SEVENTH FRAMEWORK PROGRAMME

SafeWind

Wind Power Forecasting with Focus on Extremes

Workshop, Palais Brongniart, 31.08.12, Paris

“Advances in ramp forecasting"

Robin GIRARD,

MINES ParisTech.

Robin.girard@mines-paristech.fr

MINES ParisTech

Outline

A. Introduction
   - ✓Why is ramp so important ?
   - ✓Example of problems

B. Characterization and detection of ramp
   - ✓How can we define a ramp
   - ✓Framework toward the comparison of definitions

C. Forecast solutions
   - ✓Deterministic
   - ✓Probabilistic
   - ✓Spatio-temporal modeling

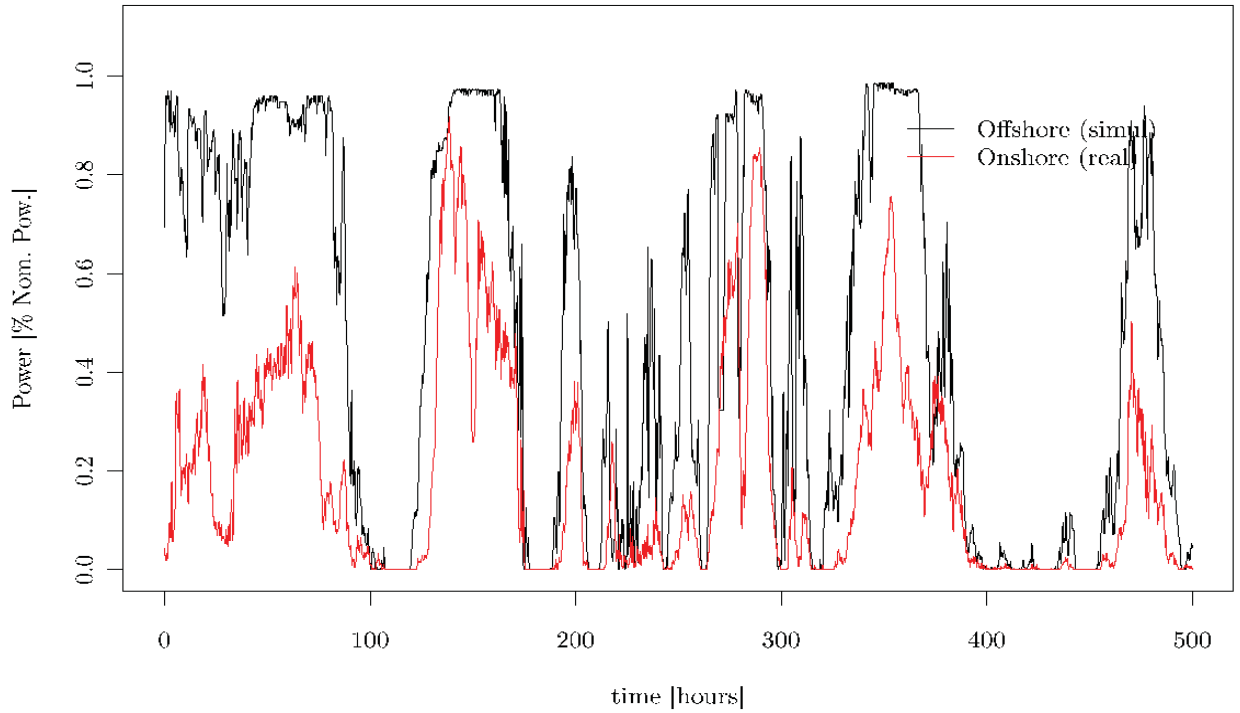
Why are ramps so important ?

What type of problem do we have with ramps?

INTRODUCTION

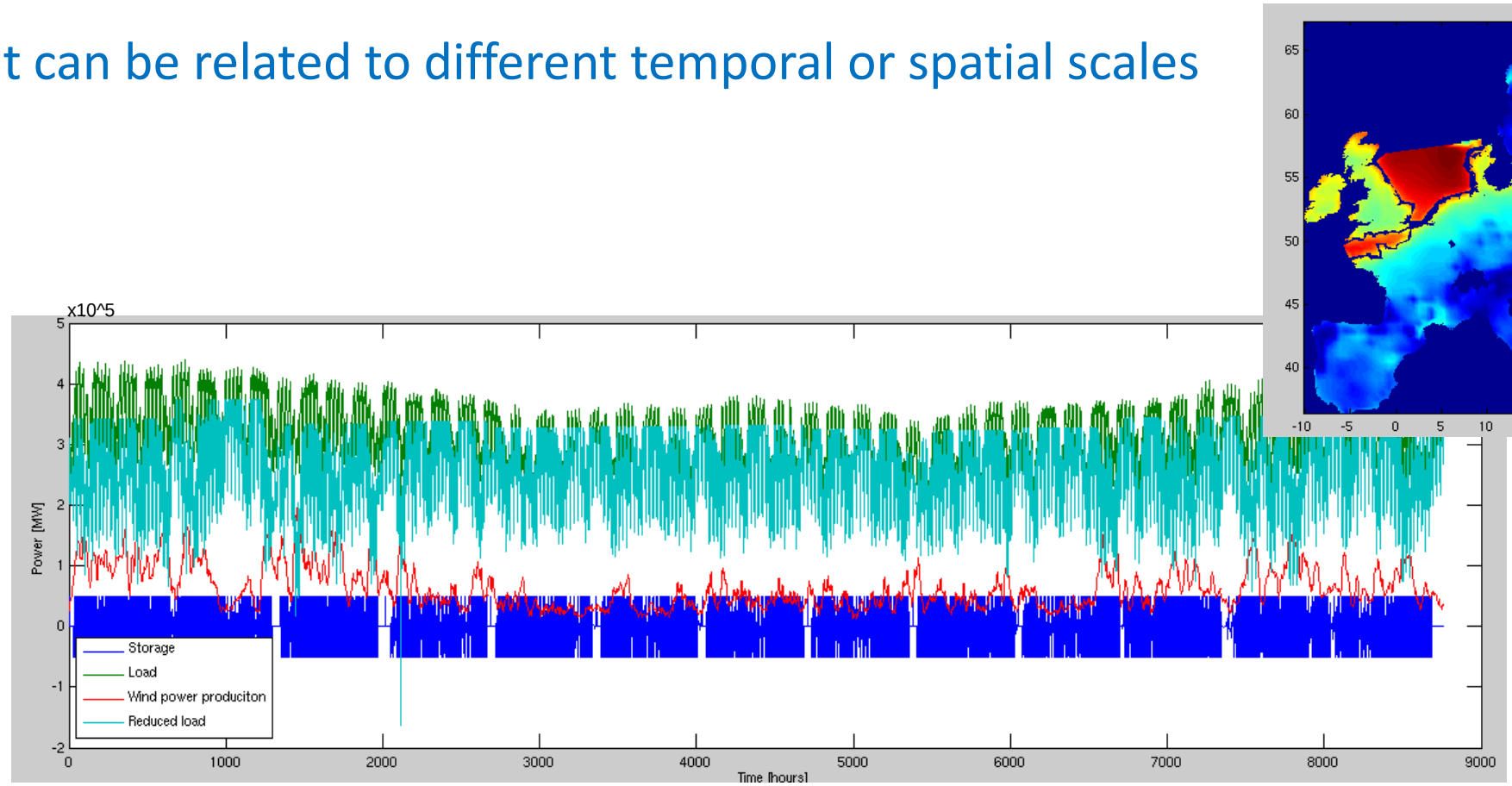
Ramp identified as a problematic situation

- Ramp: large variation of production in a small period of time
  - ✓It is more important in offshore wind power
  - ✓Can challenge the reliability of a system,
  - ✓Can generate high start-up cost, balancing cost



Ramp identified as a problematic situation

It can be related to different temporal or spatial scales



Wind power produced (red line) in Europe with a 30% penetration scenario. Load in green is obtained from 2008 observations.

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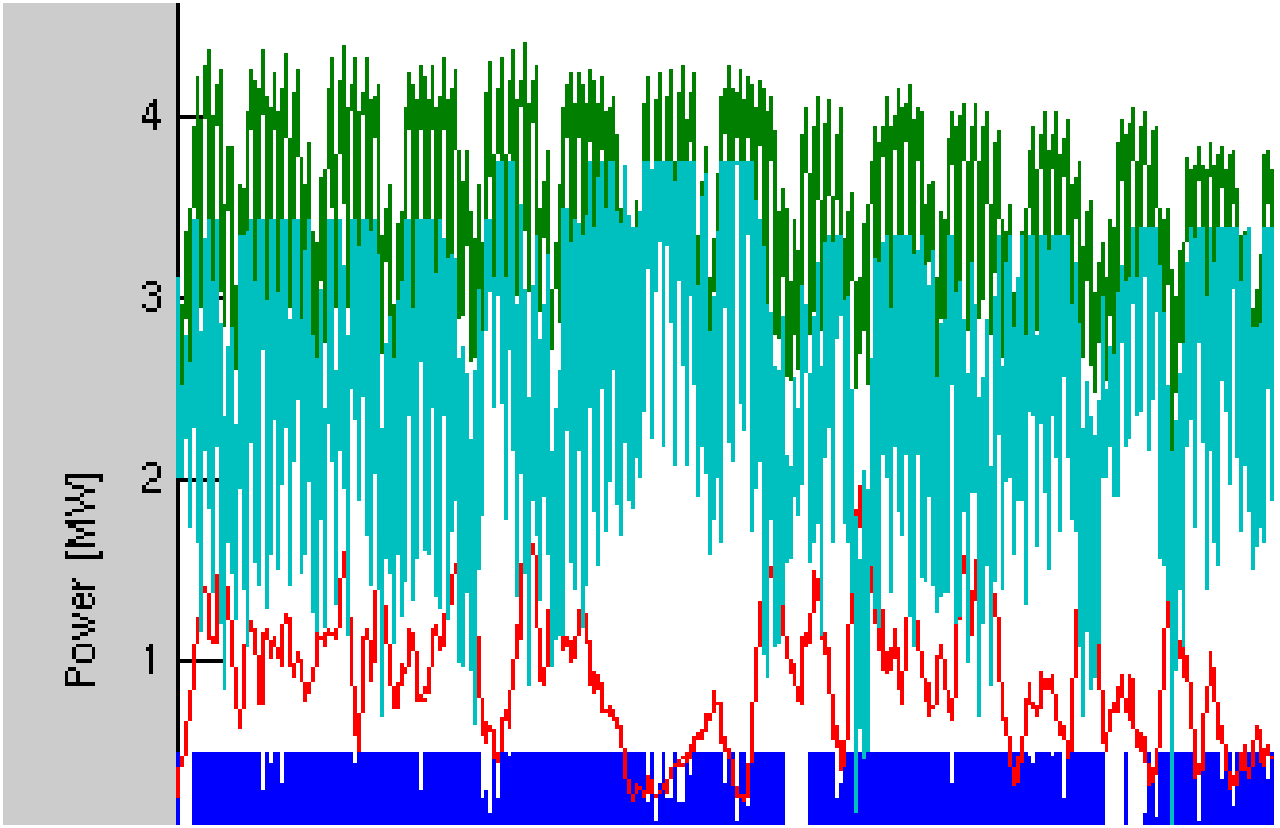
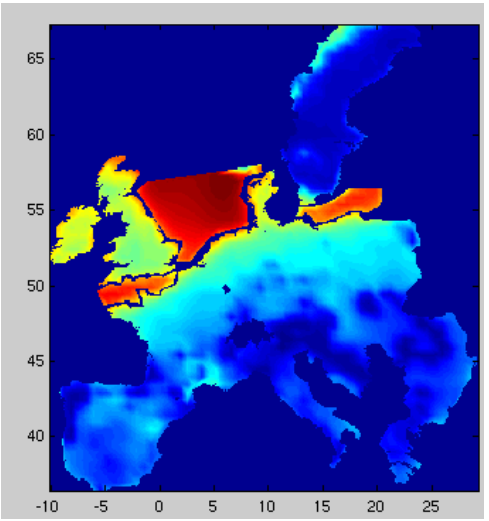
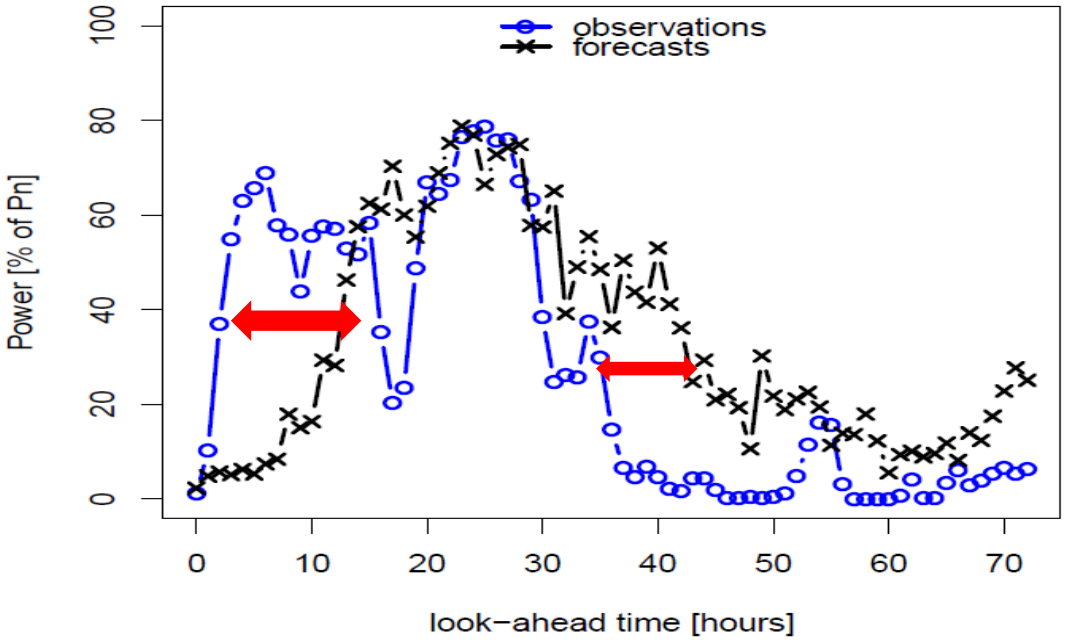




Ramp identified as a problematic situation

- In the short term forecasting framework, ramp can translate into **phase errors**
- It can be related to different look ahead times (i.e. <6h, 6-72h)
- These errors come from the meteorological models.
- For the shortest term this can be corrected with more data assimilation



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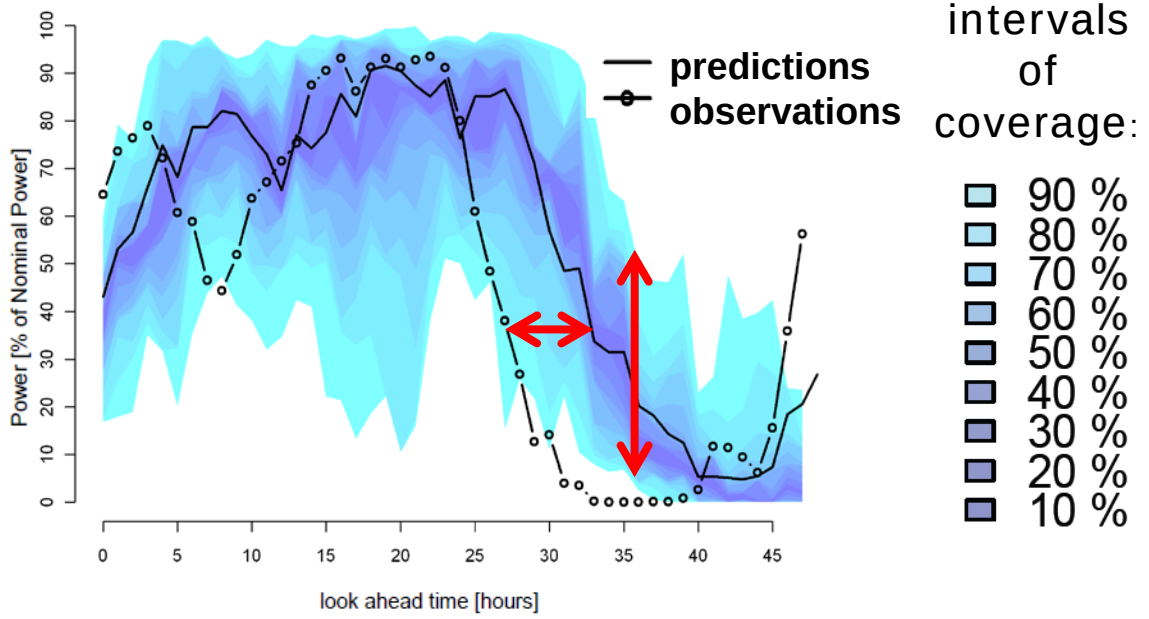
- For the shortest term this can be corrected with more data assimilation
- For the longer term better uncertainty information can be required



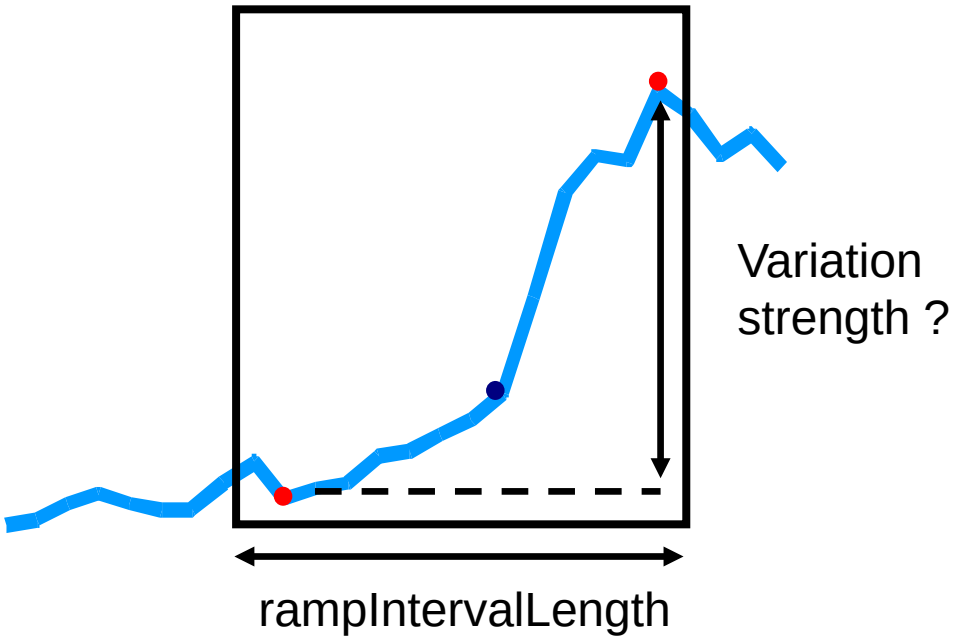
Definition of a variation

Filtering approaches

Evaluation of definitions with a ramp model

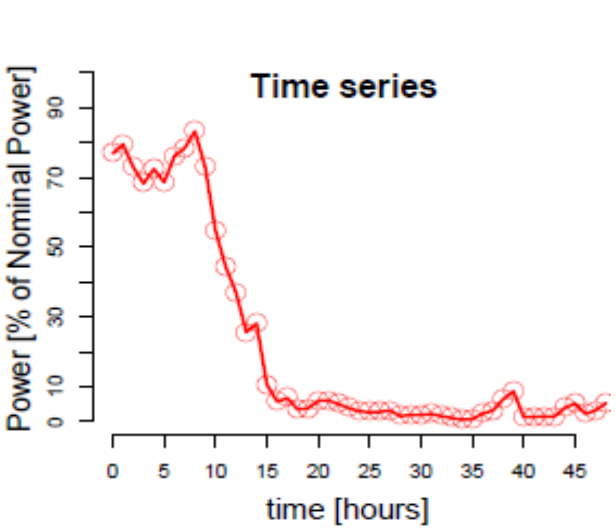
CHARACTERIZATION OF RAMPS

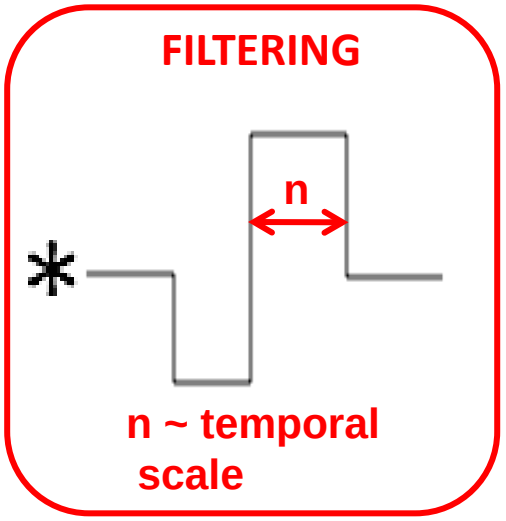
Ramp definition

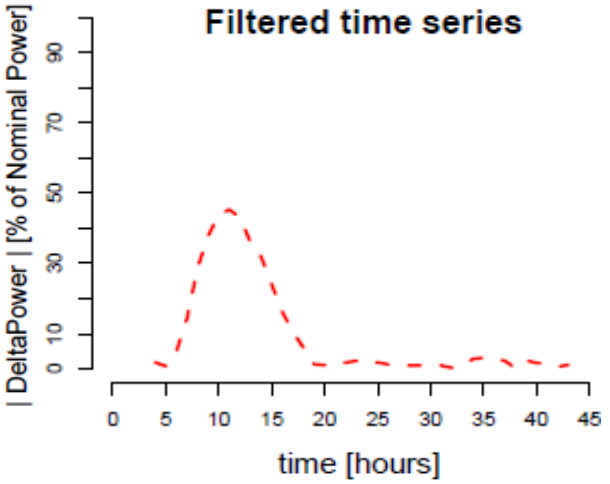


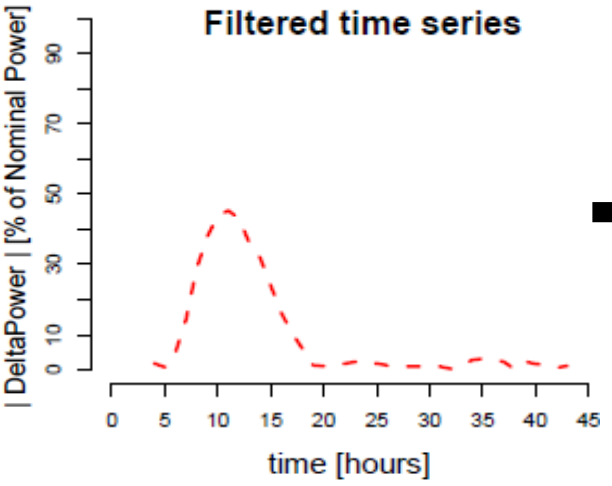
- A ramp is a strong variation in less than a few hours.
- There are two difficulties:
  - ✓How do we measure the variation
  - ✓When do we concider the variation is large enough

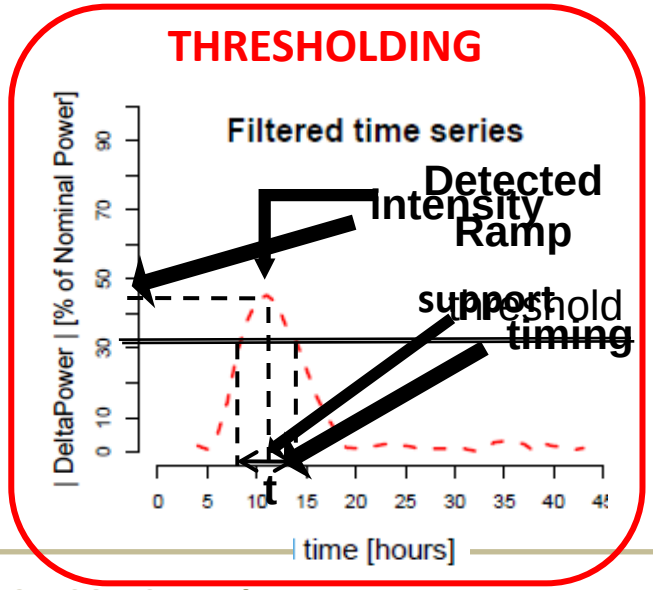
Example definition within the filtering framework





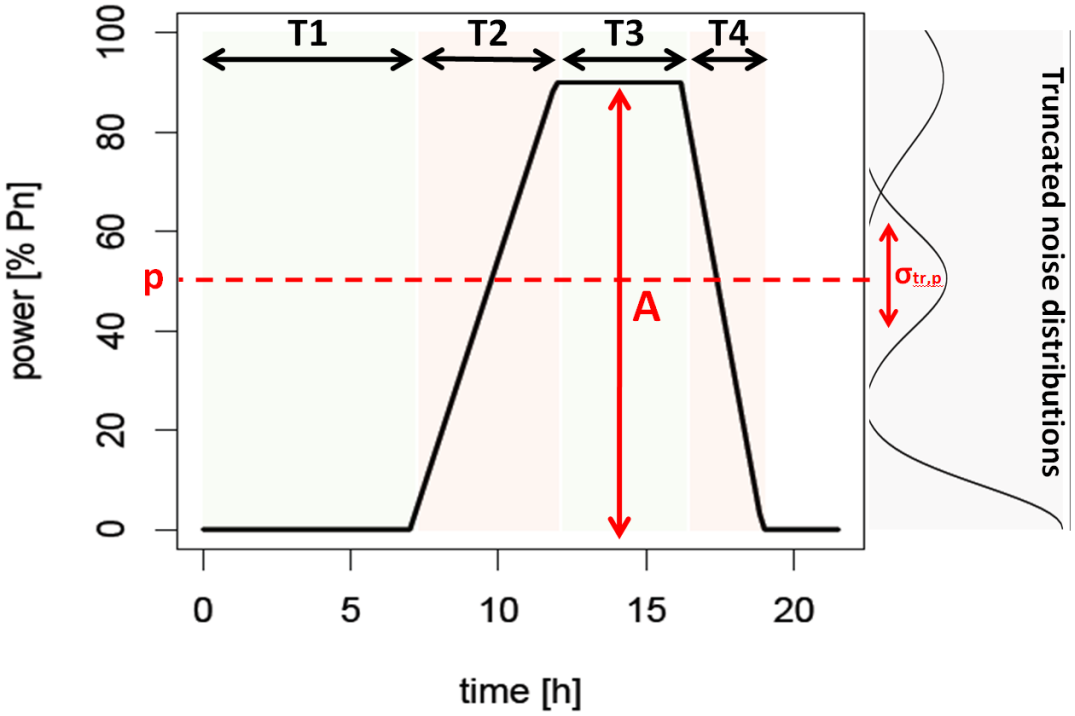


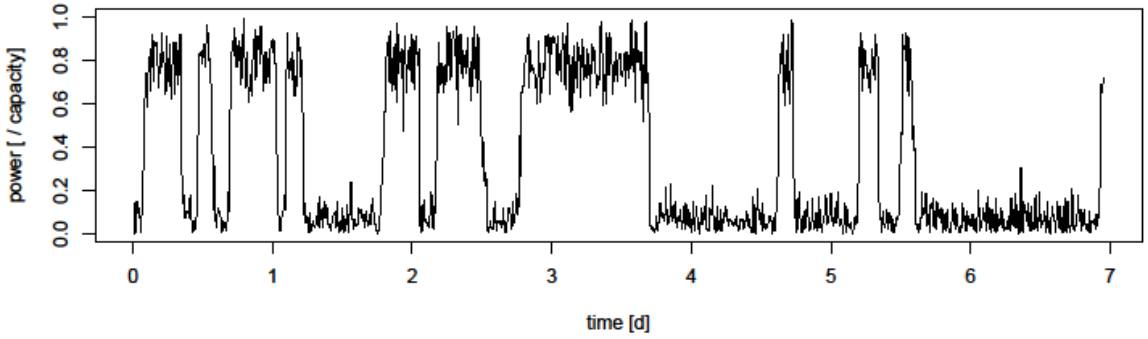




- intensity
- timing t
- support

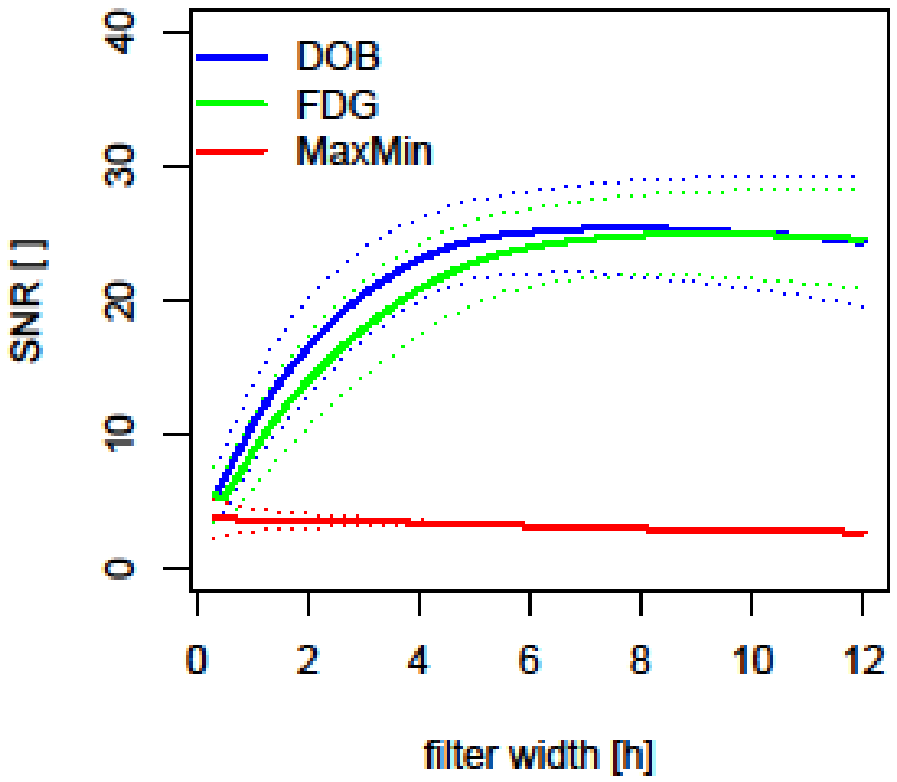
A model of ramp for the evaluation





- A ramp model has been proposed in order to compare the different methods for measuring variation.
- Methods have been compared according to their ability to detect ramp and localize them well.

A model of ramp for the evaluation



- A ramp model has been proposed in order to compare the different methods for measuring variation.
- Methods have been compared according to their ability to detect ramp and localize them well.
- The ability of the filter to distinguish signal from noise is driven by its shape and its width

Deterministic ramp forecast

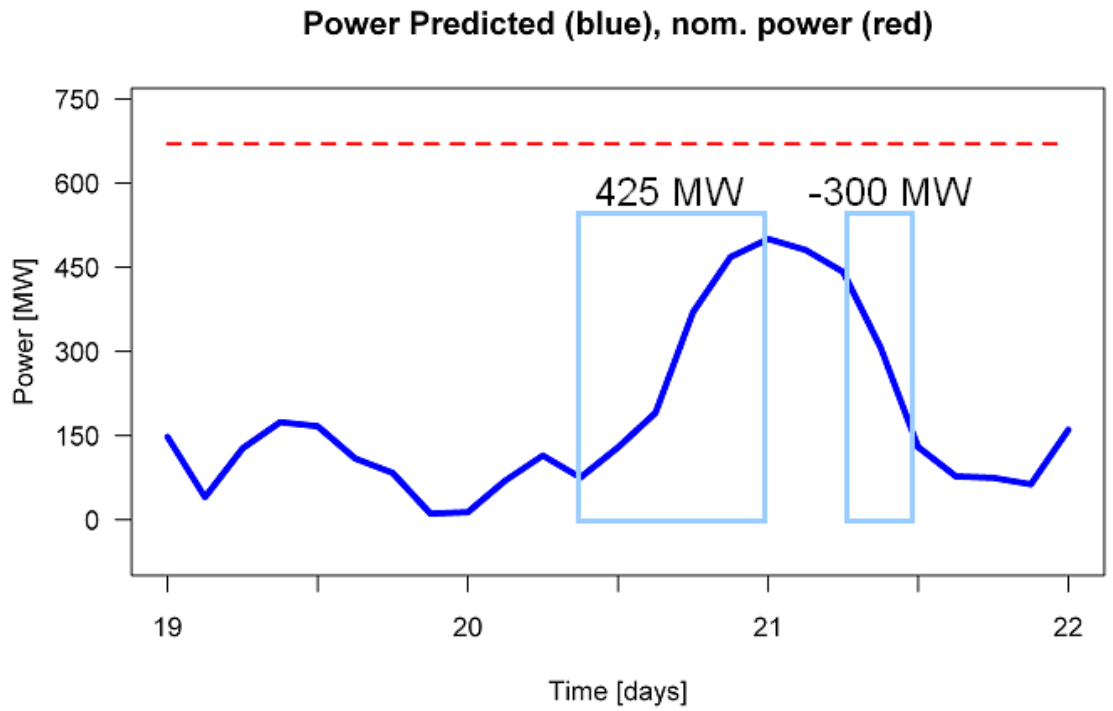
Two kind of Probabilistic ramp forecast

Spatio-temporal model for alerting

SOLUTIONS

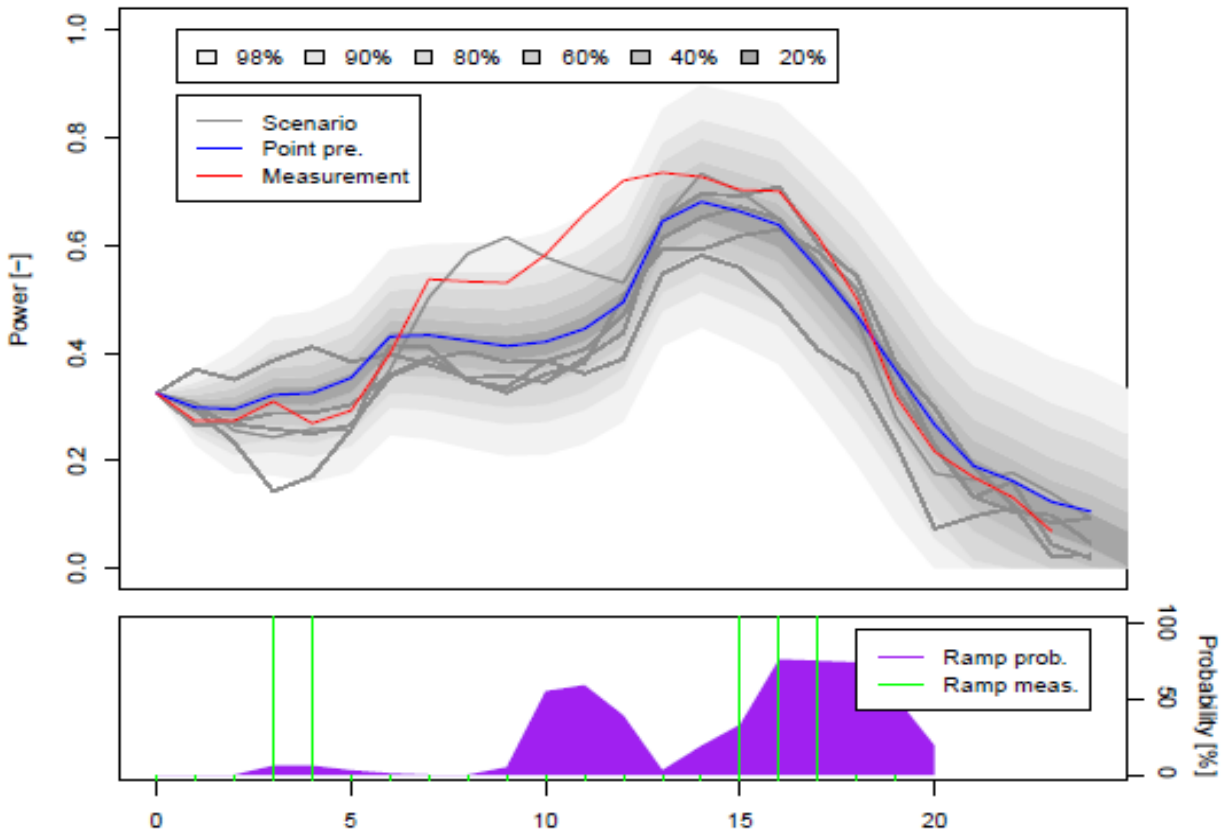
Characteristic forecasting

- Total increase (resp. decrease) in power production
- Includes a calibration of variability (usual wind power forecast underestimate variability)



Probabilistic event forecasting

- For each look ahead time t+h a probability p is forecast whether the event will occur or not
- The event is « the variation at look ahead time t+h is strong enough »
- Probabilities are forecast conditionally to forecast scenarios

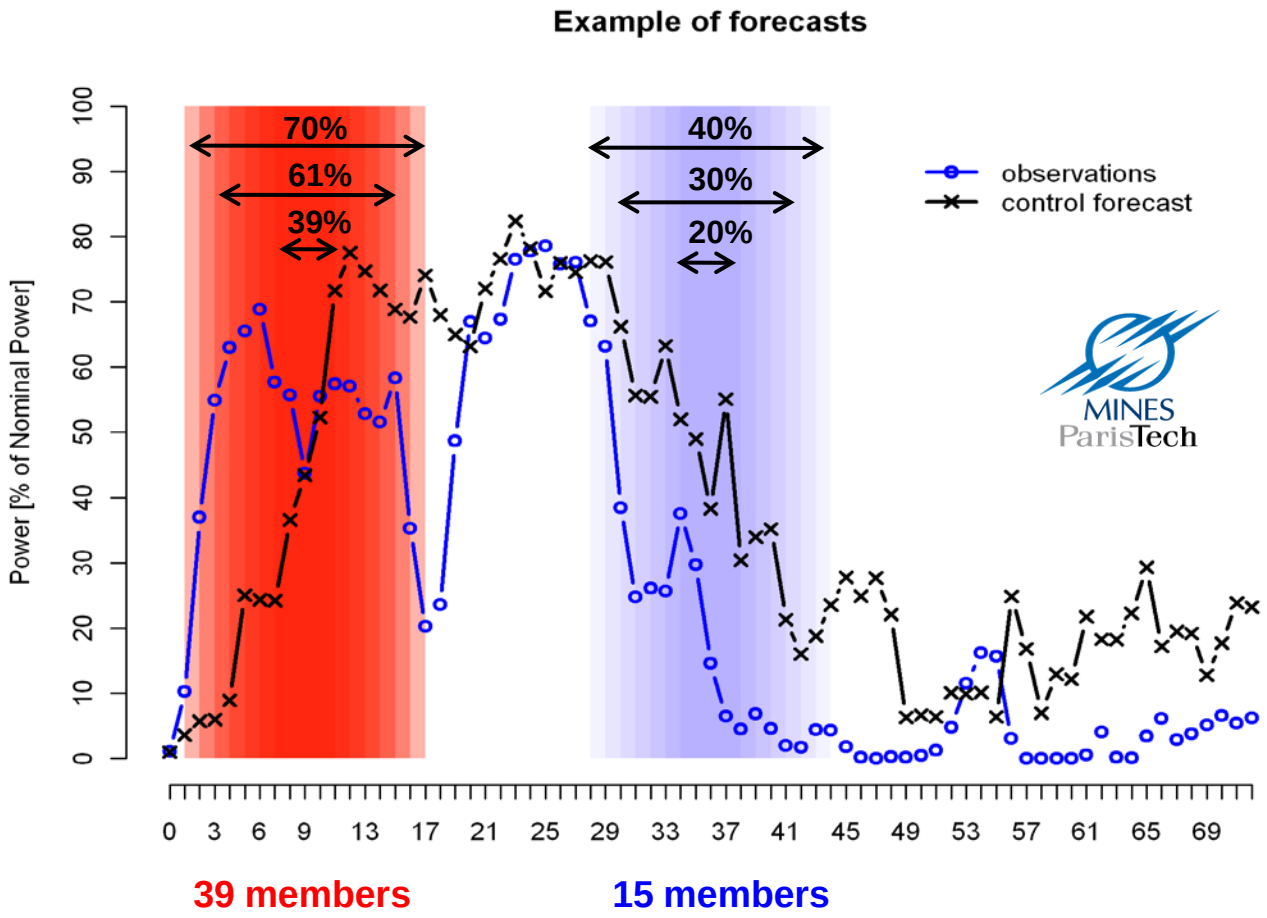


ENFOR
Forecasting and Optimization for the Energy Sector

DTU

Forecasting temporal uncertainty

- For a set of consecutives look ahead time dates of strongest variations are forecast
- The possibility of these date to shift is forecast with confidence intervals
- Probabilities are forecast conditionally to forecast scenarios



Forecasting ramps using ensembles, Evaluation

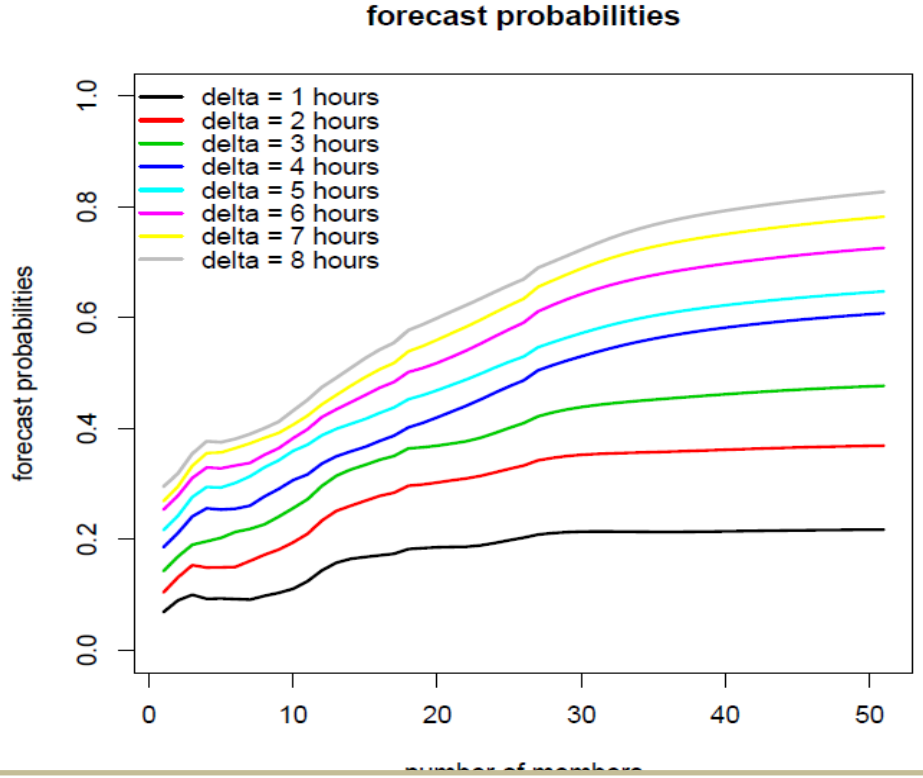
- Meteorological ensembles
  - ✓51 members of the EPS from ECMWF
  - ✓Interpolated to an hourly resolution

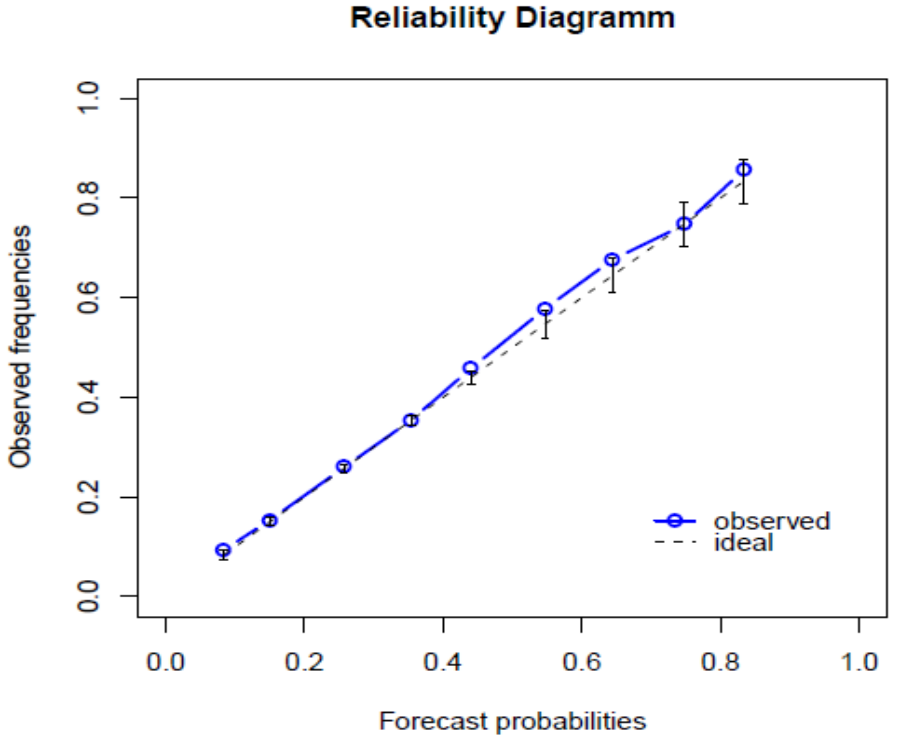
- Power measurements
  - ✓18 months of data for three wind farms in France (July 2004 - December 2005)

- Ensemble power forecasts
  - ✓Obtained using the « random forest » algorithm

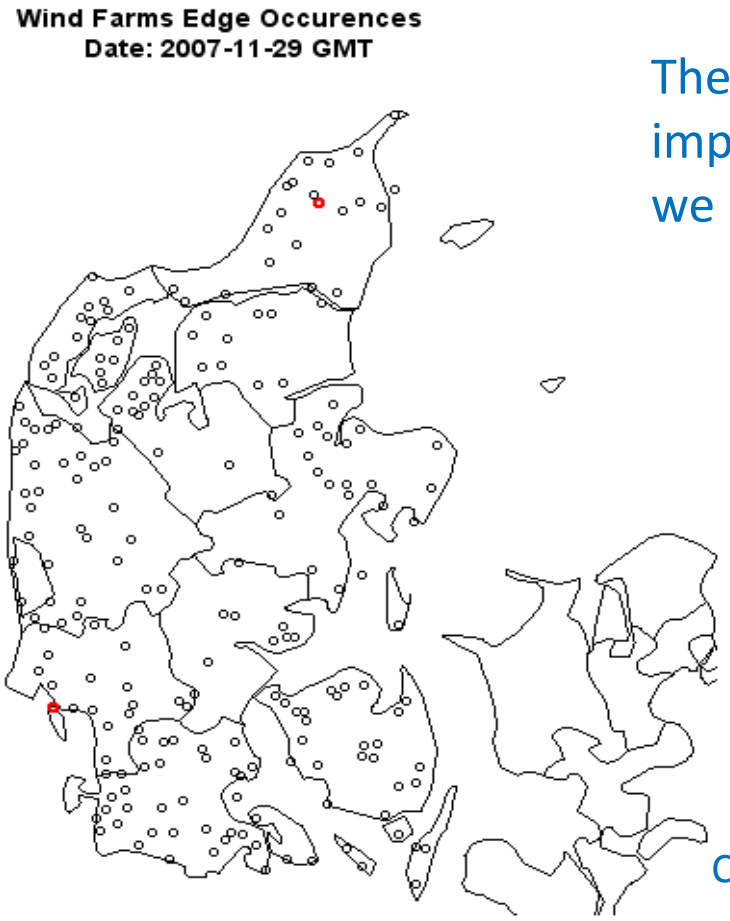
Forecasting ramps using ensembles-results

- The forecast probability to observe a ramp increases with the number of members that forecast the ramp
- The forecast probabilities correspond well to observed ones ("reliability")





Forecasting ramps using upwind rapid update



The capture of spatio-temporal information may allow to improve the very short-term forecasts of ramps. To do so we have:

- **characterized** the propagation of ramps
  A correlation analysis has revealed a preferred **westerly** propagation direction

- **integrated** the resulting information in a forecasting spatio-temporal model
- **Forecasting errors** (not ramp yet) are **reduced** by 10% or 15 % for up to 3 hours ahead

Case of western Denmark:

- **blue** are decreasing ramps
- **red** are increasing ramps

Conclusions

- Ramp is going to be more and more important in the future (more penetration, offshore wind power)
- Several definition of ramp are possible and require the measure of a variation adapted to the considered temporal scale.
- Two types of innovation have been proposed:
  - ✓Forecast more characteristic around ramp
  - ✓Improve forecast for the short term with more updates
- Many different tools have been proposed, among them: Event forecast (ramp timing, ramp slope),Probabilistic event forecast, Temporal uncertainty forecast, Spatio-temporal modeling
- These tools are statistically calibrated according to the event of interest, verification protocol have been proposed
- More research to be done on how to use (e.g. temporal uncertainty) in a stochastic unit commitment.

Thank you for your attention!

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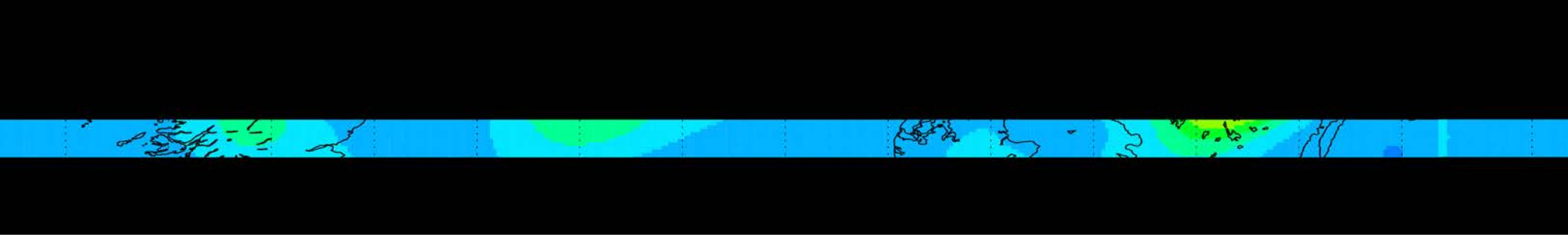

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www.safewind.eu

Forecasting ramps using upwind rapid update

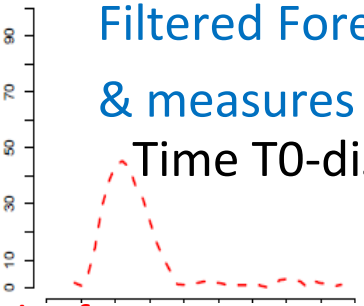
1. Our reference model makes probability forecasts using as input the filtered forecast production at the downwind farm

$$\log\left(\frac{p}{1-p}\right) = \alpha + \beta\hat{f}$$

p = probability of a ramp $\hat{f}$ = filtered forecast production

rmation, assuming a **westerly** propagation of ramps at a eed

$$\frac{p}{-p}\Big) = \alpha + \beta\hat{f} + \sum_i$$

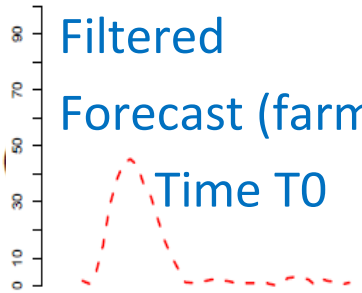


Filtered Forecast & measures (farm US)

Time T0-dist*v

upwind information

Filtered Forecast (farm DS)



Time T0

Farm US

Farm DS

$\hat{q}_i$ rtile of the forecast filtered production field

ime delay i and longitude $l - vi$