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Directional Calibrated Wind and Wave Reanalysis Databases using Instrumental Data for Optimal Design of Off-Shore Wind Farms

Roberto Mínguez, Antonio Espejo, Antonio Tomás, Melisa Menéndez, Fernando J. Méndez, and Inigo J. Losada
Universidad de Cantabria, Environmental Hydraulics Institute, Spain (roberto.minguez@unican.es)

Wind energy is recognised as a proven technology to meet increasing electricity demands in a sustainable and clean way. Offshore wind energy has the additional advantage that it has minimal environmental effects and, the best resources are reasonably well located relative to the centres of electricity demand. For these reasons it is expected that an important part of the future expansion of wind energy utilisation at least in Europe will come from offshore sites. However, the economic viability of offshore wind farms depends on the favourable wind conditions compared to sites on land, compensating the additional installation and maintenance costs. For project planning and sitting, especially for large projects, a reliable prediction of the wind resource and wave climate is therefore crucial. This would allow, for a given electricity network configuration at a particular site, and considering maintenance and repair equipments, to evaluate the probability distribution function of the energy evacuated during lifetime based on component failure simulation methods. This analysis is crucial to make an economic study and a framework to establish the optimal or best i) location, ii) electrical configuration and/or iii) maintenance and repair strategy for off-shore wind farms.

For this task to be plausible, the knowledge about both wind and wave conditions at different wind sites is required. In this work, two new wind and wave reanalysis data bases (W2RDB) developed by the University of Cantabria are presented. They offer important advantages for the statistical characterization of wind sites (continuous time series, good spatial coverage, constant time span, homogeneous forcing, more than 40 year-long time series) and for this reason, they are a powerful tool for the design of offshore wind farms. However, W2RDB are not quantitatively perfect and corrections using instrumental observations must be addressed before they are used, this process is called calibration. The calibration is especially relevant near the coast and in areas where the orography is complex, since in these places the inaccuracy of W2RDB is evident due to the insufficient forcing resolution. The quantitative differences between numerical and instrumental data suggest that different corrections should be applied depending on the mean direction of wind and waves, respectively. This work focuses on the calibration performed based on a nonlinear regression problem where the corresponding correction parameters vary smoothly along the possible mean wave directions by means of cubic splines. The correction of wind velocity and significant wave height is performed using instrumental data: i) buoy records and/or ii) satellite data. The performance of the method is illustrated considering data from different locations around Spain.