Thesis

Feasibility study of a stationary forecast system for offshore wind parks

Context

Due to the higher resource (faster and more regular wind) and minimized impact on human activities, more and more wind parks are installed offshore (for instance, see figure 1). The growing number of offshore wind parks leads to new challenges related to the cost

Figure 1: Wind park surrounding the research station FINO1 (North Sea) on May, the 12^{th}, 2021 at UTC 14:39:43.

and safety of wind turbine installation and maintenance operations. Indeed, wave-induced loads is a major driver for the motion of marine structures, making our capacity to perform offshore operations dependent on the wave conditions. Current planning methodologies of operations in offshore wind parks rely on the a priori quantification of the probability of extreme events, such as a crew transfer vessel being hit by a wave of high amplitude. However, wave predictions based on such *probabilistic* approaches are associated to a relatively high uncertainty, limiting companies in charge of wind parks management to operate during unreasonably calm conditions. Being able to provide real-time *deterministic* (wave-by-wave) predictions of the wave conditions would help to significantly increase their operational envelope and reduce the overall cost of offshore wind energy.

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Proposed topic

The main purpose of the topic is to state on the feasibility of a prediction system that continuously provides the wave conditions over a wind park in a deterministic way, i.e., in which the complete surface dynamics is represented, and not only the occurrence of extreme events such as given by probabilistic approaches.

Such deterministic predictions are typically achieved by means of X-band marine radar measurements of the ocean surface (e.g., Hilmer & Thornhill, 2015; Naaijen *et al.*, 2018), associated to a physical model representing the evolution of the wave field in space and time (e.g., Klein *et al.*, 2020; Desmars *et al.*, 2020) and providing predictions at the desired forecast horizon (see examples in figure 2). Based on the measurement capacities of marine

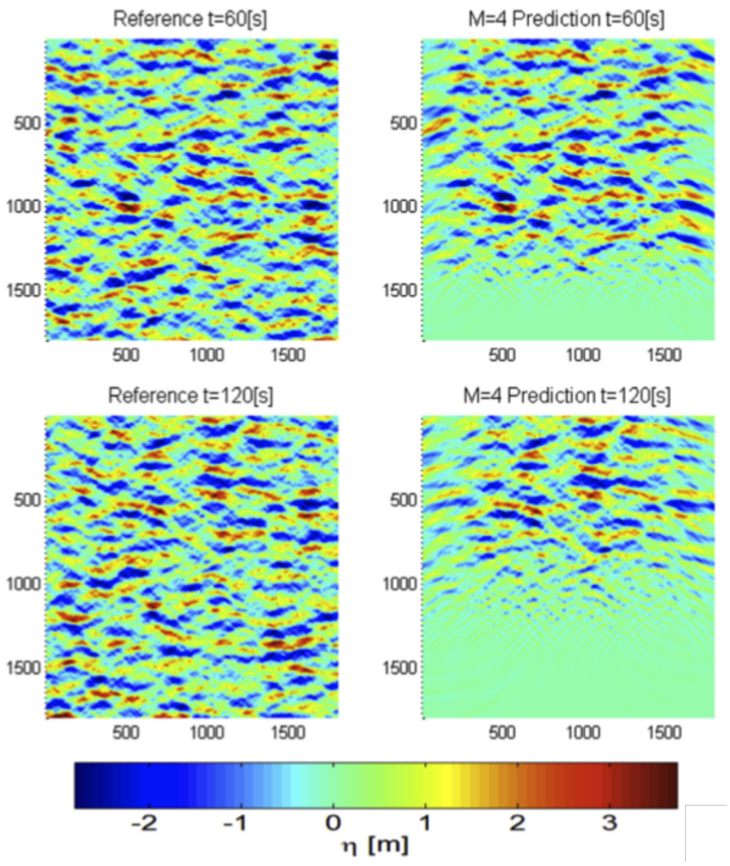

Figure 2: Examples of predicted surface elevations of a typical ocean wave field after 60 s and 120 s of propagation (Köllisch *et al.*, 2018).

radars, the characteristics of the prediction system will be investigated. More specifically, the optimal number and location of radar units, as well as the optimal measurement time will be of particular interest, with the objective of being able to know the incoming waves one to two minutes in advance at strategic points. In order to have a realistic application case, the study will be performed based on the characteristics of an existent offshore wind park. Most of the necessary theoretical background for this study consists in the calculation of the accessible prediction zone from a specific set of ocean wave measurements (Naaijen *et al.*, 2014; Qi *et al.*, 2018).

The scope of work covers the following tasks:

- Literature review of the state of the art;
- Definition of the optimization problem;
- Implementation of a resolution methodology using standard calculation tools (for instance Matlab/Python);
- Critical analysis of the results and technical reporting.

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