Size-segregation, self-channelization and enhanced runout of bidisperse granular avalanches

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In geophysical mass flows, such as pyroclastic currents and debris flows, the runout distance is of crucial importance in hazards assessment. The polydisperse character of these natural flows can have a strong influence on the flow dynamics. In particular, particle size-segregation can have a significant feedback on the bulk motion of granular avalanches when the larger grains experience greater resistance to motion than the fine grains. When such segregation-mobility feedback effects occur the flow may form digitate lobate fingers or spontaneously self-channelize to form lateral levees that enhance run-out distance. Such leveed flows have been observed in deposits from small volume pyroclastic flows.

Through small-scale laboratory experiments using bidisperse mixtures of dry grains released onto an inclined chute, we investigate the formation of elongated fingers bounded by lateral confining levees. The formation of fingers is due to particle size-segregation which leads to the transport of large material to the flow front. If the large material experiences greater frictional resistance than the fine grains, the front in unstable (Pouliquen et al. 1997; Pouliquen & Vallance 1999; Woodhouse et al. 2012) and degenerates into a series of elongated fingers bounded by large-rich static lateral levees.

By varying the composition of the mixture we assess the influence of the grain assemblage on the flow dynamics. We show that the number of fingers and the distance to which material is carried are strongly dependent on the proportion of large grains in the mixture. By utilizing a front tracking algorithm, we determine the velocity of the propagating granular avalanche and show that enhanced runout occurs due to reduced frictional resistance experienced by material flowing in leveed channels.