

Response to the interactive comments by E. Moreno-Chamarro:

Ref.: Ms. No. cp-2017-106

Title: Abrupt cold events in the North Atlantic in a transient Holocene simulation”

We highly appreciate your time and effort giving constructive comments and suggestions, which will help us to greatly improve our manuscript. We have prepared a new version of the manuscript with the comment taken into account. Below the original comment is marked in black and our response in blue.

This is indeed an interesting paper. I don't aim at giving an exhaustive review here, but I would suggest that the authors compare and discuss their results with those in Moreno-Chamarro et al. [2015]. My impression is that many of the features and mechanisms of the cold events described here with the CCSM3 model are actually very similar to those of the decadal cold events in the simulations with the MPI-ESM model in that referred paper. For example, the conspicuous cooling and sea ice expansion around the Labrador Sea, the weakening of the subpolar gyre and the oceanic deep convection shutdown, or the length of the cold events itself. I would add, nonetheless, that the authors are here able to go a step farther and identify a potential trigger mechanism of such events. Such discussion would be a very valuable contribution to the Klus et al.'s manuscript.

We agree that the mechanism described in Moreno-Chamarro et al. (2015) features a lot of similarities to the mechanism presented in our study. The authors describe and analyze decadal cold events in the North Atlantic in climate simulations and climate reconstructions. Although being triggered by internal variability the external forcing can strengthen their behavior. Moreno-Chamarro et al. explain that the events start with a weakening of the sub-polar gyre, leading to a surface freshening and cooling followed by a shutdown of deep-convection. In our study the surface conditions in the sub-polar gyre also show a freshening and cooling and a weakening the deep-water formation in the northwest Atlantic. Furthermore, we also noticed a weakened sub-polar gyre. In addition we found anomalies in the freshwater transport through Denmark Strait and the Canadian Arctic Archipelago, potentially triggered by a prolonged positive phase of the NAO. This is a major difference to the study by Moreno-Chamarro et al. (2015) since they explicitly excluded an anomalous Arctic freshwater contribution as part of the trigger for the cold events. Still, both mechanisms show a plausible sequence and mechanisms for cold events in this sensitive region. We added the corresponding comparison to the discussion in section 4.2.

References:

- Moreno-Chamarro, E., Zanchettin, D., Lohmann, K., Jungclaus, J. H. (2015). Internally generated decadal cold events in the northern North Atlantic and their possible implications for the demise of the Norse settlements in Greenland. *Geophysical Research Letters*, 42(3), 908-915.