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On the characteristic features of wind-turbine tip vortices: A wind tunnel experiment DAVID GREEN, LEONARDO CHAMORRO, ROGER ARNDT, FOTIS SOTIROPOULOS, U. of Minnesota, JIAN SHENG, Texas Tech Univ. — Understanding the complex interaction between the vortical flow structures shed by Horizontal Axis Wind Turbines (HAWT) and the turbulent flow is crucial to optimize blade design and momentum recovery in the turbine wake, which defines the wind farm layout. Tip vortices shed by the blades play a key role in shaping up the wake behind a HAWT. Phase-locked Particle Image Velocimetry (PIV) is employed to measure mean wake, flow fluctuations, and subsequently identify large-scale coherent flow structures. Twelve consecutive downstream locations up to twelve rotor diameters and three upstream locations up to three rotor diameters are measured. Experiments are conducted at Reynolds numbers of Re=3x10^5, 4x10^5 and 12x10^5 based on the rotor diameter. To achieve sufficient spatial resolution, two fields are taken at each streamwise location to cover the upper and lower half of the model turbine. It is found that tip vortices above the turbine hub have clear structural identity as they are advected downstream. Instead of following the expanding trend of mean wake, they converge. In the lower region, the identities of tip vortices remain only one rotor diameter downstream and merge into the mean near wake. Robust statistical analysis on velocity fluctuations, Reynolds stresses, and TKE budget will be discussed.

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