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A Fully Automated Supraglacial lake area and volume Tracking ("FAST") algorithm: development and application using MODIS imagery of West Greenland

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Supraglacial lakes (SGLs) on the Greenland Ice Sheet (GrIS) influence ice dynamics if draining rapidly by hydrofracture, which can occur in under 24 hours. MODerate-resolution Imaging Spectroradiometer (MODIS) data are often used to investigate SGLs, including calculating SGL area changes through time, but no existing work presents a method that tracks changes in individual (and total) SGL volume in MODIS imagery over a melt season. Here, we present such a method. First, we tested three automated approaches to derive SGL areas from MODIS imagery by comparing calculated areas for the Paakitsoq and Store Glacier regions in West Greenland with areas derived from Landsat-8 (LS8) images. Second, we applied a physically-based depth-calculation algorithm to the pixels within the SGL boundaries from the best performing method, and validated the resultant depths with those calculated using the same method applied to LS8 imagery. Our results indicated that SGL areas are most accurately generated using dynamic thresholding of MODIS band 1 (red) with a 0.640 threshold value. Calculated SGL area, depth and volume values from MODIS were closely comparable to those derived from LS8.

The best performing area- and depth-detection methods were then incorporated into a Fully Automated SGL Tracking ("FAST") algorithm that tracks individual SGLs between successive MODIS images. It identified 43 (Paakitsoq) and 19 (Store Glacier) rapidly draining SGLs during 2014, representing 21% and 15% of the respective total SGL populations, including some clusters of rapidly draining SGLs. We found no relationship between the water volumes contained within these rapidly draining SGLs and the ice thicknesses beneath them, indicating that a critical water volume linearly related to ice thickness cannot explain the incidence of rapid drainage. The FAST algorithm, which we believe to be the most comprehensive SGL tracking algorithm developed to date, has the potential to investigate statistical relationships between SGL areas, volumes and drainage events over wide areas of the GrIS, and over multiple seasons. It could also allow further insights into factors that may trigger rapid SGL drainage.