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Simulation of debris flow spreading on low-gradient fans: a comparison of two modelling approach.

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Debris-flows are dangerous phenomena which can cause major damages, especially when they spread on alluvial fans. In order to provide scenario for the danger under consideration, and progress to a quantitative hazard assessment, analysing the characteristics of the debris runout must be carried out. The results of such analyses are the maximum extent of the spreading zone, maximum flow heights and velocities of the mixture.

A physically-based model running in a GIS environment has been developed to analyze the dynamics of confined and unconfined debris-flows over complex topography. The debris flow mixture is described as an incompressible fluid-like continuum. Mass and momentum balance laws are used for the computation; the net driving force consists of the tangential component of weight, the pressure term is computed according to the model proposed by Hutter and the flow resistance term depends on the rheology of the material. A Bingham plastic rheology and a Voellmy friction rheology have been implemented. The two-dimensional model distributes a debris-flow hydrograph over a system of square grid cells representing topographic data. To account for lateral and longitudinal complexities in the topography several flow routing schemes (D8, diffuse lower pixels, block routing, X-Y routing) are available. Such algorithms determine the way in which the outflow for a given cell is sequentially distributed to lower cells according to the mathematical equations representing processes. The solution is explicit and occurs in time steps. The model is implemented in the PCRaster scripting language.

Performance of the GIS-based model has been tested against debris-flow characteristics simulated with the two-dimensional finite-difference spreading model of *Cemagref* based on the conservative form of the steep-slope shallow-water equations. In both models, the snout and its influence on the flow are neglected. This assumption seems realistic in conditions of wide spreading as we consider in this study, since in that case, the snout usually splits up or stops early in a confined area of the spreading zone and does not substantially contribute to the formation of levees. Erosive power of the spreading debris-flow is also neglected since erosion is likely to be limited on low-gradient slopes.

Both models have been applied on several theoretical fans characterized by different slope gradient, curvature and aspect, for both a viscoplastic and a frictional rheology. Influence of these parameters are investigated through a sensitivity analysis. Potentials and limits of both modelling approaches for hazard mapping are compared. Representation of the debris-flow characteristics are discussed and possible improvements to the GIS-based model are proposed.