Geophysical Research Abstracts
Vol. 15, EGU2013-7283, 2013
EGU General Assembly 2013

Multi-scale coupling strategy for fully two-dimensional and depth-averaged models for granular flows

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

We developed a full two-dimensional Coulomb-viscoplastic model and applied it for inclined channel flows of granular materials from initiation to their deposition. The model includes the basic features and observed phenomena in dense granular flows like the exhibition of a yield strength and a non-zero slip velocity. A pressure-dependent yield strength is proposed to account for the frictional nature of granular materials. The yield strength can be related to the internal friction angle of the material and plays an important role, for example, in deposition processes. The interaction of the flow with the solid boundary is modelled by a pressure and rate-dependent Coulomb-viscoplastic sliding law. We developed an innovative multi-scale strategy to couple the full two-dimensional, non depth-averaged model (N-DAM) with a one-dimensional, depth-averaged model (DAM). The coupled model reduces computational complexity dramatically by using DAM only in regions with smooth changes of flow variables. The numerics uses N-DAM in regions where depth-averaging becomes inaccurate, for instance, in the initiation and deposition regions, and (particularly) when the flow hits an obstacle or a defense structure. In these regions, momentum transfer must be, and is, considered in all directions. We observe very high coupling performance, and show that the numerical results deviate only slightly from results of the much more cumbersome full two-dimensional model. This shows that the coupled model, which retains all the basic physics of the flow, is an attractive alternative to an expensive, full two-dimensional simulations.

We compare simulation results with different experimental data for shock waves appearing in rapid granular flows down inclined channels and impacting a wall. The model predicts the evolution of the strong shock wave and the impact force on a rigid wall for different inclination angles and sliding surfaces. It is demonstrated that the internal friction angle plays an important role in the deposition process, and show that classical depth-averaged models cannot accurately describe the flow dynamics of material impinging on a rigid wall. Therefore, depth-averaged models should not be used as stand-alone models, but can be used successfully as part of a multi-scale coupling strategy. This novel and computationally economic strategy has great potentiality to be used in the large scale natural snow avalanches and debris flows.

References:

Domnik, B., and S. P. Pudasaini (2012): Full two-dimensional rapid chute flows of simple viscoplastic granular materials with a pressure-dependent dynamic slip-velocity and their numerical simulations. *J. Non-Newtonian Fluid Mech.*, 173-174, 72-86.

Pudasaini, S. P., K. Hutter, S.-S. Hsiau, S.-C. Tai, Y. Wang, and R. Katzenbach (2007): Rapid flow of dry granular materials down inclined chutes impinging on rigid walls. *Phys. Fluids*, 19(5), 053302, doi:10.1063/1.2726885.