Northwest Atlantic Fisheries Organization

Serial No. N6152 **NAFO SCR Doc. 13/004**

SCIENTIFIC COUNCIL MEETING – JUNE 2013

Report about hydrographic conditions off West Greenland in 2012

By Boris Cisewski, Anna Akimova and Ismael Núñez-Riboni

Thünen Institute of Sea Fisheries, Palmaille 9
D-22767 Hamburg, Germany

Abstract

An overview of the atmospheric and hydrographic conditions off West Greenland in autumn 2012 is presented. The large scale atmospheric circulation is described in terms of the North Atlantic Oscillation (NAO) index and mean air temperature at Nuuk Weather Station in West Greenland. The NAO index was positive (3.17) and the mean air temperature at Nuuk was 1.4°C, being the second highest ever reported since the record beginning in 1881. The water mass properties are monitored with SST from NOAA and with yearly surveys at two standard NAFO/ICES sections, which span across the western shelf and continental slope of Greenland near Cape Desolation and Fyllas Bank. Two stations of these sections are historically used to analyse the interannual variability of the oceanic conditions (Cape Desolation Station 3 and Fyllas Bank Station 4). SST data indicate that annual sea surface temperature anomalies further increased between 2011 and 2012. Water temperature of the upper 700 meters in the Cape Desolation Station 3 was higher than its long-term mean and thus continued the series of warm anomalies started in 1998. The salinity of the upper 700 meters reveals positive anomalies with the exception of the layer between 200 and 300 m depth, where week negative anomalies are apparent. The upper 50 to 300 meters of Fyllas Bank Station 4 are characterized by negative potential temperature anomalies, while the layer between 300 and 700 m by positive temperature anomalies. The salinity of the upper 500 m was below its long-term mean in this station.

Introduction

The water mass circulation off Greenland comprises three main currents: Irminger Current (IC), West Greenland and East Greenland Currents (WGC and EGC respectively; Figure 1). The EGC transports ice and cold low-salinity Surface Polar Water (SPW) to the south along the eastern coast of Greenland. The East Greenland Coastal Current (EGCC), predominantly a bifurcated branch of the EGC on the inner shelf, transports cold fresh Polar Water southwards near the shelf break (Sutherland and Pickart, 2008).

The IC is a branch of the North Atlantic current and transports warm and salty Atlantic Waters northwards along the Reykjanes Ridge (Figure 1). The current bifurcates south of the Denmark Strait and a small branch continues northward through the strait to form the Icelandic Irminger Current. The bulk of the IC recirculates to the south making a cyclonic loop in the Irminger Sea. The IC transports then southwards salty and warm Irminger Sea Water (ISW) along the eastern continental slope of Greenland, parallel to the EGC.

The core properties of the water masses of the WGC are formed in the western Irminger Basin where the EGC meets the IC. After the currents converge, they turn around the southern tip of Greenland, forming a single jet (the WGC) and propagate northward along the western coast of Greenland. During this propagation considerable mixing takes place and ISW gradually deepens (Clarke and Gascard, 1983; Myers et al., 2009). The WGC consists thus of two components: a cold and fresh inshore component, which is a mixture of the SPW and melt water, and saltier and warmer ISW offshore component. The WGC transports water into the Labrador Sea and, hence, is important for Labrador Sea Water formation, which is an essential element of the Atlantic Meridional Overturning Circulation (AMOC). Data from the German groundfish surveys off Greenland, which are herewith and periodically reported to NAFO, reveal significant interannual and decadal variability of both components of the WGC since 1981.

Materials and Methods

The German groundfish survey off Greenland is conducted since 1981, aiming at monitoring groundfish stocks in particular of cod and redfish, collecting environmental data and performs ecosystem studies in the area. The monitoring is carried out by the Thünen-Institute of Sea Fisheries from board of RV 'Walter Herwig III': Yearly in autumn, the WGC is monitored at two standard ICES/NAFO oceanographic sections across the slope off West Greenland near Cape Desolation and Fyllas Bank. The sections (identified with CD and FY, respectively) and station locations for the 2012 expedition are shown in Figure 2.

CTD profiler casts were conducted with a Sea-Bird 911plus profiler attached to a 12-bottle water sampler. The hydrographic database consisted of 116 hydrographic stations sampled between October 12 and November 04, 2012, from R.V. 'Walther Herwig III'. For in situ calibration, salinity samples were analyzed with a Guildline Autosal-8400A salinometer immediately after the cruise. The collected data were interpolated to a 1 m grid in the vertical. If data were missing at the top of a profile, we assumed constant properties from the first measurement (normally 2–5 m) up to the surface.

Air temperature at Nuuk station on the western coast of Greenland is used to characterize the atmospheric conditions. Monthly mean values were obtained from Goddard Institute for Space Studies of the National Aeronautics and Space Administration (NASA), accompanied by the data from the Danish Meteorological Institute.

Results and Discussion

Atmospheric conditions in 2012

The variability of the atmospheric conditions over Greenland and the Labrador Sea is driven by the large scale atmospheric circulation over the North Atlantic, which is normally described in terms of the North Atlantic Oscillation (NAO). During a positive NAO strong northwest winds bring cold air from the North American continent and cause negative anomalies of the air temperatures over Greenland, Labrador Sea, Baffin Bay (Hurrell and Deser, 2010). During a negative NAO the westerlies slacken and the weather is normally milder over the whole region. According to ICES standards, we use in this study the Hurrell winter (DJFM) NAO index, which is available at *http://www.cgd.ucar.edu/cas/jhurrell/indices.html*. The correlation between annual air temperature timeseries and winter NAO index time series is -0.51 for the period from 1876 to 2009 and slightly varies between decades. However, the NAO index gives us only the information about the strength of Icelandic Low and Azores High and gives no information about their spatial location, which also affects the direction of winds and regional weather. That might explain the low correlation between the two parameters.

In 2012, the NAO index was positive (3.17; Figure 3) describing anomalous strong westerlies over the North Atlantic Ocean. Both, the Icelandic Low and the Azores High were strengthening resulting in an increased pressure difference over the North Atlantic sector than normal. While the circulation cell reveals no shift in comparison with its long-term mean location (Figure 4), the Greenland High was lower and the Icelandic Low pressure zone was stronger than the long-term mean, respectively. The mean air temperature at Nuuk Weather Station in West Greenland was 1.4°C in 2012 (Figure 5), which is the second highest ever reported temperature since the beginning of the observations in 1881. The monthly temperatures were higher than the corresponding long-term means throughout the year 2012 with the exception of March (Figure 6).

Hydrographic Conditions

Here a short overview of the hydrographical condition west off Greenland during autumn 2012 is presented. There is more than one definition of the water masses carried by the WGC (Clarke and Gascard, 1983; Stein, 2005; Schmidt and Send, 2007; Myers et al., 2009). Here we consider the upper layer down to 700 m water depth and define SPW and ISW following the study of Myers et al., 2009 (Table 2). Deeper Labrador Sea Water and North East Atlantic Deep Water stay beyond the scope of this report.

The annual sea surface temperature (NOAA OI SST) anomalies for 2012 indicate positive anomalies of the SST in the Northwestern Atlantic and around Greenland (Figure 7). The annual sea surface temperature and the area of positive temperature anomalies have further increased between 2011 and 2012. Negative anomalies were observed only along the eastern coast of Greenland and associated with the EGC.

Generally, the upper layer temperature near Cape Desolation in autumn is well above zero due to the summer heat accumulation and, hence, only salinity can be used as SPW tracer (Myers et al., 2009). A salinity of less than 32 was observed at station 1069 in 2012 (Figure 8). The most offshore station of the 2012 section (Station 1072) corresponds to the standard Cape Desolation Station 3, which was reported in ICES WGOH since 2001 (Stein, 2010). No SPW was observed at this station in 2012. Moreover, the water temperature of the upper 700 meters was higher than its long-term mean, and thus continued the series of warm anomalies started in 1998 (Figure 9). The salinity of the upper 700 meters reveals positive anomalies with the exception of the layer between 200 and 300 m depth, where week negative anomalies are apparent. Whether these processes exert a control on slowing down the Subpolar Gyre is still under debate (*Häkkinen and Rhines*, 2004; *Hátún et al.*, 2005; *Hátún et al.*, 2009).

The Fyllas Bank section is situated further to the north over the broad shallow Fyllas Bank that affects strongly the structure of the West Greenland Current (Myers et al., 2009). In 2012, fresh PSW was seen in top 100 m over the entire section (Figure 10) and it spread at least 100 km away from the shelf. The core of ISW (θ >5 °C, S>34.9) was found between 467 and 785 m water depth at the station 1103. The Station 1103 at the continental slope at 900 m depth corresponds to standard Fyllas Bank Station 4 (e.g. ICES, 2002; ICES, 2004). While the upper 50 to 300 meters of this station are characterized by negative potential temperature anomalies, positive temperature anomalies dominate the layer between 300 and 700 meter water depth. The salinity of the upper 500 m was below its long-term mean (Figure 11).

Acknowledgements

We would like to thank the crew of RV Walther Herwig III.

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Tables.

Table 1. Details on the times series, analysed in this study. Lat is used for the latitude, long is used for longitude.

Name	Lat (°N)	Lon (°W)	Type
Nuuk	64.36	-51.75	Weather station
Cape Desolation Station 3	60.45	-50.00	Oceanographic station
Fyllas Bank Station 4	63.88	-53.37	Oceanographic station

Table 2. Water mass characteristics in the area of research.

The water masses in the area	Potential temperature (θ)	Salinity (S)
Surface Polar Water (SPW)	$\theta \leq 0$	$S \leq 34.4$
Irminger Sea water (ISW)	$\theta \geq 4.5$	$S \geq 34.95$

Figures.

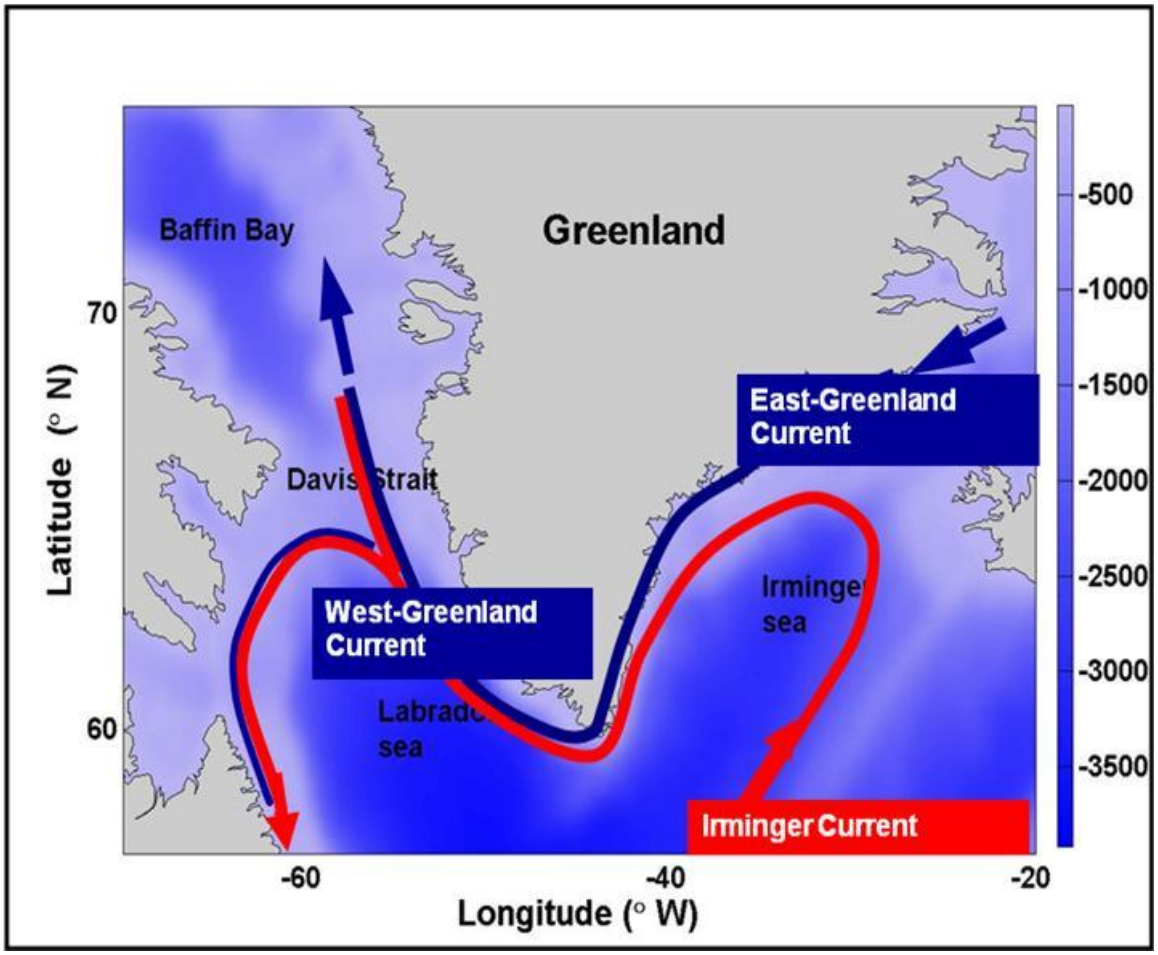

Figure 1. Scheme of the upper ocean circulation in the study area. Red and blue curves show the trajectories of warm Irminger Sea Water and cold Surface Polar Water correspondingly.

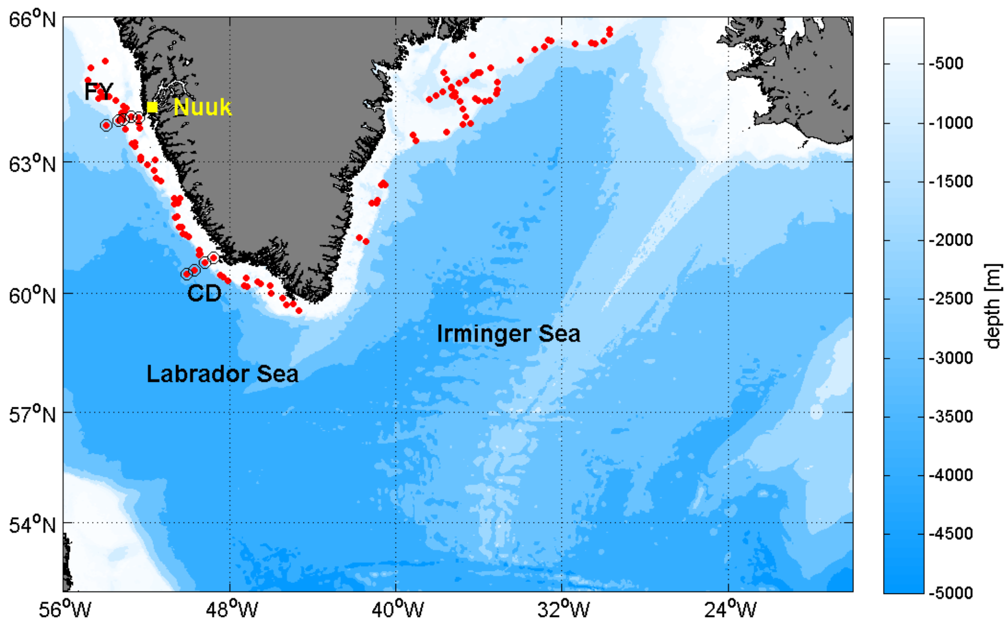

Figure 2. Map and bathymetry of the study region. Meteorological station location is shown in yellow. Red dots show the location of the fisheries stations, conducted during the survey in 2012. Gray edged dots show the two ICES/NAFO standard sections (CD – Cape Desolation section, FY – Fyllas Bank Section; geographic coordinates are given in Table 1).

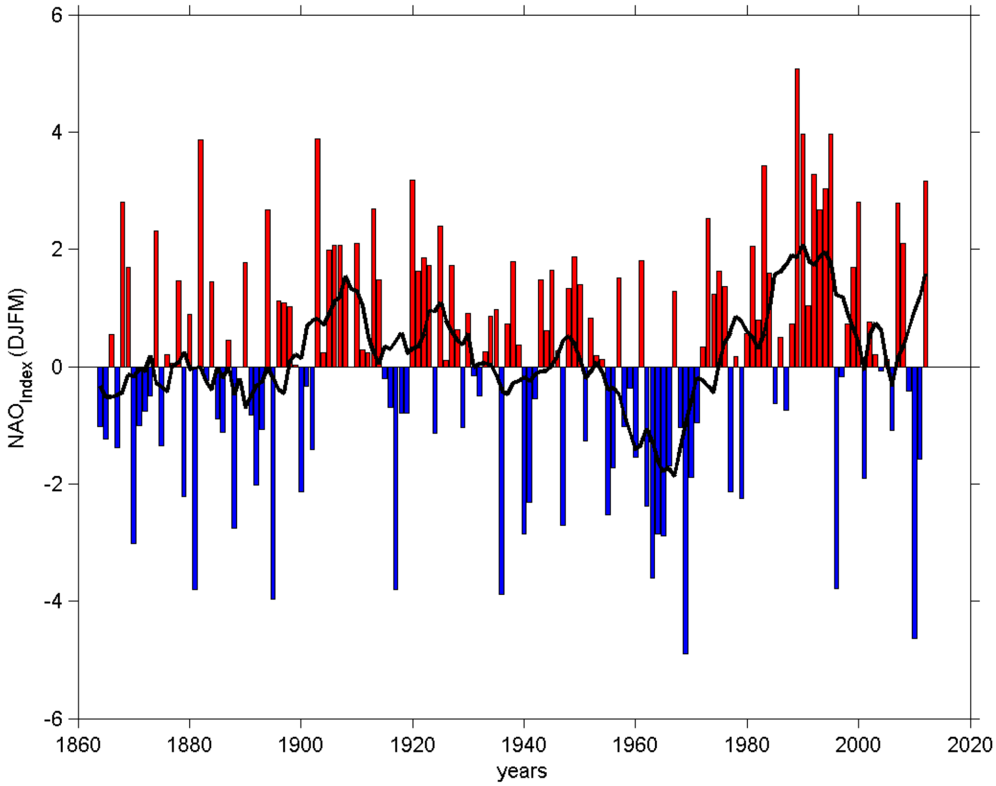

Figure 3. The Hurrell winter (DJFM) NAO index with a 5-year running mean (black curve).

Data source: http://www.cgd.ucar.edu/cas/jhurrell/nao.stat.winter.html.

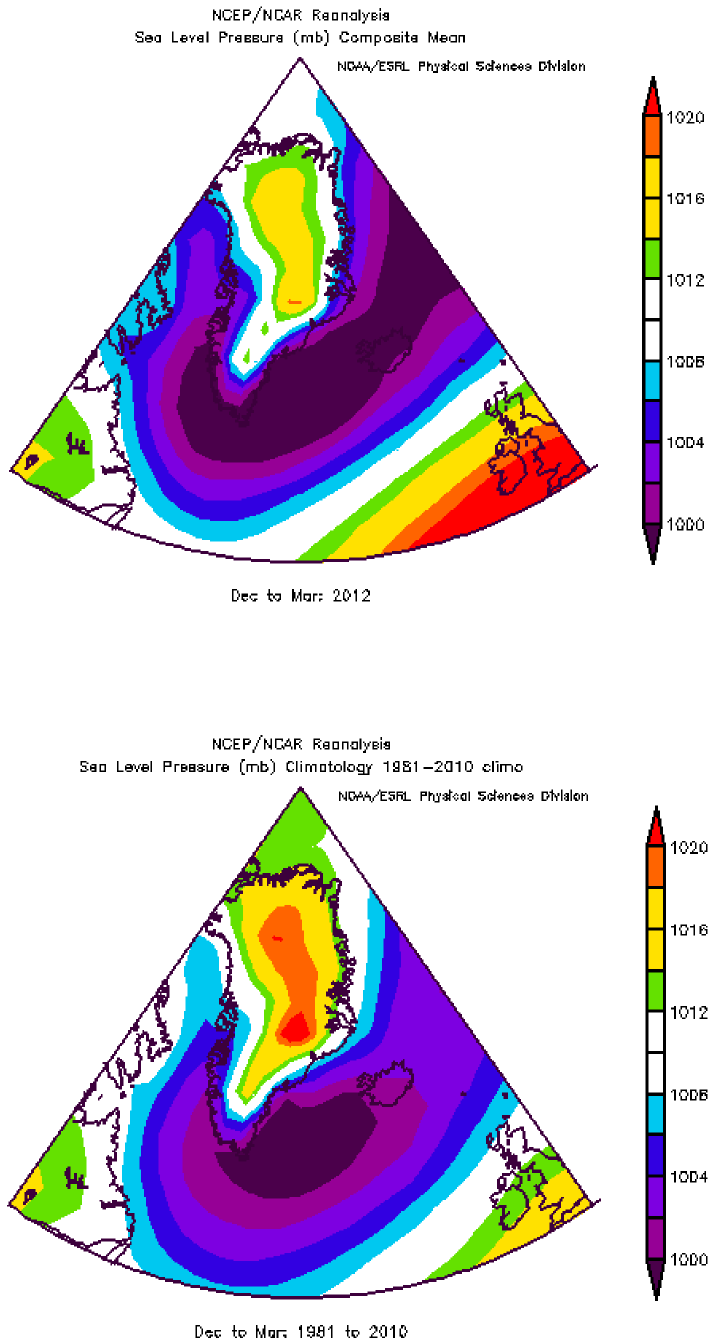

Figure 4. Maps of winter (DJFM) sea level pressure (SLP) over the North Atlantic. Upper panel: mean SLP in winter 2012. Lower panel: mean winter SLP from 1981 to 2010. *Image is provided by the NOAA/ESRL Physical Science Division, Boulder, Colorado*

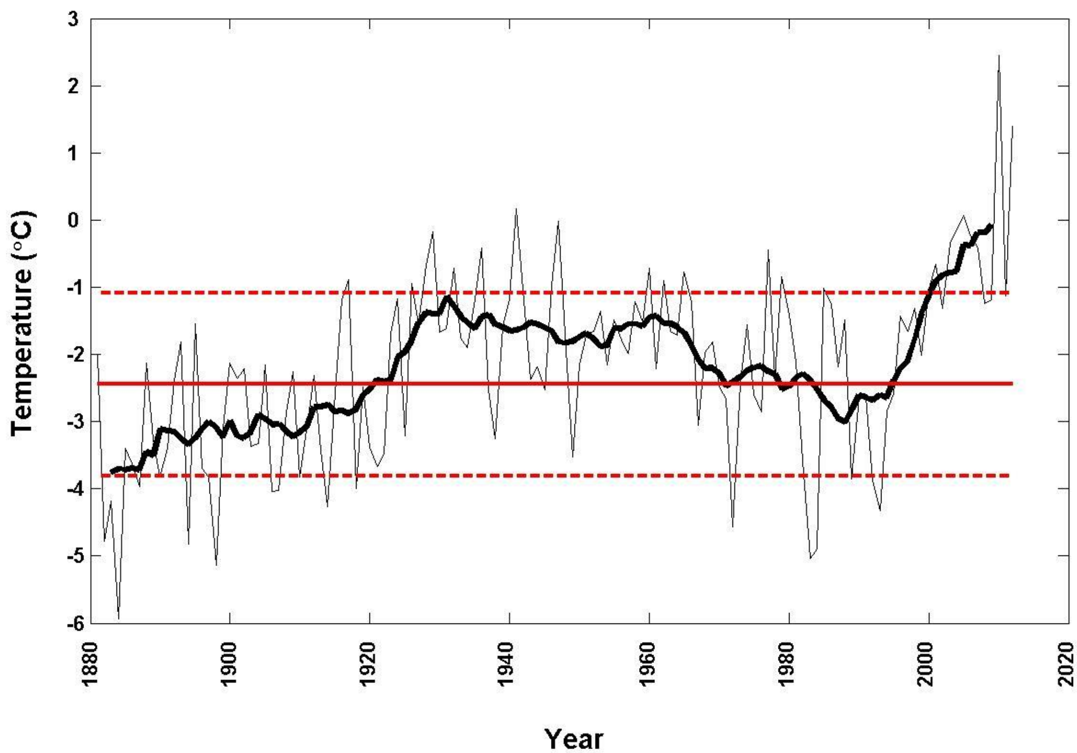

Figure 5. Annual mean air temperature at Nuuk station (geographic coordinates are given in table 1). Thick black line shows the 5-year smoothed data. Red solid line indicates the long-term mean temperature, referenced to 1971-2000. Dashed red lines mark corresponding standard deviations.

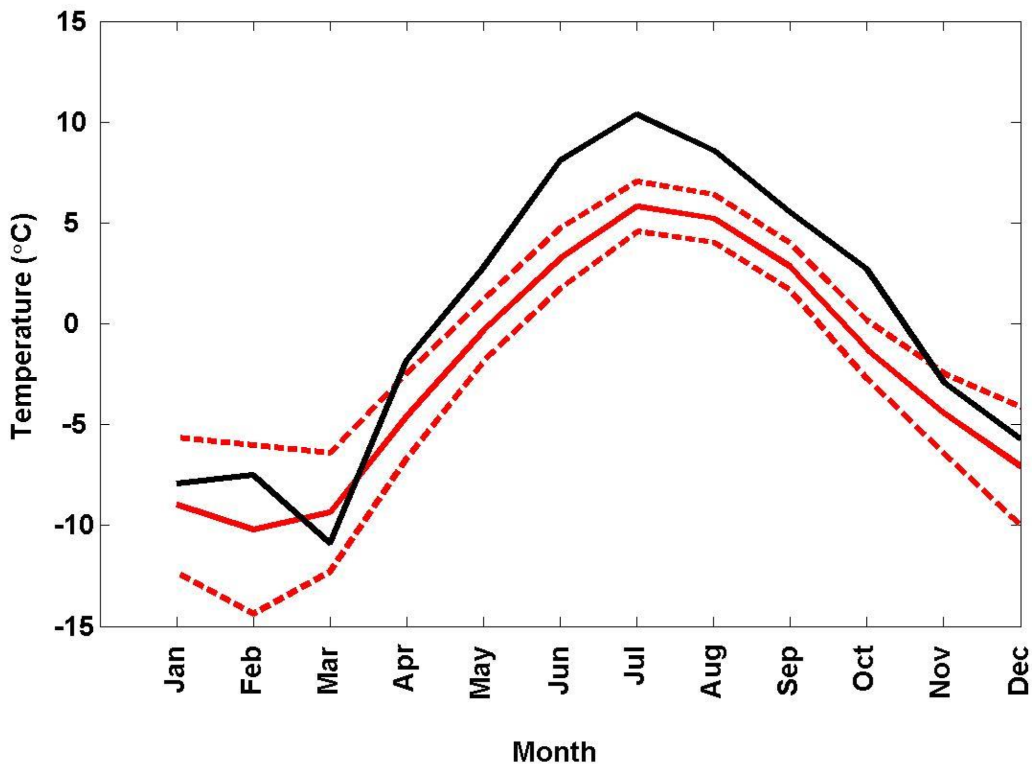

Figure 6. Monthly mean temperature at Nuuk station (geographic coordinates are given in Table 1). Monthly mean temperature in 2012 (black line), long-term monthly mean temperature (red solid line) and one standard deviation (red dashed lines) are shown. Reference period is 1981 to 2010.

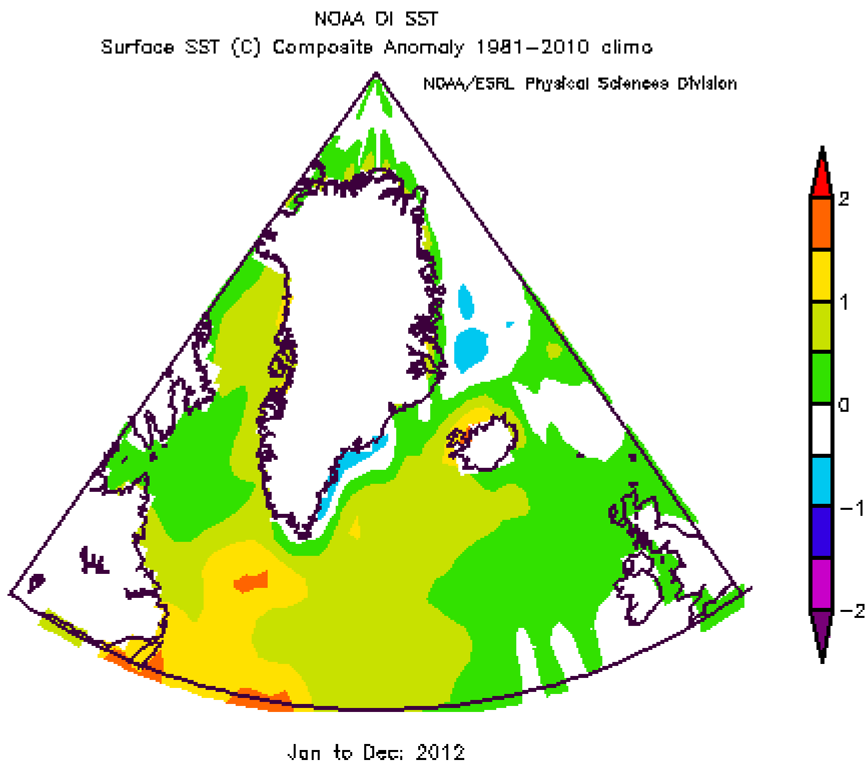

Figure 7. Map of 2012 annual sea surface temperature (NOAA OI SST) anomalies in the study region. The long-term mean corresponds to 1981-2010. *Image is provided by the NOAA/ESRL Physical Science Division, Boulder, Colorado*

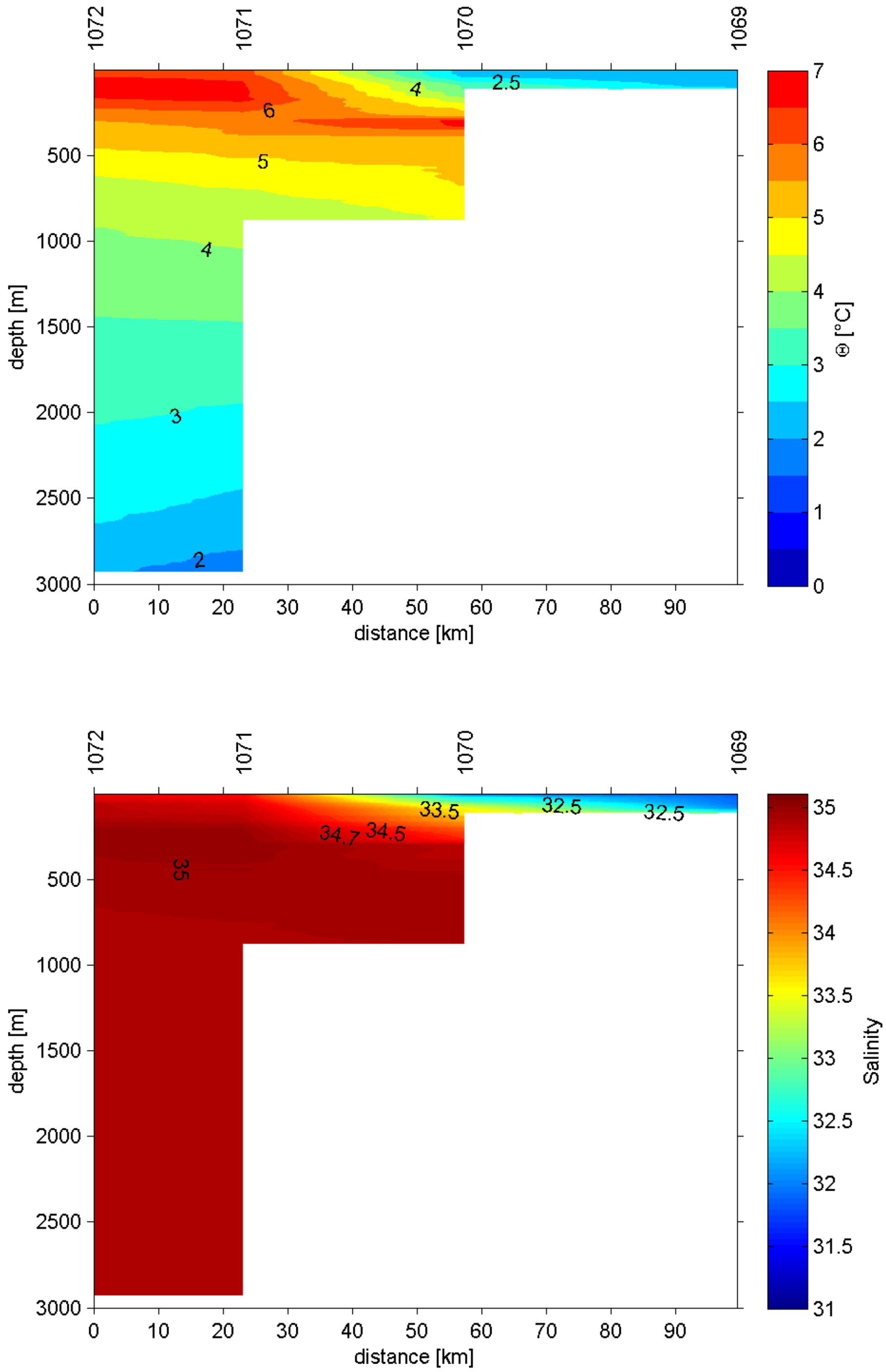

Figure 8. Vertical distribution of potential temperature (upper panel) and salinity (lower panel) along the Cape Desolation section in 2012.

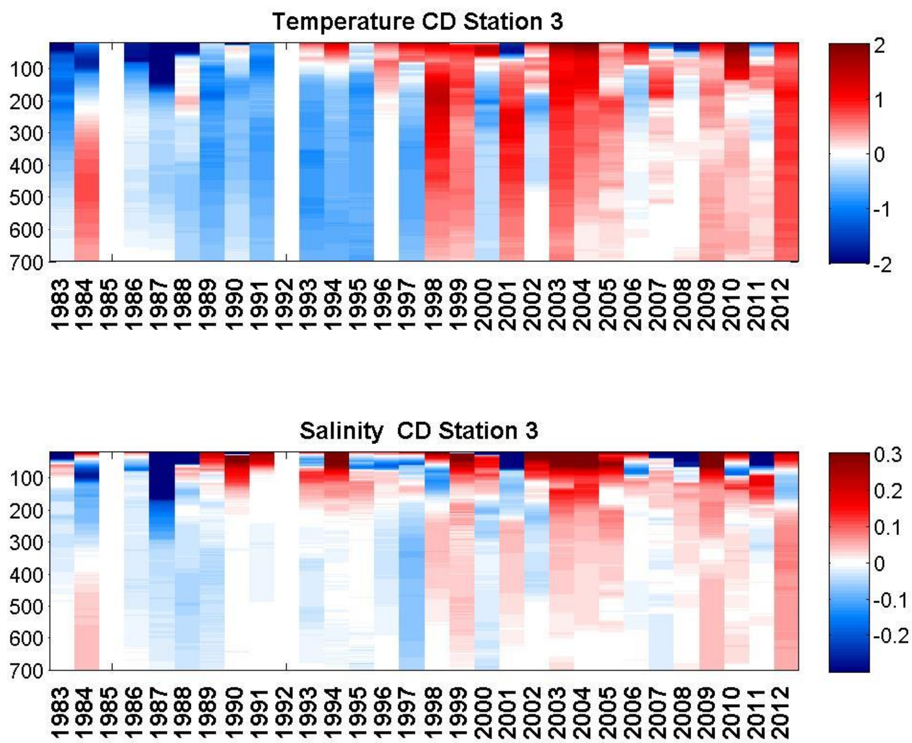

Figure 9. Hovmoeller diagram of potential temperature anomalies (upper panel) and salinity anomalies (lower panel) in the upper 700 m at Cape Desolation Station 3. Reference period is 1983-2011.

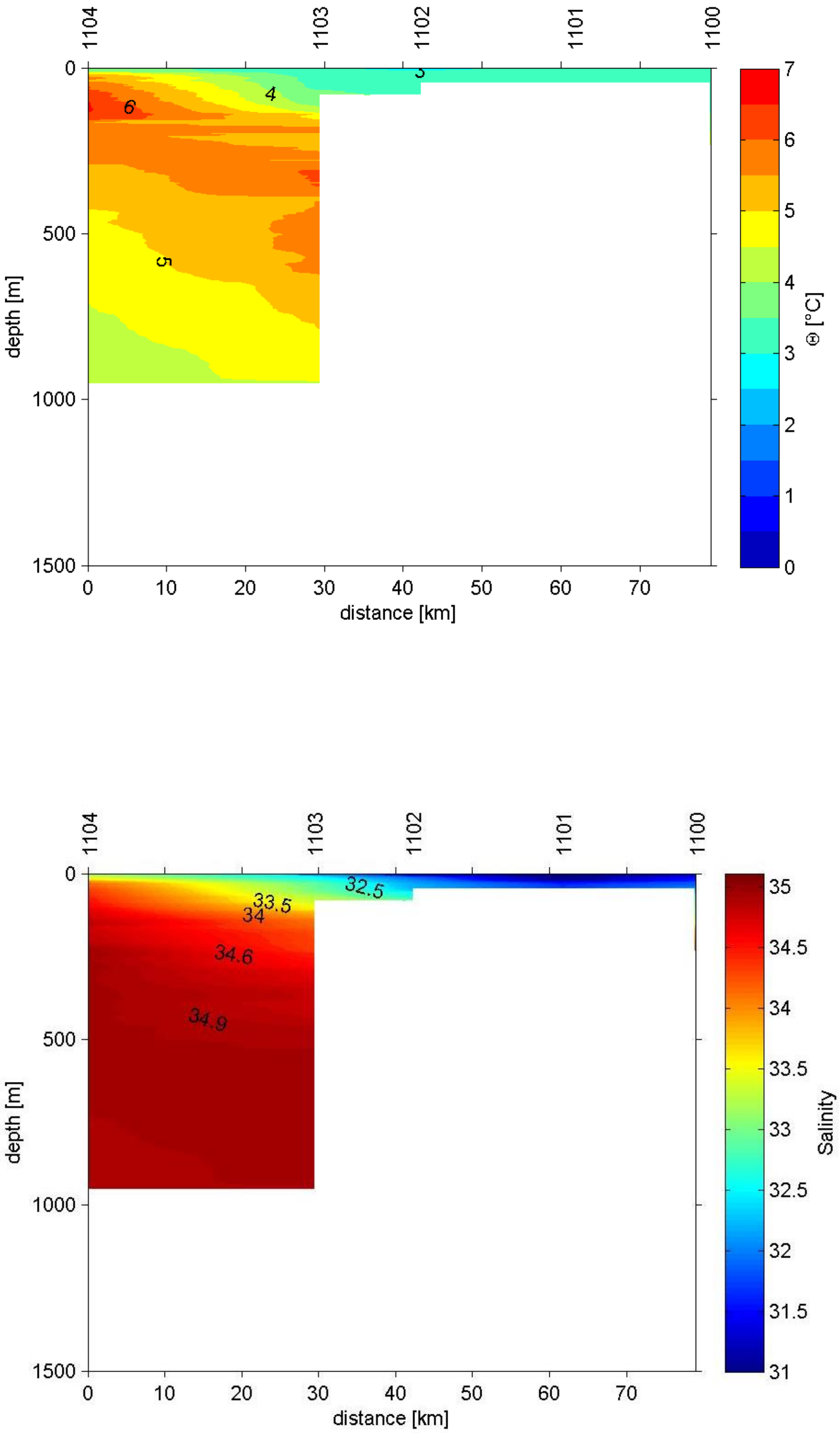

Figure 10. Vertical distribution of potential temperature (upper panel) and salinity (lower panel) along Fyllas Bank section (Figure 8) in 2012.

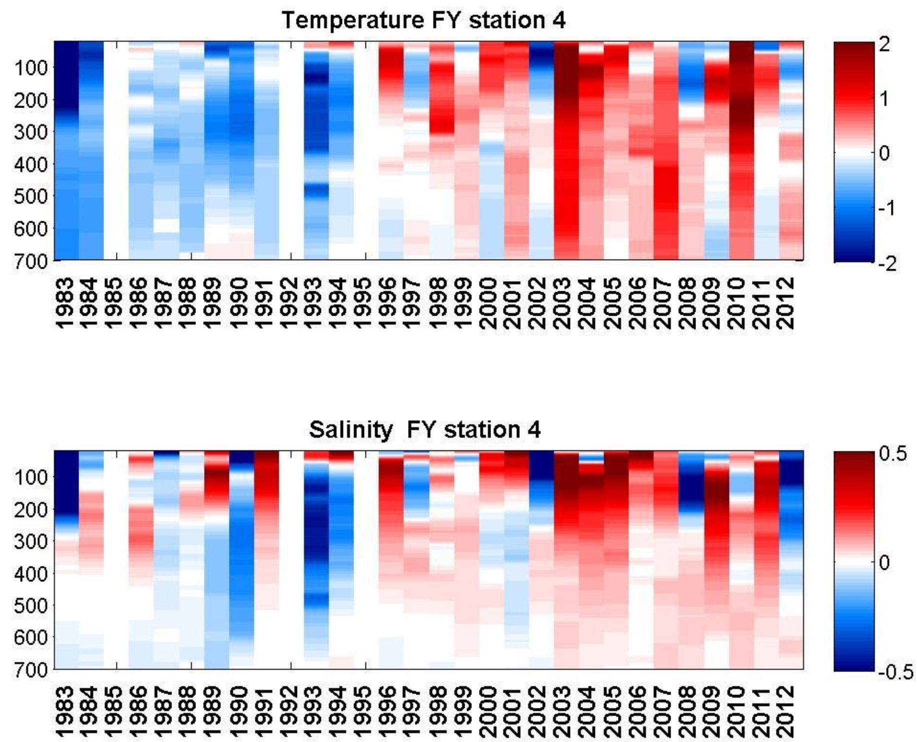

Figure 11. Hovmoeller diagram of potential temperature anomalies (upper panel) and salinity anomalies (lower panel) in the upper 700 m at Fyllas Bank Station 4. Reference period is 1983-2011.