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Ocean Science
Discussions

Interactive comment on "The impact of melt water discharge from the Greenland ice sheet on the Atlantic nutrient supply to the Northwest European Shelf" *by* Moritz Mathis and Uwe Mikolajewicz

Moritz Mathis and Uwe Mikolajewicz

moritz.mathis@hzg.de

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Authors responses to

Anonymous Referee 1

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In this study the authors investigated the impact GIS meltwater has on future nutrient supply on the NW European Shelf Seas (NWS). Under RCP8.5, the upper North At-

lantic is projected to freshen and warm, with a shoaling MLD, reducing surface nutrient levels. Increased GIS discharge is projected to shoal the MLD further. The NWS shelf edge processes allow some mixing of sub pycnocline water to the surface, which can decouple the NWS nutrient regime from the adjacent surface NE Atlantic. The focus of this paper is to investigate how the varying changes and mechanisms will affect the NWS. I thought the paper was novel, through and would recommend it for publication with minor corrections.

Comments

The authors use a GCM with varying levels of GIS discharge to provide surface boundary conditions for their global ocean model with regional focusing to simulate the response to the GIS discharge. They run a control simulation, a 3-member ensemble under rcp8.5 (from 1920 – 2150) with no hosing, a 3-member ensemble with (a linear increase to) 0.1Sv hosing, and two additional runs with 0.25 and 1Sv. Their methodology is sound, and it good to see they use of (small) ensembles rather than individual simulations.

There are lots of papers on Atlantic Hosing studies, and I felt this should be discussed more in the introduction. I think this paper needed to have a section comparing your model simulations to these other studies. I am not aware of anyone looking at the impact of hosing on the NWS nutrient supply, so this study is novel, but it would be good to see, for example, that the MLD/AMOC/SSS etc response, is consistent with other studies etc. Through the text you occasionally make statements about this, but I think you should be clear about it at the start. You want the reader to know that your model results are applicable beyond just your model, but to the real world. To do this, you want to show them that your model behaviour is typical (or atypical) – perhaps put into context of Swingedouw et al. 2013 (https://link.springer.com/article/10.1007

https://link.springer.com/article/10.1007https://agupubs.onlinelibrary.wiley.com/doi/full/10.10

R: We added a dedicated model evaluation section (section 2.3), putting our model

results into context of observations and other model studies. Specifically, we consider present-day conditions and projected changes in MLD, strength of AMOC, SSS, SST, nutrient concentrations and primary production. In the introduction, we mainly reflect on expected meltwater impacts on the MLD, which are essential to understand the motivation of the study.

I think you should have a figure showing the model domain, outlining model crosssections – even if this is in the additional material. I don't think it's enough to refereeing to M19 for such a fundamental point. I'd even be happy with it in the appendices.

R: We added a respective figure as Fig. 4.

Clarify where the GIS meltwater is added geographically. Equally around the coast of Greenland?

R: We added another figure showing the spatial distribution of the freshwater discharge around the coast of Greenland (Fig. 2).

Perhaps refer to MLD anomalies as deeper, deepening/shoaling etc rather than positive/negative?

R: The term "anomaly" is partiularly useful here because it refers to a deviation from the mean state. Using deeper/shallower or deepening/shallowing instead would be prone to confusion with future changes or differences between experiments and realizations. Besides, "positive MLD anomaly" is only used once. To facilitate understanding, we added "(deepening)" in brackets.

L61: "In particular, a positive MLD anomaly (deepening) leads to an erosion of warm and saline subpycnocline water masses and initiates a positive feedback on the surface heat flux, the upper ocean buoyancy and the MLD."

Figure 10 also looks like the East Atlantic/West Russian Pattern e.g. Roberts et al. 2016 (http://dx.doi.org/10.1175/JCLI-D-15-0886.1).

R: Indeed, the western part of the EA-WR pattern is very similar. The other two characteristic pressure centers over West Siberia and China, however, are not shown in the larger structure of the SLP anomaly simulated by MPI-ESM. We added the following:

L479: "It also resembles the European/North Atlantic sector of the East Atlantic-West Russian pattern, a higher-order atmospheric mode of the northern hemisphere which occasionally mixes with the NAO (Barnston and Livezey, 1987; Fagherazzi et al., 2005). The other two characteristic pressure centers over West Siberia and China, however, are not shown in the larger SLP anomaly structure corresponding to Fig. 13 (simulated by MPI-ESM; not shown)."

Line 286 – "... higher SSS on the NWES than in the NE Atlantic." Is this referring to figure A1.b? if so, refer to it. Higher SSS on the NWES or just in the Celtic Sea?

R: True, only in the Celtic Sea SSS becomes higher than in the NE Atlantic. We changed this sentence and added a reference to Fig. A2 (former A1).

L358: "Moreover, in all experiments the mixing of saline subpycnocline water masses to the upper ocean near the shelf break establishes an ocean-shelf salinity front with higher SSS in the Celtic Sea than in the NE Atlantic (Fig. A2)."

Line 296 near the Celtic shelf break - where? Add to the new model domain figure? Give e.g. lat/lons?

R: We added a new figure showing the model domain and respective cross sections (Fig. 4) and refer to it in the relevant figure captions.

Line 361 – define inner and outer shelf? On new figure??

R: This is meant as a qualitative distinction related to the influences of Atlantic inflow (outer shelf) and river runoff (inner shelf). We added this information in brackets.

L449: "In addition to the decrease in the nutrient transport across the shelf break, this further intensifies the mean nutrient gradient between the inner (dominated by river

loads) and outer (dominated by Atlantic inflow) shelf areas as well as its interannual variability."

Lines 428-431 – Either add a figure showing the ensemble overlapping etc,. or point to where this is shown in the figures. I don't think a table is sufficient.

R: We have transferred the table into a new figure (Fig. 15) and moved the table to the appendix (Table A1) to also provide exact values.

Line 461 – you haven't mentioned ansatz before.

R: We changed "ansatz" to the synonym "approach" (L560).

Captions in the Appendices need some work. Figure A2, define vectors. A3, describe how composites are made, add a, b c etc to the subplots. I assume they were the same as figure 10 – if so, say so. Figure A5 4, a b, maybe clarify that the different colours are different ensemble members. A6, what is the contour.

R: All figures have been updated according to the reviewers suggestions.
Fig. A2 became Fig. A3
Fig. A3 -> Fig. A4 (Fig. 10 -> Fig. 13)
Fig. A4 -> Fig. A5
Fig. A5 -> Fig. A6
Fig. A6 -> Fig. A7

The English in the manuscript is good, although some sentences can be unusual, and could perhaps do with being edited for clarity. A couple of examples are:

"The related decrease in the density strengthens the stratifcation and reduces the MLD in addition to the climate change signal from the atmosphere." Would be clearer as "In addition to the climate change signal from the atmosphere, the related decrease in the density strengthens the stratifcation and reduces the MLD."

R: This sentence has been changed according to the reviewer's suggestion. Moreover,

the English of the entire ms and in particular the structure of sentences have been polished by a colleague with particularly profound English skills.

Lines 292-294 are unclear...

R: We modified this paragraph to be more clear:

L366: "The shallow-ML regime is fully established when the ML near the shelf break becomes as shallow as the depth of the shelf edge, i.e. about 150-200 m. As can be expected, the impact of GIS meltwater discharge on the stratification strengthening and ML shoaling (section 3.1) implies that the MLD in the NE Atlantic decreases faster when GIS meltwater is added, passing this critical depth earlier in the 21st century (Fig. A6)."

I didn't really focus on typos, but there are a few in the paper, for example: line 49 collapse; line 49 lose; caption for figure 10: pressure... etc.

R: Typos have been removed in the course of the English polishing.

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