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Ocean Science Discussions

Interactive comment on "Deep water formation in the North Atlantic Ocean in high resolution global coupled climate models" *by* Torben Koenigk et al.

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The aim of this paper is to investigate the effect of increasing the ocean and/or atmosphere resolution on the modelled deep convection in the North Atlantic. Let's start with the major comments:

1) The results shown are far less clear than described.

The authors work with 7 models. The abstract indicates that for "most models, higher ocean resolution leads to increased deep convection". In the text (line 230), this already is reduced to "generally", NEMO models only (5/7). But tables and figures show that it is not the case for EC Earth or CMCC, so we are down to 3/7. ... I suggest a less exciting but more honest rephrasing of the results section, which clearly explains that

the results are model-dependent. And which investigates what in the ocean component (or in the atmosphere component, as you later suggest it is all set by the wind) causes it.

2) Section 4 is not robust, and its methods are not detailed.

Section 4.2 treats of the potential relationship between horizontal freshwater fluxes and deep convection. Nowhere are the freshwater calculations presented. All that we know comes from line 386, that the liquid component is the "vertical integrated liquid freshwater export". How did you do that? Was it on each model's grid, or interpolated onto a regular section? What is your reference salinity? Did you take the same for all models (e.g. use the same ref. salinity as in past literature), or have one per model (e.g. each model's mean deep salinity in the GIN seas)?

Moreover, you show no data / result for most of the section. At least, add the mean or min/max transport values to Table 2. Same for section 4.1: the SHF discussion is based on data you show, but not the NAO/wind one. Show it! Show where the NAO lies in these models (centres are most likely shifted depending on the resolution, see literature).

3) How is accuracy defined?

In section 3, your comparison observation - models was hard to follow as you never defined what an accurate model should be. For example, line 237, you write "the only simulation that shows similar values in the Labrador Sea as ARGO is EC-Earth3P-HR". ARGO is at 3.95; EC-Earth HR, at 0.95. But HadGEM-LL and MPI XR are at 4.3 and 4.6 respectively, and CNRM CM6.1 is at 1.09. What is wrong with these, that made you reject them in favour of EC Earth?! Same again line 298: ARGO is at 6.5 and AWI HR at 6.1, but this model is not mentioned. It feels like an extra criterion is required for you to accept a model as accurate, but you never specified it, so the reader is left with their confusion.

4) Other methodological, rather major comments

You purposely exclude the Irminger Sea, even though a lot of models convect here instead of the Labrador Sea. Why? And why not investigating whether deep convection shifts from the Irminger to the Labrador Sea depending on the resolution?

Line 200, you admit that comparing the models to the ARGO period would be better, but you do not. For the frequency analysis, I agree that you should not. But at least in table 2, you should.

Section 5 is introduced as having already been done in Roberts et al. (subm). So, why having section 5 at all? What is different from Roberts et al.?

|| To finish, here come some more minor comments, by order of appearance:

The introduction is mostly about the AMOC and its relationship to deep convection. But the AMOC is not the topic of this paper (apart from section 5, see above). Please modify the introduction, focussing on deep convection and its importance for the ocean and the climate in general, including the AMOC sure, but not only.

Throughout the text, you use Greenland Sea when you mean GIN or Nordic Seas. Please correct.

The figures really need to be improved. The most crucial ones are the line plots, especially Fig. 3, where black and blue, or magenta and red, or red and green, are on the same panel, with the same line style. First, as the lines are supposed to represent an increase in resolution, what about some colours that are more intuitive? With e.g. LR in blue, moving to green, then yellow (with black contours), then orange, and finishing at XR with red. Then, to help the reader distinguish the lines, vary their styles. Again, just an example, make every other line dashed, and/or vary their thicknesses.

Figs 6 and 9, as the aim is resolution comparison, give the same y-axis to all panels. And since in the text you comment on the "peak around 10 years", use a log10 x-axis instead of a log2.

Fig 11, the increase of SHF with resolution is not visible as the colour scales are saturated. This information can be retrieved from table 2, so up to you whether to also improve Fig 11.

Line 260 (and Fig 4), which density are you using?

Section 4.1, clarify whether SHF > 0 means heat lost or gained by the ocean (from the figures and results, I assume it's lost by the ocean).

Lines 377-378: spell out what the relationship means in practice, i.e. that larger DMV is associated with larger heat fluxes out of the ocean. Furthermore, comment on lagged relationship (calculate it if needed) to see which comes first.

— end —

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