

Interactive comment on “Impact of the oceanic geothermal heat flux on a glacial ocean state” by M. Ballarotta et al.

Anonymous Referee #2

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The authors aim to show that potentially oceanic geothermal heating (OGH) has a significant impact on the Last Glacial Maximum (LGM) ocean state. To this end, they carried out two simulations with a numerical ocean model under LGM boundary conditions - one without, the other with OGH.

My main concern with this particular methodology is as follows: In my view, a comparison to the impact of the geothermal heat flux on the present-day state in the same ocean model and a comparable configuration (without salinity restoring) is missing. A second pair of “control” experiments “GH_control” vs. “REF_control” is needed for present-day conditions to allow for a meaningful assessment, minimizing the influence of the “model error” that arises from using different ocean models. The present-day simulations referred to in the Discussion section (p. 3603) were either carried out un-

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der different boudary conditions (with salinity restoring - Emily-Geay and Madec, 2009) or with a different ocean model (POTSMOM-1.0 - Hofmann and Maqueda, 2009).

Furthermore, in the present manuscript the simulations are not shown to be consistent with reconstructions (they are not “validated”), except for the temperature and salinity of the deepest waters in Section 3.1. Hence it is not clear in which sense the GH and REF simulations represent the LGM ocean state, other than that the atmospheric forcing fields from Brandefelt and Otto-Bliesner (2009) were obtained under LGM boundary conditions. As long it is not clear which ocean state is represented, it is not possible to assess in which way the results add to the previous work by Emily-Geay and Madec (2009) or Hofmann and Maqueda (2009).

In this regard, the coarse-resolution simulation of the LGM ocean referred to in Ballarotta et al. (2013a) is actually compared to reconstructions, but this simulation may not be consistent with the current REF simulation as it is initialized from different temperature and salinity fields by Brandefelt and Otto-Bliesner (2009). It is interesting to note that the article by Ballarotta et al. (2013a) also lacks a consistent control simulation.

Further points

1. How sensitive are the results to the selected parameterization of vertical mixing (p. 3601)? In the selected parameterization, what is the source of the energy for mixing? What is the “mixing efficiency”?
2. Please explain which ocean state was taken from Zhang et al. (2013) to serve as initial conditions and why the atmospheric boundary conditions were taken from Brandefelt and Otto-Bliesner (2009).
3. How does the the total energy input from OGH forcing (29.9 TW) and the mean value over the ocean ($\sim 88 \text{ mW m}^{-2}$) compare to observational estimates? Are these values “realistic”?

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4. The LGM is not a glacial period, but just a part of it. Depending on the definition, it lasts about four thousand years, about twice the characteristic time scales shown in Figure 1. Forcing was probably not constant, and the climate not in perfect equilibrium.

5. P. 3622, Figure 8: It looks as if almost NADW is formed south of about 45° N, which seems strange. What do the sea-surface temperature and sea-ice distributions look like, and how do they compare to reconstructions? What would the corresponding present-day overturning look like?

Minor points

P. 3601, line 9: sea-ice dynamics [plural]

P. 3601, line 11: a 4000-year long [without “s”]

P. 3604, line 2: subtracting the streamfunction in latitude-density coordinates [“in” is missing]

P. 3618: Figure 2 is very small.

P. 3622: Figure 6 and elsewhere: please note that the volume of the lower meridional circulation cell does not necessarily coincide with the volume occupied by Antarctic Bottom Water, because circulation boundaries do not necessarily match water-mass boundaries.

Overall, the manuscript is well structured and well written. Once the methodological issues were taken care of, it would certainly present results that would be relevant to the paleoclimate community that is interested in the reconstruction and modeling of the LGM ocean.

References

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