Dynamic response of a floating offshore wind turbine structure to extreme wave loading in nonlinear, directional seas.

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The large amounts of greenhouse gases set free by the use of fossil fuels have already a tremendous impact on the weather extremes. 2017 was one of the top three warmest years and, already, the start of 2018 is marked by extremely low temperatures on the whole East Coast of the US, caused by a so-called "bomb cyclone" (World Meteorological Organization, 2017, 2018). As further climate change puts our societies at risk, the transition to renewable energy resources must be fast. Due to its high resource availability and high technology readiness level, wind energy remains the most promising to facilitate this transition (Esteban et al., 2011; Green & Vasilakos, 2011). As offshore wind turbines are currently founded on the sea floor, their installation is limited to water depths smaller than 50m. In order to extend their application to deeper waters with larger wind energy potential, floating offshore wind turbines (FOWTs) are strongly recommended (Bilgili et al., 2011; Breton & Moe, 2009).

Currently, the design of FOWTs is solely based upon the elaborate experience from the oil and gas industry in designing floating rigs. As FOWTs are, due to their specific architecture, more susceptible to higher-order wave loading, the current design practices do not properly account for their hydrodynamic response to highly nonlinear extreme wave events. Also, as the current numerical models, which also stem from these proven practices, lack the ability to model these higher-order nonlinearities, they cannot fully represent the complex dynamic nature of FOWTs (Roald et al., 2013). Computational Fluid Dynamics (CFD) is able to overcome these difficulties and has shown to be promising in modelling wave loading on monopile-founded offshore wind turbines (Higuera et al., 2013; Jacobsen et al., 2008; Paulsen, 2013). Unfortunately, these CFD models remain computationally demanding in cases that imply large spatial and temporal domains and 3-D (mesh) motion, which are typical for the case considered.

Therefore, this doctoral research will contribute to a more safe and efficient FOWT design by improving the assessment of extreme wave loading on FOWTs. To this end, a one-way coupling between a higher-order spectral model, which represents the far-field where the wave field can attain its nonlinearity characteristic for extreme waves, and a 3-D CFD model, which models the near-field where the wave-structure interaction takes place, will be set-up. Additionally, this approach will be validated by experimental results.

Currently, an overset mesh approach is used to model the 3-D mesh motion. Although the first results are reasonable and come at an acceptable cost, they suffer from interpolation errors. Ultimately, a trade-off between accuracy and cost will be made out of several more approaches.

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