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Interactive comment on "ACCESS-OM2: A Global Ocean-Sea Ice Model at Three Resolutions" *by* Andrew E. Kiss et al.

Anonymous Referee #2

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Review of "ACCESS-OM2: A Global Ocean-Sea Ice Model at Three Resolutions by Kiss et al.

This is a thorough description of the performance of the ocean and sea-ice component of the Australian Community Climate and Earth Simulator (ACCESS-OM2). In my view this paper will be a really useful reference for anyone working with ACCESS but also for anyone looking for a good reference to illustrate the impact of model resolution on ocean simulations. The paper provides a nice overview of key ocean circulation features at horizontal resolutions of 1, 0.25 and 0.1 degrees. Even though it is well known that the circulation changes with resolution there are (to my knowledge) not too many examples of papers showing a systematic comparison of the global ocean circulation at non-eddying, eddy-permitting and eddy-rich resolutions.

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Discussion paper

The paper itself is clear and well written and perfectly fits the scope of Geoscientific Model Development. I strongly recommend publication subject to some clarifications of the minor points listed below.

Comments:

1) Page 4, line 5: I was a bit surprised at the choice of 50 vertical levels for the ACCESS-OM2 and ACCESS-OM2-025 rather than 75 levels. Given that most HPC time is eaten up by ACCESS-OM2-01 the amount of time saved seems minimal. This seems to go against the philosophy outlined earlier, namely to keep the three resolutions as similar as possible. It would be worth explaining a bit more why this choice was made (e.g. 50 levels are sufficient at 1 and 0.25 degree as suggested in Stewart et al. 2017).

2) Page 6, line 10: Perhaps it would be worth noting why the choice of 0.004s-1 was made for the buoyancy frequency. Is this a typical value for this depth range?

3) Page 9, line 5: “downwelling” → “downward”

4) Page 9, line 5: I suppose the river run-off is essentially climatological -especially during the first part of the forcing?

5) Page 9, lines 29-31: I am not sure I really understand what is being done here. This could be read as if salinities were being nudged to WOA +/- 0.5 psu whenever, restoring fluxes try to push SSS outside that range. Obviously this is not what is being done since in Figure 11 there are regions where the salinity mismatch exceeds 0.5 psu (e.g. in ACCESS-OM2-01 off Grand Banks, in the Arctic and at the entry into the Caribbean Sea). This needs to be explained a bit more carefully.

6) Page 10, lines 26-27: Is there any particular reason why the period from May 1984 – to April 1985 is chosen? Was this a year that was reasonably neutral for most major indices e.g. ENSO. . .etc i.e. “normal" year-ish"?

7) Page 10, line 33: Do you mean that the Kuroshio separation was too far north? Also

I suppose this refers to the 0.25 and 0.1deg versions as WBCs are so diffuse at 1 deg?

8) Page 12, line 32: Is the timestep for ACCESS-OM2-01 400 or 450s? (The latter number is given in table 2).

9) Figure 3: To me it seems that for the globally averaged SST (panel b) the last pass looks different from passes 1-4. In passes 1-4 the globally averaged SST varies between about 17.8C to 18.4C and looks very similar for all passes. However, in pass 5 the SSTs vary between about 18 and 18.4C. This seems quite a large difference for a global average. It is noticeable that ACCESS-OM2-01 starts from much colder conditions (panel c). this linked to the stronger MOC in ACCESS-OM2-01? At the end of the spinup the globally averaged temperature is about 0.2 deg colder than for the lower resolutions. Again, for a globally averaged value this is quite a big difference.

10) Page 16, line 5: The initial cold drift cannot be seen in Figure 3a.

11) Page 16, lines 23-25: It is interesting that a large ACC variability is only really seen in the first pass for 1 and 0.25 degrees where there is a pronounced and broad peak in transport during the first pass which is not seen at 0.1 deg. Is there a spike in the AABW formation during the first pass in ACCESS-OM2/-025?

13) Page 18, lines 16-18: There are clear differences for e.g. the Gulf Stream at 0.1 deg. The SSH variability suggests that Gulf Stream path may be too variable just after separating from Cape Hatteras. The SSH variability is confined to a broad patch North of Cape Hatteras rather than extending further east along the extension as suggested by AVISO.

14) Page 18, lines 25-28: I don't think that this can really be inferred from Figure 6. . .

15) Page 18, line 30, Figure 7, Page 19, line 10: It would be nice to plot the overturning for the full range of densities i.e. not to cut off the lightest densities . I'd also suggest to expand the higher densities e.g. between 36.5 and 37.5 as this would show the AABW cell more clearly. This I feel could be relevant to understand differences in the ACC

strength between the different resolutions (see comment 21) below.

16) Page 22, Figure 9: Is the data temporally filtered for the 1 and 0.25 degree resolutions? A seasonal signal is clearly visible in the surface layers of the 0.1 degree model but not at 1 and 0.25 degrees.

17) Pages 23, lines 3-4, Figure 10: For some regions the anomaly patterns look quite different in ACCESS-OM2-01. For example in the Northern North Atlantic there is a large-scale warm bias and a strengthening cold bias in the southern SPG whereas the rest of the northern North Atlantic is warmer in ACCESS-OM2-01 than in the other cases.

18) Page 26, lines 7-8: To me the picture does not always seem as clear cut here. Between 0-30S ACCESS-OM2 has the best agreement with Ganachaud & Wunsch.

19) Page 27, line 15: Define all terms for the PV equation.

20) Page 29, Figure 15: I suppose the maximum/minimum mixed layer depths are from September (max) and March (min)?

21) Page 34, Figure 20: I can see that there seems to be a problem with the Antarctic mode water at the lower resolutions. However, what is equally pronounced in my view is the cold bias seen south of about 60S. In addition there is also a weaker cold bias at depth extending from the high southern latitudes to the northern end of the domain for the 1 and 0.25deg resolution versions of the model. This is also seen for the latitude-depth sections through the Atlantic and Indian Oceans (Figures 23 and 25) as well as for the zonally averaged temperatures shown in Figure 12. Could this explain why the ACC transport is weaker in ACCESS-OM2-01 than in ACCESS-OM2? The cold bias around Antarctica increases the meridional density gradient across the ACC which may explain the higher ACC transport in ACCESS-OM2 (where the cold bias is strongest). The coldest bias around Antarctica in ACCESS-OM2 may seem at odds with the overturning cell associated with AABW formation shown which is weaker than

for the higher resolutions (Figure 7). However, my impression is that although weaker the overturning associated with AABW involves higher densities at 1 deg than at 0.25 and 0.1 deg. This would come out more clearly if the overturning is expanded for higher densities in Figure 7 (see comment 15).

22) Page 36, lines 8-9: Note that there are also uncertainties in the observational estimate of the barotropic streamfunction of DeVerdiere & Ollitrault. So I suppose that rather small features of the barotropic streamfunction such as this recirculation have to be taken with care.

23) Page 42, lines 3-4, Figure 27: The sea ice decline only seems too slow for ACCESS-OM2-025. For 1 and 0.1 deg there is a small positive bias compared to the observations that remains almost unchanged during the simulations but the long-term sea-ice decline looks very similar.

24) Caption Figure 16 (and other Figure captions): I suggest to replace “overlain” with “overlaid”.

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