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Optimising a hydrostatic ocean model for long-term climate runs of glacier-fjord dynamics

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Glacier-fjord systems in Greenland contribute substantially to the total ice discharge via submarine melting and calving. Especially in South East Greenland, where warm saline water from the Atlantic enters deep narrow fjords at the bottom, melt und calving rates of marine terminating glaciers are high.

The subglacial discharge of fresh and cold water at the glacier's grounding line drives a buoyant plume, which turbulently rises up. Due to entrainment of ambient warm Atlantic water, the higher thermal forcing causes drastically increased submarine melting and induces a circulation in the fjord. Beside this buoyant plume, pycnocline displacements and stratification profiles for temperature and salinity at the fjord's mouth as well as bathymetry, winds and tides are relevant to fjord dynamics.

We investigate the long-term response of generic glacier-fjord pairs to climate change varying bathymetry and external forcings. In the end, a fjord model coupled to a comprehensive ice-sheet model of intermediate complexity running for up to thousand years is to be developed. Therefore, we examine the fjord dynamics applying the hydrostatic General Estuarine Circulation Model (GETM). For the sake of efficiency (I) across-fjord effects are neglected by modelling only in along-fjord direction and (II) a vertically adaptive grid is employed requiring less vertical layers. A modified plume model including a melt rate parameterisation has been implemented to handle non-hydrostatic effects appearing at the glacier front due to highly buoyant fresh subglacial discharge. Further, the shifting of the grounding line changes the bathymetry at the glacier front and thereby affects the submarine melt rate. We resolve this with a newly implemented horizontally adaptive grid following the glacier's movement.

We present implementation details of our modified plume model and compare the output of our optimised hydrostatic model with non-hydrostatic model results near the glacier front. Additionally, we examine the influence of bathymetry and several forcings on the circulation in the fjord and thus on melt rates. Finally, we demonstrate our new horizontally adaptive grid and evaluate its performance in a long-term run.