Geophysical Research Abstracts
Vol. 13, EGU2011-2135-1, 2011
EGU General Assembly 2011

Gravity currents moving on smooth and rough beds

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The aim of this work is the analysis of gravity currents moving on both smooth and rough beds by laboratory experiments. Gravity currents occur when two fluids with different densities come in contact. The lighter fluid overlays the heavier one, causing a relative motion between the two fluids. Full depth lock-exchange release experiments were performed to produce gravity currents in the laboratory and the instantaneous velocity field was measured by Particle Image Velocimetry (PIV). The experiments were performed in a Perspex tank of rectangular cross-section 3 m long, 0.3 m deep and 0.2 m wide. The tank was divided in two portions separated by a vertical sliding gate placed at a distance x_0 from the left end wall of the tank. The lock was filled with salty water with density ρ_{01} and the other part of the tank was filled with tap water with density ρ_2 ($\rho_{01} > \rho_2$). The desired density was obtained dissolving a quantity of salt into the fresh water and measurements of the initial density were performed by a pycnometer. Both in the right and in the left part of the tank the total depth of the fluid was h_0. A quantity of dye was dissolved into the salt water to allow the visualization of the gravity current after the gate's removal. At the beginning of each experiment the gate was suddenly removed, and the heavier fluid moved from the left portion of the tank forming a gravity current. The experiment was completed when the gravity current reached the right wall of the tank. All the experiments were recorded by a CCD camera and an image analysis technique, based on a threshold method, was applied to measure the space-time evolution of the gravity currents' profiles.

The experiments were performed with two different values of bed's roughness ε = 0 mm and 4.5 mm and keeping constant the initial density of the salty mixture ρ_{01} = 1015 Kg/m^3, the density of the lighter fluid ρ_2 = 1000 Kg/m^3, the position of the gatex_0 = 0.1 m and the depth of the two fluidsh_0 = 0.2 m. The desired roughness ε was obtained by gluing sand with a defined mean diameter on the bottom of the tank. In agreement with previous studies, three different phases in the gravity current's dynamics were observed: a first slumping phase, in which the front position varies linearly with time and the front speed is constant; a second self-similar non-viscous phase, in which the front speed decreased as $t^{-1/3}$; a third self-similar viscous phase, which occurs when viscous effects become predominant and in which the front velocity decreased as $t^{-4/5}$. The space-time evolution of gravity currents' profiles, measured for different bed' roughness, shows that as the bed's roughness increases the front speed decreases. Preliminary velocity measurements, performed by PIV, show the presence of interfacial instabilities at the boundary between the lighter and the heavier fluid.