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From cliff inspection to rockfall reach probability evaluation with catchments: A comparative case study from Bex, Vaud, Switzerland

Jacques Locat (1), François Noël (2), Thierry Oppikofer (3), Clément Michoud (3), Sébastien Lévy (4), and Michel Jaboyedoff (2)

(1) Laval University, LERN, Geological engineering, Québec, Canada (jacques.locat@ggl.ulaval.ca), (2) Institute of Earth Sciences, University of Lausanne, Switzerland, (3) Terranum – Geosciences and software solutions, Switzerland, (4) Direction générale de l'environnement de l'état de Vaud, Switzerland

To locally evaluate the rockfall hazard for some buildings of the municipality of Bex, Switzerland, a 30 m high by 110 m long gypsum cliff was inspected between March 2017 and 2018. Comparative rockfall simulations were then performed from five observed potential instabilities using four different rockfall simulation programs/models to estimate the probability for the buildings to be reached by rockfalls. A present catchment ditch was considered in the simulations, and to extend it, some catchment designs (fences and ditches) were also tested.
The visual inspections were accompanied by temporal acquisitions of 3D point cloud terrain models (DTM) with terrestrial laser scanner (TLS), mobile TLS and photogrammetry. During this period, 15 small rockfalls were observed by comparing the DTMs and confirmed visually on pictures. Their mean volume evaluated with the DTMs is around 0.012 m3 with a standard deviation (std.) of 0.016 m3. The largest of these observed rockfalls was a thin block with a width of 1.2 m and a height of 0.5 m, for a volume of 0.058 m3.
The main joint-sets of the rock face were measured on the point clouds. Five potential instabilities were identified based on the observation of surrounding open cracks for three of them, and 3 to 8 m persistent open cracks for the two others. Their mean volume is around 11 m3 with a std. of 11 m3 and a maximum volume of around 25 m3.
The potential propagation was then evaluated and compared using: RocFall simulation program from RocScience that works on detailed 2D slope profiles with their 1) lumped mass and 2) rigid body models; 3) Rockyfor3D from ecorisQ that works on 2.5D gridded terrain models with 2x2 m pixels at best resolution; and 4) our 3D rockfall simulation program in development that works on highly detailed 3D point cloud DTMs or gridded terrain models. The reach distances and energy lines obtained with our program in development and RocFall are very similar. They reach the buildings in average from 0.4 to 6.3 % of the simulated trajectories. Those with Rockyfor3D goes further, with more lateral spreading and reach buildings in average for 69 % of the simulated trajectories. The existing catchment ditch, where present, seems efficient based on most simulations from three of the four programs/models used. In contrast, those from Rockyfor3D show that this catchment has almost no effect on the propagation and reach distances. Similar behaviours were obtained with the extension catchment ditch design. The same goes with the extension catchment fence designs, but this time with reduced propagation in some Rockyfor3D's simulations. The results of similar case studies combining Rockyfor3D and protective measures should be interpreted with caution.
In summary, this study shows that at local scale, rockfall simulations seems to be greatly influenced by the quality/resolution of the terrain model, especially for runout distance and 3D effects. Thereby, the results of such rockfall simulations must be interpreted with caution because the local hazard value might greatly variate compared to the one from regional hazard mapping.