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Optimizing the analog ensemble for probabilistic wind power forecasting at four on and offshore wind farms

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Ensemble forecasts allow the quantification of forecast uncertainties and the definition of risk indices associated with the prediction. Both can be of great value for wind energy applications. Information on the prediction uncertainty can support the decision-making process related to the operational management of a wind farm, and can also be the basis for defining optimal trading strategies in liberalized electricity markets to reduce penalties related to regulation costs.

Since ensemble meteorological forecasts are subject to systematic errors and spread deficiencies, several methods have been developed for calibrating ensemble wind predictions [e.g. univariate Ensemble Model Output Statistics (EMOS; Thorarinsdottir and Gneiting, 2010); adaptive bivariate calibration (AUV; Pinson, 2012)]. These methods have shown to outperform other state-of-the-science methods for calibrating ensemble-based wind predictions (Junk et al., 2014). Recently, Delle Monache et al. (2013) have proposed the analog ensemble (AnEn) method to generate an ensemble forecast from a purely deterministic prediction. By design, the analog ensemble method is a very efficient downscaling approach that can significantly reduce forecast errors and can generate reliable ensemble estimates.

In this study, we explore static- and dynamic-weighting approaches for an optimized predictor selection to improve the AnEn for short-term probabilistic forecasts of wind power. We use several predictors from deterministic forecasts of the ECMWF Integrated Forecast System such as wind speed, direction and temperature at several model heights in the atmospheric boundary layer, sea level pressure and boundary layer height. The weighting approaches are applied to several wind farms with different characteristics (e.g. offshore, hilly and mountainous environments). The AnEn is also compared to EMOS and AUV wind power ensembles that are based on 10-m and 100-m ECMWF 51-member ensemble wind forecasts. The uncalibrated ensemble forecasts are calibrated with observed wind time series and transformed to wind power applying a derived neural network.

The probabilistic skill of the AnEn increases considerably when applying static- and dynamic-weighting approaches compared to taking 10-m or hub height wind speed and direction as predictors, particularly at wind farms located in areas with complex topography. At the onshore sites, AnEn outperforms EMOS and AUV ensemble wind power forecasts. At offshore sites, the AnEn shows similar forecast skill as EMOS and AUV wind power ensembles particularly for intraday and day-ahead forecast horizons.