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Climatic Conditions Around Greenland – 1998

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

Abstract

Warmer than normal conditions were observed around Greenland for most of 1998. Based on sea-surface temperature (SST) anomaly maps for all months of 1998, it was shown that the arctic water mass components had increasing influence on the surface waters from October onwards, and could be traced by the SST anomalies well into early summer. Oceanographic observations made at Standard Oceanographic Stations off West Greenland revealed 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 200–300 m water layer these findings were 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 indicated that the salinity anomaly, which was observed during autumn 1997, was a single year's event. Air temperatures as measured at Nuuk/West Greenland revealed higher than normal (0.4K) anomalies. As analysed for the 1997 NAFO Scientific 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.

Key words: climate, Greenland area, hydrography, salinity, temperature

Introduction

Monitoring environmental data over a considerable time of systematic sampling leads to a better understanding of environmental variability. Following this philosophy, after starting observations in the middle of the last century, meteorologists have collected long time-series of for example air temperature data, which cover periods of more than 100 years. Oceanographers have similarly followed long time-series of data collection at Oceanographic Standard Stations, where standard annual 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. Oceanographic data have also been collected 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 has been observed to exhibit 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 of climate. This allows to separate the anthropogenic signals from the natural background noise.
- Long-term changes in the climate might influence short-term climate fluctuations. A better knowledge of the slowly evolving background state can substantially improve the prediction of the faster climate variations.

NAFO Scientific Council through its Standing Committee on Fisheries and Environment (STACFEN) has encouraged research scientists to continue sampling of oceanographic conditions whenever there is research activity carried out in the NAFO Convention Area. This has led to the existence of some really long-term time-series of data at NAFO Oceanographic Standard Stations (Stein, 1988). Valuable scientific information drawn from these data sets is indeed available through the NAFO publications. The following given references cover documentation from the decade of the 1990s 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, 1995a; Parsons *et al.*, 1998; Stein, 1995a; Stein, 1995b; Drinkwater, 1995b; Drinkwater, 1996a; Drinkwater, 1996b; Stein, 1996a; Stein and Lloret, 1996; Drinkwater *et al.*, 1996a; Stein, 1996b; Drinkwater *et al.*, 1996b; Stein, 1996c; Stein and Borovkov, 1997; Drinkwater *et al.*, 1998; Stein, 1998a; Stein, 1998b). The present paper is the seventh in a series of reviews of climatic conditions around Greenland, which started with the year 1992.

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. From these data, monthly air temperatures were plotted for 1998 in Fig. 1–3, and time-series Nuuk atmospheric conditions were plotted in Fig. 4 and 5. The climatic mean, which the air temperature anomaly charts, is referenced to the base period 1961–90.

Ice charts plotted for periods in 1998 (Fig. 6 and 7) were taken from the INTERNET (http://www.natice.noaa.gov). 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 (Fig. 8–12) were available from German measurements for the West and East Greenland area. The NAO Index (Fig. 13) gives the mean December, January and February (DJF) Sea Level Pressure (SLP) from the Azores and from Iceland. The individual SLPs were 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

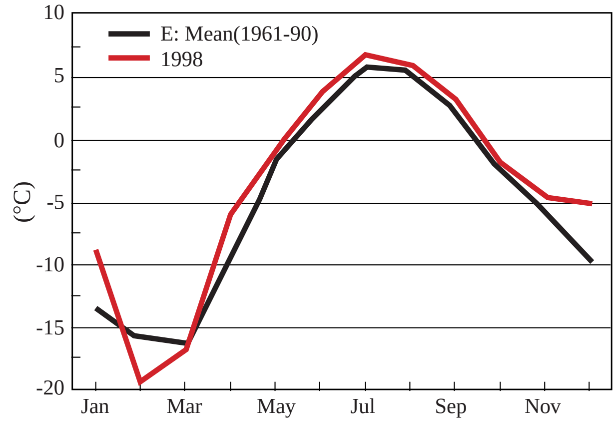

Fig. 1. Monthly mean air temperature at Egedesminde during 1998 and climatic mean (1961–90).

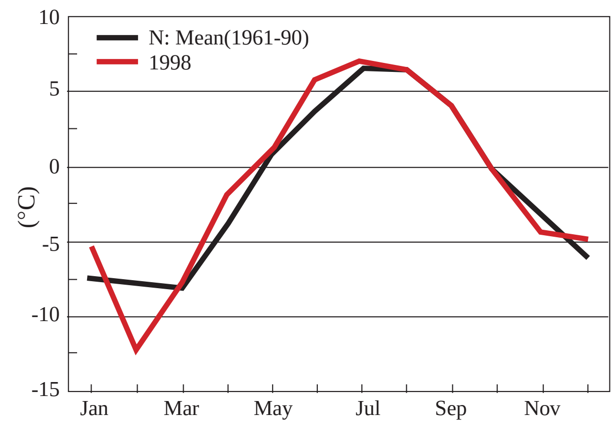

Fig. 2. Monthly mean air temperature at Nuuk during 1998 and climatic mean (1961–90).

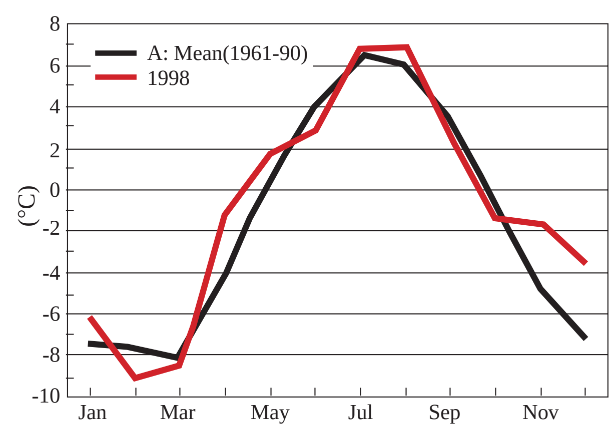

Fig. 3. Monthly mean air temperature at Angmagssalik during 1998 and climatic mean (1961–90).

and 1999 for Ponta Delgada were defined by regression of SM (1961–98) data (Loewe and Koslowski, 1998).

$$P(PD) = a*P(SM)+b, \text{ with } a = 1.0512, b = -52.8933$$

Results

Air Temperature and Climatic Means

Similar to the 1997 conditions (Stein, 1998c), in 1998 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 centred over the town of Egedesminde. This may have led to the relatively cold February with air temperature anomalies of -4.5K at Nuuk (with the mean air temperatures for February of -12.3°C) and -3.3 K at Egedesminde (with the mean air temperature for February of -19.3°C).

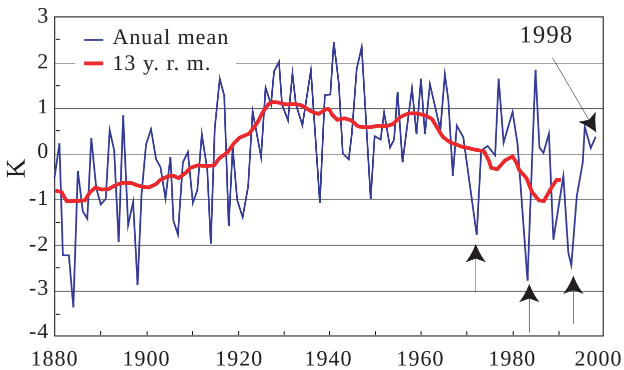

Fig. 4. Time series of annual mean air temperature anomalies at Nuuk (1880–1997, rel. 1876–1997) and 13-year running mean.

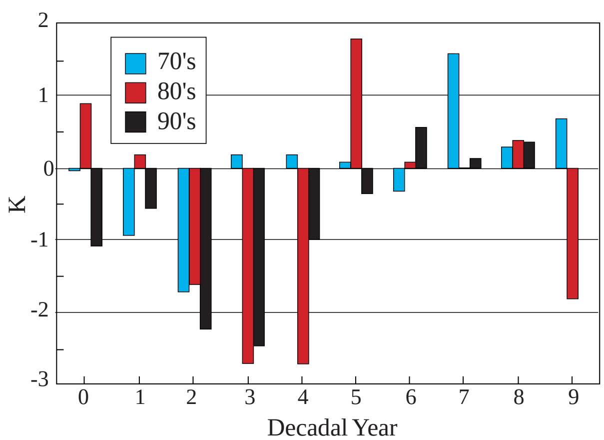

Fig. 5 Composite of decadal air temperature anomalies at Nuuk given relative to the climatic mean of 1961–90 for the decades of the 1970s, 1980s and 1990s.

The annual air temperature curves referenced to the climatic means at the three observation sites off West and East Greenland, (Fig. 1 to 3) showed 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 consecutive year since 1988. The decadal presentation of Nuuk means 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 (1998c) pointing at intermediate warming. This is a feature, which was also observed during the 1970s, and 1980s (Fig. 4).

Ice Conditions in the Northwest Atlantic

Winter ice conditions were normal 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 mid-March and mid-April. From end of April through to August, however, there was above normal ice cover in the Julianehaab bight (Southwest Greenland, Fig. 7).

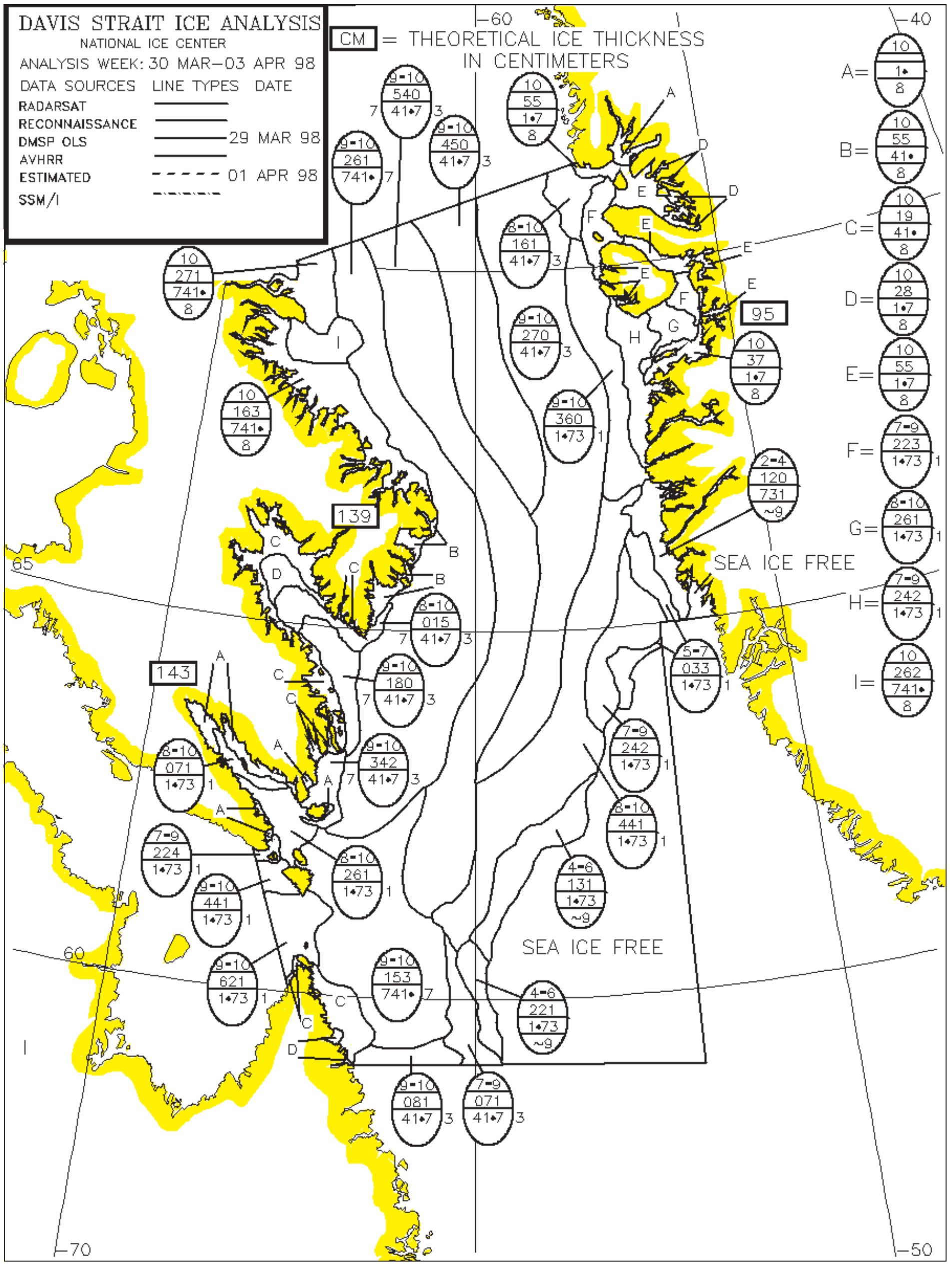

Fig. 6. Ice edge during week of 30 March to 3 April 1998.

Sea-Surface Temperature Anomalies

The month of September showed largest positive anomalies in sea-surface temperatures (SST) between Greenland and Labrador, which amounted to more than +1.5K. There was a gradual cooling taking place in the following months of the year, and during the winter season a patch of warmer than normal water was 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 showed nearly identical structures: With core temperature anomalies of more than 2.5K a warm pool of surface water was found at about 60°N, 55°W. The arctic water masses confined to the shelf regions off West Greenland and Labrador, indicated cooling of more than -2.5K.

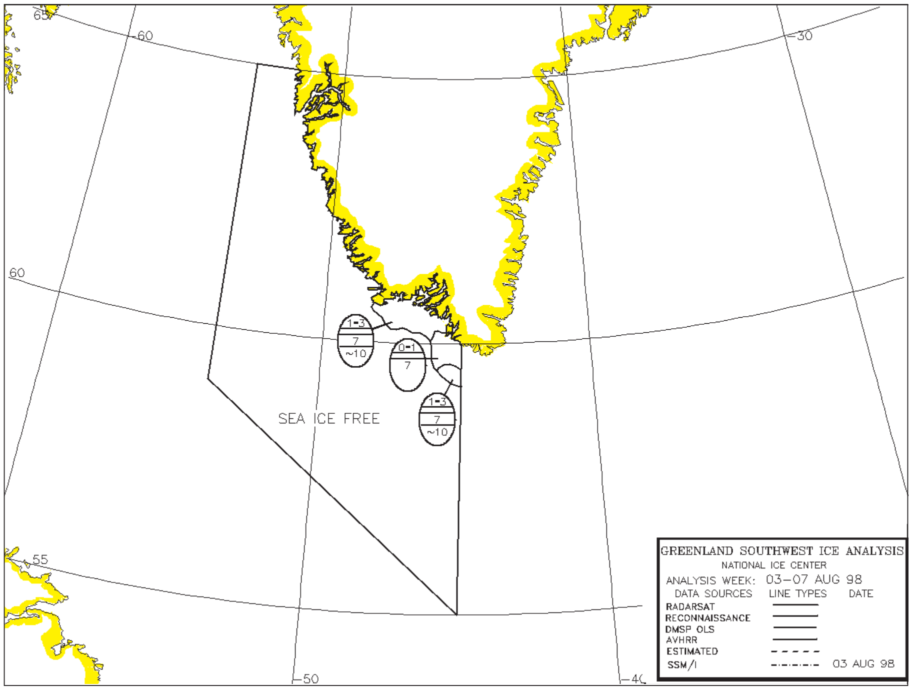

Fig. 7. Ice edge during week of 3–7 August 1998.

Subsurface Observations off West Greenland

Observations on Standard Oceanographic Stations (Stein, MS 1988) were done at the Cape Desolation Section and at the Fyllas Bank Section. Figures 9 and 10 display the time series of temperature and salinity at station 3 of the Cape Desolation Section. Thermal conditions in the top 300 m of the water column were slightly warmer than in the previous year. Salinity measurements at Cape Desolation Section Station 3 (3 000 m depth) showed 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. All three layers indicated anomalous warming (Fig. 11).

Also salinities were above the normal and they indicated that the previous year (1997) conditions with slightly lower than normal surface layer salinities (0–50m, 0–200m) were 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). Figure 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 were visible and 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.

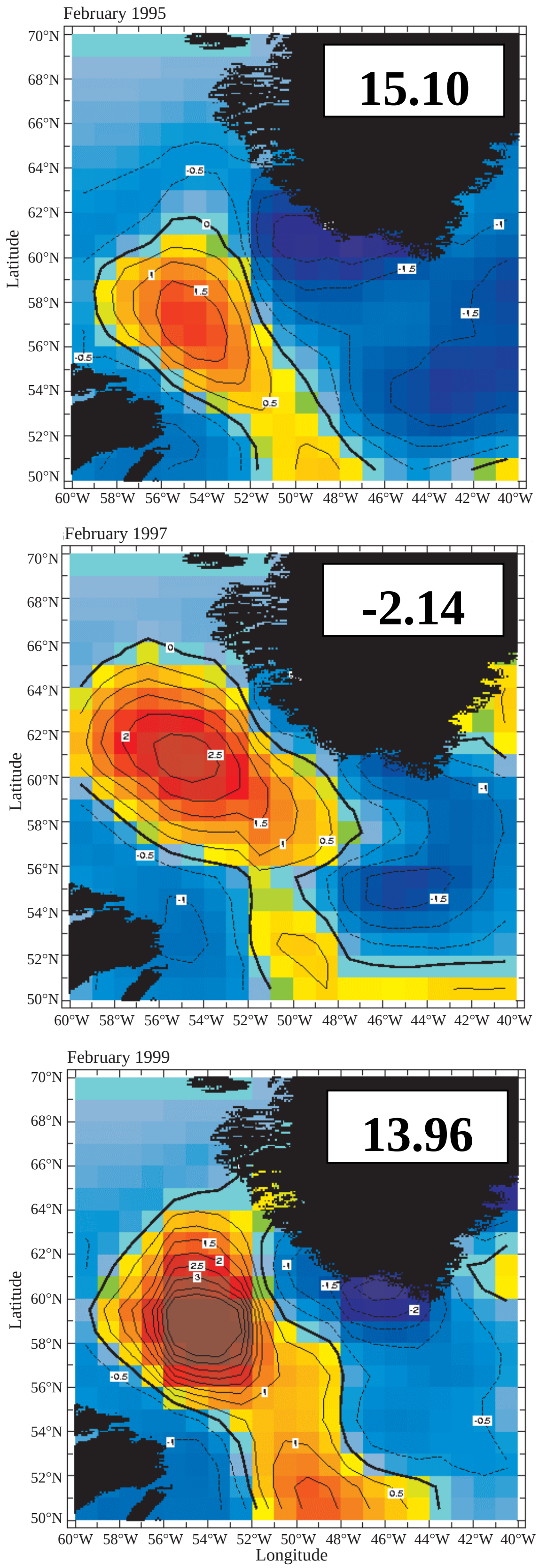

Fig. 8. Composite of SST Anomalies for the months of February (1995–99), and NAO Index of the corresponding winter season (DJF) given as insert.

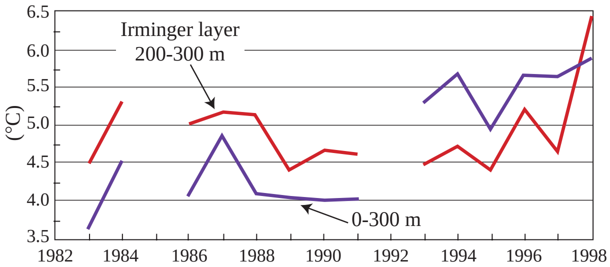

Fig. 9. Time series of temperature at Standard Oceanographic Station 3 of the Cape Desolation Section (1983–98) for layers 0–300 m, and Irminger Water layer 200–300 m.

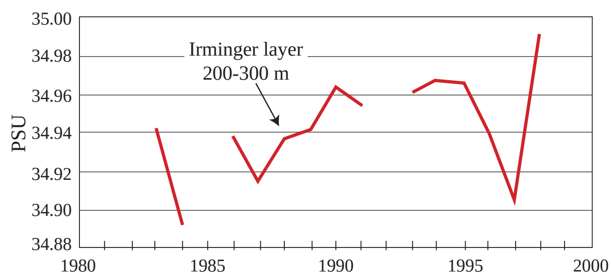

Fig. 10. Time series of salinity at Standard Oceanographic Station 3 of the Cape Desolation Section (1983–98) for Irminger Water layer 200–300 m.

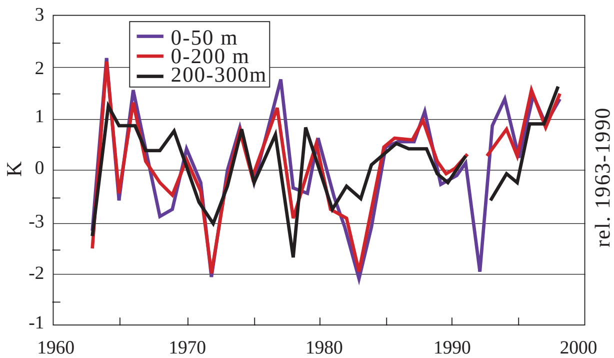

Fig. 11. Time series of temperature at Standard Oceanographic Station 4 of the Fyllas Bank Section (1963–98) for surface layers 0–50m, 0–200 m and Irminger Water layer 200–300 m.

Except for the area Southwest off Greenland, positive SST anomalies were prevailing around Greenland from April 1998 onwards (Fig. 14, 15).

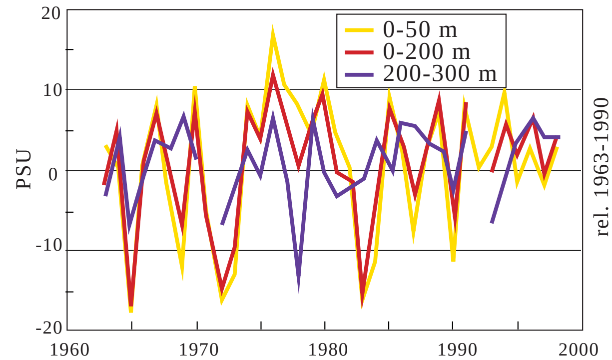

Fig. 12. Time series of salinity at Standard Oceanographic Station 4 of the Fyllas Bank Section (1963–98) for surface layers 0–50m, 0–200 m and Irminger Water layer 200–300 m.

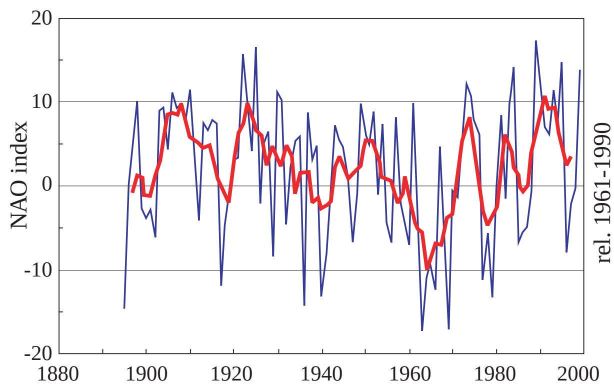

Fig. 13. Normalized North Atlantic Oscillation Index defined as the winter (December, January, February) Sea Level Pressure (SLP) at Ponta Delgada in the Azores minus Akureyri in Iceland.

The sequence of monthly SST anomalies, as given in Fig. 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 an overall warming as compared to the climatic means. Record high warming was observed in the Irminger Water layer (200–300 m) 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 were temperatures observed which were slightly above 6.0°C.

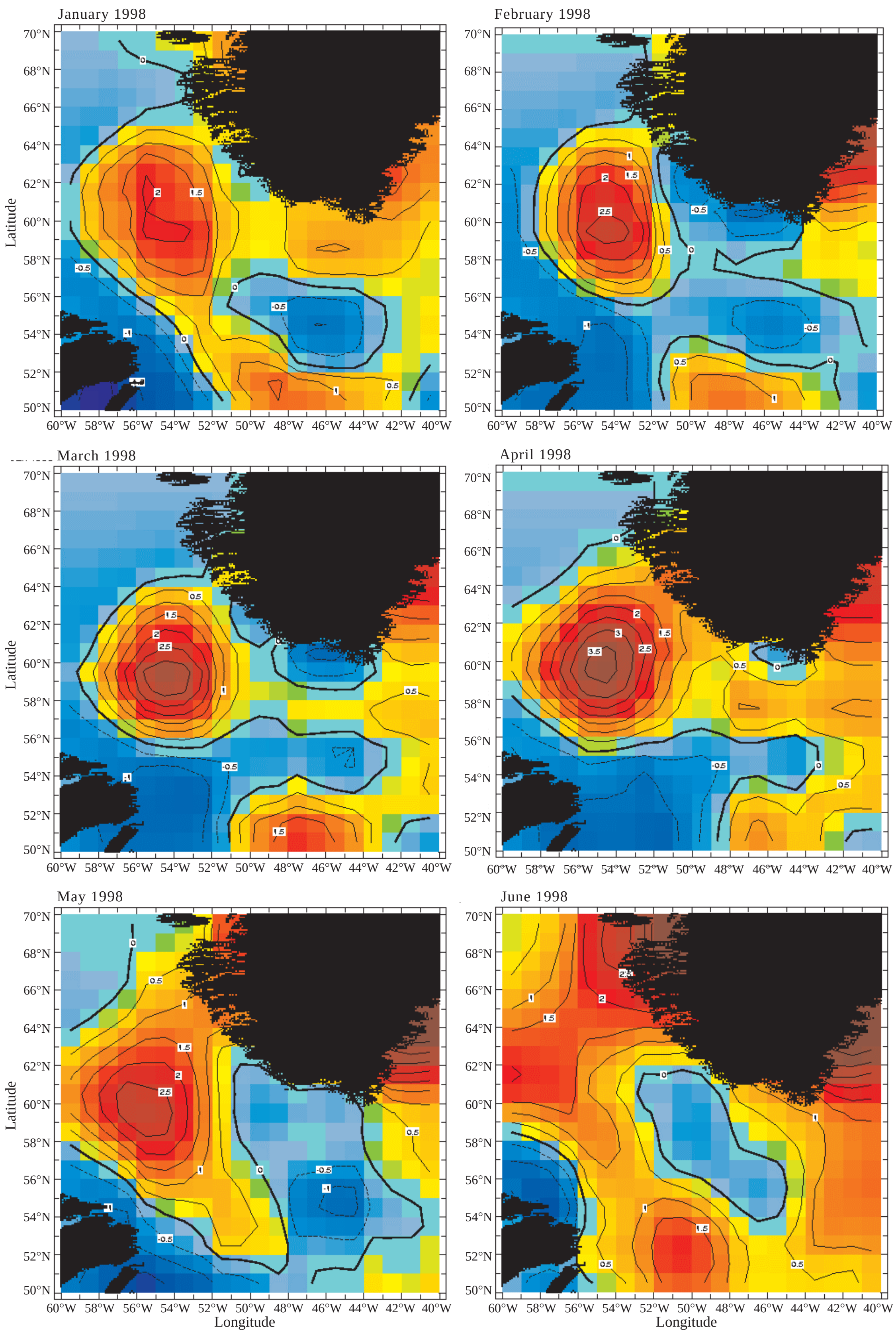

Fig. 14. Composite of SST Anomalies for the months of January to June 1999.

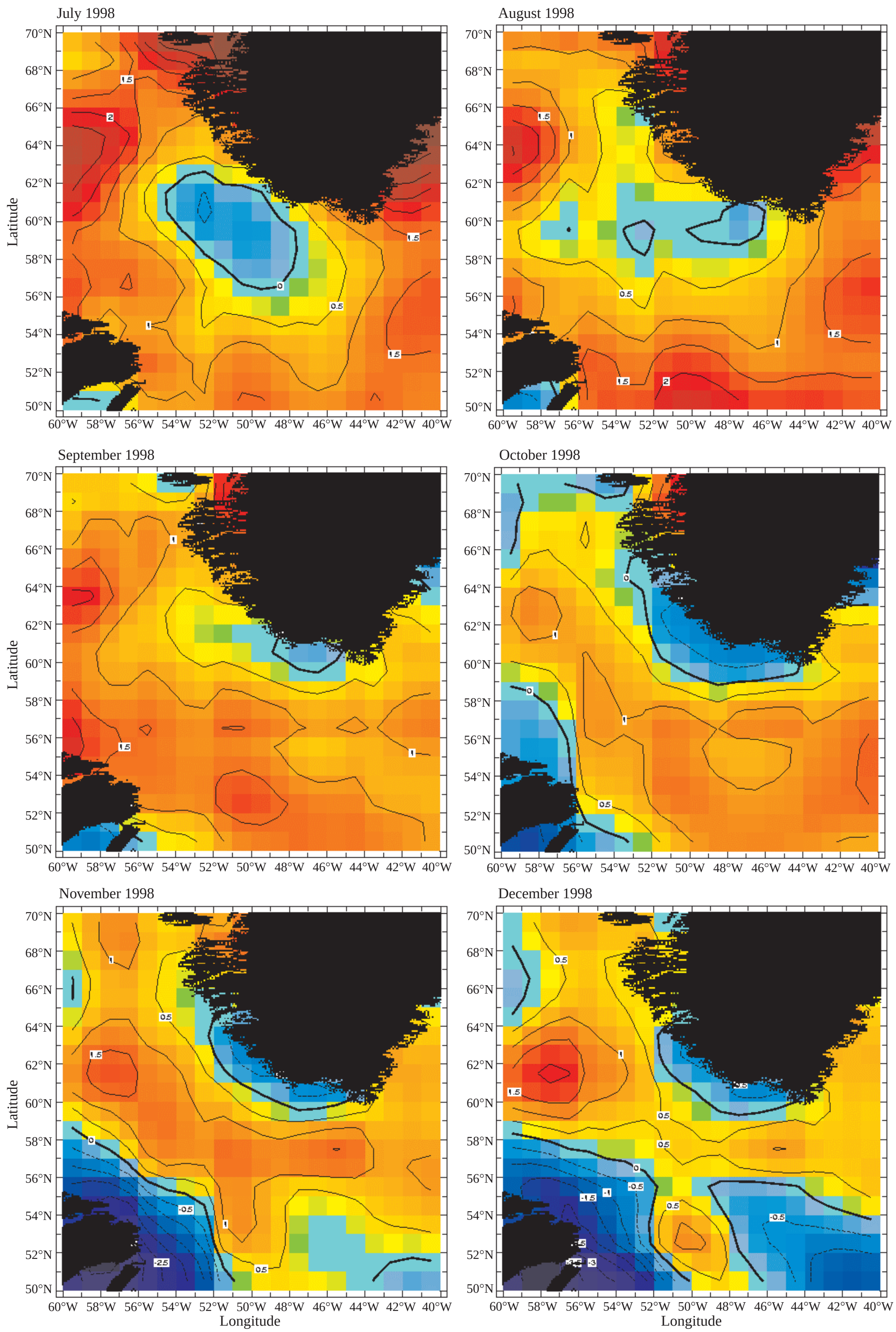

Fig. 15. Composite of SST Anomalies for the months of July to December 1999.

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