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Interactive comment on "Carbon isotopes support Atlantic meridional overturning circulation decline as a trigger for early deglacial CO₂ rise" *by* A. Schmittner and D. C. Lund

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Thank you for your comments. In our response below some of your original comments are quoted.

"1. The model simulations start from pre-industrial boundary conditions (also pointed out by Referee #2). As shown by Schmittner et al. (2007), the effect of water-hosing on the UVic model in a pre-industrial state is much larger (27 ppmv) than on an LGM state (5 ppmv). Since the real deglaciation started from the LGM state, it seems the impact of the AMOC shutdown on CO2 should be overestimated by something like a factor of five in the model experiments shown here. This contrasts with marine isotope

stage 3, when the intermediate ocean state would have presumably still left the AMOC with a larger amount of leverage on CO2. So if Schmittner et al. (2007) is still right, the actual direct effect of the AMOC shutdown during HS1 should have been much smaller, according to the UVic model (nevermind disagreement with other models, which show equivocal impacts of AMOC shutdown on CO2)."

The LGM state of the global physical and biogeochemical ocean is currently unknown. The initial LGM state that Schmittner et al. (2007) used in their simulations was not tested against deep ocean reconstructions because at that time the model didn't include d13C. Thus we don't know if Schmittner et al.'s (2007) result is realistic.

Anyway, we now include an extensive discussion of this topic in the revised manuscript's discussion and conclusion section.

"2. The comparison with data stops short just before the B-A. Prior experience with the UVic model shows clearly that the ocean will take up CO2 once again when the AMOC resumes (e.g. Schmittner and Galbraith, 2008). However, this did not happen during the deglaciation - instead, there was a permanent, net increase in CO2 between the LGM and the B-A. The mechanism behind the HS1 CO2 increase was therefore either a) did not include an input from the AMOC shutdown, or b) did include an input from the AMOC shutdown, which was followed immediately by a compensatory subsequent source of CO2 that masked the AMOC re-uptake of CO2 during the B-A."

You're right, an AMOC resumption would lead to a decrease of atmospheric CO2 in the model. We discuss this now (hopefully more clearly than before) at the end of the discussion and conclusion section. However, the HS1 – B-A transition is beyond the scope of our mansucript, which focusses only on the LGM – HS1 transition only. We prefer to keep speculations on the B-A to a minimum (see last paragraph of discussion and conclusions section).

"Together, these two points suggest to me that the AMOC variability played only a minor role in the CO2 rise during HS1."

We don't agree with that inferrence. Neither of those points implies a minor role of the AMOC on the HS1 CO2 rise.

"That's not to say it didn't have any role, nor that it didn't have a big impact on the redistribution of carbon isotopes within the ocean during HS1 - it probably did, and these results provide very useful support to the idea that NADW formation really did shut down at the time."

We don't claim that and think that it cannot be inferred from our study. We only infer a substantial AMOC reduction for a multi-millennial time period during HS1. The fact that the model overestimates the d13C changes in the North Atlantic may indicate that the AMOC was not completely shut down during HS1.

"But I think there's enough wiggle room between the model d13C and the foraminiferal d13C observations to allow other processes, such as iron fertilization, changes in sea ice, changes in Southern Ocean convection, and changes in the marine ecosystem to have done the heavy lifting of atmospheric CO2 during HS1."

We cannot exclude causes other than the AMOC for the HS1 CO2 rise, but we think it is possible that it was entirely caused by the AMOC.

"If the authors agree with me (at least partially) on these points, perhaps it would be helpful to somehow quantify the model disagreement in a way that would suggest the non-AMOC processes that contributed to the net CO2 rise during HS1? In other words, could the model-data mismatch help to diagnose any other processes that were behind the net CO2 rise?"

Thank you for the suggestion but this is presently impossible. We require realistic initial conditions to improve these estimates in the future.

Interactive comment on Clim. Past Discuss., 10, 2857, 2014.