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New approaches for 3D rockfall modelling with or without the effect of forest in Rockyfor3D

Luuk Dorren (1,2) and Frédéric Berger (3)
(1) ecorisQ, France, (2) Federal Office for the Environment FOEN, Switzerland, (3) Cemagref Grenoble, France

Rockyfor3D is a simulation model that calculates trajectories of single, individually falling rocks, in three dimensions (3D). The model combines physically-based, deterministic algorithms with stochastic approaches, which makes Rockyfor3D a so-called 'probabilistic process-based rockfall trajectory model'. Rockyfor3D has been developed initially on the basis of earlier published rockfall research work (e.g. Habib 1977; Azimi et al. 1982; Falcetta 1985; Wu 1985; Bozzolo and Pamini 1986; Spang 1988; Pfeiffer and Bowen 1989; Van Dijke and Van Westen 1990; Zinggeler 1990; Descoeudres 1997; Meissl 1998) and later on the basis of personal field observations, full scale rockfall experiments and simulation tests with many self-developed or other published model algorithms. The objective of this paper is to provide a transparent and consistent overview of the algorithms that are used by the current version of the program (Rockyfor3D v3.0). Latest developments include firstly, the possibility to use rectangular, ellipsoidal, spherical and/or disc type block forms as input for the simulations. This block form determines 1) how the block volume (and consequently its mass) and 2) how the moment of inertia is calculated on the basis of three defined block diameters d1, d and d3. For calculating the rock position, the rebound on the slope surface and impacts against trees, Rockyfor3D always uses a circular shape, which can have 2 different diameters. Secondly, Rockyfor3D calculates the penetration depth of the block at the impact location on the basis of the work of Pichler et al. 2005. Thirdly, the effect of the height of a tree impact on the energy dissipated by a tree is included by a new algorithm on the basis of on a recent analysis of data published by Dorren and Berger (2006), Jonsson (2007) and Lundström et al. (2009). Finally, Rockyfor3D uses a new algorithm that calculates the deviation angle after a rebound on the slope surface, which is determined by the topography, the fall direction of the block before the rebound and the velocity of the falling block. All detailed descriptions and algorithms can be found in the online publication: http://www.ecorisq.org/docs/Rockyfor3D.pdf.

The new version of Rockyfor3D is currently being tested by several users working in the field of rockfall hazard analysis throughout the Alps. Their feedback will hopefully lead to further developments and improvements of the 3D model.