Mass loss of Qaanaaq Ice Cap in northwestern Greenland from 2012 to 2022

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Peripheral glaciers and ice caps in Greenland account for 13 % of the global glacier mass loss from 2000 to 2019 (IPCC, 2021). Despite observations showing recent increase in ice loss in northwestern Greenland (Kjær et al., 2012), details of the spatial and temporal variabilities of the glacier change remain unclear because only a few in-situ glaciological studies have been reported in northern Greenland. To acquire a long-term glacier mass balance and better understand the mechanisms of its temporal variations, we have conducted surface mass balance and surface elevation measurements on Qaanaaq Glacier, an outlet glacier of Qaanaaq Ice Cap in northwestern Greenland since 2012 (Figure 1) (Sugiyama et al., 2014). In this study, we quantified the mass change of Qaanaaq Ice Cap from 2012 to 2022 and compared the result with meteorological data collected on the ice cap at 944 m a.s.l. (SIGMA-B) (Aoki et al., 2014). We also compare the surface mass balance with elevation change to study the role of the ice dynamics in the observed glacier thinning.

Surface mass balance was measured by using aluminum poles installed at six locations distributed at 243–968 m a.s.l. (Figure 1b). The height of the poles above the ice or snow surfaces was measured every August to obtain annual specific balance at each site. Snow density was measured when the glacier surface was covered with snow to calculate water equivalent snow depth. Mean specific mass balance over the entire ice cap was computed for each year, by assuming that surface mass balance is a function of elevation. Glacier surface elevation was measured by kinematic GPS surveys in July–August 2012, 2019 and 2022. The survey was performed along the central glacier flowline with approximate intervals of 22 m.

The results of the mass balance measurement from 2012 to 2022 showed 10-year-mean specific balance of 0.15 m w.e. a^{-1} at 968 m a.s.l. and −1.67 m w.e. a^{-1} at 243 m a.s.l.. Significant interannual variations of ~2 m w.e. a^{-1} were observed at each site. The cumulative mass balance of the ice cap from 2012 to 2022 was −4.02 ± 0.22 m w.e.. The most negative specific mass balance was observed in 2014/15 (−1.08 ± 0.04 m w.e. a^{-1}), which we attribute to relatively high summer temperature (degree day factor of 208 ℃ d and small amount of snow accumulation (0.27 ± 0.11 m w.e. a^{-1}). The glacier surface elevation dropped from 2012 to 2022, with a rate greater in 2019–2022 (−0.87 m a^{-1}) than in the earlier period of 2012–2019 (−0.61 m a^{-1}). The magnitude of the rate increased in the later period particularly in the middle of the ablation zone, whereas the change was smaller in the regions near the equilibrium altitude and near the terminus. Comparison of the elevation change and surface mass balance suggested that ice thickness change was affected by slowdown of the glacier. We attribute the recent acceleration in the ice loss to more negative surface mass balance and changes in the glacier flow speed.

Our results imply that glaciers and ice caps in the Qaanaaq region are rapidly losing mass over the last decade at a rate varying from year to year. Warming climate is the most important driver of the mass loss, but changes in the snow accumulation play a key role as well. Continuous effort for monitoring glacier mass balance and ice dynamics is required for furthering our understanding of the mass loss of glaciers in Greenland and the Arctic.

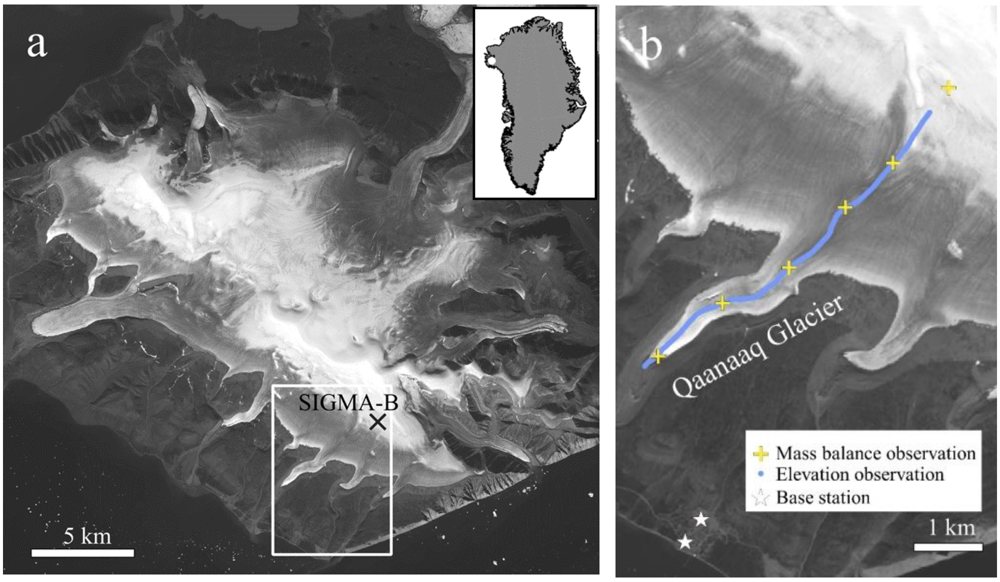

Figure 1. (a) Satellite image (Landsat 8, 25 July 2020) showing Qaanaaq Ice Cap, northwestern Greenland. The box indicates the area shown in (b). The location of the weather station (SIGMA-B) is indicated by ×. (b) Satellite image of Qaanaaq Glacier. The mass balance observation sites are indicated by +, and the surface elevation was measured along the blue line. The base stations of the GPS survey were installed at the locations indicated by ★.

References

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