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Catchment-Scale Terrain Modelling with Structure-from-Motion Photogrammetry: a replacement for airborne lidar?

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In recent years, 3D terrain reconstructions based on Structure-from-Motion photogrammetry have dramatically democratized the availability of high quality topographic data. This approach involves the use of a non-linear bundle adjustment to estimate simultaneously camera position, pose, distortion and 3D model coordinates. In contrast to traditional aerial photogrammetry, the bundle adjustment is typically solved without external constraints and instead ground control is used a posteriori to transform the modelled coordinates to an established datum using a similarity transformation. The limited data requirements, coupled with the ability to self-calibrate compact cameras, has led to a burgeoning of applications using low-cost imagery acquired terrestrially or from low-altitude platforms.

To date, most applications have focused on relatively small spatial scales (0.1-5 Ha), where relaxed logistics permit the use of dense ground control networks and high resolution, close-range photography. It is less clear whether this low-cost approach can be successfully upscaled to tackle larger, watershed-scale projects extending over 102-3 km2 where it could offer a competitive alternative to established landscape modelling with airborne lidar. At such scales, compromises over the density of ground control, the speed and height of sensor platform and related image properties are inevitable. In this presentation we provide a systematic assessment of the quality of large-scale SfM terrain products derived for over 80 km2 of the braided Dart River and its catchment in the Southern Alps of NZ. Reference data in the form of airborne and terrestrial lidar are used to quantify the quality of 3D reconstructions derived from helicopter photography and used to establish baseline uncertainty models for geomorphic change detection. Results indicate that camera network design is a key determinant of model quality, and that standard aerial photogrammetric networks based on strips of nadir photography can lead to unstable camera calibration and systematic errors that are difficult to model with sparse ground control. We demonstrate how a low cost multi-camera platform providing both nadir and oblique imagery can support robust camera calibration, enabling the generation of high quality, large-scale terrain products that are suitable for precision fluvial change detection.