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Effect of available entrainable material on a viscous gravity current including run-out characteristics and internal flow properties

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It has long been accepted that entrainment of loose material by geophysical gravity flows such as dense snow avalanches and debris flows may change their behaviour significantly. Run-out distances and bulk-flow velocities are notable examples of susceptible behaviours. It is still disputed how this has an effect but it has been noted that the availability of entrainable material is a principal parameter.

Laboratory and numerical results are studied side-by-side to demonstrate the effects of a finite erodible bed of varying length and depth, which is placed in the path of a flowing gravity current. Both the current and the bed are composed of the same material. Natural geophysical flows are simulated as idealized viscous gravity currents at zero degrees inclination in order to study the link between the internal dynamics and the bulk features in the simplest case.

In the laboratory, a PIV configuration using a laser sheet allows the visualization of a vertical stream-wise cross section of the flow in the transition region from rigid to erodible bed, far from the side-walls. This allows the study of the velocity field within the cross-section of the flow in the entrainable region. Run-out speeds and distances are measured after the current exits the erodible bed and flows over a rigid base once more.

A relationship is sought between the released volume, the erodible bed dimensions (that is, length and depth) and the run-out characteristics of the flow. This bulk run-out behaviour is investigated with reference to the internal flow dynamics as measured by PIV.

This work is supplemented by results obtained modelling the same system using the open source CFD software OpenFOAM. We were able to track the front of the current during the flow and found that even the presence of a shallow entrainable bed (3 mm deep) significantly advanced the run-out front compared to the no-bed case. A further increase in bed depth led to a slight increase in run-out. The length of the bed was also a strongly controlling parameter, highlighting the change in flow characteristics across this region, and underlining the necessity to investigate the internal dynamics when a gravity current flows over an entrainable bed.