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Probabilistic landslide run-out assessment with a 2-D dynamic numerical model using a Monte Carlo method

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An essential component of a quantitative landslide hazard assessment is establishing the extent of the endangered area. This task requires accurate prediction of the run-out behaviour of a landslide, which includes the estimation of the run-out distance, run-out width, velocities, pressures, and depth of the moving mass and the final configuration of the deposits. One approach to run-out modelling is to reproduce accurately the dynamics of the propagation processes. A number of dynamic numerical models are able to compute the movement of the flow over irregular topographic terrains (3-D) controlled by a complex interaction between mechanical properties that may vary in space and time. Given the number of unknown parameters and the fact that most of the rheological parameters cannot be measured in the laboratory or field, the parametrization of run-out models is very difficult in practice. For this reason, the application of run-out models is mostly used for back-analysis of past events and very few studies have attempted to achieve forward predictions. Consequently all models are based on simplified descriptions that attempt to reproduce the general features of the failed mass motion through the use of parameters (mostly controlling shear stresses at the base of the moving mass) which account for aspects not explicitly described or oversimplified. The uncertainties involved in the run-out process have to be approached in a stochastic manner. It is of significant importance to develop methods for quantifying and properly handling the uncertainties in dynamic run-out models, in order to allow a more comprehensive approach to quantitative risk assessment.

A method was developed to compute the variation in run-out intensities by using a dynamic run-out model (MassMov2D) and a probabilistic framework based on a Monte Carlo simulation in order to analyze the effect of the uncertainty of input parameters. The probability density functions of the rheological parameters were generated and sampled leading to a large number of run-out scenarios. In the application of the Monte Carlo method, random samples were generated from the input probability distributions that fitted a Gaussian copula distribution. Each set of samples was used as input to model simulation and the resulting outcome was a spatially displayed intensity map. These maps were created with the results of the probability density functions at each point of the flow track and the deposition zone, having as an output a confidence probability map for the various intensity measures. The goal of this methodology is that the results (in terms of intensity characteristics) can be linked directly to vulnerability curves associated to the elements at risk.