Near-shore wind resource estimation using lidar measurements and modelling

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**Abstract**

The atmospheric flow in the coastal zone is investigated using (scanning) lidars, mast measurements and the mesoscale WRF model. The WRF model is set-up in 12 different configurations using 2 planetary boundary-layer schemes, 3 horizontal grid spacings and varied sources of land use, and initial and lower boundary conditions.

**Objectives**

- Describe the impact of boundary layer scheme, resolution, land use data and atmospheric forcing on the WRF modelled wind speed
- Estimate the wind resource using scanning and vertically profiling lidars

**Methods**

![Image of the WRF model set up to cover the northern European coastline.](image)

The WRF model was set up to cover the northern European coastline. The scanning lidars were located in pos 1-3, vertically profiling lidars in pos. 2, 4-5 and floating lidars in pos. 6 and 7 (see below).

**Horizontal transects**

![Image of horizontal wind speed profiles at different locations.](image)

The horizontal gradient in mean wind speed across the experimental site from 5 km offshore up to 2 km inland is shown above. Data were filtered based on the CNR ratio (measurement quality) and availability in the whole transect, leaving 731 transects at 50, 100 and 150 m. The model output from all simulations was extracted during the same 10-min intervals.

Generally the model prediction show slightly higher wind speeds offshore. Over land at 50 m the observed wind speed is much lower than the modelled wind. The WRF model cannot capture the effect of the cliff well, partly due to its coarser resolution.

Both scanning lidar systems agree well far offshore. The vertical profiling lidars show a lower mean wind speed.

**Vertical profiles**

![Image of vertical wind speed profiles at different locations.](image)

Mean vertical wind speed profiles at different locations (see map at the left) observed by lidars and modelled with the MYJ scheme (abbreviations explained at the left).

In the figure above it can be seen that shape of the wind profile is modelled well by all model simulations and than the bias is generally less than 0.5 m/s. Note the different scale at the x-axis: the wind speed at the inland locations is much lower than at offshore locations close to the ground. At location two, two lidars were measuring at the same location and both of them are shown.

**Velocity spectra and error metrics**

Velocity spectra are often used to gain insight in the ability of models or observations to represent atmospheric motions. Below the spectral energy from the cup anemometer at 100 m at the Høvsøre mast is shown as a function of frequency. At low frequencies (left) the model and observations compare well, showing the model resolves the energy at these scales. At high frequencies, the model set-ups with fine horizontal grid spacing have more energy than the observations. This has an impact on the model performance (see below).

![Image of velocity spectra comparison.](image)

The table below shows a summary of different metrics during the whole campaign for all sites, for example the root-mean-square error (RMSE) and Pearson correlation coefficient (R). There were 237493 10-minute mean measurements available. The simulations with the MYJ scheme and the ERA-interim boundary conditions have the lowest RMSE and mean absolute error. It can be seen that using a higher resolution leads to worse error metrics.

**Conclusions**

The WRF modelled wind speed was close to scanning lidar observations in a transect across the coastline, although all simulations showed wind speeds that were slightly higher than observed. Inland at 50 m, the model did not capture the strong decrease in mean wind speed resulting from the surface roughness change when moving eastward from the coastline. Using ERA-interim data as boundary conditions improved the model skill scores. Using a finer horizontal grid spacing deteriorated the model performance. Modelled and observed spectra were compared and showed that the horizontal grid spacing had a large impact on the ability of the different setups to capture high frequency atmospheric motions. Combining the WRF model with lidar measurements can be useful to describe and understand the flow in the coastal zone.

**References**


Lea, G., Courtney M., 2016, Validation of long-range scanning lidars deployed around the Høvsøre Test Station. DTU Wind 2016. 109. (DTU Wind Energy E; No. 0119).