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Application of a Monte Carlo method for modeling debris flow run-out

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A probabilistic framework based on a Monte Carlo method for the modeling of debris flow hazards is presented. The framework is based on a dynamic model, which is combined with an explicit representation of the different parameter uncertainties. The probability distribution of these parameters is determined from an extensive collected database with information of back calibrated past events from different authors. The uncertainty in these inputs can be simulated and used to increase confidence in certain extreme run-out distances. In the Monte Carlo procedure; the input parameters of the numerical models simulating propagation and stoppage of debris flows are randomly selected. Model runs are performed using the randomly generated input values. This allows estimating the probability density function of the output variables characterizing the destructive power of debris flow (for instance depth, velocities and impact pressures) at any point along the path. To demonstrate the implementation of this method, a continuum two-dimensional dynamic simulation model that solves the conservation equations of mass and momentum was applied (MassMov2D). This general methodology facilitates the consistent combination of physical models with the available observations. The probabilistic model presented can be considered as a framework to accommodate any existing one or two dimensional dynamic model. The resulting probabilistic spatial model can serve as a basis for hazard mapping and spatial risk assessment. The outlined procedure provides a useful way for experts to produce hazard or risk maps for the typical case where historical records are either poorly documented or even completely lacking, as well as to derive confidence limits on the proposed zoning.