Geophysical Research Abstracts
Vol. 20, EGU2018-1104-2, 2018
EGU General Assembly 2018

Full dimensional simulations of flow-obstacle-interactions in a channel with a novel generalized quasi two-phase mixture model

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We apply a newly constructed full-dimensional generalized quasi-two phase debris mixture model to simulate flow obstacle interactions as mixtures of viscous fluid and grains impact obstacles. The model can be applied to the whole spectrum of the mixture, from dense to dilute flows. The model is characterized by some fundamentally new rheological, mechanical and dynamical concepts of generalized bulk and shear viscosities, pressure and velocities of the mixture. The rheology extends the pressure-and rate-dependent Coulomb-viscoplastic law (Domnik et al., 2013) and the properties of the mixture (Pudasaini, 2012). We present high resolution and full-dimensional simulations for the flow geometry, mixture velocities, impact pressures and shear-rates through the flow depth when debris masses of different compositions flow down a channel and encounter obstacles of different inclinations, heights, positions and numbers. Our model is capable of acquiring the detailed interacting mixture velocities with obstacles, the flow overtopping, detachments off the bed, formation of debris jets and ballistic projection, and landing on the bed again. The dynamics of the debris jets, trajectories, impact at landing and the subsequent flow spreading are found to be strongly dependent on the geometrical settings of the obstacles, the mixture composition - as characterized by the solid volume fraction, the granular friction and yield strength, and the viscosity of the fluid in the mixture. However, the solid fraction plays the dominant role in controlling the jets, trajectories and the flow dynamics over the other parameters. These novel findings can be applied in advanced design of the defence structures in debris-prone regions, and thus, can help in hazard mitigation.

References:

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