Vertical Structure of the Atmospheric Boundary Layer and Applications (VSABLA)
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The three dimensional wind fields in the Atmospheric Boundary Layer (ABL) are among the major drivers of local weather, climate, air pollution, and renewable energy sources. Therefore, both observations and modeling studies of vertical profiles of the wind are highly needed. Moreover, the complex turbulent processes in the atmosphere require studies of turbulence parameters, the height and structure of the atmospheric boundary layer. Thus, the studies within VSABLA and the related Danish project Tall Wind aim to define a set of observations and modeling tools needed to improve the wind resource assessment, the design of wind generators, tall buildings and other structures, as well as the performance air pollution models and other applications.

The results of VSABLA are published in journals and at scientific and more applied conferences and in this way findings are disseminated and made available for application. VSABLA is also directly linked to wind industry through wind energy industry partners within the Tall Wind project.

The main scientific goals of VSABLA project were to assess the current ability of meso-scale models and ABL parameterizations to model the wind profile within the entire ABL based on new technology high resolution in time and space measurements (performed at RISOE DTU within the Tall Wind project) and also to develop new parameterizations.

In line with this, wind speed and direction data from one year measurements at the western coast of Denmark performed using a wind-pulsed lidar (Wind Cube 70) were compared with simulations carried out by the WRF ARW model of NCAR, USA on a 6-kilometer resolution grid (Gryning et al, ICEM2011), Figure 1. It was found that the model underestimates the mean wind speed within 3.3% at 100 m and within 4.5% at all heights up to 600 m. Further analysis is being performed on comparisons of modeled and observed momentum flux and roughness parameters (Floors et al, EMS2011). The height resolution of the data is 50 m in the range from 100 to 600 meters and the resolution in time is 10 minutes.

In addition, based on the analysis of these long-term data, a new parameterization for the shape parameter in the Weibull distribution was suggested and tested (Gryning et al, ICEM2011), Figure 1.

Different physical options, in particular ABL schemes of the WRF ARW model, as well as runs in forecast and analysis mode were evaluated against the measurements for two 2-week periods (Batchvarova et al, EWEA2011 and Floors et al., ASR, 2011). Generally, the model under predicts the wind speed at all heights above 60 m. Classifying the wind profiles according to thermodynamic stability in the surface layer and normalizing them with the measured friction velocity, reveals that the model performs best at neutral conditions, slightly overestimates the wind profile under unstable conditions and underestimates at stable conditions.

The novelty of the results consists of the high resolution of the data in space and time (50 m vertical resolution and 10 minutes intervals) within the ABL, provided by the pulsed lidar; the evaluation of model predictions and further development of parameterizations.

Within VSABLA, a novel theory of model evaluation or model-to-data comparison is developed by suggesting a method that combines model prediction and variability of the meteorological parameters, estimated from the measurements (Batchvarova and Gryning, 2010, Batchvarova et al., 2010). The variability for wind speed depends on the mean wind speed and the averaging period of the measurements. In case the data fall within the variability interval set along with the model results, the model is performing well and can in principle not be improved. The method was applied in a model comparison exercise performed within COST728, based on data from the Observatory of the German Weather service at Lindenberg.

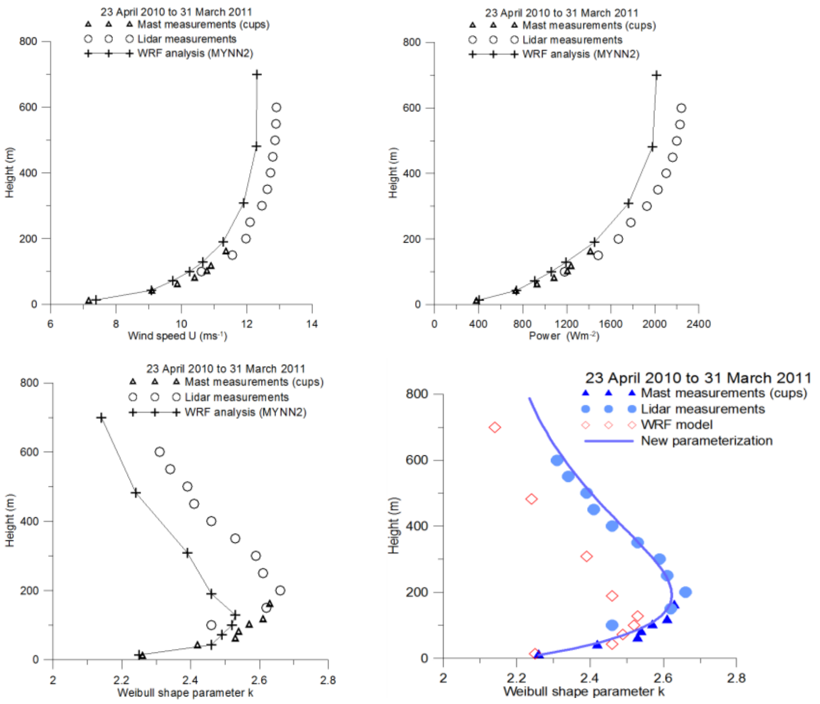

Figure 1. Measured and modelled wind speed (upper left panel), power (upper middle panel), Weibull A parameter (upper right panel), Weibull k parameter (lower left panel) and the same with the proposed new parameterisation (lower right panel).

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