Response to reviewer 2 for EGU2023-21

We thank the reviewer for their comments, and are happy to make the changes as suggested. The changes are provided in response to each comment (in blue) listed below, with line numbers referring to the manuscript with tracked changes:

- Line 34 (plain language summary): This explanation of CDW transformation is incomplete. Some of this water mass becomes lighter by mixing with surface waters.

Line 34: "Warm and salty deep water enters the Weddell Sea in its east, and is transported by the gyre circulation first southward, then westward, and back northwards again following the continental boundaries. During this circulation, some of this water becomes lighter by mixing with the overlying surface waters, thus shoaling as it circulates. It also loses heat to the atmosphere and by contact with the ice shelves. When this occurs, the water becomes heavier, as also by salt released during the freezing of sea ice."

- Line 171: The unresolved time variability term is also unknown.

Line 177: "Thus, in addition to the unknown time variability term, $d\Theta/dt$, we also have an unknown 5th term in the heat budget in Eq. 1.1 and 1.2, R"

- Line 218: Sorry for not mentioning this earlier, but is this double-gyre a robust circulation feature? This is the first time I have encountered a description of a sub-gyre in the eastern Weddell.

Reeve et al. (2019) is the first comprehensive study showing the synoptic scale horizontal circulation from in situ measurements, which shows the double-cell structure of the Weddell Gyre. It has also been shown in numerical model simulations previous to this work (Beckmann et al., 1999; Timmermann et al., 2002), and hypothesized in early observation-based studies (with the spatial limitations of observations preventing more than speculation): Matano et al., (2002) suggested the cause is topographic steering where the SW Indian Ridge constrains the flow in the northern limb east of the Prime Meridian, and Orsi et al., (1993) observed that the double-cell structure is more prominent in deeper layers, which may be why it has been challenging to observe. More recent studies providing estimates of volume transports across various ship-based transects in the Weddell Sea also support the concept of a double-gyre structure, in that the eastern sub-gyre exhibits stronger circulation (and thus transport estimates) than in the western Weddell Sea (see figure 7 in Reeve et al. 2019). The lead author has preference for the terminology of "sub-gyres", because it is not clear how significant, or how synced, these sub-gyres are, and there also appears to be a network of sub-gyres in play across the entire Southern Ocean (Sonnewald et al., 2023).

We added the following sentence in the opening to section 4, line 239:

"While large uncertainties are associated with the eastern part of the eastern sub-gyre, numerical model simulations (e.g., Timmermann et al., 2002), historical observations (e.g., Orsi et al. 1993), and direct volume transport estimates support the concept of a double-gyre structure in the Weddell Sea (e.g., Fig. 7 in Reeve et al., 2019)."

- Line 270: Sorry if I missed this, but it would be helpful to state why the analysis focuses on the region west of Maud Rise (i.e. because the uncertainty is too great in the eastern Weddell).

We explain this in the results section part 2, when integrating zonally. Line 312:

"For both regions, the area east of Maud Rise (3° E) is omitted, due to large uncertainties east of Maud Rise (discussed in Section 5)."

- Line 475: According to Table 3, the heat budget for the IC region does not close.

We updated the sentence accordingly (now line 539), and checked the rest of the document for any related sentences in need of updating. Thanks for pointing this out (it was remnant of the results before we updated the analysis).

"While the heat budget does not close on regional scales, it does approximately close when integrating over the open southern limb west of Maud Rise (SL), but not over the interior west of Maud Rise (IC). Nonetheless, important and useful information can be provided from comparing the four resulting heat budget terms."

References

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