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Rock face stability analysis and 3D geological mapping in Yosemite Valley (California): new remote sensing methods

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In Yosemite Valley rockfall hazard and risk are high due to the presence of tall, steep granitic cliffs and to the large number of visitors. The main information needed to assess rockfall hazard is the location of the most probable rockfall source areas and the establishment of the frequency of activity from these areas. Terrestrial Laser Scanning (TLS) has been widely deployed to collect very accurate point clouds, with point-to-point spacing smaller than 0.1 m. We conducted two series of TLS acquisitions of the main cliffs of Yosemite Valley in October 2010 and June 2012, using an Optech Ilris-LR scanner. This provided the necessary data to identify the main joint sets, perform spacing and trace length measurements, and calculate past rockfall volumes. Subsequently, we developed a methodology to carry out kinematic tests on the TLS point clouds, taking into account for each joint set the orientation, spacing and persistence measurements directly measured from the TLS data. The areas with the highest density of potential failure mechanisms are shown to be the most susceptible to rockfalls, demonstrating a link between high fracture density and rockfall susceptibility. The presence of surface parallel sheeting or exfoliation joints is widespread in the granitic faces of Yosemite Valley, contributing significantly to the occurrence of rockfalls. Thus, through TLS, sheeting joints have been mapped in 3D over wide areas to get valuable information about the depth, spacing, persistence and orientation of these joints. Several exfoliation sets can be identified and evaluated for their relevance in the development of rockslope instabilities and rockslab failures. Another important parameter that must be constrained to identify potential rockfall sources is rock type, as the fracturing pattern of a rock face varies according to rock type. Therefore, we have focused on the precise mapping of geologic limits on the basis of the intensity value associated with each point of a TLS point cloud. We validated the mapping with field observations and high resolution digital photographs.

TLS provides 3D data to precisely characterize the morphology of vertical and overhanging rock faces. With the recently developed methods it is possible to remotely map geologic limits and exfoliation joints, as well as to assess the density of potential failure mechanisms directly on the TLS point clouds. These advances in remote sensing methods provide new tools to locate the most probable future rockfall sources and provide key elements needed to evaluate the potential rockfall hazard of every area of the cliffs in Yosemite Valley.