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Statistical analysis of kinetic energy entrainment in a model wind turbine array boundary layer[1] RAUL BAYOAN CAL, NICHOLAS HAMILTON, Portland State University, HYUNG-SUK KANG, US Naval Academy, CHARLES MENEVEAU, Johns Hopkins University — For large wind farms, kinetic energy must be entrained from the flow above the wind turbines to replenish wakes and enable power extraction in the array. Various statistical features of turbulence causing vertical entrainment of mean-flow kinetic energy are studied using hot-wire velocimetry data taken in a model wind farm in a scaled wind tunnel experiment. Conditional statistics and spectral decompositions are employed to characterize the most relevant turbulent flow structures and determine their length-scales. Sweep and ejection events are shown to be the largest contributors to the vertical kinetic energy flux, although their relative contribution depends upon the location in the wake. Sweeps are shown to be dominant in the region above the wind turbine array. A spectral analysis of the data shows that large scales of the flow, about the size of the rotor diameter in length or larger, dominate the vertical entrainment. The flow is more incoherent below the array, causing decreased vertical fluxes there. The results show that improving the rate of vertical kinetic energy entrainment into wind turbine arrays is a standing challenge and would require modifying the large-scale structures of the flow.

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Raul Bayoan Cal
Portland State University

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