Geophysical Research Abstracts
Vol. 18, EGU2016-15140, 2016
EGU General Assembly 2016

Resolved granular debris-flow simulations with a coupled SPH-DCDEM model

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Debris flows represent some of the most relevant phenomena in geomorphological events. Due to the potential destructiveness of such flows, they are the target of a vast amount of research (Takahashi, 2007 and references therein). A complete description of the internal processes of a debris-flow is however still an elusive achievement, explained by the difficulty of accurately measuring important quantities in these flows and developing a comprehensive, generalized theoretical framework capable of describing them. This work addresses the need for a numerical model applicable to granular-fluid mixtures featuring high spatial and temporal resolution, thus capable of resolving the motion of individual particles, including all interparticle contacts. This corresponds to a brute-force approach: by applying simple interaction laws at local scales the macro-scale properties of the flow should be recovered by upscaling. This methodology effectively bypasses the complexity of modelling the intermediate scales by resolving them directly. The only caveat is the need of high performance computing, a demanding but engaging research challenge.

The DualSPHysics meshless numerical implementation, based on Smoothed Particle Hydrodynamics (SPH), is expanded with a Distributed Contact Discrete Element Method (DCDEM) in order to explicitly solve the fluid and the solid phase. The model numerically solves the Navier-Stokes and continuity equations for the liquid phase and Newton's motion equations for solid bodies. The interactions between solids are modelled with classical DEM approaches (Kruggel-Emden et al, 2007). Among other validation tests, an experimental set-up for stony debris flows in a slit check dam is reproduced numerically, where solid material is introduced trough a hopper assuring a constant solid discharge for the considered time interval. With each sediment particle undergoing tens of possible contacts, several thousand time-evolving contacts are efficiently treated. Fully periodic boundary conditions allow for the recirculation of the material. The results, comprising mainly of retention curves, are in good agreement with the measurements, correctly reproducing the changes in efficiency with slit spacing and effective density.

Ackownledgements: Project RECI/ECM-HID/0371/2012, funded by the Portuguese Foundation for Science and Technology (FCT), has partially supported this work. It was also partially funded by Xunta de Galicia under project Programa de Consolidacion e Estructuracion de Unidades de Investigacion Competitivas (Grupos de Referencia Competitiva), financed by European Regional Development Fund (FEDER) and by Ministerio de Economia y Competitividad under de Project BIA2012-38676-C03-03.

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