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A comparison of two approaches to modeling multiphase gravity currents

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Debris flows constitute a major hazard in mountainous areas. They consist of mobilized sediments spanning a wide range of grain sizes, and the flows are typically fully or partly saturated with water. Depending on the amount of water in the debris flow and the slope of the channel, among other factors, they have velocities in some cases exceeding 10 m/s. In fluid dynamical terms, debris flows are polydisperse gravity currents with an interstitial fluid that is less dense than the particulate matter, but more dense than the ambient fluid. Attempts to physically model the dynamics of such flows tend to follow two different approaches. The first approach is to treat the entire debris flow as one bulk material with non-Newtonian flow behaviour; the challenge is to find the suitable rheology. Such models work well in describing certain aspects of the flow, but often fail when applied to different flow regimes. The second approach is to explore the internal dynamics by describing the debris flow as a multiphase gravity current where each phase is considered separately. This approach is complicated by the difficulty in formulating the suitable coupling forces. This paper compares two depth-averaged multiphase approaches to describing debris flows. The first is derived by integrating the two-phase mass and momentum conservation equations over height resulting in a set of two shallow water equations, one for the solid and one for the fluid phase. Both are coupled via a viscous drag term on the right hand side of the momentum equation. A second model explicitly incorporates transport equations for solid components of different sizes. The models are implemented in a comparable framework. In a reduced-dimension inclined plane case, velocity, height and runout distances as well as impact forces are compared.