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Experimental modelling of debris flows using a conveyor belt channel

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Debris flows are gravitary surges made of complex mixtures of water and particles of all sizes, from clays to metric boulders. They represent one of the most dangerous natural hazards in mountain areas. Progresses in the modelling of these phenomena would be of paramount importance to improve existing protection measures. In this respect, our study aims to get better insight into the physical and rheological properties of these natural flows using laboratory experiments. An experimental setup has been developed in order to generate gravitary free-surface flows which are stationary in laboratory frame. It is a 3 meter long and 0.4 meter wide inclined channel whose bottom consists of a conveyor belt, moving upstream with a controlled velocity. At channel upper boundary, fluid recirculation is forced by a rigid wall perpendicular to the bottom. Flow characteristics are monitored using ultrasonic height sensors and pattern projection techniques. Unlike classical laboratory rheometers, this setup allows testing complex heterogeneous materials involving centimetric particle sizes.

Debris flow material is simulated using mixtures of grains in a viscoplastic fluid whose rheological properties are representative of muddy debris flow matrix. First experiments were carried out with homogeneous viscoplastic materials, namely a Carbopol gel and a kaolin slurry. For the two materials, we report on the evolution of surge height and front shape as a function of belt velocity and slope. These data are compared with a theoretical model based on rheological properties measured in a laboratory rheometer. We show in particular that the flow obtained in our channel cannot be modelled using steady-state rheological properties of the fluids, and that visco-elastic effects must be accounted for. Then, experiments consisting in adding solid particles to the viscoplastic matrix are presented. We discuss the conditions under which a gran-

ular front forms at the head of the surge, and the influence of this front on the global properties of the flow.