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3D Detection, Quantification and Correlation of Slope Failures with Geologic Structure in the Mont Blanc massif

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A thorough understanding of supply from landslides and knowledge of their spatial distribution is of fundamental importance to high-mountain sediment budgets. Advances in 3D data acquisition techniques are heralding new opportunities to create high-resolution topographic models to aid our understanding of landscape change through time. In this study, we use a Structure-from-Motion Multi-View Stereo (SfM-MVS) approach to detect and quantify slope failures at selected sites in the Mont Blanc massif. Past and present glaciations along with its topographical characteristics have resulted in a high rate of geomorphological activity within the range. Data for SfM-MVS processing were captured across variable temporal scales to examine short-term (daily), seasonal and annual change from terrestrial, Unmanned Aerial Vehicle (UAV) and helicopter perspectives. Variable spatial scales were also examined ranging from small focussed slopes (∼0.01 km2) to large valley-scale surveys (∼3 km2). Alignment and registration were conducted using a series of Ground Control Points (GCPs) across the surveyed slope at various heights and slope aspects. GCPs were also used to optimise data and reduce non-linear distortions. 3D differencing was performed using a multiscale model-to-model comparison algorithm (M3C2) which uses variable thresholding across each slope based on local surface roughness and model alignment quality. Detected change was correlated with local slope structure and 3D discontinuity analysis was undertaken using a plane-detection and clustering approach (DSE). Computation of joint spacing was performed using the classified data and normal distances. Structural analysis allowed us to assign a Slope Mass Rating (SMR) and assess the stability of each slope relative to the detected change and determine likely failure modes. We demonstrate an entirely 3D workflow which preserves the complexity of alpine slope topography to compute volumetric loss using a variable threshold. A number of slope failures were detected beyond the threshold level of detection (LOD95%). Alignments of SfM-MVS data were generally of better quality across smoother surfaces, and single failures to a volume of approximately 0.03 m3 were detected. Our results demonstrate that SfM-MVS models can add key data on spatial patterns of slope behaviour when due care and consideration is given throughout the processing, alignment and change-detection phases. We highlight the importance of a well-distributed GCP network for data optimisation, and show that semi-automated discontinuity analyses using SfM-MVS data add significant value to traditional in-field site assessments, which are usually performed through labour-intensive approaches.