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Area and volume quantification of arctic thaw slumps using time-series of digital elevation models generated from radar interferometry

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Vast areas of the Arctic host ice-rich permafrost, which is becoming increasingly vulnerable to terrain-altering thermokarst in a warming climate. Among the most rapid and dramatic changes are retrogressive thaw slumps. These slumps evolve by a retreat of the slump headwall during the summer months, making their change visible by comparing digital elevation models over time. In this study we use digital elevation models generated from single-pass radar TanDEM-X observations to derive volume and area change rates for retrogressive thaw slumps. At least three observations in the timespan from 2011 to 2017 are available with a spatial resolution of about 12 meter and a height sensitivity of about 0.5-2 meter. Our study regions include regions in Northern Canada (Peel Plateau/Richardson Mountains, Mackenzie River Delta Uplands, Ellesmere Island), Alaska (Noatak Valley) and Siberia (Yamal, Gydan, Taymyr, Chukotka) covering an area of 220.000 km^2 with a total number of 1853 thaw slumps.

In this presentation we will focus on the area and volume change rate probability density functions of the mapped thaw slumps in these study areas. For landslides in temperate climate zones the area and volume change probability density function typically follow a distribution that can be characterized by three quantities: A rollover point defined as the peak in the distribution, a cutoff-point indicating the transition to a power law scaling for large landslides and the exponential beta coefficient of this power law. Here we will show that thaw slumps across the arctic follow indeed such a distribution and that the obtained values for the rollover, cutoff and beta coefficient can be used to distinguish between regions. Furthermore we will elaborate on possible reason why arctic thaw slumps can be described by such probability density functions as well as analyzing the differences between regions. This characterization can be useful to further improve our understanding of thaw slump initiation, the investigation of the drivers of their evolution as well as for modeling future thaw slump activity.