Glacial runoff and flooding under the warming climate in the northern most region, Qaanaaq — field observation and numerical study on the outlet stream of Qaanaaq Glacier —

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Glacial meltwater discharge is increasing in Greenland under recent warming climate. Discharge from Qaanaaq Glacier in northwestern Greenland rapidly increased on 21 July 2015 and 2 August 2016, leading to floods and destruction of a road between a settlement and Qaanaaq Airport. These disasters are recognized as a consequence of changing Arctic climate.

To investigate the mechanism of the flood as well as to forecast glacial discharge under the warming trend, we conducted field and numerical studies on Qaanaaq Glacier and its outlet stream. The goal of the study is to provide future prospect of the river discharge using a melt-runoff routing model developed based on field campaigns in summer 2017–2019, which should help for planning sustainable future.

Meteorological data obtained on the glacier at 944 m a.s.l. showed remarkably high air temperature (daily mean of 9.5 ºC and 7.7 ºC) before the flood events in 2015 and 2016. This observation implies intensive melting and subsequent exposure of bare ice in the early melt seasons. In addition to the warm temperature, heavy rainfall (89 mm d^{-1}) was observed on the day of the flood in 2016. Snowpack plays a role to store water in a glacier, so it is likely that the disappearance of them helped immediate runoff during the events.

To compute surface melt and discharge from Qaanaaq Glacier, a runoff routing model was developed by combining surface energy balance and linear–reservoir models. Numerical experiments were performed to compute discharge under a progressively warming atmospheric condition. The results of the experiments showed that annual discharge linearly increases as a function of temperature. Assuming a 4 ºC warmer condition in 2015–2019, the model estimates 3.3-fold increase in total discharge (34.5 Mt) over the 5-year period. This result suggests the risk of floods increases under ongoing warming trend.

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