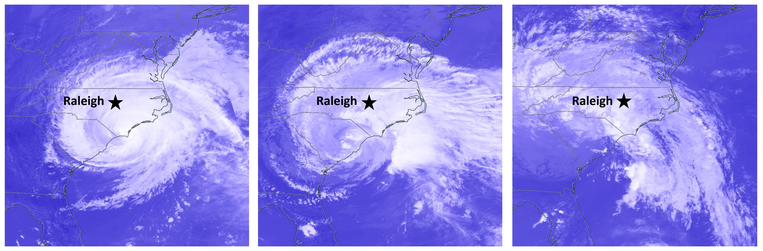
Variability of the Urban Heat Island in Raleigh, NC

Ronak Patel, Sandra Yuter, Matthew Miller

Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University, Raleigh, NC

Introduction

An urban heat island is an urban area with higher temperatures than the surrounding rural area (Arya, 1988). In this study, we examine the local variations within Raleigh's urban heat island during the day and night. We also consider the impact of Hurricane Florence on variability within the heat island and on the diurnal temperature cycle. Florence was a slow moving hurricane that impacted the Raleigh area from the 13th-16th September 2018.



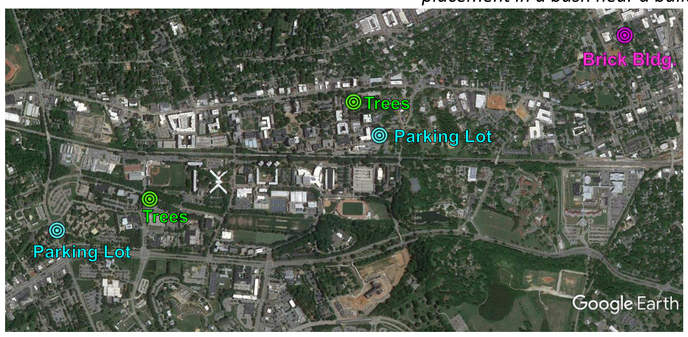
Suomi NPP Visible Infrared Imaging Radiometer Suite (VIIRS) daytime brightness temperature on September 14, 15, and 16, 2018 (left to right). Images were taken 1835 Z, 1820 Z, and 1805 Z respectively. Hurricane Florence made landfall on September 14.

Data and Methods

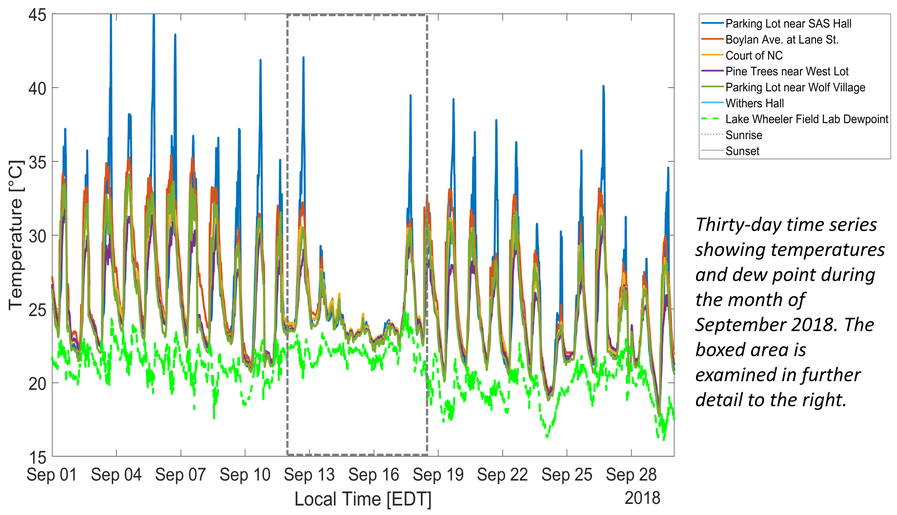
Five HOBO MX2201 temperature sensors were deployed across North Carolina State University (NCSU) and in Raleigh, NC. Sensors were placed in one of three environments: paved areas, forested areas, and built-up areas (i.e. buildings nearby). They were all placed in bushes to reduce the impacts of direct solar radiation. Temperature sensors logged data every five minutes from July to October. We also used solar radiation and dew point data measured at the Lake Wheeler NC ECONet site, located 6 km from our temperature sensors.

Above: Temperature sensor placement in a bush near a building

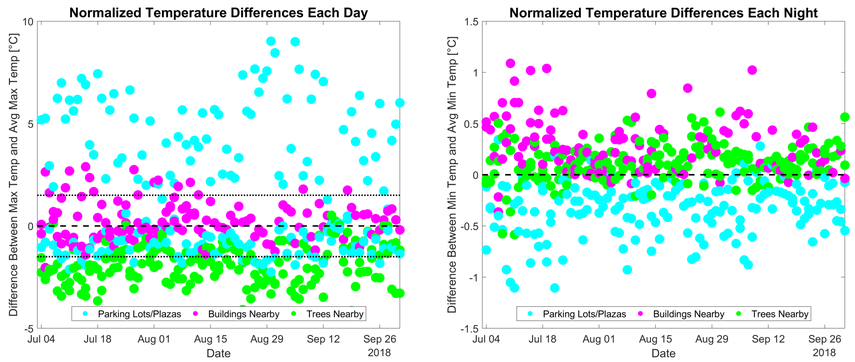
Below: Map of Raleigh area showing sensor placement and environment types



Heat Island Variability

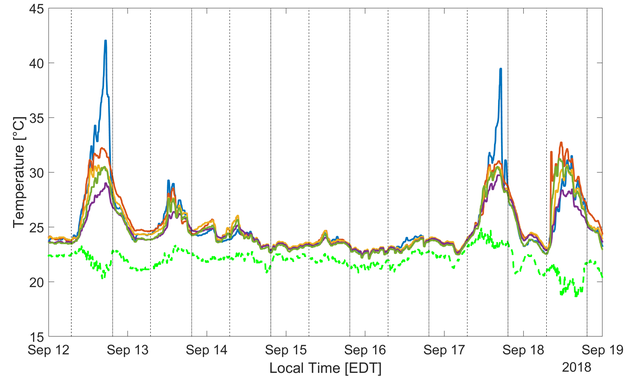


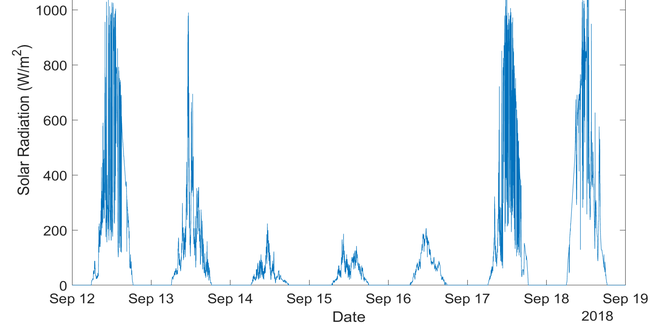
Thirty-day time series showing temperatures and dew point during the month of September 2018. The boxed area is examined in further detail to the right.



Scatter plot showing the difference in max temperatures at each site compared to the average maximum temperature of all sites each day (left). Scatter plot showing the difference in min temperatures at each site compared to the average minimum temperature of all sites each night (right). The temperature scale on the nighttime plot fits within the ±1.5°C dotted line indicated on the daytime plot.

During Hurricane Florence





The cloud shield associated with Hurricane Florence affected the Raleigh area starting on the afternoon of September 13, 2018. There was thick, low-based cloud cover on the 14th-16th of September. Seasonal average peak incoming solar radiation was ~1000 W/m^2, but the observed values dropped to around 200 W/m^2 on these dates. This factor led the urban heat island and the diurnal temperature cycle to dramatically diminish.

Summary

In Raleigh, NC during July-September 2018:

- Air temperatures near paved/impervious surfaces were about 3-5°C (5-9°F) higher during the day and forested areas were 2-3°C (4-5°F) lower than the average among all sites
- During the night, the temperatures near paved/impervious surfaces were about 0.5°C (1°F) lower and areas with buildings nearby were 0.5°C (1°F) higher than the average among all sites

As compared to the other days over the 4 month study period, during Hurricane Florence:

- The amplitude of the diurnal temperature cycle decreased by ~85%
- Thick low-based clouds decreased the amount of incoming solar radiation to ~20% of its seasonal average value
- Persistent rainfall yielded air temperatures close to the dew point
- Differences in air temperature among urban environments also decreased

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

Acknowledgements: Special thanks to Levi Lovell, Luke Allen, Daniel Hueholt, Lindsay Hochstatter, and Spencer Rhodes for their advice and for their help in deploying the temperature sensors. Travel grant provided by the NCSU Office of Undergraduate Research.