The Cryosphere Discussions

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# Reply on RC1

Ryan Schubert et al.

Author comment on "The Antarctic Coastal Current in the Bellingshausen Sea" by Ryan Schubert et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-43-AC1, 2021

## Comment #1

This paper uses an exciting data set of seal-borne observations collected over several years in the Bellingshausen Sea to characterise hydrographic conditions – and in particular to examine the development of the Antarctic Coastal Current as it transits the region. The authors describe key features of the flow, in particular how it varies from east to west, and quantify volume transport along its path.

I have a few comments about the methods and structure of the paper, but it is clearly of interest to the community and worthy of publication after minor revisions. I wonder, though, whether The Cryosphere is the best place for it: it's very much an oceanography paper – albeit one about the polar regions – and to my mind it would be a better fit in Ocean Science. I'm not sure how easy it is to shunt papers between the EGU journals, and going through peer review again would be too much like hard work. But ultimately, of course, that's a matter for the authors and the editor and I leave it to their judgement.

- We thank the reviewer for their time in reviewing this manuscript. We appreciate the positive comments as well as your consideration about the most relevant journal. While we agree that this is largely an oceanography paper, we feel that we actually more directly address our target audience by publishing in *Cryosphere* as opposed to *Ocean Science* -- and we certainly agree that we would prefer to avoid another round of reviews. We appreciate all of the constructive comments -- we address them in detail below.

## Overall structure

A good deal of figures in this paper are included in the appendix. I understand that many of these figures are repetitive and look very similar, but they are referenced a good deal in the text, and I cannot help but feel that they should somehow be included in the main body of the paper. Perhaps the authors could compile figures of, for instance, the annual-mean fields for each water mass for the main paper, and leave the summer and winter means for the appendix? Similarly with the section plots – I would prefer to see these plots in the main paper.

- This was a topic that all of the co-authors went back and forth on while structuring the paper; it is helpful to have an external opinion. We decided on only showing Section 3 and referencing the other sections in relation to it, so that the figures wouldn't take up a large amount of space in the main body of the paper, and so that the reader could see more detail of Section 3 instead. However, it is clear that Figures A5 and A6 would best serve the reader if they were included in the main part of the text, which is where we have moved them.

Secondly, I think that the description of the WW, transition layer and hydrography CDW (ie Section 3.2) could be better focussed on the AACC. While the results in this section are interesting – and certainty don't need changing – the message of the paper would be much clearer if the relevance of the hydrographic results to the AACC were made more explicit. In particular, there are a few paragraphs where you have to get to the end before the AACC is even mentioned.

- This is a valid comment, and we agree that the relevance of the hydrography to the AACC should be more clear and a larger part of our discussion in this section. We have carefully revised the section of the manuscript where we discuss the different water masses and include a specific discussion of how the water masses relate to the vertical structure of the AACC.

**Methods**

I am not convinced of the wisdom of changing the width over which the median is calculated when gridding the hydrographic sections (Section 2.3 and Table 1). Given that temperature and salinity are used to calculate geostrophic shear, couldn't changing the width of these bins have a small influence on the description of the dynamics? I think it would be safer to use the same binning window for each section, and then to interpolate over any gaps.

- We agree that binning with a fixed width would be optimal, but our choice was partially based on data availability -- there tend to be more observations along the WAP, where the composite sections are shorter and less observations in the BellS where the sections are longer. We did, however, consider the relative error in our ability to resolve the lateral structure of the AACC by changing the bin width and it did not qualitatively or quantitatively change our results. We now include additional text to state this. Finally, since we are calculating geostrophic transport, the total transport is not strongly affected by the bin width.

Secondly, the authors use the 0% meltwater fraction contour to define the outer limit of the AACC when calculating transport. But they rightly note in the methods that the composite tracer method used to calculate meltwater fraction can't always be relied upon to give the most reliable results. Have the authors investigated the influence that uncertainty in the location of the 0% meltwater fraction contour has on transport estimates? Would the results be more reliable if they used a velocity contour as the outer limit of the AACC instead? By no means do I think big changes are needed, but at the least perhaps a few sentences of explanation would be welcome.

- Both reviewers commented on our choice of the 0% meltwater fraction to define the offshore extent of the AACC. Upon further consideration we agree with the reviewers that a less technical definition would be more appropriate and less dependent on assumptions in the meltwater calculation. We will look into a more straightforward approach using either a salinity threshold at a fixed depth, the point at which net

transport flattens out, or where the dynamic height gradient is smaller than some value. This will lead to an identification of the AACC's offshore extent that is more consistent with the reduction in the geostrophic transport. Note however, that our results on changes in the AACC's transport in the along-coast direction does not change, since the transport is largely confined to the coast, regardless of our detection criteria. The figures and text have been updated to address this change.

Thirdly, the authors use the 400 dbar as their level-of-no-motion when referencing geostrophic shear. My instinct, particularly on-shelf, would be to use the seafloor, but I understand that you sometimes have to choose a level and stick with it. Using 400 dbar, however, does make the velocity plots look a little odd – they all have a flow reversal at 400 dbar that doesn't look physical. Might it be an idea to plot the referenced velocity only above this level?

- We tried a number of different depths for our level of motion and we still feel that our choice of 400 dbar is the best compromise. As mentioned in the text, this is specifically because some sections would intersect the seafloor if we chose a deeper reference level. We now include a sentence in the text that reads:
- "Some sections reveal a slight flow reversal below our reference level, however the bulk of the baroclinic coastal current flow is above this reference level. We have opted to keep it consistent and apply it across all composite hydrographic sections to limit the impact of varying topography."

**Line-by-line comments**

**Line 185** – Section 3.1 feels more like introduction than results – perhaps it would work better in the introduction if it doesn't present any new material?

- This section is left as introductory material without its own separate section number.

**Line 209** – Should Section 3.2.1 be entitled just "Winter Water"? The transition layer is dealt with later on.

- We have changed the title of this section.

**Figure 5** – Would Figure 5 work better in the Methods section, when discussing how the sections were constructed? (And perhaps it could be combined with Figure 2 if the authors are worried about having too many figures?)

- We have moved Figure 5 to the Methods section.

**Line 281** – It feels a little odd to say that surface temperature is uniform, and then to quote its average temperature.

- This was primarily to compare the reference section to the other sections. However, we agree that this could be a bit confusing and we have removed the statement that the temperature is uniform.

**Line 282** – The authors say that "The uniformity of surface layer properties is a feature that is consistent across all sections in the Bellingshausen Sea", then a couple of sentences later say that "surface salinity shows substantial lateral variations", albeit in

section three. This makes for a clunky paragraph that I'd recommend re-wording.

- We will modify the text here to read "the uniformity of surface temperature" instead of "the uniformity of surface layer properties". There are variations in the temperature from section to section in the Bellingshausen Sea, but they are quite small. This section will be revised to make this information clearer.

**Line 321** – "This is thought to be due to continued entrainment" – is this this authors' suggestion or does it need a reference?

- This is a suggestion that we have made. We modify the text to read that "We propose that this occurs due to continued entrainment of meltwater by the coastal current from the melting ice shelves."

**Line 327** – In what way is salinity the "dominant change"? Does it have the biggest effect on density?

- We mean to say that the most noticeable change in properties is in salinity. However, it is also true that salinity has the largest effect on density here. We have now clarified this in the text.

**Line 334** – "The deeper change in the stratification is likely due to the outflow of glacially modified CDW and marks the base of the AACC". Is there evidence for this, or is it a question of the definition of the AACC?

- We agree we should have included a citation here. There are two recent papers that have been accepted for publication in the JGR that make the case for a salinity driven overturning circulation in the Bellingshausen Sea that would support this statement. We have included citations to Ruan et al. (2021) and Schulze Chretien et al. (2021) in the revised text.

**Line 381** – I initially thought that APCC was a typo, so maybe spell it out to avoid confusion? The acronym isn't used all that often.

- At the first introduction to the Antarctic Peninsula Coastal Current, we now acknowledge that this current extends beyond the WAP and we will refer to it at the Antarctic Coastal Current (AACC). We have removed the acronym APCC.