

Interactive comment on “The simulated climate of the Last Glacial Maximum and insights into the global carbon cycle” by Pearse J. Buchanan et al.

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Review of Buchanan et al. 2016 Climate of the Past Discussions: “The simulated climate of the Last Glacial Maximum and insights into the global carbon cycle”

The authors present model simulations of the LGM ocean biogeochemistry. I think the results are well described and make sense and the paper is well written and illustrated. The authors also compare their model to paleo reconstructions at least qualitatively. I agree with many of the authors findings but I think that some conclusions drawn need to be rephrased because the evidence provided is insufficient in supporting them.

The main issue I have with this paper is that the authors conclude both in the abstract (lines 13-14) and in the conclusion section (page 16, lines 8-9) that “physical changes ... are not sufficient to explain “ the CO₂ drawdown. I think these conclusions refer

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to the physical changes simulated by their model. I don't think the authors can conclude that the model exactly reproduces the real LGM ocean physics. Therefore the statements should make clear that they do not refer to the real ocean but to the model simulated ocean. I suggest to rephrase by e.g. including in the abstract "physical changes simulated by our model cannot in isolation produce ..." and a similar change in the conclusion section.

Below I also suggest to include some recent relevant references.

Page 2, line 5: include Annan and Hargreaves (2014; doi:10.5194/cp-9-367-2013) for a more up-to-date global mean estimate

Page 2, line 19: "inseparable" is a too strong word. I'd suggest "connected" instead.

Page 2, lines 20-24: In this discussion of physical mechanisms I would suggest to include recent work that has improved understanding of the effects of wind stress changes in the North Atlantic (Muglia and Schmittner, 2015, GRL, doi:10.1002/2015GL064583) and tidal mixing (Schmittner et al. 2015, GRL, doi:10.1002/2015GL063561) on the circulation

Page 3, lines 32-33: please clarify if Bering Strait is open or closed?

Page 4 lines 4-6: I don't understand this sentence. How does coupling between a cooler atmosphere and the ocean lead to a 0.5 psu increase in salinity? That is about half the increase it should be based on the 120 m sea level drop.

Page 4, line 16: "averages" do you mean monthly averages or annual?

Page 4, line 30: please explain the other variables in this equation. What is $F(l)$? Light limitation? Why is there a multiplication by 12? What is V_{max} and P_k ?

Page 7, lines 10-13: Note that Ferrari et al. (2014) do not consider other processes that we know are important for determining the MOC strength such as closure of Bering Strait (Hu et al. 2010, Nat. Geosc., DOI: 10.1038/NGEO729), wind stress and tidal

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mixing changes (see above papers).

Page 7, line 33: “ The Cpl-LGM sea ice in this study is broadly consistent with the palaeo evidence in the North Atlantic,” the simulated perennial sea ice cover seems inconsistent with proxy based evidence of seasonal ice free Nordic Seas

Page 8, line 15: “18392 to 5391 Sv” looks like a typo

Page 8, line 16: See Muglia and Schmittner (2015) for updated numbers from the PMIP3 models

Page 8, line 22: check Broecker 2013 reference. I couldn't find it based on the information in the reference list.

Page 8, line 26: for a different view on diapycnal mixing see Schmittner et al. (2015) and references therein.

Page 8, lines 32-35: see my previous comments on Ferrari et al.

Page 10, lines 8-11: compare with data constrained model of Schmittner and Somes (2016, PO, doi: 10.1002/2015PA002905)

Page 11, lines 9-10: this is probably due to the neglect of sediment interactions and whole ocean alkalinity changes (see also discussion in Schmittner and Somes 2016)

Page 13, lines 29-31: I don't think that the reduction in export production is contrary to arguments for a strengthened biological pump. The strength or efficiency of the biological pump is best defined as the global mean respired carbon or phosphorous content (see discussion in Schmittner and Somes 2016). Thus a more efficient biological pump which results in sequestration of organic carbon and nutrients in the deep ocean will cause a reduction in export production due to the loss of upper ocean nutrients.

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