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Interactive comment on “Heat loss from the Atlantic water layer in the St. Anna Trough (northern Kara Sea): causes and consequences” by I. A. Dmitrenko et al.

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Review of manuscript by Dmitrenko et al., “Heat loss from the Atlantic water layer in the St. Anna Trough (northern Kara Seas): Causes and consequences,” submitted to Ocean Science Discussions.

I reviewed this paper for Ocean Dynamics 3 times.

We highly appreciate the reviewing efforts by Reviewer #1. We have got many constructive comments allowing a significant improvement of the original manuscript. In what follows, the bold text corresponds to new/revised text introduced in the manuscript.

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In my last review, I made these comments: (i) I asked that the authors change their abstract to more accurately reflect their inability to conclusively attribute heat loss to shear instability. They have done so in this latest version.

Thank you for acknowledging that fact. We have made further efforts in that direction by rewriting the third sentence of the abstract as follows: “Although we cannot substantiate our conclusions by direct observation-based estimates of mixing rates in the area, we hypothesize that the enhanced vertical mixing along the St. Anna Trough eastern flank favors the upward heat loss from the intermediate warm Atlantic water layer. Modeling results support this hypothesis. The upward heat flux inferred from hydrographic data and model simulations is of $O(30-100) \text{ W m}^{-2}$ ”.

(ii) I asked the authors to estimate the uncertainty in their heat loss estimates in Section 4.2 based on undersampling. They have responded with an estimate of the uncertainty in their estimate of the horizontal temperature gradient of $1 \text{ degC} / 10 \text{ km}$. I have two comments: First, I would like to see how they estimate this (presently it is “not shown”).

This comment is similar to issues #12 and #13 made by Reviewer #2. The horizontal temperature gradient was estimated based on CTD data from the on-slope stations at 81°N . To make this clear we have:

1) Depicted these stations with temperature and heat content numbers in Fig. 2 as of other stations employed for our analysis (see Fig. 2 below).

Fig. 2. Map of the northern Kara Sea showing the St. Anna Trough (ST). Arrows show the Fram Strait branch of the AW inflow into the Arctic Ocean which recirculates in the ST (red arrows, SFSBW) and follows the continental margin (yellow arrows, FSBW). Crosses depict the positions of CTD stations taken in September 2009 at two sections crossing the ST at $\sim 81^\circ\text{N}$ and 82°N . Red squares and circles identify stations taken through the core of the SFSBW inflow and outflow to/from the ST, respectively. The yellow square identifies a station taken through the core of the FSBW boundary current. The pink square depicts the mooring position. The pink and blue squares

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with gray shading identify the stations used for estimates of uncertainty in the vertical heat flux due to spatial under-sampling of the AW jet. The first (yellow/red) number shows the FSBW/SFSBW core temperature (in °C) in September 2009. The first pink and blue numbers give the temperatures at 110 m. The second (white) number is heat content (in MJ m⁻²), computed relative to the freezing temperature, between 30 to 90 m depth. The third (black) number denotes the station number.

2) Added new text below line 10, page 552: “At 81°N, the horizontal cross-slope temperature gradient between sts. 26 and 27 at 110 m (depth of the temperature maximum at st. 25 – Fig. 3a) is 0.18°C km⁻¹ and the horizontal cross-slope gradient of heat content is 16.25 MJ m⁻² km⁻¹ (Fig. 2). ”.

Second, I am still looking for an estimate of the uncertainty in the vertical heat flux owing to spatial undersampling.

Following this comment we added new text right after the sentence added above introducing an estimate of the uncertainty: “We hypothetically extend this gradient further off-slope to st. 26 in order to obtain an estimate of uncertainty related to spatial undersampling of the relatively narrow AW jet between sts. 25 and 26. This approach gives heat content estimates from 457 MJ m⁻² to 629.75 MJ m⁻² in ~4 km to 15 km off st. 26, respectively (note that the distance between st. 25 and 26 is ~16 km). This suggests the upper bound of potential heat content underestimate at st. 26 to be 173 MJ m⁻².”.

We also added the following: (i) below line 12, page 553: “An estimate of the uncertainty in the vertical heat flux owing to spatial undersampling of the AW jet at 81°N is obtained based on the heat content underestimate by 173 MJ m⁻², which reveals the heat flux lower bound of ~50 W m⁻².”; (ii) at the very end of the next paragraph (below line 21, page 553): “Finally, the discrepancy between estimates derived from simulations and CTD data can also be explained by spatial undersampling of the AW jet over the ST eastern slope. The lower bound of heat flux at ~50 W m⁻² retrieved from the

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CTD data is consistent with the 7-year mean (30-50 W m⁻², 2003-2010) simulated vertical heat fluxes.”.

Also, the final paragraph in Section 4.2 discusses many ideas, but I cannot find a conclusion. Can you summarize your thoughts at the end of this section?

Addressing this comment we introduced a new last paragraph in section 4.2, page 553: “In summary, both the CTD data and the model simulation suggest that the upward heat loss from the AW layer in the SAT eastern flank significantly exceeds that over the Siberian continental margin. The spatial undersampling results in relatively high uncertainty of our observationally-based heat loss estimates. However, even at the lower bound of ~50 W m⁻² the amount of heat transferred to the upper layer is capable of modifying the sea ice cover, as we discuss in the following section.”.

(iii) My final comment from the previous review was that your stated plans for another paper on the same subject using a different model implied that you might be covering the same material twice. Well, we will have to wait and see about that.

Reviewer #1 maybe refers to the manuscript by Dmitrenko, Kirillov, Aksenov, Ivanov, Schauer, Polyakov, Janout, Lien, Coward and Barber entitled “Atlantic Water inflow into the Arctic Ocean through the St. Anna Trough (northern Kara Sea)” that is drafted for submitting to Progress in Oceanography (PO). The PO manuscript focuses the water mass structure of the SAT outflow to the Arctic Ocean based on mooring data and CTD transects. In contrast, the present Ocean Science (OS) manuscript is focused on the vertical heat flux in the SAT and its impact on the ice cover. There is no overlap between these two manuscripts whatsoever, except for introductory figures showing position of moorings, CTD transects and key CTD profiles. In both manuscripts, simulations are used only to strengthen the results obtained from the observational data. The manuscript dedicated to the AW simulation in the SAT based on the MITgcm configuration developed in the Univ. Hamburg is scheduled for the near future; but we didn’t start working on that yet. To avoid further misunderstanding on

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this issue, we made the choice of submitting the present manuscript to the OS, where the preliminary draft is publically available online, thus stopping any speculations on the double submission issue.

Please also note the supplement to this comment:

<http://www.ocean-sci-discuss.net/11/C207/2014/osd-11-C207-2014-supplement.pdf>

Interactive comment on Ocean Sci. Discuss., 11, 543, 2014.

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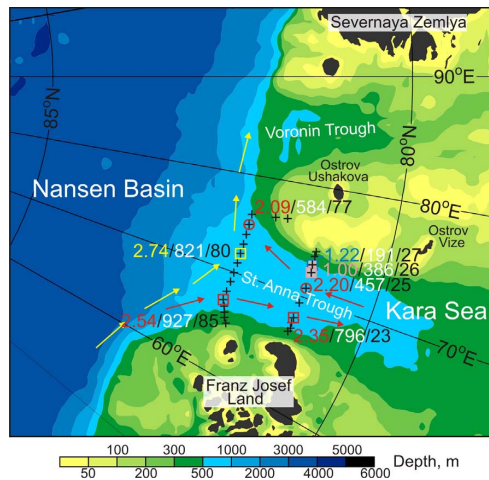


Fig. 1. Fig. 2

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