Predicting Offshore Windpower

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Energy Meteorology

CARL VON OSSIETZKY universität OLDENBURG

Overview

- The Oldenburg ***Previento*** prediction system
- Specific Offshore situation
- First investigation for the german bight and Horns Rev
- Further development

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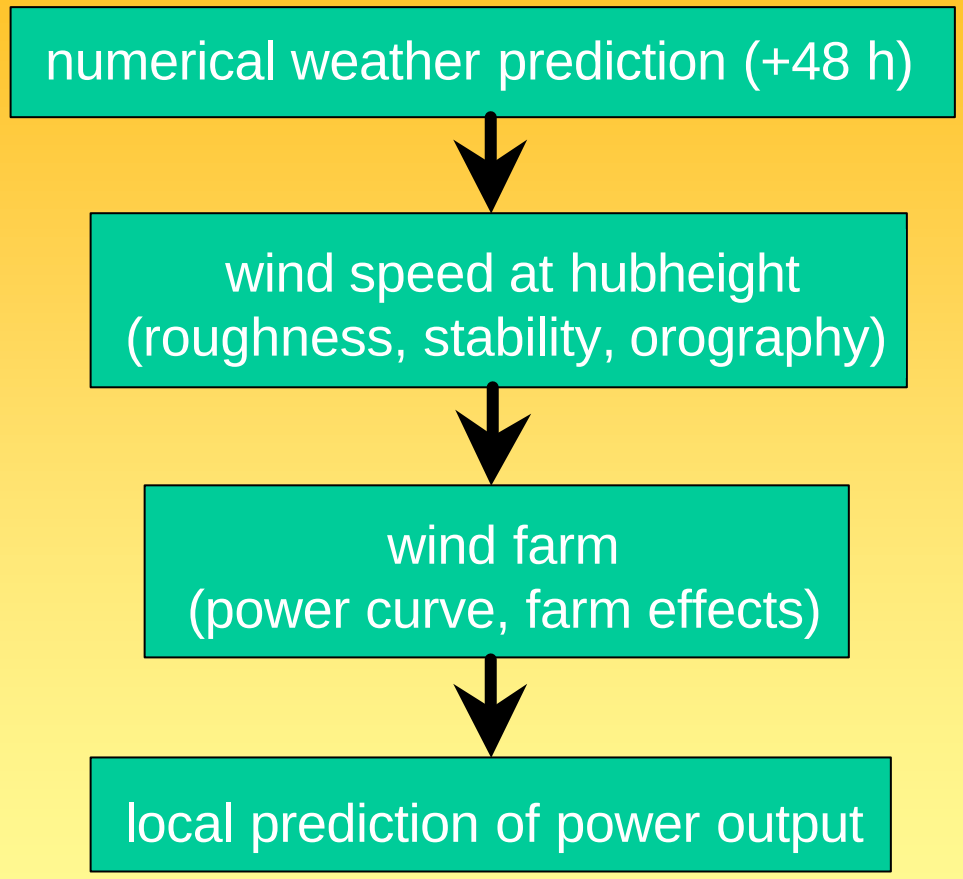
Prediction System *Previento*



Physical approach

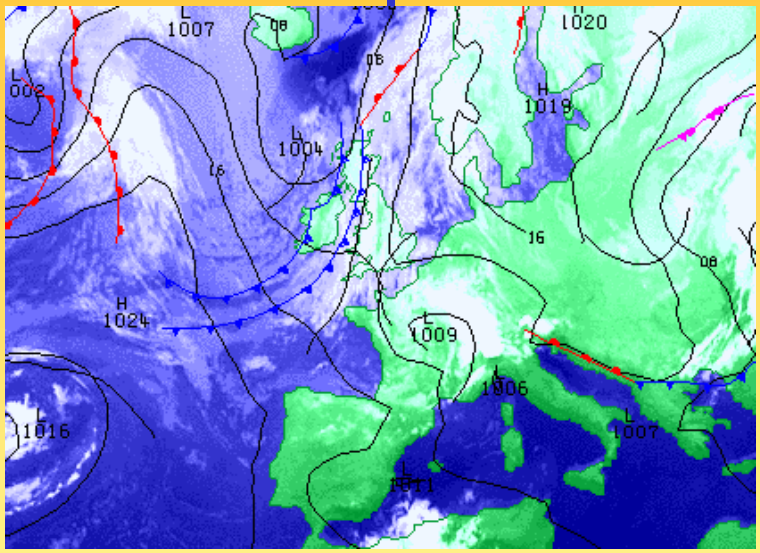
Prediction System *Previento*

numerical weather prediction (+48 h)

wind speed at hubheight
(roughness, stability, orography)

wind farm
(power curve, farm effects)

local prediction of power output



Prediction System *Previento*

numerical weather prediction (+72 h)

wind speed at hubheight
(roughness, stability, orography)

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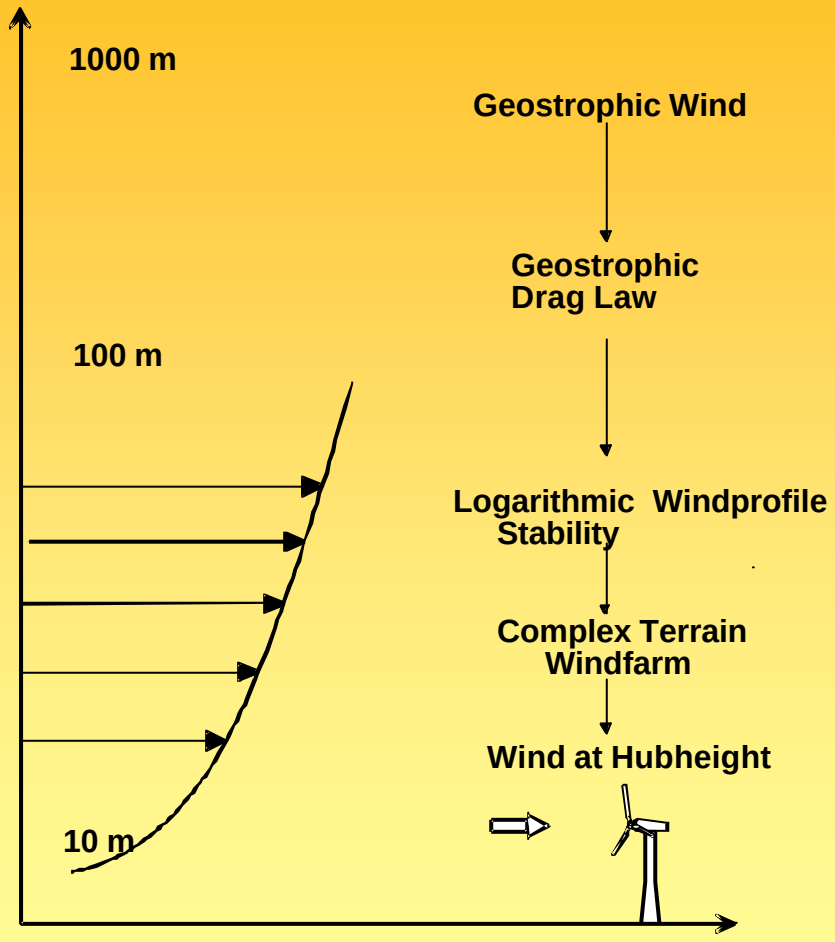
local prediction of power output

Physical modelling approach



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

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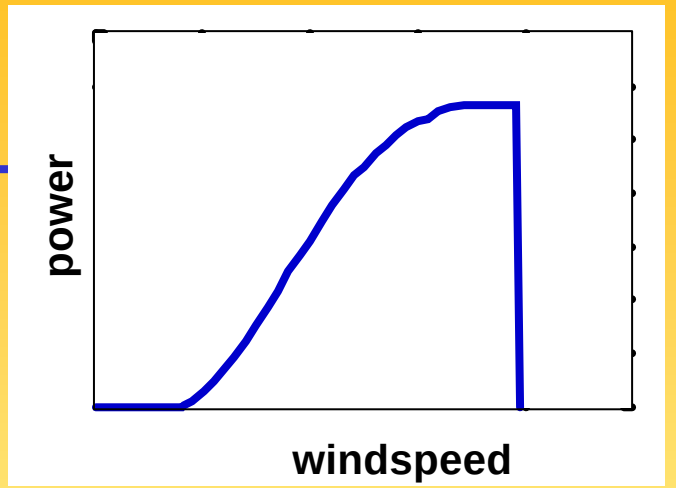

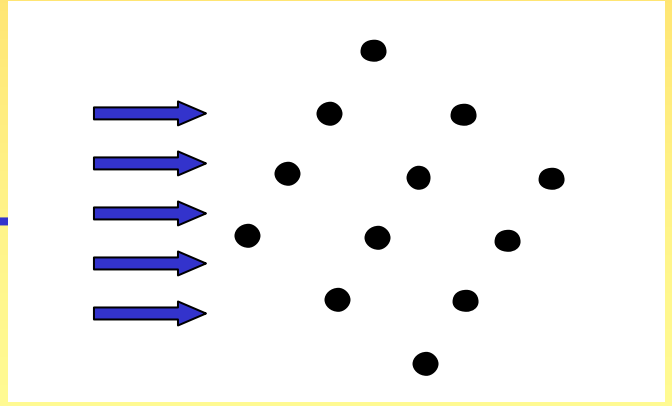

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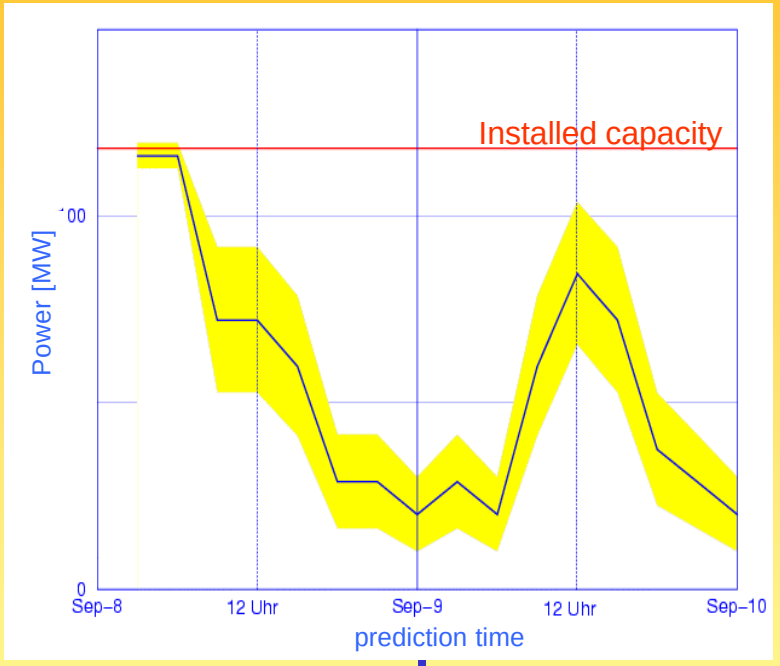
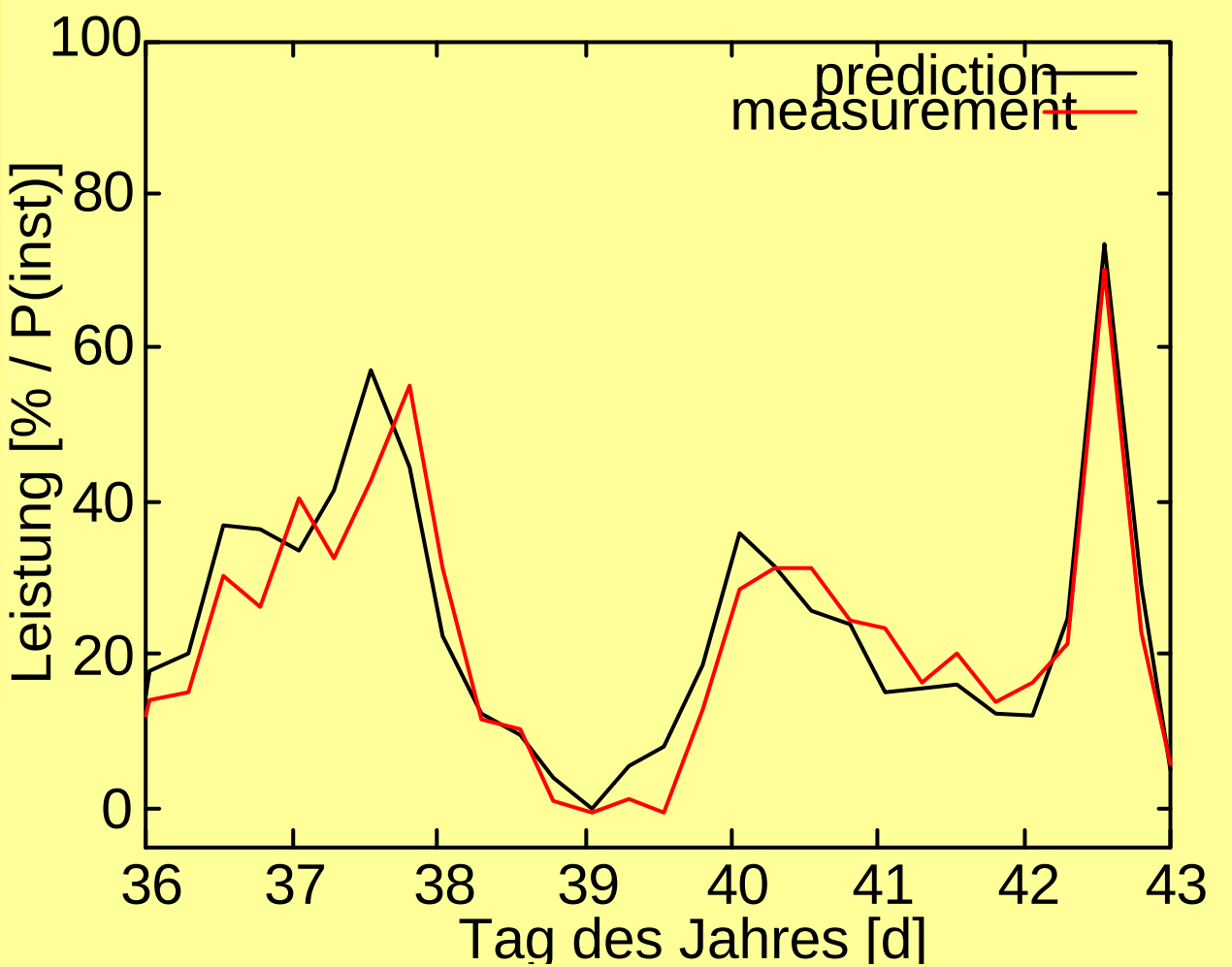


Example for Single Wind Farm



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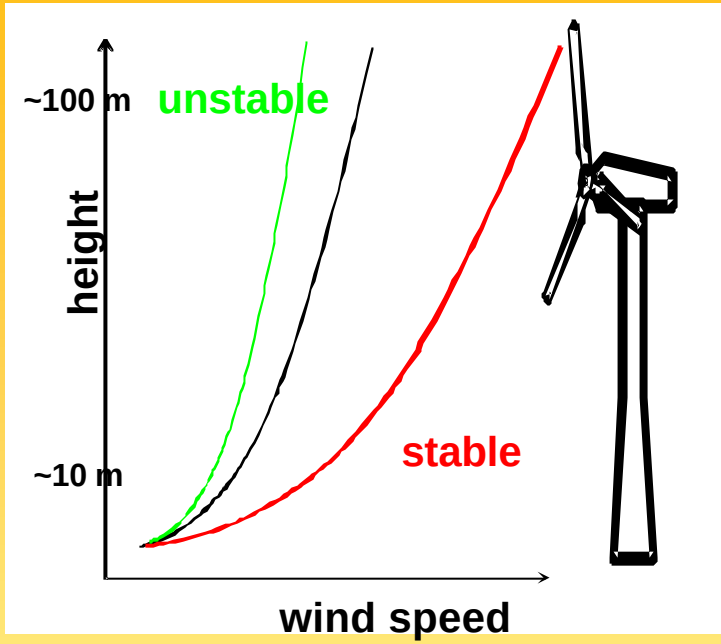
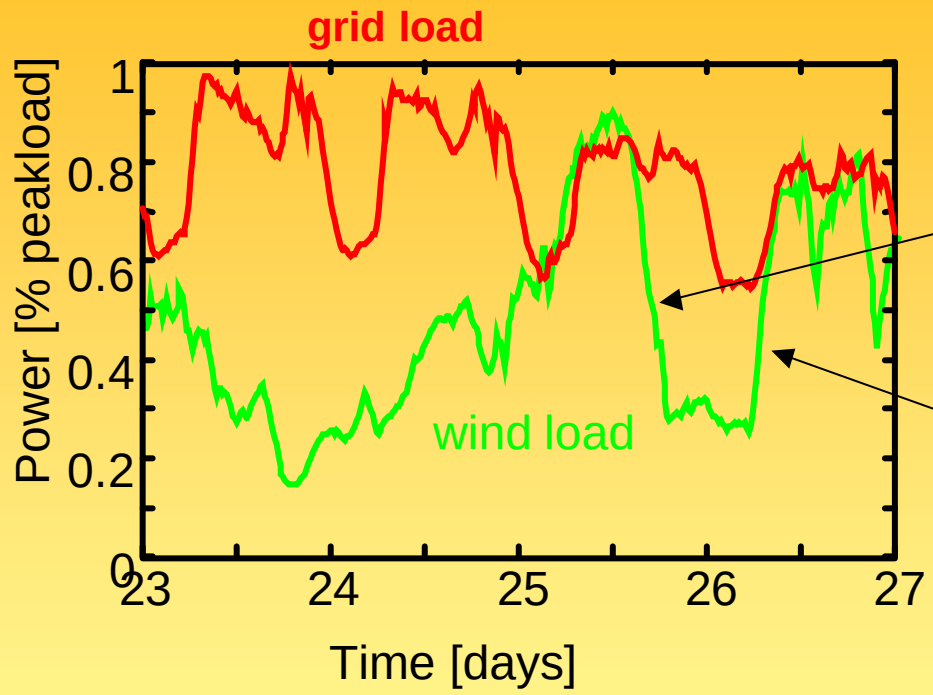
Offshore - different meteorological situation



- **Thermal stratification**
  different from land
- **Low roughness**,
  wind – wave interaction
- low **turbulence intensity**
- **Fetch –** direction dependent
- low **ekman layer** ???

Very concentrated capacity

Example: Storm „Janet“ October 2002 in the grid of EWE



Shutdown by 55 % of total Grid load in 4 hours

Increase: 45 % in 3 hours

Offshore: no smoothing effects!!!! →

Power output fluctuation offshore much higher

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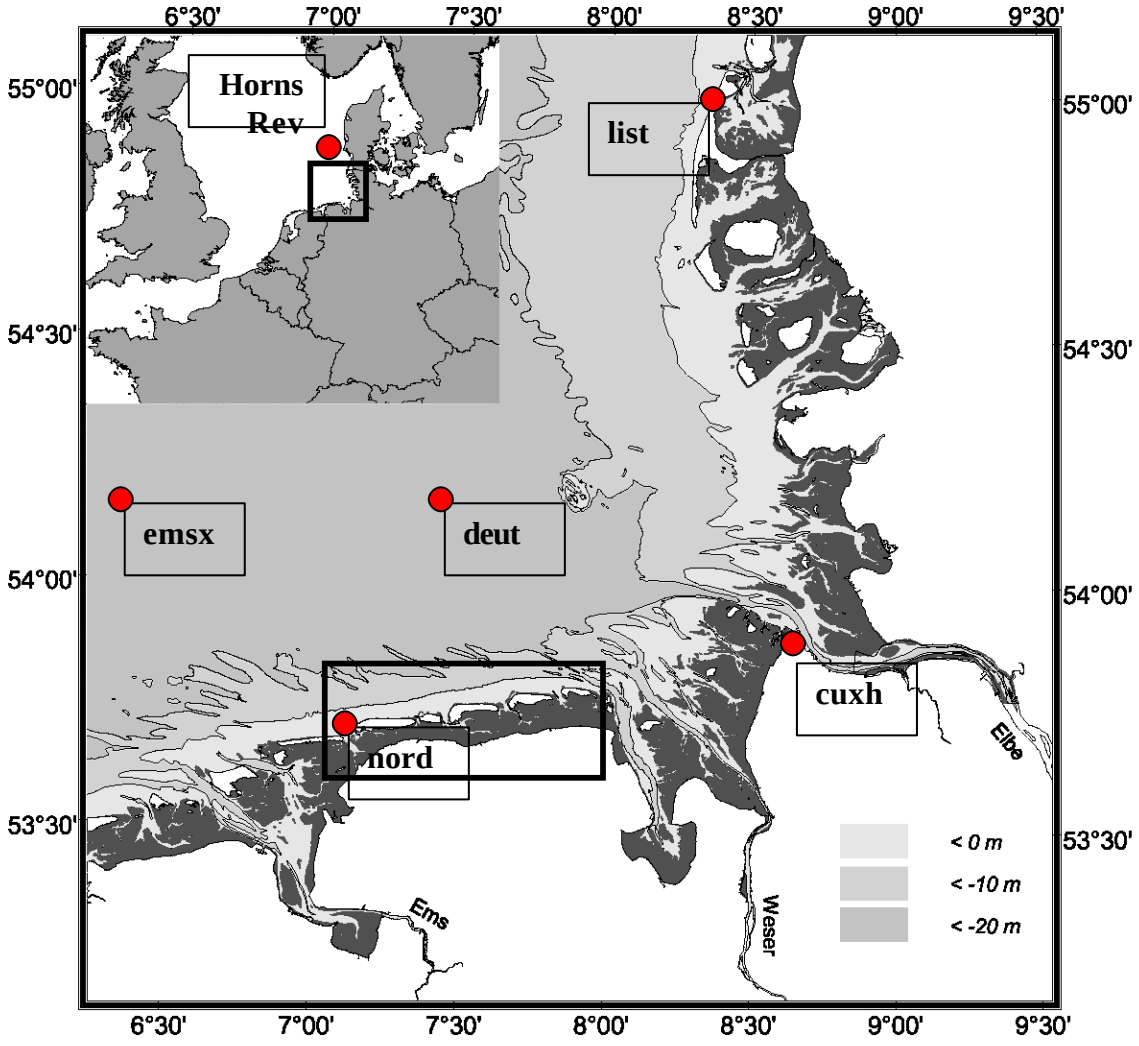
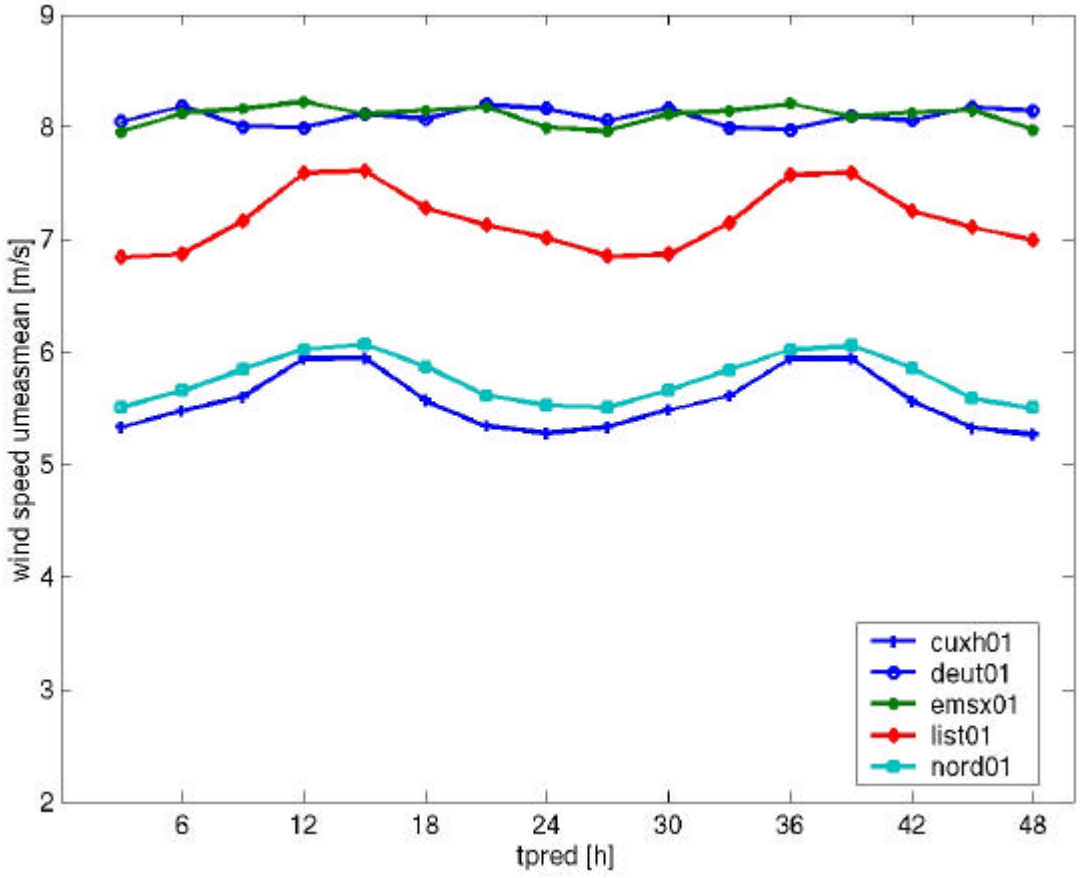
Evaluation of LM wind speed forecast

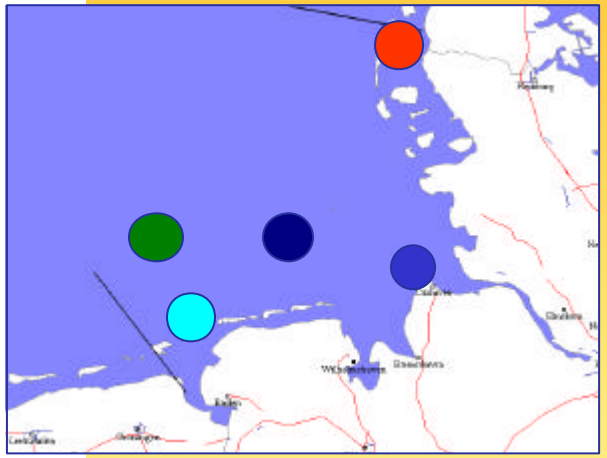
- ***Lokal-Modell*** **(LM) of German Weather Service *DWD***
  - **spatial resolution: 7 x 7 km²**
  - **heights: 10 m (diagnostic level), 33 m and 110 m (model)**
  - **offshore: Charnock formula (wind - wave interaction)**
- **Measurements**
  - **Light ships and island synoptic stations, 10 m height**
  - **Horns Rev met mast, different heights up to 62 m**

Used offshore sites in North Sea



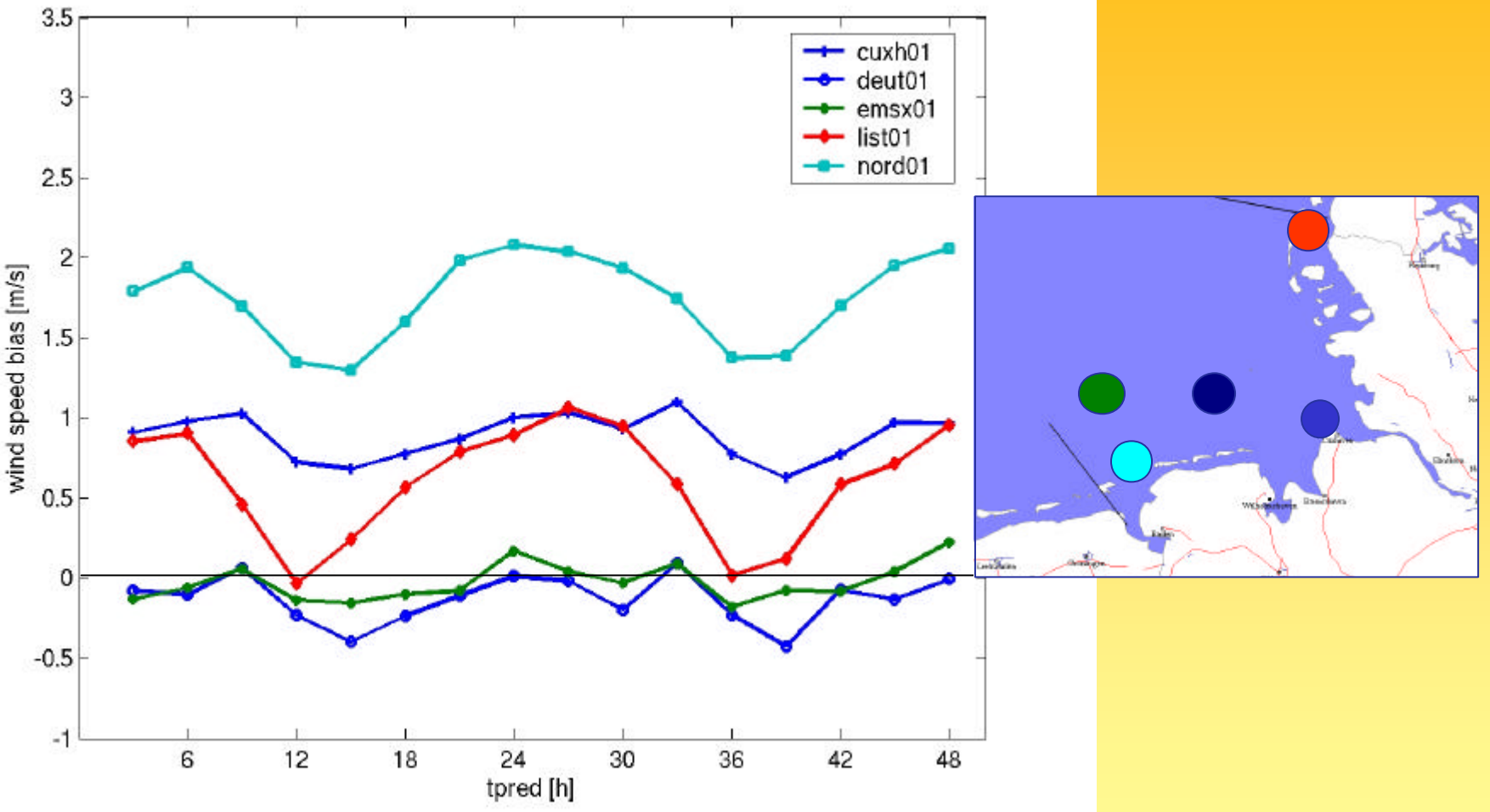
Mean measured wind speed



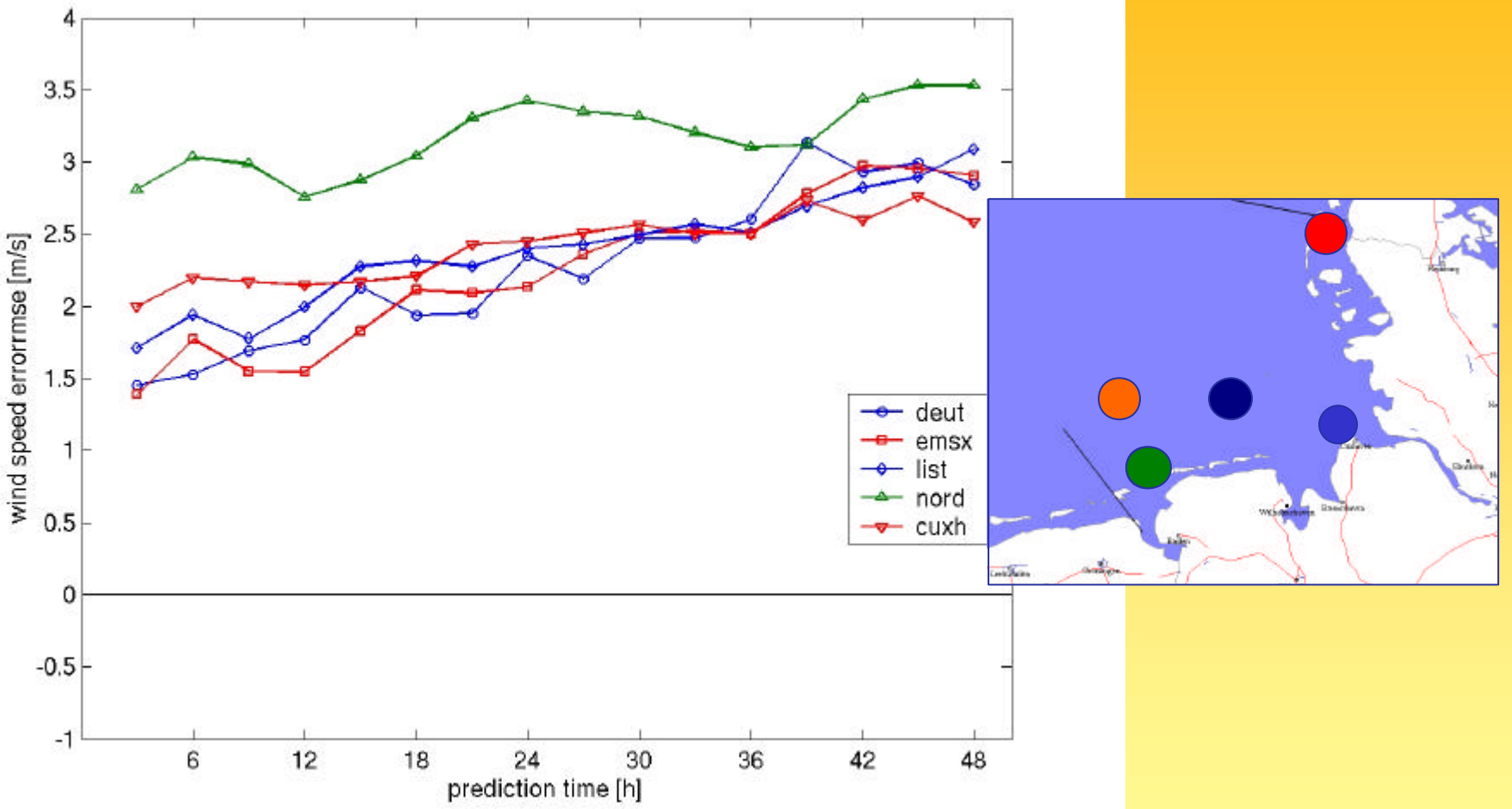


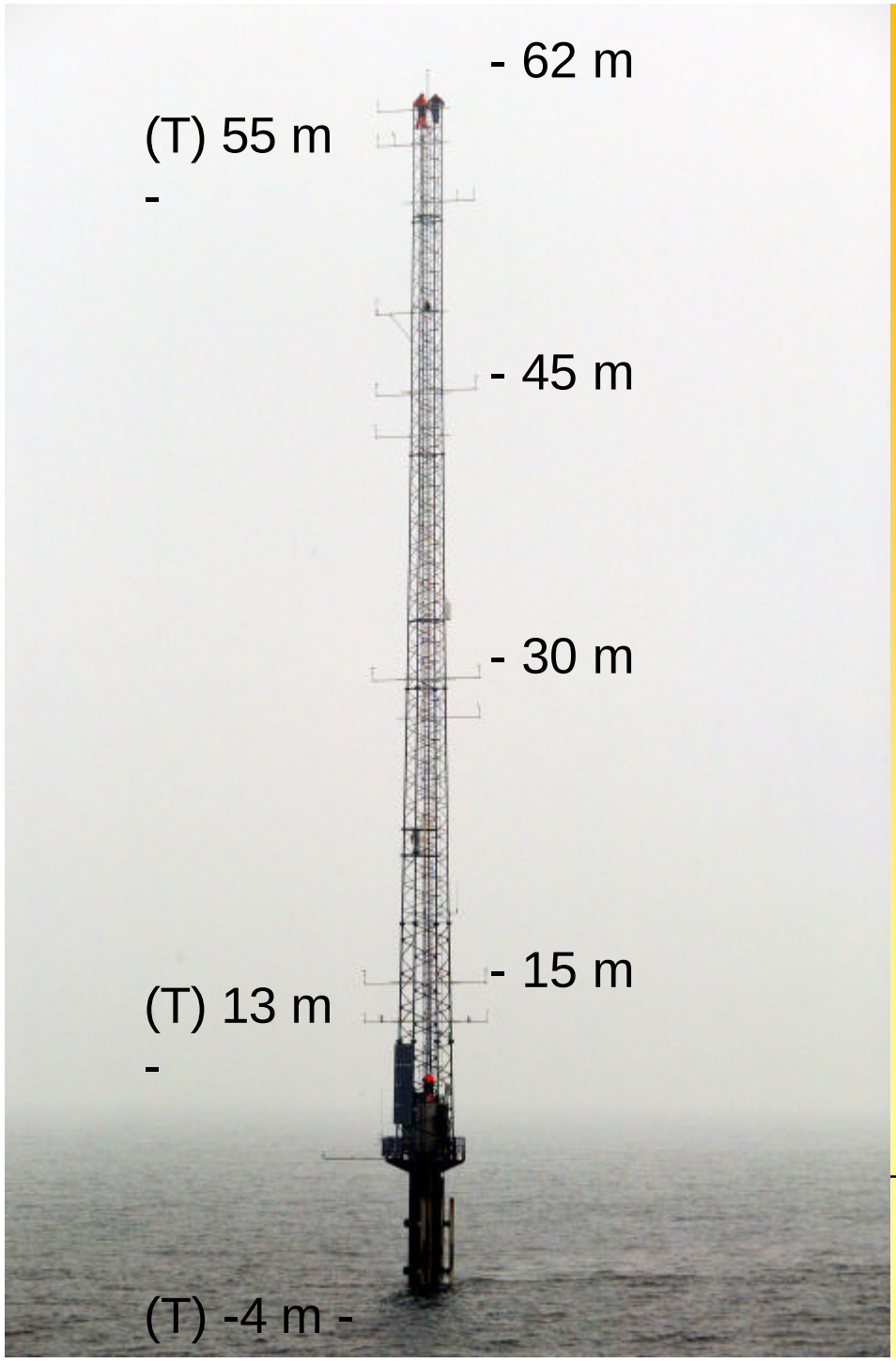
virtually no diurnal variations for real offshore sites

Mean deviation of forecast: bias



Rmse of forecast





Measurements at Horns Rev

- Cup anemometers in 4 heights
- Temperature at 3 heights (T)
- Investigated period: 10/2001 – 4/2002

LM forecasts

- in 3 relevant heights
- 10, 34, 110 m

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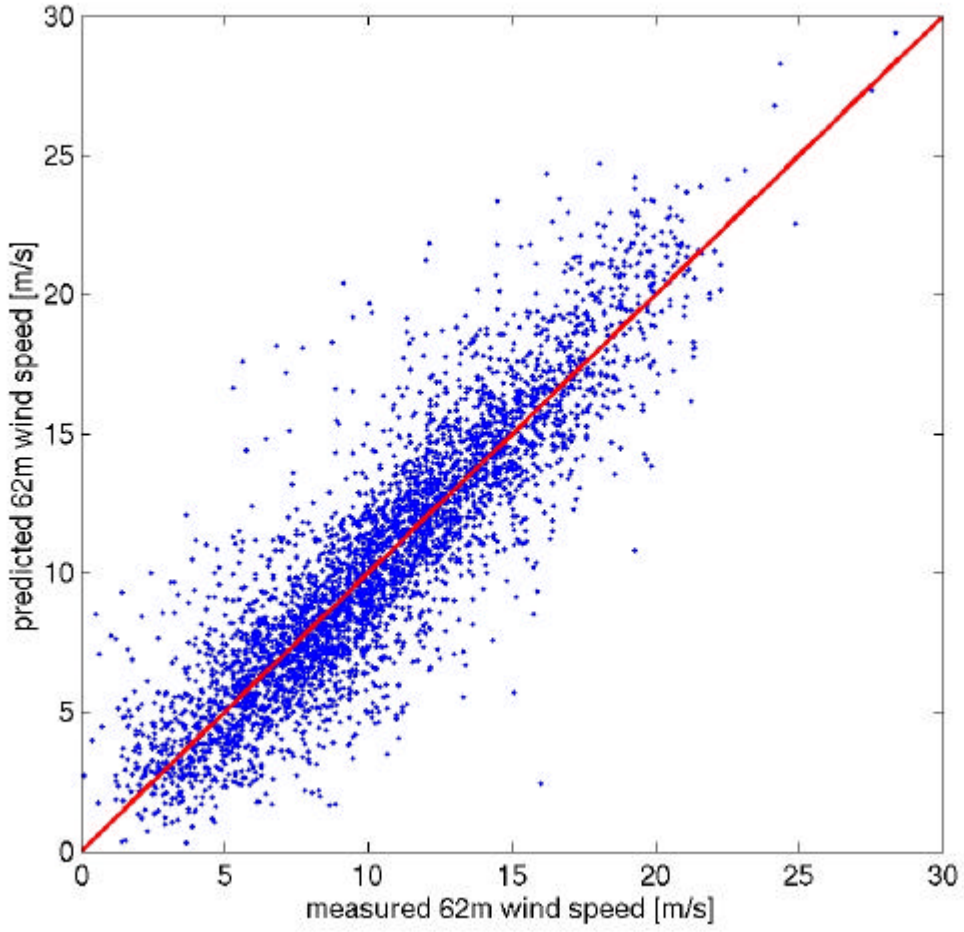
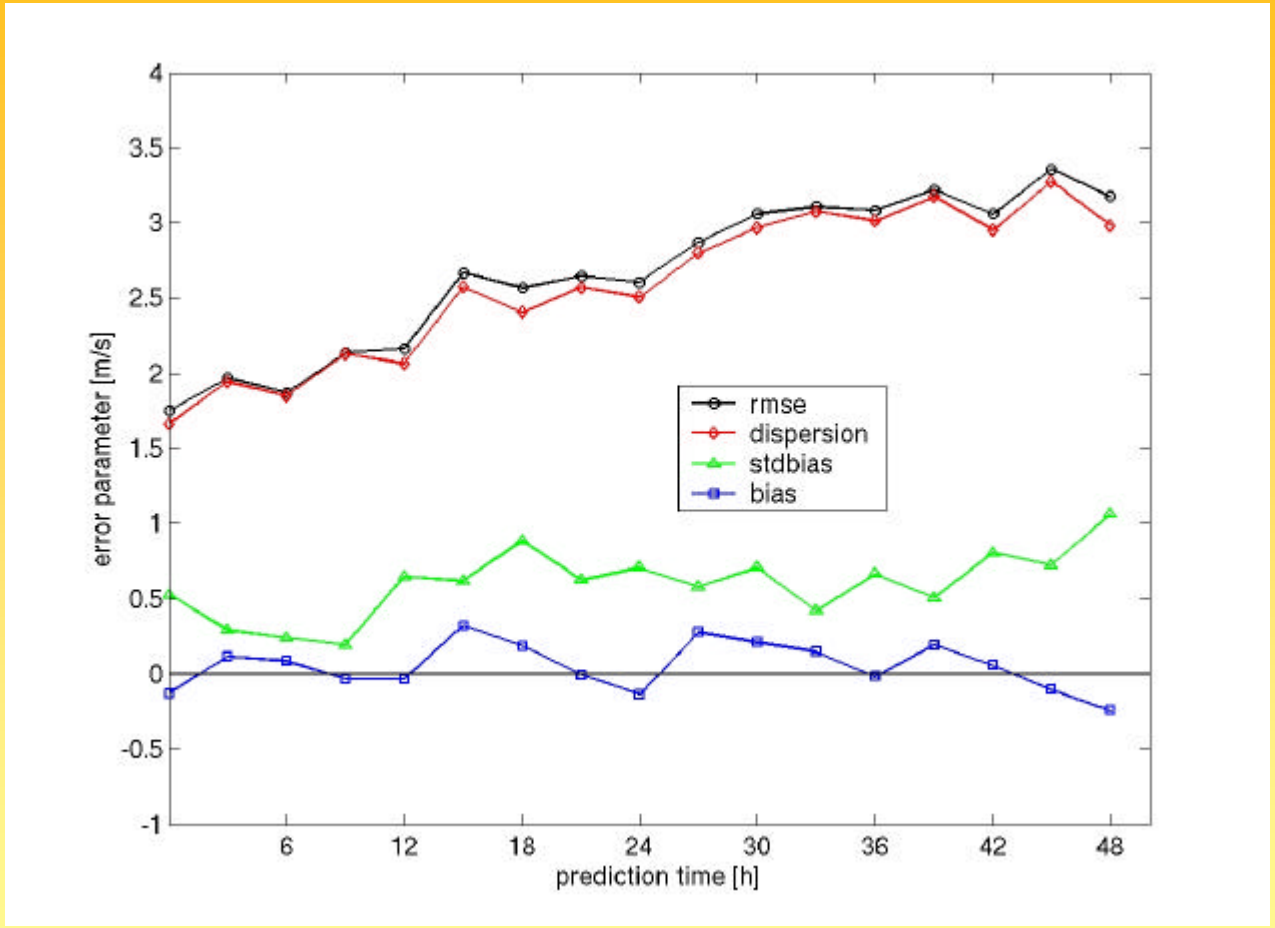
Forecasts for Horns Rev



Predicted versus measured wind speeds at 62m height

Forecasts for Horns Rev

$Rmse^2$ = $bias^2$ + (difference of std)^2 + (dispersion)^2



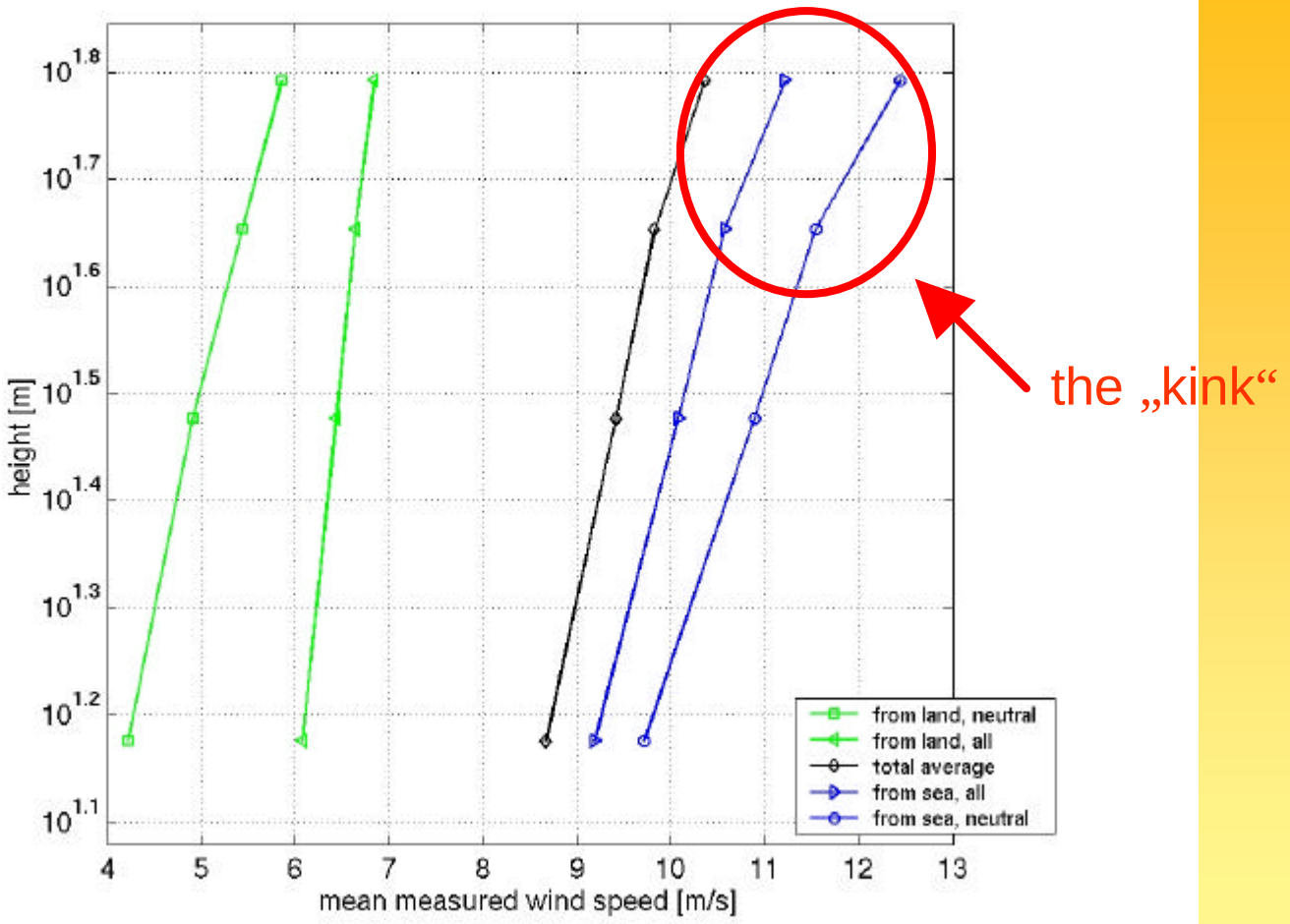
Rmse (wind at 62m) dominated by the phase errors

Comparision with onshore forecasts for 36 hours

	Offshore	Onshore
Mean speeds	8 m/s	4.5 m/s
Bias	0.1 m/s	-1.5 - +1.5 m/s
Difference of std	0.3 m/s	-0.8 - +0.3 m/s
correlation	0.95 – 0.83	0.83 – 0.77
rmse	1.5 - 2.5 m/s	1.5 – 2 m/s
	20% - 30% of mean wind speed	33% – 45% of mean wind speed

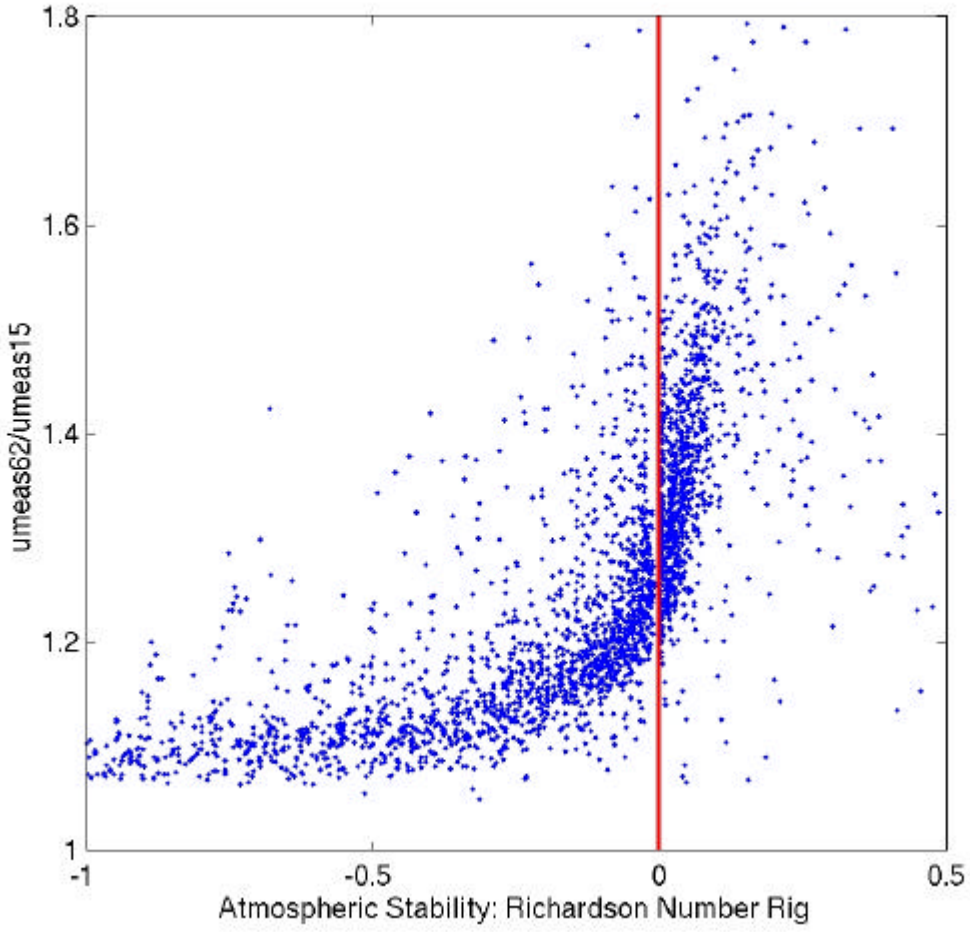
- No diurnal variation offshore and this is well predicted
- „Phase errors“ (dispersion) dominate the rmse

Profiles at Horns Rev



Mean measured speed profiles, blowing from land (l) and sea(r)

Profiles at Horns Rev



Measured ratios u(62m):u(15m) against Richardson Number

Summary forecast evaluation offshore

- Error of the Offshore wind speed forecast in 10 m height is in the magnitude of onshore forecast error (RMSE = 1.5 – 2.5 m/s)
- Nearshore the diurnal cycle is not forecasted resulting in high uncertainty
- Offshore forecast error is dominated by phase errors
  difficult to be corrected by wind power prediction models

→

Next step:
Evaluation of different numerical weather forecasts
e.g. Hirlam, AVN, ECMWF, …

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- Evaluation of different numerical weather forecasts e.g. Hirlam, AVN, ECMWF, …
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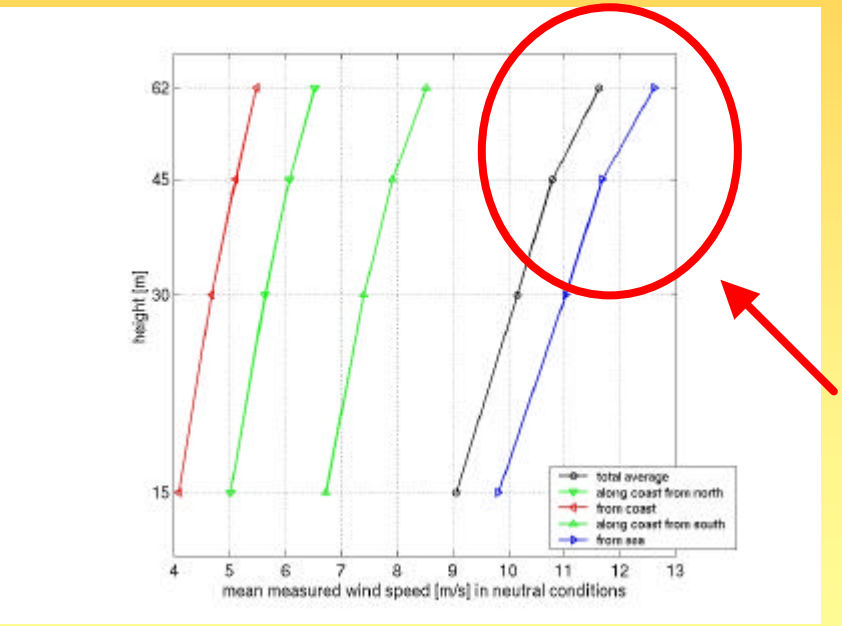

not logarithmic

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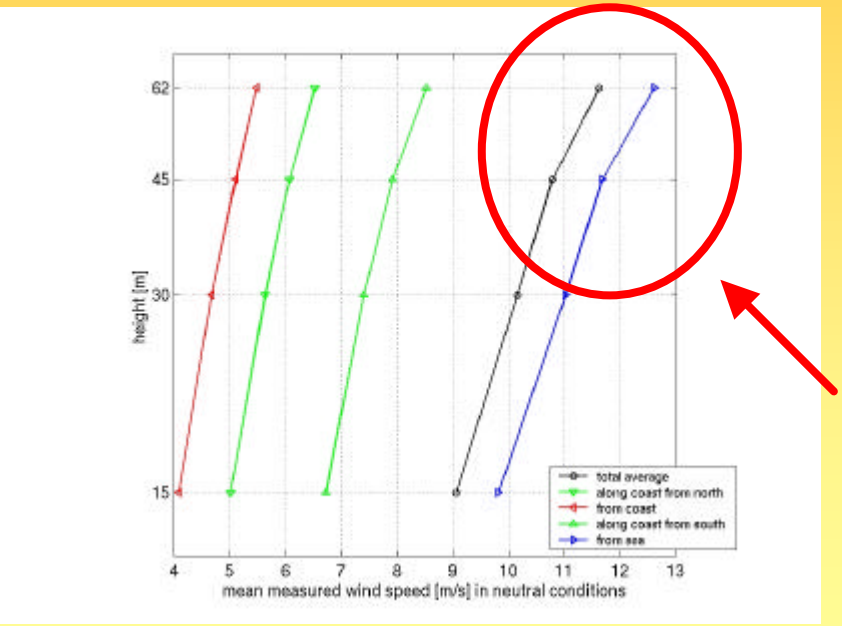

Higher measurements:
Fino Platform 100 m

not logarithmic

Further development

- Evaluation of different numerical weather forecasts e.g. Hirlam, AVN, ECMWF, …
- Description of the vertical wind speed profile
- Comparison of different prediction models for offshore sites: WPPT, *PREVIENTO*, PREDIKTOR, LOCALPRED, ...
- Modelling spatio-temporal characteristics in large offshore wind farms, e.g. effect of crossing fronts

Two EU-Projects: Anemos, Honeymoon

EU - Project: ANEMOS

UNI Oldenburg: Workpackage Leader Offshore-Forecast

- **Task 5.1:** Impact of high resolution meteorological forecasts *(Armines , ARIA , Risoe , EHF)*
- **Task 5.2:** Contribution of Satellite-radar information *(Armines)*
- **Task 5.3:** Development of physical and statistical models *(Armines , ARIA , Ciemat , DTU , Overspeed , Ral , Risoe , EHF)*
- **Task 5.4:** Modelling spatio-temporal characteristics in large offshore wind farms *(Armines , ARIA , Overspeed , Risoe , EHF)*