Hot water drilling and measurements beneath the grounding zone of Langhovde Glacier, East Antarctica

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Ice discharge from outlet glaciers into the ocean plays a key role in the mass budget of Antarctic and Greenland ice sheets. Recent satellite observations have shown speed up, thinning, and retreat of glaciers and ice streams in Greenland ice sheet, and similar observations are reported in Antarctica as well. The mechanism of the drastic change is not fully understood, but warming ocean is suspected as a trigger. Despite the importance of interaction between outlet glaciers and the ocean, direct observations at ice-water interface are very few. Subshelf measurements in the vicinity of the grounding line are particularly crucial, because such data may indicate how far and how fast changes in the ocean spread into inner part of subshelf environment. In 2011/2012 austral summer season, we performed hot water drilling on the floating tongue of Langhovde Glacier, an outlet glacier in East Antarctica. Here, we report subshelf measurements carried out in boreholes drilled nearby the grounding line.

Langhovde Glacier is located at 69° 12' S, 39° 48' E, approximately 20 km south of a Japanese research station Syowa (Fig. 1a). The glacier discharges ice into Lützow-Holm Bay through a 3-km-wide calving front at a rate of 130 m a-1. The glacier surface is flat near the terminus, suggesting that the lower most several kilometers forms a floating tongue. In January 2012, we set up a hot water drilling system at 2.5 and 3 km from the terminus to drill through the glacier (Site 1 and 2 in Fig. 1b). The hot water system had been developed in Hokkaido University and previously used for subglacial measurements in the Alps and Patagonia (e.g. Sugiyama and others, 2011). During a one-month field campaign, four boreholes were drilled to the glacier bottom and used for subglacial observations. According to borehole camera inspections, as well as other measurements described below, ice was underlain by a shallow saline water layer. Ice and water column thicknesses were 398 and 24 m at Site 1, and 431 and 10 m at Site 2 (Fig. 2). The total drilling length was 1650 m and the mean drilling speed was 40 m hr-1. The ice surface and bed elevations implied that the drilling sites were situated within a several hundred meters from the grounding line.

A CTD profiler and current meter were lowered into the boreholes to measure subshelf water properties and current. Salinity and temperature were 34.15 PSU and −1.5°C, which are similar to the values reported for the ocean near the calving front (Ohshima and Kawamura, 1994). Subshelf current flow speed was up to 3 cm s^{-1}, which is able to transport water from the calving front to the study site within a few days. After the borehole profiling, a pressure sensor was installed to measure subshelf water pressure. Temporal pressure variations were consistent with ocean tides as measured in the open ocean near the calving front. The changes in the pressure were correlated with ice speed variations as previously observed on other floating and grounded ice in Antarctica (e.g. Anandakrishnan, and others, 2003).

Our borehole observations imply that subshelf environment in the vicinity of the grounding line is well connected to the ocean through a current system. Together with the tidally modulated ice dynamics, outlet glaciers are considered to be susceptible to changes in the ocean, even in the vicinity of the grounding line. We are expecting further field data from several borehole sensors and GPSs, which are running over the winter until the 2012/2013 season.

References

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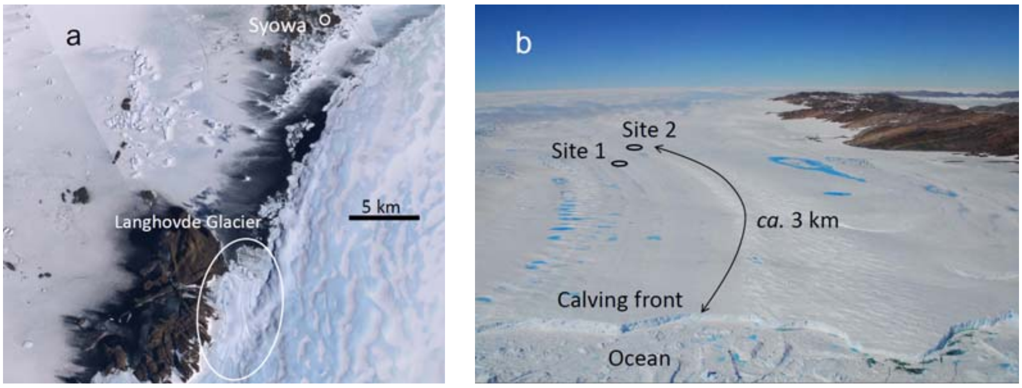

Figure 1. (a) Satellite image showing the location of Langhovde Glacier. (b) Langhovde Glacier viewing upglacier from the ocean.

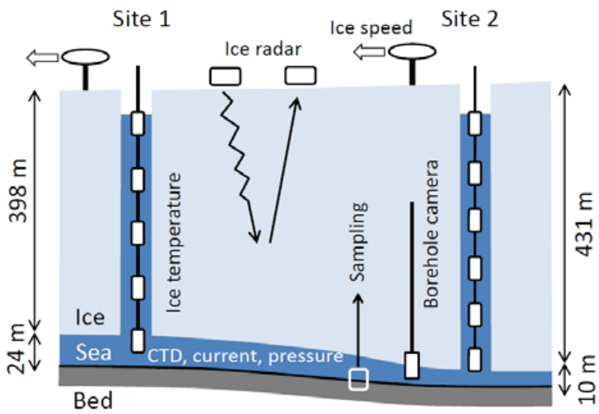

Figure 2. Schematic diagram showing the longitudinal cross section of the studied region of Langhovde Glacier. Filed measurements performed on, within, and beneath the glaciers are depicted.