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Geoscientific Model Development Discussions

Interactive comment on "Introducing LAB60: A 1/60° NEMO 3.6 numerical simulation of the Labrador Sea" *by* Clark Pennelly and Paul G. Myers

Anonymous Referee #1

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1 General comments

This study presents first results of a 10-year long nested high-resolution (∼1 km) ocean hindcast run focused on deep convection in the Labrador Sea and the associated mixed layer depth (MLD) restratification and water mass composition. The authors find that small-scale eddies transport buoyant water masses of different origin into the Labrador Sea interior which increase stratification. A marginally coarser horizontal resolution (∼5 km) leads to a significant reduction of these effects and yield too dense waters and too deep MLDs compared to observations.

This model experiment description paper highlights the importance of the ocean model resolution to adequately represent the interplay of small-scale dynamics and the large-scale water mass composition and is hence of interest for the climate community. I consider the overall quality good and suggest this paper accepted with minor revisions.

2 Specific comments

62-66: In this sentence, I find it difficult that you 1) use model results only to explain a real world phenomenon and 2) cite yourself only.

73-77: There are other model studies showing the opposite, see e.g. Cael and Jansen (2020) and references therein.

130: It is not discussed at all why a factor of 5 is used to obtain the 1/60° horizontal resolution. Please add this.

Fig. 3 and 4: The LAB60 North Atlantic Current seems to be less vivid and eddy-rich compared to both ANHA12 and AVISO. Can you discuss this?

The "Discussion" section is rather a summary than a discussion. A discussion section is not explicitly required (https://www.geoscientific-model-development.net/for_authors/manuscript_preparation.html → Manuscript composition), so either rename the section or add a discussion. Personally, I would like to see a discussion. For instance, the videos indicate that the LAB60 setup exhibits a model drift and is far from equilibrium (drag the slider of the video player with the mouse from start to end rather fast and you can see a large-scale accumulation of the runoff and Irminger Water tracers in the respective videos). Would a potential model drift influence the LSW time series or the described eddy dynamics? In addition, the shown model data is particularly suited to discuss ongoing questions about meso- and submesoscale energy transfers during convective/unstable situations. Furthermore, your results indicate that even if an ocean model performs under a high spatial resolution, buoyant water needs to be provided by e.g. the boundary current in the first place to be available for eddies. If this is the case, a nested model configuration like the presented one would have a severe handicap given the coarser resolutions of the parents which provide the boundary current.

3 Technical corrections

- sections are not numbered
- its de Steur et al. 2009 (not 2018), Treguier (not Trequier) and Yashayaev (not Yashauaev); Fi* references not in alphabetical order
- 125 & 130: Please specify "temporal refinement".
- Table 2: Please reference LIM2 and CORE as you did for other settings.
- Table 2: Please add the atmospheric forcings (CGRF and DFS) and their respective time periods
- 160-185: LAB60 was forced by CGRF from 2002-2006 (5 years) and by DFS from 2007-2011 (5 years). If this is correct, I find it difficult to plot one LAB60 time series in Fig. 9. Can you at least indicate the two different forcing data sets in the plot/caption?
- 189 & 329: Please specify which sigma/density is used.
- 202: Did the simulation length really increase or rather decrease when the number of CPUs increased?
- 225: configuration"s"?

- 232: Please define how you computed the eddy components (e.g. u') in the model and AVISO data.
- Fig. 5 and Video 1: It is more informative to show relative vorticity normalized by the planetary vorticity, ζ/f, to learn about the transition from meso- to submesoscales.
- 250 & 265: Please define meso- and sub-mesoscales in the introduction and how you separate them.
- 256: Please define convective energy (CE) including the mixing depth to which you refer to in Fig. 6 b. On this snapshot, all CE values are >= 500 J m^{-3}. However, a winter situation is shown (17 January 2003) and I would expect CE values < 0 J m^{-3} indicating unstable situations. Is this a misunderstanding?
- 295: First, you find the LSW with σ_Θ > 27.68 kg m^{-3} (line 189; I assume you used σ_Θ in this step). Then, you calculate σ_1 of this water mass. Then, I don't understand why you define the "yearly maximum density of this water mass as the thickest depth where the density changes by 0.001 kg m^{-3}". I don't understand how a "depth" can be "thick" and to which density the 0.001 kg m^{-3} change refers to. Can you reformulate this here and in the caption of Fig. 9? Formulated as it is, I would have problems reproducing this quantity.
- Videos: Adding the sea ice edge and some MLD contours would make the videos even more helpful.

4 References

Cael, B. B, and M. F. Jansen (2020): On freshwater fluxes and the Atlantic meridional overturning circulation. Limnology and Oceanography Letters 5, 2020, 185–192, https://aslopubs.onlinelibrary.wiley.com/doi/full/10.1002/lol2.10125

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