Dynamics of Bowdoin Glacier, a marine-terminating outlet glacier in northwestern Greenland

Shin Sugiyama[1], Shun Tsutaki[1,2], Daiki Sakakibara[1], Jun Saito[1], Mihiro Maruyama[1], Naoki Katayama[1], Takanobu Sawagaki[3], Martin Funk[4] and Andreas Bauder[4]

[1] *Institute of Low Temperature Science, Hokkaido University*

[2] *Arctic Environment Research Center, National Institute of Polar Research*

[3] *Graduate School of Environmental Science, Hokkaido University*

[4] *Section of Glaciology, Laboratory for Hydraulics, Hydrology and Glaciology, ETH-Zurich, Switzerland*

Marine-terminating outlet glaciers are retreating, thinning, and accelerating in Greenland. These changes are associated with rapid ice dissipation, which plays a crucial role in recent mass loss from the Greenland ice sheet (e.g. van den Broeke et al., 2009). Atmospheric and ocean warming is suspected as the driver of the observed changes, but available data are not sufficient to explain detailed mechanisms. In-situ field data are lacking particularly near the calving front, where glacier flows fast and interacts with the ocean. This lack of data hampers our understanding of important processes related to the glacier changes, i.e. calving, basal ice motion, subglacial hydrology, and ice-ocean interaction.

To better understand the processes driving the recent changes in Greenland outlet glaciers, we carried out field measurements near the calving front of Bowdoin Glacier in the summer 2013 and 2014. This research activity is a part of GRENE snow and ice project. Satellite data have shown that Bowdoin Glacier is rapidly retreating since 2008. On this glacier, we used the global positioning system to measure surface elevation and ice flow speed. Ice thickness was surveyed over the study area with ice radar. We also performed hot water drilling at approximately 2 km from the calving front to measure basal water pressure as well as ice temperature. The glacier flows into Bowdoin Fjord, which extends 20 km from the calving front to the main trunk of a fjord system. In this fjord, we measured water temperature, salinity, turbidity and dissolved oxygen by lowering a CTD profiler at several locations. Depth of the fjord was measured with a sonar mounted on a boat.

Our measurements revealed rapid thinning of the glacier. Ice has thinned by 20–30 m from 2007 and 2013, and the rate of the thinning was greater near the calving front. Ice thickness near the calving front showed that the ice is very close to flotation, which suggests flotation of the glacier terminus as the driver of the recent retreat. We drilled three boreholes through ~260 m thick glacier to the bed. Water in two of the boreholes drained when the drilling reached the bed, which confirmed the existence of a drainage system beneath the glacier. Ocean measurements showed the structure of the water properties in the fjord, which were heavily influenced by the glacier. Water was cold, fresh and turbid near the surface under the influence of upwelling of subglacial melt water discharge. Deeper part was filled with relatively warm and salty water, which was probably flowing into the fjord from the open ocean. These data set forms the basis to investigate the recent rapid changes in the outlet glaciers, and contribute to the quantification of the current and future mass loss of the Greenland ice sheet

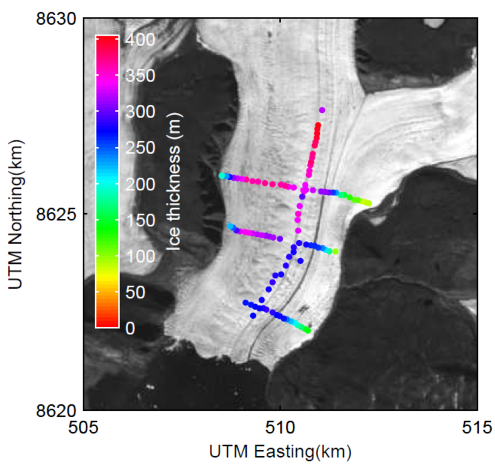

Figure 1. Satellite image of Bowdoin Glacier with ice thickness data.

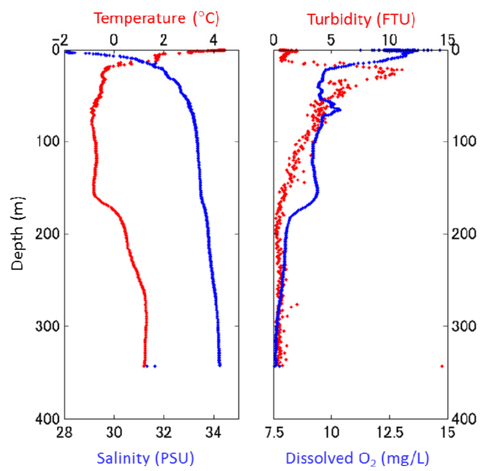

Figure 2. Water temperature, salinity, turbidity and dissolved oxygen measured in Bowdoin Fjord at 2 km from the calving front.

References

van den Broeke et al., 2009. Partitioning recent Greenland mass loss. Science, 326(5955), 984–986.