Geophysical Research Abstracts
Vol. 21, EGU2019-7903, 2019
EGU General Assembly 2019

Fjord circulation response to retreating tidewater glaciers : A case study for Kongsfjorden, Svalbard

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Many Arctic glaciers extend into fjords or coastal waters, and their fronts can extend several hundred meters below the sea surface. Meltwater runoff from such marine terminating or tidewater glaciers often enters the sea near the sea bed, and then rapidly rise towards the surface due to having lower density than the ambient sea water. The discharge of meltwater tends to be concentrated at a few locations along the glacier front, creating distinct plume structures where large volumes of meltwater turbulently mix with sea water, thereby inducing strong vertical and lateral exchanges that plays a prominent role in the overall fjord circulation.

Tidewater glaciers in Kongsfjorden, Svalbard, are steadily retreating, in one case (Kronebreen) by 11km over the last 150 years, and will become land terminating at some time in the future if the trend continues. We investigate the impact that this transition will have on the general fjord circulation by comparing the present day circulation and predicted future circulation in the fjord using the ocean model system ROMS. The model setup for the present day Kongsfjorden area is based on a model grid with 160m horizontal resolution and 35 vertical S-coordinates. Atmospheric forcing is provided by 3km WRF data, climatology at lateral open boundaries is provided by a larger domain 800m resolution ROMS model, and fresh water discharges are provided by SnowModel output, where discharge from 3 tidewater glaciers are treated as subglacial sources. A coastline for the future scenario has been constructed based on ice-penetrating radar data. Setup for the future scenario is identical to the present day case, except for the new coastline configuration and associated location of fresh water discharge sources.

Our study found that the removal of tidewater glaciers causes a substantial reduction in volume fluxes across transects in the inner part of the fjord, and results in an increased stratification during the summer months. The increase in fjord extent landward due to removal of tidewater glaciers resulted in a slight increase in tidal velocities, in particular for overtide components, but this effect was not strong enough to compensate for the removal of fresh water plumes at tidewater glacier fronts. Fresh water content (salinity < 34.8) in the fjord during the melting season is predicted to increase in the future, primarily due to enhanced retention of fresh water in the inner parts of the fjord. However, fresh water in the future will mostly be confined to a thin surface layer whereas at present fresh water is found in a thicker layer, in particularly near tidewater glacier fronts.