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Two Key Discoveries on Atmospheric Turbulent Wind Forcing of Nonsteady Wind Turbine Loadings, from HPC[1] JAMES BRASSEUR, GANESH VIJAYAKUMAR, ADAM LAVELY, BALAJI JAYARAMAN, Penn State U, ERIC PATERSON, VA Tech, PETER SULLIVAN, NCAR — Loading transients on wind turbine blades underlie premature component failure. We research the underlying causes of nonsteady blade loadings from interactions with atmospheric eddies in the atmospheric boundary layer (ABL) using combinations of blade-boundary-layer-resolving HPC simulation and lower-order blade models (ALM, BEMT). A daytime ABL simulated with a 760 760 256 pseudo-spectral LES interacts with a 62 m rotating wind turbine blade, simulated with advanced finite-volume-based algorithms in two complex multi-grid/scale domains in relative motion. We focus on two key discoveries: (1) Whereas nonsteady blade loadings are generally interpreted as in response to nonsteadiness in wind speed, time changes in wind vector direction are a much greater contributor to load transients, and strongly impact boundary layer dynamics; (2) Large temporal variations in loadings occur within two disparate time scales, an advective time scale associated with atmospheric eddy passage, and a sub blade-rotation time scale associated with turbulence-induced forcings as the blades traverse internal atmospheric eddy structure. The latter generates the strongest transients; the former modulates the response.

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