Validation of a GPU-Accelerated Fully Viscous Numerical Ice Tank Using Lattice Boltzmann Method

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ABSTRACT

Efficient computational approaches based on viscous free-surface flows and fluid-structure interactions (FSI) are highly appreciated. This particularly holds for the field of ship-ice interactions, where FSI is the core issue and experimental studies are cumbersome, difficult to scale and typically expensive. The contribution is concerned with a novel efficient numerical ice tank, which is accelerated by graphics processing units (GPUs). The model considers fully viscous and turbulent flows, interactions between the fluid and the (pre-broken) rigid ice floes, as well as additional effects of inertia, collisions and friction within the colliding multi-body system of the ice floes, the propulsion system and the ship hull. The aim is to introduce a simulation environment which supports comprehensive parameter studies to increase propulsion efficiency and reduce propeller-ice interactions by modifications of the hull shape.

The in-house code *elbe* [1, 2] was successfully extended in various aspects to conquer the complex setup as an efficient numerical ice tank [3]. *elbe* is based on an enhanced GPU-accelerated Lattice Boltzmann Method (LBM) and allows for simulations of ship-ice interactions in the order of hours on local workstations. The FSI is modeled on a monolithic bidirectional coupling approach of the fluid solver *elbe* and the physics engine *Open Dynamics Engine* for the contacts dynamics.

The talk will focus on the validation and simulation of an azimuth thruster propelled ice breaking vessel in pre-broken ice conditions. For simplification the propulsion system is emulated by the propeller induced velocities acting on the fluid as additional forcing terms and the propeller blades only interact with the ice floes. Ice breaking is not considered. Ice floes of arbitrary shape and pattern are physically consistent added to the simulation domain and advanced towards the vessel. The simulation results are compared to experimental studies, e.g. [4]. Results indicate that the proposed method is able to provide accurate results in a very competitive computational time.

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