Extensive Verification of Mesoscale and CFD-Model Downscaling

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Abstract
The mass of commonly used wind data for site assessment grows rapidly. But the detailed verification in a broad range is rare. To find out the benefit of further downscaling approaches, a high resolution mesoscale data set was created and verified with various measurements in Germany and Poland. Out of simulated years 2011 and 2012 we separately focused on seasons dominated by high and low pressure systems and seasons with strong convective situations for investigations of atmospheric stability. One special forest site is used for detailed consideration of CFD – Mesoscale coupling.

Methods
Regionally distributed wind data with 120 high quality and certified anemometers, shared on 40 measurement masts within a height range from 30 up to 200 m, are prepared for verification. With respect to these measurements the MERRA Reanalysis data turn out to be the best choice for further refinement. So we use the WRF mesoscale model to scale the MERRA data down to 3 km horizontal resolution. A separate simulation with 15km horizontal resolution provides a reference data set to quantify the need of higher resolutions. The following verification allows us to estimate the uncertainty of the modelled wind speeds. Further on we locate benefits and handicaps of the model in rotor affected heights.

Results
The main statistics - correlation R², MAE and BIAS (model-observation) - are calculated for the 15 best quality wind speed measurements in 100m (+/- 20m) height on hourly time base. The data cover 12 consecutive months with a recovery rate from 80% to 99% and are located in flat or medium complex terrain. The modelled wind speeds are interpolated to the specific anemometer heights. The results are summarized, with respect to their recovery, as weighted averages.

The improvement from the 15km to the 3km horizontal resolution is significant in all statistics. The 3km resolution overestimates the wind speed in 100m height with a positive BIAS of 0.29 m/s (5.17%). The MAE reaches up to 1.4 m/s (29%).

The detailed statistics show large variations in BIAS and MAE for several masts.

All masts show a better correlation for a higher resolution. Except for the offshore masts M24 and M11 the resolution doesn’t change the correlation, but BIAS and MAE are improved for offshore masts. Mast M18 sticks out with an obvious increase in performance for WRF-3km. This mast is located nearby a high mountain, which significantly forces the flow direction. A second main wind direction is observed. While this easterly wind direction sector is nearly missed in the forcing MERRA-data, it is slightly included in the 15km resolution and best resolved by the 3km resolution.

The vertical wind shear is investigated for a convective summer season of 12 weeks. Masts with anemometers in height ranges from 40m to 100m and more turn out to be useful in observing diurnal variations of shear. This also indicates that the model simulates the atmospheric stability conditions on site. At a farmland site over flat topography, large temperature differences from night to day have a significant impact on convection. Here WRF-3km catches the maximum on midday. Also at night, the full shear is reached by the model.

Obviously the lower resolution of 15km does not resolve such small scale convective systems and consequently leads to an underestimation of wind speed for the whole vertical profile. Also the frequency distribution and the quantile-quantile diagram show a positive impact of the higher model resolution on this site.

For the complex forest site "Wohlenberg" WRF overestimates the diurnal mixture around midday and thus fails, to reproduce the forest induced impact on the profile. We provide the CFD-Model Meteodyn WT with the mesoscale time series and try to improve the result with Meteodyn WT forest model parameters. The variation of the forest height scaling factor results in a better accordance to the measured profile.

Conclusions
Latest sets of reanalysis data perform very well in simple correlation parameters, presented on PO 134 (EWEA2014). To figure out the possibilities of the mesoscale model WRF and the microscale model Meteodyn WT to improve the reanalysis, we focus on vertical wind shear and find some key issues which lead to a better fit in absolute wind speed values. A horizontal resolution of 3km adds significant scales to the model data. With respect to 15 high quality measurements in 100m height, the mesoscale data perform with a BIAS of 5.17% and a MAE of 29%. As verified on one site, the microscale model Meteodyn WT seems to improve the model chain. But further verifications on different sites are necessary.

References

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