

Interactive comment on “On the export of dense water from the Weddell and Ross Seas” by R. Kerr et al.

Anonymous Referee #2

Received and published: 5 September 2011

General comments: The authors describe seasonal and interannual variabilities of water mass export from the Weddell and Ross Seas, based on a state-of-the-art ice-ocean coupled model (OCCAM). For the interannual variability, they show spatial and time-varying characteristics of dense water export from the basins and shelf water mass, and find a coherent variation between the two, mainly due to the change of the wind-driven ocean circulation. I think the topic is generally interesting and important for Antarctic research. The structure and analysis method of the paper are totally reasonable and all figures are fine. Therefore, I think this paper is basically worth for publishing in Ocean Science.

However, I have one critical concern about the definition for estimating (dense water) export, and my decision for the current manuscript is major revision. In this paper, wa-

C594

ter export are estimated by calculating the transport across some specified sections. I think that this calculation leads to underestimate or overestimate for the exports. (For example, some changes of the position of density front could easily and largely modify the estimated value.) In particular, I think that the export from dense shelf water formation area should be defined by all export from shallower region to deeper region in continental shelf (i.e. export across shelf break) to take account of all dense shelf water mass formation over the continental shelf. Moreover, for the current AABW estimation, I could not separate the transport over continental shelf (upper layer) or over continental slope and rise (lower layer). I think export in the lower layer should be treated as AABW transport.

Specific Comments:

[1. Introduction]

I think this introduction is well written.

(P1660/L27-28) "..., therefore modelling results ... an alternative way to ...on AABW export."

I think the expression is too strong. This sentence is only valid when the model shows perfect performance. I recommend that authors rephrase it.

[2. Model description and forcing]

(P1661/L11-14) Remove the sentences. Why do you describe a different model (NCAR-CCSM) performance in section 2?

(P1661/L24) "explicitly"

Does the effect of ice shelves, icebergs, and runoff from ice sheet include implicitly in the model?

(P1661/L25) "66 levels"

C595

Generally, a Z-coordinate model has difficulty to simulate downslope flow of dense water over continental slope (Wang et. al 2008). Does the model have enough vertical resolution for reproducing AABW formation processes?

Reference: Q. Wang, S. Danilov, and J. Schroter (2008), Comparison of overflow simulations on different vertical grids using the Finite Element Ocean circulation Model. *Ocean Modelling* 20, 313-335

(P1662/L9-11) "Sea ice ... in each affected grid cell"

Is this description for an initial condition for sea ice field?

[3. Southern Ocean representation]

As mentioned above, please consider to redefine the estimation of AABW and shelf water exports. Since this paper is model-based study, the more precise and consistent definition for the exports in the model should be used.

[3.1 Modelled hydrographic sections]

(P1663/2nd paragraph and Fig. 2)

In my reading, HSSW is also missing in Figs. 2a, 2c, and 2e. Therefore, I could not reach the conclusion in L23-L24 ("the water masses ... represented reasonably well in the sections (Fig. 2)")

(P1664/L1-4) "We conclude ..., which provides a high degree of confidence in the analysis of the model time series"

There isn't any result of time series of water masses.

[3.2 AABW source layers depth]

For discussing water masses which are separated by neutral density surfaces, some more information (e.g. contours of 28.00 and 28.27 of neutral density) should be overlaid in Fig. 3. In alternative way (and its direct way), authors can discuss water masses

C596

averaged over the neutral density layer.

(P1664/L26-27) "the highest salinity plume .."

Is there any result or reference that supports this sentence?

[4. Cross-section volume transport]

[4.1 Full-depth volume transport]

The volume transport of the gyre should be described by one value (e.g. maximum value of barotropic stream function). I think that the difference between export and formation sections indicates missing flow branches of the gyre in the estimation.

(P1666/L6-9) "Nevertheless, the OCCAM model ..."

Judging from the mean, the variance, and the trend (Fig. 4 a-b), the sentence could not be a reason for underestimation of full-depth volume transport.

[4.2 Bottom layer definition]

(P1666/L19-20) "Moreover, OCCAM model.."

Add some references that show the model performance for reproducing bottom waters around Antarctica.

(P1666/L20-22) "This can be clearly seen ..."

A figure based on observation (temperature and density) is needed for the comparison against the model result (Fig. 5).

[4.3 bottom layer volume transport]

(P1667/2nd paragraph and Fig. 7) Instead of performing normalization, I recommend that authors use the right vertical axis (different scale from the left axis) to show the counterpart timeseries. I think that the difference of absolute value is important information when comparing the model result with observation.

C597

(P1668/L1) "slightly"

It seems that the modeled mean transport of 0.5 Sv is much lower than the observed one (1.95 Sv). It is not a "slightly" difference.

(P1669/L15-16) Why does the variability export from the Ross Sea formation section show low?

(P1669/L16-22) Although a reference (Venegas and Drinkwater 2001) is cited for the explanation of the export variability shown in Fig. 9, I think that some results are needed to show dynamical link between dense water export and surface variables (wind, temperature, sea ice production, and so on).

[5. Correlations between AABW sources properties and deep ocean export]

In my reading, judging from timeseries in Fig. 10, the high correlation in the section 5 is achieved by decadal variability (a low state in 1990-1994, and high states in 1988-1989 and 1999-2005). Is the discussion/timescale of correlation analysis in this section consistent with those in the previous sections?

(P1671/L4-5) "faster or slower phase of the wind-driven Weddell Gyre"

What does this phrase mean?

(P1671/L16-18) "Finally, another positive feedback ..."

I didn't understand the sentence at all. If it is important, please add more explanation.

(P1672/L11-15) "Thus, the correlation maps are"

In Hellmer et al 2011, there is a freshening trend (0.09 psu / 17 years) over the north-western Weddell Sea continental shelf. In timeseries of salinity anomaly in Fig. 10, however, there is a significant increasing trend in the salinity over the northwestern Weddell Sea continental shelf. Is it possible to discuss the phenomena associated with observed freshening trend?

C598

(P1672/L21-23) "In general, bottom water export ..."

Add some references.

(P1673/L13-15) "We have shown that ..."

What kind of change of wind are observed in the forcing dataset? Does the change of wind forcing explain the variability of AABW export?

(P1673/L21-P1674/L4) Does the model reproduce the absence of the AABW cold pulse in the Northwestern Weddell sea in 2000?

Technical corrections:

There are different expressions for deep ocean in the manuscript (deep regime/ deep ocean regime/ open ocean regime/ oceanic regime), and they are very confusing.

[Fig.2 and its caption] The line for 28.27 of neutral density should be drawn.

[Reference] (P1679/L32) Validation of ***three*** global ocean models in the Weddell Sea

Interactive comment on Ocean Sci. Discuss., 8, 1657, 2011.

C599