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Integrating Structure-from-Motion and time-lapse imagery to investigate ice-margin dynamics

Joseph Mallalieu, Jonathan Carrivick, Duncan Quincey, Mark Smith, and William James
School of Geography, University of Leeds, United Kingdom (j.mallalieu@leeds.ac.uk)

Recent advances in Structure-from-Motion (SfM) and Multi-View Stereo (MVS) techniques have driven a dramatic increase in the use of high-resolution topographic datasets to investigate a wide variety of geomorphological processes and landforms. However, to date, many SfM-MVS based studies have been typified by low temporal resolution and discontinuous data collection, which can make the processes behind any changes difficult to disaggregate. The limitations of intermittent data collection are further compounded where processes themselves are unpredictable or require prolonged monitoring. In such cases time-lapse photography has been widely employed to facilitate the generation of continuous datasets at fine-temporal resolutions. Consequently, the integration of SfM-MVS techniques with time-lapse imagery has remarkable potential for revealing mechanistic drivers and triggers of geomorphological change. Here we demonstrate the use of a novel SfM-MVS and time-lapse setup to investigate ice-margin dynamics under hostile environmental conditions in western Greenland.

Fifteen trail cameras were installed around a lacustrine-terminating margin of the Greenland ice-sheet between July 2014 and September 2015. Cameras acquired imagery 3 times a day over a continuous 426 day period, yielding a dataset of ∼19 000 images. SfM-MVS analysis of the image dataset demonstrated the viability of the setup for generating high-resolution point clouds of ice-margin topography throughout a seasonal cycle. Differencing of successive point clouds identified calving events ranging from 234 to 1475 m^2 in area and 815 to 8725 m^3 in volume, induced by ice cliff undercutting at the waterline and the collapse of spalling flakes. The density of the dataset also facilitated an analysis of ice-margin dynamics at multiple temporal scales (from sub-daily to annual), thus permitting investigation of calving event magnitudes and frequencies. Analysis of smaller scale ice-margin dynamics was hindered by factors including low ambient light levels, locally reflective surfaces and a large survey range.

This study demonstrates that an integrated SfM-MVS and time-lapse setup can be employed to generate continuous topographic datasets and thus quantify ice-margin dynamics at a fine spatio-temporal scale. This approach provides a template for future studies of geomorphological change.