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Editorial: Offshore wind energy: Modeling and measurements

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Editorial on the Research Topic
Offshore wind energy: Modeling and measurements

Introduction

The global offshore wind industry is growing with unprecedented speed. The Global Wind Energy Council has raised its outlook for 2030 to a total of 316 GW installed for offshore wind (Lee and Zhao, 2022). Over the sea basins, we see wind farms and clusters getting increasingly larger, turbines becoming taller, and floating wind turbines moving from the demonstration phase to the pre-commercial phase and being installed in deeper waters. The increase in size raises a series of challenges to the fundamental science and technologies that have been calibrated and applied to smaller turbines, small wind farms, and simpler systems. Thus, for the modeling of wind turbine and farm wake effects, we are facing the challenge of having both high fidelity and large coverage. For modeling turbulence, we need to break through the classical boundary layer turbulence theories by considering large-scale atmospheric variability. For grid integration and system control, we need to advance our tools to handle big data. For floating turbines and farms, we need to take the complicated sea and ocean conditions into account, as well as the multiscale atmospheric flow effects. Additionally, we need to understand how the new seascape in the presence of wind farms affects the overall offshore environment. The rapid success of the offshore wind industry leaves us little time to identify knowledge gaps, speed up relevant research, and catch up technologically to accommodate efficient, effective, and healthy offshore wind development.

Published papers

The studies featured in this Research Topic allow us to examine the research on offshore wind energy development across several continents, including Asia, Africa, America, and Europe. The papers cover many of the most relevant subjects, including wind resource and energy management for bottom-fixed and floating turbines.

The subject of wind resource assessment has been addressed by Shi et al., Raghukumar et al., and Fischereit et al. Shi et al. provided a systematic review of wind speed distribution functions, and through an automatic workflow and the application of evaluation criteria, the best distribution function can be found for a special regime, e.g. a complex coastal site. Raghukumar et al. used the Weather Research and Forecasting (WRF) model (Skamarock et al., 2008) to examine wind resource in the northwesterly winds along the California offshore waters in the presence of virtual floating wind farms. They simulated data over a 13-year period. Fischereit et al. used a wind-wave coupled modeling system through the WRF and the wave model Simulating Waves Nearshore (SWAN) (Booij et al., 1999) and simulated a selection of approximately 180 days that represented 30 years worth of wind and wave conditions in a selected region in the North Sea. Fischereit et al. modeled the wind reduction caused by the actual wind farms in the region and validated the results using a large collection of measurements. Both Raghukumar et al. and Fischereit et al. analyzed the effect of offshore wind farms on environmental conditions, such as temperature and precipitation.

While both Raghukumar et al. and Fischereit et al. mentioned the effects of wind farms on the ocean and waves, Raghukumar et al. pointed out the possible effect on ocean upwelling in the coastal waters of California, whereas Fischereit et al.'s simulation showed the climatological effect of the existing wind farms on significant wave height.

The wind farms featured in Raghukumar et al. used floating turbines due to the depth of the water in the study area. The fundamental dynamics of actual floating turbines were investigated by Wei et al., who proposed a dynamic response calculation method for floating turbines. This method decouples the transfer function and converts the decoupled functions to a series of state-space models, thus transforming the problems related to dynamic response calculations to obtain the outputs of the estimated state-space models. This method was applied to a spar-type floating turbine and showed high computational accuracy and efficiency.

Zhen-Zhou et al. established a simplified vibration model of a converter valve with constant key physical parameters to reduce model complexity and increase calculation efficiency. The study used machine learning and deterministic screening experimental design. This new model simplified the original complex model by 95%, with errors for various parameters below 5%.

Artificial Intelligence and machine learning are also becoming very handy tools for forecasting wind power generation and power demand in grid-connected wind energy systems. Jamii et al. proposed an artificial neural network-based paradigm to predict wind power generation (short-term and medium-term). The performance was compared with several machine learning methods and was highly effective and accurate. Altogether, we hope that readers will find the papers in this Research Topic useful for getting an overall idea of the broad subjects regarding offshore wind energy.

Author contributions

XL drafted the paper, reviewed by JS, AR and JL.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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