

Remote sensing of supraglacial lakes in Greenland using a combined Sentinel-2 and Landsat-8 record

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Although remote sensing is commonly used to investigate surface lakes on the Greenland Ice Sheet, most satellite records must trade-off high spatial resolution for high temporal resolution (e.g. MODIS) or vice versa (e.g. Landsat). Here, we overcome this issue by developing and applying a method that can monitor changes to lake areas and volumes at high spatial resolution (10–30 m) with a high revisit time (\sim 3 days). We achieve this by mosaicking imagery from the Landsat-8 OLI with imagery from the recently launched Sentinel-2 MSI, which is focused on a \sim 12,000 km 2 study site in West Greenland in summer 2016. First, we validate a physically-based method for calculating lake depths with Sentinel-2 by comparing measurements against those derived from the available contemporaneous Landsat-8 imagery; we find close correspondence between the two sets of values ($R^2 = 0.811$; RMSE = 0.584 m). This provides us with the methodological basis for automatically calculating lake areas, depths and volumes from all available Landsat-8 and Sentinel-2 imagery. These automatic methods are then incorporated into our new Fully Automated Supraglacial lake Tracking at Enhanced Resolution (“FASTER”) algorithm. This produces hydrographs for the evolution of all lakes during the 2016 melt season, from which we identify rapidly (≤ 4 days) and slowly (> 4 days) draining lakes. The FASTER algorithm, using the combined Landsat-8 and Sentinel-2 record, can identify many more lake-drainage events than would be possible with either set of imagery alone (due to their poor temporal resolution) or with the MODIS record (due to its omission of lakes < 0.125 km 2 in size). The FASTER algorithm therefore holds great potential for generating novel insights into lake evolution on the Greenland Ice Sheet.