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Validation of Boundary Layer Winds from WRF Mesoscale Forecasts over Denmark

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1 Introduction

Since May 2009, the Wind Energy Division at Risø-DTU has maintained a real-time weather forecast modelling system (Wang et al. 2009) to forecast boundary-layer atmospheric conditions over Denmark. Wind speed and direction forecasted by the model are verified against hourly winds from 10-meter conventional METeorological Aerodrome Report (METAR) measurements and wind measurements at several masts across Denmark.

The National Center for Atmospheric Research (NCAR) Advanced Research WRF (Weather Research and Forecast) model is used in the simulations. The WRF model is a numerical weather prediction and atmospheric simulation system designed for both research and operational applications.

The goal of the real-time WRF system at Risø-DTU is to provide guidance to understand the WRF behavior and to aid in selecting the best parameterizations and parameters for wind power meteorology applications.

2 Description of the model setup

Figure 1 displays the grid configuration used for the runs. The mother domain (D1) has a horizontal grid spacing of 18 km, the first nested domain (D2) 6 km and the second and innermost nest (D3) 2 km. The model forecasts use 37 vertical levels from the surface to the top of the model located at 100 HPa; 12 of these levels are placed within 1000 m from the surface. The

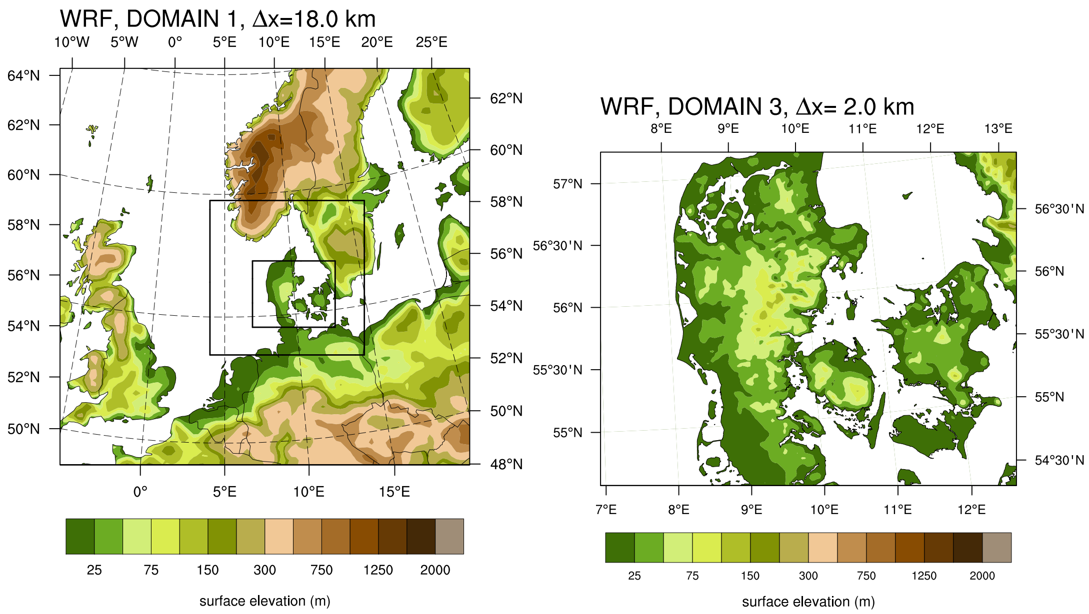

Figure 1: Left: Domain configuration and terrain elevation of the Risø's WRF model setup. The black squares indicate the boundaries of three domains and Δx the horizontal grid resolution. Right: The innermost domain, $\Delta x = 2$ km, covering Denmark.

model setup uses standard parameterizations including the Yonsei University (YSU) PBL scheme (Hong et al. 2006).

The location of the METAR stations used in this study is presented in Fig. 2. The data from these stations is mainly hourly and include wind speed and direction, air temperature, dew-point temperature, and sometimes sea-level pressure. These stations are complemented by measurements at towers maintained by Risø-DTU. Output from the model forecasts of these same fields is hourly for the integration time of 48 hours. Forecasts are started twice daily at 0000 and 1200 UTC driven by the USA NOAA Global Forecast System analysis and forecasts. For simplicity, we verify only the 1200 UTC runs here; similar results are found for the 0000 UTC runs.

3 Methodology and first results

A variety of verification statistics are calculated, including biases, mean absolute error (mae), and root mean square error and analyzed according to forecast time, time of the day, level from surface, and in their distribution in space.

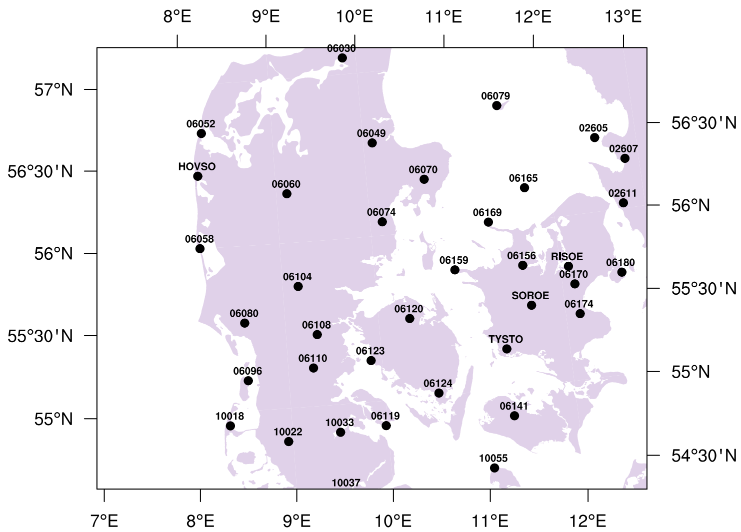

Figure 2: Location on WRF innermost domain of the METAR and Risø-maintained stations.

The verification against 10-meter winds shows positive biases (i.e. forecast wind speeds are larger than those observed) at night over most inland stations. Coastal stations and stations on islands show smaller biases than those inland. Biases are reduced to almost zero during the daytime hours. For two towers maintained by Risø (namely HOVSO and RISOE in Fig. 2), in general, wind speed biases and mae are reduced as the validation height increases, but the same diurnal patterns as in the 10-meter stations are seen.

A particular case is studied using data from the HOVSO station. There, a heavily instrumented tall meteorological mast observes winds from a direction where the terrain is flat and the flow is homogenous (Peña 2009). The vertical wind speed profile, the influence of atmospheric stability, and boundary-layer and turbulence characteristics from this sector has been the matter of recent studies (Gryning et al. 2007; Peña et al. 2009a; Peña et al. 2009b).

Using the knowledge acquired from these previous investigations, we perform a comparison between the horizontal wind speed profile observed by the cups from 10 up to 160 meters and the model results. Although the biases at the observational heights can be considered as minimal, both observed and modeled wind profiles do not show *a priori* a good agreement for the purpose of wind power calculations for large wind turbines. This seems to be caused mainly by inaccuracies on the model inputs, such as the surface roughness length and the land use properties, and the turbulence parameterizations and assumptions of the WRF model. Therefore, we have started to test and evaluate different parameterizations schemes, in order to understand their influence on the forecasts and to improve the model, if possible.

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