A GPU-ACCELERATED MODELING OF SCALAR TRANSPORT BASED ON BOUSSINESQ-TYPE EQUATIONS

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ABSTRACT
This paper describes a two-dimensional scalar transport model solving advection-diffusion equation based on GPU-accelerated Boussinesq model called Celeris (Tavakkol and Lynett (2017)). Celeris is the firstly-developed Boussinesq-type model that is equipped with an interactive system between user and computing unit. Celeris provides greatly advantageous user-interface that one can change not only water level, topography but also model parameters while the simulation is running. In this study, an advection-diffusion equation for scalar transport was coupled with extended Boussinesq equations to simulate scalar transport in the nearshore. In the model, the advection-diffusion equation was solved by using a hybrid finite volume-finite difference scheme as adopted in Celeris. A second-order well-balanced positivity preserving central-upwind scheme was applied to the advective flux term (Kurganov and Petrova (2007)). In particular, the scheme was modified by adding an anti-dissipation function to minimize undesirable numerical dissipation (Liu (2019)). For the diffusion terms, second-order central finite difference scheme was adopted. Besides, wave breaking model was considered to account for energy dissipation and turbulent mixing under breaking waves (Kennedy et at. (2000)). Finally, four benchmark tests were conducted to validate the coupled model. Two analytical cases were studied to examine the numerical diffusion. Moreover, two laboratory experiments were investigated. Firstly, a breaking solitary wave runup on a slope with a conical island was tested (Lynett et al. (2019)). The experiment observed dye performance while a solitary wave propagated, broke and eventually run-up over the shallow shelf with an island. The second test was associated with the development of vortex shedding in the wake behind the submerged island under the constant flow velocity field (Lloyd and Stansby (1997)). Dye transport by the vortex shedding was computed and compared with experimental data. Throughout these benchmark tests, the computed results showed good agreement with analytical solutions and experimental data.

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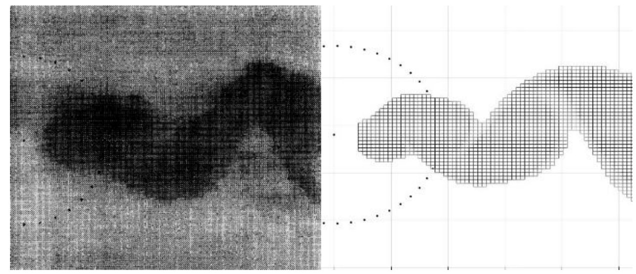

Figure 1 - Benchmark tests of Lloyd & Stansby (1997); (left) observed, (right) modeled.

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