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Formation and influence of granular fronts in debris flows: an experimental approach

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Debris flow surges are characterized by a composition and rheological properties that evolve both in space (longitudinally and transversally) and time. Typically, the surges exhibit steep coarse-grained fronts with granular behavior, followed by relatively fine-grained muddy slurries. This gradation is caused by a process of dynamical grain-size segregation inside the flow, and may also be enhanced by the continuous entrainment of material along the debris flow path. In return, such a sorting phenomenon probably strongly affects the flow dynamics, and may play an important role in the development and persistence of the surges. At present, the complex interplay of mechanisms involved in the front formation remains poorly understood. Existing models for the propagation and deposition of debris flows are basically unable to account for the granular front.

In this study, we present a new experimental setup specifically devoted to addressing the formation and influence of granular fronts in debris flows. It consists of a 3 m-long and 0.6 m-wide inclined channel whose rough bottom is made of an upward-moving conveyor belt with controlled velocity. This setup enables us to create small-scale surges that are immobile in the laboratory frame. Velocity profile in the body of these surges is very close to that of steady uniform rectilinear flows. Both macroscopic (height, discharge) and microscopic (concentration, velocity profile) flow quantities are monitored continuously during the experiments. We present several validation tests in which the setup is used as a large-scale rheometer to retrieve the mechanical properties of newtonian and non-newtonian fluids. Results are compared to independent measurements performed on a standard rotational viscosimeter. The stability of steady uniform flows in the conveyor belt channel for these different types of fluids is also examined. Finally, preliminary results are presented regarding: (1) the feasibility in

the lab of realistic granular fronts (properly down-scaled with respect to their natural counterparts), and (2) the influence of these fronts on average flow properties.