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Towards coupling the WRF-model with a CFD model for wind power applications in complex terrain

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Hilltops are potentially suitable locations for on-shore wind turbines due to the increased average wind speed associated with the elevated terrain. However, complex terrain provides challenges due to increased turbulence level and extreme spacial heterogeneity of the wind field. Numerical simulations of the wind field can help to understand the flow and turbulence structure at a given site and help to identify an optimal site and to estimate yield and maintenance cost of a turbine.

We are using the Weather Research and Forecasting (WRF) Model with multiple nesting steps to provide weather simulations for a test-site in development, which is located near Stötten at the Schwäbische Alp in southern Germany. The innermost domain has a horizontal mesh size of 150 m and is run in large-eddy-simulation mode (i.e. without the use of a boundary layer parametrization). Relevant data, like wind components, pressure and temperature is extracted every minute to provide boundary conditions for further refinement using a CFD model. This CFD model solves the Navier-Stokes equations with buoyancy, an energy equation and a $k - \epsilon$ turbulence model. The analysis of the model results is focused on processes along the boundaries between the models as well as the development of turbulence. We are comparing simulations over sea and over complex terrain.

This work is part of the project WINSENT (Wind Science and Engineering), which aims at developing a test-site for wind power applications in complex terrain. This test-site is located at the Schäbische Alp near a terrain edge which faces the prevailing wind direction. Three 100-m high meteorological masts are erected at this site and mounted with sonic and cup anemometers at multiple levels. Additional measurements with instrumented unmanned aerial vehicles (UAVs) and LiDARs are performed as well. A complete modelling chain which spans from the meso- to the micro-scale is being developed and will provide together with the measurements an assessment of the micro climate at the test-site.