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Quantifying river response to landsliding: experiments in DEM differencing using wide-area, structure-from-motion terrain models.

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Sediment delivery to alpine rivers is characterized by large but infrequent pulses of material sourced from landslides and debris flows. In extreme cases, when the rate of sediment supply exceeds the transport capacity of channels, a landslide dam forms; impounding river flows and creating an inline lake. These rare events play a crucial but weakly understood role in the evolution of catchment drainage, channel morphology and sediment flux from mountain catchments to their sedimentary sinks. Until recently, insights into the response of river systems to such sediment overloading have been based on either localized ground surveys or expensive airborne lidar campaigns. The recent development of structure-from-motion photogrammetric methods offers the potential to bridge this scale-cost barrier, but has yet to be applied over wide-area (10^{1-2} km^2) extents which push the boundaries of traditional SfM workflows based on dense ground-control and low-altitude or terrestrial imagery.

Here, we present preliminary insights into the response of the braided Dart River, Otago as it adjusts to a major pulse of sediment supplied by landsliding at Slip Stream (44.59 S 168.34 E) in January 2014. DEM differencing (DoD) is used to develop a sediment budget for this extreme slope-channel coupling, using wide-area ($>$80 km^2) terrain models derived from SfM photogrammetry based on aerial helicopter surveys in May 2014 and 2015. Contrasting camera networks, image density and camera models were used in the two surveys providing an opportunity to evaluate the sensitivity of the resulting terrain model to data acquisition strategy. In both cases, georeferencing was based on a network of ground-control distributed along the 40 km valley floor which was also used to provide cross-validation tests on horizontal and vertical model reliability. Both models were subject to inherent systematic bias associated with compensation between the inferred interior and exterior model geometry. The use of a convergent camera network was found to reduce systematic bias, giving rise to independent 3D errors of 0.21 m compared to 0.44 m for models based on nadir only photography. The effects of systematic bias are, however, most effectively managed by developing an empirical correction model based on correlation of stable regions beyond the channel margins. In this paper, we document this workflow and develop a simple error framework to quantify geomorphic change between the surveys. A preliminary sediment budget, quantifying the volumes of material delivered by landsliding, in storage on the debris fan, and then longitudinally redistributed along the Dart River is presented.