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Warm water and life beneath the grounding zone of an Antarctic outlet glacier

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Ice-ocean interaction plays a key role in rapidly changing Antarctic ice sheet margins. Recent studies demonstrated that warming ocean is eroding floating part of the ice sheet, resulting in thinning, retreat and acceleration of ice shelves and outlet glaciers. Field data are necessary to understand such processes, but direct observations at the interface of ice and the ocean are lacking, particularly beneath the grounding zone. To better understand the interaction of Antarctic ice sheet and the ocean, we performed subglacial measurements through boreholes drilled in the grounding zone of Langhovde Glacier, an outlet glacier in East Antarctica.

Langhovde Glacier is located at 69°12'S, 39°48'E, approximately 20 km south of a Japanese research station Syowa. The glacier discharges ice into Lützow-holm Bay through a 3-km-wide floating terminus at a rate of 130 m a-1. Fast flowing feature is confined by bedrock to the west and slow moving ice to the east, and it extends about 10 km upglacier from the calving front. In 2011/12 austral summer season, we operated a hot water drilling system to drill through the glacier at 2.5 and 3 km from the terminus. Inspections of the boreholes revealed the ice was underlain by a shallow saline water layer. Ice and water column thicknesses were found to be 398 and 24 m at the first site, and 431 and 10 m at the second site. Judging from ice surface and bed elevations, the drilling sites were situated at within a several hundred meters from the grounding line.

Sensors were lowered into the boreholes to measure temperature, salinity and current within the subglacial water layer. Salinity and temperature from the two sites were fairly uniform (34.25±0.05 PSU and -1.45±0.05°C), indicating vertical and horizontal mixing in the layer. The measured temperature was >0.7°C warmer than the in-situ freezing point, and very similar to the values measured in the open ocean near the glacier front. Subglacial current was up to 3 cm/s, which is sufficient to carry coastal water to the study sites within several days. A video camera suspended in the boreholes captured a crustacean and krill beneath the grounding zone. Subglacial water samples contained abundant phytoplankton, which were most likely transported from the open ocean and served as trophic resources to the animals living under >400 m thick glacier.

Our observations indicate that warm coastal water is actively transported to the grounding zone by subshelf current, and efficiently melting the floating ice bottom. It is also implied that changes in the ocean would immediately reach and influence physical and biological environment beneath the grounding zone.