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## ***Interactive comment on “Assessment of the ECCO2 reanalysis on the representation of Antarctic Bottom Water properties” by M. Azaneu et al.***

### **Anonymous Referee #1**

Received and published: 2 April 2014

This manuscript discusses compares water properties (theta, salinity, and neutral density), velocities, and AABW transports from the ECCO2 reanalysis against observations within the Southern Ocean. The manuscript is reasonably well written, and the material is probably of interest to the community. However, there are a number of flaws. First, while the manuscript is commendably complete, it is long and difficult to wade through. It lacks a unifying story, but the good news is that there is one which could be told. Second, the manuscript has way too many tiny little figures. These are so small that they appear to be jokes. Many of them must be magnified to 3x their nominal size to be able to read them. This deficit needs to be fixed by reducing the number of panels in many figures and arranging them so they use more of the page. Third, paragraphs

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are often rambling, and lacking topic sentences. Repetition of figure captions within the text adds unnecessarily to the rambling and the length. Fourth, the manuscript is full of vague and unqualified assessments like "adequate", "fair", or "good". The reader is left asking "good for what"? Very frequently the comparison shows persistent biases or large discrepancies between data and observation, yet the reanalysis output are deemed good in the end. The conclusions often seem divorced from the careful comparisons that proceed them. Specific comments follow, indexed by page and line number as appropriate.

1. The title might be better written: "Assessment of the representation of Antarctic Bottom Water properties in the ECCO2 reanalysis."
2. The authors might find Wunsch and Hemibach (in press J. Phys. Oceanogr.) of interest, since it attempts to use ECCO2 output to look at global deep ocean temperature changes in recent decades.
3. There does seem to be a unifying story here that could be used. It seems that the coarse resolution and lack of ice shelf processes make AABW formation weak in the first part of the reanalysis period, until a Polynya opens up and floods the Weddell Sea with AABW. This is highly reminiscent of work by Martin and Latif over the past few years, and more recently a 2014 article in Nature Climate Change by some other authors. In these works, which analyze coarse resolution models, it is argued that heat builds up in the Southern ocean until it melts sea ice and a polynya opens, cooling the ocean interior and forming bottom water the only way these models can. Perhaps something similar is happening here, since the model does not allow much AABW to be formed on the shelf. Thus the AABW properties are too warm and velocities and transports are weak early on in the reanalysis period, and then the polynya opens up, flooding the deep Southern Ocean with a very unrealistic amount of very dense AABW.
4. P1024, L14. A reanalysis produces output, not data. Please fix this error throughout the manuscript.

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5. P1024, L19. Change "deep" to "bottom".
6. P1025, L11-12. The amount and distribution of AABW in the global ocean is quantified in Johnson (2008, J. Geophys. Res.).
7. P1026, L11. Change "Eventually" to "Occasionally".
8. P1026, L21-22. Change "Most of . . . up to 80%" to "Antarctic Sea Ice area undergoes a large seasonal cycle, varying by up to 80%." Also, surely there are more recent works on this than Zwally et al. (1979), Cavalieri and Parkinson (2008, J. Geophys. Res.) takes advantage of many years of satellite data, for instance.
9. P1027, L9-11. Recent AABW salinity changes are described around Antarctic in Purkey and Johnson (2013, J. Climate).
10. P1027, L19. Huhn et al. (2013, Deep-Sea Res. I) should also be of interest here regarding recent reductions in Weddell Sea deep and bottom water ventilation.
11. P1027, L23. Change "Ocean modeling powered . . . products" to "Assimilation of data into ocean models".
12. P1029, L10. Change "ARGO" to "Argo" throughout.
13. P1030, L15 and throughout the manuscript. Sentences like "Figure 1 shows . . ." or "are presented in Fig. 2", or "Table 1 lists" generally duplicate figure or table captions, wasting space. Always try to start paragraphs with a topic sentence, the devote the rest of that paragraph to supporting that topic. Try to refer to figures and table parenthetically as they support that topic, describing them only as that description advances an argument. Doing this for each paragraph will make the manuscript shorter, better focused, and much more readable.
14. P1034, L20. Change "seek" to "sought".
15. P1035, L11. Change "closer" to "closest".

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16. P1035, L4-7. This is a great example of tuning a metric to accommodate a model failure. Because the model fails to make a sufficiently cold water mass, but also makes it much too salty, just switch to density and then it is possible to say it is "adequate", because the errors in temperature and salinity partly compensate in density.

17. P1040. Wouldn't it be better to describe the formation of the polynya immediately, then proceed with the rest of the analysis, discarding the polynya period for most time-averaged analyses and retaining it as appropriate to show its effect in some of the time-series analyses?

18. P1043, L16 and following. Should "narrow" be replaced with "thin"?

19. P1045, L3-14. This paragraph seems important, but it is unclear. Please rewrite it.

20. P1045, L24 and following. Aren't the cross-sectional area of AABW and the depth of its upper limit closely related? Why not just use one or the other?

21. P1047, L11 and following. Again, the bottom water is much too warm and salty, so just consider density so the two errors compensate and agreement is good. This is not convincing.

22. P1057, L25 and following, Purkey and Johnson (2013) estimate basin-averaged rates of salinity change for AABW in recent decades that might be useful here.

23. P1058, L5-7 and elsewhere. Considering the volume-averaged properties of AABW below an isopycnal is not a good choice, as the convoluted discussion here and elsewhere shows. The size of the control volume and the volume-averaged density both change with time, which leads to results that are difficult to interpret. It is better to stick to changes on pressure surfaces, density surfaces, or in Theta-S space.

24. P1061, L11-12. Is a reanalysis that first fails to make enough AABW and has overly warm and salty varieties until a polynya opens up to flood the abyss with huge volumes of unrealistically dense AABW of "good quality".

25. P1064, L5-15. If one just read this paragraph, one would think ECCO2 was great in the Southern Ocean, yet the manuscript details so many deficiencies in physics and discrepancies in water properties and transports.

26. Figure 2 is horrible. The brown blobs almost completely cover the grey blobs, making meaningful comparison impossible. Also, isn't the focus here on AABW? Skip the full water column T-S, and show the deep T-S diagrams. Just use two colors, one for the data and one for the reanalysis output. Lay approximate neutral density contours over the top.

27. Figure 3 is also pretty bad. The maps are tiny. Only data-output density differences are shown, making it hard to see what the reanalysis compares to data in temperature or salinity.

28. Figure 4. Is there some better way to show the changes than with 20 tiny postage-stamp size maps? How about two time series near Maude Rise? If the postage stamps are absolutely necessary, please get rid of the longitude labels and make the maps bigger.

29. Figure 5. Note the time-period compared on this Taylor Diagram in the figure caption.

30. Figure 6. Again, these sections are tiny. At least get rid of the maps and just refer to Flg. 1, but could these maybe be redone to show the difference in properties as colors with the properties of the observations overlaid as contours. Then you would only need to squeeze 9 sections and 3 T-S diagrams onto one page!

31. Figure 7. The top and middle panels, while not quite duplicates, show similar information. Why not get rid of the middle panels, allowing a bit more room for the remaining plots?

32. Figure 13. More tiny postage-stamp sized maps! Get rid of the longitude labels, consider getting rid of the top 5 maps on the right side, and figure out a lay-out that

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uses the page and allows for much bigger maps. Alternately, devise time series plots (either for the entire region or for a few sectors).

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Interactive comment on Ocean Sci. Discuss., 11, 1023, 2014.

**OSD**

11, C163–C168, 2014

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