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Observations and modelling of subglacial discharge and heat transport in Godthåbsfjord (Greenland, 64 °N)

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Subglacial discharge from tidewater outlet glaciers forms convective bouyant freshwater plumes ascending close the glacier face, and entrainment of ambient bottom water increases the salinity of the water until the plume reaches its level of neutral buoyancy at sub-surface levels or reaches the surface. Relatively warm bottom water masses characterize many fjords around Greenland and therefore entrainment would also increase the temperature in the plumes and, thereby, impact the heat transport in the fjords. However, relatively few oceanographic measurements have been made in or near plumes from subglacial discharge and, therefore, the potential for subglacial discharge for increasing heat transport towards the tidewater outlet glaciers are poorly understood. We present the first direct hydrographic measurements in a plume from subglacial discharge in Godthåbsfjord (located on the western coast of Greenland) where a XCTD was launched from a helicopter directly into the plume. Measurements of the surface salinity showed that the plume only contained 7% of freshwater at the surface, implying a large entrainment with a mixing ratio of 1:13 between outflowing meltwater and saline fjord water. These observations are analyzed together with seasonal observations of ocean heat transport towards the tidewater outlet glaciers in Godthåbsfjord and we show that subglacial discharge only had modest effects on the overall heat budget in front of the glacier. These results were supported from a high-resolution three-dimensional model of Godthåbsfjord. The model explicitly considered subglacial freshwater discharge from three tidewater outlet glaciers where entrainment of bottom water was taken into account. Model results showed that subglacial discharge only affected the fjord circulation relatively close (∼10 km) to the glaciers. Thus, the main effect on heat transport was due to the freshwater discharge itself whereas the subsurface discharge and associated entrainment only had a minor dynamical effect on the fjord circulation. However, mixing of bottom water by subglacial discharge also brings large amounts of nutrients to the surface and estimates of the potential nutrient transport show that this may have a significant impact on the biological production in front of tidewater outlet glaciers.

Related publications:

Bendtsen, J., Mortensen, J., Lennert, K. and S. Rysgaard (2015), Heat sources for glacial ice melt in a West Greenland tidewater outlet glacier fjord: the role of subglacial freshwater discharge, Geophys. Res. Lett., 42, doi:10.1002/2015GL063846.

Bendtsen, J., Mortensen, J., and Rysgaard, S. (2015), Modelling subglacial discharge and its influence on ocean heat transport in Arctic fjords, Ocean Dynamics, 65, 1535–1546, 10.1007/s10236-015-0883-1.

Mortensen, J., J. Bendtsen, K. Lennert, and S. Rysgaard (2014), Seasonal variability of the circulation system in a west Greenland tidewater outlet glacier fjord, Godthåbsfjord (64°N), J. Geophys. Res. Earth Surf., 119, 2591–2603, doi:10.1002/2014JF003267.

Mortensen, J., Bendtsen, J., Motyka, R. J., Lennert, K., Truffer, M., Fahnestock, M. and S. Rysgaard (2013), On the seasonal freshwater stratification in the proximity of fast-flowing tidewater outlet glaciers in a sub-Arctic sill fjord. J. Geophys. Res. 118, 1-14, doi:10.1002/jgrc.20134.