SPECIAL PROJECT PROGRESS REPORT

All the following mandatory information needs to be provided. The length should *reflect the complexity and duration* of the project.

Reporting year	2024
Project Title:	Impacts of an AMOC collapse on atmospheric circulation in the Euro-Atlantic area
Computer Project Account:	andrea.vacca@polito.it
Principal Investigator(s):	Andrea Vito Vacca
Affiliation:	Politecnico di Torino, Italy
Name of ECMWF scientist(s) collaborating to the project (if applicable)	Katinka Bellomo
Start date of the project:	1/01/2024
Expected end date:	31/12/2025

Computer resources allocated/used for the current year and the previous one

(if applicable)

Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	-	-	72,000,000	0
Data storage capacity	(Gbytes)	-	-	180,000	0

Summary of project objectives (10 lines max)

The aim of this project is to perform ad-hoc model experiments with EC-Earth3 to investigate the atmospheric circulation response to the AMOC slowdown in the Euro-Atlantic region. To this end, we will analyse the atmospheric circulation in a set of climate experiments where the sea surface temperature is artificially modified to isolate the response to the AMOC reduced heat convergence.

Summary of problems encountered (10 lines max)

No major problems have been encountered so far.

Summary of plans for the continuation of the project (10 lines max)

We plan to start the simulations in September 2024. We will conduct a series of Atmospheric-only experiments (AMIP) with prescribed sea surface temperature (SST) anomalies under different forcing scenarios (i.e. SSP5-8.5 and abrupt-4xCO2). Similarly to Gervais et al. 2019, we will produce "SST-patches" representing the North Atlantic Warming Hole pattern in EC-Earth3. We will than compare the atmospheric circulation response in the control runs with those in modified runs where the NAWH is either "filled" or "deepened". In addition, we will analyse the atmospheric sensibility to the position of the NAWH by imposing the SST pattern at different latitudes.

List of publications/reports from the project with complete references

No publications so far.

Summary of results

Our results (Vacca et al., in prep.) indicate that the AMOC decline plays a key role in the inter-model variability of future atmospheric circulation in the North Atlantic in climate model projections archived in CMIP6. We showed that the impact of the AMOC on the atmospheric circulation is mainly mediated by the SST anomalies generated by the future reduction of poleward oceanic heat convergence. These anomalies are linked to the North Atlantic Warming Hole (NAWH) pattern (Caesar et al., 2018, Drijfhout et al., 2012), a common feature of climate change projections across different models (Figure.1).

Therefore, to investigate the role of the AMOC in the future changes of Euro-Atlantic atmospheric circulation, we will employ the granted resources to perform a series of AMIP simulations with EC-Earth3. We will start the experiments in September. So far, we have compiled the model on Atos, and discussed the model setup. In EC-Earth3, under the abrupt-4xCO2 forcing the AMOC declines of about 7.5 Sv, and the NAWH is observed at the end of the simulation in the Irminger Sea (Figure 2). We will construct SST seasonally varying patches representing the NAWH in the abrupt-4xCO2 and SSP5-8.5 forcings that will be imposed as boundary conditions in the AMIP experiments to "fill" of "deepen" the NAWH. This experimental setup allows to isolate the impact of the NAWH on the atmospheric circulation.

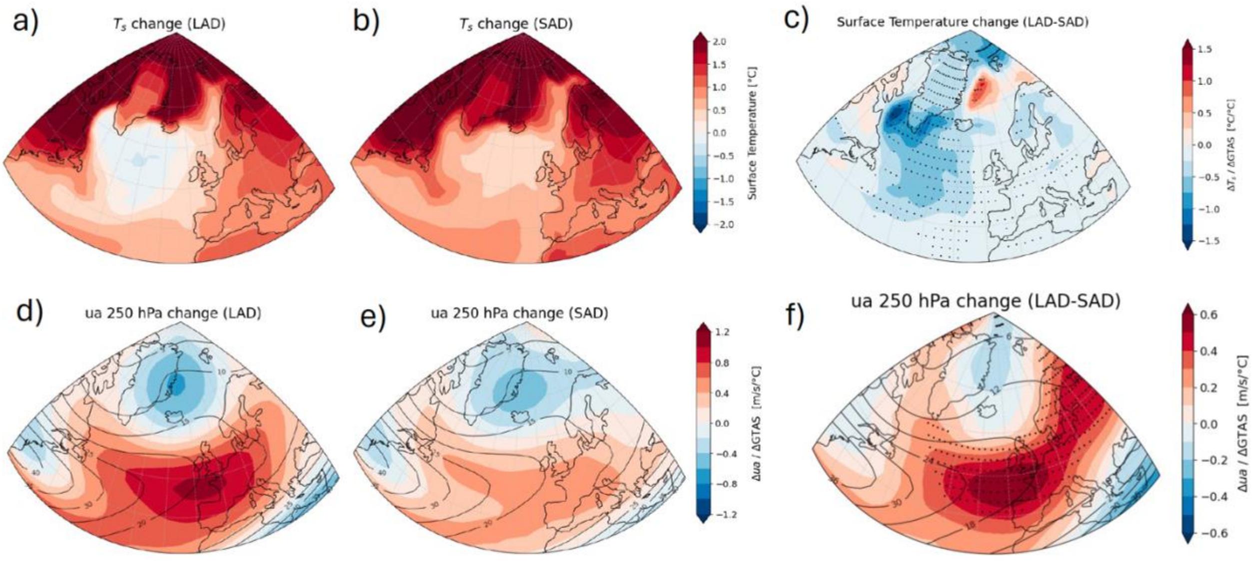

Figure1: The temperature a-c) and zonal wind d-f) response to the AMOC decline in CMIP6 models. A multi-model ensemble of 22 SSP5-8.5 simulations has been splitted into Large AMOC decline models (LAD) and Small AMOC decline models (SAD) based on the projected AMOC decline change at the end of the century. c) shows the difference in the mean surface temperature responses between a) LAD and b) SAD responses. d) shows the difference in mean zonal wind responses between d) LAD and e) SAD responses. LAD models project a more pronounced NAWH in the Labrador and Irminger sea, and an intensified North Atlantic jet stream.

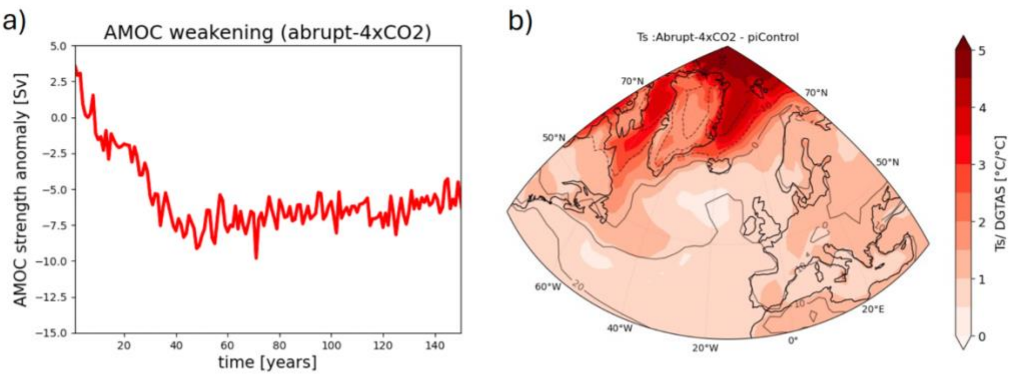

Figure2: EC-Earth3 response in a) AMOC strength and b) surface temperature under the abrupt-4xCO2 forcing.

We are currently working on the refinement and application of a novel methodology to diagnose the North Atlantic Eddy-Driven-Jet stream (EDJ) (Perez et al., revised), which allows a multi-dimensional characterization of the daily atmospheric variability. We plan to apply this methodology to analyse the output of the EC-Earth3 experiments to investigate the role of the AMOC-induced SST anomalies in the future change of EDJ.

Main References

Vacca, A. V., Bellomo, K. , Fabiano, F., Hardenberg, J. The role of a weakening AMOC in shaping wintertime Euro-Atlantic atmospheric circulation. In prep.

Caesar, L., Rahmstorf, S., Robinson, A. *et al.* Observed fingerprint of a weakening Atlantic Ocean overturning circulation. *Nature* **556**, 191–196 (2018). https://doi.org/10.1038/s41586-018-0006-5

Drijfhout, S., G. J. van Oldenborgh, and A. Cimatoribus, 2012: Is a Decline of AMOC Causing the Warming Hole above the North Atlantic in Observed and Modeled Warming Patterns?. J. Climate, 25, 8373–8379, https://doi.org/10.1175/JCLI-D-12-00490.1

Gervais, M., J. Shaman, and Y. Kushnir, 2019: Impacts of the North Atlantic Warming Hole in Future Climate Projections: Mean Atmospheric Circulation and the North Atlantic Jet. J. Climate, 32, 2673–2689, https://doi.org/10.1175/JCLI-D-18-0647.1

Perez, J., Maycock, A., Griffiths, S., Hardiman, S., and McKenna, C.: A new characterization of the North Atlantic eddy-driven jet using 2-dimensional moment analysis, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2024-318, 2024.