Abstract

The X-WiWa project was motivated by Denmark's long term vision for offshore wind energy and the many technical and scientific challenges in existing methodologies for assessing the design parameters, for both winds and waves.

X-WiWa succeeded in developing a most up-to-date modeling system for wind modeling for offshore wind farms. This modeling system consists of the atmospheric Weather Research and Forecasting (WRF) model, the wave model SWAN and an interface the Wave Boundary Layer Model WBLM, within the framework of coupled-ocean-atmosphere-wave-sediment transport modeling system COAWST (Hereinafter the WRF-WBLM-SWAN model). WBLM is implemented in SWAN, and it calculates stress and kinetic energy budgets in the lowest atmospheric layer where the wave-induced stress is introduced to the atmospheric modeling. WBLM ensures consistent calculation of stress for both the atmospheric and wave modeling, which was considered a major improvement to previous attempts in the literature. This methodology thus provides an option to avoid the parametrization of an often used interface parameter, the roughness length. Many parametrization schemes for the roughness length have brought diverse estimates and associated uncertainties to the modelled wind speed. Data validation using measurements from the Baltic Sea and North Sea around Denmark suggests that the coupled modeling system WRF-WBLM-SWAN outperforms the non-coupled, no-wave, WRF modeling of wind; an improvement by 10% or more is present at strong winds, which can affect the choice of the offshore wind turbine type.

X-WiWa examined various methodologies for wave modeling. The offline coupling system using atmospheric data such as WRF or global reanalysis wind field to the MIKE 21 SW model has been improved with considerations of stability, air density, currents and new wind drag relations. X-WiWa suggests that, implementation of an online coupling technology does not necessarily provide better estimation of the waves, if the physics have not been properly described. This is supported by the comparisons of the modeled wave data between offline MIKE 21 SW modeling and the WRF-WBLM-SWAN modeling. The two provide comparably good wave calculations for coastal areas but the latter underestimates the wave height for far offshore areas, which is speculated to be related to the dissipation description in the wave source functions, where further improvement is seen necessary.

X-WiWa puts modeling efforts on storms that are defined to be contributors to the extreme wind and extreme significant wave height through the annual maximum method. Thus for 23 years from 1994 to 2016, 429 storm days are simulated for the extreme wind, and for 1994 to 2014, 932

storm days are simulated for the extreme significant wave height. The 50-year winds at 10 m, 50 m and 100 m over the waters around Denmark are calculated and validated and agreement is satisfactory. The 50-year significant wave height for the Danish waters and surrounding North Sea and Baltic Sea are presented from the online and offline systems.

The modeling systems, data, analysis, results and publications are introduced and provided on www.xwiwa.dk. These outputs are expected to be useful for general offshore wind and wave applications such as Operation and Maintenance, Forecasting, and Design.