An evidence of a subglacial freshwater discharge into a fjord at the boundary of Bowdoin Glacier, northwestern Greenland

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Boundary region between a marine-terminating glacier and a fjord is a key to understand glacier-ocean interaction in Greenland. Due to the difficulty of oceanographic observations in a proglacial fjord, processes occurring at the glacier-ocean interface are poorly understood. In the summer of 2017, we conducted oceanographic measurements near the calving front of Bowdoin Glacier, a marine-terminating glacier in northwestern Greenland. Conductivity sensor equipped with thermistor (Model: 4319RB, Aanderaa, Norway) and pressure sensor (Model: 4117RB, Aanderaa, Norway) were deployed at the depths of 5 and 100 m in the fjord, by lowering the sensors with cables from the edge of the glacier front. Additional oceanographic measurements were conducted with a conductivity-temperature-depth profiler (Model: ASTD 102, JFE Advantech, Japan) on a boat from 1.4 km off the glacier front to the outer area of the fjord. During our study period, a lake which is dammed by the lateral margin of the glacier completely drained into a subglacial channel (glacier-dammed outburst flood event). Just after the event, the instruments recorded the remarkable decreases of salinity at depth of 100 m in the fjord at the boundary of the glacier. We interpret these processes as indicating that this lake drained from a subglacial flow path into the fjord and the subglacial freshwater discharge decreased salinity. To quantify the fraction of subglacial freshwater discharge in the fjord, we calculated volumetric water mass fractions by assuming a mixture of three different water masses: subglacial freshwater, submarine meltwater and entrained water at the level of the glacier bed (approximately 200 m below sea level). Fractions of mass, salinity and temperature balance equations were solved using the water properties of these three end-members. After the glacier-dammed outburst flood event, the water observed at depth of 100 m contained ~3% of the subglacial freshwater and ~0.5% of the submarine meltwater, and the remaining >90% of the water was attributed to entrained deep fjord water. This result explains that these freshwaters upwell with significant amounts of deep fjord water, suggesting the entrainment of nutrient-rich deep water to the surface of the fjord.

