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Full two-dimensional and two-phase mass flows down a channel: Mathematical modeling and simulation

by
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Following Pudasaini (2012) and Domnik and Pudasaini (2012) we present a new, full-dimensional, physical-mathematical model for two-phase mass flows down channels. The fully coupled model consists of a set of highly non-linear partial differential equations describing the dynamics of rapid flows of two-phase mixtures consisting of solid particles and viscous fluid. The new model includes mass and momentum balances, and pressure-Poisson equations both for solid and fluid phases and describes the flow dynamical quantities and internal dynamical pressures. So, the model can be applied in complex situations when topography changes are large, in the vicinity of the flow obstacle interactions, for strongly converging and diverging flows, and in deposition processes. To solve the model numerically, appropriate boundary conditions are applied, including Coulomb sliding for solid, basal no-slip for fluid, tractionless free surface for both solid and fluid, and Neumann boundary conditions for pressures. We adequately design the dynamical variables, and develop a suitable novel simulation strategy. The new full-dimensional model is discretised by using staggered grid. We use Euler's method for time discretization, central difference for diffusion, and the combination of donor-cell and central difference for convection. This prevents possible pressure oscillations. The model is simulated and visualized by applying suitable high resolution shock capturing schemes, including the marker-and-cell methods. The simulation results describe the evolution of full-dimensional velocities and pressures for both the solid and fluid phases. This substantially contributes to more accurately understanding the very complex dynamics of mixture flows in natural slopes, in the form of landslides and debris flows, and particle-fluid transport in industries.

Keywords: Two-phase mass flow, Pressure-Poisson equations, Donor-cell discritization, Staggered grid, Marker and cell method

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