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Basal Shear Relationships for Debris Flows and Snow Avalanches: When can Pouliquen's Granular Model be Applied?

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The purpose of this presentation is to resolve the question of when can a constitutive relation describing friction in granular systems be used to model natural geophysical movements, particularly debris flows and snow avalanches. Granular mechanics based constitutive relations, most notably the non-linear relations proposed by Pouliquen (Pouliquen et al. 1999; Job et al., 2006), have been derived from small scale chute experiments using ideal granular materials on well-defined, frictional flow surfaces. Such experiments differ strongly from natural geophysical movements of mud, rock or snow in complex terrain. It would appear that Pouliquen's relations are not directly applicable, although one of the primary fields of application is "to predict runout distances of natural hazards" (Job et al., 2006). In this communication we show that Pouliquen's model can in fact be applied to model geophysical flows, but not in the way intended. We compare measured basal shear and normal stresses of both debris flows, snow avalanches and granular material with Pouliquen's model. We find that Pouliquen's model – which is derived from simple kinematic measurements (velocities, flow heights and inclination angles) – can represent the measured basal shear stresses, but only at the tail of the movement when the flow heights decrease to zero and there exists some nonlinearity in shear versus normal stress relationship. Thus, without significant modification, the model cannot be used to compute the exceptional mobility of natural geophysical movements, in which the friction angle decreases as some function of the size, velocity and running surface. This is an important conclusion since it links, and therefore clarifies, experimental results arising from both the granular mechanics and geophysical communities.