Hydrodynamic modelling of Floating offshore wind turbines

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Likhitha Ramesh Reddy
PhD Researcher
Delft University of Technology

Axelle Viré, Delft University of Technology
John Walker, ORE Catapult
Daniel Milano, ORE Catapult

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Introduction

Floating offshore wind turbines (FOWTs):

- Stronger and steadier wind resources
- Efficient installation and maintenance

Challenges

- Commercial feasibility of FOWTs
  - Standardization of offshore wind system is difficult
  - Modeling and design tools to capture the physical behavior

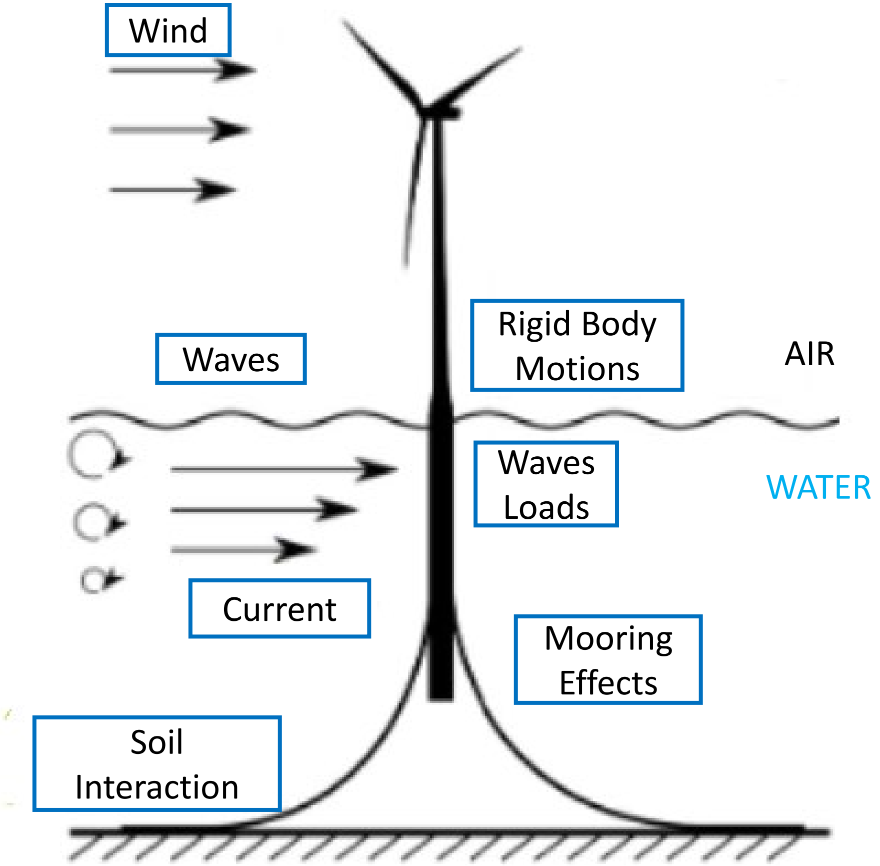

Figure 1: Components of floating offshore system[1]

[1] Simon B., et al., Towards credible CFD simulations for floating offshore wind turbines, Ocean Engineering, 2020

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Motivation

- Understand Non-Linear Hydrodynamic behaviour
  - Engineering models are based on potential flow(PF) theory, Morison's equation, or a combination of both.
  - Engineering tools tend to under-predict the loads/motion at it's surge and pitch natural frequencies[2]
  - Therefore, higher fidelity models is required study non-linear behavior
- Computational cost
  - Navier-Stokes based solvers are computationally demanding when compared to engineering models

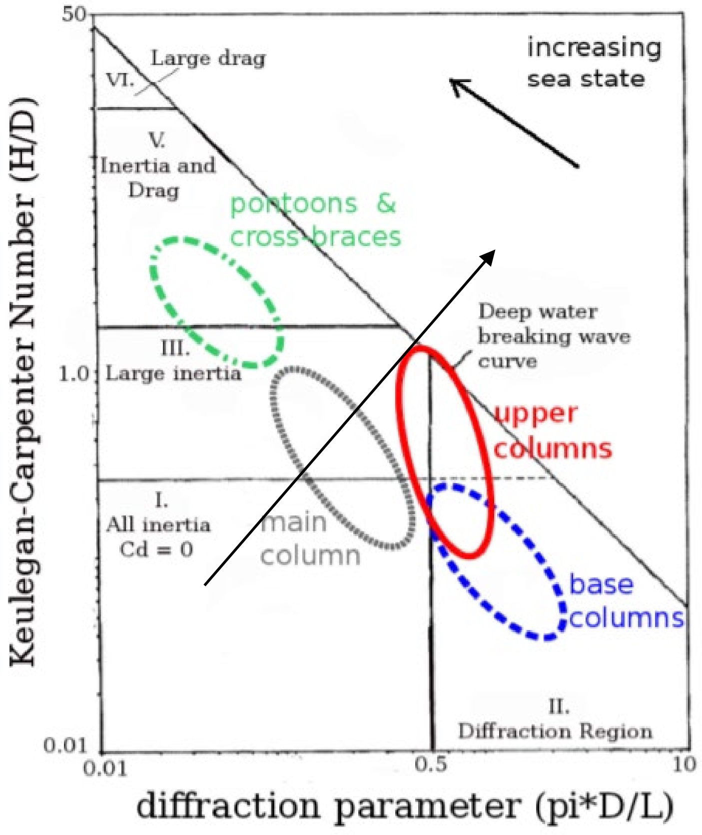

Figure 2: Applicability of engineering model [3]

[2] Robertson et. al., OC6 Phase1:Investigating the underprediction of lowfrequency hydrodynamic loads and responses of a floating wind turbine , NREL, 2020
[3] Maija et. al., Comparison of Hydrodynamic Load Predictions Between Engineering Models and Computational Fluid Dynamics for the OC4-DeepCwind SemiSubmersible, NREL, 2014

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Research Objectives

- CFD solver for a semisubmersible floater
- Implementation of Mesh adaptation technique
- Fully-coupled aero-hydro simulations

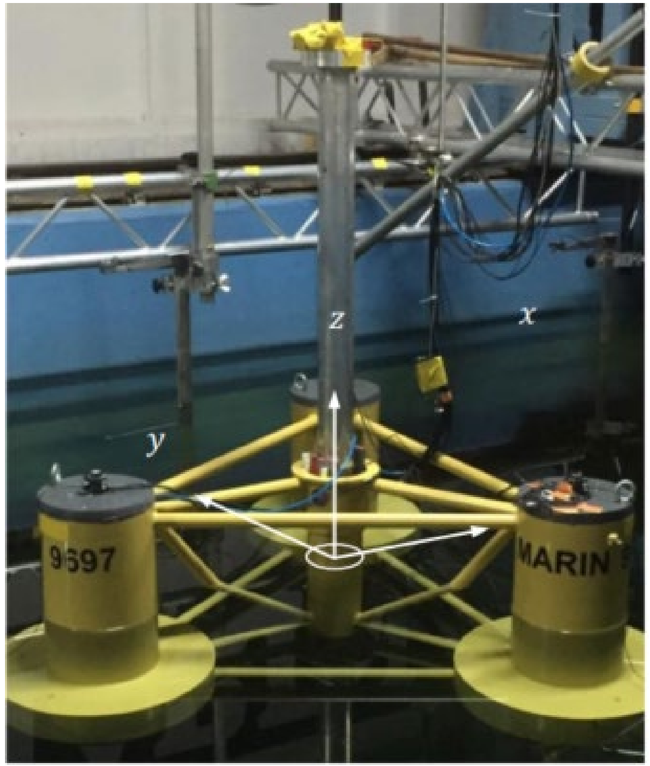

Figure 3: OC5 DeepCwind FOWT semisubmersible with a rigid tower (source: NREL)

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Numerical method

- YALES2 LES Solver
    - Mainly developed at CORIA
    - 4^{th}-order finite-volume
    - 4^{th} order Runge-Kutta time integration
    - Unstructured meshes with adaptive grid refinement
    - Massively parallelised (>32,000 procs)

http://www.coria-cfd.fr

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Why YALES2?

- Scalability
- Mesh adaptation
- Aerodynamics model - Actuator line model

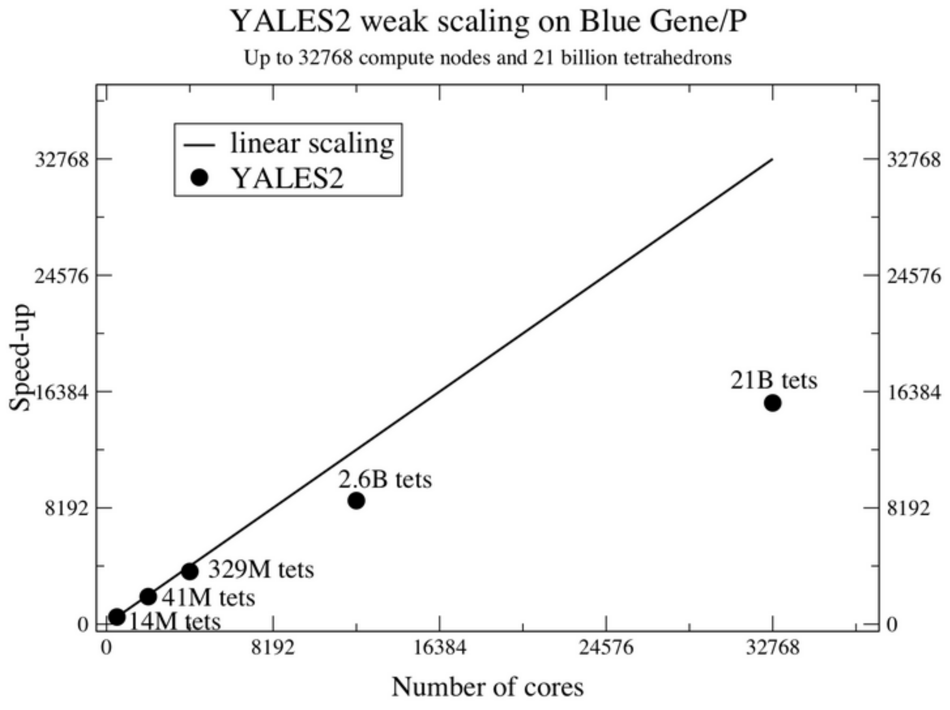

Figure 4: YALES2 Scalability [4]

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Numerical modelling – Fluid structure interaction

- Movement of the semisubmersible platform
    - In YALES2, Fluid Structure Interactions (FSI) is formulated using an Arbitrary Lagrangian Eulerian (ALE) approach
- Air-water interface
    - Two-phase flow is solved using incompressible solver with Level set method and Ghost fluid method (GFM)
    - In YALES2, this two-phase flow solver (mainly used for spray applications) is abbreviated as SPS (spray) solver

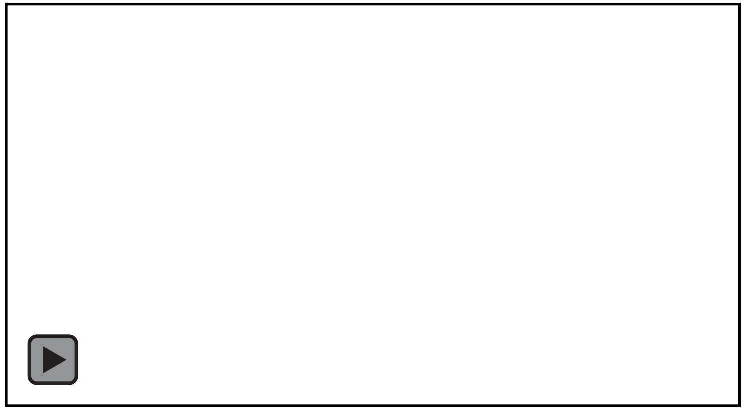

Figure 5: Simulation of semisubmersible platform [5]

[5] www.cape-horn-eng.com

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Development of YALES2 Hydrodynamic solver

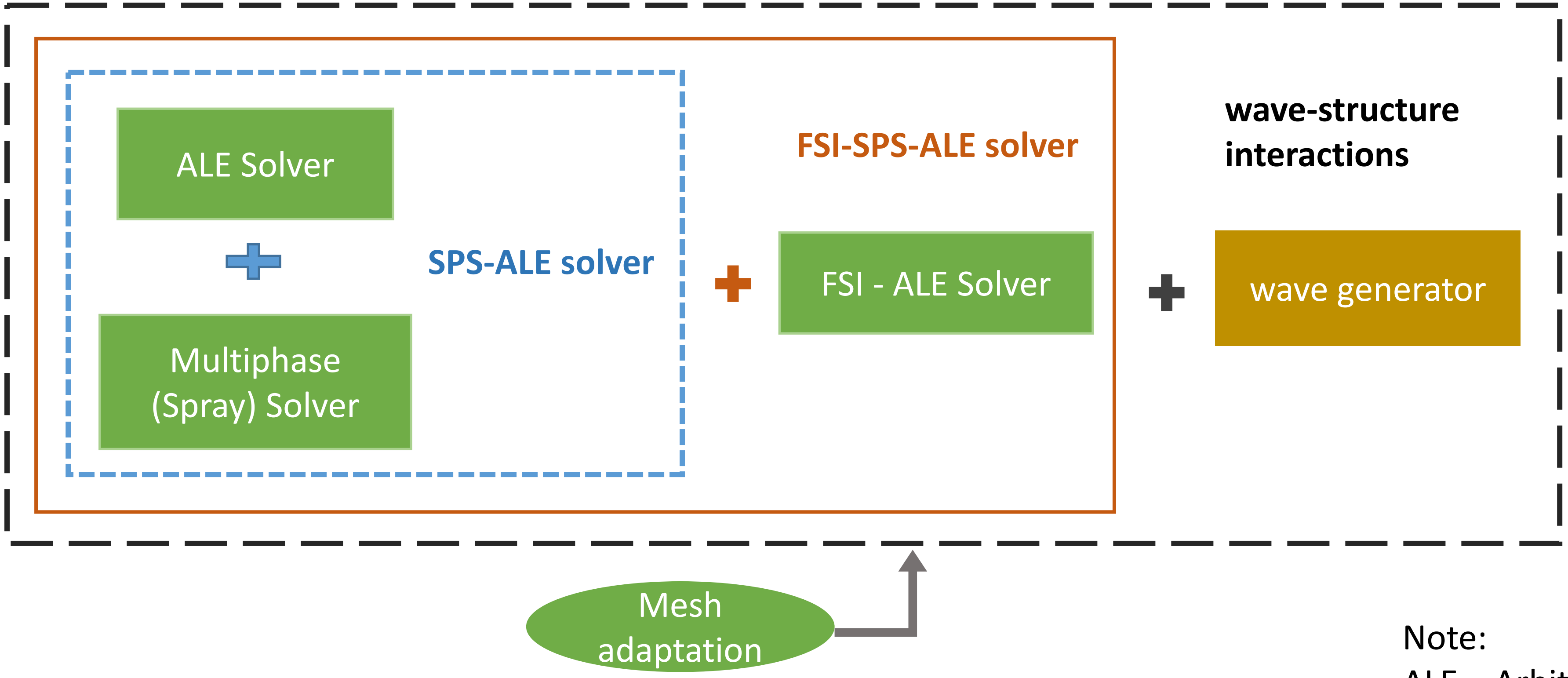

Figure 6: Overview of solver code development

Note:
ALE – Arbitrary Lagrangian Eulerian
SPS – Spray solver
FSI – Fluid Structure Interactions

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Ongoing work

- SPS-ALE validation
  - 2D box with prescribed motion
  - Validated against OpenFOAM results

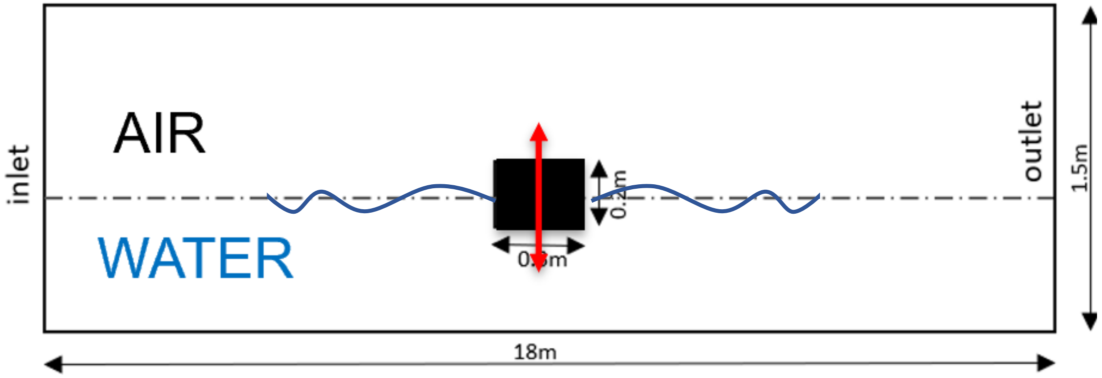

Figure 7: Validation test case - 2D box

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Questions?

Contact: l.rameshreddy@tudelft.nl