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Debris flow analysis with a one dimensional dynamic run-out model that incorporates entrained material

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Estimating the magnitude and the intensity of rapid landslides like debris flows is fundamental to evaluate quantitatively the hazard in a specific location. Intensity varies through the travelled course of the flow and can be described by physical features such as deposited volume, velocities, height of the flow, impact forces and pressures. Dynamic run-out models are able to characterize the distribution of the material, its intensity and define the zone where the elements will experience an impact. These models can provide valuable inputs for vulnerability and risk calculations. However, most dynamic run-out models assume a constant volume during the motion of the flow, ignoring the important role of material entrained along its path. Consequently, they neglect that the increase of volume enhances the mobility of the flow and can significantly influence the size of the potential impact area. An appropriate erosion mechanism needs to be established in the analyses of debris flows that will improve the results of dynamic modeling and consequently the quantitative evaluation of risk.

The objective is to present and test a simple 1D debris flow model with a material entrainment concept based on limit equilibrium considerations and the generation of excess pore water pressure through undrained loading of the in situ bed material. The debris flow propagation model is based on a one dimensional finite difference solution of a depth–averaged form of the Navier-Stokes equations of fluid motions. The flow is treated as a laminar one phase material, which behavior is controlled by a visco-plastic Coulomb-Bingham rheology. The model parameters are evaluated and the model performance is tested on a debris flow event that occurred in 2003 in the Faucon torrent (Southern French Alps).