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Development of a 3D rockfall simulation model for point cloud topography

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Rockfall simulations are generally used, for example, as input data to generate rockfall susceptibility map, to evaluate the reach probability of an infrastructure or to define input parameter values for mitigation designs. During the simulations, the lateral and vertical deviations of the particle and the change of velocity happening during the impacts have to be evaluated. Numerous factors control rockfall paths and velocities, like the particle's and terrain's shapes and compositions. Some models, especially the ones using discrete element methods, can consider a lot of physical factors. However, a compromise often has to be done between the time needed to produce a sufficient amount of 2D or 3D rockfall trajectories and the level of complexity of the model. In this presentation, the current version of our rockfall model in development is detailed and the compromises that were made are explained. For example, it is hard to predict the sizes and shapes of the components that could fall from a developing rock instability, or if they will break after the first impact or stay as massive blocks. For this reason, we decided for now to simplify the particle's shape to a sphere which can vary in size and to use a cubical shape to compute the 3D rotational inertia. In contrast to the particle's characteristics, the terrain's shape is known and can be acquired in detail using current topographical acquisition methods, e.g. airborne and terrestrial laser scans and aerial based structure from motion. We made no sacrifice on that side and developed our model so it can simulate rockfalls directly on 3D point clouds topographical data. It is also been shown that calibrating velocity weighting factors, often called restitution coefficients, is not an easy task. Divergent results could be obtained by different users using the same simulation program simply because they use different weighting factors, which are hard to evaluate and quantify from field work. Moreover, the normal velocity weighting factor does not seems to be constant as the impact conditions change, even if the terrain composition does not change. It could be correlated with the incident angle. We then decided for now to let impact characteristics control velocity changes with some variability and to use the detailed topographic representation to control the direction after a rebound. As a high topographical level of detail is used, less random variability is needed. Therefore, it would be easier for different users working on the same study area to get similar results as long as detailed enough topographical data are used. Some applications cases are also shown. Further development should focus on more calibration with known rockfall events, taking into account impact against trees and fragmentation of rock blocks, and improving the impact model by studying impacts on different terrain compositions from a mechanical approach using discrete element method based simulations.