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Debris flows: physics and modelling

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ABSTRACT

Debris flows are rapid massive sediment motions that occur in relatively small and steep catchments. In specific geomorphological situations and after intense rainstorms, large amounts of sediments can become instable and start to flow downhill as a dense mixture of water and poorly sorted sediments, which is moved by gravity.

Many different massive movements are regarded as debris flows: debris torrents, debris floods, mudflows, mudslides, hyper-concentrated flows and rock avalanches. The classification of debris flows based on the geometrical features of debris represents a too simplistic and often misleading schematization. On the contrary it is much more appropriate define these flows based on the rheological law that governs them, as it is normally done in fluid mechanics.

We will show that it is convenient to treat debris flows as two-phase flows in the frame of the granular flows mechanics. This way of framing the problem is much closer to the physics of the phenomenon than the approaches that treat the debris flows as homogeneous non-Newtonian fluids (e.g. Bingham fluids).

The fundamentals of granular fluid mechanics will be revisited, also in the context of the gas kinetic theory analogy.

We will then discuss some still open problems of the biphasic currents driven by gravity.

Finally, we will tackle the problem of mobile bed depth integrated models, under the shallow flow approximation, also analysing advantages and limitations of this approach.