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A perturbative method for double-layer shallow water equations

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A double layer formulation for 3D gravity currents is proposed in this paper. This formulation is obtained starting from the shallow water equations for two layers of immiscible liquid, with
different densities and thicknesses, and then imposing the rigid-lid condition, i.e. that the free surface of the upper layer remains perfectly flat during the motion of the two liquid layers. As a
consequence a non zero pressure Ps, which must be determined by solving the motion equations, arises on the free surface of the upper layer. This fact is not a problem for 2D and axisymmetric
gravity currents, because the pressure Ps can be easily eliminated from the motion equations, thanks to an algebraic relations between the field variables of the two layers. On the contrary, for 3D
gravity currents the pressure Ps must be determined by solving a Poisson equation, together with momentum and mass balance equations. By means of a perturbative expansion of the field variables, the formulation of the problem is suitably simplified. Numerical results obtained from this simplified model are compared to experimental results found in literature, relative to a 3D lock exchange problem realized in different conditions. The comparisons between numerical and
experimental results are encouraging and show that numerical results are consistent with the experiments.