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On the influence of initial conditions on spatially developing gravity currents

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Gravity currents are abundant and important in in the geophysical environments. These can develop over short/long distances before reaching an equilibrium state.
Most laboratory experiments considered gravity currents on horizontal or constant slope, smooth boundaries, using finite volume releases (lock exchange conditions). Studies of the layer flow of constant supply gravity currents on slopes have mainly focused on the equilibrium state of the current. This state is generally considered to be reached at a distance from the supply of about 10 times the initial depth of the current. The flow up to this equilibrium state and the dependency on initial conditions and slope angle, which includes spatially developing currents due to topography changes, has received so far only little attentions.
The spatial development of an arrested wedge flow current over a sill has been studied by Pawlak & Armi 2001. The effects of topography changes on a continuously supplied dense current have been investigated by Negretti et al 2017, who considered well developed currents on a horizontal boundary, having a large interfacial Richardson number before reaching concave or linear slopes. The resulting down-slope current was found to have a completely different behaviour. Three distinct development regions were identified characterized by strong variations of velocity, entrainment and bottom friction coefficient.
We present here experimental results on the influence of the initial conditions on the development of a steady-state gravity current over sloping boundaries using a Particle Image Velocimetry and Laser Induced Fluorescence measurement techniques for both velocity and concentration fields, respectively. We show that the initial development of the current before reaching the slope, expressed in terms of the initial Richardson number J, is crucial in determining its further development so that the current does not always reach the commonly assumed self-similar regime even within long distances. It is demonstrated that the drag terms cannot be predicted using the proposed relations available in the literature. The different reported current behaviours can be expressed in terms of an overall acceleration parameter, which scales with the initial Richardson number J and the slope angle.
By solving numerically the governing equations, the gravity flow velocity, depth and buoyant acceleration in the flow direction can be well predicted for all the performed experiments over the full measured domain. The numerical solution for the experiments with $J>0.3$ predicts that the current requires a distance 50 times larger than the current initial depth to reach an equilibrium state of constant velocity, which is much larger than the distance required in the case of a current with critical interface already at slope begin ($J<0.3$).
These results are of interest because in nature slope changes are frequent and the resulting may be far from the known idealized condition.