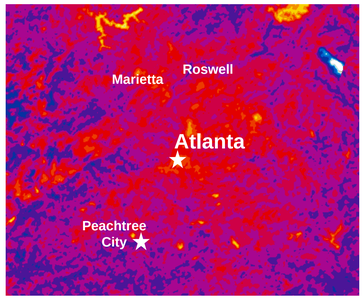
Variability of Urban Heat Islands

Ronak Patel, Sandra Yuter, Matthew Miller

Department of Marine, Earth, and Atmospheric Sciences, N.C. State University, Raleigh, NC

Introduction



Suomi NPP Visible Infrared Imaging Radiometer Suite (VIIRS) nighttime image of temperatures in the Atlanta metropolitan area on June 7, 2018. Orange areas are warmer and blue areas are colder.

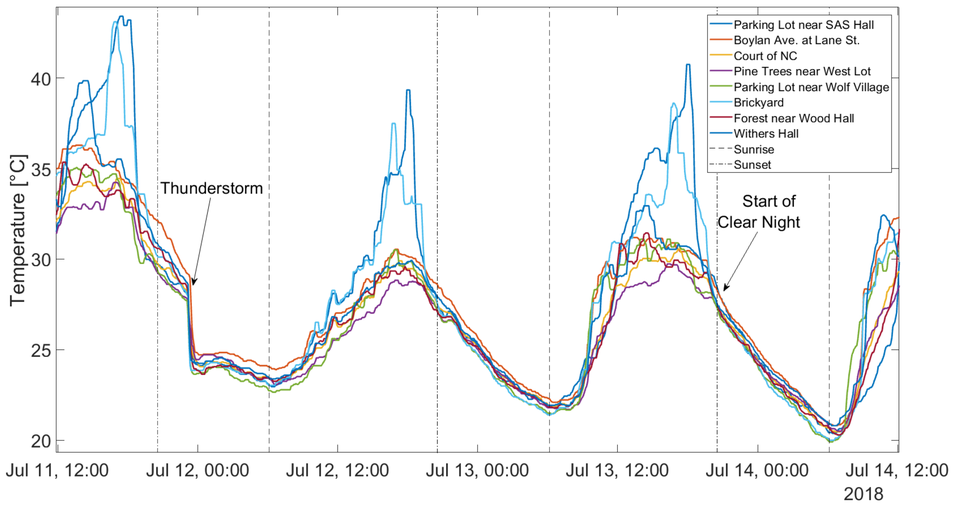
As humans continue to urbanize the natural environment, the increase in paved or build-up areas has the potential to change local climates by locally increasing temperature. One of these changes is an increase in size and intensity of the "urban heat island." An urban heat island is an urban area with higher temperatures than the surrounding rural area.

Data and Methods

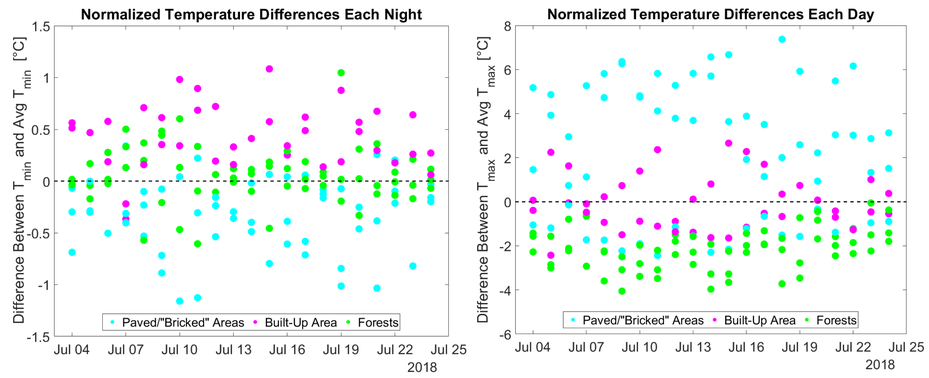
We looked at hourly temperature data for urban and rural/suburban sites in the Atlanta, GA and Wilmington, NC metropolitan areas. Automated Surface Observing System (ASOS) data was used for the sites in Atlanta (urban), Peachtree City (suburban), and Wilmington (urban), while NC State Climate Office data was used for the site in Castle Hayne (rural). The average temperature at each hour was calculated at each site.

Eight HOBO MX2201 temperature sensors were deployed across NCSU and in Raleigh. Sensors were placed in one of three environments across campus: paved areas, forested areas, and built-up areas. Google Earth satellite and ground-based imagery were used to estimate the percent of area within a 10 meter radius of each sensor that was impervious or had tree cover. Temperature sensors logged data every five minutes for three weeks.

Map and image showing sensor placement.



Three day time series showing temperatures from 12:00 July 11 to 12:00 July 14 (local time – EDT). Timing of thunderstorm/rain provides explanation for sharp drop in temperature overnight.



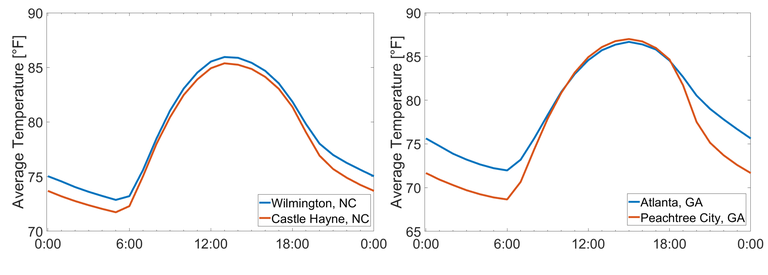
Scatter plots showing the difference in temperatures at each site compared to the average maximum or minimum temperature for each day or night respectively.

Microclimatic Influences

Energy comes to the earth from the sun primarily in the form of shortwave radiation. The shortwave radiation absorbed by surfaces causes an increase in near surface air temperatures. Areas with forests and grass tend to be cooler than paved surfaces. Rain usually cools the air as some of it evaporates before reaching the surface. Colder air associated with rain storms can yield rapid changes in air temperature. At night, clear skies allow more rapid cooling as compared to cloudy nights.

Diurnal Variations in Urban Heat Island

During the day, the air temperatures within a city are usually higher than or similar to the surrounding suburban and rural areas. During the night, the surrounding areas are usually cooler than within the city. Hence, the biggest difference between the air temperatures occurs at night.



Time-series plots showing the average hourly temperatures in the Wilmington and Atlanta areas during the summer (JJA). Times are in Eastern Standard Time (EST).

Summary

On the NCSU campus:

- Air temperatures near paved/impervious surfaces were on average 4-6°C (7-11°F) higher during the day as compared to tree covered areas.
- During the night, air temperatures near paved/impervious surfaces were on average 0.5-1°C (1-2°F) lower compared to tree covered areas.

Future Work

- Find better methods of shielding sensors from solar radiation. Using bushes did not work for certain sensors
- Longer-term study is needed to examine possible seasonal patterns of heat island variability
- Future analysis should consider the role buildings and anthropogenic heat (air conditioning, vehicles, etc) have on heat island intensity

Reference: Arya, S. P. (1988): *Introduction to Micrometeorology*. San Diego, CA: Academic Press
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