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Computational Investigations of gravity and turbidity currents

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We will present an overview of high-resolution, Navier-Stokes based simulations of gravity and turbidity currents, with the focus being on the standard lock-exchange configuration. The turbidity currents considered are driven by particles that have negligible inertia and are much smaller than the smallest length scales of the buoyancy-induced fluid motion. For the mathematical description of the particulate phase an Eulerian approach is employed with a transport equation for the local particle-number density. The governing equations are integrated numerically with a high-order, mixed compact finite difference and spectral/spectral-element technique.

We will discuss differences between two- and three-dimensional gravity current dynamics, along with the influence of slip and no-slip walls. Flow features due to large, non-Boussinesq density differences will be analyzed, and differences in the dynamics of the light and heavy fronts will be discussed. In the presence of a sloping bottom the early, constant front velocity phase is seen to give rise to a second phase characterized by the dynamics of horizontal layers accelerating past each other, similar to the classical analysis by Thorpe. Some effects due to stratification of the ambient will be discussed as well. Some first results will be shown regarding the unsteady interaction of a gravity current with a submarine structure, such as a pipeline.

In the analysis of turbidity currents, special emphasis is placed on the sedimentation and resuspension of the particles, and on their feedback on the flow. Resuspension is modeled as a diffusive flux of particles through the bottom boundary. Time-dependent sedimentation profiles at the channel floor are presented which agree closely with available experimental data. A detailed study is conducted of the balance between the various components of the energy budget of the flow, i.e., the potential and kinetic energy, and the dissipative losses. Two- and three-dimensional computations are compared which reveal that a two-dimensional model can reliably predict the flow development at early times. However, concerning the long-time evolution of the flow, more substantial differences exist between a two- and a three-dimensional model. The conditions under which turbidity currents may become self-sustaining through particle entrainment are investigated as a function of slope angle, current and particle size, and particle concentration.