

# ***Interactive comment on “Antarctic Bottom Water and North Atlantic Deep Water in CMIP6 models” by Céline Heuzé***

**Anonymous Referee #1**

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This manuscript discusses differences of ocean water properties between observations and the CMIP6 suite of coupled climate models, focusing on density, temperature, and salinity at the sea floor in the North Atlantic and Southern Ocean, where North Atlantic Deep Waters and Antarctic Bottom Waters are formed, as well as thicknesses of both of those water masses. The work is interesting and original. The manuscript should be worthy of publication after revision. However, there are some inaccurate statements in the manuscript that should be corrected before acceptance. Furthermore, one major suggestion is offered, which would hopefully increase the usefulness of the work substantially, but would require some more text. That one major suggestion, that the author might consider, then a detailed list of comments, follow.

Major suggestion:

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1. While the 6x6 postage stamp figure format is quite useful, especially for the modelers, it may be a bit much for some readers. Please consider putting all the postage stamp figures into the appendix and switching the text figures to 3-panel figures (water property reference, mean or median difference of water property from reference, std deviation or interquartile range of water property difference from reference). This would keep 4 figures in the main text:

Two 3x3 figures (3 panels each of reference, mean, and standard deviation for potential temperature, practical salinity, and sigma-4) in the S. Ocean and N. Atlantic.

Two 1x3 figures of reference, mean differences, and standard deviations of AABW thickness and NADW thickness

This change would mean eight postage stamp “difference” figures in the appendix (NADW thickness, AABW thickness, and temper, salinity, and sigma-4 for both the Southern Ocean and North Atlantic.

This suggested change would also require some additional text to describe the means and standard deviations of the differences of the models from observations, but it might be worth it. The statistical figures would probably be much more widely used than the postage stamp figures. They would be great in a general presentation on climate model evaluation.

Major comments:

2. L1. The first sentence is arguably inaccurate, as the global ocean circulation is mostly wind driven. Maybe “Deep and bottom water formation are an important part of the global ocean circulation” would be better.

3. Throughout. Please use the commonly accepted terminology “bottom water” to distinguish Antarctic Bottom Water from “deep water” (North Atlantic Deep Water). The manuscript may be slightly longer as a result (as sometimes the use of “deep and bottom water” will be required), but will be more in line with the field, and easier to

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read.

4. L19. The opening sentence of the introduction doesn't seem accurate, and it is difficult to parse the meaning. How about "Bottom water formation around Antarctica and deep water formation in the North Atlantic ventilate the global abyssal and deep ocean."?

5. L23. This sentence does not seem quite right, as AABW influence spreads quite far into the N. Atlantic, albeit in a form highly diluted by mixing with NADW above. How about "In a substantial portion of the Atlantic, Antarctic Bottom Water spreading north is overlain by North Atlantic Deep Water spreading south."

6. L63-65. This sentence conflates two different issues, and perhaps should be broken in two at the "and".

7. L140-142. This portion is overly concise. How about something along the lines of: "Presently, Antarctic Bottom water is primarily formed in several locations (including the Weddell Sea, the Ross Sea, and the Adelie Lands) as water is cooled, made saltier, and denser on the continental shelves, then cascades down the continental slopes, entraining deep waters on its way to the sea floor."

8. L160-161. The recent Polynya in the Weddell Sea that is mentioned later in the paper should also be mentioned here.

9. Tables 2 and 3. Consider that instead of years out of 30, a percentage would be more quickly and easily interpreted by most readers.

10. L205. How is it possible that "No model has regional biases"? Perhaps just delete the part of this sentence on L206, and start the sentence with "CMIP6 models tend to be either biased light or biased dense".

11. L265. Consider changing "The picture is less grim regarding bottom property biases" to "CMIP6 water property biases at the bottom of the North Atlantic are smaller than those at the bottom of the Southern Ocean".

12. L298. Here “convenient” seems like the wrong word. This reviewer can’t guess at what to suggest for a replacement.

13. L329-330. Consider changing “are rather accurately represented” to “often agree within observational uncertainties”.

14. L469-470. This is a problematic sentence, because NADW does not occupy the global ocean, and in the real world the signatures of upper (subpolar gyre) and lower (GIN sea overflow) NADW are both traceable for substantial distances from their formation regions. How about “NADW formed in the subpolar gyre of the models clearly spreads southward, but the signature of the portions formed in the Nordic seas is less evident.”?

Minor comments (typos, debatable word choices, and grammatical errors):

15. L3. Add comma to “transport, and”.

16. L7 & L8. Change to “the colder the AABW” & “the saltier the NADW”.

17. L10. Change “who” to “which”.

18. L25. Change “saltiest” to “saltier”.

19. L26. Change “when” to “where”

20. L28. Consider changing “reveal” to “suggest”.

21. L29-30. Change “to the bottom of the ocean” to “to the abyssal and deep ocean”.

22. L41. Replace the “. . .” with a “,”.

23. L45. Delete “in fact”.

24. L77. Delete “note that”.

25. L165. Change “who” to “which”.

26. L233. Change “convects” to “convect”.

27. L373. Change “least” to “less”.
28. L402. Change “This sentence is” to “These findings are”.
29. L421. Change “blame on” to “attribute to”.

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