Urban Heat and Mitigation Potential in the Kansas City Metropolitan Area:

Insights from Integrated Numerical Modeling and Heat Mapping

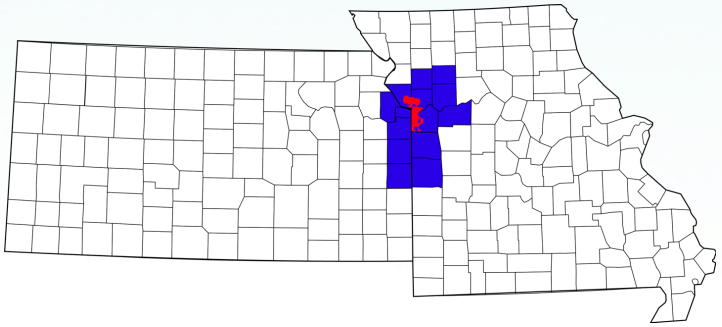
Fengpeng Sun

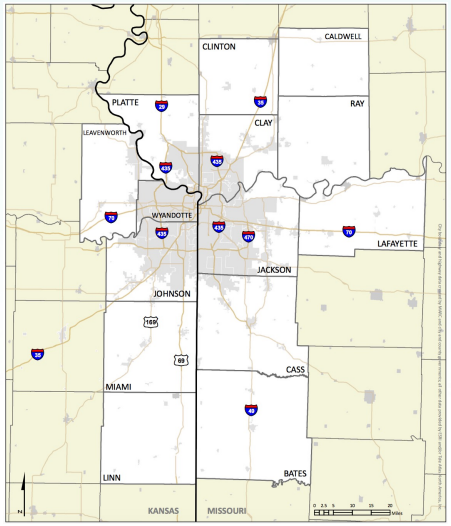
Earth and Environmental Sciences

University of Missouri–Kansas City (UMKC)

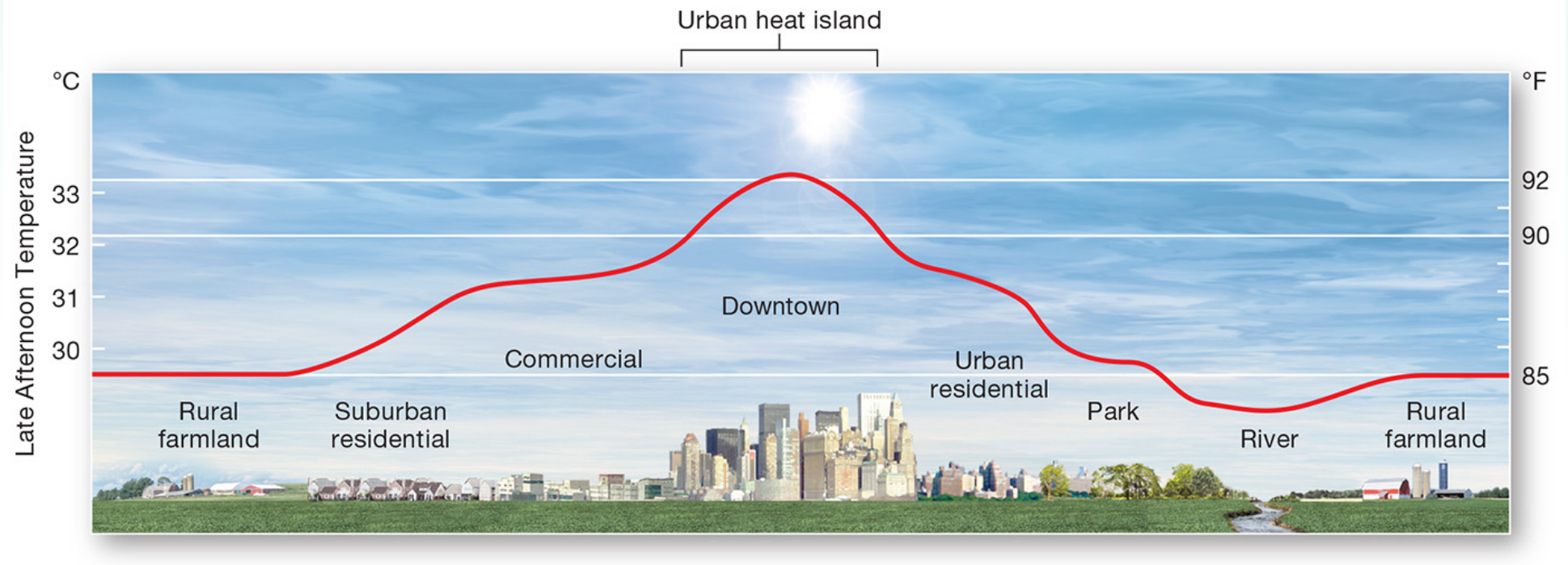
Kansas City Metropolitan Area

Kansas City Metropolitan Area





Kansas City Urban Heat



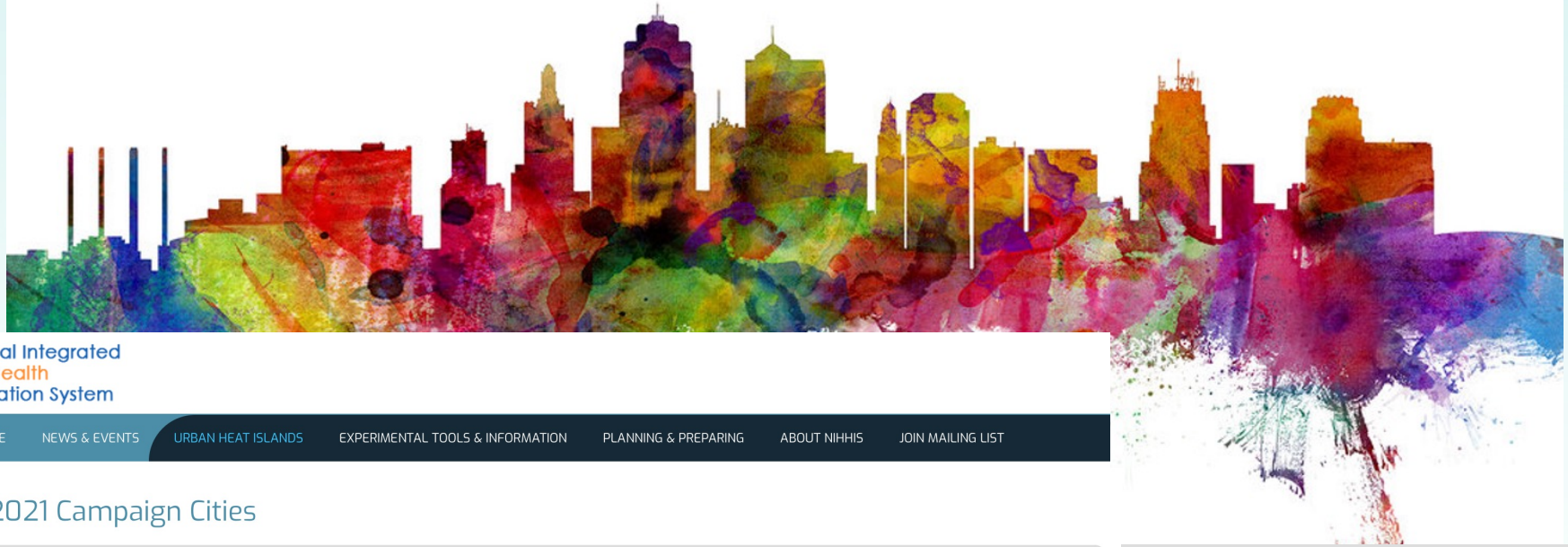
Outline

- Heat Mapping
  - A field heat mapping campaign in KCMO
  - Citizen science project & community engagement
  - Awareness & knowledge

- Numerical Modeling
  - High-resolution WRF/UCM regional climate simulations
  - Sensitivity experiments
  - Heat mitigation potential

- Applications of the results
  - Data sharing with stakeholders, local government, non-profits etc.
  - KCMO Climate Protection and Resiliency Plan
  - Help KCMO secure $12M for Trees from USDA and tree planning

Kansas City
Urban Heat Mapping Campaign



National Integrated Heat Health Information System

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Meet the 2021 Campaign Cities

Kansas City, Missouri

Year: 2021

Campaign Lead Organization(s): University of Missouri–Kansas City Department of Earth and Environmental Sciences

Get Involved:

Fengpeng Sun | sunf@umkc.edu

Lead Organization(s)

University of Missouri–Kansas City Department of Earth and Environmental Sciences

Partner Organizations

- The Kansas City Missouri Office of Environmental Quality
- The Missouri Local Science Engagement Network
- The Mid-America Regional Council
- Missouri Office of the Public Counsel
- Evergy
- Bridging The Gap Inc.
- Kansas City Teen Summit

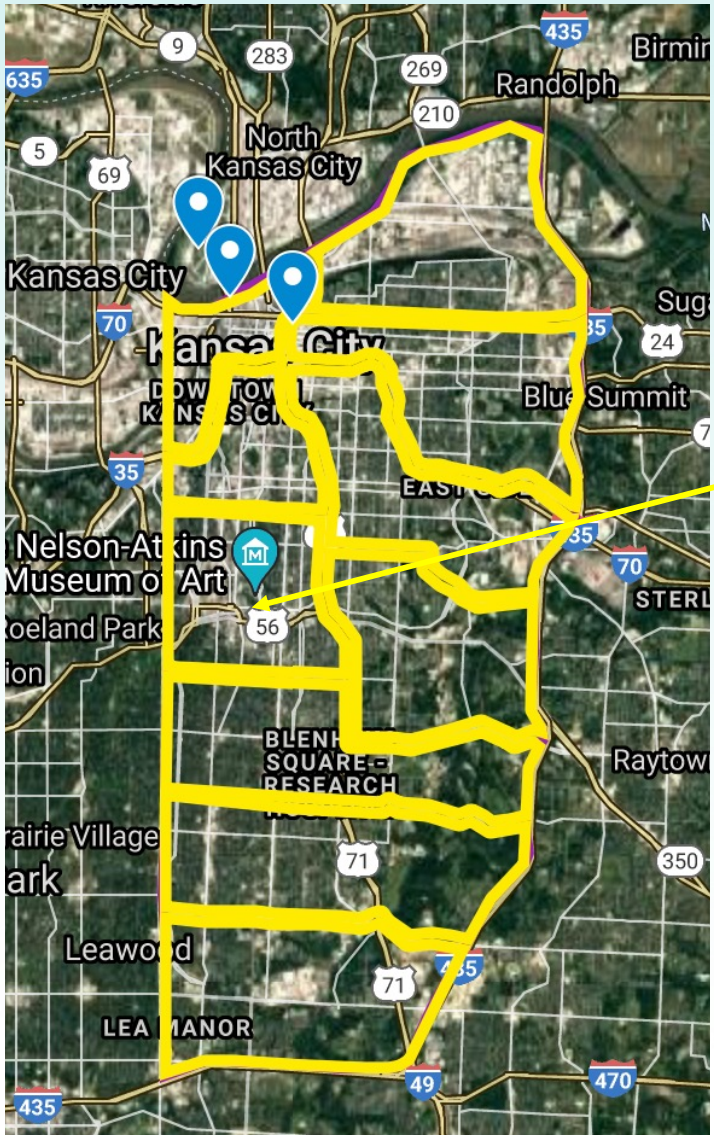
How are data collected?

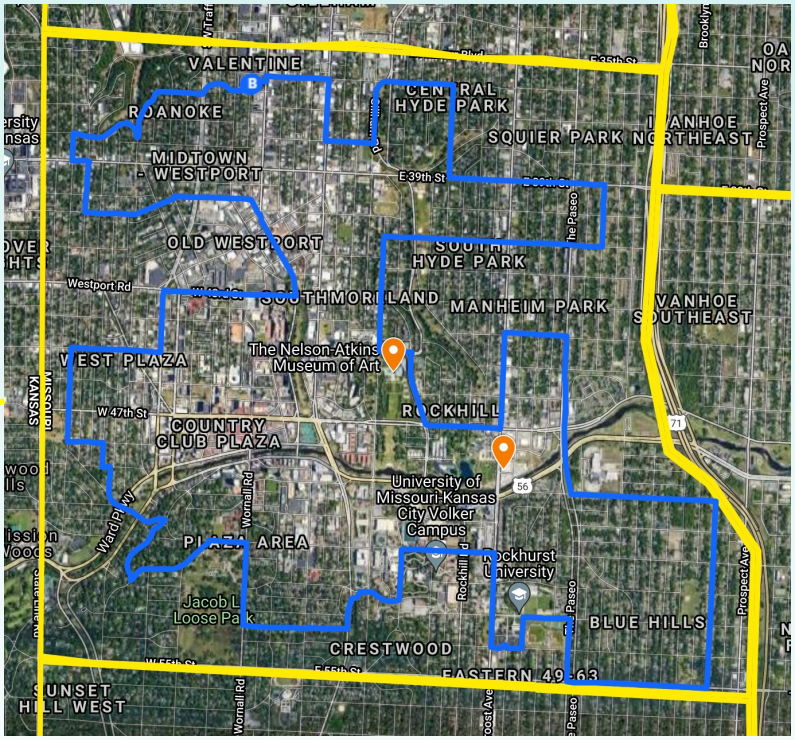
- A heat sensor mounted to the passenger side of a car.
- Recording the ambient temperature, humidity, and GPS every one second as volunteers transport the device through pre-planned routes, or "traverses".

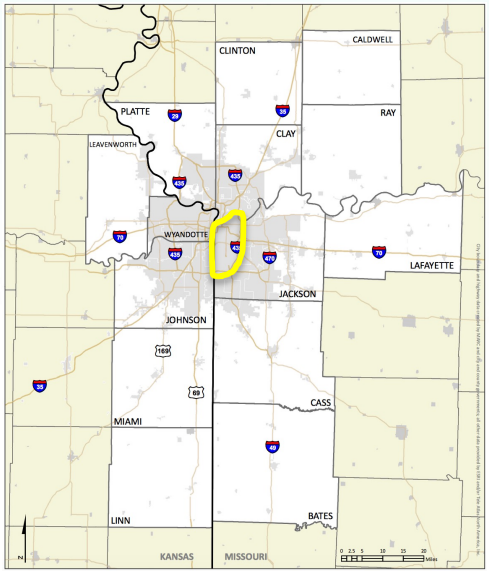
What do campaign volunteers do?

- Collecting data at three times throughout the designated campaign day, ideally the same route for all three shifts.
  - 6-7 a.m.
  - 3-4 p.m.
  - 7-8 p.m.
- Paired drivers & navigators (to help steer drivers) is assigned to a pre-planned routes or "traverses".

Kansas City Urban Heat Mapping
Campaign traverses (10)

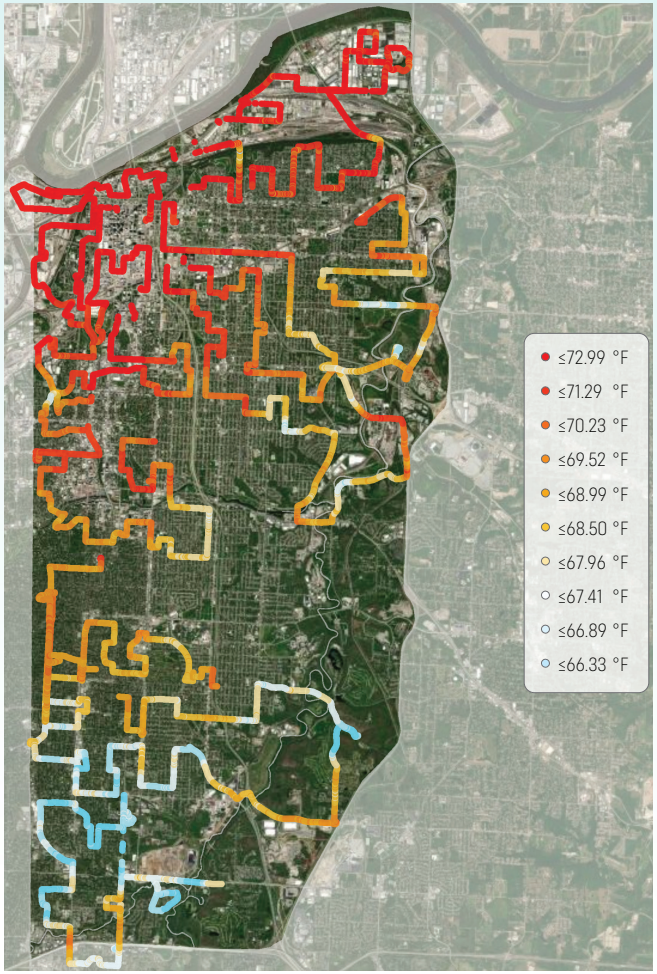




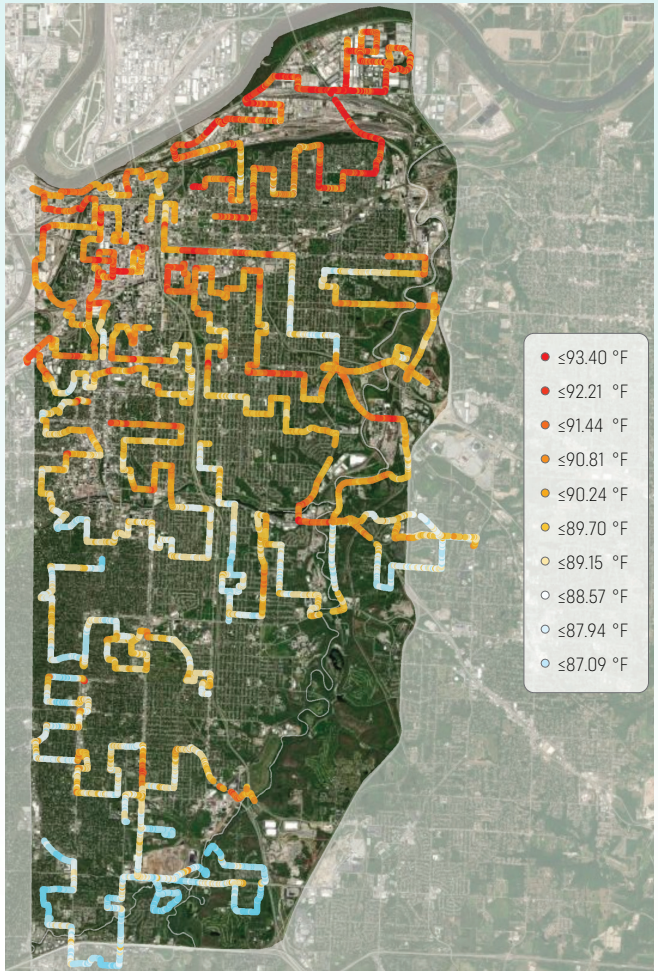


Kansas City Urban Heat Mapping
raw data for temperature
(traverse point measurements)

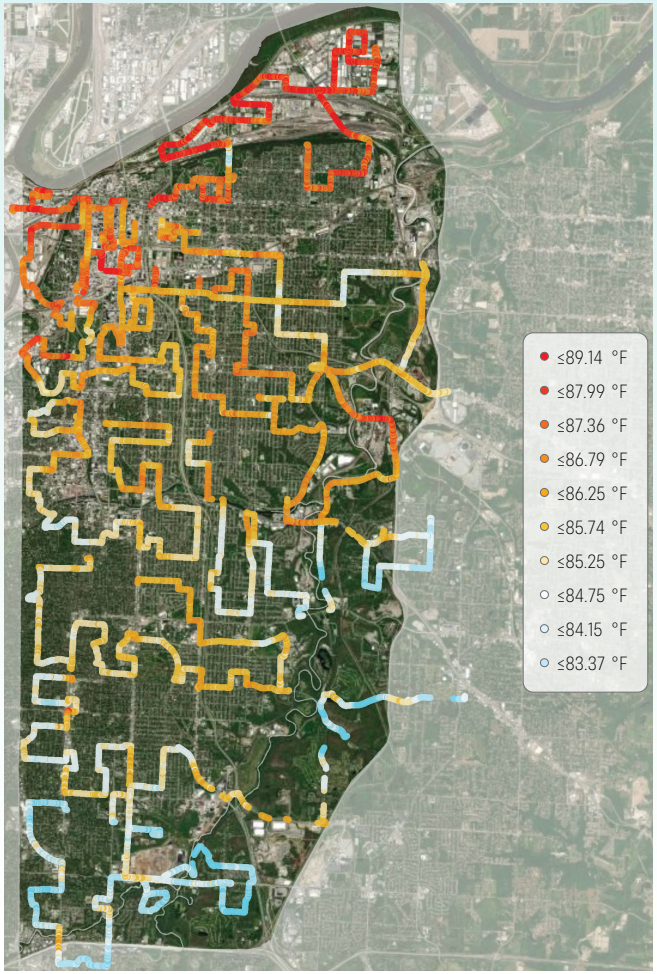
6-7 am



3-4 pm

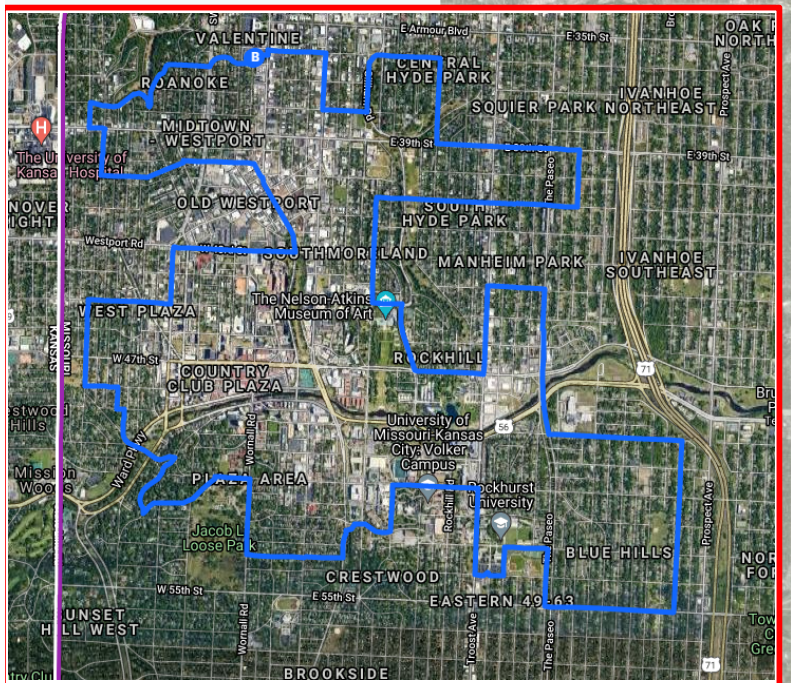


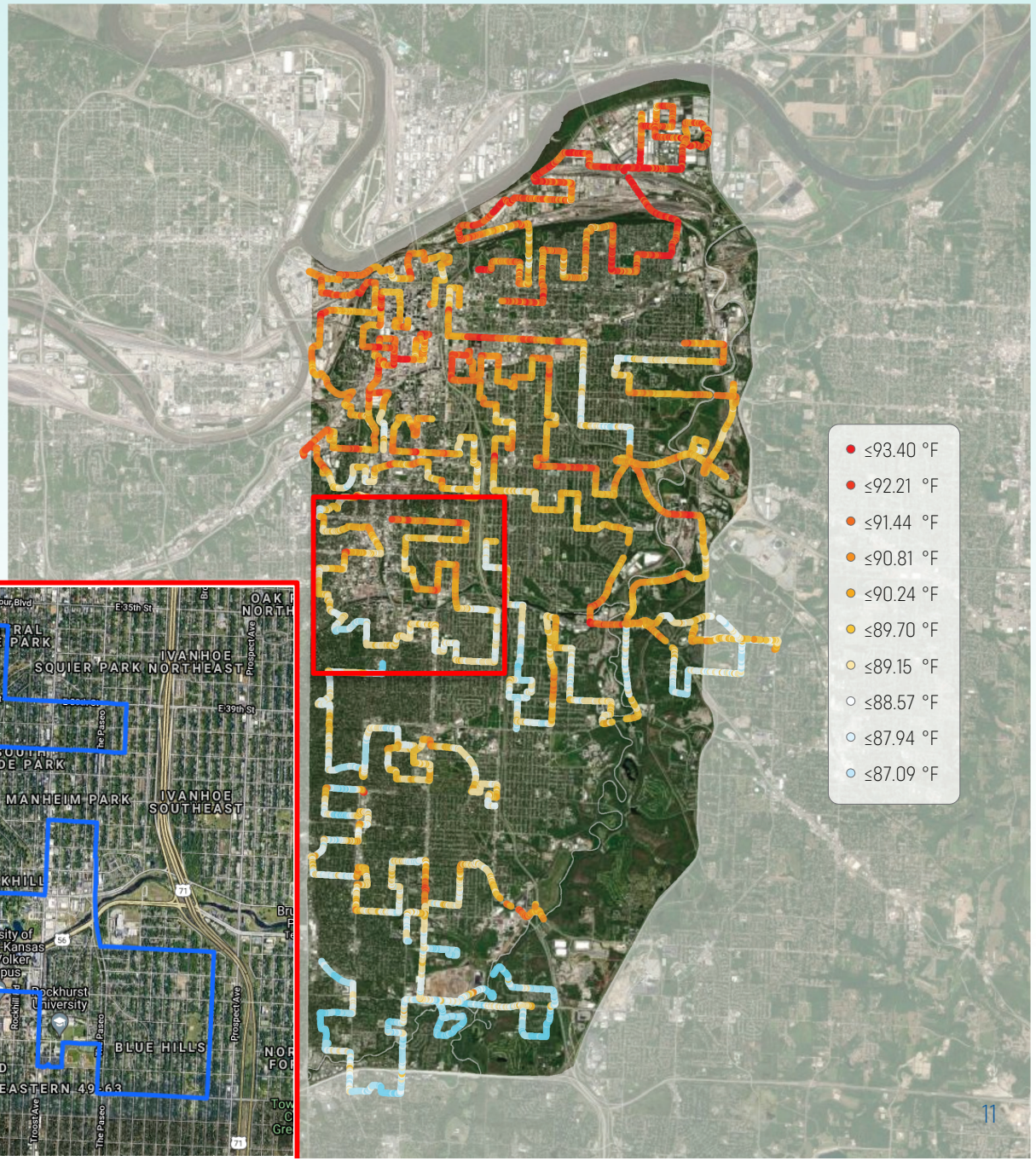
7-8 pm



Afternoon Traverse Points

Temperature (3 - 4 pm)



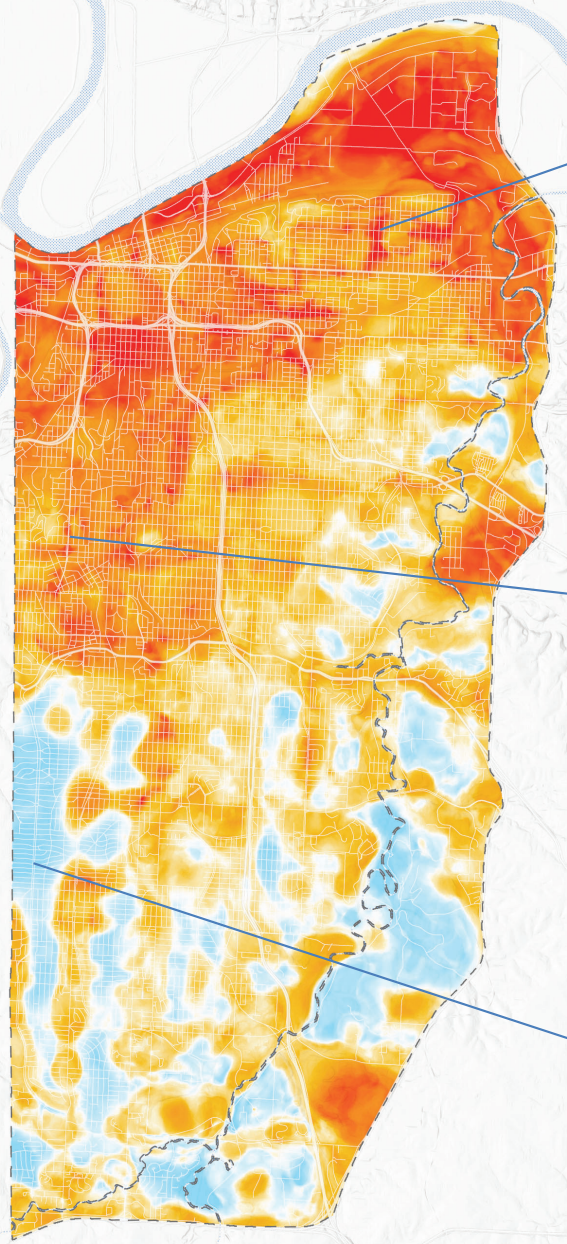


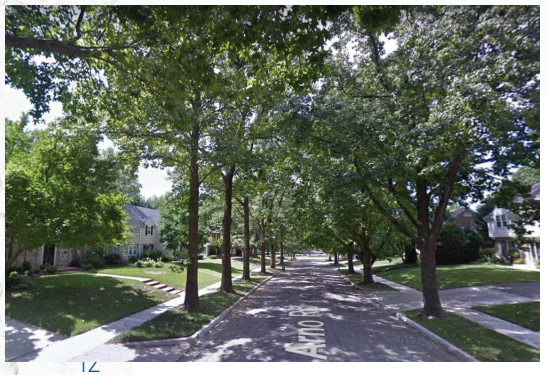
Afternoon Area-Wide Predictions

Temperature (3 - 4 pm)

CAPA

HEAT WATCH





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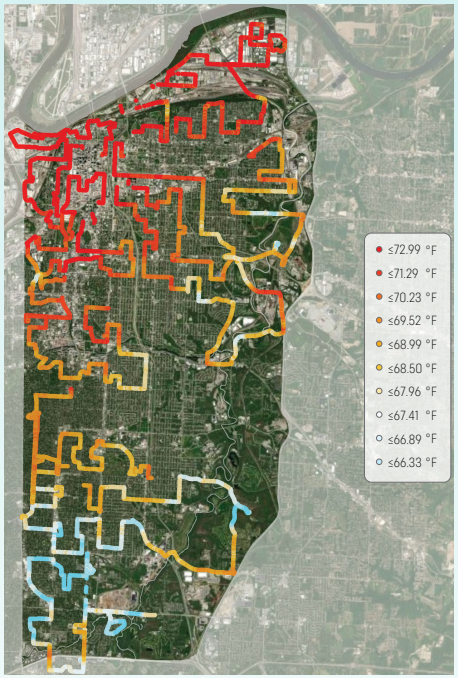
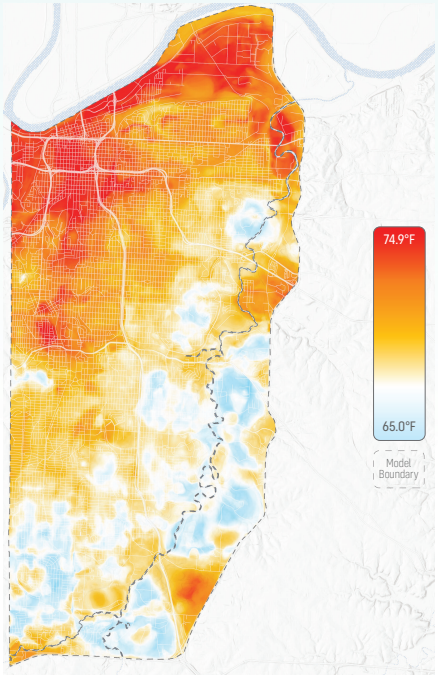
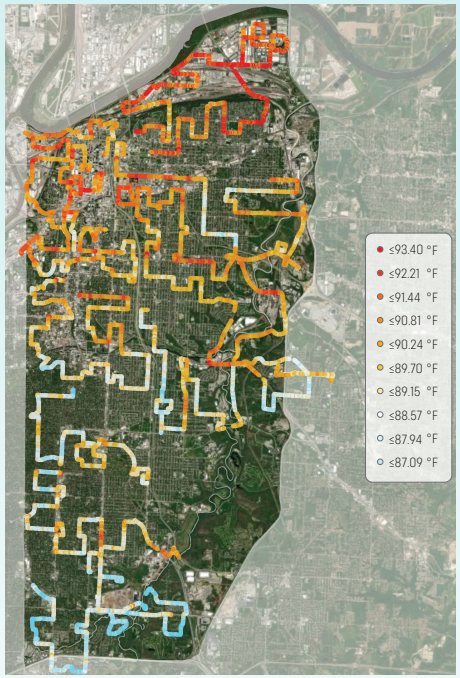
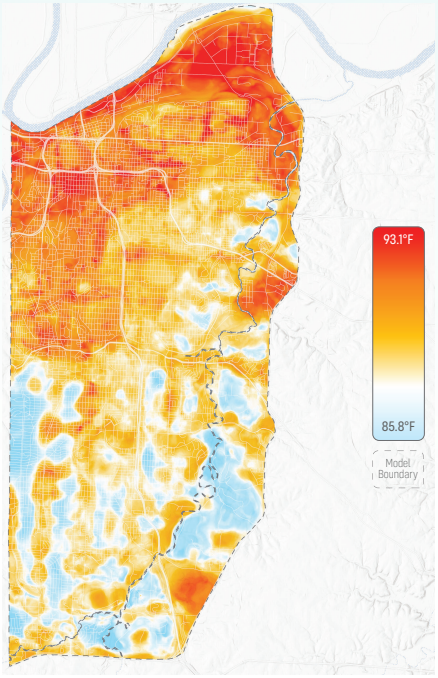




3-4 pm





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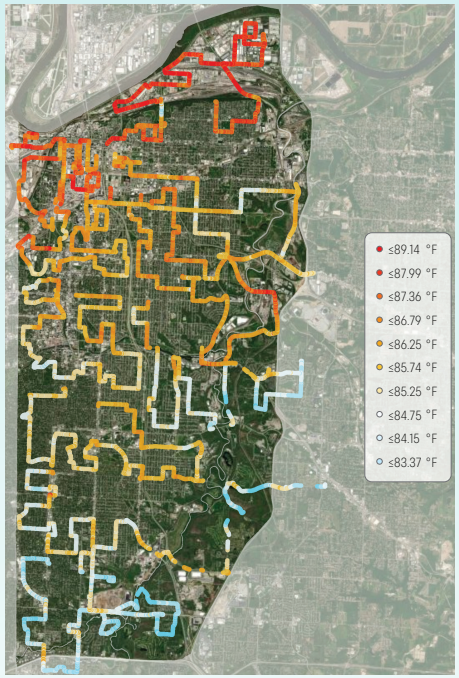

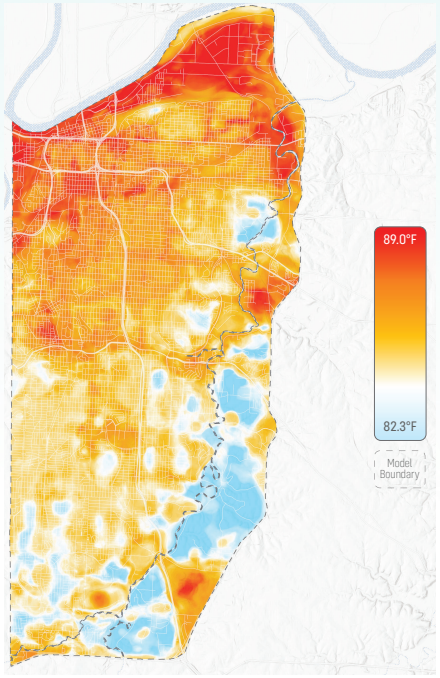

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- Numerical Modeling
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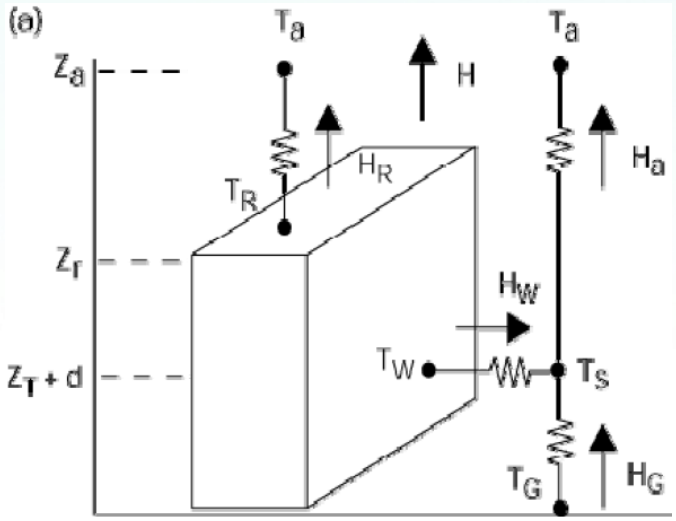
High-resolution Regional Climate Modeling

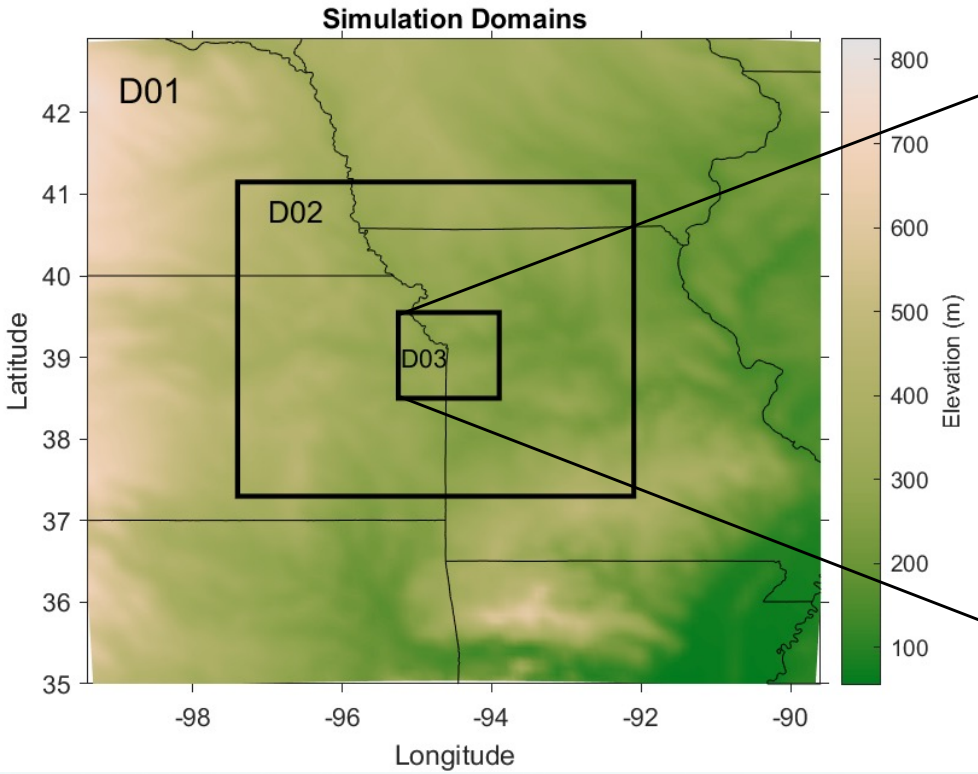
- Weather Research and Forecasting (WRF) Model Coupled to an Urban Canopy Model (UCM)
  - WRF: Mesoscale numerical weather prediction and climate projection system
  - UCM: Accounts for urban physical processes, e.g., heat fluxes from various surfaces, including roofs, building walls, and road surfaces



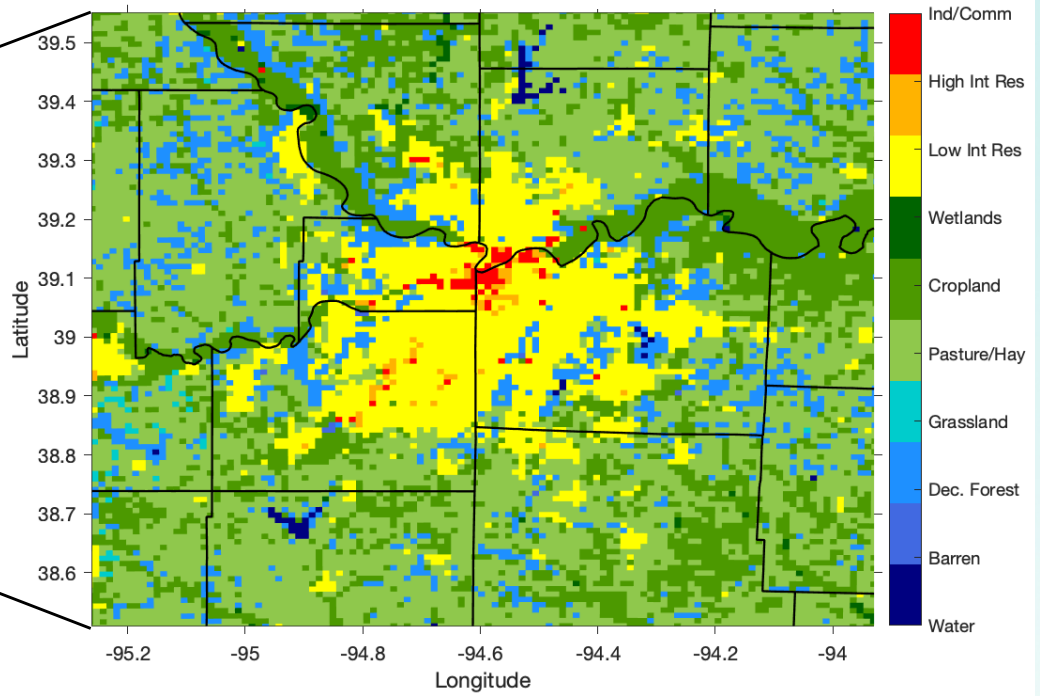
WRF configurations

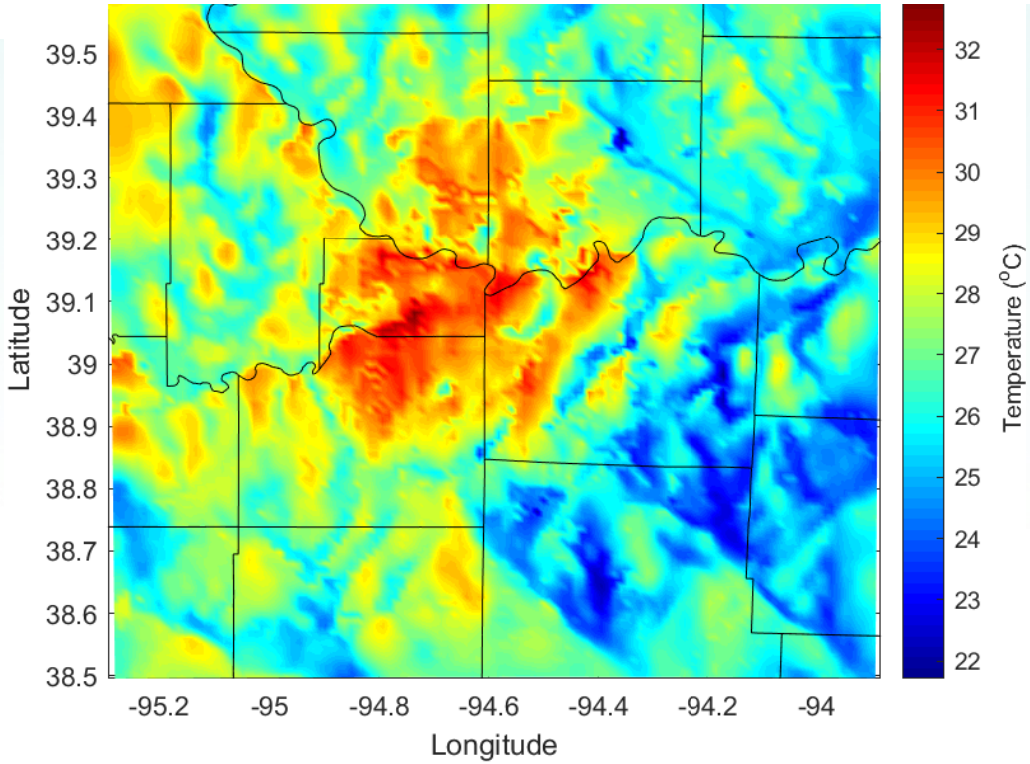
- Area of interest: Kansas City metropolitan area
- High-resolution (1km x 1km)
- Time frame: July 17th – 26th, 2012
  - Maximum temperature: 41°C (106°F)
  - Average temperature: 31°C (88°F)
- Initial and boundary conditions:
  - North American Regional Reanalysis (NARR, 32-km)
- Land cover
  - Non-urban pixels: MODIS
  - Urban pixels: National Land Cover Database (NLCD) 2011
    - NASA/USGS Landsat-based product

WRF Optimization Sensitivity Simulations	•Land cover: NLCD 2011 •Run time/NARR data: 15 July to 25 July 2012 •Roof albedo: 0.3
Control Simulation	•Land cover: NLCD 2011 •Run time/NARR data: 18 July to 24 July 2012 •Roof albedo: 0.3
Historical Simulation	•Land cover: USGS 1938 •Run time/NARR data: 18 July to 24 July 2012 •Roof albedo: 0.3
Cool Roof Simulations (x2)	•Land cover: NLCD 2011 •Run time/NARR data: 18 July to 24 July 2012 •Roof albedo: •1) New roof: 0.8; 2) Aged roof: 0.5



KC Metro land use/land cover



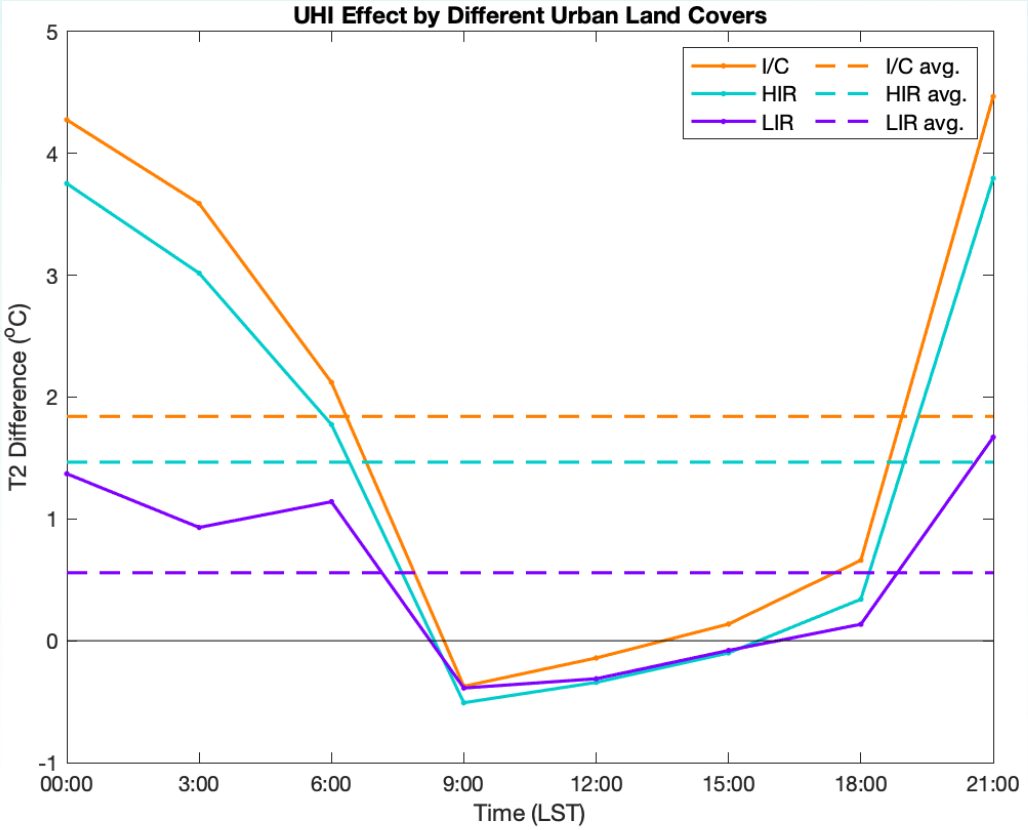


Present-day Urban Heat Island (UHI) in Kansas City Metropolitan Area (control run)

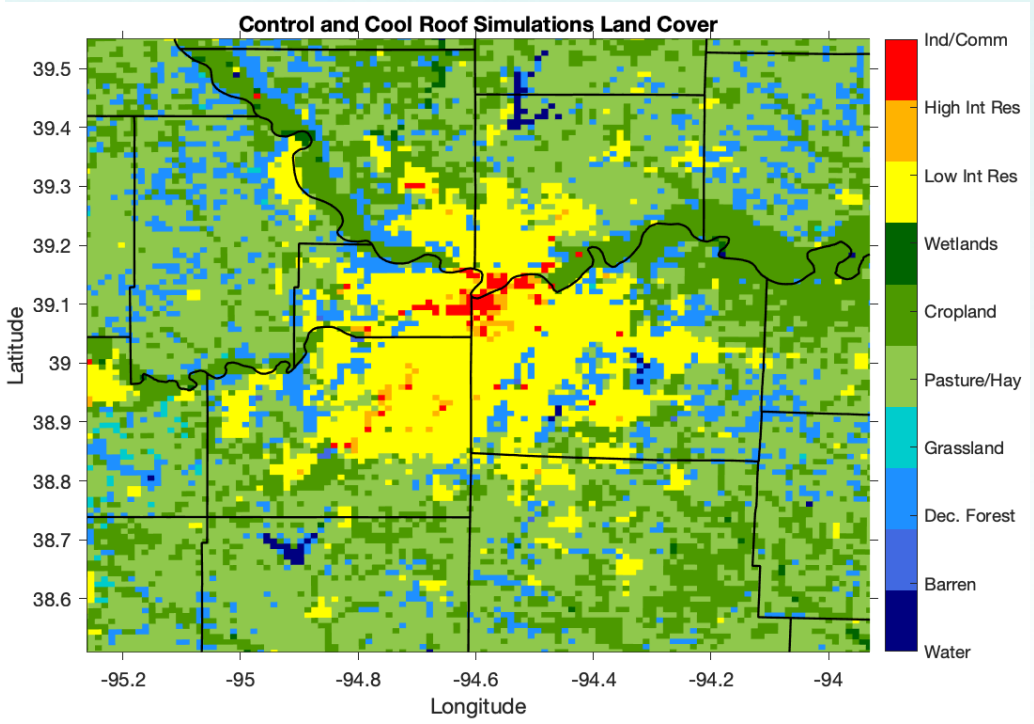
Average UHI Effect

I/C: Industrial and Commercial
HIR: High Intensity Residential
LIR: Low Intensity Residential

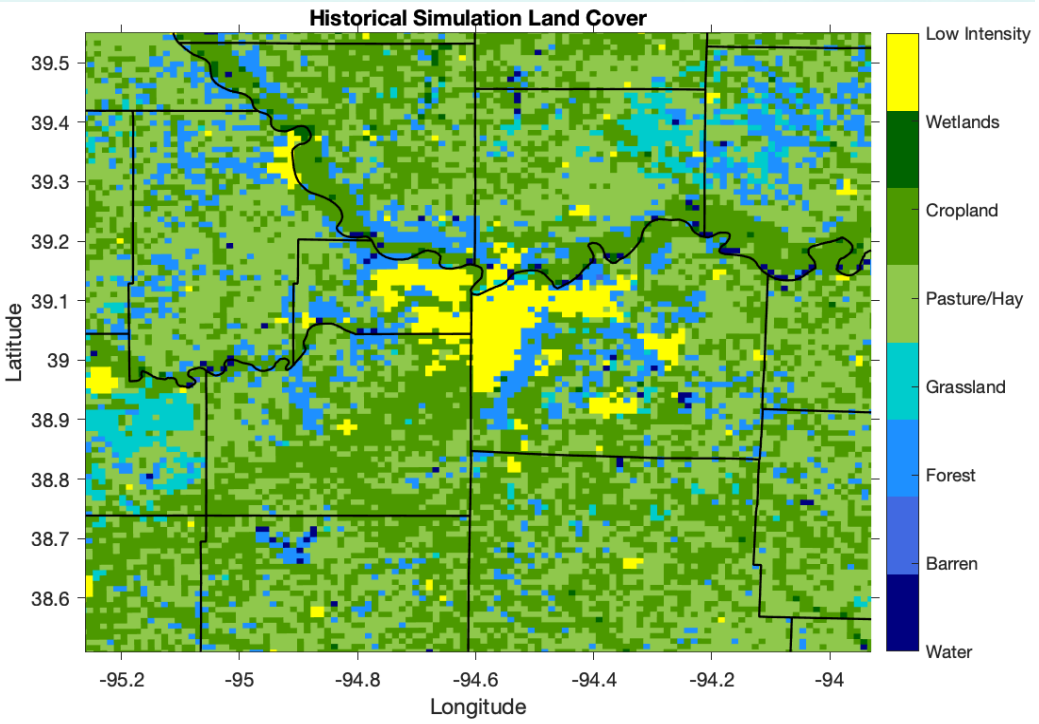
- $UHI = T2_u - T2_r$
  - Considered urban categories separately
- Strongest UHI effect is in the late evening/night
- Rural areas warm faster in the morning due to lower thermal inertia



Present-day vs Historical Urban T2



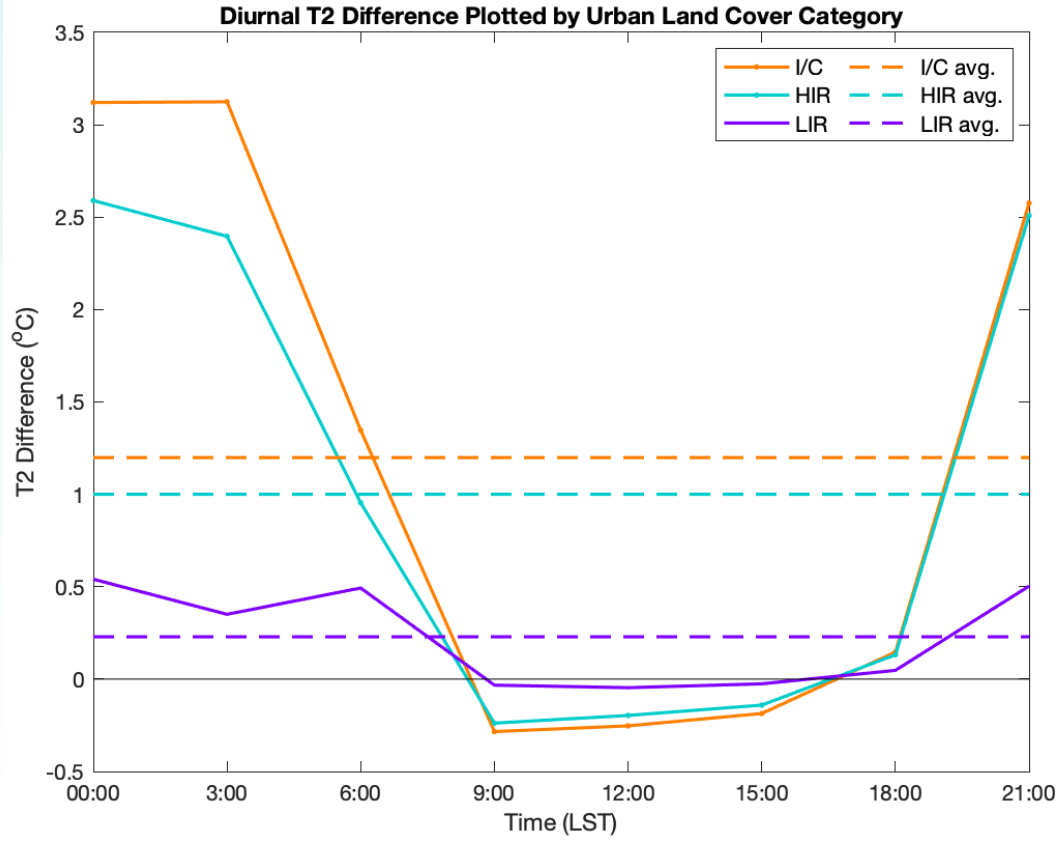
Present-day LULC



1938 LULC

Present-day vs Historical Urban T2

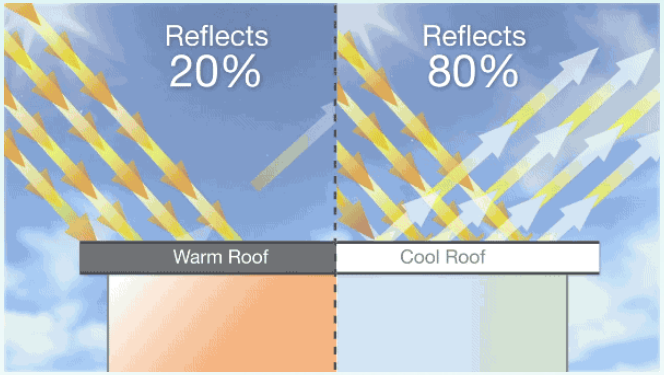
- Difference between urban land cover categories
  - $T2_{urb,2012} - T2_{urb,1938}$
- Larger differences in urban surface air temperature
- Higher intensity and Industrial urban areas are over 2.5°C warmer at night

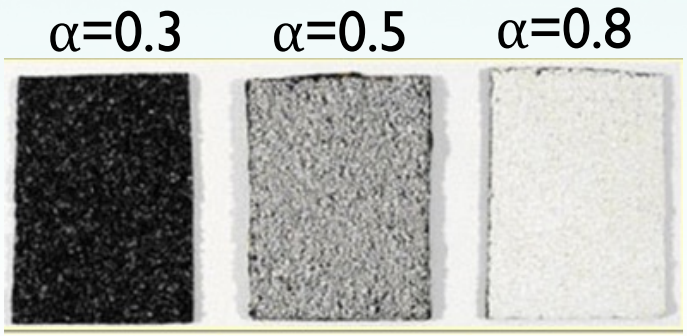


Cool roofs as a warming mitigation strategy

- Replacing conventional roofing materials with lighter-colored materials

Albedo (α)





Cool Roof Simulations (x2)

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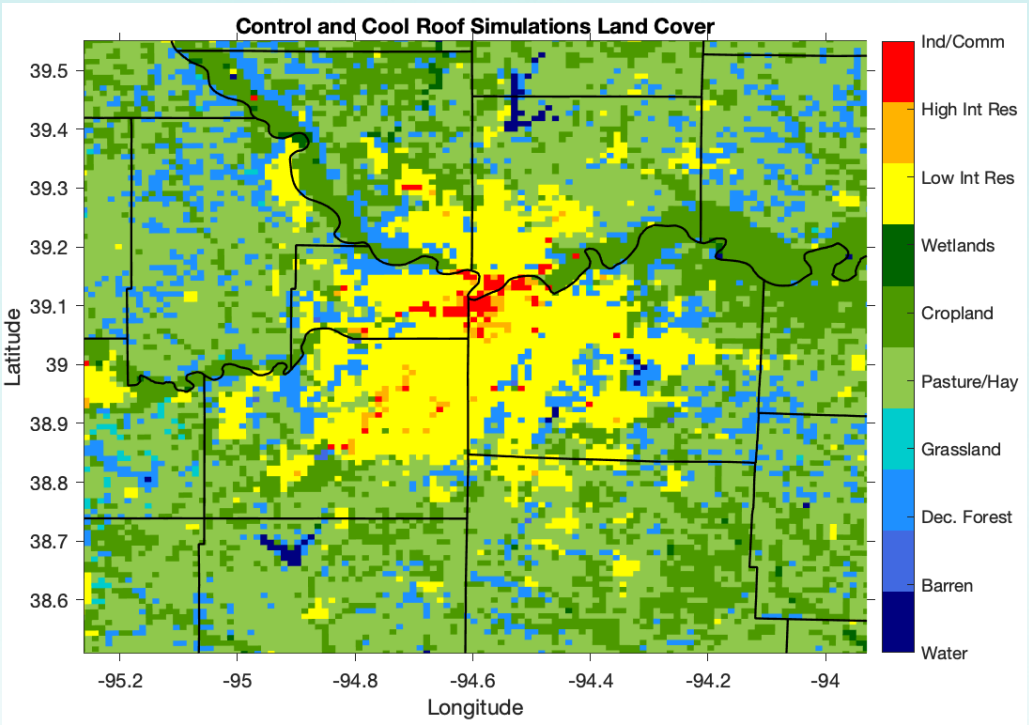
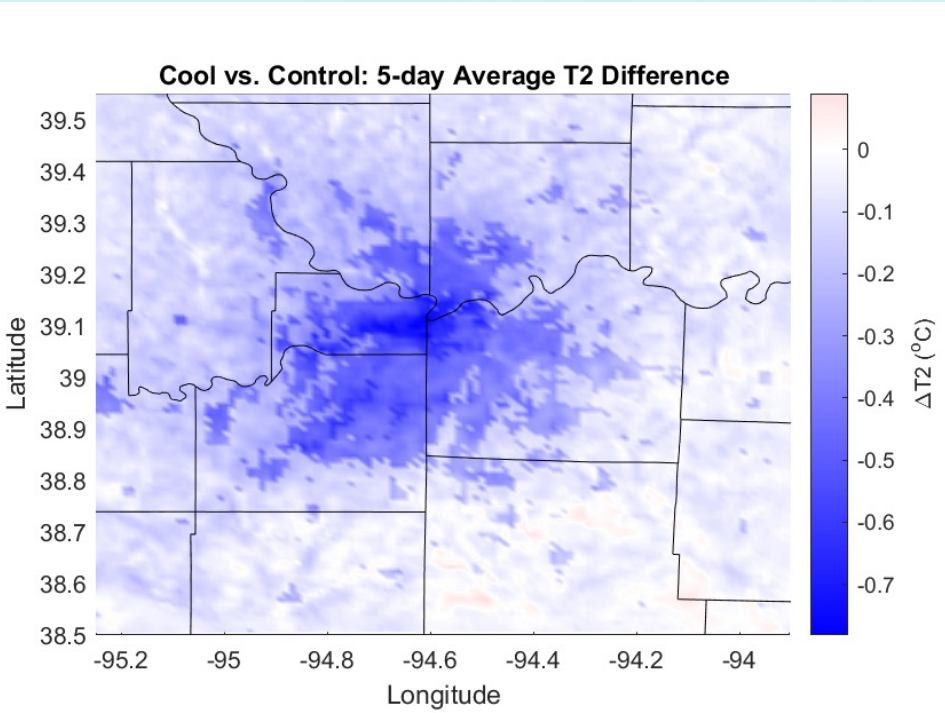
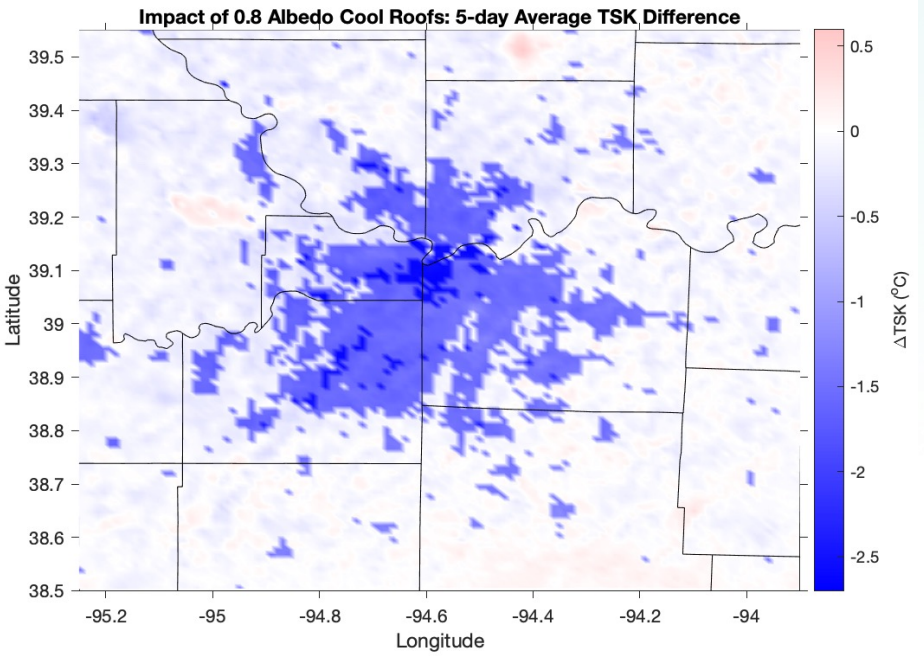


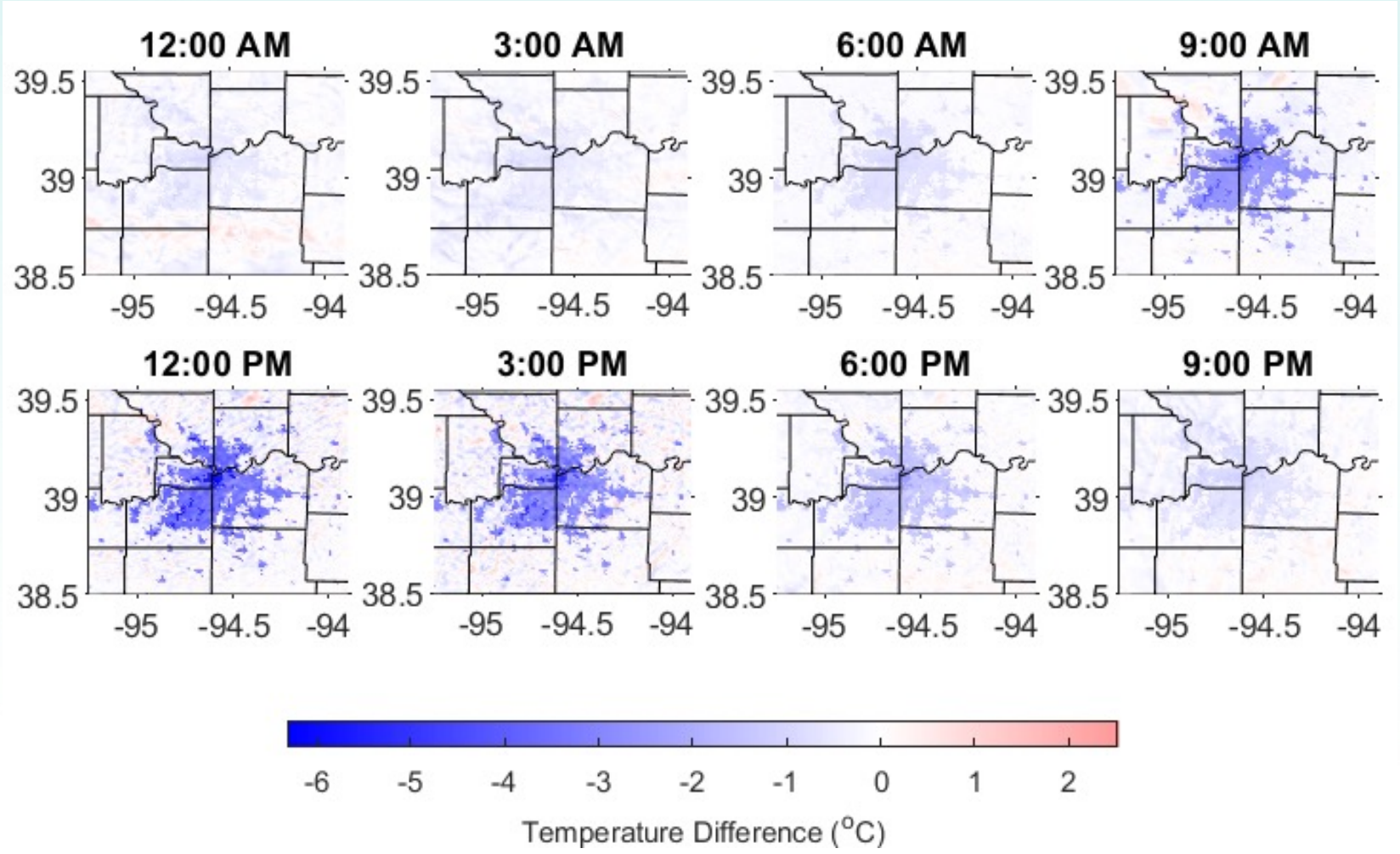


- Surface air temperature is lower throughout the KCMA
- Lesser impact in the low-intensity residential areas

- Surface skin temperature is much lower throughout the KCMA
- Greatest cooling experienced centrally and clear delineation between two higher-intensity urban land cover categories and low-intensity residential areas



Cool Roof Mitigation Quantifications – TSK



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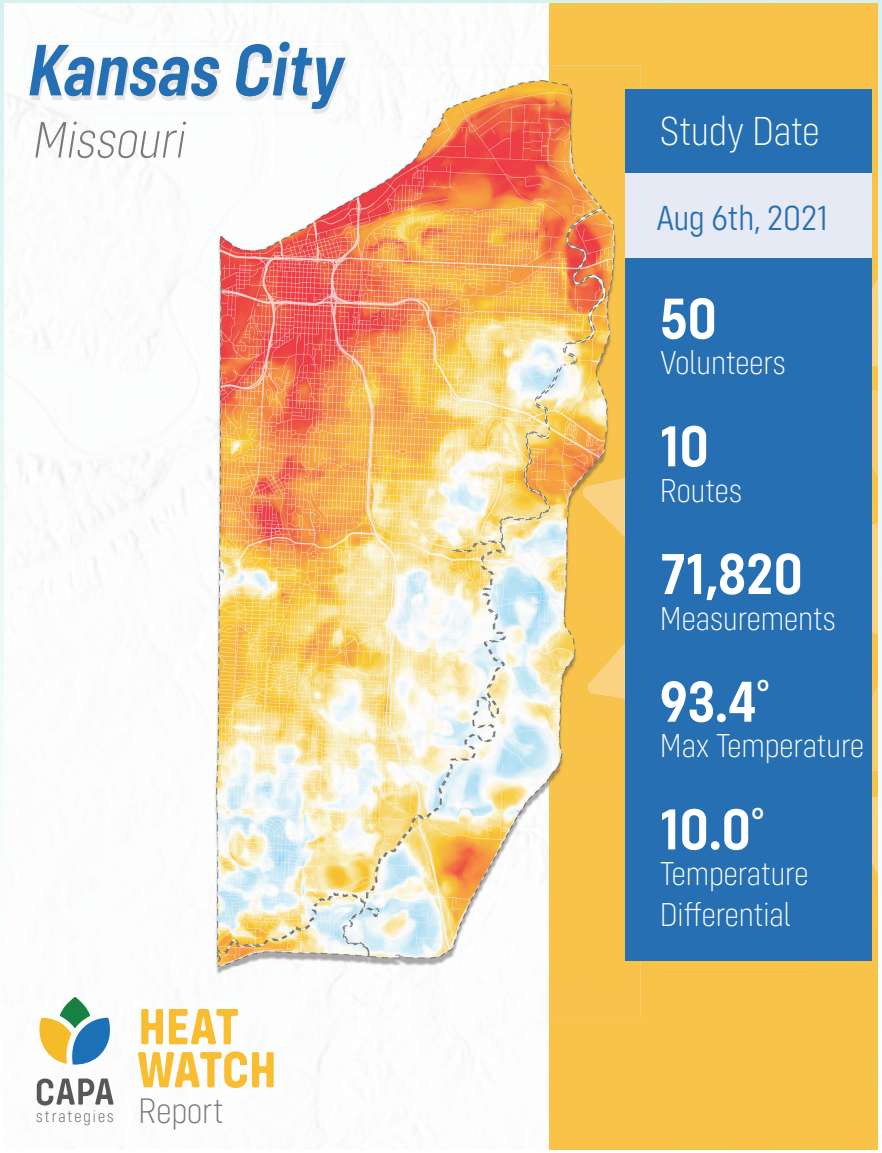

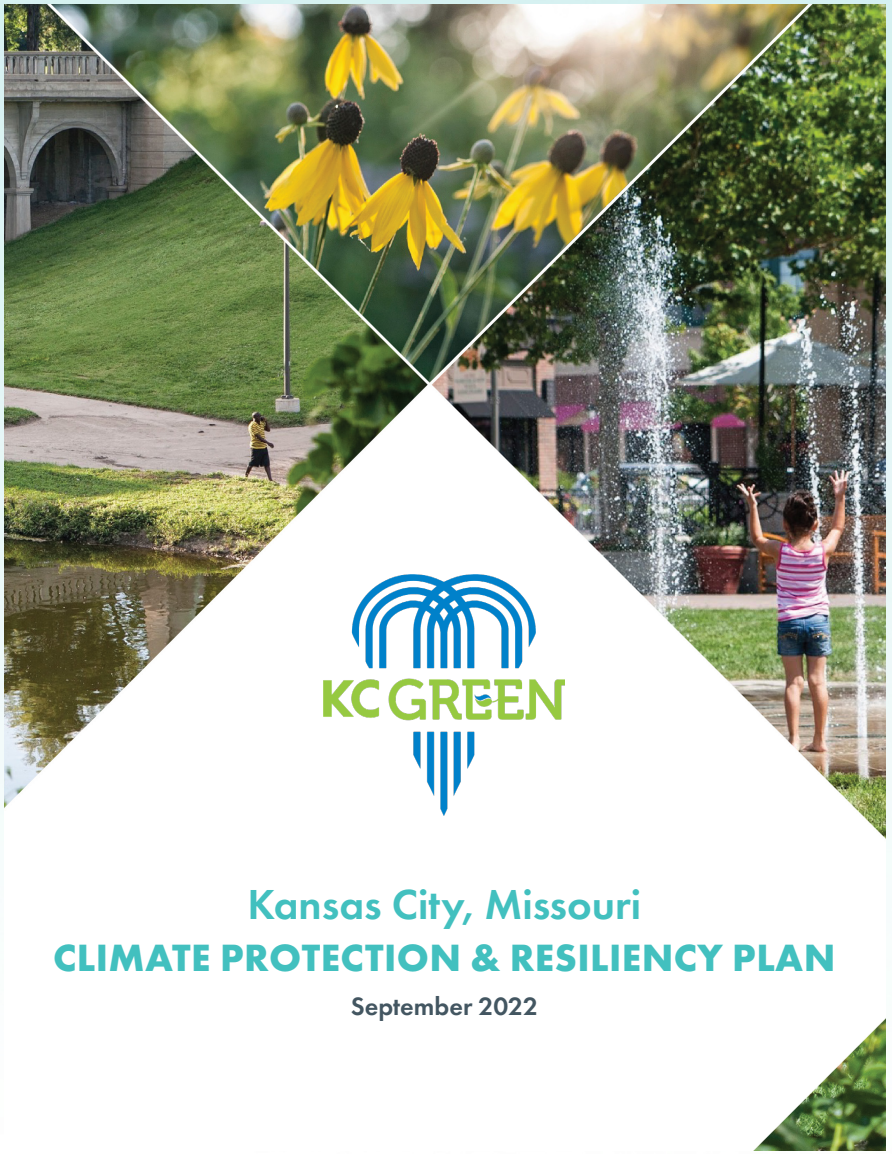

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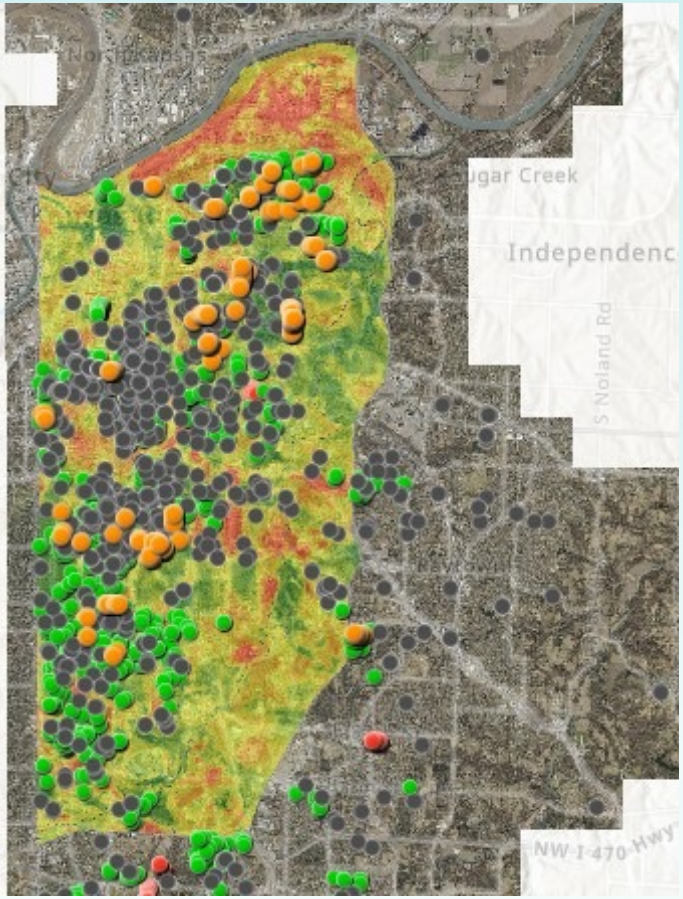
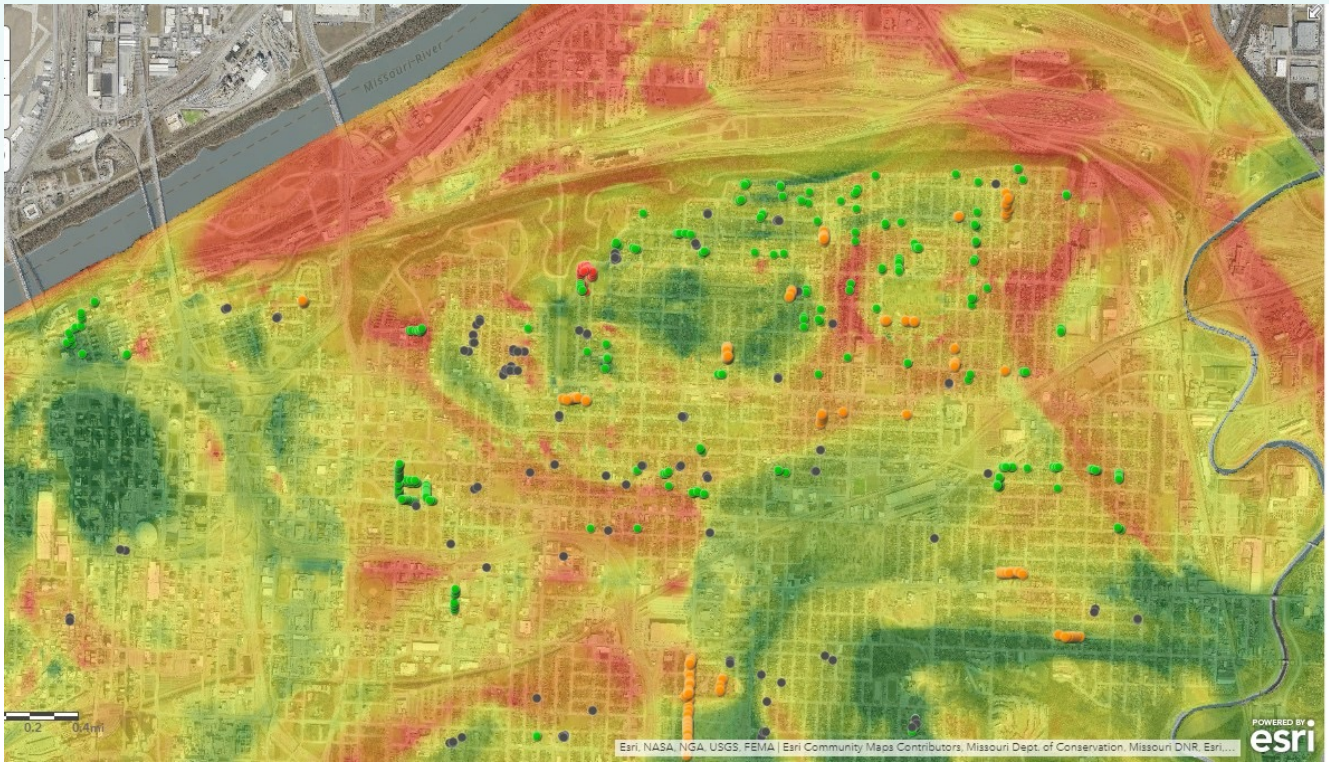
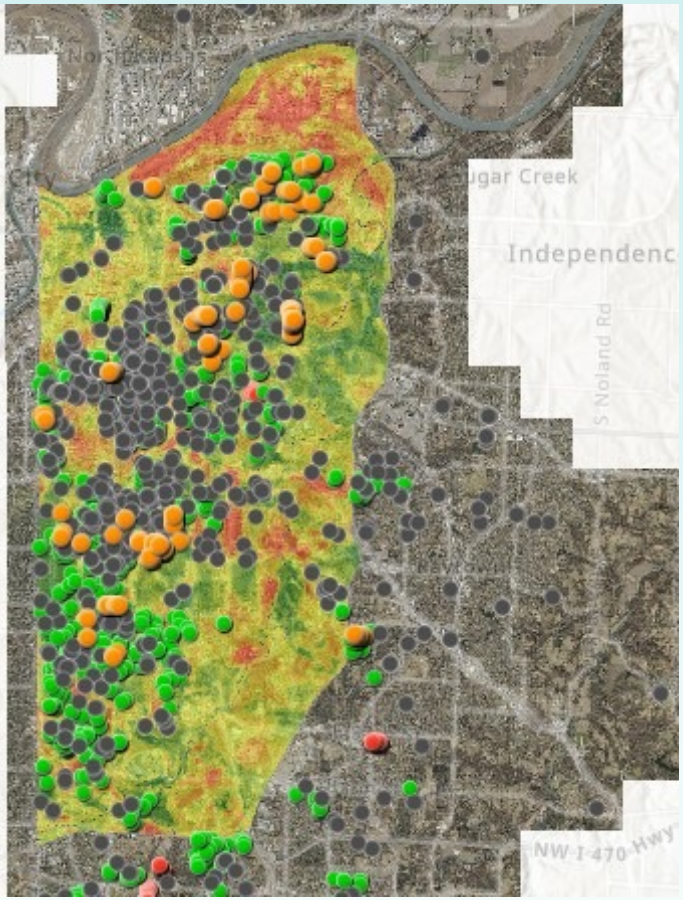


Heartland Tree Alliance

Bridging The Gap

Credit: Joe Weelock @ BTG





Kansas City Awarded $12M for Trees

City committed to planting 10K trees

KANSAS CITY

- Help KCMO secure $12M for Trees from USDA and tree planning

City of Kansas City	**Kansas City Urban Forest Canopy:** This project will increase density and strength of tree coverage by at least 17%, and completing a tree inventory will provide necessary data to improve future forestry. Community education and outreach will make certain that residents are centered in this project, increasing neighborhood investment in the growth of the urban tree canopy and other environmental justice efforts.	• Tree Planting & Maintenance • Restoration & Resilience • Planning & Community Engagement • Extreme Heat	**$12,000,000**

- **KC Urban Heat Mapping Campaign Report & Data**

https://osf.io/5d3uk/

- **Climate Modeling Study on KC Urban Heat Island and Mitigation**


Climate Dynamics
https://doi.org/10.1007/s00382-022-06296-z

Investigating the potential for cool roofs to mitigate urban heat in the Kansas City metropolitan area

Kyle Reed[1] · Fengpeng Sun[1]

https://link.springer.com/article/10.1007/s00382-022-06296-z

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