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Effects of the interaction between rock avalanche and substrate material

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The role of substrate material (i.e. material located along the path, below the topographic surface, or temporarily above the topographic surface, e.g. snow or water) in controlling the dynamics of rock- or debris-avalanches has been suggested both on the basis of field and experimental observations (Hungr and Evans, 2004; Crosta et al., 1992, 2006, 2009; Dufresne et al., 2010; Mangeney et al., 2010) and modeling results (Crosta et al., 2006, 2009; Mangeney et al., 2010).

The material (e.g. soil, rock, ice) forming the surface over which the rock/debris avalanche moves can influence the emplacement mechanisms and in some cases also the observed runout distances. The material located along the path can be in dry or wet conditions (partially or fully saturated), with different thickness (up to tens of meters) and physical mechanical properties (frictional, cohesive, with constant or variable strength), and characterized by different mechanical behavior (e.g. collapsible, liquefiable, dilatant). As a function of these controlling parameters the basal material can be entrained, dragged and sheared or almost completely unaffected. Material can be entrained at the front by ploughing or at the base by shearing, or can be bulldozed at the avalanche front, and eventually can be entrained and mixed up with the avalanche material.

We have run a series of 2- and 3-dimensional numerical models to simulate experimental tests of granular column collapse over erodible layers and to back analyze a real case study. Models have been run with a finite element code already tested for this type of phenomena and considering an elasto-plastic material and a Mohr-Coulomb yield rule both for the rock/debris avalanche material and the basal layer. Fully 3D modelling of avalanche and basal layer interaction is completely new with respect to our previous efforts.

The experimental tests that we simulated numerically, consider both an horizontal and an inclined (at constant slope) runout zone with and without a layer of erodible material.

Back analysis of a real case study (Arvel, Switzerland) has been carried out by changing material properties and basal layer thickness. This allowed us to verify also the role played by the materials properties and the basal layer thickness. In fact, the combination of this two set of parameters controls (together with the geometrical constrains of the slope and basal layer) the evolution and the entrainment as well as the mobility.

Models have been run in two and three dimensions allowing a more complete understanding of the processes and the coincidence with field measurement and observations, and showing local effects on material spreading and redistribution.

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