Geoscientific Model Development Discussions

Geosci. Model Dev. Discuss., referee comment RC1
https://doi.org/10.5194/gmd-2022-277-RC1, 2022

Comment on gmd-2022-277

Wilbert Weijer (Referee)

Referee comment on "Understanding AMOC stability: the North Atlantic Hosing Model Intercomparison Project" by Laura C. Jackson et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2022-277-RC1, 2022

Review of: Understanding AMOC stability: the North Atlantic Hosing Model Intercomparison Project, by Jackson et al.

In this paper the authors introduce a protocol for systematically investigating the stability of the Atlantic Meridional Overturning Circulation in climate models. This protocol includes two distinct experimental procedures, where anomalous freshwater is either applied over the entire Arctic, or around Greenland. The authors present initial results from 8 coupled climate models that participated in this NAHosMIP experiment. They compare the AMOC response to these freshwater prescriptions, and try to identify an indicator to predict whether the AMOC will recover or not.

The paper is short and to the point and is well written. It succeeds in its main goal of introducing the NAHosMIP protocol, and this paper forms a solid basis for more detailed analysis. I recommend accepting this paper after some minor revisions.

General comment:
Just a general comment: The paper does not make the claim that the weakened AMOC state is a collapsed state, and that seems to be the right approach. The weakened AMOC structures in Fig. 2 (middle column) just seem weakened versions of the control AMOC states (left column), and do not seem topologically different. In other words, they don't look like a collapsed or reversed circulation as one would expect from a true off-state --as for instance in simple box models, or in the bifurcation diagrams from the Dijkstra group (e.g., Fig. 2 of Huisman et al. 2010). Instead, they seem to be more representative of the 'cold on' state of the glacial period (Fig. 8 in Weijer et al. 2019) in which any convection was pushed southward. This may be a useful distinction to make.

Specific comments:
p. 1, l. 2: "…there are theories…" -> "…theories suggest…"?

p. 1, l. 7: or -> of
p. 2, l. 26: "…a couple of…" -> "…several…"?
p. 2, ll. 34-47: "… North Atlantic…": Obviously the salt advection in the North Atlantic is a strong positive feedback, but as far as I am aware, only Fov on the southern boundary of the Atlantic (34S) has been proposed as a stability indicator with a reasonable degree of theoretical underpinning (e.g., Dijkstra 2007, Huisman et al. 2010). But the relative role of the double-hemispheric and hemispheric salt advection feedbacks in AMOC stability is an interesting problem.
Section 2.3.4: Is this volume correction (which depends on time-varying surface salinities) calculated at each time step?
l. 134: I think the official abbreviation is piControl, so I would suggest sticking with that convention (but then again it doesn't look like that abbreviation is further used in the manuscript).
l. 186: Please correct bracketing of Bellomo.
Fig. 7: Apparently the lower row is for AMOC at 45N, instead of 26.5N.
l. 245: what period do these averages represent? Is that the decade before hosing stops?
ll. 245-251; l 305: It seems to me that the qualifying difference is surface salinity, and not the temperature, if surface waters are fresher and less dense in those models that do not recover. So maybe it is better to show salinity (or density) in panels c and d, instead of temperature. It looks like in these cases the salt advection feedback has indeed won from the temperature advection feedback.
l. 272, Fig. 9: Maybe this is for a follow-up study, but I would be interested to see if Fov(34S) indeed scales with AMOC – with Fov moving closer to 0 when AMOC weakens. In other words, is the feedback truly acting as we believe it should? Or is Fov contributing to flushing freshwater from the Atlantic (and for how long after hosing stops?). I suspect that Fov simply can't do its job when the Atlantic is affected by a significant freshwater perturbation.
l. 560: Please correct the url.
Figs. 11: What do these structures look like at the maximum of hosing? That may matter more than the gyre structure of the control state (which I suspect is depicted here) when it comes to the possibility of freshwater escaping southward.