CALIBRATION AND COMBINATION OF A REGIONAL MULTI MODEL ENSEMBLE FOR PREDICTING OFFSHORE WIND SPEEDS

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Session: Forecasting of Wind Production

J. Dobschinski*, L. von Bremen**, A. Wessel*, B. Lange*, S. Hagemann*

* Fraunhofer IWES, Kassel, ** ForWind, Oldenburg, Germany

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Outline

- Introduction of probabilistic forecasting of offshore wind speeds
- Ensemble prediction system ‘PEPS’ & Case study
- Illustration of the problem using a simple probabilistic approach
- Investigation of an advanced approach: “Gaussian Ensemble Dressing”
- Summary, Conclusion & Outlook

Forecasting offshore wind speeds at the research platform FINO 1

RAVE
RESEARCH AT ALPHA VENTUS

Aims:

- Investigation of the predictability of offshore wind speeds
- Handling of the high fluctuating offshore wind speeds

Method:

- Forecasting in terms of probability theory
  → Offering all information that are relevant for the grid integration of wind energy

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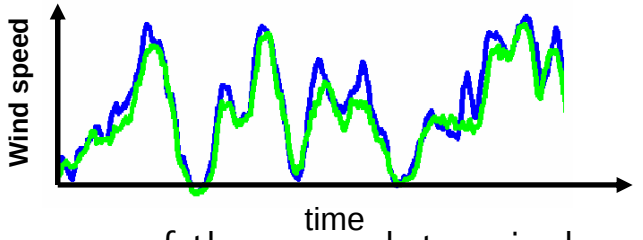
Probabilistic Forecasting

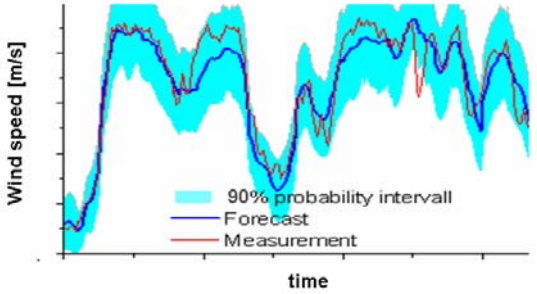
Difference to the common (deterministic) 'spot'-forecast:

- *(deterministic) 'spot'-forecast* forecasts one wind speed value per forecast horizon



- *probabilistic forecast* forecasts a probability of occurrence of the complete wind speed range.

Example: prediction interval = forecast with range of uncertainty



General application of probabilistic forecasts:

→ All decision making problems

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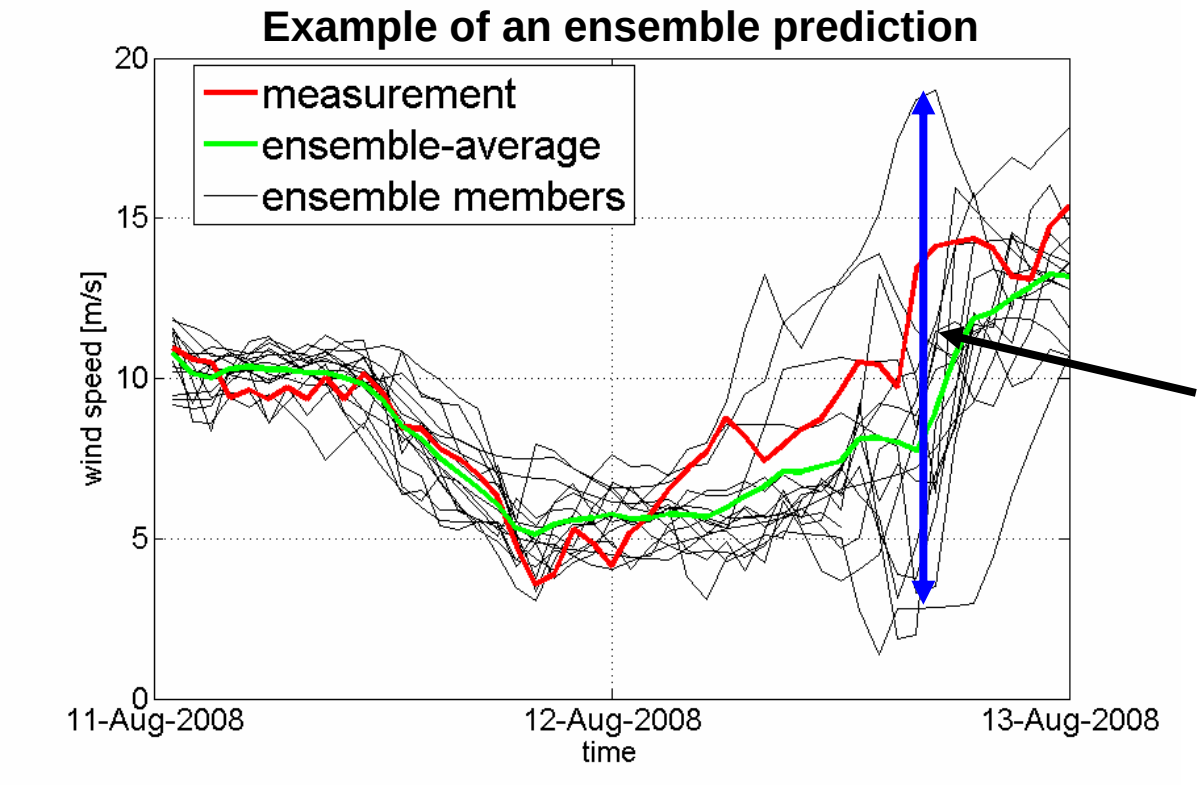
Probabilistic forecasting based on ensemble predictions



- Ensemble prediction = a set of forecasts for the same forecast horizon
- Ensemble average = (normally) a high quality forecast
- Ensemble spread = (normally) a good indicator of the forecast uncertainty

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The used ensemble prediction system

Poor Man's Ensemble Prediction System (**PEPS**)

- Multi-Model-Ensemble:
  Collection of 23 deterministic forecasts from 20 European weather services
- Based on four different limited area models (COSMO, HIRLAM, UKMO, ALADIN)
- Provided by the German Weather Service

Case study: "*Probabilistic forecasting of offshore wind speeds at FINO 1*"

- Investigated time period: 2007 and 2008
- Used PEPS-members: 12

Used assessment criteria for probabilistic forecasts

Reliability : How reliable are the probabilities ?

→ Answered by a **"Reliability plot"**

Skill : Is there an advantage of using the forecast system compared to simple reference systems like climatology ?

→ Answered by the **"Ranked Probability Skill Score"**

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Simple approach to generate the probabilistic forecasts

… based on ensemble prediction systems (EPS)

Assumption: Wind speed forecast error is normal distributed $\Delta_{ws} \sim N(\mu, \sigma^2)$

→ Probabilistic forecast at time t is based on a normal distribution

$$FC(t) \sim N(\mu(t), \sigma^2(t))$$

- mean value $\mu(t)$ = ensemble average at time t
- standard deviation $\sigma(t)$ = standard deviation of the ensemble members at time t

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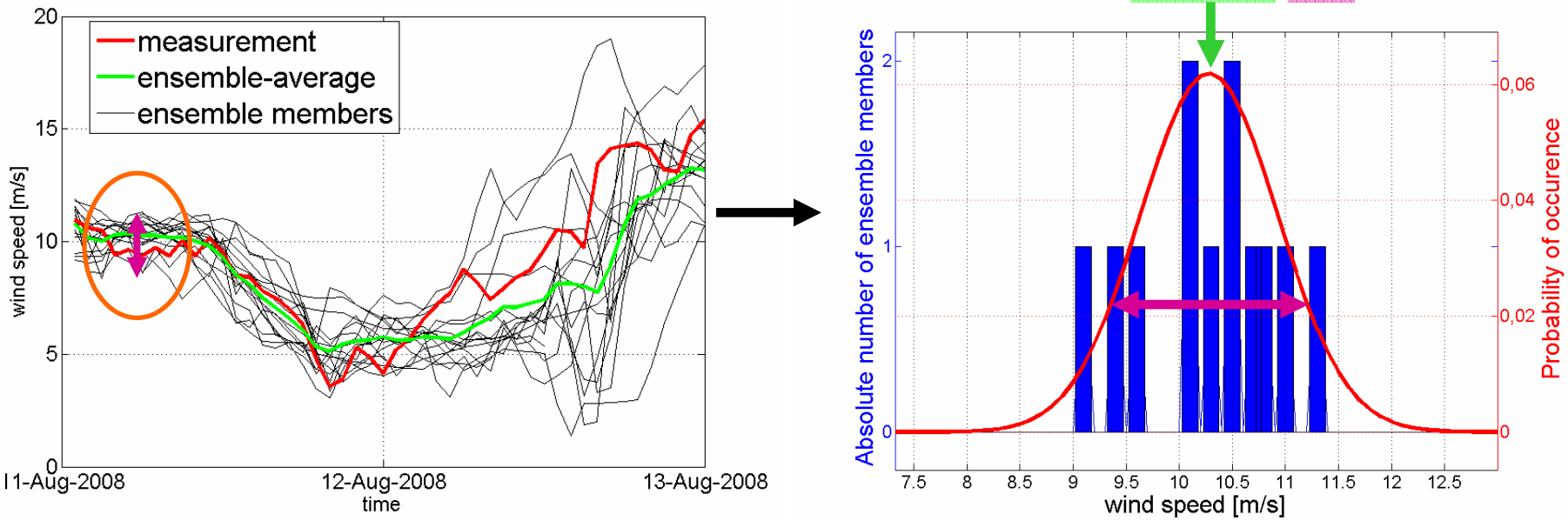
Probabilistic Forecast at time t → $FC(t) \sim N(\mu(t), \sigma^2(t))$



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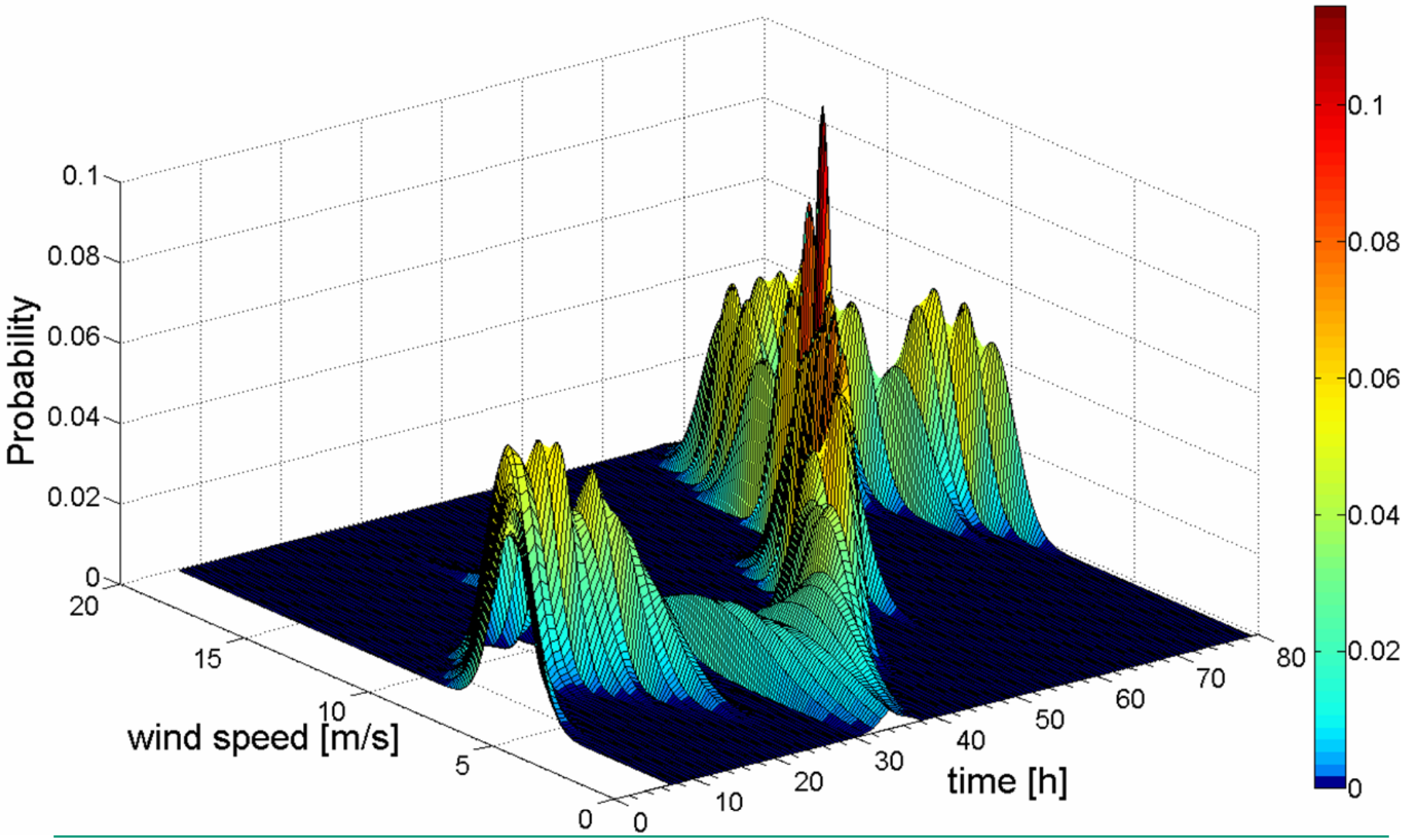
Probabilistic forecast based on the simple approach



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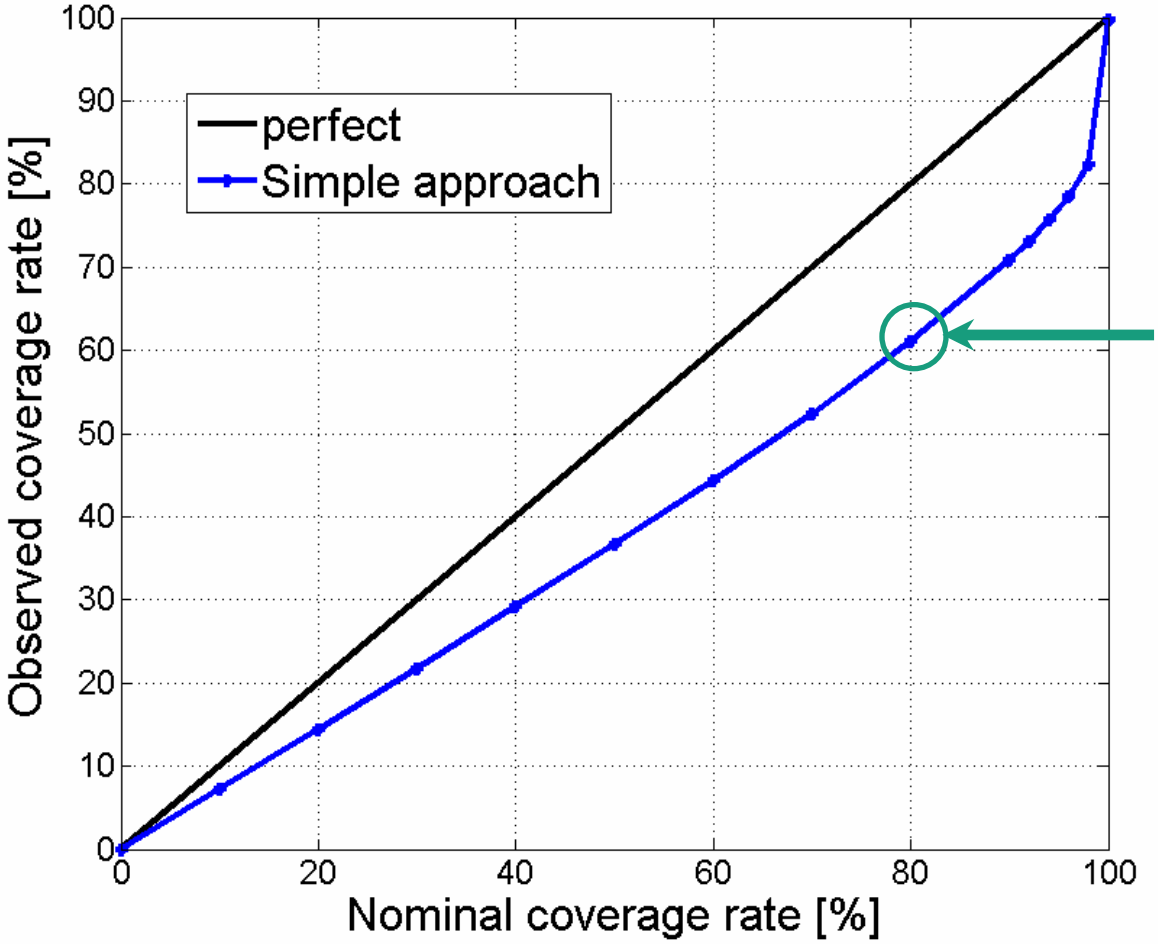
Reliability of the forecast based on the simple approach



→ Bad reliability

e.g. only 60% of all measure-ments are within the 80%-interval !!!

A more reliable method Is needed !!

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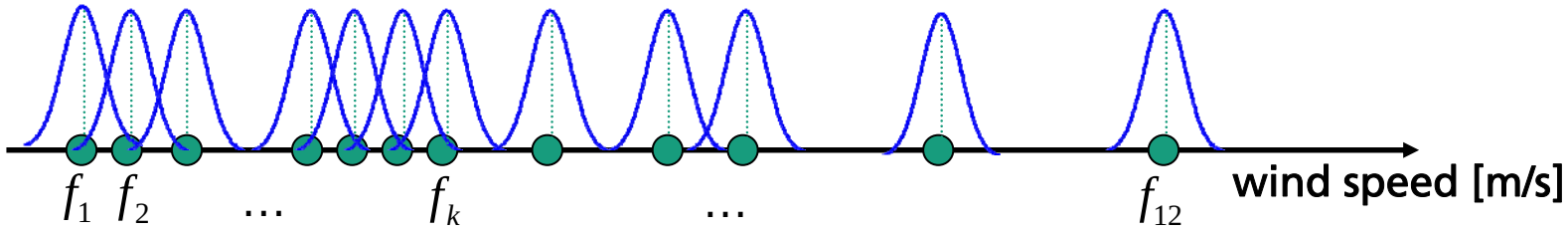
Advanced approach: Gaussian Ensemble Dressing

1) A normal distribution is defined around each ensemble member at time t

$N_t(f_k, \sigma^2)$ with: f_k is the forecast of ensemble member k

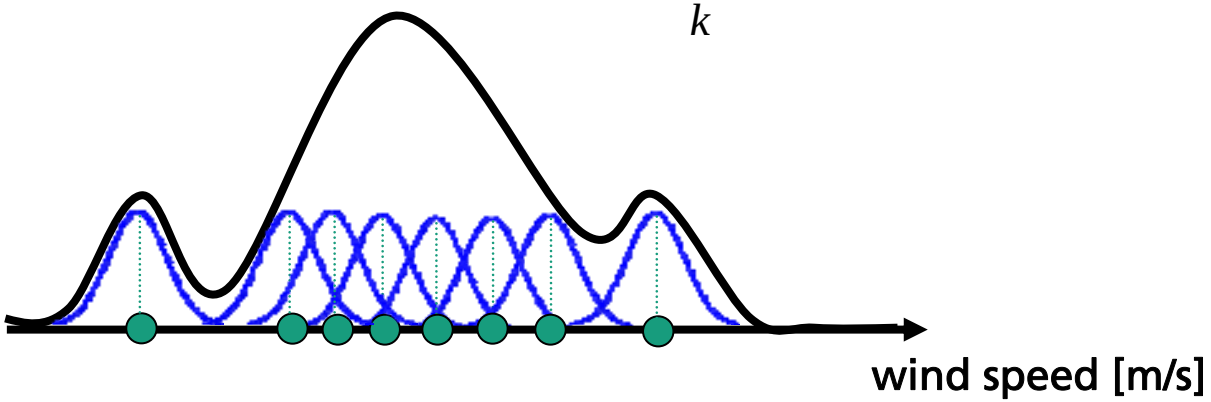
σ is the standard deviation which is constant for the normal distribution all members



Advanced approach: Gaussian Ensemble Dressing

2) Weighted linear combination

$$P_t = \sum_{k}^{12} w_k N_t(f_k, \sigma^2) \qquad \text{with} \quad \sum_{k}^{12} w_k = 1$$



3) Optimization of the unknown parameters $w_1, w_2, \ldots, w_{12}$ & σ

… by Minimization of the *"Ranked Probability score"*

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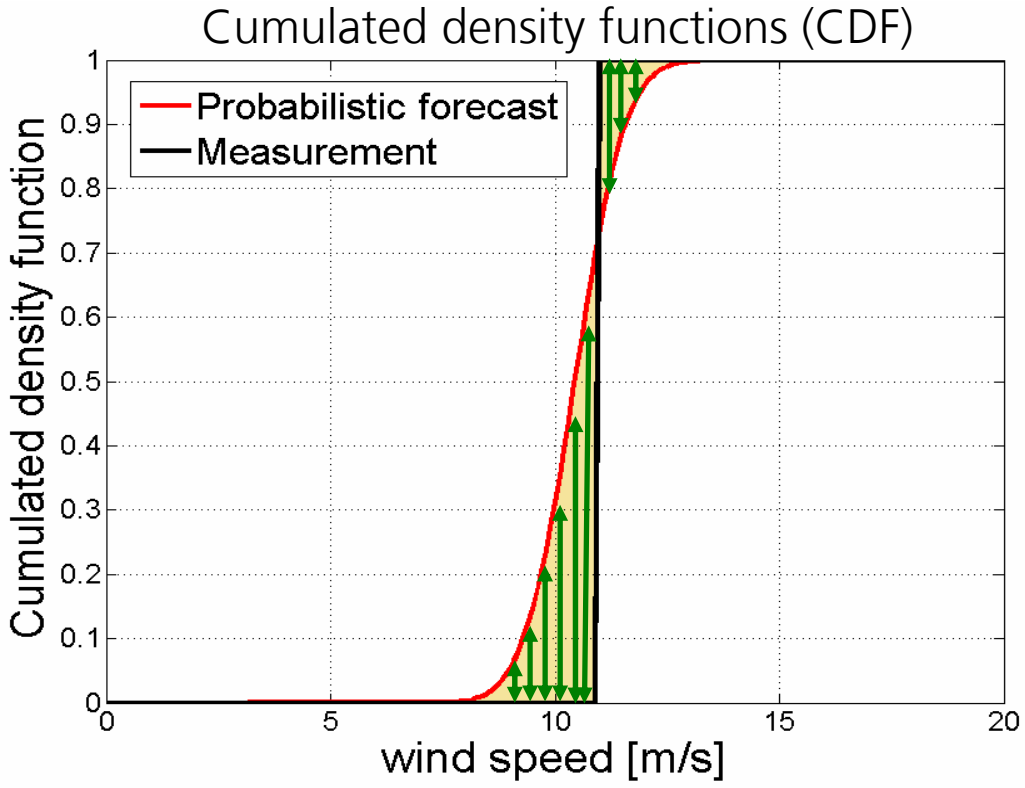
Advanced approach: Gaussian Ensemble Dressing

Definition of the "ranked probability score (RPS)"

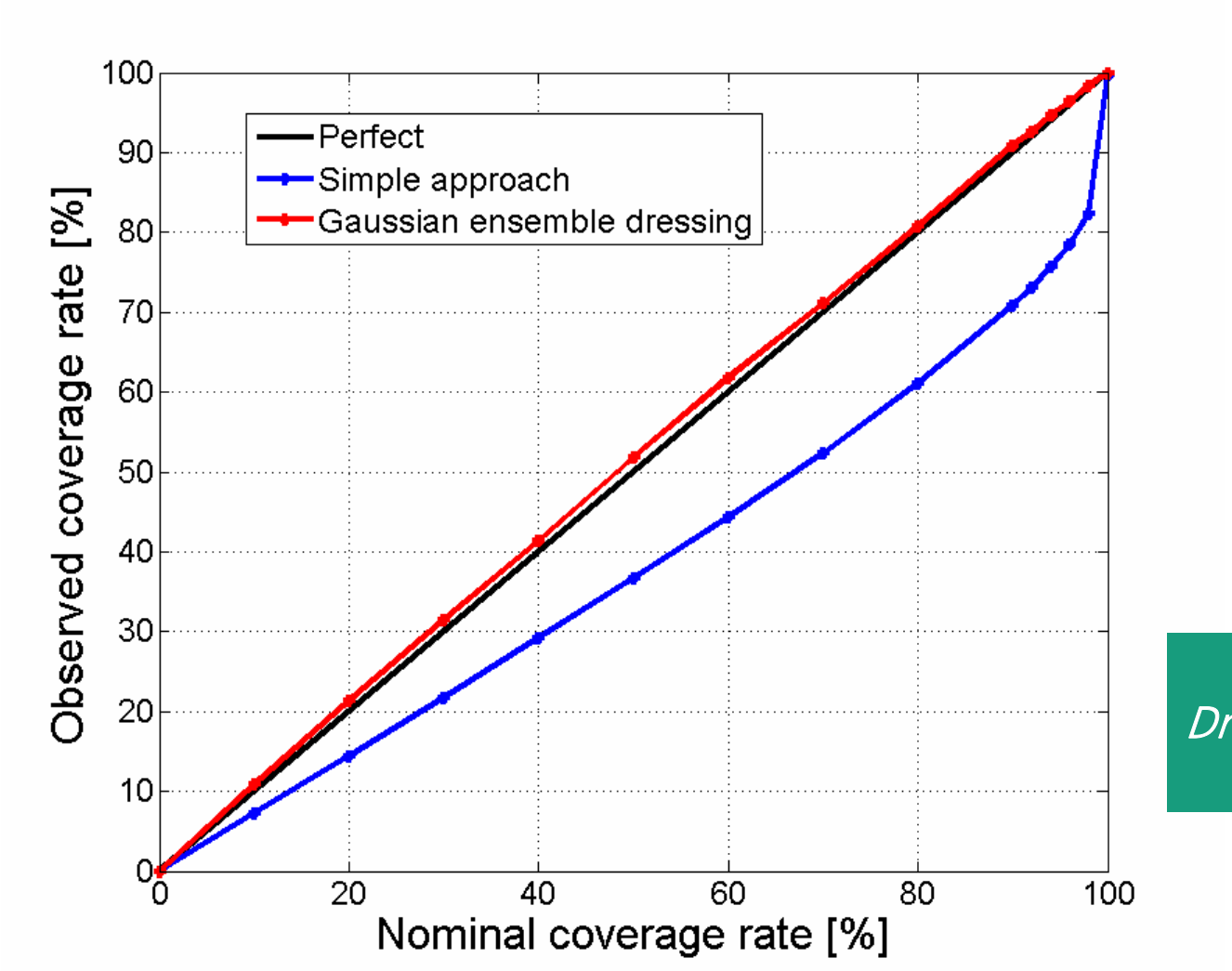
- (Probabilistic) RPS ≙ (Deterministic) RMSE (root mean square error)

RPS at time t =
∑ square of all differences

$RPS =$ *mean of historical data set*



Reliability of the "Gaussian Ensemble Dressing"



"Gaussian Ensemble Dressing" presents a very good reliability.

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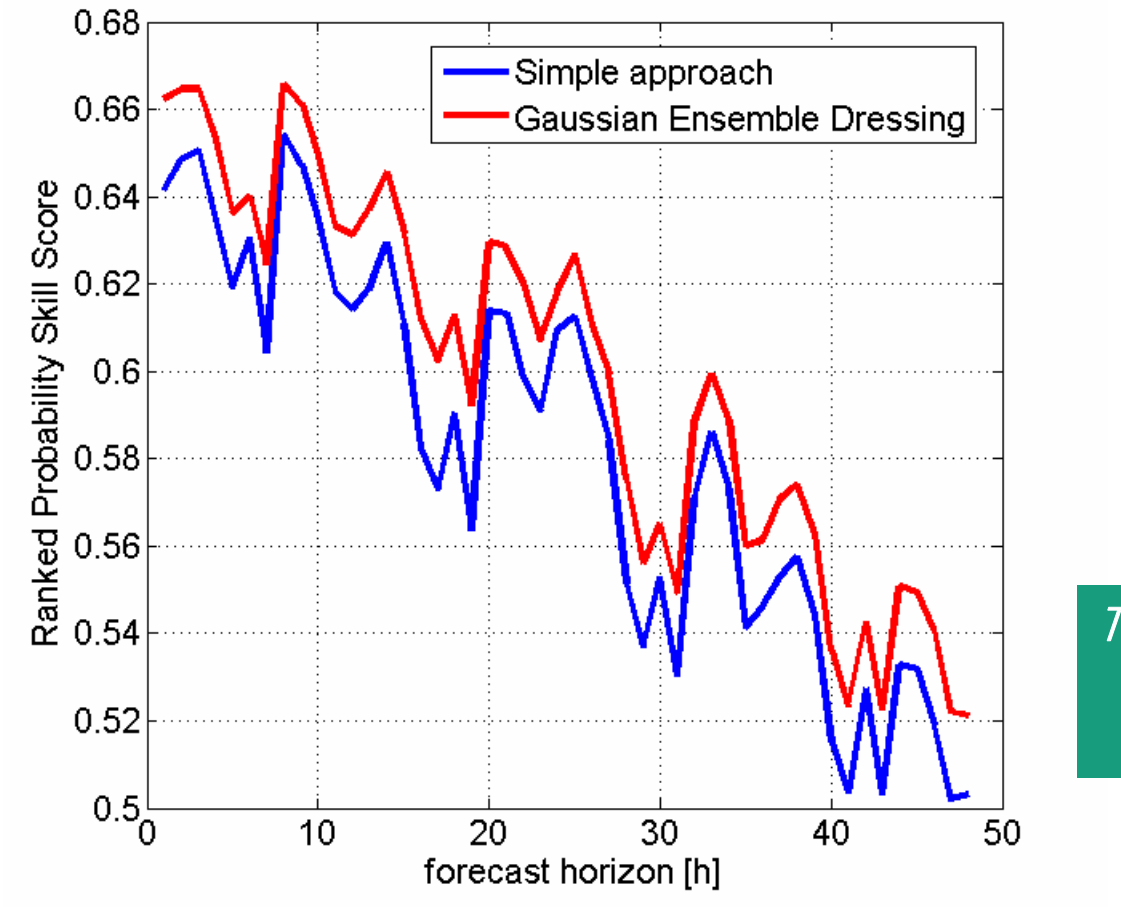
Ranked Probability Skill Score (RPSS) of the both approaches



RPSS-Range = 0 - 1

0 → no skill
1 → perfect skill

The "Gaussian Ensemble Dressing" presents a clearly higher skill than the simple approach

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Summary

- Comparison of methods for probabilistic forecasting of offshore wind speeds
- Simple approach vs. “Gaussian Ensemble Dressing”
- Investigations concerning reliability and skill.

Conclusion

- The method of “Gaussian Ensemble Dressing” leads to forecasts with high reliability and skill.
- The optimization of the probabilistic forecast by minimization of the “Ranked Probability Score” is a successful method.

Outlook

- Development of a reliable probabilistic wind power forecast systems for “Alpha Ventus”

Thank you for your attention

Fraunhofer IWES

Jan Dobschinski
jdobschinski@iset.uni-kassel.de

Energy Meteorology & Wind Power Management
R&D Division Energy Economy and Grid Operation

Fraunhofer Institute for Wind Energy and
Energy System Technology IWES
Königstor 59, 34119 Kassel

Fraunhofer IWES