Abstract for the conference *The Science of Making Torque from Wind*

Modeling of wind-field fluctuations using the one-dimensional-turbulence model

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Abstract

Wind-energy farms are located in the Earth's Ekman layer, where pressure gradient, Coriolis force, and turbulent drag balance each other. The induced velocity spiral, the turbulent entrainment from the upper free-atmosphere, and buoyancy effects complicate the problem with respect to a convectional turbulent boundary layer. A detailed understanding of the Ekman layer during day and night time is essential to optimize wind energy farms in several respects. Short-time fluctuations are especially important to estimate the lifetime of the wind-energy converter (WEC) as well as its power output. Detailed numerical simulation (DNS) is currently the numerical tool to investigate fundamental problems in fluid mechanics since it solves the governing physical conservation equations without assumptions. So it could yield the complex statistics of the wind field, but unfortunately due to the range of spatial and temporal scales currently affordable it is limited to mostly fundamental research. Typically, simulations of the atmospheric boundary layer are based on large-eddy simulations (LES) or the Reynolds averaged Navier-Stokes (RANS) equations which both do not resolve the smallest turbulent scales. Interesting alternatives are stochastic approaches based on the one-dimensional-turbulence model (ODT) [1] and multi-dimensional approaches that incorporate ODT. ODT resolves molecular effects (as DNS) on small scales, but uses a stochastic process compatible with conservation laws to reduce the degrees of freedom. The present study extends an earlier atmospheric-boundary-layer application [2] by focusing on fluctuations in intensity and direction of the wind field. Numerical simulations will be compared to experimental data from wind masts, e.g. [3]. Future work will exploit the capability of ODT to predict time-resolved histories of vertical wind profiles in order to evaluate WEC performance under relevant atmospheric conditions.

References

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