Water properties and circulation in front of tidewater glaciers in northwestern Greenland

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Tidewater glaciers in Greenland are rapidly retreating, and it contributed global sea-level rise during the twentieth century. Studies have been carried out to understand the mechanisms of the glacier retreat. Previous studies suggested the importance of submarine melting, but physical processes relevant to submarine melting (e.g. heat source of the melting, water circulation and bathymetry) are not understood well. This is because in-situ observations are difficult in front of a glacier where icebergs usually cover the ocean. In addition to this, there is no hydrographical observation in front of tidewater glacier in northwestern Greenland. To better understand the ice-ocean interaction, we measured ocean temperature, salinity, turbidity, chlorophyll, dissolved oxygen, $\delta^{18}O$, d-excess and bathymetry in front of Bowdoin and Sun Glaciers, tidewater glaciers in northwestern Greenland, in 2014 and 2015 summer. We also performed high spatial (2560x1920 pixel) and temporal (10 s) time-lapse photography in front of Bowdoin Glacier in 2015 July.Below the depths of 280 m (2014) and 250 m (2015) in the Bowdoin Fjord, we observed Atlantic Water (AW), which is believed as the heat source of submarine melting. The mean temperature and salinity within the layer of AW was 1.2°C and 34.4 g kg^{-1} in 2014, and 1.1°C and 34.5 g kg^{-1} in 2015. The results suggested that warm water flows into the Bowdoin Fjord from the open ocean. Contrasting to these observations at Bowdoin, AW was missing in front of Sun Glacier and relatively fresh and cold water mass was found. It was suggested that relatively shallow bathymetry (~100-m deep) and existence of sill (~10-m deep) inhibited entering warm water from the open ocean. Near the surface in the vicinity of plume of Sun Glacier (~200 m away from the front), water mass properties were completely different from those in the open ocean. Water was highly turbid, fresh and cold, suggesting subglacial discharge of meltwater as the origin of the water.The time-lapse photographs revealed fjord circulation near the ice-ocean interface. It was clear that the circulation was driven by buoyant plume, which was generated subglacial discharge and/or submarine melt. In early July, waters emerged by buoyant plume was always visible along the surface approximately 5 km from the front, but it was only visible near the front in late July. The change from early July to late July may be explained by amount of subglacial discharge and the stability of stratification near the ocean surface as reported by recent modelling studies.Our observations water mass structures and circulation in the fjord in front of the tidewater glaciers in northwestern Greenland, which are important properties to calculate submarine melting rate in two different types of tidewater glaciers.

Keywords: Tidewater glacier, Greenland, Fjord, Submarine melting

