Dear Christopher Sabine,

Thanks for those positive and helpful comments on our manuscript. Please, find below replies to the issues you raised and the way we will address them in the revised version of the manuscript.

Sincerely,

Damien Couespel, Marina Lévy and Laurent Bopp

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The one aspect that I thought could use a little clarification is how the MOC works in the simplified, two-gyre model. The authors state that the two-gyre model could represent the Atlantic or the Pacific, but of course in the real world the MOC is quite different in these two oceans. I was unclear what exactly drives the MOC in this configuration and how real-world climate change effects that earth system models have suggested will lead to a slowdown of the MOC would be replicated in this two-gyre model.

> We agree that a clarification of the factors driving the MOC slowdown in our simplified model as compared to more realistic configurations would be of interest. This was also pointed out by the other reviewer. Change in our model's MOC is driven by change in the air-sea heat flux which is thought to be the primary driver of a slowdown of the MOC in climate models (Gregory et al. 2005, Weaver et al. 2007, Marshall et al., 2015). However changes in wind stress, freshwater inputs are recognized to influence the MOC (Bras et al. 2021, Saenko et al. 2005, Bronsaeler et al. 2016, Yang et al. 2020).

In the conclusion we will state that this simplified model allows us to investigate the resolution sensitivity of warming induced AMOC decline related with the reduction of the formation of a unique deep water mass - although the link between the two may be more tenuous than previously thought (Lozier et al. 2012). AMOC response driven by freshwater input and wind stress pattern changes or related to changes in other oceanic regions and water masses would require more detailed and realistic configurations.

I would also like to see at least some recognition in the manuscript that this work is examining the climate change effects only on the idealized large-scale open ocean NPP. The simplified two-gyre model with vertical walls and only one ocean, clearly does not reflect the complexities of the real world with dynamic coastal regions and marginal seas that may respond very differently to climate change and anthropogenic forcing. It also does not address how changing ecosystems, for example nitrogen fixers, might take advantage of the increased stratification and reduced nitrogen supply to compensate for a decline in the traditional primary producers. I don't think the lack of coastal waters or multiple ocean basins is a problem, but it should be recognized that this is just one piece of a much broader and more complicated response of the ocean to climate change.

> We agreed that the manuscript should better emphasize that our work is just one piece of a much broader and complicated response of the ocean to climate change. Thanks for pointed this out. We will emphasize this point in the abstract and the conclusion section. In particular, as mentioned above and in the reply to the other reviewer, we will add in the conclusion that because of the

closed boundaries our model do not allow the inflow of water masses significant for a more realistic MOC.

I appreciate all the figures in the manuscript and as part of the appendix. The one figure that I did not find particularly interesting or necessary is figure 7. I appreciate that the authors were trying to produce a summary infographic, but this did not clearly convey the idea that model resolution was the driver for the changes outlined in the figure. Perhaps something more than just the words at the top to illustrate this central aspect of the study.

> We agreed the main results of our study (impact of increasing resolution) may be better emphasized in this figure. We will modify this figure in consequence.

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