Boussinesq/Navier Stokes two way coupling for the simulation of wave energy converters

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ABSTRACT

The standard approach when studying and simulating the interaction between waves and floating structures is to use a single mathematical model in the whole numerical domain. This brings to a trade off between the precision of the simulation and the computational speed to solve the model: where high fidelity models can be used only for small computational domains as they are computationally heavy, simpler and more efficient models will lose potentially important information. The choice of the model becomes of key importance, especially for wave energy converters (WEC) as an accurate description of the wave dynamics will lead to better estimated results for the converter. However, choosing a high fidelity model will limit the simulation to only one WEC, making the study of energy farms challenging.

To overcome these limitations, we propose a hybrid approach that aims to mix a low performance, high fidelity Navier Stokes (NS) model [1] with the faster performances of asymptotic models such as Boussinesq (B) models [2, 3]. Given the computational cost, NS is be used only on a local scale: the domain will surround the floating structure to capture at best the wave/structure interaction, which may involve strong nonlinearities, overtopping and complex WEC displacements. Afar from the structure, asymptotic models are enough to properly describe wave propagation and weakly nonlinear waves. The Boussinesq models approximate the Euler wave equation by integrating it vertically thus reducing the original problem to a lower dimension one ($\mathbb{R}3 \rightarrow \mathbb{R}2$), resulting in efficient models that take into account weakly nonlinear effects and non-hydrostatic kinematics. The B domain does not contain the WEC as the integrated nature of the model is not adapted to handle free floating structures.

The coupling between the two models is inspired by the perfectly match layer method where the exact solution is superimposed to the simulation solution on a small layer thanks to a relaxation of the model [4]. This relaxation layer is used here to transfer the waves generated in the global domain to the local one [5]. Moreover, this approach can be easily expanded to propagate waves from the local NS domain back to the B domain resulting in a two way coupling between models.

This work will present the resulting coupled system that permits a precise description on the local scale of the wave energy converter while remaining efficient over the larger propagation domain. It is also easily scalable to accommodate multiple NS domains for each WEC, potentially up to full wave energy farms with a reduced use of computational power. Preliminary results of the coupling will be presented.

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