

Interactive comment on “A modelling study of the hydrographic structure of the Ross Sea” by M. Tonelli et al.

Anonymous Referee #3

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Review of "A modelling study of the hydrographic structure of the Ross Sea," by M. Tonelli, I. Wainer and E. Curchitser.

In this paper the authors describe a circumpolar ocean/sea-ice/ice shelf model of the Southern Ocean (using the Regional Ocean Modeling System) that was created in order to examine (not in this study, but in the future) possible changes in bottom water formation and its effect on the Global Thermohaline Circulation. The utility of the model for this purpose is examined here by using Optimum Parameter Analysis (OMP) to study the types of water masses created by the model in the Ross Sea, which is an important site for Antarctic Bottom Water formation.

This model appears to be a very useful tool for studying possible changes in bottom water formation. It is impressive that it manages to keep High Salinity Shelf Water on

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the Ross Sea continental shelf after 100 years (not an easy task with a dynamic sea-ice model around Antarctica, although the surface relaxation of salinity probably helps). The OMP is also a nice tool to examine the different types of water masses in the Ross Sea. However, I feel much more needs to be done besides just showing a TS diagram and a water mass contribution plot for one section (which probably isn't in the best location...more on that below) before it can be shown that the "Current configuration allows very realistic representation" (line 16, pg. 3432) of the Ross Sea water masses and thus is a good tool for looking at Antarctic Bottom Water (AABW) formation.

1) There isn't enough information given on how the OMP is used. None of the terms in eq. 1 are defined and, although most are obvious, is "O" supposed to be Oxygen and "PV" potential vorticity? No mention of oxygen is given (or whatever "O" is) and the one brief mention of potential vorticity (line 16, pg. 3441) does not discuss at all how the PV is calculated or what value of PV is used to define the different water types.

2) There is no comparison of Figure 4 to observations. Couldn't the authors use the Orsi and Wiederwohl climatology to make a similar section from observations?

3) The results are limited to a single cross-section. If the utility of the model for creating AABW is to be judged, than I think it would be helpful to look at quantities over the entire Ross Sea shelf. The Orsi and Wiederwohl TS plot that Fig. 3 (which, I think, is just along 165W) is compared to is for the entire Ross Sea. What about comparing actual temperature and salinity cross-sections? Volumetric comparisons of water masses (observation based volume estimates are available in Orsi and Wiederwohl)?

4) Also, if just one section is to be examined, shouldn't it be somewhere along the western Ross Sea (specifically, near the Joides and/or Drygalski troughs, which are well to the west of 165W) where the modified Shelf Water continues over the shelf break as new AABW?

5) The paper does examine the water masses (CDW and Shelf Water) that go into making AABW, but never directly looks at how the model is doing in creating AABW

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itself.

I have several other specific comments listed below (although most of those are pretty minor). I think this model could be a good tool for doing what the authors hope to do with it, but my summary recommendation is that the manuscript be sent back to the authors for major revision including a much more extensive comparison with observations.

SPECIFIC COMMENTS

3432/9-11: I don't think the details about the CORE normal year forcing need to be in the abstract. I suggest removing this sentence.

3433/18 and Figure 2: I think Cape Adare and Cape Colbeck should be marked on a figure somewhere. I suggest adding an inset to figure 2 that shows a blowup of the Ross Sea (or just showing the Ross Sea as figure 2) with Cape Adare and Cape Colbeck labeled and the cross section shown.

3433/21-22: The current along the continental slope is not the eastward flowing ACC, but rather the westward flowing southern limb of the Ross gyre (as the authors mention previously).

3433/26-3434/2: The Ross Sea Polynya likely produces much more ice than the Terra Nova Bay (TNB) polynya (Martin et al. (2007), Journal of Marine Systems) and has a major effect on HSSW formation. It should probably be mentioned along with the TNB polynya.

3435/2: I think a more up to date reference for ROMS (e.g. Haidvogel et al., 2008) should be used.

Section 2.1: Was tidal forcing used in the model?

3435/5-6: I think it's a little deceptive to state that the resolution reaches "less than 5 km over the continental shelf". The resolution is less than 5 km at the model southern

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boundary at 85.5S, but the zonal resolution at the southernmost open ocean point ($\sim 78\text{S}$ in the Ross Sea) is 11-12km. I don't know how the meridional resolution is changed w/ latitude, but I suspect the meridional resolution at 78S is similar to the zonal resolution. I suggest rephrasing this to something like "reaching less than 5 km at the southern model boundary".

3435/28: I don't think the Holland and Jenkins (2001) reference is appropriate here as it is more about adding an ice shelf to an isopycnic coordinate model than the heat and salt fluxes in any kind of sea-ice model.

3435/28-3436/7: What kind of mechanical friction is used between the ice shelf base and the top water surface?

3437/5: I think Fairall et al. (1996) is COARE2.5. Doesn't ROMS now use COARE3.0? If so, I think the reference should be Fairall et al. (2003).

3437/eq.1: As mentioned above, please explicitly define all the terms in this equation. Also, if this what is used, where do "O" and "PV_Obs" come from?

3438/11-17: I think the density comparison is actually better than the authors think. Orsi and Wiederwohl used neutral density while it looks like the authors are using sigma-0. If the authors recalculate their TS plot to use neutral density, I'd bet it's a lot closer to what Orsi and Wiederwohl got.

3439/22-23: Again, try using neutral density (as in Orsi and Wiederwohl) instead of sigma-0.

3440/4-6: These results may suggest that the model is reproducing AABW formation, but then why not explicitly compute the modeled AABW formation?

3440/16: The authors could explicitly calculate the modeled Ross Ice Shelf basal melt rate and compare it to observed estimates to prove that the basal melting is reasonable.

Table 1: 0.5 C seems cool for end member CDW. I guess that's what the model has

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(Figure 3), but can the authors speculate as to why the offshelf CDW is that much cooler than reality? Also, do the types for SW and ISW overlap? Is that why Figure 4 shows both $\sim 100\%$ SW and $\sim 100\%$ ISW in the ice shelf cavity and along the bottom of the open shelf close to the cavity?

Figure 1: I think this figure needs to include an extra line below the farthest offshelf ISW line showing HSSW going offshelf (as in Figure 1 of Smethie and Jacobs). The figure as drawn implies that AABW is formed just from ISW and CDW, when in fact the volume on the continental shelf of HSSW is much greater than that of ISW (Orsi and Wiederwohl) and the HSSW is a critical component of the AABW.

Figure 4: See Table 1 about overlapping 100% SW and ISW. Also, I don't think the phrase "at the meridional section along the 165 W Latitude" needs to be repeated four times in the figure caption.

TECHNICAL CORRECTIONS

3432/8: Add "the" between "using" and "Regional Ocean Model".

3433/11: Typo, "the the".

3433/15: This should be "Smethie and Jacobs" (only two authors).

3433/18: Typo, "105" should be "10⁵".

3434/17: Should "taste" be "task"?

3435/24: Change "is used" to "are used".

3437/2: Remove "a" from "includes a 6 hourly 10 m winds".

3438/2: Typo, "were were".

3441/7: Typo, "ate".

3444/2: There is only one "S. Jacobs" author.

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