REQUEST FOR A SPECIAL PROJECT 2027-2029

MEMBER STATE: Ireland

Principal Investigator[1]: Dr. Tido Semmler

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Project Title:

The fate of the Atlantic Meridional Overturning Circulation in refined climate simulations

To make changes to an existing project please submit an amended version of the original form.)

If this is a continuation of an existing project, please state the computer project account assigned previously.	spiesemm	
Starting year: (A project can have a duration of up to 3 years, agreed at the beginning of the project.)	2027	
Would you accept support for 1 year only, if necessary?	YES X☐	NO ☐

Computer resources required for project year:		**2027**	**2028**	**2029**
High Performance Computing Facility	[SBU]	189 million	98 million	189 million
Accumulated data storage (total archive volume)[2]	[GB]	500,000	800,000	1,300,000

EWC resources required for project year:		**2027**	**2028**	**2029**
Number of vCPUs	[#]			
Total memory	[GB]			
Storage	[GB]			

[1] The Principal Investigator will act as contact person for this Special Project and, in particular, will be asked to register the project, provide annual progress reports of the project's activities, etc.

[2] These figures refer to data archived in ECFS and MARS. If e.g. you archive x GB in year one and y GB in year two and don't delete anything you need to request x + y GB for the second project year etc.

[3]The number of vGPU is referred to the equivalent number of virtualized vGPUs with 8GB memory.

Number of vGPUs[3]	[#]			

Continue overleaf.

Principal Investigator:
Tido Semmler
Project Title: Freshwater influence on the Atlantic Meridional Overturning Circulation

Extended abstract

All Special Project requests should provide an abstract/project description including a scientific plan, a justification of the computer resources requested and the technical characteristics of the code to be used. The completed form should be submitted/uploaded at https://www.ecmwf.int/en/research/special-projects/special-project-application/special-project-request-submission.

Following submission by the relevant Member State the Special Project requests will be published on the ECMWF website and evaluated by ECMWF and its Scientific Advisory Committee. The requests are evaluated based on their scientific and technical quality, and the justification of the resources requested. Previous Special Project reports and the use of ECMWF software and data infrastructure will also be considered in the evaluation process.

Requests exceeding 5,000,000 SBU should be more detailed (3-5 pages).

For north-western Europe the fate of the AMOC is extremely important. The AMOC does not only ameliorate the climate of north-western Europe transporting warm and salty water masses towards north-western Europe, but also keeps the sea level low. In other words, without the AMOC the sea level would be 30 cm higher along the north-western European coastlines (Couldrey et al., 2023).

Various studies indicate that the AMOC has been weakening over the last decades and climate models from the last generations of the Coupled Model Intercomparison Project (CMIP) indicate that a weakening of the AMOC is to be expected as a response to greenhouse gas concentration increases. Caesar et al. (2020) even indicate that the AMOC is at its weakest since at least a millennium. According to the IPCC-AR6 report (IPCC, 2021), a total shutdown of the AMOC is very unlikely but should still be considered as a low-likelihood, high-risk event.

While state-of-the-art climate models often do not explicitly consider Greenland and Antarctic ice sheet melting and the corresponding freshwater input and are often run at resolutions too coarse to represent narrow boundary currents and overflows over the Scotland – Iceland – Greenland ridge, a lot of progress has been made in the framework of the special project "Freshwater influence on the Atlantic Meridional Overturning Circulation" in 2024-2026 and in other high resolution climate simulations with the Community Earth System Model (CESM, Chang et al., 2020) and in the framework of Destination Earth (Doblas-Reyes et al., 2026). A recent study by Sinet et al., (2023) indicates that there is a tug-of-war between Greenland and Antarctic ice sheet melting. Additional freshwater input from Greenland ice sheet melting on top of Arctic sea ice melting and increase of precipitation could lead to further weakening of the AMOC while additional freshwater input from Antarctic ice sheet melting would strengthen the AMOC. However, their study has been conducted with a conceptual model.

To make a step change towards the next Coupled Model Intercomparison Project (CMIP7) to inform the next IPCC assessment report, for this computing time proposal the idea is to build on the successful work of the special project "Freshwater influence on the Atlantic Meridional Overturning Circulation". There are three steps: (a) extend the realistic Greenland freshwater forcing experiments till 2100 using best estimates for the future evolution of the Greenland ice sheet, (b) consider in addition Antarctic ice sheet freshwater forcing in a simulation from 1950 to

2100 using the historical data by Mankoff et al. (2025) for Antarctica and best estimates of the future evolution of the Antarctic ice sheet, (c) conduct a simulation following the SSP1-2.6 emission scenario instead of the SSP5-8.5 emission scenario used in the previous simulations from 2015 to 2100 with the same freshwater forcing data. This is to investigate the positive impact that an ambitious greenhouse gas emission reduction would have on the AMOC.

Our tool for the proposed simulations is the same AWI-CM 3.0 like in the previous special project consisting of OpenIFS cycle 43r3 (ECMWF, 2017) in TCO319 resolution (32 km globally) coupled to the Finite Element Sea ice Ocean Model 2.0 (FESOM2) (Danilov et al., 2017; Danilov et al., 2015).

The FESOM model features an unstructured mesh which makes it possible to resolve the areas of interest in a high resolution and leave other less dynamically active regions such as the subtropics at a relatively coarse resolution. The ocean model setup to be applied features a 6 km resolution over the North Atlantic current and even 4-5 km resolution over the Irminger Current and in the Labrador Sea. Also, around the north-western European coasts the resolution is between 4 and 6 km, and over the Southern Ocean around 10 km (Fig. 1).

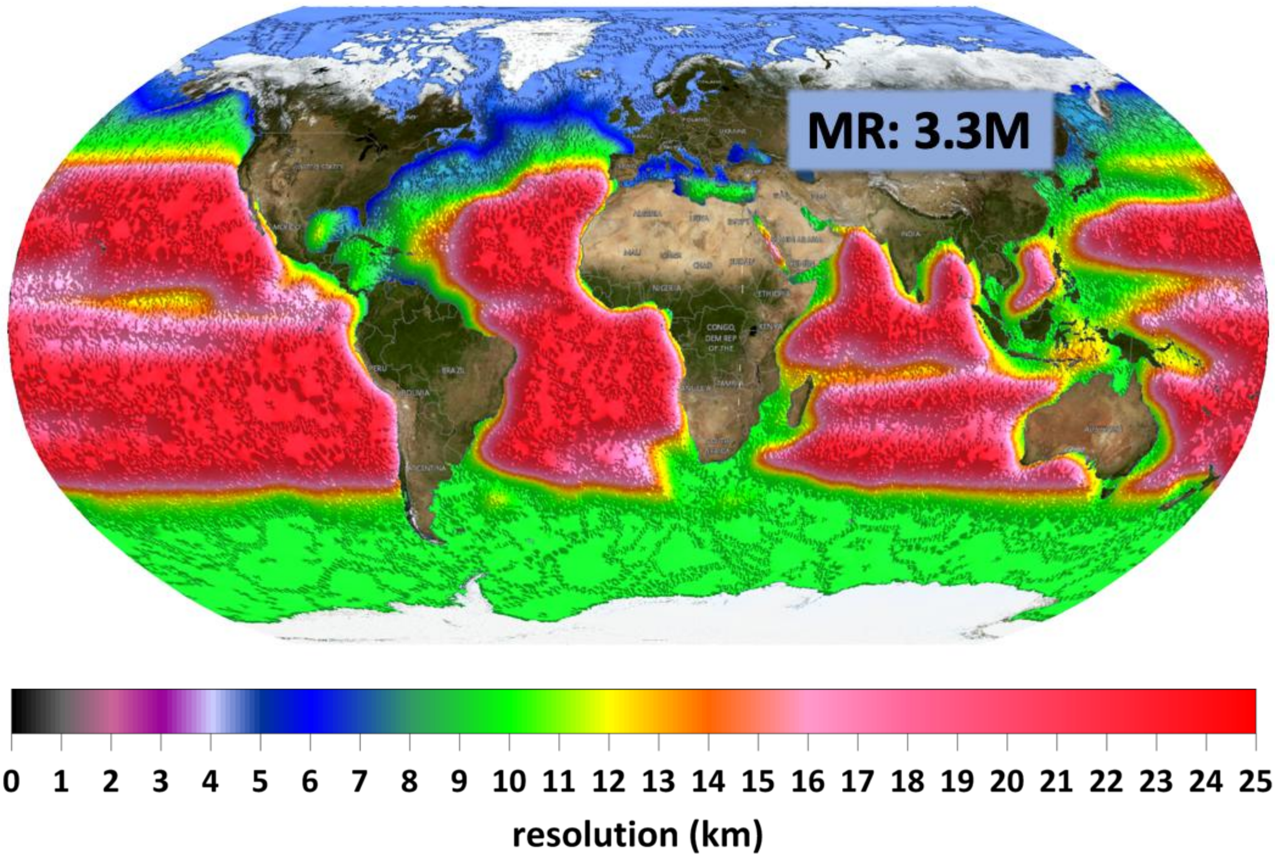

Fig. 1: horizontal resolution of the high resolution FESOM mesh

Baseline simulations according to an extended HighResMIP protocol (100 years spin-up simulation with constant 1950 greenhouse gas and aerosol forcing, 150 years of 1950-control simulation, 65 years of 1950-historical simulation with increasing greenhouse gas and changing aerosol concentrations for 1950-2014, and 185 years of SSP5-8.5 scenario simulation for 2015-2200) but without any consideration of additional Greenland or Antarctic meltwater input already exist. In addition, 73 years of simulation with realistic Greenland freshwater input for 1950-2022 exist. A novelty of the latter simulation is that the latent heat of fusion that is used to melt the ice bergs has been considered. This leads to a weaker AMOC decline compared to the standard high resolution AWI-CM3 simulation. In the future, with an expected increase of the liquid partition and a decrease of the solid partition of Greenland freshwater input, the cooling effect might decrease. It remains to be seen if the AMOC decline intensifies as a result.

The evaluation of the different sensitivity simulations shall focus on the changes in the AMOC due to the additional freshwater input as well as the impact on the north-western European climate with a focus on Ireland. Of particular interest will be the impact of the AMOC changes on the seasonal cycle of temperature, precipitation, and wind.

The OpenIFS model has been extensively tested on the HPC ECMWF-atos for the obvious reason that the model is developed and maintained at ECMWF. FESOM2 has been extensively tested not only on HPC ECMWF-atos, but also on many different HPCs including the HPC levante (German Climate Computing Centre), HPC aleph at the IBS Centre for Climate Physics in South Korea, and others. Therefore, we believe that the ECMWF-atos is the right HPC for this application and an efficient use of the resources can be made.

This application for a new special project is due to a delay of the planned simulations for 2026 because of staffing issues. For this reason, 179 million out of the 180 million SBU's granted for 2026 have been returned to ECMWF for use by other projects requiring extra resources for the second half of the year. Instead of running simulations already this year, two papers on the interesting results of the previous special project are being written to be submitted in the second half of this year. Furthermore, an additional simulation using the SSP1-2.6 emissions scenario is proposed to investigate the positive impact of possible ambitious emissions reductions.

The schedule for the work is as following:

First half of 2027: Greenland freshwater experiment from 2023-2100 with SSP5-8.5 forcing:
78 years * 1.25 million SBU = 97.5 million SBU

Second half of 2027: Greenland and Antarctic freshwater experiment from 1950-2022 with historical forcing: 73 years * 1.25 million SBU = 91.25 million SBU

First half of 2028: Greenland and Antarctic freshwater experiment from 2023-2100 with SSP5-8.5 forcing: 78 years * 1.25 million SBU = 97.5 million SBU

Second half of 2028: Publish the results

First half of 2029: Greenland and Antarctic freshwater experiment from 1950-2100 with historical / SSP1-2.6 forcing: 151 years * 1.25 million SBU = 188.75 million SBU

Second half of 2029: Publish the results

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