

National Aeronautics and  
Space Administration



# ASHEVILLE URBAN DEVELOPMENT II

Mapping Urban Heat to Support Cooling  
Initiatives and Climate Resilience Planning  
in the Greater Asheville Area

Kimberly S. Becerril

Caleb V. Kluchman

Sarah L. McMullen

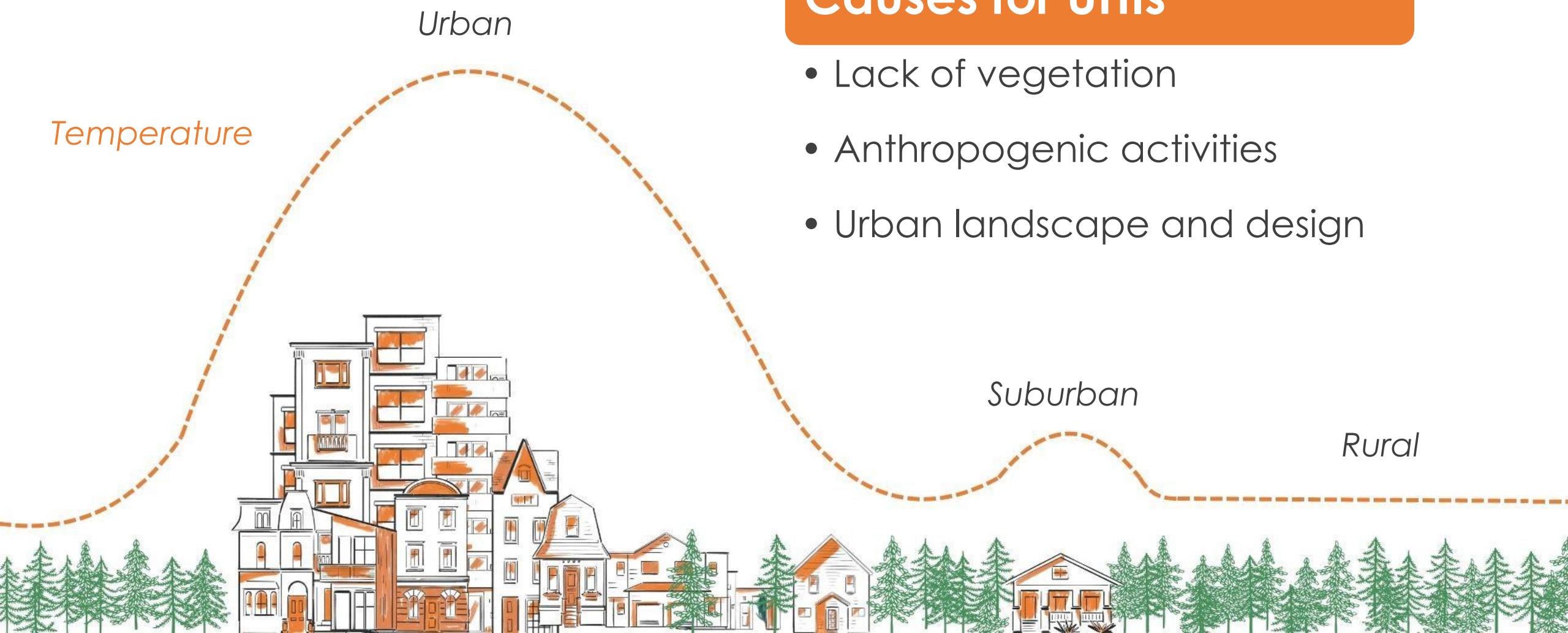
Caroline M. Tintinger



North Carolina – NCEI Summer 2024



# Background – Urban Heat Islands (UHI)



# Background – Effects of UHIs

Environmental  
and human health  
implications

Implications are  
uneven: hotspots

Spatial environmental  
injustice



Visualization of Land Surface Temperature in Asheville, NC  
Image Credit: Darcy Gray, Amiya Kalra, and Amy Kennedy

# Study Area and Period



**Study Area** Asheville, NC

**Study Period** 2019 - 2023

Asheville - Study Area

North Carolina

Bodies of Water



Basemap Credit: State of NC, U.S. Census

# Asheville Community Concerns

## Asheville UHI Influences

- Population Increase
- Tree cover decline
- Infrastructure expansion
- Climate change intensification

## Asheville UHI Consequences

- Environmental degradation
- Social vulnerability to heat



Image of Asheville, NC  
Image Credit: Ken Lane

# Partners

**Asheville GreenWorks**



Image of Asheville GreenWorks  
Image Credit: Sarah McMullen

**City of Asheville  
Sustainability Department**



Image of Asheville City Hall  
Image Credit: Dan Phairas

# Project Objectives

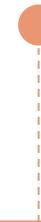
***Expand on and update the 2019 NASA DEVELOP Asheville Urban Development I project, to support cooling initiatives and climate-resilient urban planning.***

Identify hot spot areas



**UHI Hot Spots**

Identify heat-vulnerable areas



**Social Vulnerability**

**Heat Vulnerability**

**UHI Mitigation and Adaption**

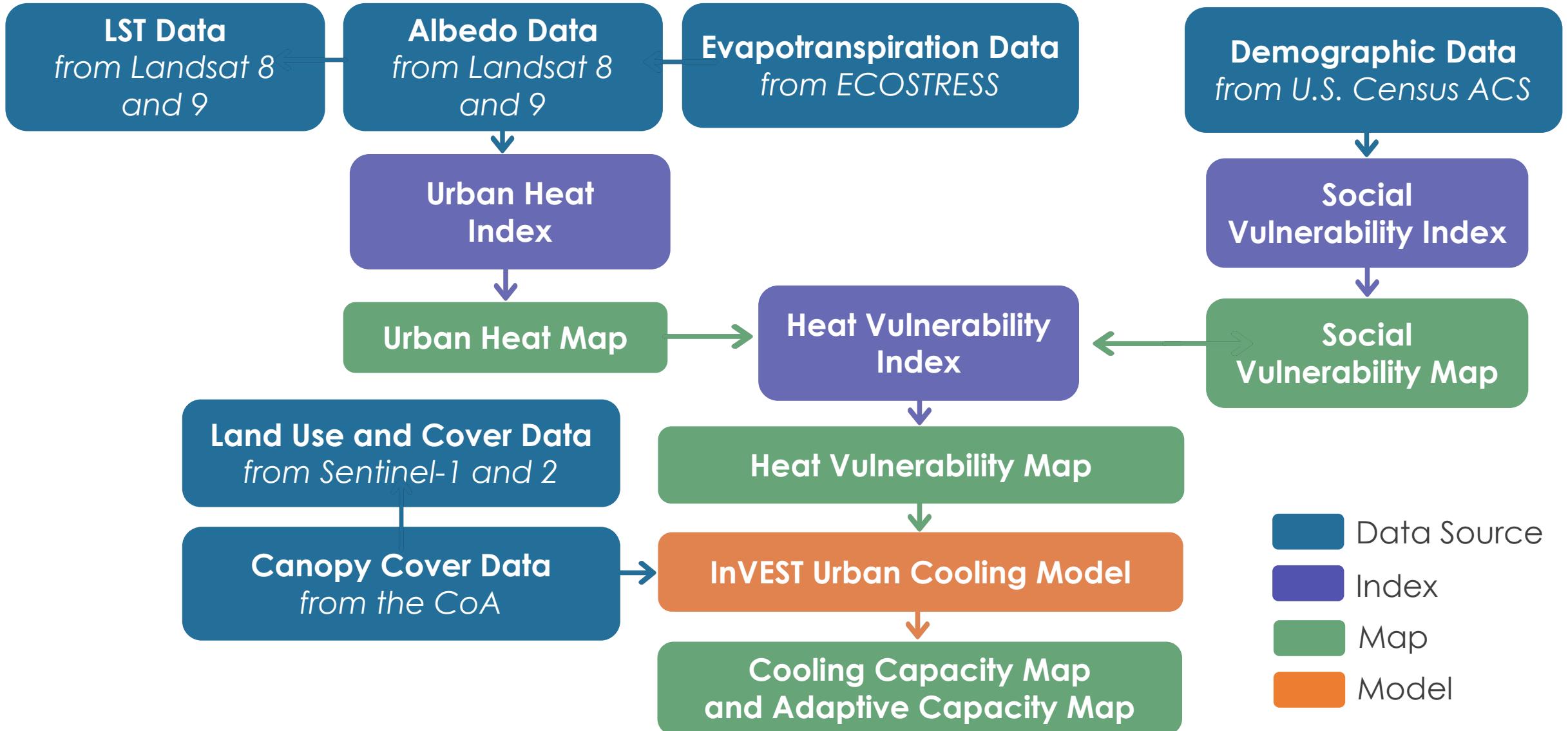
Identify socially vulnerable areas



Assess the spatial suitability  
of mitigation and adaption measures  
based on cooling capacity

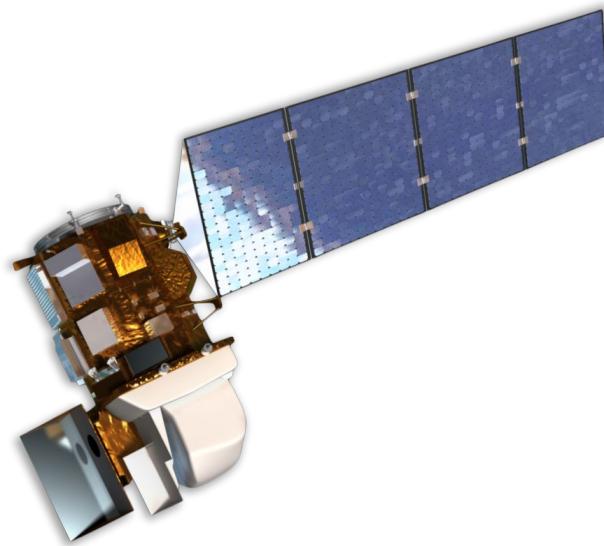


# Methodology



# Earth Observations

**Landsat 8**  
OLI and TIRS



**Landsat 9**  
OLI-2 and TIRS-2



**ECOSTRESS**  
PHyTIR

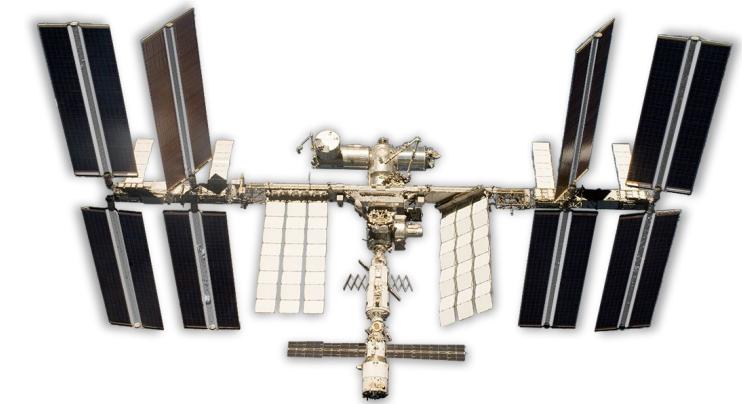


Image Credit: NASA, Northrop Grumman

# Earth Observations

**Sentinel-1**  
C-SAR

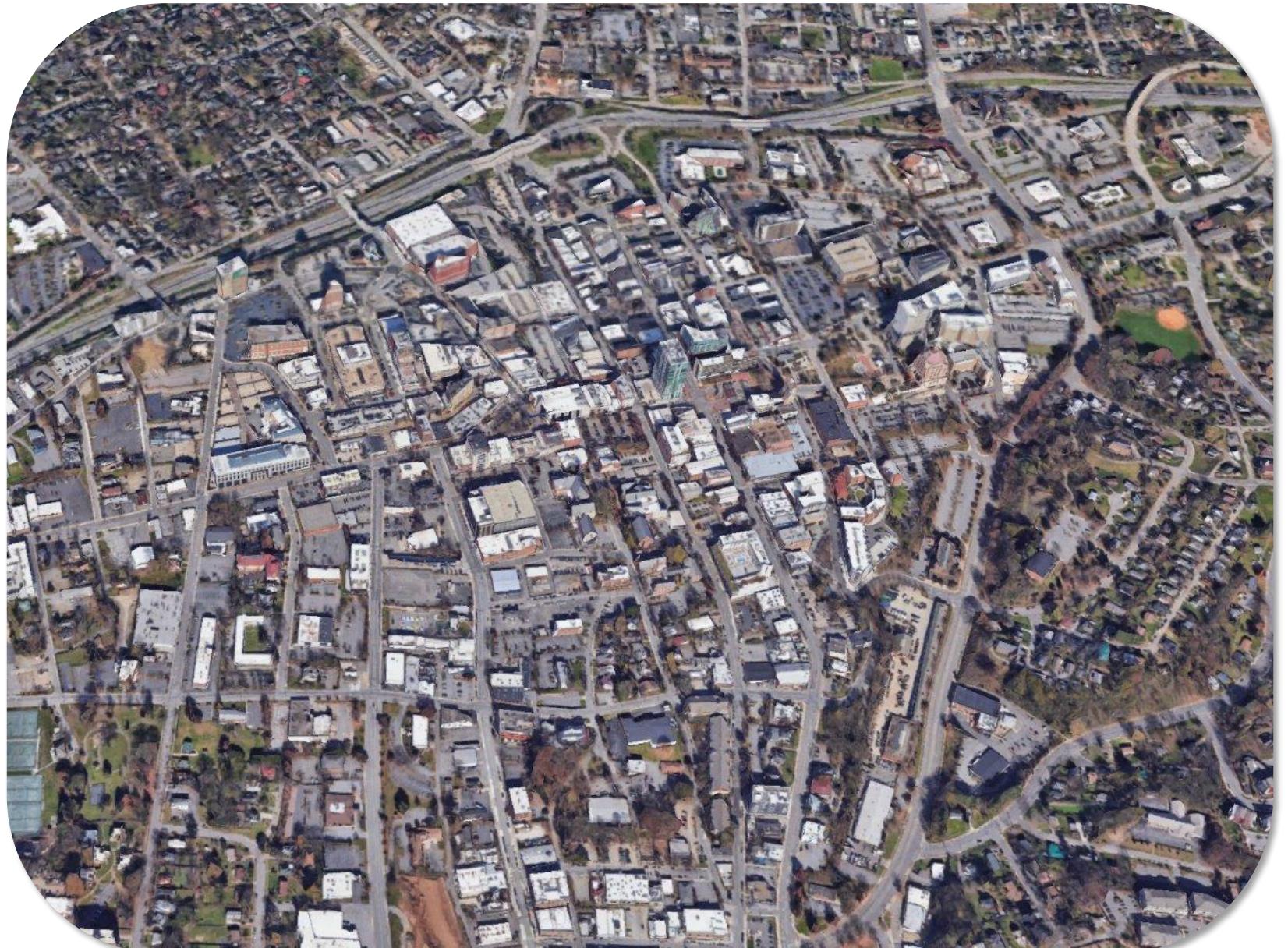


**Sentinel-2**  
MSI



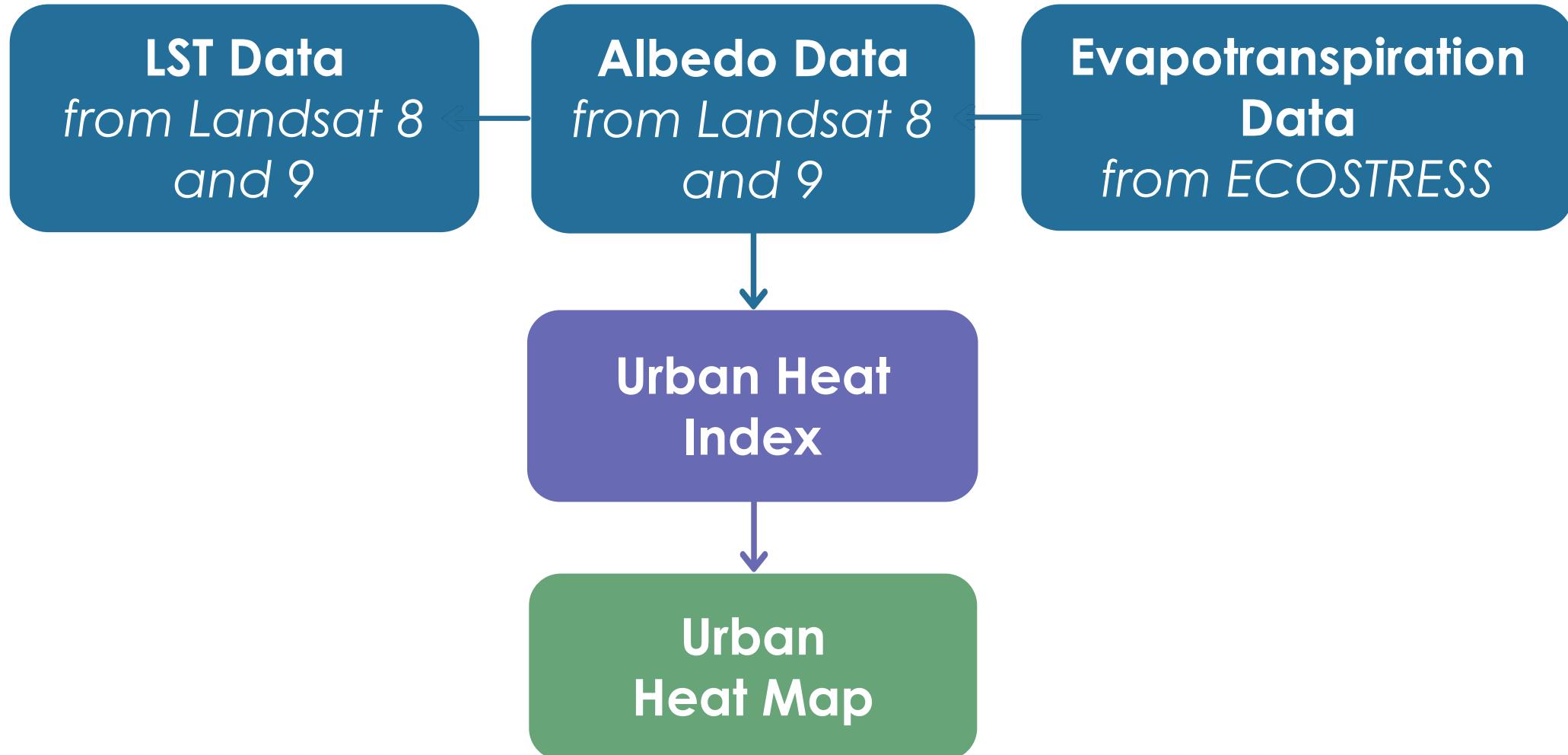
Image Credit: European Space Agency

# Urban Heat



Aerial Image of Downtown Asheville, NC  
Image Credit: Google Earth

# Urban Heat

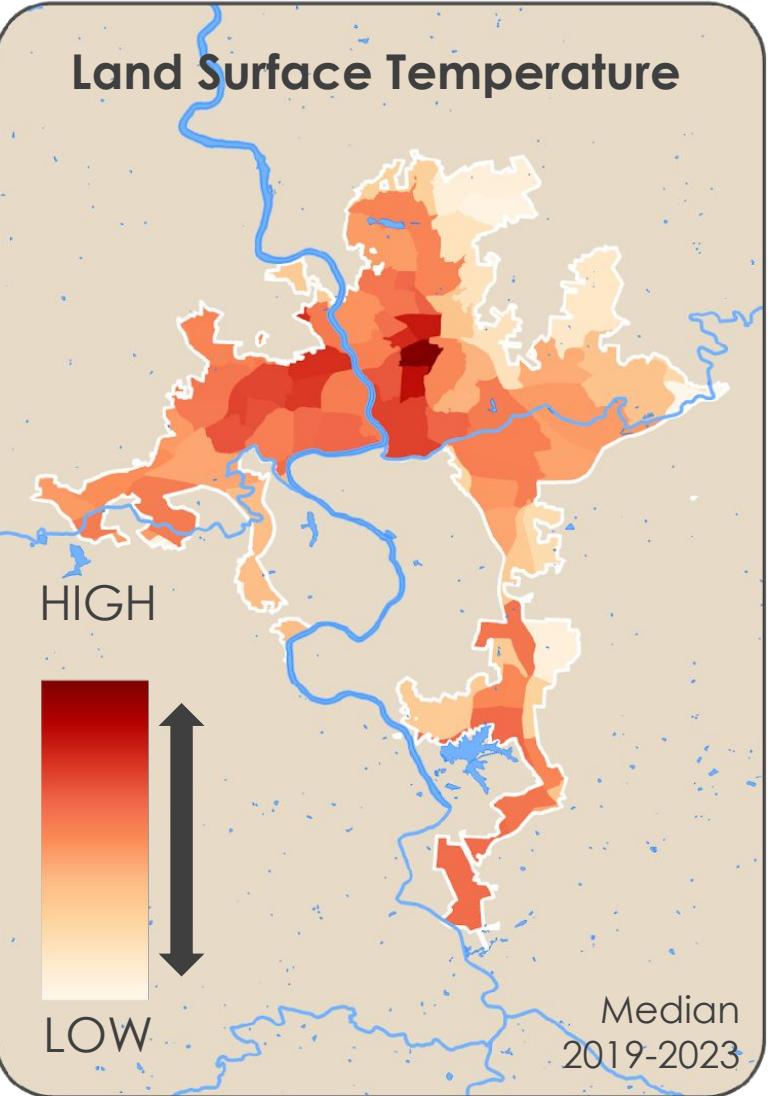


# Urban Heat

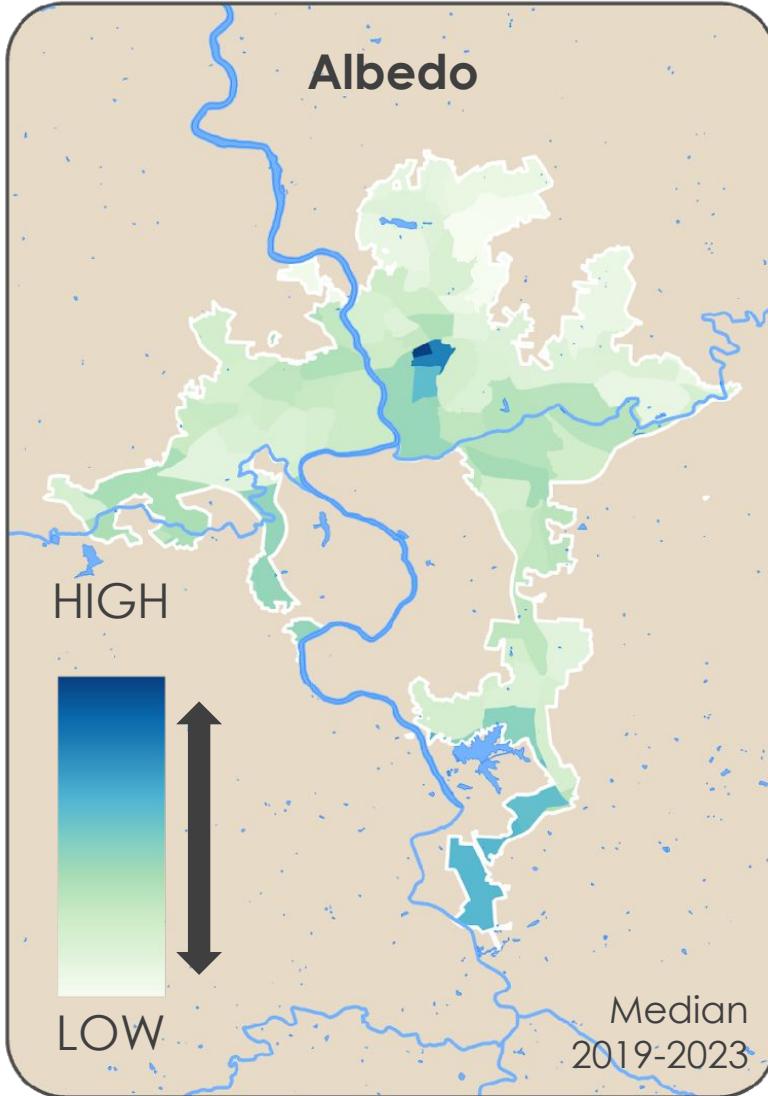
10 km



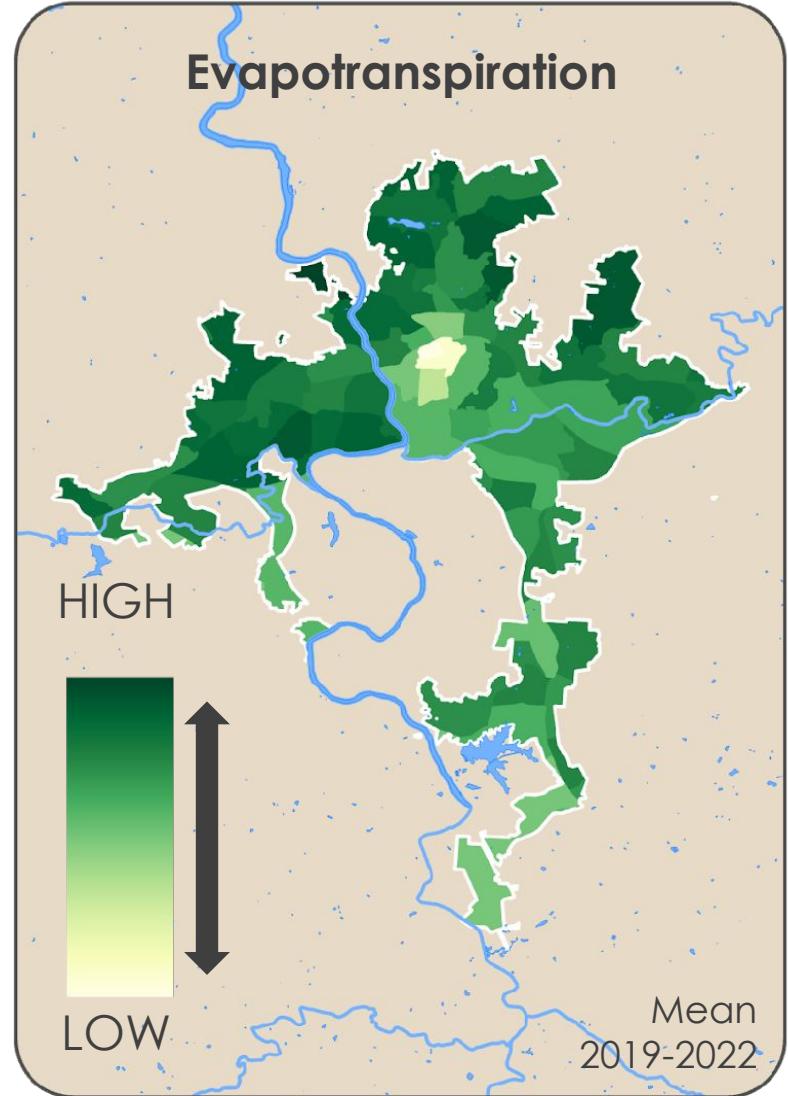
Land Surface Temperature



Albedo



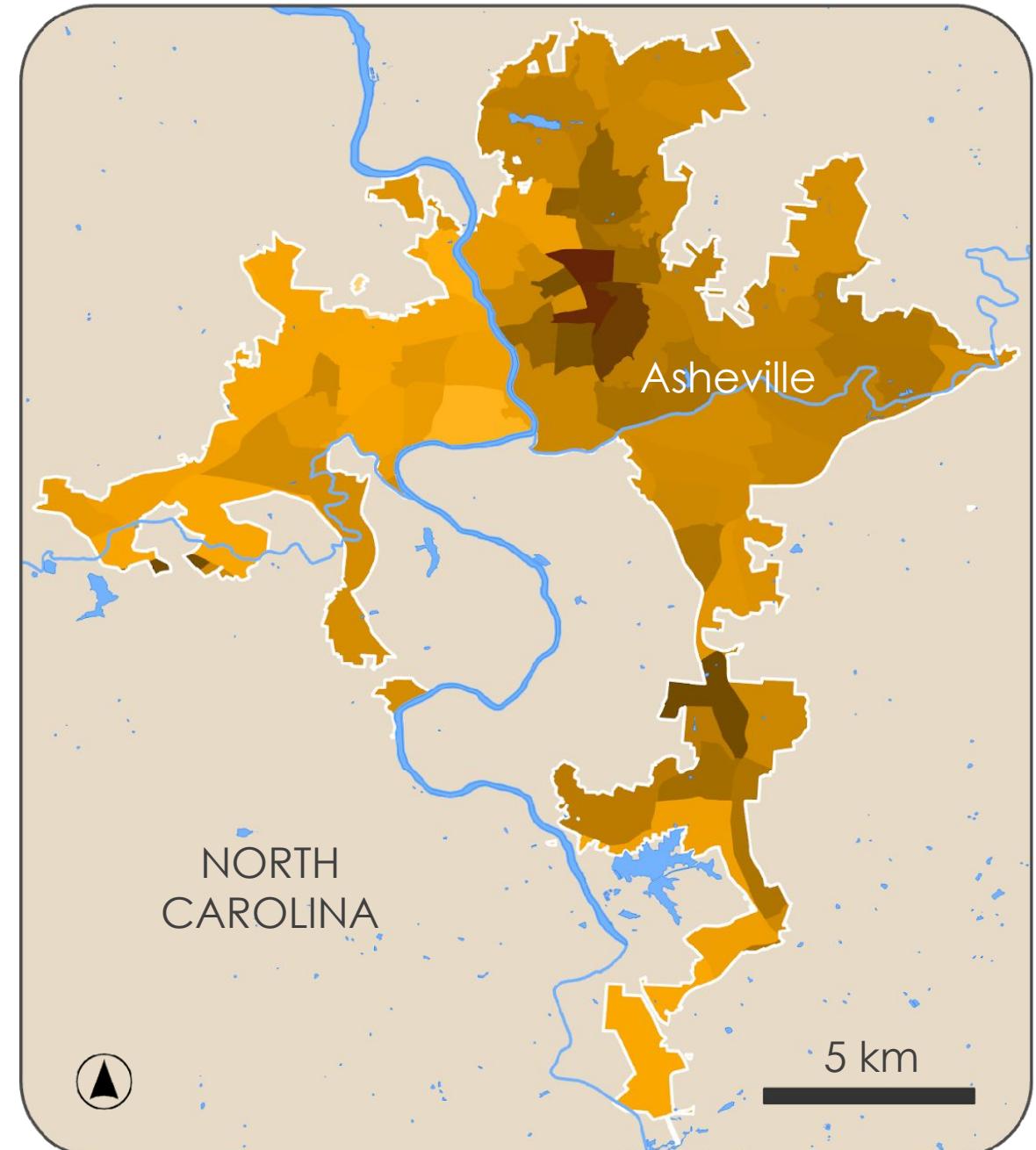
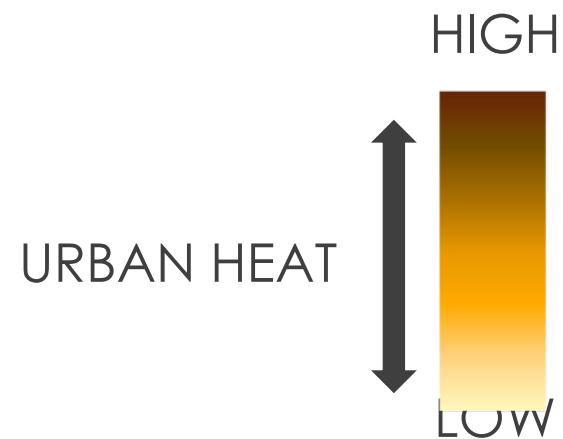
Evapotranspiration



# Urban Heat

Data LST | Albedo | Evapotranspiration

Geometry U.S. Census Block Groups

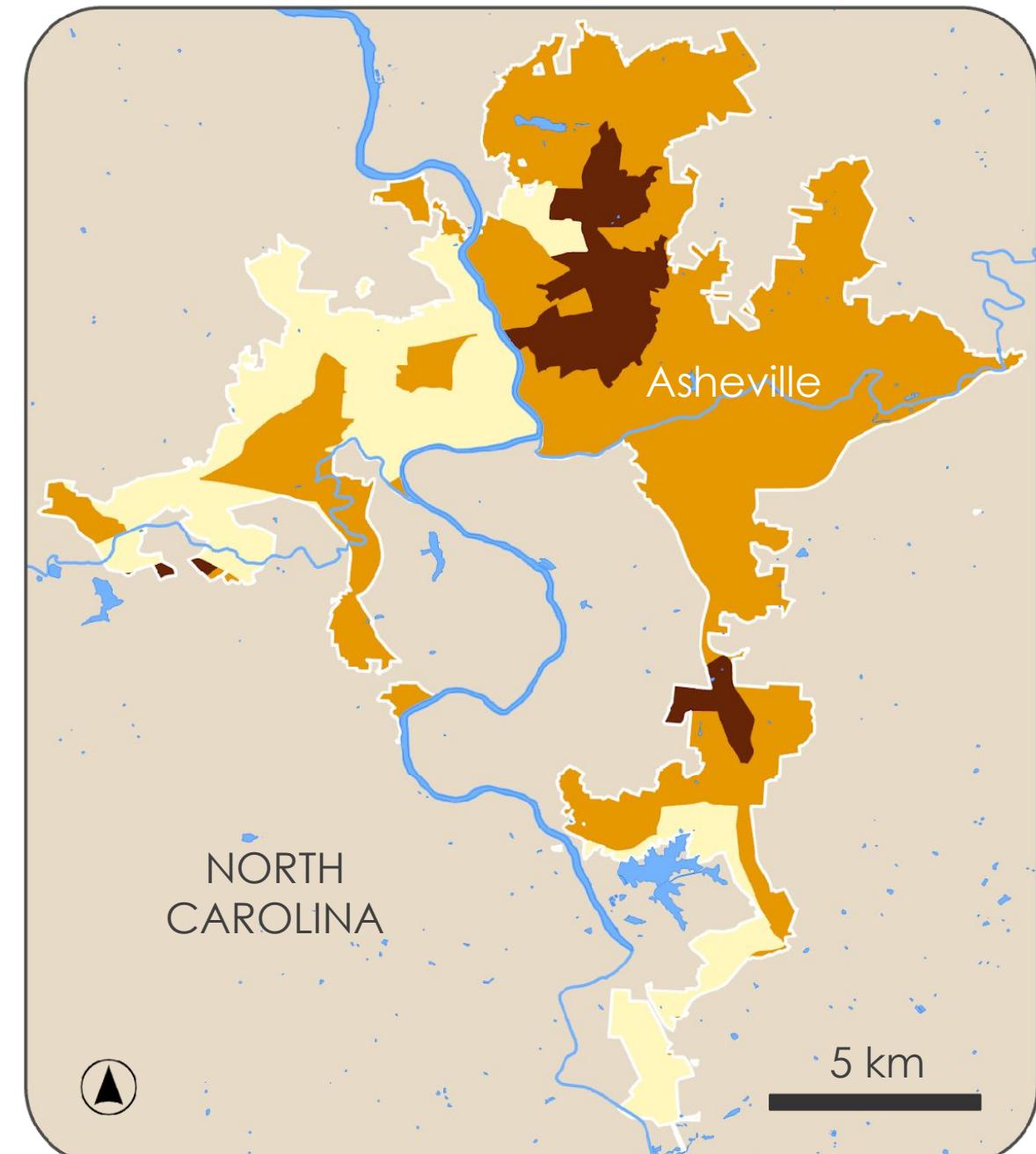
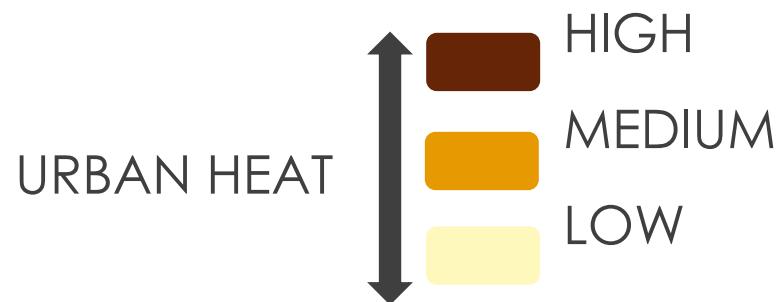


Basemap Credit: State of NC

# Urban Heat

Data LST | Albedo | Evapotranspiration

Geometry U.S. Census Block Groups



# Social Vulnerability



Image of Asheville Citizens  
Image Credit: Will Thomas

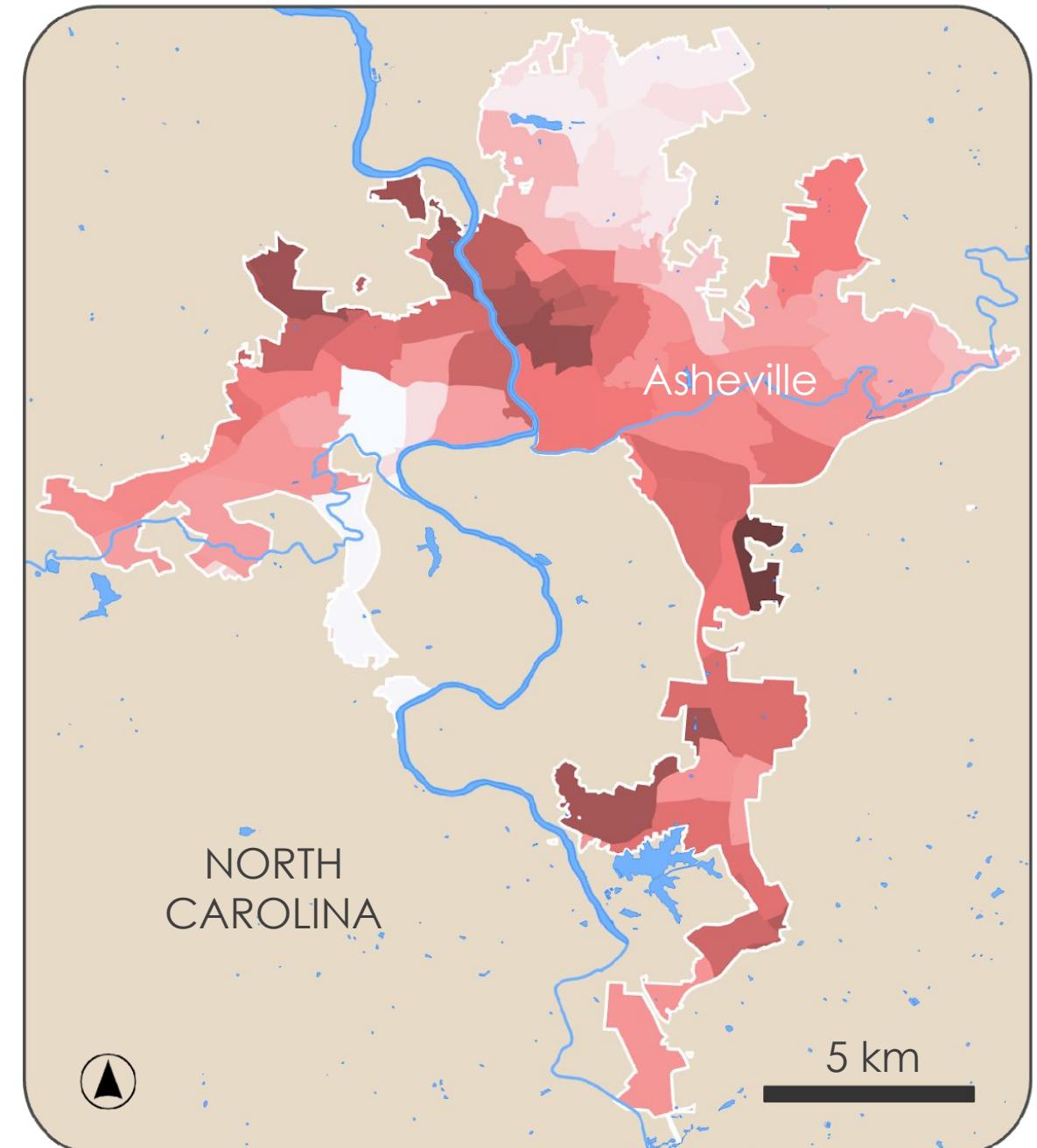
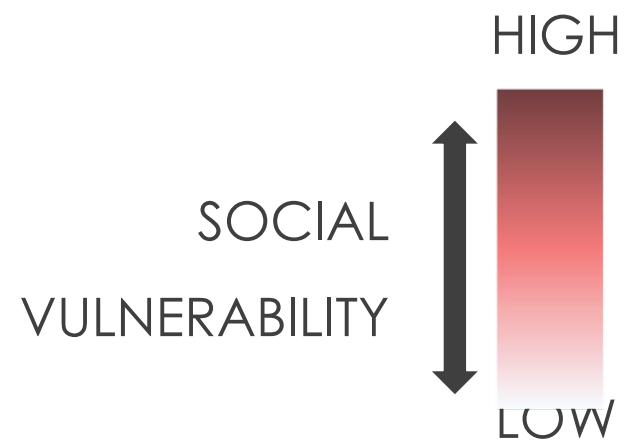
# Social Vulnerability



# Social Vulnerability

Data SVI from 2022

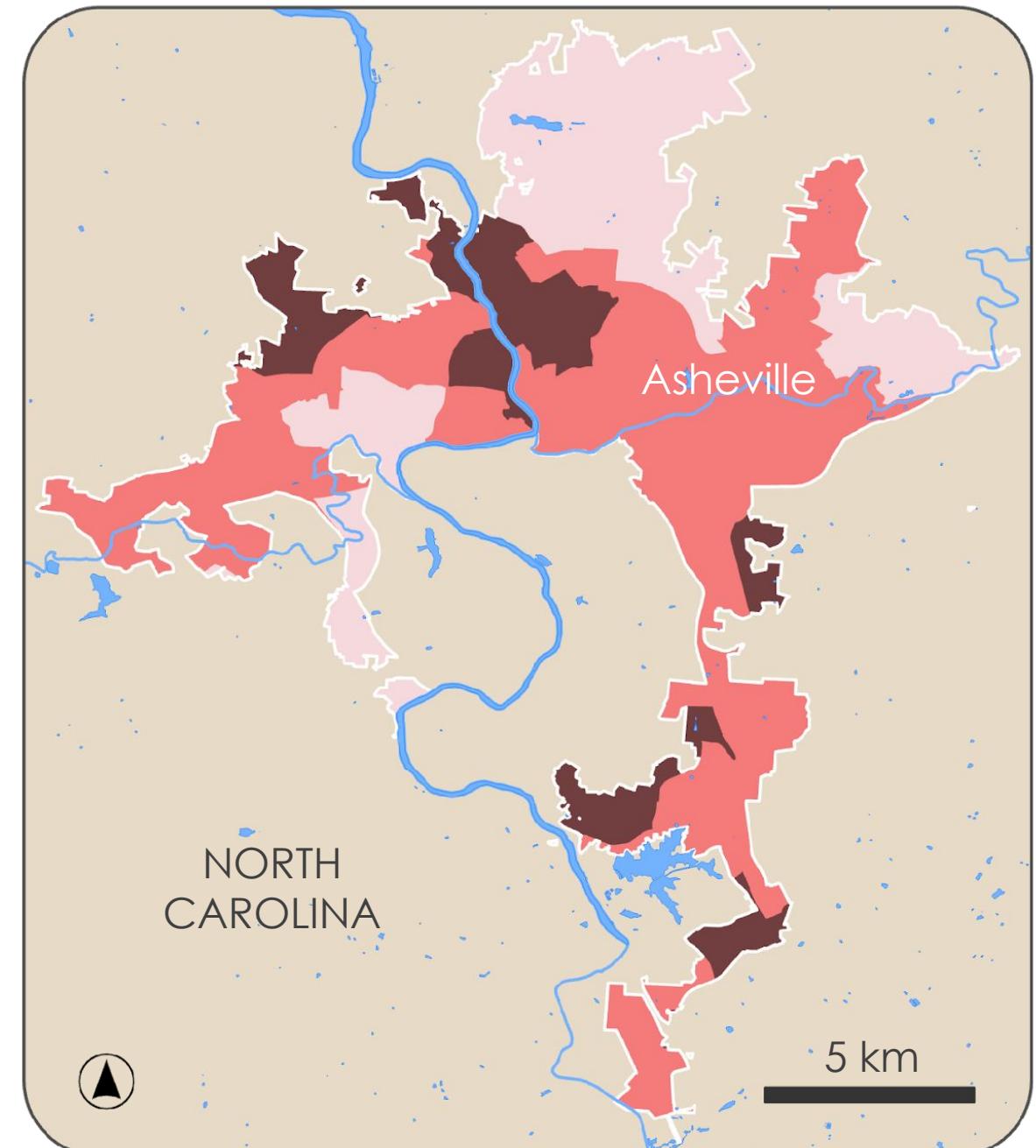
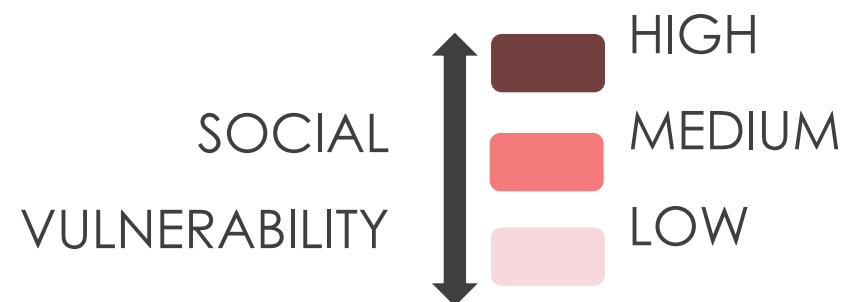
Geometry U.S. Census Block Groups



# Social Vulnerability

Data SVI from 2022

Geometry U.S. Census Block Groups

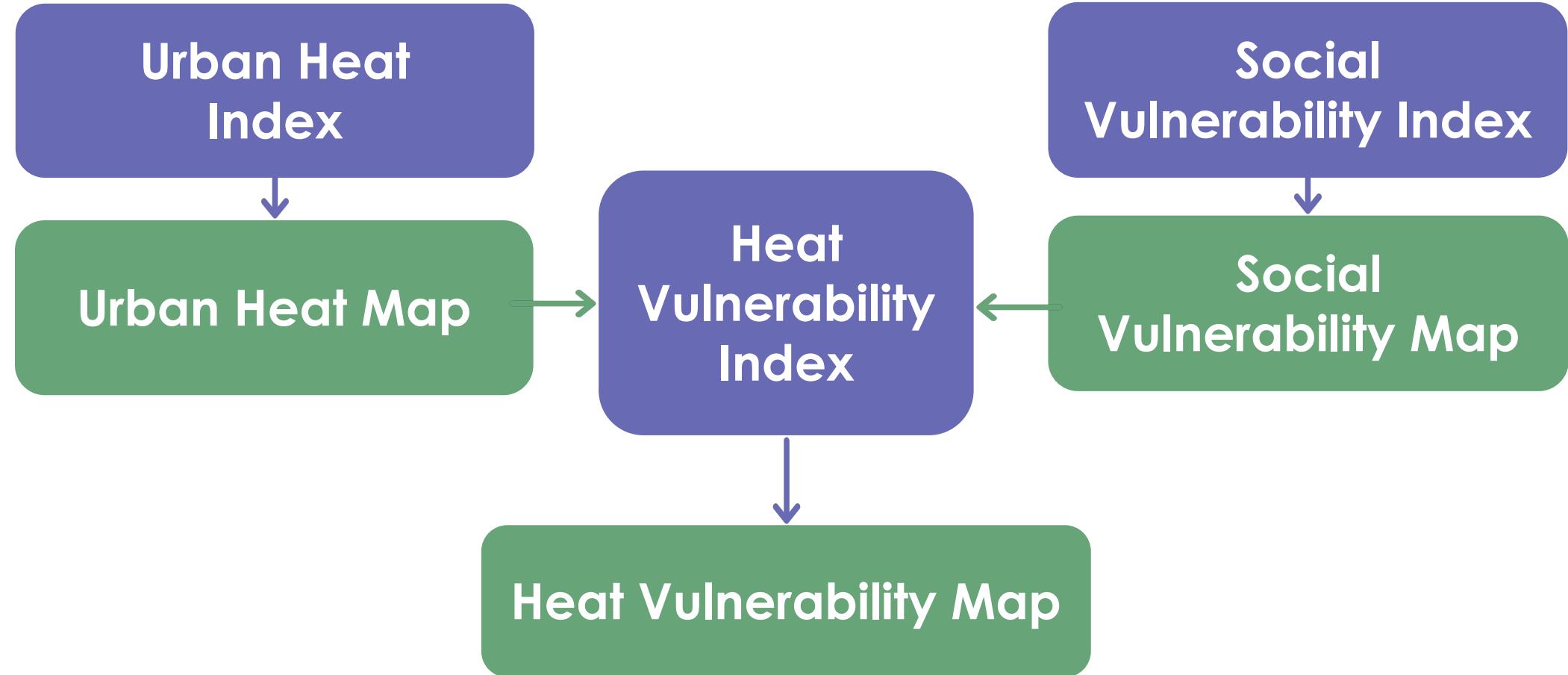


# Heat Vulnerability



Aerial Image of Neighborhoods in North Asheville, NC  
Image Credit: Google Earth

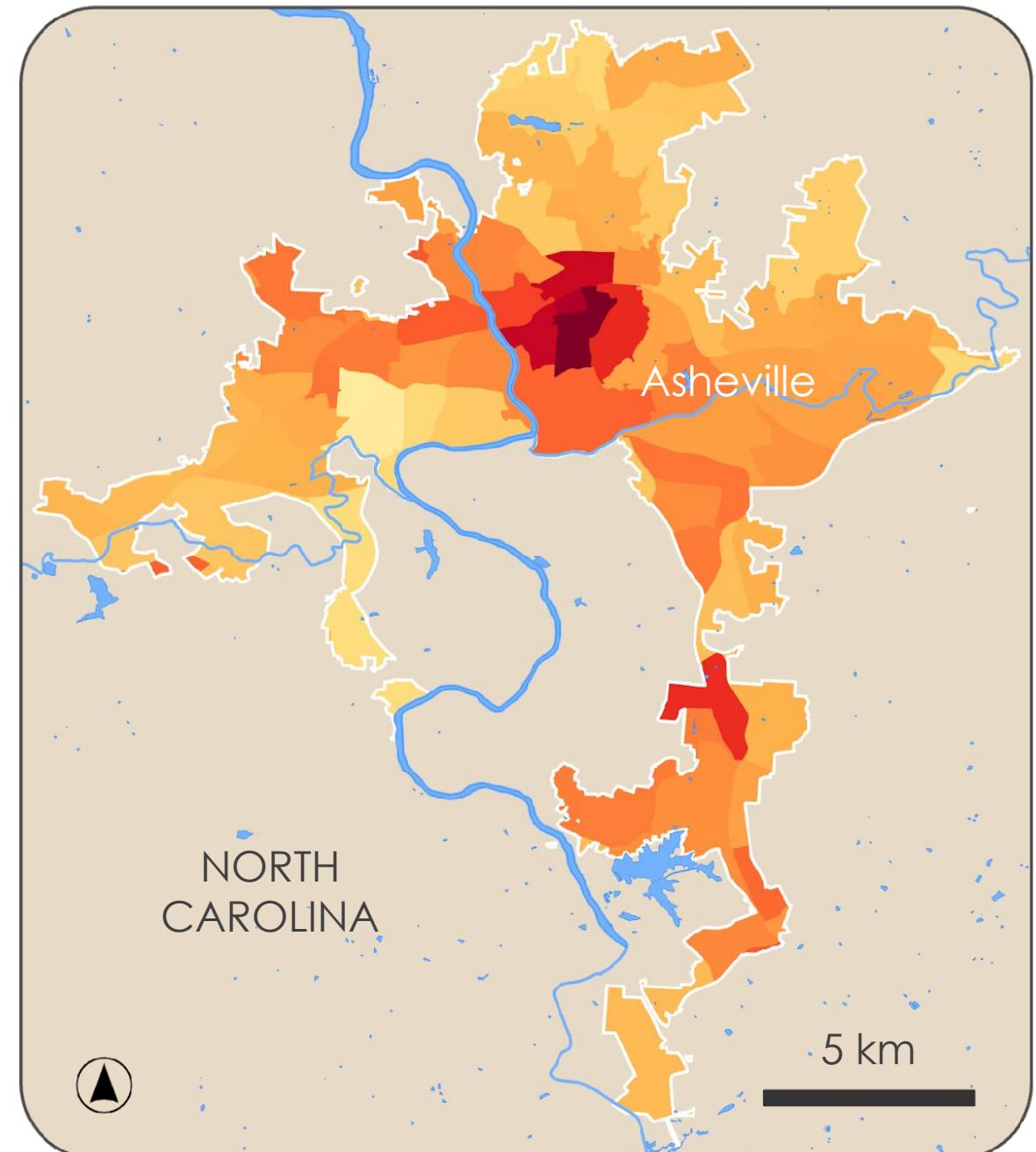
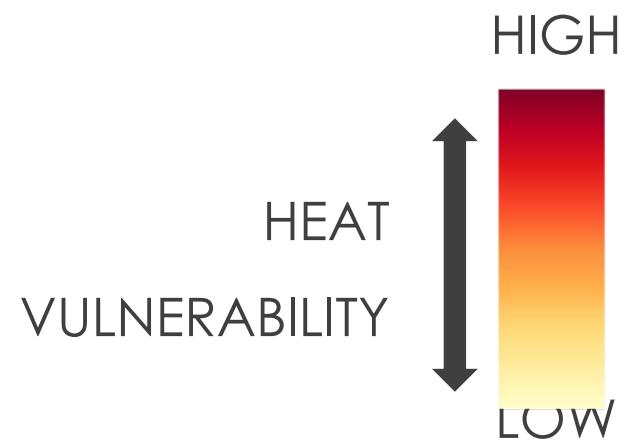
# Heat Vulnerability



# Heat Vulnerability

Data LST | Albedo | Evapotranspiration | SVI

Geometry U.S. Census Block Groups

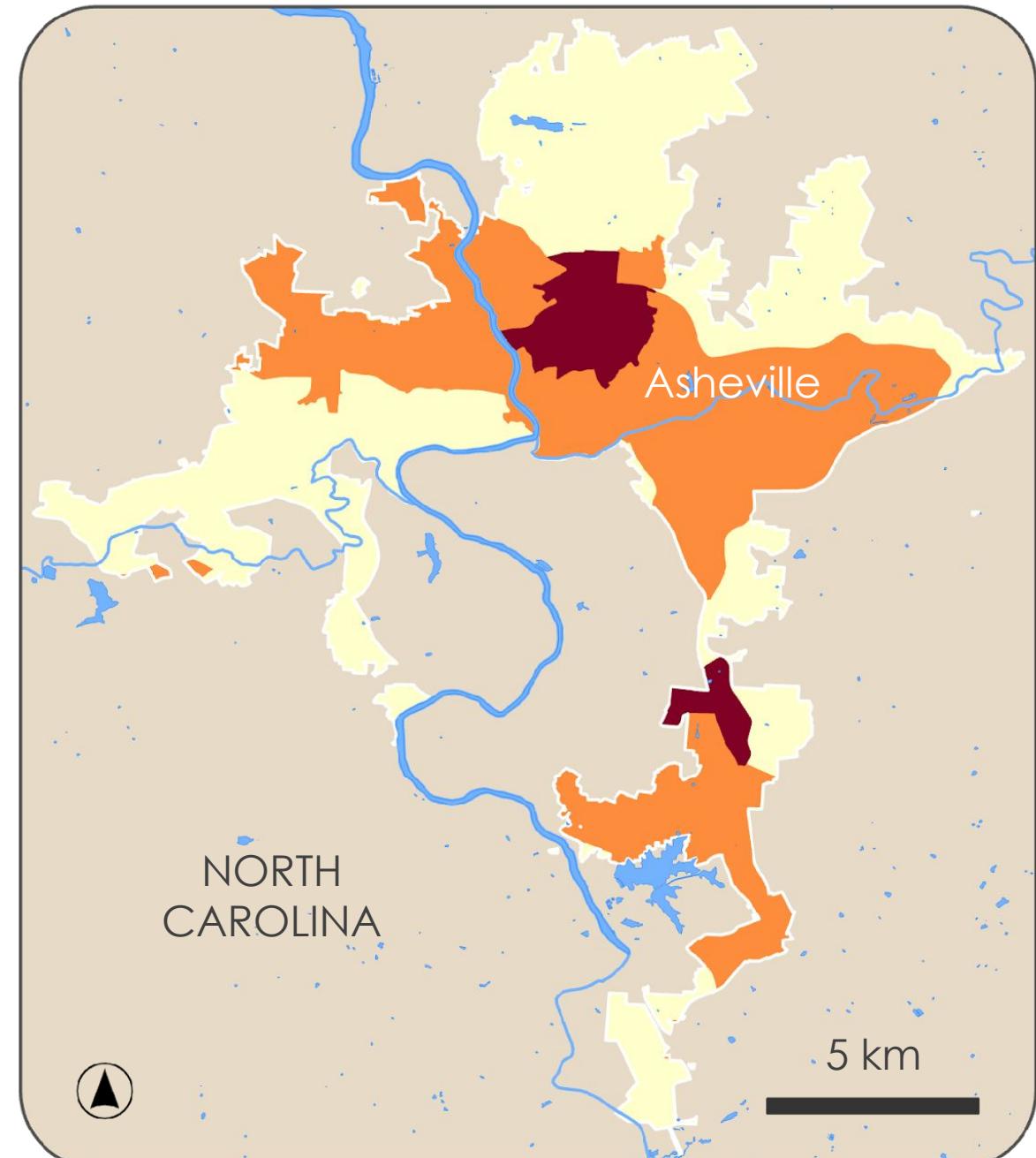
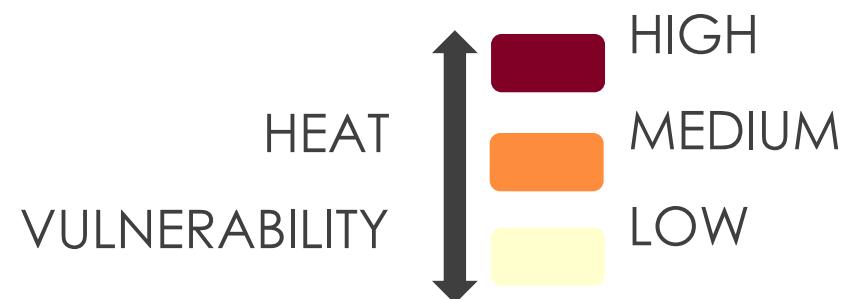


Basemap Credit: State of NC

# Heat Vulnerability

Data LST | Albedo | Evapotranspiration | SVI

Geometry U.S. Census Block Groups



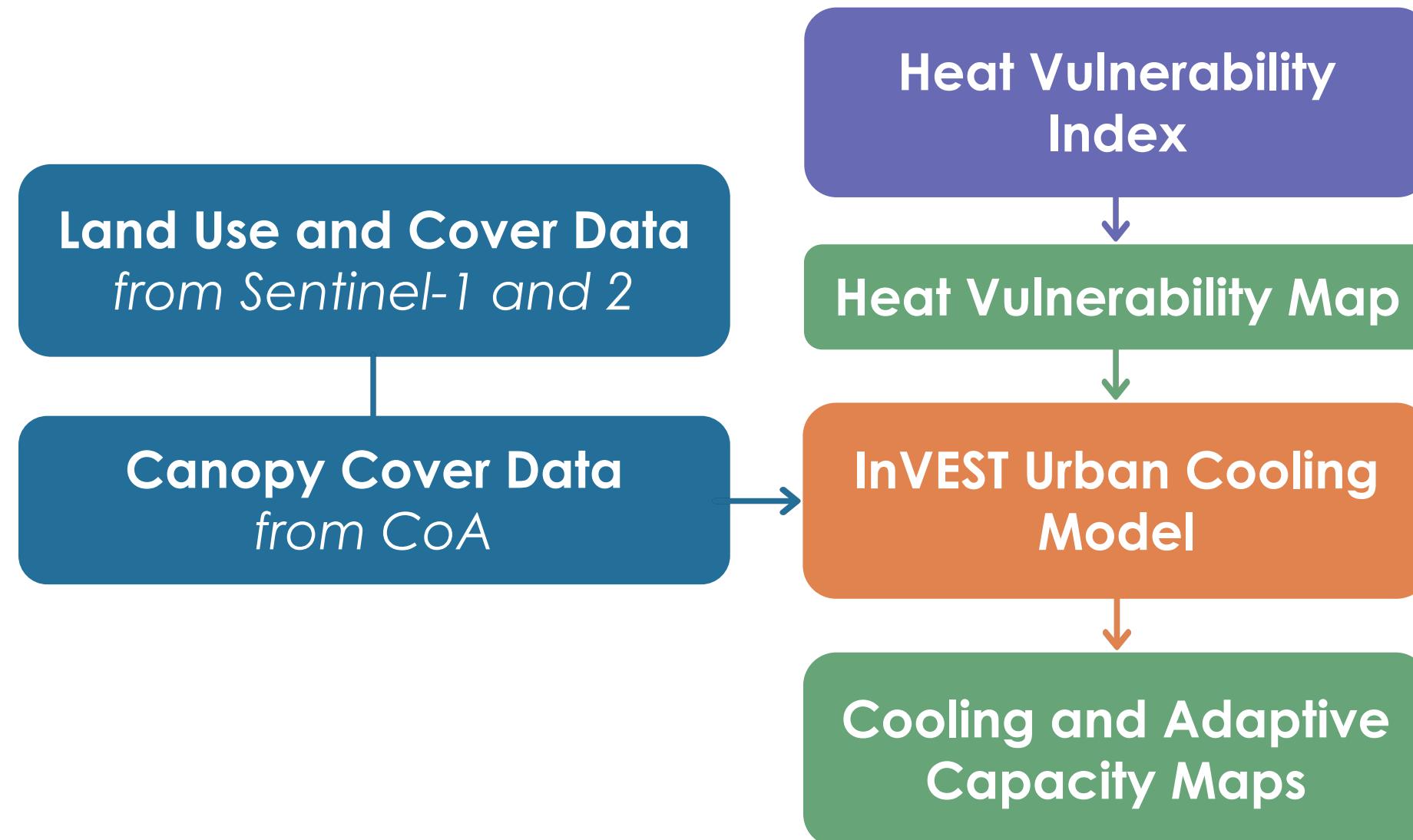
Basemap Credit: State of NC

# UHI Mitigation and Adaptation



Image of Asheville GreenWorks Volunteers  
Image Credit: Asheville GreenWorks

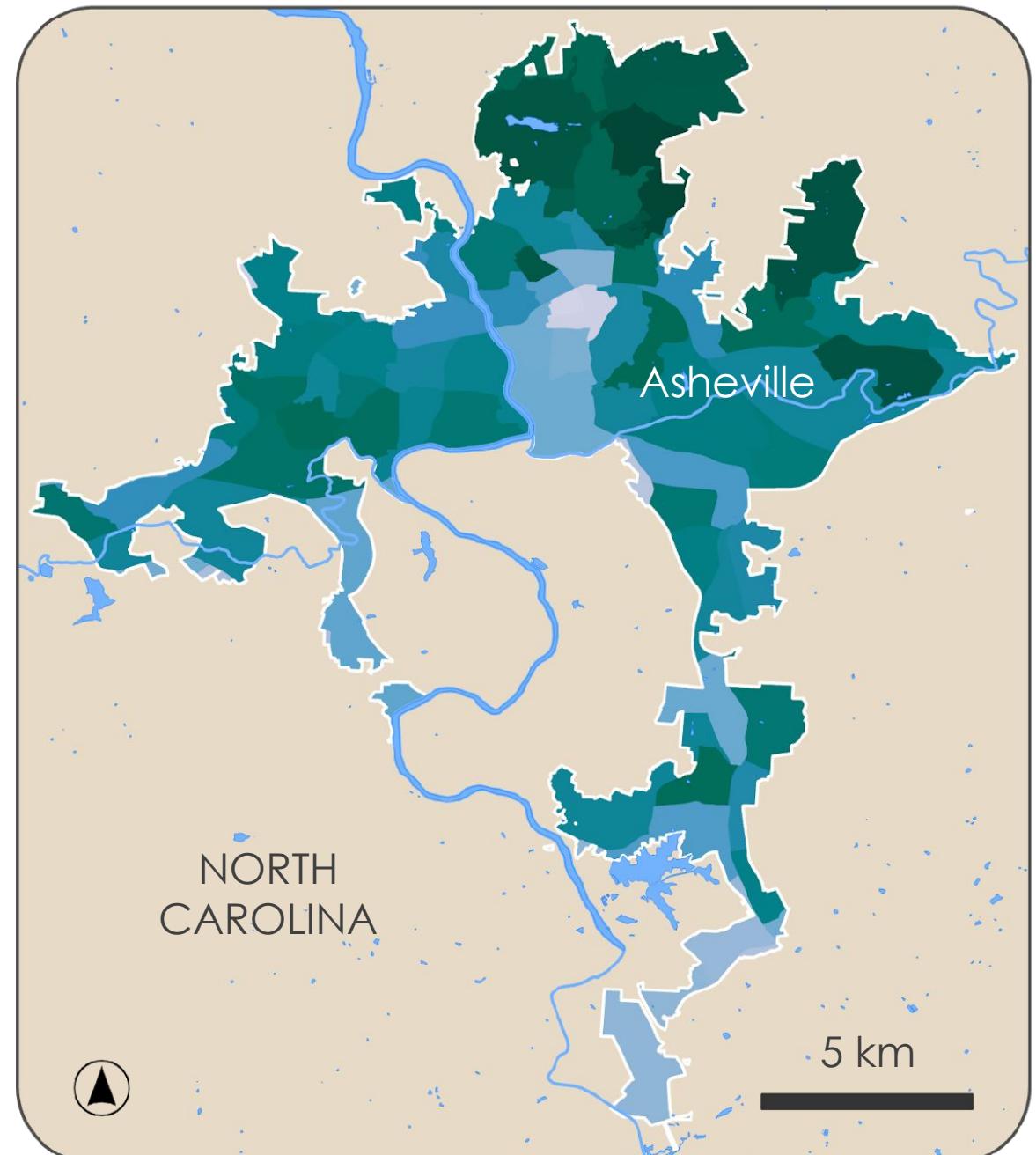
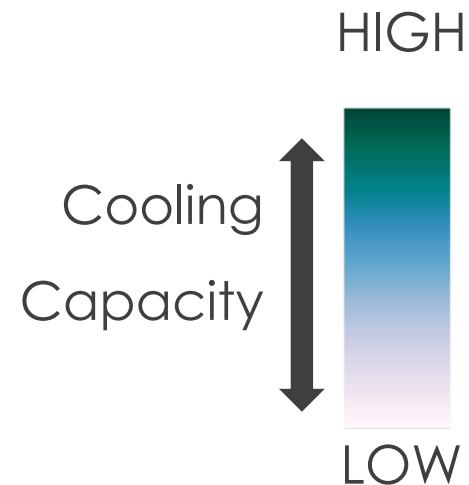
# Cooling and Adaptive Capacity



# Cooling Capacity

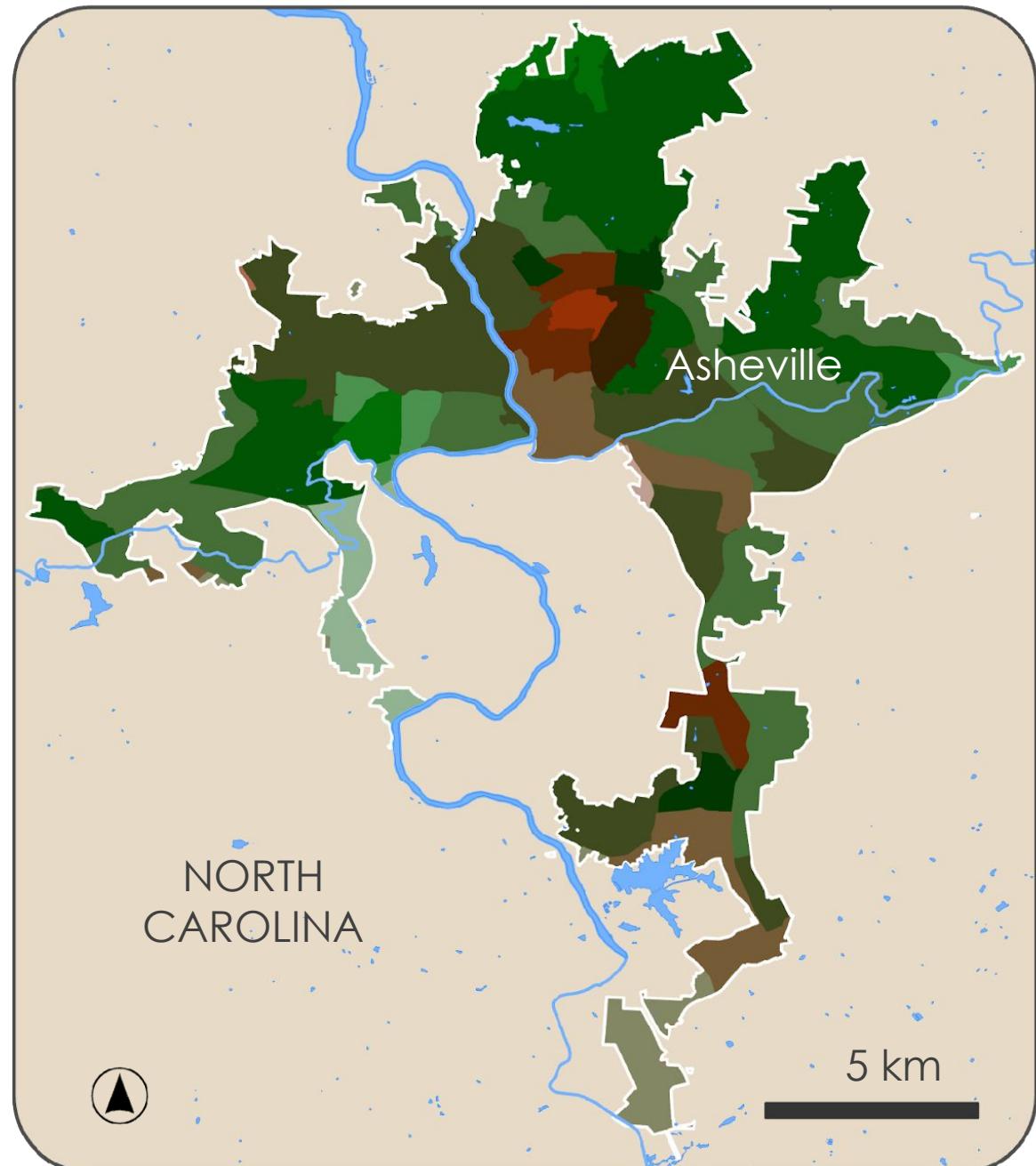
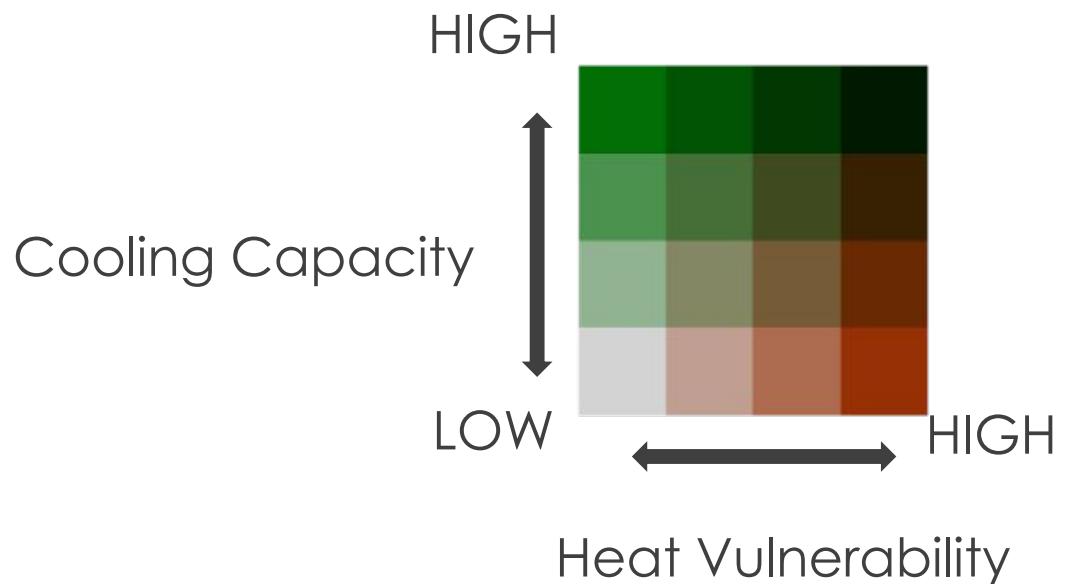
Data LULC | Albedo | Evapotranspiration |  
Canopy Cover

Geometry U.S. Census Block Groups



# Adaptive Capacity

**Data** Cooling Capacity | Heat Vulnerability  
**Geometry** U.S. Census Block Groups



# Errors and Uncertainties

Scale and Data Sources

LST ≠ Ambient Air Temperature

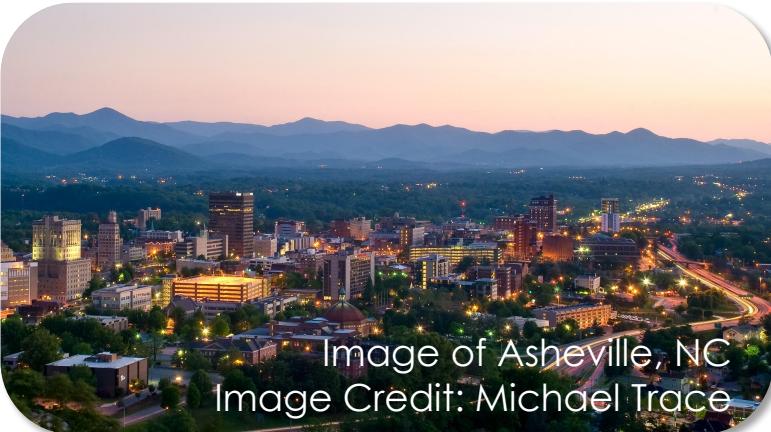


Image of Asheville, NC  
Image Credit: Michael Trace

Albedo Complexity

Evapotranspiration Parameters/Calculation



Image of Downtown Asheville, NC  
Image Credit: Nick Ledford

# Errors and Uncertainties

**Social Vulnerability**



**Cloud Masking**



Image Rendition of Landsat Satellite  
Image Credit: NASA

**Time and Aspect of Satellites**

**Data Processing and No Statistical Analysis**

# Conclusion



Asheville's UHI was characterized by a radial pattern of decreasing urban heat from downtown to more rural areas



Socially vulnerable communities were disproportionately located in urban heat hotspots, indicating environmental inequity



Implementing cooling measures in hotspots can mitigate urban heat effects



Need for targeted interventions to reduce heat impacts, address environmental injustices, and enhance urban climate resilience

# Acknowledgments



## NASA DEVELOP Program

- Tallis L. Monteiro – Center Lead, North Carolina – NCEI

## Project Partners

- Chris Defiore – Asheville GreenWorks
- Chris Clarke – Sustainability Department, The City of Asheville

## Science Advisors

- Douglas Rao – NOAA National Centers for Environmental Information
- Edward Macie – Asheville GreenWorks, City of Asheville Urban Forestry Commission
- Molly Woloszyn – NOAA National Integrated Drought Information System

## Past Contributors

- Darcy Gray (Project Lead)
- Amiya Kalra
- Amy Kennedy

## Special Thanks

- Kathryn Caruso – Prior Center Lead for the NCEI Node
- Jared Rennie – NOAA National Centers for Environmental Information
- Dr. Kenton W. Ross – NASA Langley Research Center

This material contains modified Copernicus Sentinel data (2024), processed by ESA.

This material is based upon work supported by NASA through contract 80LARC23FA024. Any mention of a commercial product, service, or activity in this material does not constitute NASA endorsement. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Aeronautics and Space Administration and partner organizations.

