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Climatic Conditions Around Greenland – 1997

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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 characterize 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 represented an 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 Irminger Water layer (200–300 m), as well as an increase of water temperature since 1996. It appears 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 (December, January and February) NAO index was negative during winter 1996/97, And this favours the flow of mild air masses from the mid-latitude Atlantic Ocean to the Greenland/Labrador Sea region.

Key words: climate, ice, Greenland, oceanography, salinity, temperature

Introduction

The North Atlantic Oscillation (NAO) is a large scale alternation of atmospheric mass with centres 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 westerlies are weak.

The NAFO Standing Committee on Fisheries and Environment (STACFEN), during its meetings in 1996 and 1997, recognized that the NAO is the dominant mode of atmospheric behaviour in the North Atlantic sector throughout the year, although it is most pronounced during winter (Drinkwater *et al.*, 1996; Drinkwater *et al.*, MS 1997; Stein, MS 1996; Stein, MS 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 decrease in the NAO index, the single largest annual decrease on record in over 100 years (Drinkwater *et al.*, MS 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 mean conditions (Fig. 13).

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 1700s, 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 climatic issues around Greenland which might be of relevance to fishery assessment work.

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 1961–90. 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 above normal 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 in the Davis Strait/Labrador Sea region with it's center 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 Fig. 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.

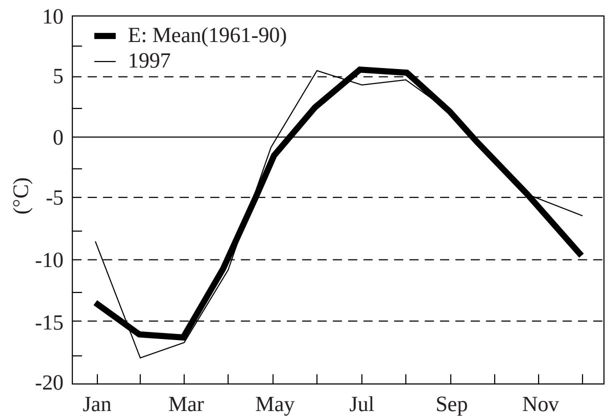

Fig. 1. Monthly mean air temperature at Egedesminde during 1997 and climatic mean (1961–90).

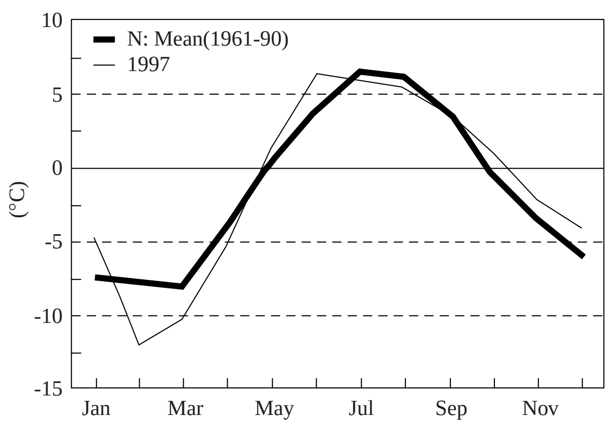

Fig. 2. Monthly mean air temperature at Nuuk during 1997 and climatic mean (1961–90).

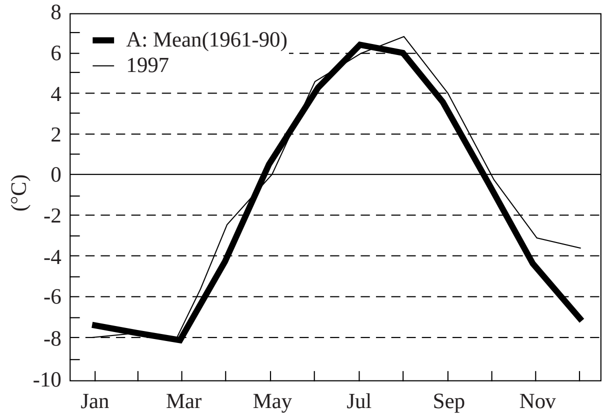

Fig. 3. Monthly mean air temperature at Angmagssalik during 1997 and climatic mean (1961–90).

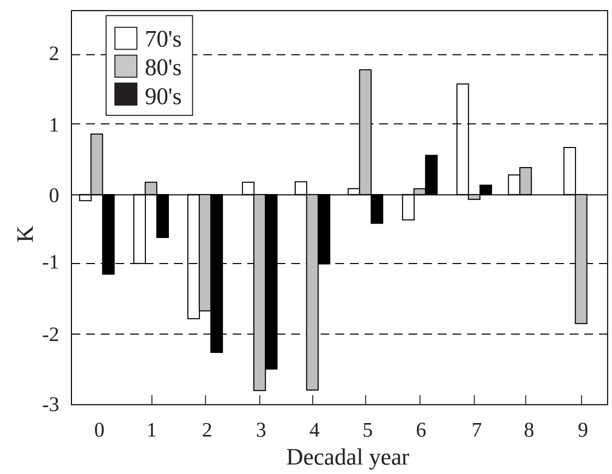

Fig. 5. Composite of decadal air temperature anomalies at Nuuk given relative to the climatic mean of 1961–90 for the decades of the 1970s, 1980s and 1990s.

Climatic Variability off West Greenland

The annual mean air temperature anomalies indicated above normal 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).

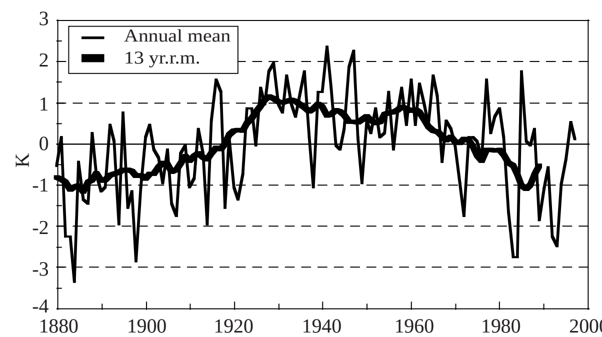

Fig. 6. Time series of annual mean air temperature anomalies at Nuuk (1880–1997, rel. 1876–1997) and 13-year running mean.

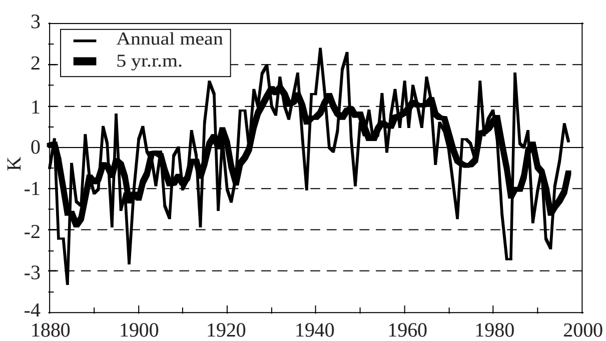

Fig. 4. Time series of annual mean air temperature anomalies at Nuuk (1880–1997, rel. 1876–1997) and 5-year running mean.

Ice Conditions in the Northwest Atlantic

Winter ice conditions revealed below normal ice cover during 1997 off West Greenland. The southernmost location of the ice edge was found in the beginning of March (970303, Fig. 7). There was ice around Cape Farewell during winter and spring.

Subsurface Observations off West Greenland

Observations on Standard Oceanographic Stations (Stein, MS 1988) were done at the Cape Desolation Section and at the Fylla Bank Section. Fig. 8 and 9 display time series of temperature and salinity at station 3 of the Cape Desolation Section. Thermal conditions in the 200–300 m layer of the water column indicated cooling during 1997 compared to 1996 (Fig. 8). Salinity measurements at Cape Desolation Section Station 3 (3 000 m depth) showed a significant drop in salinity since 1996 in the

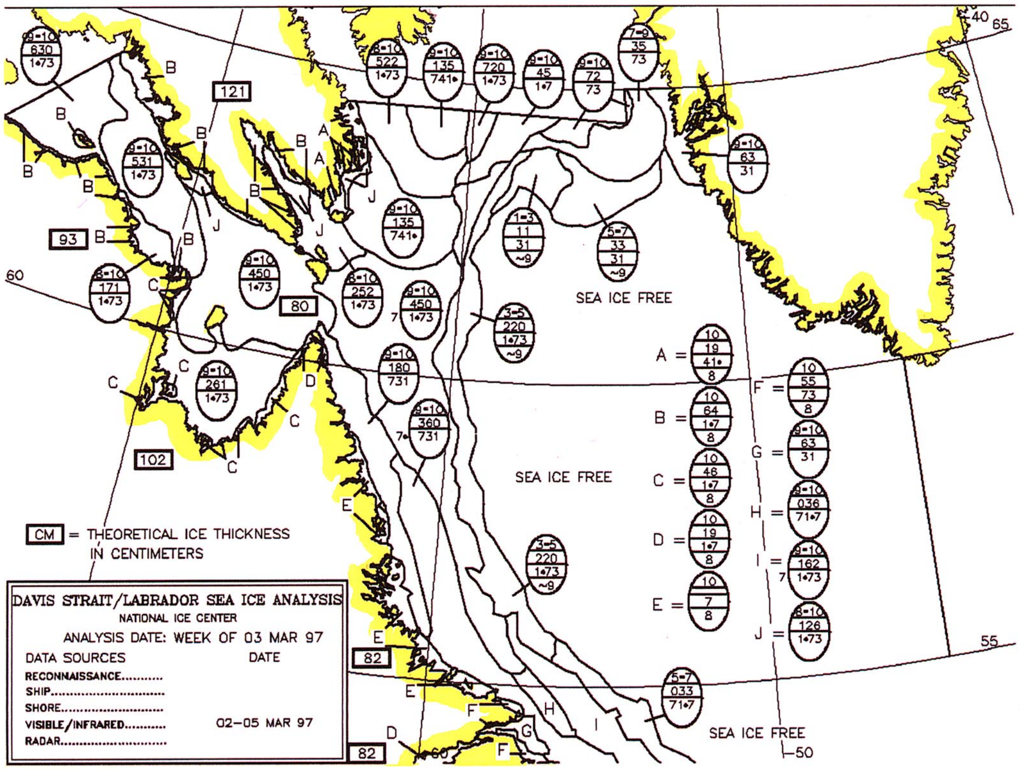

Fig. 7. Ice edge during week of 3 March 1997.

Irminger Water Layer (200–300 m) (Fig. 9). In detail: 1995 (34.966), 1996 (34.940), 1997 (34.904); this drop is larger than that one observed 10 years ago: 1987 (34.914 for the 200–300 m 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 900 m and 1 300 m 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.

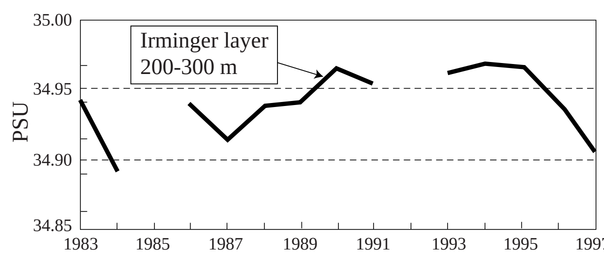

Fig. 9. Time series of salinity at Standard Oceanographic Station 3 of the Cape Desolation Section (1983–97) for Irminger Water layer 200–300 m.

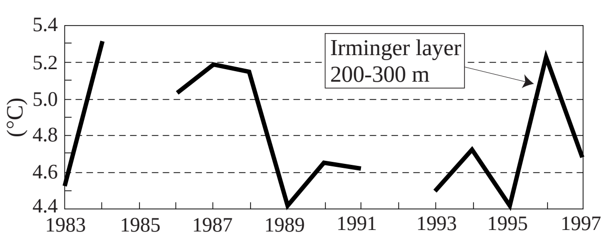

Fig. 8. Time series of temperature at Standard Oceanographic Station 3 of the Cape Desolation Section (1983–97) for Irminger Water layer 200–300 m.

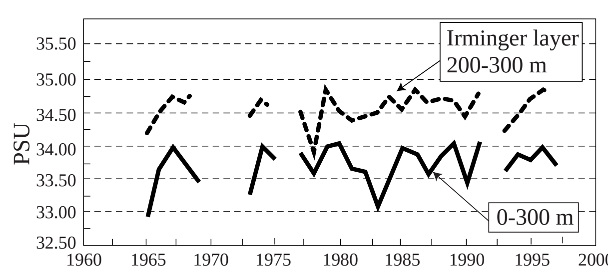

Fig. 10. Time series of salinity at Standard Oceanographic Station 4 of the Fylla Bank Section (1965–97) for layers 0–300 m, and Irminger Water layer 200–300 m.

Thermohaline conditions on Fylla Bank Station 4 (Fig. 11, 12) are given for the years 1963 to 1997, relative to the 1963–90 climatological mean. All water layers indicate warmer than normal conditions, salinity shows a decreasing trend, however the 1997 values of the surface layers are near the norm.

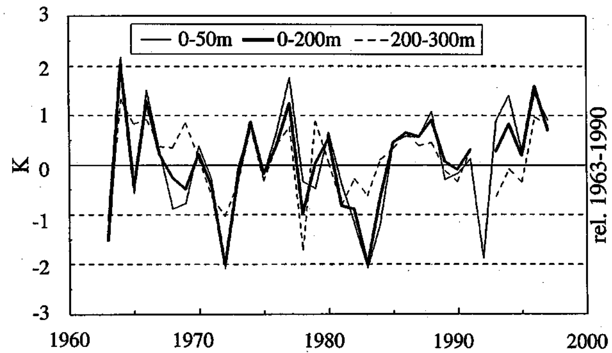

Fig. 11. Time series of temperature at Standard Oceanographic Station 4 of the Fylla Bank Section (1963–97) for surface layers 0–50 m, 0–200 m and Irminger Water layer 200–300 m.

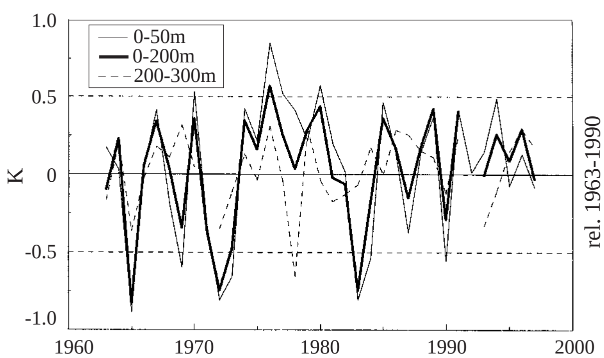

Fig. 12. Time series of salinity at Standard Oceanographic Station 4 of the Fylla Bank Section (1963–97) for surface layers 0–50 m, 0–200 m and Irminger Water layer 200–300 m.

Discussion

The NAO Index 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 now continuing* (Anon., 1998).

As discussed by Stein *et al.* (MS 1998), a negative winter NAO index yields favourable 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 (Fig. 1 and 2). Since the February air temperature variability explains 58% of the mean annual air temperature variability at Nuuk (Fig. 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 (Institut für Meereskunde, Hamburg, 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 tempera-tures 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 variations 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. 6). As one can see from this figure the model curve (dashed line, period 3.8 yr) correlates fairly well with the year mean curve, and the mid-1990s

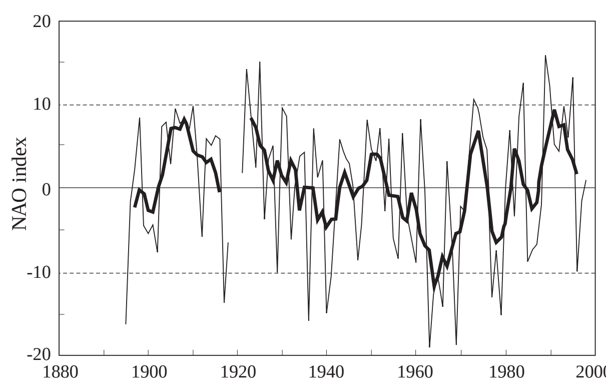

Fig. 13. Normalized North Atlantic Oscillation Index defined as the winter (December, January, February) sea level pressure at Ponta Delgada in the Azores minus Akureyri in Iceland.

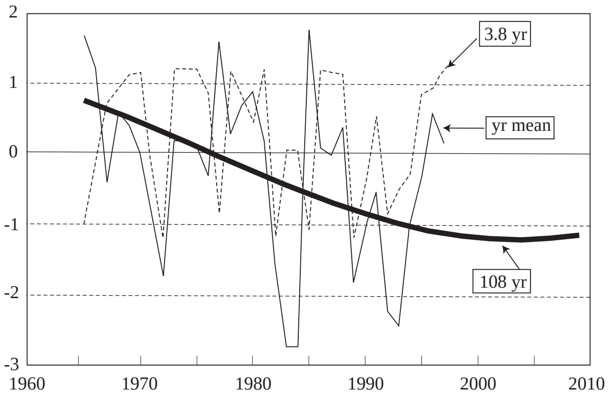

Fig. 14. Analysis of "Intermediate warming" features (dashed line), year mean curve of air temperature at Nuuk/West Greenland (thin line), and the long-term model (bold line) of assumed climatic variation.

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 (Fig. 1 to 3) for most of the year 1997, vary in the normal range. Also the ice cover represents variation within the norm.

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