

Evaluation of MITgcm-based ocean reanalyses for the Southern Ocean

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We thank the Reviewer for the constructive comments. The reviewer's comments are displayed in *italics*, replies are shown in **bold text**.

General comments

I thank the authors for all their efforts in response to my previous comments, especially adding some quantitative comparisons and the mixed layer depth analyses. I have some new comments below, but these are all very minor and I think the authors have produced a nice comparison that will be quite useful (especially the warning about continental shelf properties) to the Southern Ocean community. I'm happy to see this published after the authors have taken the comments below into consideration.

Thank you very much for your comments.

Specific comments

Line 204: I think it would be helpful to compute the mean too shallow MLD bias for each of the models compared to WOA.

As suggested, we computed the mean MLDs for all ocean state estimates and WOA (Lines 204-206).

Lines 205-211 and Fig. 7: I think this figure is really helpful. My only suggestion is that, since the authors have already computed MLD for different months from WOA for Fig. 6, they add the WOA seasonal cycle of MLD for these two locations in 7c and 7d (similar to what was done for sea ice in 2d and 3d, even though I realize they will not be able to give a variability range for the MLD since WOA is a climatology).

In the revised version, I still keep this figure without including timeseries from WOA. All of my plots are either created by plotting WOA directly or plotting ocean observations directly. We do not want to extract data from WOA and plot them because (1) WOA is an interpolated product and (2) there are likely not enough observations to support and evaluate the temporal variability of WOA at these locations.

Lines 212-221: Apologies if I missed it, but I never saw it explicitly mentioned what the error in the RMSE is computed with respect to. Is it the WOA values? Also, I know it's discussed later specifically for the Ross and Weddell Gyres, but should there be some mention here of the general Southern Ocean estimated natural variability for the deep temperature and salinity so the reader can see how the variability in the RMSE shown in Figure 8 compares to the observations?

The manuscript is revised as suggested (Lines 214-216).

Technical corrections

Line 42: When the authors state “including GECCO2 (a prior version)”, they have not yet introduced GECCO3 and thus I think “a prior version” could be confusing. Suggest expanding the phrase to something like “a prior version of the GECCO3 reanalysis discussed below”.

Done.

Line 59: Suggest changing “improve the Southern Ocean” to either “simulate the Southern Ocean” or “improve the simulation of the Southern Ocean”.

Done.

Lines 108-109 and Table 1: From Verdy and Mazloff (2017), I thought B-SOSE iteration 105 used ERA-Interim, not ERA5, for the initial atmospheric forcing.

Thank you for pointing this out. The manuscript is revised as suggested.

Lines 144-145: Should “small differences between ECCOv4r5” be “small differences between B-SOSE and ECCOv4r5”?

Fixed.

Line 161: I think “show good agreement at a similar level” should be “show good agreement in February at a similar level”.

Done.

Lines 186-187 and Figure 5: When first looking at Figure 5, it was hard for me to see a fresh bias in the surface salinity between the AP and the Ross for any of the solutions except B-SOSE because of the different color scale for WOA. The contour lines certainly help with this, but I think the different scale for the WOA salinity should be explicitly noted in the Figure 5 figure caption.

Thank you for pointing this out. The manuscript is revised as suggested.

Lines 197-198: I think the authors should add a reference for the choice of a 0.03 kg/m difference for the definition of MLD.

Done.

Line 199: Typo, missing “are” between “coincide with or” and “close to”.

Fixed.

Line 331: “Fig. 12” should be “Fig. 13”.

Fixed.

Line 365: I think “presents” should be “present”.

Fixed.

Line 387: Should the location of the Totten Ice Shelf be indicated on some figure?

The location of Totten ice shelf is included in Figure 1.

Line 453: Should “(Figs. 12,14)” be “(Figs. 12,15)”?

Done.

Line 492: Suggest putting “However, “ at the beginning of the sentence with “MITgcm-based ocean reanalyses...”.

Done.

Line 493: Suggest changing “your research goals” to “their research goals”.

Done.

Figure 5: Did not see the “red and blue ellipses” mentioned in the figure caption.

This sentence is removed in the revised manuscript.

Captions for Supplementary Figures 3-6: The figures in the main text referred to in these captions have not been updated (e.g. Supp. Fig. 3 caption says “Close-ups of Figs. 9i and 10i” when it should be “12i and 13i”).

Thank you for pointing this out. We revise the SI as suggested.