A Multi-fidelity Coupling Methodology for the Simulation of Wave Energy Converter Farms

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ABSTRACT

As the energy scenario quickly evolves, the marine sector is adapting to make the most of the enormous potential of the sea as a clean energy resource. Many types of wave energy converter (WEC) are currently being developed at different levels of technology readiness, but they all share the same destiny: their deployment in farms. It is a necessary step for power production to reach commercial scale, and it also needs a numerical simulation phase preliminary to the deployment in real sea sites. Such simulations are challenging because, in addition to the high computational burden due to the large area covered by multiple WECs, the hydrodynamics involved is complex and must take into account both the wave field close to the converter and the wave propagation in the far-field. For those reasons, high-fidelity simulations are not appropriate, so simplifying assumptions are usually made to lower the fidelity and the computational cost [1]. Furthermore, coupling techniques are commonly developed to combine a fluid-structure interaction solver and a wave propagation solver, thus offering the possibility to choose the most appropriate method for the representation of the different hydrodynamics.

We propose here a coupling methodology combining a high-fidelity solver (CFD) for the near-field description and a Reduced-Order Model (ROM) for the wave propagation in the far-field [2]. The choice of the high-fidelity solver is supported by the fact that the assumptions lowering the fidelity of the simulation are often overly simplifying and limiting the range of conditions that can be numerically represented. The CFD keeps the accuracy high in the vicinity of the converter but its computational cost is constrained to the small domains around the WECs. A ROM technique is applied in the domain farther from the WECs: the Proper Orthogonal Decomposition (POD) conserves the characteristics of the full order model, but highly reduces the size of the problem [3]. The connection between the two solvers is achieved, at each time-step, through the boundary conditions of the high-fidelity domain and the domain itself, yielding to a two-way coupling.

This multi-fidelity technique is tested on a free-surface problem, for different flow conditions and also with a floating body, showing a good reconstruction of the flow and a considerable reduction in computational memory, that facilitates the implementation of optimization strategies and design processes for wave energy converter farms.

REFERENCES

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