Referee #2, Michael A. Spall

This is our preliminary response to the reviewer's comments to encourage discussion when the discussion period is still open. We will provide a more complete response in our final response shortly after the discussion closes. The reviewer's comment is reproduced in black Calibri font **followed by our response starting with Re. in red, bold Arial font.**

This is a timely analysis of mooring data within the Norwegian Atlantic Slope Current on the eastern side of the Lofoten Basin. This region has been identified as a source of eddy kinetic energy and offshore eddy heat flux, which is important for the basinscale stratification and air-sea exchange. The analysis is fairly straightforward and I recommend that it be published subject to relatively minor revisions. There are a couple suggestions for additional analysis that, while not crucial, would provide more context for the results.

Re. We thank the reviewer for the detailed reading and constructive comments. We addressed all comments as detailed below. In response to the reviewer's comments, we aim to include two new figures (Figs. R1 and R2) in the revised version as described below.

Would it be possible to compare the transport in density and depth with that at the Svinoy section? If the transport there is barotropic, and here it is baroclinic, that implies that there has been some upwelling between these two stations, or a loss of transport in the deeper layers. If the transports are similar, can you tell if the isopycnals have risen or if there has been a water mass transformation between these two sections? I think a more complete comparison with that upstream section can reveal more about what has happened between these locations. Even if the years are different, maybe you can consider the seasonal cycle, which should be representative.

Re. There is indeed substantial AW transformation between the Svinøy and Gimsøy sections. This was the subject of a previous paper (Bosse et al, JGR 2018). Analyses on a T-S diagram and in isopycnal layers showed that AW was progressively transformed to denser isopycnals. This generated a poleward warming in density surfaces just below the AW at Svinøy (a signal already shown by Rossby et al, DSR 2009). While the most important transformation occurred in the western part of the Lofoten Basin, lateral exchanges generated by instabilities of the slope current substantially modified the characteristics of the AW transported from the Svinøy to Gimsøy section.

In order to examine the vertical structure of the slope current, we have constructed mean T-S sections along the Svinøy and Gimsøy sections using freely accessible dataset of the Nordic Seas (Bosse and Fer (2018) Hydrography of the Nordic Seas, 2000-2017: A merged product https://doi.org/10.21335/NMDC-1131411242), see figure R1. We will include this figure (Fig R1) in the revised manuscript.

About isopycnal displacements: isopycnals with σ_0<27.7 kg m^{-3} rise due to AW transformation peaking at the 27.5 isopycnal with a displacement of 150 m at the core of the slope current. This isopycnal switches from being located below the AW core to above. This is also where the largest spiciness injection by vertical mixing was reported by Bosse et al (2018). In deeper layers, we observe a sinking of isopycnal from Svinøy to Gimsøy, which can be explained by the presence of other intermediate waters subducted along the Mohn Ridge Front and AW transformations in the Lofoten Basin, decreasing the stratification in the AW pycnocline.

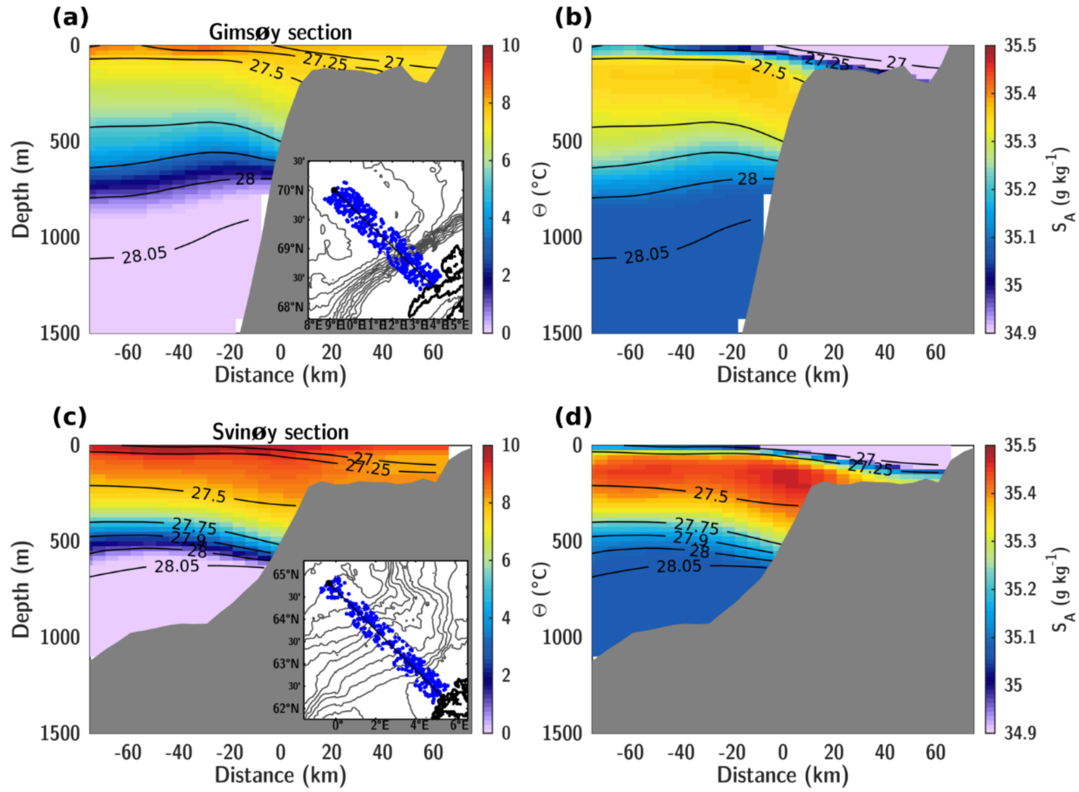

Figure 1: Mean (a-c) temperature and (b-d) salinity cross-front sections taken along the Gimsøy and Svinøy sections. Isopycnals are shown by black contours. A map shows all profiles used, located within 25 km distance from the sections. The annual mean was constructed by averaging over four seasonal sections. Each section is obtained by binning profiles projected onto the section in 5 km cross-section intervals. The seasonal sections for temperature and salinity were smoothed using a Gaussian moving window of 10 km variance prior to annual averaging.

Can the authors provide error bars for the velocity and transport estimates?

Re. We now provide error bars for the velocity and transport estimates: for winter profiles in Fig 4 (for both the temperature and velocity profiles), for monthly averaged AW transport in Fig 6b, for the annual average in T-binned histogram of Fig. 7, and in Table 2 where we list the average transports. We will post the updated material in the revised manuscript after the discussion.

In the figures, the error bars are based on the standard error, se = std / sqrt(DOF), using the standard deviation (std) over the analysis period and using the effective degrees of freedom, DOF, estimated as the number of observation points divided by the decorrelation length scale of 7 days (this was estimated in the manuscript). For example, for the winter averages using daily profiles, the standard deviation is over the number of winter days (90), and DOF = 13.

In addition to the standard error, we estimate a representative error for the transport (including error estimate from the width and depth-averaged current). Table 2 will be updated with errors calculated for each analysis period (annual, summer and winter; and summer 2016 and summer 2017, separately). More details in error calculations can be found in our response to reviewer 1.

Introduction:

You might also reference Clark and Straneo (Observations of Water, Mass Transformation and Eddies in the Lofoten Basin of the Nordic Seas, JPO, 2015).

Re: Done. We normally cite Clark Richards & Straneo in our Lofoten Basin papers. Unfortunately it was overlooked in this manuscript.

I had a 2010 paper in Ocean Modeling that would be more appropriate to reference than the 2010 JPO paper as it addresses the lateral eddy heat flux in (an idealized) Lofoten Basin (Spall,Non-local topographic influences on deep convection: An idealized model for the Nordic Seas, Ocean Modeling, 32, 72-85).

Re. Thank you for point this reference out. Changed as suggested.

lines 120-124: It should be possible to quantify the source of the increased vertical shear, or at least break it down into temperature and haline contributions via thermal wind.

Re. We calculated the vertical shear of geostrophic current perpendicular to Gimsøy and Svinøy sections (Figure R2), derived from the Nordic Seas data set described above. To compare the baroclinicity of the slope current at these two locations, we vertically integrated the shear with a level of no motion at the bottom. This allows to confirm the increase in baroclinicity of the slope current with latitude (63 cm/s at Gimsøy vs 46 cm/s at Svinøy, once vertically integrated).

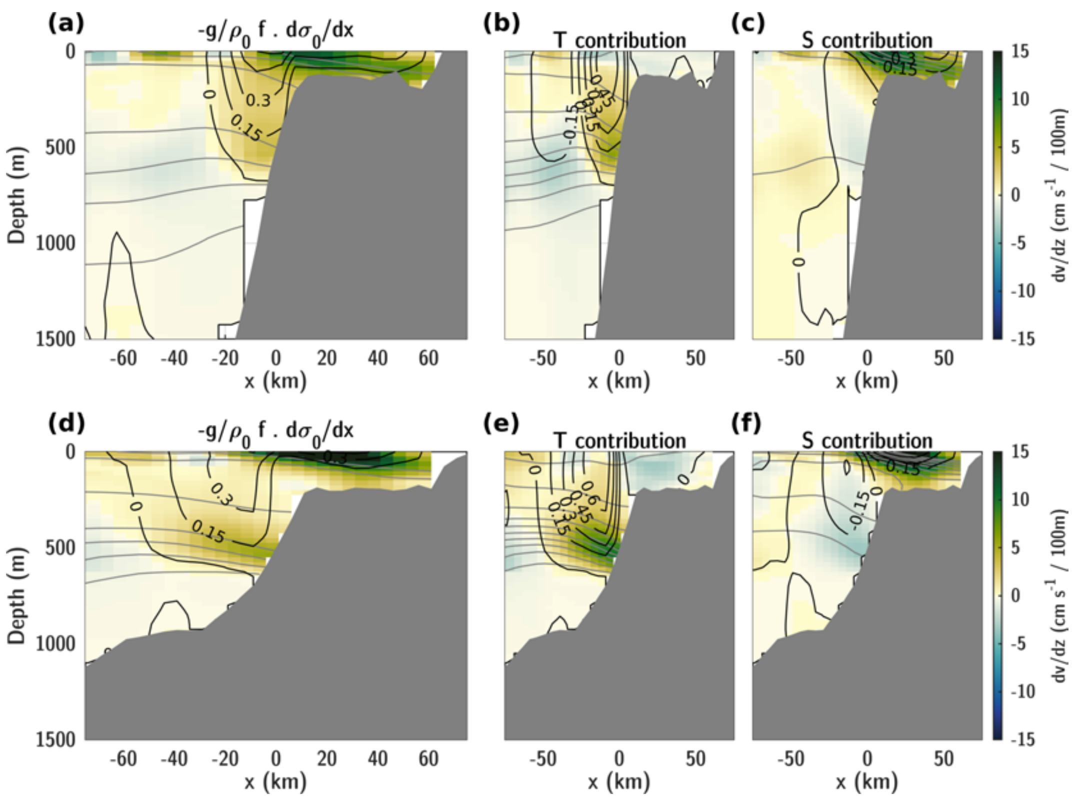

Figure R2: Vertical shear from thermal wind balance for (a-b-c) Gimsøy and (d-e-f) Svinøy sections. Panels a&d show the total shear, and b&e the thermal and c&f the haline contribution. In each plot grey contours are isopycnals in a&d, isotherms in b&e and isohalines in c&f. The black contours correspond to the bottom to surface integrated vertical shear in m/s.

In particular, it is interesting to note that the contribution of temperature to shear is actually stronger south at Svinøy (75 cm/s vs 56 cm/s once integrated), but counter-balanced by a strong negative contribution of salinity reaching -31 cm/s integrated from bottom to 150m and -25cm/s to the surface (due to the presence of a deep patch of more saline AW at the slope). The negative shear due to salinity only reaches -12 cm/s from the bottom to 250 m and become insignificant when integrated to the surface.

There is a weaker signature of AW in T-S at Gimsøy, so the corresponding positive and negative shear contributions to geostrophic currents in the slope current are weaker there. Furthermore, a stronger interaction of the coastal current with the slope current at Gimsøy (because of proximity of the slope current to the coast due to steep slope) contributes positively (i.e., poleward) to the transport than at Svinøy. Note that the broader region of isopycnal gradients at the Svinøy slope does not necessarily imply a broader current than for Gimsøy, but could be due to a more variable position linked to the steepness of the slope constraining the circulation.

We will include this figure and the related discussion in the revised manuscript.

line 157: It might be useful to provide a scaling for the expected response to changes in the wind stress. One could calculate the onshore Ekman transport, downward deflection of the isopycnals, and the geostrophic response. The paper by Choboter et al. (2011, Exact Solutions of Wind-Driven Coastal Upwelling and Downwelling over Sloping Topography, JPO, 41, 1277-1295) provides analytic solutions but you might be able to do something useful just with simple scaling.

Re. This is not addressed yet at the time of this response.

line 191: It seems likely that the transport variability is due to the current meandering outside the moorings (rather than a change in the along-slope transport), but this isn't explicitly mentioned..

Re: Agreed. We now mention this point.

Figure 7: I found this to be the most surprising part of the paper. Any ideas why there is more warm water in winter than in summer? When/where was this water last exposed to the atmosphere? Was this subducted in the previous summer? If you see the same phase at Svinoy, which is O(1000 km) upstream, that would argue against it simply being advected along the slope. I think some more discussion around this finding would be helpful. The penetration of AW down to 650 m depth is likely related to that being the sill depth upstream.

Re. The increase of the temperature might of different origins, including the increase of AW thickness observed in winter at the mooring position as vertical mixing occurs; a seasonal peak in temperature; or the absence of moored observations in the upper 80 m where most of the seasonal warming is observed.

In Fig R3 we plot the time series of depth-averaged along-isobath current and temperature at Svinøy and the Lofoten moorings, MN and MW. The records are from the same period starting from June 2016. The Svinøy data are from the S1 mooring, kindly provided by Kjell Arild Orvik, and include hourly time series from RCM7 current meters at 100, 300 and 490 m depth. A seasonal signal in temperature is clearly observed at Svinøy. The pattern is similar at Gimsøy, and the winter temperature anomaly is larger. There is no apparent phase difference. The temperature anomaly in January observed at MW is not seen at Svinøy and cannot be advection. Note the largest current in January (same time as this temperature peak), detected in all moorings with no phase lag.

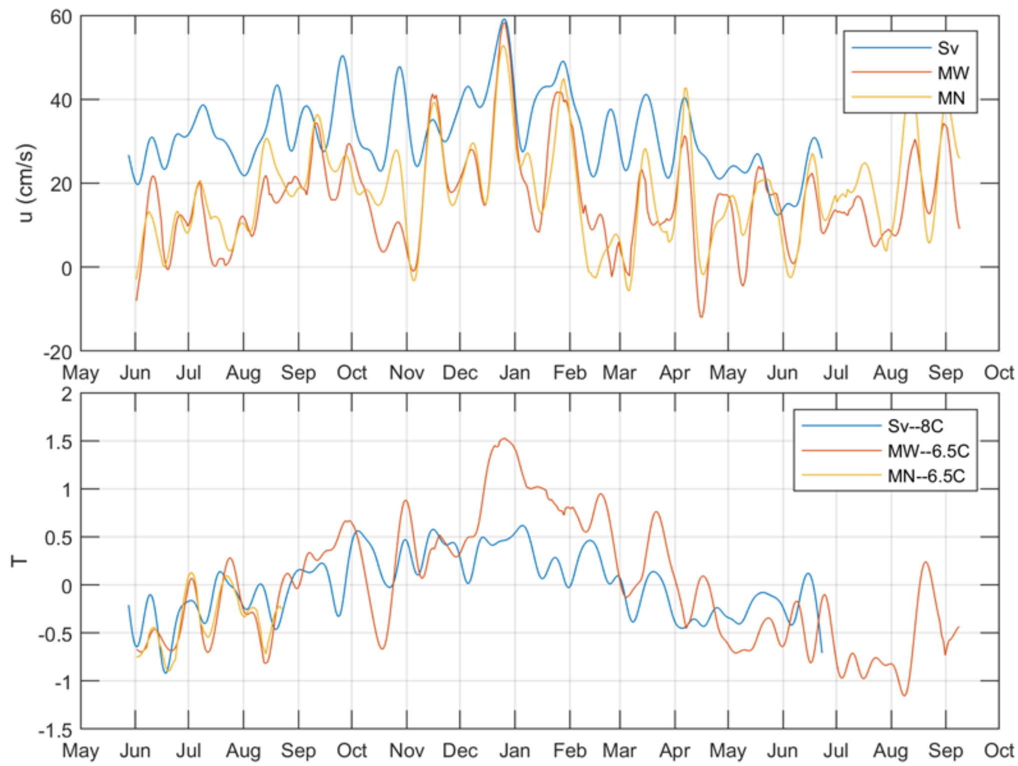

Figure R3. Vertically averaged along-isobath current and temperature anomaly at Svinøy mooring S1 (Sv), and Lofoten moorings MN and MW. S1 data are kindly provided by Kjell Arild Orvik and used with permission. S1 data include hourly time series from RCM7 current meters at 100, 300 and 490 m depth (20 m above bottom). Vertical averaging is 100 m to 20 m above bottom for Sv and MN, and to 600 m depth for MW. The indicated time-averaged values are removed from the temperature records (8C from Sv and 6.5C from MN and MW).

Note that Fig R3 vertical averaging starts from 100 m depth. Vertical averages from the hydrography, averaged between surface and 500 m depth using monthly climatology at the mooring locations are shown in Fig R4. This somewhat supports the annual cycle with warm water in winter. Unfortunately, Gimsøy time series lack winter data. Svinøy temperatures are larger in fall and winter than in summer consistent with Fig R3b.

Overall, we interpret the largest warm water transport in winter as a consequence of the annual cycle of depth-averaged temperature coinciding with the time of strongest currents (winter).

Figures R3 and R4 will not be used in the revised manuscript. We will probably not discuss these points

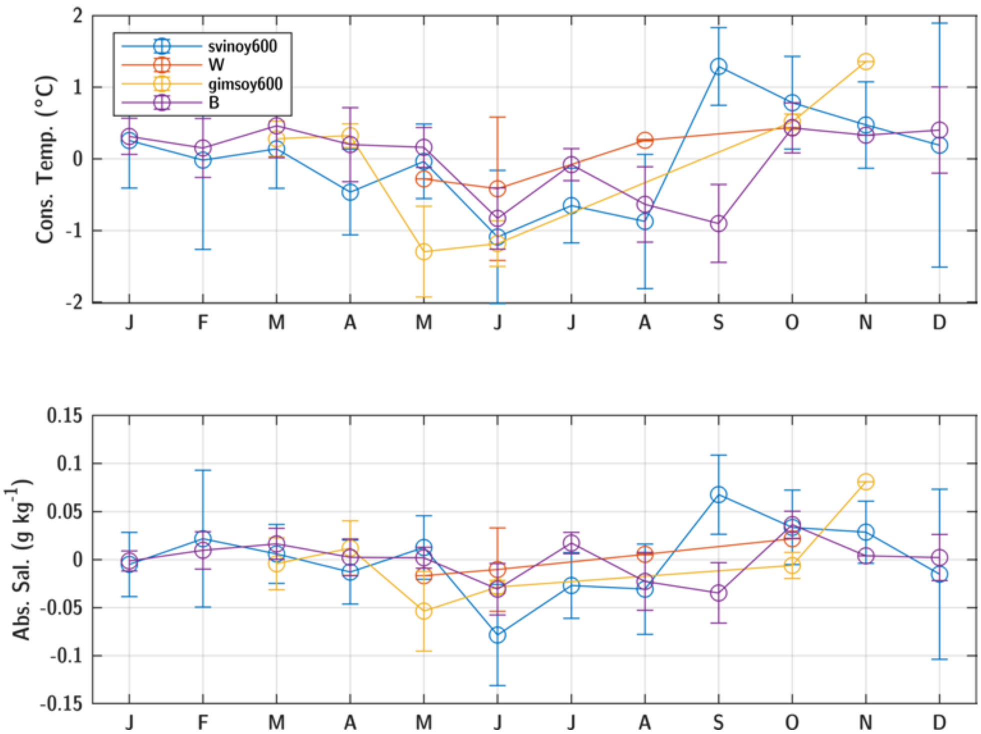

Figure R4. Temperature and salinity anomalies (annual mean removed) at different sites. Vertical averaging is from 0 to 500m. Svinøy600 and Gimsøy600 can be directly compared to Sv and MN. W is at the position of MW (and B is at the position of MB in the Lofoten basin).

line 232: BC and BT were also calculated from a high resolution mooring array in Spall et al. (2008).

Re: We now include this in our list of examples.

line 238-239: CHECK!NOT 1 MONTH?

Re: Apologies for this confusing “note-to-self”, which we forgot to remove (we had posted a short comment on this later).

lines 242-245: This justification is not very convincing, I suggest deleting it.

Re: Deleted as suggested.

line 340: Magenta does not stand out compared to the colorbar, I suggest using a different color to mark the line.

Re: We improved this figure.