DTU Library

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

Rosgaard, Martin Haubjerg; Hahmann, Andrea N.; Nielsen, Torben Skov; Giebel, Gregor; Sørensen, Poul Ejnar; Madsen, Henrik

Publication date:
2014

Document Version
Peer reviewed version

CITIES
Centre for IT Intelligent Energy Systems

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

Technical University of Denmark DTU
ENFOR Forecasting and Optimization for the Energy Sector

mhr@enfor.dk Martin Haubjerg Rosgaard
ahah@dtu.dk Andrea Noemí Hahmann
tsn@enfor.dk Torben Skov Nielsen
grgi@dtu.dk Gregor Giebel
posq@dtu.dk Poul Ejnar Sørensen
hmad@dtu.dk Henrik Madsen

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.

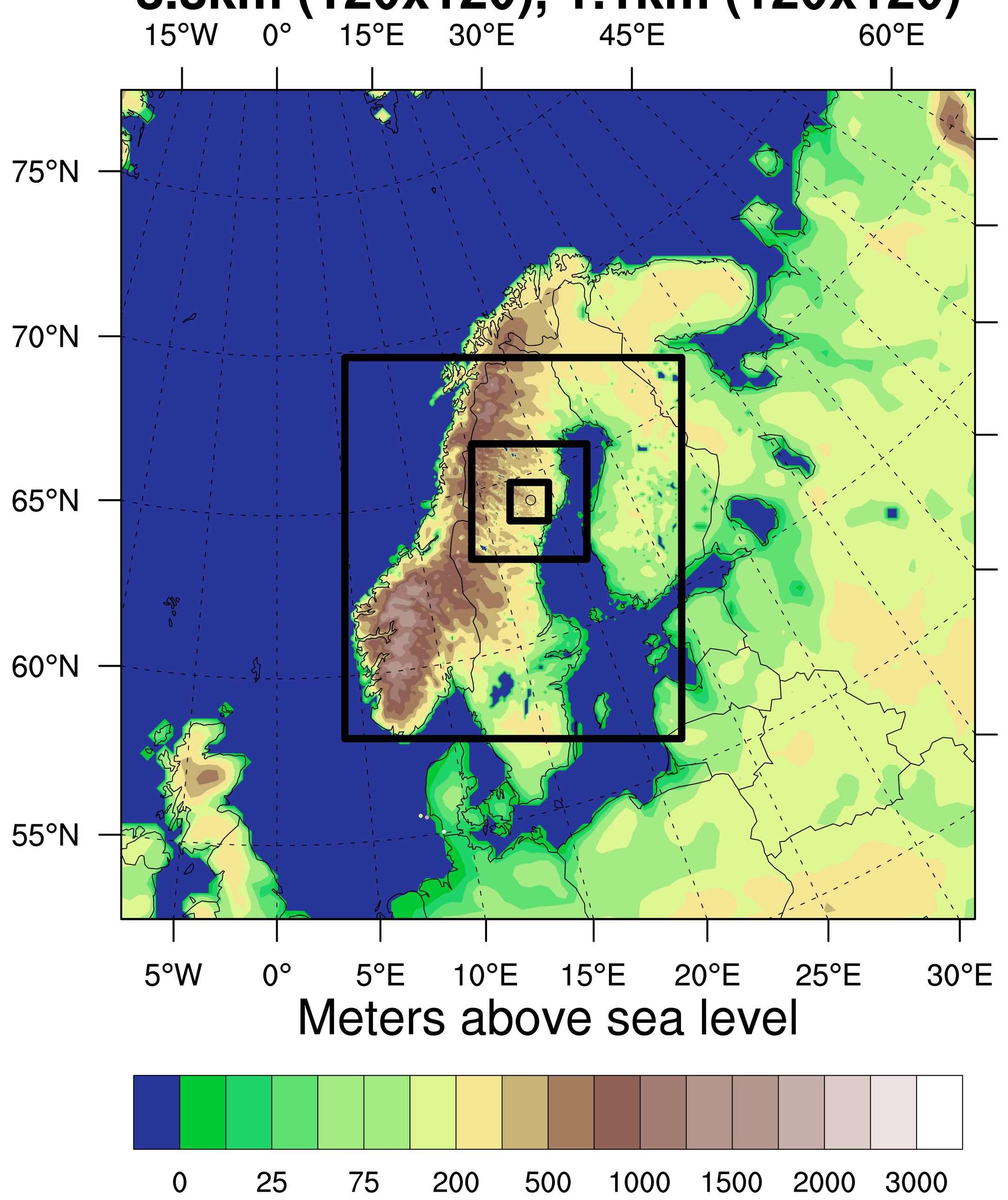
Wind power is nonlinearly transformed wind speed, and the two are monotonically dependent up till wind speeds of ~ 25m/s, which is the typical wind farm cut-out. Thus, an improvement in the correlation accuracy metric evaluated for wind speed data consistently translates to an improvement for wind power.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

Results on limited-area model (LAM) 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.

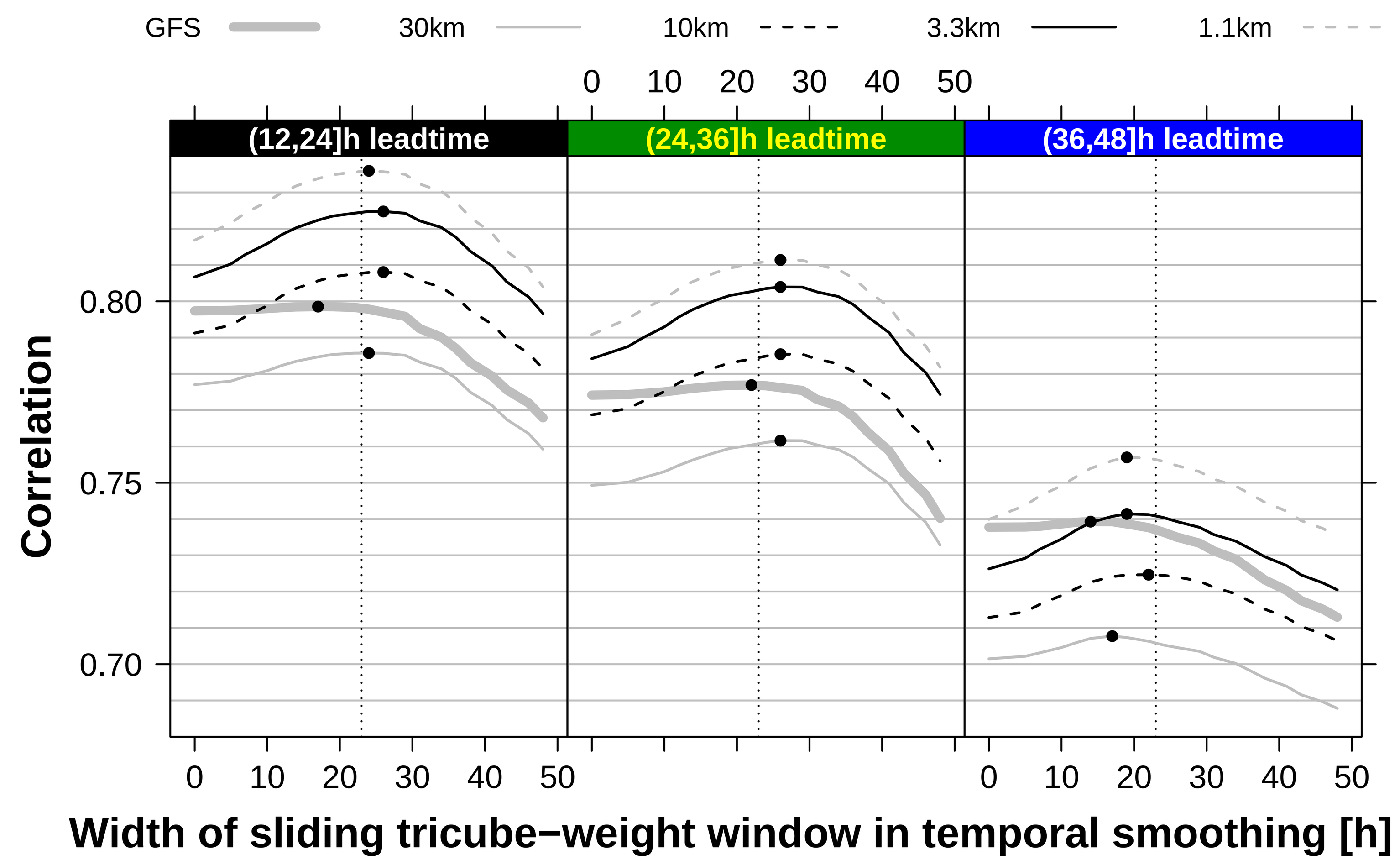
Limited-area NWP model domains

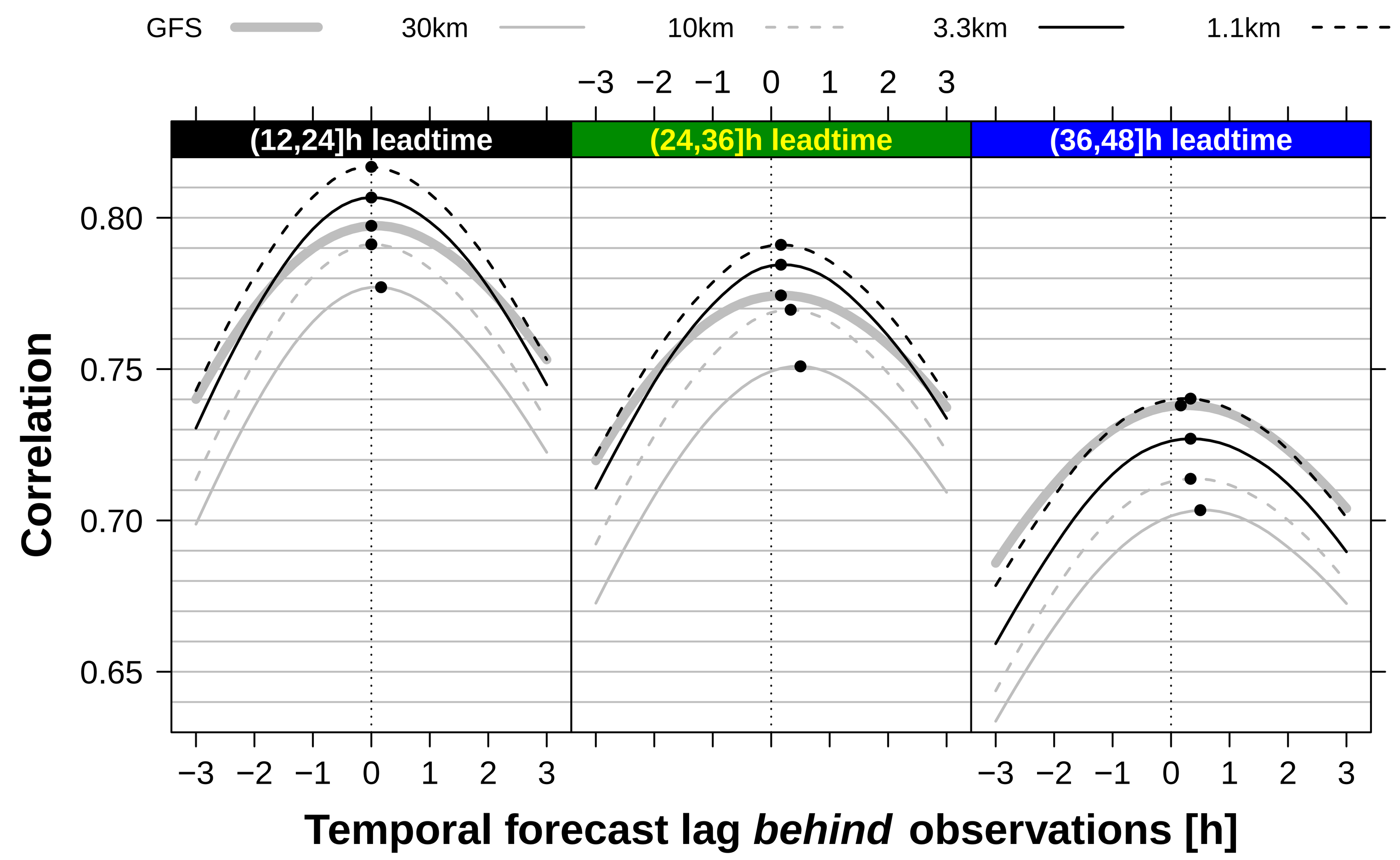
Using the mesoscale NWP model WRF [4], the extent to which model resolution affects wind power forecasts is sought quantified in the form of correlation between forecasted and measured wind speed.

30km (99x96), 10km (117x132), 3.3km (120x120), 1.1km (120x120)



Correlation between farm-averaged nacelle measurements and forecasts



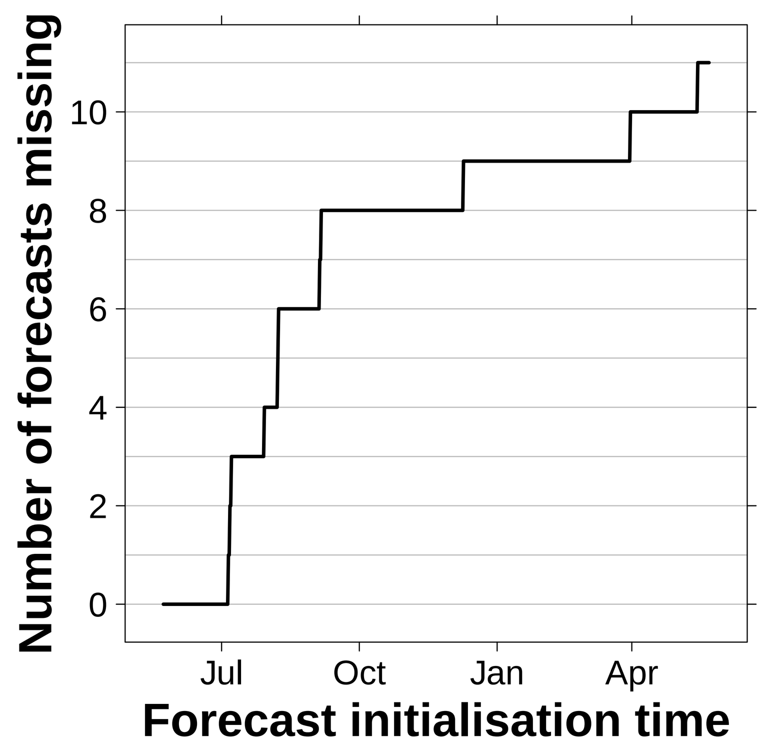


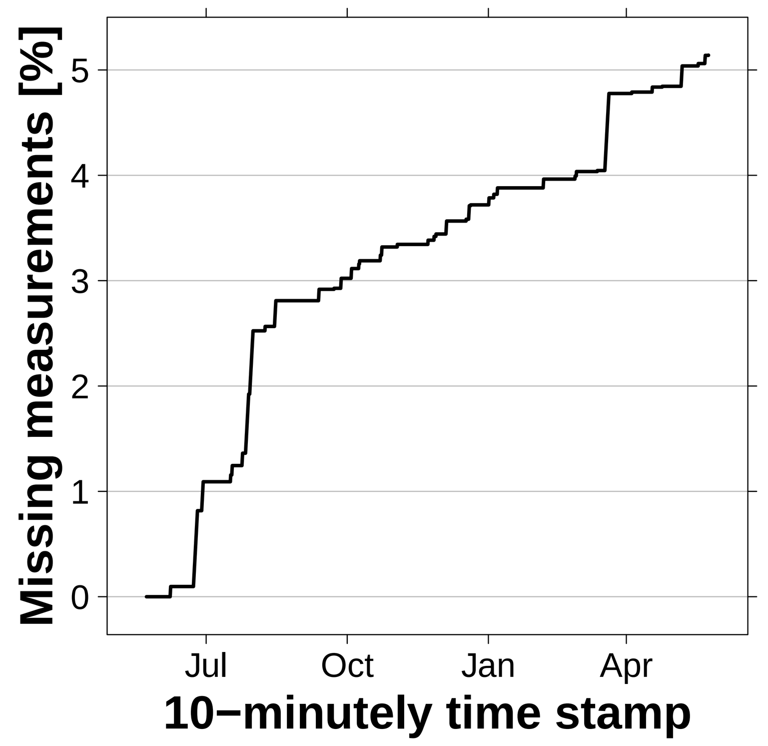
The smoothing method employed is local $2nd$ order polynomial regression fitting [3]. The dotted vertical line at 23 hours seems to be a good compromise across horizons. All LAM optimal correlation smoothing-windows are wider for horizon groups (12,24]h and (24,36]h, while after the $36th$ leadtime hour optimal correlation smoothing-window widths are more narrow.

Although differences between optimal correlation and no timelag are no larger than 0.001, the plot above indicates a consistent tendency of the unsmoothed 10-minutely forecast data to fall behind observed dynamics as the leadtime increases. Consequently the performance metric may gradually fail to capture correctly predicted severe wind speed fluctuations slightly off in timing.

The dataset

- Full year 48-hour forecasts initialised at 00 and 12 UTC.
- Time period 23-05-2012 00 UTC till 22-05-2013 12 UTC.
- Spatial resolution of LAM domains: 30, 10, 3.3, and 1.1km.
- LAM forcing is from the global NWP model GFS 0.5° [5].
- Farm-averaged turbine nacelle wind speed measurements.
- All data @10-min. resolution, 3h-GFS is time-interpolated.





- There are 93% complete observation-forecast pairs.

Future work

The correlation metric sharply penalises phase errors and unless there is a systematic timelag between observations and forecasts the metric cannot reward correct severe-fluctuation predictions a bit displaced temporally. Therefore it is natural to expand the present study with ramp-metrics inspired by previous work, e.g. [6] and [7], in order to attribute value to timelagged but otherwise correct forecasts by tolerating phase errors up to 1-2 hours.

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] **Robust Locally Weighted Regression and Smoothing Scatterplots.** *Cleveland.* Journal of the American Statistical Association, pp. 829-836 (1979).

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

[5] **http://www.emc.ncep.noaa.gov/**

[6] **Verification of temporal variations in mesoscale numerical wind forecasts.** *Rife et al.* Monthly weather review, Volume 133, Issue 11, pp. 3368-3381 (2005).

[7] **Forecasting uncertainty related to ramps of wind power production.** *Bossavy et al.* European Wind Energy Conference and Exhibition, EWEC, Volume 2, pp. 1099-1107 (2010).