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# A method for monitoring the thermal performance of trees in urban local microenvironments: results from the first experimental campaign of the InfruTreeCity project

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Exchanges of energy, mass, and momentum that determine local microclimates are highly complicated in urban areas due to urban heterogeneity, involving a variety of natural and anthropogenic factors and spanning a wide range of atmospheric scales. One key factor is urban trees and their interactions with other components of urban fabric. Recent research suggests that urban trees have significant benefits on the environment and energy consumption of buildings. Yet, systematic research is sparse, especially at micro-$\gamma$ scale ($\sim$10 m) and a clear framework for enquiry is lacking. Towards this, the InfruTreeCity project aims to advance our understanding of urban tree – built environment interactions by experimentally addressing the interaction of radiative energy exchanges, tree physiological processes, and urban built forms.

An experimental campaign took place between 1st July and 8th October 2018: two groups, each consisting of five identically arranged containerised columnar maples (Acer platanoides), were placed in two adjacent local microenvironments (LMEs) very close to Reading University Atmospheric Observatory (RUAO). The first LME (yard) was a 6 m X 3m paved surface, enclosed with a wooden fence, with a small building attached to its western side. The second LME (control) was a grassy open area of similar size, 5 m away from the first.

A prototype experimental approach was used for probing radiative and thermal characteristics of urban LMEs. It consisted of a spectrometer (Spectral Evolution, SM-2500) for field spectrometry measurements and an infrared camera (Optris PI 640) for thermal imaging. Both instruments were mounted on a movable powerhead (UPH – Hague underslung powerhead), placed at the end of a 7.3 m jib (Proaim).

A Campbell Scientific IRGASON system placed on a 6-m mast measured momentum and convective energy (sensible and latent heat) fluxes. Measurements were taken at both LMEs, in the absence and presence of trees. Air temperatures were measured with 5 Tinytag dataloggers attached to the trees at 1.2 m heights. Background meteorological conditions, including radiative and convective energy fluxes, were assessed with measurements provided from the RUAO. Soil moisture and tree condition (stress) were also recorded.

Convective fluxes and air temperatures were monitored over several weeks, hence there was significant variation in sunrise/sunset times and day length over the course of the experiment. Therefore, a new time frame that would account for such changes was deemed necessary. Two time-frames were constructed: i. conventional (24-h) time in a transformed triangular pulse, and ii. the time defined in relation to sunrise and sunset only. The new time frame was developed from the polar transformation of the two frames and it was used as the basis of the convective energy fluxes and air temperature analysis.

Mean NIR reflectance was higher in the control LME, and mean tree canopy surface temperatures were cooler by $\sim$8 degrees C (5.5 degrees C) than the underlying grassed (paved) surface. After sunset, and under calm wind conditions, statistically significant differences were found between the yard LME and background convective energy fluxes, highlighting the contribution of transpiration in the energy balance even at this small scale.