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Ocean Science Discussions

Interactive comment on "Hydrography, transport and mixing of the West Spitsbergen Current: the Svalbard Branch in summer 2015" *by* Eivind Kolås and Ilker Fer

Anonymous Referee #2

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Review of "Hydrography, transport and mixing of the West Spitsbergen Current: the Svalbard Branch in summer 2015" by Kolas&Fer

The manuscript presents data from three shipboard sections occupied in summer 2015 northwest of Svalbard. The analysis focuses on explaining the along-pathway cooling of the West Spitsbergen Current concluding that vertical turbulent heat flux is not sufficient and that bottom mixing with shelf waters also makes a contribution. This material is relevant for a better understanding of the inflow of warm Atlantic Water to the Arctic Ocean and its modification processes along the inflow. This is appropriate and interesting for the readership of Ocean Science. The manuscript is well written and presents

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the results in an easily digestible way even though the presented observations and analyses are complex. In my opinion, the authors missed one point in the discussion of their results which I would like the authors to comment upon/include in their discussion. Otherwise, the manuscript should be accepted after the correction of a few small suggestions. Therefore, I recommend minor revision.

Main comment: Inherent to the your interpretation of the presented results are the assumptions that the current is uniform in the along pathway direction, that there is no temporal variability in the current, and that your observations sampled the current at the same time. This does not hold for two reasons: There is strong mesoscale variability and individual shipboard sections may even capture substantial southward flow in the WSC (e.g. Richter et al 2018 Ocean Science). Therefore, one would not necessarily expect volume conservation between consecutive (in along pathway distance) synoptic sections. Put another way, differences between the transport in consecutive sections do not need to correspond to volume transport loss from the current. Furthermore, there is a seasonal cycle in the temperature of the WSC and its extension. The maximum in temperature of the Atlantic Water (well below the highly stratified low salinity cap on top of the current) is reached later in the season north(east) of Svalbard (recent A-TWAIN results) compared to the WSC west of Svalbard. In my opinion this is mainly due to the northward advection of a characteristic seasonal cycle set further south. For example, consider that the seasonal cycle has a slope of 2.5°C in 5 month (=0.5°C/month) west of Svalbard (e.g. von Appen et al 2016 Journal of Physical Oceanography). If one – for the sake of argument – considers a mean advective velocity of 0.1m/s (also quoted on page 10 line 32), the advection from your section C to your section A (distance of 170km) would take approximately 19 days. In those 19 days, the current (due to the seasonal cycle) at the southern location would have warmed by approximately 0.3°C. Put another way, at any one point in time (prior to the seasonal maximum in AW temperature), one would expect it to be 0.3°C cooler at section A than at section C. This corresponds to a horizontal temperature gradient of 0.18°C/100km, which is a number not substantially different from your 0.2°C/100km (page 10 line 19).

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On top of that comes that your different sections were obviously not occupied on the same day, but with some (consider specifying explicitly) days in between them. I do not want to claim that this explains everything which you see and your interpretation is probably still broadly appropriate for what is happening to the current. Nevertheless, I think it would be worthwhile to discuss these points and to carefully consider where they might (and where they would not) impact your conclusions.

p1l11 Consider adding "We conclude that – at least in summer – convectively-driven bottom mixing. . ."

p1l12 Consider adding "can lead to substantial cooling and freshening of the WSC"

p2l21 Consider adding "These eddies may control"

p2l33 Note that these heat losses (in W/mˆ2) are dependent on the mean advective speed resp. the residence time of the water in the area of cooling.

p4l29 "averaging" Is this averaging in space or in time? Over what distance?

p5l21 Note that the smoothing does not necessarily remove all ageostrophic motions.

p5l28 Before this paragraph might be a good time to present the info on how long it took to occupy the individual sections. Is there e.g. contamination from multiple tidal cycles possibly being represented incorrectly?

p6l2 Here the considerations of my main comment come into play.

p6l26 Does this not require that the transport in the stream tube is exactly constant, not just to +-10%?

p7l27 e.g. Richter et al 2018 Ocean Science present data from 2016 which is similarly warm both near the surface and at greater depths as your observations.

p8l8 Consider "were higher in all sections by (range)." And then provide a range of salinity values.

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p8l17-19 It might be helpful (though not necessary) to show a TS plot to better make this point.

p8l24 At what x-value in your plots would the YP branch supposedly be if it were present?

p9l33 Consider “If . . . follows the f/H contours and there is no synoptic variability between the sections, . . .”

p10l20 Be consistent with using “-0.20°C” versus “0.20°C” in this paragraph.

p11l3 “all vertical diffusive . . . (i.e. directed . . .)”

p11l6 “top”, “bottom” It is not sure which values you refer to. Quote the numbers in your text.

p11l17 “If it is not cooled” Does it have to be cooled?

p12l9 Consider “the qualitative pattern”

p12l14 “weakly-stratified”

p12l35 Vertical or horizontal heat flux?

p13l2 “In winter . . .” Where does this supposedly (based on the reference) happen?

p13l18 Where/how was this average lateral temperature gradient estimated?

p14l14 “less dense waters” Where do these waters come from? How is that pool sustained? You could either elaborate on this a bit in the introduction or (more valuably) you could use this information to do some speculations on how changes in the sources of these water might affect the processes that you looked at/the cooling fo the WSC.

p15l29 This reference appears to be incomplete.

p18 LAIW line: The distinction between “>” and “>=“ is meaningless for a continuous distribution.

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Fig2/3 The near surface stratification due to salinity is really hard to see in this (Fig2) kind of figure. Consider plotting salinity instead of Fig3. The benefit of Fig3 is not obvious.

F6 Would this figure not be more effective with three subplots (1 for transport, 1 for temperature, 1 for salinity) and to have three differently colored lines in each of the subplots for each of the three sections.

Fig7/Fig8 Is 700m equal to the bottom depth here? Consider to have the same spacing (in centimeters on the paper) of the y axis in both Fig7 and Fig8.

Fig7 caption: “Shaded bands” Why are these bands so wide?

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