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## Highlight results

- **Extreme wind power forecast scenario for electrical system security modelling**
- **Forecast uncertainty for maintenance planning**

## Meteorological Ensembles

The uncertainty in Numerical Weather Prediction (NWP) can be quantified by Ensemble Forecasting [1]. At the European Centre for Medium-Range Weather Forecasts (ECMWF) 50 members of the Ensemble Predictions System (EPS) are computed with slightly different initial conditions. The different trajectories of the forecasts can be used to estimate the probability of certain events or to quantify in general if the uncertainty of the forecast is high or low. The effect of thermal stability of the atmosphere on hub height winds is accounted for by using the new 100 m wind product of ECMWF. All wind speeds are transformed to wind power with 25 km horizontal resolution using regional power curves [2].

## Application: Extreme wind power scenario for electrical system security modelling

Transmission system security modeling becomes more and more important due to increasing shares of fluctuating renewable energy sources and limited transmission capacities.

The University of Oldenburg (ForWind) has developed an approach to demonstrate the extreme wind power penetration for each individual grid point as input to electrical system security modeling for lead times up to +120 h. In the example storm Xynthia already approaches from the south-west (Figure 1), although the center of the storm is expected 12-18 hours later (Figure 2). The verifying analysis (Figure 3) shows that no extreme wind power had occurred in the south-west, yet.

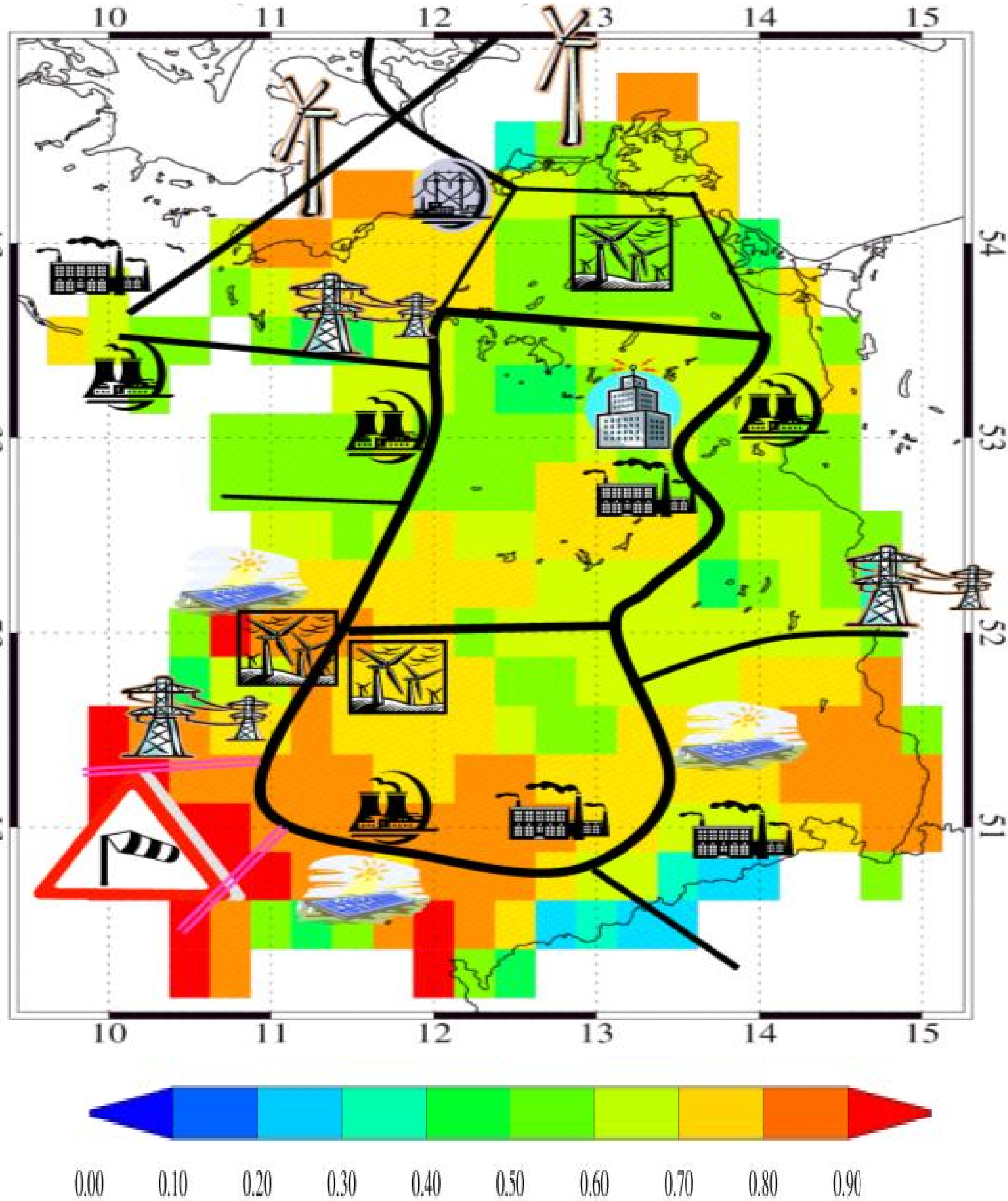



**Fig. 1: Example of an extreme wind power forecast scenario normalized with installed wind power capacity for electrical system security modelling for approaching storm Xynthia. Forecast issued 26 Feb 2010, 0 UTC valid for 28 February 2010, 12 UTC (+60 h).**

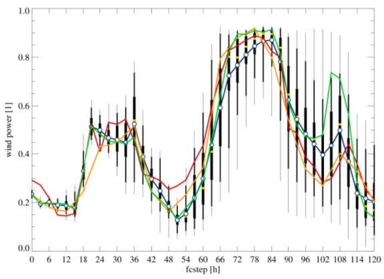



Fig. 2: Powergram of probabilistic wind power forecast for storm Xynthia in the 50Hertz control zone normalized with wind power installed capacity issued at 26 Februar 2010 (0 UTC). Measured wind power (red), ensemble mean (blue), control (deterministic) forecast (green) and simulated wind power (orange). The vertical boxes represent the 50 % and 90 % inner quantiles while the minimal and maximal value of the ensemble is indicated by the tip of the vertical thin line. The +60 h forecast step is marked with red arrows and the corresponding forecast for the extreme scenario is shown in Figure 1.

## Application: Forecast uncertainty for maintenance planning

Maintenance of wind turbines or other components of the power supply system have to be scheduled several days in advance. Spatial diversity of forecast uncertainty can be used in the planning process.

The ensemble mean wind power forecast shows four days before storm Xynthia no signs that very high wind power penetration might occur (Figure 4). However, the forecast uncertainty (Figure 5, top) expressed as standard deviation of the ensemble members to the mean forecast is almost of the same size indicating that a high potential error in the forecast might occur. Indeed, the verifying wind power analysis shows that the absolute forecast error had been very high four days before the storm (Figure 5, bottom). The 48 h wind power fore-cast of Xynthia was almost perfect [3].

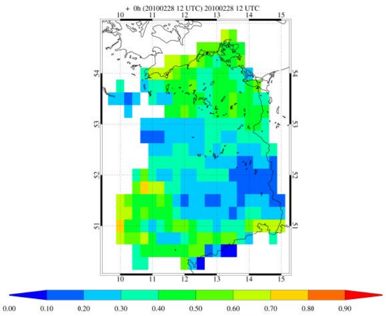


Fig. 3: Verifying analysis of wind power production at 12 UTC of 28 February 2010 (normalized with installed wind power capacity).

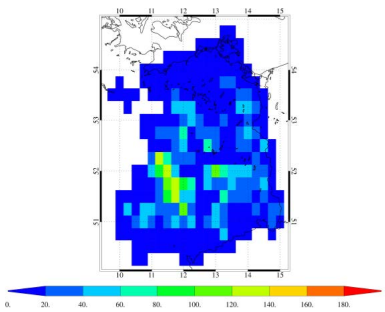
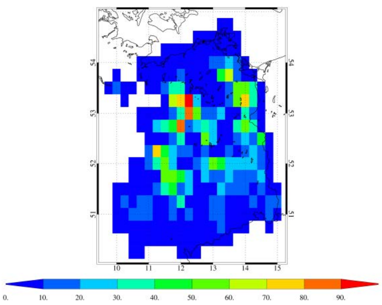


Fig. 4: +96h forecast of ensemble mean for wind power in MW valid at 1 March 2010, 0UTC



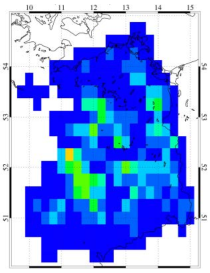


Fig. 5: +96 h forecast of ensemble spread (top) and absolute forecast error of the ensemble mean (bottom) at 1 March 2010, 0 UTC (units in MW).

# Bibliography

[1] Leutbecher, M., T. Palmer (2008), Ensemble forecasting, Journal of Computational Physics, 227(7), 3515–3539.

[2] McLean JR (2008) Equivalent Wind Power Curves. Deliverable 2.4 of the TradeWind Project

[3] Deliverable 6.6 of the SafeWind Project