Hot-water drilling for exploring subglacial environment of the Antarctic ice sheet

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Subglacial environment of the Antarctic ice sheet is one of the least investigated areas on the Earth. Base of the ice sheet forms an important boundary, which controls ice dynamics and thermal conditions. Existence of subglacial channels and lakes poses important questions about basal hydrology and microbial ecosystem under several-kilometer-thick ice. Recent mass loss of the ice sheet is driven by the melting of ice shelves, which occurs at the basal boundary of floating ice. Sensing physical properties beneath the ice is possible by using seismic and electromagnetic waves, but in-situ measurements and sampling are required to answer many of the questions. Hot-water drilling is a powerful tool to provide an access to the bed of glaciers and ice sheets. In this contribution, I introduce recent progress in our understanding of subglacial environment of the Antarctic ice sheet based on direct observations through boreholes, including our project in Langhovde Glacier in East Antarctica.

Langhovde Glacier is a 3-km wide outlet glacier located 20 km south of the Japanese Syowa Station in East Antarctica. Lower 2–3 km of the glacier forms a floating tongue, which feeds into the Lützow-holm bay. To study basal melting and subshelf ocean environment, we drilled four boreholes in January 2018 using a hot-water drilling system. The boreholes were utilized to measure spatial variations of temperature, salinity and current under the ice. Two of the boreholes were equipped with a temperature and CTD/current sensors for year-round observations. Potential temperature of the seawater underneath the ice was between −1.4 and −1.1˚C, approximately 1˚C warmer than the freezing temperature. Water temperature within several hundred meters from the grounding line was −1.2˚C in January 2018. Temperature dropped to −1.6˚C from January to May, which was followed by gradual warming to −1.55˚C in December. The temperature in January 2018 (−1.2˚C) was significantly warmer than that in the summer 2019 (−1.55˚C), as well as temperature measured at the same location in 2012 and 2013 (−1.55˚C). A possible interpretation of the unusually warm water in 2018 was break-up of land-fast sea ice in the Lü tzow-holm bay in 2016. Presumably, open water near the glacier front facilitated transport of heat to the grounding line. Our subshelf observations implied significant amount of basal melting occurs under the entire ice shelf of Langhove Glacier, and thermal conditions near the grounding line is susceptible to changes in the ocean.

