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Title: Effects of strongly eddying oceans on multidecadal climate variability in the Community Earth System Model
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Point by point reply to reviewer #2

February 12, 2021

We thank the reviewer for their careful reading and for the useful comments on the manuscript.

1 Reviewer Summary:

This study analyses the impact of model resolution on the simulation of multidecadal climate variability. 250-year simulations are run with the Community Earth System Model at high (0.1° ocean) and low (1° ocean) resolution, which are then compared to 149 years of observational data. It is found that the higher resolution run simulates larger multidecadal variability in the Atlantic and Southern Ocean (and more like observations), with little difference between the two runs in the Northern Pacific. The improvements are linked to better resolution of mesoscale ocean dynamics, and therefore larger heat content variability in the higher resolution run. Some assessment is made with regards to the impact on global mean surface temperature (GMST), but little difference is seen in multidecadal GMST variability across the two resolutions.

The paper is well-written, well-presented, and certainly worthy of publication in Ocean Science. The question around the impact of model resolution on the representation of multidecadal variability is likely to be of interest to the community. Clearly a lot of time has been spent on polishing the manuscript, and it is in an excellent state. There are a small number of minor points below that may require some attention.

2 Minor Comments:

1. L9: *“The effect on global mean surface temperature is relatively minor”.* It might be better to clarify here that the effect on multidecadal GMST variability is relatively minor, since you show that there are changes to interannual variability.

We will make the suggested change.

2. L34: *please indicate here that Pacific Decadal Oscillation is abbreviated to PDO later (PDO is used at L58 for the first time).*

We will add the abbreviation here.

3. L151: *appears to be the first use of ‘SOM’, and yet to be defined.*

We will add the name in the introduction paragraph.

4. L173-178: *it might be useful to move the index definitions into Section 2.*

We will move l.173-180 to the methods section, but kept Figure 2 and its description (l.180-184)

at the beginning of section 3.1.

5. *L181: “The AMV and SOM indices (in units of Kelvin) exhibit a smaller amplitude in the simulations than in the historical data”. This is also true for the PDO index?*
We will rephrase the sentences describing the PDO standard deviations.
6. *L181: How much of the difference between observations and model runs can be attributed to the different data lengths? In panel d, it might be helpful to show uncertainty bars indicating the range of standard deviations for the model data, if you were to compute it in 149-year moving windows (i.e. same length as observed data).*
We will perform a block bootstrap estimate of the standard deviation.
7. *L183: “Larger PDO amplitudes ...”. I don’t follow this sentence. Larger PDO amplitudes with respect to what?*
(see comment 5)
8. *Fig. 2 caption: The sentence beginning with “The monthly time series of ...” requires some editing. (Fig. 2 caption) We will rephrase the sentence.*
9. *L198: “This suggests possible correlations between the Indian and Pacific basins and the Atlantic basin at multidecadal time scales. . . but such correlations are not significant in observations.” Apart from sparse observations in the earlier record, this may also be a result of non-stationary teleconnections (see for example Cai et al. (2019))*
We will elaborate on the insignificant teleconnection correlations and added a reference to Cai et al. (2019).
10. *L218: “To allow a comparison between the results, also the period of variability of the historical data has been extended to 50 years. . .”. The word ‘also’ is not required.*
We will change the sentence to make it easier to understand.
11. *L223: “...but they overwhelmingly remove a linear trend...”. I assume you mean here simply that a majority of the studies remove a linear trend? ‘Overwhelmingly’ seems to be too overwhelming a word to use. Simply stating that ‘a majority remove a linear trend’ is sufficient. Or ‘almost all’.*
We will change the sentence as suggested.
12. *L235: For the Fig. 5 analysis, is the Indian Ocean the only additional component for the ‘Global Ocean’? In other words, if a timeseries for the Indian Ocean were added to panels 5a and 5b, would Indian+Atlantic+Pacific+Southern = Global? I’m not suggesting you add the Indian Ocean time-series to the figure, but it might be useful to clarify this point in the text.*
We will clarify the definitions of the ocean basins. The Global Ocean includes all oceans and marginal seas, such that it is not the sum of the Indian, Atlantic, Pacific, and Southern Oceans.
13. *L262: “On the other hand, in the Pacific remarkable differences exist: only in the HIGH simulation OHC anomaly signals propagate equatorward around 30° N, imprinting on the global pattern.” Could you please explain this further? In particular, how to see this ‘imprinting’?*
We will mention the pattern that is imprinted.

References

Cai, Wenju et al. (2019). "Pantropical climate interactions". In: *Science* 363.6430. ISSN: 10959203. DOI: 10.1126/science.aav4236.