# REGIONAL AND LOCAL ROCK FALL HAZARD AND RISK ASSESSMENT: EXAMPLES FROM YOSEMITE NATIONAL PARK, CALIFORNIA, USA

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Rock falls are common natural occurrences throughout Yosemite Valley a glacially carved canyon in granite located in the central Sierra Nevada, California. Since 1857 more than 600 rock falls, rock slides, debris slides, and debris flows have been documented in Yosemite National Park, with rock falls representing the majority of the events. In the last 150 years over 800 rock fall events have occurred in the National Park, causing 15 fatalities, numerous injuries, and considerable damage to infrastructure. Recent examples include a rock fall on 26 December 2003, originating from west of Glacier Point, which sent approximately 200 $m^3$ of rock debris onto the talus slope below, producing fragments of flying rock that struck occupied cabins in Curry Village. On 8 October 2008, a rock fall from Glacier Point sent about 5,600 $m^3$ onto the talus slope behind Curry Village, damaging cabins and causing minor injuries. A series of rock falls totalling about 1,500 $m^3$ fell from near the Royal Arches on 26 August 2009, damaging vehicles in the parking lot of the Ahwahnee Hotel. These events highlight the need for further rock fall hazard and risk assessment.

We have investigated and modeled the extent of areas potentially subject to rock fall hazards for the entire Yosemite Valley and for single rock fall events (Figure 1), by using STONE, a three-dimensional rock fall simulation computer program. The software computes 3-dimensional rock fall trajectories starting from a digital elevation model (DEM), the location of rock fall release points, and maps of the dynamic rolling friction coefficient and of the coefficients of normal and tangential energy restitution. For each DEM cell the software calculates the number of rock falls passing through the cell, the maximum rock fall velocity and the maximum flying height. The spatial extent of simulated rock falls helps to define areas of rock fall hazard in Yosemite Valley and, when combined with infrastructure and human use data, provides information for risk assessment.

The model simulations have been used, in conjunction with field mapping and other hazard assessment techniques, to make changes to infrastructure in Yosemite Valley. For example, following the 8 October 2008 Glacier Point rock fall, nearly three hundred buildings within an identified hazard zone were permanently closed, and vehicle parking at the Ahwahnee Hotel was moved back from the talus slope following the 26 August 2009 rock falls. Ongoing STONE modelling will help to better assess rock fall hazard and risk for other areas within Yosemite National Park.

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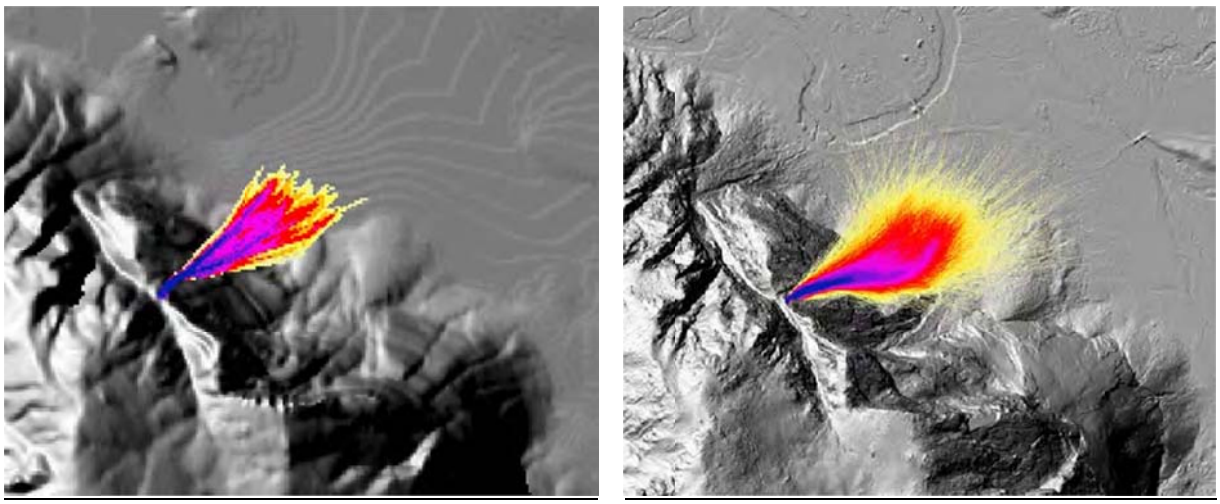
Figure 1: Staircase Falls rock falls. Comparison of STONE rock-fall simulations on Digital Elevation Models (DEMs) of varying resolution. Colors show number of rock-fall trajectories. (Left) simulation performed on 10 m DEM; (right) Simulation performed on filtered (bare earth) 1 m DEM derived from airborne LiDAR data.



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