Department of Aerospace and Mechanical Engineering

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Wake dynamics in the atmospheric boundary layer: Challenges in land-atmosphere interaction and wind energy

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Lower Level Auditorium,

Geddes Hall

Refreshments served at 3:00 p.m. in the Geddes Hall Coffee House

The goal of my research is to advance our understanding of atmospheric boundary layer processes over heterogeneous landscapes and complex terrain. The atmospheric boundary layer (ABL) is a relatively thin (~1 km) turbulent layer of air near the earth's surface in which most human activities and engineered systems are concentrated, including many renewable energy systems. Its dynamics are crucially important for biosphere-hydrosphere-atmosphere couplings and for global atmospheric dynamics, with significant implications for our ability to predict and mitigate potential adverse impacts of land use and climate change. In models of the ABL, land surface heterogeneity is typically represented "ideally," in the context of Monin-Obukhov Similarity Theory, as changes in aerodynamic roughness length and surface heat and moisture fluxes. However, many landscapes are more complex, often leading to massive boundary layer separation and wake turbulence. Trees, building clusters, and steep topography produce extensive wake regions characterized by large coherent eddies, which are generated by a separated shear layer due to Kelvin-Helmholtz instability. These dynamics strongly affect near-surface transport and are currently not accounted for in models of the ABL. The effect of wakes are also not fully understood or accounted for in measurements of land-atmosphere exchanges. Wind turbines and wind farms also generate wakes that combine in complex ways, modifying the ABL, impacting wind farm performance, and altering land-atmosphere exchanges. Wind farms are covering an increasingly significant area of the globe and the effects of large wind farms must be included in regional and global scale models. I will present results from recent laboratory and field experiments that demonstrates the effect of wakes caused by landscape heterogeneity and propose new methods to improve flux parameterizations for momentum, heat, and mass (water vapor and trace gases, e.g. CO_2 and CH_4) in ABL simulation and prediction models. The experimental results are also an important complement for developing and validating advanced numerical models of land-atmosphere interactions, including large-eddy simulations. Accurate representation of these processes is crucial for the predictions of weather, urban air quality and energy efficiency, lake and reservoir processes, and ecosystems response to climate change.

If you are interested in meeting individually with Dr. Markfort, please contact Linda at 631-5431.