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Estimating Intra-urban Microclimate Variability in a Desert City using a bottom-up multi-method approach

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Mapping spatial and temporal variability of urban microclimate is pivotal for an accurate estimation of ever-increasing exposure of urbanized humanity to global warming. This concerns particularly cities in the often over-looked arid/semi-arid regions which cover two fifths of the global land area and are home to more than one third of the world's population. In this study, we investigate the spatial and temporal patterns of urban-rural and intra-urban temperature variability by means of satellite observation, vehicular traverse measurement and computer simulation using an urbanized energy balance model – the Canyon Air Temperature (CAT) model. The CAT model incorporates several previous parameterization schemes accounting for the atmospheric stability and canyon heat storage on the one hand; on the other, it relies on a precise description of urban geometric parameters including canyon aspect ratio and street orientation. We derive the latter parameters for grids of 90 x 90 m^2 across the entire city of Beer Sheva, Israel, using a bottom-up approach based on building footprints data. We further advance the model by adjusting 1) the anthropogenic heat release according to building-related canyon parameters and hourly mean temperature, and 2) the availability of soil moisture in the presence of irrigation of landscaping. These modifications significantly improve the model's performance when validated using both reference weather station observations and the vehicular measurement. Beer Sheva exhibits a well-developed nocturnal canopy layer urban heat island in the winter but a weak diurnal cool island in the summer. Urban-rural and intra-urban differences in air temperature during the daytime are very weak, despite pronounced urban surface cool islands observed in satellite images (ASTER and Landsat-8). This phenomenon, also recorded in other desert cities, is explained by the rapid increase in LST of exposed desert soils (in the absence of vegetation or moisture) after sunrise, while urban surfaces are heated more slowly. The study highlights differences among the three methods used for describing urban temperature variability, each of which may have different applications in fields such as urban planning, climate change mitigation and epidemiological research.