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# Rockfall susceptibility assessment at Naples, Italy, through inter-comparison of different models

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The implementation of models devoted to the evaluation of the rockslope stability, with the purpose is a task of notable scientific interest and relevance. In a rockfall three main moments can be distinguished: block detachment, descent along the slopes, and runout/impact in the footslope zone. As for the first issue, rock masses have to be suitably classified in homogenous zones, to evince the different grades of detachment susceptibility. To this purpose, Rock Engineering System (RES - Hudson, 1992) offers a versatile approach, being an interactive and dynamic objective-based system. RES, in fact, includes two phases dedicated to select the most relevant parameters which contribute to the project and to analyse their reciprocal interactions in a matrix respectively. After weighing each parameter according to its degree of interactivity on the system, a Rock Mass Instability Index is defined, which gives an idea on the potential instability of each slope, assuming that all parameters contribute to instability. In parallel, taking into account only a selected number of indicators of instability, a Predictability Rating is computed. By comparison of both indices, critical slopes can be identified on a relative scale. During the present study, the analysis of rockfall trajectories and rockfall runout has been eventually performed through three different programs: CRSP (Pfeiffer & Bowen, 1989), ROTOMAP (Scioldo, 1991), CONEFALL (Jaboyedoff & Labiouse, 2005). CRSP is a 2D code which applies equations of gravitational acceleration and conservation of energy to describe the motion of the rock. Empirically derived functions relating to velocity, friction, and slope material properties are used to model the dynamic interaction of the rock and slope. The statistical variation observed among rockfalls is modelled by randomly varying the angle at which a rock impacts the slope within limits set by rock size and slope characteristics. This program provides a site-specific analysis of rockfall with output of velocity and bounce height statistics at various locations on the slope. ROTOMAP is a 3D statistical model used for both rockfall analysis and design of protective systems. The program requires a detailed contour map which serves to create a DEM. Rockfall initiation is modelled according to detachment lines rather than individual points. Stop points are given as a frequency distribution, which permits to create an iso-frequency contour map, useful to predict the invasion hazard level. The programme can generate print-outs of topography, rockfall trajectories, energies, frequencies of stop-points and vertical sections for each simulated fall. CONEFALL adopts a quite simple principle. Provided that a block can propagate downslope if the slope is sufficiently steep, it accelerates if the slope is steeper than a limit angle; on the contrary, if the slope angle is lower then the limit value, the block decelerates. Using the previous assumption, a block can propagate from its source to the point of intersection of the topography with a line starting from the source point forming an angle with the horizontal. The space where a block can propagate from a grid point is located within a cone of slope with a summit placed at the source point. This procedure is applied to all source points. The above procedure and the related codes have been applied to evaluate the rockfall susceptibility in the southern and northern sectors of Camaldoli Hill (Naples, Italy). Here, volcanic tuffs crop out forming steep highly-fractured cliffs which threaten some densely populated urban districts. From such cliffs, number of rock falls and topples have occurred over the time, as demonstrated by both an archival research and geomorphologic surveys. The results deriving by each of the selected programs have been finally compared, especially as regards their capability to predict the rockfall runout.