EGU22-2903, updated on 18 Aug 2022
https://doi.org/10.5194/egusphere-egu22-2903
EGU General Assembly 2022

Understanding the melting of Greenland's largest glacial ice tongue with high-resolution modelling and adaptive coordinates

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Melting of the Greenland ice sheet has a big influence on the climate system. Therefore, it is important to understand how the ice melts. Since direct measurements at the underside of floating ice tongues are sparse, high-resolution models for the interaction of ocean and glacial ice are needed to determine sub-glacial melt rates and to understand melt processes. A common problem is that model resolution is often too low, so that the meltwater plume is only represented by one or two layers, and thus the entrainment of warmer water into the plume is not well captured. However, this heat transport towards the ice is crucial for the sub-glacial melt rate.

In this talk, we show how we solve this problem with the General Estuarine Transport Model (GETM). GETM features adaptive vertical coordinates that zoom automatically to areas of interest, in particular strong density gradients. A high density contrast exists in the entrainment layer between the relatively fresh and cold meltwater of the plume, and the ambient ocean water. By zooming towards this interface, our adaptive vertical coordinates resolve the meltwater plume with several layers, while keeping the total number of model layers at a modest level to ensure a feasible computation time. In addition, the coordinate levels align to the moving isopycnals – they “follow” the plume –, which strongly reduces numerical mixing and pressure gradient errors.

We present this for the fjord of the 79°N-Glacier (79NG), which has the largest floating ice tongue in Greenland. In our idealized 2D-setup, we obtain layers as thin as 0.2 m to 1 m in the meltwater plume, for only 100 levels over a water column of several 100 m depth. Thanks to this high resolution of plume and entrainment layer, our model reproduces the overturning circulation in the glacier cavity correctly; in particular, it shows that the salinity stratification of the adjacent ocean determines the level at which the meltwater plume detaches from the ice tongue. Almost all sub-glacial melting occurs before this detachment, *i.e.,* where the plume is directly at the ice–ocean interface. Furthermore, we can confirm that the highest melt rates exist near the grounding line of the glacier. Finally, our simulated melt rates are consistent with observations at 79NG.

Our model, developed in the GROCE (Greenland ice sheet–ocean interaction) project, will form the basis of a realistic 3D-model of the 79NG-fjord in the future.