Circulation and heat sources for glacial melt in a subarctic sill fjord (Godthåbsfjord)

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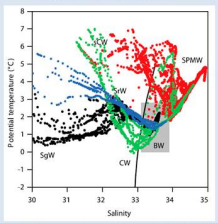
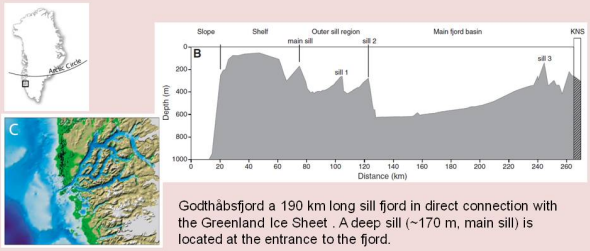
Recent warming of Subpolar Mode Water off Greenland has been suggested to accelerate the mass loss from tidewater outlet glaciers of the Greenland Ice Sheet. We present a comprehensive analysis of water masses, dynamics, and interannual hydrographic variability in Godthåbsfjord, a sill fjord in contact with tidewater outlet glaciers on the west coast of Greenland. Through multi-annual seasonal observations we recognize an intermediate baroclinic circulation mode and the formation of a warm subsurface water mass (sill region water (SrW)) an important local heat source for the fjord.

Water masses



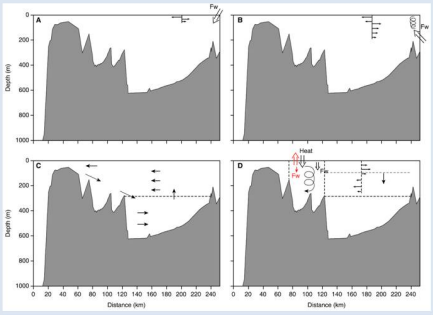
TS-diagram from a CTD-section in August 2008 along the main fjord branch. Characteristic water masses from various parts of the fjord are shown: Slope (red), shelf (green), outer sill region (blue) and main fjord basin (black)

Topography: Outer sill region and main fjord branch



Godthåbsfjord a 190 km long sill fjord in direct connection with the Greenland Ice Sheet . A deep sill (~170 m, main sill) is located at the entrance to the fjord.

Seasonal circulation modes



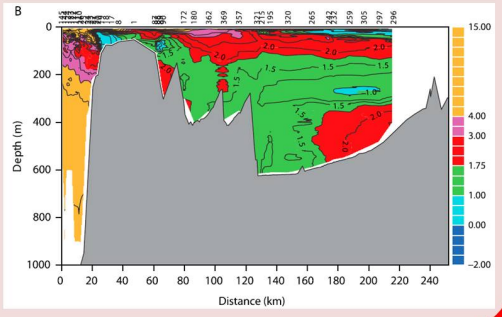
The seasonal variation of the characteristic circulation modes in the fjord can conceptually be described as: A) estuarine circulation, B) subglacial circulation, C) dense coastal inflow, and D) intermediate baroclinic circulation.

Local warming of subsurface water masses from tidal mixing in the outer sill region

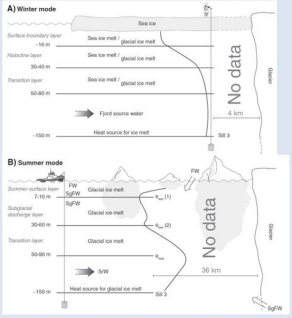
Potential temperature length section along the main fjord branch, August 2008.

Basin water fills the deepest parts of the fjord with temperatures below 1.75 ºC, except for a remnant warmer mass in the innermost part of the section.

The relatively warm sill region water mass (SrW) fills the intermediate part of the fjord (~ 100 - 150 m depth).



Freshwater distribution and dynamics close to a tidewater outlet glacier



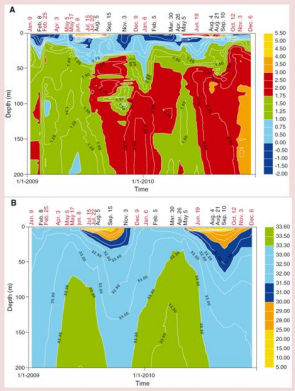
Conceptual figures of the vertical distribution of freshwater and temperature profiles near a tidewater outlet glacier. During the summer season a characteristic cold subsurface layer is formed close to the glacier and the warm SrW is seen deeper in the water column.

Inner fjord property variations close to the glacier

Depth-time contour plots of a) potential temperature and b) salinity from the inner-most part of Godthåbsfjord (Kangersuneq) in 2009 – 2010. The various stations collected for the time series are indicated by dates and the date labels colored in black and red indicate stations occupied inside and outside Kangersuneq, respectively.

Significant freshening of the surface layer is seen during late summer and low temperatures just below the surface layer show the influence from glacial melt and subglacial freshwater discharge on the water properties.

Analysis of the TS-slopes in the subsurface water masses shows significant amount of subglacial freshwater and freshwater from melting ice in the upper water masses in Kangersuneq [Mortensen et al., 2013].



Large seasonal variation in the general fjord circulation has recently been analyzed from multi-annual data sets of temperature and salinity along the main fjord branch [*Mortensen et al.,* 2011] and significant glacial melt fractions were found in near-glacial water masses [Mortensen et al., 2013].

However, so far many observations from various fjord systems around Greenland have been analyzed, but how many of these results are representative for the 200+ fjords in Greenland? Some results are general (blue) whereas others are unique (red).

Our results from Godthåbsfjord, which currently is the most comprehensively monitored fjord in Greenland, show large seasonal variability and a complex circulation pattern during the summer season with significant influence from subglacial freshwater discharge and glacial melt on the other water masses in the fjord.

References:

Mortensen, J., K. Lennert, J. Bendtsen, and S. Rysgaard (2011), Heat sources for glacial melt in a sub-Arctic fjord (Godthåbsfjord) in contact with the Greenland Ice Sheet, J. Geophys. Res., 116, C01013, doi:10.1029/2010JC006528.

Mortensen, J., J. Bendtsen, R. J. Motyka, K. Lennert, M. Truffer, M. Fahnestock, 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. Oceans, 118, 1382–1395, doi:10.1002/jgrc.20134.