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Modelling debris flows down general channels: Theory, simulation and experiments

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We present an extension of the single-phase dry granular avalanche model over general channels proposed by Pudasaini and Hutter (2003). It is a generalisation of the Savage-Hutter equations to a two-phase fluid-solid mixture of debris material. Important terms emerging from the correct treatment of the kinematic and dynamic boundary condition, and the variable basal topography are systematically taken into account. For vanishing fluid contribution and torsion-free channel topography our new model exactly degenerates to the previous model equations. The model equations have been rigorously derived; they include the effects of the curvature and torsion of general topography. The equations are put into a standard conservative form of PDEs. Simulation results reveal new physical insight of debris flows over such non-trivial topography. Model equations are applied to laboratory avalanche and debris-flow-flume tests. The Particle Tracking Velocimetry (PTV)-technique is applied to measure the dynamics of the velocity field of debris avalanches down curved and twisted channels merging into a horizontal plane. Also the geometries of the deposited masses in the fan-like open transition and run-out zones are measured. We show that geometric parameters like curvature and twist of the channel, and the pore pressure play a vital role in the description of the avalanching debris. It is demonstrated that the theory and experimental observations are in very good agreement.

References:

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