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Simulation of Ship Hydrodynamics using a Direct Forcing Immersed Boundary Method in REEF3D

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ABSTRACT

Previously, an improved direct forcing immersed boundary method (DF-IBM) within the computational fluid dynamics (CFD) model REEF3D::CFD for simulating floating objects was presented (Soydan et al., 2023). This method was applied to a wave energy converter (WEC) under extreme wave conditions, demonstrating promising results. Recently, an open-source mooring model MoorDyn (Hall et al., 2015) has been integrated into the numerical framework. Its performance was tested against a quasi-static mooring model, focusing on the motion responses of a semi-submersible platform (Soydan et al., 2025).

Given the comprehensive capabilities of the method, such as solving the six degrees of freedom (6DOF) motion, wave generation and absorption (Miquel et al., 2018) and Hydrodynamic-Coupling (HDC) between the fully non-linear potential flow (FNPF) solver and the CFD solver (Wang et al.,2022 and Kamath et al.,2022), it offers a complete numerical framework for realistic ship-wave interaction and seakeeping simulations.

The hydrodynamics are governed by the Navier-Stokes equations, solved on a staggered structured grid. A level-set method (LSM) is employed to resolve the water-air interface. The LSM, combined with high-order discretization and initialization techniques, accurately captures the complex free surface dynamics of ocean waves and their interactions with structures. This study explores the improved DF-IBM's potential for ship hydrodynamics, presenting new insights and results.

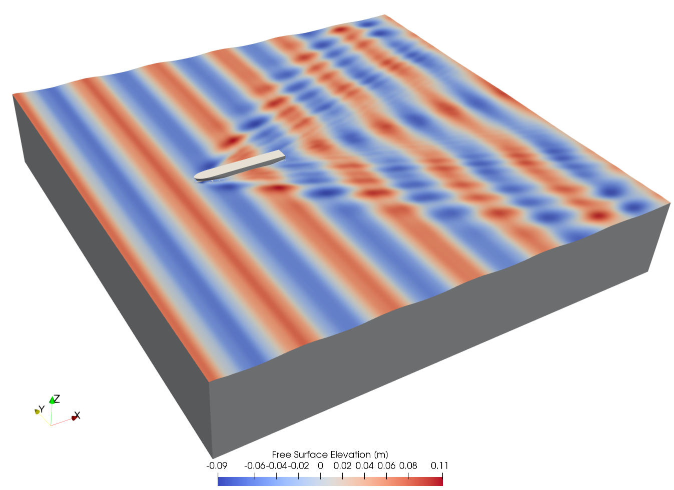

Figure 1: Free Surface Elevation

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