

Review: "Impact of the oceanic geothermal heat flux on a glacial ocean state"

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This study presents the influence of oceanic geothermal heating (OGH) on the paleo ocean, specifically the LGM. This is not the first study to test the influence of geothermal heating on the global ocean, but its novel contribution is testing previously theorized salinity and temperature changes under a paleo climate in a well-cited global coarse resolution (2-degree) ocean/ice model. Overall, the paper is a useful contribution to the geothermal heating model literature and CPD readers. I suggest the paper requires minor revisions to be acceptable for publication.

Specific comments:

INTRODUCTON: I think you need to make it clearer that this study differs from, for example, Adkins et al. (2005) because here you're actually testing the theories in a global ocean/ice model with realistic bathymetry. This will help strengthen the novel nature of the study.

TERMINOLOGY: Often thermohaline circulation is used, but it is not specified where in the global ocean, or what part (upper lower, deep/bottom, etc.). Clarification is needed. Also, I suggest chaning "effective" to "residual" or "total" when describing the combined Eulerian and eddy overturning circulation.

GRAMMAR: The grammar is fine, but a lack of indefinite/definite articles (e.g., "a", "the") in several places makes requires attention. I have noted a few instances below.

APENDICES: There are two appendices, but they are not referred to explicitly in the main body text. For example, specify "Appendix A", "Appendix B".

On the subject of Appendix A, is it really necessary that you include a latitude-depth analysis of the MOC? I find including both density and depth frameworks is confusing for the reader and makes it difficult to extract your key points for MOC changes. I suggest that you just add an extra sentence or two describing the MOC in latitude-density space in the REF state so the reader has a basic idea of which overturning cells are which, and then state the results with OGH applied.

Technical corrections:

Abstract

l. 6: "including or not INCLUDING geothermal heating"

Introduction

l. 5: "ocean dynamic" → "ocean's dynamics"

l. 8: "By applying A spatially constant..."

l. 12: Is the 5 Sv just for bottom water or for the global thermohaline circulation?

- l. 13-20: This whole paragraph needs re-writing. The first sentence is very long-break it into two. The second sentence is unclear. What do you mean by “supports the strong effect of the OGH on local scale”? And is the minimized impact on the GLOBAL thermohaline circulation?
- l. 22: Replace “deep ocean is invoked for explaining the rapid...” with “deep ocean is responsible for the rapid ...”
- l. 26. Insert a citation for this sentence “It is also postulated...CO2 storage”.
- p. 3600, l.10: Replaced “We aimed at (1) evaluating...and (2) testing...” with “Here, we aim to (1) evaluate...and (2) test”.
- p. 3602: l. 3: “drifts” → “drift”.

Results

- l. 10 (and all other instances afterward): replace “drift” with “trend”, otherwise the reader would assume you are referring to the drift in the model itself, not the response associated with OGH.
- l.12-13: Add a sentence explaining why there is colder water above warmer water in the Atlantic only.
- p. 3603, l. 2 and l. 11: “depthS”.
- l. 12-14: Add a sentence explaining the reason behind these salt anomalies.
- l. 19: By stratification, you mean density gradient here, yes?
- l. 22: “circulation in the latitude-depth” → “circulation in latitude-depth”.
- l. 24: Why is the circulation better explained in a density framework, such as less work along required to move the water parcel along lines of constant density surfaces? Add in a sentence/expand the present sentence, referencing papers by T. McDougall.
- p. 3604, l. 2: insert “in” after “functions”.
- l. 17: How much denser is the NADW? Quantify.
- l. 21: “is ONLY slightly larger”.
- l. 26: “reaches A maxima”.
- l. 27: “Northern Hemisphere, AND southward”.
- p. 3605, l. 8-12: You refer to Northern Hemisphere deep mixed layers, but in the previous sentence you refer to the Southern Ocean where similarly deep MLD exist also.
- Section 3.4: This seems like a summary section...you might want to note this in the subsection title or first sentence.
- l. 20-22: The first sentence here says surfaces waters transported toward Antarctica freshen. The second sentence says AABW freshens. But there needs to be a sentence in between that says that high salinity shelf waters contribute to the formation of AABW. And note that this is NOT the only contribution to AABW formation (e.g., modified southward flowing warm and salty deep waters also contribute to AABW formation).
- p. 3606, l. 1: “dynamicS”.

Discussion

General comment: I find the first paragraph difficult to understand. Your comparing you're results to present day analyses (e.g. Hofman and Maqueda) and then saying that the difference in results is due to salinity restoring. What about all the other differences, like not including an interactive atmosphere (this is noted later, perhaps move it forward), or describing the individual models'

mixing parameterisations and resolution, or timescale for simulations, or individual models' drifts, or the type of geothermal heating each of those studies uses, or the fact that they're analyzing different ocean climate states to your study....my point is that salinity restoring is unlikely the sole reason behind bottom water anomalies.

l. 5: "simulationS".

l. 18: remove "(reduced salinity)" as this is obvious.

l. 24 and 25: replace "value" with "anomaly"/"trend".

l. 27: Replace "time scale, but..." with "time scale. However,..."

p. 3607, l. 1: "scaleS".

p. 3608, l. 1: change to "Antarctic Bottom Water transports geothermally heated waters..."

l. 4-13: Here you should re-emphasise that this study is testing previously posed theories in a global ocean/ice model with realistic bathymetry...otherwise you imply that the study just proved an already well-formed theory (e.g. Adkins et al. work)...you need to stress this study is novel!

l. 14: Replace with "Our results are based on a forced (i.e.,)"

l. 16: "Sensitivity studIES".

Appendix A: delete "A" at the start of the first paragraph.

Figures

Figure 1: The y-axis label on the bottom panel is too small to read. Perhaps use a word/single symbol label and expand to the equation in the caption. In the caption, change "drift" to "trend".

Figure 2: Fix salinity units in the third line of the caption. Also in the caption, why is 34S classed as the entrance to the South Atlantic, even in the INP panels? I suggest changing "South Atlantic" to "Southern Ocean" in this and other captions. Changed "dashed contours" to "hatched/stripped regions". Also, I can barely see those regions in your figure- might want to draw the reader's attention to specific panels and depths.

Figure 5: Make the zero contour bold.

Figure 5 and 8: Why haven't you similarly added hatched/stripped regions in Figure 5?