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Tsunami propagation and high-resolution inundation modelling of the 2017 Karrat rock avalanche and potential future tsunamis from proximal slope failures

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On June 17, 2017, a 40 Mm^3 rock avalanche generated a tsunami that impacted several coastal communities in Karrat Fjord, Central West Greenland. The tsunami run-up was 10-12 m high in the nearest village 30 kilometres away from the rock avalanche and caused four fatalities. The two villages most heavily affected are still evacuated. In the aftermath of this event, several unstable rock slopes have been discovered proximal to the 2017 rock avalanche. One of these volumes, coined Karrat 1, has a volume of about 0.5 km^3 and is hence at least an order of magnitude larger than the volume involved in the 2017 event. To put this in perspective, it has a volume 2-3 times larger than the 2018 Anak Krakatau tsunami that led to more than 400 fatalities in Sunda Strait, Indonesia (which is also much more heavily populated). Hence, the Karrat 1 worst case scenario poses a threat to a much larger area than the event that took place in 2017 and could potentially affect the whole fjord system. In this study, we quantify the tsunami hazard from this unstable rock slope as well as the 2017 event. We first provide a set of landslide tsunami simulations using a frictional-collisional Voellmy type model coupled to a tsunamis model for the event in 2017 and compare it with observations. We found that the model results agree closely with observations of the tsunami run-up heights, observations of the tsunami arrival times, and the wave periods. The 2017 tsunami model was then used to calibrate the landslide source model for the future hazard, simulating the Karrat 1 landslide tsunami with an included uncertainty range. Extreme run-up heights (10-70 m) are found for the nearest villages, as well as complete inundation of entire low-lying villages, some more than 100 km away from the landslide release area. The large modelled run-up heights, involving extreme run-up heights and relatively short arrival times for the nearby villages, demonstrate the need for better understanding of the risk as well as risk-reducing measures. With few or no previous subaerial events that have taken place historically of this scale, the possible implications of a catastrophic release are widespread, but they also imply substantial uncertainties.