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Rockfall susceptibility mapping of Yosemite Valley (USA) using a high-resolution digital elevation model

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In Yosemite National Park (California, USA) rockfalls from the steep valley flanks are frequent (>600 documented events in 150 years) and threaten infrastructure in this popular tourist area. This study focuses on a methodology to map the susceptibility to rockfall initiation based on a high-resolution digital elevation model (HRDEM) obtained from aerial laser scanning (1 meter cell size). This methodology is based on geometric factors derived from the HRDEM, i.e., the steepness of the topography, the presence of joints or fractures enabling either a planar or a wedge failure mechanism, and a high denudation potential.

The slope angle histogram computed using standard GIS routines was simulated using Gaussian distributions, which were attributed to different parts of the topography, i.e., the cliffs, the valley flanks and the valley floor. Slopes steeper than 36° are found to form cliffs and thus potentially lead to rockfalls.

A morpho-structural analysis of the HRDEM was performed in Coltop3D software to determine the major discontinuity sets that shape the topography. Kinematic analyses were made for each of these 7 discontinuity sets in order to determine the HRDEM cells that fulfil the geometric criteria for a planar or wedge failure mechanism. Most of the cliffs in Yosemite Valley enable one or both of these failure mechanisms.

The denudation potential was assessed using the sloping local base level (SLBL) concept. The SLBL defines a basal erosion surface and the above lying rock masses (up to 400 m in some of the vertical cliffs) are susceptible to erosion by mass wasting. A thickness of 20 m above the SLBL surface was chosen as lower limit for the denudation potential criterion.

The HRDEM cells that satisfy 1, 2 or all 3 criteria are considered having low, moderate and high susceptibility to rockfall initiation. The areas with highest susceptibility (El Capitan, Glacier Point, Yosemite Falls and Half Dome) coincide well with post-glacial talus accumulations and historic rockfall sources. Compared to previous maps of potential rockfall sources that were mainly based on the slope angle criterion, this study provides a more refined analysis of potential rockfall sources and is useful for focussing detailed field investigations on those areas with high susceptibility.