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Rockfall hazard assessment integrating probabilistic physically based rockfall source detection (Norddal municipality, Norway).

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Traditional techniques to assess rockfall hazard are partially based on probabilistic analysis. Stochastic methods has been used for run-out analysis of rock blocks to estimate the trajectories that a detached block will follow during its fall until it stops due to kinetic energy loss. However, the selection of rockfall source areas is usually defined either by multivariate analysis or by field observations. For either case, a physically based approach is not used for the source area detection. We present an example of rockfall hazard assessment that integrates a probabilistic rockfall run-out analysis with a stochastic assessment of the rockfall source areas using kinematic stability analysis in a GIS environment.

The method has been tested for a steep more than 200 m high rock wall, located in the municipality of Norddal (Møre og Romsdal county, Norway), where a large number of people are either exposed to snow avalanches, rockfalls, or debris flows. The area was selected following the recently published hazard mapping plan of Norway. The cliff is formed by medium to coarse-grained quartz-dioritic to granitic gneisses of Proterozoic age. Scree deposits product of recent rockfall activity are found at the bottom of the rock wall. Large blocks can be found several tens of meters away from the cliff in Sylte, the main locality in the Norddal municipality.

Structural characterization of the rock wall was done using terrestrial laser scanning (TLS) point clouds in the software Coltop3D (www.terranum.ch), and results were validated with field data. Orientation data sets from the structural characterization were analyzed separately to assess best-fit probability density functions (PDF) for both dip angle and dip direction angle of each discontinuity set. A GIS-based stochastic kinematic analysis was then carried out using the discontinuity set orientations and the friction angle as random variables. An airborne laser scanning digital elevation model (ALS-DEM) with 1 m resolution was used for the analysis. Three failure mechanisms were analyzed: planar and wedge sliding, as well as toppling. Based on this kinematic analysis, areas where failure is feasible were used as source areas for run out analysis using Rockyfor3D v. 4.1 (www.ecorisq.org). The software calculates trajectories of single falling blocks in three dimensions using physically based algorithms developed under a stochastic approach. The ALS-DEM was down-scaled to 5 m resolution to optimize processing time. Results were compared with run-out simulations using Rockyfor3D with the whole rock wall as source area, and with maps of deposits generated from field observations and aerial photo interpretation.

The results product of our implementation show a better correlation with field observations, and help to produce more accurate rock fall hazard assessment maps by a better definition of the source areas. It reduces the time processing for the analysis as well. The findings presented in this contribution are part of an effort to produce guidelines for natural hazard mapping in Norway. Guidelines will be used in upcoming years for hazard mapping in areas where larger groups of population are exposed to mass movements from steep slopes.