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The effect of debris-flow composition on runout distance

Tjalling de Haas, Lisanne Braat, Jasper Leuven, Ivar Lokhorst, and Maarten Kleinhans
Faculty of Geosciences, Utrecht University, Utrecht, Netherlands (t.dehaas@uu.nl)

Estimating runout distance is of major importance for the assessment and mitigation of debris-flow hazards. Debris-flow runout distance depends on debris-flow composition and topography, but state-of-the-art runout prediction methods are mainly based on topographical parameters and debris-flow volume, while composition is generally neglected or incorporated in empirical constants. Here we experimentally investigated the effect of debris-flow composition and topography on runout distance. We created the first small-scale experimental debris flows with self-formed levees, distinct lobes and morphology and texture accurately resembling natural debris flows. In general, the effect of debris-flow composition on runout distance was larger than the effect of topography. Enhancing channel slope and width, outflow plain slope, debris-flow size and water fraction leads to an increase in runout distance. However, runout distance shows an optimum relation with coarse-material and clay fraction. An increase in coarse-material fraction leads to larger runout distances by increased grain collisional forces and more effective levee formation, but too much coarse debris causes a large accumulation of coarse debris at the flow front, enhancing friction and decreasing runout. An increase in clay fraction initially enlarges the volume and viscosity of the interstitial fluid, liquefying the flow and enhancing runout, while a further increase leads to very viscous flows with high yield strength, reducing runout. These results highlight the importance and further need of research on the relation between debris-flow composition and runout distance. Our experiments further provide valuable insight on the effects of debris-flow composition on depositional mechanisms and deposit morphology.