Geoscientific Model Development Discussions

Geosci. Model Dev. Discuss., referee comment RC2
https://doi.org/10.5194/gmd-2021-95-RC2, 2021
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Comment on gmd-2021-95

Anonymous Referee #2

Referee comment on "Comparison of ocean heat content estimated using two eddy-resolving hindcast simulations based on OFES1 and OFES2" by Fanglou Liao et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2021-95-RC2, 2021

This study provided a comparison of the simulations results by OFES1 and OFES2 against EN4 objective analysis product. There are many apparent differences between OFES1 and OFES2, between OFES and EN4. The authors tried to decompose the local temperature changes to the vertical displacement of neutral surfaces and the changes along the neutral surface. They further investigated the surface heat flux and heat transport to better understand the difference. Overall, I think most of the texts in this paper are devoted to present the differences rather than providing insights, therefore, the biggest issue is that the reasons behind all these differences are poorly known. Further, many of the analyses are not tenable in my opinion (see below). The conclusions of this study are not supported by the results. I could not suggest publication of the manuscript in the present form.

Major issues:

- The decomposition into HV and SP. One major conclusion of this paper is "There was an OHC increase in most of the global ocean over a 57-year period, mainly a result of vertical displacements of neutral density surfaces.". However, I don't think it is a robust conclusion given the fact that neither OFES1 nor OFES2 well simulate the OHC changes globally or at each major ocean basin.
- The investigation of heat flux and heat transport are not well designed and not useful. To examine the mechanisms for the change of OHC, you have to check the trends in heat flux and heat transport, not the climatology field (Figs. 10, 11). In another word, you have to know where more heats are input into the ocean and how they are transported.
- The water mass analyses in section 3.3 are also problematic, because the water masses are defined by the density or the temperature/salinity range as in Tables 4,5, however, the figures 6 and 7 are presented at z-coordinate, so the discussions are very confusing and not corresponding to the plot.
- Section 3.2. The zonal integrated OHC, HV and SP. This section superficially described the results without any in-depth analyses or insights. It is not useful for the audience.

- Section 3.1. Why not also provide the global or basin time series for surface heat flux for comparison? Globally, the heat content change is balanced by surface heat exchange. The decomposing into HV and SP does not help to understand the mechanisms here.
- I expect an answer of why is OFES2 so different from OFES1, so a formal ocean heat budget analysis should be done.
- Another conclusion "However, these differences, more specifically in the heat transport, were only partially responsible for the OHC differences." Is not tenable, because I did not see an analysis for ocean heat budget, and the current analyses are wrong because only climatological heat flux and transport are shown.
- Final conclusion in the abstract "The marked OHC differences may arise from the different vertical mixing schemes and may impact the largescale pressure field, and thus the geostrophic current". This is a full speculation without any evidence.
- Is the decomposing of EN4 data into HV and SP consistent with previous results? How large is the uncertainty behind the decomposing method given the data errors?
- For zonal integrated OHC analyses, why some regions models are closer to observations and some places are not? What are the possible reasons and what are the implications? Again, an ocean heat budget analysis at each zonal band might help to identify if the difference comes from surface or ocean heat transport.
- Section 3.4: diving the ocean by 0-500m and 500-1400m will cross-cut several different water masses. It is really strange to use vertical levels in water mass analyses.

In summary, the manuscript looks like a superficial analysis of model results and I don't think it will help the audience if the paper is in present form.