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Real-size rockfall experiment: Applying observed impact dynamics to 3D rockfall simulations on highly detailed terrain models

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To manage rockfall hazards, it is important to correctly estimate the reach distances and velocities of falling rock blocks. To do so, it is often needed to perform 3D rockfall simulations. However, finding the right set of parameters is often done subjectively given the lack of empirical 3D data to finetune the runouts and more generally the simulation models. However, during the last years, several 3D rockfall experiments has been performed to overcome this problem.

Last autumn (2018), we joined our efforts to work on a larger rockfall experiment and improve a 3D rockfall database while benefiting from the knowledge and diversity of the collectivity. That time, commercial (MSR Electronics GmbH) and custom-made data loggers, accelerometers and gyroscopes were embedded in some of the launched blocks and a dense seismic network was deployed. Highspeed 4k and HD cameras were used in combination with different telephoto lenses from different locations on the ground and in the air to visually reconstruct the 3D trajectories. A highly detailed (many points per cm2) 3D point cloud terrain model was also acquired with terrestrial laser scanner (TLS), mobile TLS and UAV photogrammetry.

In this presentation, the aspects of observed dynamics from the rockfall experiments that applies to rockfall simulations are detailed. An emphasis is made to the relation in between the impact angle, deviation that happen after an impact and velocity changes. Examples of how angles are strongly affected by the size of the particle and the encountered terrain surface roughness are given. In parallel, the compromises that we have made to allow our adapted simulation model to run on highly detailed terrain model while keeping a decent modeling speed are discussed.

Also, the geometric approaches on point cloud and raster terrain models allowing the small particles to get caught into the surface roughness while letting the large ones travel further, like it is usually observed in scree slope, are explained with examples. They both consist at finding the "perceived" surface orientation by the block at impact instead of using the terrain local "slope and aspect" orientations. On raster, this is done by calculating a buffer over and around the terrain corresponding to the radius of the block. On the terrain, this translate into geometrically displacing the particle in contact over the surface while filling in the asperities that are too small to be reached.

The same is performed with point cloud, but the approach is slightly different. It consists of finding where on the block the contact happens at impact. Then drawing a normed vector from this point toward the center of mass of the block. This vector is then used as the "perceived" normal to the ground at impact.

The recently tuned rockfall model is finally applied to reconstruct previous real punctual natural and experimental rockfall events on several sites. It is interesting to see how few parameters must be adjusted with these combinations of approaches to get corresponding runouts. This restrains the biases associated with the subjectivity of choosing the right parameters.