Ice speed and frontal variations of outlet glaciers on Lützow-Holm Bay, East Antarctica, after a breakup of land-fast sea ice

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The Antarctic ice sheet drains ice into the ocean through floating ice shelves and outlet glaciers, which play key roles in the mass balance of the ice sheet. Ice shelves are important for ice dynamics near the grounding line because they exerts buttressing force against grounded ice. Therefore loss of ice shelves may lead to flow acceleration and mass loss of the ice sheet. Despite the importance of the dynamics of ice shelves, observational data are sparce particularly in East Antarctica and the mechanisms of ice shelf variations are poorly understood. Lützow-Holm Bay located in East Antarctica is the central area of Japanese research activity in Antarctica. The bay is usually covered with land-fast sea ice, but a large portion of sea ice broke up in April 2016 (Aoki et al., 2017). This event might have influenced outlet glaciers in the region because sea ice is considered as one of the factors affecting the stability of ice shelves by exerting buttressing force on the ice front (Miles et al., 2017). To quantify recent glacier and ice-shelf variations as well as to investigate a possible link between the glacier change and the sea ice breakup, we carried out satellite observations on five outlet glaciers terminating in Lützow-Holm Bay (Figure 1). Glacier terminus positions and ice flow velocity were measured by using Advanced Spaceborne Thermal Emission and Reflection (ASTER) radiometer and Landsat 4, 5, 7, 8 imagery within a period of 1988–2020. Sea ice and open water areas in front of the glacier were also measured by using ASTER, Landsat 7 and 8 imagery.

The terminus positions progressively advanced from 2006 to 2015, when the ocean near the glacier fronts was largely covered with sea ice. Rapid retreat of the ice front was observed in 2016–2018 at all the studied glaciers, i.e. retreat by 10.8 km at Shirase, 0.4 km at Langhovde, 1.6 km at Skallen and Telen, and 1.2 km at Honor (Figure 2). This retreat was approximately coincided with the breakup of land-fast sea ice in 2016. All the glaciers showed ice flow deceleration in 2000–2016, reaching the lowest speeds in 2015–2016. Ice speed increased after the sea ice break up. The magnitudes of the speed up from 2016 to 2019 were 70 m a^{-1} at Shirase, 40 m a^{-1} at Skallen, Telen and Honor, and 10 m a^{-1} at Langhovde). The results of this study suggest the glacier had been stabilized by the land-fast sea ice by 2016. Rapid retreat and acceleration after the break up event strongly suggest significant influence of sea ice on the dynamics of outlet glaciers in Antarctica.

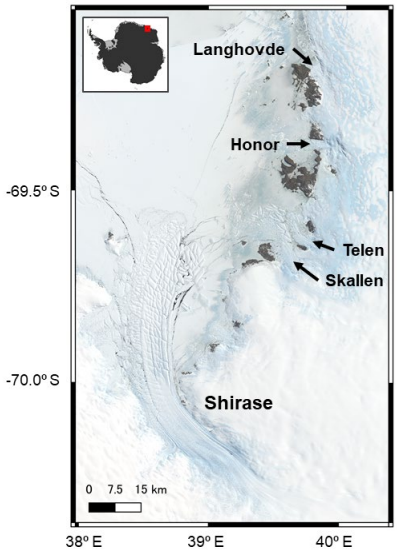

Figure 1. Landsat 8 OLI image on 7 March 2016 showing Lützow-Holm Bay, East Antarctica

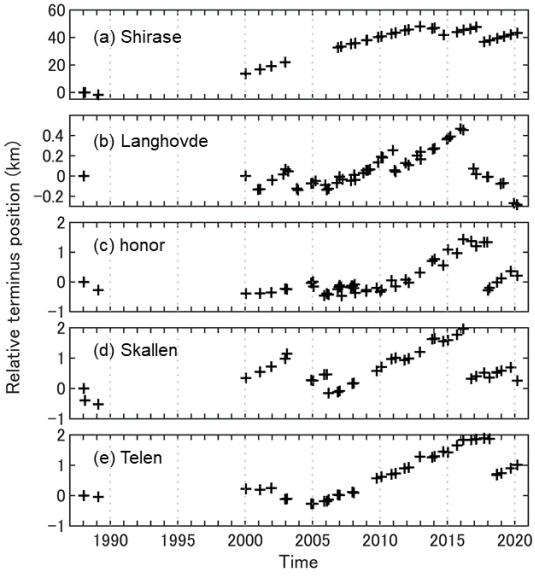

Figure 2. Glacier front displacement relative to the position in 1988.

References

Miles, B.W.J. and Stokes, C.R. and Jamieson, S.S.R (2017), Simultaneous disintegration of outlet glaciers in Porpoise Bay (Wilkes Land), East Antarctica, driven by sea ice break-up, The Cryosphere, 11, 427-442.

Aoki, S. (2017), Breakup of land-fast sea ice in Lützow-Holm Bay, East Antarctica, and its teleconnection to tropical Pacific sea surface temperatures, Geophys. Res. Lett., 44, 3219–3227.