

Response to editor's comments for: An evaluation of the E3SMv1-Arctic Ocean/Sea Ice Regionally Refined Model

February 24, 2022

We thank the editor for the suggestions and the careful review of the manuscript. We believe that we have addressed all the raised concerns and comments. Please note that the editor's comments are indicated in blue; line numbers, as well as Figure and Table numbers, refer to the new version of the manuscript.

Reviewer #1

- Major comment #1:
 - Thank you for adding Table 1. In the legend, can you be more specific about the two columns for "This paper" (I suppose the left one is for E3SM-Arctic-OSI and the right one for E3SM-LR-OSI) and about the two columns for Petersen et al. 2019 (I don't know what the two columns refer to).
 - Why isn't the RASM simulation described in this table?
 - Also in the text where you introduce Table 1, L112-113, please give a short written description of the differences so to help the reader understanding Table 1.

Thank you for suggesting this. Indeed the original table was a bit unclear. The table has now been updated, reformatted, and described properly. We have also added the RASM simulation details to it.

- Major comment #2: Please provide some details about how parameterizations other than GM vary with resolution; if they don't please specify that.

We have added the following sentence on line 103: "Other parameterizations used in MPAS-ocean are invariable with horizontal resolution."

- Major comment #3:
 - Please add details in the text to justify the use of 3 cycles only.
Done. Please see lines 122-125.
 - Furthermore, for me a "trend" is a variation of a quantity per unit of time. I think you should change on L141 "a cooling trend by up to 0.5°C" by "a cooling persistent anomaly of up to 0.5°C".
Done.
 - Why is the upper ocean freshening more concerning than the other, especially more than the OHC 0-700 one?

Indeed it is not more concerning than the other. We have now removed that sentence entirely and added instead: "Overall, the top-to-bottom trends are all reduced during the third cycle, whereas the upper ocean warming and freshening are both still present towards the end of the simulation." (lines 153-154).

- Major comment #5: ... I think L.175 "current GM implementation in MPAS-Ocean" is confusing. Maybe replace "current GM implementation in MPAS-Ocean" with "activation of GM in MPAS-Ocean".

We can see how that sentence is confusing and have decided to remove it from the text.

- Major comment #7: Please add in the text some of your conclusions reported to the reviewer, even if you don't add Figures 1 and 2 from your reply.

We have now added the following paragraph on lines 257-261: "The model climatologies are computed over the last 12 years of the third JRA cycle. A comparison with climatologies computed on an analogous period of the first cycle (not shown) indicate that, while some T and S changes are apparent below the Atlantic Water layer in Fram Strait and the BSO, and in the West Greenland Current in Davis Strait, the overall structure of the gateways stratification is quite consistent between the first and third JRA cycle, and consequently the velocity structures are also very comparable."

- Major comment #8: ... Please add in the text some of your conclusions reported to the reviewer, i.e. the fact that the drift affects the stratification over the whole Arctic and locally over the Canada Basin only.

We had actually already added this in the text, and then forgot to note it in the response to the reviewers.. Apologies for that. Please see lines 315-317.

- Major comment #9: Is the fact that salt/fresh water fluxes assume that sea ice has salinity of 4 psu mentioned somewhere in the text? If not do so, as the reviewer explicitly asked for that information.

We added the following text on lines 104-106: "The version of MPAS-Seaice used in this paper and the way that the sea ice and ocean components are coupled together are fully described in Turner et al. (2022) and Petersen et al. (2019); we have not changed any default MPAS-Seaice parameter for the purposes of the present effort."

- Major comment #11: Can you add something about this in the text?

We are a bit concerned that adding something like this in the text may be seen as too speculative, especially now that we believe that the appropriate corrections were applied over sea-ice in the JRA55-do forcing (see next comment below).

- Major comment #12: I don't see anywhere in the text that you version v1.3 of the JRA55-do data set, can you add this and also something about the fact that you don't do any correction over ice?

We had mentioned the JRA55-do version in the text (line 108). Regarding the correction issue: upon further investigation (Tsuji et al. 2018), we believe that the JRA55-do forcing used in the paper does indeed include corrections over sea-ice with respect to the JRA55-raw data set (see, for example, the comparison between shortwave and longwave radiation between JRA55-do and JRA55-raw and other data sets in Fig. 15 of Tsuji et al. 2018). We apologize for misstating that in our previous reply to Reviewer 1.

- Minor comments #2 and #3: Can you clarify these details somewhere in the text?

Please see lines 104-106.

- Minor comment #12: Thanks for adding the profiles for the last 12 years of the first JRA cycle as dark red dashed lines in Figures 14, 15. In your reply, you write "They give a good idea of how the stratification changes from cycle to cycle over the whole Arctic and locally over the Canada Basin only."; can you explicitly detail your observations on this in the text?

Please see lines 315-317.

Reviewer #2

- Comment #4: These are interesting remarks; please add something about this in the text.

Good point. We have now added the following paragraph on lines 48-53: "A similar configuration to this, but with Arctic regional refinement of 6 km was also considered initially; that simulation, while being approximately three times more expensive than the one described in this paper, did not produce any significant improvements in the Arctic and subarctic ocean and sea-ice representation. We concluded that a resolution of at least 3 km is necessary to really resolve the local Rossby radius of deformation in most of the Arctic, and we plan to actively work on such very high resolution E3SM-Arctic configuration in the near future."

My additional comments:

- Table 2: The captions mention E3SM-Arctic-OSI, E3SM-LR-OSI and observations but not RASM, which is indeed included in the Table; please modify the captions.

Done.

- L 409: remove "they" at the end of the line.

Done.