Abstract
The circulation in Sermilik Fjord is investigated using a non-hydrostatic ocean general circulation model with a melt rate parameterization at the vertical glacier front. The two-layer stratification of the fjord’s ambient waters causes the meltwater plume at the glacier front to drive a ‘double cell’ circulation. In summer, the discharge of surface runoff at the base of Helheim Glacier causes the circulation to be much more vigorous and associated with a larger melt rate than in winter. Seasonal differences are also present in the vertical structure of the melt rate. The simulated ‘double cell’ circulation is consistent, in both seasons, with observations. Simulated submarine melt rates are strongly sensitive to the amount of subglacial discharge, to changes in water temperature, and to the height of the layers.

1. Question addressed
Seasonal and oceanic variability influences fjord circulation and submarine melting?

2. Model Formulation
To explore the seasonal variability we consider a glacier/buoyancy driven circulation without external forcing and with a variable runoff distribution. To explore the oceanic variability we consider changes in the AW properties inside the fjord.

2D, non-hydrostatic, high-resolution configuration of the MITgcm with a geometry ideally based on the topography of Sermilik Fjord.

3. Model results - Seasonal variability
Due to the two-layer stratification, a ‘double cell’ circulation is found year-round. Large seasonal variability of $\text{smr}$ driven by runoff. The vertically averaged $\text{smr}$ changes of one order of magnitude from winter $(70 \; \text{m yr}^{-1})$ to summer $(738 \; \text{m yr}^{-1})$. The $\text{smr}$ is maximum at the AW/PW interface in winter, and at the bottom of the glacier in summer.

4. Model results - Dynamical regimes
As the subglacial discharge increases, the dynamics evolves into three different regimes. The transition between these regimes can be estimated by comparing the density of the PW layer $(\rho_3)$ with the density of the plume at the interface $(\rho_2)$:

$$\rho_2(z) = \alpha \frac{Q_d Q_{smr} Q_{aw}}{Q_d Q_{aw} + Q_{smr}}$$

where $Q_d$ is the flow of entrained ambient waters $Q_d(z) = \alpha w A_p(z)$

5. Model result - Oceanic Variability
The $\text{smr}$ is only sensitive to AW properties and, runoff is one of the main driver of the dynamics. $\text{smr}$ depends linearly on AW temperature and thickness and has a small dependence on AW salinity.

Vertically averaged submarine melt rate as a function of AW temperature and thickness.

Increasing the AW temperature form $4^\circ$ to $5^\circ$ is comparable to increasing the AW thickness from 450m to 500m. The layer’s thickness may be as, if not more, important than a temperature change in the AW layer.

What’s next?
Can externally/oceanic driven circulations change this dynamics?

Reference

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