Evaluation of Dynamical Downscaling Resolution Effect on Wind Energy Forecast Value for a Wind Farm in Central Sweden

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Publication date:
2014

Document Version
Publisher's PDF, also known as Version of record

Citation (APA):
Rosgaard, M. H., Hahmann, A. N., Nielsen, T. S., Sørensen, P. E., Madsen, H., & Giebel, G. (2014). *Evaluation of Dynamical Downscaling Resolution Effect on Wind Energy Forecast Value for a Wind Farm in Central Sweden*. Poster session presented at 3rd International Lund Regional-Scale Climate Modelling Workshop, Lund, Sweden.

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ENFOR — Forecasting and Optimization for the Energy Sector

Motivation

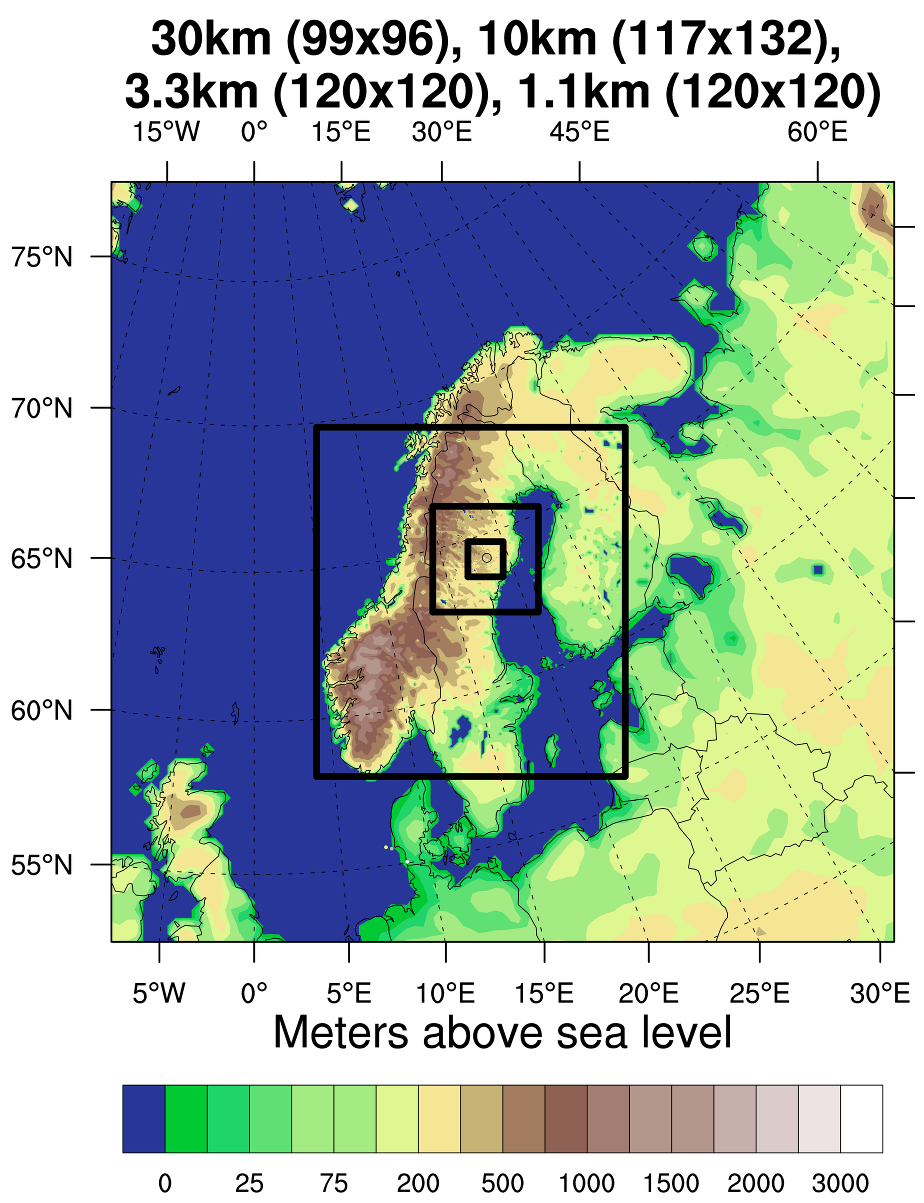
For any energy system relying on wind power, accurate forecasts of wind fluctuations are essential for efficient utilisation in the power grid. Statistical wind power prediction tools [1] use numerical weather prediction (NWP) model data along with measurements and can correct magnitude errors operationally. It is, however, entirely up to the NWP input to describe the timing of fluctuations correctly.

Wind power is nonlinearly transformed wind speed, and the two are monotonically dependent up till wind speeds of $\sim$ 25m/s, which is the typical wind farm cut-out. Thus, an improvement in the correlation accuracy metric evaluated for wind speed data consistently translates to an improvement for wind power. For two time series describing the temporal development of the same variable, though by different means, it is assumed that phase errors account for most of the departure from perfect correlation between the two time series.

Results on limited-area NWP model performance, with focus on the $12th$ to $48th$ forecast hour horizon relevant for Elspot auction bidding on the Nord Pool Spot market [2], are presented.

Dataset

Using the mesoscale NWP model WRF [3], twice-daily 48-hour forecasts initialised 00 and 12 UTC are generated for the time period 23 May 2012 till 22 May 2013.



References

[1] **Prediction of wind power using time-varying coefficient-functions.** *Nielsen et al.* Presented at, and in proceedings of, the 15th IFAC World Congress on Automatic Control, Barcelona, Spain (2002)

[2] **http://www.nordpoolspot.com/TAS/**

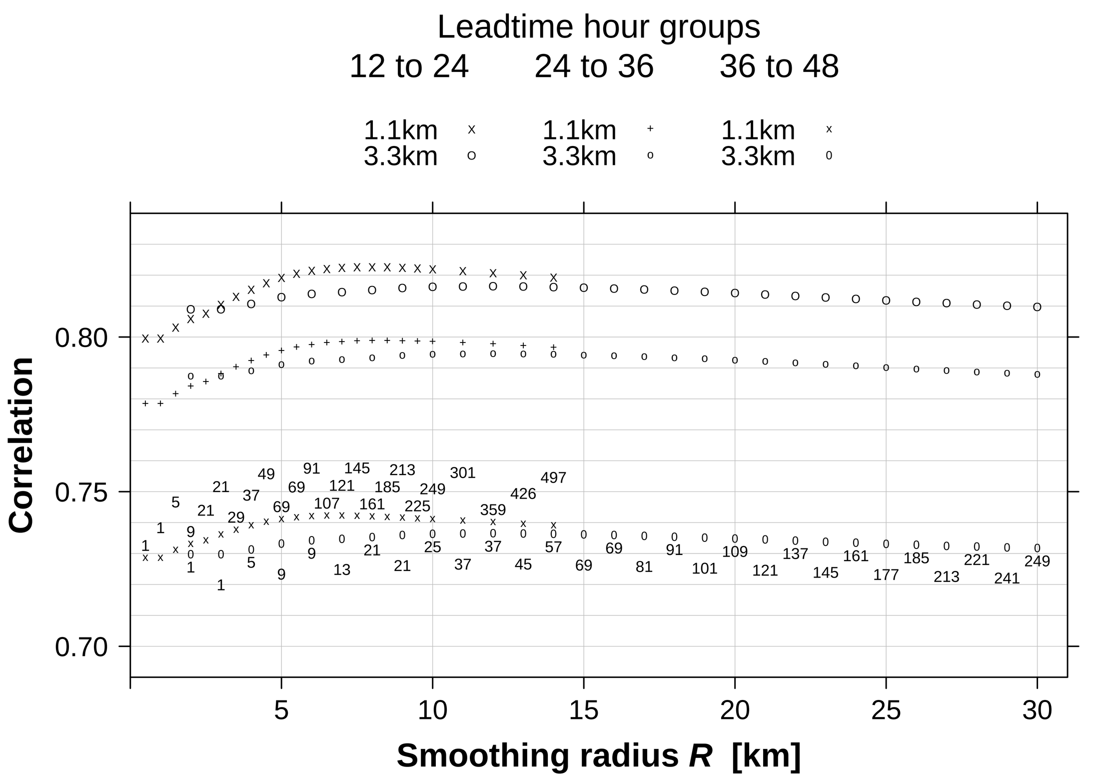
[3] **A Description of the Advanced Research WRF Version 3.** *Skamarock et al.* NCAR/TN?475+STR. NCAR Technical Note (2008)

Forecast performance vs. smoothing radius

Forecasted wind speed is compared to farm-averaged nacelle anemometer measurements.

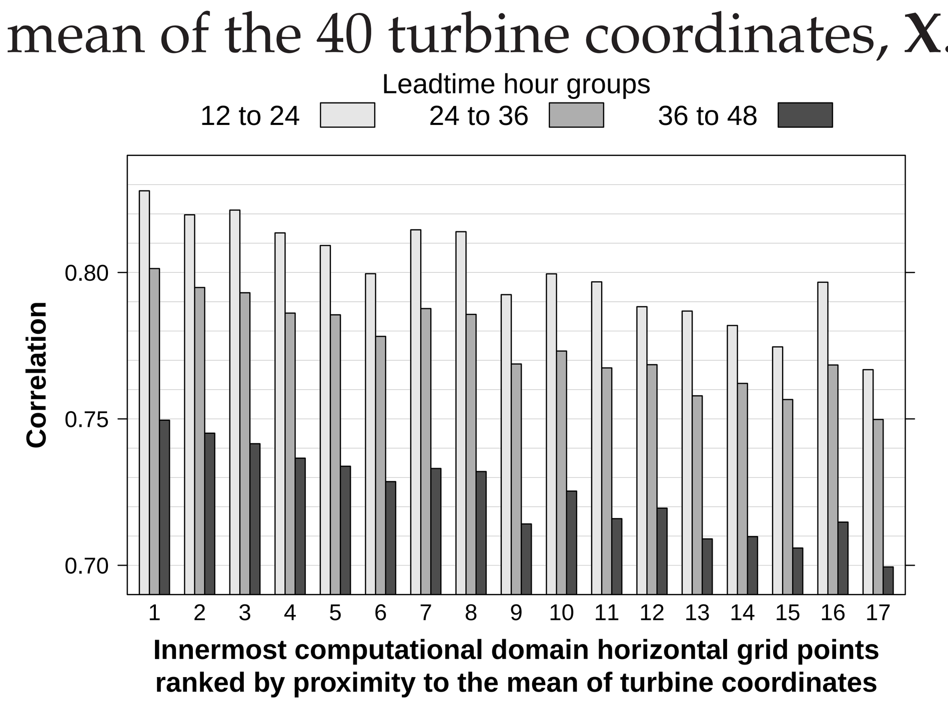
The figure to the right shows the performance of wind speed forecasts as a function of the distance, R, to the official coordinates of the wind farm. Based on the distances, r, of each of the N high-resolution computational grid points for which $r \leq R$ wind speed data is weighted according to the normalised tricube function

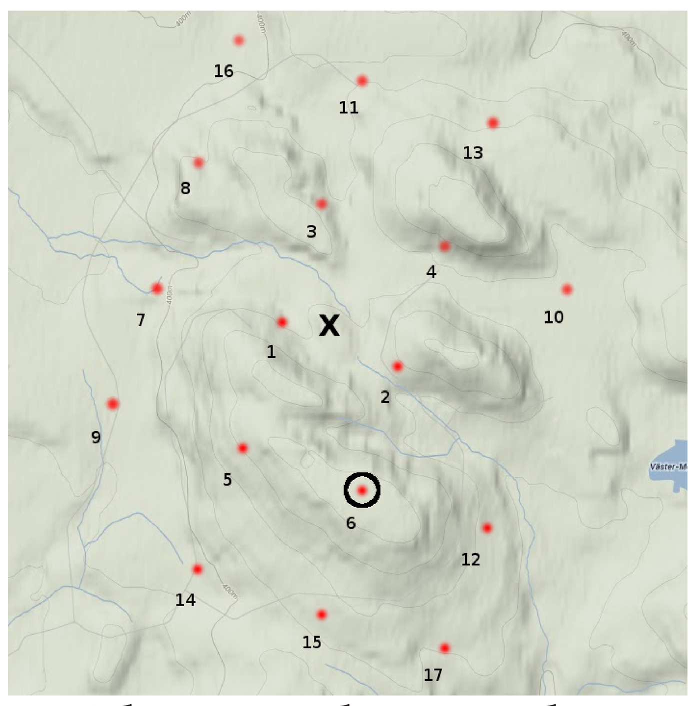
$$\mathrm{T}(r) = \begin{cases} \dfrac{(R-r)^3}{\sum_{i=1}^{N} \mathrm{T}(r_i)} & \text{if } r \leq R \\ 0 & \text{if } r > R \end{cases}$$

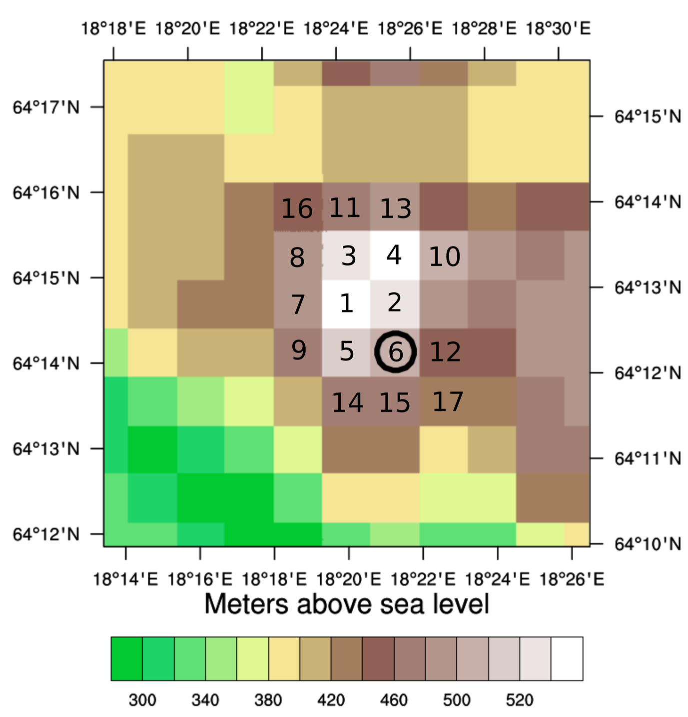


Note, in the figure above to the right, that performance of the NWP data with the highest spatial resolution is worse than for the second-highest resolution for small smoothing radii, while the highest resolution peaks well beyond the wind farm spatial extent; roughly 4×5km.

A closer look at the performance of the individual grid points covering the wind farm turbine locations reveals that the official wind farm coordinates, **O**, are $\sim$ 1km away from the mean of the 40 turbine coordinates, **X**.

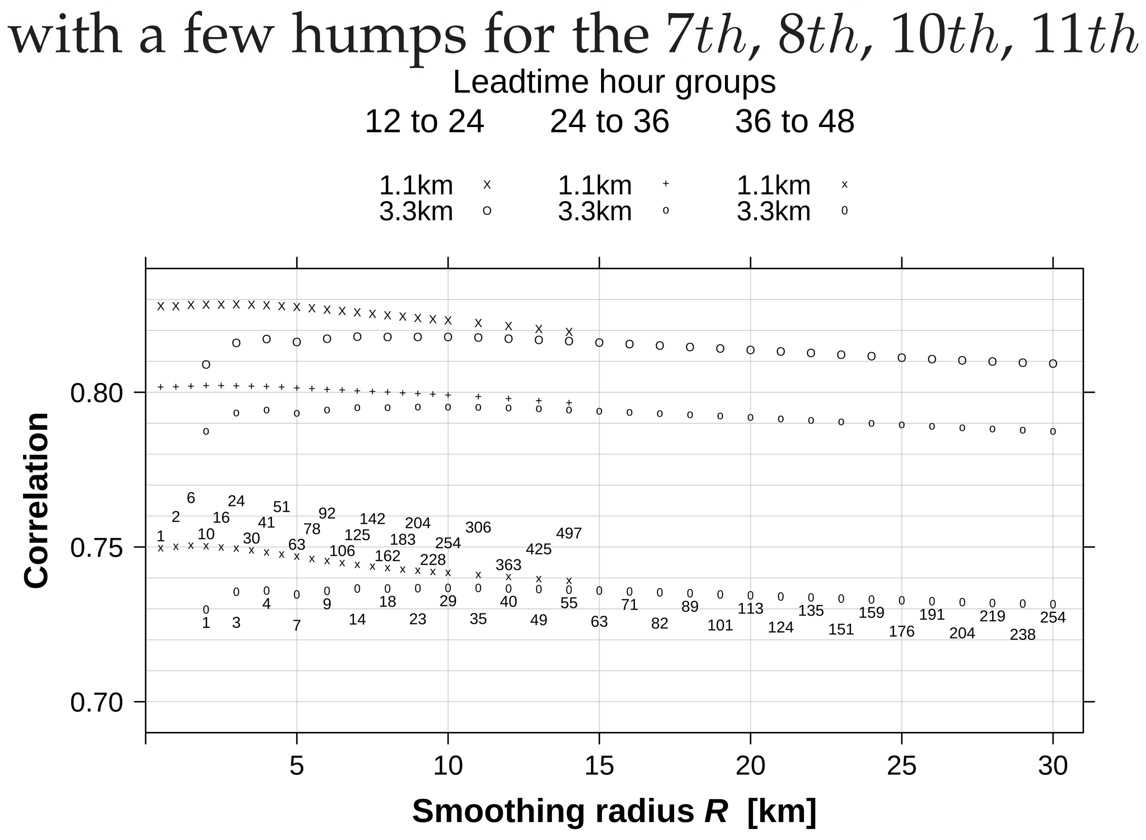






The sketches above show the 1.1km grid points that overlap turbine positions for observed and modeled topography, respectively. Observed **O** is 569m above sea level (ASL), while modeled **O** is only 505m ASL. Furthermore, the point closest to **X** 495m ASL is modeled as 537m ASL. The three horizon group correlations for the grid point at **O**, the $6th$ closest to **X**, are $\sim$ 0.02-0.03 lower than for the grid point closest to **X**. Overall, there is a steady drop in performance as a function of distance from **X**, though with a few humps for the $7th$, $8th$, $10th$, $11th$ and $16th$ closest grid points to **X**.

The effect of switching the R reference from **O** to **X** is shown in the figure to the right. With this correction the highest dynamical downscaling resolution consistently performs best for all smoothing radii. The numbers above (below) the 1.1km (3.3km) data points are the number of computational grid points with finite tricube weight.



Conclusion

For smoothing radii covering the spatial extent of the wind farm, performance of the 1.1km forecast data is found to be inferior to that of the 3.3km data when using the official wind farm coordinates, **O**, as reference. Two potential sources of this adverse effect of high-resolution modeling are identified:

1. The mean of the 40 turbine coordinates, **X**, is found to be $\sim$1km from **O**.
2. Comparing observed and modeled topography reveals inconsistencies.

Individual grid point performance is largely decreasing as a function of distance to **X**, indicating that the 1.1km data is indeed picking up observed dynamics at fine scales. When shifting the smoothing reference from **O** to **X** the 1.1km data consistently outperforms the 3.3km data for all smoothing radii.

The results underline the importance of carefully studying the validity of the spatial prerequisites for high-resolution NWP performance evaluation, as added quality is found to be highly sensitive to spatial miss-representations.