The characterization of slope damage using an integrated remote sensing-numerical modelling approach

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The stability of high rock slopes is controlled by many important factors, including geological structures, lithological features, rock mass quality, and hydrogeological conditions. The occurrence of exogenous and endogenous processes, such as seismic activity, alteration and weathering, erosion, anthropogenic activities, may weaken the slope and promote deformations at various scales. Slope deformation is associated with the formation of a range of internal and external features, such as tension cracks, rock mass dilation, and rockfall, that can be comprehensively referred to as “slope damage”. Mapping and characterizing the spatial and temporal distribution of these features provides insight on the style of deformation, and the factors that control the stability and failure of rock slopes. In this research, a range of remote sensing techniques, including terrestrial and airborne laser scanning (TLS and ALS), terrestrial digital photogrammetry (TDP), structure-from-motion (SfM), high-resolution photography, infrared thermography (IRT), and hyperspectral imaging (HSI), are employed to map and characterize slope damage features. Using remote sensing datasets, changes in intensity distribution of slope damage is investigated both spatially and temporally at various rock slopes in British Columbia and Alberta (Canada). The processes and mechanisms controlling the formation and distribution of slope damage are also investigated at selected sites in Canada and in Italy using advanced numerical modelling techniques, including Distinct Element Method (DEM), Hybrid Finite-Discrete Element Method (FDEM), and lattice-spring scheme methods.

The results from field-mapping and numerical modelling analyses are then summarized in a slope damage interaction matrix, highlighting the correlation between geological features, structural setting, hydrogeology, slope morphology, and slope damage. This research highlights the need to include slope damage mapping techniques as a standard procedure in rock slope characterization, in order to obtain important insights on the mechanisms and processes that affect the stability, deformation, and failure of rock slopes.