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Climatic Conditions Around Greenland - 1998

by

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Abstract

Warmer than normal conditions were observed around Greenland for most of the year 1998. Based on sea surface temperature (SST) anomaly maps for all months of 1998 it is shown that the arctic water mass components have increasing influence on the surface waters from October onwards, and may be traced by the SST anomalies well into early summer. Oceanographic observations made at Standard Oceanographic Stations off West Greenland reveal record high warming of the advective component of the West Greenland Current, the Irminger component. With a mean temperature of 6.43°C in the water layer 200-300m these findings are the highest temperatures ever observed at Fyllas Bank Station 4 during autumn. Salinity measurements made for the same water layer at the Cape Desolation Station 3 indicates that the salinity anomaly which was observed during autumn 1997, was a single year's event. Air temperatures as measured at Nuuk/West Greenland reveal higher than normal (0.4K) anomalies. As analysed for the last year's NAFO Sc. Council contribution the author is convinced that the observed warming is of the same type as in the previous decades of the 1970s and 1980s: an intermediate warming.

Introduction

Monitoring environmental data leads after a considerable time of systematic sampling to understanding environmental variability. Following this philosophy, meteorologists arrived at time-series of e.g. air temperatures which cover periods of more than 100 years, after starting observations in the middle of the last century. Oceanographers have followed long time-series of data collection at Oceanographic Standard Stations, where measurements were performed at the same position, during the same season of the year (Stein, 1998). Some examples are Station 27 off St. John's, NFLD, the Fyllas Bank Station 4 off Nuuk, Greenland, or oceanographic data from Ocean Weather Ships (e.g. BRAVO at about 56°30'N, 51°W).

There is now, at the end of this century, increasing interest to use these long-term observations for prognostic approaches (Stein and Lloret, 1999).

Following Latif (1998), the climate system exhibits considerable natural variability on time scales of the order of decades. Decadal climate variability is an important issue for three reasons:

- A better understanding of the mechanisms generating decadal climate variability might open the possibility to make predictions at decadal time scales.

- The detection of anthropogenic climate change requires information about natural variability to separate the anthropogenic signal from the natural background noise.
- Long-term changes in the climate state might influence short-term climate fluctuations. A better knowledge of the slowly evolving background state can improve the prediction of the faster climate variations substantially.

NAFO through its Standing Committee on Fisheries and Environment (STACFEN) encouraged research scientists to continue sampling of oceanographic data whenever there is research activity in the NAFO Convention Area. This led to the existence of some really long-term time-series of NAFO Oceanographic Standard Stations (Stein, 1988). Scientific information from these data sets fills - in the mean time - bookshelves (the given references cover documentation from the 1990s as published in the NAFO Journal of Northwest Atlantic Fisheries Science, and the NAFO Scientific Council Studies: Trites and Drinkwater, 1990; Stein and Wegner, 1990; Drinkwater and Trites, 1991; Stein, 1991; Stein and Buch, 1991; Stein, 1993; Drinkwater and Trites, 1993; Drinkwater et al., 1994; Colbourne, 1994; Drinkwater, 1995; Parsons et al., 1998; Stein, 1995; Stein, 1995a; Drinkwater, 1995a; Drinkwater, 1996; Drinkwater, 1996a; Stein, 1996; Stein and Lloret, 1996; Drinkwater et al., 1996; Stein, 1996a; Drinkwater et al., 1996a; Stein, 1996b; Stein and Borovkov, 1997; Drinkwater et al., 1998; Stein, 1998; Stein, 1998a).The present paper is the seventh 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 , Figs. 6, 7).They originate from NOAA satellite ice observations.

Sea surface data for the region between Greenland and Labrador were taken from the IGOSS Data Base http://ingrid.ldgo.columbia.edu/SOURCES/.IGOSS .

Subsurface ocean data are available from German measurements for the West and East Greenland area. The NAO Index (Fig. 13) gives the mean December, January, February (DJF) Sea Level Pressure (SLP) from the Azores and from Iceland. The individual SLP's are standardized to 1961-90 base period.

Station Ponta Delgada was closed and the Azores SLP data come from station Santa Maria. DJF pressures for 1997 and 1999 for Ponta Delgada were defined by regression of SM(1961-1998) data (Loewe and Koslowski, 1998).

$P(PD)=a*P(SM)+b$, with $a = 1.0512$, $b = -52.8933$.

Results

Air Temperature and Climatic means

Similar to the 1997 conditions (Stein, 1998b), February was the coldest month off West Greenland, and the positive air temperature conditions as observed during December 1997 at the West Greenland sites, were maintained through to January 1998. Air temperature anomalies during the coldest month (February) ranged from –2K to –7K at the west coast of Greenland (Anon., 1998). As it was normally encountered during the first half of this decade, there was a cold air mass centered over the town of Egedesminde. This may have led to the relatively cold February with air temperature anomalies of –4.5K at Nuuk (-12.3°C), and –3.3 K at Egedesminde (-19.3°C). Mean air temperatures for February are given in brackets.

The annual air temperature curves referenced to the climatic means at the three observation sites off West and East Greenland, are given in Figs. 1 to 3. Colder than normal conditions were encountered at the west coast of Greenland during February and March. Except for November 1998 Nuuk (Fig. 2) air temperatures were above the climatic mean from April onwards. Angmagssalik (Fig. 3) experienced climatic conditions which were similar to the West Greenland conditions during the first quarter of the year. Except for June 1998 air temperatures remained above normal until August when temperatures started to fall slightly below the climatic mean (1961-90). November and December showed warmer than normal conditions.

Climatic Variability off West Greenland

As in the previous two years, the annual mean air temperature anomalies indicated positive conditions (+0.4 K, Fig. 4) for the third year in consecution since 1988. The decadal presentation of Nuuk mean air temperature anomalies (Fig. 5) reveals about the same positive anomalies as during the previous decades. The long-term trend of Nuuk air temperature anomalies (the 13-year running mean as well as the 5-year running mean) is, as emphasised by Stein (1998b) pointing at intermediate warming, a feature which was also observed during the 1970s and 1980s (Fig. 4).

Ice Conditions in the Northwest Atlantic

Winter ice conditions were favourable during 1998 off West Greenland. The southernmost location of the ice edge was found in the end of March (980330, Fig. 6). There was ice around Cape Farewell between January and first half of March (East Ice), it was sea ice free between the mid of March and mid of April. From end of April through to August, however, there was above normal ice cover in the Julianehaab bight (Southwest Greenland, Fig. 7).

Sea Surface Temperature Anomalies

The month of September shows largest positive anomalies in sea surface temperatures (SST) between Greenland and Labrador which amount to more than +1.5K. There is a gradual cooling taking place in the following months of the year, and during winter season a patch of warmer than normal water is seen to remain in the centre of the Labrador Sea. Examples from February 1998 (Fig. 8), and February of the previous and the following year show nearly identical structures: With core temperature anomalies of more than 2.5K a warm pool of surface water is found at about 60°N, 55°W. The arctic water masses confined to the shelf regions off West Greenland and Labrador, indicate cooling of more than –2.5K.

Subsurface Observations off West Greenland

Observations on Standard Oceanographic Stations (**Stein, 1988**) were done at the Cape Desolation Section and at the Fyllas Bank Section. Fig. 9, 10 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 slightly warmer than in the previous year. Salinity measurements at Cape Desolation Section Station 3 (3000m depth) show that the last years evidence of a "Salinity Anomaly" can be documented as a single year event which took place in the Irminger layer, and thus points at an advective phenomenon.

Warm air temperature conditions and advection of warm Irminger waters led to the about 1.5K above normal conditions in the Fyllas Bank region. As one can see, all three layers indicate anomalous warming (Fig. 11).

Also salinities are above the norm, and they indicate that the previous year (1997) conditions with slightly lower than normal surface layer salinities (0-50m, 0-200m) are no longer in effect (Fig. 12).

Discussion

After the record low winter NAO Index 1995/96 (Fig. 8, -8.18; Fig. 13) the conditions during 1997/98 returned to normal, whereas the 1998/99 index was record high on the positive side (Fig. 8, 13.96; Fig. 13). Fig. 8 displays

SST anomalies for the months of February (1995 to 1999). A common feature in all years is the patch of warmer than normal surface water in the centre of the Labrador Sea. Even in years with high NAO index which is indicative for increased transport of arctic water masses (e.g. the East Greenland Current component, and the Baffin/Labrador Current component), SST anomalies are visible which amount to > 4K. It is suggested here that due to vertical convection during winter, the heat content of the upper water layers as present during the anomalous warmth during previous autumn is maintained through to the winter/spring season.

From Fig. 8 it would appear that during “NAO negative” periods the transport of arctic water masses is reduced, and there are positive anomalies visible during these times in the Southeast Greenland region.

Except for the Southwest off Greenland positive SST anomalies were prevailing around Greenland from April 1998 onwards (Figs. 14, 15). The sequence of monthly SST anomalies as given in Figs. 14, 15 reveals the decreasing influence of the arctic water mass components from June to September, and an increasing influence of these components from October onwards. All subsurface observations reveal warming as compared to the climatic means. Record high warming was observed in the Irminger Water layer (200-300m) at Fyllas Bank Station 4. With a mean temperature of 6.43°C the 1998 measurements reveal record high values which have never been observed since 1963 when the autumn time series began at Fyllas Bank. Only during 1964 temperature were observed which were slightly above 6.0°C.

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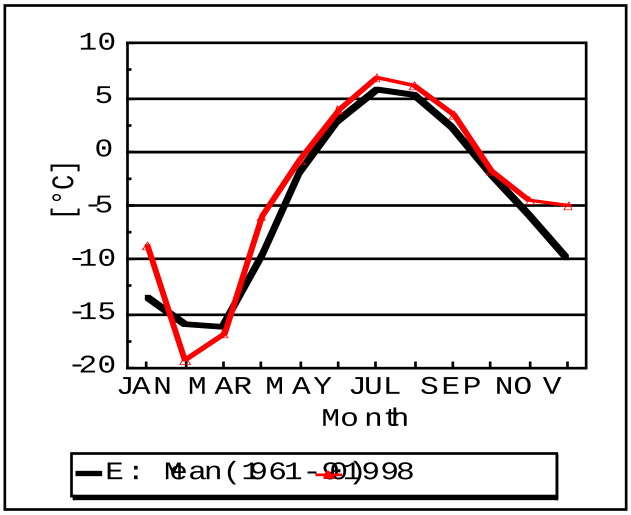


Fig. 1 Monthly mean air temperature at Egedesminde during 1998 and climatic mean (1961-1990)

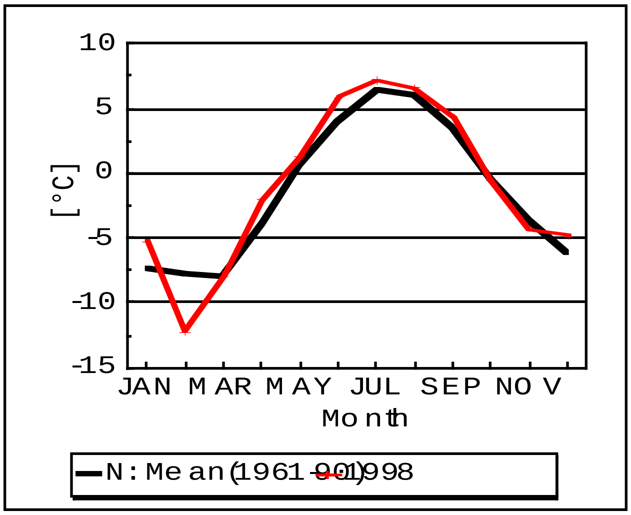


Fig. 2 Monthly mean air temperature at Nuuk during 1998 and climatic mean (1961-1990)

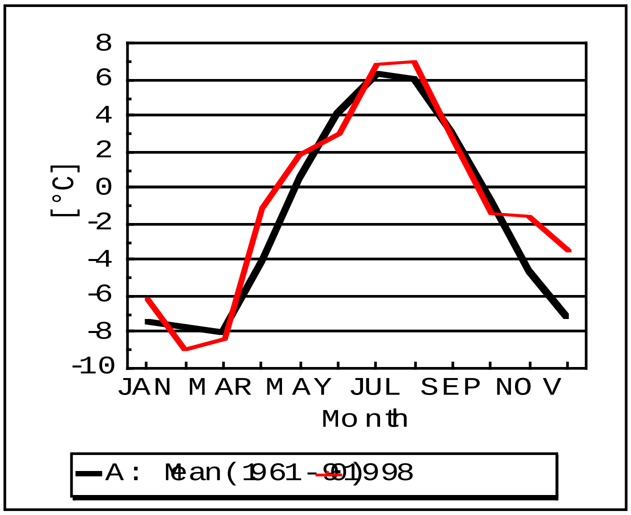


Fig. 3 Monthly mean air temperature at Angmagssalik during 1998 and climatic mean (1961-1990)

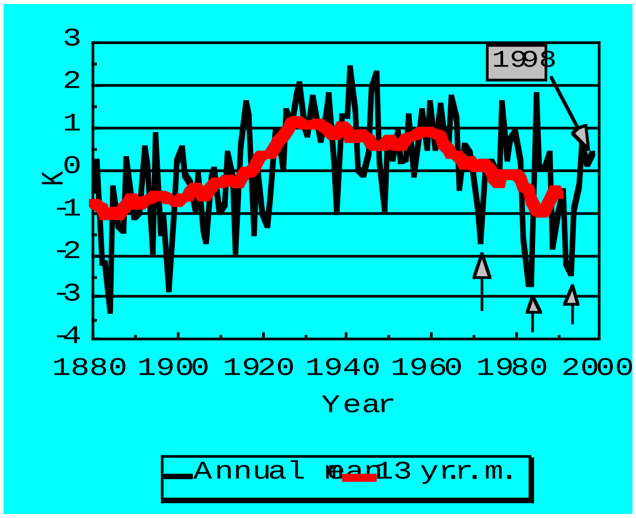


Fig. 4 Time series of annual mean air temperature anomalies at Nuuk (1880-1997, rel. 1876-1997) and 13 year running mean

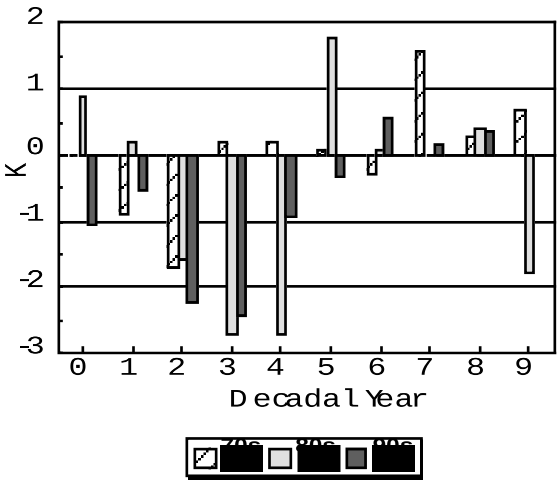


Fig. 5 Composite of decadal air temperature anomalies at Nuuk given relative to the climatic mean of 1961-90 for the decades of the 1970s, 1980s and 1990s

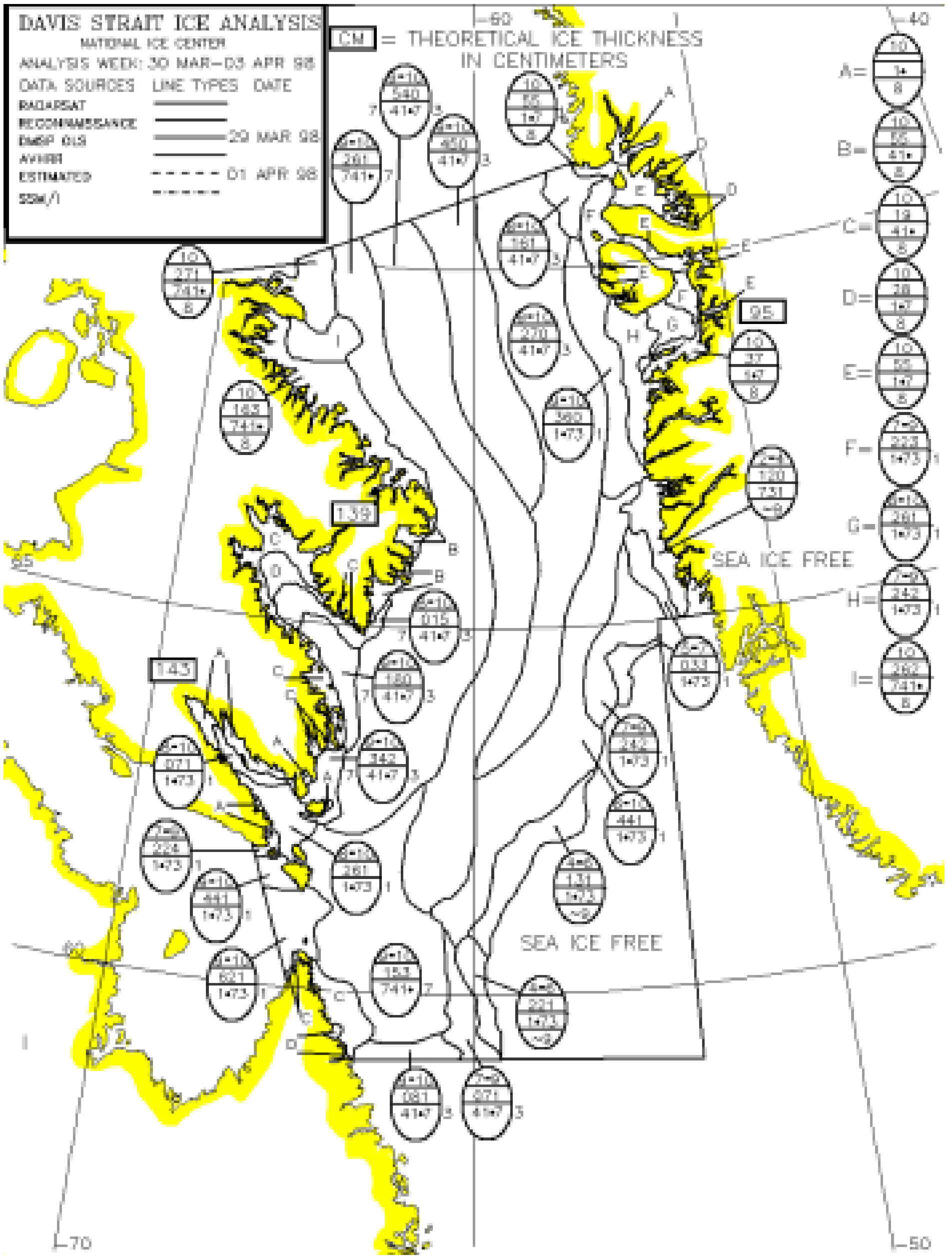


Fig. 6 Ice edge during week of March 30 to April 3, 1998

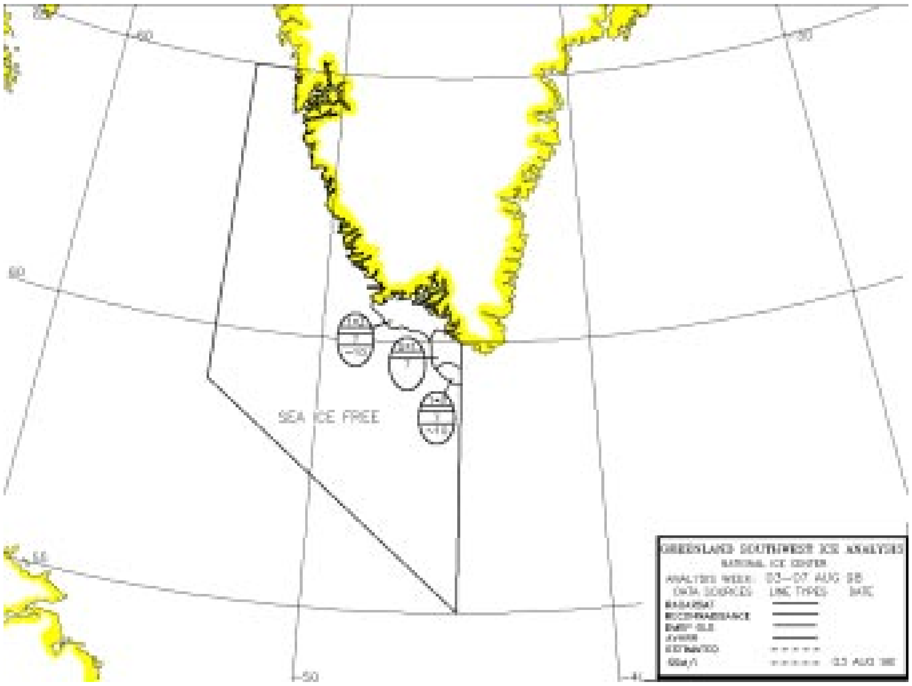
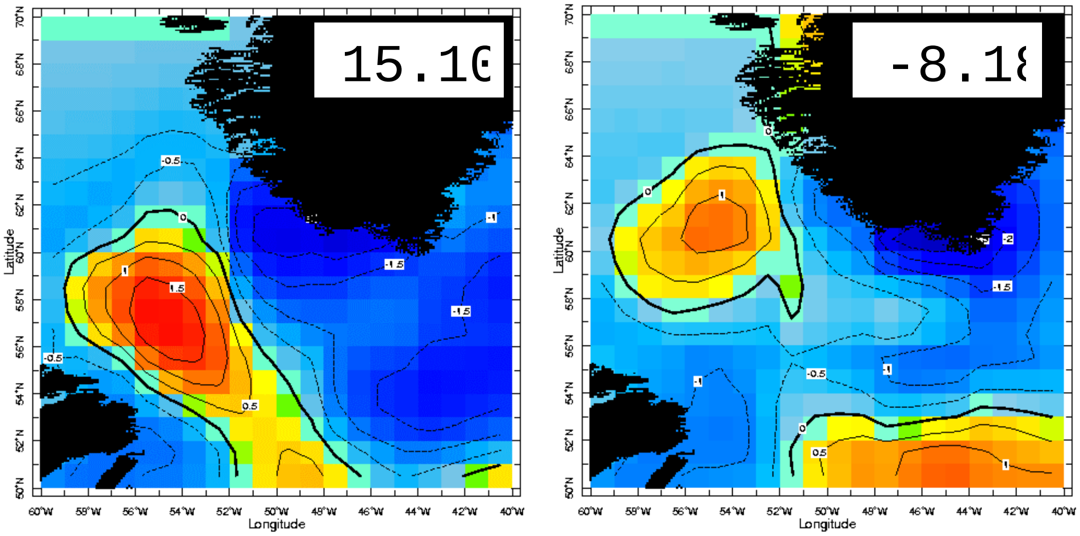


Fig. 7.   Ice edge during week of August 3 to 7, 1998



Feb 1995

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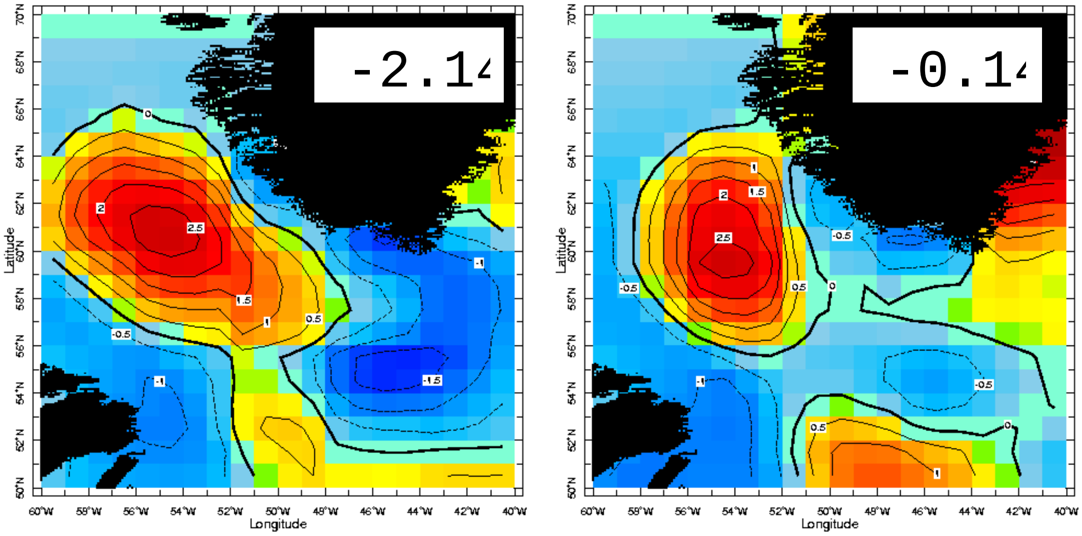

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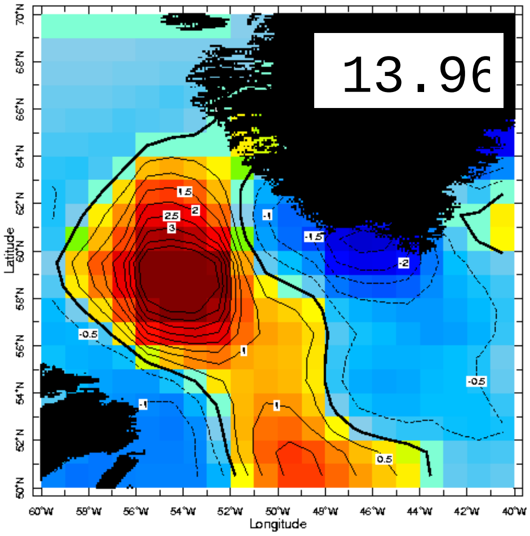

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Fig. 8 Composite of SST Anomalies for the months of February (1995 to 1999), and NAO Index of the corresponding winter season (DJF) given as insert.

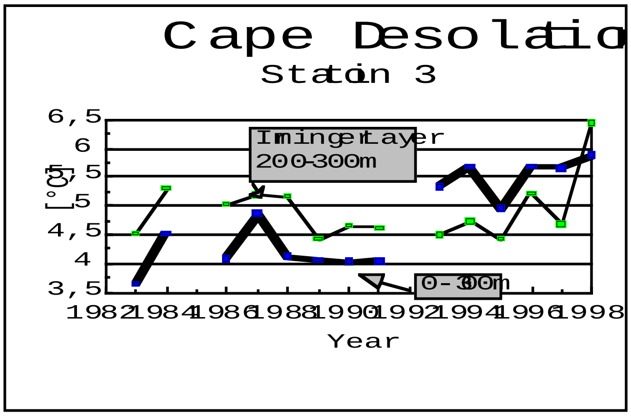


Fig. 9 Time series of Temperature at Standard Oceanographic Station 3 of the Cape Desolation Section (1983-1998) for layers 0-300m, and Irminger Water layer 200-300m.

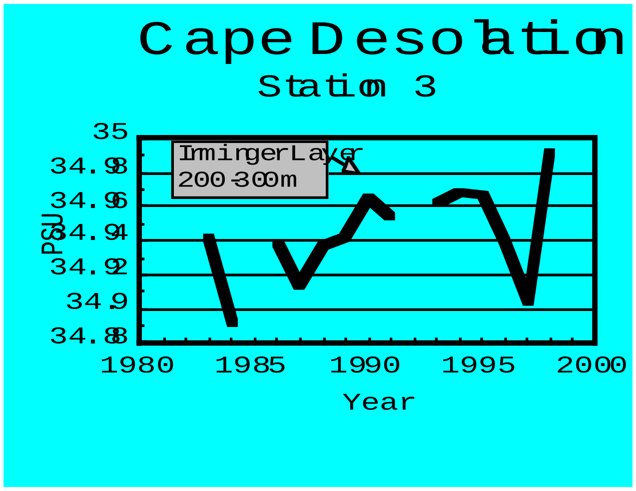


Fig. 10 Time series of Salinity at Standard Oceanographic Station 3 of the Cape Desolation Section (1983-1998) for Irminger Water layer 200-300m.

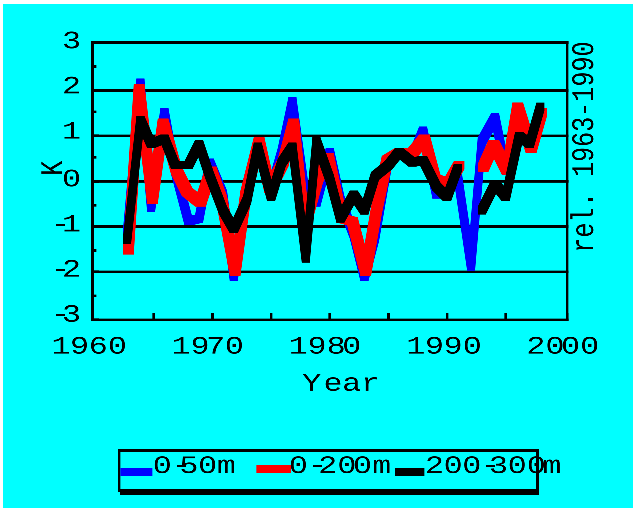


Fig. 11 Time series of temperature at Standard Oceanographic Station 4 of the Fyllas Bank Section (1963-1998) for surface layers 0-50m, 0-200m and Irminger Water layer 200-300m

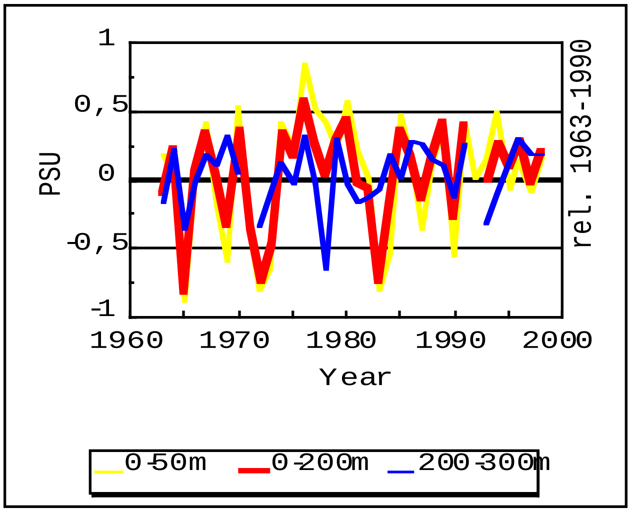


Fig. 12 Time series of salinity at Standard Oceanographic Station 4 of the Fyllas Bank Section (1963-1998) for surface layers 0-50m, 0-200m and Irminger Water layer 200-300m

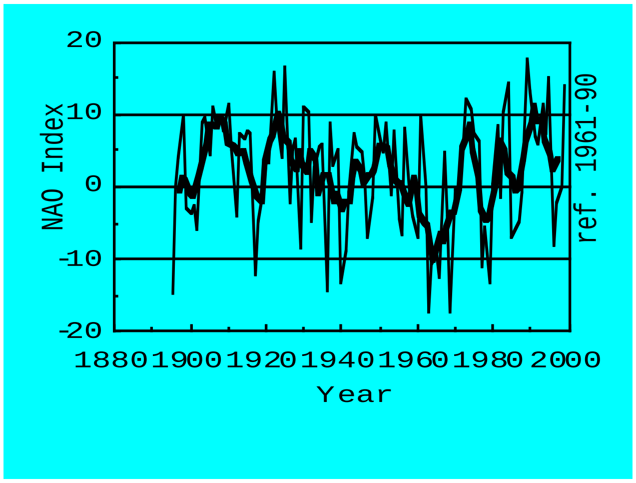
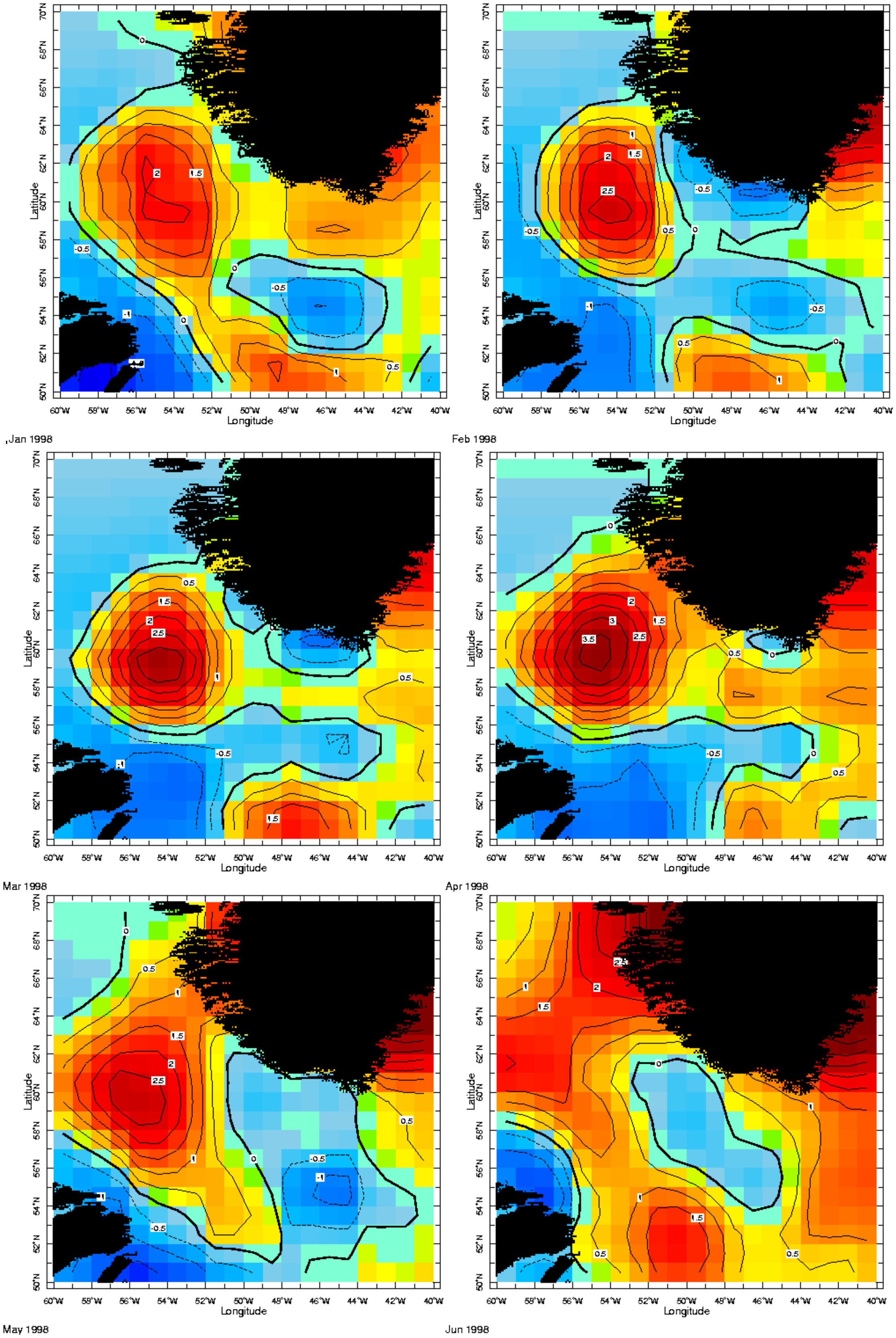


Fig. 13 Normalised North Atlantic Oscillation Index defined as the winter (December, January, February) sea level pressure at Ponta Delgada in the Azores minus Akureyri in Iceland.



,Jan 1998

Feb 1998

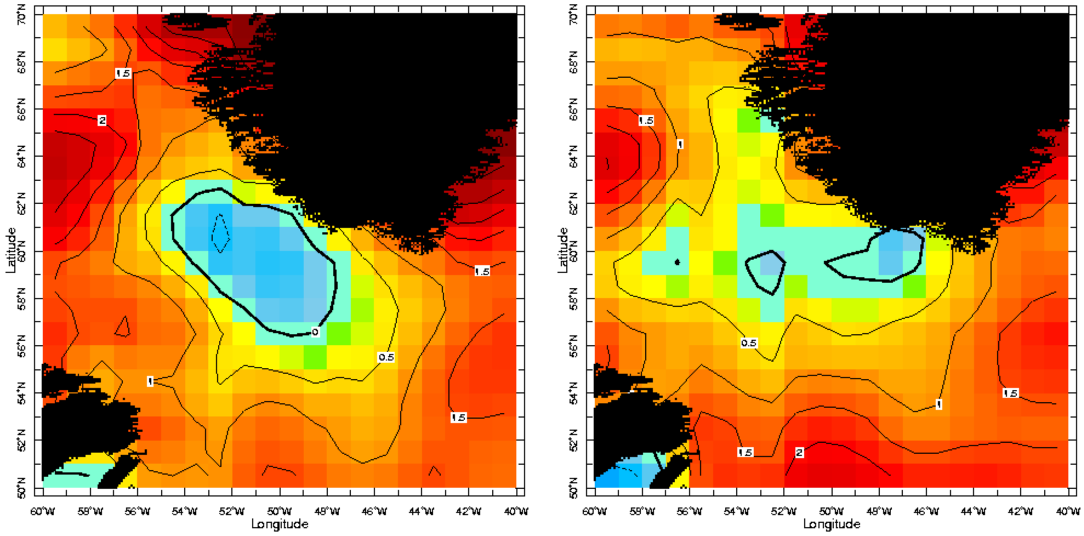
Mar 1998

Apr 1998

May 1998

Jun 1998

Fig. 14 Composite of SST Anomalies for the months of January to June, 1998.



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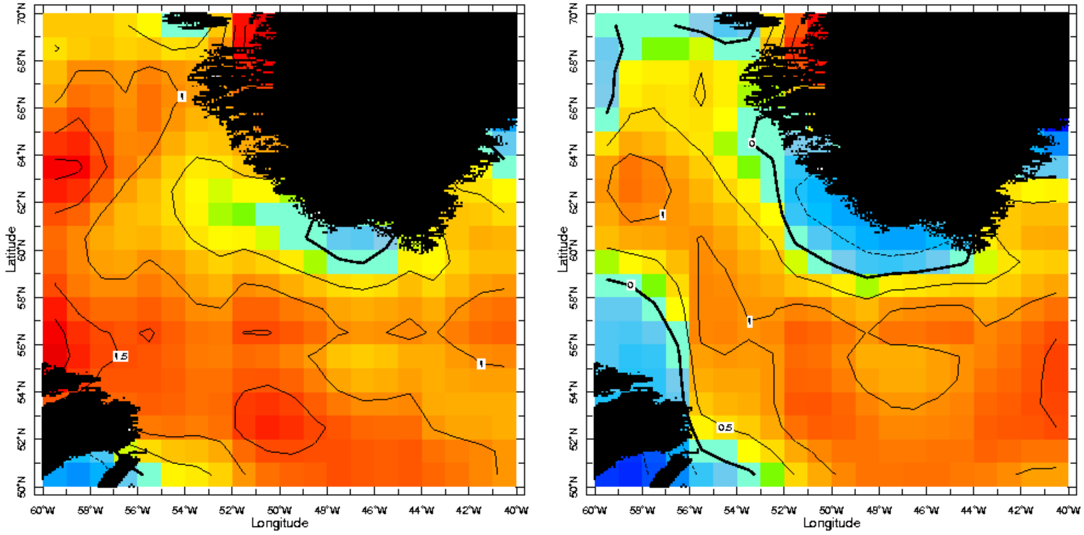

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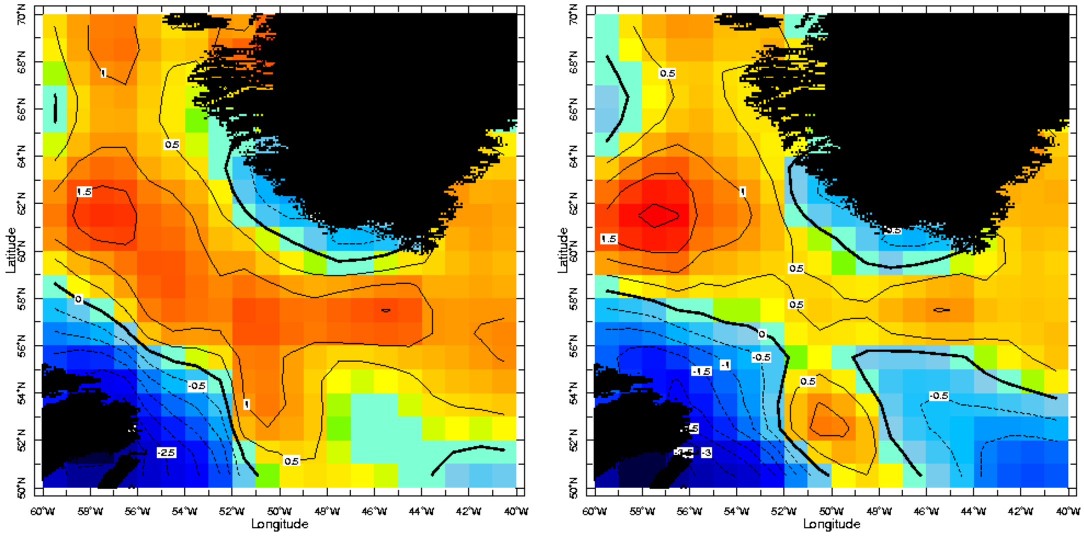

Nov 1998

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Fig. 15 Composite of SST Anomalies for the months of July to December, 1998.