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Numerical simulations of granular free surface flows using Smooth Particle Hydrodynamics (SPH)

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We present a SPH numerical model to simulate rapid, free-surface flows of dry granular material. SPH (Smooth Particle Hydrodynamics) is a meshless numerical approach based on a Lagrangian description of continuum fluid mechanics equations, using a particulate discretization of the simulated domain. This method is well adapted, in particular, to simulate free-surface flows of complex fluids in complex geometries. The formalism requires considering fluids as slightly compressible, pressure being evaluated from density variations. The rheology of flowing dry granular materials is implemented using the 3D constitutive law recently proposed by Jop *et al.* (Nature, 2006), which considers granular materials as pressure-sensitive, viscoplastic fluids.

We first run our model on steady flows down a chute. We compare results to analytical solutions predicting hydrostatic pressure and Bagnold velocity profile inside the flow. We obtain good agreement between simulations and theoretical model when reasonably low Froude number values are considered ($Fr < 1$ typically). The role of some SPH key parameters such as sound speed, particle number, and density smoothing, are also discussed.

Secondly, the model is used to simulate unsteady flows, namely interactions of finite volume free-surface surges with an obstacle. This configuration allows testing the limits of the used granular rheology. The main characteristics of the flow around the obstacle, including measurements of exerted forces, are shown. This work shows that combination of SPH with a suitable granular rheological model provides an efficient tool to simulate natural geophysical free-surface flows (snow avalanches, debris flows,...) over complex topographies.