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Temporal characteristics of POD modes from wind farm LES[1]
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Large eddy simulations of a fully developed wind farm in the turbulent atmospheric boundary layer have been analyzed using 3D Proper Orthogonal Decomposition (POD). In this study we consider the temporal variations of the POD modes and their relationship to unsteadiness in the wind turbine power production. We find that the streamwise-constant counter-rotating roller modes vary on time-scales much longer that the mean advection time from turbine to turbine. The structure of these roller modes and their long-time variations are consistent with meandering of high- and low-speed streaks in the turbulent flow within the wind farm. Another class of POD modes—one with significant streamwise-variation—is found to correspond to advection of velocity perturbations in the streamwise direction. Temporal variations of the shear-type modes are found to strongly correlate with power production of the wind farm as a whole. Overall, the long-time power production is well captured by reconstructions using fewer than 50 POD modes ($< 1\%$ of the total), but variations faster than the inter-turbine advection time are only captured by higher-order, less energetic modes.

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