Climate of the Past Discussions

Clim. Past Discuss., referee comment RC1
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Comment on cp-2021-187

Anonymous Referee #1

Referee comment on "The first 250 years of the Heinrich 11 iceberg discharge: Last Interglacial HadGEM3-GC3.1 simulations for CMIP6-PMIP4" by Maria Vittoria Guarino et al., Clim. Past Discuss., https://doi.org/10.5194/cp-2021-187-RC1, 2022

This study presents a water hosing simulation using the HadGEM3 to study the dynamical processes that are relevant for the H11 event. The authors document changes in the atmosphere, ocean, and the coupled system. One particularly interesting finding is the sea ice expansion in the Southern Ocean in response to the AMOC weakening, which the author attribute to the atmospheric processes, i.e., shifts of jet stream and changes in the Southern Annual Mode (SAM).

The manuscript is well written. The use of state-of-the-art model, the HadGEM3, is beneficial for the community to study the latest CMIP6-class models. Analyses from the atmosphere, ocean, and the coupled perspectives are also very useful. However, some of the authors' conclusions are not well-supported by the current analyses and therefore lack well-established casual relationships in the authors' simulations. Please see my comments below. These comments should be addressed before the manuscript can be published in Climate of the Past.

Major comments

- The authors need to tone down the rhetoric regarding their work being the "the first time that the classical "thermal bipolar seesaw" associated with the H11 event has undiscovered consequences in both Hemispheres". AMOC and the associated climate change have been studied for several decades using water hosing experiments by the climate dynamics community (e.g., Stouffer et al., 2006). The feedbacks from ocean transport and air-sea interactions that are relevant for the AMOC have also been studied extensively (e.g., Buckley and Marshall, 2016; Stocker et al., 2001). Moreover, how the North Atlantic processes can impact the remote regions has also been studied in much detail, including the impact on the tropics and subtropics (e.g., Zhang and Delworth, 2005), global atmospheric teleconnections (e.g., Wu et al., 2013), in a paleoclimate (e.g., Kageyama et al., 2013), and on the Southern Ocean in the context of climate variability in the present-day climate (e.g., Zhang et al., 2017). Given the rich literature on this topic, I think it is unjustified to claim the authors' results are the "first" and show "previously undiscovered consequences in both Hemispheres", unless the authors can show that the AMOC's influences are uniquely tied to the LIG climate and have different dynamics from previous studies.

- The sea ice increase over the Southern Ocean in the authors' simulations is interesting and somewhat surprising; more analysis on this is warranted. Is the sea ice increase occurring throughout the year or only in specific seasons? Is the time evolution of the sea ice cover consistent with a SAM-driven mechanism? Can you also show time series of the sea ice expansion? Causal relationship needs to be better established in the authors simulations. Please show the details of the dynamical and thermodynamical processes (Line 242) that drive the sea ice expansion. Are the results model dependent, given the model-dependent responses, e.g., documented in Kageyama et al. (2013)?
- Where does the deep-water formation take place in the PI and the LIG simulations using HadGEM3? Can the model simulate deep convection over the GIN Seas that has been suggested by observations (e.g., Holte et al., 2017; Lozier et al., 2019)? How are the sites of deep-water formation linked to the heat transport by the AMOC (Figure 9e)? Is it possible that the small heat transport by the AMOC at 50N northward (Line 220–223 & Line 359–361) is caused by the model bias in the deep-water formation over the GIN seas.
- A comment related to the above, please consider adding plots of the meridional overturning stream function and the winter maximum mixed-layer depth in the PI, LIG, and H11 simulations. Please also add the mixed-layer depth from observation (Holte et al., 2017) for comparison.

Minor comments:

- Line 79: change "N_20" to "N_2O"
- Line 109–110: the criteria of p-value should be 0.05 (instead of 0.5), right?
- Figure 2 and related discussion: how is the North Atlantic and Southern Hemisphere defined spatially? Does the North Atlantic include the Greenland, Iceland, and Norwegian Seas?
- Line 179–182: Please add a mechanistic understanding of the shift of the polar jet in the Southern Hemisphere.
- Figure 5: I do not see "error bars" in the plots.
- Figure 12: is the sea ice concentration annual mean, or for the winter?

References:

Buckley, M. W., & Marshall, J. (2016). Observations, inferences, and mechanisms of the Atlantic Meridional Overturning Circulation: A review. *Reviews of Geophysics*, *54*(1), 5–63. https://doi.org/https://doi.org/10.1002/2015RG000493

Holte, J., Talley, L. D., Gilson, J., & Roemmich, D. (2017). An Argo mixed layer climatology and database. *Geophysical Research Letters*, *44*(11), 5618–5626. https://doi.org/https://doi.org/10.1002/2017GL073426

Kageyama, M., Merkel, U., Otto-Bliesner, B. L., Prange, M., Abe-Ouchi, A., Lohmann, G., Ohgaito, R., Roche, D. M., Singarayer, J., Swingedouw, D., & Zhang, X. (2013). Climatic impacts of fresh water hosing under last glacial Maximum conditions: A multi-model study. *Climate of the Past*, *9*(2), 935–953. https://doi.org/10.5194/cp-9-935-2013

Lozier, M. S., Li, F., Bacon, S., Bahr, F., Bower, A. S., Cunningham, S. A., ... & Zhao, J. (2019). A sea change in our view of overturning in the subpolar North Atlantic. Science, 363(6426), 516-521. https://doi.org/10.1126/science.aau6592

Stocker, T. F., Knutti, R., & Plattner, G.-K. (2001). The future of the thermohaline circulation - A perspective. In *The oceans and rapid climate change: Past, Present and Future. Geophysical Monograph 126* (Vol. 126, pp. 277–293). AGU. https://doi.org/10.1029/GM126p0277

Wu, L., Li, C., Yang, C., & Xie, S.-P. (2008). Global Teleconnections in Response to a Shutdown of the Atlantic Meridional Overturning Circulation. *Journal of Climate*, *21*(12), 3002–3019. https://doi.org/10.1175/2007JCLI1858.1

Zhang, L., Delworth, T. L., & Zeng, F. (2017). The impact of multidecadal Atlantic meridional overturning circulation variations on the Southern Ocean. *Climate Dynamics*, *48*(5), 2065–2085. https://doi.org/10.1007/s00382-016-3190-8

Zhang, R., & Delworth, T. L. (2005). Simulated tropical response to a substantial weakening of the Atlantic thermohaline circulation. *Journal of Climate*, *18*(12), 1853–1860. https://doi.org/10.1175/JCLI3460.1