Enhanced Descriptions of Real Two-phase Landslides and Debris Flows

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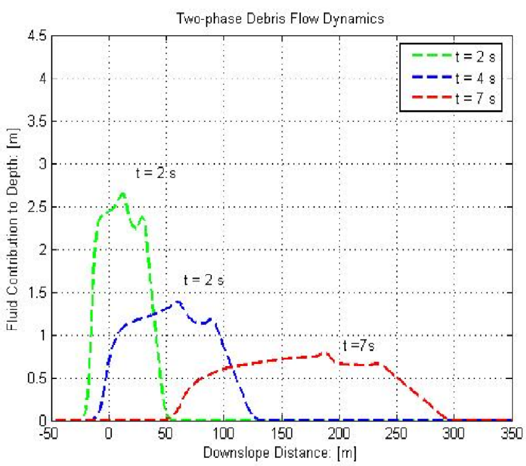
1 Introduction

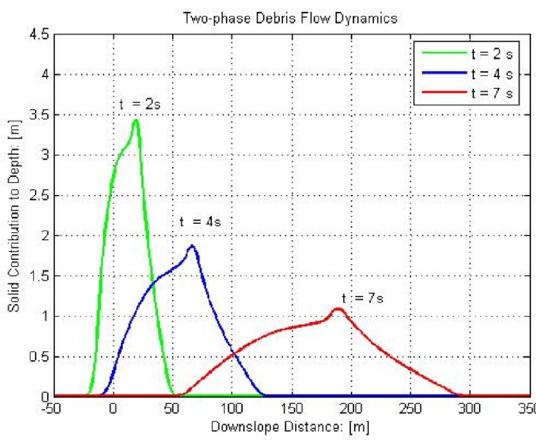
Landslides and debris flows are some examples of mass transports that are widely found in nature. These are large mass movements and extremely destructive natural hazards that often occur as the motion of the mixture of soil, rock and fluid down mountain slopes. So, reliable methods are needed to accurately predict the flow evolution, run-out distances, inundation areas, deposition behavior, impact forces, and the overall flow dynamics from inception to standstill.

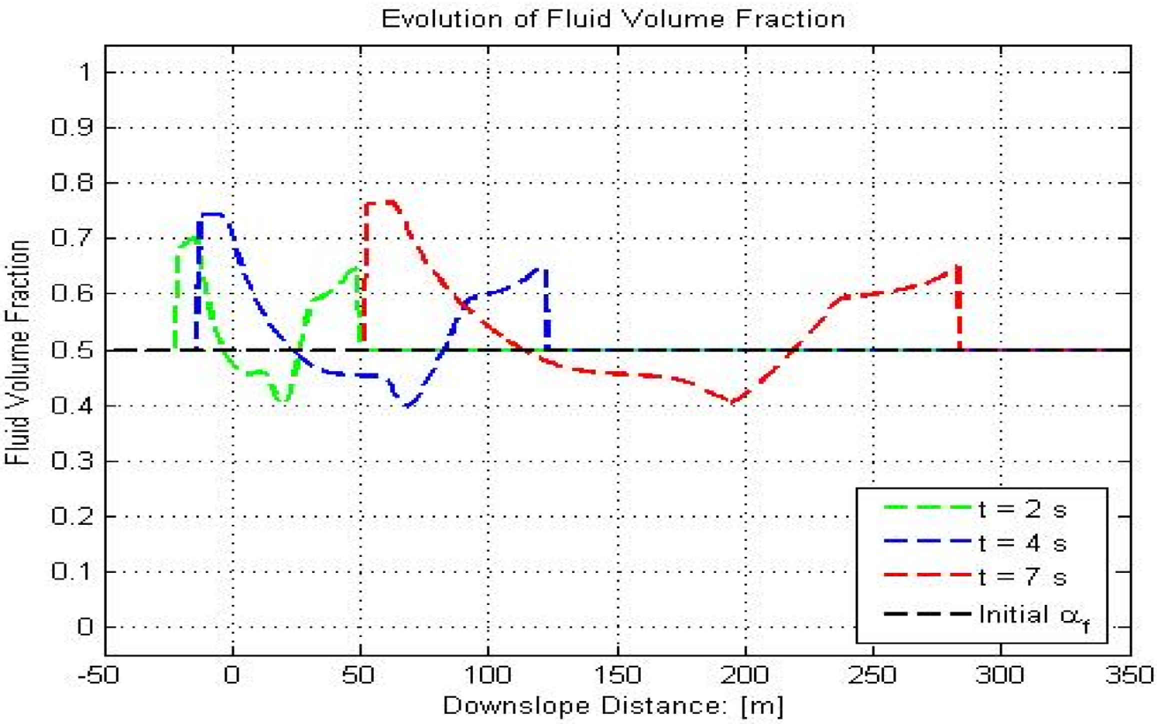
This is required for the prevention measures and enhanced mitigation strategies in geo-hazard-prone areas. Depending on the material involved and the flow dynamics and the momentum transfer between the constituents, these flows can be effectively single phase, or must be described by applying the real two-phase mass flow models. As these flows are advective-diffusive processes, these events are modeled by some complex hyperbolic-parabolic partial differential equations.

For the correct and reliable description of flow behavior, we need the exact description of eigenvalues of the system. From eigenvalues, we extract wave speeds and determine the Froude number (Fr). As the wave speeds for both the solid and fluid are very important information in the simulation, their accurate knowledge plays vital role in correctly describing real two-phase flows. Fr determines the nature of mass flows by distinguishing subcritical (slow), critical (moderate) and supercritical (rapid) regimes. Accurate knowledge of Fr is very desirable in the design of the defense structures that may be hit by the flow. So, for two-phase mass flows, the determination of the general and complete eigenvalues, wave-speeds, and Fr are of special interest in landslide and debris flow community.

Figure: The upper and lower triangles are initially filled with uniform mixtures with 48% solid (UT) and 75% solid (LT), respectively, as shown in the inset (for t = 0) and also indicated by the step function. (top) The spatial and temporal evolution of the solid and fluid phases, represented by the solid and dashed lines, respectively. It is observed that both the front and central body of the flow are dominated by solids. Both the solid and fluid phases are continuously elongated in time by changing their shapes. The relative







difference between the solid and fluid fractions that contribute to flow depth decreases in time, indicating more and more mixing as debris moves down slope. (bottom) The evolution of the fluid volume fraction, a_f, during the debris flow. Right after the mass collapse, the jump in the initial profile of a_f is immediately transformed into a strong non-linearity.

2 Concluding remarks

For the first time, we present the exact and complete eigenvalues for both the solid- and fluid-phase for the real two-phase, general mass flow model presented by Pudasaini (2012). We call them: solid-phase-eigenvalues and fluid-phase-eigenvalues (phase-eigenvalues).

The associated Froude numbers are called the solid-phase Froude numbers and fluid-phase Froude numbers (phase-Froude-numbers). Similarly, phase wave speeds are defined and determined. Simple eigenvalues, wave speeds and Fr are deduced from the general ones. The derived eigenvalues, wave speeds and Fr are applied in the unified and high resolution simulation codes to appropriately determine the enhanced flow dynamical quantities, including the evolution of the solid- and fluid-phase, fluid volume fraction, total debris and landslide height, inundation area, phase velocities, and the impact forces.

References

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