Particle size segregation and spontaneous levee formation in geophysical mass flows

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Hazardous geophysical mass flows, such as snow avalanches, debris-flows and pyroclastic flows, often spontaneously develop large particle rich levees that channelize the flow and enhance their run-out. Measurements of the surface velocity near an advancing flow front have been made at the United States Geological Survey (USGS) debris-flow flume, where $10m^3$ of water saturated sand and gravel are allowed to flow down an $80m$ chute onto a run-out pad. In the run-out phase the flow front is approximately invariant in shape and advances at almost constant speed. By tracking the motion of surface tracers and using a simple kinematic model, it was possible to infer bulk motion as incoming material is sheared towards the front, over-run and shouldered to the side. At the heart of the levee formation process is a subtle segregation-mobility feedback effect. Simple models for particle segregation and the depth- averaged motion of granular avalanches are described and one of the first attempts is made to couple these two types of models together. This process proves to be non-trivial, yielding considerable complexity as well as pathologies that require additional physics to be included.

References

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