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Forcing of Wind Turbine Blade Boundary Layer Dynamics by Atmospheric Turbulence with Hybrid URANS-LES[1] GANESH VIJAYAKUMAR, ADAM LAVELY, BALAJI JAYARAMAN, BRENT CRAVEN, JAMES BRASSEUR, The Pennsylvania State University — We analyze spatio-temporal changes in blade boundary layer structure on a commercial-scale wind turbine blade interacting with a canonical daytime Atmospheric Boundary Layer (ABL). The time scales of the energy-containing ABL eddies are of order multiple rotations of commercial wind turbines and force large temporal fluctuations in integrated loads and bending moments. We study details of blade boundary layer dynamics underlying space-time variations in surface stress by simulating a single blade of the NREL 5MW turbine in a moderately convective ABL produced using LES from a spectral code at high resolution (147M cells). Inflow ABL boundary conditions are extracted for an OpenFOAM ABL simulation with the rotating blade. The blade boundary layer is well resolved with a new hybrid URANS-LES model that blends a 1-equation SFS stress model in the ABL with the k-ω-SST-SAS model near the blade. We perform Hybrid URANS-LES computations of the flow around the blade and compute spatio-temporal fluctuations in surface stresses in response to ABL turbulence eddies. Of particular interest are sources of integrated load transients, load response time scales, and near wake temporal dynamics of vortex shedding in relationship to passage of energy containing atmospheric eddies.

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