Geophysical Research Abstracts
Vol. 17, EGU2015-9476, 2015
EGU General Assembly 2015

Internal dynamics of a free-surface viscoplastic flow down an inclined plane: experimental results through PIV measurements

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Debris flows constitute one of the most important natural hazards throughout the mountainous regions of the world, causing significant damages and economic losses. These mass are composed of particles of all sizes from clay to boulders suspended in a viscous fluid.
An important goal resides in developing models that are able to accurately predict the hydraulic properties of debris flows. First, these flows are generally represented using models based on a momentum integral approach that consists in assuming a shallow flow and in depth averaging the local conservation equations. These models take into account closure terms depending on the shape of the velocity profile inside the flow. Second, the specific migration mechanisms of the suspended particles, which have a strong influence on the propagation of the surges, also depend on the internal dynamics within the flow. However, to date, few studies concerning the internal dynamics in particular in the vicinity of the front, of such flows have been carried out.
The aim of this study is to document the internal dynamics in free-surface viscoplastic flows down an inclined channel. The rheological studies concerning natural muddy debris flows, rich in fine particles, have shown that these materials can be modeled, at least as a first approximation as non-Newtonian viscoplastic fluids. Experiments are conducted in an inclined channel whose bottom is constituted by an upward-moving conveyor belt with controlled velocity. Carbopol microgel has been used as a homogeneous transparent viscoplastic fluid. This experimental setup allows generating and monitoring stationary gravity-driven surges in the laboratory frame. We use PIV technique (Particle Image Velocimetry) to obtain velocity fields both in the uniform zone and within the front zone where flow thickness is variable and where recirculation takes place. Experimental velocity profiles and determination of plug position will be presented and compared to theoretical predictions based on lubrication approximation.