



Does Urban Heating Spark Thunder Potential?

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Abstract

This project is conducted to study a potential increase in thunder day frequency in urbanized areas. The rationale for this research is to demonstrate evidence of urban heat islands (UHI), which occur when temperatures are higher in urban areas than their surrounding rural counterparts. This will be used to provide information regarding local atmospheric warming in three separate terrains. Additionally, this research studies how monthly averaged UHI temperature could play a role in the number of convective storm occurrences, or even display their intensity. Meteorological variables such as dew point, visibility, wind speed, wind gust, and fog days will also be taken into consideration. All this will be done by comparing Huntsville, Alabama, San Jose, California, and Minneapolis, Minnesota for thunder days during August over a forty-three year period, starting in 1973. The results could depict an increase in thunder day activity with warmer convective temperatures caused by continuous urbanization. A "thunder day" is the NOAA term for a day thunder is present in its recorded area, and thunder cannot exist without lightning, which can be deadly. Understanding factors that initiate it is beneficial to reduce the threat of lightning-related injuries and death.

Methodology

Weather Station Data

Weather station data in urban and rural areas was used to compare ambient air temperatures for UHI evidence. This is plotted with thunder days on a time series graph.

Huntsville Transect Data

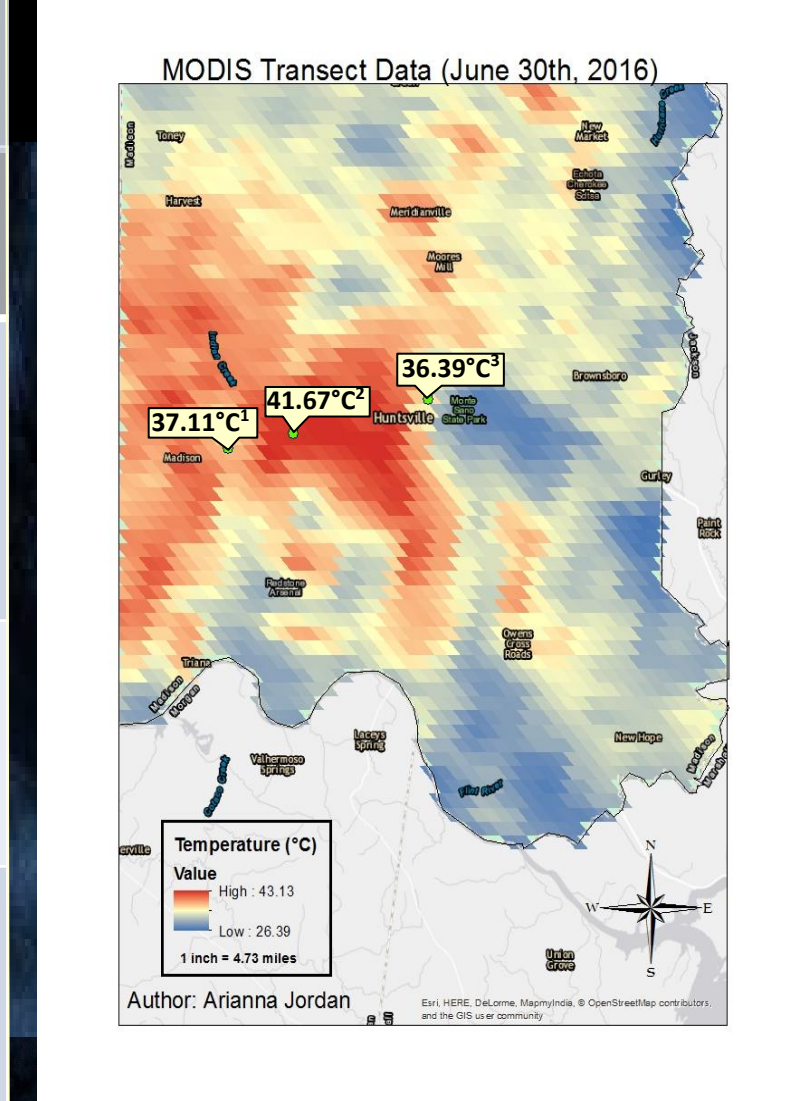
A transect plan was applied to take heat gun temperatures on asphalt, sunny grass and shady grass for one point in urban Huntsville, and two points in its rural areas. This was used as a direct method to determine the spatial relationship of land surface temperatures. Heat gun temperatures were compared to the MODIS satellite temperatures taken on the same day.

Correlation Matrix Data

The correlation coefficient, or *r* value, was used to assess how close thunder days were linked with the meteorological variables. The closer the 1 these values are, the stronger the correlation is.

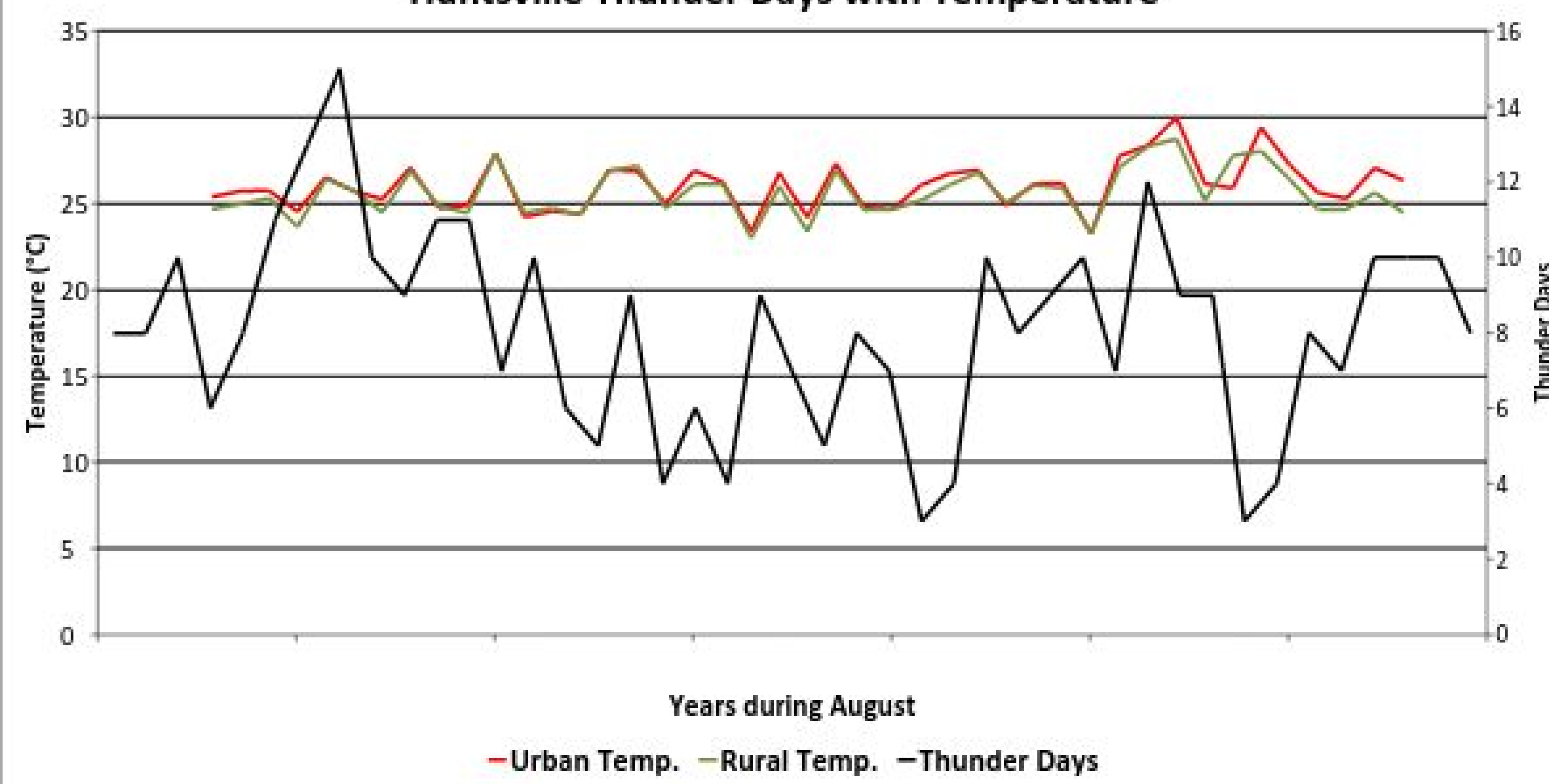
Heat Gun Temperatures

	Asphalt	Sunny Grass	Shady Grass
¹ Indian Creek Greenway	65 °C	38 °C	31 °C
² NSSTC	65 °C	63 °C	35 °C
³ Alms Creek Trail	61 °C	36 °C	29 °C



Data Analysis and Results

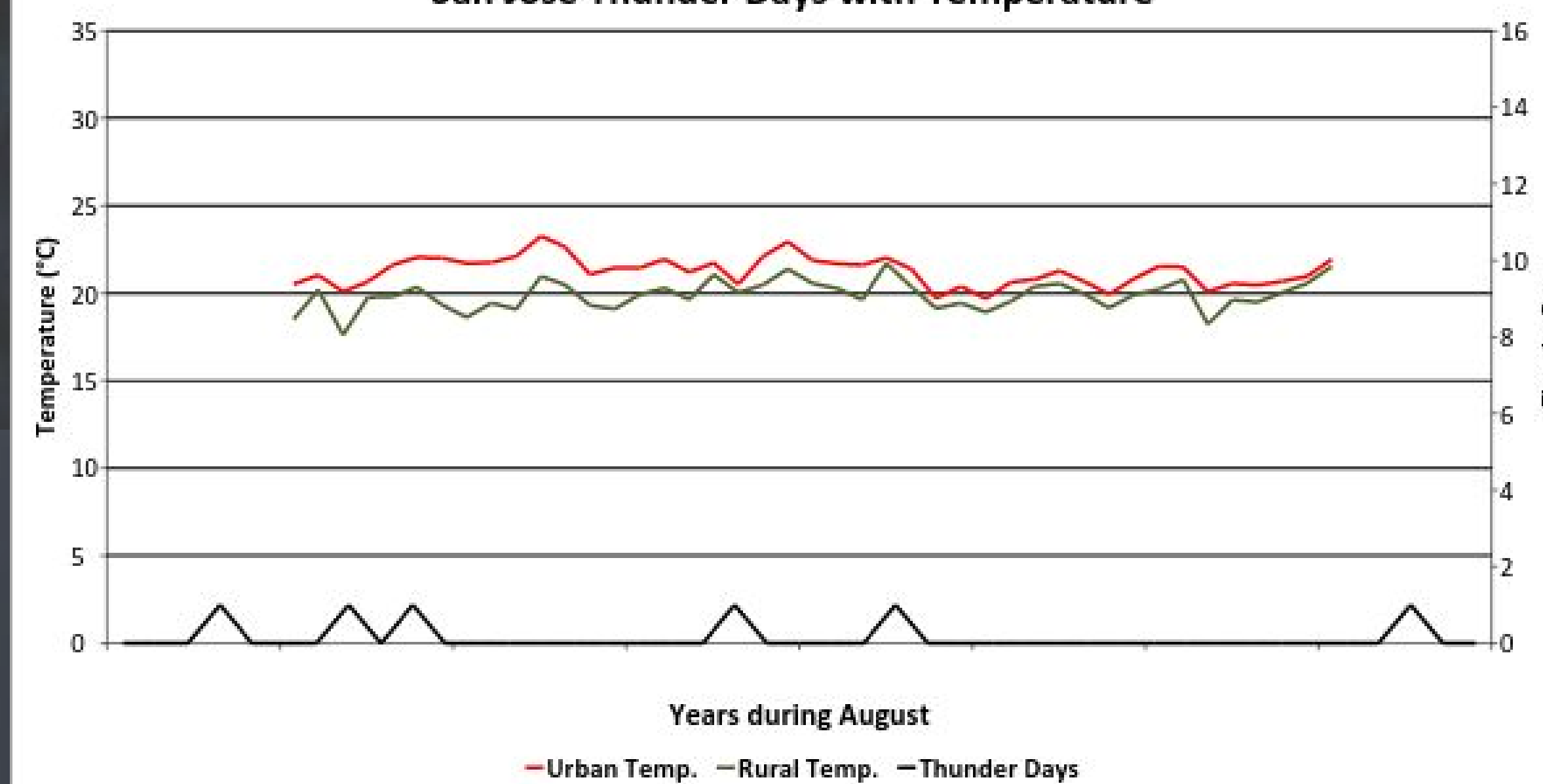
Huntsville Thunder Days with Temperature



Variable	r value
★ Dew Point	0.31
Temperature (°C)	0.09
Wind Gust	0.08
Visibility	0.05
Wind Speed	0.00
Fog Days	-0.05

- Overall, the urban temperature is shown to be higher for Huntsville than the rural.
- There is a distinct peak in thunder days in 1980.
- Though thunder days do not have the strongest correlation, there are instances thunder days rise and fall with temperature, especially in the 2000s.
- Dew point has the highest *r* value, indicating moisture is most related to thunder days for Huntsville.

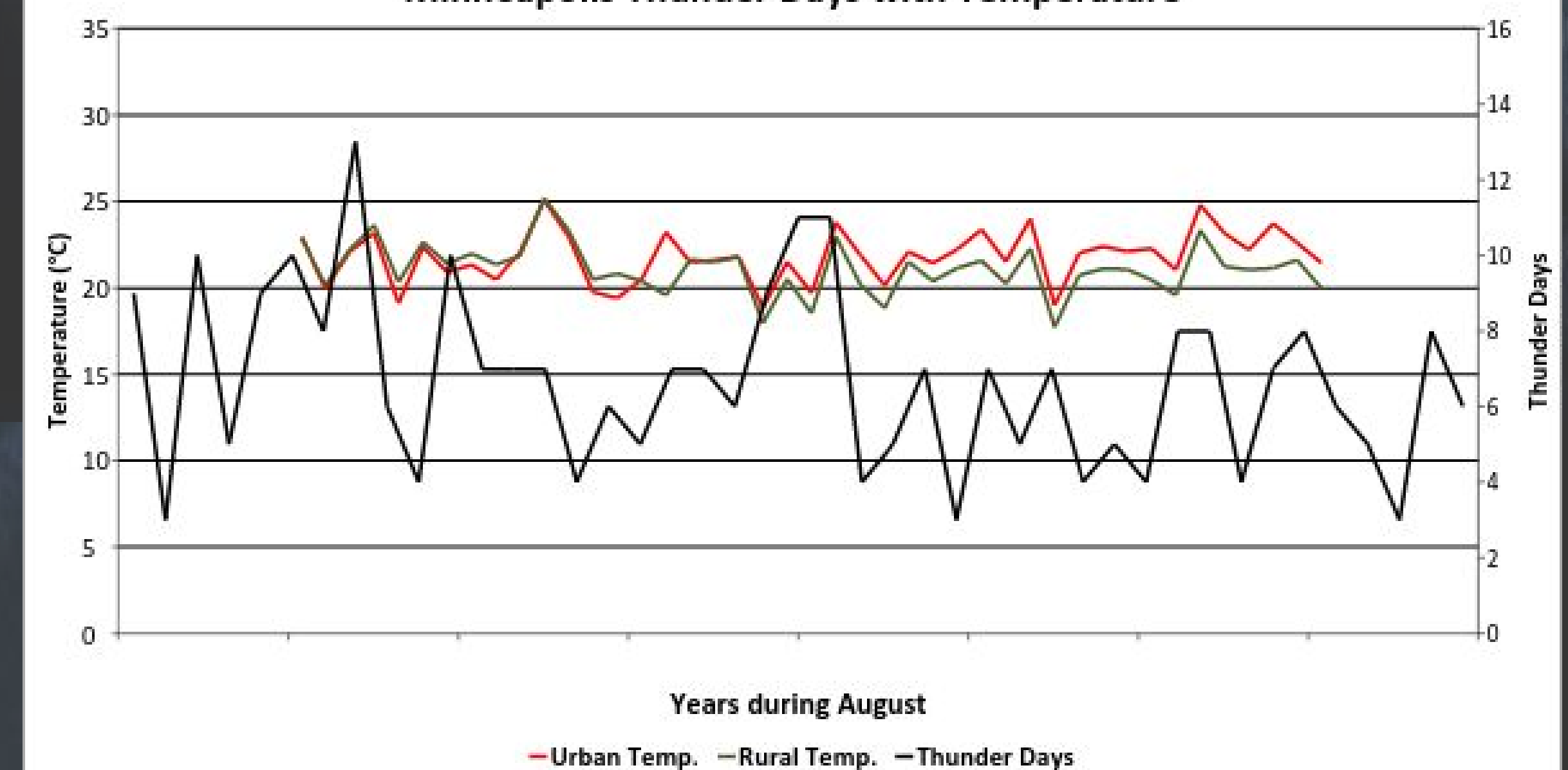
San Jose Thunder Days with Temperature



Variable	r value
★ Dew Point	0.21
Wind Speed	0.20
Visibility	0.17
Temperature (°C)	0.14
Wind Gust	0.09
Fog Days	-0.02

- Urban UHI always remains hotter whereas rural occasionally spikes for the other cities.
- The few thunder days that do occur happen while the temperature is rising or at a peak.
- Temperature is not the strongest correlated, but it is still greater than Huntsville and Minneapolis.
- Like Huntsville, dew point is the closest correlated to thunder days while number of fog days has a negative correlation.

Minneapolis Thunder Days with Temperature



Variable	r value
★ Visibility	0.32
Dew Point	0.31
Wind Speed	0.15
Fog Days	0.10
Temperature (°C)	0.06
Wind Gust	0.03

- The urban UHI is higher only after about 1990.
- Like the other cities, there is a distinct peak in 1980.
- Thunder days do seem to rise and drop with temperature.
- Like Huntsville, there is a distinct peak in thunder days in 1980.
- The most correlated variable is visibility, but dew point still comes in second.
- Unlike the other cities, there are no negative correlations for Minneapolis.

Conclusion

- An urban heat island was identified in all three cities. Reasons for varying fluctuation could be due to increasing urbanization and less vegetation land cover.
- There is not much correlation with thunder days and temperature, but dew point is always the first or second most correlated variable for all the cities; moisture content seems to be a bigger contributing factor than localized UHI temperatures.
- Thunder days had a peak in 1980 for all three cities in August. This was the same year a major heat wave hit the U.S. It is possible unusually extreme temperatures triggered this peak. This would mean temperature is more related to thunder days from a nationwide standpoint than a local one.
- Visibility for Minneapolis might have a high *r* value due to torrential rain during thunder days. If this is the case, these days in Minneapolis could be more intense than San Jose or Huntsville.

Future Work

- Look at the intensity of days with thunder occurrences.
- Study different meteorological variables such as humidity, precipitation amount, and radiation.
- Check area downwind of cities for thunder days. Wind may blow developing storms to those locations.
- Analyse weather synoptic conditions higher in the atmosphere rather than just near the surface.

Acknowledgment

Thank you to Allison Daniel for mentoring, Dr. Kevin Doty for thunder day data assistance, Dr. Sen Chiao for his support and guidance in producing this project. Thank you also to NASA for helping me learn something new while engaging myself in something I love.

Support provided by NASA Office of Education's Minority University Research and Education Project, Contract NNX15AQ02A.