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Calibration and validation of rockfall models

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Calibrating and validating landslide models is extremely difficult due to the particular characteristic of landslides: limited recurrence in time, relatively low frequency of the events, short durability of post-event traces, poor availability of continuous monitoring data, especially for small landslide and rockfalls. For this reason, most of the rockfall models presented in literature completely lack calibration and validation of the results. In this contribution, we explore different strategies for rockfall model calibration and validation starting from both an historical event and a full-scale field test. The event occurred in 2012 in Courmayeur (Western Alps, Italy), and caused serious damages to quarrying facilities. This event has been studied soon after the occurrence through a field campaign aimed at mapping the blocks arrested along the slope, the shape and location of the detachment area, and the traces of scars associated to impacts of blocks on the slope. The full-scale field test was performed by Geovert Ltd in the Christchurch area (New Zealand) after the 2011 earthquake. During the test, a number of large blocks have been mobilized from the upper part of the slope and filmed with high velocity cameras from different viewpoints. The movies of each released block were analysed to identify the block shape, the propagation path, the location of impacts, the height of the trajectory and the velocity of the block along the path. Both calibration and validation of rockfall models should be based on the optimization of the agreement between the actual trajectories or location of arrested blocks and the simulated ones. A measure that describe this agreement is therefore needed. For calibration purpose, this measure should simple enough to allow trial and error repetitions of the model for parameter optimization. In this contribution we explore different calibration/validation measures: (1) the percentage of simulated blocks arresting within a buffer of the actual blocks, (2) the percentage of trajectories passing through the buffer of the actual rockfall path, (3) the mean distance between the location of arrest of each simulated blocks and the location of the nearest actual blocks; (4) the mean distance between the location of detachment of each simulated block and the location of detachment of the actual block located closer to the arrest position. By applying the four measures to the case studies, we observed that all measures are able to represent the model performance for validation purposes. However, the third measure is more simple and reliable than the others, and seems to be optimal for model calibration, especially when using a parameter estimation and optimization modelling software for automated calibration.