Geophysical Research Abstracts
Vol. 15, EGU2013-5154, 2013
EGU General Assembly 2013

Historical Account to the State of the Art in Debris Flow Modeling

Shiva P. Pudasaini
University of Bonn, Department of Geodynamics and Geophysics, Bonn, Germany (pudasaini@geo.uni-bonn.de)

In this contribution, I present a historical account of debris flow modelling leading to the state of the art in simulations and applications. A generalized two-phase model is presented that unifies existing avalanche and debris flow theories. The new model (Pudasaini, 2012) covers both the single-phase and two-phase scenarios and includes many essential and observable physical phenomena. In this model, the solid-phase stress is closed by Mohr-Coulomb plasticity, while the fluid stress is modeled as a non-Newtonian viscous stress that is enhanced by the solid-volume-fraction gradient. A generalized interfacial momentum transfer includes viscous drag, buoyancy and virtual mass forces, and a new generalized drag force is introduced to cover both solid-like and fluid-like drags. Strong couplings between solid and fluid momentum transfer are observed. The two-phase model is further extended to describe the dynamics of rock-ice avalanches with new mechanical models. This model explains dynamic strength weakening and includes internal fluidization, basal lubrication, and exchanges of mass and momentum. The advantages of the two-phase model over classical (effectively single-phase) models are discussed. Advection and diffusion of the fluid through the solid are associated with non-linear fluxes. Several exact solutions are constructed, including the non-linear advection-diffusion of fluid, kinematic waves of debris flow front and deposition, phase-wave speeds, and velocity distribution through the flow depth and through the channel length.

The new model is employed to study two-phase subaerial and submarine debris flows, the tsunami generated by the debris impact at lakes/oceans, and rock-ice avalanches. Simulation results show that buoyancy enhances flow mobility. The virtual mass force alters flow dynamics by increasing the kinetic energy of the fluid. Newtonian viscous stress substantially reduces flow deformation, whereas non-Newtonian viscous stress may change the overall flow dynamics. Strong non-linear dynamics of the fluid fraction demonstrates the typical state of the two-phase debris flow. An innovative formulation provides a unique opportunity, within a single framework, to simultaneously simulate the sliding debris, the water lake or ocean, the debris impact, the tsunami generation and propagation, and the sediment transport and deposition process in the bathymetric surface. The simulation results demonstrate the applicability of the model equations to adequately describe the complex dynamics of two-phase debris flows, avalanches, particle-laden, dispersive flows, turbidity currents, landslide and debris-induced tsunami and the associated applications to hazard mitigation, geomorphology and sedimentology.

Reference:

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