Wintertime glider measurements in the western Iceland Sea

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Introduction

Warm Gulf Stream-origin waters flow northward across the Greenland-Scotland Ridge into the Nordic Seas where they are subject to intense heat loss. The resulting cold and dense water mass returns southward by flowing through gaps in the ridge and descending the continental slope as overflow plumes. These overflows are the headwaters of the lower limb of the Atlantic Meridional Overturning Circulation (AMOC). The largest contributor is the Denmark Strait overflow plume, which passes southward between Greenland and Iceland.

An important source to this overflow plume is the North Icelandic Jet (NIJ), which transports dense water into the Denmark Strait along the slope off northern Iceland. It has been hypothesized that the NIJ is the deep limb of a local overturning loop that involves the boundary current system north of Iceland and water mass transformation in the Iceland Sea. Sparse wintertime hydrographic data confirm that dense waters are formed in the Iceland Sea, but indicate that the densest component may be formed only to a limited extent.

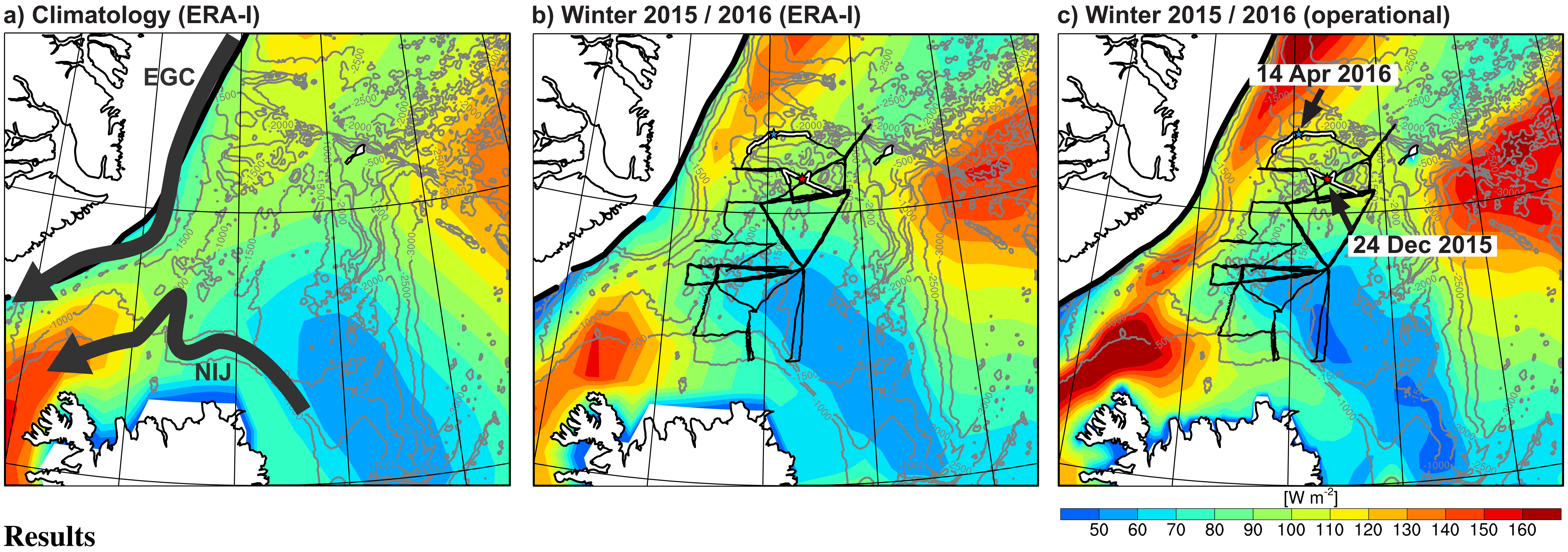

Figure 1: Winter (November to April) mean sensible and latent heat fluxes for (a) winters 1980 to 2014 and (b, c) winter 2016 from (a, b) the ERA-Interim reanalysis and (c) high-resolution forecasts from the operational model at ECMWF. Additionally shown are the 50% sea ice concentration contour (thick black) and bathymetry in intervals of 500 m (gray). The black lines represent the tracks of the three gliders during the full deployment period. The white segments highlight the locations of the glider shown in Fig. 3 during two selected CAOs whose peak magnitudes are indicated by the red and blue stars.

Results

Three Seagliders were deployed north of Iceland in August/October 2015 and recovered in May 2016. The purpose of the deployment was to investigate the wintertime evolution of the mixed layer in the Iceland Sea. The mean atmospheric forcing of the Iceland Sea is characterized by a local minimum in heat fluxes to the southeast and increasing heat fluxes toward the north and near the ice edge along east Greenland (Fig. 1a). In winter 2015-16 the most intense cold air outbreaks (CAOs) occurred early, with the strongest event taking place around 24 December, while the late winter was characterized by a sequence of moderate CAOs. The mean heat fluxes in winter 2015-16 were lower in the central Iceland Sea but enhanced to the west relative to climatological values (Fig. 1b). The spatial distribution of heat fluxes in the operational model is similar to ERA-Interim, but the CAOs are likely better represented due to higher resolution and improved boundary layer parameterizations (Fig. 1c). This is particularly evident in the vicinity of the ice edge.

From historical hydrographic data the deepest and densest mixed layers were found on the outskirts of the cyclonic gyre in the Iceland Sea [Fig. 2a; Våge et al., 2015]. While the absolute values of near-surface density measured by the Seagliders were lower than the climatological values, the pattern of enhanced convection toward the west and north was confirmed (Fig. 2b). In particular, the deepest convection took place in the previously unsampled western Iceland Sea in the vicinity of the marginal ice zone.

Cold air outbreaks provide some of the most intense atmospheric forcing of the Nordic Seas [Papritz and Spengler, in revision]. The impacts of two such events on the mixed layer development are illustrated in Fig. 3. The more intense CAO around 24 December cooled the mixed layer by 1.5–2°C and eroded a substantial amount of stratification from the upper 200 m. The weaker CAO around 14 April, when the water column was more weakly stratified near the end of the convective season, resulted in convection to depths approaching 600 m.

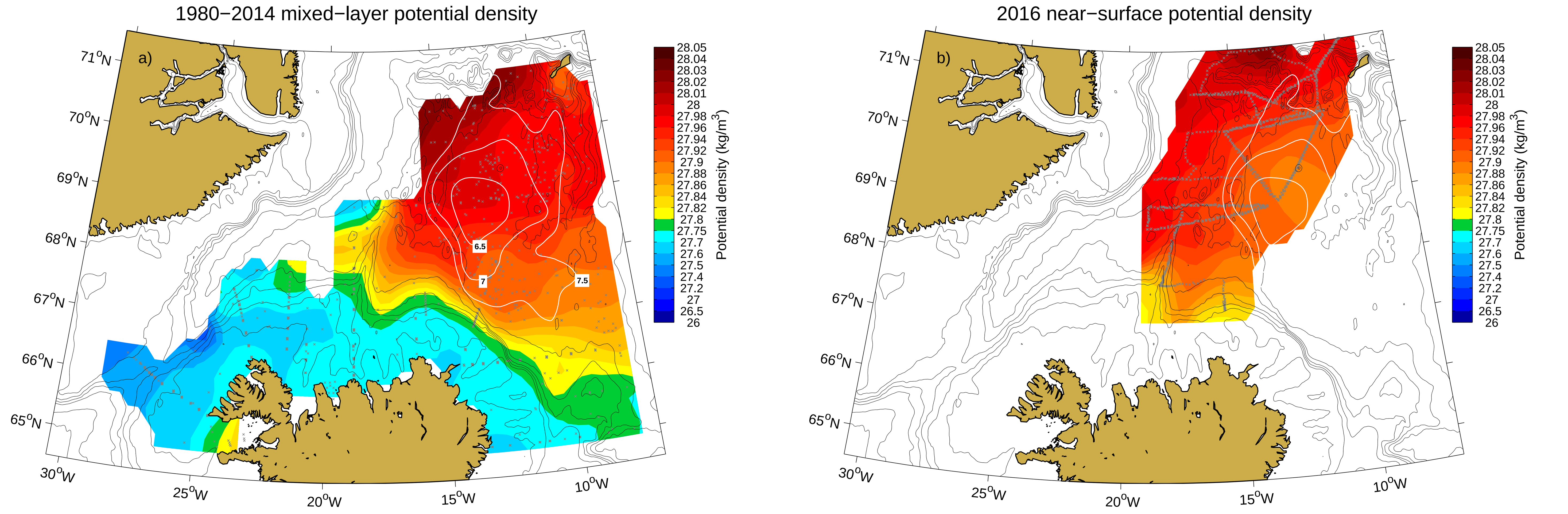

Figure 2: Late winter (February to April) mixed-layer/near-surface potential density from historical hydrographic data for the period 1980-2014 [(a), Våge et al., 2015] and from glider data for the winter 2015-16 (b). The white lines are contours of dynamic height of the surface relative to 500 db in units of dynamic cm. The 200, 400, 600, 800, 1000, 1400, and 2000 m isobaths are contoured as black lines.

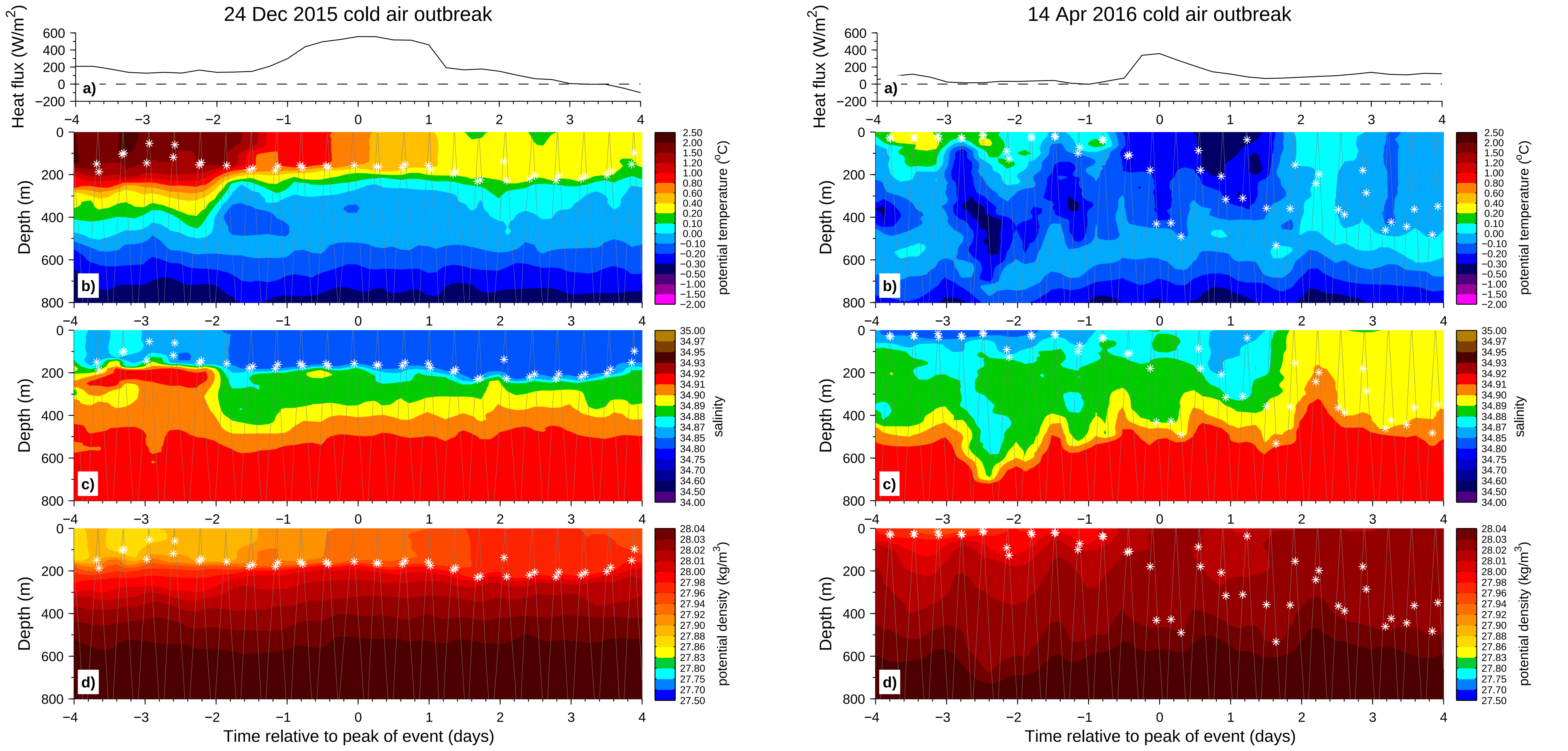

Figure 3: Total turbulent (latent + sensible) heat fluxes (a) and vertical sections of potential temperature (b), salinity (c), and potential density (d) for a period of 96 hours before and after the 24 December 2015 (left column) and the 14 April 2016 (right column) CAOs. The gray lines represent the glider track and the white stars indicate the depth of the mixed layer.

Individual cold air outbreaks substantially impact the wintertime evolution of the mixed layer in the Iceland Sea

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