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Validation of an integrated, dynamic 3D forest growth - rockfall model

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Rockfall is a widespread hazard in mountainous areas. Forests may provide efficient means to substantially reduce rockfall hazard. Model-based assessments of the interaction between rockfall and forest vegetation have gained considerable attention recently. In this contribution we introduce PICUS-Rockfall, a 3-dimensional numerical rockfall simulation tool built into the 3D forest patch model PICUS v1.41. The tight integration of rockfall and forest modelling allows the analysis of the temporal development of the protection function of heterogeneous mountain forests against rockfall under natural and managed conditions as well as under changing environmental conditions. The rockfall model is a lumped mass model that takes free fall, ground impacts and rolling motions of rocks into account and simulates tree impacts based on basic mechanics and empirical findings. The topography is represented by a triangulated irregular network (TIN), the spatial distribution of surface parameters is defined by raster grids. Both types of input data are generated and pre-processed using GIS software like ESRI(TM) ArcMap. PICUS-Rockfall simulates individual rockfall trajectories using a probabilistic approach. Trajectories can start anywhere in the simulated stand with predefined initial velocity, jump height and jump angle. Output of the rockfall model includes rock velocities, rebound heights and runout distances in individual, aggregated or spatially distributed manner. The focus of this paper is on the validation of rockfall model performance on the basis of empirical data from three 2-dimensional rockfall trajectories from Austria and Switzerland and data from real-size rockfall experiments on a forested and non-forested slope in France. For the 2D-trajectories and the non-forested test site in Vaujany the focus is the anal-

ysis of restitution and roughness parameters and their interaction regarding simulated boulder velocities, jump heights and lengths. Model sensitivity to uncertain values for restitution and roughness parameters is tested. Data from the forested test site in Vaujany allows a detailed analysis of the implemented tree impact algorithm. Based on the experiments we draw conclusions on further model improvements. In addition, we will discuss potentials as well as limitations of the integrated modelling approach.