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Hub vortex instability and wake dynamics in axial flow wind turbines[1] DANIEL FOTI, KEVIN HOWARD, XIAOLEI YANG, MICHELE GUALA, FOTIS SOTIROPOULOS, University of Minnesota — The near wake region of an axial flow wind turbine has two distinct shear layers: an outer tip vortex shear layer, which rotates in the same direction as the rotor, and an inner counter-rotating hub vortex shear layer. Recent simulations (Kang et al., J. Fluid Mech., vol. 744, 2014, pp. 376-403), corroborated with experiments (Chamorro et al., J. Fluid Mech., vol. 716, 2013, pp. 658-670), showed that the hub vortex can undergo spiral vortex breakdown immediately downstream of the turbine. The precessing hub vortex core intercepts and interacts with the tip vortex shear layer causing the large-scale wake meandering motions in the far wake to intensify. These results were obtained for an axial flow hydrokinetic turbine in a turbulent open channel flow. Here we integrate high-resolution LES with experiments to show that a hub vortex instability also occurs in the near wake of a wind turbine in a wind tunnel. We show that the interactions of the hub vortex with the outer flow have significant effects on the wake meandering amplitude and frequency. Our results reinforce the conclusions of Kang et al. (2014) that the hub vortex must be included in wake models to simulate wake interactions at the power plant scale and optimize turbine siting for realistic terrain and wind conditions.

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