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Probabilistic assessment of debris flow hazard on alluvial fans.

J.-P. Malet (1), S. Begueria-Portugués (2)

(1) CNRS UMR 6554, University of Caen Basse-Normandie, France, (2) CSIC, Instituto Pirenaico de Ecología, Zaragoza, Spain. (jean-philippe.malet@unicaen.fr / Phone: +33-231-565-608)

Many of the published works on debris flow hazard assessment on alluvial fans are qualitative in nature, and very often limited to the prediction of the runout distance and the extent of the spreading area, and in some cases to the estimation of the debris momentum (thickness and velocity). More recently there has been a trend towards quantification of the hazard by analysing, in addition to the extent of the natural processes, their probability of occurrence and their intensity of impact. Thus estimating debris flow hazards necessitates the application of a full set of methods, and among them the evaluation of former documented events and the forecast of future events through the use of physical and mathematical models.

Since detailed information on past events is often lacking or incomplete, the temporal probability (frequency) of spreading on a fan is often not included in the assessments. The objective of this study is to propose a general methodology to compute the characteristics of low-frequency debris flows. The approach is based on Monte Carlo techniques, combining a deterministic 2D flow model and a probabilistic description of the model input parameters. The proposed methodology is very general in scope in order to be applied independently of the type of environment.

The methodology involves 5 major steps. First magnitude/frequency relationships will be determined for the hydrological parameters defining the input sedigraph (total volume, peak discharge). A multivariate distribution function is fitted to geomechanical parameters (mixture density, mixture rheology) using data from various well-documented torrents in the French Alps. Second, random input parameter vectors are generated by using inverse probability functions calculated before. To avoid unsound

simulations the randomly generated input vectors are evaluated by expert judgement to avoid unlikely or impossible parameter combinations. Third, model runs are performed using the randomly generated input values. The model is a 2D numerical model of debris flow spreading based on the conservative form of the steep-slope shallow-water equations. The model simulates the flow height and velocity. Fourth, the cells for which the predicted debris flow momentum overcomes a series of predefined threshold values are determined for each model run, and the spatial probability of occurrence (ie. probability of being affected) is estimated considering all the model runs. Finally the degree of hazard, expressed as a time probability or a recurrence interval, is computed by combining the magnitude/frequency of the sedigraph and the probability of occurrence. A matrix approach is used to combine both factors and to delineate high, medium and low hazard areas.