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	2021
Project Title:	AMOC hysteresis in the EC-Earth model
Computer Project Account:	spitmec2
Principal Investigator(s):	Virna Loana Meccia
Affiliation:	Institute of Atmospheric Sciences and Climate, National Research Council (ISAC-CNR), Italy.
Name of ECMWF scientist(s) collaborating to the project (if applicable)	-
Start date of the project:	01-01-2021
Expected end date:	31-12-2022

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)	-	-	9,500,000	9,500,000
Data storage capacity	(Gbytes)	-	-	22,500	22,500

Summary of project objectives (10 lines max)

We plan to explore the bi-stability of the Atlantic Meridional Overturning Circulation (AMOC) in the EC-Earth state-of-the-art climate model by applying different water hosing forcings in the North Atlantic. The main aim of this special project is to participate with EC-Earth in a model inter-comparison project studying the AMOC hysteresis. In this way, this project will contribute to a better understanding of the likelihood of AMOC collapse in the future. Additionally, we aim at assessing the feedback mechanisms in a warmer climate.

Summary of problems encountered (10 lines max)

We have realized that some of the variables needed to participate in the model inter-comparison project on the AMOC hysteresis are not saved in the existing pre-industrial (*piControl*) run. Therefore, we had to run additional 150-yrs of *piControl* experiment. Instead, the proposed simulation of moderate water hosing of 0.3 Sv for 150 years could not be run.

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

We plan to continue with the original proposal. That is, to repeat the water hosing experiments already run but starting from an initial condition corresponding to the CMIP6 *abrupt4xCO_2* experiment (steady 4xCO_2 forcing). This will allow us to explore the bi-stability of the AMOC in a warmer climate with respect to the pre-industrial one.

List of publications/reports from the project with complete references

- Bellomo K., V. Meccia, F. Fabiano, R. D'Agostino, P. Davini, J. v. Hardenberg and S. Corti. Weather impacts of an AMOC decline in the EC-Earth climate model. *TIPES General Assembly*, 7-11 June, 2021, online.

- Jackson L.C., R.A. Wood, K. Bellomo, G. Danabasoglu, A. Hu, J. Jungclaus, V. Meccia, O. Saenko, D. Swingedouw. AMOC tipping points in GCMs. *TIPES General Assembly*, 7-11 June, 2021, online.

Summary of results

If submitted **during the first project year**, please summarise the results achieved during the period from the project start to June of the current year. A few paragraphs might be sufficient. If submitted **during the second project year**, this summary should be more detailed and cover the period from the project start. The length, at most 8 pages, should reflect the complexity of the project. Alternatively, it could be replaced by a short summary plus an existing scientific report on the project attached to this document. If submitted **during the third project year**, please summarise the results achieved during the period from July of the previous year to June of the current year. A few paragraphs might be sufficient.

We have used the CMIP6-generation EC-Earth version 3 in its standard resolution (T255 L91, ORCA1L75) to run common experiments of the North Atlantic Hosing Model Intercomparison Project (NAHosMIP). The model code of NEMO was modified in order to account for the water hosing. The hosing is applied as an additional freshwater flux uniformly distributed over the region between 50°N in the Atlantic and the Bering Strait (Figure 1).

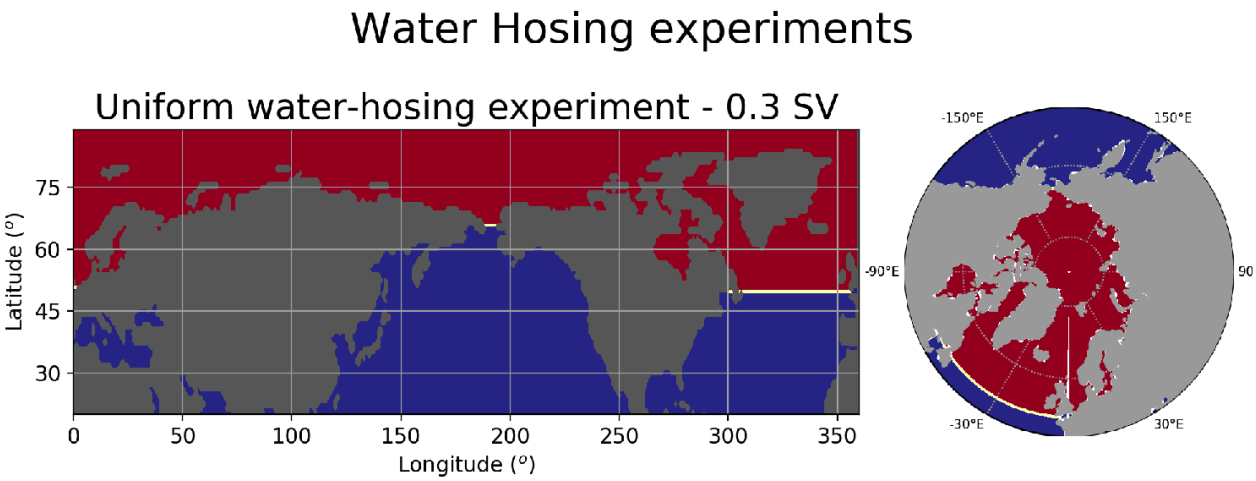

Figure 1: Area in red indicates the region in which the freshwater flux anomaly is applied for a total water hosing of 0.3 SV of intensity.

In order to explore the hysteresis or resilience of the AMOC, the following experiments have been run so far:

- pre-industrial conditions for 150 years;
- moderate water hosing of 0.3 Sv for 20 years, stop the hosing and continue the simulation for 130 years with no hosing;
- moderate water hosing of 0.3 Sv for 50 years, stop the hosing and continue the simulation for 100 years with no hosing.

The results regarding the AMOC strength are plotted in Figure 2, where the dashed (solid) lines represent monthly (annual) values of the AMOC index at 26.5N. The black line is the control run corresponding to the pre-industrial simulation, the grey line represents the 50 years of water hosing of 0.3 Sv; the green (red) line corresponds to the recovery of the AMOC after 20 (50) years of freshwater perturbations.

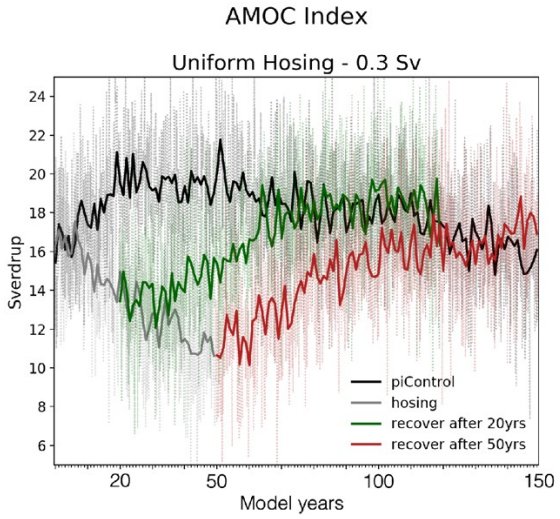

Figure 2: Monthly (dashed lines) and annual (solid lines) AMOC index at 26.5N for all the experiments run so far.

From Figure 2 it can be concluded that the AMOC is recovered after both, 20 and 50 years of water hosing in EC-Earth3. These results will be compared to the results from others 5 climate models and the feedback mechanisms that control the hysteresis/resilience of the Atlantic Overturning circulation will be evaluated. Besides, the climate impacts of a reduced AMOC will be evaluated by comparing the perturbed simulation with the control run between the model years 20 to 60 when the difference in the AMOC strength is maximum.