Creating a numerical twin for the brand new physical Coastal & Ocean Basin in Ostend, a waste of effort?

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The development of ocean energy convertors, such as wave energy converters, tidal energy convertors and offshore wind turbines has gained significant attention in the last decade to produce renewable and low-carbon energy. Designing such complex structures requires good knowledge of wave-current and wave-current-structure interactions (WCSIs). These interactions determine the loading conditions in operational seas. In 2014, Ghent University and KU Leuven successfully obtained funding from the Hercules Foundation to equip a wave-current basin. Together with Flanders Hydraulics, they convinced the Flemish Government to build the Coastal and Ocean Basin (COB) in the new Maritime Research Center in Ostend. Once fully operational, the COB is designed to generate waves and currents at arbitrary angles to each other. There exist very few basins where arbitrary angles between waves and currents are possible, so this is considered as a unique selling feature of the COB.

My research has the aim of creating a numerical equivalent of the physical COB. Since the goal of the COB is to investigate WCSIs, it is clear that my Numerical Wave Tank (NWT) needs to be able to simulate those WCSIs as well. Detailed modelling of the flow and flow-structure interaction is often needed in the immediate region near the structure to take into account the complexity of the flow. Computational Fluid Dynamics (CFD) models that solve the full Navier-Stokes equations coupled to structural dynamics models, can be used for this purpose. Unfortunately, these models involve high computational costs. Using such a CFD approach to make a numerical equivalent for the physical COB, would be prohibitive in terms of computational requirements. To overcome this issue, I am adapting the Higher Order Spectral – Numerical Wave Tank (HOS-NWT) [Ducrozet et al., 2012] to the specific needs of the COB. HOS-NWT is a free-surface potential flow (FSPF) model. Those models solve the Laplace equations based on the potential flow theory. HOS-NWT uses a modal expansion in the vertical direction to collapse the numerical solution to the two-dimensional horizontal plane, making it a very efficient model. However, the existing model only contains a wavemaker at one of the sides of the tank and cannot deal with currents. To mimic the situation in the COB, I adapted the model such that wave generation becomes possible at two sides of the basin and a uniform current can be accounted for. As a further optimalization, I would like to include the effect of steepness breaking on the wave evolution. Experiments in the COB will be set up to validate the adapted model. The combination of an efficient NWT (far-field) model and a nested CFD (near-field) model, will become a powerful tool.

If the final coupled model has the same features as the COB, will it replace the expensive testing facility? Fortunately not or unfortunately not, depending on the way one looks at it. The numerical model can be used to prepare physical model tests, sparing rare time available in the COB. It provides a rigorous way to account for scaling effects. The model can possibly cover a wider range of loading conditions than the physical COB and gives the solution for the entire computational domain. But physical testing will always stay an important step in designing offshore structures. It allows to validate the simulations for the specific structure you’re interested in, to make sure the models aren’t neglecting effects which turn out to be important in the given context. There is always a difference between theory and practice, so a hybrid modelling approach should be used to optimally combine the knowledge of both the physical and the numerical models.

Reference
- Ducrozet, G., Bonnefoy, F., Le Touzé, D. & Ferrant, P. (2012). A modified High-Order Spectral method for wavemaker modeling in a numerical wave tank. European Journal of Mechanics, B/Fluids, 34, 19–34.

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