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Effect of canopy and topography induced wakes on land-atmosphere fluxes of momentum and scalars

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Wakes shed from natural and anthropogenic landscape features affect land-atmosphere fluxes of momentum and scalars, including water vapor and trace gases (e.g. CO_2). Canopies and bluff bodies, such as forests, buildings and topography, cause boundary layer flow separation, and lead to a break down of standard Monin-Obukhov similarity relationships in the atmospheric boundary layer (ABL). Wakes generated by these land surface features persist for significant distances (>100 typical length scales) and affect a large fraction of the Earth's terrestrial surface. This effect is currently not accounted for in land-atmosphere models, and little is known about how heterogeneity of wake-generating features affect land surface fluxes. Additionally flux measurements, made in wake-affected regions, do not satisfy the homogeneous flow requirements for the standard eddy correlation (EC) method. This phenomenon, often referred to as wind sheltering, has been shown to affect momentum and kinetic energy fluxes at the lake-atmosphere interface (Markfort et al. 2010).

This presentation will highlight results from controlled wind tunnel experiments of neutral and thermally stratified boundary layers, using particle image velocimetry (PIV) and custom x-wire/cold-wire anemometry, to understand how the physical structure of upstream bluff bodies and porous canopies as well as how thermal stability affect the flow separation zone, boundary layer recovery and surface fluxes. We have found that there is a nonlinear relationship between canopy length/porosity and flow separation downwind of a canopy to clearing transition. Results will provide the basis for new parameterizations to account for wake effects on land-atmosphere fluxes and corrections for the EC measurements over open fields, lakes, and wetlands.

Key words: Atmospheric boundary layer; Wakes; Stratification; Land-Atmosphere Parameterization; Canopy