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A critical review of the existing models in granular flows driven by gravity

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Models of granular flows generally assume a uniform distribution of the particle diameter. However, this is a gross simplification that is acceptable only in idealised conditions. Thus, a compelling, presently still open issue is to develop reliable models capable of representing two-size mixtures, that would be suitable for real-world cases.

In granular flows involving material different in size, density and geometry, the bulk solid evolves spatially in a non-uniform state, which is called segregation. The largest particles are found at the surface and the smallest at the bottom, as they percolate due to gravity. Segregation causes a different spatial distribution of particles and the recirculation of grains in the avalanche front, and the formation of lateral levees.

Our starting point is an accurate literature review of the state of art. Most existing non-dimensional, continuous models for segregation in bidisperse mixtures (see, e.g., Bridgwater, 1994; Savage and Lun, 1988; Gray et al., 2018, and references therein) show a similar structure for the mass-balance equation, that results in an advection-diffusion equation. The two processes that define segregation (kinetic sieving and percolation) are represented in these models by the diffusion and the infiltration coefficient. However, the adopted values for these coefficients vary quite significantly across models, which may indicate that the underlying physics is not entirely understood. With the aim of improving the physical basis of these coefficients, (i) we identify the infiltration coefficient as depending on percolation velocity and particle concentration, and (ii) the diffusion coefficient as a function of the particle diameter and the granular temperature. Unlike in the reviewed models, along with the advection-diffusion equation for mass balance, we introduce the momentum and the kinetic balance equation, depending on the granular temperature.

We want to propose a comparative critical analysis of the models present in the literature to define the infiltration and diffusion processes, the underlying hypotheses and their consequences.