Figure 1: (a) Bathymetry from ETOPO 2022 (product ref. no. 4) in the study region. The thin black lines represent the regions over which MHW statistics are calculated: Labrador Shelf (LS), Northeast Newfoundland Shelf (NNS), Grand Banks (GB), and Flemish Cap (FC). Standard AZMP transects Seal Island and Flemish Cap are represented by the red lines. The dark blue dot is the location of Station 27 (Stn27). Light colored arrows represent schematics of the Labrador Current and Gulf Stream. Black line segments with dots represent the Outer and Inner Shelf transects. (b) Spatial map of highest heat wave categories in July through October 2023 calculated from GLORYS12V1 (product ref. no. 1). Subregion polygons are shown for reference in black. (c) Total number of heat wave days July through October 2023 (maximum 122 days), also calculated from GLORYS12V1 (product ref. no. 1). The white line represents the polygon used to define the entire NL Shelf. The region definitions are derived from Ecosystem Production Units (Pepin et al., 2014) and contain information licensed under the Open Government Canada Licence - Canada.
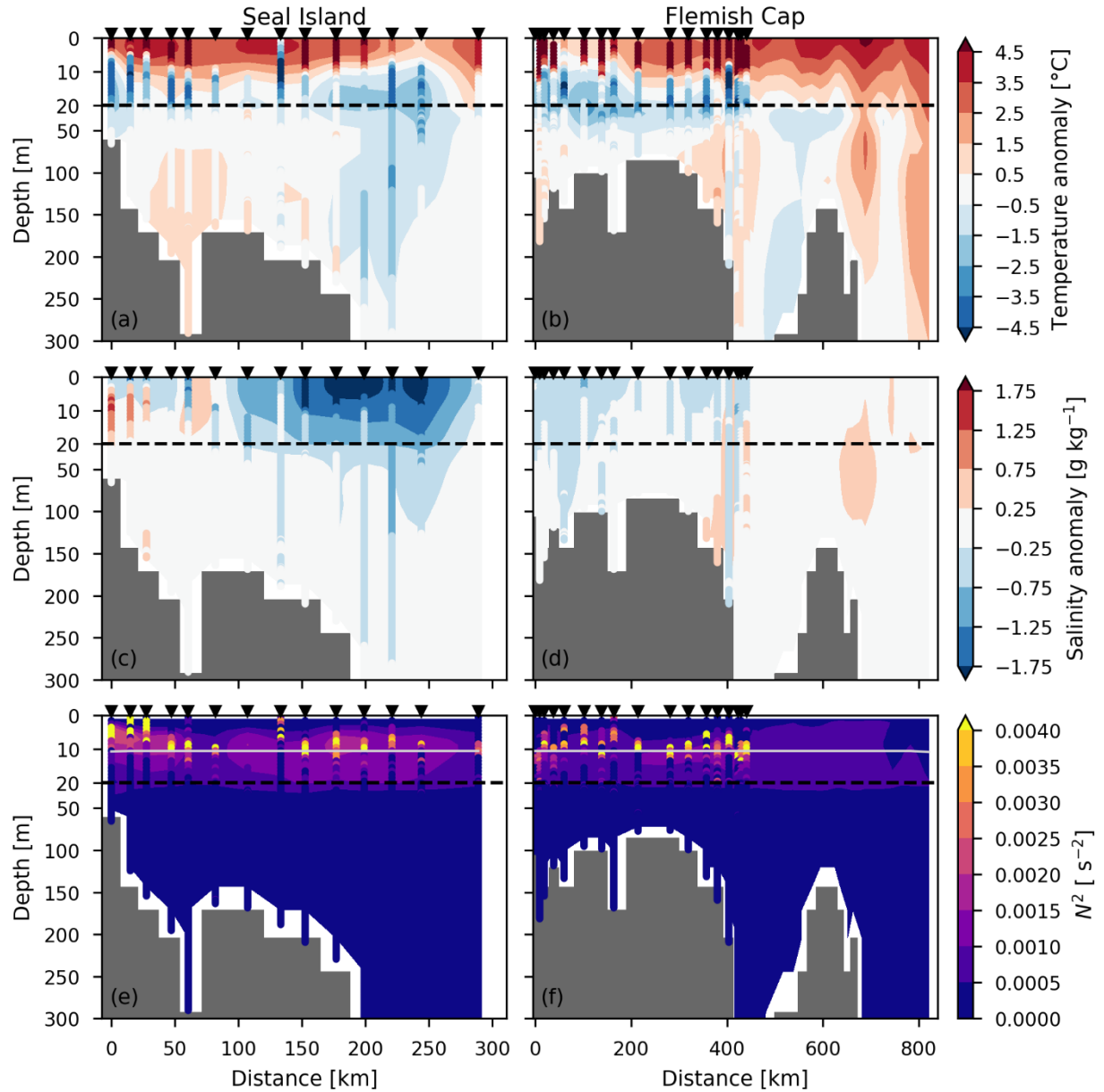
Figure 3: Temperature anomalies (top), salinity anomalies (middle), and squared-buoyancy frequency (bottom) along the Seal Island (left) and Flemish Cap (right) transects shown for AZMP July 2023 occupation dates. For Seal Island, the AZMP occupation occurred on July 25. For Flemish Cap, the stations inshore of 200 km were sampled on July 20 and the others were sampled on July 30. GLORYS12V1 data (product ref. no. 1) matched to the AZMP sampling dates are shown in shaded contours, and AZMP data (product ref. no. 2) are shown in the coloured circles which appear as lines extending from top to bottom. In the bottom panels, the solid gray line represents the GLORYS12V1 mixed layer depth. For Flemish Cap, GLORSY12V1 data at locations offshore of approximately 400km, which were not sampled by AZMP in July 2023, are taken as the mean of July 20 and July 30. A reference period of 1993-2022 is used to calculate climatologies for both GLORYS12V1 and AZMP. For AZMP, all July and August occupations in the reference period were used to construct the climatology. The black triangles represent the positions of the AZMP stations sampled in July 2023. Note the difference in vertical scale above and below 20 m (black dashed line).
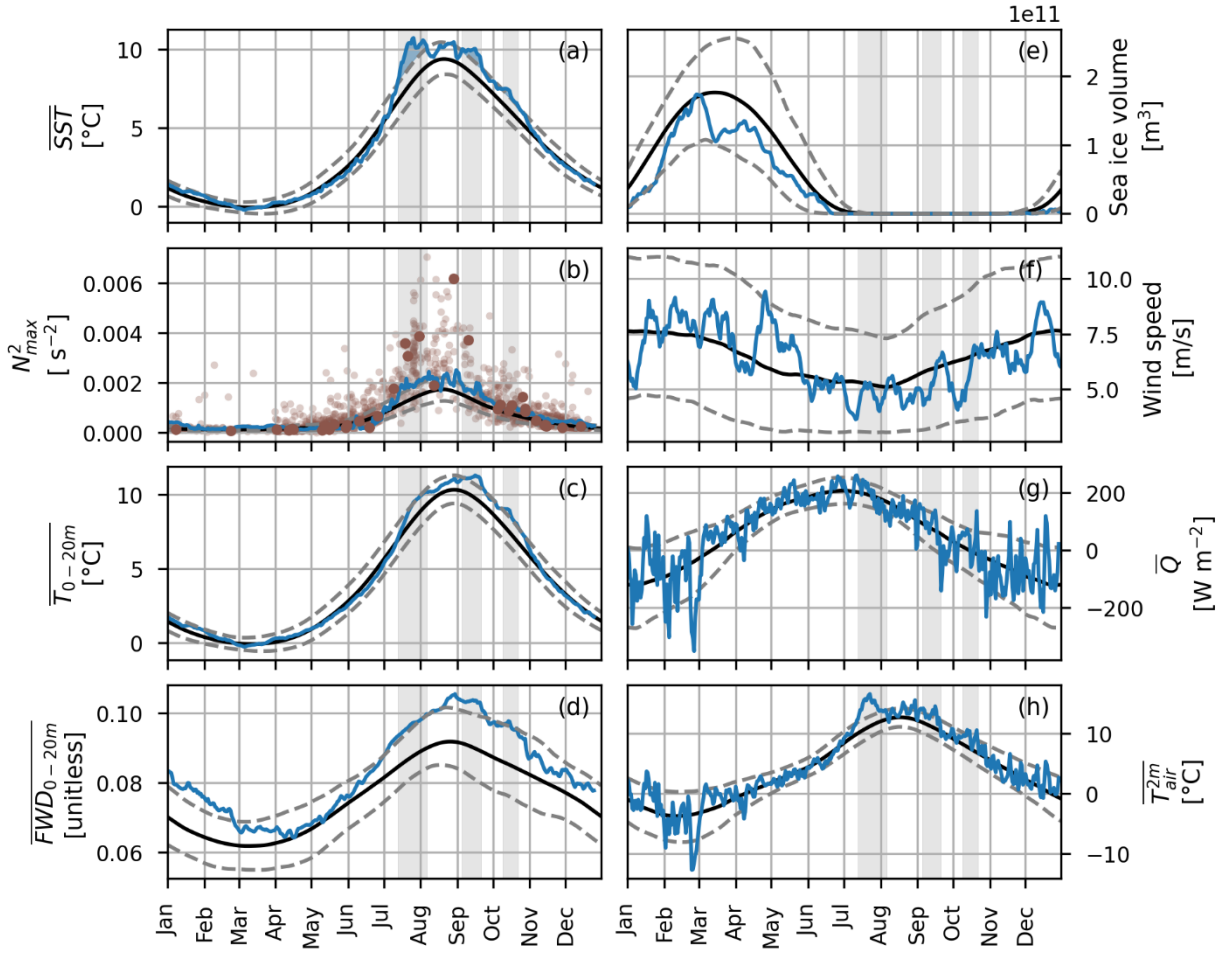
Figure 4: (a) Time series of GLORYS12V1 (product ref. no. 1) sea surface temperature averaged over the NL Shelf for 2023 (blue), the 1993-2022 climatology (black), and the 1993-2022 10th and 90th percentile (grey dashed). Heat wave periods are indicated by the grey shading. (b) As in (a) but for the maximum squared-buoyancy frequency at Station 27. Large dark brown dots represent observations from AZMP (product ref. no. 2) during 2023 while small light brown dots represent all observations (product ref. no. 2) in the 1993-2022 reference period. (c) As in (a) but for GLORSY12V1 (product ref. no. 1) depth-averaged temperature from 0-20 m spatially averaged over the NL Shelf. (d) As in (c) but for freshwater density from 0-20m. As in (a) but the sea ice volume over the NL Shelf. (f) As in (a) but for the ERA5 10-metre wind speed (product ref. no. 3) at Station 27. (g) As in (f) but for the ERA5 net surface heat flux averaged over the NL Shelf. The heat flux is positive downwards and represents a daily average. (h) As in (g) but for the ERA5 2-metre air temperature averaged over the NL Shelf.
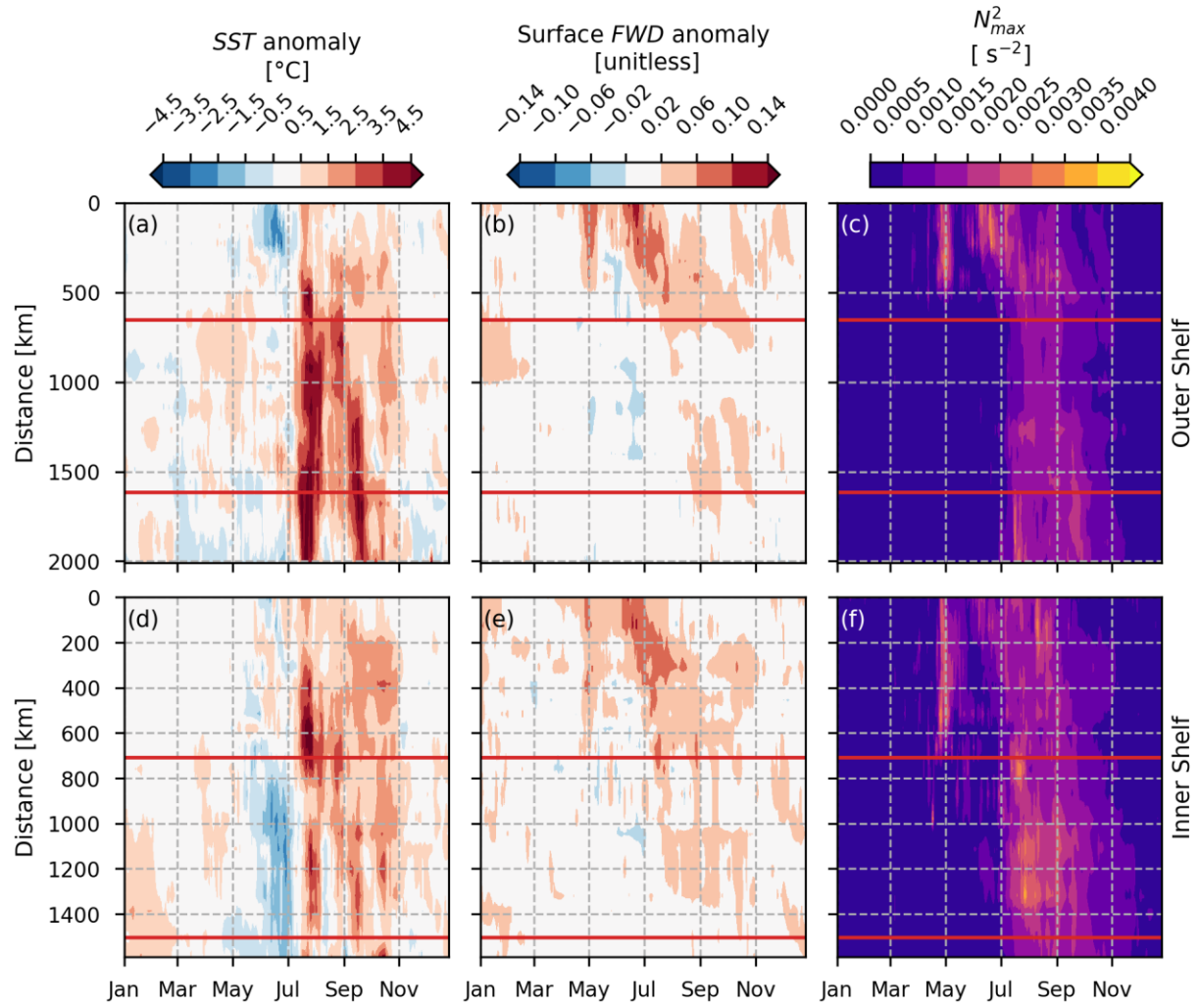
Figure 5: Time series of GLORYS12V1 (product ref. no 1) sea surface temperature anomaly (left), surface freshwater density anomaly (middle), and vertical maximum of the squared-buoyancy frequency (right) along the Outer Shelf (top) and Inner Shelf (bottom) transects for year 2023. See Fig. 1 (a) for Outer Shelf and Inner Shelf transect definitions. Distance is measured along each transect starting from the most upstream station. The red horizontal lines represent the along-shelf locations of the Seal Island (upper) and Flemish Cap (lower) transects. A reference period of 1993-2022 is used to calculate the climatology used to determine the anomalies.
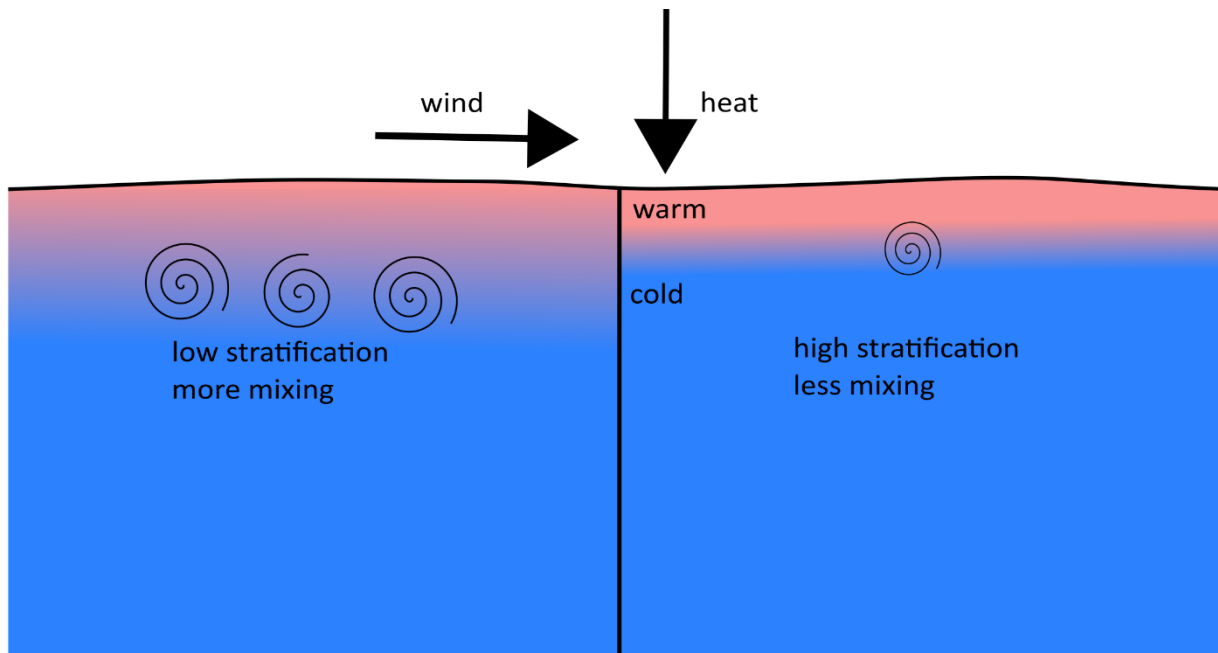
Figure 6: Schematic diagram describing the role of increased stratification on surface MHWs. On the left, lower stratification leads to more mixing. On the right, higher stratification leads to less mixing. Both scenarios receive the same heat flux and wind forcing at the surface. The case with higher stratification results in higher SSTs because the heat is confined to the surface due to less mixing.
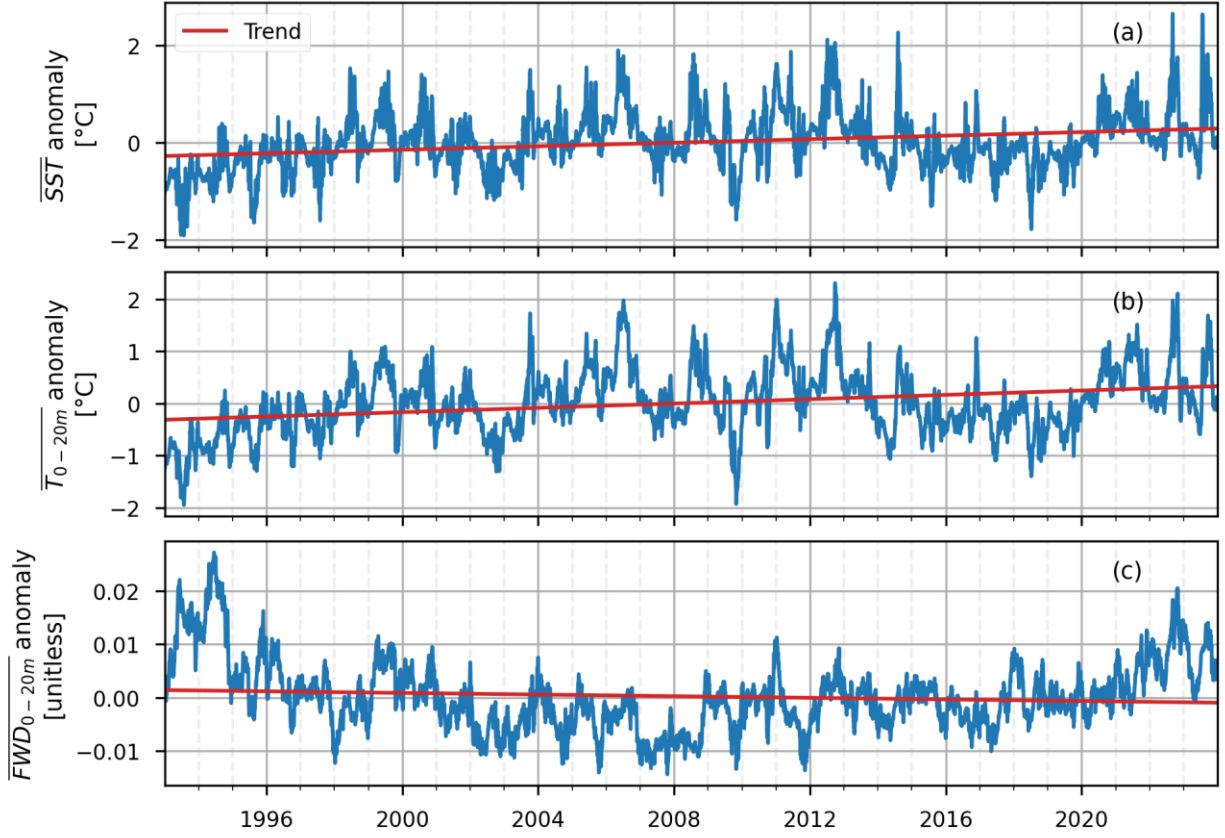
Figure S1: Time series of GLORYS12V1 (product ref. no. 1) (a) SST anomaly, (b) 0 to 20m vertically averaged temperature anomaly, and (c) 0 to 20 m freshwater density anomaly over the NL Shelf. The trend for each time series is computed using a linear regression.
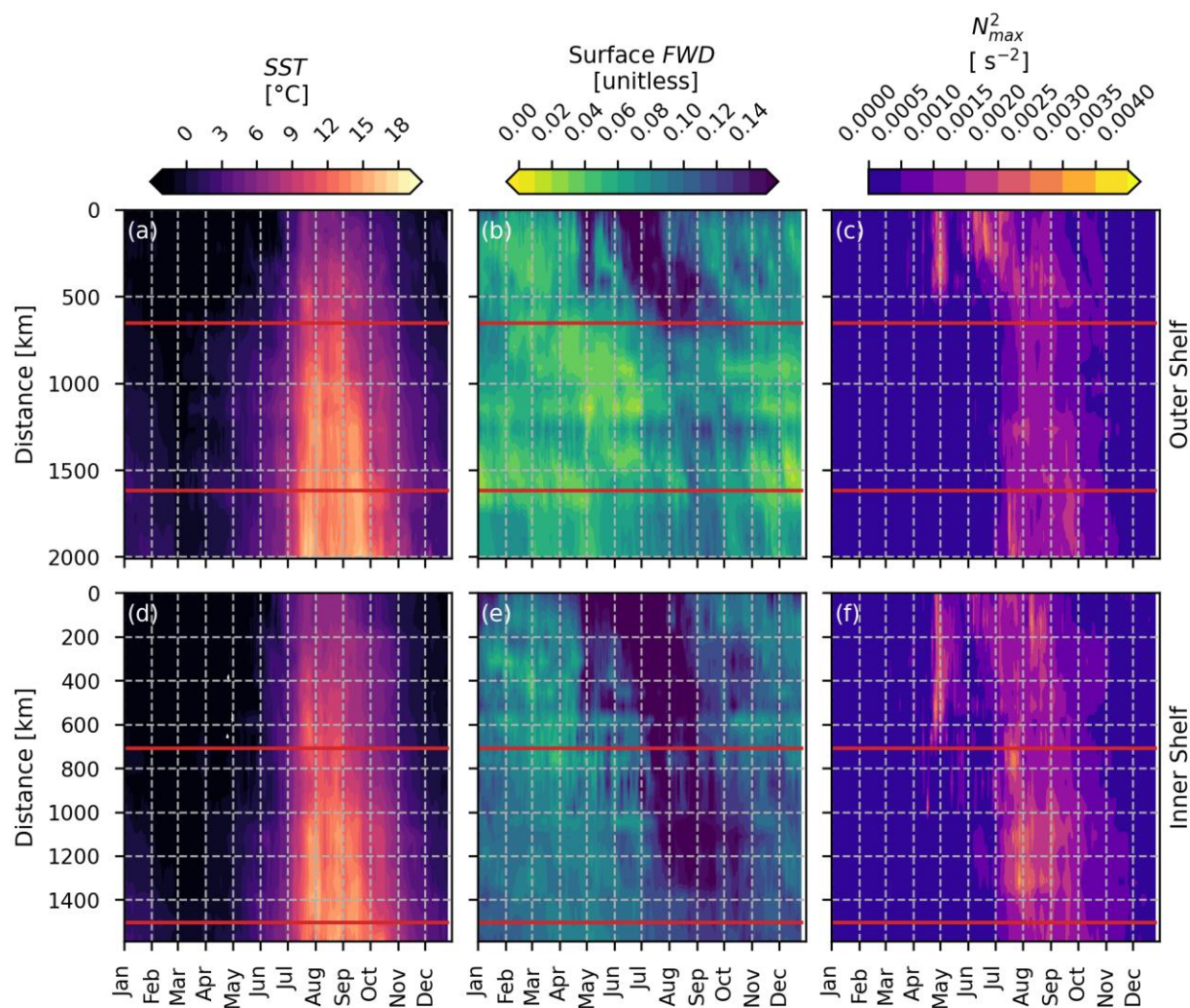
Figure S3: Time series of the GLORYS12V1 (product ref. no. 1) sea surface temperature (left), surface freshwater density (middle), and vertical maximum of the squared-buoyancy frequency (right) for year 2023 along the Outer Shelf (top) and Inner Shelf (bottom) transects (black dotted line in Fig. 1; 0 km here corresponding to the northern limit). The red lines represent the along-shelf locations of the Seal Island (upper) and Flemish Cap (lower) transects.
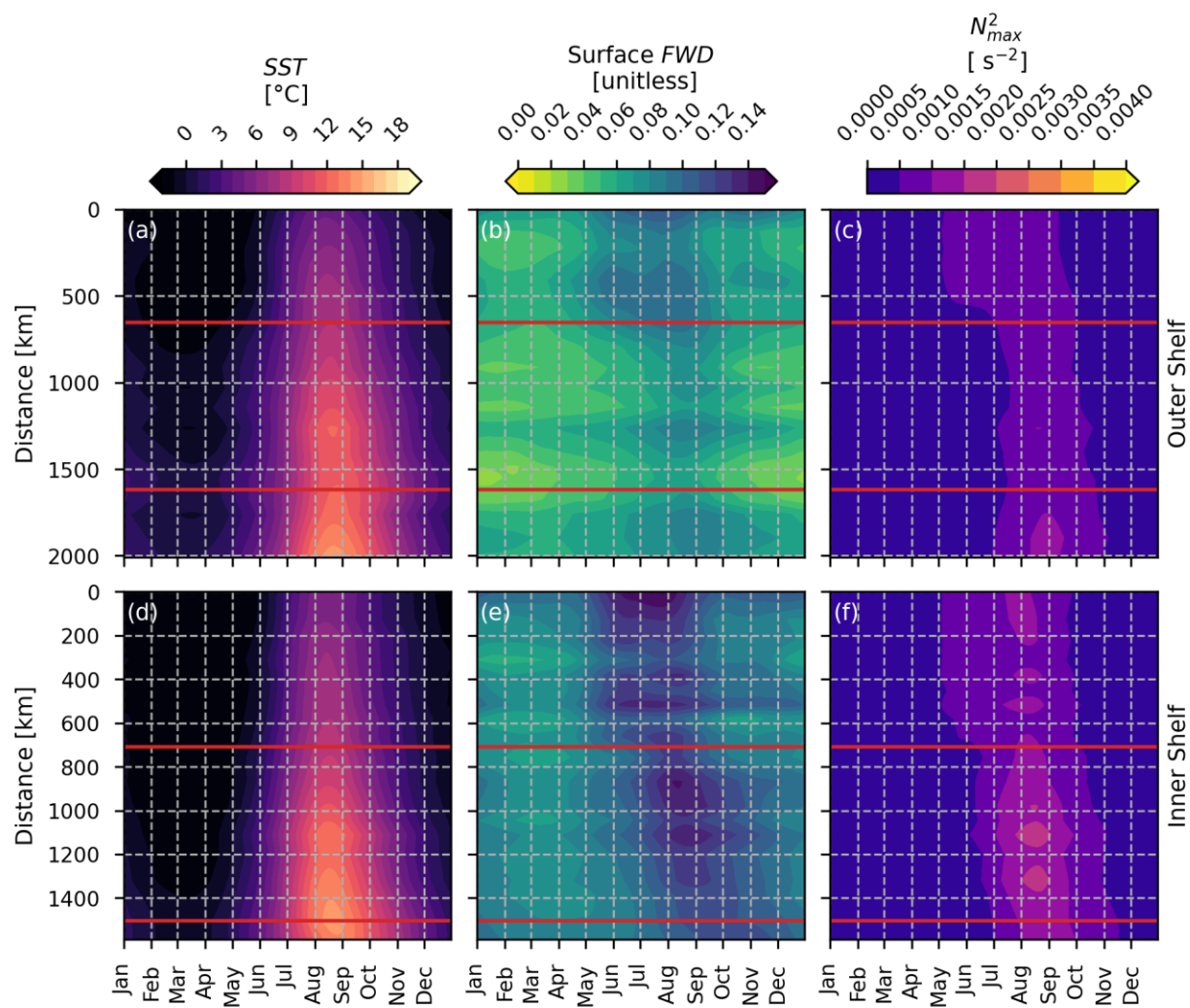
Figure S4: As in Figure S3 but for the 1993-2022 climatological fields.
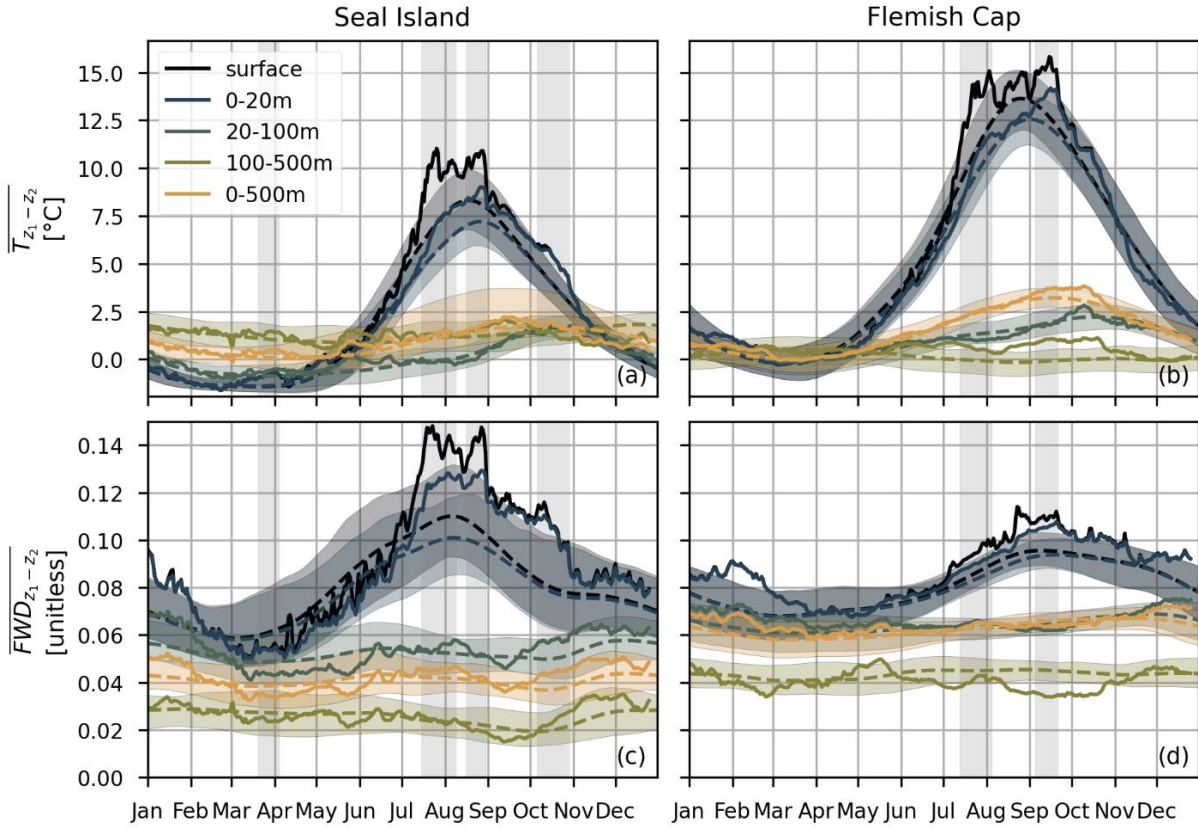
Figure S5: Depth-averaged temperature (top) and freshwater density (bottom) from GLORYS12V1 (product ref. no. 1) averaged across the Seal Island (left) and Flemish Cap transects (right). Results are shown out to the 500 m isobath for the surface (black), 0-20m (dark blue), 20-100m (dark green), 100-500m (light green), and 0-500m (orange). The solid line is the 2023 time series, the dashed line is the 1993-2022 climatology, and the shaded areas represent the 10th and 90th percentiles from the 1993-2022 period. Grey shaded rectangles represent heat wave periods based on SST along each transect. The scientific colour map batlow (Crameri 2018) is used in this plot to prevent visual distortion of the data and exclusion of readers with colour-vision deficiencies (Crameri et al., 2020).
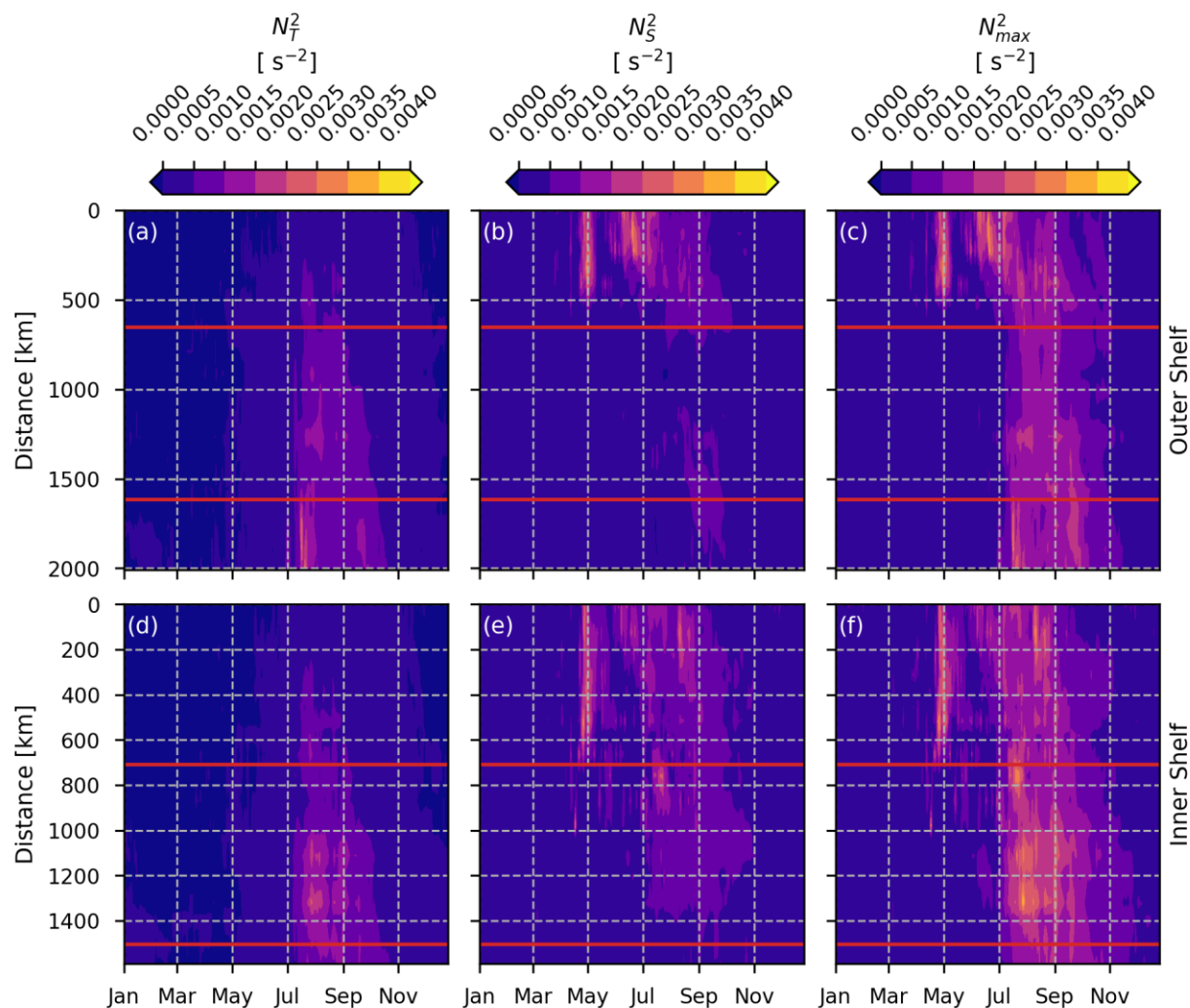
Figure S6: Time series of the temperature (N_T^2; left) and salinity (N_S^2; middle) contributions to the vertical of maximum squared-buoyancy frequency (N_{max}^2; right) for year 2023 along the Outer Shelf (top) and Inner Shelf (bottom) transects (black dotted line in Fig. 1; 0 km here corresponding to the northern limit). Values were estimated using the GLORYS12V1 (product ref. no. 1) temperature and salinity fields. The red lines represent the along-shelf locations of the Seal Island (upper) and Flemish Cap (lower) transects.
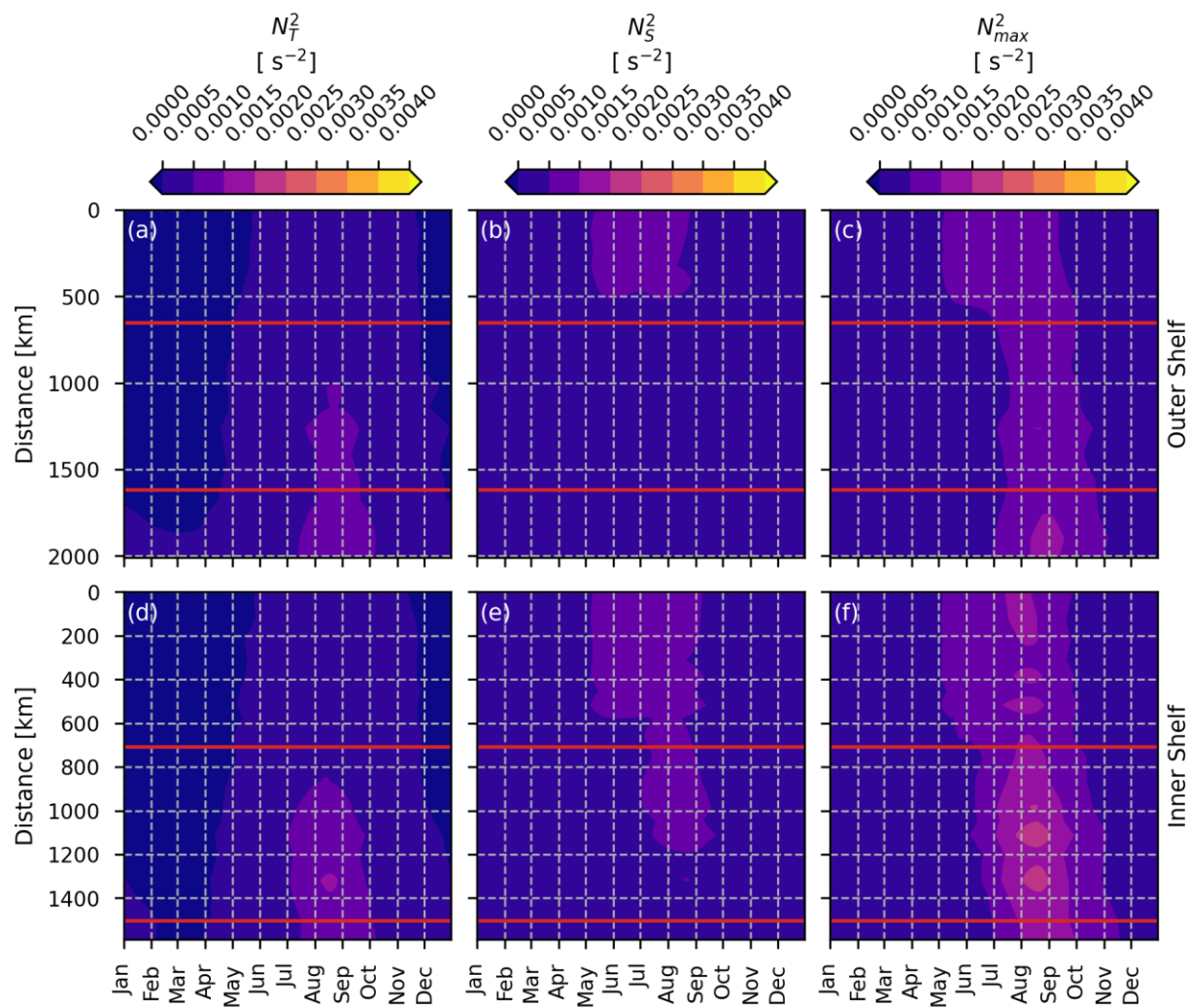
Figure S7: As in Fig. S6 but for the 1993-2022 climatological fields.