



EGUsphere, referee comment RC1  
<https://doi.org/10.5194/egusphere-2023-21-RC1>, 2023  
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## **Comment on egusphere-2023-21**

Anonymous Referee #1

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Referee comment on "The Weddell Gyre heat budget associated with the Warm Deep Water circulation derived from Argo floats" by Krissy Anne Reeve et al., EGU sphere, <https://doi.org/10.5194/egusphere-2023-21-RC1>, 2023

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In this work, the authors carry out a heat budget analysis in the Weddell Gyre using a suite of observations, including a gridded climatological product that covers 2002-2016. They find that the budget is very noisy on the grid scale, with local errors that are sometimes as large as the quantity being estimated. However, the authors claim that integrating over sufficiently large spatial scales allows them to make quantitative statements about the relative importance of advection and diffusion in both the horizontal and vertical directions. Specifically, they find that in the interior of the Weddell Gyre, net warming from horizontal turbulent heat diffusion is largely balanced by net cooling from mean horizontal advection. In contrast, in the southern limb of the Weddell Gyre, the relative contribution of these two terms switch signs, i.e. net cooling from horizontal turbulent heat diffusion is largely balanced by net warming from mean horizontal advection. As far as I am aware, this key result is novel, and it is certainly relevant to our understanding of the Weddell Gyre heat budget.

Observational analysis in the Weddell Gyre is extremely challenging due to the sparsity of measurements from that remote, harsh part of the world. The authors have managed to extract some novel estimates from these sparse observations and noisy heat budget by integration. The paper is very thorough and detailed, and it contributes to a growing body of work that the lead author has been assembling in recent years.

I do have some concerns that mostly have to do with how some of the results are presented. Although the authors have been up front about the errors in their estimates, I believe the errors should be emphasized even more in certain plots (e.g. the spatial maps). For example, when comparing Fig. 2a with Fig. S8, we see total propagated errors that are at least as large as the estimates themselves, although the saturated color bars make it difficult to compare in some regions. It is not clear to me whether some of the features in the estimate maps that are discussed in the text (e.g. the bands of alternating convergence and divergence) are robust, given the size of the propagated errors. Overall, after some edits for clarification, this manuscript will make a valuable addition to the literature; I recommend that this article be returned for minor revisions. I have included some specific suggestions below; I hope that they are helpful.

**Text**

- Line 55: Change to "en route" (it's a phrase borrowed from French)
- Line 71: Is the seasonal cycle "unresolved", or has it been excluded in your analysis in this paper? Here it's not clear whether you are saying that Argo does not resolve the seasonal cycle, or if you have excluded it by discarding everything above your dynamic upper boundary. Please clarify in the text.
- Line 130: Shouldn't this be "the rate of change of heat storage of a certain ocean volume"? It's the rate of change that is affected by the net flux.
- Lines 73-74: Is this elongation of the "shape of the area of influence" a consequence of how the objective mapping was calculated? Please clarify in the text: why does the f/H fractional scale alter the shape of the area of influence?
- Lines 202-206: I suggest moving this detailed description to the start of section 4.2, just before you start discussing it.
- Suggestion for new figure: I would suggest adding a new, separate figure to show your two analysis regions of integration in a more visually intuitive. At present, the depictions of the regions are incorporated into an already-busy figure, and the blue contour risks causing some confusion about the extent of the regions, even with the stippling (e.g. the portion of a blue contour in the bottom right of Fig. 2d is distracting). The new figure could have isobaths, streamlines, and stippling to show exactly where the two regions exist, with no extra information competing for attention.
- Lines 211-212: Why is this "small patch of divergence" being singled out? Its significance is not obvious, and given the large size of the propagated errors (Fig. S8), it's not clear if these features are robust.
- Section 4.1 overall: As discussed above, the large propagated errors calls the robustness of these features into question. It's not clear if detailed interpretation of these features, especially ones with small magnitudes, tells us very much. By comparison, the results that come out of the later large-scale integrations seem more robust. I suggest de-emphasizing some of the discussions of specific, detailed features.
- Line 224-225: It does imply that the net effect of the vertical advection is warming. The second part of the phrase could be somewhat confusing. I suggest rephrasing this as "...through the top, implying that the net effect of vertical advection is to warm the layer."
- Line 242, 245: Replace "chapter" with "section".
- Line 342-344: Change to a separate sentence, i.e. "There is an overall decrease in temperature along the southern limb of the Weddell Gyre, and an overall increase in temperature along the northern limb (Fig. 6)." That way the order of the text matches the order of someone reading the figure left-to-right.
- Line 458: Is the vertical grid uniform? A changing vertical grid could also introduce a spatial scale bias in the estimates.
- Line 478: Perhaps change "negative air-to-sea heat flux" to "radiative heat loss" for simplicity?
- Section 5.2.2: This section is very thorough, but it is very long and cumbersome. If allowed by EGU formatting, it could benefit from paragraph headers (sometimes called inline headings) to help orient the reader. Alternatively, it could be section 5.3, broken up into smaller sub-subsections.
- Lines 483-484: This statement doesn't work as a standalone phrase. Perhaps rephrase as "

## Figures and captions

- Figure 1: The red stars are very difficult to see. Perhaps make the markers much bigger and change the color so they stand out better?
- Figure 1 caption: Isn't "conservative temperature at the depth of the temperature maximum" just "maximum temperature?"
- Figure 1 caption: Change to "(1) Gunnerus Ridge, (2) Astrid Ridge, and (3) Maud Rise" instead of using the "respectively" construct.
- Figure 2: This figure risks being unintentionally misleading. If I have understood

correctly, on a local scale, the propagated error is often just as large as the estimate itself, which throws the robustness of these spatial patterns into question, patchy as they may be. There is a risk of over-interpreting features, as they may reflect biases in the estimates. The authors have been very up-front and thorough about these biases in the manuscript overall, but casual readers may get the wrong idea glancing at these figures. I'd suggest moving the spatial patterns to the supplemental information and focusing on the integrals, and/or putting the propagated errors in their own column next to the mean terms for easy comparison.

- Figure 3 caption: Explain the meaning of the shaded areas here in the caption, since this is where they are first introduced in the figures.
- Figure 6: I would suggest making this figure even more visually obvious – consider that people may only glance at it briefly. You could add a dashed vertical line separating the northern limb from the southern limb. On their side of that line, you could add a text box with either “northern limb” or “southern limb”, just to make it explicit and clear. I'd also suggest using a different symbol for 30°W (north) and 30°W (south).
- Order of Fig. 5, 6, and 7: Perhaps figure 6 should come before figure 5? You could introduce the temperature tendency first and then show the integrated budget terms afterwards, as a way of explaining these temperature trends.
- Figures 5 and 7: Please add y-axis labels for every panel, as the unit by itself is not sufficient. What quantity are we looking at?
- Figure 8: The inset figure appears to be distorted, and the y-axis labels have been cut off. As for the main figure, I suggest using a legend to help quickly orient the reader as to the meaning of the symbols and numbers. At present, trying to understand the figure from the caption is visually overwhelming. You may also want a simple figure with a legend for talks. If you get this figure right, lots of people will show it in their own talks, summarizing your important results.)

### **Additional references**

I would suggest adding two references to the paper, if the authors agree that they are suitable. (Note: I was *not* involved with either of these papers.)

First, there is a recent numerical modeling study that explored the seasonal and interannual variability of the Weddell Gyre in a high-resolution model. I suggest that the authors mention this in the discussion section; it is a concrete illustration of seasonal and interannual biases, which are relevant to this climatology.

Neme, J., England, M. H., & Hogg, A. M. (2021). Seasonal and interannual variability of the Weddell Gyre from a high-resolution global ocean-sea ice simulation during 1958–2018. *Journal of Geophysical Research: Oceans*, 126, e2021JC017662.  
<https://doi.org/10.1029/2021JC017662>

Second, the authors end the paper by mentioning the vulnerability of the Filchner-Ronne ice shelf. There is a more recent reference that explores the tipping point beyond which the cavity beneath the Filchner-Ronne Ice Shelf will flood with warm water:

Naughten, K.A., De Rydt, J., Rosier, S.H.R. et al. Two-timescale response of a large Antarctic ice shelf to climate change. *Nat. Commun.* 12, 1991 (2021).  
<https://doi.org/10.1038/s41467-021-22259-0>