A Probabilistic Approach to Forecast Ramps of Wind Power Production using Ensembles

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Context

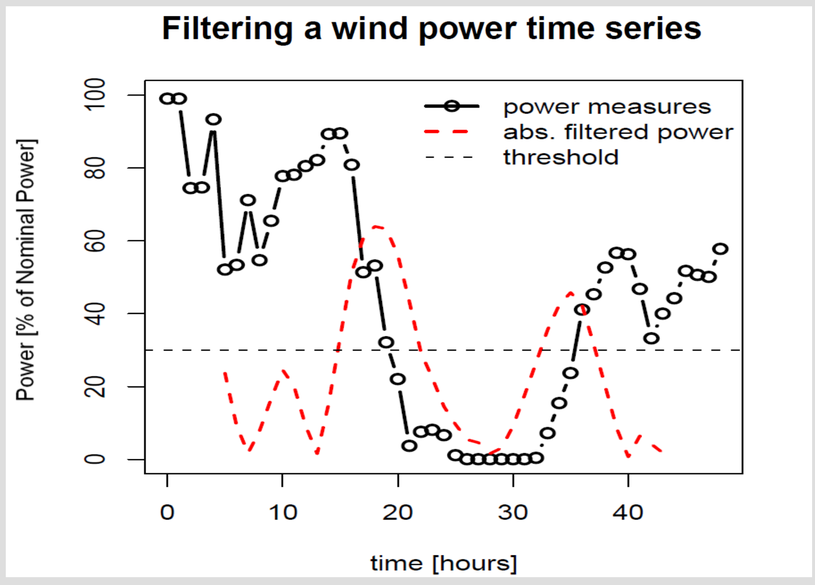
To ensure economic and secure operations of power systems with high wind penetration, accurate predictions of wind power production are necessary. In situations of high and steep variations of wind power production, the need for reliable forecast information is paramount since in such situations, forecast errors can turn into large energy imbalances. Forecasts related to their characteristics (timing, magnitude, ramping rate…) should be helpful in selecting the appropriate balancing options among storage, demand response or fast-ramping conventional plants.

Objectives

- ✓ Detecting and characterizing high and steep variations (e.g. ramps) in wind power production.
- ✓ Developing an approach to forecast ramp characteristics from Numerical Weather Prediction ensembles. Investigating the skill of ensembles in forecasting ramps of wind power production.

Methodology

To detect ramps of wind power production, we use a **linear filtering approach**. The most significant changes in power production are then determined through appropriate **thresholding**. Local extrema in the filtered production provide the characteristics of ramps: **support**, **intensity** and **timing.**



Transfering this approach to an ensemble of forecast time series makes it possible to get an ensemble of forecast characteristics and then, to forecast the uncertainty in the occurrence of ramps.

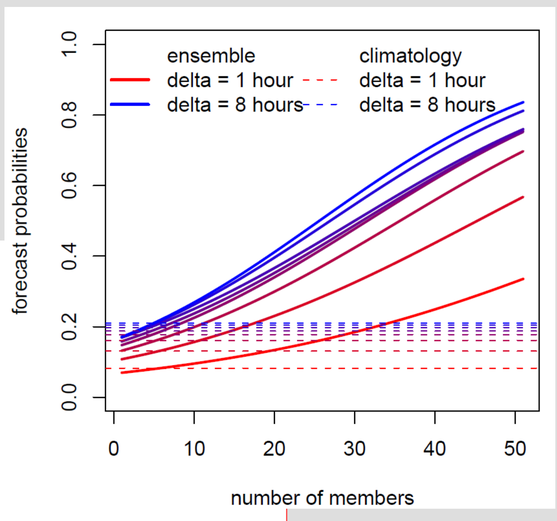
1. **Converting** NWP ensembles into power ensembles
2. **Filtering & Thresholding** the forecast time series
3. **Clustering & Averaging** the ensemble of forecast characteristics
4. **Forecasting** the temporal uncertainty in ramp occurrence

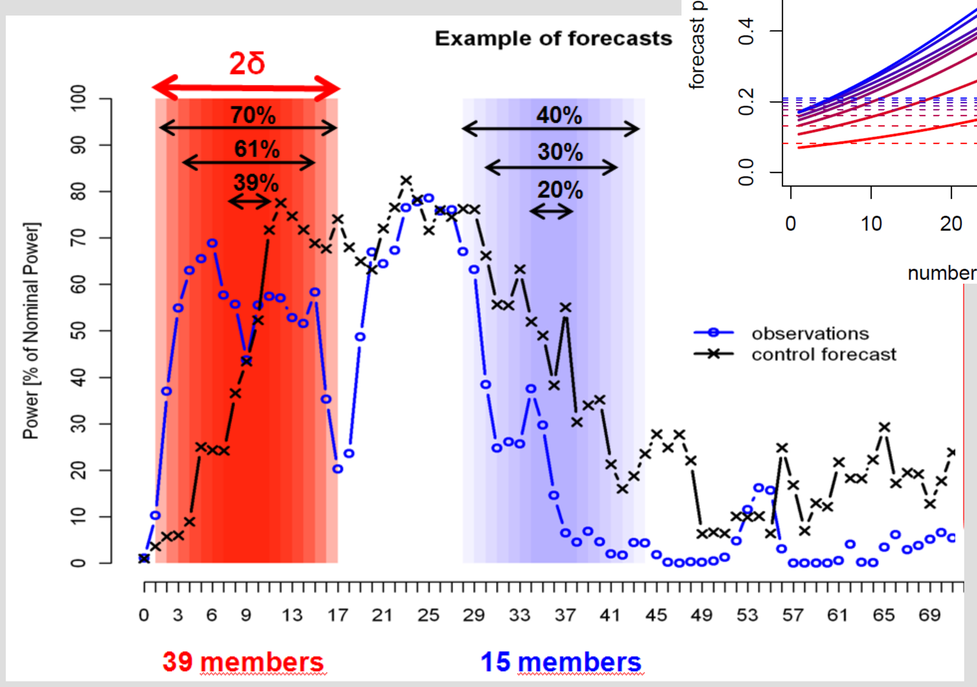
Case-study

- ✓ Power measurements from SCADA systems of 3 French wind farms, covering the period between July 2004 and Decembre 2005.
- ✓ NWP ensembles of 51 members derived from the EPS of ECMWF. Wind speed and direction converted into power forecast ensembles using the *Random Forest* machine learning algorithm.
- ✓ Ramp occurrence probabilities estimated using 2 alternative models: a Nadarya-Watson estimator with tricube kernel and nearest-neighbors procedure, and a logistic model.

Results

- ✓ The ensembles outperform the control forecast in terms of ramp capture without necessarily providing a better ramp capture/forecast accuracy tradeoff.
- ✓ Forecast probabilities of ramp occurrence are reliable. Results show that the probability to observe a ramp in prediction intervals increases with the number of ensemble members forecasting the ramp.





Conclusions & Perspectives

- ✓ We developed an approach to forecast the occurrence and characteristics of high and steep variations in wind power production from numerical weather predition ensembles, with associated uncertainty.
- ✓ The use of ensembles allows to better capture such variations and provides reliable and situation-specific probability forecasts of ramp occurrence.
- ✓ A further characterization of ramps based on multi-scale edge detection techniques should make it possible to improve such an approach.

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