Gefördert durch: Bundesministerium für Wirtschaft und Energie

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Deutscher Wetterdienst
Wetter und Klima aus einer Hand

The German Research Project *EWeLiNE*

Evaluating and improving probabilistic wind forecasts of the high-resolution ensemble system COSMO-DE-EPS

In the research project EWeLiNE, DWD (German Meteorological Service) and Fraunhofer Institute IWES are working together with three German TSOs (transmission system operators) to improve weather and power forecasts for renewable energy applications (Fig. 1). We focus on COSMO-DE-EPS wind forecasts at 100 m hub height before and after a statistical postprocessing, calibrated and verified against wind tower observation data.

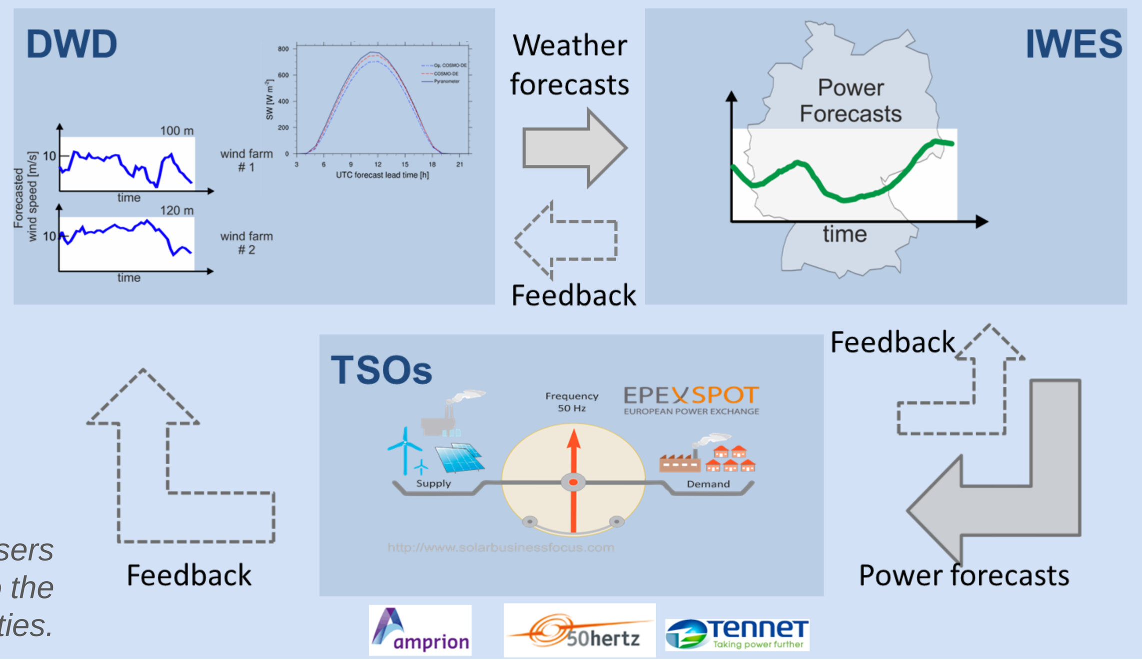

Fig. 1) Project structure of EWeLiNE. Users requirements are directly integrated into the research and development activities.

***COSMO-DE-EPS:** Convection permitting ensemble based on the high resolution model COSMO-DE*

Ensemble setup

- ***Horizontal resolution 2.8 km***
- ***Operational** since May 2012*
- ***8 starts** per day **(from 00, 03,..,18, 21 UTC)***
- ***Lead time** up to 27 h, **soon: 45 h (03 UTC)***
- ***20 members:** variations in lateral boundaries and initial conditions based on 4 global models, and 5 physics perturbations*

Gebhardt et al. 2011, Peralta et al. 2012

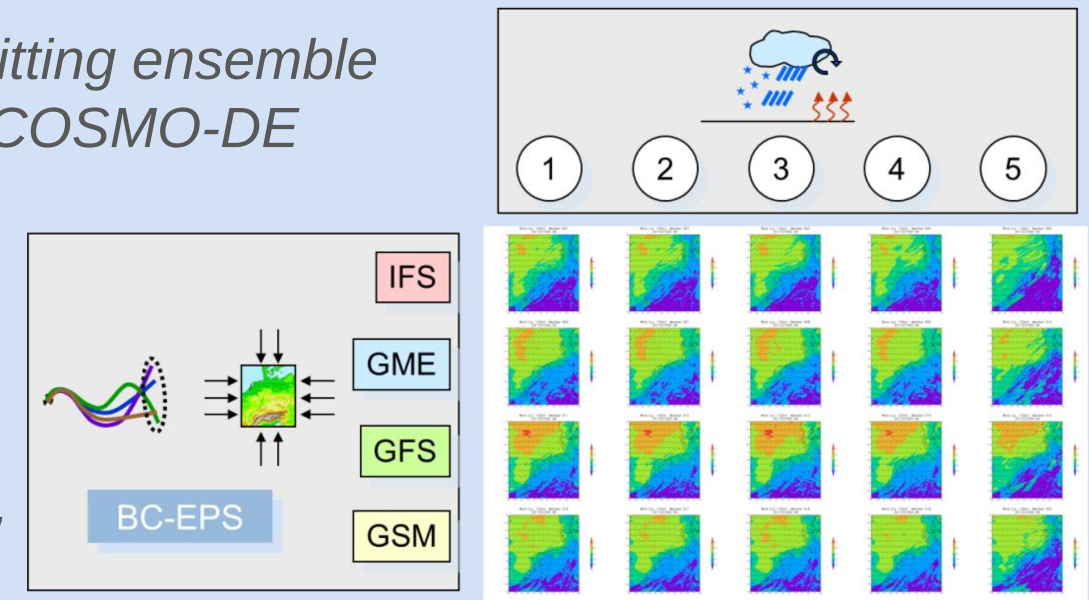

Fig. 2) Setup of the COSMO-DE-EPS at DWD

Postprocessing

COSMO-DE-EPS wind speed forecasts are underdispersive (Fig. 3). The raw ensemble does not fully reflect the model's forecast uncertainty. Statistical postprocessing aims at correcting the ensemble's deficiencies in order to reduce the ensemble spread bias.

Setup

Non-homogeneous Gaussian regression [1] is applied here as method for the calibration of the bivariate horizontal wind vector for the 03 UTC forecast run during the winter season 2012/13. The CRPS as proper scoring rule should be minimized. The 40-days training period is locally adapted to the point forecasts at 5 specific sites in Northern Germany and Denmark (Fig. 4). A local approach with local training at each station is compared to the raw ensemble (Fig. 3-6). A regional approach has also been tested which adapts the training data of all considered sites together to compute the coefficients at each site. However, this leads to overdispersive forecasts at on-shore sites (not shown).

Steps:
- Linear regression of the mean vector
- Maximum likelihood estimation of the variances
- Trigonometric correlation function between forecast wind direction and observed wind components

Finally, we apply an **ensemble copula coupling (ECC)** [2] to redraw the rank order of the raw ensemble members to the calibrated ensemble output.

Postprocessing Results

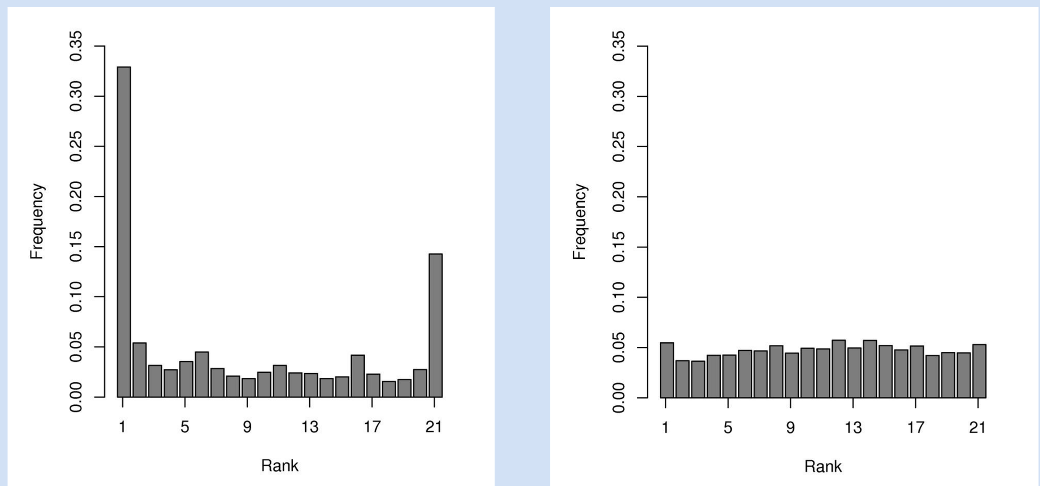

Fig. 3) Verification results of wind speed at 5 stations in Northern Germany and Denmark for Dec-Feb 2012/13 before and after applying ensemble model output statistics for wind vectors with local training data of 40 rolling days. The 03 UTC forecast run is calibrated. ***Talagrand histograms*** *of the raw ensemble forecasts (left) and of the postprcessed forecasts (right). Note: A flat rank histogram indicates a reliable ensemble forecast.*

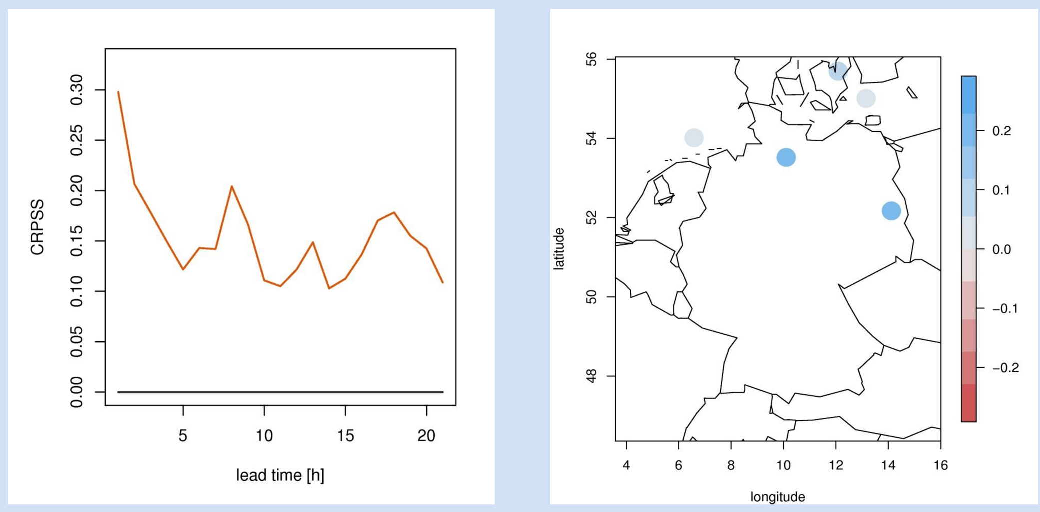

Fig. 4) ***CRPSS*** *(Continuous ranked probability skill score) of the local postprocessing approach in comparison to the raw ensemble forecast for Dec-Feb 2012/13* ***as a function of the lead time*** *for all stations (left) and* ***averaged for each site*** *separately (right). The CRPSS is improved in particular at the on-shore sites.*

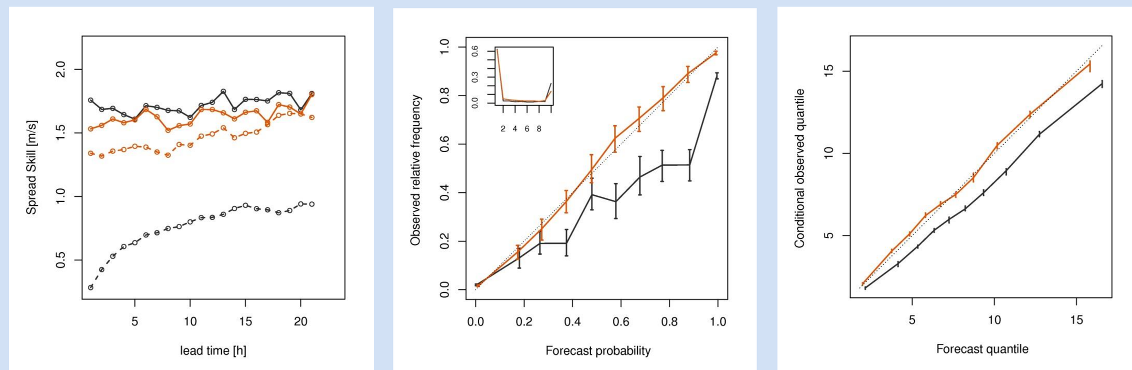

Fig. 5) Comparison of the verification results of the raw ensemble forecasts (black) and of the postprocessed ensemble forecasts (orange). The improvement by the application of the postprocessing for the winter season 2012/13 is displayed. Left: ***Spread-skill-relationship*** *as fct. of the lead time (solid = RMSE, dashed = ensemble spread). Middle:* ***Reliability diagram*** *for probabilities at the* ***threshold 10 m/s****. Right:* ***Quantile reliability diagram*** *for the* ***10%-quantile*** *(Units at axes: m/s). Bars show 5-95% confidence intervals estimated by bootstrapping.*

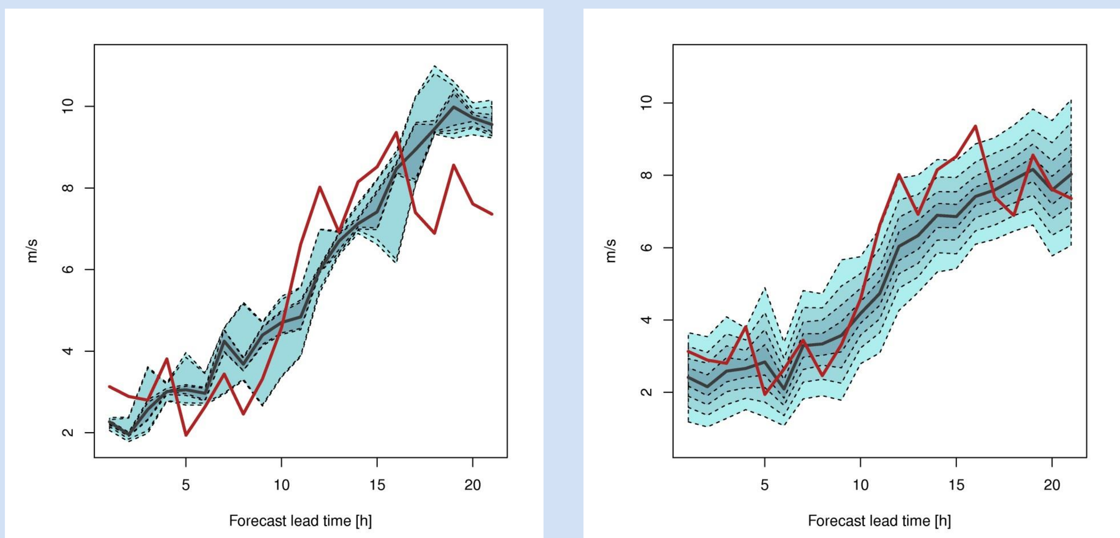

Fig. 6) ***Quantile forecast example*** *of wind speed at station Hamburg as a function of the lead time of the 3 UTC forecast run at January 25, 2013, applying ensemble model output statistics for wind vectors with a rolling local training window of 40 days. Left: Raw ensemble quantile forecasts. Right: Postprocessed ensemble quantile forecasts (red=wind tower measurements, blue: stepwise 10%-quantiles).*

Conclusion

- Improvement of the COSMO-DE-EPS forecast performance by the application of ensemble model output statistics
- Distinct increase of the ensemble spread, reliability, and the CRPSS
- Provides reliable ensemble local forecasts for an optimal use of uncertainty and probability statements

Perspectives

- Compare to other calibration methods
- Investigation of well suited predictors
- Studies on the entire grid rather than for single stations

References:

[1] Schuhen et al. "Ensemble model output statistics for wind vectors", arXiv:1201.2612, 2012.

[2] Schefzik et al. "Uncertainty quantification in complex simulation models using ensemble copula coupling", arXiv: 1302.7149, 2013.

[3] Gebhardt et al. "Uncertainties in COSMO-DE precipitation forecasts introduced by model perturbations and variation of lateral boundaries", *Atm. Res.*, vol.100, pp.168-177, 2011.

[4] Peralta et al. "Accounting for initial condition uncertainties in COSMO-DE-EPS", *JGR*, vol.117, 2012.

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