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Spectra and Large-Scale Structures in a Turbulent Boundary Layer Interacting with Wind Turbine Arrays[1] YULIA PEET, TANMOY CHATTERJEE, Arizona State University — Wind Turbine Array Boundary Layer is a relatively simple, yet useful theoretical conceptualization to study very large wind farms in an atmospheric boundary layer. In this talk, we investigate the length scales of eddies involved in the power generation in these very large, "infinite" wind farms by analyzing the spectra of the turbulent flux of the mean kinetic energy from Large Eddy Simulations (LES). A goal is to provide a fundamental understanding of the dynamic behavior, the size, the scaling laws and the anisotropic structure of the energy containing eddies responsible for power generation from the wind turbines. Large-scale structures with an order of magnitude bigger than the turbine rotor diameter are shown to have substantial contribution to wind power. The study is performed with a Spectral Element LES code with the recently implemented near-wall model and the actuator line model to represent the effect of rotating wind turbine blades. In this presentation, we also explore an idea of a "multiscale" wind farm, where larger and smaller turbines are arranged in a symbiotic way, with smaller turbines helping to harvest additional power from the wakes of the larger turbines, inspired by the findings of the spectral analysis in uniform wind farms.

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