11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

Multi-scale modelling of segregation induced fingering instabilities in granular avalanches

Anthony R. Thornton[1]

[1] Department of Applied Mathematics and Department of Mechanical Engineering, University of Twente, NL e-mail : .a.r.thornton@utwente.nl

Key Words: DEM (DPM), multi-scale, granular, fingering.

It is important to be able to predict the distance to which hazardous natural granular flows (e.g. snow slab avalanches, debris-flows and pyroclastic flows) might travel, as this information is vital for accurate assessment of the risks posed by such events. In natural flows the granular assemblage is typically composed of a large range of grain sizes and shapes. The polydisperse character of the flows can play a crucial role in the dynamics of the flow. In the high solids fraction regions of these flows the large particles commonly segregate to the surface, from where they are transported forward to the margins to form bouldery flow fronts. In many natural flows these bouldery margins experience a much greater frictional force, leading to frontal instabilities. These instabilities create levees that channelise the flow and vastly increase the run-out distance (Figure 1, right).

A similar effect can be observed in dry granular experiments that contain a combination of small round and large rough particles. When this mixture is poured down an inclined plane, size-segregation causes the uniform flow front to break up into a series of fingers (Figure 1, middle).

Here we investigate segregation induced fingering using both discrete particle simulations and continuum models. The continuum model is formulated by coupling a model for particle size-segregation to existing depth-averaged avalanche models through a particle-concentration-dependent friction law. Discrete particle simulations are used to determine the friction law for bidispersed flows and close the continuum model for a given set of particle parameters.
In this talk numerical solutions of this coupled system are presented and compared to both full-scale computationally expensive discrete particle simulations and experiments (Figure 1, left and middle). The limitations of both the continuum model and discrete particle simulations are then discussed. We conclude with a discussion of possible solutions to these limitations and future research directions.

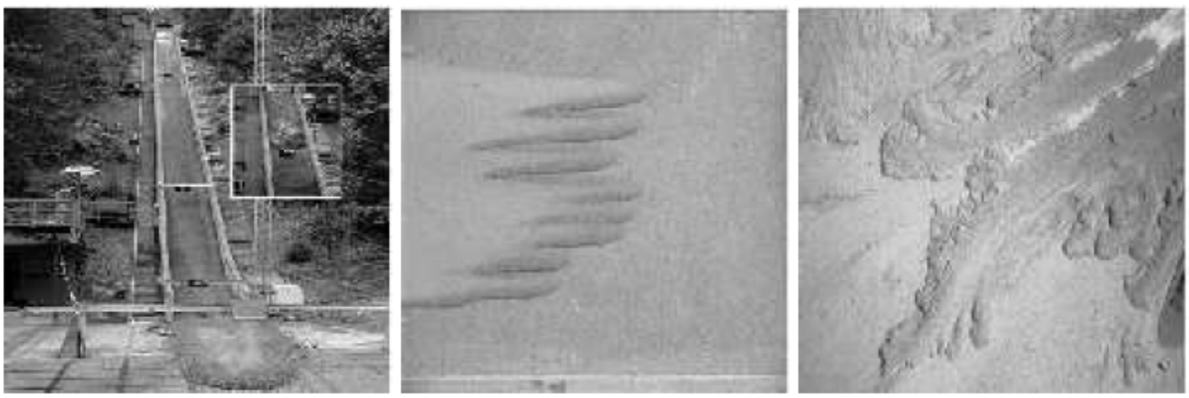

Figure 1: Left: USGS debris-flow flume. Middle : Small scale laboratory experiment showing the formation of fingers. Right : Small volume pyroclastic density current with lobate terminals

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