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Effect of Large Finite-Size Wind Farms and Their Wakes on Atmospheric Boundary Layer Dynamics

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Through the use of large-eddy simulation, the effect of large finite-size wind farms and their wakes on conventionally-neutral atmospheric boundary layer (ABL) dynamics and power extraction is investigated. Specifically, this study focuses on a wind farm that comprises 25 rows of wind turbines, spanning a distance of 10 km. It is shown that large wind farms have a significant effect on internal boundary layer growth both inside and downwind of the wind farms. If the wind farm is large enough, the internal boundary layer interacts with the thermally-stratified free atmosphere above, leading to a modification of the ABL height and power extraction. In addition, it is shown that large wind farms create extensive wakes, which could have an effect on potential downwind wind farms. Specifically, for the case considered here, a power deficit as large as 8% is found at a distance of 10 km downwind from the wind farm. Furthermore, this study compares the wind farm wake dynamics for cases in which the conventionally neutral ABLs are driven by a unidirectional pressure gradient and Coriolis forces.