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Local and synoptic controls on rapid supraglacial lake drainage in West Greenland

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Many supraglacial lakes within the ablation zone of the Greenland Ice Sheet (GrIS) are known to drain rapidly (in <1 day) in the mid- to late melt season, delivering large meltwater pulses to the subglacial drainage system, thus affecting basal water pressures and ice-sheet dynamics. Although it is now generally recognised that rapid lake drainage is caused by hydrofracture, the precise controls on hydrofracture initiation remain poorly understood: they may be linked to a local critical water-volume threshold, or they may be associated with synoptic-scale factors, such as ice thickness, driving stresses, ice velocities and strain rates. A combination of the local water-volume threshold and one or more synoptic-scale factors may explain the overall patterns of rapid lake drainage, but this requires verification using targeted field- and remotely-based studies that cover large areas of the GrIS and span long timescales.

Here, we investigate a range of potential controls on rapid supraglacial lake drainage in the land-terminating Paakitsoq region of the ice sheet, northeast of Jakobshavn Isbræ, for the 2014 melt season. We have analysed daily 250-m Moderate Resolution Imaging Spectroradiometer (MODIS) imagery in order to calculate lake areas, depths and volumes, and have developed an automatic lake-tracking algorithm to determine the dates on which all rapid lake drainage events occur. For each rapidly draining lake, the water volumes immediately prior to drainage are compared with other local factors, notably lake-filling rate and ice thickness, and with a variety of synoptic-scale features, such as slope angles, driving stresses, surface velocities, surface strain rates and the incidence of nearby lake-drainage events. We present the outcomes of our statistical analysis to elicit the statistically significant controls on hydrofracture beneath supraglacial lakes.