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The formation of granular fronts in debris flow - A combined experimental-numerical study

Alessandro Leonardi (1), Miguel Cabrera (2), Falk K. Wittel (1), Roland Kaitna (3), Miller Mendoza (1), Wei Wu (2), and Hans J. Herrmann (1)

(1) Computational Physics for Engineering Materials, Institute of Building Materials, ETH Zurich, Zurich, Switzerland (aleonardi@ethz.ch), (2) Institute of Geotechnical Engineering, University of Natural Resources and Life Sciences - BOKU, Vienna, Austria (miguel.cabrera@boku.ac.at), (3) Institute of Mountain Risk Engineering, University of Natural Resources and Life Sciences - BOKU, Vienna, Austria

Granular fronts are amongst the most spectacular features of debris flows, and are also one of the reasons why such events are associated with a strong destructive power. They are usually believed to be the result of the convective mechanism of the debris flow, combined with internal size segregation of the grains. However, the knowledge about the conditions leading to the formation of a granular front is not up to date.

We present a combined study with experimental and numerical features that aims at providing insight into the phenomenon. A stationary, long-lived avalanche is created within a rotating drum. In order to mimic the composition of an actual debris flow, the material is composed by a mixture of a plastic fluid, obtained with water and kaolin powder, and a collection of monodisperse spherical particles heavier than the fluid. Tuning the material properties and the drum settings, we are able to reproduce and control the formation of a granular front. To gain insight into the internal mechanism, the same scenario is replicated in a numerical environment, using a coupling technique between a discrete solver for the particles, the Discrete Element Method, and a continuum solver for the plastic fluid, the Lattice-Boltzmann Method. The simulations compare well with the experiments, and show the internal reorganization of the material transport. The formation of a granular front is shown to be favored by a higher drum rotational speed, which in turn forces a higher shear rate on the particles, breaks their internal organization, and contrasts their natural tendency to settle. Starting from dimensional analysis, we generalize the obtained results and are able to draw implications for debris flow research.