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Non-parametric kernel estimation of conditional probability distribution functions applied to wind energy production forecasts

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Classical forecasting techniques of wind energy production mostly rely on local non-linear regression (often with gaussian errors hypothesis) or local quantile regression between electricity production at a given site and corresponding wind speed forecasts provided by a dynamical meteorological model.

Non-parametric kernel estimators are simple and powerful statistical tools that allow estimate directly the full conditional probability distribution functions (cpdf) of energy production at a wind farm, given the wind speed forecasts of a meteorological model, without making any assumption about the shape of the underlying laws. Moreover, those estimators provide a flexible framework for ensemble forecasts outputs, compared to Bayesian Model Averaging, where parametric estimations are used.

Our dataset consists of 24 months of hourly electricity production measurements at a wind farm in Roussillon region (south of France) along with the corresponding wind speed forecasts provided by the deterministic ALADIN high resolution weather model and ARPEGE PEARP ensemble forecasts (METEO-FRANCE). Those data are available through ENSEOLE national project.

We compare three different strategies: given the provided wind speed forecast or ensemble of forecasts, we may use the most probable value of the corresponding estimated cpdf of electricity production, or its conditional expectation (obtained by integration of the cpdf, which is roughly equivalent to regression). The third tested approach relies on the simplified economical model proposed by Roulston et al. (Re-

newable Energy, 2003). The production forecast is the value that maximises the conditional expectation of a given economical utility function, provided the estimated cpdf.

We show that in terms of RMSE, the production forecasts provided by the conditional expectation of the cpdf are better, but in terms of economical performance, the economical utility approach gives better results.

The economical benefits of ensemble versus deterministic wind speed forecasts are also assessed.