Seasonal Variations of the Surface Urban Heat Island in a Semi-Arid City

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Abstract: The process of the surface urban heat island (SUHI) varies with latitude, climate, topography and meteorological conditions. This study investigated the seasonal variability of SUHI in the Tehran metropolitan area, Iran, with respect to selected surface biophysical variables. Terra Moderate Resolution Imaging Spectroradiometer (MODIS) Land Surface Temperature (LST) was retrieved as nighttime LST data, while daytime LST was retrieved from Landsat 8 Thermal Infrared Sensor (TIRS) using the split-window algorithm. Both data covered the time period from September 2013 to September 2015. To assess SUHI intensity, we employed three SUHI indicators, i.e., the LST difference of urban-rural, that of urban-agriculture and that of urban-water. Physical and biophysical surface variables, including land use and land cover (LULC), elevation, impervious surface (IS), fractional vegetation cover (FVC) and albedo, were selected to estimate the relationship between LST seasonal variability and the surface properties. Results show that an inversion of the SUHI phenomenon (i.e., surface urban cool island) existed at daytime with the maximal value of urban-rural LST difference of −4 K in March; whereas the maximal value of SUHI at nighttime yielded 3.9 K in May. When using the indicators of urban-agriculture and urban-water LST differences, the maximal value of SUHI was found to be 8.2 K and 15.5 K, respectively. Both results were observed at daytime, suggesting the role of bare soils in the inversion of the SUHI phenomenon with the urban-rural indicator. Maximal correlation was observed in the relationship between night LST and elevation in spring (coefficient: −0.76), night LST and IS in spring (0.60), night LST and albedo in winter (−0.53) and day LST with fractional vegetation cover in summer (−0.41). The relationship between all surface properties with LST possessed large seasonal variations, and thus, using these relationships for SUHI modeling may not be effective. The only exception existed in the correlation between elevation and IS, which may be useful to simulate the SUHI at night. This study suggests that in semi-arid cities, such as Tehran, with the urban-rural indicator, a surface urban cool island may be observed in daytime while SUHI at nighttime; with other indicators, SUHI can be observed in both day and night. Thus, SUHI studies require the acquisition of remote sensing image data at both daytime and nighttime and careful selection of SUHI indicators.

Keywords: surface urban heat island; surface urban cool island; urban biophysical variables; seasonality; semi-arid city; daytime and nighttime imaging
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