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Reducing GCP dependency in UAV Structure from Motion photogrammetry using differential carrier-phase GPS: applications for studying Greenland Ice Sheet dynamics

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Recent developments in the use of unmanned aerial vehicle Structure from Motion (UAV-SfM) photogrammetry have enabled the production of glacier surface velocity datasets at high spatio-temporal resolutions (sub-metre, sub-daily) over broad areas (km^2-scale), offering new understandings of processes at glacier termini and other ice-marginal environments where exposed bedrock offers stable ground control points (GCPs). However, this technique does not, as yet, offer a means to study short-term ice dynamics in the ice-sheet interior and other settings devoid of bedrock GCPs. In this study, we use a fixed-wing preplanned mission UAV with a 2 m wingspan to produce UAV-SfM-derived 3D surface models of ∼4 x 1 km transects of the Greenland Ice Sheet using Agisoft Photoscan. Data from an onboard L1 GPS receiver (a lightweight, low-cost Emlid Reach unit) were post-processed kinematically using differential carrier-phase processing in Emlid's RTKLIB 2.4.3 b27 fork, enabling accurate photo geolocation with the aim of reducing – and potentially eliminating – the dependency on GCPs during the photogrammetry process. The subsequent point clouds can be processed into high-resolution velocity datasets, providing new opportunities to investigate the variability of glacier dynamics over short temporal and spatial scales. More generically, this method could be valuable in all cases where GCP collection presents logistical difficulties. We present preliminary results from testing this method at Store Glacier, a large marine-terminating outlet glacier of the western Greenland ice sheet. At a study site located 30 km inland from Store Glacier's calving ice front, we investigated ice-flow and surface-elevation changes over periods of ∼10 hours, ∼24 hours, and ∼3 days. Preliminary results show the method is well-suited to revealing heterogeneity in ice-sheet dynamics over scales of hundreds of metres and tens of hours under variable environmental conditions in a region where the ice sheet flows over a deep trough and where surface velocities are on the order of 2 m day^{-1}.