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Particle size and concentration effects in laboratory debris flow mixtures

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Large scale chute experiments, as considered here, are essential for the proper understanding of the complex dynamic behavior of debris flow mixtures consisting of solid particles and viscous fluid. Main flow features that are measured on a laboratory scale are the debris flow front velocity, flow depth and mass evolution. We estimate the debris front position by image analysis technique, which in turn allows to evaluate the respective front velocity. Flow depths are determined by ultrasonic pulse reflections, and the masses are estimated with sensors measuring the normal forces. We investigate the influence of the two phase mixture material composition, including different fluid fractions. The laboratory set up consists of a large rectangular channel, 1.3 m wide and 7 m long. These dimensions allow also a lateral expansion of the debris flow when it moves down the inclined channel. Experiments on debris mixtures with different particle sizes and solid concentrations but same total mass are performed to evaluate the difference in spatial evolution of the debris flow dynamics with the same initial potential energy.

The experiments reveal that the debris front with large particle size is faster than with the small ones for all solid volume concentrations. The increase of solid volume fraction shows a decrease of flow velocity, which was observed only in the experiments with the small particle. The flow depth and mass measurements at multiple locations along the downslope direction of the chute indicate different dynamical behavior for different particles sizes. The debris flow depth and mass showed no significant differences for large particles with varying initial solid volume concentrations. In contrast, low solid volume concentration resulted in low debris flow depth and mass in the experiments with small particles. This indicates that the particle size plays an important role in the debris flow transport in different solid volume concentration. So, the initial material composition is of key importance in debris flow dynamics.

These experiments are parts of the project avaflow.org: Developing a GIS-based open source computational tool to describe wide spectrum of rapid geophysical mass flows, including avalanches and real two-phase debris flows down complex natural slopes.