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EGU2020-16936
https://doi.org/10.5194/egusphere-egu2020-16936
EGU General Assembly 2020

Multi-scale numerical modelling of debris flow: coupling 2D and 3D simulation strategies

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Debris flows consist of mixtures of poorly sized sediments mixed with mater, moving with high speed within natural channels. They pose a constant threat to settlements located on mountainous terrains, with casualties and economic losses reported every year. An efficient numerical model, able to aid in the design of mitigation structures, is a long-sought tool by the community of practitioners.

One of the challenging aspects of debris flows is their complex multiscale nature. Typically, events are characterized by long runouts, with debris transported for kilometres after their initial mobilization. At the same time, the scale of interaction between flow and obstacles is much smaller, because debris-resisting structures are seldom taller than a few meters. For this reason, numerical methods typically focus on one of two aspects: the runout simulation, or the flow-structure interaction problem. This is however problematic: the type of interaction is a function of the equilibrium conditions achieved by the flow during runout, which can hardly be reconstructed if the phenomenon is not reproduced in its entirety.

In an effort to bypass this problem, we present here a coupling strategy between RASH3D, a depth-averaged model based on the shallow-water equation, and the Lattice-Boltzmann Model (LBM), an innovative 3D Navier-Stokes solver. RASH3D is employed for simulating the initial mobilization and flow runout. Before impact with a barrier, the flow variables are converted from their depth-averaged values into full 3D fields, inverting the depth-averaging procedure. The 3D flow-structure interaction is then solved with LBM. The most important and innovating point about this strategy consists in saving computational time using RASH3D without losing any important information (velocity, pressure, volume etc...) at interaction between structures and flow thanks to LBM, thus reconstructing with good precision and efficiency the whole problem.

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