Assessing the Urban Heat Island Effect Across Biomes in the Continental USA Using Landsat and MODIS

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Abstract

Impervious surface area (ISA) from the Landsat TM and land surface temperature (LST) from MODIS averaged over three annual cycles (2003-2005) are used in a spatial analysis to assess the urban heat island (UHI) skin temperature amplitude and its relationship to development intensity, size, and ecological setting for 38 of the most populous cities in the continental United States. Development intensity zones based on %ISA are defined across urban gradients and used to stratify sampling of LST and NDVI. We find that ecological context significantly influences the amplitude of summer daytime UHI (urban – rural temperature difference) with the largest 8° C (average) for cities built in mixed forest biomes. For all cities ISA is the primary driver for increase in temperature explaining 70% of the total variance. Annually, urban areas are warmer than the non-urban fringe by 2.9 °C, except in biomes with arid and semiarid climates. The average amplitude of the UHI is asymmetric with a 4.3 °C difference in summer and 1.3 °C in winter. In desert environments, UHI's point to a possible heat sink effect. Results show that the urban heat island amplitude increases with city size and is seasonally asymmetric for a large number of cities across most biomes. The implications are that for urban areas developed within forested ecosystems the summertime UHI can be quite high relative to the wintertime UHI suggesting that the residential energy consumption required for summer cooling is likely to increase with urban growth within those biomes.