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Application of PIV technique to subaqueous and subaerial debris flows

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In the last two decades, the increase of computing power and progress in image capturing technology has made PIV techniques the method of choice for studying laboratory flows. We report on a novel application of this technique to subaerial and subaqueous debris flows. A series of experiments were run at the St. Anthony Falls Laboratory, University of Minnesota, in a 10 m long chute contained within a tank that allows to completely submerge the chute in water. Five mixtures of sand, clay, black tracer particles and water, differing in their clay and sand content (from 5% to 25% of clay), were used and parallel runs were conducted in water and air.

The experiments were carried out using four synchronised high-speed cameras recording at 250 frames per second. They were placed, respectively, at 3.6, 4.1, 7.3 and 7.8 metres from the release gate. All the recorded videos were analysed using a PIV algorithm that evaluates the velocity field from every pair of images. Comparing the velocity fields from different pairs of frames, we get $\partial \mathbf{u}/\partial t$ while $\partial \mathbf{u}/\partial x$ is obtained by comparing the velocity fields from pairs of cameras 0.5 m apart. At the location of the cameras, transducers measuring the total and pore pressures were installed in the bed, and normal video cameras allow to estimate the flow height.

We get in this way an almost complete characterisation of the dynamics, allowing us to approximately evaluate the stresses and deformation rates in function of the time and the clay content at two different locations of the flow. An important limitation, which our approach shares with virtually all others in the case of dense particulate flows, is that only surface velocity fields can be measured and only the presence but not the precise nature of 3D effects can be inferred from the measurements.

The application of PIV technique to debris flow is promising and the results represent a starting point for a deeper understanding of the dominant processes in such flows and the key differences between flows in water and in air, as well as for the development of a new mathematical model.