Integrated Wind Power Planning Tool

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ENFOR
Forecasting and Optimization for the Energy Sector

Project framework

This poster describes the Public Service Obligation (PSO) funded project PSO 10464 "Integrated Wind Power Planning Tool". A collaboration between ENFOR A/S and the Technical University of Denmark (DTU) departments DTU Wind Energy and DTU Compute.

Motivation

For any energy system relying on wind power, accurate forecasts of wind fluctuations are essential for efficient operation. The further the involved parties can plan ahead, the greater the savings.

Forecastquality-dependent stakeholders:

- TSO - High-voltage grid, international links and balance maintenance.
- Distribution System Operator (DSO) - local distribution networks.
- Market operator - Collects bids and determines prices.
- Electricity retailers - Sale to end users.
- Electricity producers.

Error characterisation

Electricity prices on the day-ahead market are based on forecast hours 36+ since bids are collected before noon, fixing the hour-to-hour price from midnight and 24 hours onwards.

This study aims to characterise the forecast error for a year-long test period. Provided the model reanalysis deviation from observations,

$$\mathcal{E}rror_{\mathbf{r}o} = \mathbf{reanalysis} - observed,$$

is known, and the forecast deviation from reanalysis data,

$$\mathcal{E}rror_{\mathbf{f}r} = \mathbf{forecast} - reanalysis,$$

can be computed, the forecast error can be inferred for the computional grid;

$$\begin{aligned}\mathcal{E}rror_{\mathbf{f}o} &= \mathbf{forecast} - observed,\\ &= \mathcal{E}rror_{\mathbf{r}o} + \mathcal{E}rror_{\mathbf{f}r}.\end{aligned}$$

References

[1] **THE WEATHER RESEARCH AND FORECAST MODEL: SOFTWARE ARCHITECTURE AND PERFORMANCE.** *J. MICHALAKES, J. DUDHIA, D. GILL, T. HENDERSON, J. KLEMP, W. SKAMAROCK, W. WANG.* Use Of High Performance Computing In Meteorology. 2004, pages 156-168.

[2] **From Probabilistic Forecasts to Statistical Scenarios of Short-term Wind Power Production.** *P. Pinson, H. Madsen, H. Nielsen, G. Papaefthymiou, B. Klöckl.* Wind Energy. 2009, vol. 12, no. 1.

Model set up and verification data

Model resolution

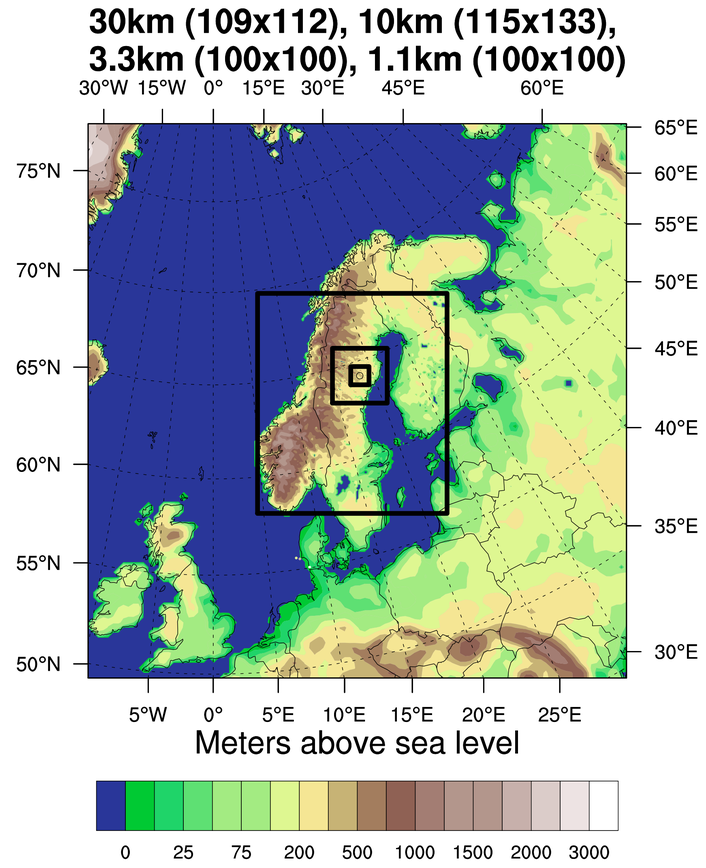
- Global model resolution: 0.5°
- Parent domain: Δx=30km, Δt=120s
- First nest: Δx=10km, Δt=40s
- Second nest: Δx=3.3km, Δt=13.3s
- Third nest: Δx=1.1km, Δt=4.4s

Wind farm data

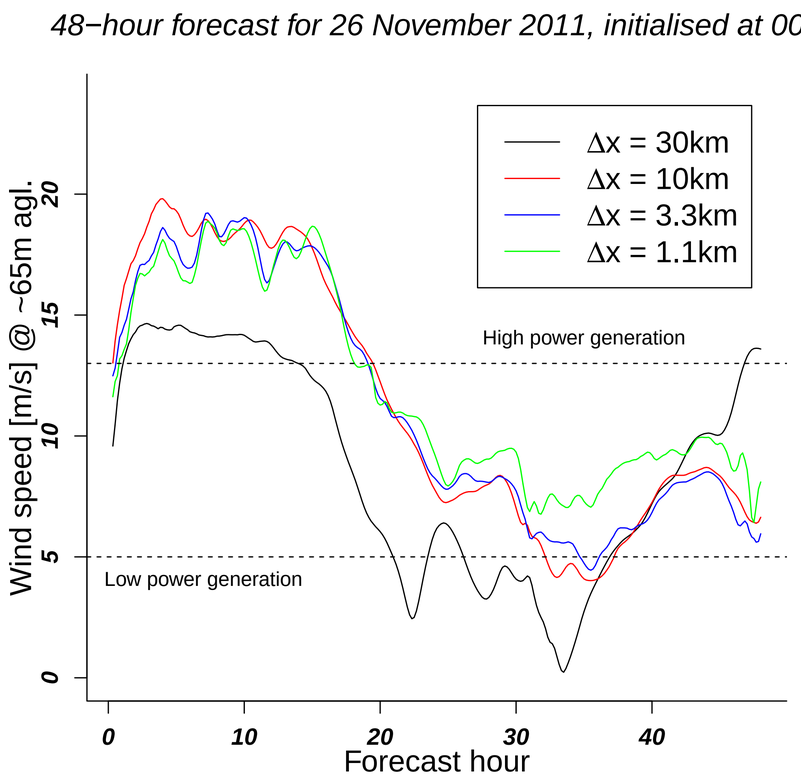
- Vattenfall 78MW "Stor-Rotliden"

Farm average of

- 5-minute nacelle wind speed
- 5-minute power production



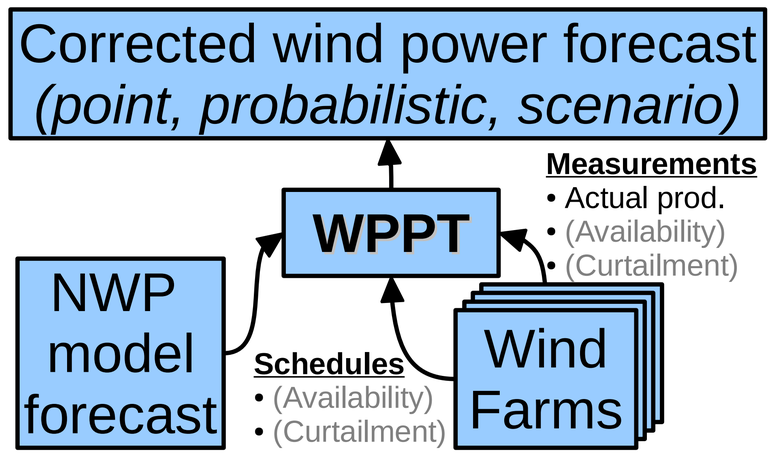
Resolution study



- Using a mesoscale numerical weather prediction (NWP) model [1], the extend to which the model resolution affects wind power forecast quality is sought quantified.
- 48-hour weather forecasts initialised two times daily are generated for the year-long period April 2012 through March 2013, covering four different model resolutions.
- One way to characterise wind energy forecast quality is to study the correlation of forecasted wind speed and corresponding observations, thus providing a measure of the benefit of NWP downscaling for resolving wind fluctuations.
- Also, the forecasted wind power density can be post processed to reflect the installed wind energy capacity and compared to recorded power time series.

Fluctuation modeling

Mesoscale NWP models cannot resolve small-scale wind fluctuations. However, the spectrum and magnitude of fluctuations do have some spatio-temporal dependence, conditional to the weather conditions.



- The Wind Power Prediction Tool (WPPT) developed and maintained at ENFOR A/S outputs wind power point forecasts and related probabilistic forecasts.
- Drawing on the well-established probabilistic forecasting competence at ENFOR A/S [2], a major goal in PSO 10464 is to further develop WPPT to account for the spatio-temporal dependence of wind power variability.
- In practice, this entails the development of correction terms that are functions of the prevailing weather and forecasts.