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Collective phenomena in large-eddy simulations of extended wind farms[1] RICHARD STEVENS, CHARLES MENEVEAU, Johns Hopkins University — A major issue with respect to the incorporation of large wind farms in power grids is that their power output strongly fluctuates over time. Understanding these fluctuations, especially its spatio-temporal characteristics, is important for the design of the backup power that must be available. The power fluctuations of the turbines depend on the effect of the wakes, created by a prior row of turbines, on the operation of the turbines, the inter-turbine correlations, and the interaction between the turbines and the atmospheric boundary layer (ABL). We analyze the power fluctuations in large eddy simulations of extended wind-parks in the ABL. We consider various aggregates of wind turbines such as the total average power signal, or sub-averages within the wind farm. In particular, we find that the power variations of the total wind park decreases more than one would expect if one assumes the power output of the turbines to be uncorrelated. The non-trivial correlations are due to the interactions between turbines placed down-stream from each other. Surprisingly, the frequency spectra of the total wind-farm output show a decay that follows approximately a -5/3 power-law scaling regime, qualitatively consistent with observations made in field-scale operational wind parks (Apt, 2007).

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