

## グリーンランド北西部カナック氷河における融解水の流出と洪水 Meltwater discharge and flooding of the outlet stream of Qaanaaq Glacier, northwestern Greenland

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Glacial meltwater discharge is increasing in Greenland under recent warming climate. As a consequence, floods and damages on infrastructures are reported at outlet streams of land terminating glaciers. For instance, discharge from Qaanaaq Glacier in northwestern Greenland rapidly increased on 21 July 2015 and 2 August 2016, leading to floods of a proglacial stream and destruction of a road between a settlement and Qaanaaq Airport. To better understand the mechanisms of the flood events at Qaanaaq Glacier, we investigated meteorological conditions during the 2015 and 2016 events by using AWS operated on the ice cap at 944 m a.s.l. (SIGMA-B) (Aoki et al., 2014). We performed field measurements in the summer 2017 and 2018 to investigate melting process of Qaanaaq Glacier and the response of the outlet discharge. These data were combined with surface mass balance of Qaanaaq Glacier observed from 2012 to 2018 to analyse the cause of floods in 2015 and 2016.

Surface mass balance was significantly more negative in 2015 and 2016 as compared to the other years. Glacier wide mass balance was  $-0.76 \pm 0.13$  m w.e. in 2014/2015 and  $-0.28 \pm 0.7$  m w.e. in 2015/2016. Before the floods, daily mean temperature rose above 5 °C for 5 days in 2015 and above freezing for almost a month in 2016 at SIGMA-B. Such warm conditions caused intensive melting over the entire glacier, resulting in saturation and disappearance of snowpack from the glacier below 950 m a.s.l. In addition to large exposure of ice surface, heavy rainfall ( $90 \text{ mm d}^{-1}$ ) occurred on the date of the flood in 2016. We assume that the exposed ice surface helped immediate runoff of a large amount of rainwater. These analyses suggested the loss of snow cover played a key role in the flood events in 2015 and 2016.

We measured discharge from Qaanaaq Glacier from 21 July to 3 August 2017. Stream discharge rapidly increased on 28 July 2017, leading to a peak value of  $8.11 \text{ m}^3 \text{ s}^{-1}$ . From 21 to 28 July, snowline elevation rose from 500 to 650 m a.s.l. after intensive melting. Runoff measured before the peak discharge accounted for only 60 % of the estimated total glacier melt, indicating the rest of meltwater remained in snowpack on the glacier. These data suggested snowpack was saturated with meltwater, and rapidly released water during the period of rapid melting and upglacier snowline migration. Together with data obtained by similar measurements in 2018, we conclude that saturation and disappearance of snowpack are the key to predict rapid increase in stream discharge and flooding.

Reference:

Aoki, T., S. Matoba, J. Uetake, N. Takeuchi, and H. Motoyama (2014), Field activities of the “Snow Impurity and Glacial Microbe effects on abrupt warming in the Arctic” (SIGMA) Project in Greenland in 2011-2013, *Bull. Glaciol. Res.*, 32, 3–20.

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