A fresh perspective on the subpolar North Atlantic

Greenland Melting: Importance of Mesoscale Ocean Processes and Global Implications

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In Short

- Implementing a new 2-way 1/10° ocean nest in a coupled global climate model
- A Greenland melting scenario as a testbed for ocean model formulations
- Effect of resolving mesoscale ocean activity in the subpolar North Atlantic

Melting of the Greenland ice sheet and the associated runoff into the subpolar North Atlantic has the potential to significantly impact the strength of the Atlantic Meridional Overturning Circulation (AMOC) and thus the entire global thermohaline circulation [1,2]. Greenland melt is not only an important player under current global warming but has likely also been a major factor in past rapid climate change [3]. As the meltwater spreads in the subpolar North Atlantic (Figure 1), it gets entrained into the Subpolar Gyre, in particular in the Labrador Sea (south-west of Greenland), where it enhances stratification. Enhanced stratification weakens deep convection and thus reduces the production of North Atlantic Deep Water, an integral part of the AMOC, which further links to the global ocean circulation. It is therefore crucial to correctly simulate the distribution of Greenland meltwater in order to understand and quantify its impacts.

Previous work at GEOMAR with forced ocean-only models has demonstrated the importance of resolving mesoscale ocean dynamics to realistically simulate the pathways of Greenland meltwater [4]. Meltwater rounding the southern tip of Greenland takes a shortcut to the center of deep convection in the Labrador Sea. It gets advected by mesoscale eddies that shed from the West Greenland Current. Models that are typically used to study the impact of rapid melt of the Greenland ice sheet do not resolve such eddies. Therefore, less meltwater may reach the deep water formation regions in such models or it may take much longer—also prolonging the lag of a potential AMOC response to Greenland melting.

Here, we propose a new model conficuration applying a high-resolution (1/10°) ocean nest to a global coupled climate model consisting of ocean (NEMO3.6), atmosphere (ECHAM6.3), land (JSBACH), and sea ice (LIM2) components (see also

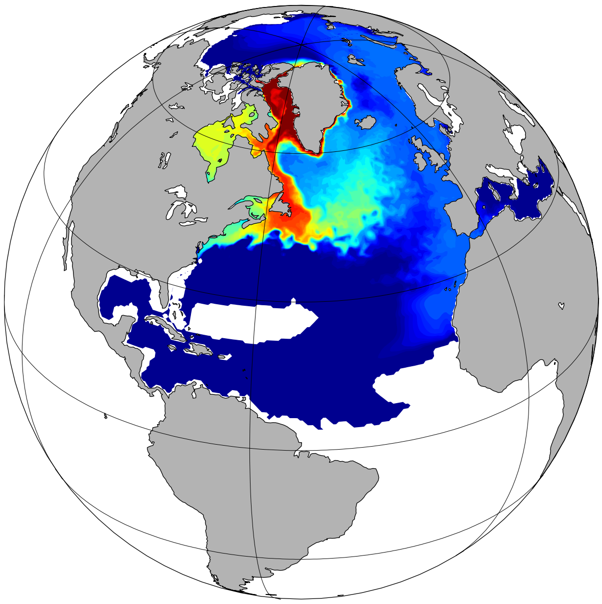

***Figure 1:** Pathway of Greenland meltwater in a VIKING10 simulation after 50 years of model integration with enhanced Greenland runoff at 0.05 Sv, which is prescribed as a spatially varying climatology. Depicted is the vertical maximum of the meltwater tracer concentration.*

"A new climate model" by Biastoch and Harlaß, proposal *shk00028*). The global ocean has a spatial resolution of 0.5° and the atmosphere of 1.9° (T63) with 46 and 95 vertical levels respectively. The ocean nest VIKING10 covers the subpolar North Atlantic and seas surrounding Greenland between 30°N and 85°N, thus facilitating the improved simulation of mesoscale eddies and the Gulf Stream including its extension into the central North Atlantic. The positioning of the Gulf Stream extension is another critical issue in coarse resolution climate models [5] with implications for the spreading and effects of Greenland meltwater in such simulations.

We propose a suite of model experiments using a hierarchy of model configurations (ocean-only and coupled climate models without and with North Atlantic grid refinement) to better understand the role of ocean model formulations and scale interaction in Greenland melting scenarios. The intended simulations contribute to the BMBF project *PalMod* and complement a series of experiments conducted by the Alfred Wegener Institute in Bremerhaven and Max Planck Institute in Hamburg to compare three ocean/sea-ice models, namely FESOM (AWI), MPI-OM (MPI), and NEMO-LIM (GEOMAR), within the same coupled model framework, i.e. with the same

ECHAM atmosphere and JSBACH land models using the OASIS3-MCT coupler, and under the same climate scenario with enhanced Greenland runoff (Figure 1).

The experiments we propose here will enhance our understanding of the implications of rapid melting of the Greenland ice sheet on the global overturning circulation and thus on our weather and climate. We also expect improved estimates of the timescales and potential thresholds associated with Greenland melting.

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http://www.palmod.de

More Information

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