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A novel mechanical model for phase-separation in debris flows

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Understanding the physics of phase-separation between solid and fluid phases as a two-phase mass moves down slope is a long-standing challenge. Here, I propose a fundamentally new mechanism, called "separation-flux", that leads to strong phase-separation in avalanche and debris flows. This new model extends the general two-phase debris flow model (Pudasaini, 2012) to include a separation-flux mechanism. The new flux separation mechanism is capable of describing and controlling the dynamically evolving phase-separation, segregation, and/or levee formation in a real two-phase, geometrically three-dimensional debris flow motion and deposition. These are often observed phenomena in natural debris flows and industrial processes that involve the transportation of particulate solid-fluid mixture material. The novel separation-flux model includes several dominant physical and mechanical aspects that result in strong phase-separation (segregation). These include pressure gradients, volume fractions of solid and fluid phases and their gradients, shear-rates, flow depth, material friction, viscosity, material densities, boundary structures, gravity and topographic constraints, grain shape, size, etc. Due to the inherent separation mechanism, as the mass moves down slope, more and more solid particles are brought to the front, resulting in a solid-rich and mechanically strong frontal surge head followed by a weak tail largely consisting of the viscous fluid. The primary frontal surge head followed by secondary surge is the consequence of the phase-separation. Such typical and dominant phase-separation phenomena are revealed here for the first time in real two-phase debris flow modeling and simulations. However, these phenomena may depend on the bulk material composition and the applied forces.

Reference:

Pudasaini, Shiva P. (2012): A general two-phase debris flow model. J. Geophys. Res., 117, F03010, doi: 10.1029/2011JF002186.