Enhanced Simulation of Two-Phase Mass Flows with General Phase-Eigenvalues and Phase-Wave-Speeds

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Abstract: Landslides, debris flows and tsunamis are some widely observed geophysical mass transports which are extremely destructive natural hazards. The exact description of eigenvalues of the system is needed for the correct and reliable descriptions of flow behavior and the stability in the numerical computation. As the physical-mathematical model, the general two-phase debris flow equations developed by Pudasaini (2012) are considered. The model is written as a set of well-structured hyperbolic-parabolic PDEs. Based on this model, we analytically construct exact eigenvalues for both the solid- and fluid-phases (Pokhrel, 2014). We call these phase-eigenvalues the solid- and fluid-phase-eigenvalues. Associated phase-Froude-numbers and phase-wave-speeds are also determined. Enhanced simulation results for two-phase mass flows down an inclined channel have been carried out by applying the exact eigenvalues together with the high-resolution simulation scheme and computational codes. This resulted in an appropriate determination of the enhanced flow dynamical quantities, including the evolution of the solid- and fluid-phase, fluid volume fraction, and total debris height. Results are also compared by applying the derived phase-eigenvalues that incorporate the phase-interactions in the two-phase debris movements against the simple and classical solid-only and fluid-only eigenvalues. Simulation results clearly indicate the importance of the phase-eigenvalues and support for the implementation of the complete phase-eigenvalues for the enhanced and appropriate descriptions of real two-phase debris flows.

Keywords: Two-phase debris flows; Physical-mathematical model; Partial differential equations; Phase-eigenvalues, wave speeds and Froude numbers; High-resolution numerical simulations.

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