Heat and Freshwater changes in the Labrador Sea

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1. Introduction

The Labrador Sea is an important site for the formation of intermediate deep water due to its seasonally recurring deep convection. The seasonal freshening of the interior counteracts the buoyancy loss caused by the deep mixing. Recent change in the rate of Greenland and Arctic ice melting can impact the formation of the deep water, if the additional freshwater reaches the interior.An understanding of freshwater exchange between the basin and boundary domain, is therfore crucial in order to determine how increasing freshwater fluxes from the Arctic will influence deep convection patterns. A 10-yr (2002-2012) timeseries of temperature and salinity, obtained from ARGO floats is used to determine interannual variabilities. **Figure 1** shows the location of all available floats in the region.

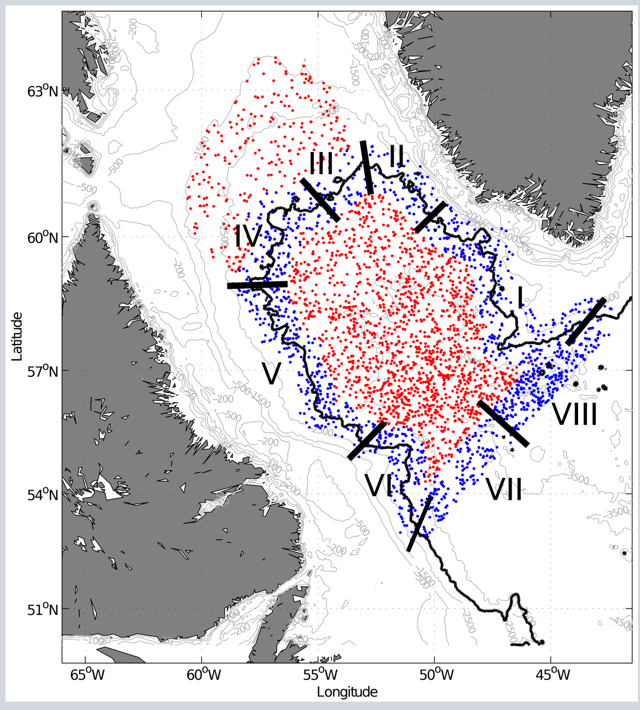

Figure 1: Location of available profiles from ARGO flaots used for this study. Red dotts show the location of profiles used for Figure 2-4. Blue dotts show the profiles used in Figure 6 and 7. Roman numbers denote the sections along the boundary of the interior used in Figure 6 and 7.

2. A freshening of the Labrador Sea?

0-200 m

200-2000 m

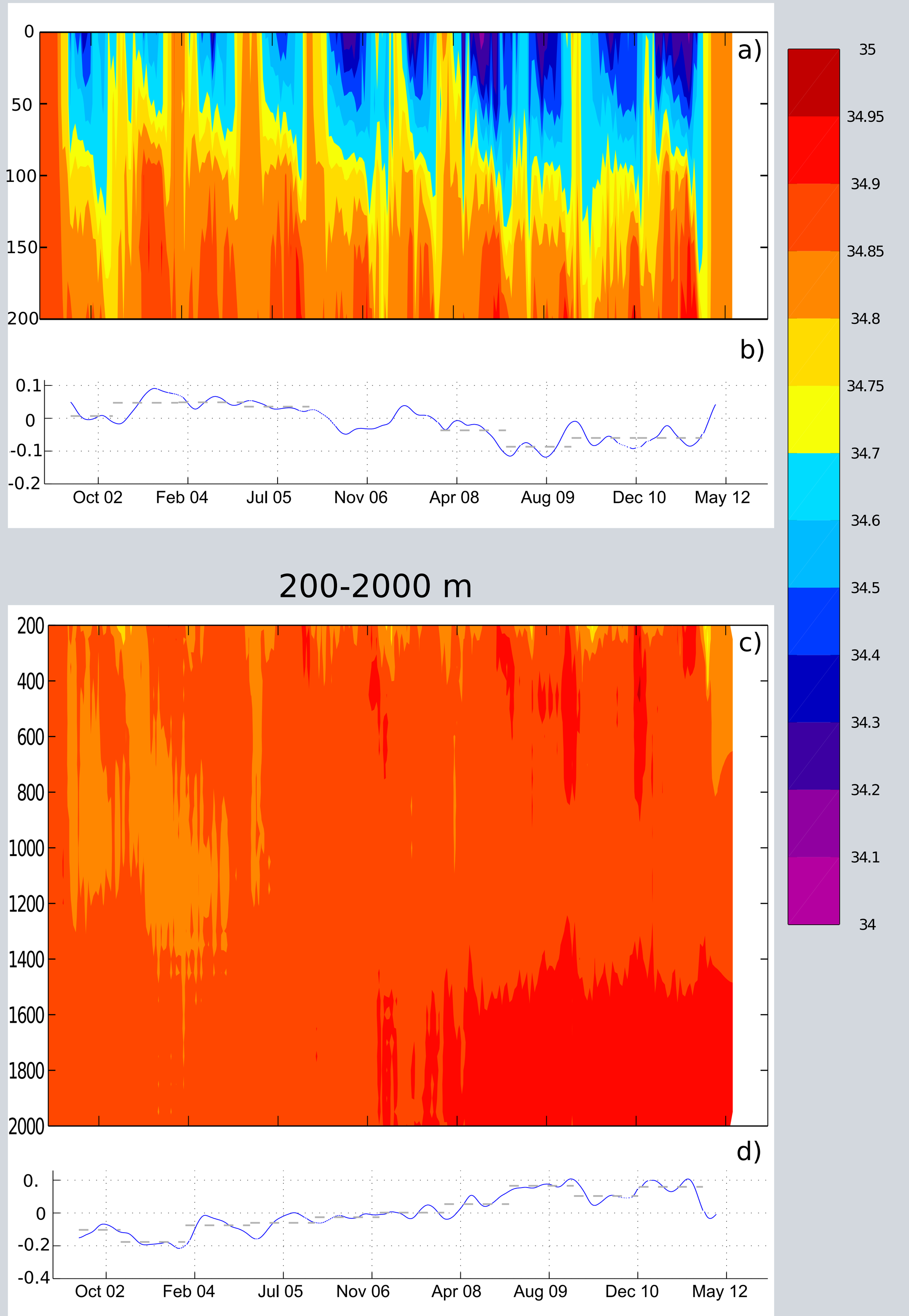

Figure 2: Salinity of the Labrador Sea interior for 0-200 m (a) and 200-2000 m (c). Panel (b) and (d) show a timeseriers of lowpass salinity with removed climatology and a yearly mean (dottet line).

When considering the average salinity of the Labrador Sea interior, we can see a seasonal freshening of the surface layer (**Figure 2a**). The freshening signal is stronger and longer lasting in the second half of the 10 years. The trend towards a fresher surface layer is highlighted by **Figure 2b** and **Figure 3** (showing the yearly change of freshwater from Oct - Feb in the upper 200 m of the region). The same trend is also present when looking at seperately at smaller regions of the interior (with some exceptions). While the freshening is limited to the upper 200m the deeper layer shows a shift towards more saline waters (**Figure 2c** and **2d**).

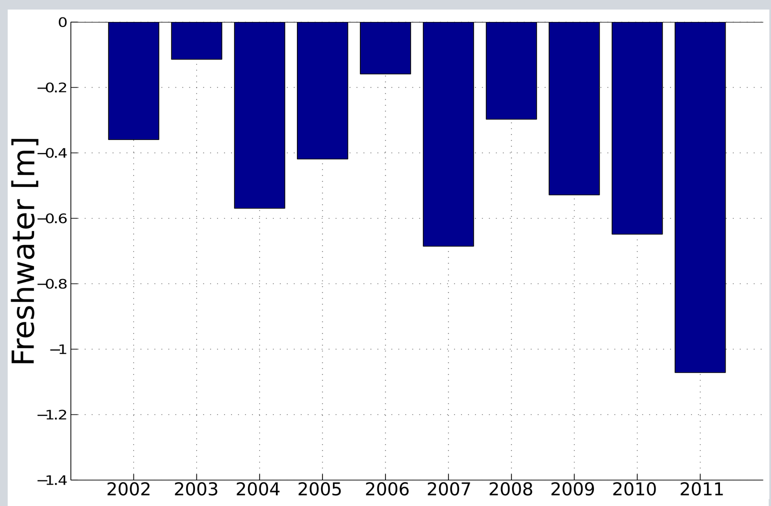

Figure 3: Freshwater change of the upper 200m (Oct - Feb) that would need to occure to account for the observed change in salinity

3. Temperature

0-200 m

200-2000 m

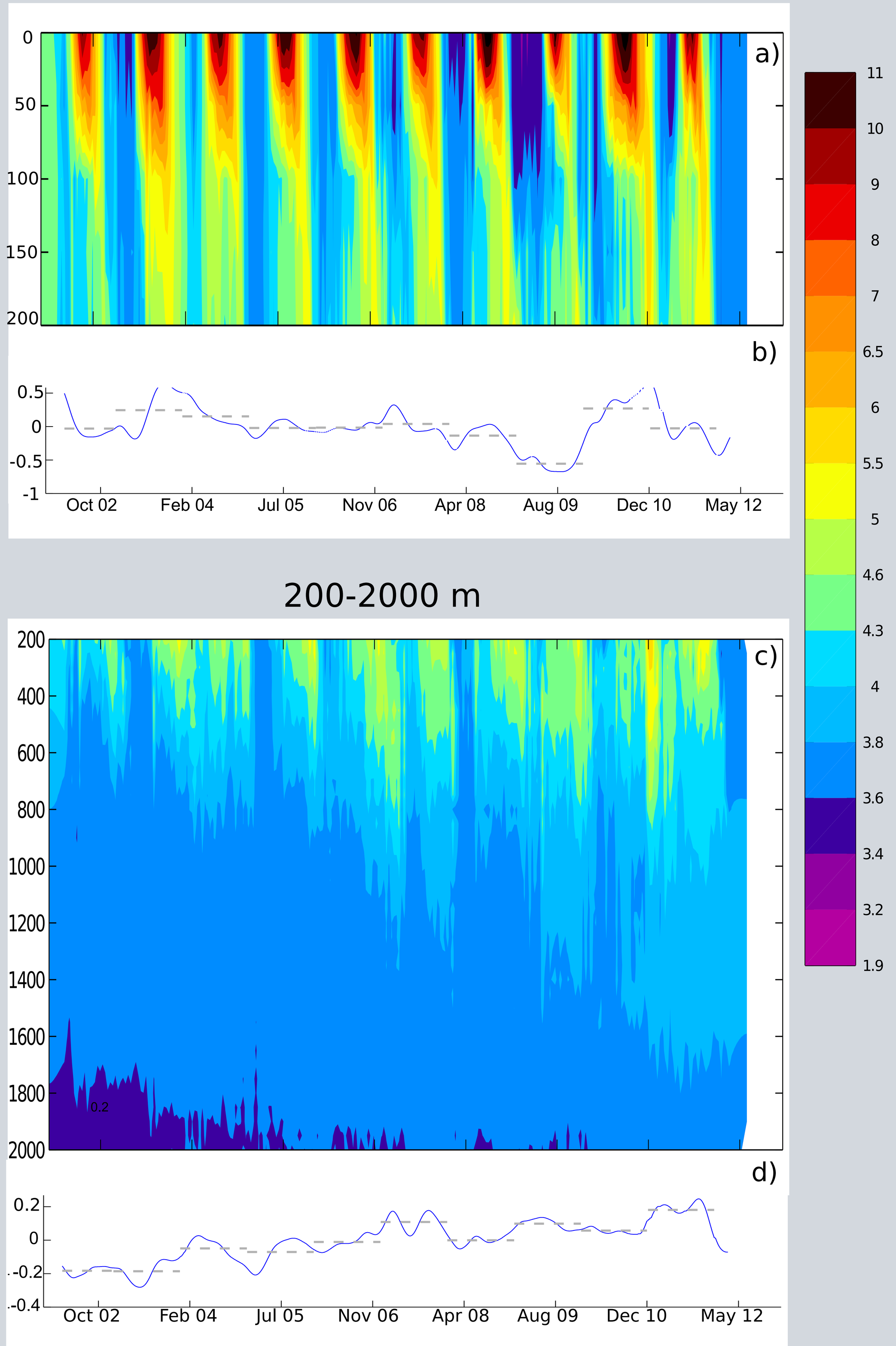

Figure 4: Same as Figure 2 but for temperature

The temperature of the surface layer is characterised by a regular seasonal cycle with no obvious trends towards changing water properties (**Figure 4a** and **4b**). This is true for the entire region (again with some exceptions). The temperature of the deep layer shows a uniform warming towards the most recent years and throughout the region (**Figure 4c** and **4d**).

4. Where does the additional freshwater come from?

Freshwater can be transported to the region via several mechanisms, including eddies, geostrophic flow, ekman transport and exchange with the atmosphere.
However the observed E-P fluxes (2002-2006 compared to 2007-2011, obtained from ERA - Interim) do not show a sufficient change to explain the observe freshening in the interior Labrador Sea (**Figure 5**). It must therefore be a result of lateral exchange with the surrounding ocean. Most likely the changes are due to enhanced import of freshwaters from the boundary currents.
Here I will present a first attempt to determine the regions of the boundary current, that play a major role in the freshening of the surface layer.

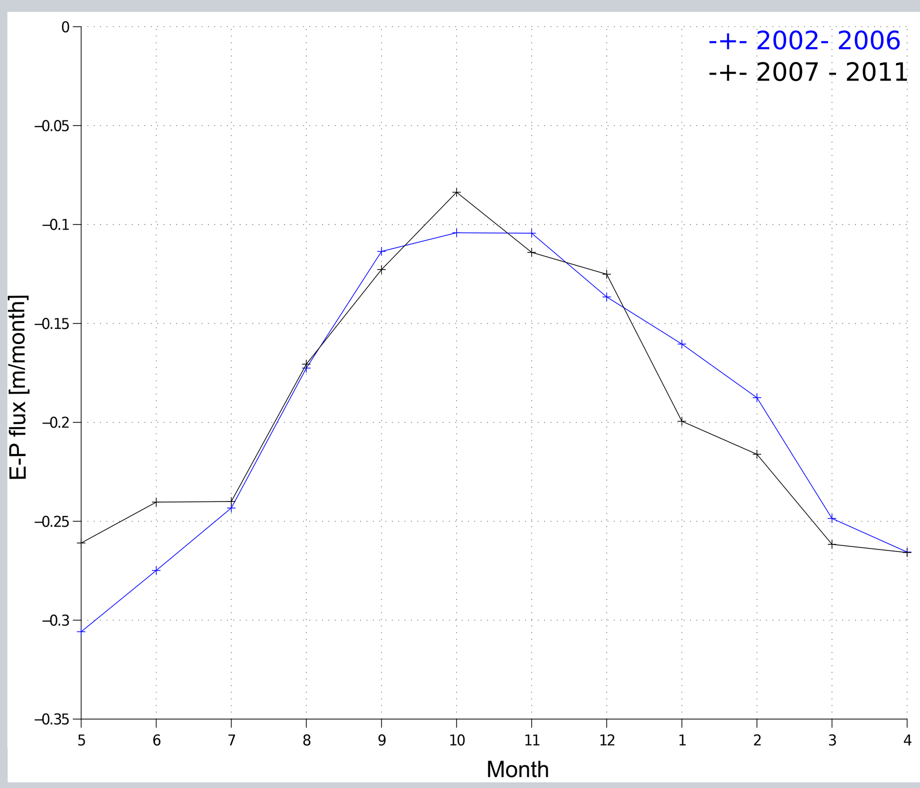

Figure 5: Climatology of ERA-Interim freshwater flux (evaporation minus precipitation) for the region of interest and the early 5 years (2002 - 2006 BLUE) and late 5 years (2007 - 2011 BLACK)

5. Lateral freshwater flux

Figure 6 shows the temperature and salinity anomalies of the two time periods (2007-2011 - 2002-2006) along the boundaries I - VIII. This gives a first understanding of the location of property change responsible for the freshening in the interior. The sections, (see **Figure** 1 for their location), show colder temperatures along the surface of Section I - VI. There also seems to be a warming in the sub-surface waters.

The change in the salinity of the waters is most pronounced in Section II - V with less saline waters present. The sub-surface and deeper layers however show a uniform change towards saltier waters.

Note the different number of floats available for the two timeperiods, and the shift towards more profiles in the fall and winter (**Figure 7**).

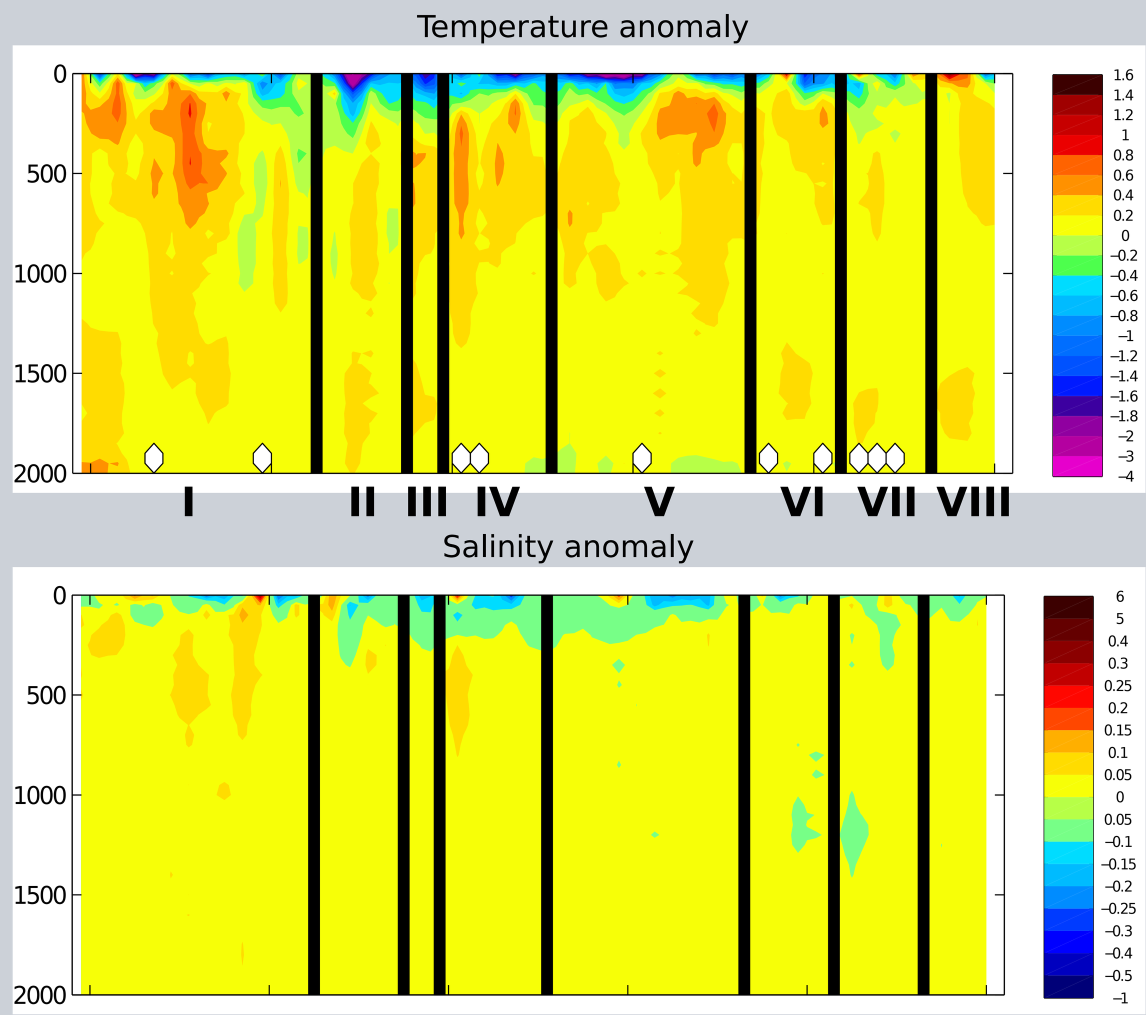

Figure 6: a) Temperature anomaly along the boundary of the interior (Section I - VIII, see Figure 1). b) As a) but for salinity anomaly

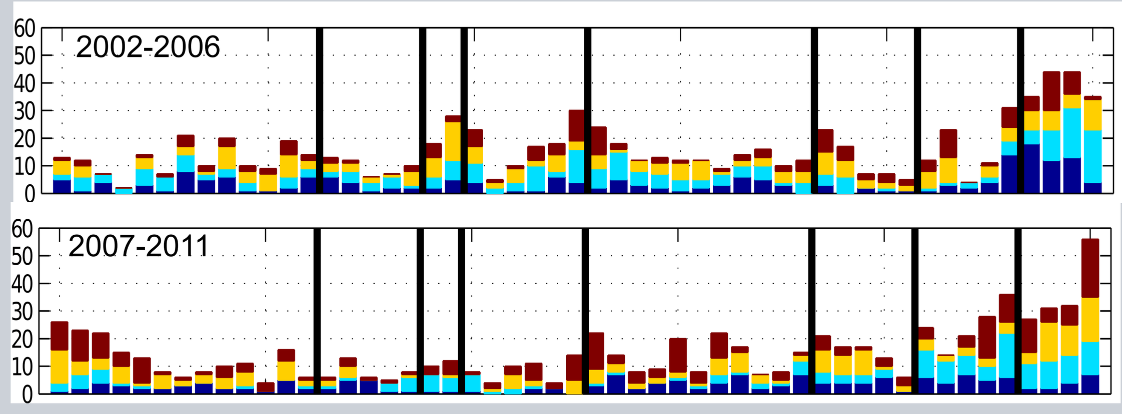

Figure 7: Number of available profiles along each Section (75 km intervals, devided into spring (blue), summer (light blue), fall (yellow) and winter (red).

5. Summary and Outlook

A freshening of the surface layer and a trend towards saltier and warmer deeper waters is observed in the region. The freshening can not be explained by the exchange between ocean and atmosphere and must be caused by lateral exchange with the surrounding ocean. Indeed changed temperature and salinities are observed along most parts of the interior boundary. To better understand the impact of this to the interior, flow across the sections will be calculated. This will help answer the question of whether changes along the boundaries reached the interior. Furthermore we need to asses the significance of these trends in light of the data coverage. Other possible mechanism and a more detailed analysis of the boundary currents will also be considered in future work.