Reversibility of North Atlantic Climate Change in Response to Stabilization of Anthropogenic CO_2 Emission

Theo Schiminovich[1], Yifei Fan[2], Laifang Li[2]

[1]Yale University, [2]Penn State University

Introduction

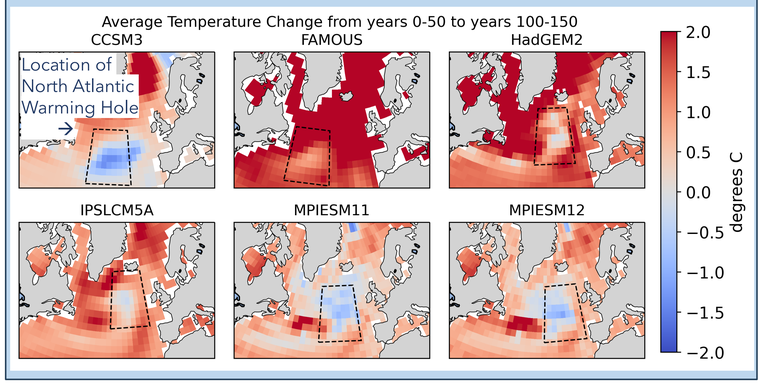
In the past 100 years, nearly all of Earth's ocean sea surface temperatures have warmed, due to anthropogenic climate change. There is one major exception; the subpolar North Atlantic. This region has cooled; this is likely due to a climate change-caused slowdown of the Atlantic Meridional Overturning Circulation (AMOC), a circulation which gives strength to the Gulf Stream, and in turn brings warm water to the subpolar North Atlantic.[1] It is less clear how the North Atlantic Warming Hole (NAWH) and AMOC would respond to a stabilization of greenhouse gas emissions; this is the focus of our research.

Objectives

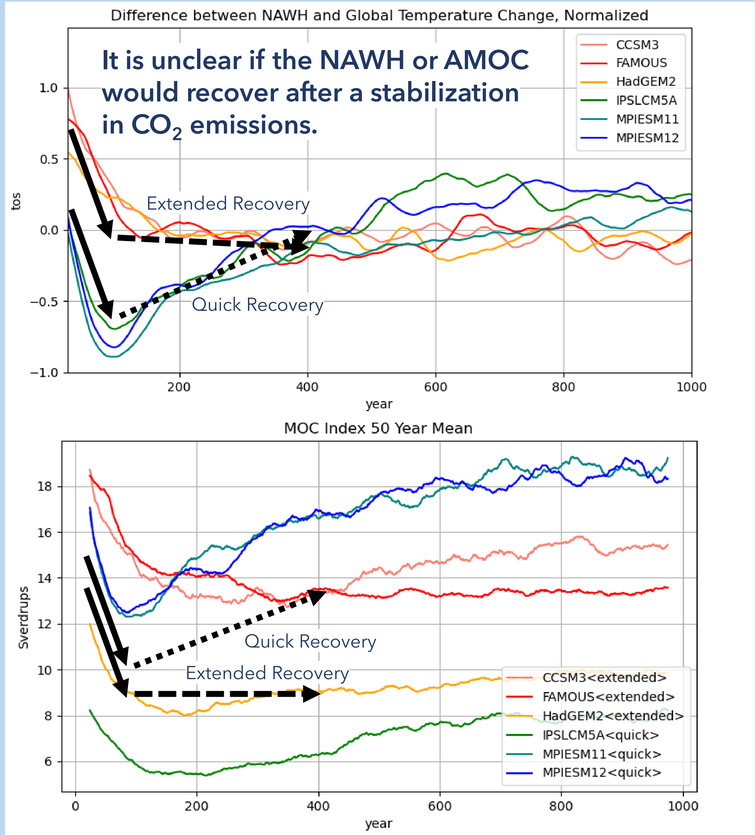
- Investigate whether a NAWH appears and if it persists in response to an abrupt 4x increase in atmospheric CO_2 levels and stabilization
- Investigate if the AMOC slows down persists after atmospheric CO_2 forcing stabilizes, and the relationship between the NAWH and AMOC
- Explore potential rationales behind model disagreement

Data & Methods

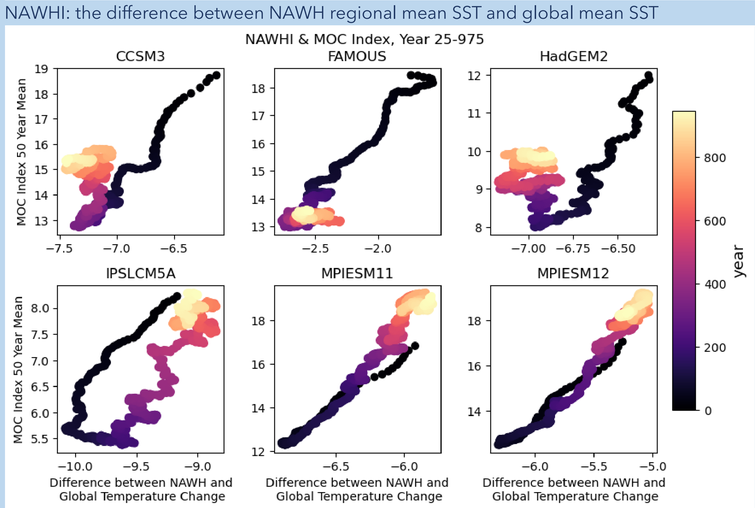
We analyzed six climate models, from five modeling agencies, within the LongRunMIP dataset[2]. Within these models, we studied variables for sea surface temperature, MOC stream function, sea salinity, and sea ice concentration.



Results



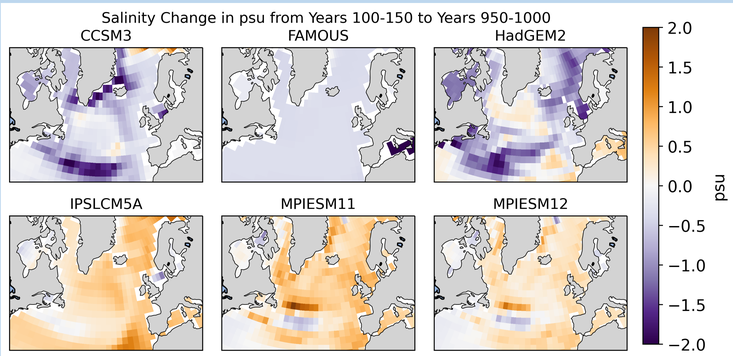
NAWHI: the difference between NAWH regional mean SST and global mean SST



Discussion

We analyzed a few other variables related to NAWHI and AMOC which could explain the model disagreement.

- Initial MOC strength did not correlate with degree of MOC recovery among these models in this dataset.
- Sea ice concentrations in years 100–150 or years 950–1000 did not correlate with degree of AMOC and NAWHI recovery.
- Salinity change from years 100–150 to years 950–1000 (post-initial cooling) did correlate with degree of AMOC and NAWHI recovery.



Conclusions

All global climate models in the dataset project a warming hole in the subpolar North Atlantic in response to CO_2 forcing. However, they disagree on whether the warming hole will recover as CO_2 forcing stabilizes.

- Quick Recovery Models: AMOC weakens and later recovers to approximately its initial state
- Extended Recovery Models: AMOC weakens and remains at a weak state

This model divergence could be associated with salinity processes, a relationship to be further explored in the future.

Acknowledgements

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1: Rahmstorf, S., Box, J., Feulner, G. *et al.* Exceptional twentieth-century slowdown in Atlantic Ocean overturning circulation. *Nature Clim Change* 5, 475–480 (2015).

2: Rugenstein, M., et al. (2019). LongRunMIP: Motivation and Design for a Large Collection of Millennial-Length AOGCM Simulations. *Bulletin of the American Meteorological Society*, *100*(12), 2551–2570.