A Residual Based Variational Multiscale Model for Sediment Transport: Towards the Simulation of Non-Dilute Turbidity Currents

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ABSTRACT

Numerical models can help to push forward the knowledge about complex dynamic physical systems. The modern approach to doing that involves detailed mathematical models. Turbidity currents are a kind of particle-laden flows that are a very complex natural phenomenon. In a simple way, they are turbulent driven flows generated between fluids with small density differences carrying particles. They also are one mechanism responsible for the deposition of sediments on the seabed. A detailed understanding of this phenomenon, including uncertainties [1], may offer new insight to help geologists to understand reservoir formation, a strategic knowledge in oil exploration. We present a finite element residual-based variational multiscale formulation applied to the numerical simulation of particle-laden flows in a Eulerian-Eulerian framework. Thus, the mathematical model results from the incompressible Navier-Stokes equation combined with an advection-diffusion transport equation. When sediment concentrations are high enough, rheological empirical laws close the model, describing how sediment concentrations influence the mixture viscosity [2]. The aim of this work is to investigate the effects on the flow dynamics of some these empirical laws. We use two configurations for numerical experiments [3]. The first is a lock-exchange configuration in a tank and the second employs a channel with sustained current. Both numerical experiments are inspired in complex laboratory tests. We show how turbulent structures and quantities of interest, such as sediment deposition, are affected by the different empirical rheological laws. This is a first attempt towards model selection in particle-laden flows with complex rheological laws.

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