Abstract Submitted
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Dominant mechanism of load fluctuations on a wind turbine in a realistic atmosphere through Hybrid URANS-LES[1] GANESH VIJAYAKUMAR, ADAM LAVELY, BALAJI JAYARAMAN, BRENT CRAVEN, JAMES BRASSEUR, Pennsylvania State University — Atmospheric turbulence causes load fluctuations on a wind turbine through various forcing mechanisms across a wide span of time scales relative to the rotation time scale. We identify the dominant mechanisms of load fluctuation through blade-boundary-layer-resolved hybrid URANS-LES of a single rotating blade of the NREL-5MW turbine in a daytime moderately convective atmospheric boundary layer (ABL) on flat terrain with surface heating simulated with high-fidelity LES. We find that the integral scale motions in the atmosphere cause the largest fluctuations over multiple rotations of the turbine, while the rotation of the turbine through eddies in the ABL cause fluctuations at the rotation time scale. Blade-boundary-layer dynamicsseparation, dynamic stall and rotational augmentation, cause further load fluctuations at time scales much smaller than the rotation time scale. At all time-scales, however, we find that the dominant mechanism underlying load fluctuation on the blade is from local spatio-temporal fluctuations in the angle of attack (AoA) associated with atmospheric eddy passage. By integrating fundamental kinematic analysis with high-resolution CFD, we describe the fundamental role of ABL-turbulence-forced AoA fluctuations on nonsteady wind turbine loadings.

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