

2020 EOL Seminar Series (Virtual)

THE COMPLEX STORY OF HOW WIND TURBINES AFFECT NEAR-GROUND PROPERTIES

Dr. Cristina L. Archer

Center for Research in Wind, University of Delaware

carcher@udel.edu

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ABSTRACT

Wind turbines generate turbulent wakes, which can potentially influence the local microclimate near the ground. The mechanism generally proposed is enhanced vertical mixing, basically an increase in mixing properties caused by the higher turbulent kinetic energy in the wake than outside of it. Whereas vertical mixing is enhanced in the wake within the rotor area, especially above hub height, evidence in the recent literature, based on wind tunnel experiments and high-resolution numerical simulations, suggests that it does not actually occur near the ground.

We conducted therefore the VERTical Enhanced miXing (VERTEX) field campaign in late summer 2016, during which we measured near-surface turbulent fluxes, wind speed, temperature, and moisture under and outside of the wake of a wind turbine located near the shore in Lewes, Delaware. We found a reduction of turbulent momentum fluxes, friction velocity, and wind speed, as well as no enhancement of sensible heat fluxes near the ground, which indicate reduced, not enhanced, vertical mixing near the ground under the wakes. We also observed a slight increase in 2-m temperature in most cases, despite unchanged surface heat fluxes. The 2-m temperature change was sensitive to the vertical temperature gradient (i.e., lapse rate) across the rotor area and to wind speed near hub height.

Based on our analysis, we propose that what controls near-surface temperature in the presence of wind turbine wakes is not heat flux per se, but rather the convergence/divergence of the heat fluxes below the wake. Because of the reduced mixing near the ground, the surface heat fluxes are slightly reduced or unchanged, but the enhanced mixing in the upper wake increases the (generally downward) heat fluxes near hub height. Convergence of the heat fluxes therefore occurs below the wake, thus warming, even during unstable conditions.

Wind farm parameterizations for mesoscale models must incorporate or resolve this convergence/divergence mechanism in their formulation and the mesoscale model must have enough vertical resolution below the wake to properly resolve it in order to predict correctly the effects of wind farms on weather and climate near the ground.

Email questions during the talk to Ulrike Romatschke: romatsch@ucar.edu

This webcast will be recorded and uploaded to the
[NCAR Earth Observing Laboratory YouTube Channel](#)

For more information, contact Melissa Ward: mward@ucar.edu