On the application of lidar and in-situ based observations and numerical simulations to examine the spatiotemporal variability in urban heat island and urban heat advection

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It is well accepted that extreme heat events have grown more serious, owing to their increasing intensity and frequency in a changing climate regime of 21st century. Our inability to predict the future course of urban heat island (UHI) intensity (i.e., UHII) for different types and sizes of urban areas around the world remains one of the primary sources of uncertainty in our understanding of meteorological processes in the atmosphere over urban areas. Meanwhile, the number of people living in urban areas around the world is projected to reach 68% by 2050, thus better forecasts over these areas are vital. Past research emphasized the UHI characterization for major metropolitan areas in the US and other parts of the world with limited or no attention to the extreme heat situation and UHI in relatively smaller sized cities (e.g., cities with a population of few hundred thousand).

Several atmospheric processes are directly or indirectly governed by UHI including convection initiation, pollutant dispersion, and urban boundary layer turbulence. Additionally, UHI impacts on health and well-being of populations is further exacerbated during heat waves because high temperatures cause significant health concerns in the summer, affecting morbidity and mortality. We argue that “small cities matter” for all types of UHI-induced meteorological processes. Additionally, a key problem exists in the UHI definition itself. It is unclear how the mean horizontal wind over a broad region affects the spatial temperature distribution, a process called urban heat advection (UHA). It is also unclear how weather forecasting models assess advection under different weather conditions in different seasons. Thus, we believe that without the consideration of UHA, quantification and forecasting of UHI will remain challenging.

This work aims to obtain some comprehensive details on the spatial variability in urban heat and its advection and to understand UHI pattern and magnitude in different heat regimes using a new network of near-surface observations of meteorological variables and Doppler lidar observations within and around a small city located in an arid region (Lubbock, TX). We will also compare results from weather forecasting models (e.g., HRRR : High Resolution Rapid Refresh) against the collected observations under widely varying weather conditions and will collect observations using rawinsondes and two Doppler lidars deployed during field campaigns. We will also use available satellite measurements of surface temperature as an independent source of observations to demonstrate the potential of satellite measurements for quantifying UHA.