

Answer to Anonymous Referee #1

We thank Referee #1 for their careful review of our paper and for the improvements and revisions suggested in their comments. In the following text, we answer to all points discussed by Referee #1, where Referee comments are written as R: and authors comments are written as A:

R: My only comment is concerned with the AMOC: While the authors do classify it as contributing both structural and state-dependent noise (in Table 7 and text), in the discussion the state-dependence becomes a bit vague. I agree that we don't know much, but I think it could be stressed a bit more that it is very likely that the AMOC contributes to state-dependent noise. The AMOC does influence SSTs (and probably globally), but it is not the only factor, and the degree to which the AMOC influences SST can depend on the period of time. See for example the analysis in this preprint: <https://doi.org/10.5194/cp-2022-35> for the Pliocene, where an attempt is made to distinguish between AMOC-driven and 'gyre-driven' ocean heat transport. The statement the authors make in line 457-59 may hint towards the fact that for the LGM the amount to which the AMOC influences NH-SSTs is again different from present day and Pliocene.

A: We agree with Reviewer #1 that there should be more emphasis on the state-dependency of the AMOC and how it may influence SST. We have added comments on the state-dependency in ocean heat transport during the Pliocene, as shown by Weiffenbach et al. (2022), and emphasized the complexity of both structural and state-dependent issues in ocean currents as sources of noise in the emergent constraint on ECS. There does not seem to be a clear connection between the AMOC and the warm Pliocene, as AMOC changes seem to have been driven by paleogeography. However, some components of the AMOC may be related to changes in the regional temperatures. We have also referred to this point in the new section on recommendations for future paleo-emergent constraints in response to the public comment of Matthew Huber. We also use this opportunity to highlight the differences that may arise from simulations being transient (abrupt4xCO₂) and near-equilibrium (LGM).

“The state-dependency of the AMOC has been studied at the Pliocene, where models show consistent global SST warming and strengthening of the AMOC compared to pre-industrial (Weiffenbach et al., 2022). Pliocene paleogeography may drive changes in AMOC rather than SSTs (Burton et al., in prep.); however, the warm state of Pliocene north Atlantic SSTs enhance oceanic heat transport by the subtropical gyre which may be responsible for regional SSTs changes (Weiffenbach et al., 2022). An additional caveat is that the simulated LGM is closer to equilibrium response than the 150-year long abrupt4xCO₂ simulation from which ECS is diagnosed. There are substantial differences in AMOC strength and structure between transient and equilibrated global warming experiments (Jansen et al., 2018). Generally, decadal time scale transient future simulations of the AMOC show a slowdown of the circulation (Weijer et al., 2020, Lee et al., 2021), where in turn, LGM models show slowdown, acceleration or similar to pre-industrial AMOC strength, suggestive that differences and therefore noise may arise based on how close the simulation is from equilibrium. Overall, this highlights the complexity of structural issues and state-dependencies in ocean currents and how they contribute as sources of noise in the emergent constraint on ECS.”

R: Minor comments: line 656: 'model' should be 'more' line 676: capitalize 'ice sheet ...' it is the start of a new sentence. Table 7, row 'Ocean': two brackets too much

A: Corrected.