Best practices in FOWT modelling

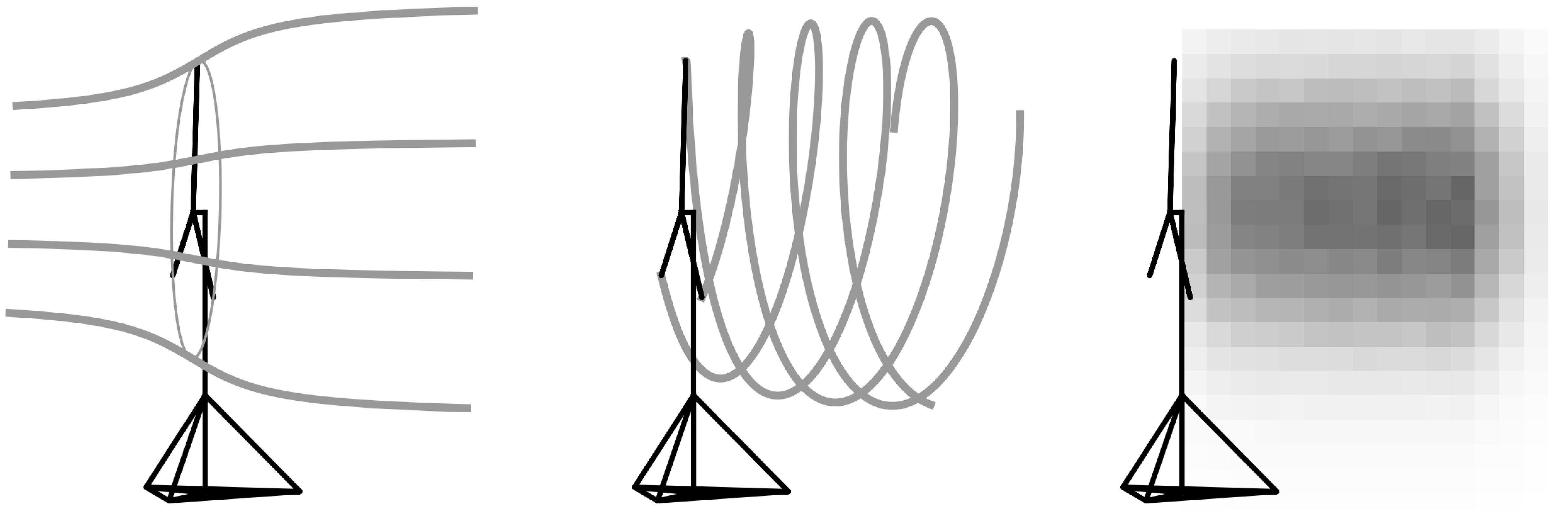
with a GPU-resident large-eddy simulation weather model coupled to OpenFAST

Evert Wiegant, dr. Delphine de Tavernier, prof. dr. Axelle Viré
Delft University of Technology, the Netherlands

RESEARCH QUESTION

How to best model the aerodynamics of floating offshore wind turbines (FOWT) numerically?

- When are lower fidelity methods sufficient?
- How can we make sense of higher fidelity methods?



INTRODUCTION & METHOD

We check how best practices from traditional (fixed) wind turbines translate to modelling floating offshore wind turbines (FOWT).
We perform simulations of the IEA15MW under prescribed motion using an atmospheric large eddy simulation model (LES, ASPIRE) coupled to a wind turbine model (OpenFAST) using the actuator line method (ALM).
We compare to simulations performed with other widely-used aerodynamic methods; blade element momentum theory (BEM, OpenFAST) and free vortex wake method (FVW, OpenFAST).

RESULTS 1/2

We perform two identical simulations (with different flow solvers; using either BEM or LES+ALM) and apply prescribed surge motions varying in amplitude and frequency.
We see differences in the thrust coefficient C_t (fig. 1) for large surge frequencies or amplitudes.
Additionally, the motion introduces a scale that may not be resolved...

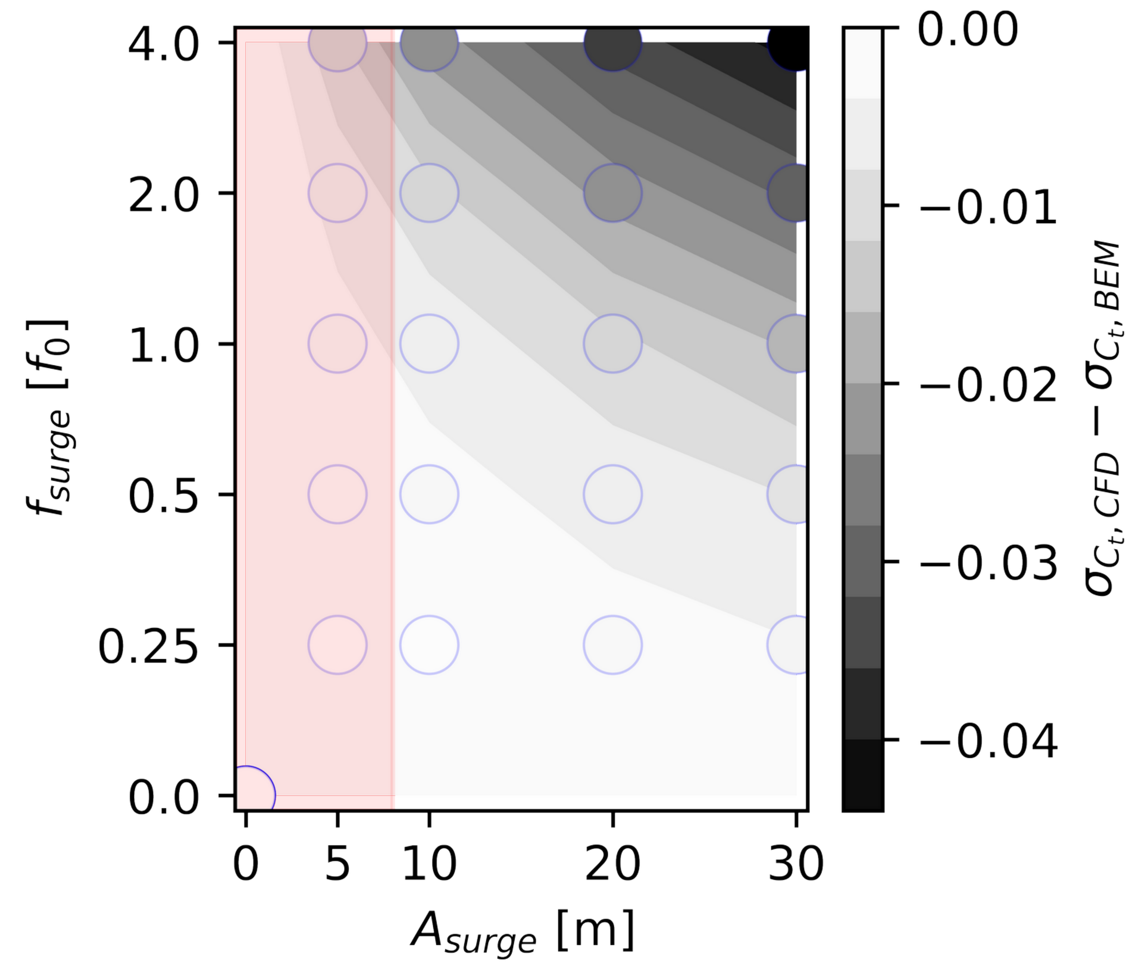


Figure 1: Difference in C_t-response resulting from surge motions between simulations using LES+ALM and BEM, quantified by the difference in standard deviations (~amplitude) of the c_t signals. Red area indicates LES subgrid scales.

RESULTS 2/2

We hypothesize:
Whether a motion is resolved depends on the choice of ε, the actuator line kernel width (moreso than grid cell size).
This is confirmed by fig. 3; the choice of ε matters for FOWT, yet we often use an unconverged ε (fig. 2).

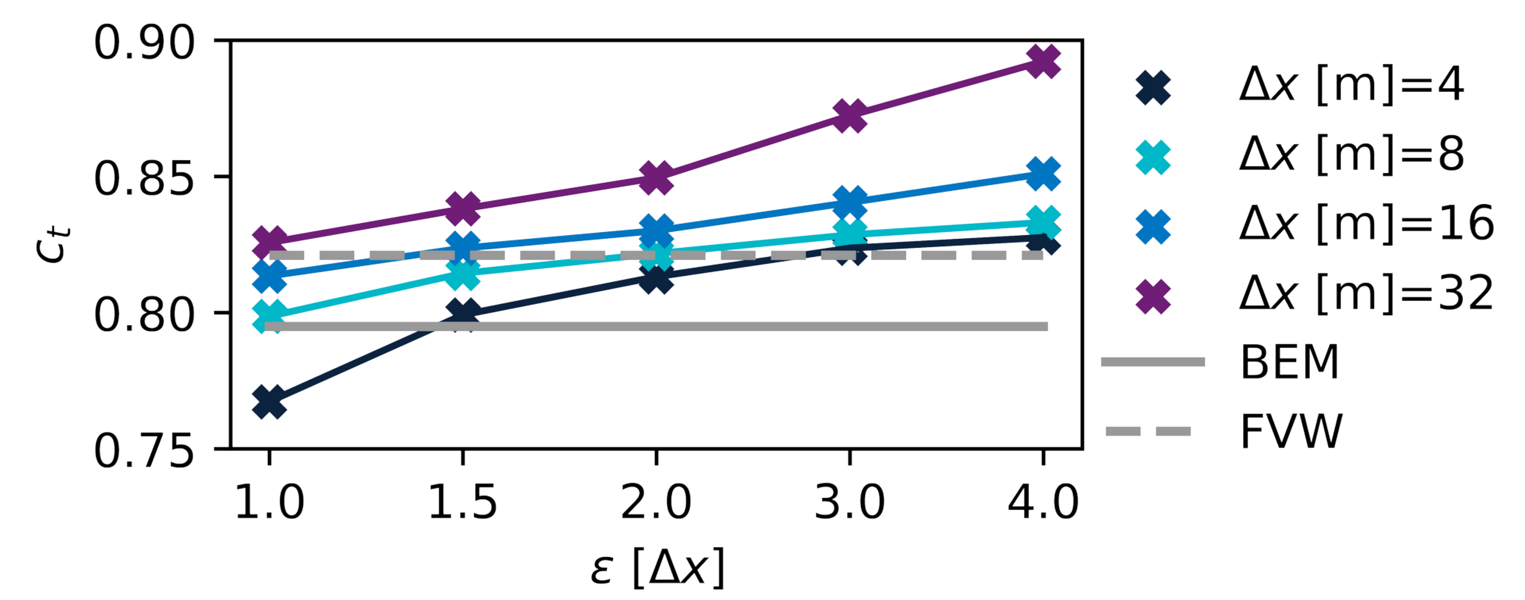


Figure 2: A cluster of LES+ALM simulations for varying numerical inputs. Sensitivity persists at the “recommended” ε=2Δx.

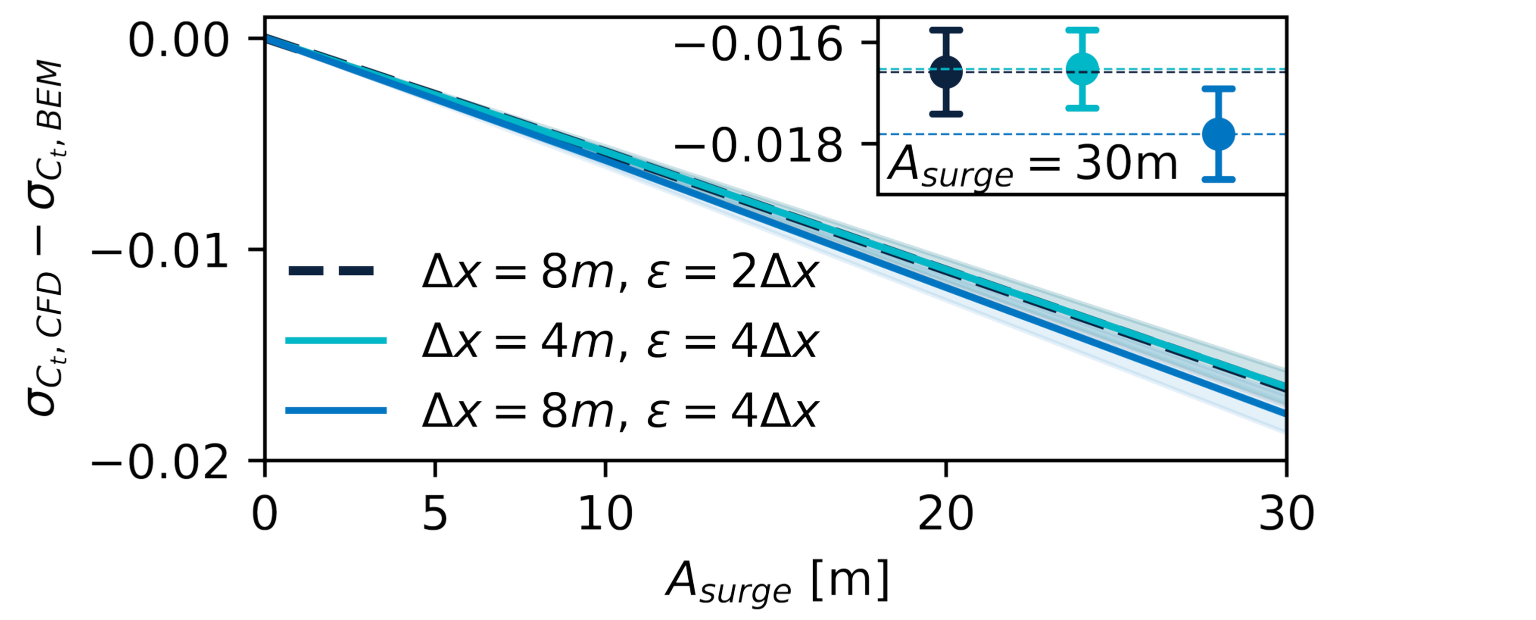


Figure 3: Intersection of fig. 1 (at f_{surge}=1f_0) for varying numerical inputs. Thrust is affected by a change in ε more than a change in Δx.

CONCLUSION & DISCUSSION

- We identified regions where lower fidelity (i.e. BEM) is sufficient. Additionally, we argue that there are regions where finite difference methods (i.e. CFD) may not be appropriate.
- A wind turbine introduces flow phenomena at the scale of the structure. One chooses the (CFD) grid cell size accordingly. For large rotors and small floater motions, what is adequate for the rotor may not be so for the motions.
- Convergence in ALM kernel width (ε) may not be reached, yet it is important at the scale of floater motions.

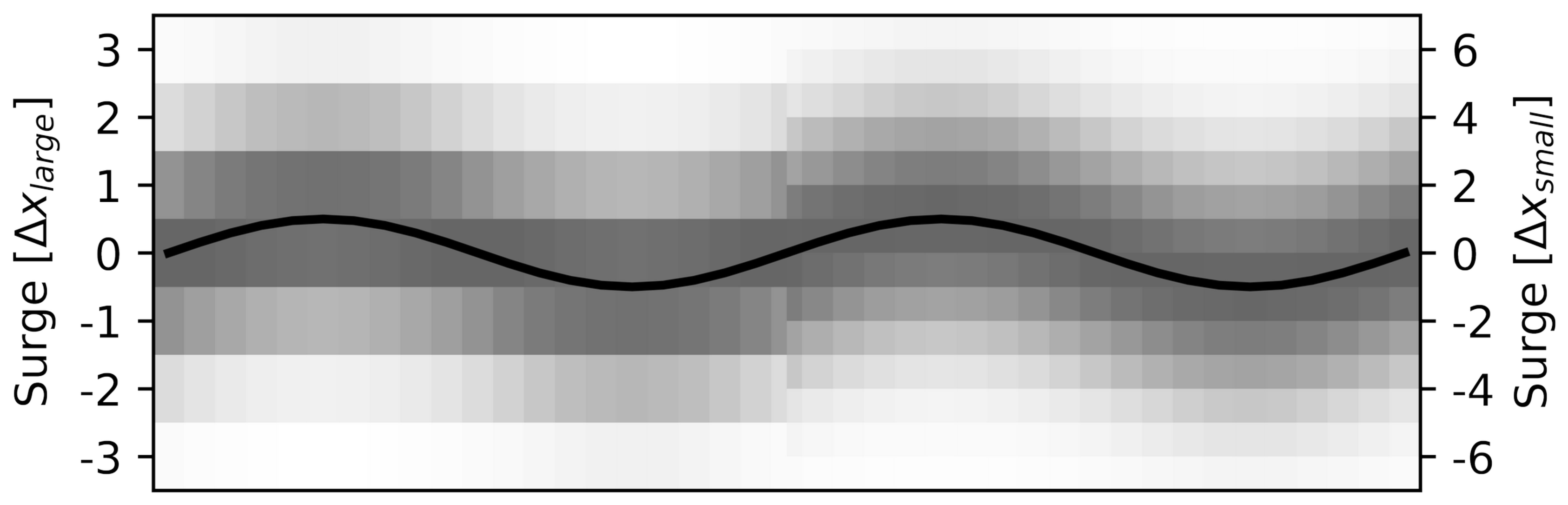
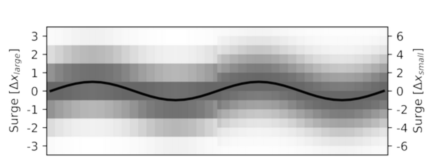


Figure 4: One signal at two resolutions. Who can tell the difference?

Now squint a little...



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CONTACT
Evert Wiegant
e.i.wiegant@tudelft.nl