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Experimental analysis on coarse-grained debris flows propagation

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The aims of the present research are to investigate experimentally the stress mechanisms governing the propagation phase of coarse-grained debris flows and the analysis of the velocity profiles.
The experiments have been carried out in a 10.0 m long, 0.2 m wide and 0.3 m deep tilting flume. The flume was initially filled with a layer of loose debris; after saturation, a prescribed water discharge was suddenly supplied over the granular bed, and the resulting runoff triggered a debris flow wave that reached nearly steady conditions in the downstream portion of the flume.
Experimental observations show that under mature debris flow condition: i) sediment particles tend to move by layers near the bed, implying the dominance of frictional (quasi-static) stresses that are transmitted through the skeletal structure; ii) at the interface between this layer and the underlying static bed, the velocity tends to zero with a tangent almost normal to the flow direction and the particle concentration tends to equal the maximum packing value; iii) in the upper flow region, where the inter-particle distance increases, particle collisions prevail, leading to a nearly linear velocity profile.
The presence of these stress-generating mechanisms is apparent in the velocity distributions, which exhibit an upper, almost linear increase, a lower concave down profile that tends asymptotically to vanish toward the underlying static sediment bed, and a usually smooth transition in between. Because of the coexistence of different physical processes acting at overlapping scales, the velocity profiles are poorly represented by a fixed non-Newtonian rheology.
Experimental data suggest that the depth-averaged velocity depends on the triggering discharge, while the flow depth and the bulk transport concentration are mainly controlled by the grain size. A remarkable collapse of all the observed velocity prfiles is attained independently of the adopted material and of the amount of water used to trigger the flow if the runoff velocity is chosen as normalization scale. A power law profile, with exponent in the range 1.7–2.2 is found to satisfactorily describe the observed velocity distributions