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## A Coupled and Efficient Multiscale Modelling of Two-phase Mass Flows

by
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Landslides, debris flows and flash floods are some widely observed geophysical mass transports which are extremely destructive natural hazards. There is a need for an appropriate description and efficient simulation of these types of flows. To do so, here, by unifying the existing methods (Domnik and Pudasaini, 2012; Pudasaini, 2012; Domnik et al., 2013), we present a new multiscale modeling and simulation of two-phase debris, and mixture mass flows consisting of solid particles and the interstitial viscous fluids down inclined channels. A set of highly non-linear and coupled partial differential equations constitutes the advanced physical-mathematical model. Our innovative technique combines the full-dimensional simulation in the regions where there are large gradients of the field variables, depth-averaged reduced-dimensional models for relatively smooth flows, and the coupling of these models and their simulations. This special strategy retains most of the basic physics of the flow along with very fast and economic numerical computation. To advance in this direction, here we present some basic and newly constructed model structures for full dimensional two-phase debris flow model, and depth-averaged model for channel flows, their domain-decompositions, appropriate coupling across the interfaces, respective boundary conditions at the interfaces, and boundary conditions for the velocities and pressure at the free and the basal surfaces. The physical, mathematical, numerical, and computational significance of the new strategy and their applications for geophysical and industrial flows are discussed in detail.

Keywords: Two-phase mass flows; Physical-mathematical model; Partial differential equations; Depth-averaged model; Non depth-averaged model; Domain decomposition; Multiscale modeling

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