



Preservation potential of subtle glacial landforms based on detailed mapping of recently exposed proglacial areas: application of unmanned aerial vehicle (UAV) and structure-from-motion (SfM)

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Ongoing glacier retreat results in the continuous exposure of proglacial areas. Such areas contain invaluable information about glacial process-form relationships manifest in specific landform assemblages. However, preservation potential of freshly exposed glacial landforms is very low, as proglacial terrains are one of the most dynamic parts of the landscape. Therefore, rapid mapping and geomorphological characterisation of such areas is important from a glaciological and geomorphological point of view for proper understanding and reconstruction of glacier-landform dynamics and chronology of glacial events. Annual patterns of recession and relatively small areas exposed every year, mean that the performing of regular aerial or satellite survey is expensive and therefore impractical. Recent advances in technology enables the development of low-cost alternatives for traditional aerial surveys. Small unmanned aerial vehicles (UAV) can be used to acquire high-resolution (several cm) low-altitude photographs. The UAV-based photographs can be subsequently processed through the structure-from-motion process to generate detailed orthophotomaps and digital elevation models.

In this study we present case studies from the forelands of various glaciers on Iceland and Svalbard representing different types of proglacial landscapes: Fláajökull (annual push moraines); Hofellsjökul (bedrock bedforms and push moraines); Fjallsjökull (marginal drainage network); Rieperbreen (crevasse squeeze ridges and longitudinal debris stripes); Ayerbreen (transverse debris ridges); Foxfonna (longitudinal debris stripes); Hørbyebreen (geometric ridge network); Nordenskiöldbreen (fluted till surface); Ebbabreen (controlled moraine complex). UAV campaigns were conducted using a low-cost quadcopter platform. Resultant orthophotos and DEMs enabled mapping and assessment of recent glacial landscape development in different types of glacial land systems. Results of our study indicate that preservation potential of geometric ridge networks and debris stripes produced by polythermal glaciers on Svalbard is very low (< 5 years), whereas subtle landforms indicative for temperate conditions: annual push moraines (Iceland) and flutings (Iceland and Svalbard) - can survive decades without being seriously modified.