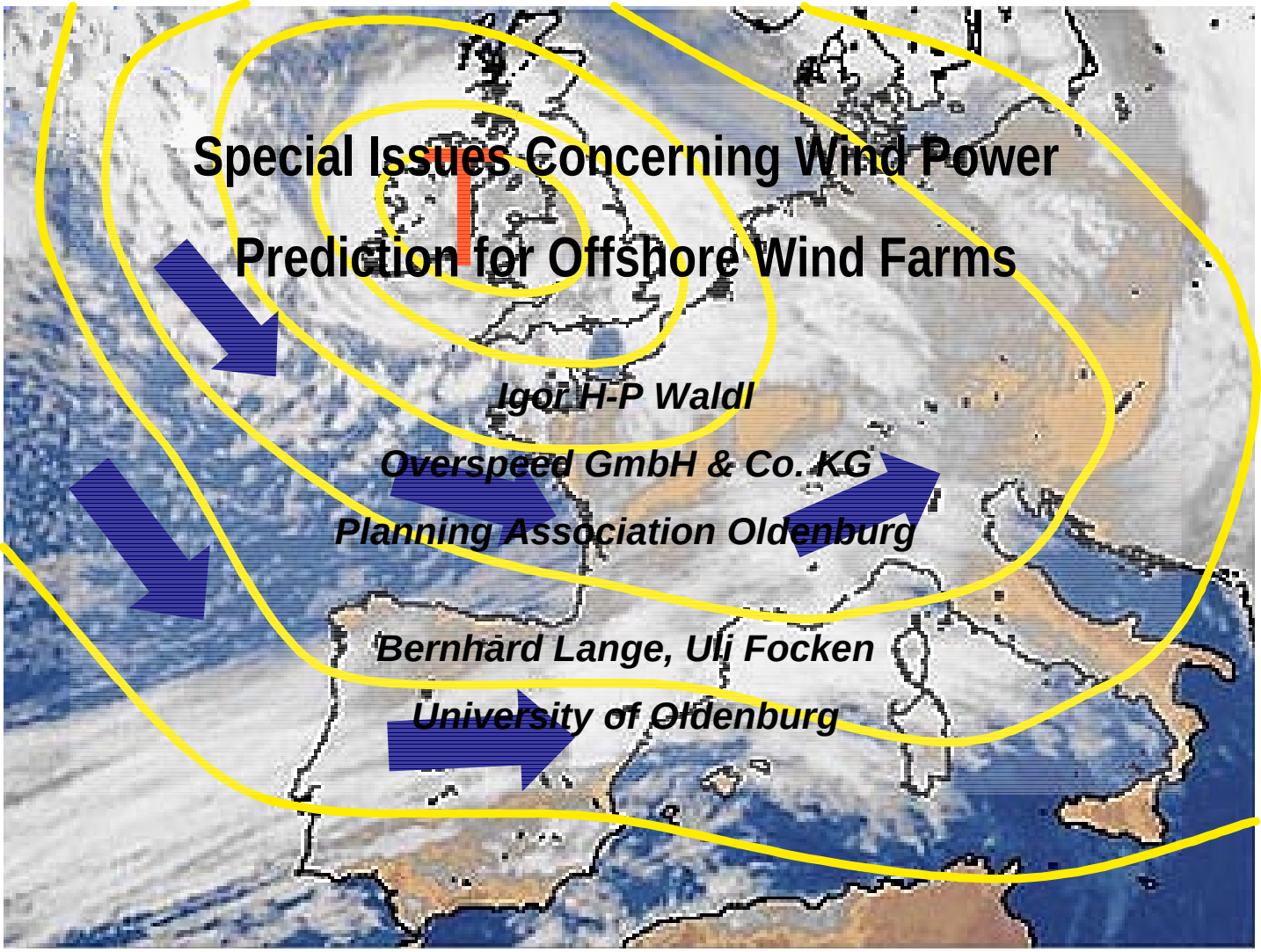

Special Issues Concerning Wind Power Prediction for Offshore Wind Farms

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Overview

- Approaches to wind power prediction
- The Oldenburg „Previento“ prediction system
- Offshore meteorology
- Offshore wind farms
- Conclusions

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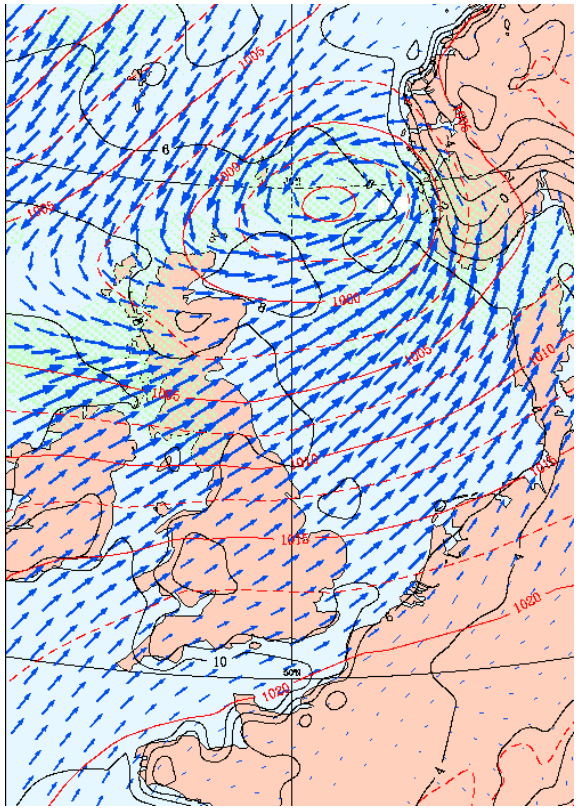
Goals Wind Power Prediction

- Prediction of wind farm and regional power output
- Prediction horizon typically 48-72 hours
- Prediction uncertainty

- Power plant scheduling
- Grid control

- Lower power reserve
- Less emissions
- Better economic performance

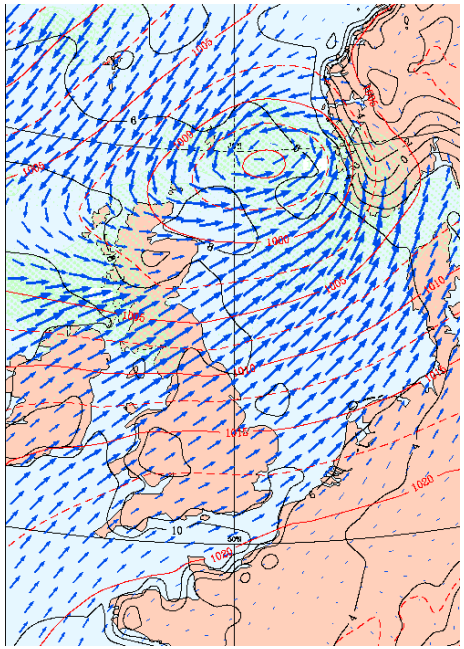
Basic Ideas and Approaches

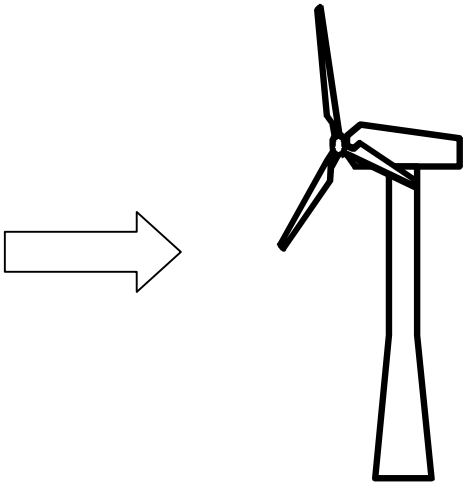


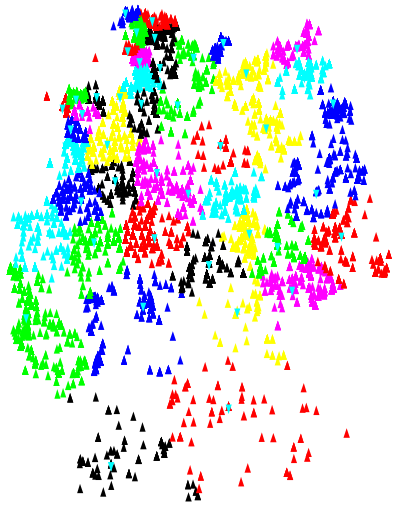
Basis: Numerical weather prediction

- Typical 72 hours ahead
- Resolution 1 hour
- Representative sites for the region(s) of interest

From Weather Forecast to Power







Numerical weather prediction (wind speed)

Wind farm power

Regional power

Wind power prediction for offshore wind farms

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Statistical Approaches

- Input:
  - Wind speed predictions
  - Historical power data (site or ensemble)
- Statistical correlation
  - Neural networks
  - Multi-dimensional regression
- Transformation

  Prediction => Wind Power

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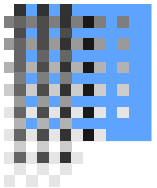
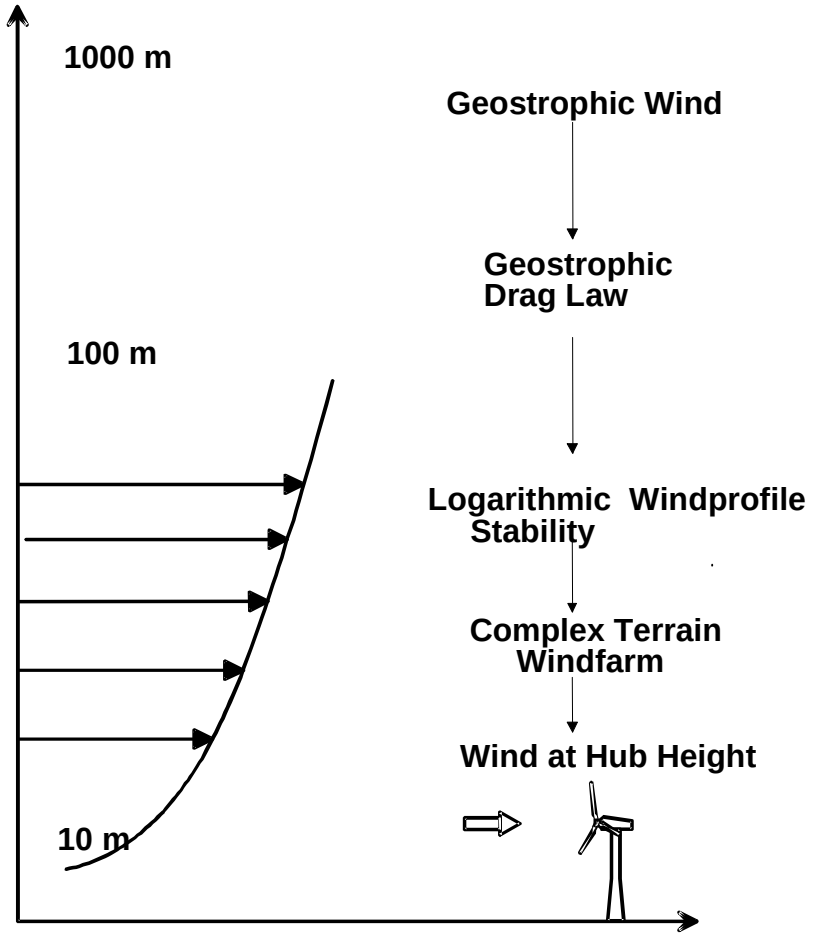


Physical Modelling Approach

- Input:
  - Wind speed predictions
  - Site descriptions (roughness, turbine, wind farm)
- Physical models
  - Meteorology
  - Wind farm
  - Wind turbine

Physical Modelling Approach (Previento)



- Wind speed predictions
- Surface Roughness
- Thermal Stratification
- Complex Terrain
- Wind farm description
- Power curves
- Wind farm power

Comparison Physical/Statistical Modelling

Statistical	Physical
+ No physical insight necessary	+ Fast response to changes, e.g. of the prediction model
+ Autom. adaption to changes	+ Chance to understand physical behaviour
- adaption takes long time	- Needs additional input data
- depending on high quality meas. data	- Changes sometimes must be made „by hand“
- NN: limited numbers of obervations may cause problems	

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www.previento.de

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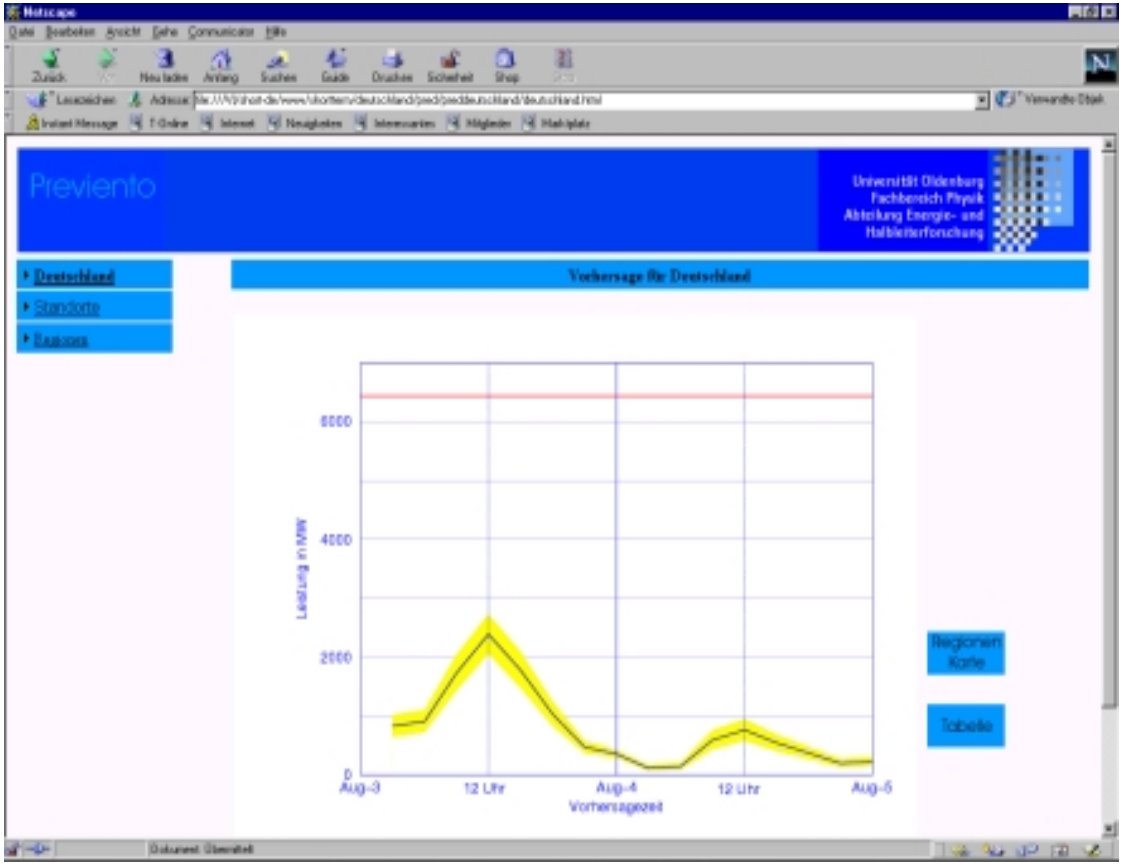
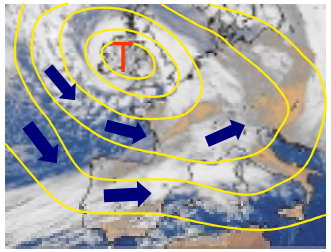


University of Oldenburg (Research&Development), Overspeed (Operator)

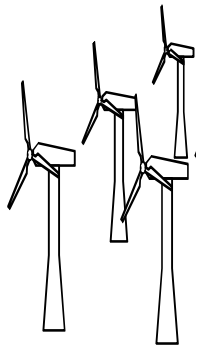
The Oldenburg „Previento“ Prediction System



NWP Data

Site Description

Site DB Germany



Measure-ments (Optional)

Calculation Module

- Refinement
- Stat. Correction
- Uncertainty
- Regional Upscaling

Ensemble Prediction

Wind power prediction for offshore wind farms

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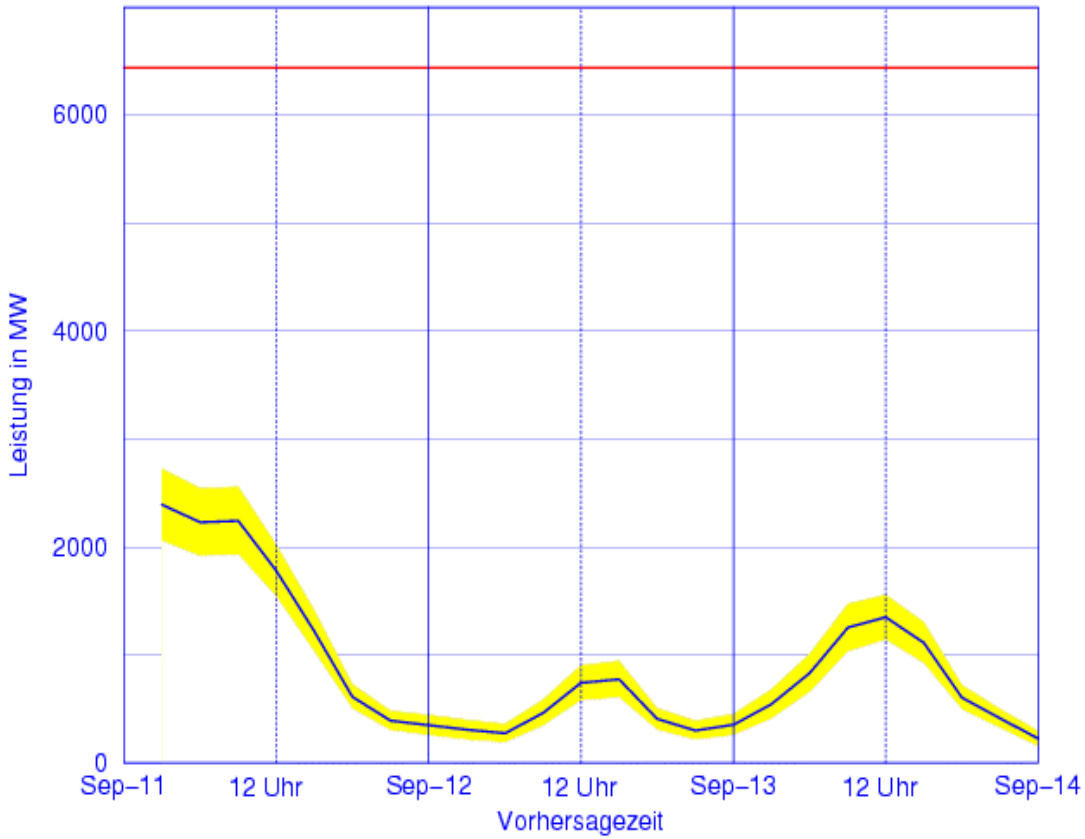
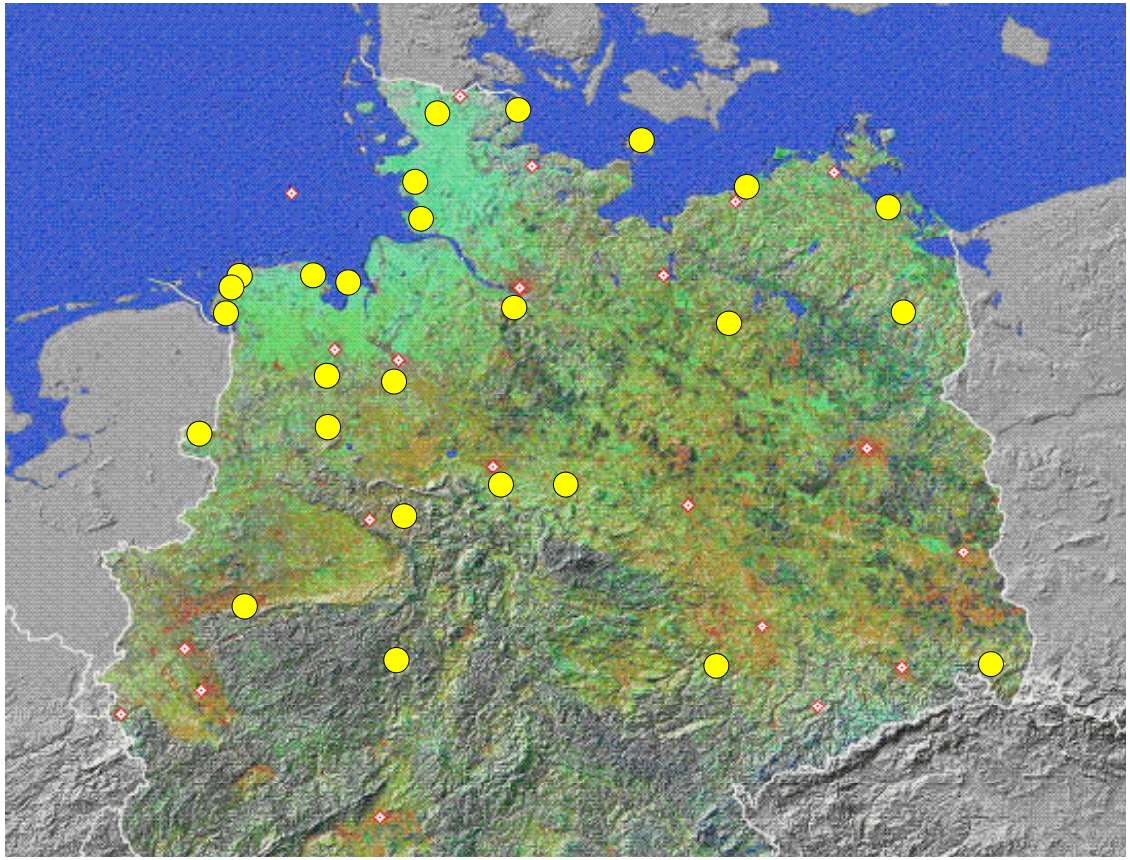
Prediction of Wind Power incl. Uncertainty



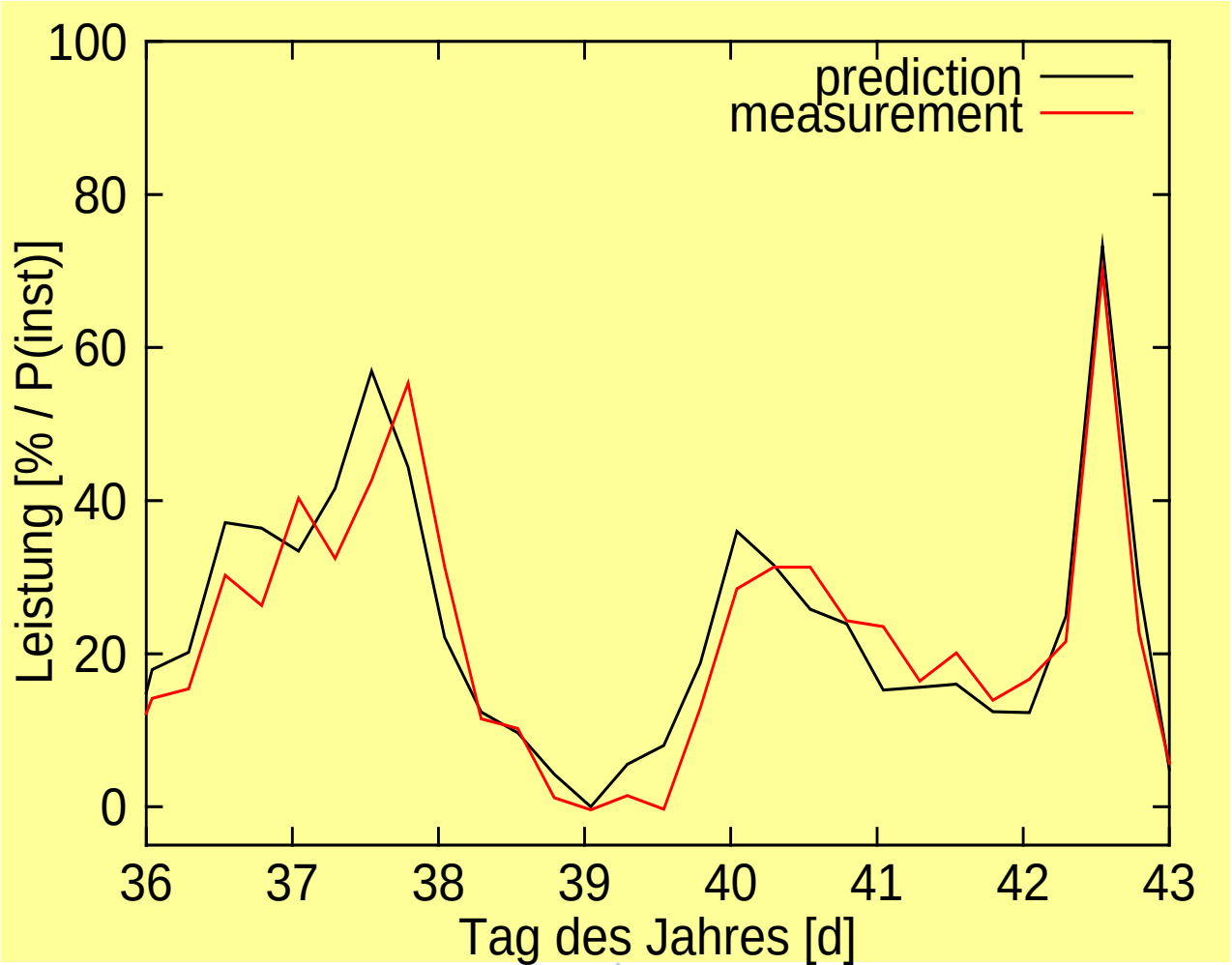
Prediction uncertainty depends on weather situation

Verification Sites



26 Sites, 4 years of data

Example Single Site



Mean Uncertainty Germany

Prediction time [h]	6	12	18	24	36	48
Uncert. [%/Pinst]	4.7	6.0	5.6	5.6	6.9	6.5

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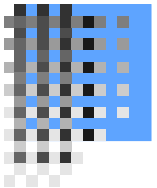

Offshore Meteorology

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Offshore Meteorology: Stratification

- **Thermal stratification** is different from land
- e.g. unstable in fall
- **Low roughness** increases this influence
- Influences wind speed and wind farm effects

Offshore Meteorology: Smoothing Effects

- Homogeneous surroundings
- Very concentrated installation of big wind farms
- Power output fluctuations may be very high,
- Especially during front crossings
- Research!

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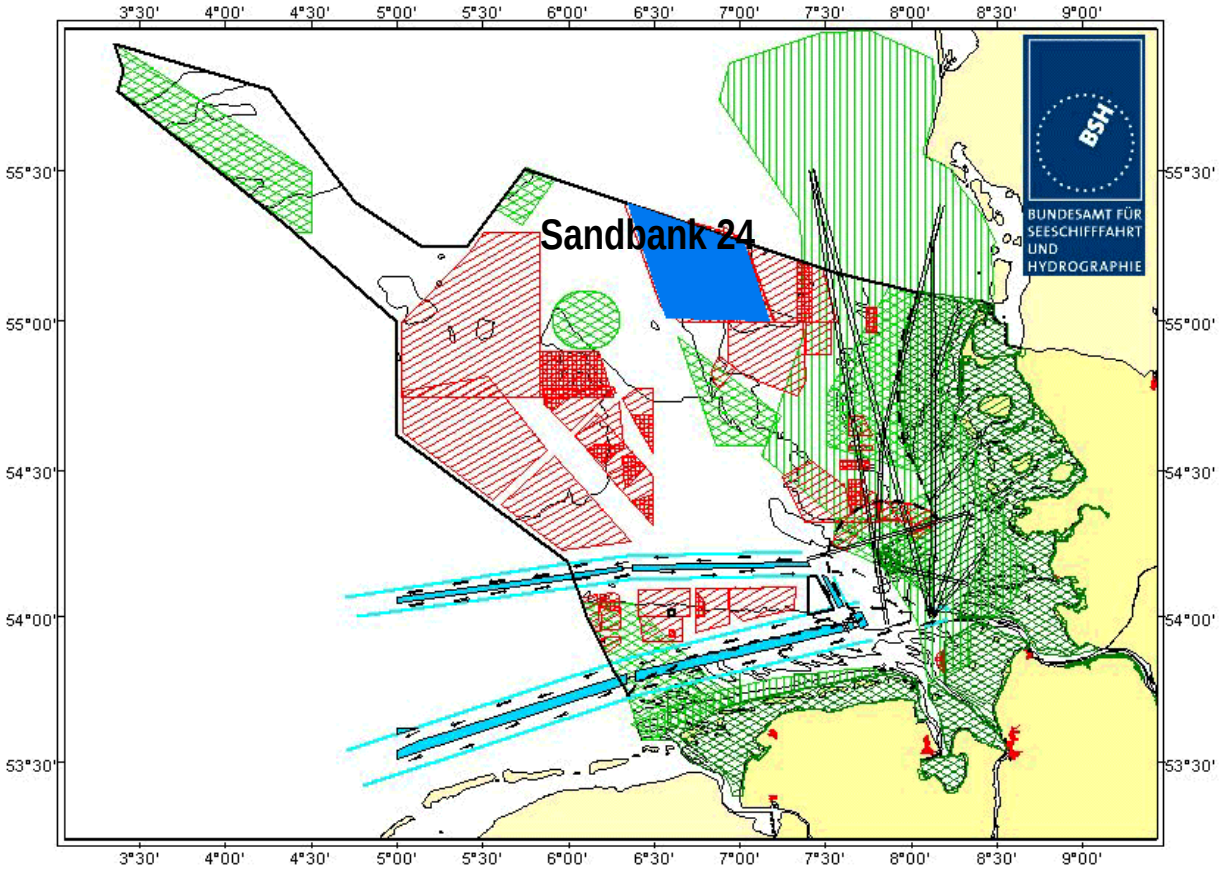
Applications Germany and „Sandbank 24“



Applications for 60 GW, 4 GW next 3-4 years

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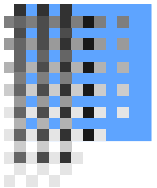
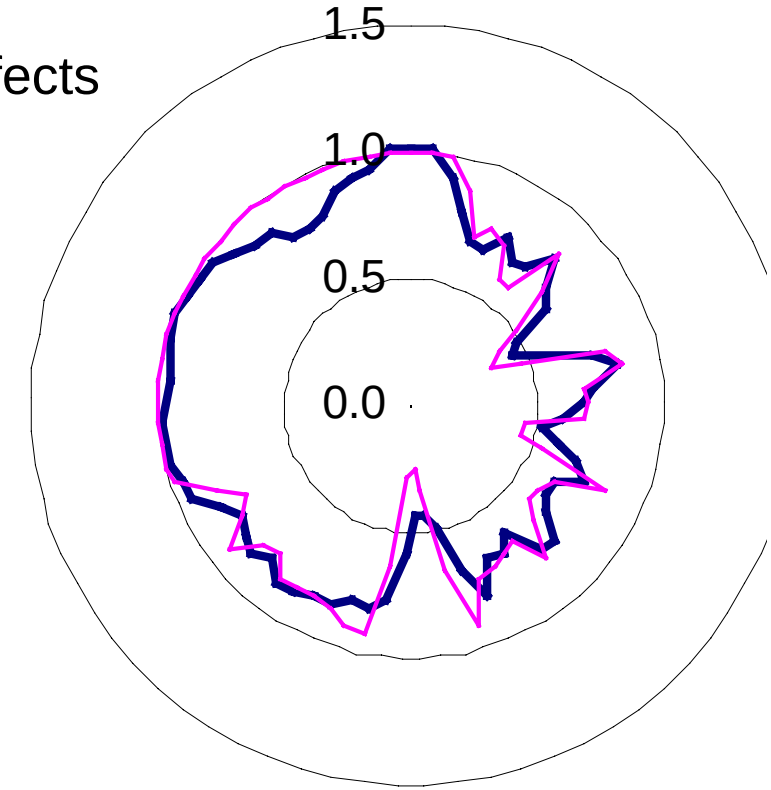


Wind Farm Shadowing Effects

- Power output is influenced by shadowing effects
- Depending on wind speed and direction
- Low roughness: high power decrease
- Very large, uniform farms
- Fluctuations from wind direction changes
- New models needed (under development)



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Wind Farm Cut-Off

- Switch off due to failures: large ensembles
- Domino effect at wind speeds near the cut-off

Very high gradients in power output

Conclusions

- Goal: Windpower prediction for offshore sites
- Meteorological situation different from on-shore
- Wind farm effects play bigger role
- Higher gradients to be expected
- Physical modelling!
- R&D, espec. smoothing and shut-down effects