National Aeronautics and Space Administration

Urban Heat Islands Observed from a Time-Series of Remote Sensing Data

George Xian & Kevin Gallo

November 24, 2020

Urban Heat Island Indicator Monitoring and Assessment

The Goal:

- This project focuses on using land surface temperature from Landsat Analysis Ready Data (ARD) with land change products to characterize the thermal features of the land's surface.
- The project develops a framework to assess the urban heat island (UHI) intensity, spatial distribution, and change over time from the 1980s to the present.
- The product provided by this project will be used to monitor UHI change in major cities in the United States.

Urban Heat Island Indicator Monitoring and Assessment

Collaborators:

- USGS National Land Imaging
- US EPA
- USGCRP/NOAA

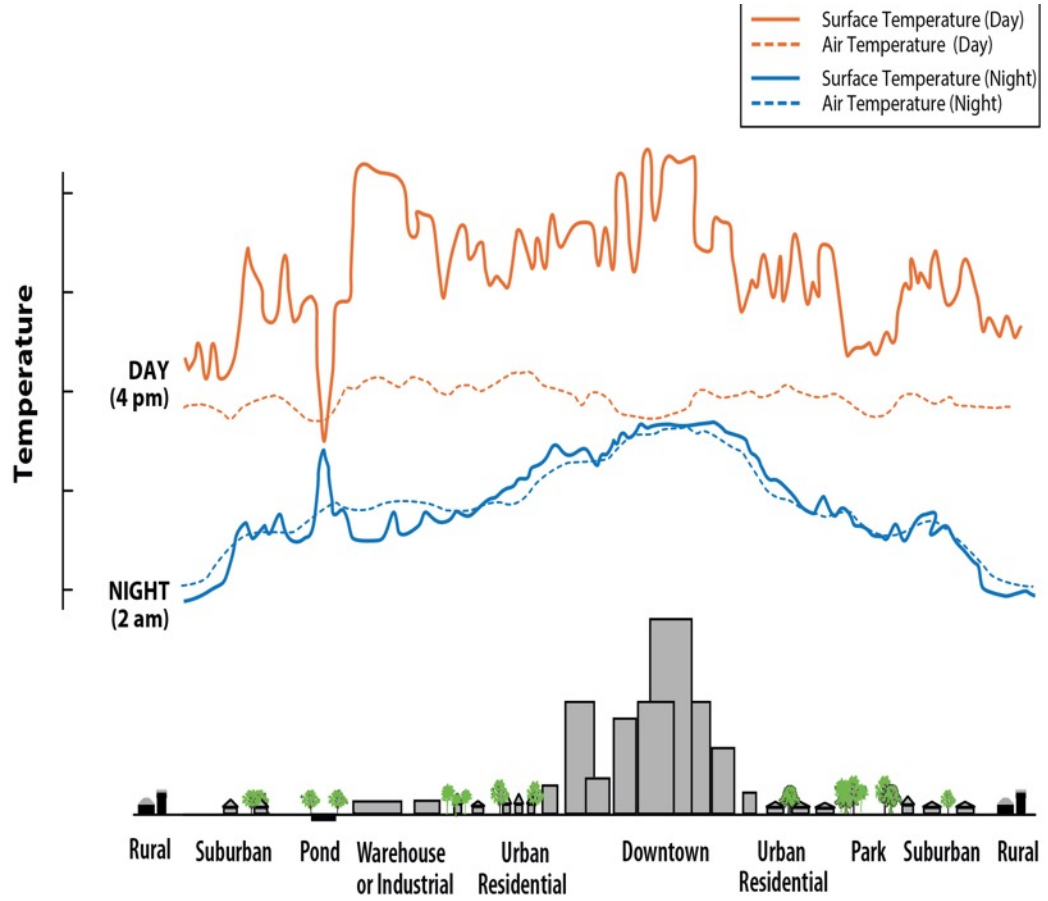
Point of Contact:

- George Xian (xian@usgs.gov)

Urban Heat Islands (UHI)
Easy to Know, Hard to Know More

- Roads, buildings, and parking lots trap and hold heat, pushing urban temperatures higher than surrounding areas – even at night.

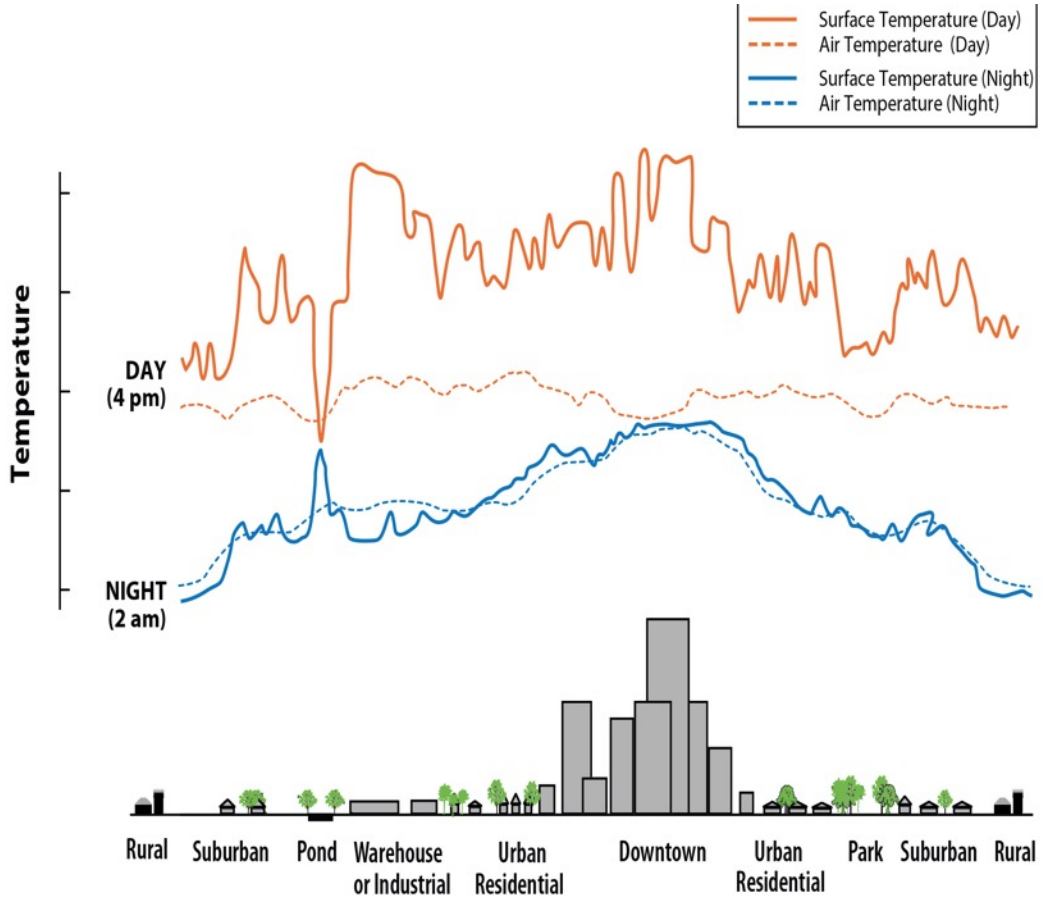
- UHI was identified nearly 200 years ago, but detailed information on hot spots is scarce.



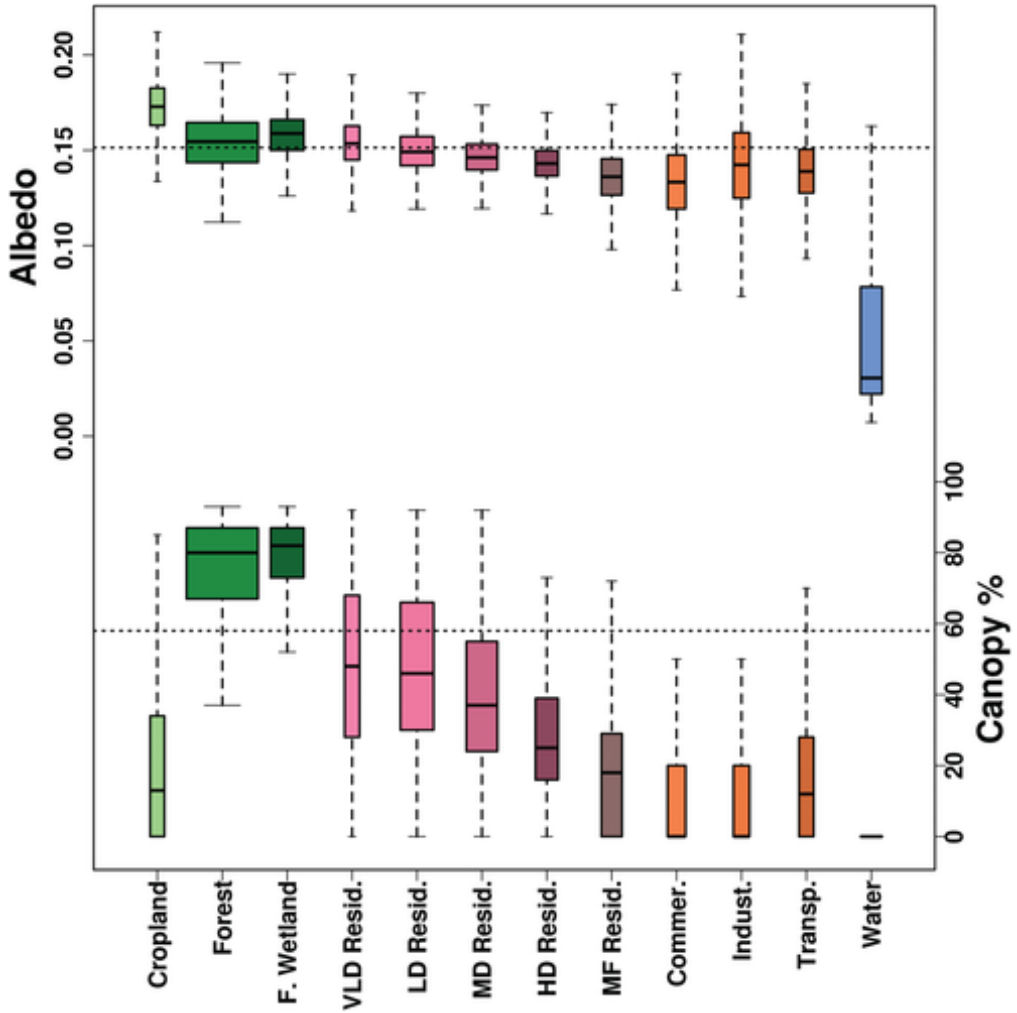
Urban Heat Islands (UHI)
Easy to Know, Hard to Know More

Hurdles to Overcome:

- Temperatures vary from block to block
- Climate stations are limited, at fixed locations, often on the outskirts of town
- Satellite data can track surface temperature with more detail, but observations are limited
- Surface temperatures do not align exactly with air temperature (air temps generally lower)
- The impact of landscape dynamic on UHI is limited



Surface Albedo of Different Land Cover Types



From Trlica et al.,2017, JGR

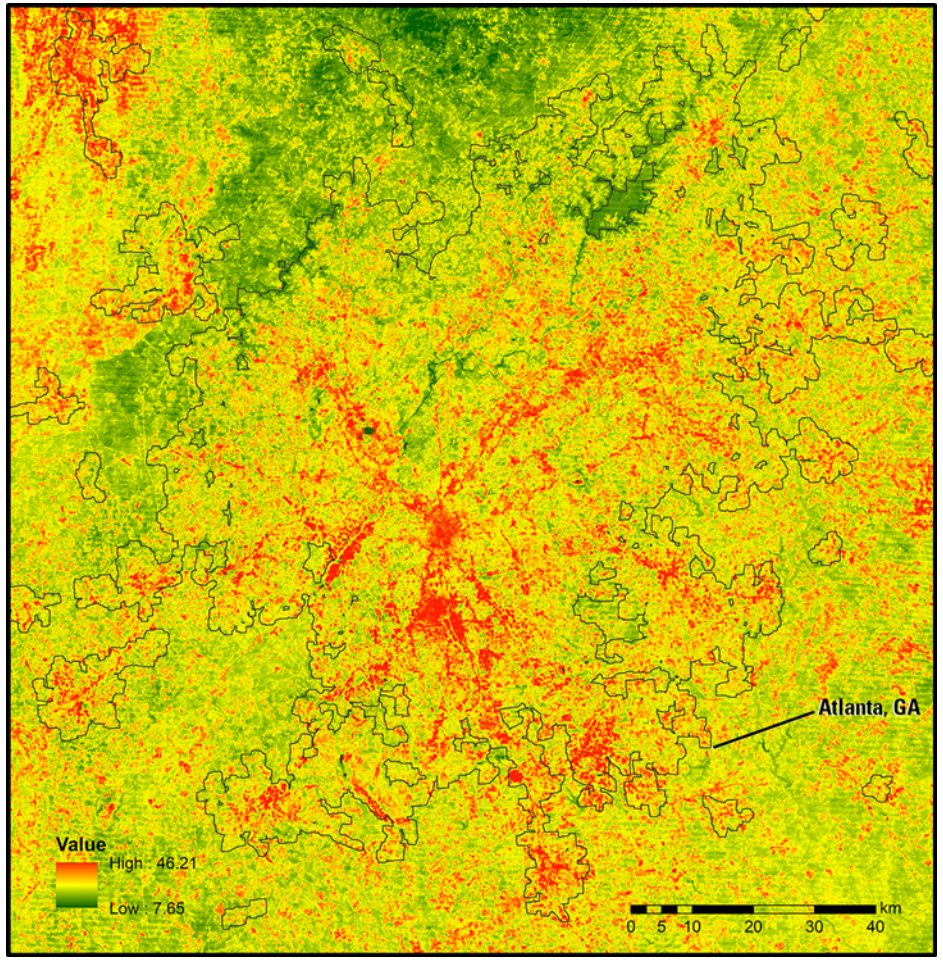
Future Uses:

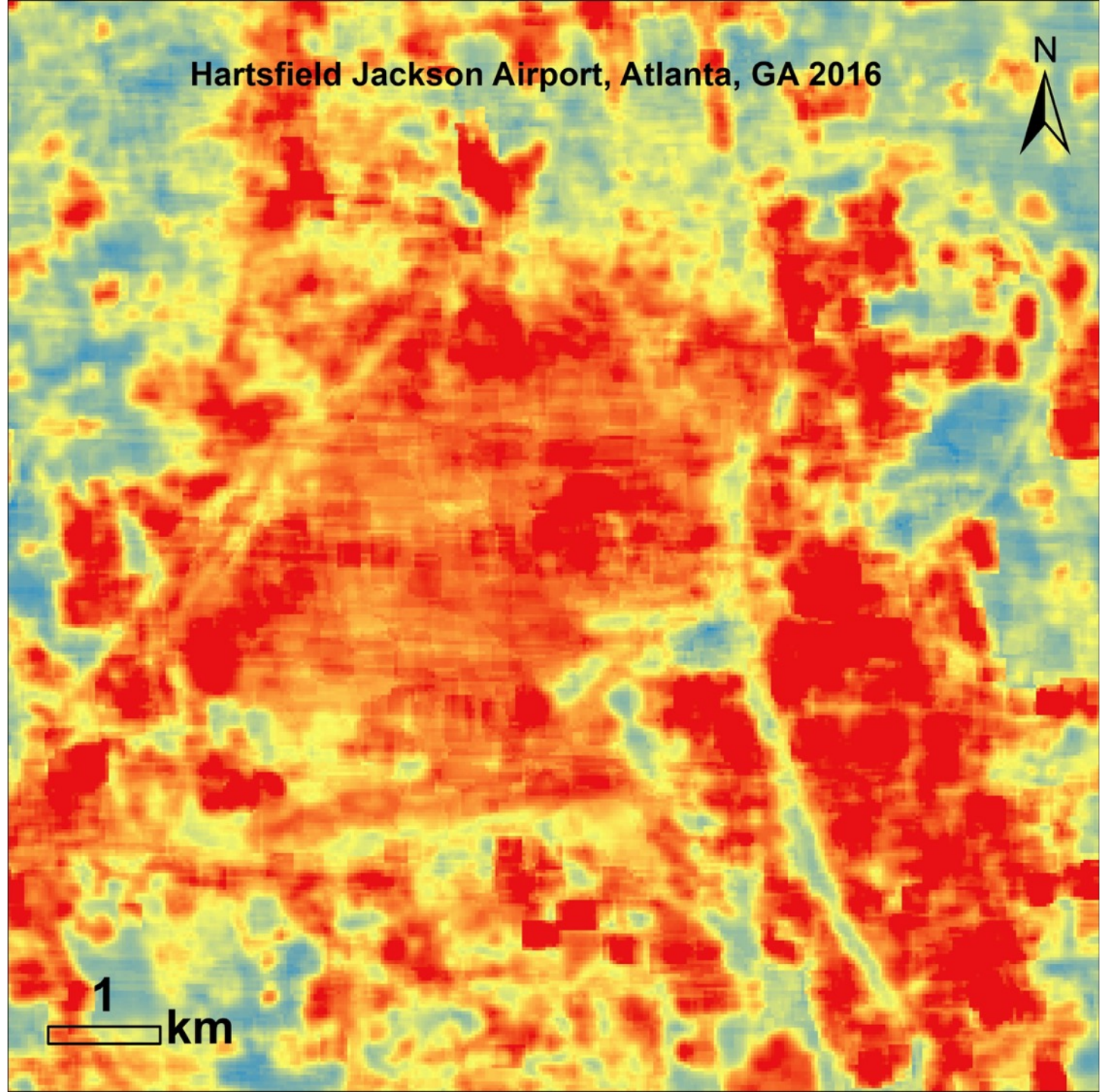
- Targeted heat warnings from NWS
- Targeted mitigation efforts by cities
- Health, urban growth, socioeconomic research and analysis
- Refinement of EPA "Heat Waves" Climate Indicator

There is far-reaching value in LST-UHI data.

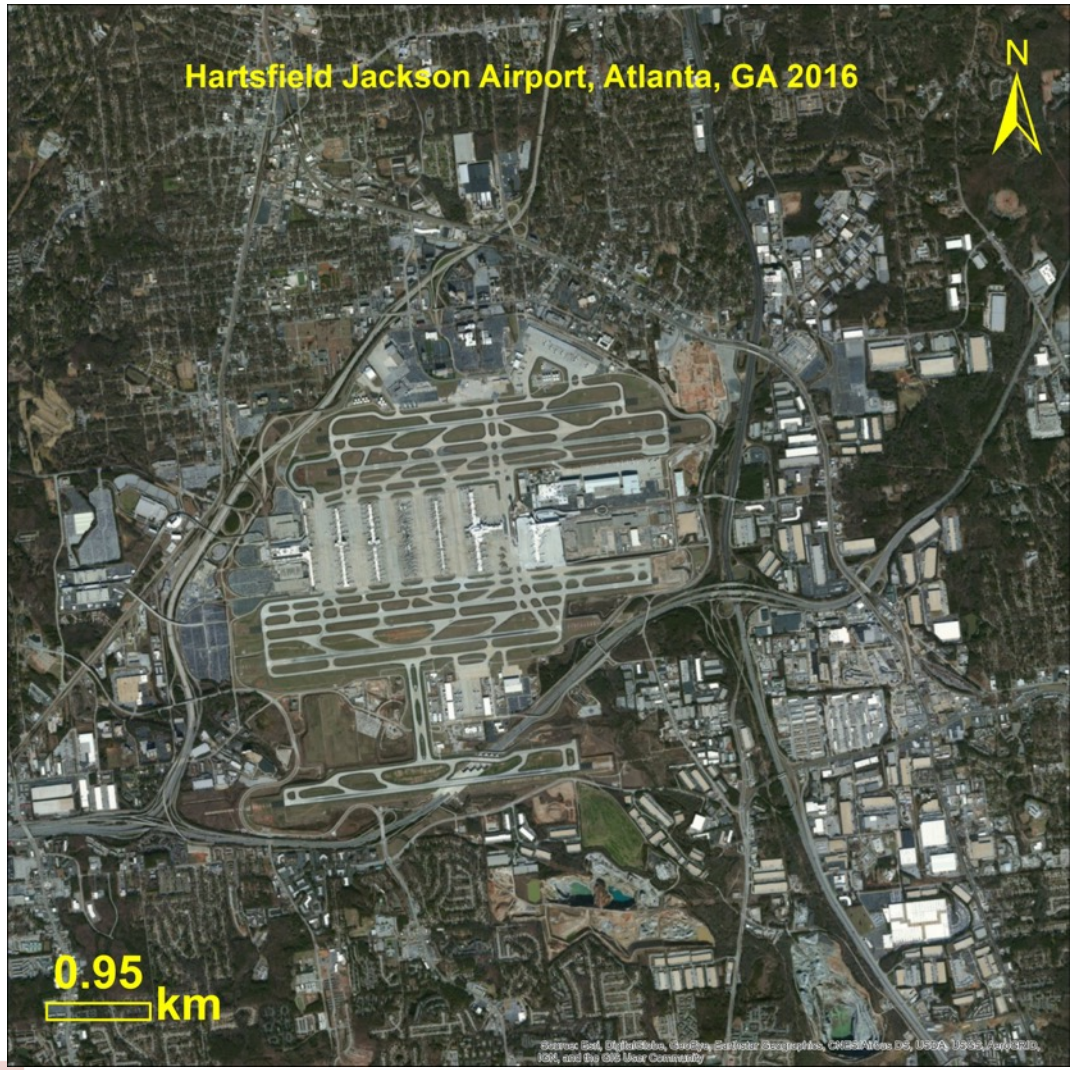
Landsat Analysis-Ready Data: *A New Approach to UHI*

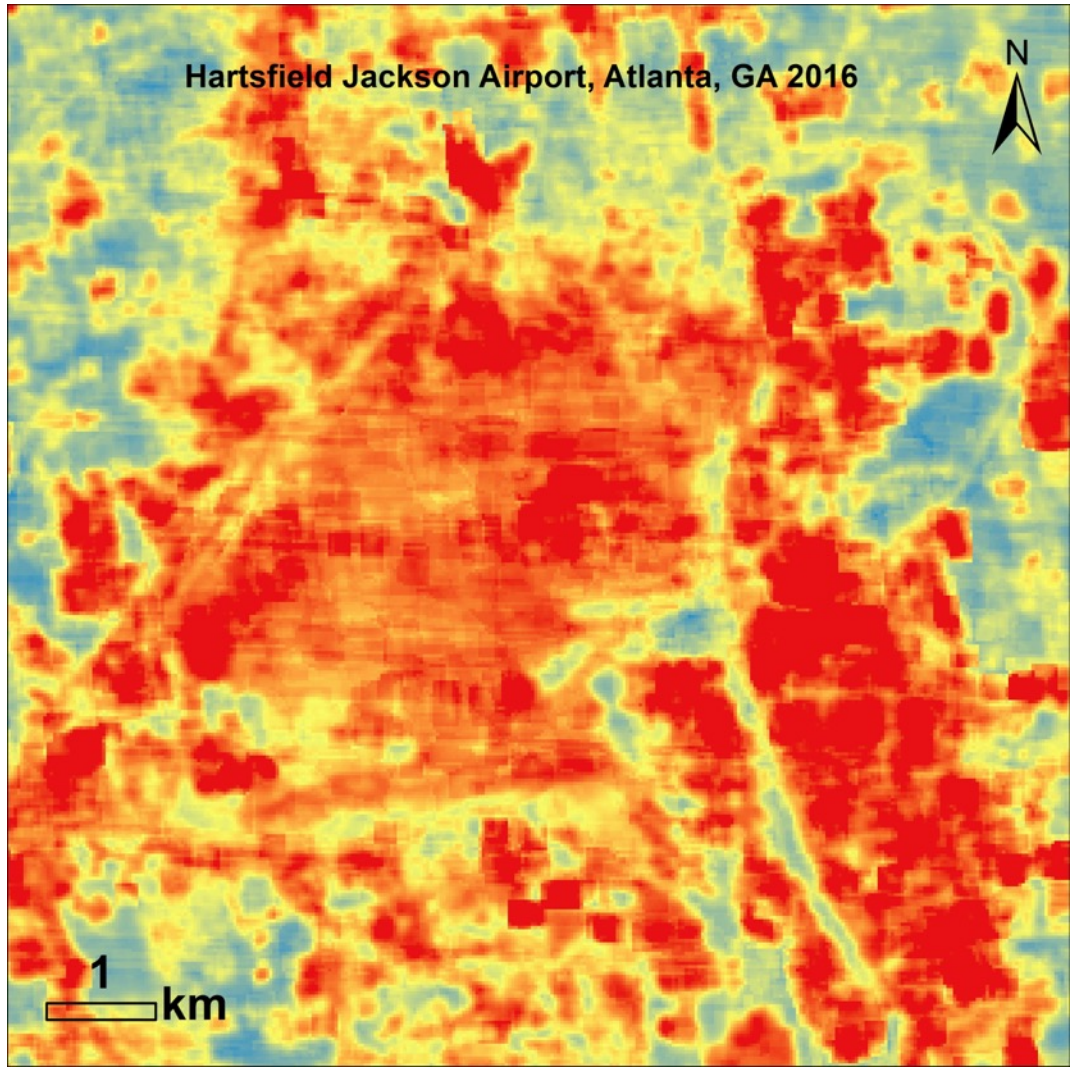
- Surface Temperature data from Landsat ARD can be used to generate annual mean temperatures at 30-meter resolution.
- Align, Verify, Automate
- All clear satellite observations used from 1985-present
- Ground stations used to compare surface temperatures with air temperatures
- Algorithm repeatable for any city, year by year



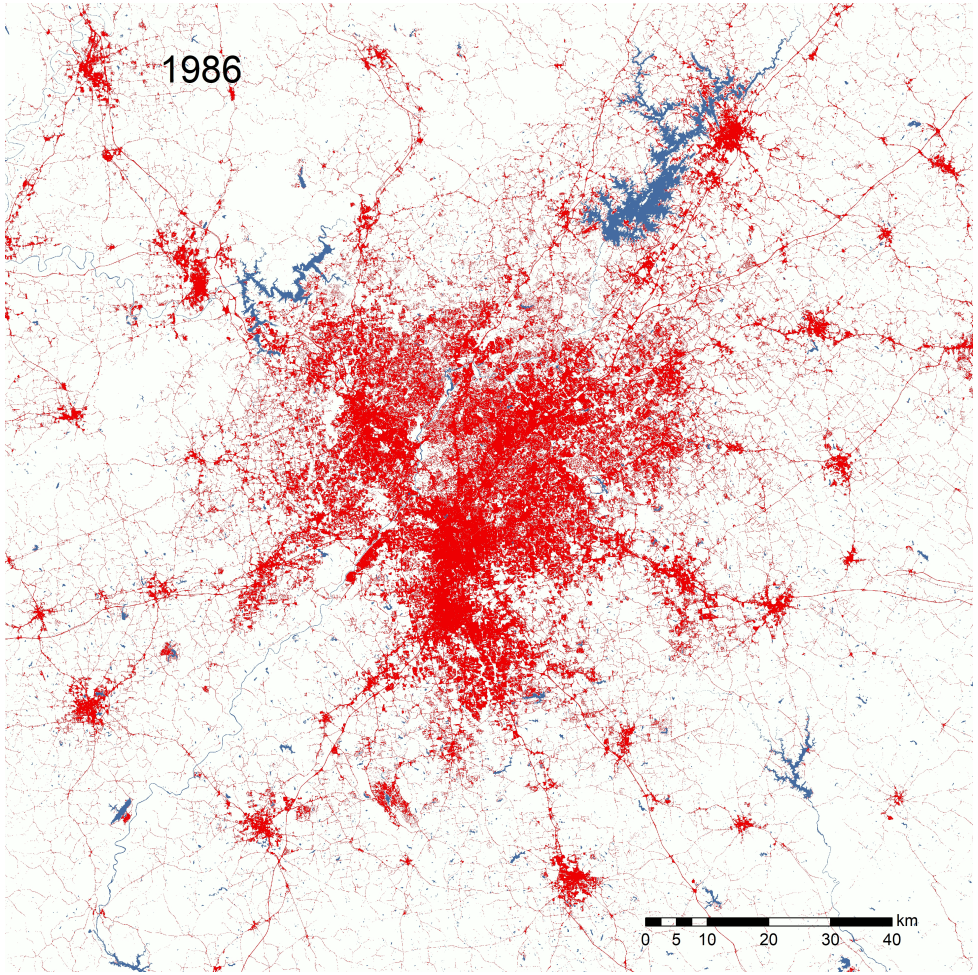

Hartsfield Jackson Airport, Atlanta, GA 2016
N
1
km

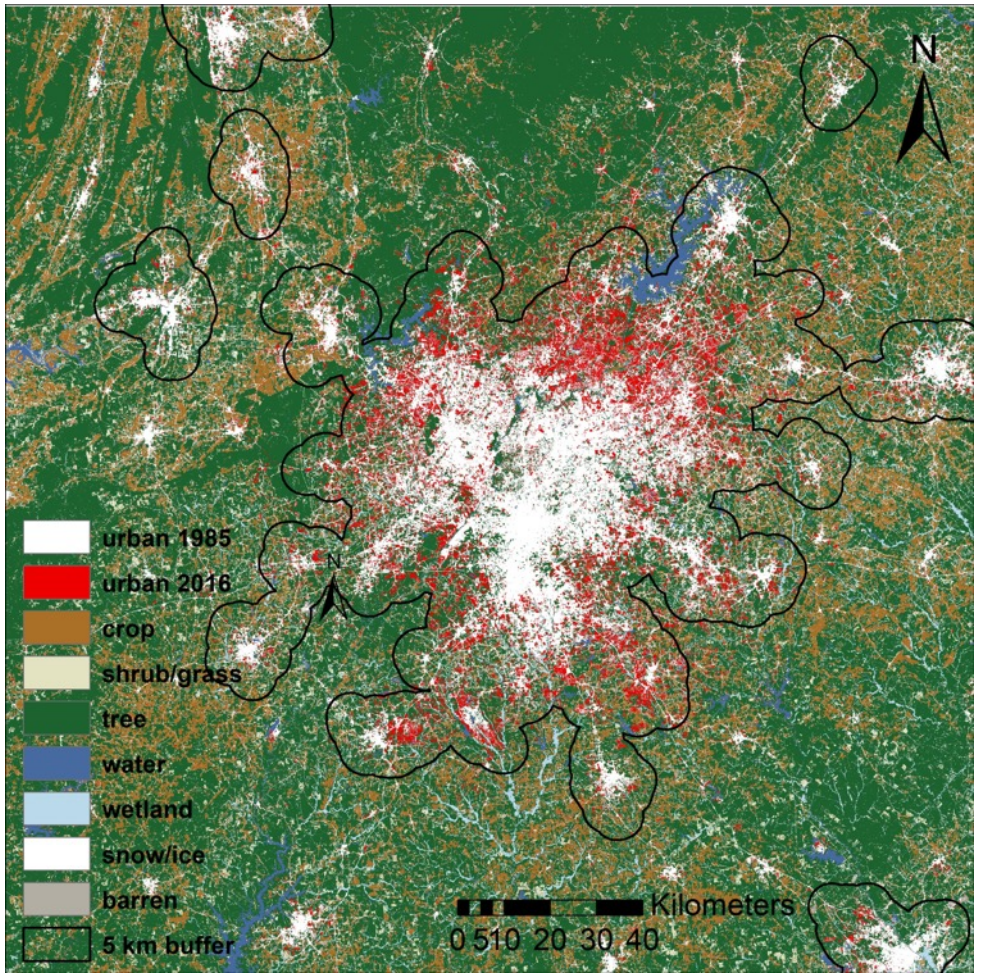
High-Resolution Image and LST in Atlanta (2016): The Airport Has a High LST



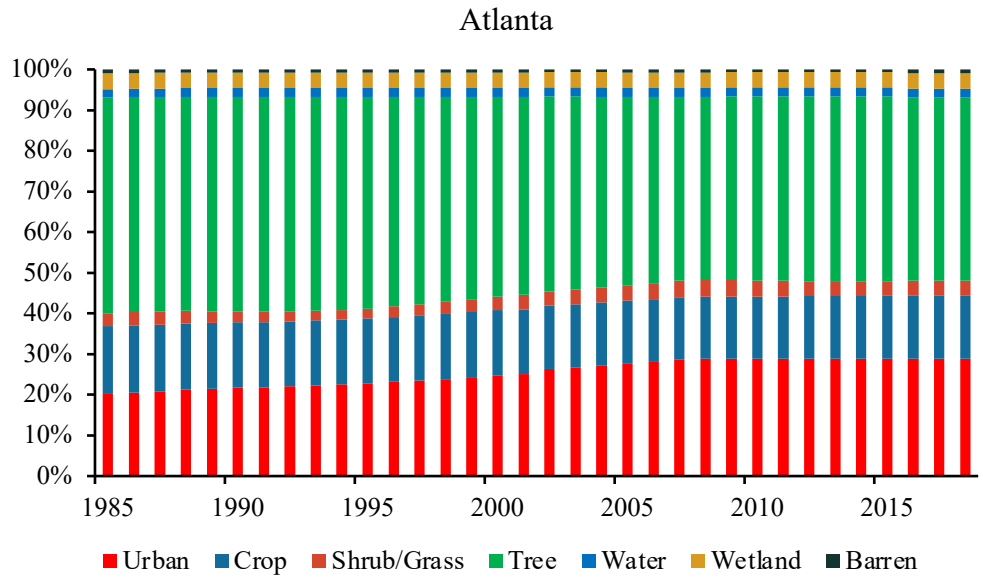


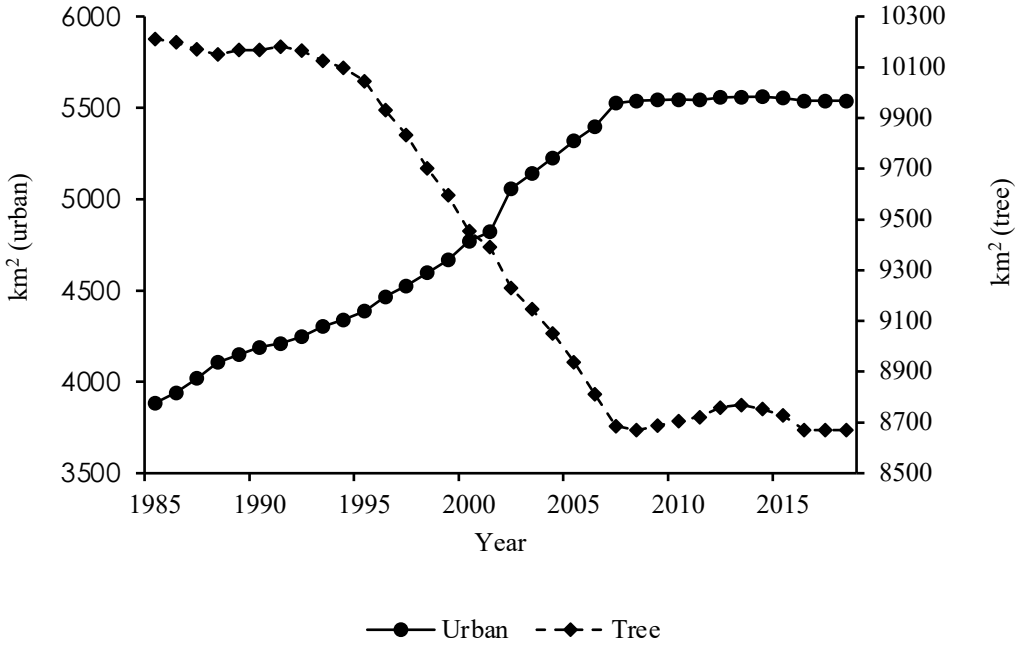
Annual Land Cover Change in the Atlanta Area



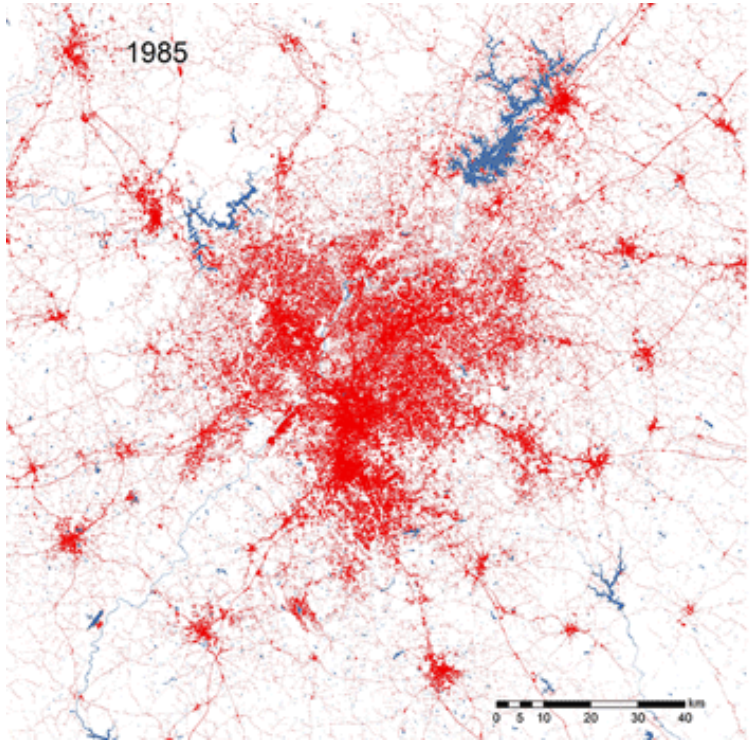


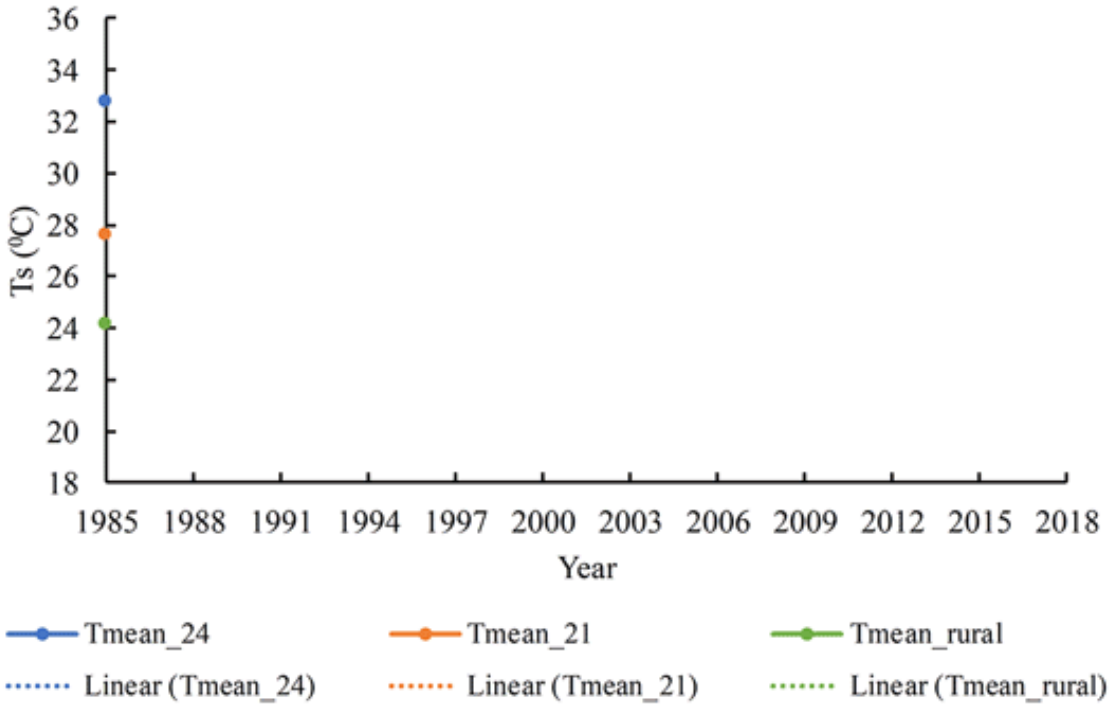
Land Cover Change in Atlanta: Urban Growth by Consuming Forest Land





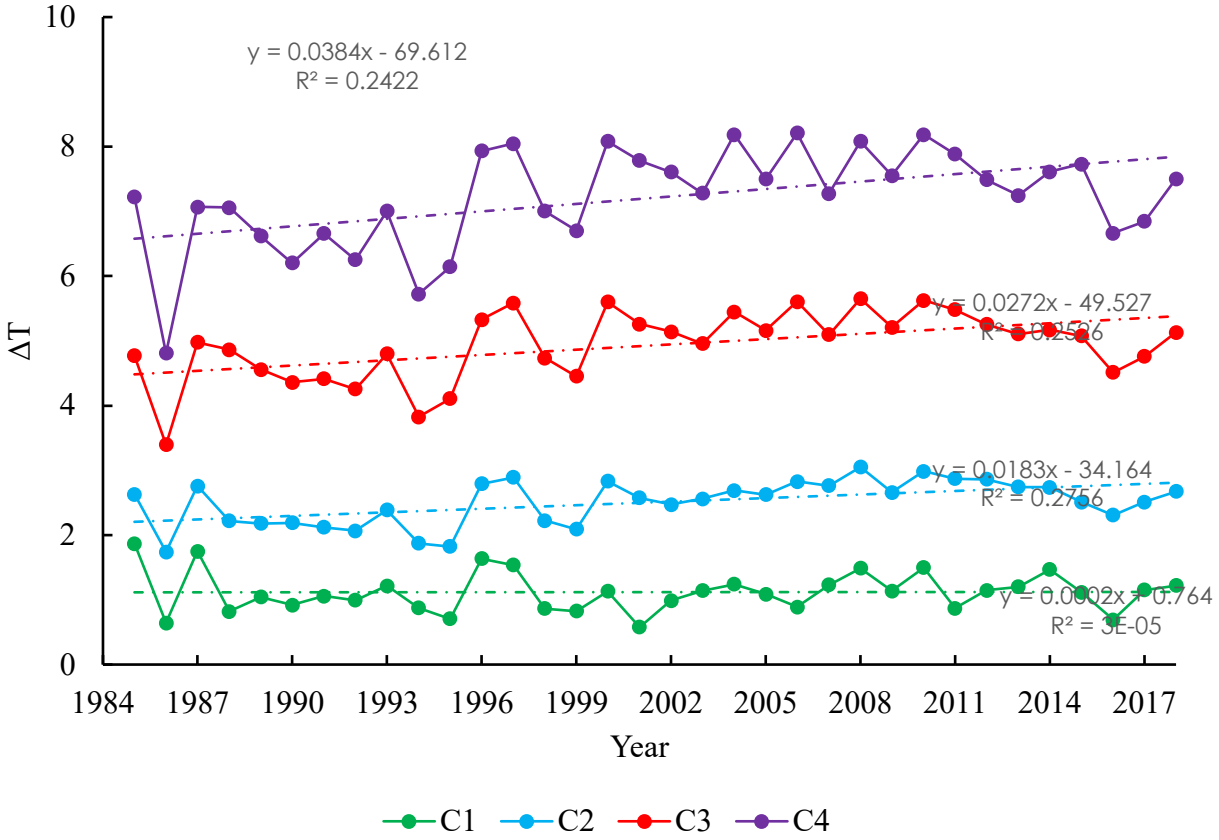
Land Cover and LST Change in Urban Atlanta, GA

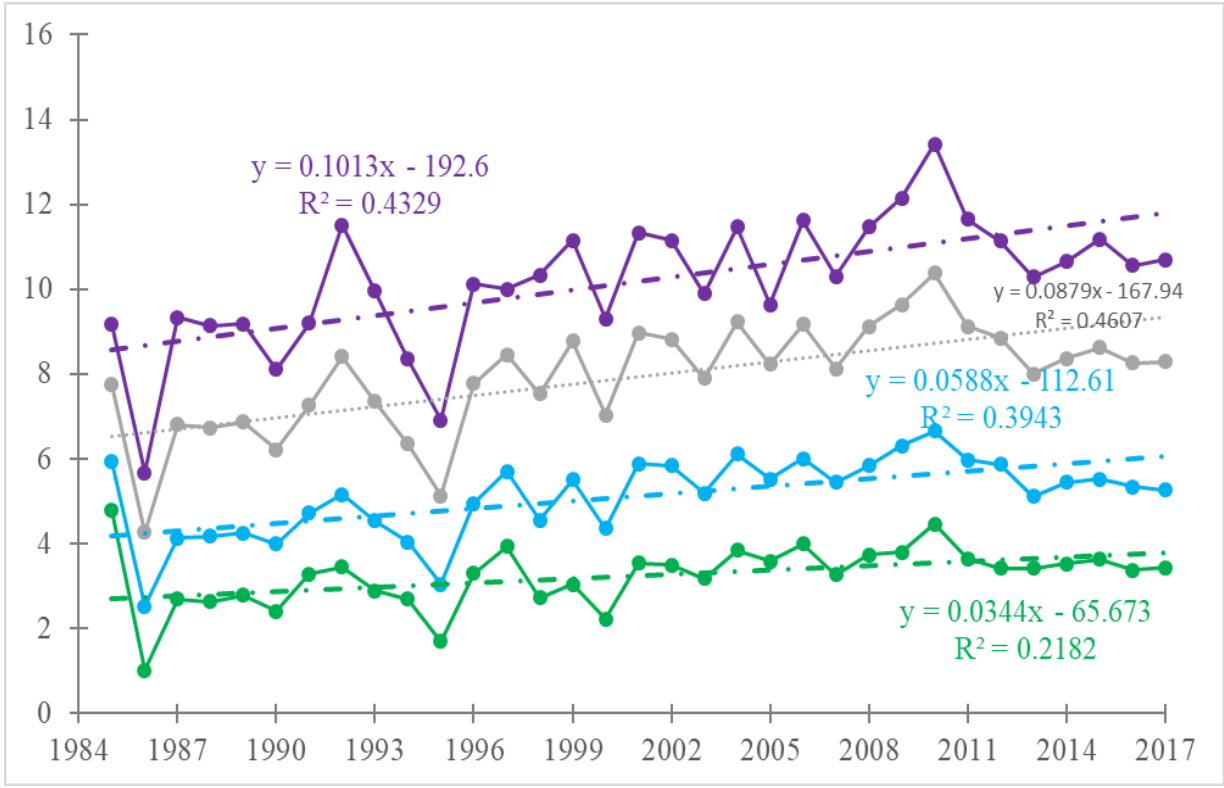


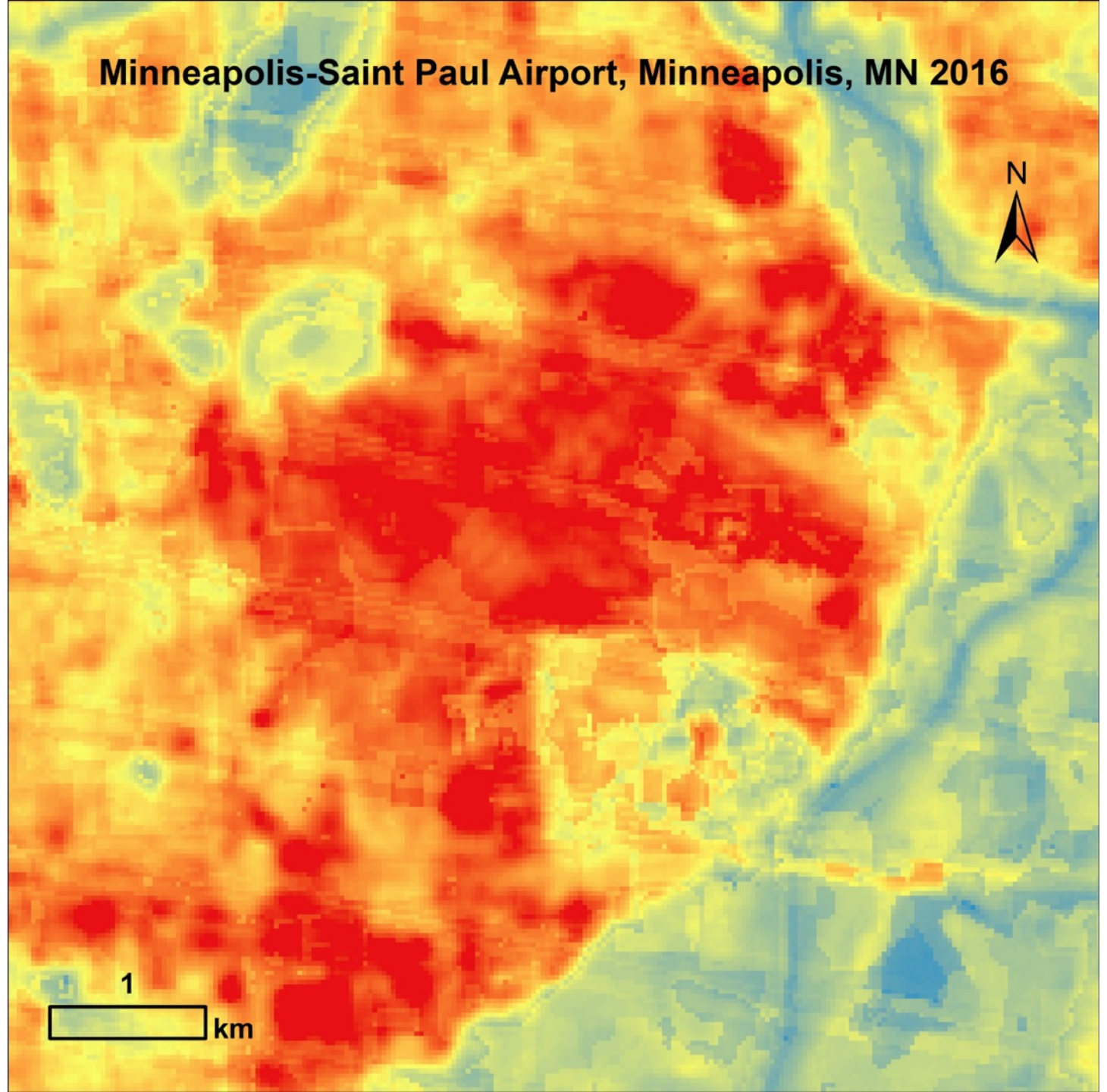


The temporal changes of surface temperature in different urban and non-urban lands. Tmean_24 is T-mean of developed, high intensity of urban; Tmean_21 is T-mean of open space development.

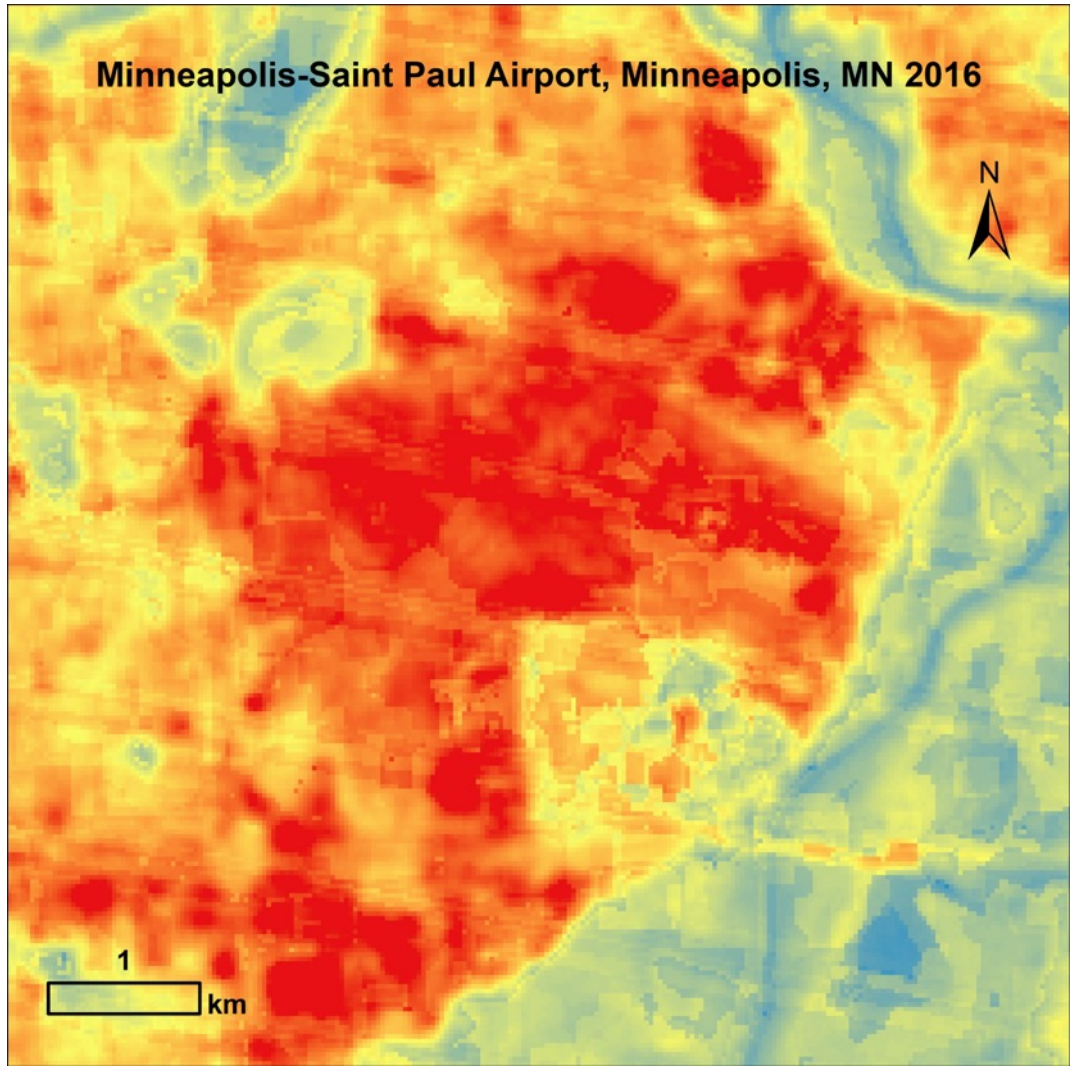
UHI Intensity Trends Quantified from T-Mean and T-Max



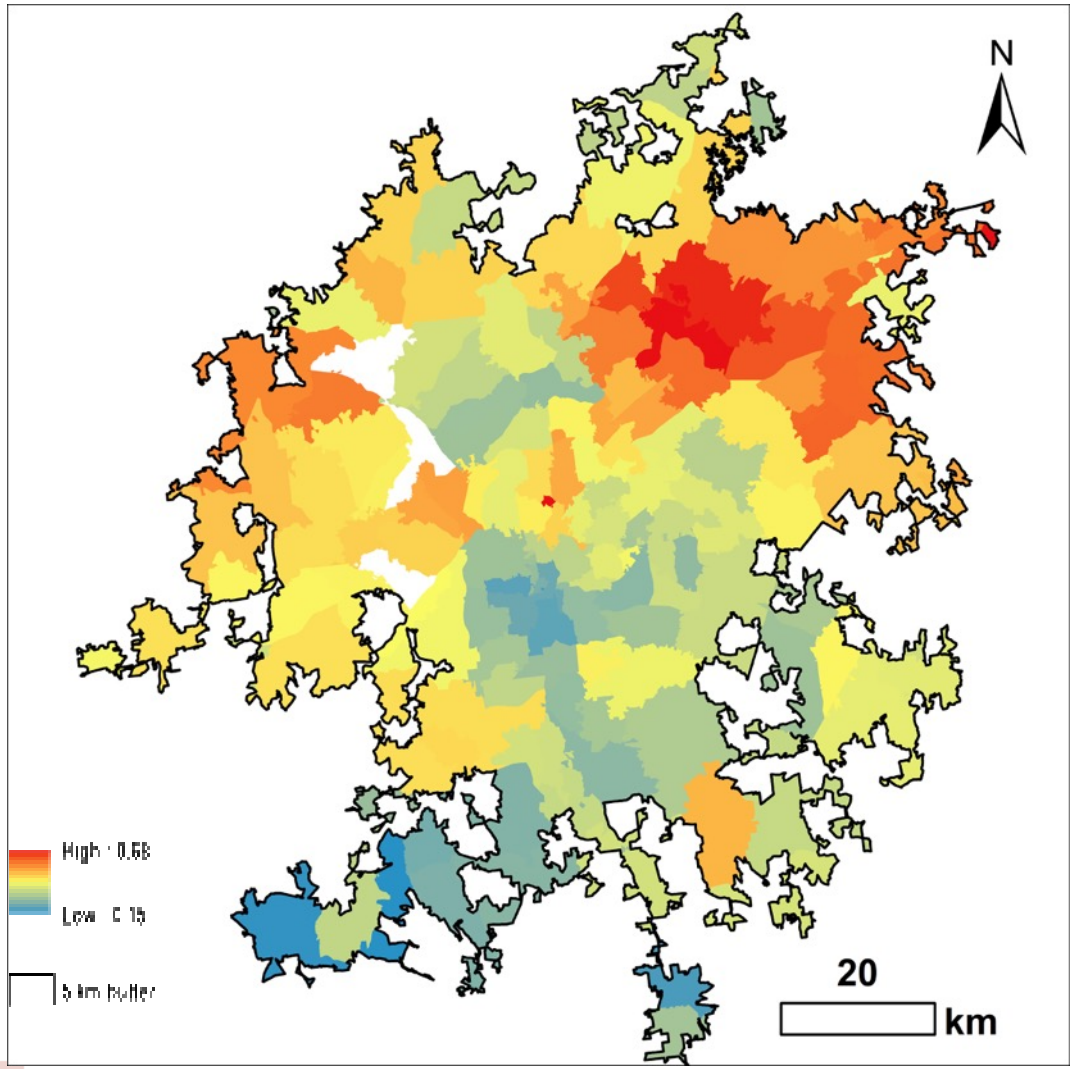


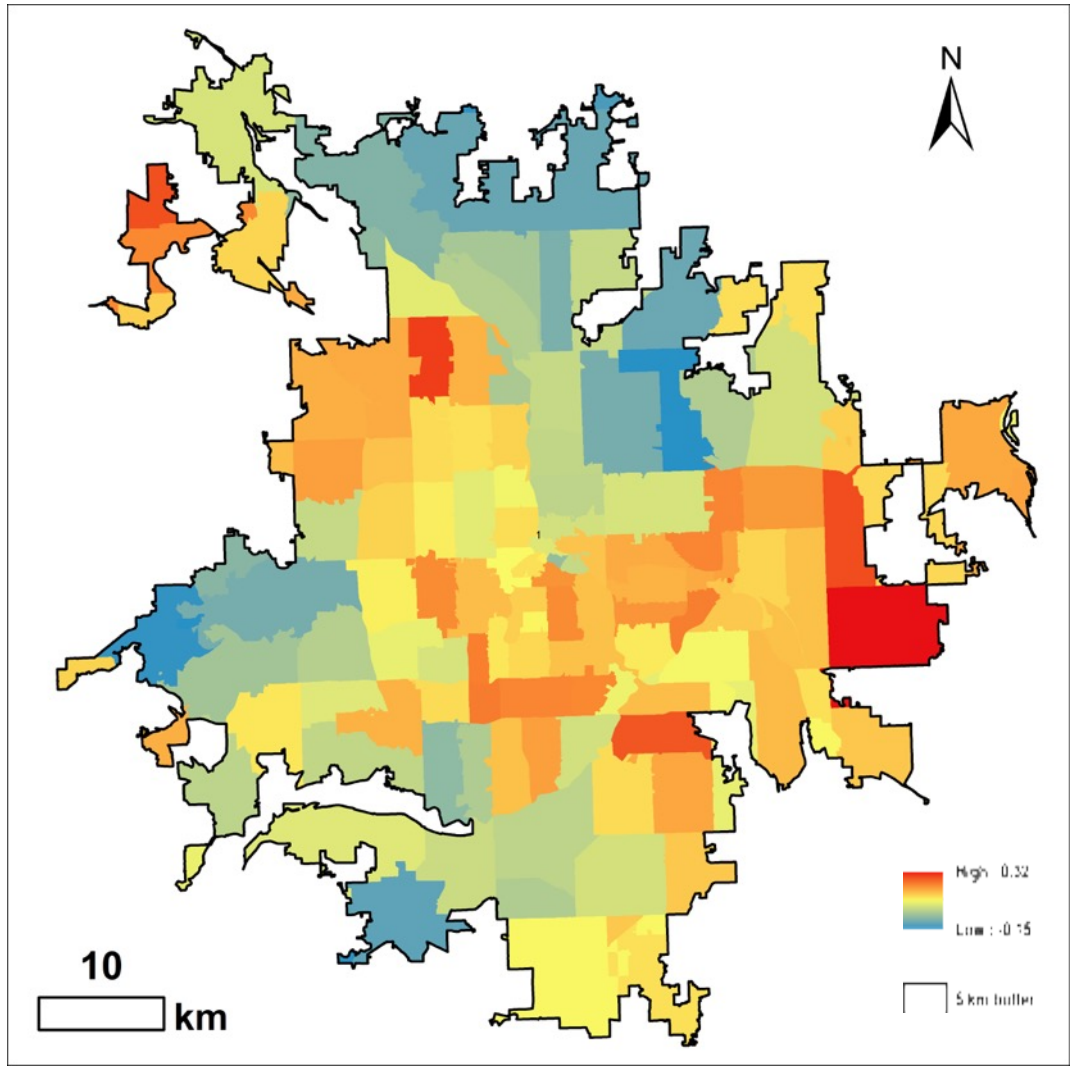

Minneapolis-Saint Paul Airport, Minneapolis, MN 2016
N
1
km

High-Resolution Image and LST in Minneapolis (2016): The Airport Has a High LST but Not the Surrounding Neighborhoods

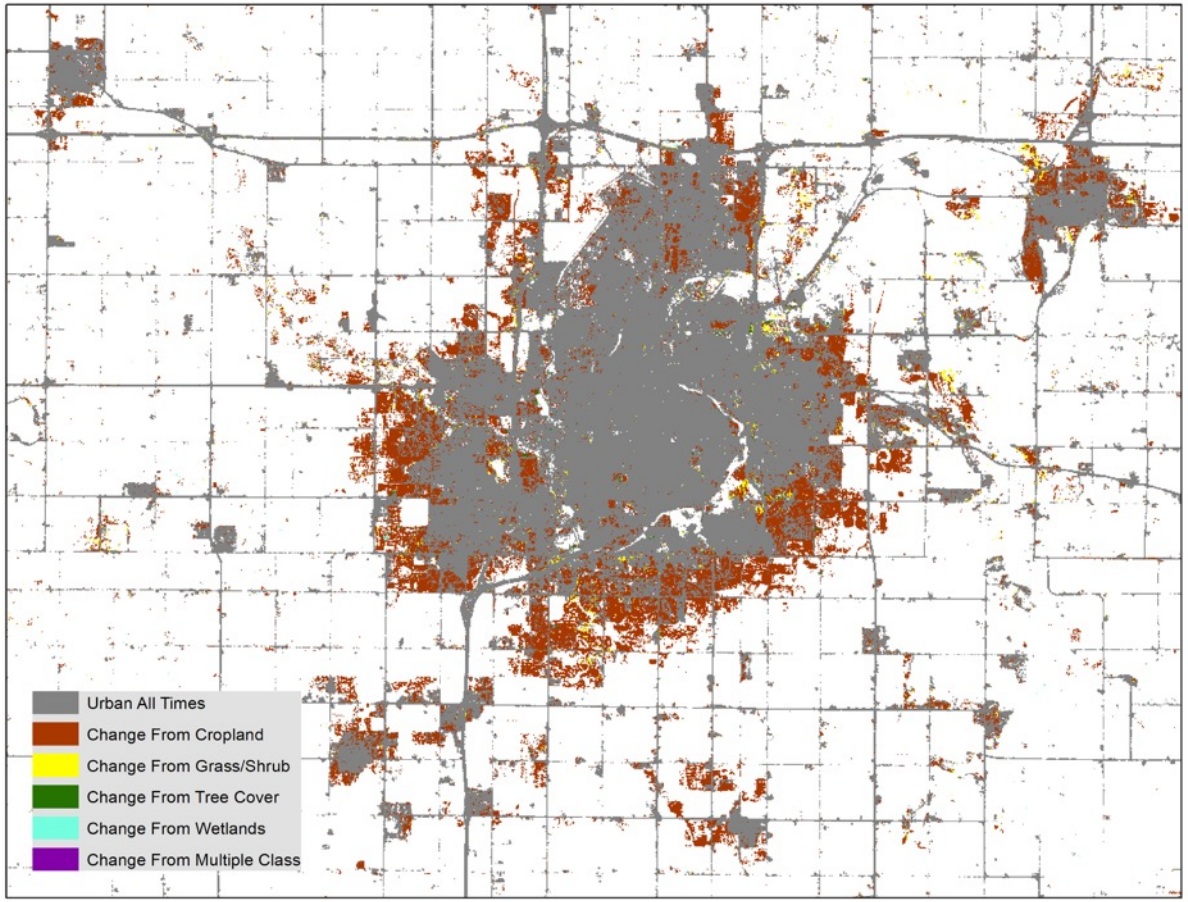


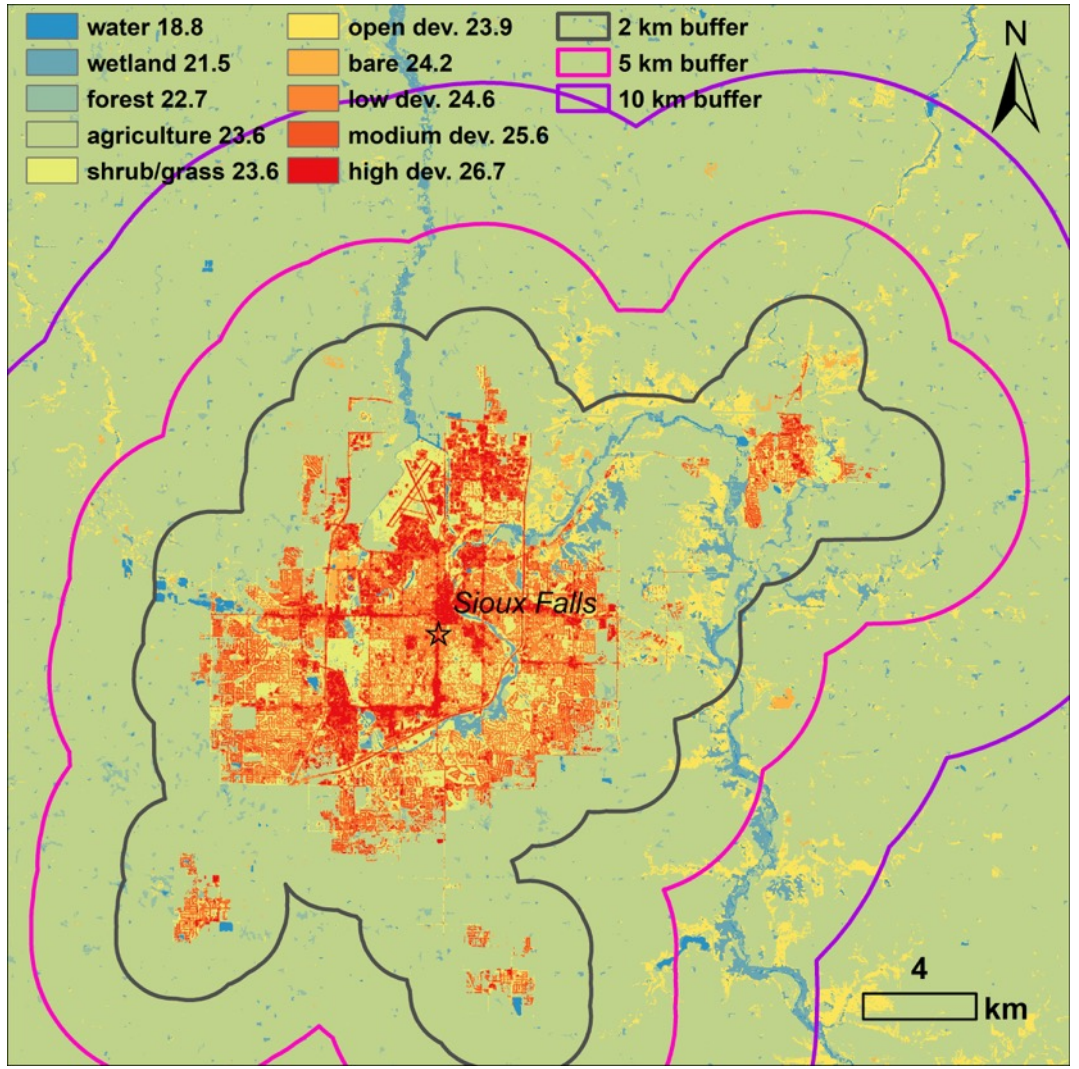
LST Temporal Trends in Atlanta (Left) and Minneapolis (Right) Averaged by US Census Tract

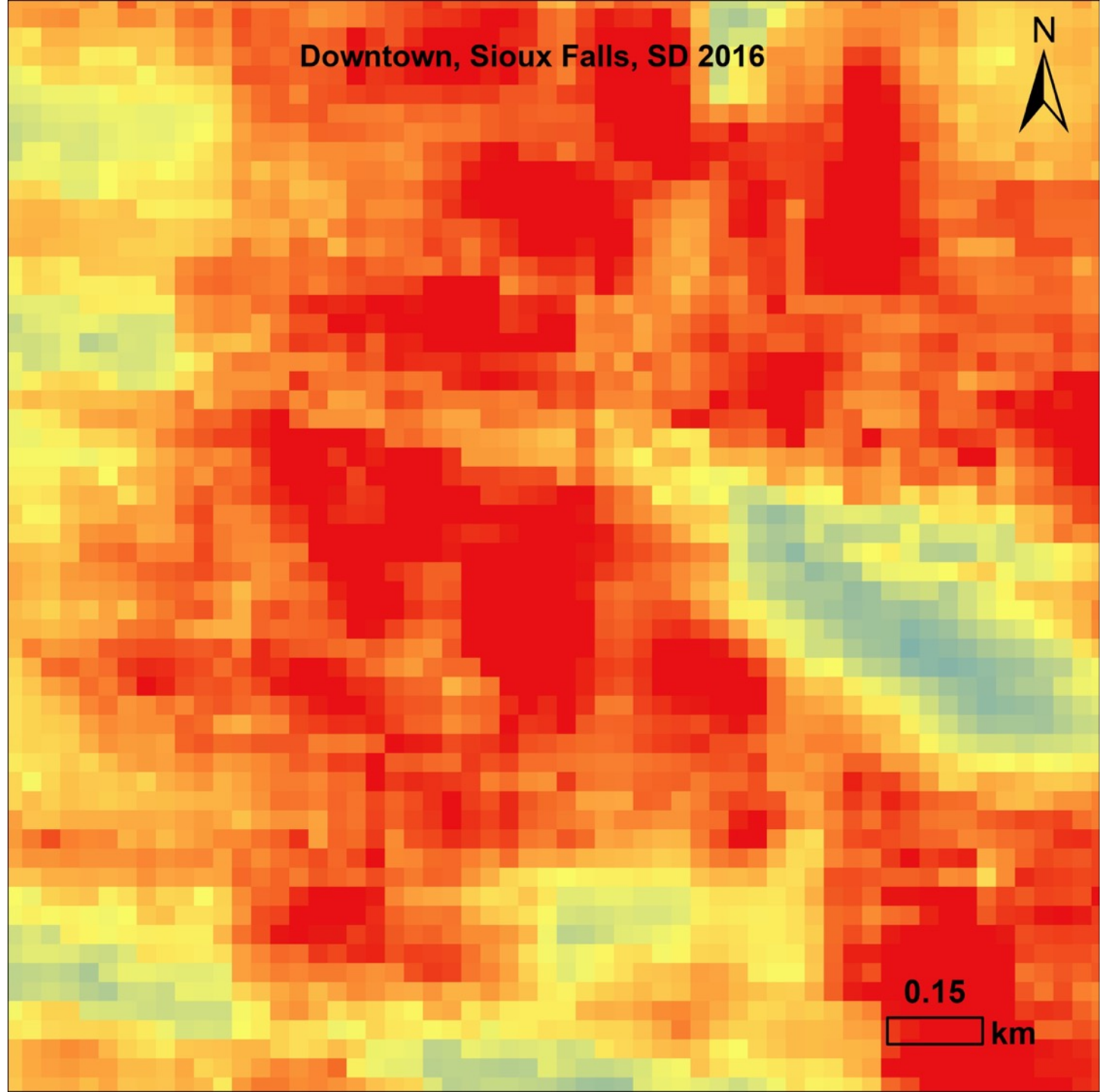




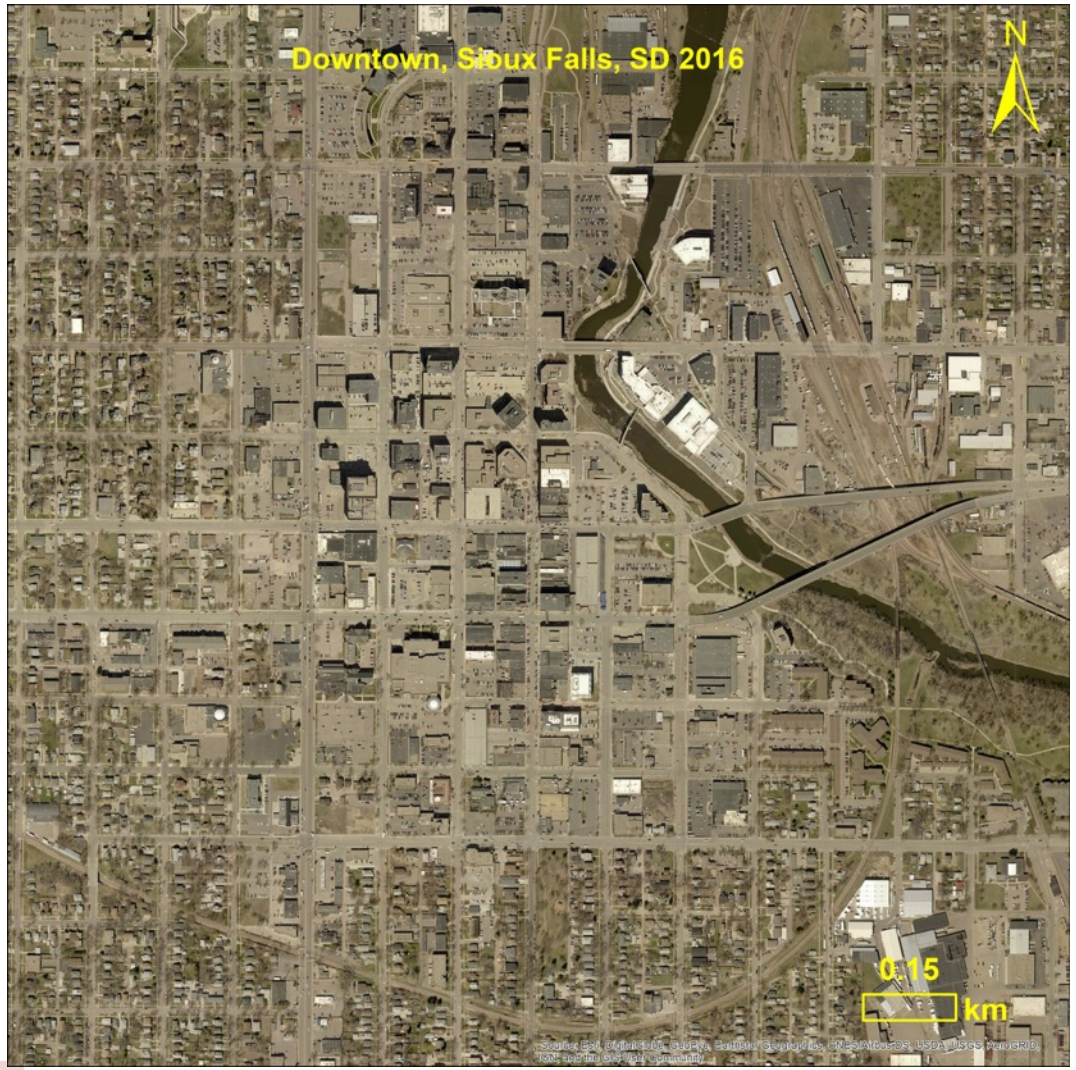
Urban Development and LST in Sioux Falls, SD

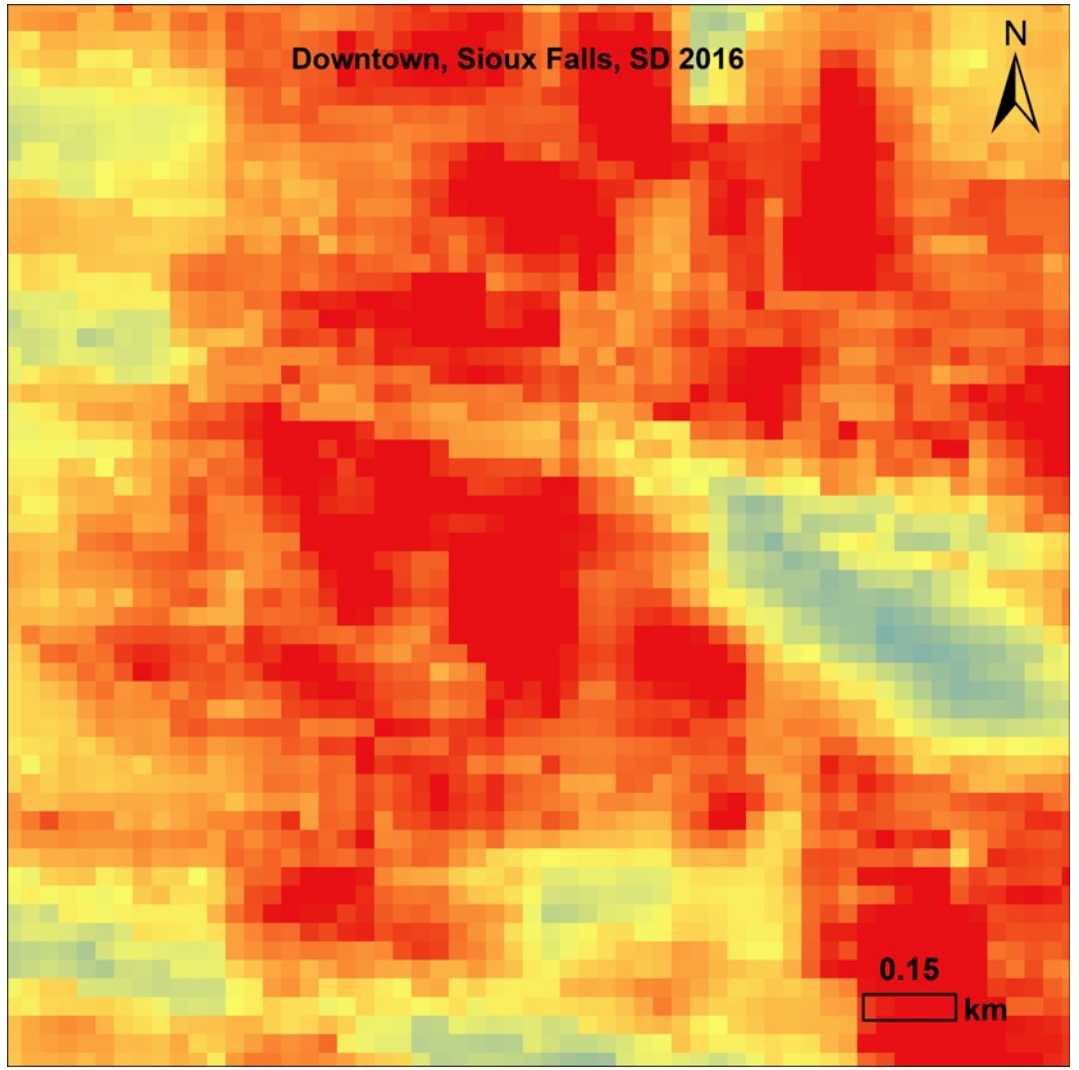




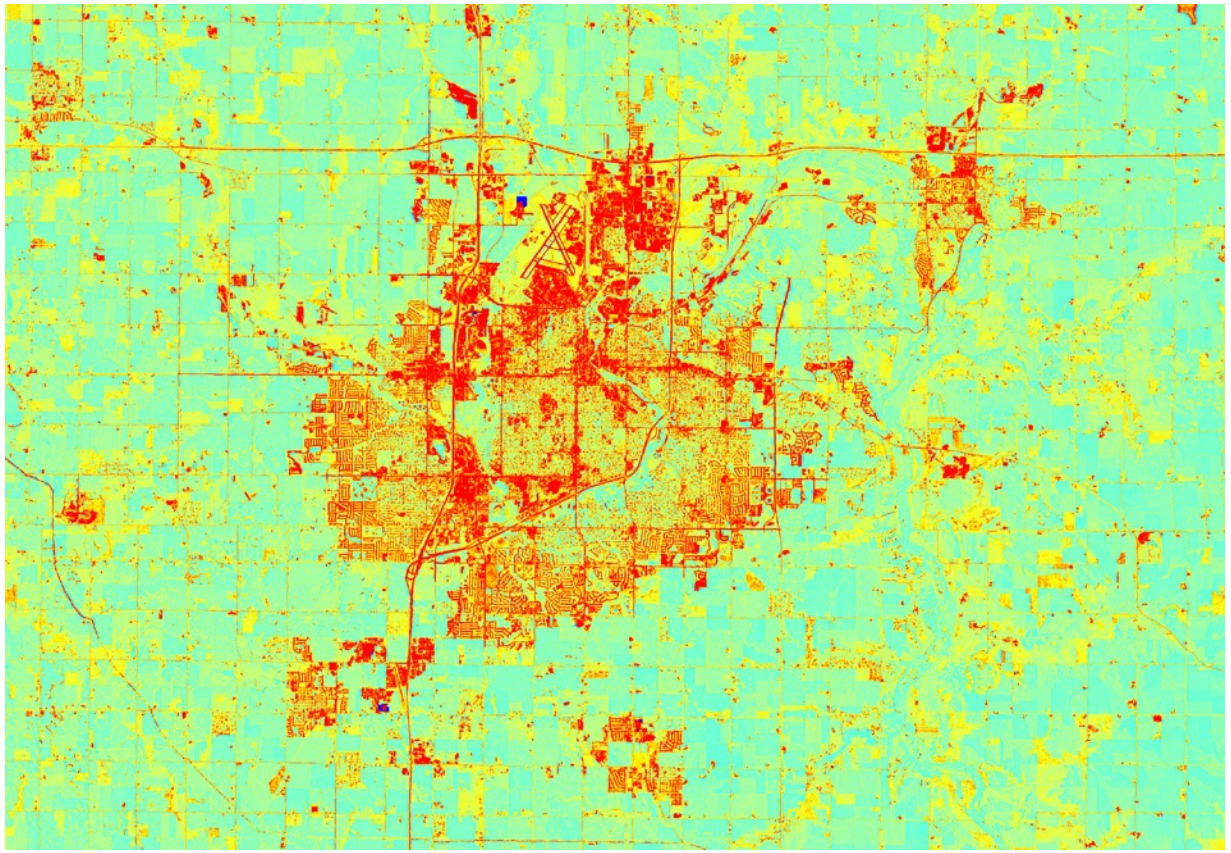

Downtown, Sioux Falls, SD 2016
N
0.15
km

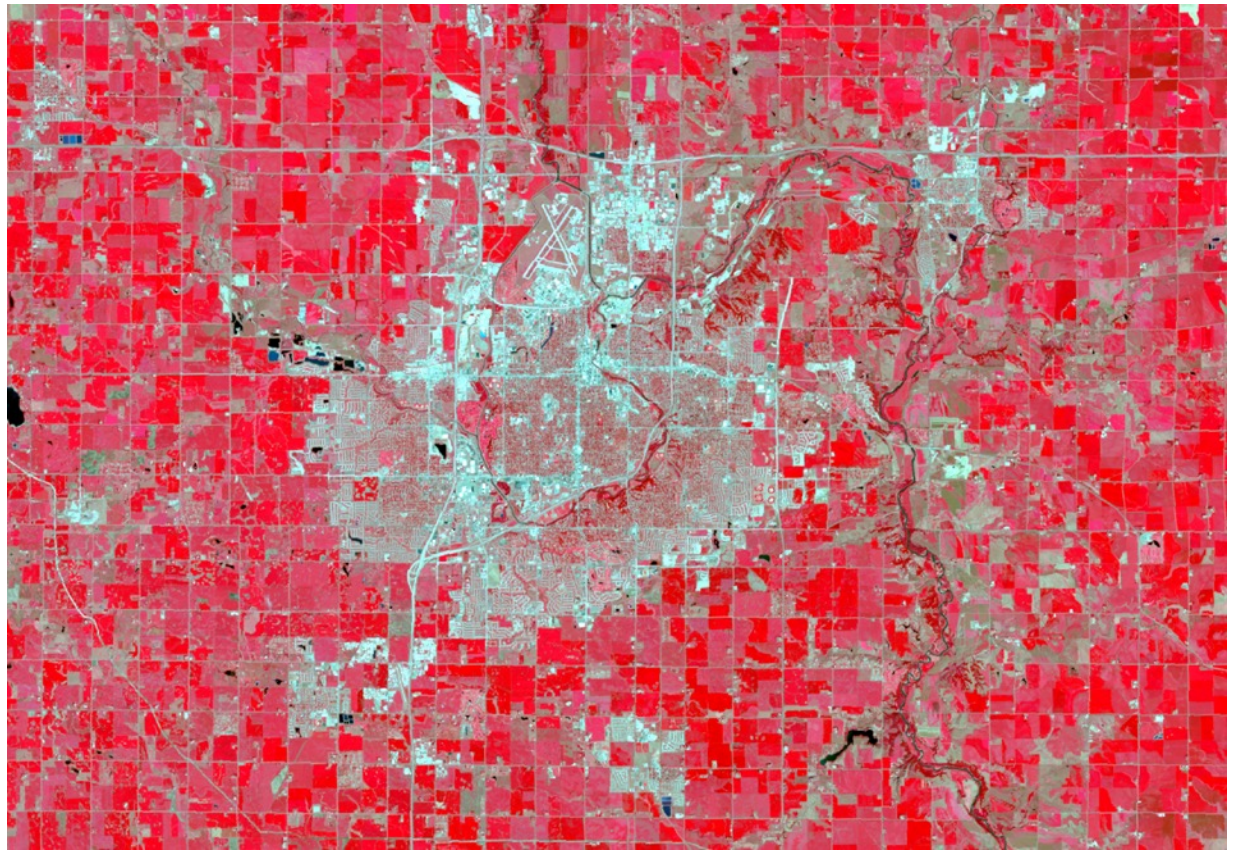
High-Resolution Image and LST in Sioux Falls, SD (2016)



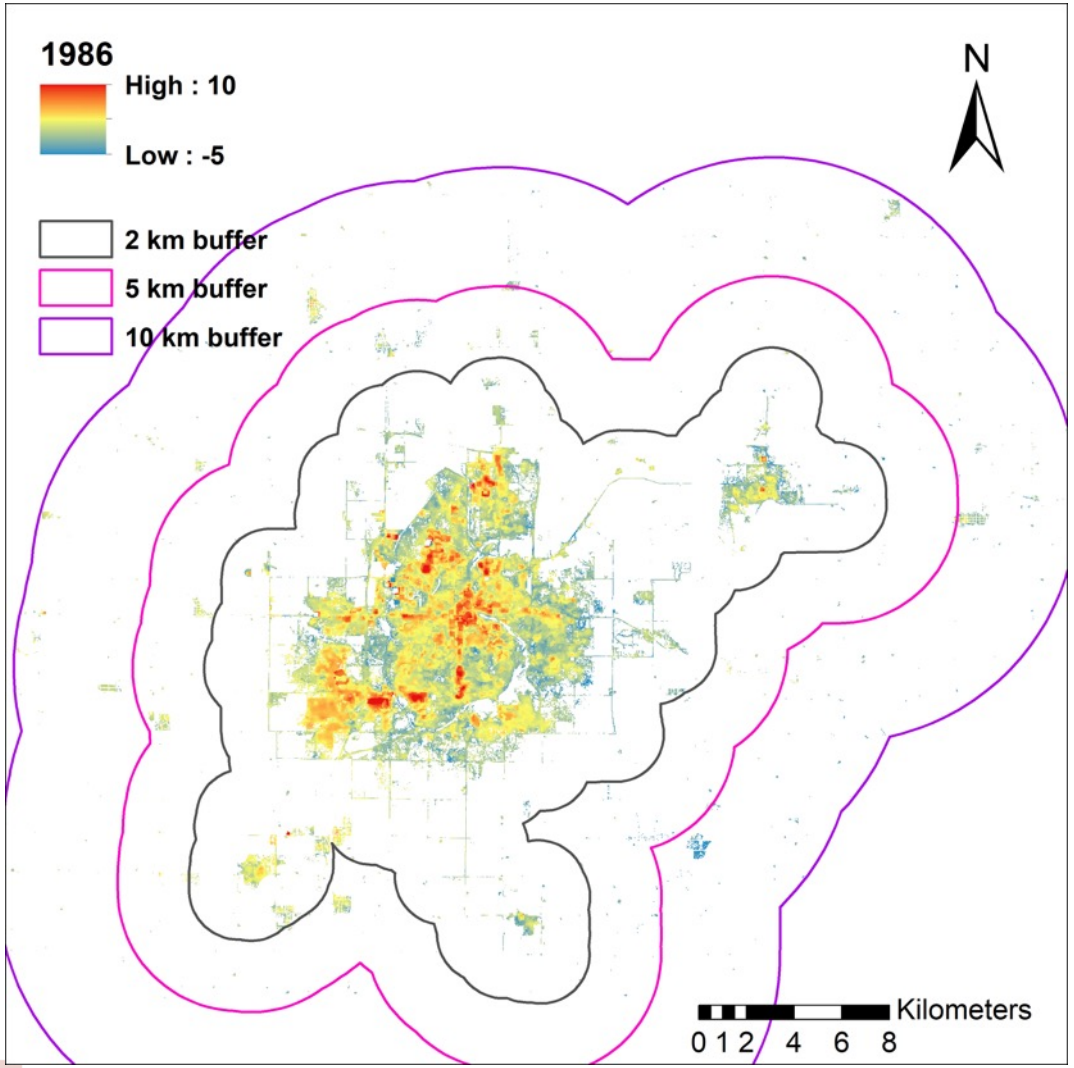


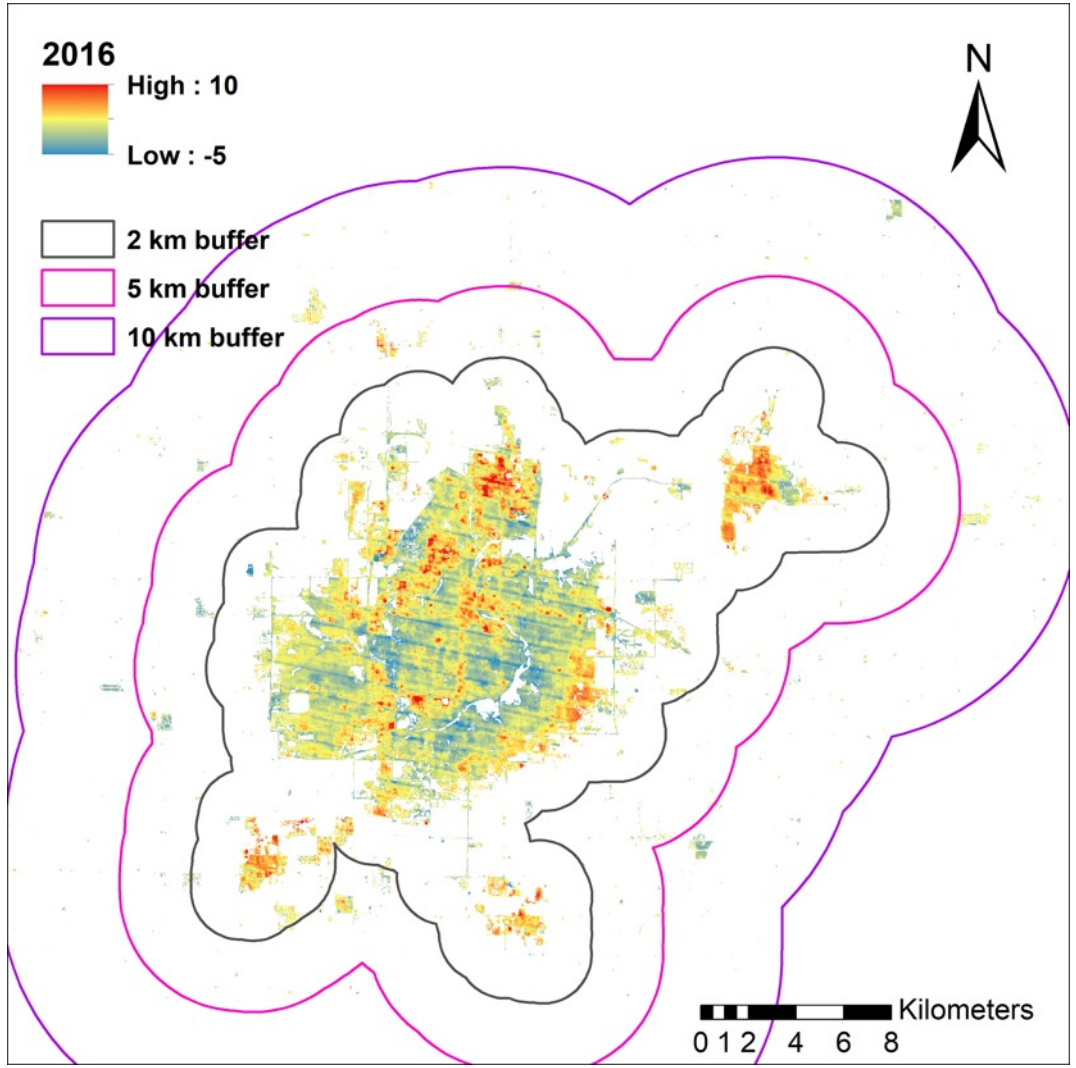
Surface Temperature Distribution in Sioux Falls, SD



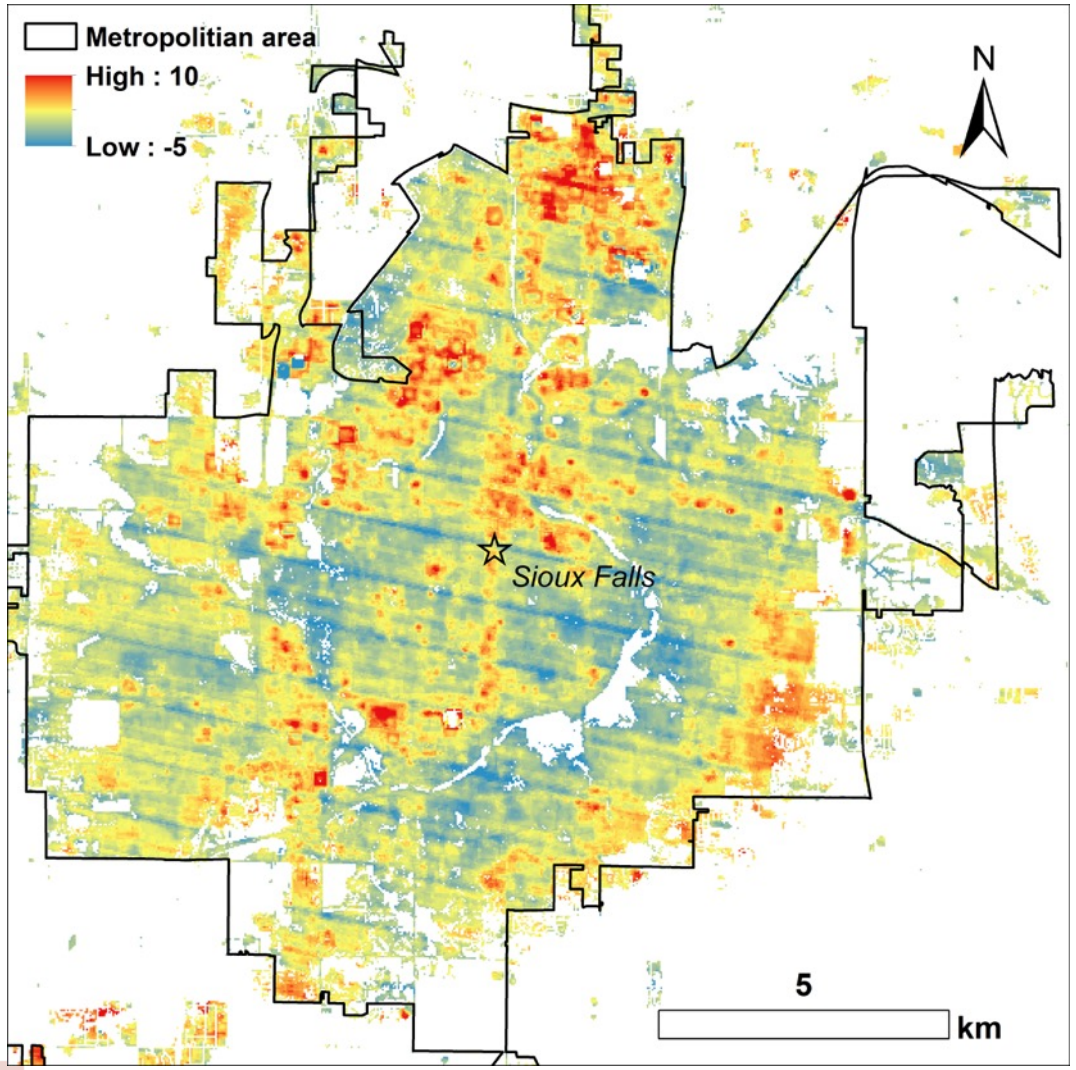


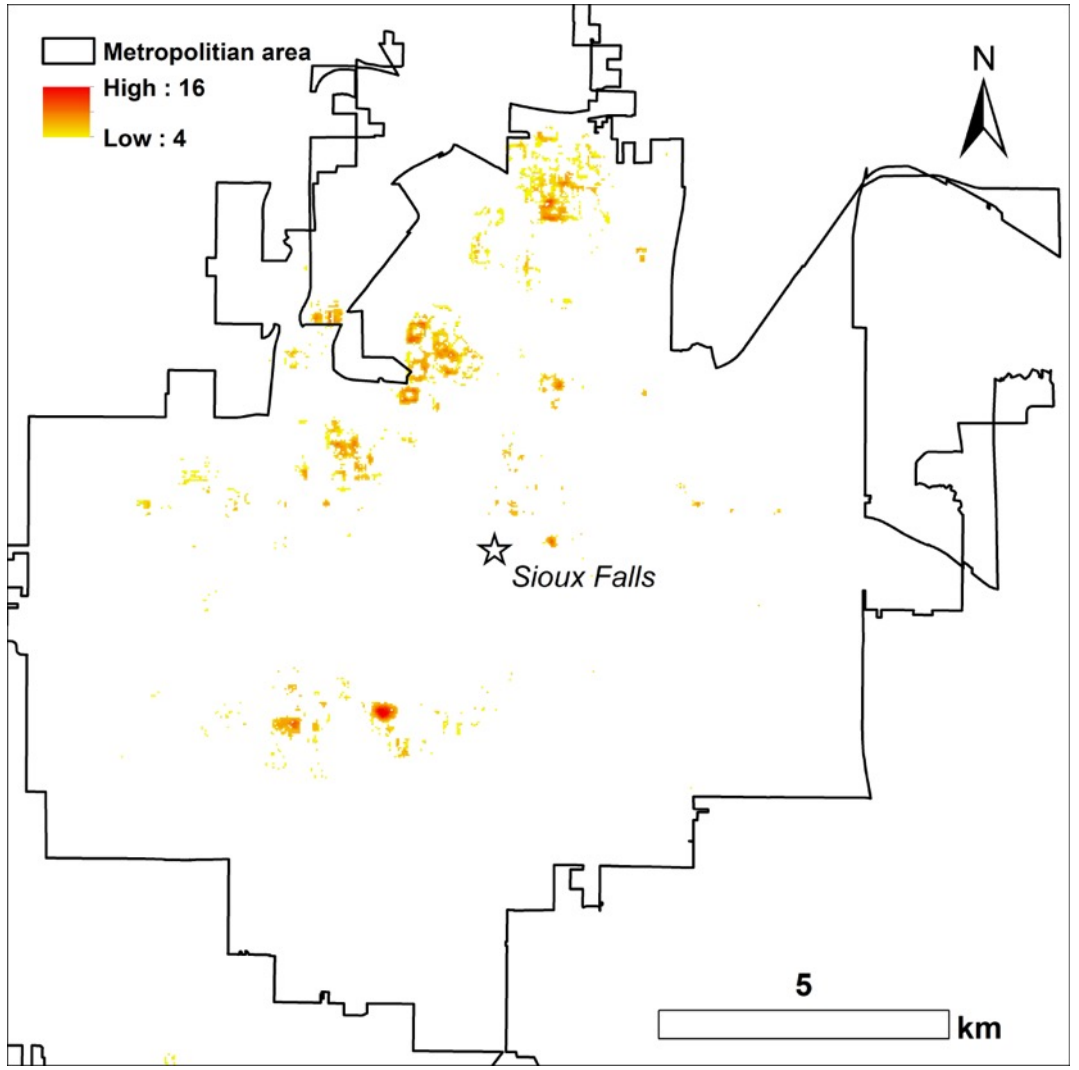
UHI Intensity in 1986 vs. 2016



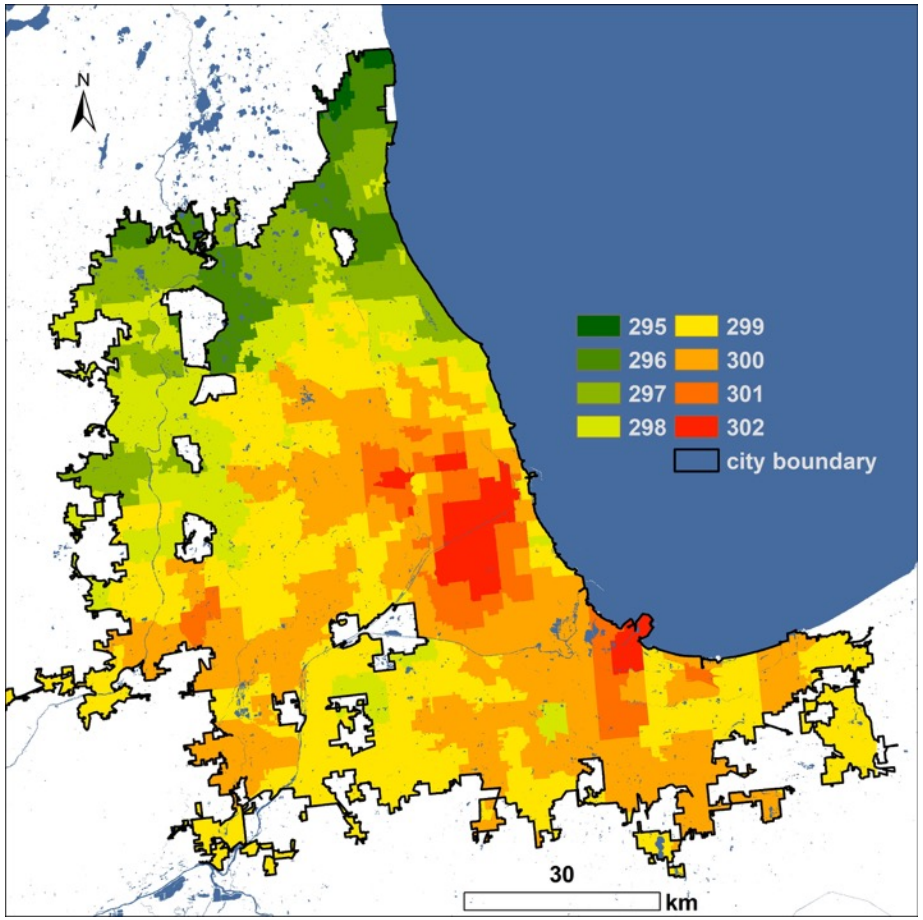


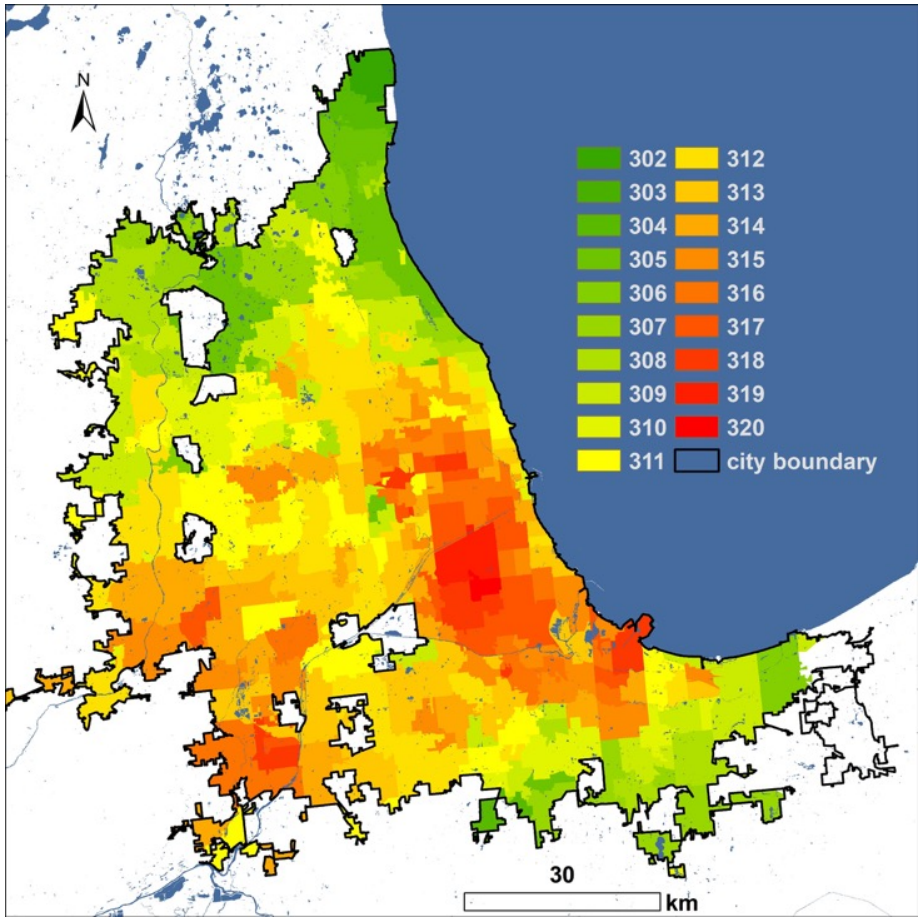
UHI Intensity and Hotspots in Downtown Sioux Falls



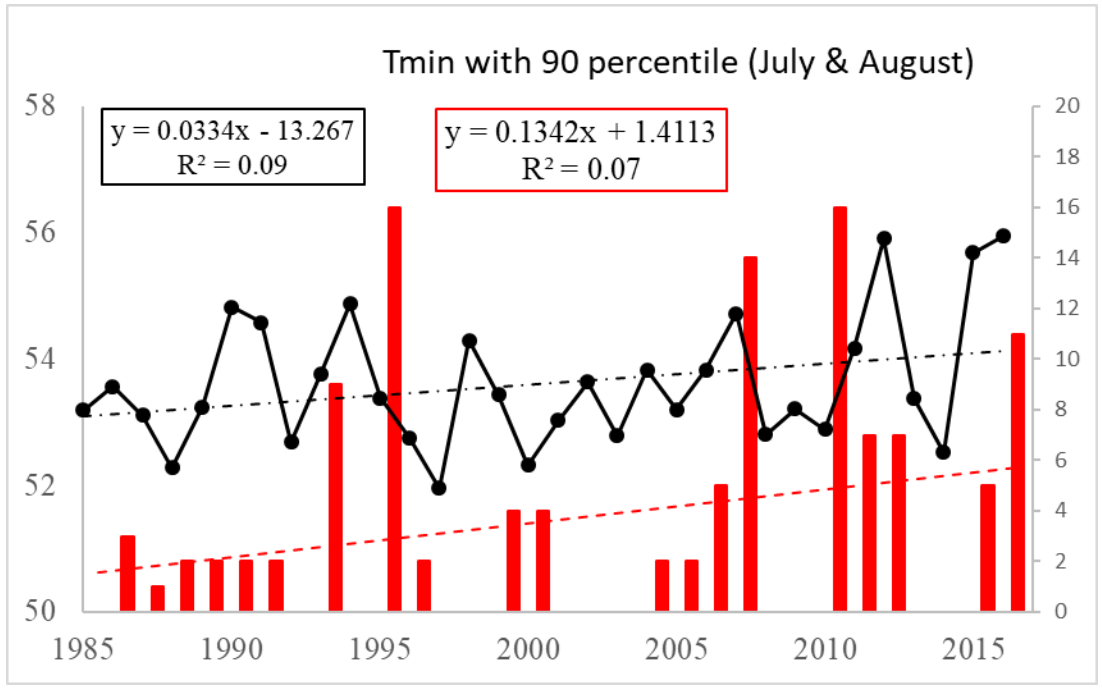


More Thermal Sensors: Mean LST in Different Zip Codes from Ecostress (Left) and Landsat (Right) – July 5, 2020

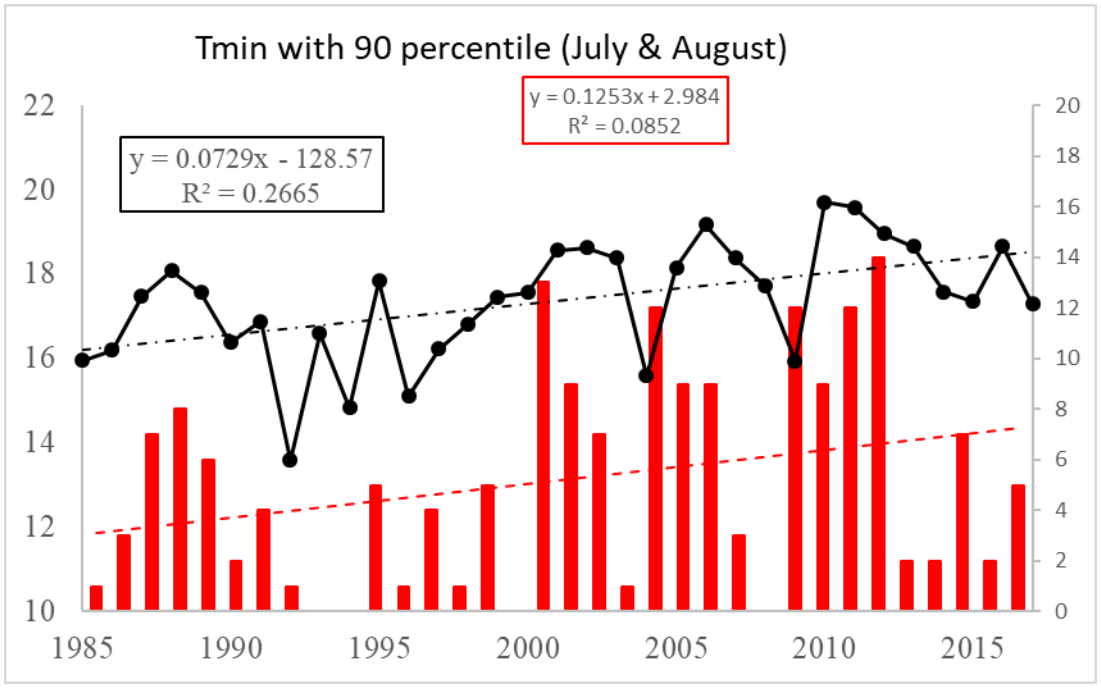




Minimum Air Temperature and 90th Percentile Hot Days in July and August



Atlanta



Minneapolis

The Land Surface Temperature product has been produced for targeted cities and is publicly available in the USGS ScienceBase.

Land surface thermal feature (Tmean) change monitoring in urban and urban wild land interface in Minneapolis, MN from 1985-2018 (version 2.0)

View

Dates

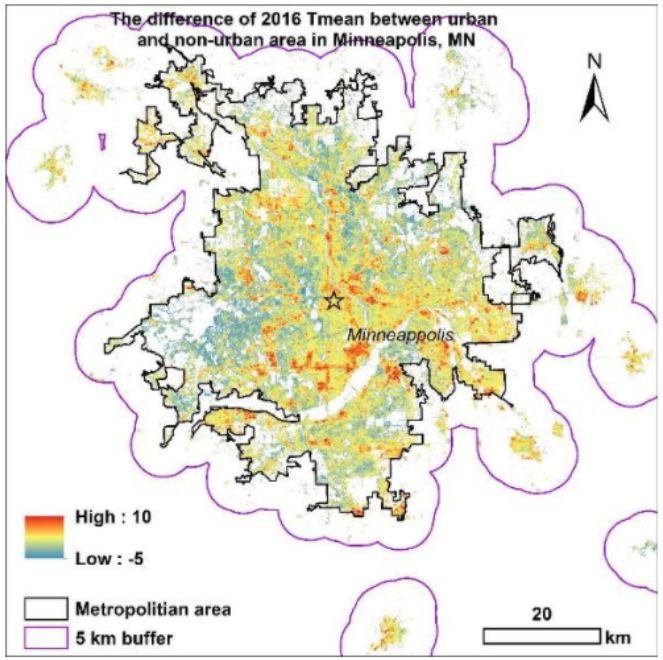
Publication Date : 2019-11-01
Start Date : 1985
End Date : 2018
Revision : 2020-08-20

Citation

Xian, G.Z., and Shi, H., 2020, Land surface thermal feature change monitoring in urban and urban wild land interface (ver. 2.0, August 2020): U.S. Geological Survey data release, https://doi.org/10.5066/P9H6E1FZ.

Summary

We developed an approach to quantify Urban Heat Island (UHI) extent and intensity in Minneapolis, MN and its surrounding area by using surface temperature from Landsat surface temperature products in a time series manner. Landsat land surface temperature data from Landsat Analysis Ready Data (ARD) were used to quantify surface temperature changes from 1985 to 2018. The current study assessed UHI intensity and its variations associated with urban development on an annual basis. This dataset, over the study period, show that the mean surface temperature in the high intensity urban area significantly increased while no significant trend was found in surrounding non-urban areas. The datasets were annual averages of mean temperature at 30 meter spatial resolution.



Map »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Thank You!