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Modelling the transport of solid contaminants originated from a point source

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The solid phases of natural flows can comprise an important repository for contaminants in aquatic ecosystems and can propagate as turbidity currents generating a stratified environment. Contaminants can be desorbed under specific environmental conditions becoming re-suspended, with a potential impact on the aquatic biota. Forecasting the distribution of the contaminated turbidity current is thus crucial for a complete assessment of environmental exposure. In this work we validate the ability of the model STAV-2D, developed at CERIS (IST), to simulate stratified flows such as those resulting from turbidity currents in complex geometrical environments. The validation involves not only flow phenomena inherent to flows generated by density imbalance but also convective effects brought about by the complex geometry of the water basin where the current propagates. This latter aspect is of paramount importance since, in real applications, currents may propagate in semi-confined geometries in plan view, generating important convective accelerations. Velocity fields and mass distributions obtained from experiments carried out at CERIS - (IST) are used as validation data for the model. The experimental set-up comprises a point source in a rectangular basin with a wall placed perpendicularly to the outer walls. Thus generates a complex 2D flow with an advancing wave front and shocks due to the flow reflection from the walls. STAV-2D is based on the depth- and time-averaged mass and momentum equations for mixtures of water and sediment, understood as continua. It is closed in terms of flow resistance and capacity bedload discharge by a set of classic closure models and a specific high concentration formulation. The two-layer model is derived from layer-averaged Navier-Stokes equations, resulting in a system of layer-specific non-linear shallow-water equations, solved through explicit first or second-order schemes. According to the experimental data for mass distribution, the results obtained with STAV-2D show the formation of a shock wave, radially propagating from the point discharge, and secondary shocks originated by reflections at the basin walls. Laboratory results evidenced the presence of two main disturbances: a wave front near the side wall and another one resulting from dispersive processes. The dispersive phenomenon suggests the presence of oscillations, instead of the constant energy state that is characteristic of isolated rarefaction waves. The ability of the existing model to reproduce these details of the experiment is assessed and discussed. The validated two-layer hydrodynamics model is seen as a proxy for fluvial flows with different sediment concentration regions and can be used for the prediction and monitoring of spatial and temporal distribution of sediments and the adsorbed phases of contaminants.

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