Modelling of the dispersed phase motion in free-surface flows with the two-fluid Smoothed Particle Hydrodynamics approach

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ABSTRACT

The phenomena involving interaction of the carrier fluid and dispersed phase are object of active research. In environmental sciences, transport of sediment (sand) in the coastal areas is a complex process of particular interest in hydro-engineering. The present work is a part of ongoing development of solver based entirely on Smoothed Particle Hydrodynamics (SPH), capable of modelling the free surface flow, its interaction with deformable seabed, as well as transport of sand carried by water [1]. While some grid-based approaches to tackle this issue exist, they suffer from problems related to the Eulerian origin. Lagrangian methods, such as SPH, are surfacing as an interesting and promising alternative.

In the present study we focus on the aspects of the carrier and dispersed phase interaction. For the calculations we employed the so-called "two-fluid approach" recently developed within SPH framework for simulation of dust sedimentation [2]. The general idea of that model is to introduce two separate sets of SPH particles for liquid and dust phases. The governing equations are solved using volume densities, while the interphase coupling is due to the drag force interaction terms in the momentum equations for both phases. To further validate the model we settled for the simple 2D configuration of a static tank with impenetrable bottom and periodic boundary conditions in the horizontal direction. The SPH particles representing sand suspension were initially placed as a thin layer right under the free surface of water. To model the continuous supply of sand, as in available experiment that serves as a reference, subsequent layers were regularly added in the same spot to maintain a prescribed mass flux. Due to sand sedimentation, the water motion is induced. As a result of interaction characteristic vortices are formed, together with characteristic "moustache-like" cloud of sand, see Fig.1.

Ongoing work is focused on validation with data from the experiment performed specifically for this task. Simulations of dust phase interacting with a free-surface flow (induced by wave generator in a water channel), similar to that observed in coastal areas, are also planned. Another issue is to include the interaction of sediment carried by the waves with the bottom treated as granular medium [3].

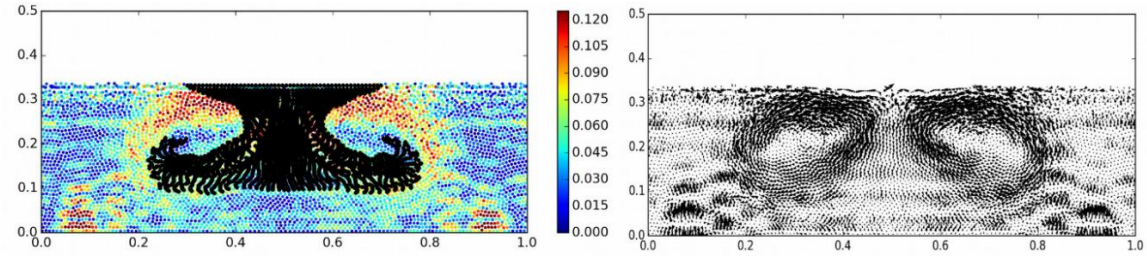

Figure 1. Left plot: positions of sediment particles (black) in water coloured with the velocity magnitude; right plot: corresponding velocity field of the carrier phase.

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