**Ocean Science
Discussions**

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

M. Tonelli et al.

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Response to referee #1

I would like to thank reviewer #1 for his helpful and very constructive comments. I have accepted all of them and introduced the comments and suggestions in the text.

The point-by-point response follows:

1. "It is never really explained what the authors mean by "The Ross Sea". Given its quoted size (section 1.1), it appears to be the continental shelf only, north of the Ross Ice Shelf. I assume that this is the region that the T-S scatter plots are prepared for (Fig. 3). This would have been much clearer if the first figure was what is now Fig. 2 (the model domain map), with a large inset or extra panel showing just the Ross Sea,

defining the area for which Fig. 3 was created, and labeling all the features that come up in the text (e.g., Cape Adare and Cape Colbeck, and the RIS)."

What is now Figure 2 (the model domain map) will be shown as Figure 1; a panel showing just the Ross Sea, labeling all the features that come up in the text (e.g., Cape Adare, Cape Colbeck and the RIS). Figure 1 was removed, since it is only cited once to describe the dense water formation under the RIS.

2. "The principal conclusion from this study is that the model does a reasonable job of reproducing the distribution of water masses as determined by comparison with Orsi and Wiederwohl (2009; OW09). So, the paper should show this..."

The reviewer is right. The visual comparison will be much clearer with an observation TS diagram shown on a side panel. We have added a NODC TS to the text as Figure 2.

3. "Along the same lines, the methodology for partitioning water mass contributions (as shown in Fig. 4) can be applied to real-world T-S, either Levitus climatology (i.e., your model's initial state) or OW09. Do the model biases relative to OW09 arise because OW09 is different from Levitus, or because your model shows that Levitus is not consistent with the CORE normal-year forcing and/or the model physics? At this stage of the analysis, explaining why the model drifts away from Levitus initial conditions is probably more useful than comparing with an extra validation data set (OW09) which has its own data limitations. It would really be interesting to see how different Fig. 4 panels were, between Levitus and the spun-up model."

There are many potential reasons for model biases, and certainly consistency between initialization fields and forcing could be one of them. The choice for validating against OW09 data set was the consideration that this data-set would be the most accurate for the Ross Sea since it consists of a high-resolution set of horizontal property distributions combined into a new climatology, which in turn is the basis of a fine volumetric psi-S census of all Ross Sea water masses. Therefore, very different than Levitus (low

resolution, summer bias).

4. "...but nothing in the paper really helps us know whether a specific feature of your model is important to getting the Southern Ocean state right. If you are doing better than other models (not yet shown), is it because of the model resolution or structure, the quality of sea-ice or ice-shelf physics, the use of terrain-following coordinates, or ???"

It is the Ice-shelf thermodynamics the novel feature in the regional implementation of this model that accounts for getting the Southern Ocean state right (Meccia et al, 2013 in revision). This is emphasized in the text.

5. "I really don't understand the choice of the 165oW transect (Fig. 4) to illustrate model performance. The water masses of the Ross Sea are spatially variable; almost all the really dense shelf water is in the western half, and the only significant outflows of AABW are from the Glomar Challenger and Drygalski troughs in the west."

The referee is correct that the choice of the 165°W transect may have not been the best to quantify the dense waters. The water column in the western RS is examined at 175°E (new Figure 1). Figures 3 to 7 show the new results.

6. "Given that there is no comparison of water mass distributions between your model results (Fig. 4) and either real-world data or other models, I have no way of knowing whether the Fig. 4 panels are reasonable. However, I cannot even accurately interpret them. There are several issues here:"

a. "Table 1 suggests that there are 4 independent seawater types involved in the fitting procedure. But..."

We cannot separate 4 water masses using only Temperature, Salinity and Potential Vorticity. The ISW contribution was computed using HSSW sea water type, although it was decided to show only the ISW since this transect is placed on the eastern RS. A different separation scheme including HSSW is provided for the western transect.

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Now, we first run OMP to separate ISW, HSSW and LSSW over de continental shelf. On a second run we separate SW, CDW and AASW along the 175°E transect up to 65°S. This was performed for our modeled results and for NODC data for comparison.

b. "Equation set (1) is really misleading..."

Equation 1 is re-writen the following way: The SWT contributions or fractions xi for each data point are obtained by finding the best linear mixing combination in parameter space defined by temperature (θ), salinity (S) and potential vorticity (PV) which minimizes the residuals in a non-negative least squares sense (R).

$x\_1\theta\_1 + x\_2\theta\_2 + x\_3\theta\_3 = \theta\_Obs + R\_\theta$

$x\_1S\_1 + x\_2S\_2 + x\_3S\_3 = S\_Obs + R\_S$

$x\_1PV\_1 + x\_2PV\_2 + x\_3PV\_3 = PV\_Obs + R\_PV$

$x\_1 + x\_2 + x\_3 = 1 + R\_mass$

where the observed values of temperature TObs , salinity SObs and PVObs with their respective residuals R define the columns on the right-hand side. The values Ti , Si and PVi (i = 1, ..., 4) represent the predetermined (known) parameter values of the 3 source water types for each parameter. The last row expresses the condition of mass conservation.

c. "In Fig. 4, I get the sense that the sum of all water masses is not 100%."

The reviewer is correct. Thee ISW distribution was obtained in separate computation considering HSSW which yielded the water mass sum is over 100% on these panels. A different separation scheme (cited above) is included in the text. Results are compared with NODC data.
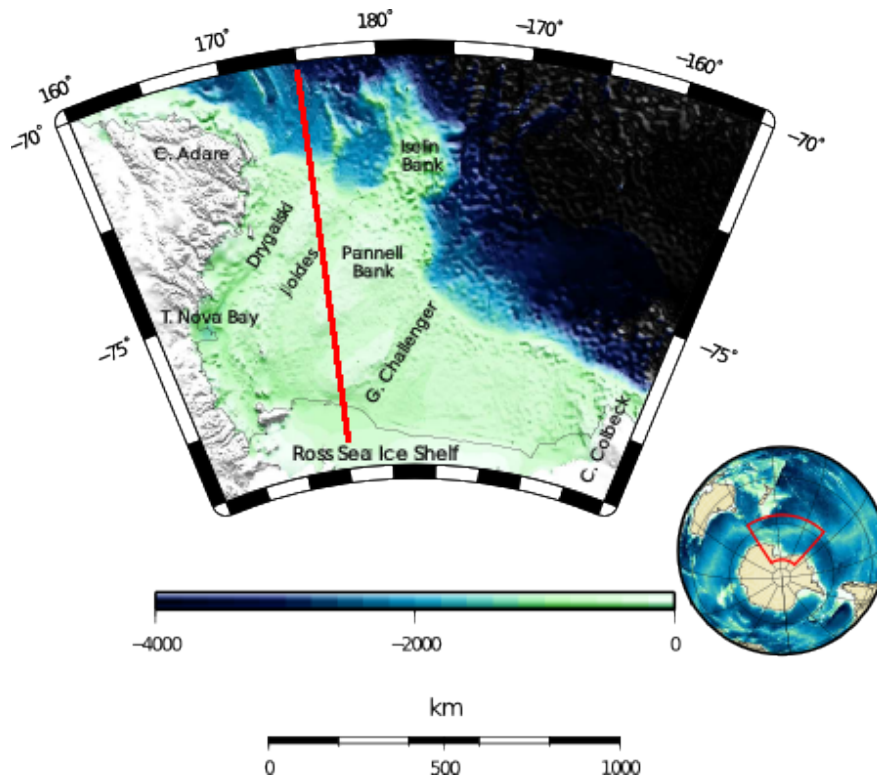
Fig. 1. Ross Sea bathymetry with the principal geomorphological features marked. The red line marks the analyzed section at 175°E.
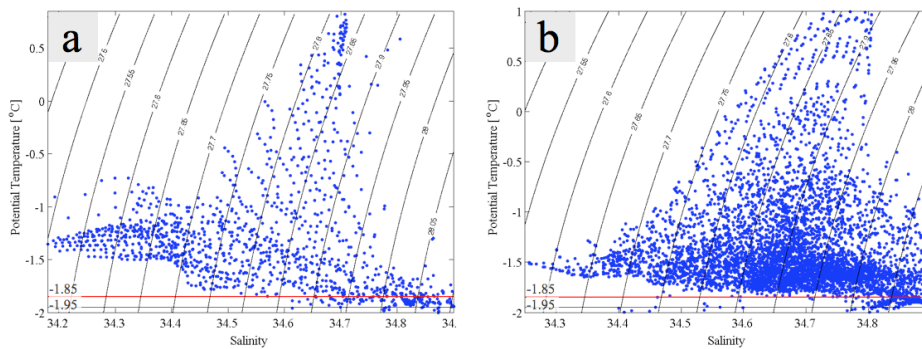
Fig. 2. TS diagrams with data from the western continental shelf of the Ross Sea. Diagram "a" represents NODC data and diagram "b" represents modeled data.
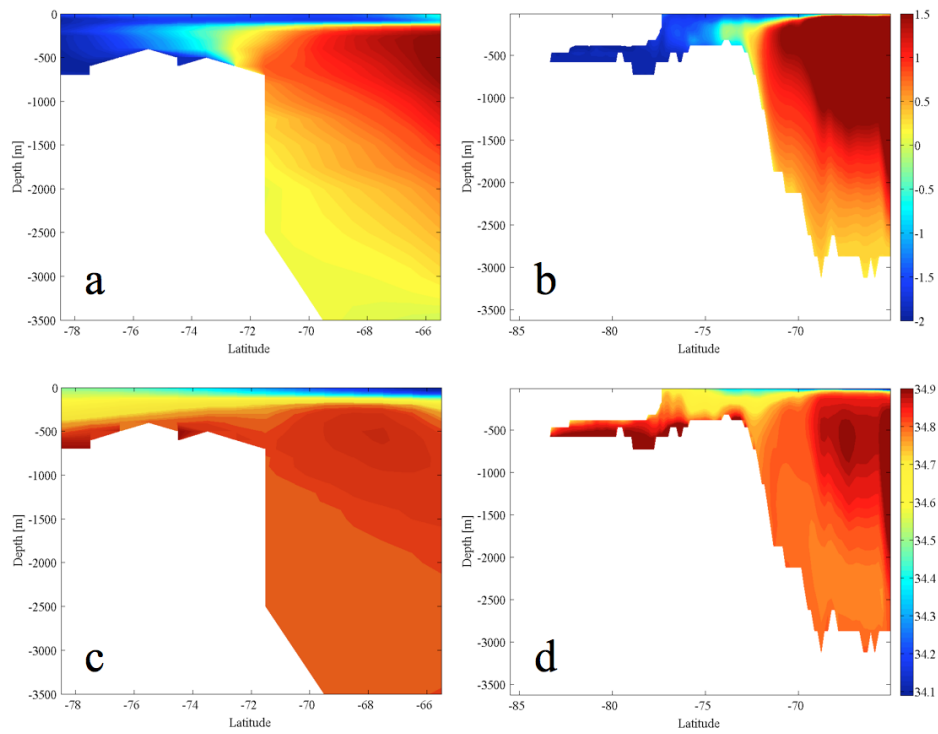
Fig. 3. Temperature and salinity cross sections at 175°E. "a" temperature from NODC; "b" temperature from modeled data; "c" salinity from NODC; "d" temperature from modeled data.
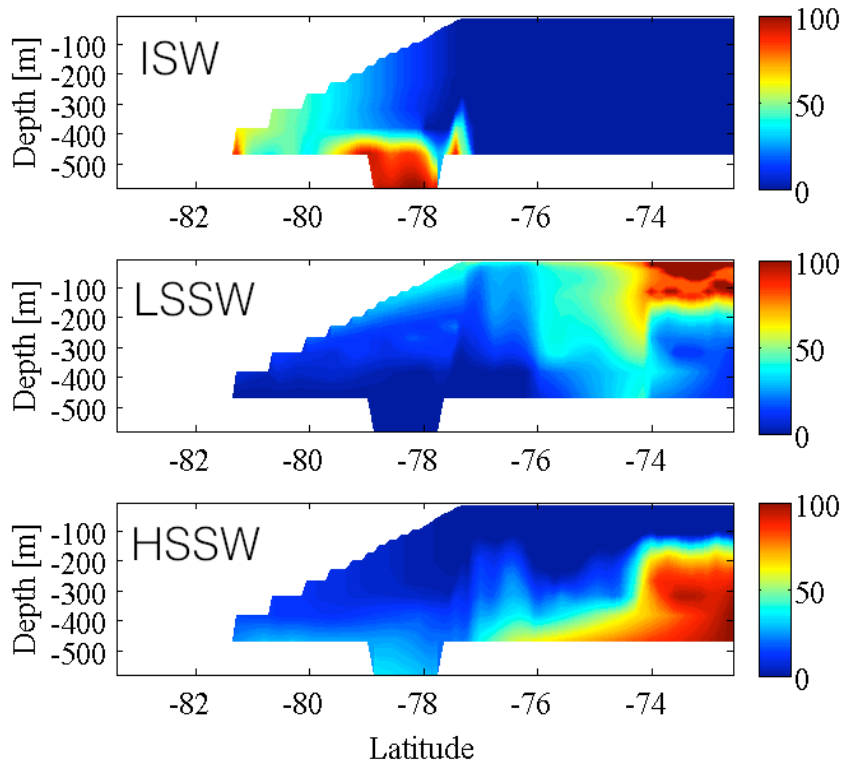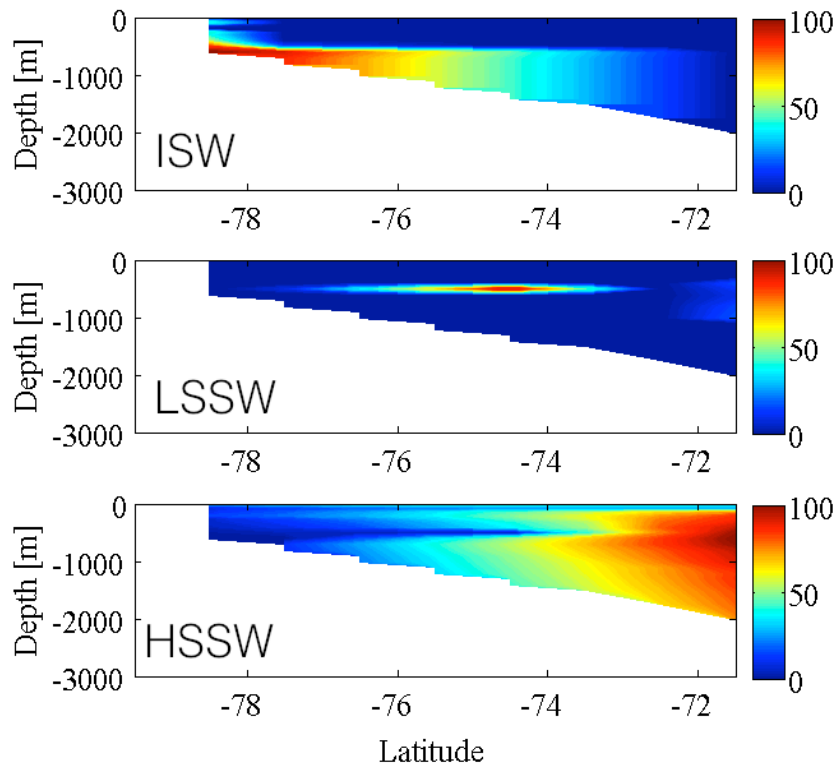
Fig. 4. Water masses spacial contribution (%) over de continental shelf at the meridional section along the 175°E from modeled data. Ice Shelf Water (ISW); Low Salinity Shelf Water (LSSW) and High Salinity Sh

Fig. 5. Water masses spacial contribution (%) over de continental shelf at the meridional section along the 175°E from NODC data. Ice Shelf Water (ISW); Low Salinity Shelf Water (LSSW) and High Salinity Shelf
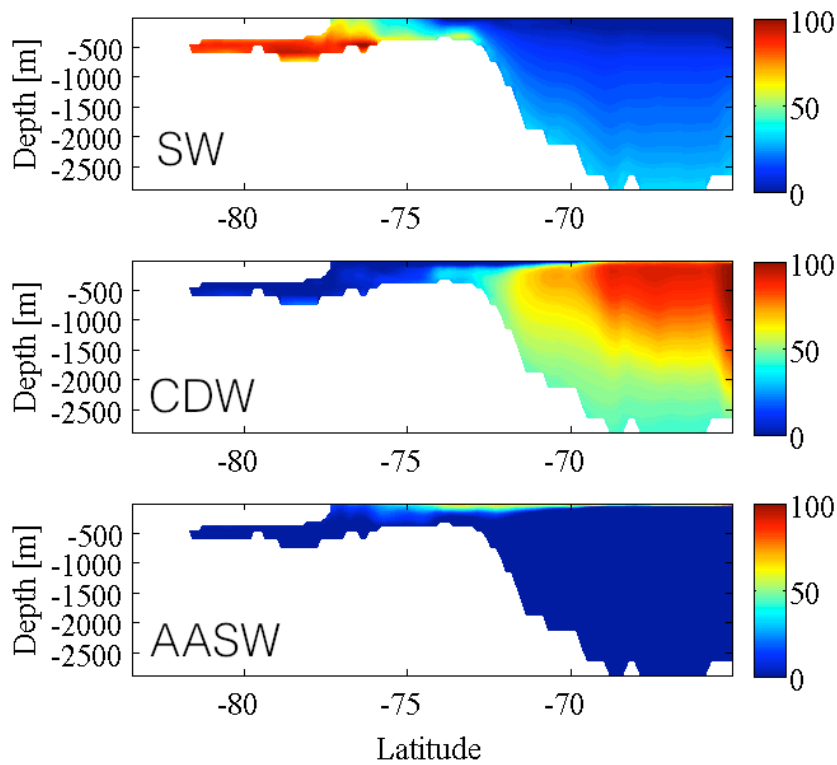
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Fig. 6. Water masses spacial contribution (%) along the meridional section at 175°E from modeled data. Shelf Water (SW); Circumpolar Deep Water (CDW) and Antarctic Surface Water (AASW).
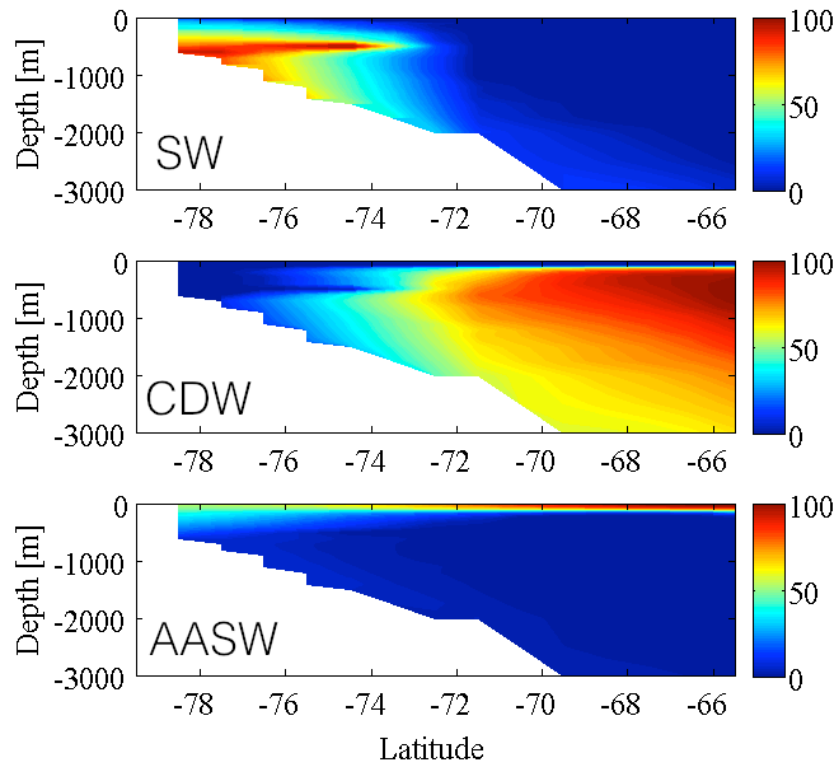
Fig. 7. Water masses spacial contribution (%) along the meridional section at 175°E from NODC data. Shelf Water (SW); Circumpolar Deep Water (CDW) and Antarctic Surface Water (AASW).

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