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Interactive comment on "Simulated stability of the AMOC during the Last Glacial Maximum under realistic boundary conditions" *by* Frerk Pöppelmeier et al.

Anonymous Referee #1

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Poppelmeier et al. study the AMOC response to glacial boundary conditions and meltwater input into the North Atlantic with a 3D model. In agreement with previous modelling studies, they find that appropriate glacial boundary conditions lead to a stronger and deeper AMOC at the LGM than during the pre-industrial control. A weaker and shallower LGM AMOC can be obtained by enhanced freshwater flux to the North Atlantic. They further assess the stability of the AMOC to different amounts of North Atlantic meltwater input under pre-industrial and glacial boundary conditions. It is a well written and interesting study, but I suggest to perform an additional experiment with changes in diapycnal diffusivity, more details need to be given about the experimental set up, and the study needs to take into account/discuss previous work done

on the subject. Please find below a few suggestions.

1) Introduction and discussion: The authors briefly describe the LGM AMOC state as inferred from paleo-proxy records (L. 43-50) as well as the LGM AMOC state as simulated by PMIP3 models (L. 51-53), however no mention is made of the work done by combining modelling work and paleo-data as in for example Hesse et al., 2011 (Paleoceanography), Gebbie 2014 (Paleoceanography, even though a rapid mention to this work is given later in the manuscript), Menviel et al., 2016 (Paleoceanography) and Menviel et al., 2020 (Paleoceanography) .

Maybe more importantly, L. 332-336, the experiments presented here cannot provide conclusions on the state of the oceanic circulation at the LGM. There is nothing in the manuscript that can justify the statement on L. 333 about the AMOC depth, and there is no argument either for the statement on L. 336, since the present simulations performed with the Bern3D are not compared to paleo-proxy records and the carbon cycle response to the changes is not studied here.

2) Changes in diapycnal diffusivity The impact of changes in diapycnal diffusivity on the AMOC strength and stability are studied. This is interesting but for consistency, it would have been better to compare the LGM-tidal to the CTL-tidal-PI. tidal -PI being the pre-industrial diapycnal diffusivity values as estimated from the UVic-OTIS. Indeed, it is stated that in CTL diapycnal diffusivity is globally uniform (what is the value of the globally uniform diapycnal diffusivity used in the Bern3D?). Applying a varying diapycnal diffusivity in the CTL might also impact the AMOC. The impact on oceanic properties of the varying diapycnal diffusivity should be mentioned.

3) North Pacific to North Atlantic freshwater flux The reasoning behind increasing the North Pacific to North Atlantic freshwater flux by up to 0.12 Sv is unclear. It is stated that this test the impact of increased runoff from glacial ice-sheets. So, effectively this is equivalent to the freshwater hosing, which is fine in principle. The problem is when the additional freshwater is added, that it can become confusing: L. 244-247: from a

LGM adjusted state of 0.1 Sv, 0.2 Sv is added into the North Atlantic, does that mean that effectively 0.3 Sv are added at that time? The model is forced (for how many years?) with an "adjusted Pac to Alt. fwf flux" of 0.1 Sv, after which the "adjusted flux" is stopped and 0.2 Sv of meltwater are added into the North Atlantic (hosing) for 500 years. At the end of the 500 years is the Atlantic flux back at 0 Sv or 0.1 Sv. This is particularly important to clarify for Figure 7, which is a bit confusing, as in each column at least the initial freshwater flux (or even the total flux) are different for each dot.

4) Impact of AMOC changes on atmospheric CO2 concentration The results are interesting, but they are not discussed at all: there is no explanation as to why the concentration of atm. CO2 changes, and how. In addition, there is no mention of the extensive literature on the topic of the impact of AMOC changes on atm. CO2 (e.g. Schmittner et al.,2008, Menviel et al., 2014, Yu et al., 2016).

Figure 6: The y axis should be adjusted so that none of the lines are cut.

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