Examining the role of horizontal advection on convective boundary layer dynamics across complex interfaces using lidar and radiosonde observations

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The atmospheric boundary layer (ABL), being the link between the surface and large-scale atmosphere, acts as a short-term "memory" of land-atmosphere interactions on diurnal time-scale, governs the distributions of water vapor, aerosols, pollutants, greenhouse gases, and potential passive tracers, and plays an important role in convection initiation and for formation of clouds. Past research has typically treated surface forcing and entrainment processes to be the key mechanisms governing ABL kinematics and thermodynamics, neglecting the horizontal advection of different airmasses on many different spatial and temporal scales.

A better understanding on the impact of advection on ABL is important as the ABL undergoes substantial dynamic changes during advective processes (e.g., frontal passages). Most NWP models strictly rely on ABL parameterization schemes under steady-state assumptions while the empirical studies also consider horizontally homogeneous atmospheric conditions for estimating ABL depth (z_i) growth rates. Under advective processes numerical models of ABL thermodynamic state suffer from two limitations: (1) the modelled vertical profiles of thermodynamic parameters are influenced by advection and (2) the parameterization schemes that diagnose z_i are not fully accurate due to the fact that schemes are based on steady-state assumptions.

Using both continuous ground-based lidar observations and quasi-regular radiosonde profiles, we will show some key results on the impact of horizontal advection on both local scale ABL dynamics and regional-scale ABL features, in particular over locations affected by flows from mountains, seas, highly urbanized areas, and over continental sites during the passage of mid-latitude cyclones. High-resolution measurements obtained from the Texas Tech Scanning Doppler Lidar (T^2-SDL) will be presented to investigate the impact frontal passages on the variability of ABL depths over an arid region (Lubbock, Texas). A "footprint" concept will be introduced where ABL processes will be explained not only by surface forcing but also by horizontal advection of mass, momentum, and energy. The new analyses will enable a detailed understanding of the impact of horizontal advection on meteorological processes taking place on diverse spatial and temporal scales over land.