Development and validation of an engineering model for floating wind turbines

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Introduction

The initial phase in the design of a floating platform for offshore wind deployment involves simulations of several configurations under different environmental conditions. Time-domain numerical tools, although accurate, can be computationally expensive if one needs to evaluate several floater designs. A quick, frequency-domain model (QuLA, Quick Load Analysis) for bottom-fixed offshore wind turbines has been recently developed at DTU Wind Energy [1]. Now, we have extended the QuLA model to a floating foundation: QuLAF. The tool is here benchmarked against a FAST [4] model of the same floating wind turbine, which has been validated against test data. The FAST model is also used for cascading, i.e. enhancement of the engineering model by using the state-of-the-art model. Once fully validated, QuLAF can become a reliable tool to be employed in the first stages of floater design, while more advanced, state-of-the-art codes can be used once the conceptual floater design is established.

Results

Response to regular waves

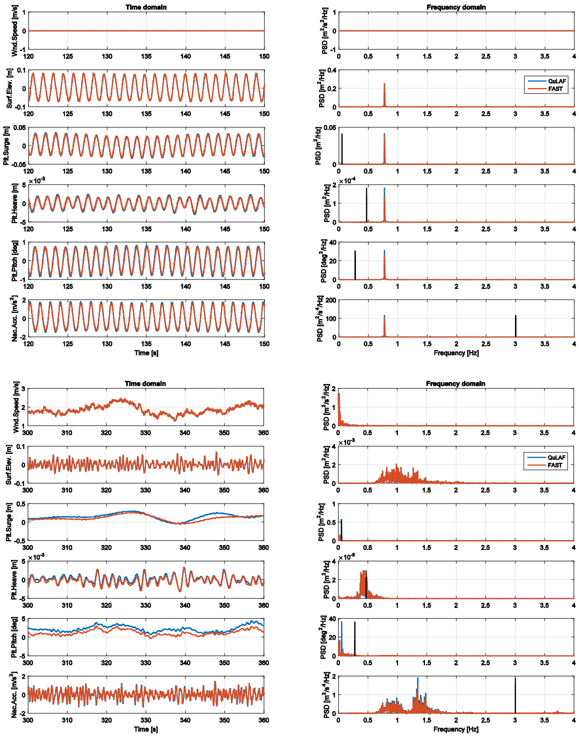
The response is dominated by the wave frequency.

There is a very good match in the response to regular waves for all degrees of freedom.

Response to irregular waves and wind

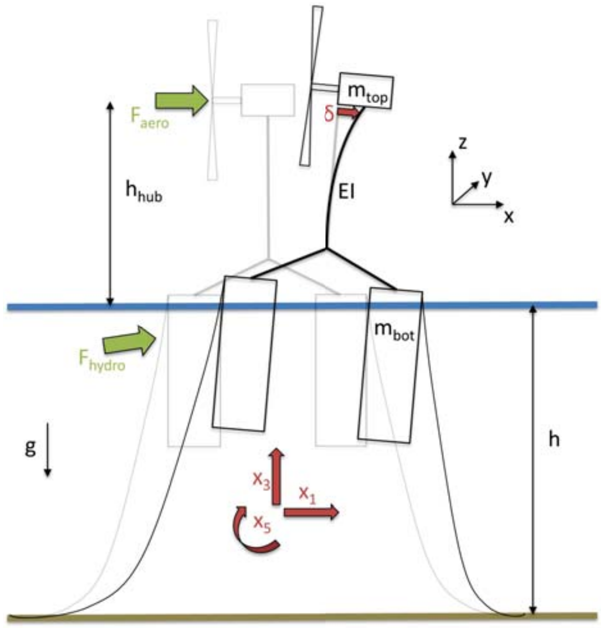
The response shows energy at the wave and wind frequency ranges, which are able to excite some of the system natural frequencies – marked for each DoF with a black line in the PSD plot.

The match is good, and it can be further improved by a better calibration of the hydrodynamic damping, which is part of the planned future work.



QuLAF model in a nutshell

- Linear, frequency-domain model
- Quick: ratio simulation time/CPU time up to 1000
- DTU10MW wind turbine on SWE-TripleSpar [2] floater, 1:60 scale
- 4 DoF: floater surge, heave, pitch and tower modal deflection
- EoM in frequency domain: $\left(-\omega^2\left(\boldsymbol{M}+\boldsymbol{A}(\omega)\right)+i\omega\boldsymbol{B}(\omega)+\boldsymbol{C}\right)\boldsymbol{x}(\omega)=\boldsymbol{F}(\omega)$
- Hydrodynamic loads extracted from diffraction-radiation solver WAMIT [3]
- Hydrodynamic viscous effects included through Morison drag term
- Aerodynamic loads precomputed with FAST for a fixed hub
- Aerodynamic damping extracted from free decay simulations in wind
- Mooring system linearized around equilibrium position



Literature cited

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