



# SafeWind

Wind Power Forecasting with Focus on Extremes

Workshop, Palais Brongniart, 31.08.12, Paris

## New statistical approaches with consideration for extremes

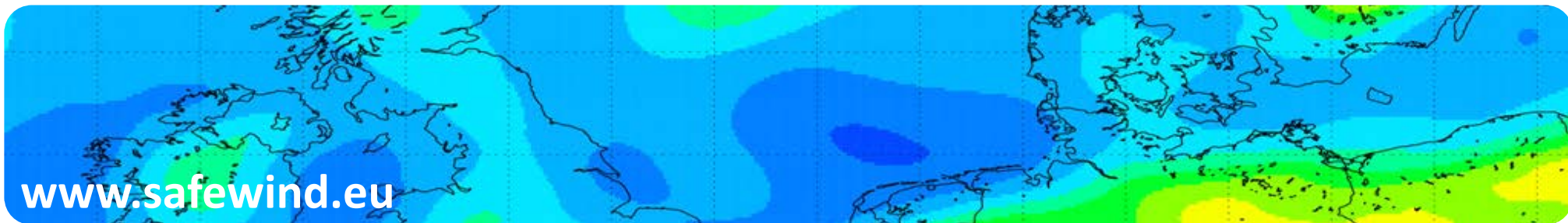
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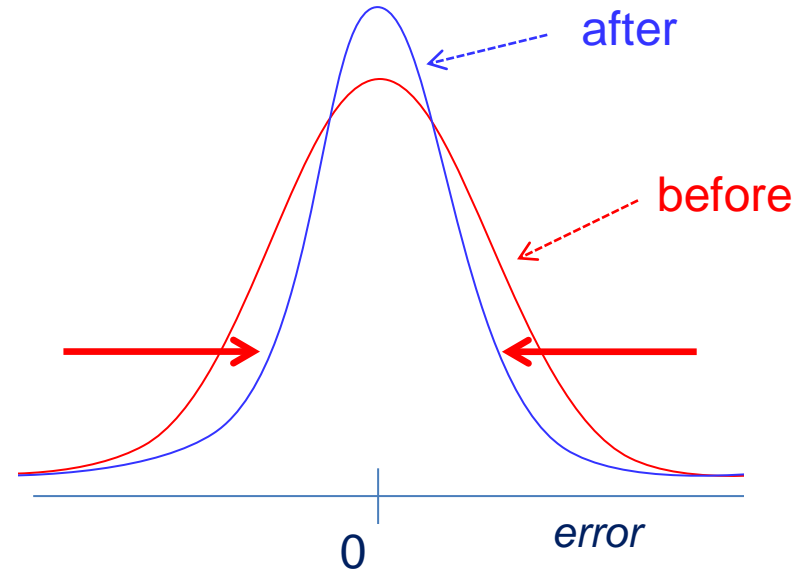
[www.safewind.eu](http://www.safewind.eu)



- Background, vision and objectives
- Some of the key advances:
  - Spatio-temporal analysis and correction of forecasts
  - Scenarios
  - Event-based view of the forecasting problem (ramps, cut-offs, etc.)
  - Regimes and forecast combination for error reduction
- Perspectives

- Distributions of forecast errors are often be seen as wide and heavy tailed...

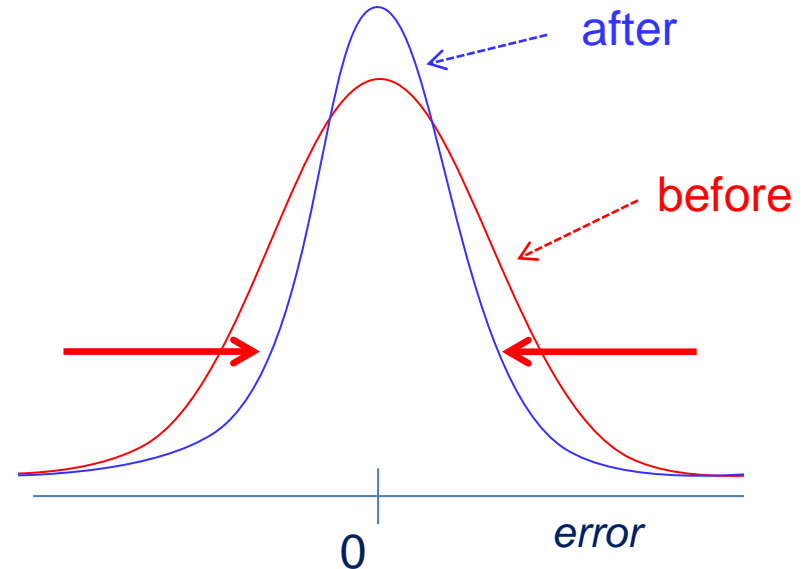
- Need to **reduce variance** (hence RMSE of point forecasts)
- Need to “**cut the tails**” (extreme events)



- But also, forecasts do not inform about important operational aspects
  - **Reliable uncertainty** information
  - **Clear message** on specific type of events, as well as their timing
  - Further development of state-of-the-art ideas and proposal of new concepts!

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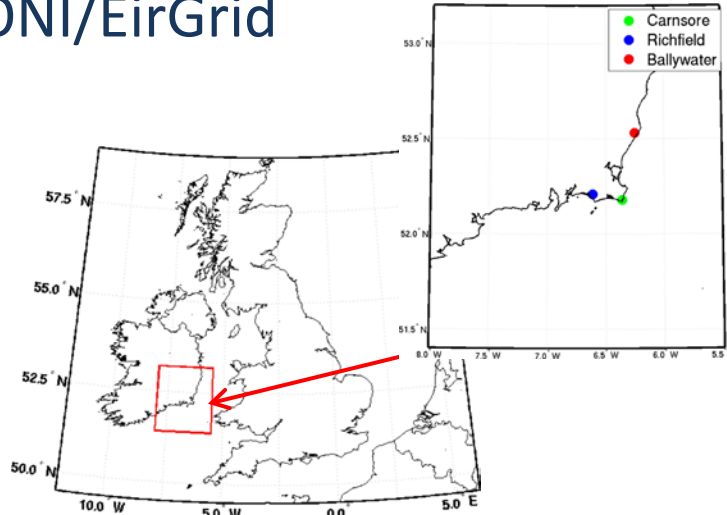


- But also, forecasts **do not** inform about important operational aspects
  - **Reliable uncertainty** information
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• Energinet.dk



• SONI/EirGrid



• France: EDF/RTE



• PPC



• India



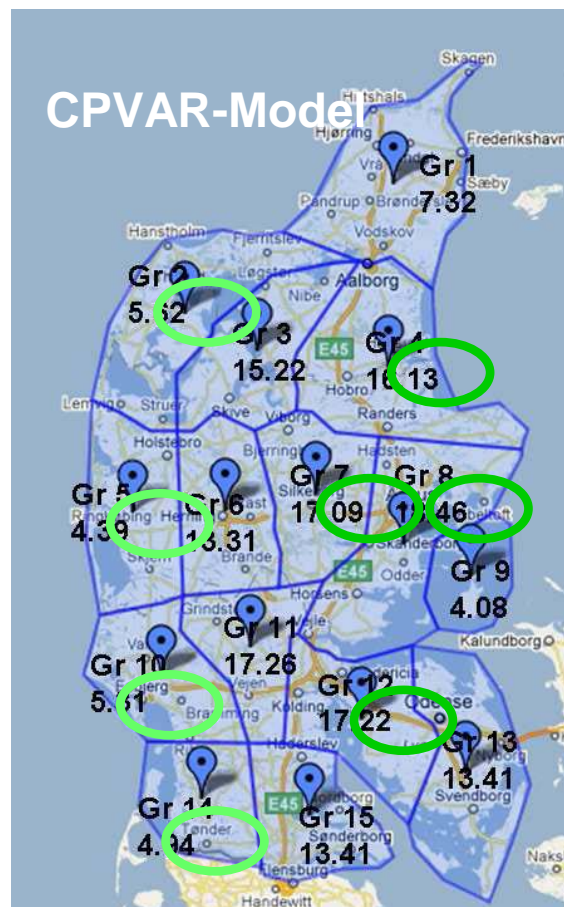
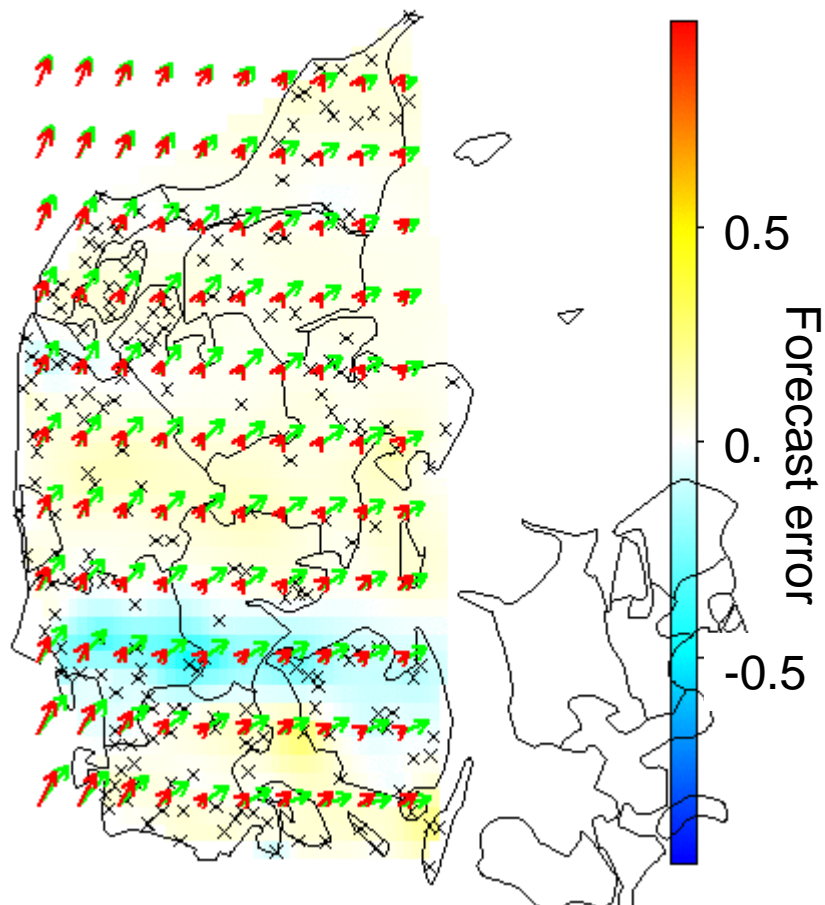


# Spatio-temporal aspects

## Spatial Interpolation of forecast error

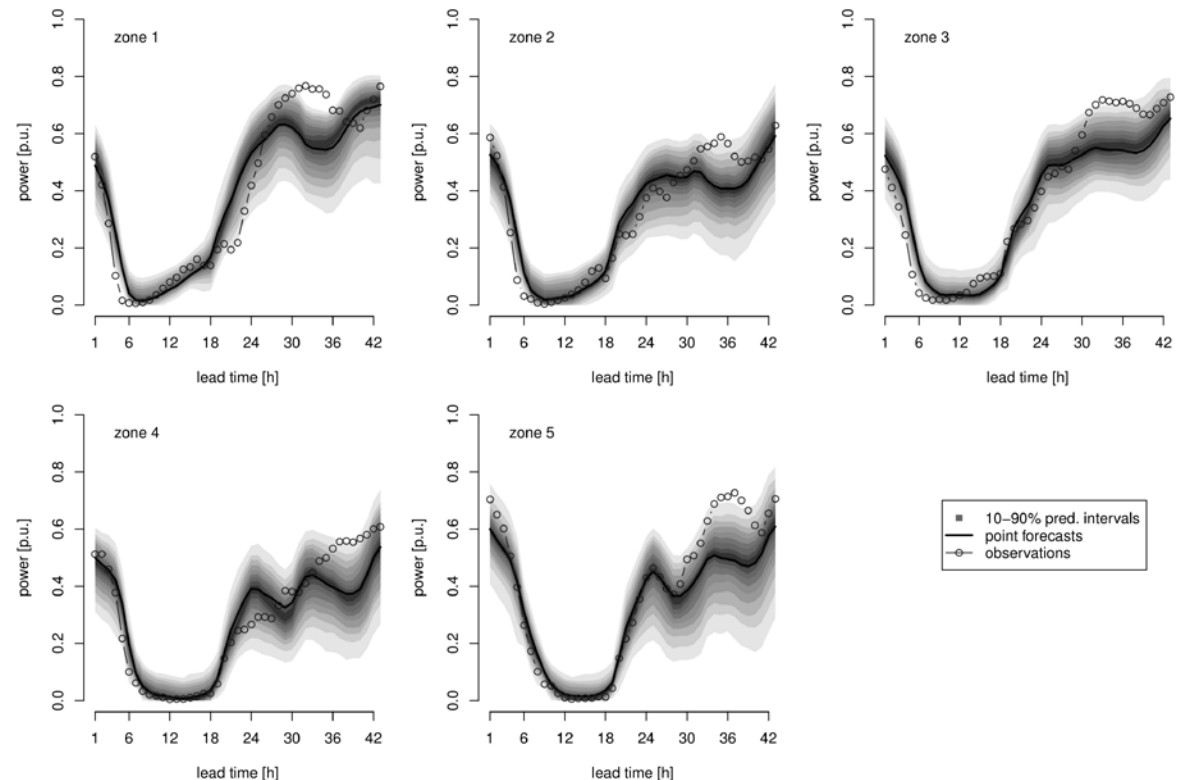
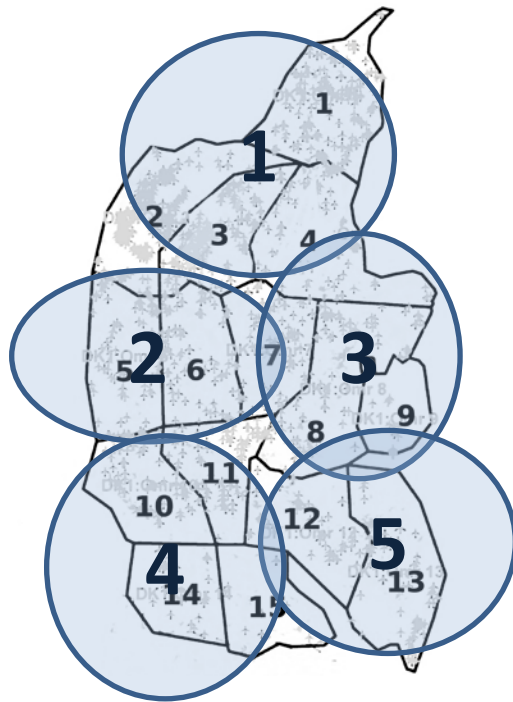
Date: 2007-01-11 08:00:00 GMT

Look ahead time: 15 minutes



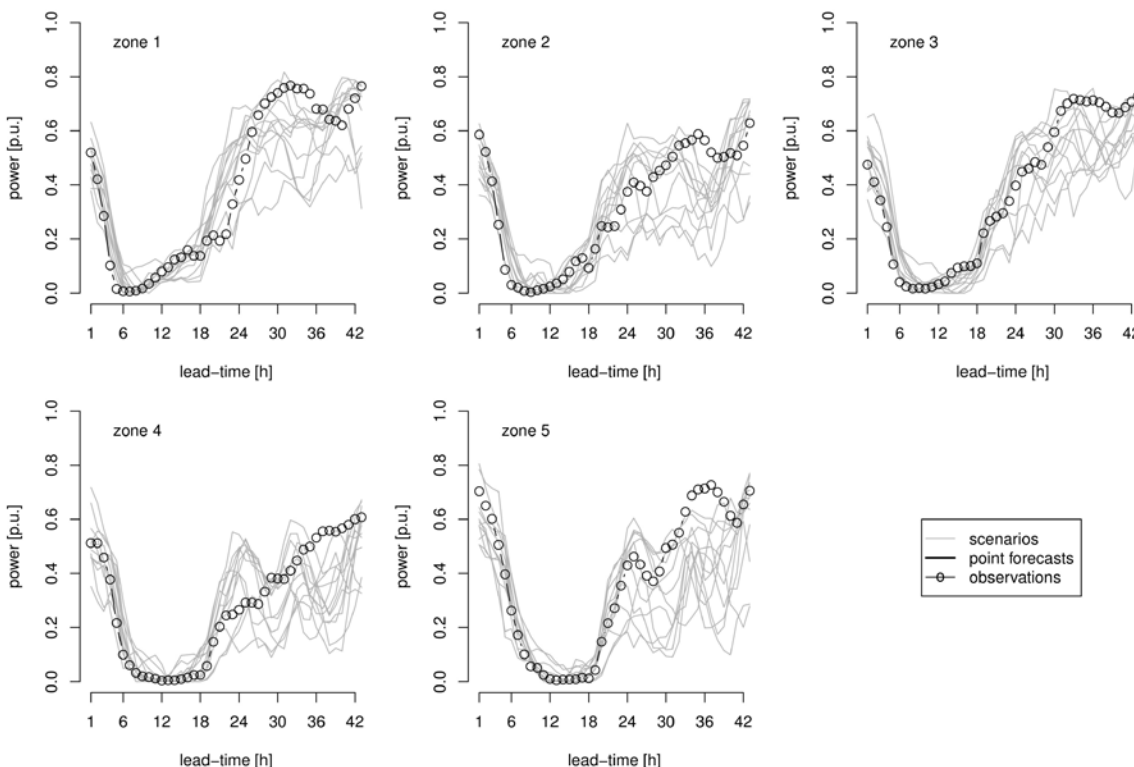
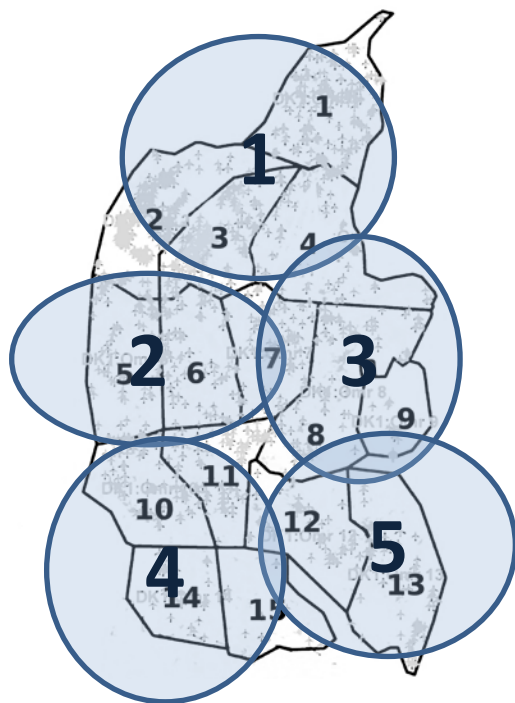
Reduction of forecast error (RMSE) up to 18%  
on the regional scale (1-5 hours ahead)

- Large emphasis placed on developments of probabilistic forecasting methods
  - Parametric and nonparametric
  - Statistical and artificial-intelligence based approaches (with point forecasts, meteorological information and new explanatory variables as input)



# Scenarios of short-term power production

- The **most complete input to decision-making** algorithms, also informing of relevant space and time correlations, based on
  - Point forecasts and past measurements
  - Probabilistic forecasts
  - Ensemble predictions



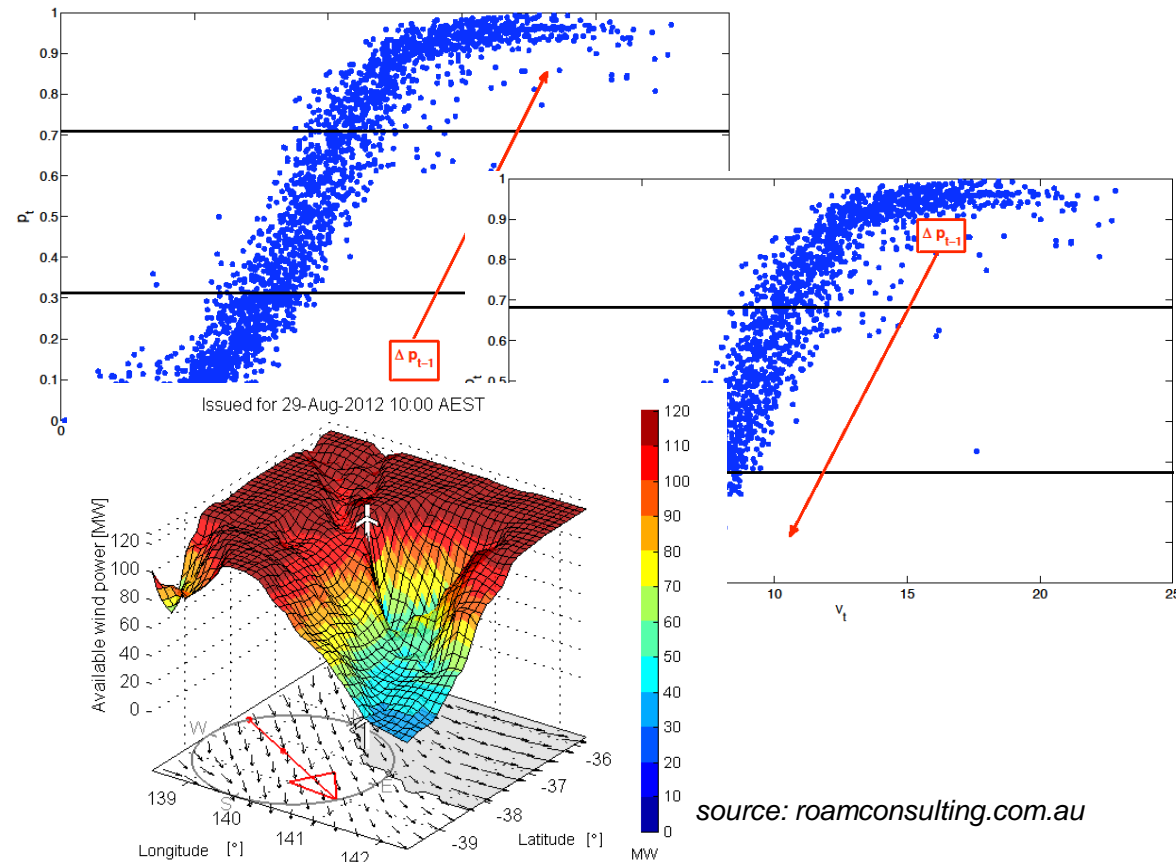


- Regarding **probabilistic forecasting**, proposal and evaluation of
  - New probability distributions
  - A set of rival (semi-)parametric approaches
  - New approaches to go from wind to power
  - New artificial-intelligence based techniques
  - Alternative explanatory variables for improving the skill of forecasts
- Resulting in
  - **Better description** of distribution tails (parametric approaches)
  - Overall **better calibration** of probabilistic forecasts
  - **Skill improvements** up to 15-20%
- For **scenarios**
  - **Overall methodology** for space-time scenarios
  - Proposal of standard **verification framework**
  - **Benchmarking/comparison** of statistical and ensemble-based approaches

- Both meteorological and mechanical aspects make that the dynamics of power generation may suddenly change

- Extensive analysis was performed to

- Better understand **time-series dynamics** themselves
- Finding **new variables** allowing to foresee change in dynamics, potentially offsite
- Regime** information in meteorological fields

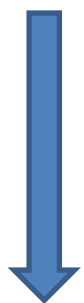


- *Example:*

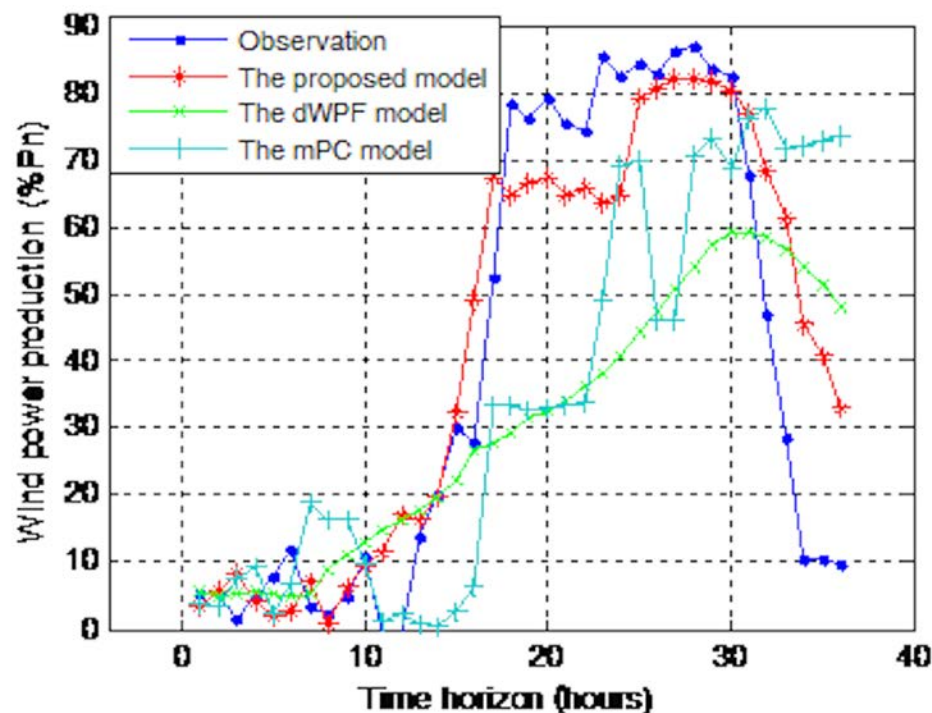
getting sharper forecasts of sudden changes in power production

- Main results:

0h  
6h  
48-72h



- Modeling of regimes in time-series dynamics provided insight and forecast **improvements of 5-10% (RMSE)**
- Including offsite information in regime modelling, though more complicated, also gave some additional percent improvements (very short lead times)
- Regime information from meteorological fields yielded **15% improvements (RMSE)**

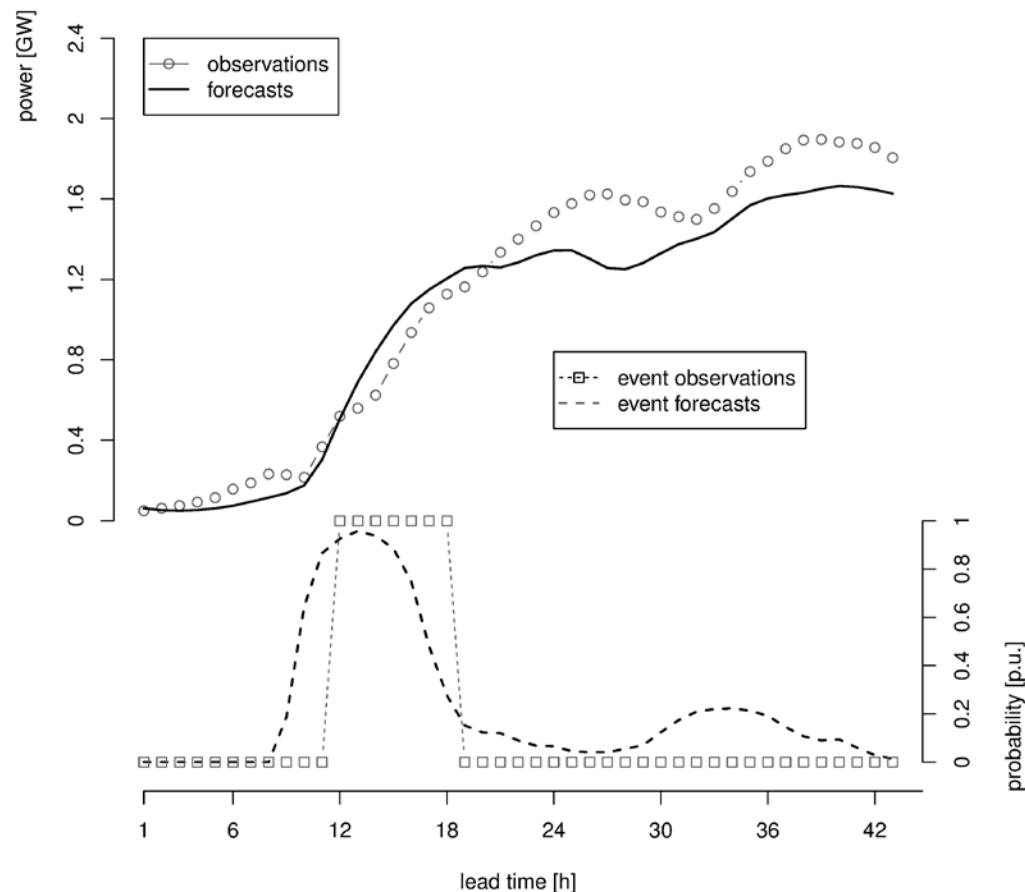


- New paradigm in wind power forecasting, though quite common in climate and meteorological forecasting

- Events of interests are

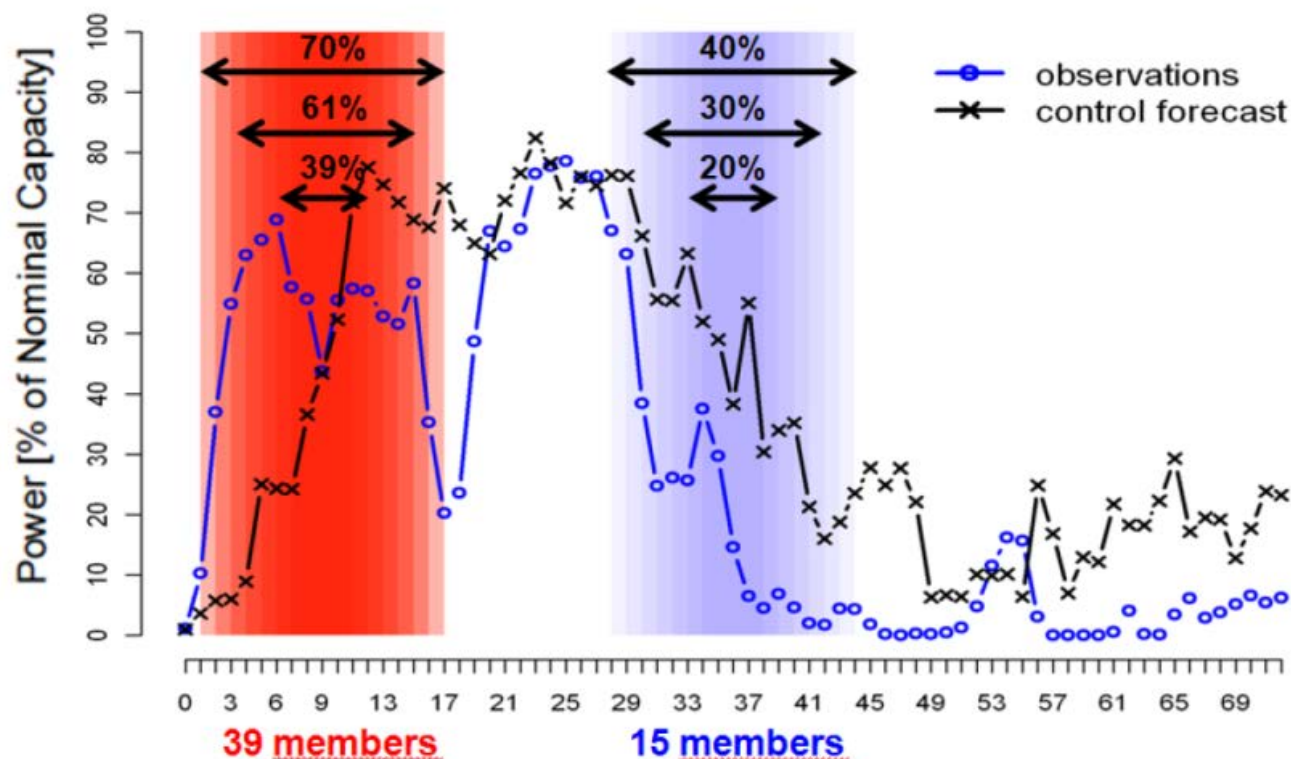
- Ramps
- Cut-offs
- High-variability

- Working with events has a lot of advantages!



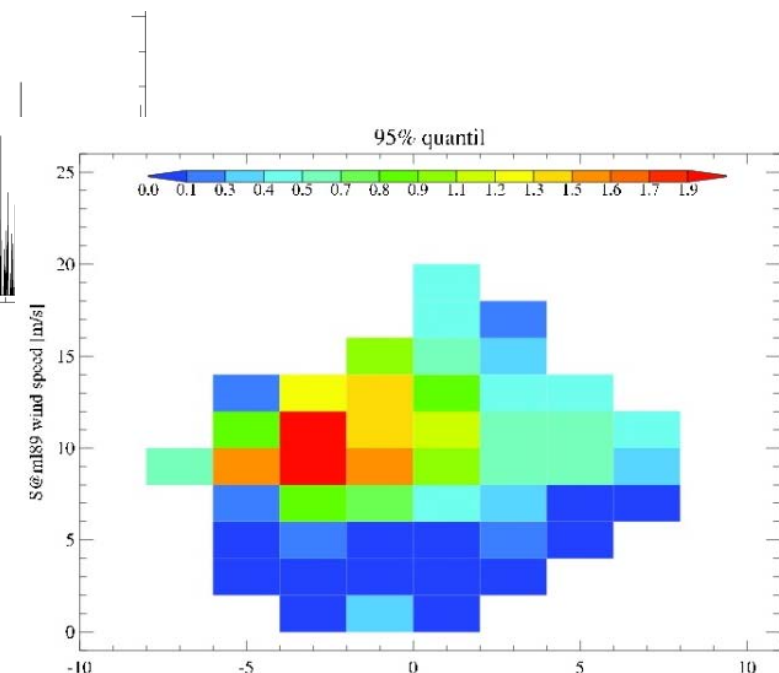
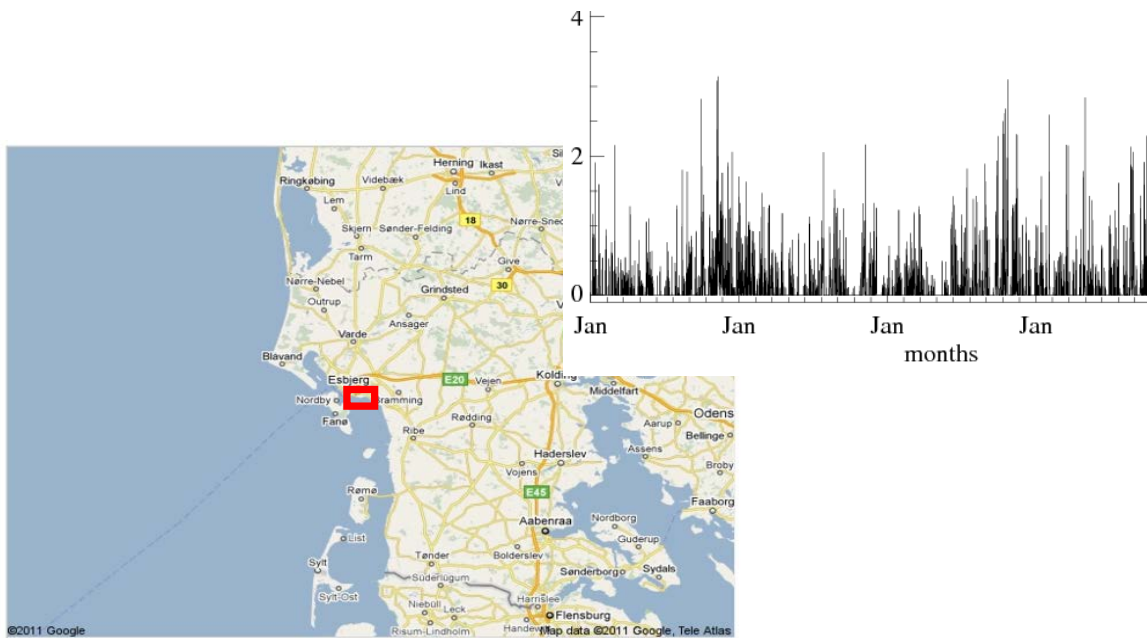
- New approaches developed for probabilistic prediction of ramp events:

- Based on Generalized linear models and deterministic / ensemble forecasts
- Informing of ramps occurrence AND timing
- Implemented for demonstration





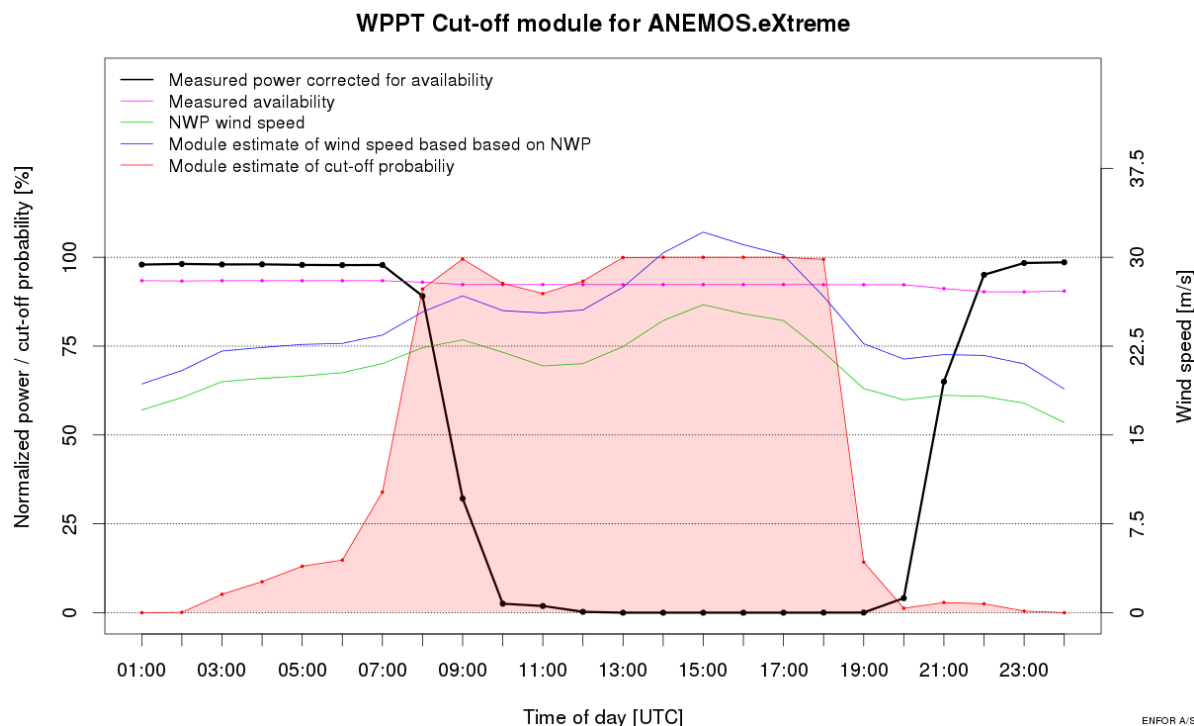
- High variability is problematic for power systems management, and difficult to predict...  
(Ex: [www.youtube.com/fluctuations](http://www.youtube.com/fluctuations))
- Various metrics and approaches were used as a basis:
  - Volatility-based (collaboration with CSIRO)
  - Hilbert-huang transform and instantaneous frequency concepts
  - « totalfluc » metric representing sum of gradients



- Cut-offs are very important but rare events...
- Two parallel methodologies were developed for cut-off prediction based on local measurements and baseline wind forecasts
- Operational modules were delivered.

- Results:

- Validation based mainly on wind information
- Limited length of evaluation period
- Cut-offs could be modelled directly in power curves used for forecasting



- The overall picture on what is going on in forecasting has totally changed:
  - New products eg. scenarios, ramp forecasts, etc.
  - Rival ideas for improving forecasts – and forecast quality is indeed improving!
- Overall some of these works and new paradigms are seen as leading internationally.
- In a more focused manner:
  - Regime switching is seen as promising for forecast improvements (<48 hours)
  - Probabilistic forecasting and scenarios are a must today
  - Some methodology (eg. for high variability) allow developing great insight, though not directly transferrable to forecasting products
- The input from meteorologists, wealth of test cases and interaction with forecast users can boost new ideas and developments.



# SafeWind

## Wind Power Forecasting with Focus on Extremes

**Workshop - 31.08.2012**

L'Auditorium, Palais Brongniart, Paris



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