Energy balance observations in two residential neighborhoods of Singapore and Mexico City

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Introduction
Observations of the incoming and outgoing solar radiation, along direct measurements of sensible and latent heat fluxes in concert with bottom-up estimations of anthropogenic heat allow to quantify the heat stored by the urban surface, and thereby obtain a clear description of the surface energy balance to understand the impact on thermal environment and local micrometeorology caused by urbanization. This work investigates the characteristics of the flux components of the energy balance in two residential neighborhoods of Singapore and Mexico City. The former is a modern tropical city of Southeast Asia and the later a large subtropical city of Latin America.

Radiative fluxes
- $K_s$: Incoming shortwave
- $K_r$: Outgoing shortwave
- $L_s$: Net shortwave
- $L_r$: Incoming longwave
- $L^*$: Outgoing shortwave
- $L^*$: Net longwave

Energy fluxes
- $Q^*$: Net radiation
- $Q_a$: Anthropogenic heat
- $Q_s$: Sensible heat
- $Q_l$: Latent heat
- $\Delta Q_s$: Storage heat

Results
Only small variations were observed in the diurnal patterns of the energy fluxes during the climatological seasons experienced in both sites, especially compared to those in temperate cities. The benign climatological conditions in (sub)tropical locations explains the lack of clear seasonal patterns.

The differences between both sites are explained by their locations and urban morphologies. In addition to the latitude and altitude, $Q^*$ depends also on the cloudiness and atmospheric pollution. The lower $Q_s$ in Mexico City is explained by its drier climate; the annual average rainfall is ~1/3 of that in Singapore. $\Delta Q_s$ is slightly lower during daytime in the low-rise neighborhood of Singapore studied here, but clearly higher in the neighborhood of Mexico City. This difference responds to the fractions of area covered by buildings and roads, and the characteristics and size of those buildings. The built-up and impervious surfaces represent 94% and 85% of the plan area of those neighborhoods in Mexico City and Singapore. Although the release of heat in the Mexican neighborhood is twice as large as in the Singapore neighborhood, in both cases it is enough to maintain turbulent conditions throughout the night.