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Probabilistic regional wind power forecasts based on calibrated Numerical Weather Forecast ensembles

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With increasing shares of installed wind power in Germany, accurate forecasts of wind speed and power get increasingly important for the grid integration of Renewable Energies. Applications like grid management and trading also benefit from uncertainty information. This uncertainty information can be provided by ensemble forecasts. These forecasts often exhibit systematic errors such as biases and spread deficiencies. The errors can be reduced by statistical post-processing.

We use forecast data from the regional Numerical Weather Prediction model COSMO-DE EPS as input to regional wind power forecasts. In order to enhance the power forecast, we first calibrate the wind speed forecasts against the model analysis, so some of the model's systematic errors can be removed. Wind measurements at every grid point are usually not available and as we want to conduct grid zone forecasts, the model analysis is the best target for calibration.

We use forecasts from the COSMO-DE EPS, a high-resolution ensemble prediction system with 20 forecast members. The model covers the region of Germany and surroundings with a vertical resolution of 50 model levels and a horizontal resolution of 0.025 degrees (approximately 2.8 km). The forecast range is 21 hours with model output available on an hourly basis. Thus, we use it for shortest-term wind power forecasts. The COSMO-DE EPS was originally designed with a focus on forecasts of convective precipitation.

The COSMO-DE EPS wind speed forecasts at hub height were post-processed by nonhomogenous Gaussian regression (NGR; Thorarinsdottir and Gneiting, 2010), a calibration method that fits a truncated normal distribution to the ensemble wind speed forecasts. As calibration target, the model analysis was used.

The calibration is able to remove some deficits of the COSMO-DE EPS. In contrast to the raw ensemble members, the calibrated ensemble members do not show anymore the strong correlations with each other and the spread-skill relationship improves significantly.

The deficits of the raw ensemble weather prediction such as a bad spread-skill relationship and high correlation of members propagate to the power forecast, even when the simulated wind power is aggregated over the whole grid zone.
By using the calibrated ensemble for production of the power forecasts, we are able to increase the probabilistic reliability of the resulting probabilistic wind power forecasts. The ensemble members are better distinguishable than before.

Our results show the possibility of using an Ensemble Prediction System, that was designed with a focus on probabilistic precipitation forecasts, for wind power forecasts. In order to gain reliable probabilistic wind power forecasts, it was first necessary to conduct a statistical post-processing of the ensemble forecasts.

References:

Thorarinsdottir, T., and T. Gneiting (2010), Probabilistic forecasts of wind speed: ensemble model output statistics by using heteroscedastic censored regression, Journal of the Royal Statistical Society: Series A(Statistics in Society), 173(2), 371–388.