Boundary layer meteorology in complex terrain and for wind energy applications

The expansion of renewable energy (particularly wind energy) not only has a direct impact on the boundary layer and thus, for example, on the propagation of sound, but also on the climate. Conversely, it is important to research the interactions of the flow with wind turbines. The aim of this project is to cumulate the model developments from previous work by our group (Wagner *et al.* 2018) and apply them to a new experimental wind research park currently being built in Krummendeich, Northern Germany. From November 2020 measurements with remote sensing have been carried out to characterize the meteorological situation at the site prior to wind turbine installation (Wildmann *et al. 2022*). The research wind farm (WiValdi) enables full-scale research for developing technologies to increase the acceptance, efficiency and cost-effectiveness of wind turbines. This research park is a large-scale facility that is internationally unique in its form, consisting of three wind turbines and which are extensively instrumented. The turbines are flanked by meteorological measurement masts and other measurement devices such as LiDARs. With this plethora of measuring equipment, it is possible to accurately measure the turbulence fields around the wind park.

This extensive dataset would provide a unique opportunity to develop improvements in the Weather Research and Forecasting (WRF) model (Skamarock *et al*. 2008), namely: (1) improvements from a better understanding of boundary layer conditions, such as better surface properties, forest parametrizations can be tested against observations; (2) improvements can arrive from modifications to turbulence parametrizations; (3) a better WRF output can initiate EULAG simulations, which in turn would provide more realistic simulations of turbulence induced by wind turbines; and (4) the unique observational dataset can be assimilated into the WRF model, leading to better forecasts in the area.

An aspect of this project is to run WRF operationally for the coming year, driven by the ECMWF operational analysis and forecast data. These operational runs, at higher horizontal resolution than offered elsewhere, should make it possible to provide more precise wind field forecasts at the DLR wind farm in Krummendeich for measurement campaigns. Extreme or special weather events, such as low-level jet (LLJ) events can then be identified in advance and singled out for further research. Accurately modelling LLJ events, which cause significant loading on wind turbines, would be an important outcome of the project. Variations in the model configuration allow different scenarios to be considered.

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Skamarock, W. C. et al., 2008. "A description of the Advanced Research WRF Version 3.", NCAR technical note, Mesoscale and Microscale Meteorology Division, National Center for Atmospheric Research, Boulder, Colorado, USA.

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