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Experimental investigation of gravity-driven particle flows in a turbulent stream

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Bed load transport is a longstanding problem in two-phase flows. Notably, the physical processes ruling coarse-particle/fluid systems are poorly known, despite their implications in a number of industrial and geophysical flows.

We present an experimental study of the motion of coarse spherical glass beads entrained by a shallow turbulent water flow down a steep channel with a mobile bed. Typically, the particle diameter is 6 mm, the Froude number is slightly over unity, the channel inclination is 7.5 to 15%, the ratio of water flow depth to particle diameter is 1 to 4, and the observing time is one minute. The particle flow is fairly two-dimensional, the channel width being slightly larger than the particle diameter. The water flow rate and the solid discharge are kept constant at the upstream entrance. These are adjusted to obtain bed load equilibrium, that is, neither bed erosion nor deposition over sufficiently long time intervals. Flows are filmed from the side by a high-speed camera. Using an image processing software makes it possible to determine the flow characteristics such as particle positions and velocities, trajectories, change of the state of motion (rest, rolling or saltating motion) and flow depth.

1) The first striking result of our experiments is that, over short time periods, bed load transport appears as a very intermittent process: for our experimental conditions, the solid-discharge fluctuations are as large as the mean value imposed at the upstream entrance. To some degree these large fluctuations result from the finite size of our observation window. However we identified as well intrinsic fluctuations which are due (i) to the exchanges of particles between the moving solid phase and the stationary

bed and (ii) to the collective entrainment of particles (see [1]).

2) Experimental runs with different solid discharges, water discharges and channel slopes allow us to study the influence of those control parameters on the bed load transport phenomena. One main result concerns the quantification of the contributions of the rolling and the saltating particles to the solid discharge: In our experiments the contribution of the rolling particles rises considerably with the channel slope.

Reference: [1] T. Böhm, C. Ancey, P. Frey, J.L. Reboud, and C. Ducottet. Fluctuations of the solid discharge of gravity-driven particle flows in a turbulent stream. Physical Review E, 69:061307, 2004.