Steps Towards the Direct Simulation of Submerged Canopy Flows

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ABSTRACT

Submerged vegetation can directly contribute to coastal protection by dampening water waves. Reductions of flow velocities and changes to the boundary layer are also important to create habitats for many organisms [1]. Researchers often employ simplified models in physical test facilities based on vertical cylinders to derive semi-analytical models of canopy flows [3].

The application of numerical models to directly resolve canopy flows is still an open challenge. Key dimensions of canopies like stem diameter range from less than a centimetre to decimetres, whereas the computational domain must extend over several wave lengths, often up to a kilometre, making direct representation of the plant shape in the grid prohibitively expensive.

We present a first attempt combining the actuator line method with LES turbulence modelling to simulate the changes to boundary layers in plant canopies. First simulations already show promising results, demonstrating how flow velocity decreases inside the plant canopy and accelerates above it, providing good agreement with experimental data.

Physical experiments generally assume the cylinders representing the canopy to be rigid, which does not match field observations of real plant canopies and, more crucially, is unlikely to be accurate considering the slenderness of the structure and significant fluid loading.

Further research will thus employ the structural solver in the ALFEA implementation [2] to investigate the effect of cylinder deformations on wave dampening and the changes to the boundary layer.

REFERENCES

[1] Kregting Louise, Britton Damon, Mundy Craig N., Hurd Catriona L. (2021) "Safe in My Garden: Reduction of Mainstream Flow and Turbulence by Macroalgal Assemblages and Implications for Refugia of Calcifying Organisms From Ocean Acidification", *Frontiers in Marine Science*, 8, doi:10.3389/fmars.2021.693695

[2] Schmitt, P. and Robinson, D. (2022) "A Coupled Actuator Line and Finite Element Analysis Tool", *OpenFOAM® Journal*, 2, pp. 81–93. doi: 10.51560/ofj.v2.51.

[3] Jie Hu, Y.H. Lin, Maria Maza. (2022) "A semi-analytical theory for water waves interacting with a submerged/suspended circular cylinder patch", *Ocean Engineering*, Volume 247