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

2023

Project Title:

Mechanisms and impacts of an abrupt decline in the Atlantic Meridional Overturning Circulation (AMOC) strength

Computer Project Account:

spitbell

Principal Investigator(s):

Katinka Bellomo

Affiliation:

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[2]Department of Environment, Land and Infrastructure Engineering, Polytechnic University of Turin, Turin, Italy

Name of ECMWF scientist(s) collaborating to the project
(if applicable)

N/A

Start date of the project:

01/01/2023

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)	N/A	N/A	10,000,000	5,711,232
Data storage capacity	(Gbytes)	N/A	N/A	18,000	18,000

Summary of project objectives (10 lines max)

The aim of this project is to use the EC-Earth3 general circulation model to investigate mechanisms of precipitation change associated with changes in the strength of the AMOC, with or without the influence of increasing concentrations of greenhouse gases. This is a continuation of a past project titled 'Impacts of the AMOC decline on European climate'. To address this question, we proposed to run ad-hoc model experiments in which we artificially modify the strength of the AMOC by modifying a virtual salinity flux in the North Atlantic. We then proposed to apply a moisture budget framework to investigate mechanisms of precipitation change.

Summary of problems encountered (10 lines max)

We didn't encounter specific problems. We noticed that the output of the model requires larger storage space than expected, which is delaying some of the runs that we intended to perform, but we are working on a better experimental setup so that we don't encounter this problem in future runs.

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

We managed to run few experiments in which the AMOC is artificially weakened. We needed more than one for statistical significance. We now need to finalize the analysis of the current runs and plan for a comparison run setup in which we also impose greenhouse gas forcing.

List of publications/reports from the project with complete references

Bellomo K., V. Meccia, F. Fabiano, R. D'Agostino, J. von Hardenberg, and S. Corti, 2023: Impacts of a weakened AMOC on precipitation over the Euro-Atlantic sector in the EC-Earth3 climate model. *Climate Dynamics*. *https://doi.org/10.1007/s00382-023-06754-2*

[highlight] Oral: "Impacts of a weakened AMOC on the European climate" (selected as a "highlight" presentation), April 23-28 2023, EGU General Assembly, Vienna, Austria.

Oral: "Impacts of a weakened AMOC on precipitation over the Euro-Atlantic region in the EC-Earth3 climate model", January 9-12 2023, AMS annual meeting, Denver, CO, USA and online.

Oral: "Impacts of a weakened AMOC on precipitation over the Euro-Atlantic region in the EC-Earth3 climate model", December 12-16 2022, AGU annual meeting, Chicago, IL, USA and online.

[invited] Oral: "Impacts of a weakened AMOC on precipitation over the Euro-Atlantic region in the EC-Earth3 climate model", TiPES monthly webinar series, December 7 2022, online.

Oral: "Impacts of a weakened AMOC on precipitation over the Euro-Atlantic region in the EC-Earth3 climate model", November 17-18 2022, THEMES, Venice, Italy.

Oral: "Impacts of a weakened AMOC on precipitation over the Euro-Atlantic region in the EC-Earth3 climate model", EC-Earth General Assembly, October 11-13 2022, Lund, Sweden and online.

Summary of results

We ran EC-Earth3 in its standard resolution (T255 L91, ORCA1L75) to run a water hosing simulation in which we imposed a freshwater flux anomaly of 0.3 Sv in the North Atlantic and Arctic Oceans (see fig. 1) for 140 years. After 1400 years, we stopped the water hosing and let them model freely recover. Then, we examined the precipitation impacts over Europe for 60 model years (shaded in fig. 1a) in which the AMOC was sufficiently weak (less than half the strength of the preindustrial control).

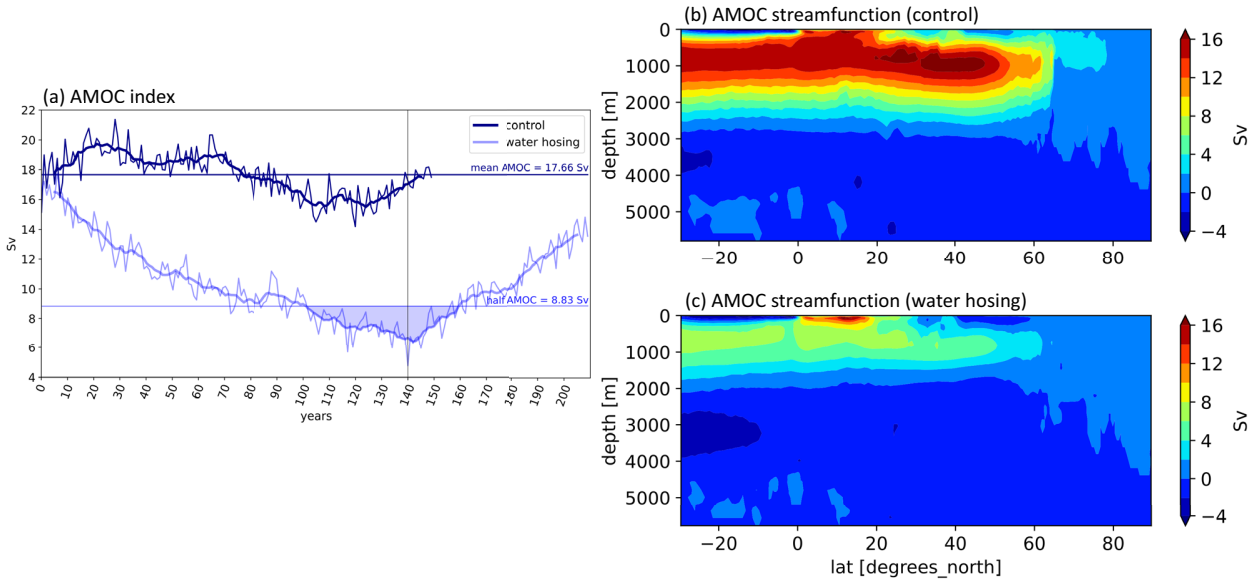

Fig 1 (*from Bellomo et al. 2023*): Timeseries and streamfunctions of the AMOC in the preindustrial control water hosed model experiments.

Precipitation change over Europe shows a drying anomaly, which we attributed to the role of transient eddies through the atmospheric moisture budget. Changes in large-scale atmospheric circulation instead show an enhanced jet stream which bring wetter daily anomalies in northwestern Europe. These results are summarized in fig. 2. We also computed weather regimes, finding a large increase in the frequency of NAO+ events, which is consistent with precipitation impacts (fig. 3).

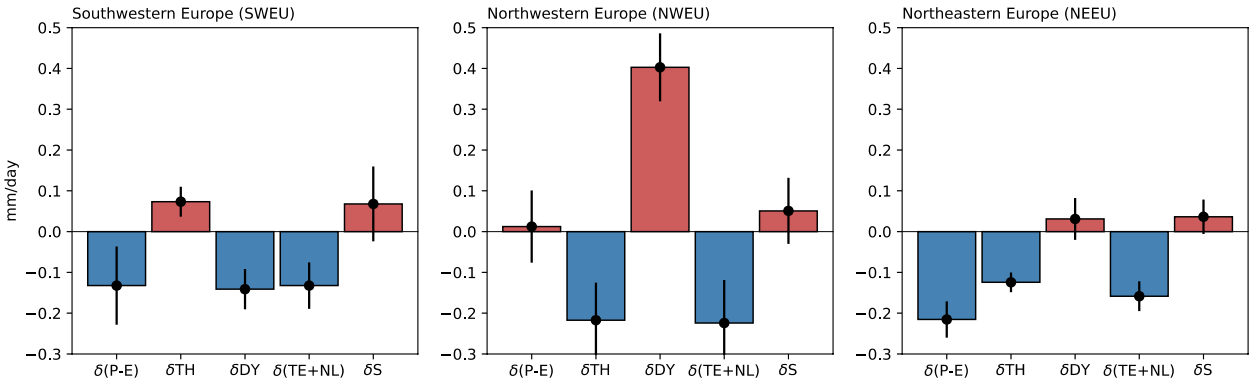

Fig. 2 (*from Bellomo et al.. 2023*): Moisture budget terms explaining precipitation change in representative European sub-regions.

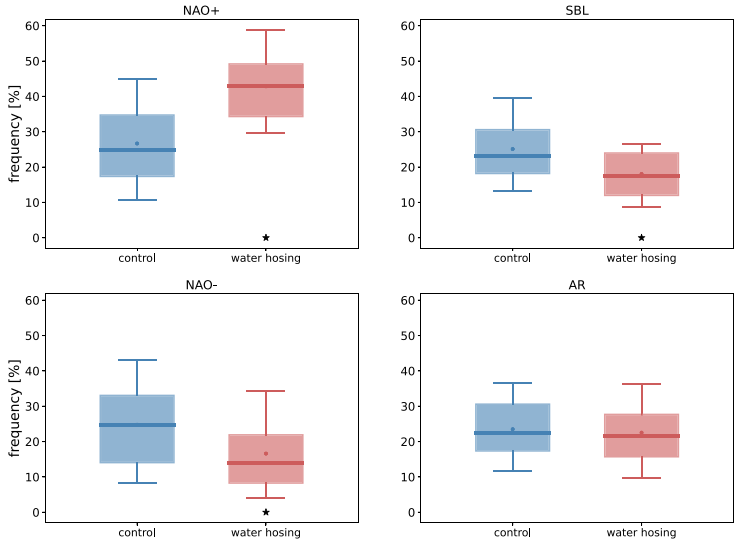

Fig. 3 (*from Bellomo et al.. 2023*): Changes in the four main Euro-Atlantic weather regimes .

We are currently working on improving statistical significance, and we are designing the upcoming experiments to be performed in conjunction with rising concentrations of greenhouse gases. We are optimizing the moisture budget tool to diagnose drivers of precipitation change in the model.