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Center for Coastal Physical Oceanography

Fall 2023 Virtual Seminar Series

Title "Modeling and Observations of Wind Turbine Wakes in the Atmosphere"
Speaker Cristina Archer, University of Delaware
Date Monday, October 2, 2023
Time 3:30 PM EST

Zoom Info Link
Meeting ID: 941 5567 0673
Passcode: 619240

Abstract Wind energy has been growing steadily in the U.S. and worldwide in the past decades. As wind farms are increasing in size and number, however, concerns are rising about possible undesirable effects of wind turbines near the Earth's surface, in particular on surface temperature. The mechanism generally proposed is that turbulence generated in the wind turbine wakes enhances vertical mixing near the ground. Wakes are plume-like volumes downwind of wind turbines that are characterized by lower wind speeds (i.e., a wind speed deficit) and higher turbulent kinetic energy (TKE) than the undisturbed upwind flow.

Here we study vertical mixing in the wakes of wind turbines using both measurements (collected during the VERTEX field campaign in late summer 2016) and simulations (conducted with the WRF-LES model). We report that effects of wind turbine wakes near the ground (i.e., temperature, moisture, and turbulent flux changes) are generally modest. Enhanced vertical mixing only occurs in the upper portion of the wakes, not near the ground. Temperature changes, with magnitude <0.4°C, depend on atmospheric stability, with warming and cooling associated with stable and unstable conditions, respectively. The mechanism that causes the temperature changes near the ground in the presence of wind turbine wakes is the vertical convergence (or divergence) of turbulent heat fluxes below the rotor. In conclusion, a wind turbine wake cannot be fully characterized just by the wind speed deficit because added turbulence is another important property of the wake and it does not behave like the wind speed deficit. In other words, the wake has a “dual nature”, i.e., both wind speed deficit and added turbulence are necessary to fully characterize it.

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Biography Dr. Cristina L. Archer is the Unidel Howard Cosgrove Career Development Chair in the Environment and a Professor in the Department of Geography and Spatial Sciences and in the Mechanical Engineering Department of the University of Delaware. Dr. Archer is the Director of the Center for Research in Wind (CReW), which focuses on wind energy, in particular offshore, and its integration in the electric grid. She earned a B.S. in Civil and Environmental Engineering from the Politecnico di Milano (Milan, Italy) in 1995, an M.S. in Meteorology from San Jose State University in 1998, and a Ph.D. in Civil and Environmental Engineering from Stanford University in 2004. She was a Postdoc there in 2004-05 and then worked as an Atmospheric Modeler in the air quality district of San Francisco in 2005-07. Dr. Archer joined the Carnegie Institution for Science in 2007 as a Research Associate. She was an Assistant Professor in the Department of Geological and Environmental Sciences of the California State University Chico during 2008-11. She joined the University of Delaware in 2011. Dr. Archer's research interests include wind power, meteorology, air quality, climate change, numerical modeling, and computational fluid dynamics.