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A full-scale numerical tool for debris flow simulation based on the lattice-Boltzmann method

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The mitigation of debris-flow phenomena remains problematic from both a practical and a theoretical point of view. The relevant length scales of the problem are a multitude, ranging from the smallest grain to the full size of event. This has historically limited numerical approaches to depth-averaged, bi-dimensional methods. Notwithstanding the achievements of these models in estimating the run-out path, their applicability for the design of structural countermeasures remains problematic. The flow-structure problem is intrinsically 3D, as are many macroscopic features of debris flow such as phase separation and segregation. In an effort to tackle this problem, a 3D numerical model is developed, able to simulate the extent of a whole event, while retaining the precision to deal with mitigation measures. The model is based on the lattice-Boltzmann method, a highly efficient and parallelizable solver for fluid dynamics. A set of rheological laws is implemented, with special focus on non-Newtonian and frictional behaviors. After a set of validation examples is performed, the model is used to back-analyze the dynamics of the disastrous flow event that followed the collapse of the tailing dams at Stava, Italy (1985). The major flow features are obtained with remarkably few calibration parameters.

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