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Experimental Modelling of Debris Flows

P. Paleo Cageao (1,2), B. Turnbull (1), and P. Bartelt (2)

(1) Faculty of Engineering, University of Nottingham, University Park, Nottingham NG7 2RD. UK, (2) WSL, Swiss Federal Institute for Snow and Avalanche Research SLF, Flüelastr. 11, CH-7260 Davos Dorf, Switzerland

Debris flows are gravity-driven mass movements typically containing water, sediments, soil and rocks. These elements combine to give a flow complex phenomenology that exhibits characteristics common to diverse geophysical flows from dry granular media (e.g. levee formation) to viscous gravity currents (viscous fingering and surge instabilities). The exceptional speeds and range debris flows can achieve motivate the need for a co-ordinated modelling approach that can provide insight into the key physical processes that dictate the hazard associated with the flows. There has been recent progress in theoretical modelling approaches that capture the details of the multi-component nature of debris flows. The promise of such models is underlined by their qualitatively successful comparison with field-scale experimental data. The aim of the present work is to address the technical difficulties in achieving a controlled and repeatable laboratory-scale experiment for robust testing of these multi-component models.

A laboratory experiment has been designed and tested that can provide detailed information of the internal structure of debris flows. This constitutes a narrow Perspex chute that can be tilted to any angle between 0° and $\approx 60^\circ$. A mixture of glycerine and glass balls was initially held behind a lock-gate, before being released down the chute. The evolving flow was captured through high speed video, analysed with a Particle Image Velocimetry algorithm to provide the changing velocity field. A wide parameter space has been tested, allowing variations in particle size, dispersity, surface roughness, fluid viscosity, slope angle and solid volume fraction. While matching key similarity criteria, such as Froude number, with a typical field event, these experiments allow close examination of a wide range of physical scenarios for the robust testing of new multi-component flow models. Further diagnostics include force plate and pore pressure measurements, with a view to gaining insight into the interaction between fluid and particles, and for direct comparison with similar field-scale measurements. Here, details of the experimental design, initial results and their analysis will be discussed and contrasted with predictions of new multi-component theoretical models.