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Development and Validation of an Actuator Line Method for Floating Turbines

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ABSTRACT

The integration of wind energy into the global power network has proven its capacity to deliver renewable and cost-effective energy. However, conventional fixed-bottom turbines are limited by water depth and cannot access the vast wind resources found in deeper waters, estimated to constitute 80% of all practical wind energy potential (GWEC. 2022). Floating Offshore Wind Turbines (FOWTs) can overcome these challenges but introduce additional complexities and unsteadiness into the system due to floating platform motion. Understanding the dynamic wake system poses a major challenge in FOWT farm optimisation and requires high-fidelity yet computationally affordable models.

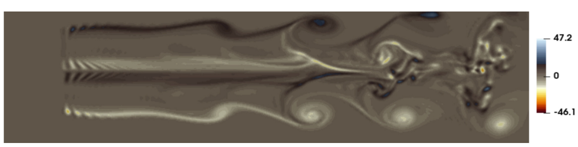

Figure 1: Vorticity contour of a model turbine during harmonic surge.

In this study, an OpenFOAM-based actuator line method, previously validated for fixed-bottom wind (Wimshurst et al. 2017) and tidal (Willden et al. 2023) turbines, is modified to allow for prescribed six-degree-of-freedom motion representative of a FOWT. Large eddy simulations combined with the divergence-free synthetic eddy method of Polleto et al. (2013) are used to reproduce experimental inflow turbulence characteristics. The methodology is validated against open-source experimental datasets (Fontanella et al. 2021; Fontanella et al. 2024) making use of harmonic platform motions, allowing for high interpretability and generalisability of results. Comparison of the rotor loads, near wake and far wake behaviours demonstrates good agreement. These findings suggest the methodology is suitable for future investigations, such as the interplay between inflow turbulence and the platform-motion induced coherent structures, multi-turbine interactions, and informing dynamic corrections for lower-fidelity models.

References

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