2017-03-02 11:02:08

77. Jahrestagung der Deutschen Geophysikalischen Gesellschaft e.V., Potsdam

Topic: Schwerpunktthemen: S2 Naturgefahren durch Erdbeben (Natural hazard for eathquakes, volcanoes and landslides)
Additional topic(s): Umwelt- und Ingenieurgeophysik
Type: Oral presentation
Abstract no.: A-434
Status: submitted
Young authors No

Erosion and phase-separation - coupled and dominant processes in geophysical mass flows

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Content
Landslides and debris flows are gravity driven mixture flows of soil, sand, rock and water. Solid particles and viscous fluid governs the rheological properties, and their coupling significantly influences the dynamics. Landslides can dramatically increase their volume, become exceptionally mobile and highly destructive by entraining bed sediment and fluid. The mixture composition can evolve and strikingly change the spatial distribution of particles and fluid. This results in local changes of frictional and viscous resistance. As erosion-deposition and phase-separation between solid and fluid strongly depend on material composition these natural phenomena play critical role in flow and deposition dynamics. Proper understanding of these complex physical processes is very important for an accurate description of impact forces, inundation areas, landscape evolution and reliable mitigation plans. Quantifying the underlying processes of erosion, phase-separation and deposition are among the long-standing challenges in mass flow simulation.

No reliable runout prediction method including bed erosion, entrainment, transportation and mixing exists. The same knowledge gap applies for particle sorting, separation between solid and fluid phases, levee formation and evolution of deposition patterns. Here, based on two innovative mechanical models for erosion-deposition and phase-separation, we present a novel, unified, efficient and fully coupled solution approach for these multi-phase, three-dimensional mass flow problems. As debris flows are better described by a three-phase mixture that include viscous fluid, and fine/coarse grains as compared to often used single-phase models, we propose model extensions that consists of multi-phases including yield strength. Thus, we present an advanced mass flow simulation model aiming to accurately predict debris flow dynamics, phase-separation, erosion, and runout. The new model has been implemented with the advanced open-source GIS simulation tool r.avaflow. We demonstrate this implementation for selected generic case studies. As such, the modeling technique will substantially help landslide and debris-flow hazard mitigation.

References:

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