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Hydrographic conditions off West Greenland in 2020

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Abstract

An overview of the atmospheric and hydrographic conditions off West Greenland in autumn 2020 is presented. In winter 2019/2020, the NAO index was positive for the seventh consecutive winter. The annual mean air temperature at Nuuk Weather Station in West Greenland was -0.8°C in 2020, which was 0.6°C above the long-term mean (1981-2010). The core properties of the water masses of the West Greenland Current (WGC) are monitored at two standard NAFO/ICES sections across the western shelf and continental slope of Greenland near Cape Desolation and Fyllas Bank. However, the Cape Desolation Section had to be abandoned due to time constraints in autumn 2020. The water properties between 0 and 50 m depth at Fyllas Bank Station 4 are used to monitor the variability of the fresh Polar Water component of the West Greenland Current. In 2020, the temperature of this water mass was 2.92°C, which was 0.28°C above its long-term mean (1983-2010). The salinity decreased in 2020 and was 0.38 below its long-term mean.

Introduction

The water mass circulation off Greenland comprises three main currents: Irminger Current (IC), West Greenland Current (WGC) and East Greenland Current (EGC). The EGC carries ice and cold low-salinity Surface Polar Water (SPW) to the south along the eastern coast of Greenland. On the inner shelf the East Greenland Coastal Current (EGCC), predominantly a bifurcated branch of the EGC, transports cold fresh Polar Water southward near the shelf break (Sutherland and Pickart, 2008). The IC is the northward flowing component of the North Atlantic subpolar gyre. It carries relatively warm water that mixes with colder water transported by the EGC from the Arctic Ocean. South of the Denmark Strait (DS) the current bifurcates. While a smaller branch continues northward through the DS to form the Icelandic Irminger Current, the bulk of the current recirculates to the south and transports salty and warm ISW southward along the eastern continental slope of Greenland. After EGC and IC converge, they turn around the southern tip of Greenland, form the WGC and propagate northward along the western coast of Greenland. During this propagation considerable mixing between two water masses takes place and the ISW gradually deepens (Clarke and Gascard, 1983; Myers et al., 2009). The WGC carries the water northward and consists of two components: a cold and fresh inshore component, which is a mixture of the SPW and melt water, and a saltier and warmer ISW offshore component. The WGC transports water into the Labrador Sea, and thus is important for Labrador Sea Water formation, which is an essential element of the Atlantic Meridional Overturning Circulation. The dynamics of the current is monitored yearly in autumn at two standard ICES/NAFO oceanographic sections across the slope off West Greenland (Figures 1, 2).

Materials and Methods

The German groundfish survey off Greenland has been conducted since 1981, aiming at monitoring groundfish stocks, cod and redfish in particular. The monitoring is carried out by the Thünen-Institute of Sea Fisheries (TI-SF) and reveals significant interannual and long-term variability of both components of the WGC. Hydrographic profiles were collected with a Sea-Bird 911plus CTD attached to a 12-bottle water sampler. The hydrographic database consisted of 41 hydrographic stations sampled between October 11 and November 2, 2020, from R/V *Walther Herwig III*. Study area and station locations are shown in Figure 2. For in-situ calibration, salinity samples were analyzed with an OPTIMARE Precision Salinometer (OPS) immediately after the cruise. The sea level pressure (SLP) and its anomalies during the winter months (December through March) were taken from NCEP/NCAR reanalysis data available from the NOAA-CIRES Climate Diagnostics Centre (http://www.cdc.noaa.gov/). Air temperature at Nuuk station (Table 1) on the western coast of Greenland was used to characterize the atmospheric conditions in 2020. Annual and monthly mean values were obtained from the Danish Meteorological Institute (Cappelen, 2021). The climatological mean of this time series were referenced to 1981-2010. Information about sea surface temperature anomalies was provided by NOAA/ESRL Physical Science Division, Boulder, Colorado, based on objective interpolation product (NOAA OI SST, Reynolds et al., 2002).

Results and Discussion

Atmospheric conditions in 2020

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 and Baffin Bay (Hurrell and Deser, 2010). During a negative NAO, the westerlies slacken and the weather is normally milder over the whole region. In winter 2019/2020, the NAO index was positive for the seventh consecutive winter. Figure 3a shows the winter sea level pressure (SLP) averaged over 30 years (1981-2010), mainly dominated by the Iceland Low and the Azores High. Both the Icelandic Low and the Azores High were strengthening, resulting in a greater than normal increase in pressure difference over the North Atlantic sector during the winter of 2019/2020 (Figure 3b). The resulting negative anomalies in the north and the positive in the south reveal characteristics typical for a positive NAO (Figure 3c). Air temperature at Nuuk was used to characterize the atmospheric conditions in 2020. Annual mean values were obtained from the Danish Meteorological Institute (Cappelen, 2021). In 2020, the annual mean temperature at Nuuk was -0.8°C in 2020, which was 0.6°C above the long-term mean (1981-2010) (Figure 4).

Hydrographic Conditions in 2020

The annual sea surface temperature (NOAA OI SST) anomalies for 2020 indicate positive anomalies in the Northwestern Atlantic with highest values occurring in the central Labrador Sea (Figure 5). The core properties of the water masses of the WGC are monitored at two standard NAFO/ICES sections across the western shelf and continental slope of Greenland near Cape Desolation and Fyllas Bank. However, the Cape Desolation section has to be abandoned due to a rescue operation. The Fyllas Bank section is located further to the north over the broad shallow Fyllas Bank that strongly affects the structure of the West Greenland Current (Myers et al., 2009). Fyllas Bank Station 4 reveals positive potential temperature anomalies within the upper 700 (Figure 6a). While strong negative salinity anomalies are restricted to the upper 100 m, positive anomalies are found between 150-200 m. The depth range between 200 and 700 m however reveal weak negative salinity anomalies (Figure 6b). The water properties between 0 and 50 m depth at Fyllas Bank Station 4 are used to monitor the variability of the fresh Polar Water component of the West Greenland Current. In 2020, the temperature of this water mass was 2.92°C, which was 0.28°C above its long-term mean (1983-2010). The salinity decreased in 2020 and was 0.38 below its long-term mean (Figures 7a, b).

Tables

Table 1. Details on the times series, analysed in this study.

Name	Lat (°N)	Lon (°W)	Type	Source
Nuuk (4250)	64.17	51.75	Weather station	DMI
Cape Desolation Station 3	60.47	50.00	Oceanographic station	TI-SF
Fyllas Bank Station 4	63.88	53.37	Oceanographic station	TI-SF

Table 2. Water mass characteristics in the study area.

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)	$\theta \geq 4.5$	$S \geq 34.95$

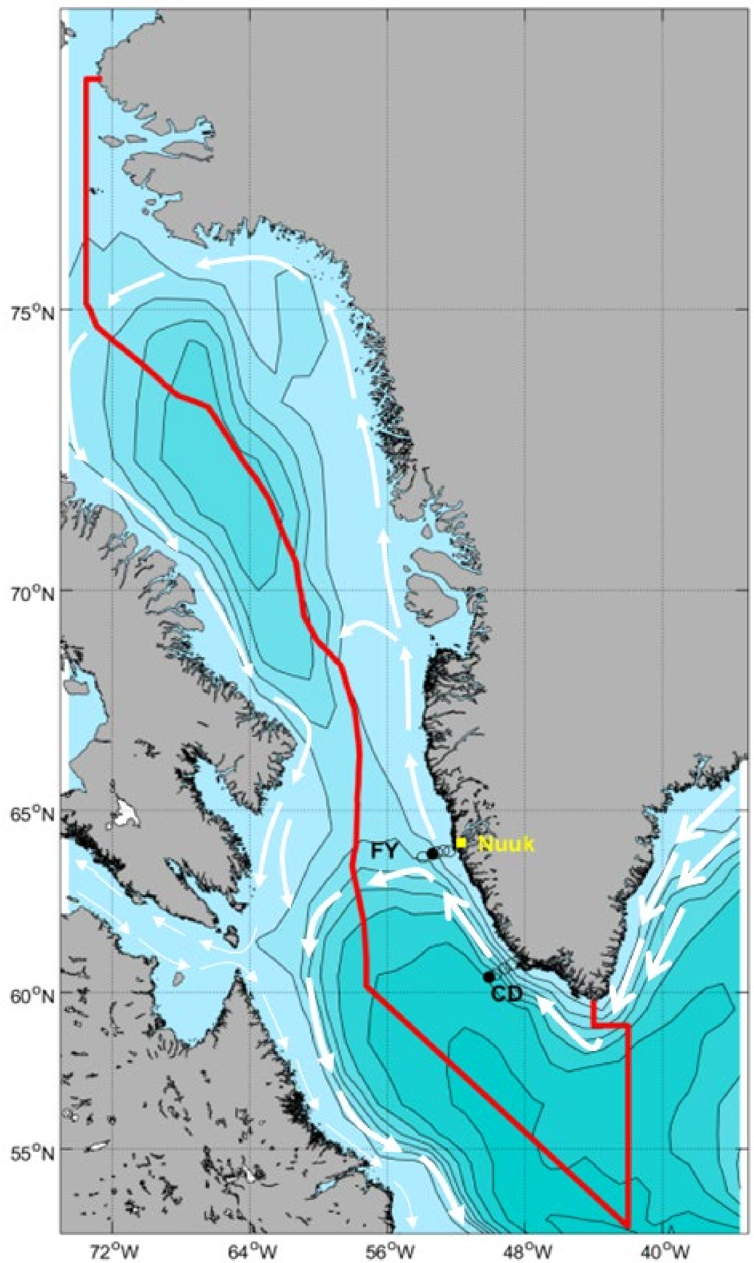

Figure 1. Scheme of the upper ocean circulation in the study area. Meteorological station location is shown in yellow. Black edged dots show the two ICES/NAFO standard sections (CD – Cape Desolation section, FY – Fyllas Bank Section; geographic coordinates are given in table 1).

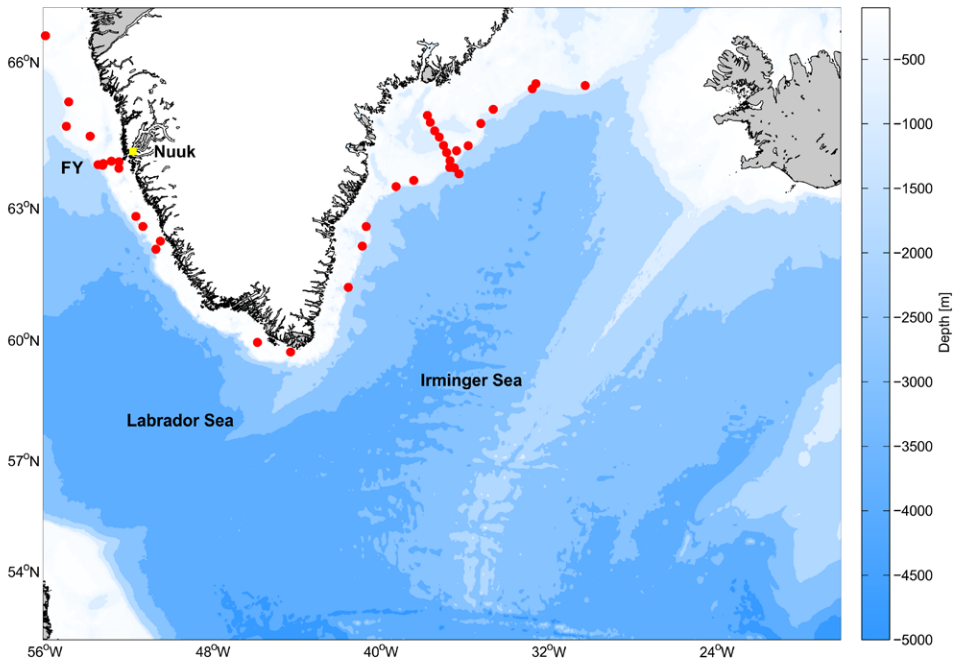

Figure 2. Map and bathymetry of the study region. Red dots show the location of the hydrographic stations, conducted during the survey in 2020.

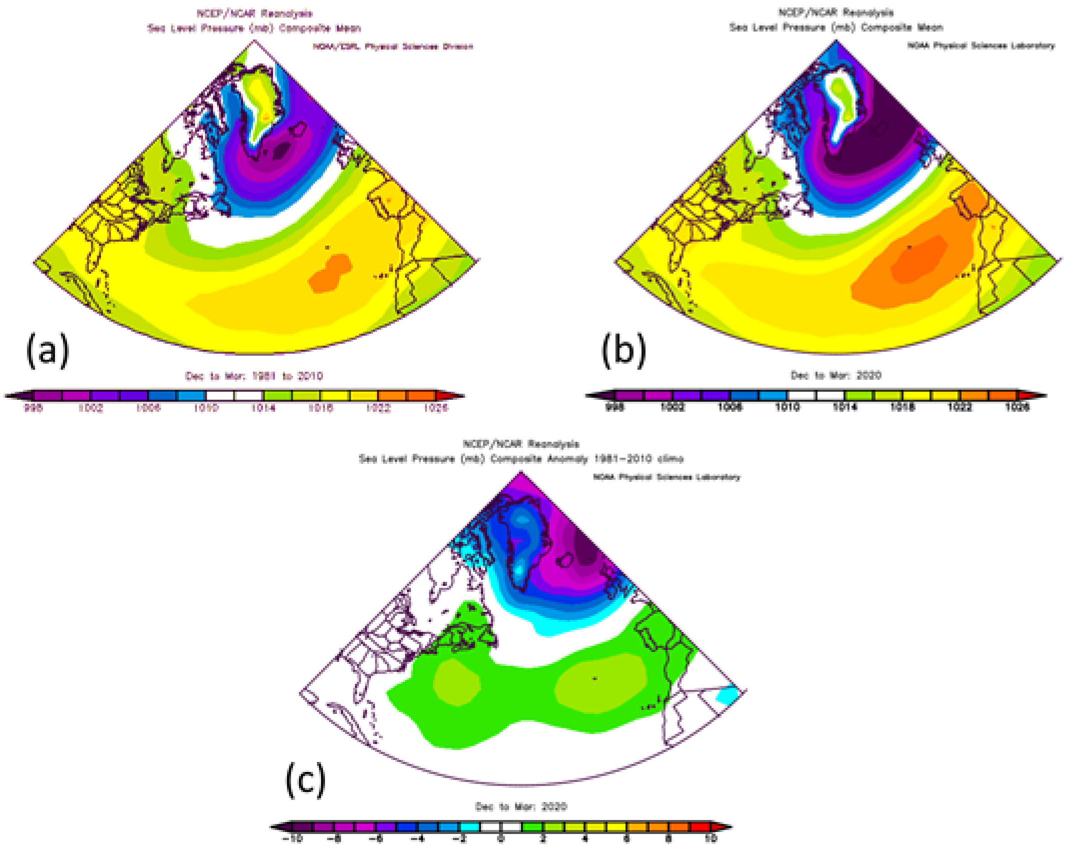

Figure 3. Maps of winter 1981-2010 (DJFM) mean sea level pressure (SLP) **(a)**, winter 2020 SLP **(b)**, and resulting SLP anomaly **(c)** over the North Atlantic.
Images are provided by the NOAA/ESRL Physical Science Division, Boulder, Colorado

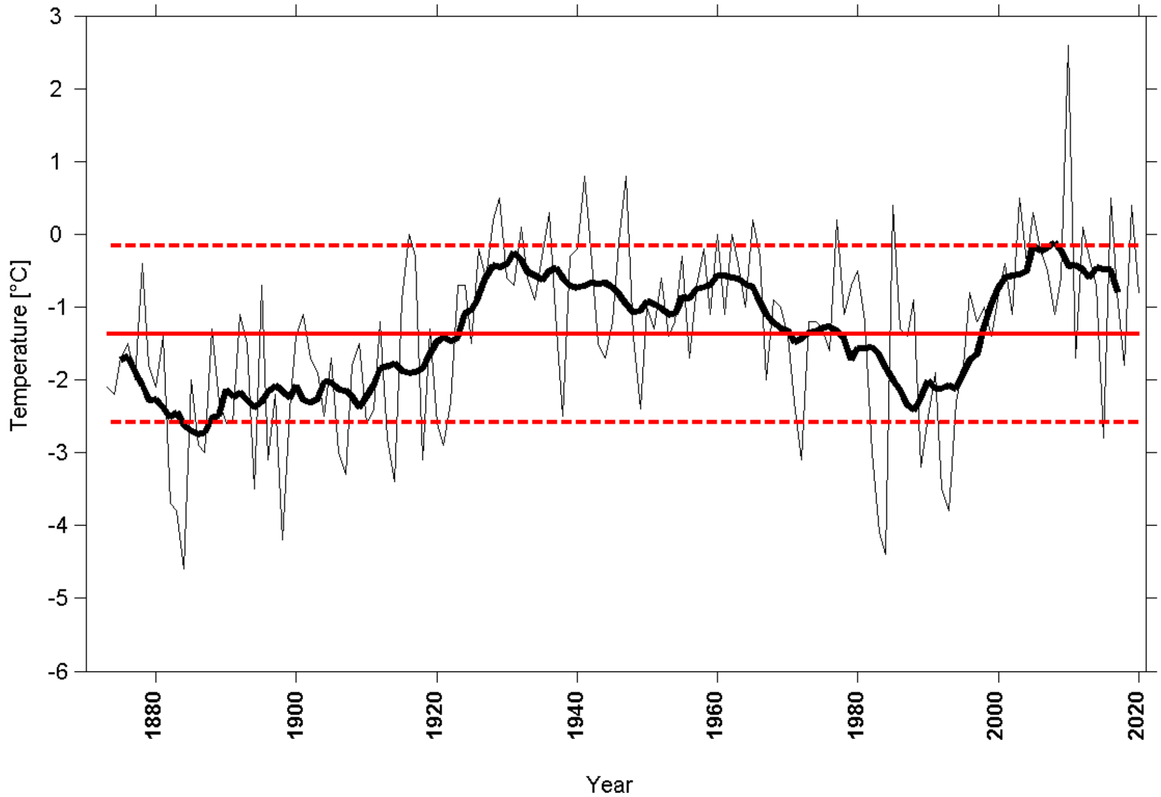

Figure 4. Annual mean air temperature at Nuuk station. Thick black line shows the 5-year smoothed data. Red solid line indicates the long-term mean temperature, referenced to 1981-2010. Dashed red lines mark corresponding standard deviations. Data source: Cappelen, J. (ed.), 2021: Greenland - DMI Historical Climate Data Collection 1784-2020. DMI Technical Report 21-04. Copenhagen.

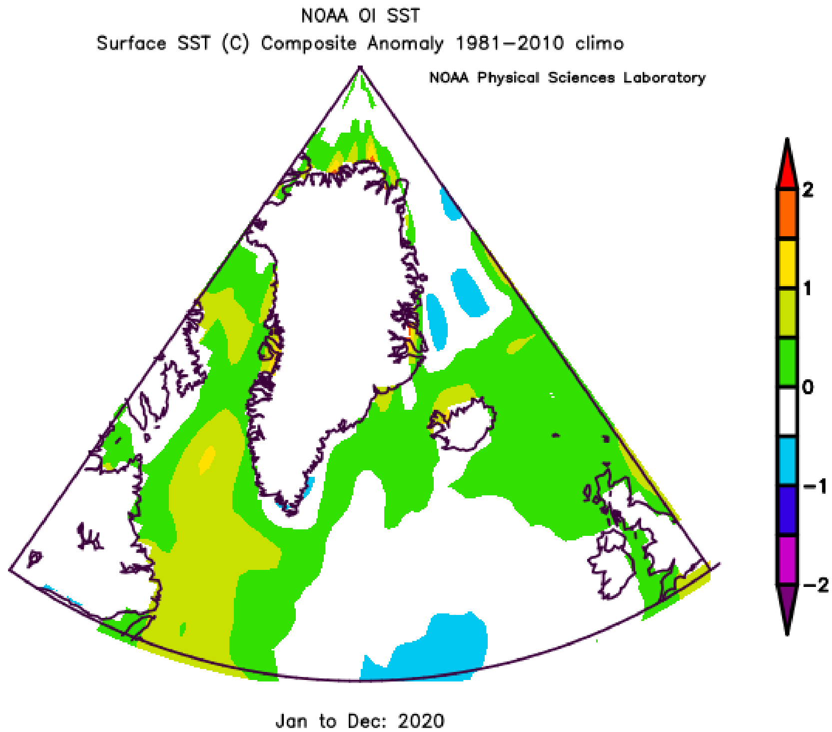

Figure 5. Map of 2020 annual sea surface temperature (NOAA OI SST) anomalies in the study region. The long-term mean corresponds to 1981-2010.
Image is provided by the NOAA/ESRL Physical Science Division, Boulder, Colorado

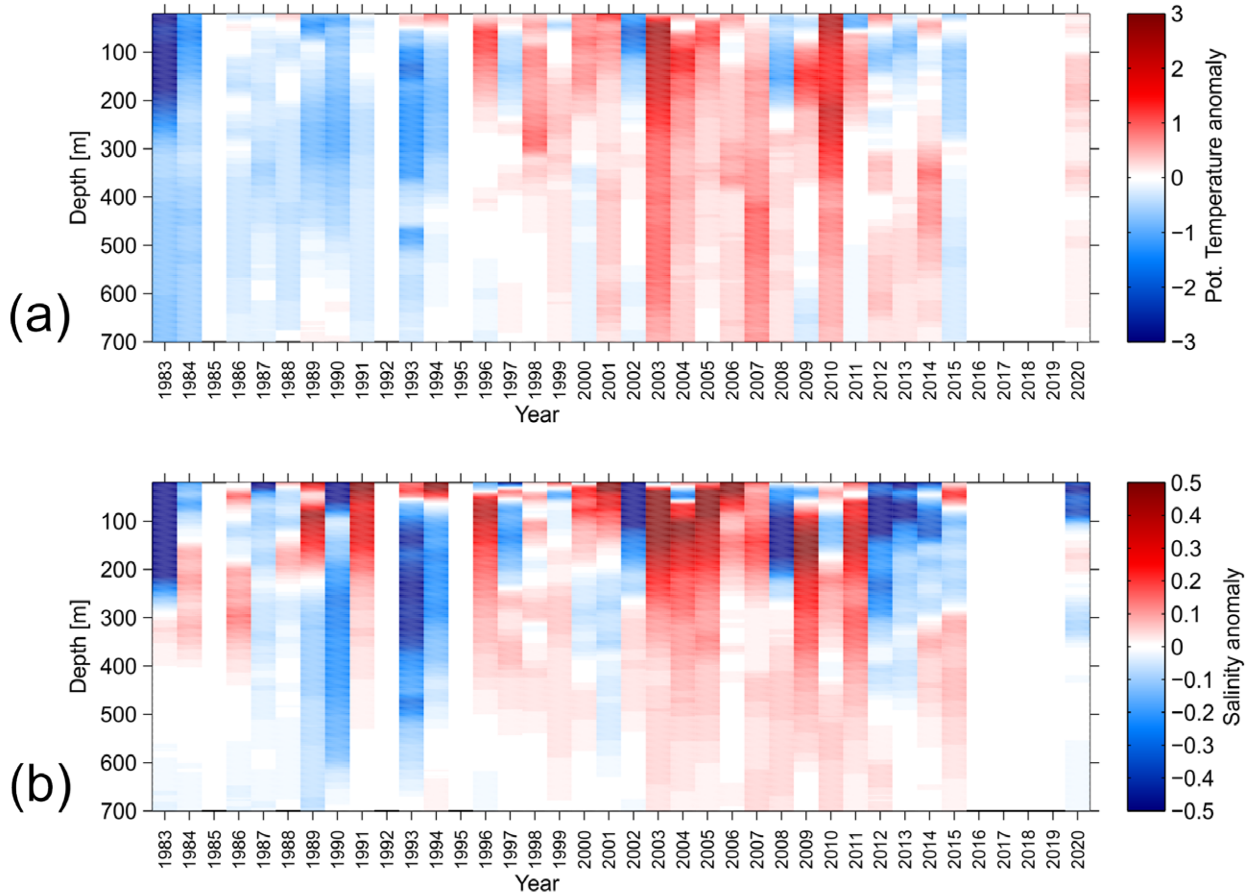

Figure 6. Hovmoeller diagram of the potential temperature anomalies **(a)** and salinity anomalies **(b)** in the upper 700 m at Fyllas Bank Station 4. Reference period is 1983-2010.

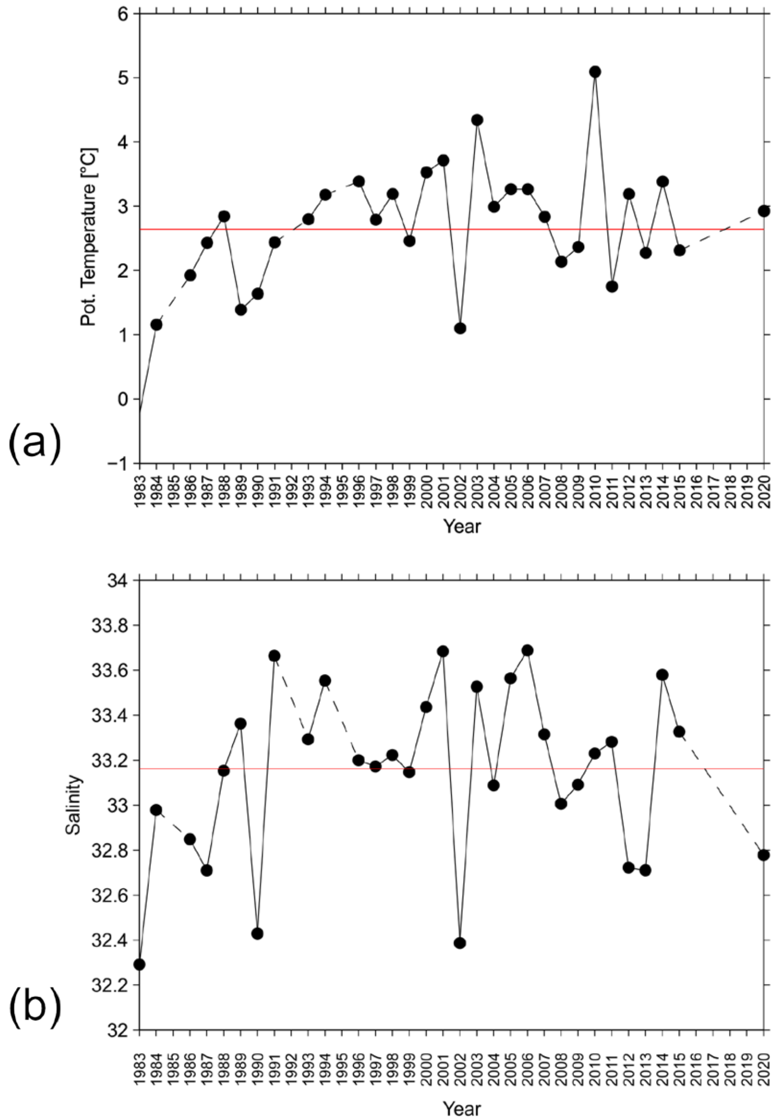

Figure 7. Potential temperature **(a)** and salinity **(b)** in 0-50 m water layer at Fyllas Bank Station 4 (63.88°N, 53.37°W). Red lines indicate the long-term mean potential temperature and salinity, referenced to 1983-2010.

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