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Dynamic interaction of two-phase debris flow with pyramidal defense structures: An optimal strategy to efficiently protecting the desired area

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In this work we analyze the dynamic interaction of two phase debris flows with pyramidal obstacles. To simulate the dynamic interaction of two-phase debris flow (a mixture of solid particles and viscous fluid) with obstacles of different dimensions and orientations, we employ the general two-phase mass flow model (Pudasaini, 2012). The model consists of highly non-linear partial differential equations representing the mass and momentum conservations for both solid and fluid. Besides buoyancy, the model includes some dominant physical aspects of the debris flows such as generalized drag, virtual mass and non-Newtonian viscous stress as induced by the gradient of solid-volume-fraction. Simulations are performed with high-resolution numerical schemes to capture essential dynamics, including the strongly re-directed flow with multiple stream lines, mass arrest and debris-vacuum generation when the rapidly cascading debris mass suddenly encounters the obstacle. The solid and fluid phases show fundamentally different interactions with obstacles, flow spreading and dispersions, run-out dynamics, and deposition morphology. A forward-facing pyramid deflects the mass wider, and a rearward-facing pyramid arrests a portion of solid-mass at its front. Our basic study reveals that appropriately installed obstacles, their dimensions and orientations have a significant influence on the flow dynamics, material redistribution and redirection. The precise knowledge of the change in dynamics is of great importance for the optimal and effective protection of designated areas along the mountain slopes and the runout zones. Further important results are, that specific installations lead to redirect either solid, or fluid, or both, in the desired amounts and directions. The present method of the complex interactions of real two-phase mass flows with the obstacles may help us to construct defense structures and to design advanced and physics-based engineering solutions for the prevention and mitigation of natural hazards caused by geophysical mass flows.

References:

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