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Experimental Investigations of Debris Flow Entrainment

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Debris flows – flows of boulders, gravel, sand, fine particles, and fluids – erode sediment from steep hillsides and deposit them at lower slopes. Debris flows can grow tremendously over the course of a single event by entraining bed materials. Both instantaneous entrainment rates and average bed erosion influence debris flow hazards, both directly, via the absolute size of the debris flow and indirectly via instantaneous changes in mobility and avulsion likelihood. Previous field and experimental results indicate that particle size, interstitial fluid, matrix properties, and bed fabric may all significantly influence entrainment rates and net erosion. In this presentation, we discuss experimental and computational efforts to understand better the dynamics through which these properties influence instantaneous entrainment rates and average bed erosion toward better model representation of these dynamics. We focus on new results obtained instrumented laboratory flume using different interstitial fluids and particle sizes. During each experiment, we measure instantaneous bed dynamics including entrainment rates, temperature and bed fabric as well as evolving pore pressures and measured bed stresses. We discuss these results in the context of model frameworks for erosion which vary significantly from those that consider macroscopic fields such as excess shear stresses, to those that consider the "granular" physics such as granular temperatures (related to random kinetic energy of the flow). We show that the erosion dynamics can transition from stress dominated to granular temperature-dominated and we discuss how the bed fabric influences these controls. We present these results and discuss initial efforts to understanding issues of scaling up these results to field-scale dynamics.