Generation of homogeneous wave field in a numerical basin for modelling WEC (array and farm) interactions and far field effects

Panagiotis Vasarmidis[1], Vasiliki Stratigaki[1], Peter Troch[1]

[1] Department of Civil Engineering, Ghent University, Technologiepark 60, 9052 Ghent, Belgium;

E-mails: Panagiotis.Vasarmidis@UGent.be; Vicky.Stratigaki@UGent.be; Peter.Troch@UGent.be

One of the challenges in the field of renewable wave energy is to determine the optimal geometrical layout for wave energy converter (WEC) arrays or farms, targeting the maximum energy production and the correct assessment of the impact of WEC arrays or farms on the surrounding wave field. For this purpose, accurate and detailed numerical modelling of WEC arrays and farms under realistic 3D wave conditions is considered crucial, which is a topic addressed by "Working Group1" of the WECANet COST Action CA17105. This kind of application requires a homogeneous wave field in the entire numerical domain and thus two new wave generation techniques have been developed and implemented in two different phase resolving numerical models at Ghent University, Belgium.

Traditionally, in time-domain models oblique waves are generated along two intersecting L-shaped wave generation lines. In our study, a wave generation layout using periodic lateral boundaries has been developed (Vasarmidis et al., 2019a) in a time dependent mild-slope wave propagation model, MILDwave (Troch and Stratigaki, 2016), in order to accurately generate regular and irregular waves in any direction. With this technique, the information leaving one end of the numerical domain enters the opposite end and thus no lateral wave absorbing sponges are required. In this way, the wave diffraction patterns that appear inside the numerical domain as a result of the intersection of the two wave generation lines and due to the interaction with the lateral sponge layers are avoided. This technique has been used by Verao Fernandez et al. (2019) to study WEC farms under short-crested waves.

In addition, a new internal wave generation method combined with wave absorbing sponge layers has been derived and applied in the non-hydrostatic model SWASH (Zijlema et al., 2011), in order to generate waves in a more accurate way and avoid re-reflections at the boundaries. With this technique, a spatially distributed source term in the form of mass is added to the continuity equation. This source term is a function of a velocity that is called the energy velocity and for the system of SWASH equations has been mathematically derived by Vasarmidis et al. (2019b). The numerical results of water surface elevations, orbital velocities, frequency spectra and wave heights, showed a very good agreement with the analytical solution and the experimental data. This indicates that SWASH with the addition of the proposed internal wave generation technique can be used to study WEC farms even under highly dispersive and directional waves without any spurious reflection from the wave generator.

Both above mentioned techniques are employed at Ghent University and are proposed here for studying WEC (array or farm) effects.

COST is supported by the EU Framework Programme Horizon 2020. COST (European Cooperation in Science and Technology) is a funding agency for research and innovation networks. COST Actions help connect research initiatives across Europe and enable scientists to grow their ideas by sharing them with their peers.

References

Troch, P., Stratigaki, V., 2016. Phase-Resolving Wave Propagation Array Models, in: Folley, M.E. (Ed.), Numerical Modelling of Wave Energy Converters. Elsevier, pp. 191–216. https://doi.org/10.1016/B978-0-12-803210-7.00010-4

Vasarmidis, P., Stratigaki, V., Suzuki, T., Zijlema, M., Troch, P., 2019b. Internal Wave Generation in a Non-Hydrostatic Wave Model. Water 11, 986. https://doi.org/10.3390/w11050986

Vasarmidis, P., Stratigaki, V., Troch, P., 2019a. Accurate and fast generation of irregular short crested waves by using periodic boundaries in a mild-slope wave model. Energies 12, 785. https://doi.org/10.3390/en12050785

Verao Fernandez, G., Stratigaki, V., Vasarmidis, P., Balitsky, P., Troch, P., 2019. Wake Effect Assessment in Long- and Short-Crested Seas of Heaving-Point Absorber and Oscillating Wave Surge WEC Arrays. Water 11, 1126. https://doi.org/10.3390/w11061126

Zijlema, M., Stelling, G., Smit, P., 2011. SWASH: An operational public domain code for simulating wave fields and rapidly varied flows in coastal waters. Coast. Eng. 58, 992–1012. https://doi.org/10.1016/j.coastaleng.2011.05.015

Acknowledgements

This research was funded by Research Foundation—Flanders (FWO), Belgium, grant number of Ph.D. fellowship 11D9618N.