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Erosion of a model geophysical fluid

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A specificity of natural flows such as debris flows, landslides or snow avalanches is that, mostly, the material forming the static bed has mechanical properties similar to those of the flowing material (mud/mud, snow/snow). To explore the bed erosion phenomenon induced by such geophysical flows, we consider the geomaterial as a continuum by performing experiments in laboratory on a model fluid that can behaves as a solid or as a liquid, depending on the conditions. Indeed, we propose an experimental study where a yield-stress fluid is implemented to model both the eroding flow and the eroded bed. Our approach is to capture the process of erosion in terms of solid-liquid transition.

The studied hydrodynamics consists of a pipe-flow disturbed by the presence of an obstacle. We use a polymer micro-gel Carbopol that exhibits a Hershel-Bulkley (HB) rheology. By taking advantage of the fluid transparency, the flow is monitoring by Particle Image Velocimetry (PIV) internal visualization technique. Upstream of the obstacle, a solid-liquid-like interface between a flow zone and a dead zone appears in the fluid. In this study, we aim to investigate the dominant physical mechanism underlying the formation of the static domain, by combining the rheological characterization of the yield-stress fluid (using a rheometer), with the observation of the morphological evolution of the system substratum / flow and the local measurement of related hydrodynamic parameters.

Our first result shows that the flow above the dead zone behaves as a classical plug flow, whose velocity profile can successfully be described by a Hagen-Poiseuille equation including a HB rheology, but except in a thin zone (compared to the whole flow zone) at the close vicinity of the solid-liquid interface. Thanks to a high PIV measurement resolution, we then properly examine the typical feature lying at the tail of the velocity profile. The numerical derivation of the profile shows that the shear rate in this zone increases continuously from zero to a maximal value. Considering the HB law, this behavior reflects the stress increase that the complex fluid needs to ensure in order to goes from the yield stress value at the static domain border until the value imposed by the bulk flow. In particular, we intend to discuss the possibility to describe this specific flow related to the existence of a dead zone, with a simple hydrodynamic model coupled with a HB law.