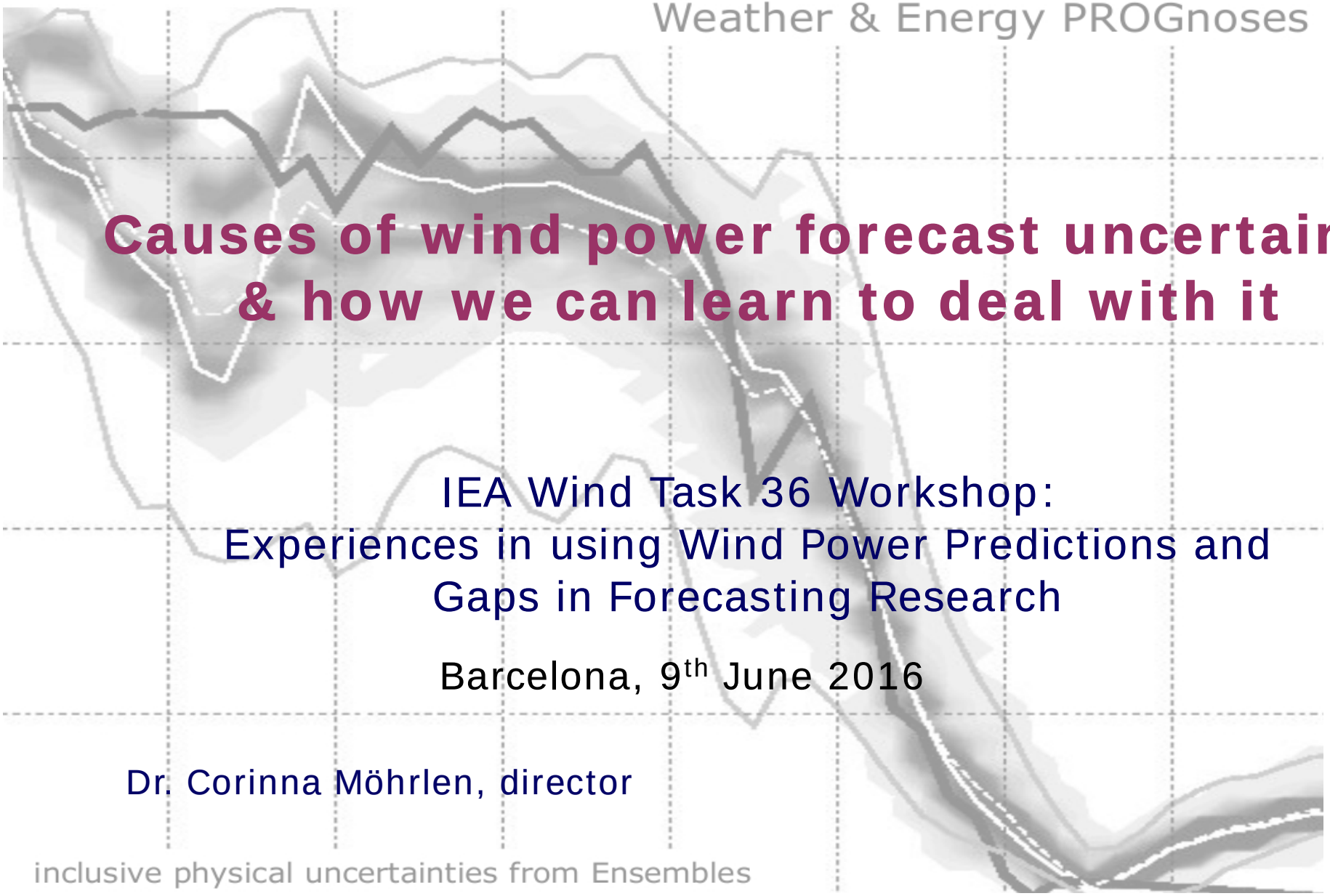
WEPROG

Weather & Energy PROGnoses



Causes of wind power forecast uncertainty & how we can learn to deal with it

IEA Wind Task 36 Workshop:
Experiences in using Wind Power Predictions and Gaps in Forecasting Research

Barcelona, 9th June 2016

Dr. Corinna Möhrlen, director

inclusive physical uncertainties from Ensembles

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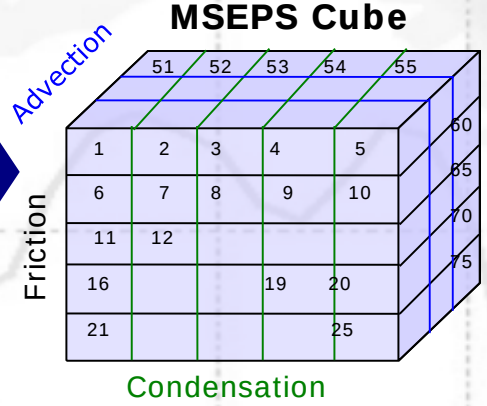
Who is WEPROG ?

Specialists in Ensemble Weather Forecasting
&
World wide Weather-, Wind-, Solar Power and Power market Applications

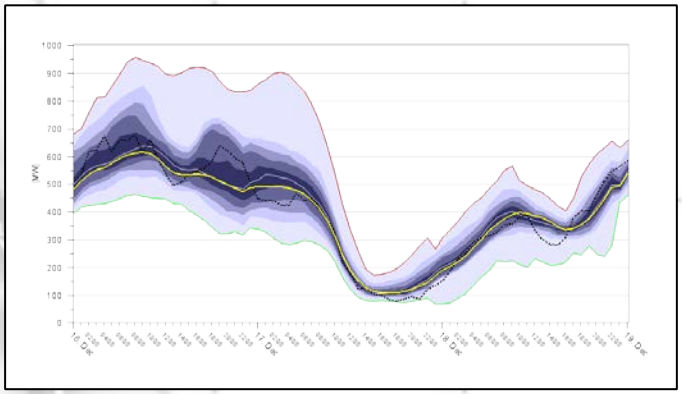
Global Analysis
(State Estimate)

75 independent weather forecasts

MSEPS Cube



Probabilistic weather, wind & solar power forecasts



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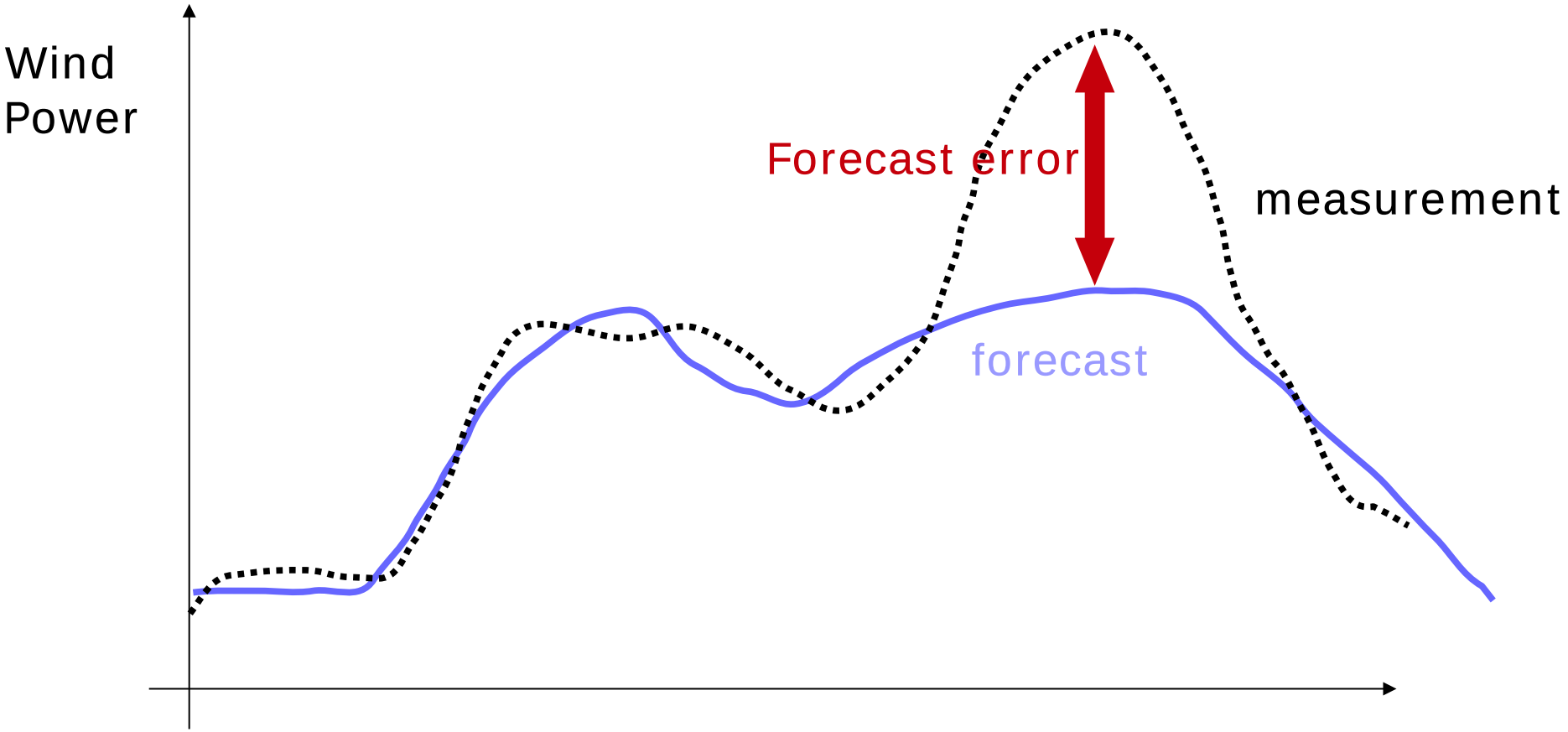
We all know it...

Forecast for today:

What's happening in reality:

what is gone wrong with the weather forecast ?

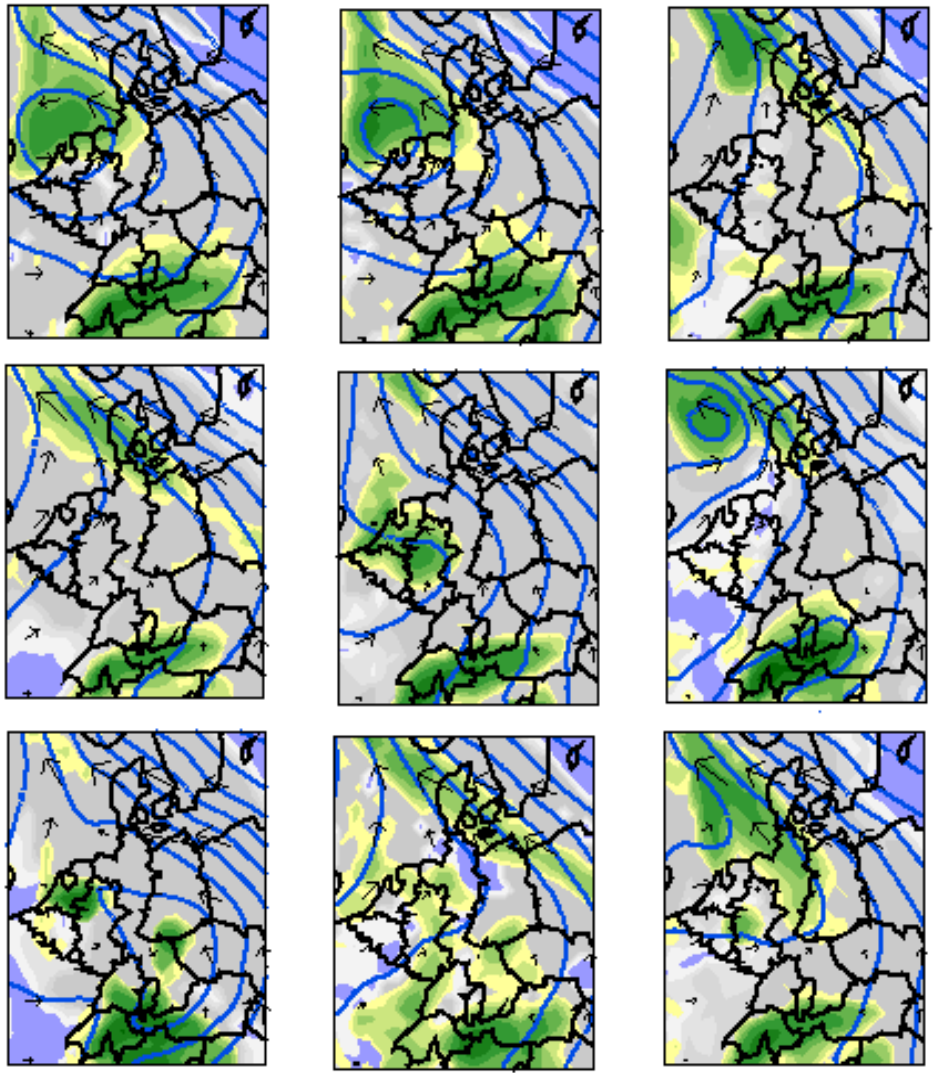
Some know this...

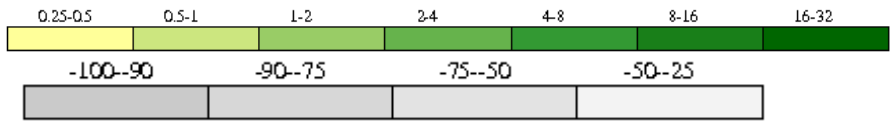


what is gone wrong with the weather forecast ?

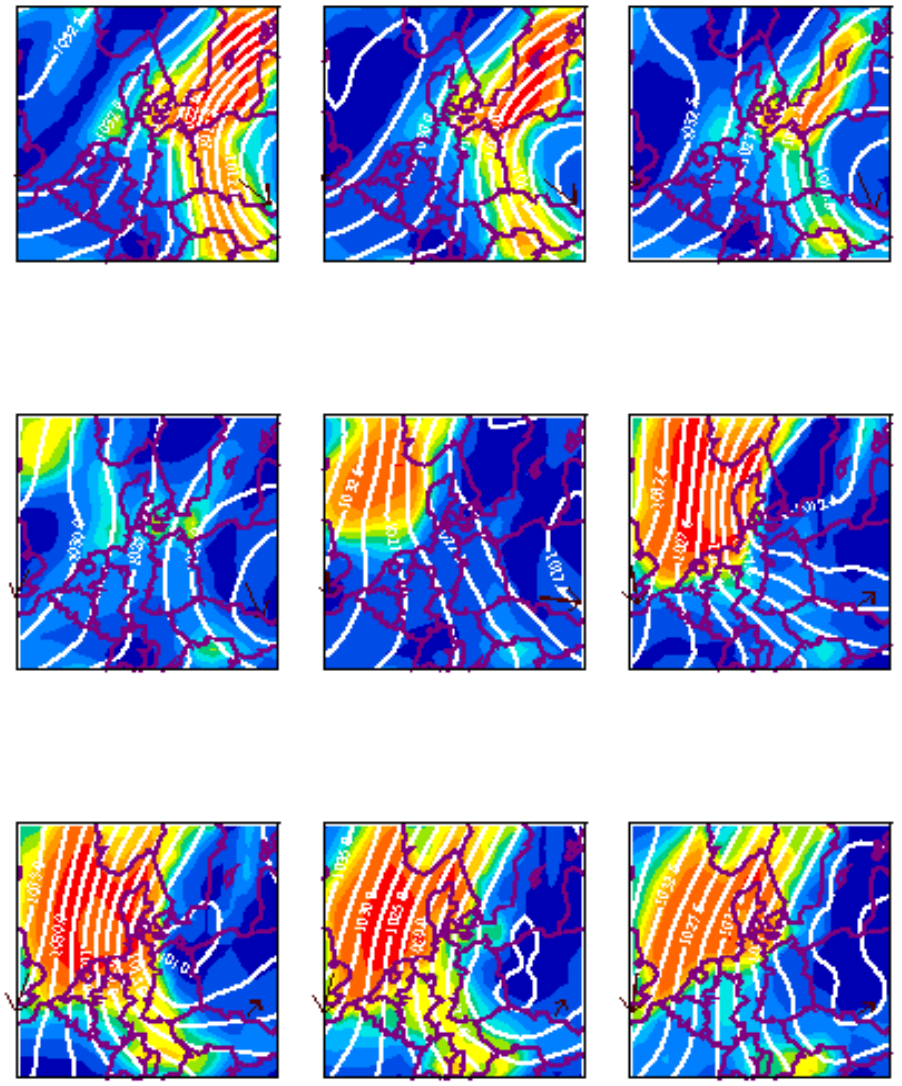
Is it the same weather forecast we are talking about ?

Precipitation & cloud cover



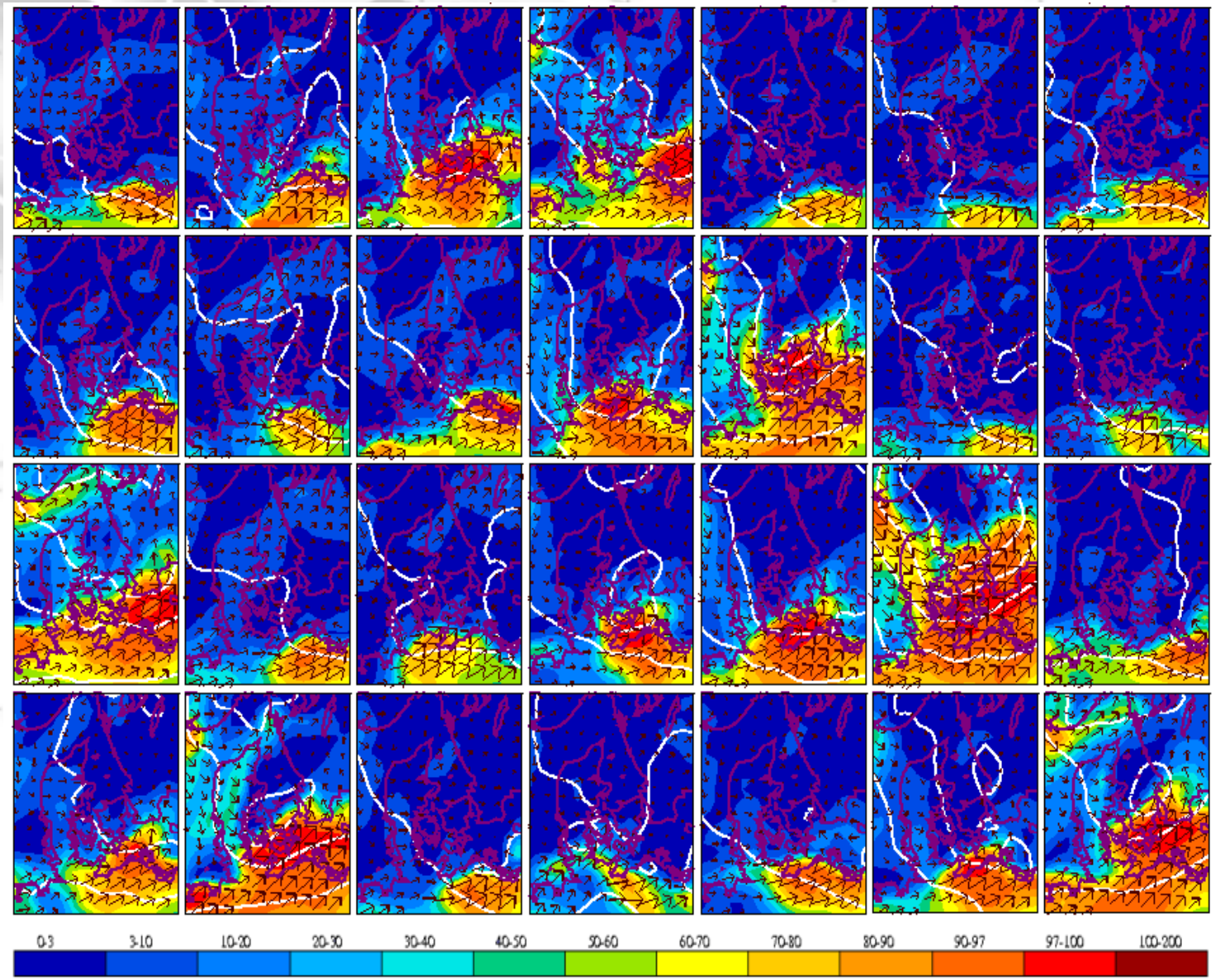


Wind Speed



Is it the same weather forecast we are talking about ?

Wind Power [% inst. cap]



What are the reason for uncertainty in the power generation of Renewables ?

Weather Uncertainty

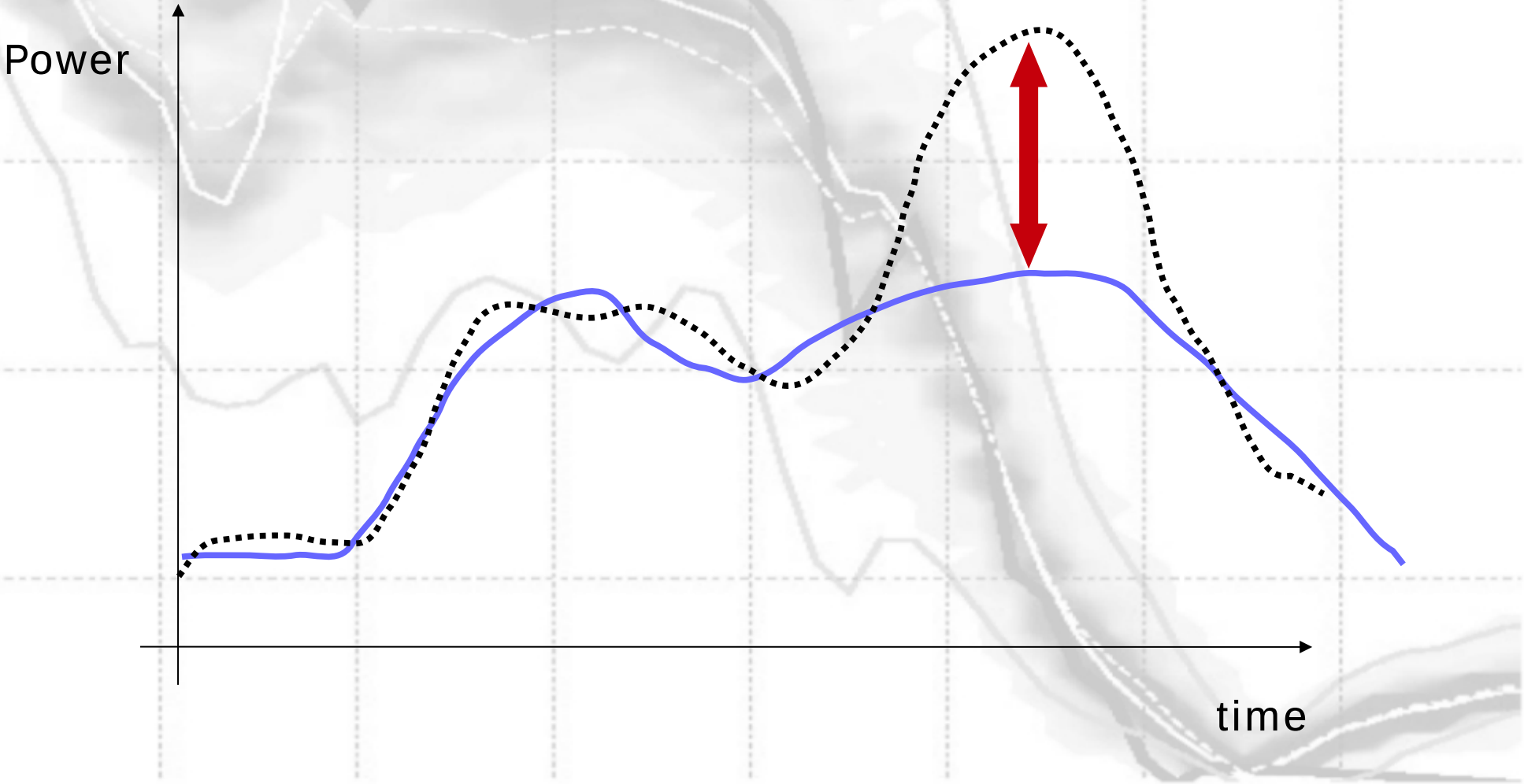
Uncertainty in Power Production

Let's have a Closer look ...

What is uncertainty...

and, when do we get concerned about uncertainty ?

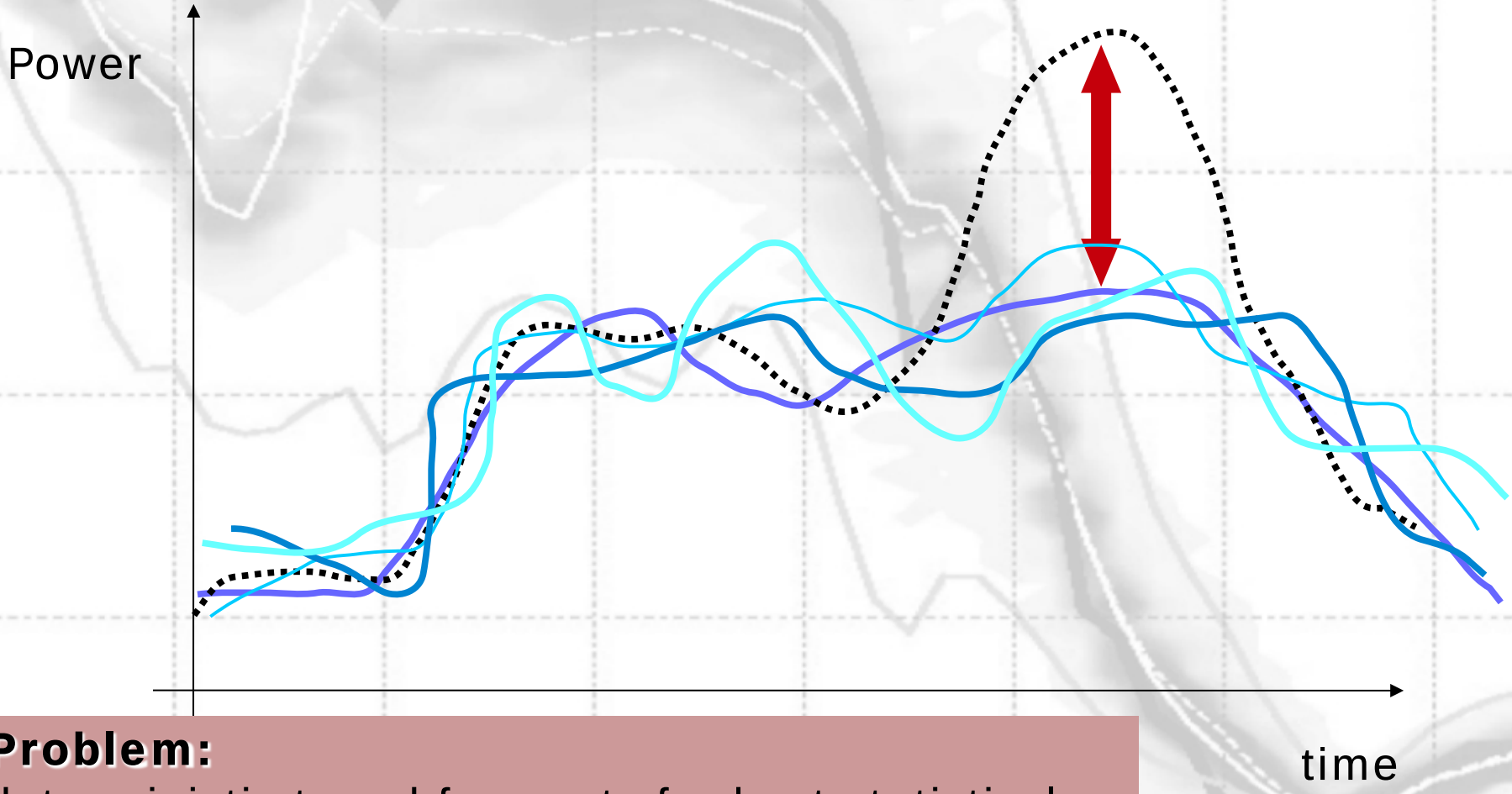
=> When the error can increase over the level of available reserve



What is uncertainty...

and, does it help to have many different forecasts ?

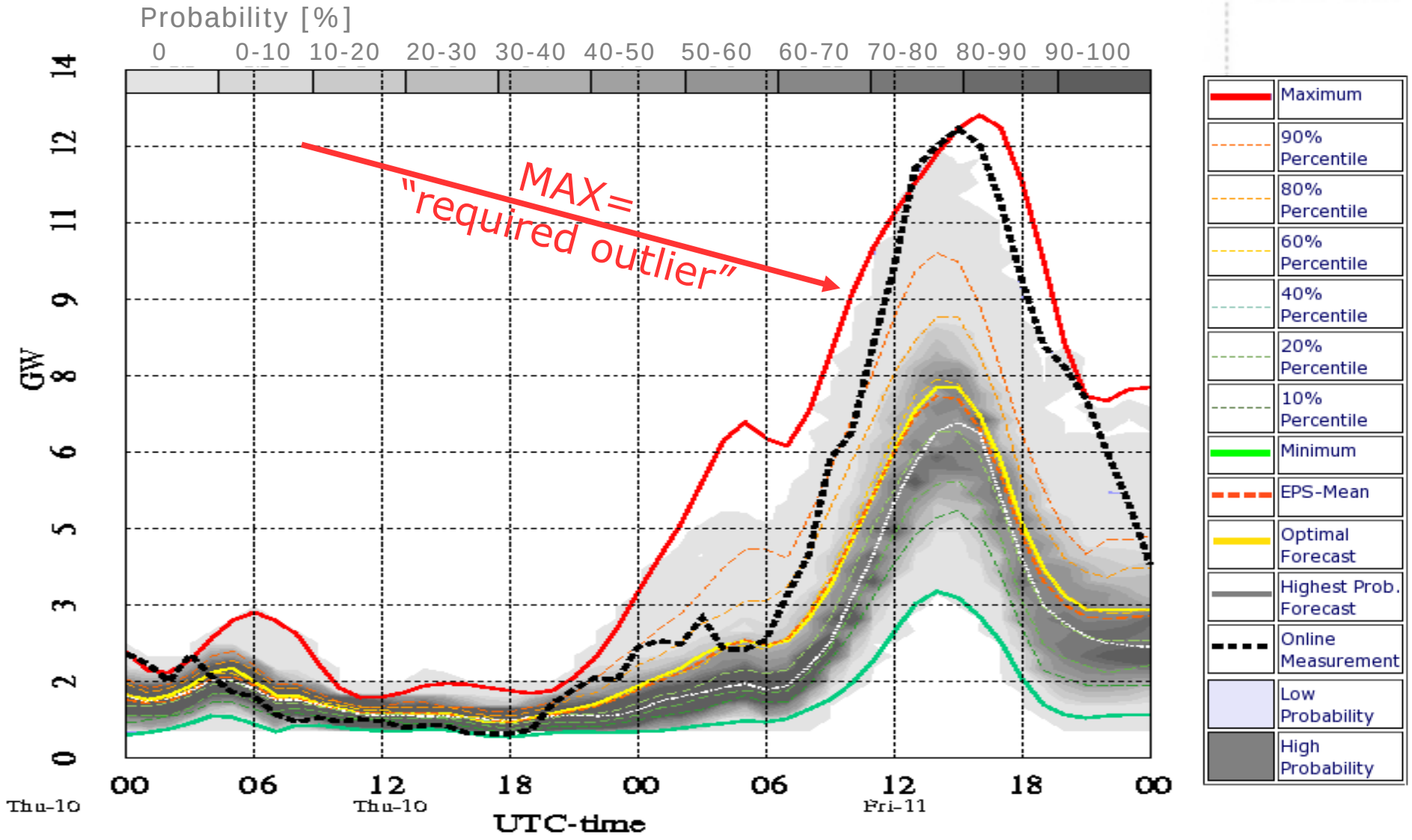
=> ONLY if there is one forecast that "sees the trouble"...



Problem:
deterministic tuned forecasts for best statistical scores, suppress extremes!

What is uncertainty...

...if we use a well-defined “Ensemble” of forecasts that can produce the “required outliers”..



What causes uncertainty...

and are forecast errors only due to the weather forecast ?

=> Yes and No!

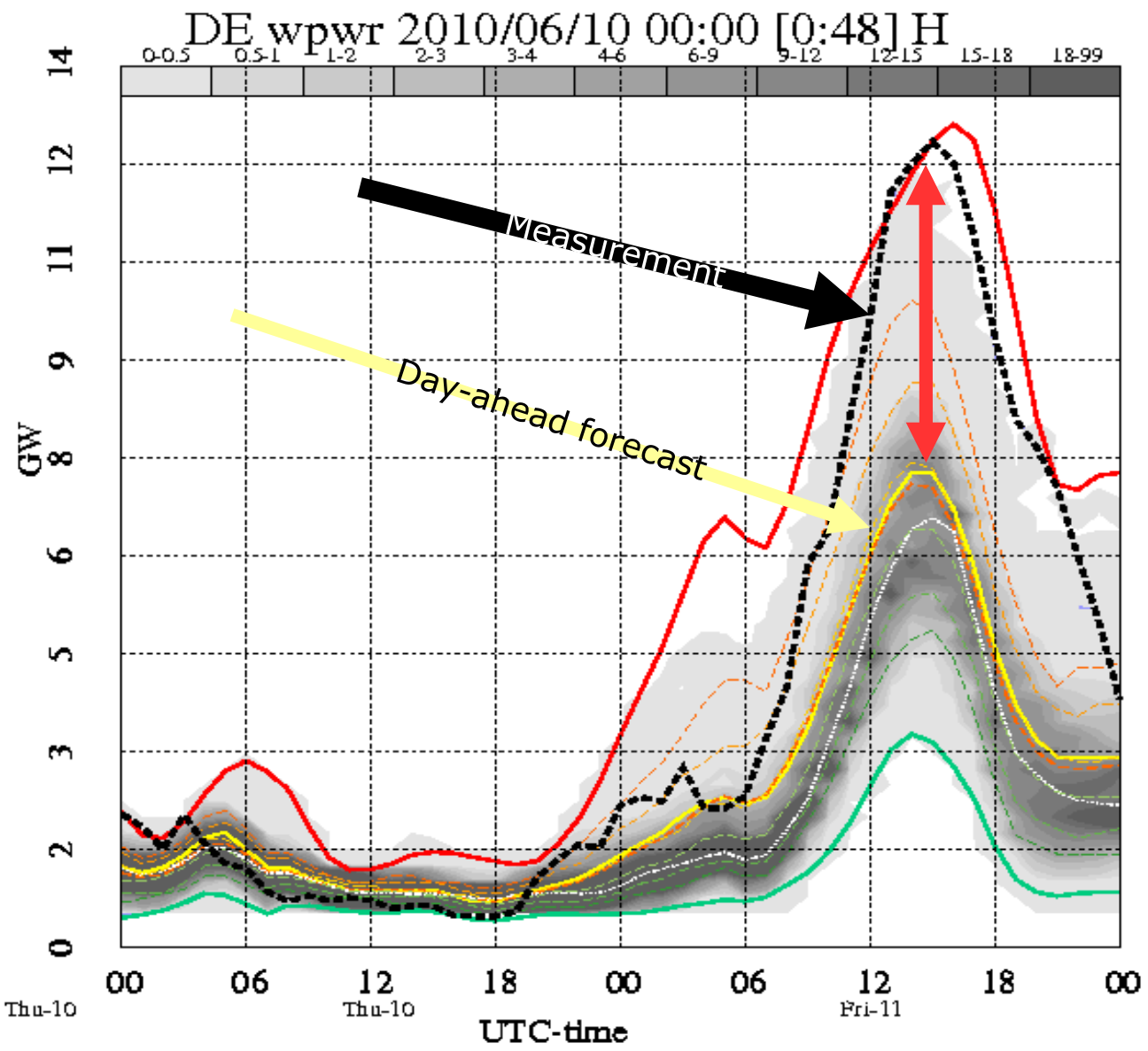
Some reasons for weather forecast uncertainty:

→ weather analysis & forecast never has 100% accurate weather data
→ NWP model's formulations contain assumptions that do not hold in 100% of all weather situations
→ the model area may be too small to develop correctly
→ model resolution insufficient to resolve small scale phenomena
→ atmosphere is non-linear!

Some reasons for wind power uncertainty:

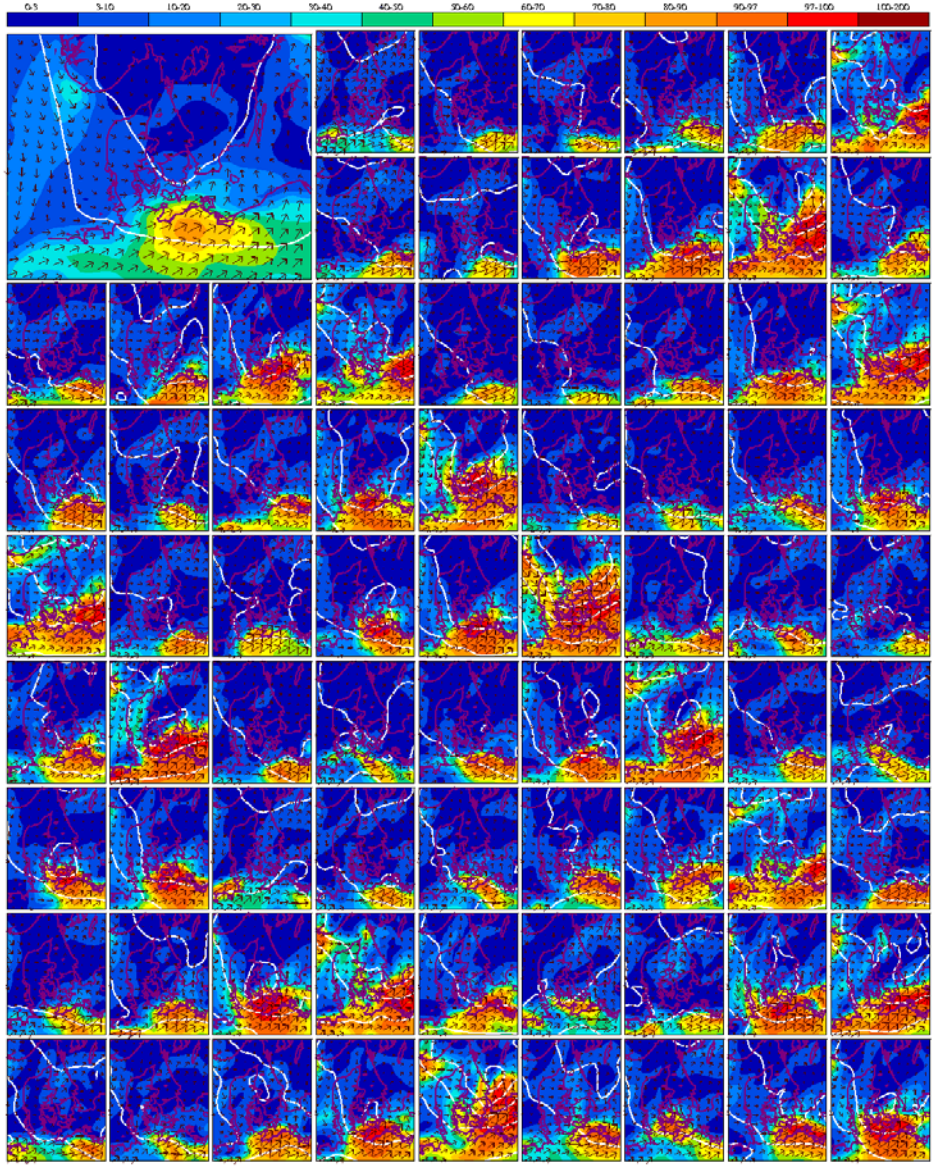
→ Interpretation of weather forecast can be wrong
→ Different forecast algorithms for power are “better” or “worse”
→ Availability information of the wind turbines are missing
→ Technical Reasons for different production pattern
→ Unknown curtailment, shut down or maintenance

A typical extreme event situation:
...when does it become a nightmare ?



A forecast error of many GW over a number of hours:

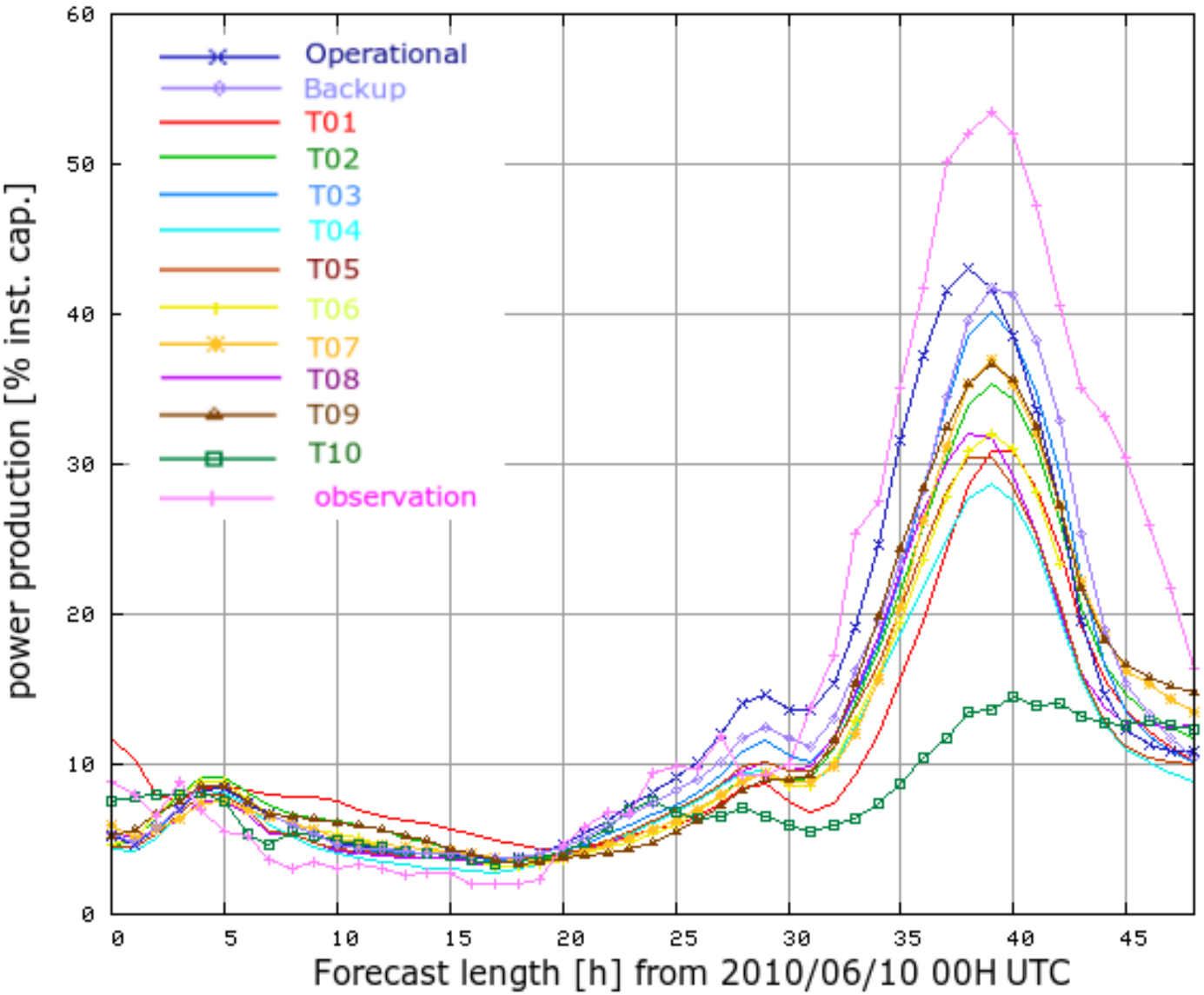
How did the wind power distribution look like ?



Looking at 75 forecasts of 100m wind + a mean forecast show that the models did not agree well

Large spread = high uncertianty

Experiments to simulate the event in Retrospect



Experiment:

10 experiments with 75 forecasts == 750 forecasts for the same event!

Result:
non of the "mean" (deterministic) forecasts hit the target!

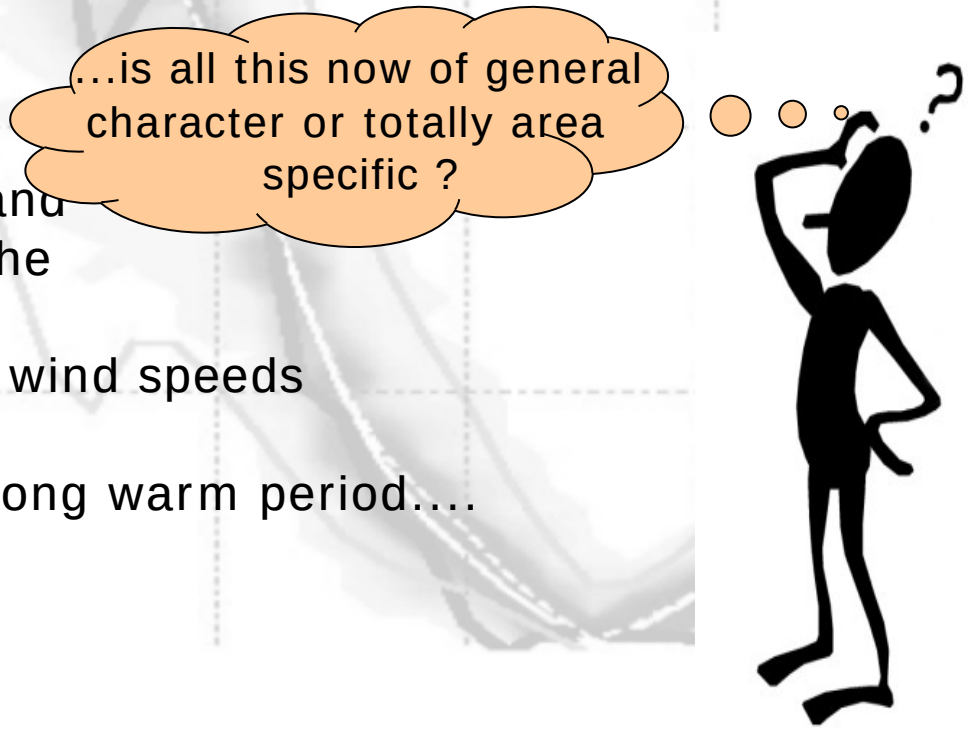
What triggered these conditions ?

A meteorologiest analysis:

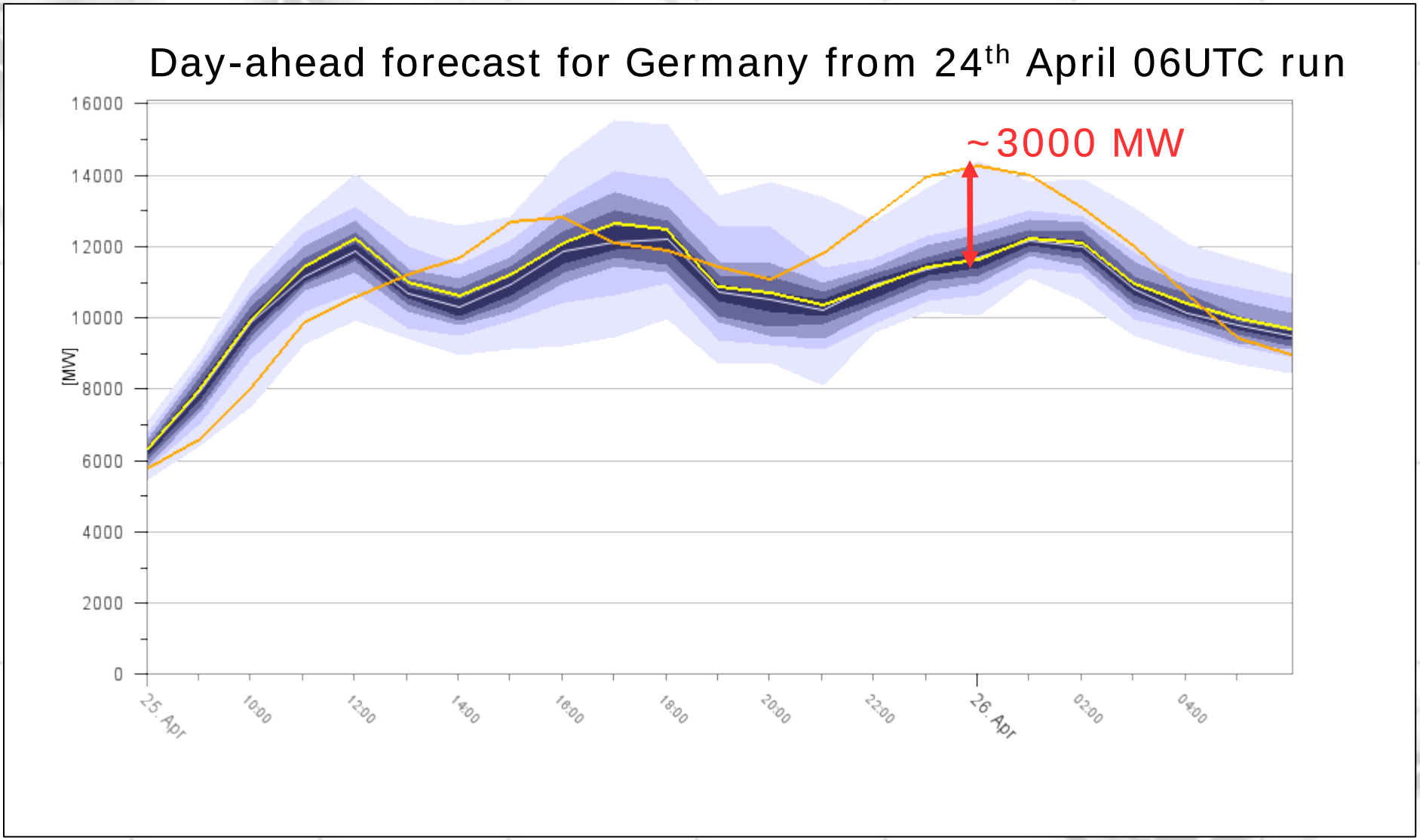
- A cold weak low pressure system located in the NO mountains at initial time
- Mid tropospheric advection from the mountains in direction of wind turbines
- Strong heating of the ground due to short wave radiation during daytime
- High humidity in the afternoon caused by southerly winds

If all these conditions are present,
→ convection on the small scale evolves and
→ convection interacts with weak low in the middle of troposphere
Result: sudden amplification & increasing wind speeds

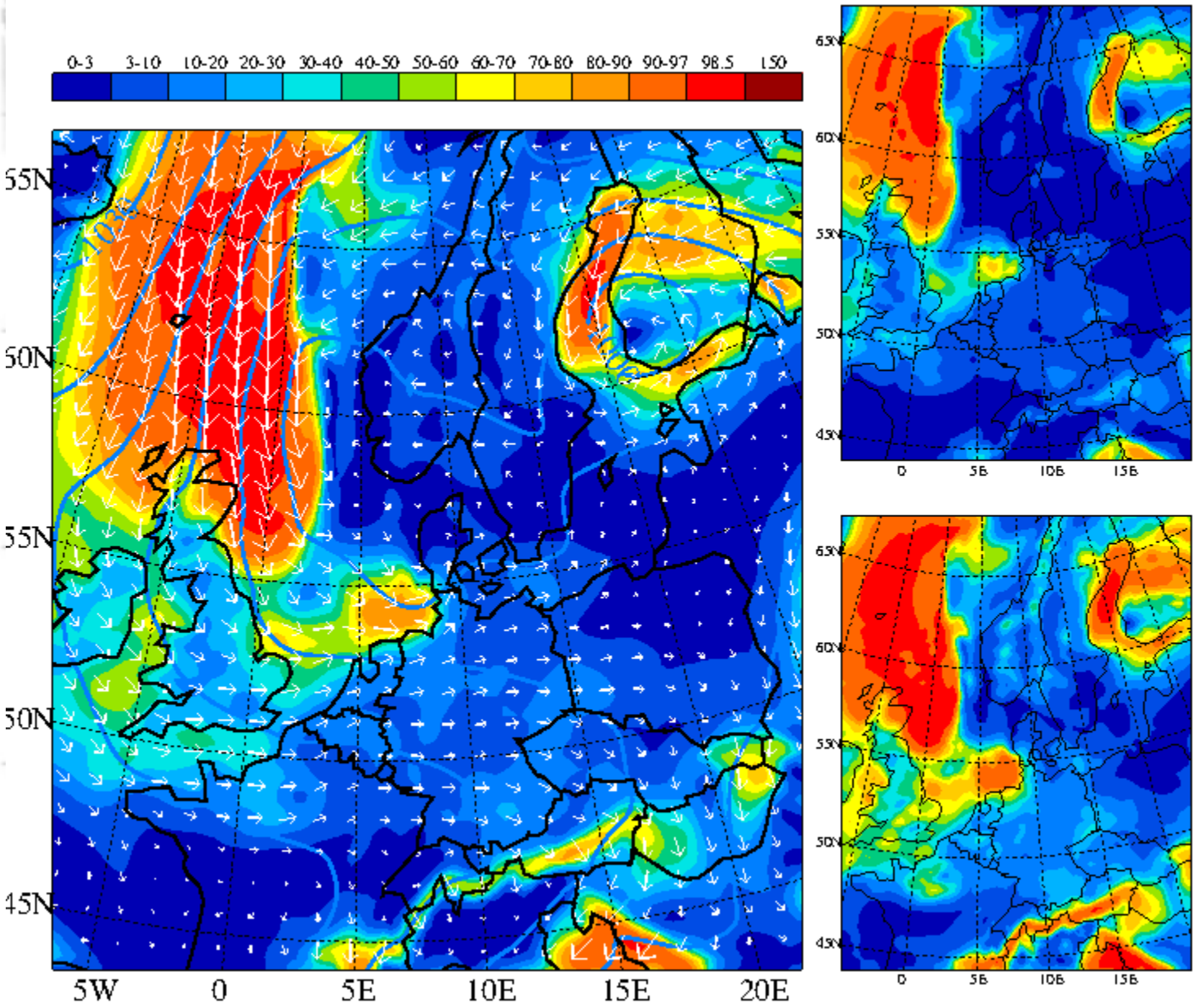
The event will in most cases terminate a long warm period....



Case 2: Center of low pressure system uncertain



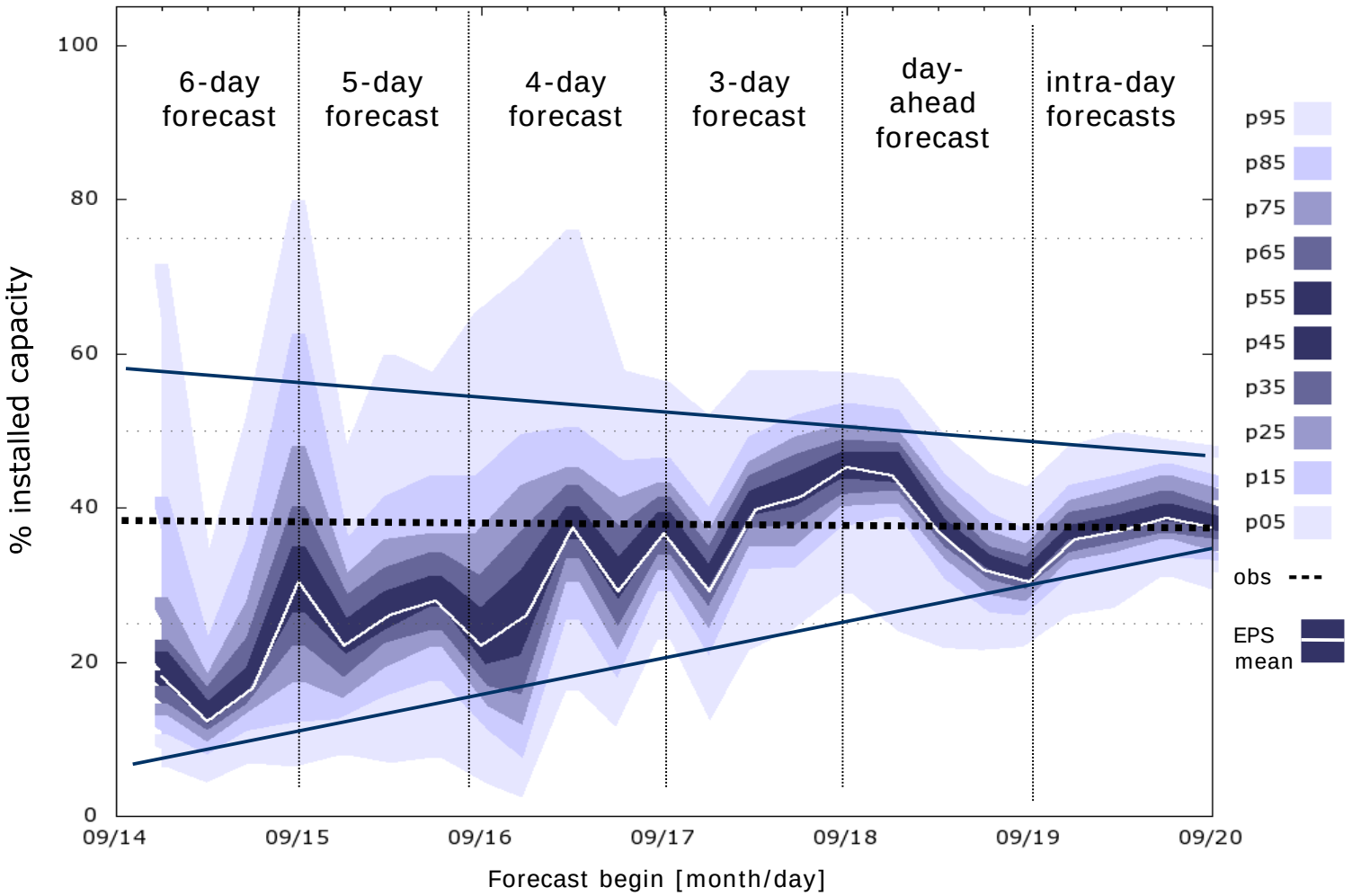
Case 2: Center of low pressure system uncertain



Typical development of forecast quality & uncertainty

Day-ahead trading alone is insufficient

→ Short-term forecasting is required to balance errors in the intra-day



"Trumpet" graph shows:

Forecast error decreases over forecast horizon

Uncertainty is variable over forecast horizon

→ short-term wind power handling requires knowledge of **current actual uncertainty!!!**

Forecast + uncertainty bands starting with 144 hours in 6 hour intervals up to the point in time when the forecast is valid.

What can we learn from these examples ?

We cannot hope not rely that we receive a “perfect forecast”

Short-term forecasting is essential !

Forecast errors must be balanced “along the way”, dependent on:

→ forecast uncertainty
→ market development (liquidity)
→ congestion constraints

Amounts of data and information may be complex,

---> there are tools to help condense the important information

What tools are there to actively work with uncertainty ?

Ensemble forecasts

climato logy

Statistical tools

What are the tools ensemble forecasts are good to solve?

Warning system

Reserve forecasts

Decision Support (Tool)

Uncertainty on Grid point level

Measure-ment control

How do we design a warning system and why do we need uncertainty forecasts ?

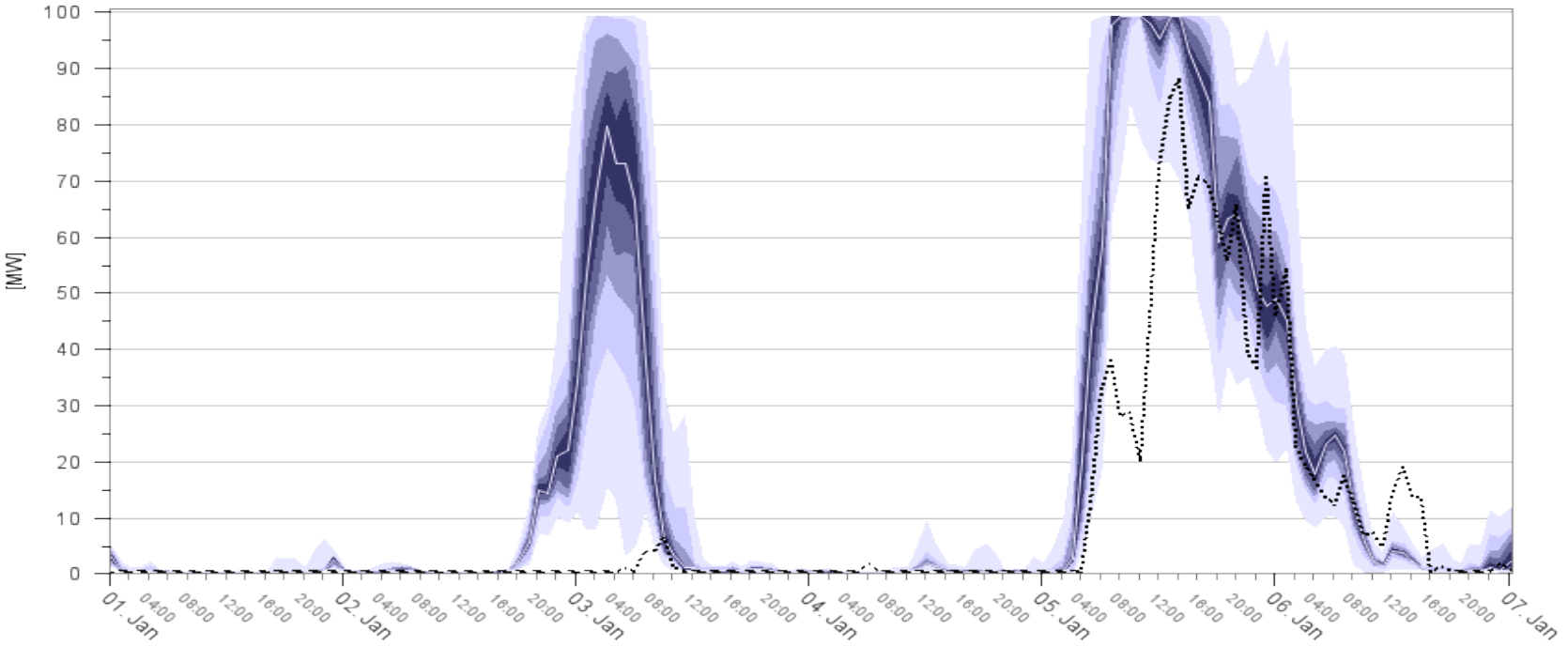
Forecast spread is an indication of uncertainty in the weather

Forecast spread gives objective indication on goodness of measurements

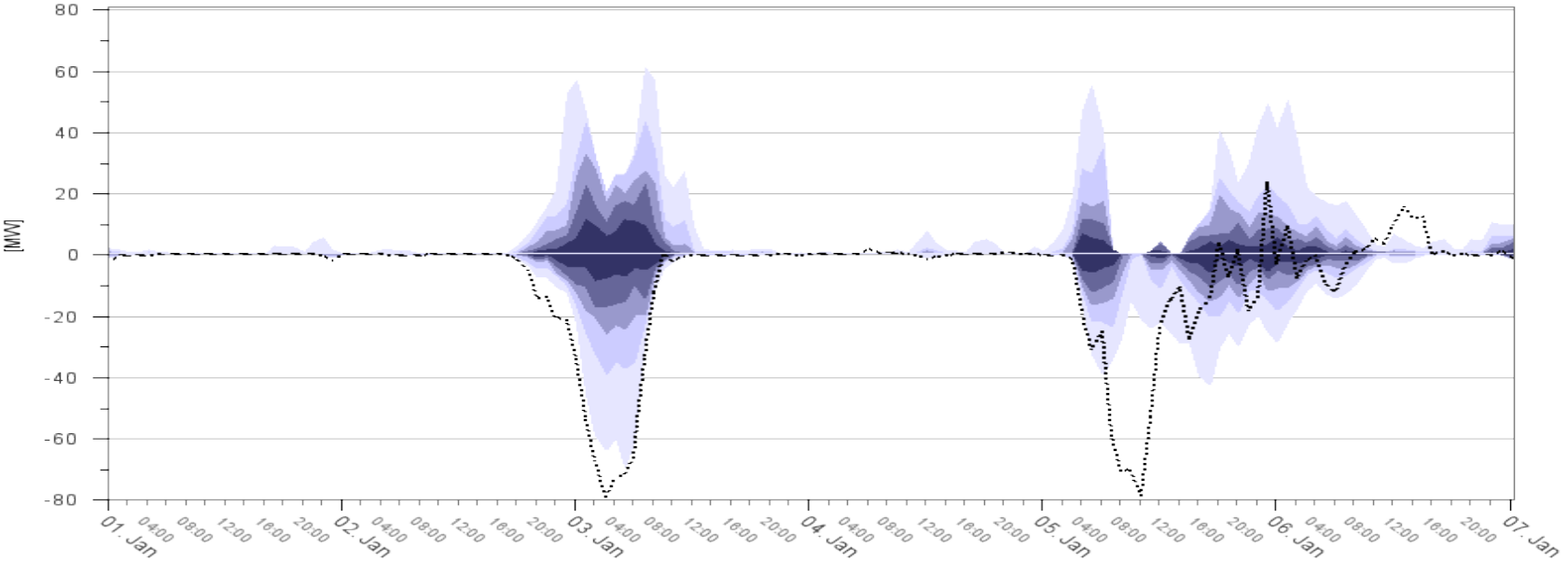
Let's have a closer look at how much information we can gain from ensemble data..

Wind farm Forecast power forecast with 7-12h lead time

Normal View Power

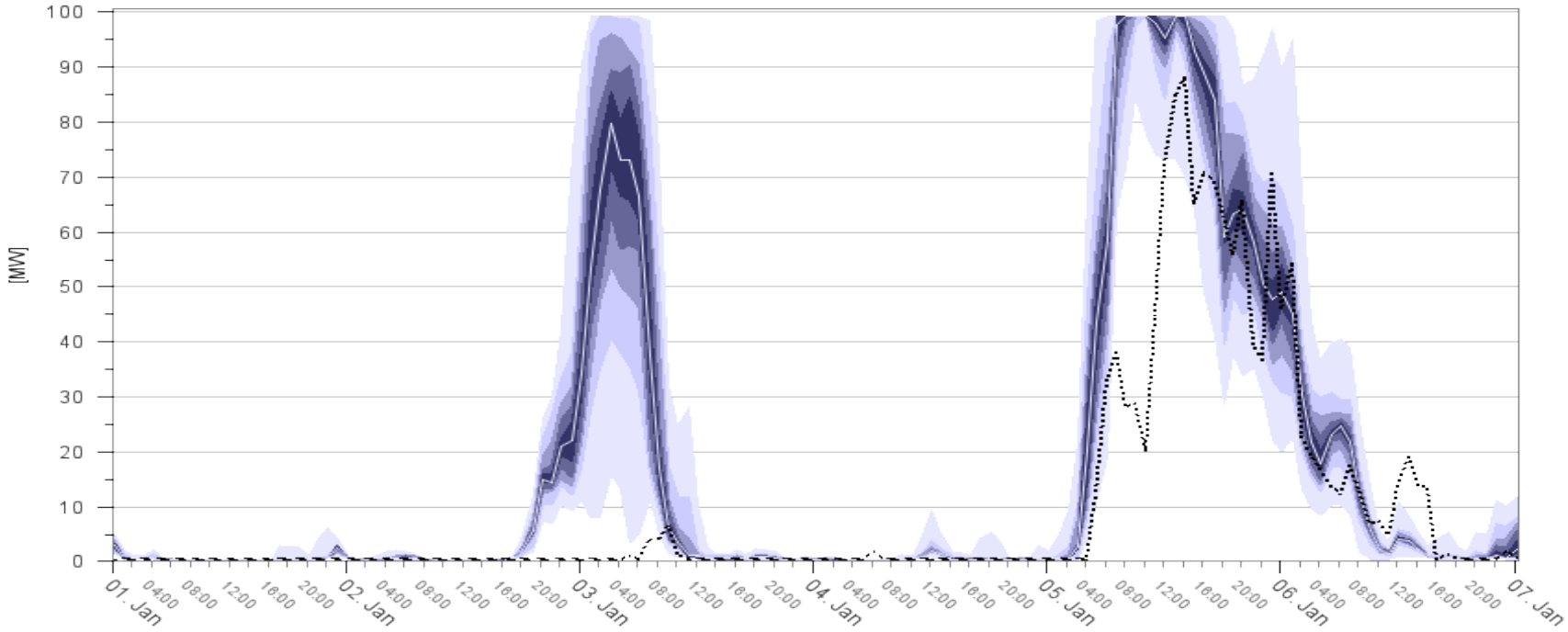


Relative to p50

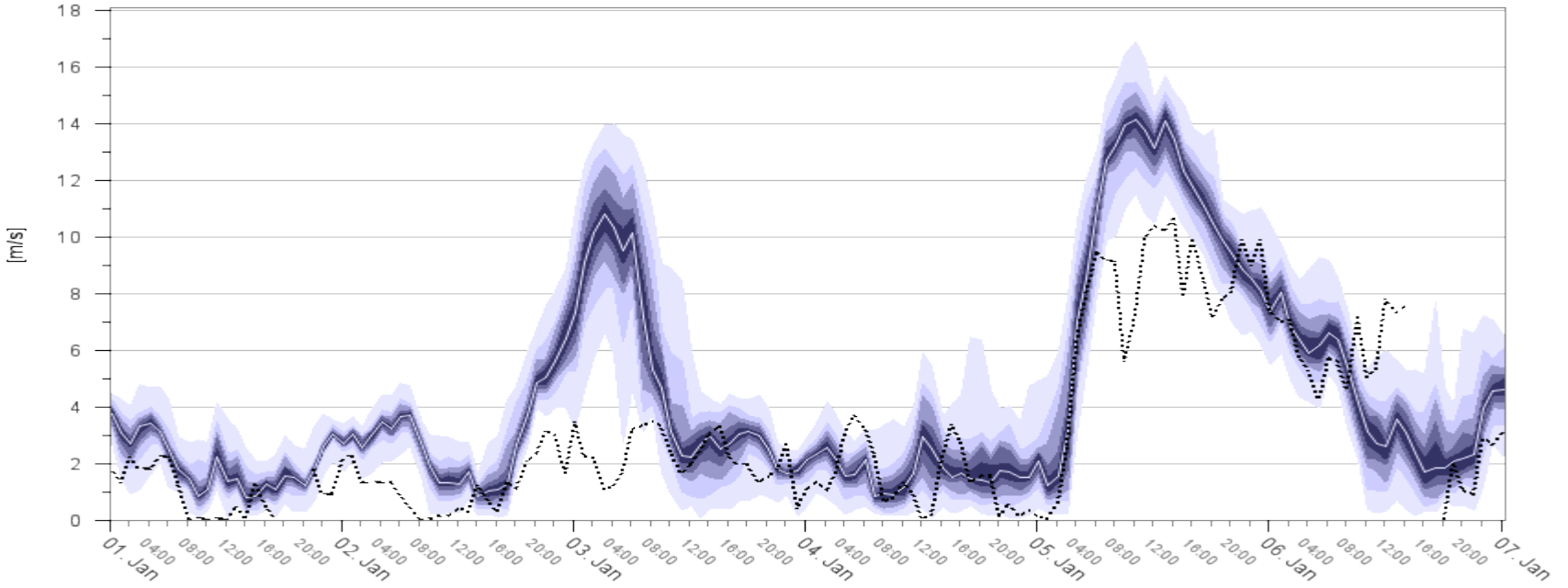


Wind farm Forecast power and wind speed forecast with 7-12h lead time

Normal
View
Power

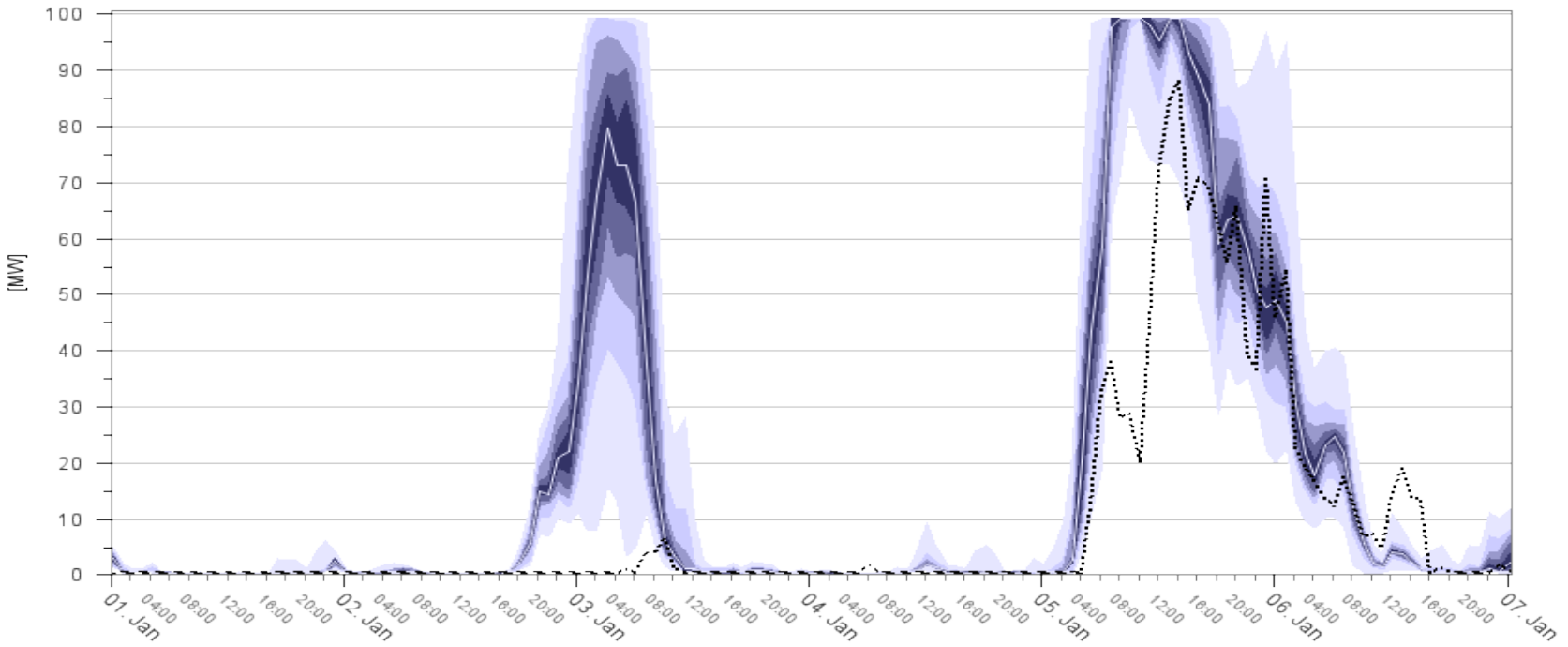


Normal
View
Wind speed

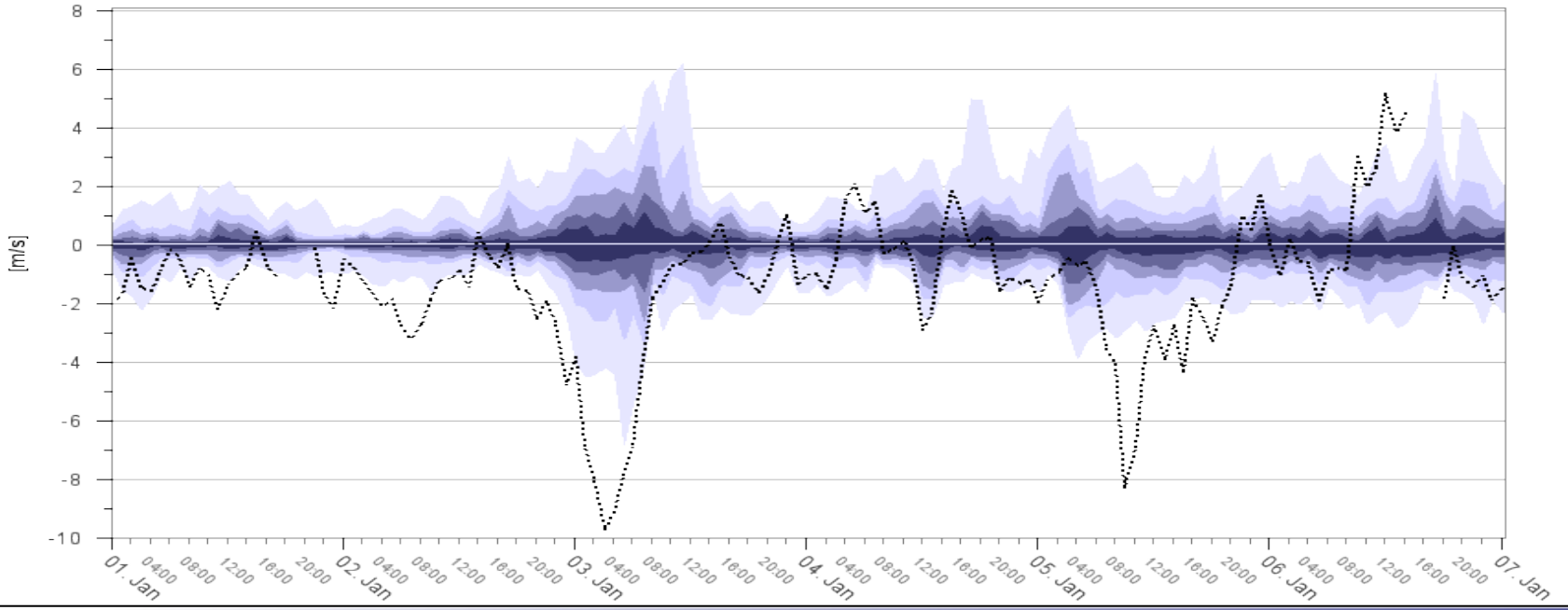


Wind farm Forecast power and wind speed forecast with 7-12h lead time

Normal View Power

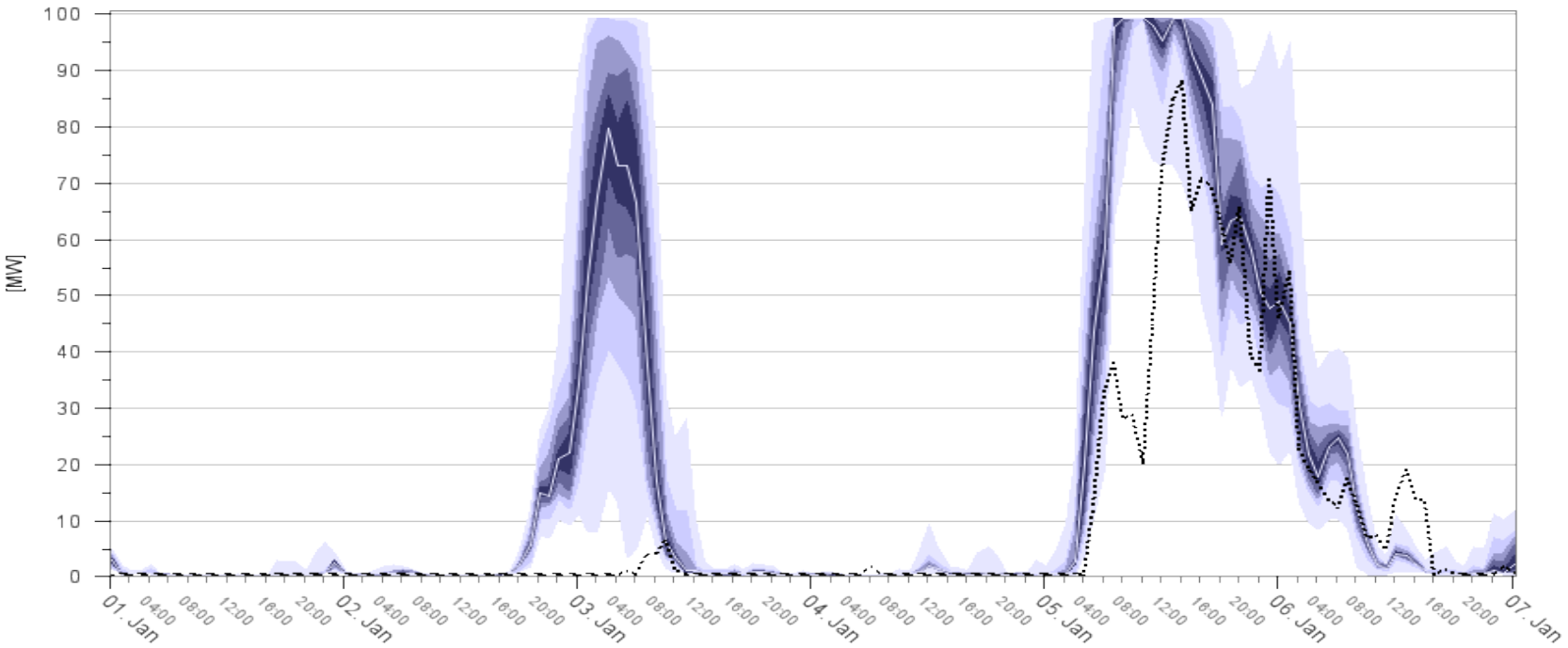


Wind speed relative to p50

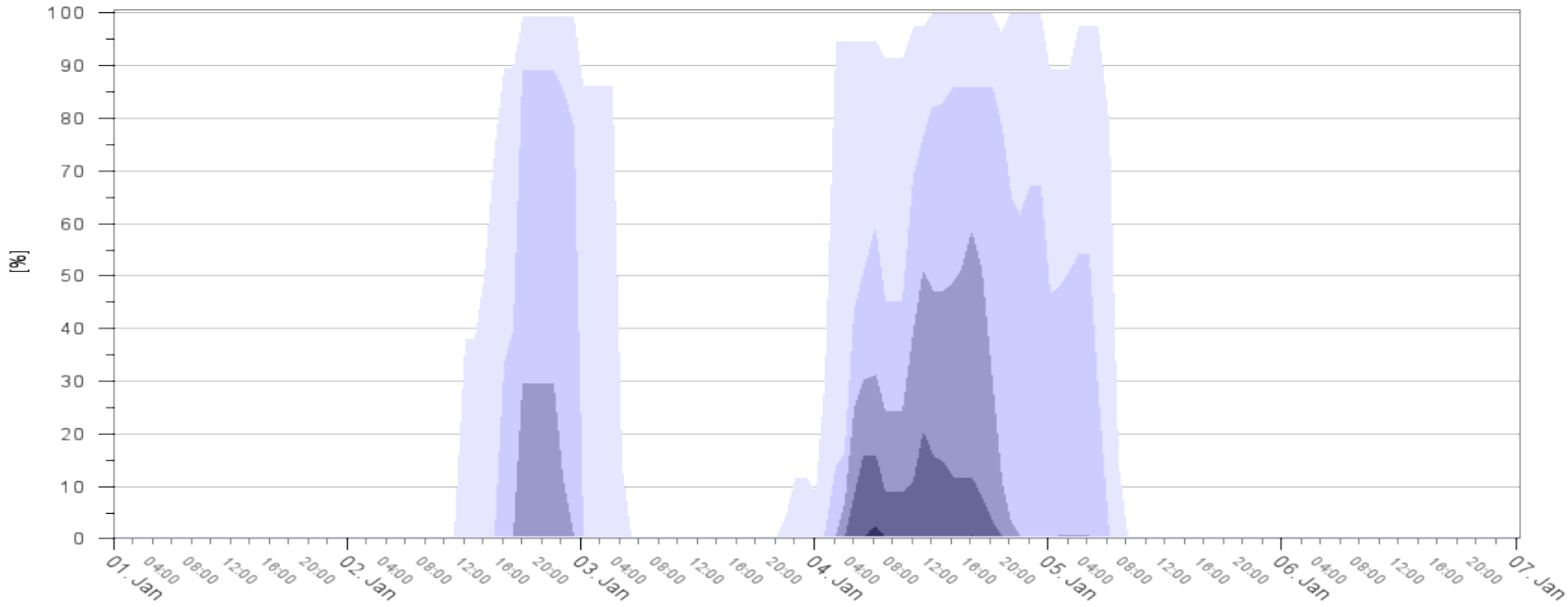


Wind farm Forecast power and Ice Up forecast with 7-12h lead time

Normal View Power

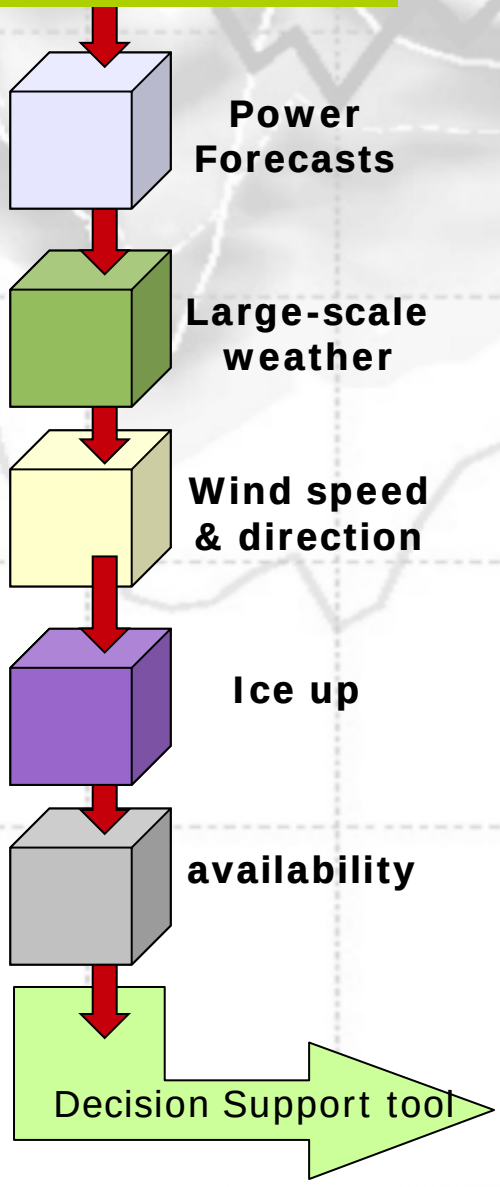


Ice Up risk



Possible design of a warning system

power production evaluation criteria



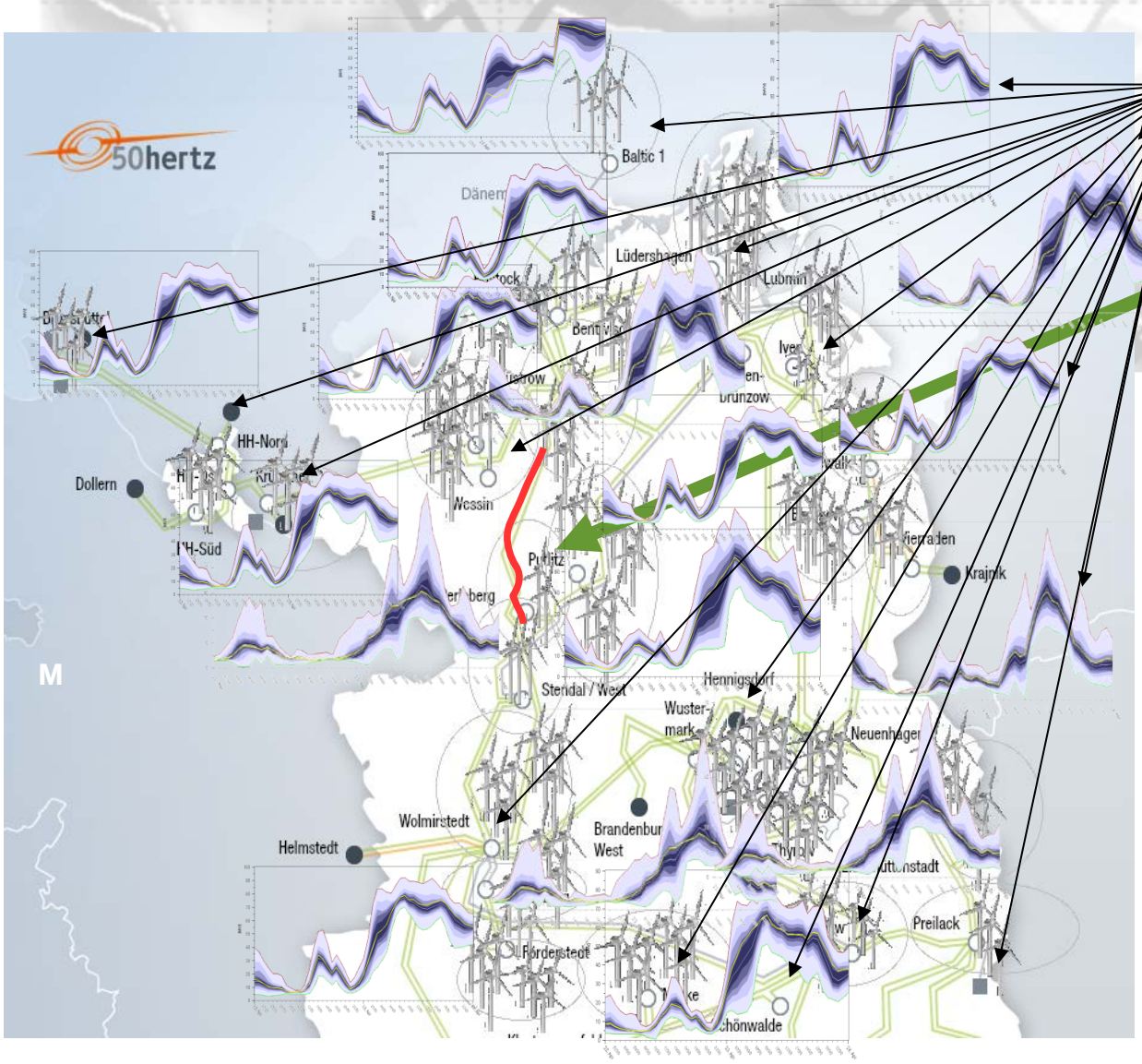
Power forecasts are compared to measurements
→ do they lie within the spread of uncertainty ?

Large scale weather forecast is analysed
→ does the power forecast correspond to the large scale development ?

Wind speed forecasts and direction are verified
→ does the power production correspond to the wind speed
→ in the winter: **is there risk of ice-up**
→ if wind speed does not fit power, is there unexpected **unavailability** ?

Example of how to generate grid point forecasts and to use uncertainty for planning purposes – part 2 -

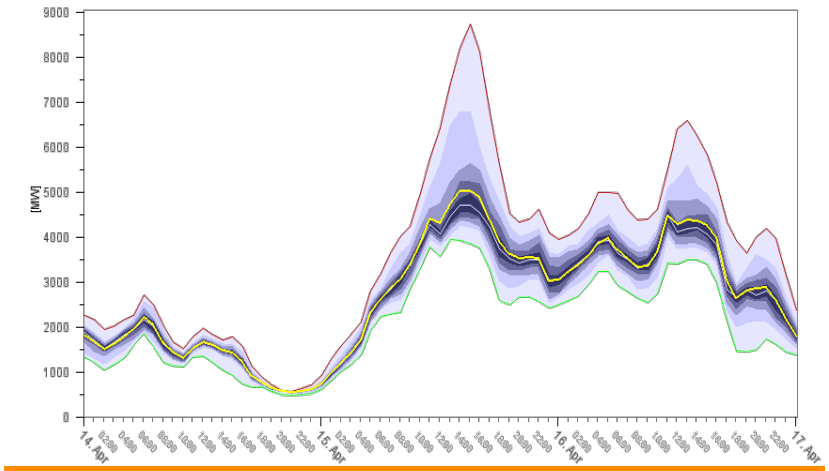
Schematic Example at a German control area



Ensemble Forecasts are made on all grid points, where VG plant are feeding in to the grid

possible congestion areas are easy to discover with uncertainty information at main grid points

forecast for total control area

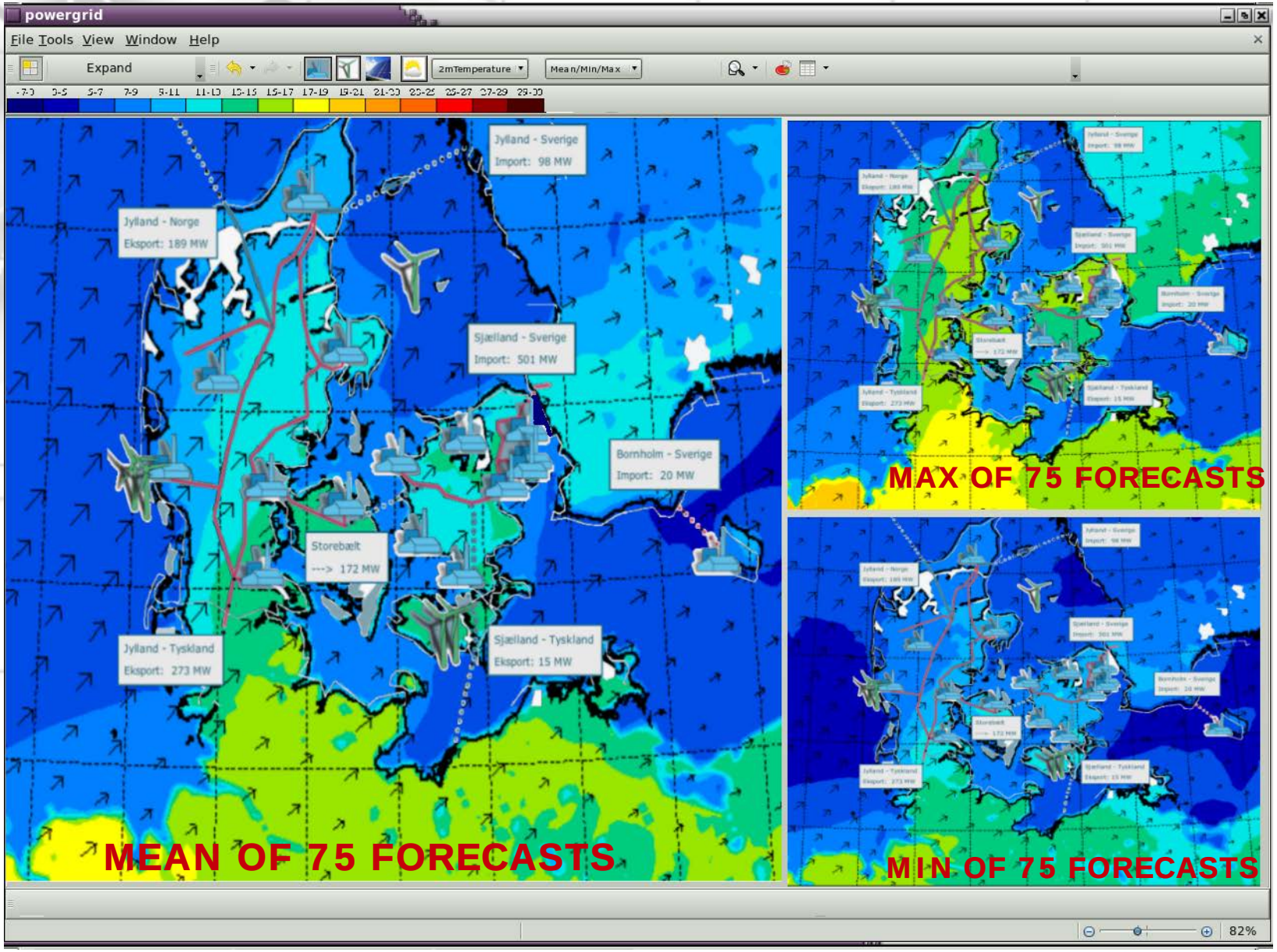


Forecast for entire control area does not provide information about areas that may suffer from congestion

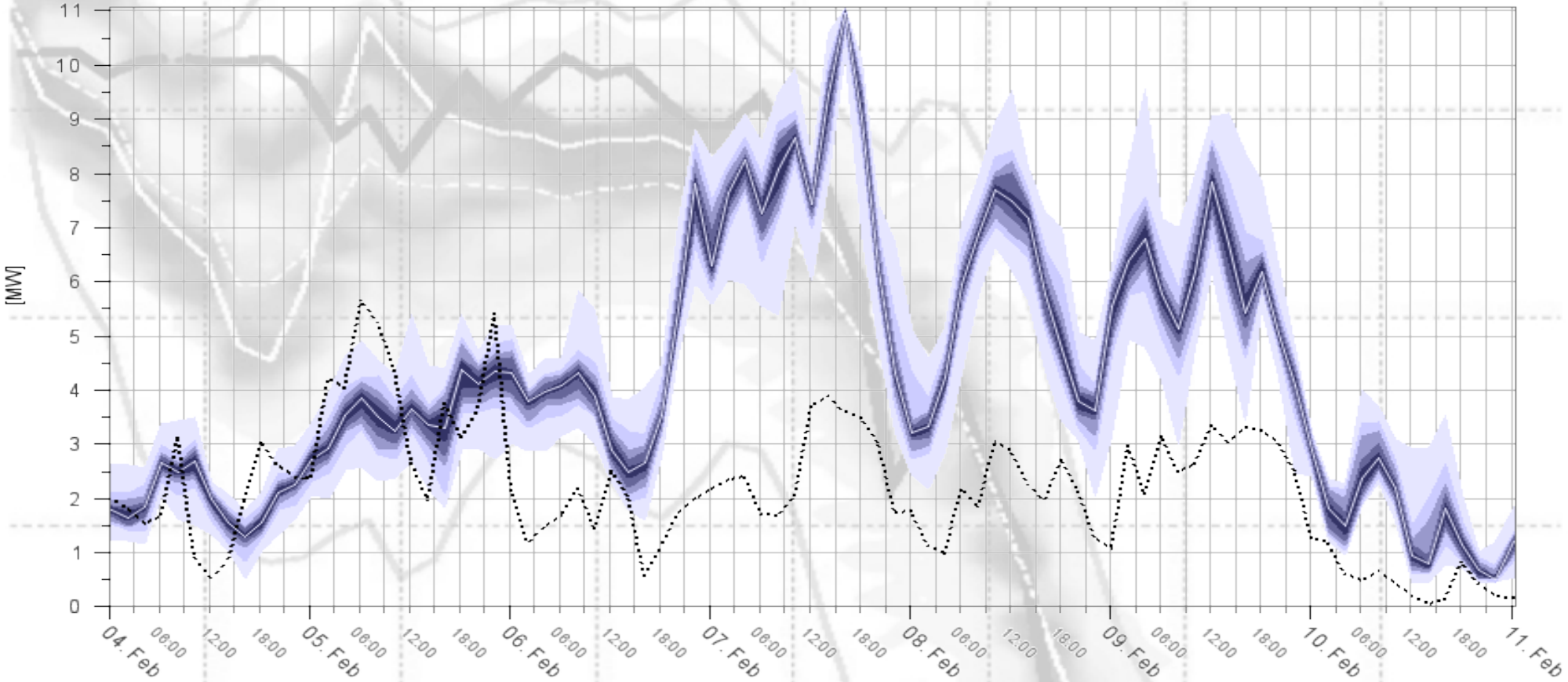
Integration of weather maps of MEAN – MIN- MAX into GUI of control room to know where extremes can be expected

Example

DK-West
Wind speed



Using Ensemble Forecasts for monitoring purposes



Windfarm, where the production suddenly drops

If you don't know what the Farm should produce, the Time series of measurements does not “look” wrong…could be just low wind

Summary & final remarks

Uncertainty forecasts and weather dependent short-term forecasting is a must for efficient handling of Renewables when under market rules

Forecasting areas have to become larger to be able to provide large scale forecasts, but also provide more details

The energy market is getting more complex, but...
having the right tools to meet this increased complexity helps !

Interdiciplinary Communication across department
& investment in flexible IT solutions

are key to the future of

energy market participation & grid operation!

Thank you for your attention !

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Increasing the Competition on Reserve for Balancing Wind Power with the help of Ensemble Forecasts
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Investigation of various trading strategies for wind and solar power developed for the new EEG 2012 rules
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