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# Wind-wave-wake interactions in offshore wind farms

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Offshore wind farms are exposed to a dynamic environment where the interactions between wind and waves modify wind resources. By extracting energy from the flow, wind farms alter these interactions and traditional wind resource assessment usually simplifies or ignores the interactions between wind and waves. However, in recent years some progress has been made in properly considering these interactions. In this presentation, we will highlight the relevance of these wind-wave-wake interactions for wind energy applications by summarizing the findings of two studies.

First, we show which role these interactions play in tropical cyclone development. For that, we use Typhoon Megi, a category 5 cyclone that hit Taiwan in late September 2016, as an example. Second, we demonstrate the relevance of wind-wave-wake interactions for resource assessment. We use a statistical-dynamical downscaling approach to represent the 30-year climate in the German Bight and assess the impact of waves and wakes on wind resources (Fischereit et al. 2022).

For both studies, we use the Coupled-Ocean-Atmosphere-Wave-Sediment Transport Modeling System (COAWST; Warner et al. 2008, 2010). In this modelling system, we activate the atmospheric model WRF (Weather, Research and Forecasting model) and the wave model SWAN (Simulating WAves Nearshore model) . We apply the Wave Boundary Layer Model (WBLM; Du et al. 2017, 2019) to ensure that the exchange of flux and energy between these two models are consistent. To derive the range of possible wind farm effects, we use two different wind farm parameterizations (WFP) in the simulation, namely the WFP by Fitch et al. (2012) and the Explicit Wake Parameterization (EWP) by Volker et al. (2015).

The studies show that wind-wave-wake interactions influence wind resources, and that they also affect the intensity and track of a typhoon. This highlights that these interactions should be considered in wind energy applications.