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Abstract

It has long been known that the urban surface energy balance is different to that of a rural surface, and that heating of urban surface after sunset gives rise to the Urban Heat Island (UHI). Less well known is how flow and turbulence structure above the urban surface are changed during different phases of the urban boundary layer (UBL). This paper presents new observations above both an urban and rural surface and investigates how much UBL structure deviates from classical behaviour. A five-day, low wind, cloudless, high pressure period over London, UK, was chosen for analysis, during which there was a strong UHI. Boundary layer evolution for both sites was determined by the diurnal cycle in sensible heat flux, with an extended decay period of c. 4 hours for the convective UBL. This is referred to as the "Urban Convective Island" as the surrounding rural area was already stable at this time. Mixing height magnitude depended on the combination of regional temperature profiles and surface temperature. Given the daytime UHI intensity of 1.5 C, combined with multiple inversions in the temperature profile, urban and rural mixing heights underwent opposite trends over the period, resulting in a factor of three height difference by the fifth day. Nocturnal jets undergoing inertial oscillations were observed aloft in the urban wind profile as soon as the rural boundary layer became stable: clear jet maxima over the urban surface only emerged once the UBL had become stable. This was due to mixing during the Urban Convective Island reducing shear. Analysis of turbulent moments (variance, skewness and kurtosis) showed "upside-down" boundary layer characteristics on some mornings during initial rapid growth of the convective UBL. During the "Urban Convective Island" phase, turbulence structure still resembled a classical convective boundary layer but with some influence from shear aloft, depending on jet strength. These results demonstrate that appropriate choice of Doppler lidar scan patterns can give detailed profiles of UBL flow. Insights drawn from the observations have implications for accuracy of boundary conditions when simulating urban flow and dispersion, as the UBL is clearly the result of processes driven not only by local surface conditions but also regional atmospheric structure.

see also http://www.actual.ac.uk/