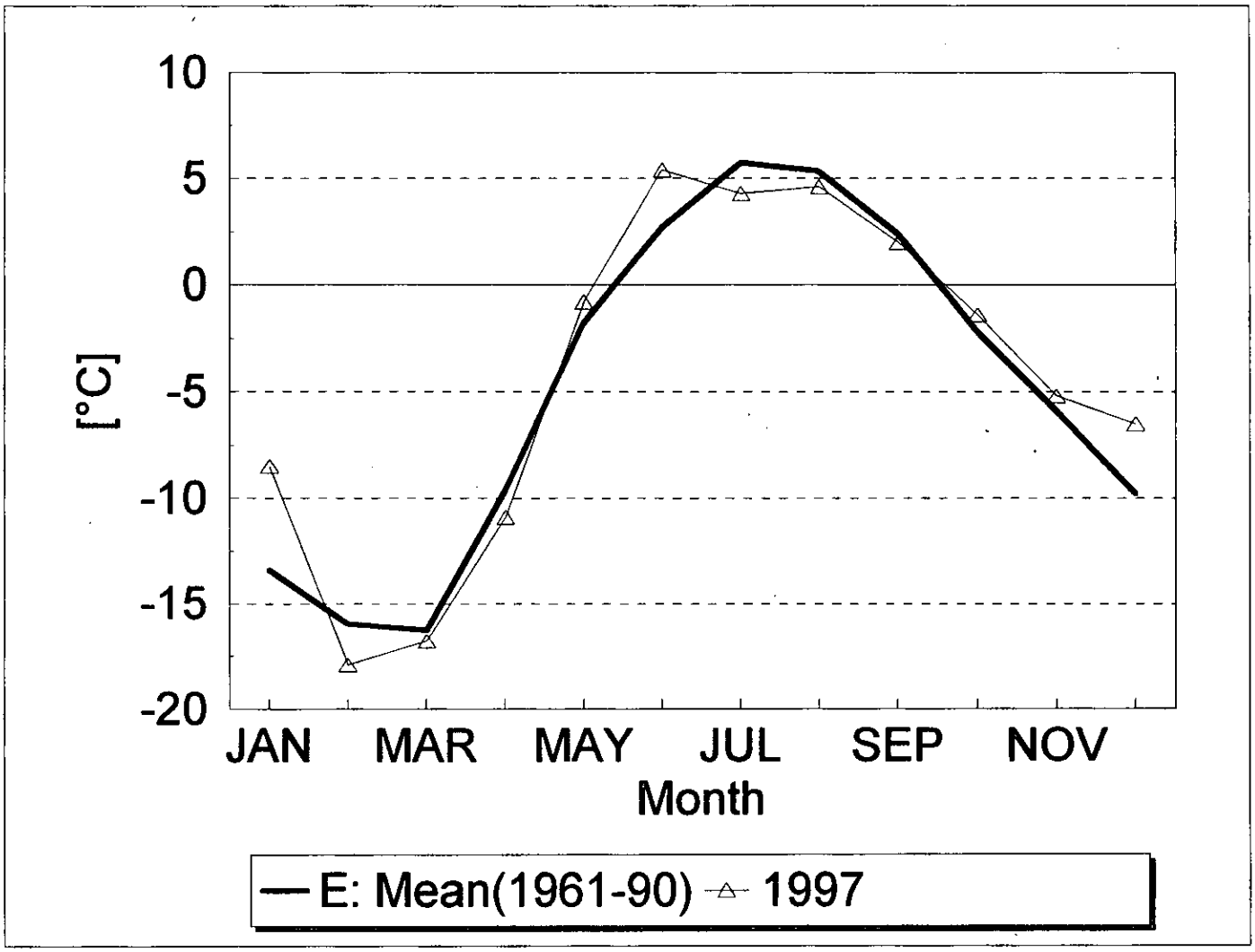

Fig. 1 Monthly mean air temperature at Egedesminde during 1997 and climatic mean (1961-1990)

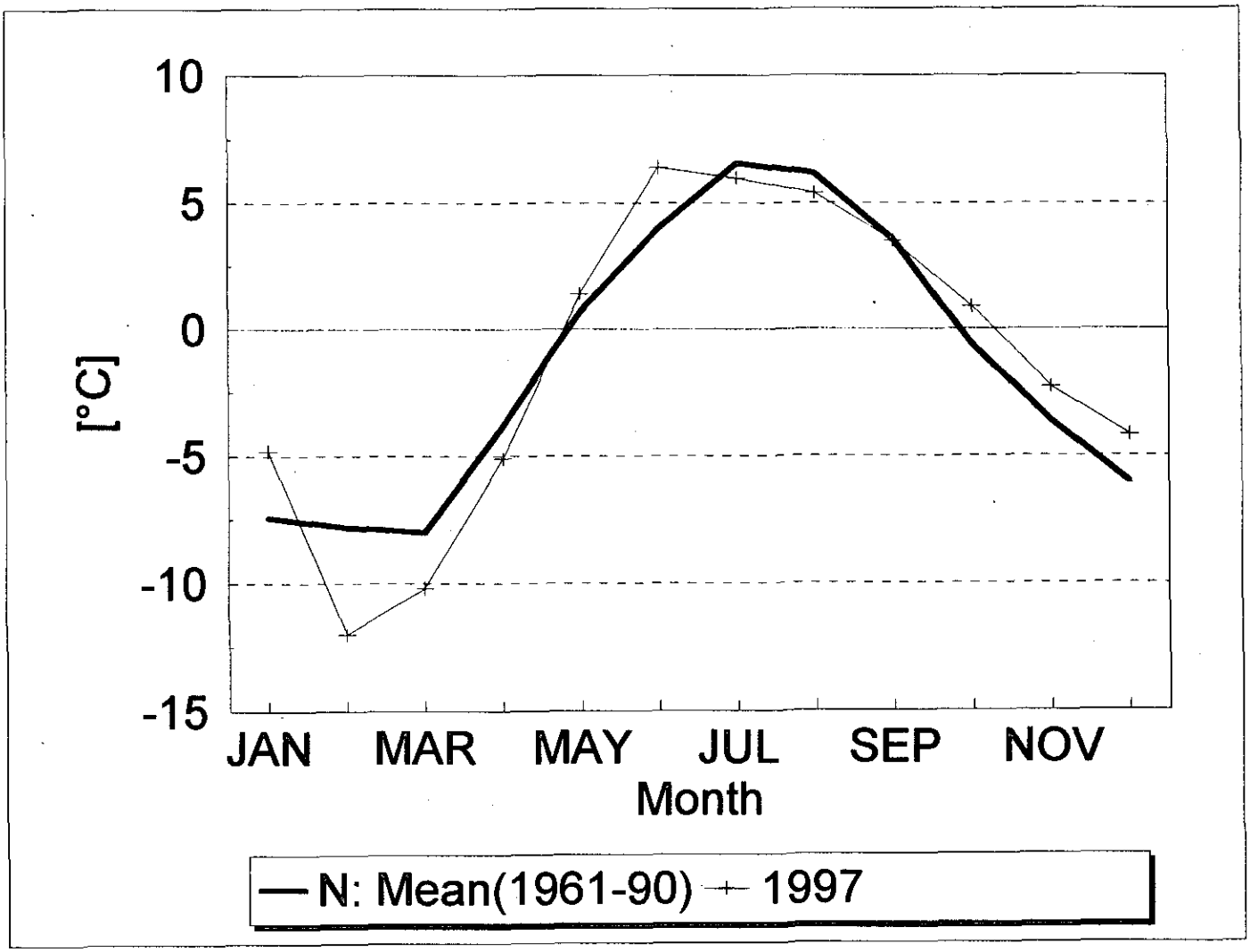

Fig. 2 Monthly mean air temperature at Nuuk during 1997 and climatic mean (1961-1990)

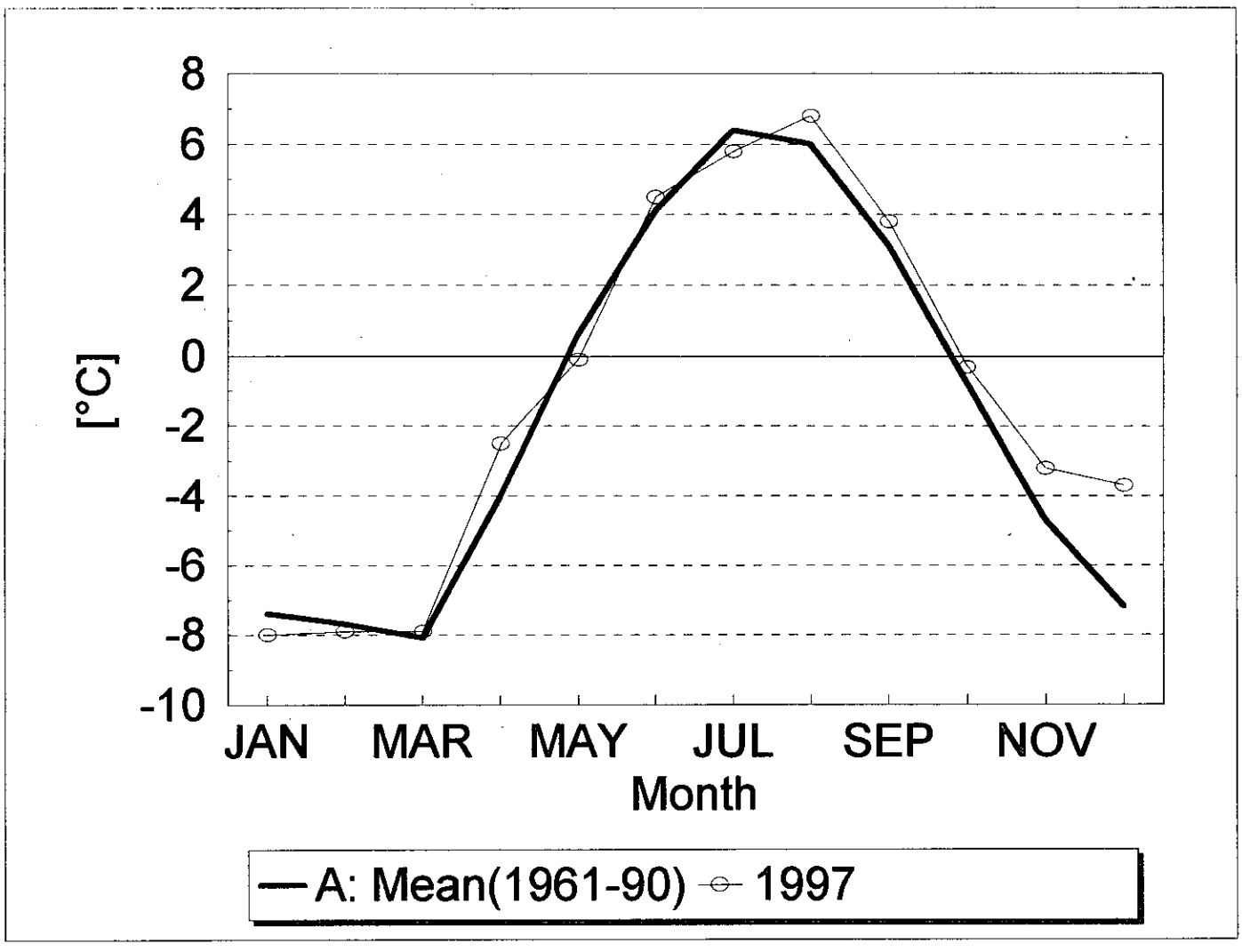

Fig. 3 Monthly mean air temperature at Angmagssalik during 1997 and climatic mean (1961-1990)

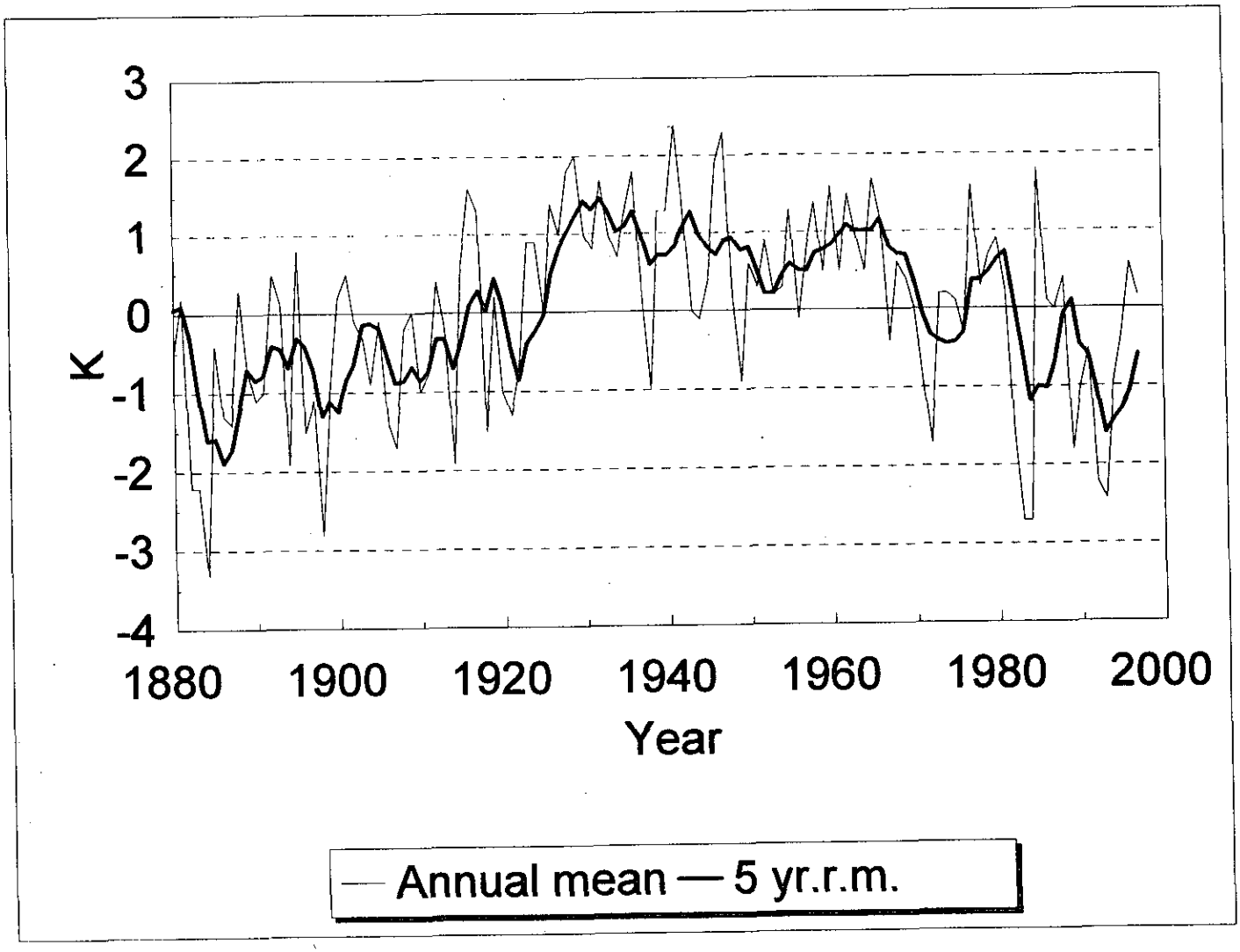

Fig. 4 Time series of annual mean air temperature anomalies at Nuuk (1880-1997, rel. 1876-1997) and 5 year running mean

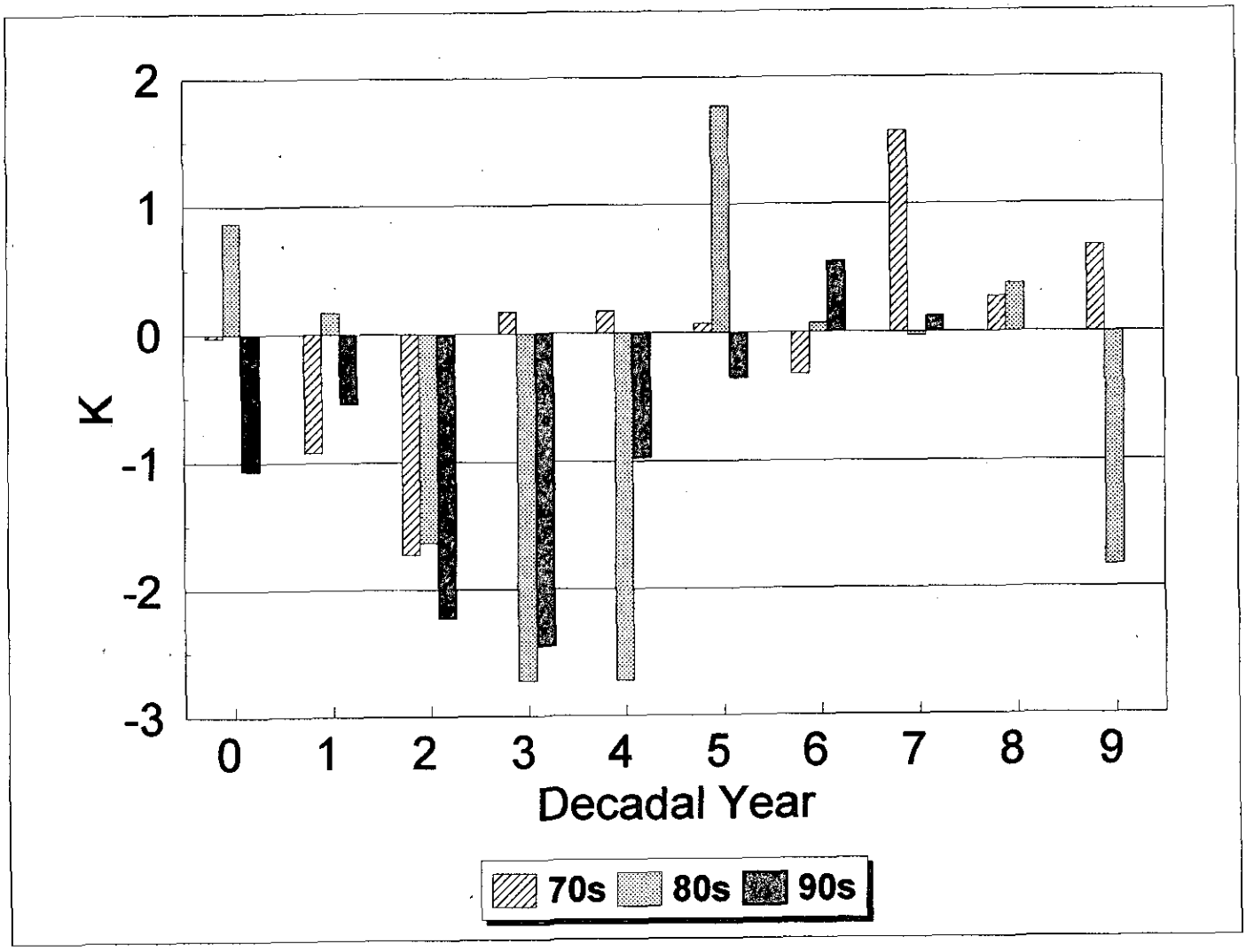

Fig. 5 Composite of decadal air temperature anomalies at Nuuk given relative to the climatic mean of 1961-90 for the decades of the 1970s, 1980s and 1990s

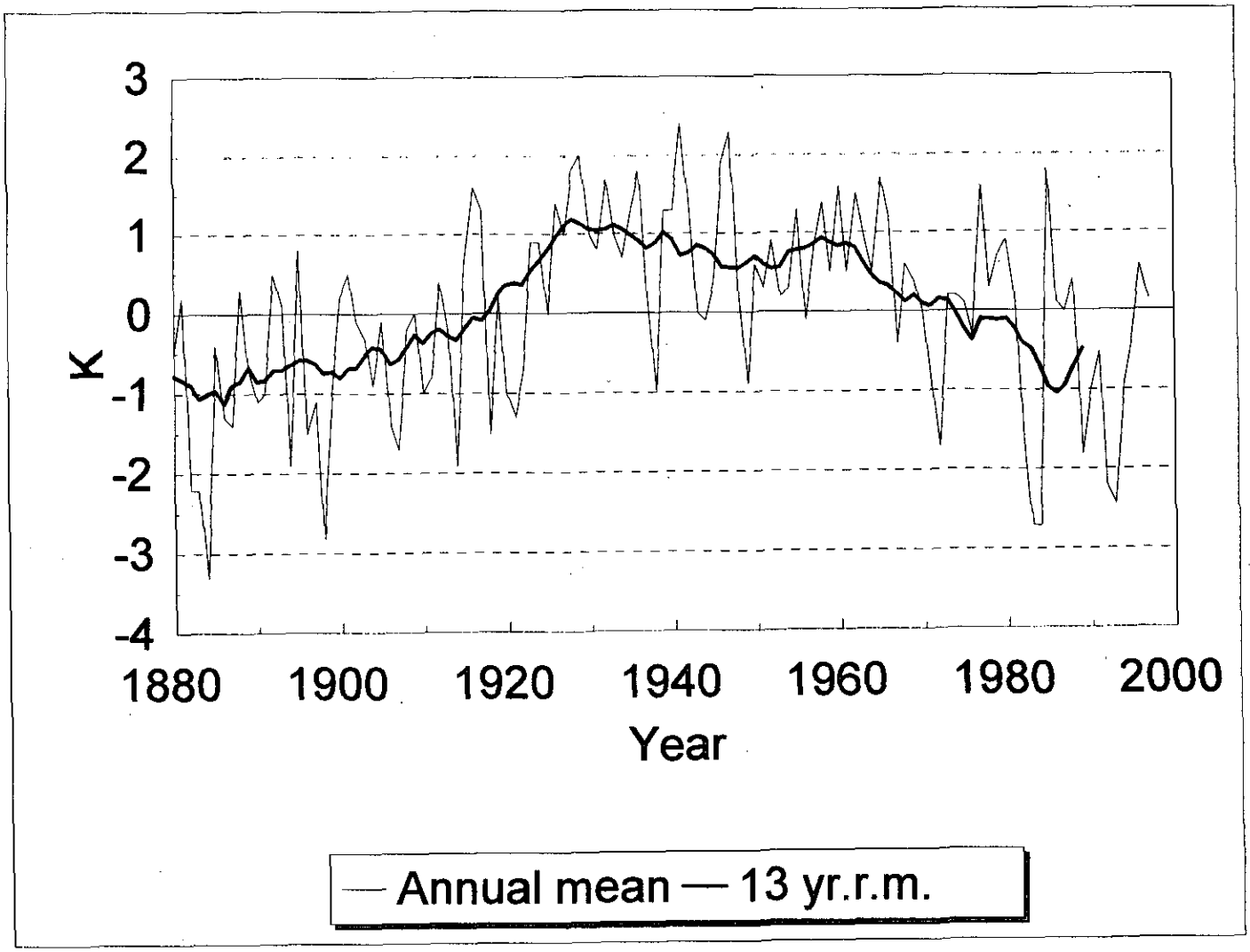

Fig. 6 Time series of annual mean air temperature anomalies at Nuuk (1880-1997, rel. 1876-1997) and 13 year running mean

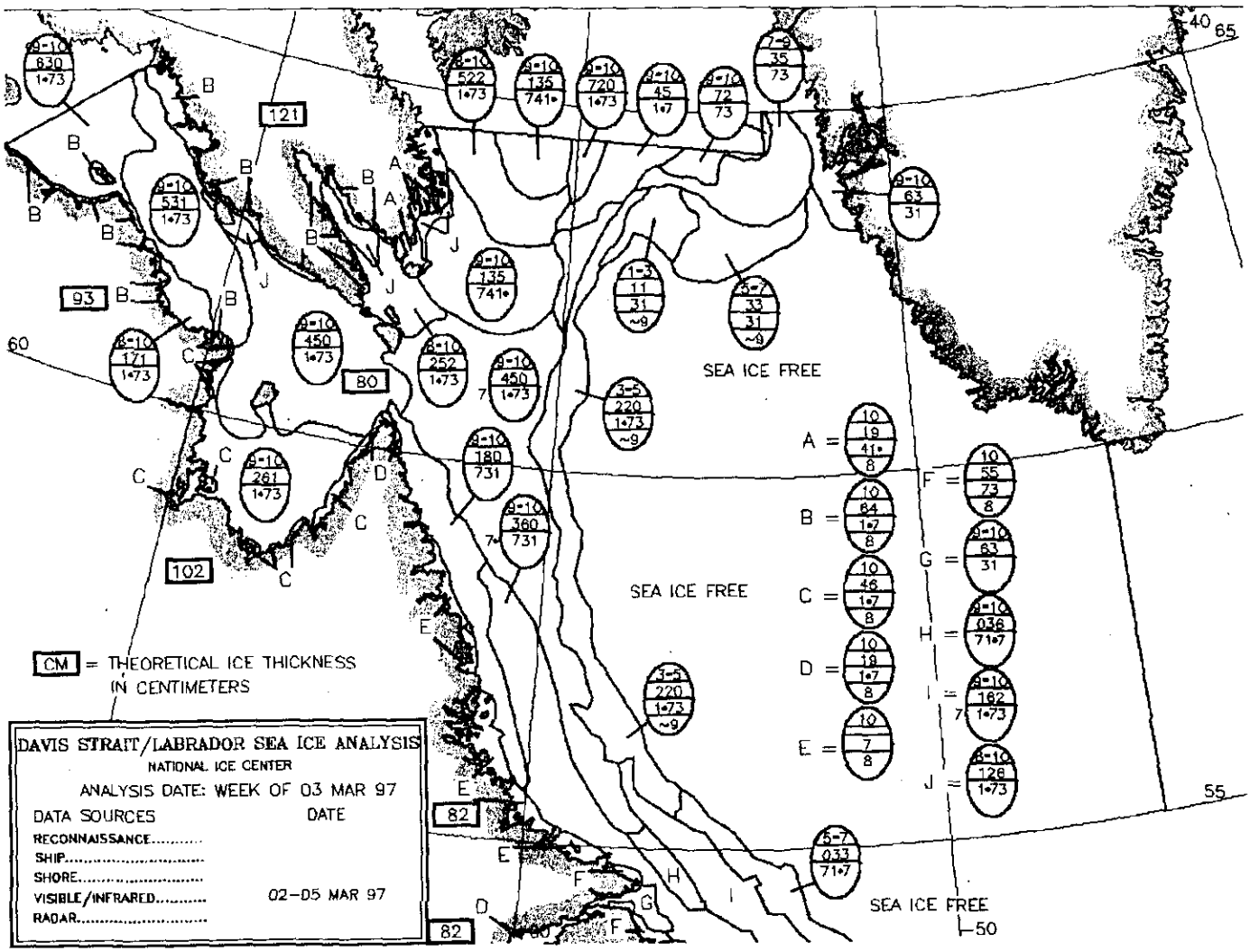

Fig. 7 Ice edge during week of March 3, 1997

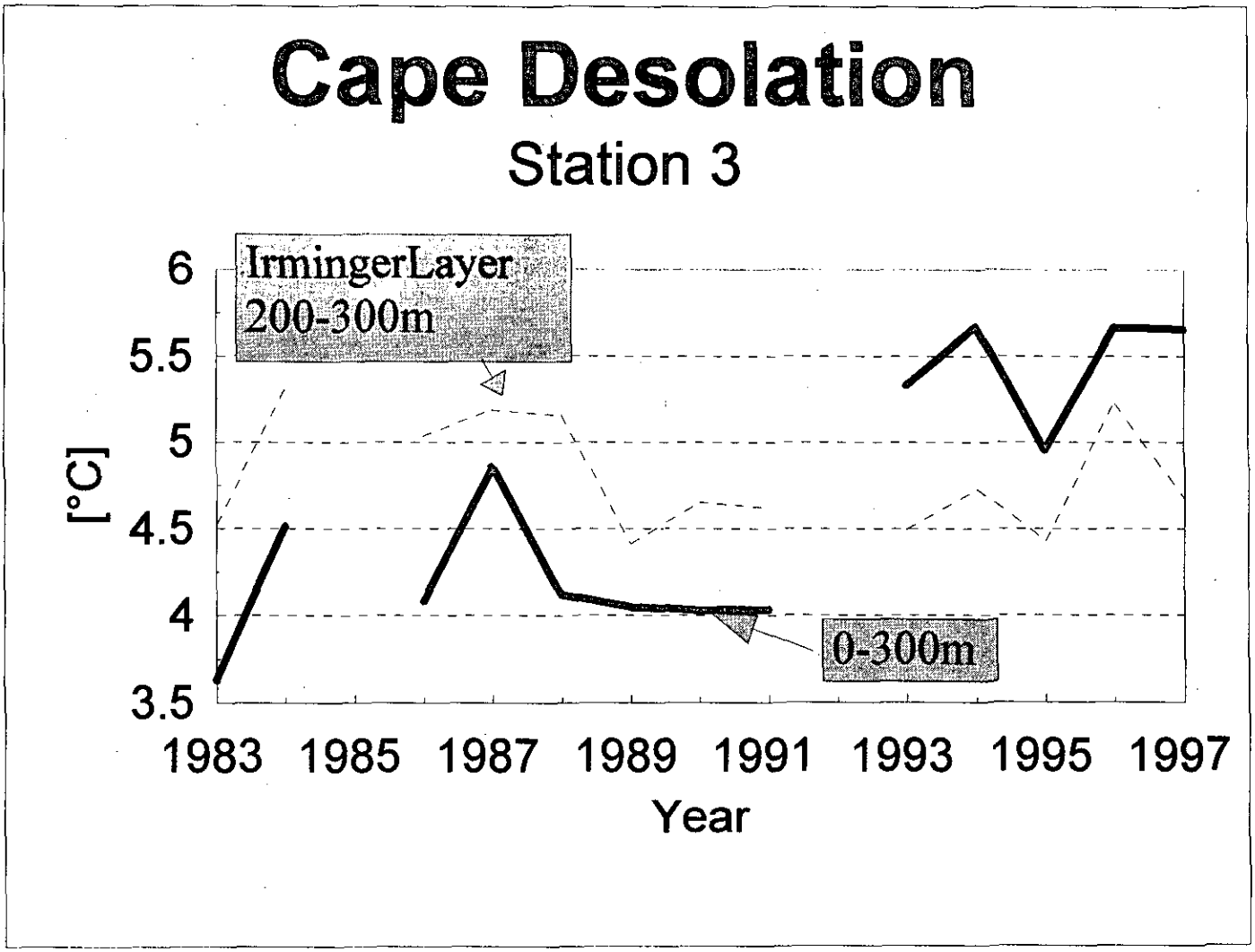

Fig. 8 Time series of temperature at Standard Oceanographic Station 3 of the Cape Desolation Section (1983-1997) for layers 0-300m, and Irminger Water layer 200-300m

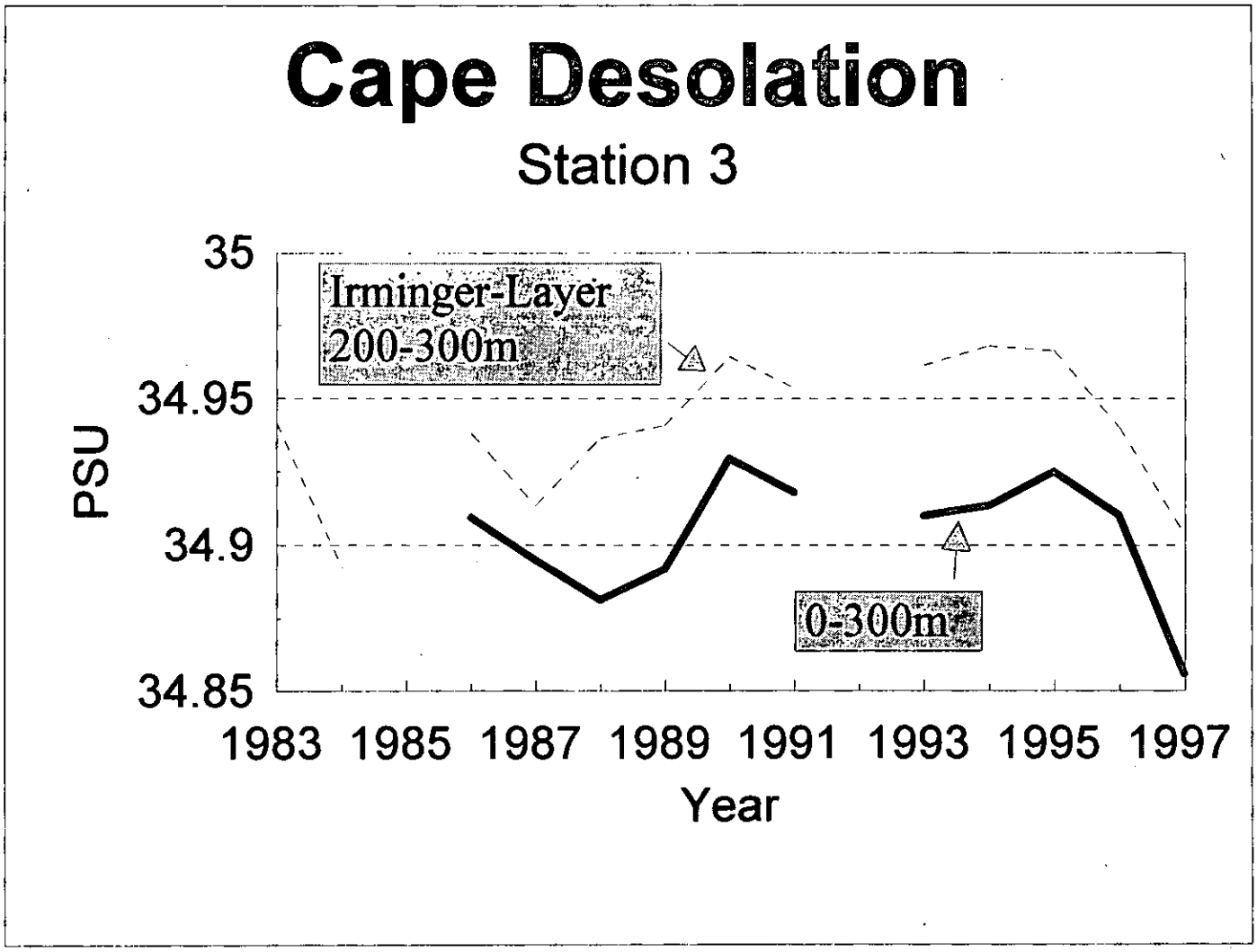

Fig. 9 Time series of salinity at Standard Oceanographic Station 3 of the Cape Desolation Section (1983-1997) for layers 0-300m, and Irminger Water layer 200-300m

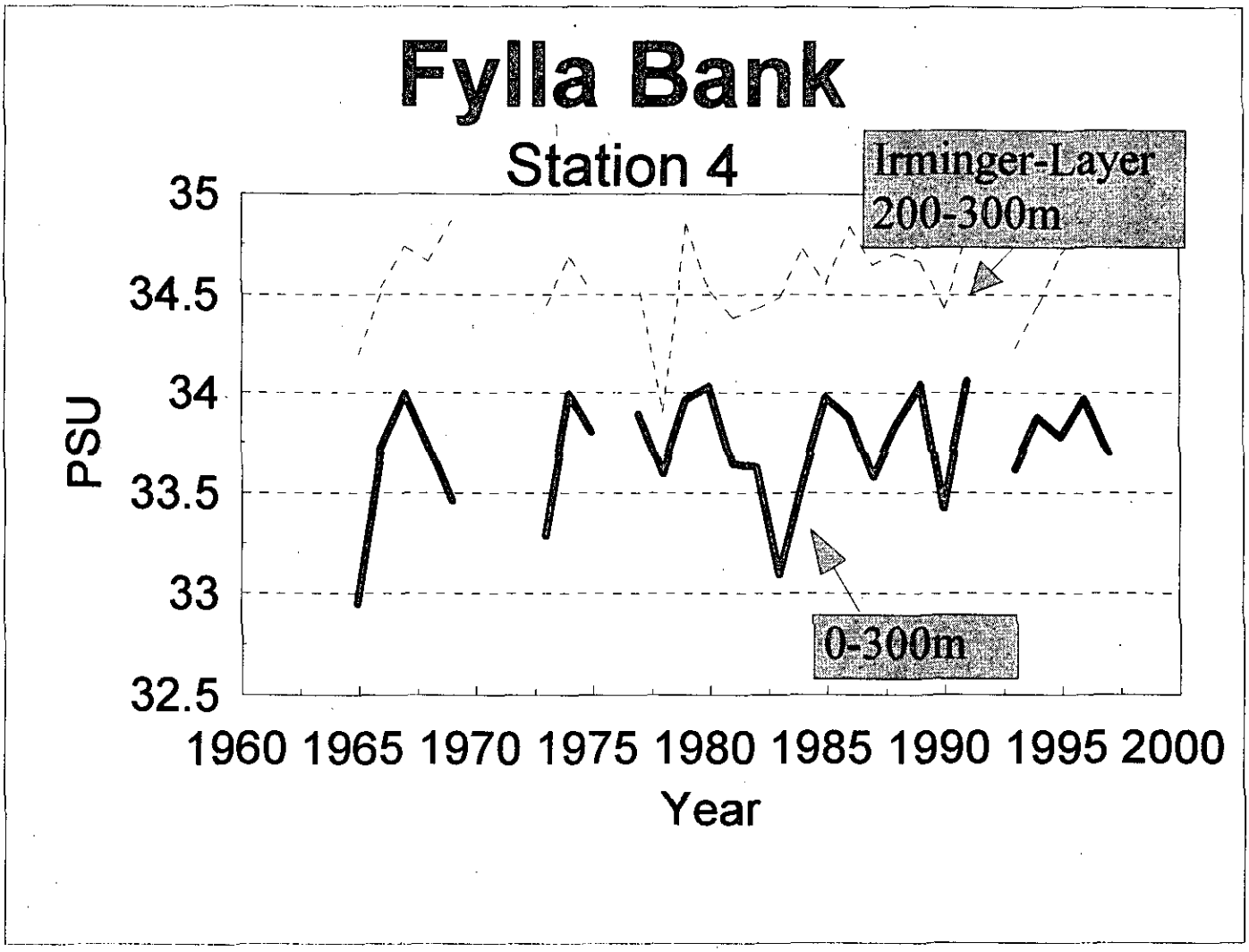

Fig. 10 Time series of temperature at Standard Oceanographic Station 4 of the Fylla Bank Section (1965-1997) for layers 0-300m, and Irminger Water layer 200-300m

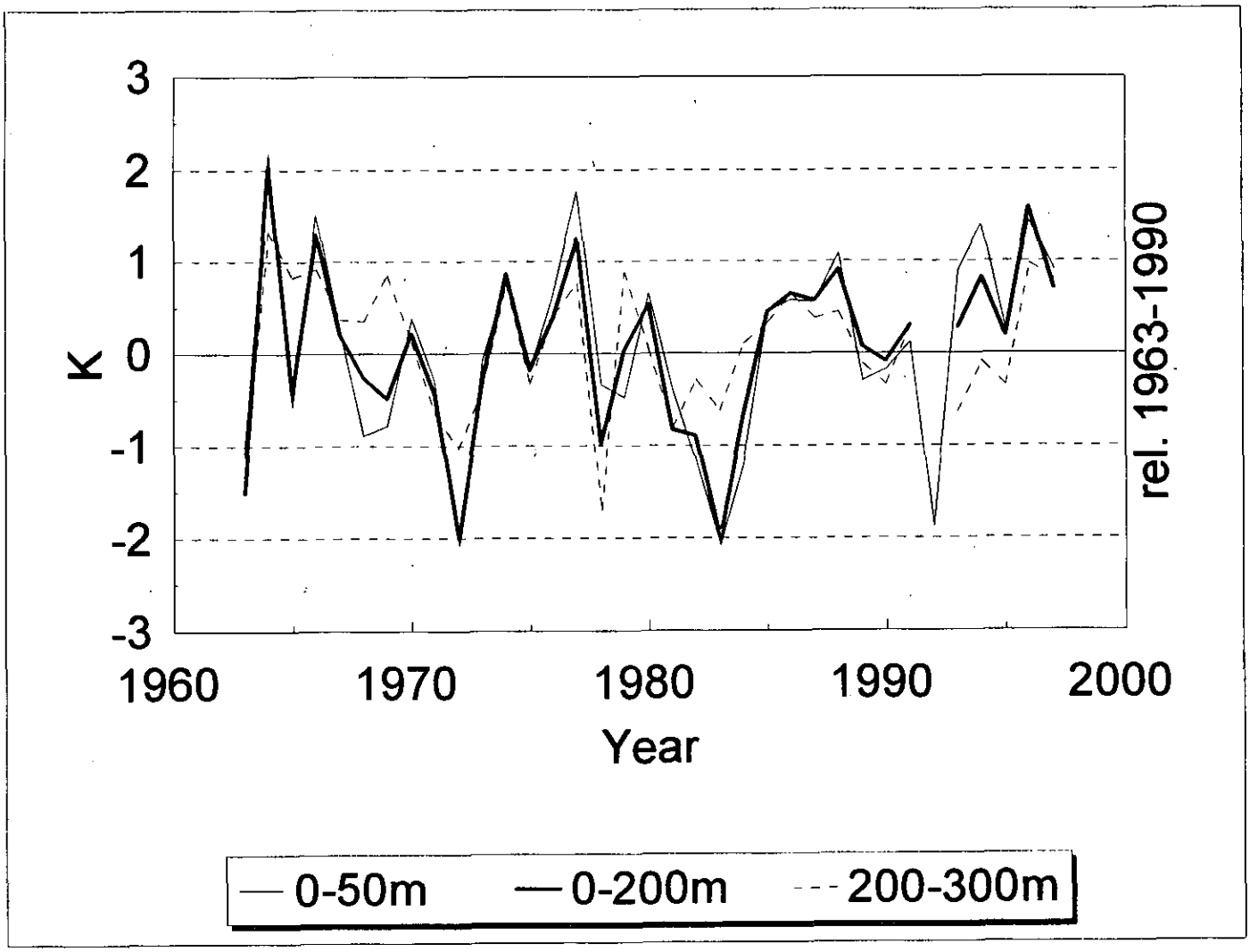

Fig. 11 Time series of temperature at Standard Oceanographic Station 4 of the Fylla Bank Section (1963-1996) for surface layers 0-50m, 0-200m and Irminger Water layer 200-300m

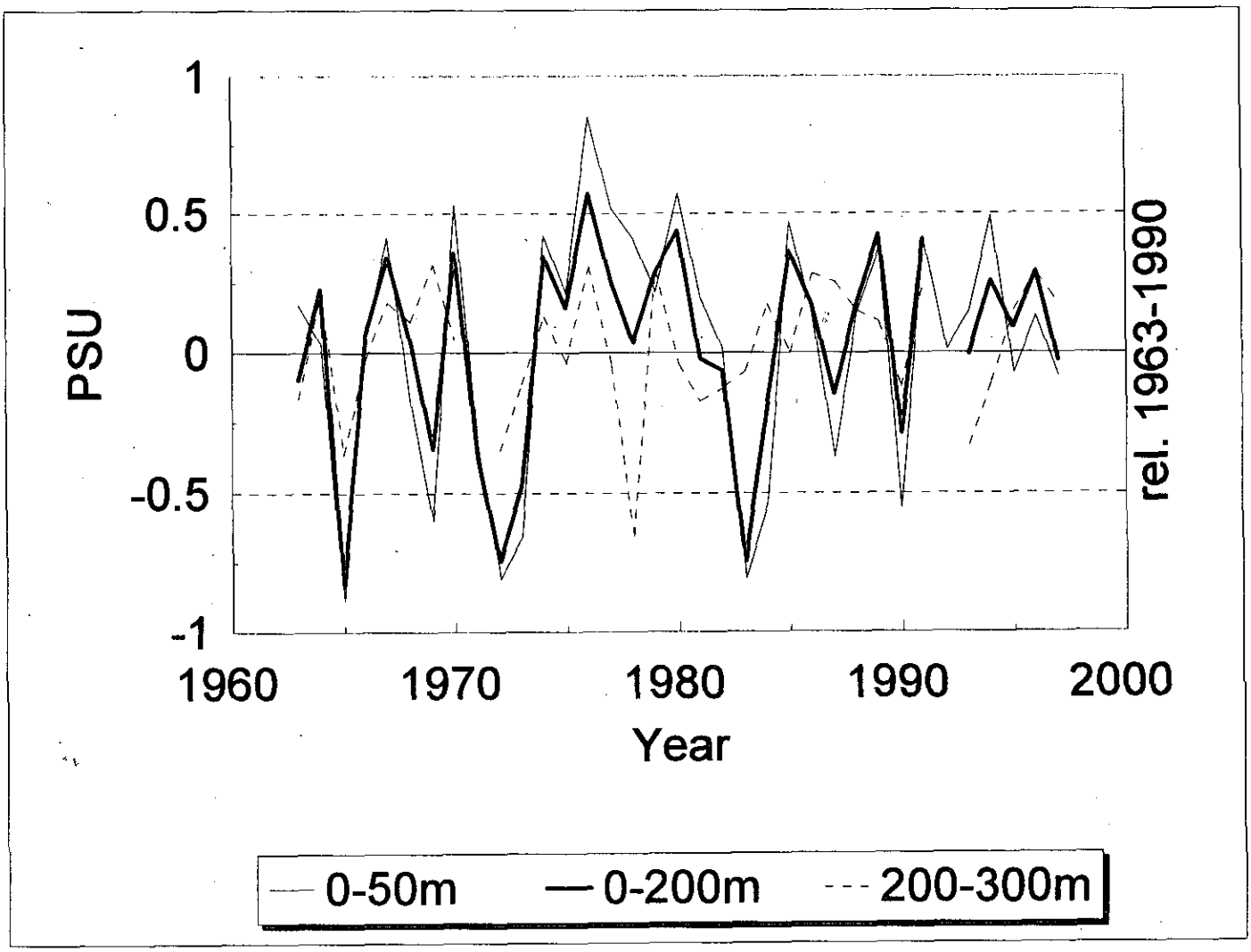

Fig. 12 Time series of salinity at Standard Oceanographic Station 4 of the Fylla Bank Section (1963-1996) for surface layers 0-50m, 0-200m and Irminger Water layer 200-300m

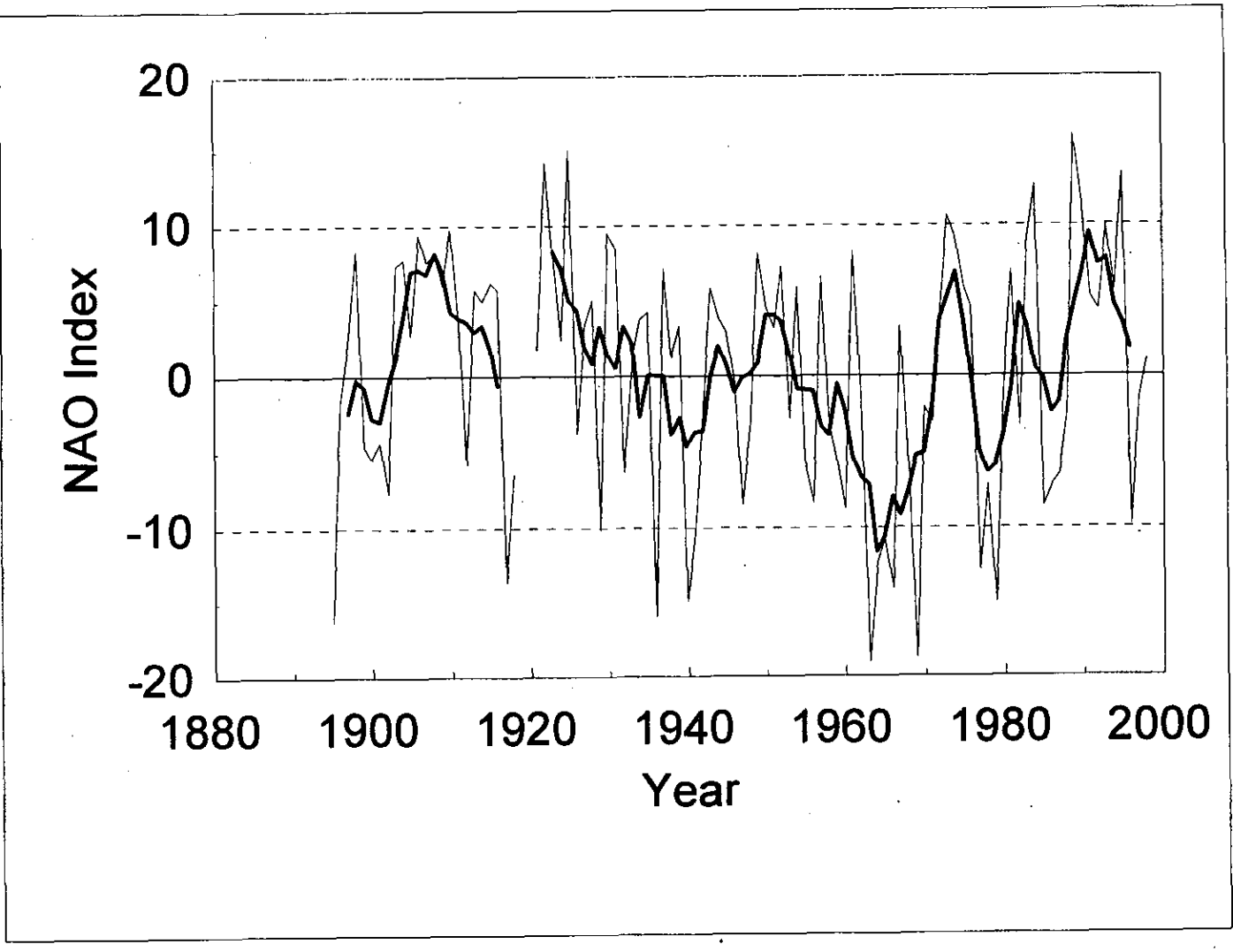

Fig. 13 Normalised North Atlantic Oscillation Index defined as the winter (December, January, February) sea level pressure at Ponta Delgada in the Azores minus Akureyri in Iceland

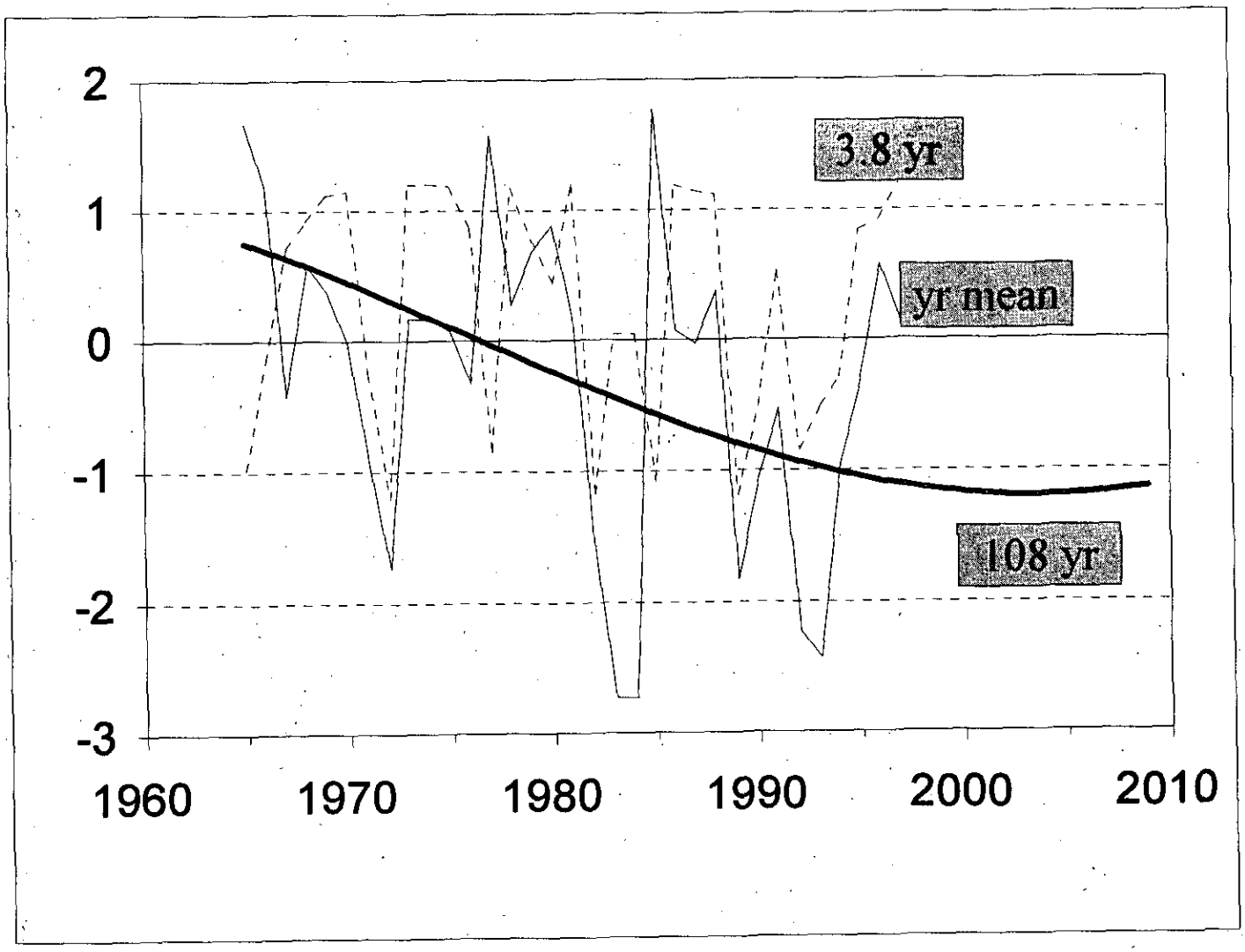

Fig. 14 Analysis of "Intermediate warming" features (dashed line), year mean curve of air temperature at Nuuk/West Greenland (thin line), and the long-term model (bold line) of assumed climatic variation