

## Wind Power Forecasting using Weather Ensembles

Lueder von Bremen

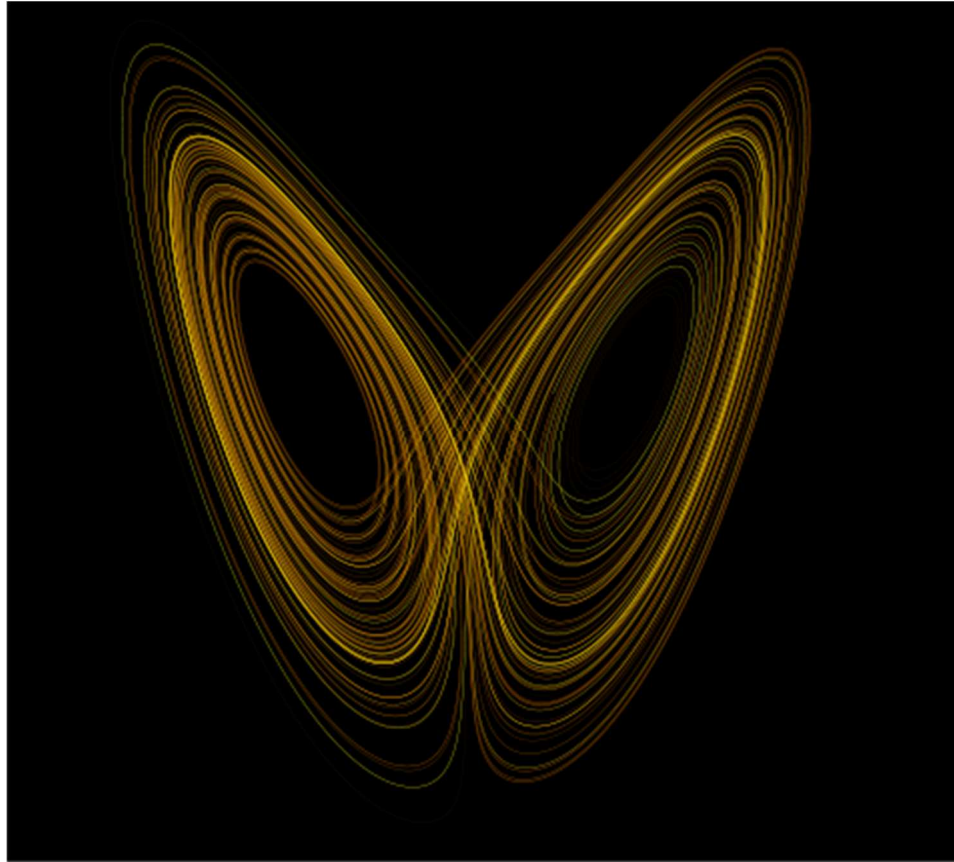
ForWind  
Center for Wind Energy Research  
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SafeWind End Users Workshop, Fredericia, Denmark, 2 March 2012

# Outline

- Wind Power Forecasting using meteorological Ensembles
- Spatial distribution of forecast uncertainty
- Ensemble Prediction System with 100m winds for improved Wind Power Forecasting
- Summary

# Why weather forecasts can not be precise?

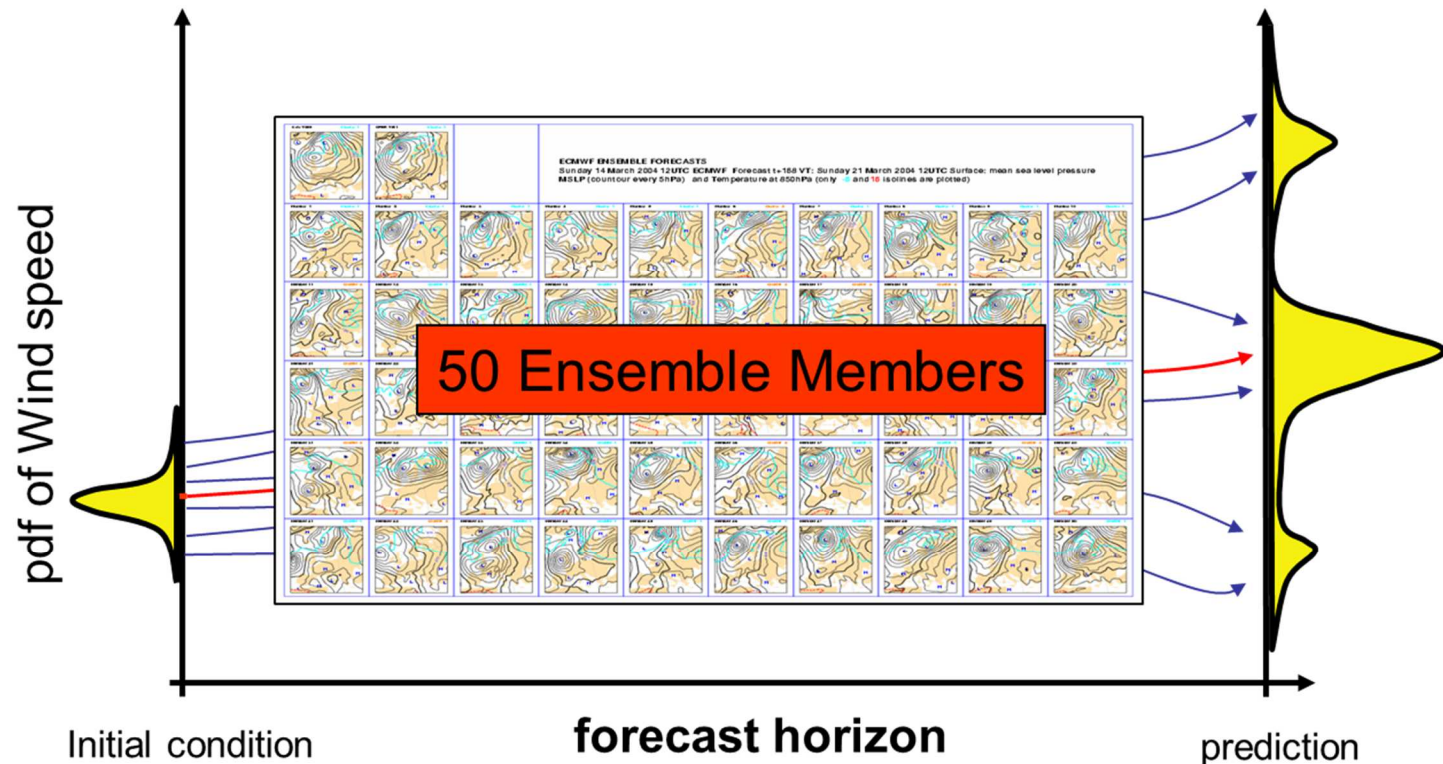


$$\begin{aligned}dx / dt &= a (y - x) \\dy / dt &= x (b - z) - y \\dz / dt &= xy - c z\end{aligned}$$

(E. Lorenz, 1963)

- Lorenz Paradigm: Numerical Weather Forecasting is an initial state problem
- Quantify the uncertainty in the forecast to be aware of forecast errors

# Ensemble Prediction System (EPS) at ECMWF

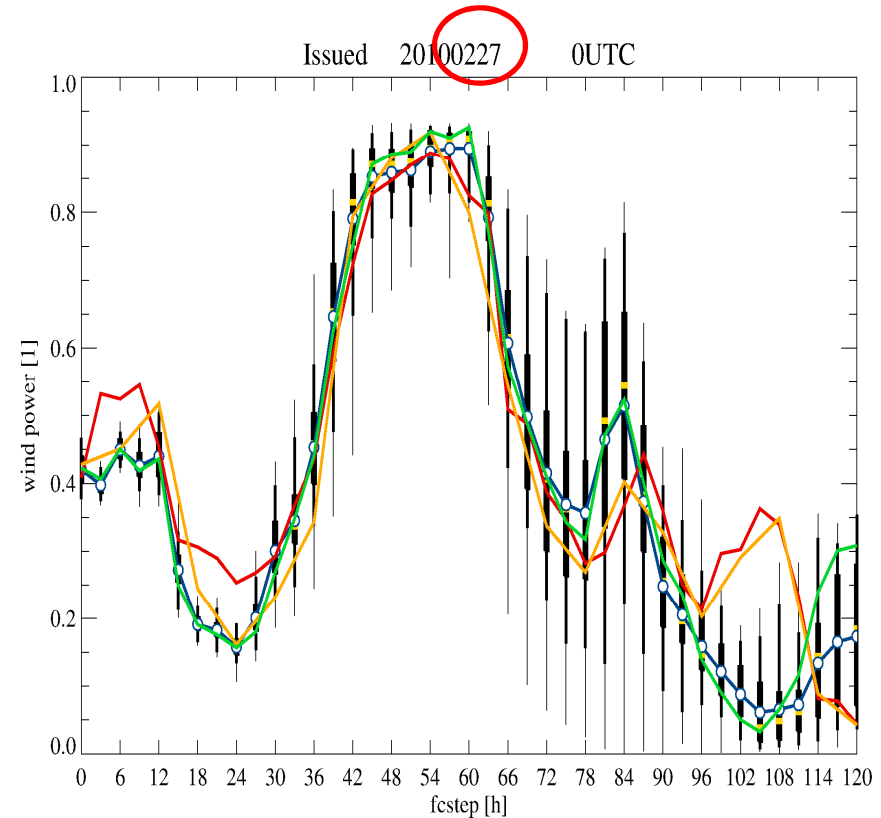
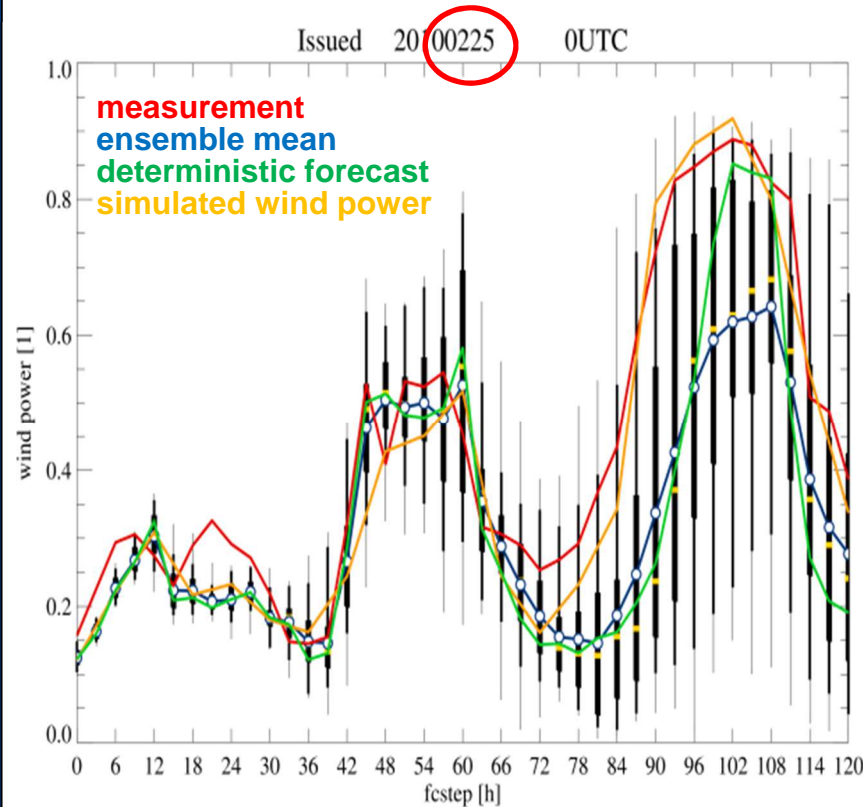


Source: European Centre for Medium-Range Weather Forecasts (ECMWF), R. Hagedorn

- Lorenz Paradigm: Numerical Weather Forecasting is an initial state problem
- Quantify the uncertainty in the forecast to be aware of forecast errors

# Powergrams: Communicating Ensemble Forecasts utilizing prediction intervals

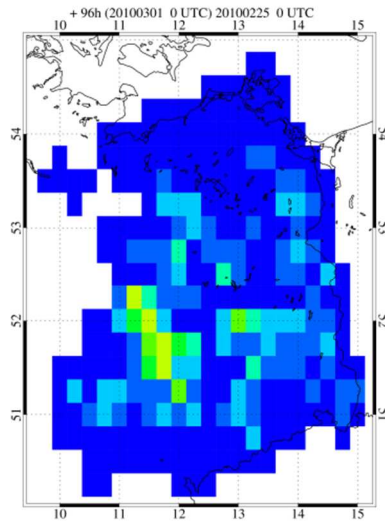
- Example: Extreme event Storm Xynthia in 50Hertz control zone



- New: What is the **distribution** of uncertainty in the control zone

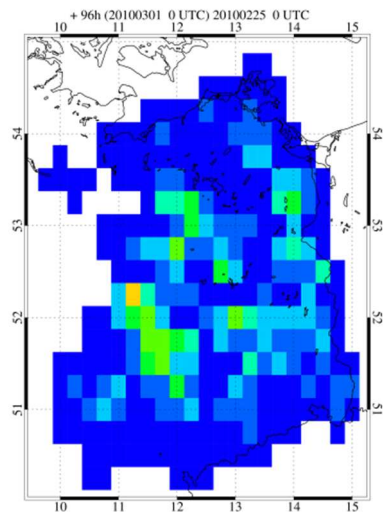
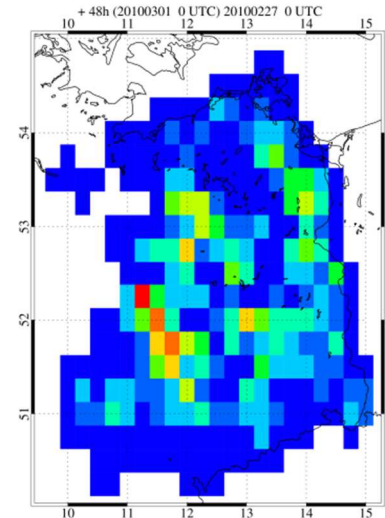
# Example: Storm Xynthia, 1 March 2010

**+96h**

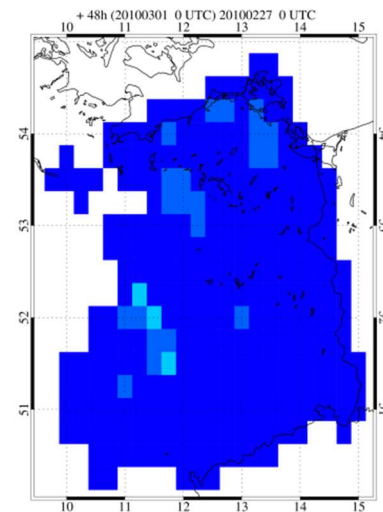


Ensemble Mean

**+48h**



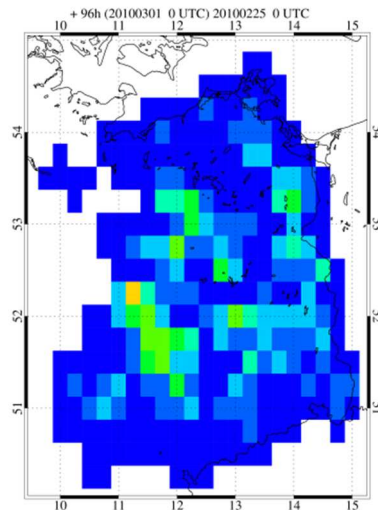
Forecast Uncertainty





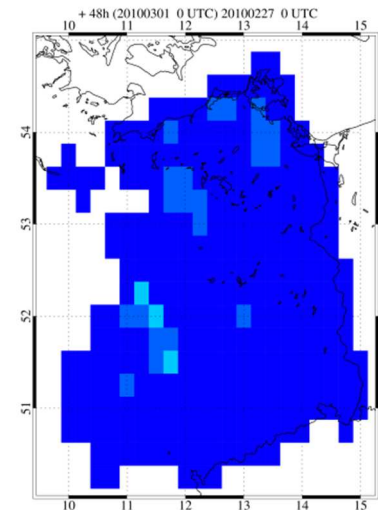
# Evaluation: Storm Xynthia, 1 March 2010

**+96h**

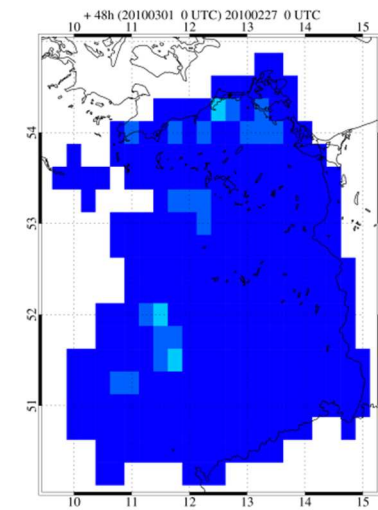
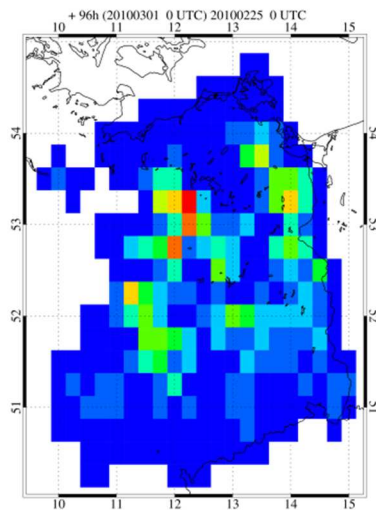


Forecast uncertainty

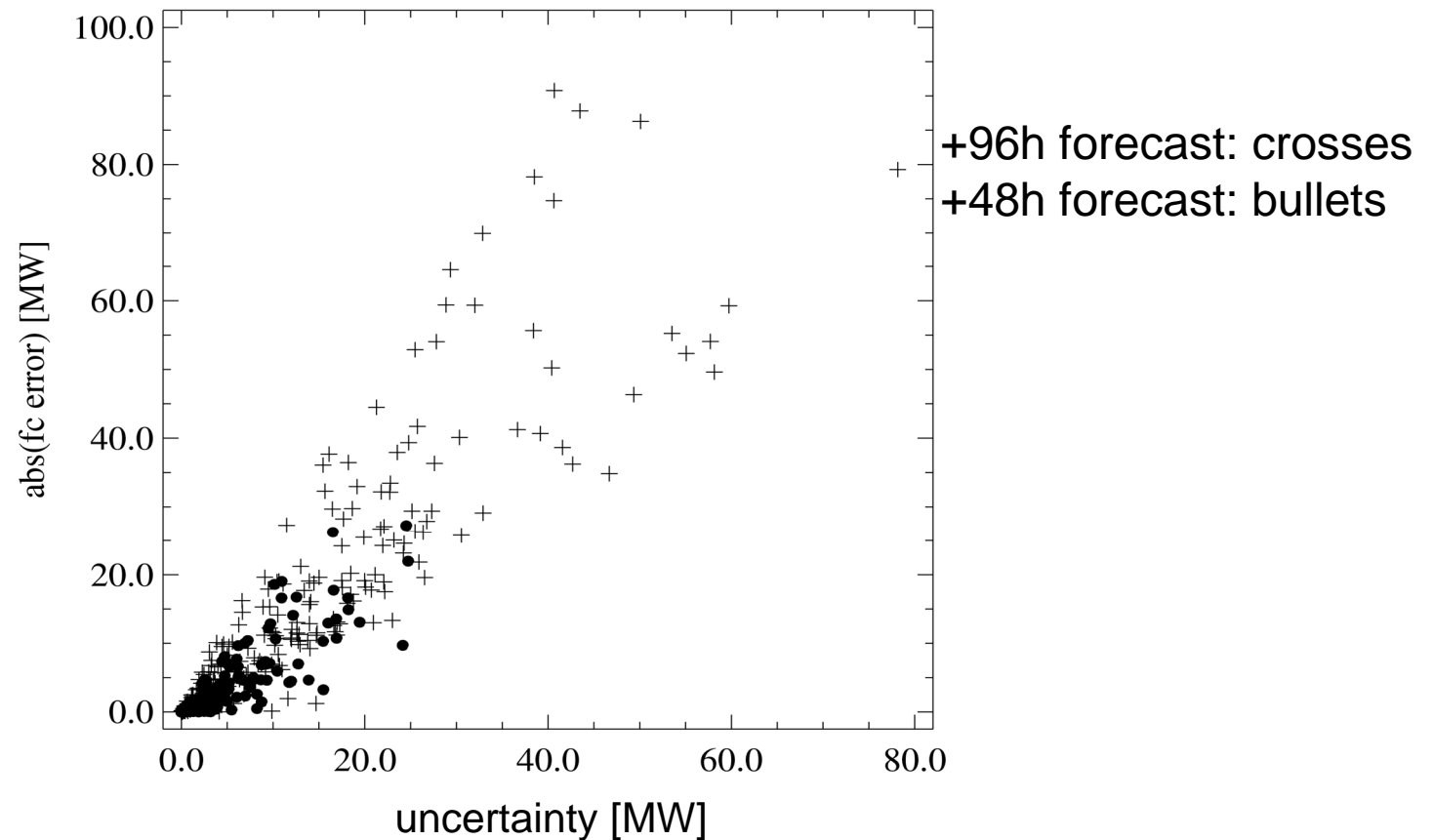
**+48h**



absolute forecast error



# Evaluation of storm Xynthia

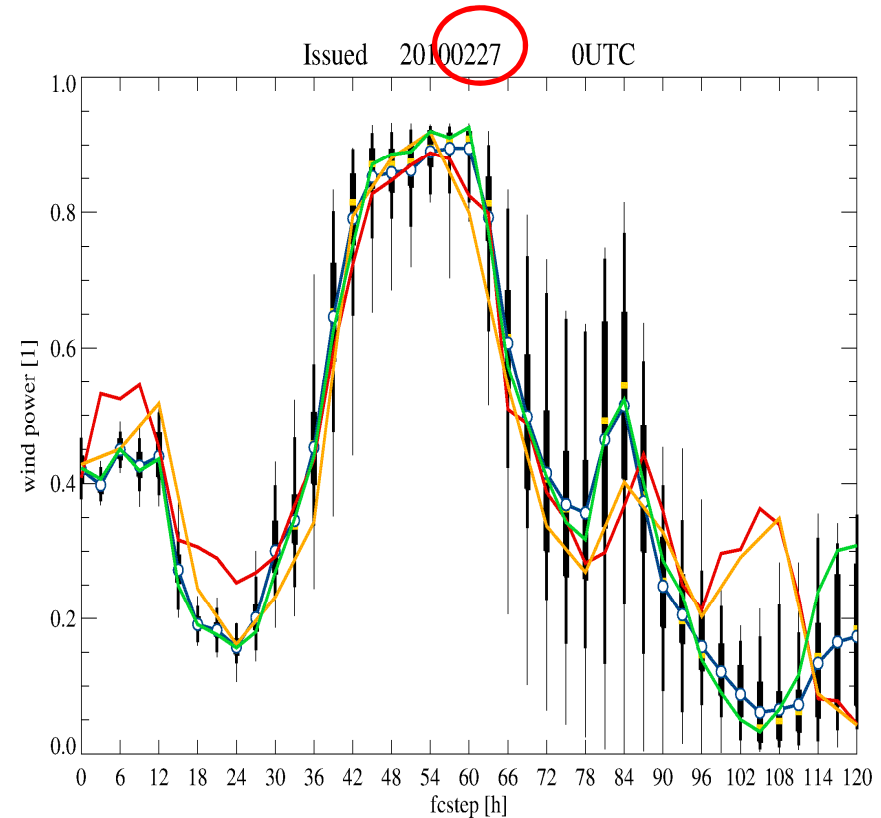
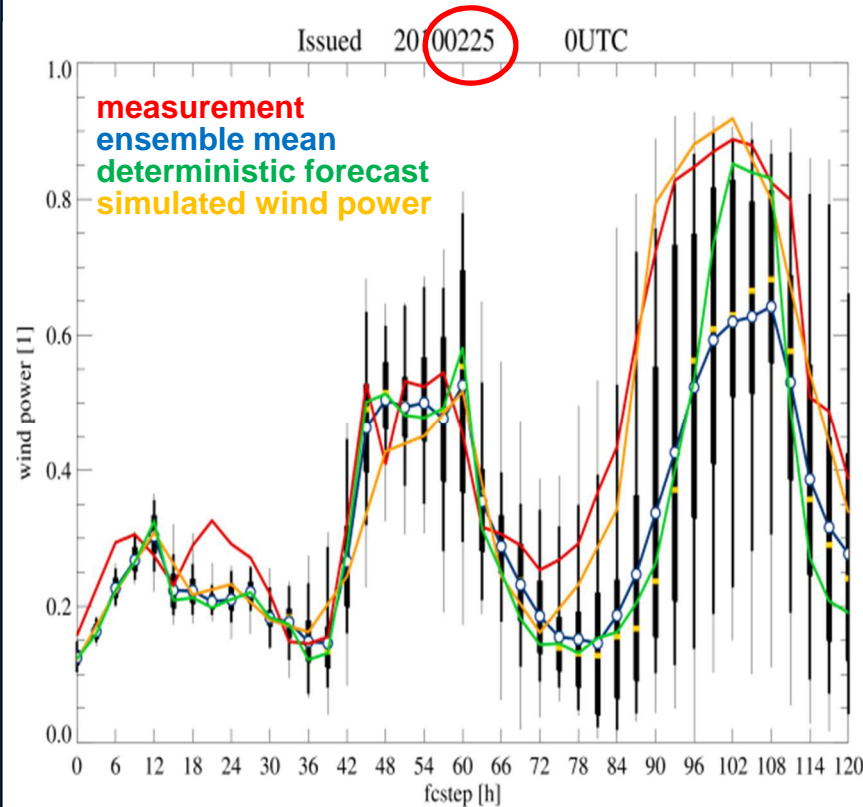


- The level of uncertainty can be used as indicator of the (possible) fc error

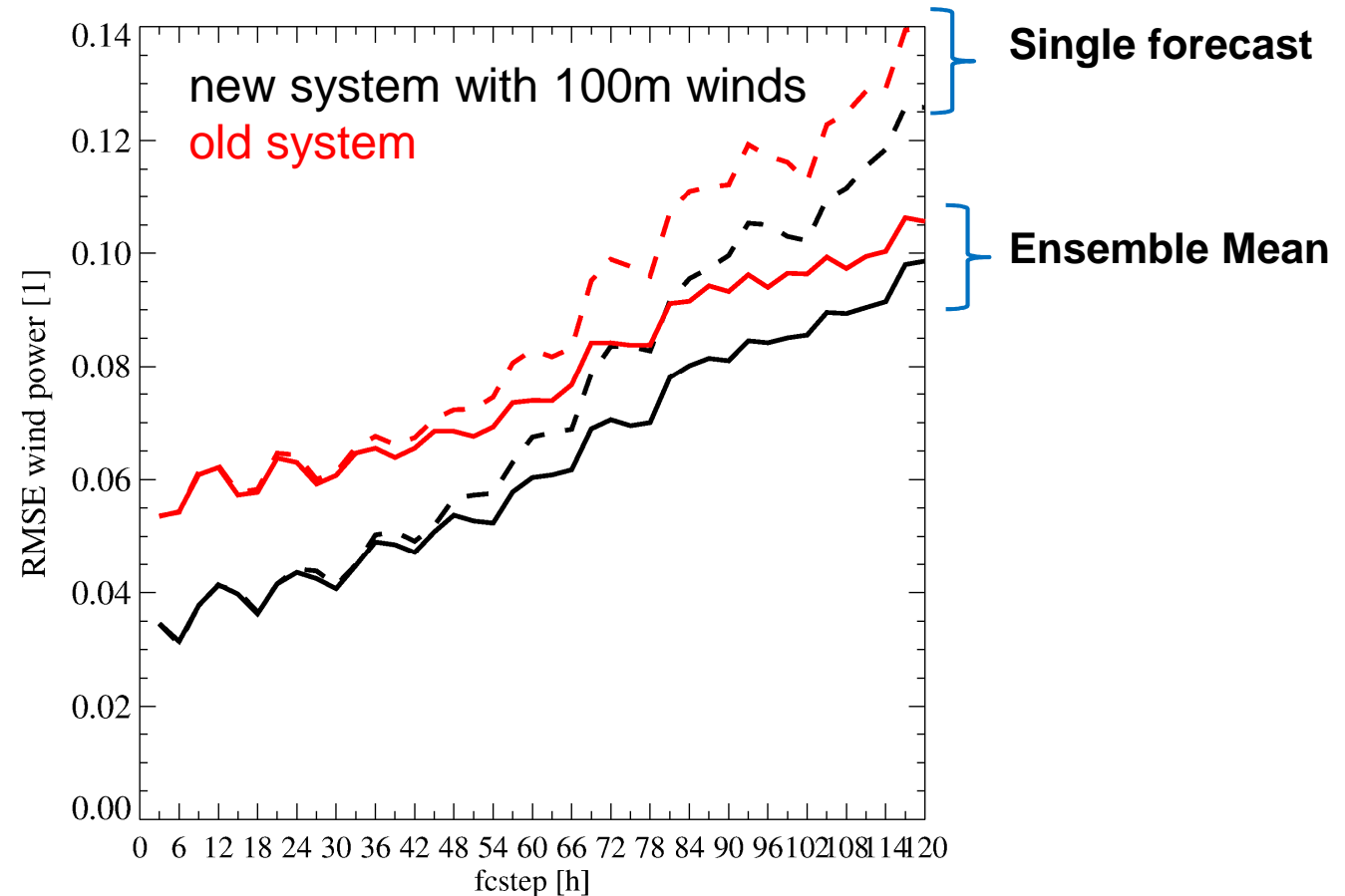


# Powergrams: Communicating Ensemble Forecasts utilizing prediction intervals

- Example: Extreme event Storm Xynthia in 50Hertz control zone



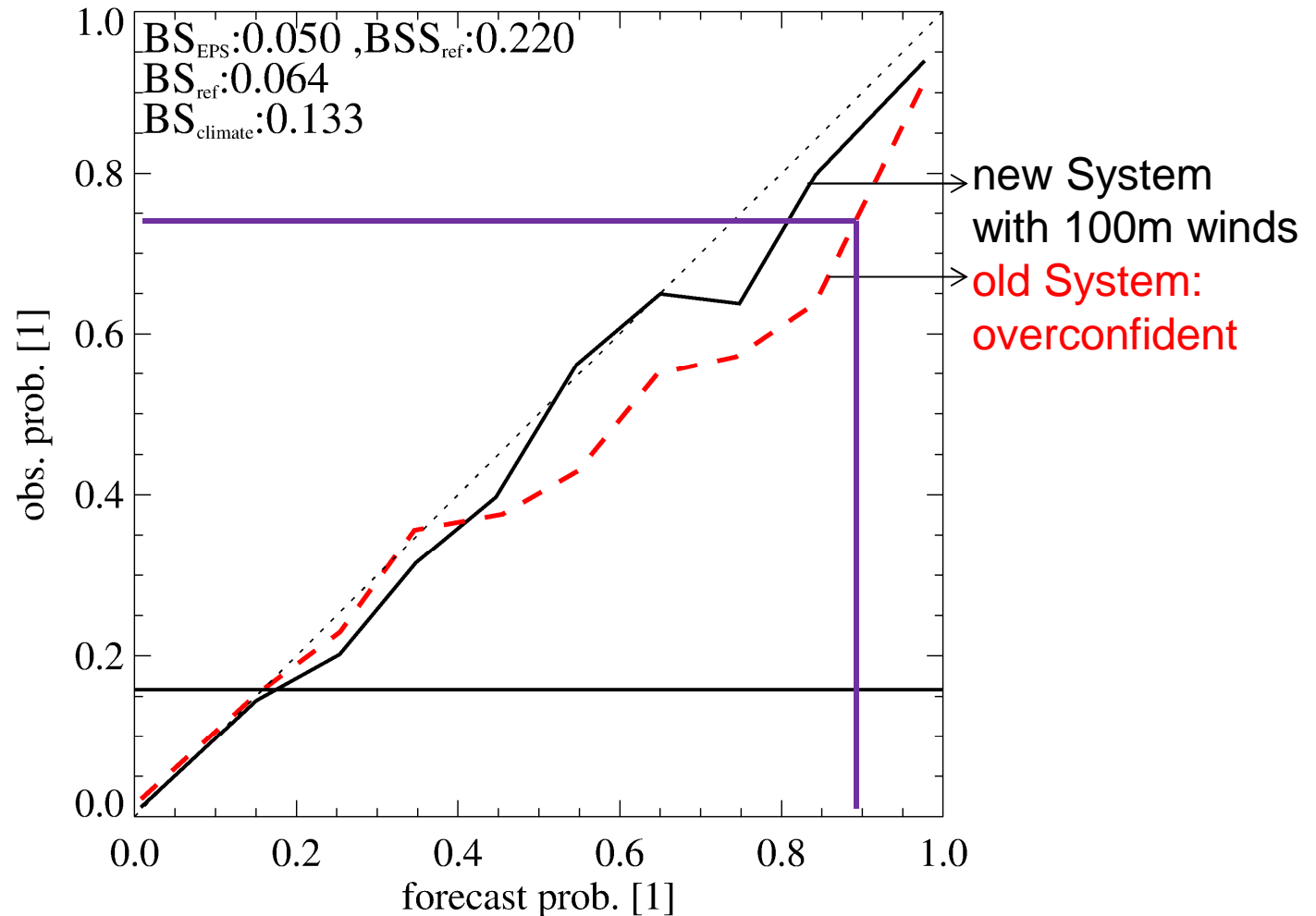
# Performance of the Ensemble System compared to a single forecast (Germany)



- at D+2 ensemble mean starts to be better than single forecast
- New system is improved up to 40%

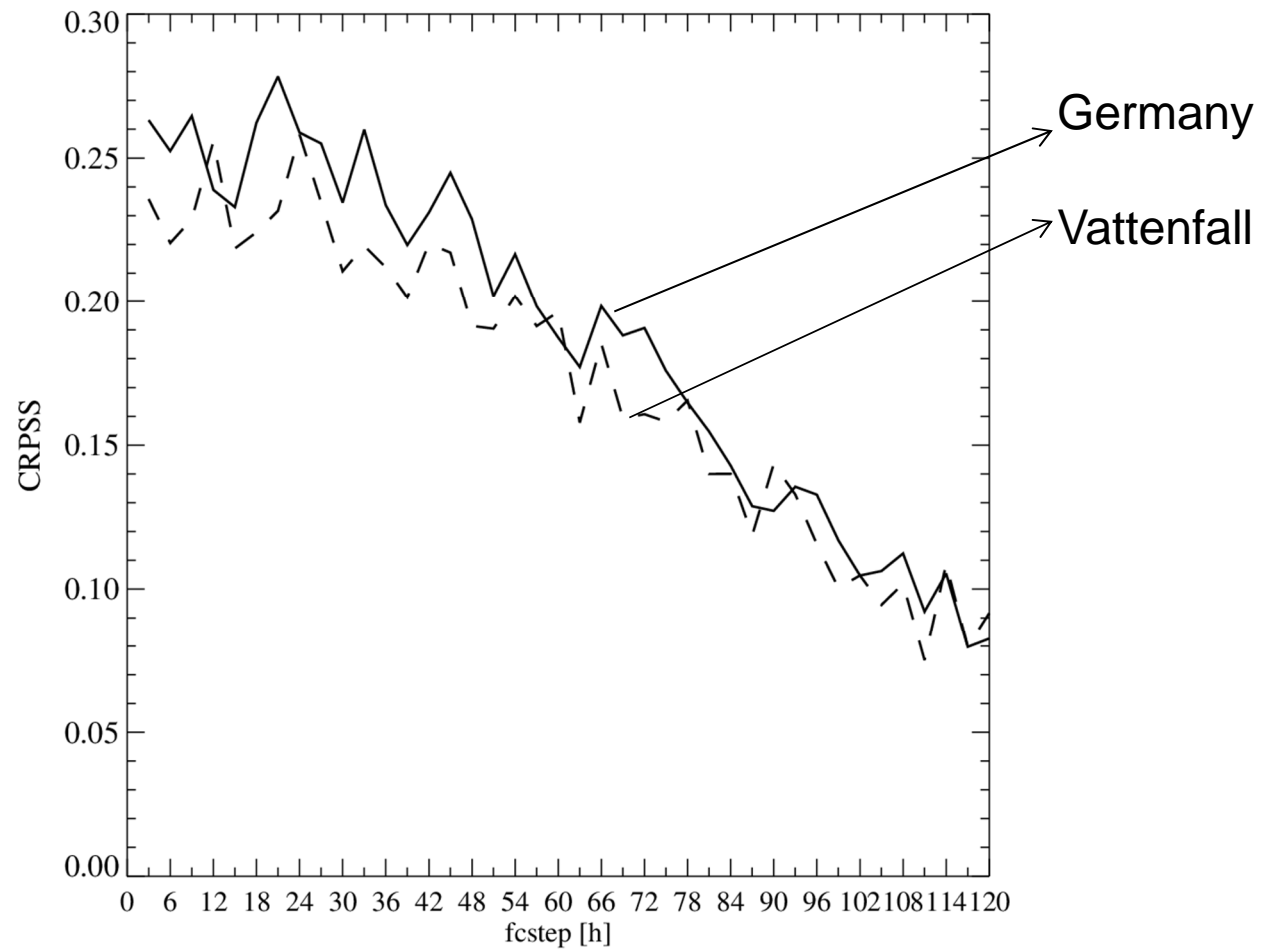
# Can we trust the probabilistic forecast?

- Evaluation of reliability of the Ensemble Prediction System
- here: Event wind power > 9GW in Germany
- +72h forecast horizon



- New system has much better reliability

# Improvement of probabilistic forecasts



- Very strong (25%) improvement of skill in Ensemble forecast

# Summary

- Forecast uncertainty can be derived from meteorological Ensembles and is related to the occurrence of fc errors
- at Day+2 Ensemble mean starts to be better than single fc
- Probabilistic forecast score is improved by 10-25% using the new Ensemble Prediction system

**Thank you for your attention**

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