

# Development & Validation Of An Actuator Line Model For Floating Offshore Wind Turbines

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## Objectives

- Implement generalised 6-DOF platform motions into in-house OpenFOAM Actuator Line Model (ALM).
- Validate model predictions of rotor loads and wake dynamics against experimental data.

## Validation Case

- NETTUNO<sup>7</sup> & UNAFLOW<sup>8</sup> experimental campaigns.
- 1:75 thrust scaled DTU 10MW.
- Low turbulence (I=2%) uniform inflow conditions.
- Monochromatic prescribed motions.

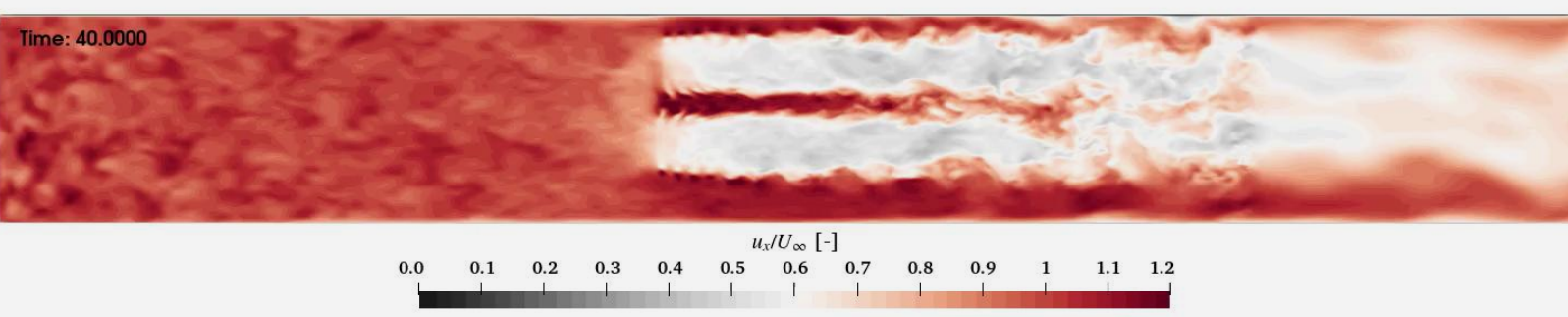
## Motivation

- 80% of all practical offshore wind resource lies in deeper (60m+ waters)<sup>1</sup>.
- Platform motions perturb the nonlinear wake system generating additional unsteadiness and enhancing wake recovery<sup>2,3,4,5</sup>.
- Low-order wake models fail to account for platform-induced dynamics<sup>6</sup>.

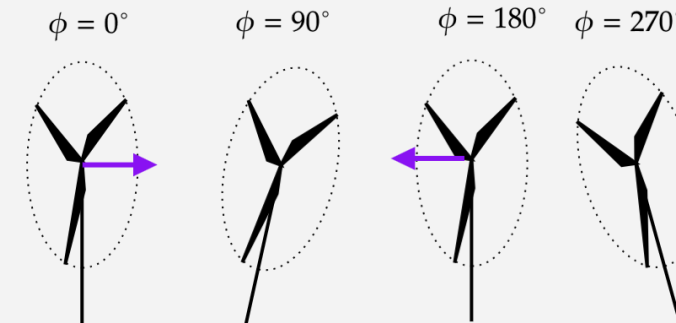
## Method

- Blade representation: ALM using static polars.
- Support structure representation: None(!).
- Inflow turbulence: divergence free synthetic eddy method<sup>9</sup>.
- Wind tunnel blockage: Spalding wall function.
- Finite volume method solving the incompressible Navier-Stokes equations.
- Turbulence: Large eddy simulation with Smagorinsky subgrid model.

### Time Series data



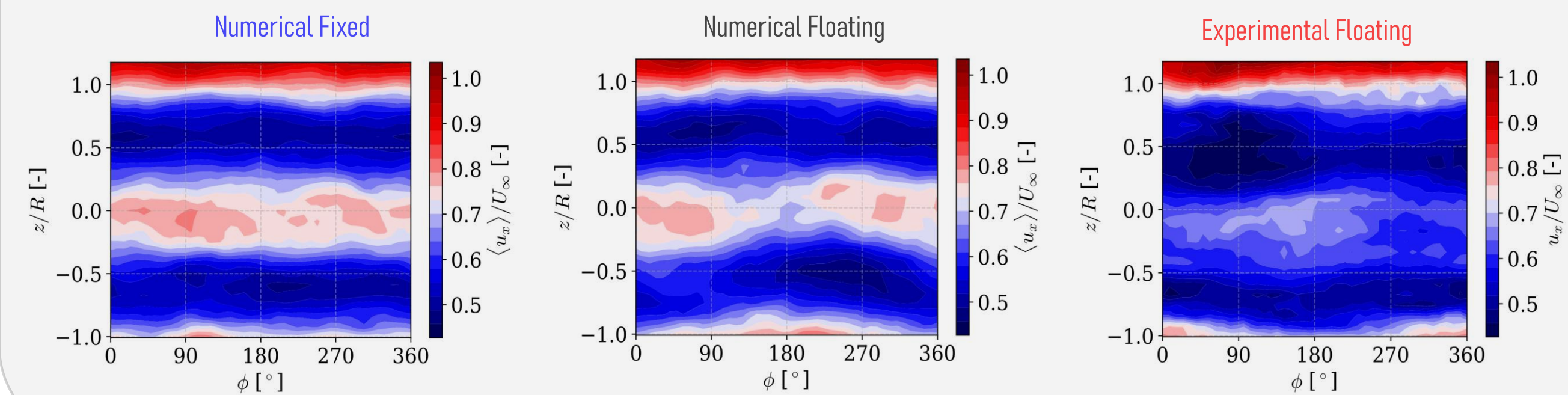
### Prescribed Platform Motion Phase $\phi$



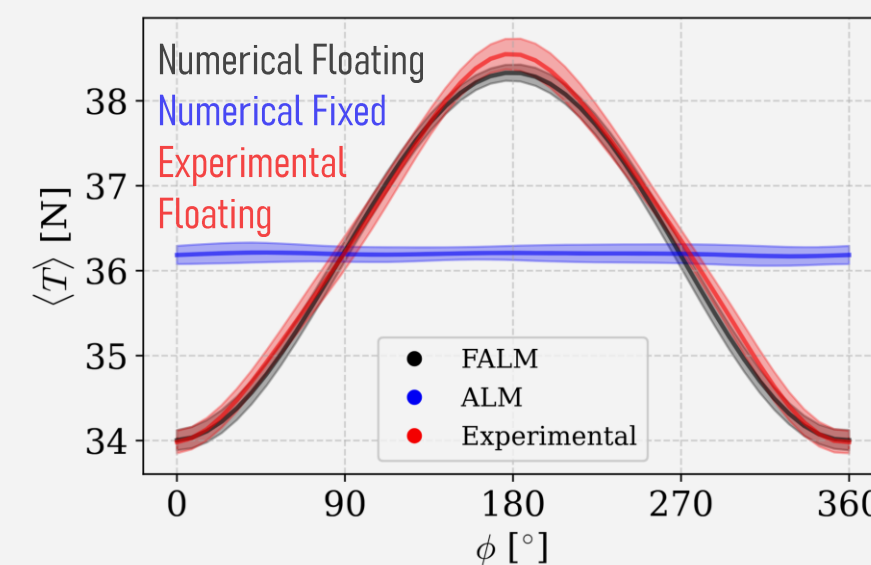
Phase Averaged Streamwise Velocity  $\langle u_x \rangle$

## Wake

- Fixed-bottom results are almost invariant w.r.t  $\phi$ .  $\partial_\phi \langle u_x \rangle \neq 0$  due to high convergence requirements for phase averaged results.
- Numerical results contain a spurious nacelle jet due to lack of representation.
- The numerical model reproduces the bending of the lower wake.
- The bypass flow ( $\frac{z}{R} > 1$ ) due to high local wind tunnel blockage constrains the upper wake bending.
- The numerical model underpredicts the velocity deficit in the upper section of the wake ( $\phi \approx 180^\circ, z \approx 0.75R$ ).
- Underprediction of velocity deficit may be due to reenergisation of the wake by the nacelle jet ( $\phi \approx 180^\circ, z \approx 0$ ).



Phase Averaged Rotor Thrust  $\langle T \rangle$

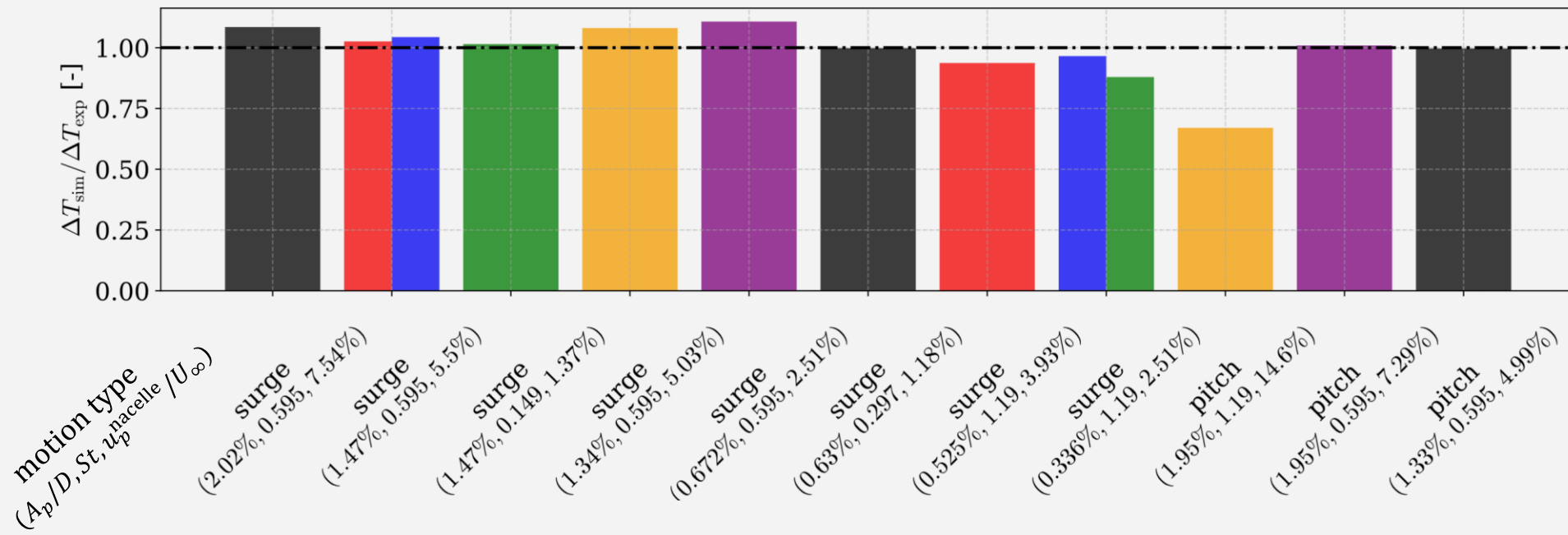


Surging turbine,  $A_p = 0.0147D, St = 0.595$

## Thrust

- Good agreement in thrust oscillation,  $\Delta T$ , across majority of cases.
- Some cases with  $St = 1.19$  demonstrate poor agreement but represent highly dynamic cases outside of operational conditions.
- Phase averaged thrust,  $\langle T \rangle$ , is approximately linearly related to platform induced (Lagrangian) velocity.
- Time averaged thrust is approximately equal for floating and fixed-bottom results.

$$\Delta T = \int T(t) e^{i2\pi f_p t} dt$$



## Conclusions

- The FALM reproduces the dynamic wake features observed in experiments.
- The rotor loads are predicted with good accuracy.
- The method requires a fraction of computational resources compared to equivalent blade resolved simulations.
- The method has been validated and is suitable for future research!

References:  
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