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Annual to sub-annual 3D surface evolution of an Antarctic blue-ice moraine using multi-platform, multi-temporal high resolution topography

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High-resolution topographic data products are now routinely used for the geomorphological characterisation of Earth surface landforms and landscapes, whilst the acquisition and differencing of such datasets are swiftly becoming the preferred method for quantifying the transfer of mass through landscapes at the spatial scales of observation at which many processes operate. In this research, we employ 3-D differencing of repeat high-resolution topography to quantify the surface evolution of a 0.3 km2 blue-ice moraine complex in front of Patriot Hills, Antarctica. We used terrestrial laser scanning (TLS) to acquire multiple overlapping 3D datasets of the moraine surface at the beginning and end of the austral summer season in 2012/2013 and during a resurvey campaign in 2014. An additional topographic dataset was acquired at the end of season 1 through the application of a Structure-from-Motion with Multi-View Stereo (SfM-MVS) workflow to a set of aerial photographs acquired during a single unmanned aerial vehicle (UAV) sortie. 3D cloud-to-cloud differencing was undertaken using the M3C2 algorithm. The results of 3D differencing revealed net uplift (median ∼0.05 m) and lateral (xy) movement (median 0.02 m) of the moraine crests within season 1. Analysis of results from the longest differencing epoch (start of season 1 to season 2) suggests gradual but persistent surface uplift (median ∼0.11 m) and sustained lateral movement (median ∼0.05 m). Locally, lowering of a similar magnitude to uplift was observed in inter-moraine troughs and close to the current ice margin. This research demonstrates that it is possible to detect dynamic surface topographic change across glacial moraines over short timescales through the acquisition and differencing of high-resolution topographic datasets. Such data and methods of analysis offer new opportunities to understand glaciological and geomorphological process linkages in remote glacial environments.