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Evaluation of NWP Resolution Effect on Wind Speed Forecast Quality for a Wind Farm in Central Sweden

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Abstract

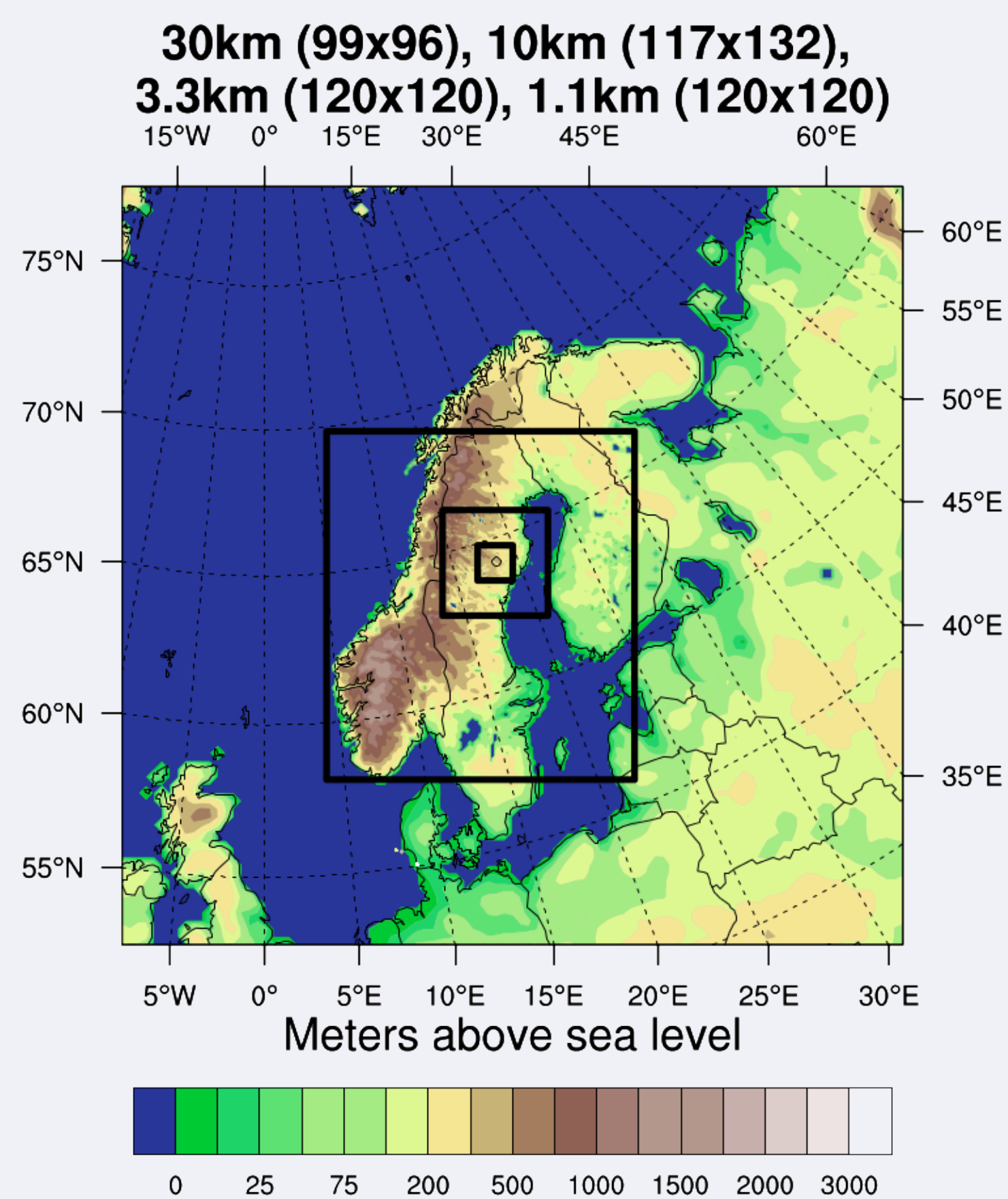
For any energy system relying on wind power, accurate forecasts of wind fluctuations are essential for efficient operation. Increased forecast precision allows end-users to plan ahead within narrowing uncertainty tolerances which in turn strengthens the feasibility of wind energy¹. The project aims to quantify and explore various aspects of value added to wind power forecasts in the 12-48h leadtime horizon by downscaling global numerical weather prediction (NWP) data using a mesoscale NWP model.

Preliminary results on deviation, correlation and spectral properties of forecasted and observed wind speed are presented.

Farm-averaged nacelle wind speed time series forms the basis of comparison for four daily 48-hour Weather Research and Forecast model² (WRF) forecasts at 30km, 10km, 3.3km and 1.1km spatial resolutions for the yearlong period April 2012 to April 2013.

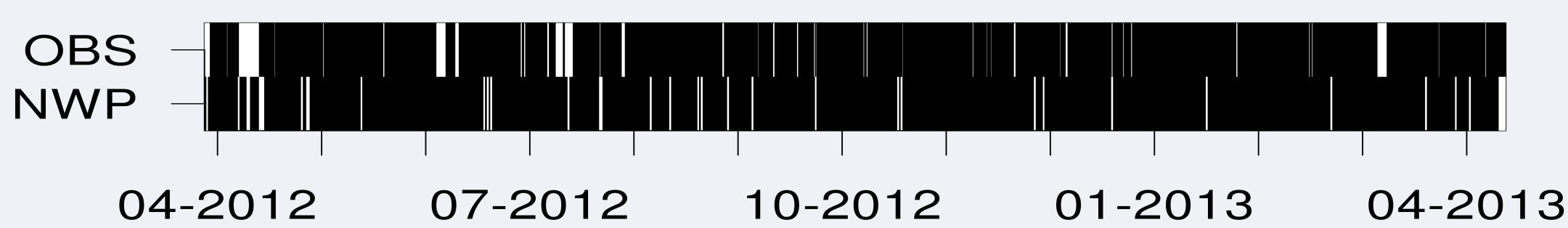
Dataset

The wind farm is situated in central Sweden and consists of 40 Vestas V 90 turbines with a tower height of 95 meters. The installed electricity capacity is 78MWe and annually ~240 GWh are produced.



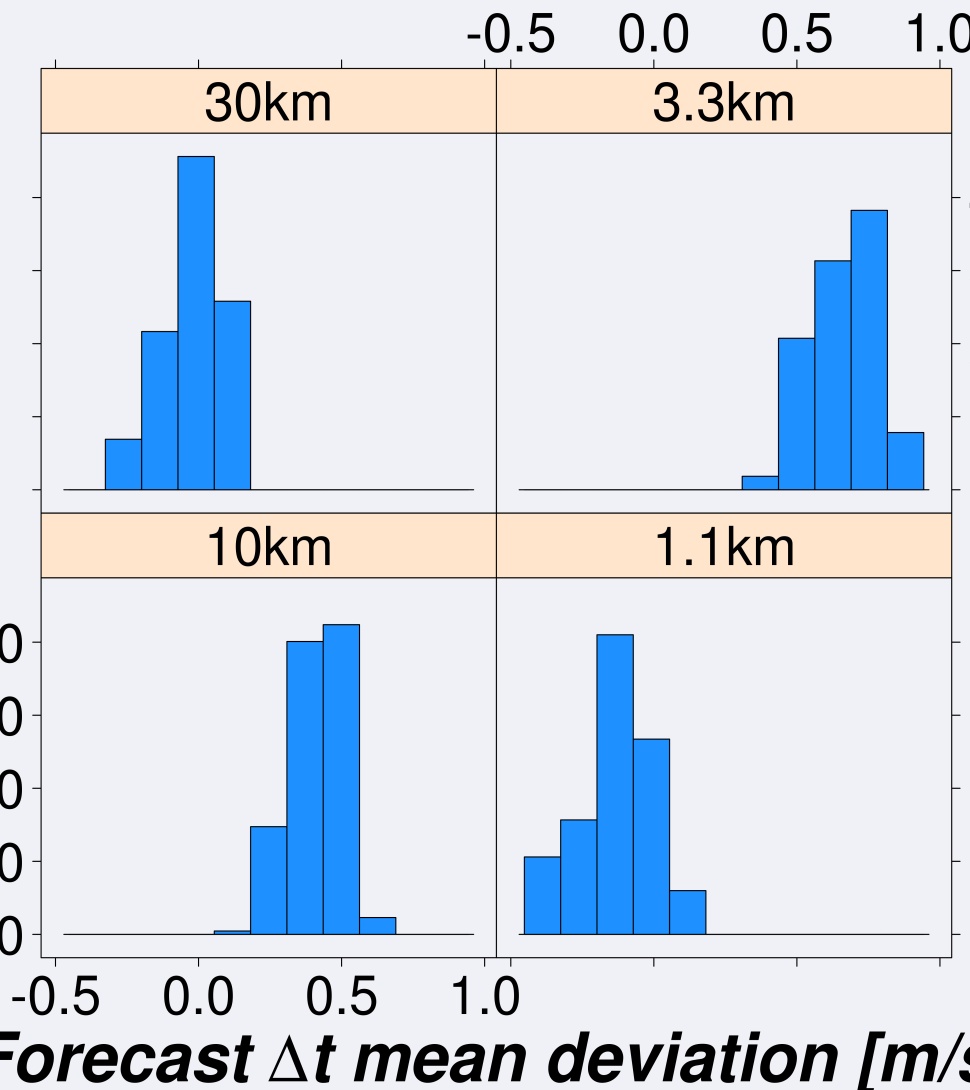
Dataset spans 1 year

- ~7% nacelle wind speed data is missing
- ~5% NWP forecast data is missing

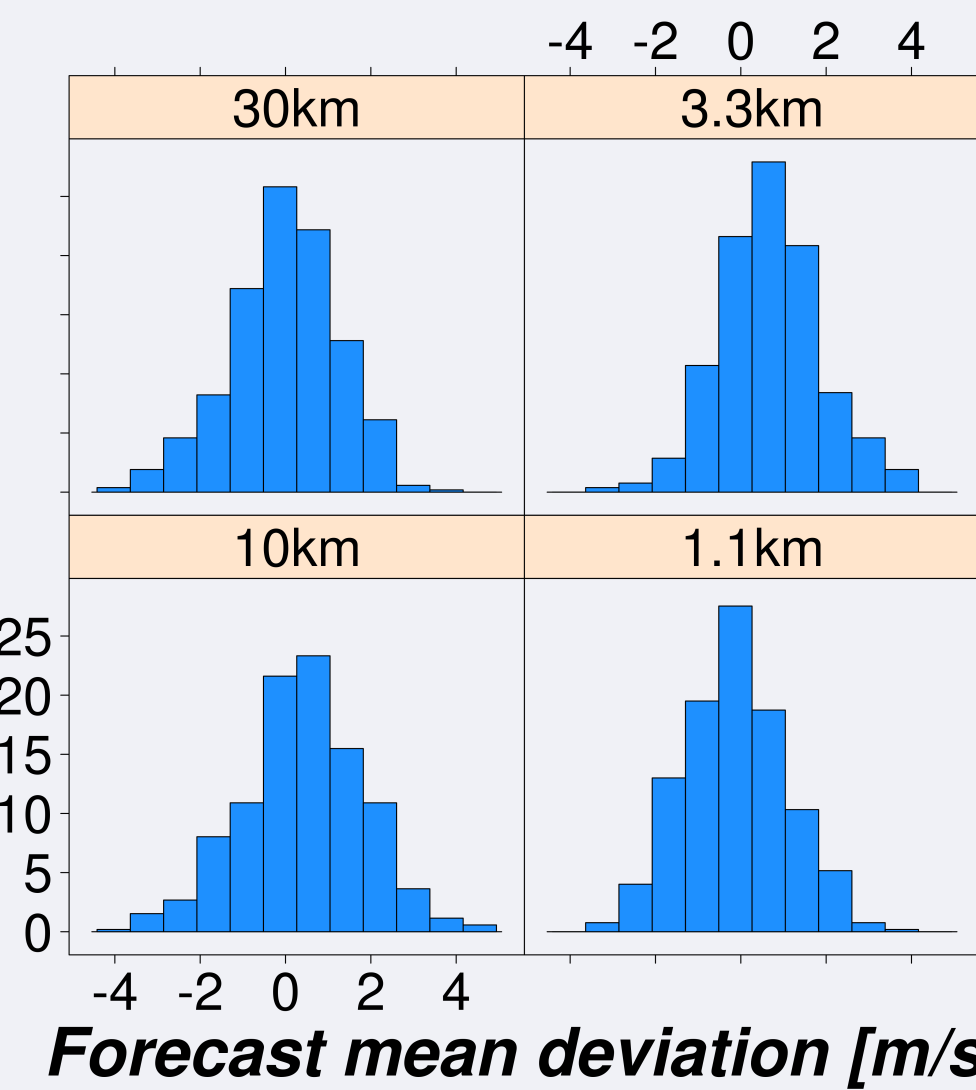


Mean deviation

Mean deviation for leadtime



Mean deviation for forecasts



Deviation is here defined as mean of NWP minus nacelle wind speed.

Forecast hour

Leadtime mean

Forecast N

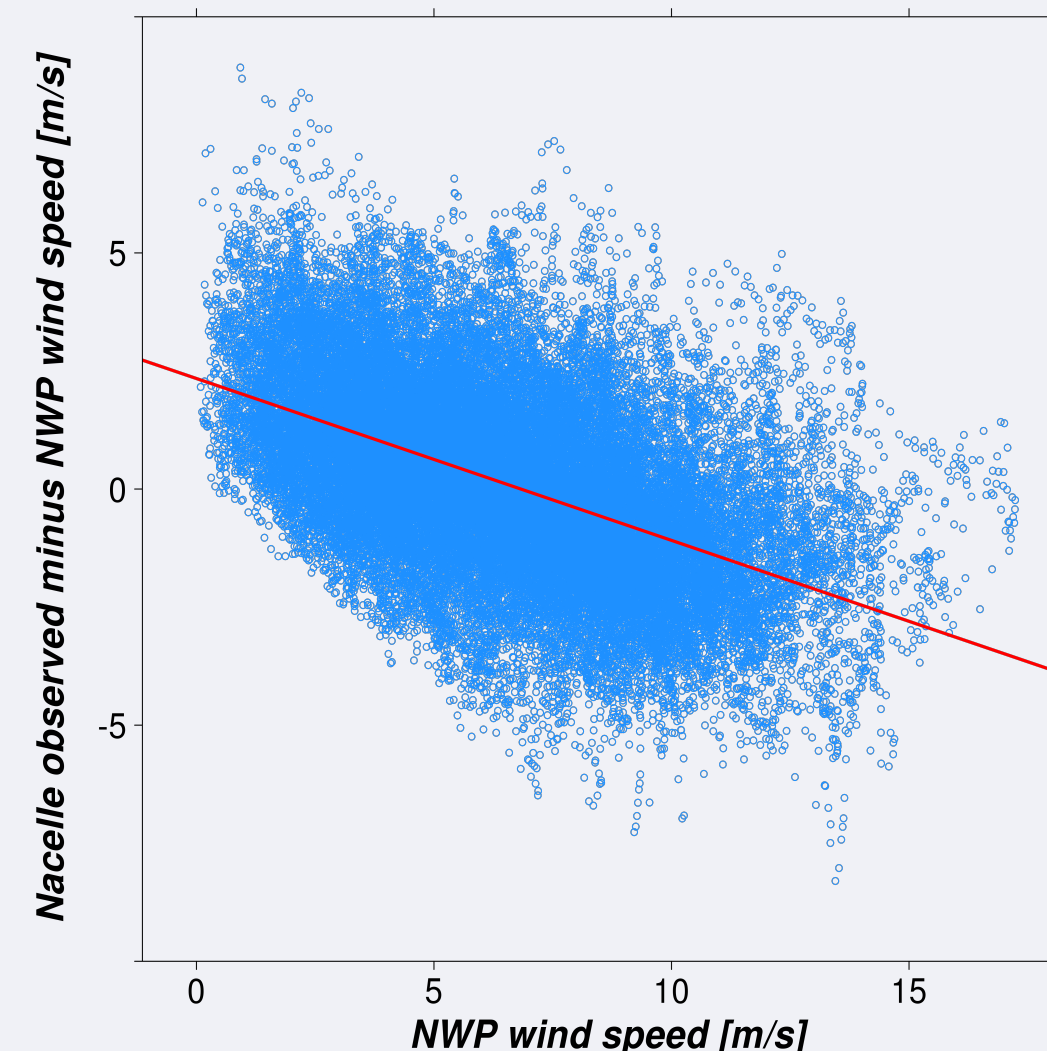
Forecast N+1

Forecast hour

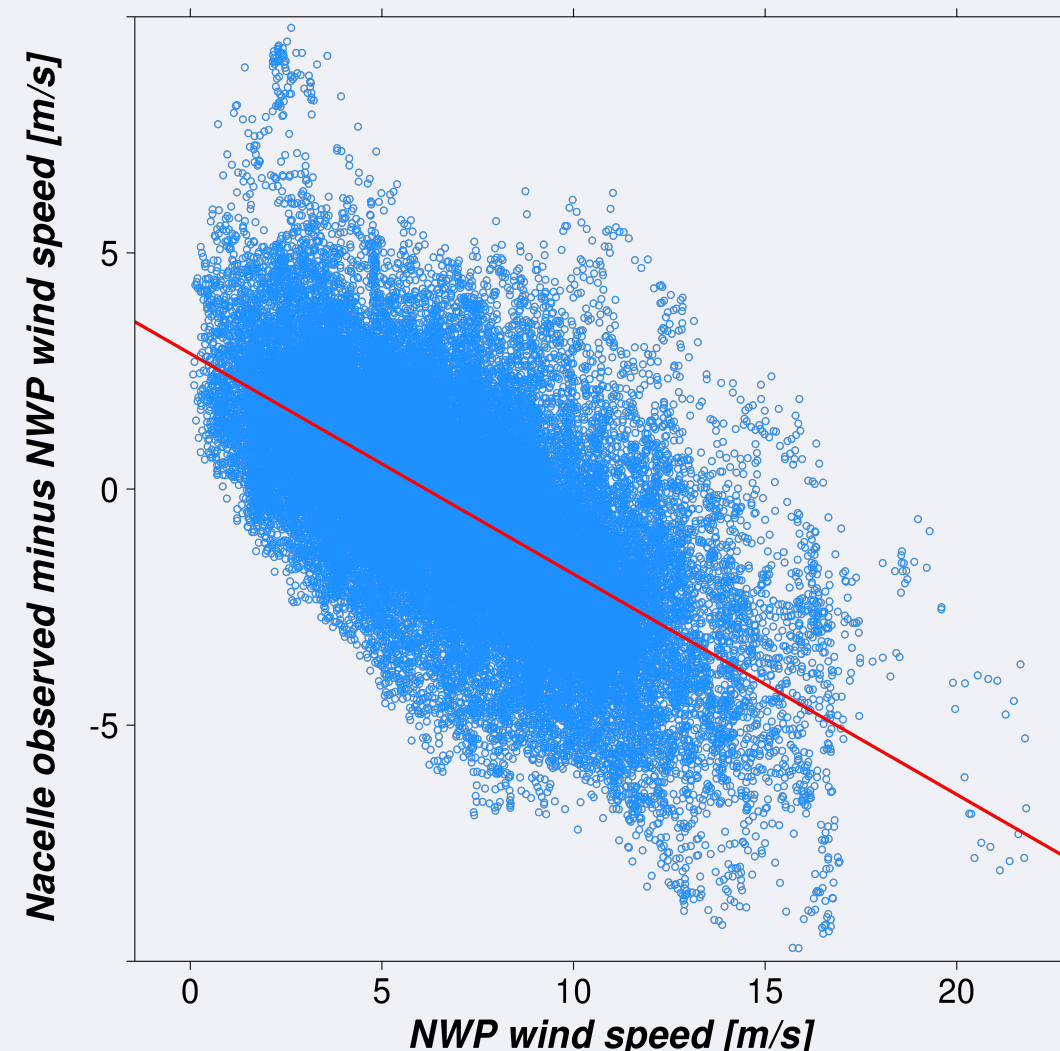
Forecast mean

Bias sign dependence on wind speed

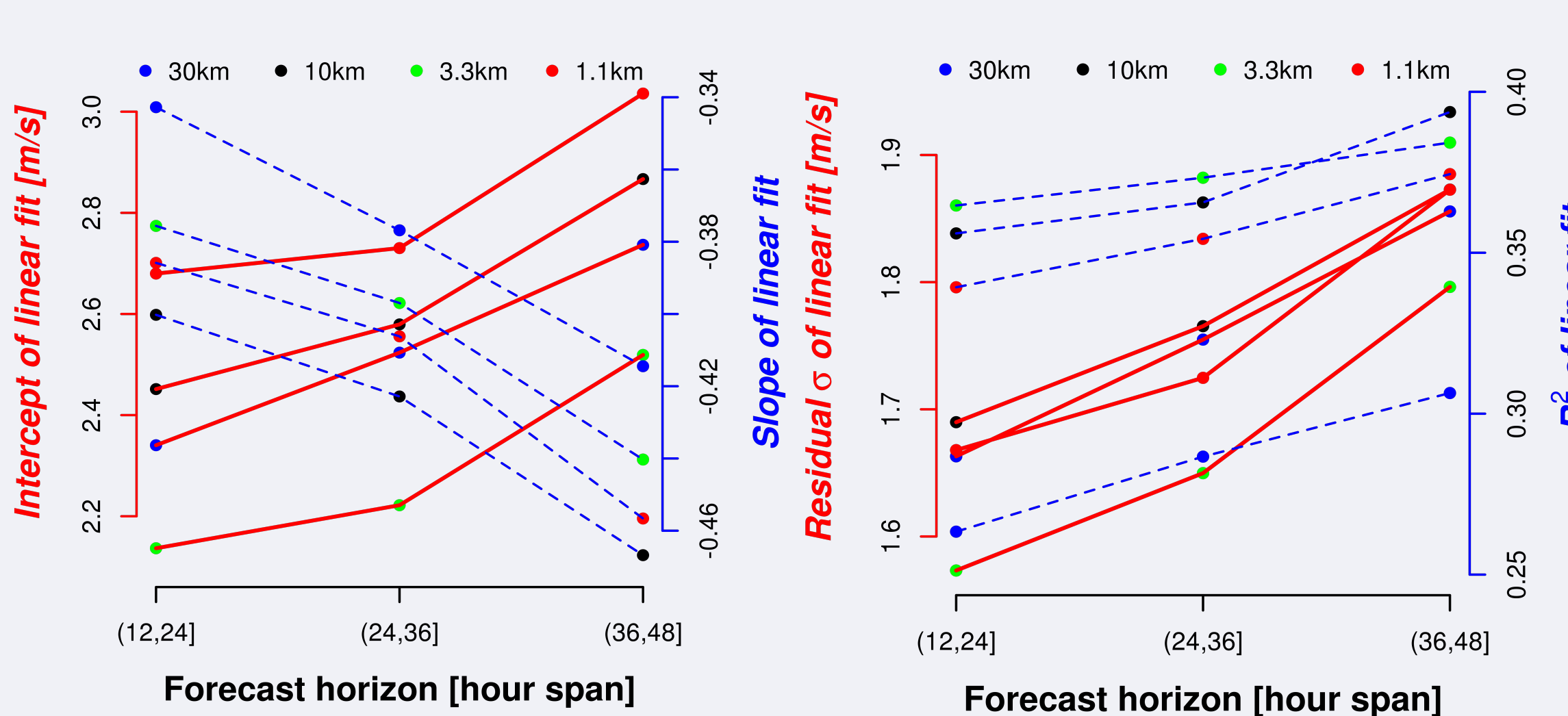
Horizon group (12,24)h, resolution: 30km



Horizon group (36,48)h, resolution: 10km



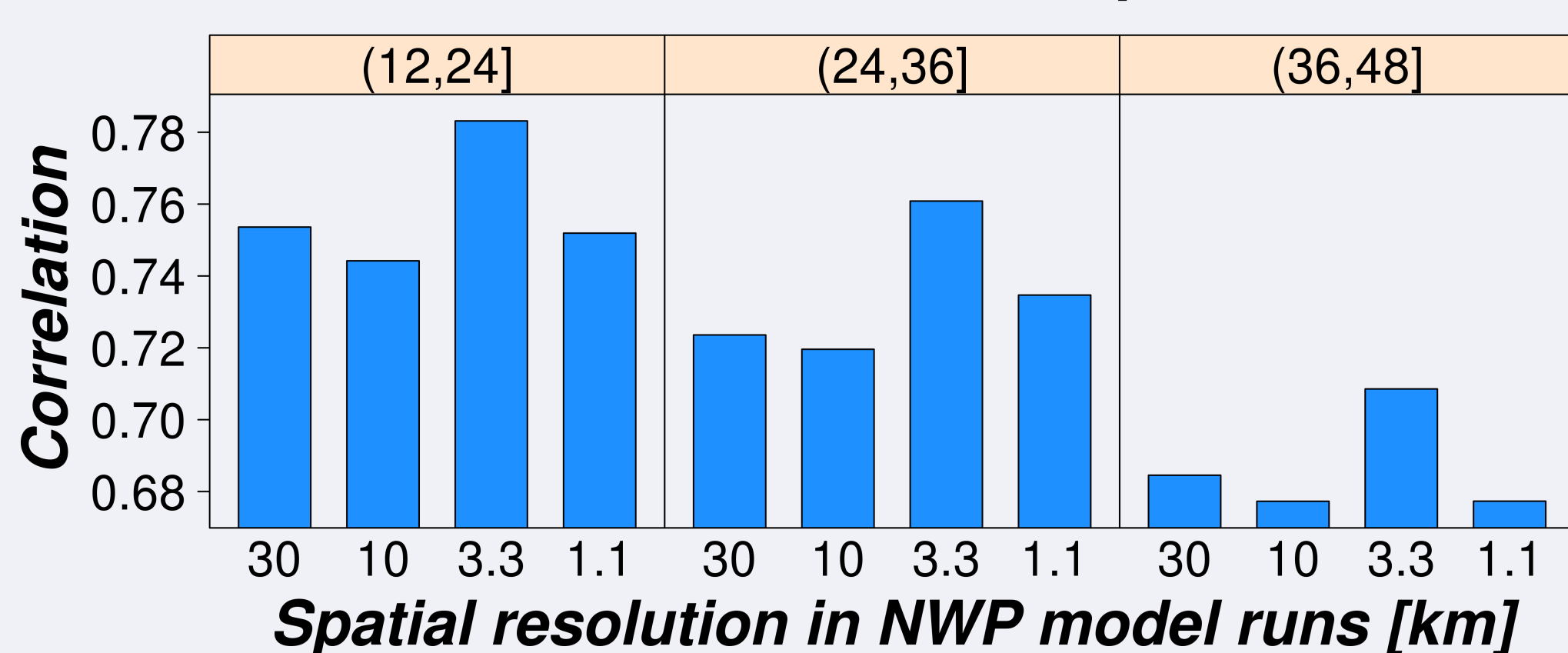
Below: Linear fits to scatterplots of the type shown above; the two R^2 extremes



Systematic overprediction for low wind speeds and underprediction for high wind speeds is observed

Correlation for horizon groups

Forecast horizon [hour span]

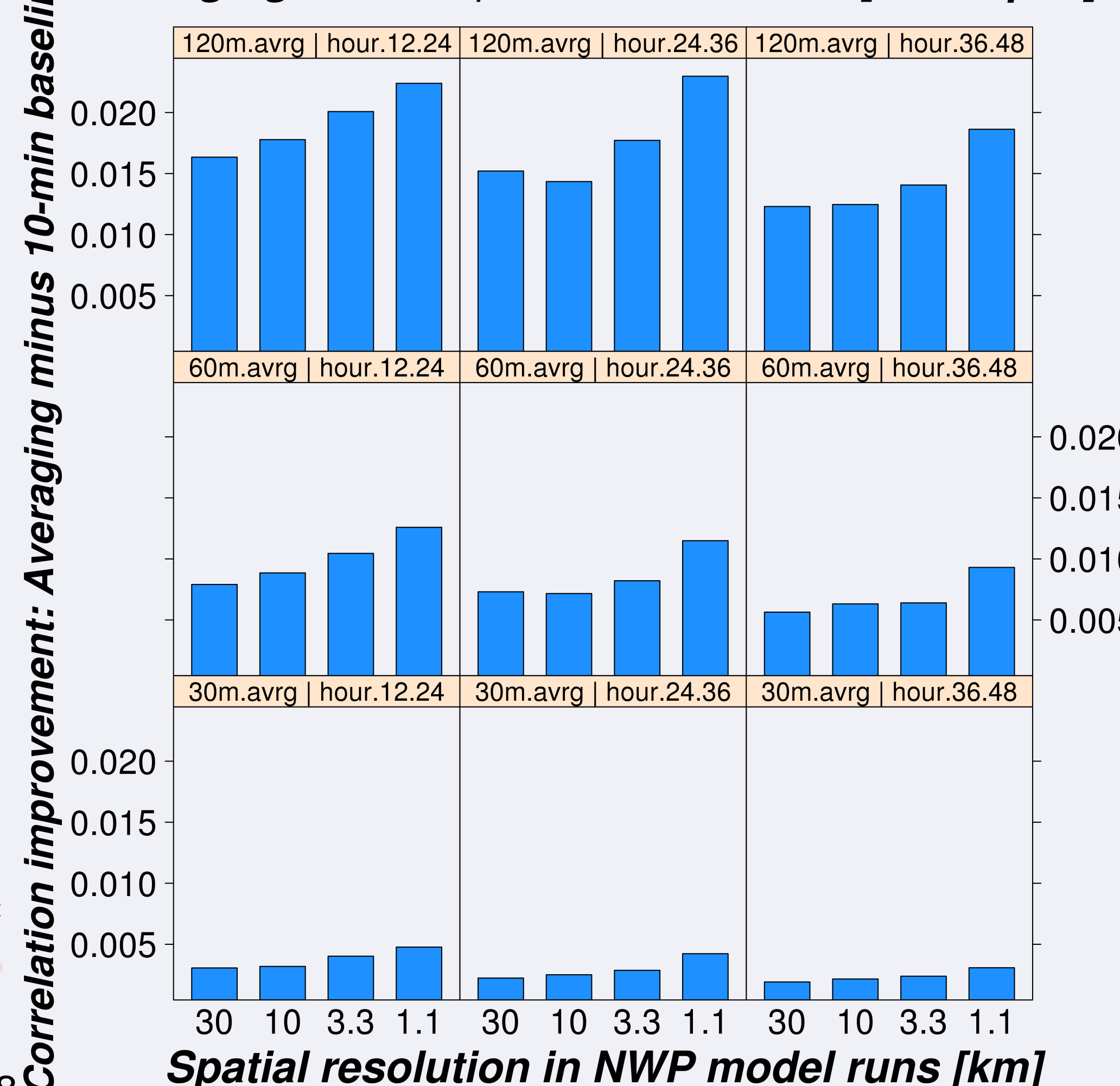


Correlations between observed and NWP-predicted wind speeds drop steadily for all resolutions by ~0.07 from the first till the third horizon group.

The WRF domain with 3.3km resolution appears to capture fluctuation timing slightly better than other model domains

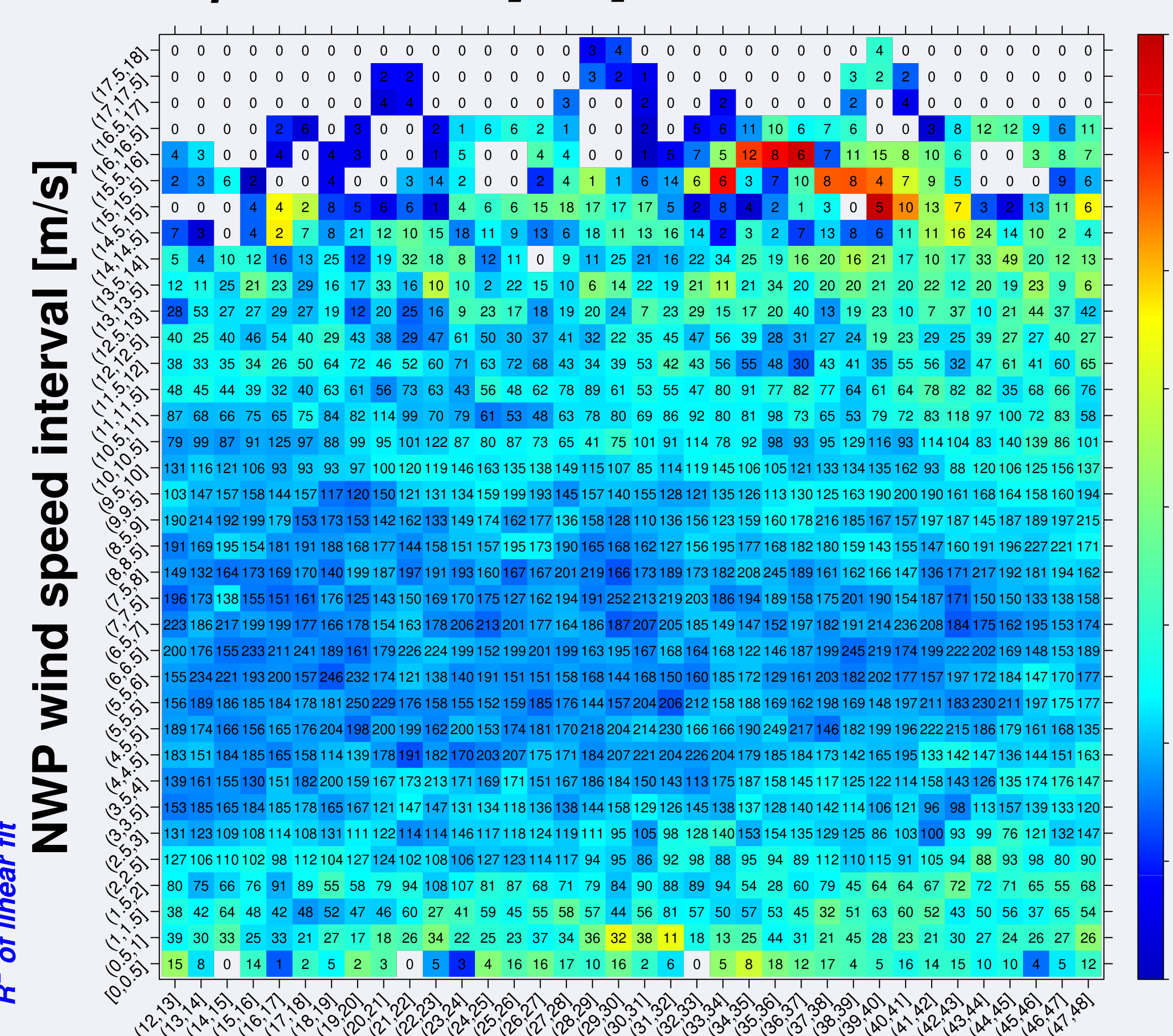
As an initial step in assessing whether smoothing could improve correlation for the high resolutions in particular, correlation improvements are investigated for simple averaging in order to probe potential value of a more sophisticated approach

Averaging window | Forecast horizon [hour span]



Root mean square deviation

Wind speed RMSE [m/s] with # mean elements



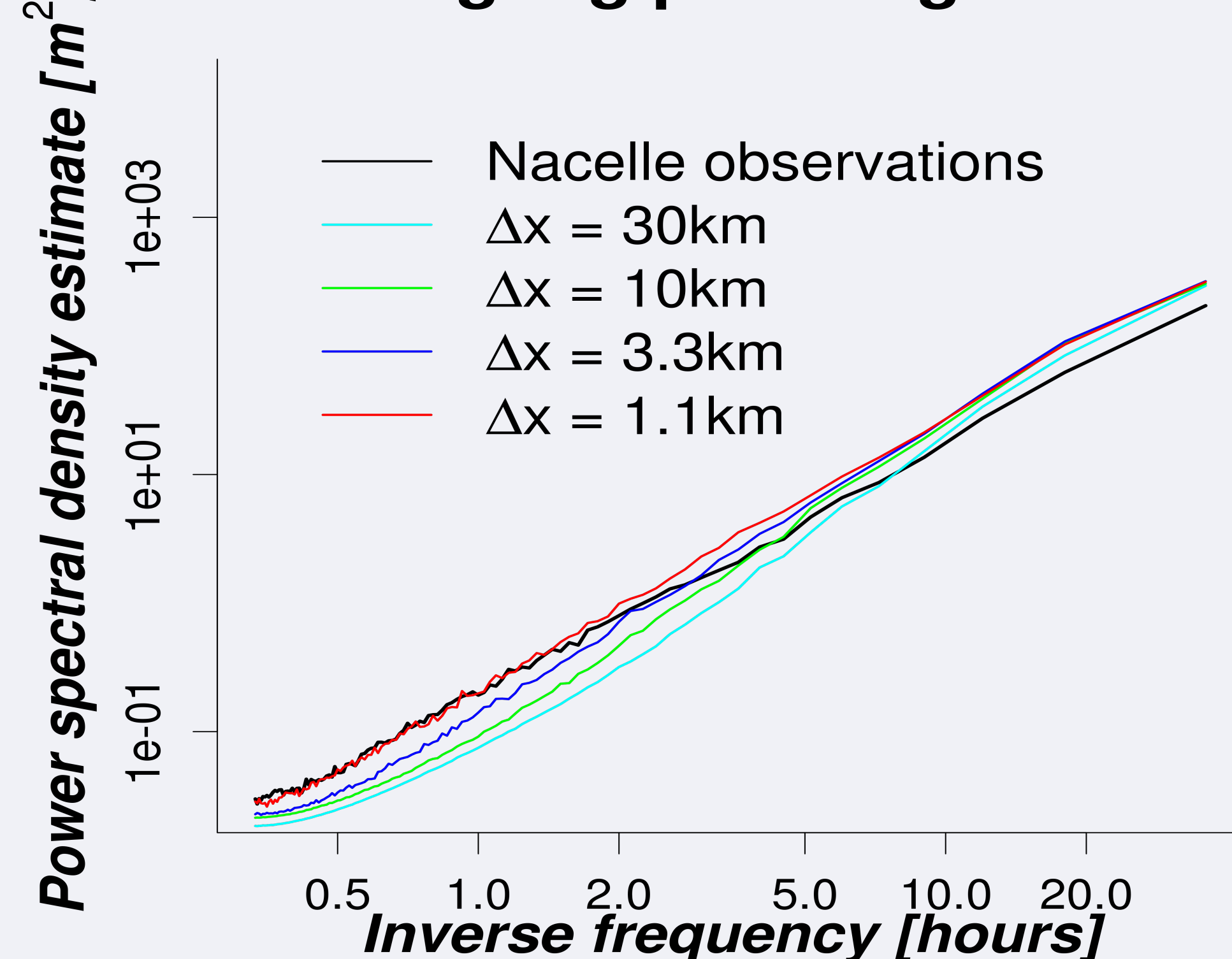
Forecast hour interval

Overview of wind speed root mean square deviation as a function of leadtime hour

The RMSE plot includes information about data point "weight", thus quantifying the RMSE estimate's credibility

Spectral properties

Log-log periodogram



The periodogram displays good agreement between wind speed variability for the highest NWP resolution and the nacelle observations for high-frequency fluctuations

Conclusions & outlook

The exploratory data analysis results presented forms the basis for further investigations on the value of mesoscale NWP forecasts for wind predictions.

- Correlation results indicate a NWP resolution limit around 3.3km beyond which forecast value decreases.
- Periodogram results indicate that high resolution might yet provide the best forecast value with regard to variability content. Studying yearlong augmented 12-hour forecasts will shed further light on this.

Acknowledgements

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References

1. FORECASTING THE WIND TO REACH SIGNIFICANT PENETRATION LEVELS OF WIND ENERGY, *Bulletin of the American Meteorological Society* 2011
2. A Description of the Advanced Research WRF Version 3, NCAR/TN-475+STR NCAR TECHNICAL NOTE 2008



EWEA Wind Power Forecasting Technology Workshop, Rotterdam, 3-4 December 2013

