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Low-level jets and their possible impact on wind climatology at hub heights of wind turbines

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The increasing hub height of wind turbines aims at optimizing the wind energy yield at one location and offers the possibility to provide new areas for wind power, for example forests. However, inhomogeneous environmental conditions of locations for wind turbines cause challenges for the wind power assessment. Thus, daily and seasonal periodic interactions between the airflow and other meteorological fields, e.g. the variable thermal stratification of the atmosphere, have to be realistically modelled.
To specify the wind field at hub heights of modern wind turbines (100 m to 200 m) in a consistent way, a high-resolution wind climatology for Germany will be generated within the project QuWind100. For this purpose, a chain of non-hydrostatic models consisting of the mesoscale model COSMO in climate mode (COSMO CLM) and the microscale model HIRVAC2D (HIgh Resolution Vegetation Atmosphere Coupler 2D) is applied. The concept of this methodology resulting in a new wind atlas for current and future conditions of climate and land use is presented.
The model HIRVAC2D is capable of modelling different vegetation types by explicitly considering the highly resolved structure of varying plant parameters. Beyond that, the model enables the resolution of variable atmospheric circulation patterns. In this way, daily courses of wind vector can be simulated and analyzed in their seasonal variability. The performance-optimized model is particularly suitable for sensitivity studies, which allow the separate analysis of temporal and spatial effects on the wind field under conditions of a 'virtual' laboratory. This includes special features of the wind field like low level jets (LLJs), frequently observed local wind maxima in the nocturnal boundary layer. Due to the possible increase in yields, but also the mechanical load on wind turbines, there is a great need for studies on LLJs and their dependency on the kind of land use, properties of vegetation (e.g., leaf area density and vegetation height) and temporally variable meteorological conditions. Results of several HIRVAC2D simulations will be presented in order to deduce quantitatively the sensitivity of LLJs to vegetation and model parameters as well as meteorological quantities. It is shown, that the geostrophic wind speed is an important criterion for the development, height and intensity of LLJs. Thus, a statistical frequency distribution of the geostrophic wind speed is used to evaluate the probability of LLJs in Germany and possible influences on the wind climatology at hub heights between 100 m and 200 m.