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RESEARCH SYMPOSIUM

MEASURING & REDUCING SOCIETAL IMPACTS

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Mary Wright
Arizona State University

Evan Mallen
Georgia Institute of Technology

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CLIMATE ADAPTATION
RESEARCH SYMPOSIUM
MEASURING & REDUCING SOCIETAL IMPACTS

UCLA Luskin Center for Innovation

Mary Wright

Ph.D. Candidate, Arizona State University

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A Meta-Analysis of Social and Environmental Factors Predicting Household-Level Heat-Related Illness in Phoenix, Arizona

School of Geographical Sciences and Urban Planning
Arizona State University

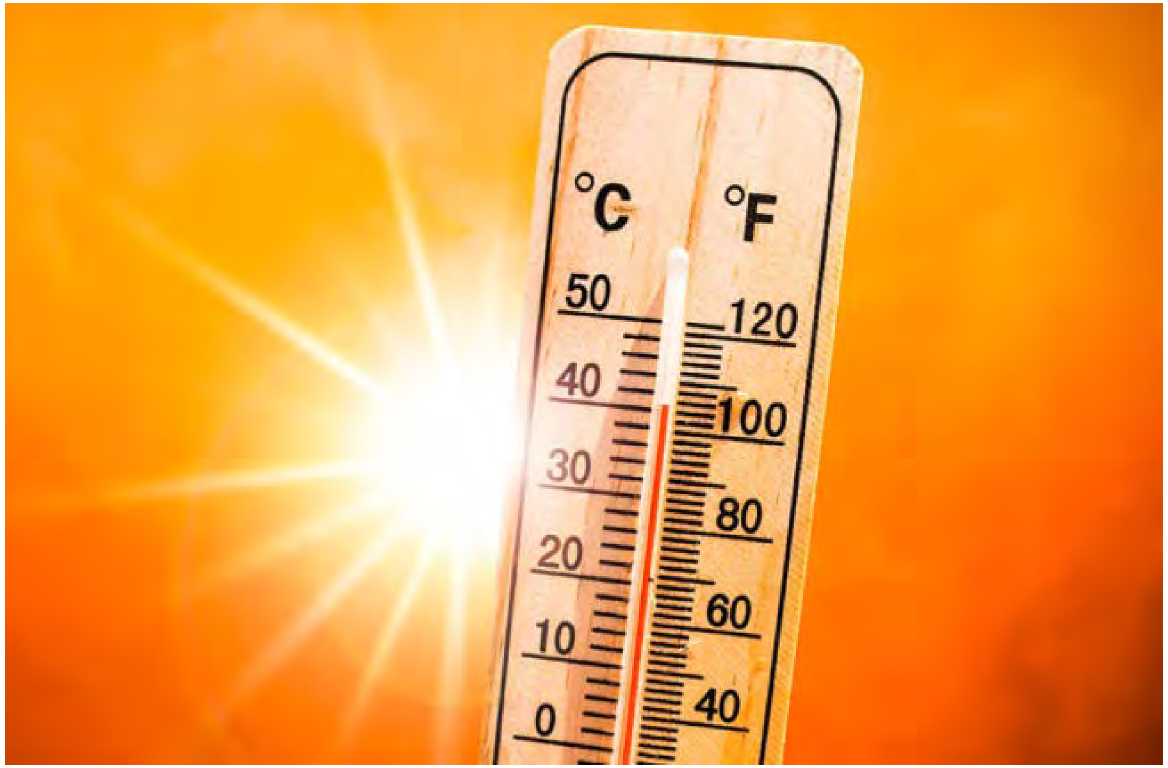
A meta-analysis of social and environmental factors predicting household-level heat-related illness in Phoenix, Arizona

Mary Wright, David Hondula, Kelli Larson

UCLA Climate Adaptation Research Symposium
September 8, 2021

The impact of heat on people

- Heat impacts health
- Heat impacts quality of life
- Heat impacts are not equitable
  - Physiological
  - Social/behavioral

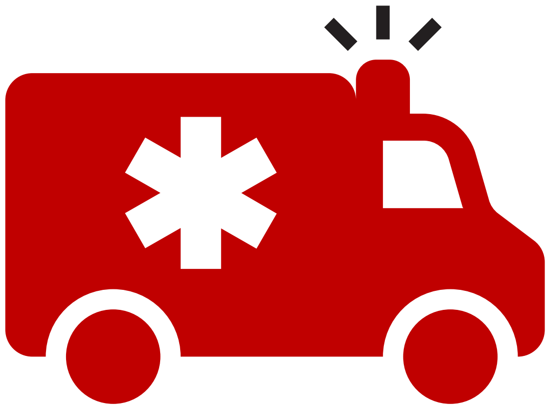


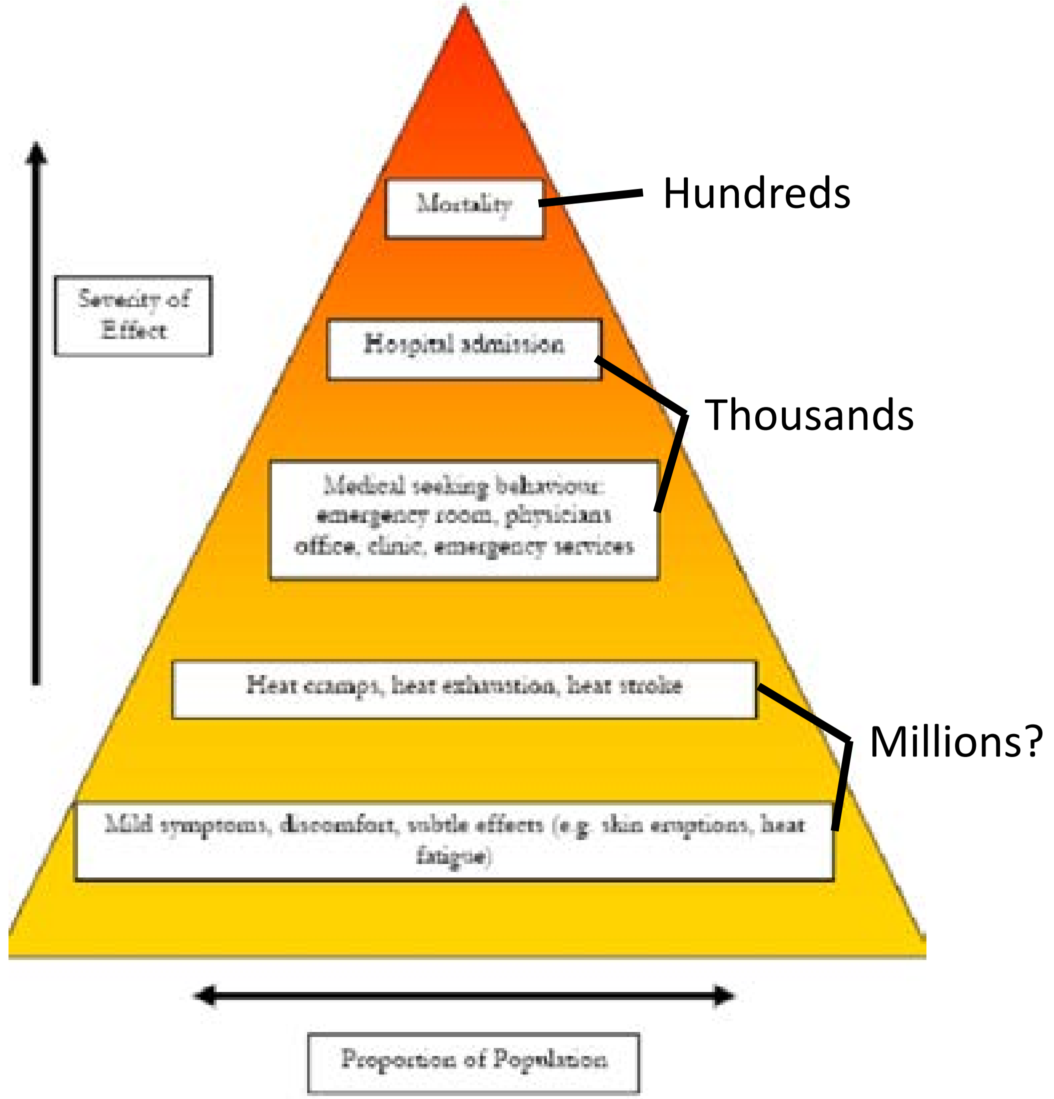
Anderson & Bell 2011; Robinson 2001; Robine et al. 2008; Semenza et al. 1996; Azhar et al. 2014; MCDPH 2020

Knowledge Gap

Most studies related to heat and its impacts on people,

1. Focus on severe health events





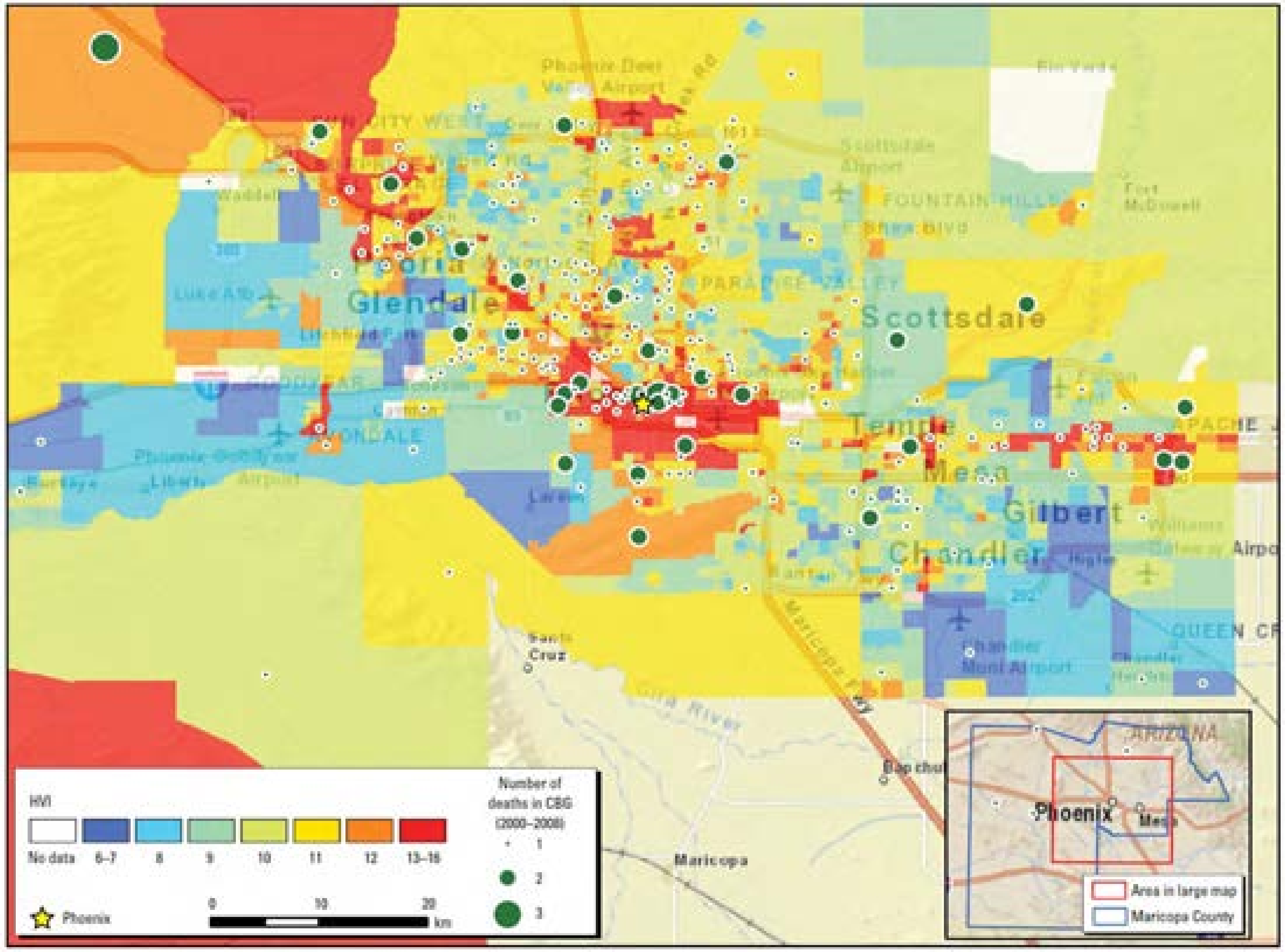
Source: Mills & Kalkstein 2012

Knowledge Gap

Most studies related to heat and its impacts on people,

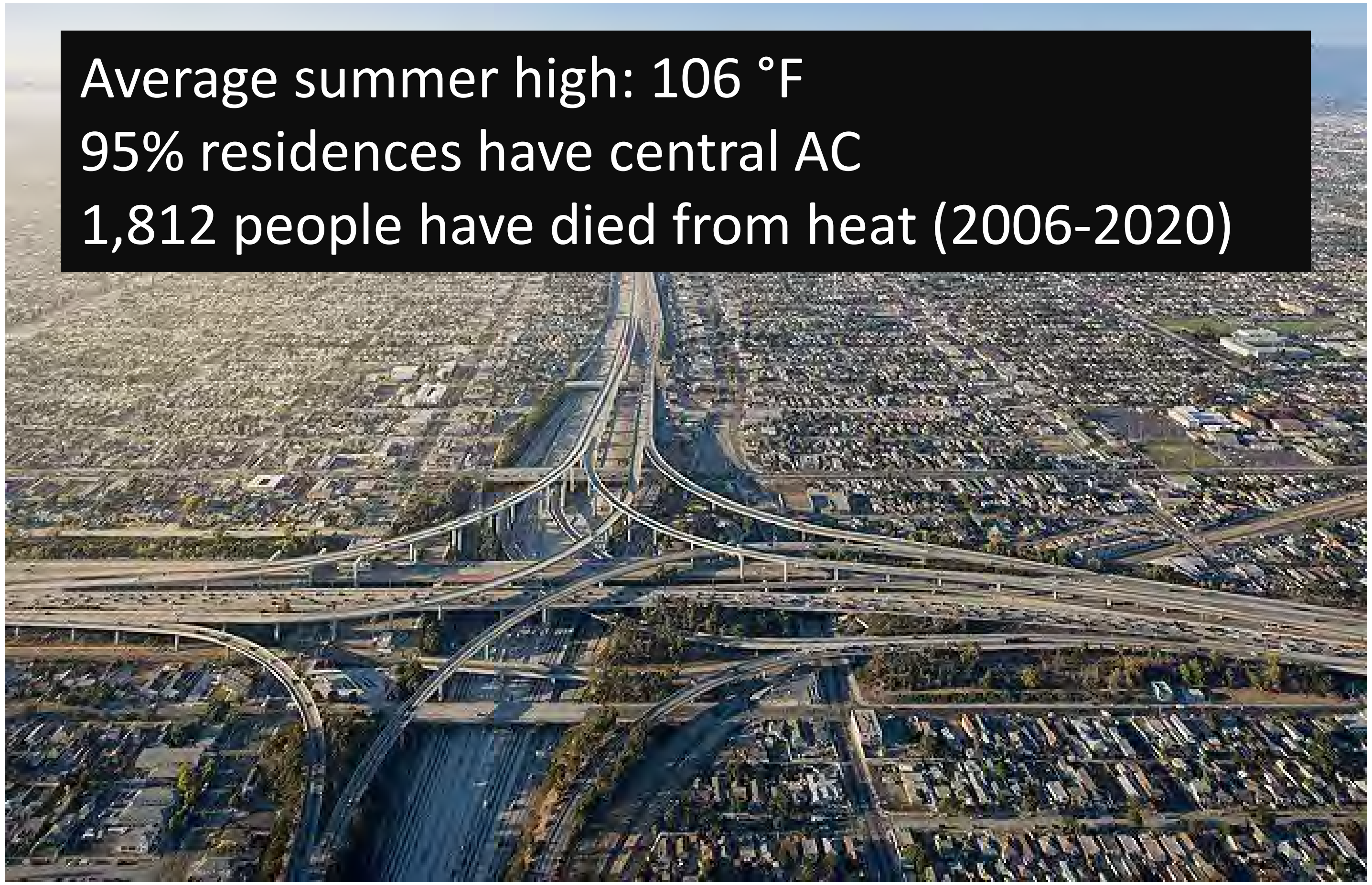
2. Use aggregate data

- Hard to measure adaptive capacity
- Ecological fallacy?



Heat Vulnerability Index map of Maricopa County. Source: Harlan et al. 2013

Study site: Phoenix, Arizona



Average summer high: 106 °F
95% residences have central AC
1,812 people have died from heat (2006-2020)

Heat surveys in the Greater Phoenix Area

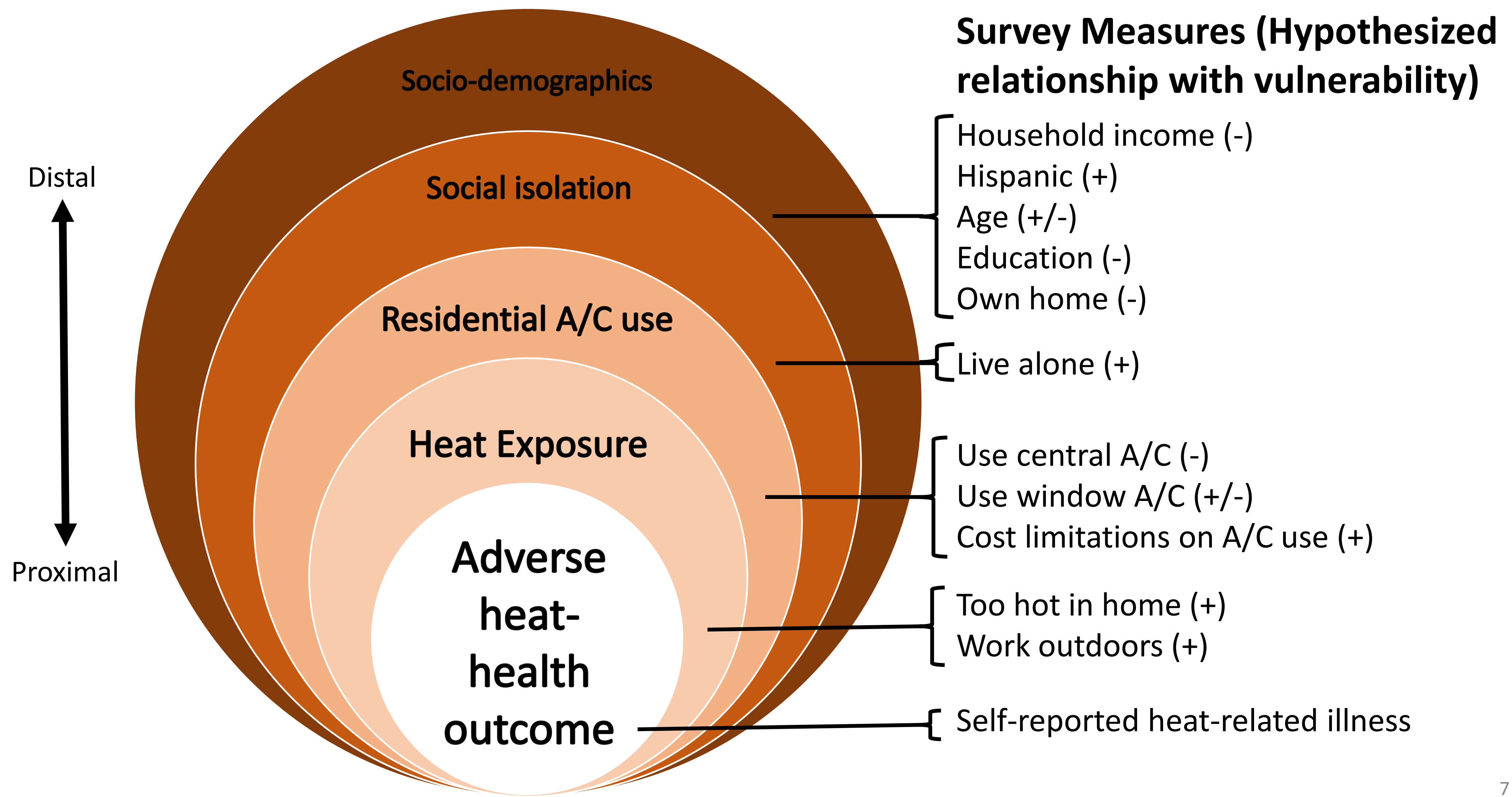
Central Arizona-Phoenix Long-Term Ecological Research CAP LTER

NSF

Maricopa County Public Health WeArePublicHealth.org

Tempe

Survey	Administered by	N	year
PASS 2011	Central Arizona-Phoenix Long-Term Ecological Research (CAP LTER)	744	2011
CASPER	Maricopa County Department of Public Health	328	2015
3HEAT	ASU researchers (Harlan, Hondula, Chakalian, et al.)	163	2016
PASS 2017	Central Arizona-Phoenix Long-Term Ecological Research (CAP LTER)	487	2017
HOME-Air	ASU Urban Climate Research Center (Sailor, Crank, et al.)	303	2017
Schmidt Futures	ASU Knowledge Exchange for Resilience (Solis, Hondula, Kurtz, et al.)	45	2019
Tempe Survey	ASU researchers (Hondula, Kurtz), City of Tempe	193	2020



Adapted from Gronlund 2014

Objective

Conduct a meta-analysis of heat surveys in Phoenix to synthesize measures of heat vulnerability and their impact on self-reported heat-related illness.

Calculate effect sizes for individual surveys

1. Identify shared questions between surveys
2. Convert survey questions as needed to binary responses
3. Control for household size as appropriate
4. Calculate OR of HRI for each survey variable individually

1. Too hot in home
2. Work outdoors
3. Use central A/C
4. Use window A/C
5. Cost A/C limiting
6. Live alone

7. Own home
8. Income < $40K
9. Hispanic/Latino
10. Bachelor's degree
11. Over 64 years old

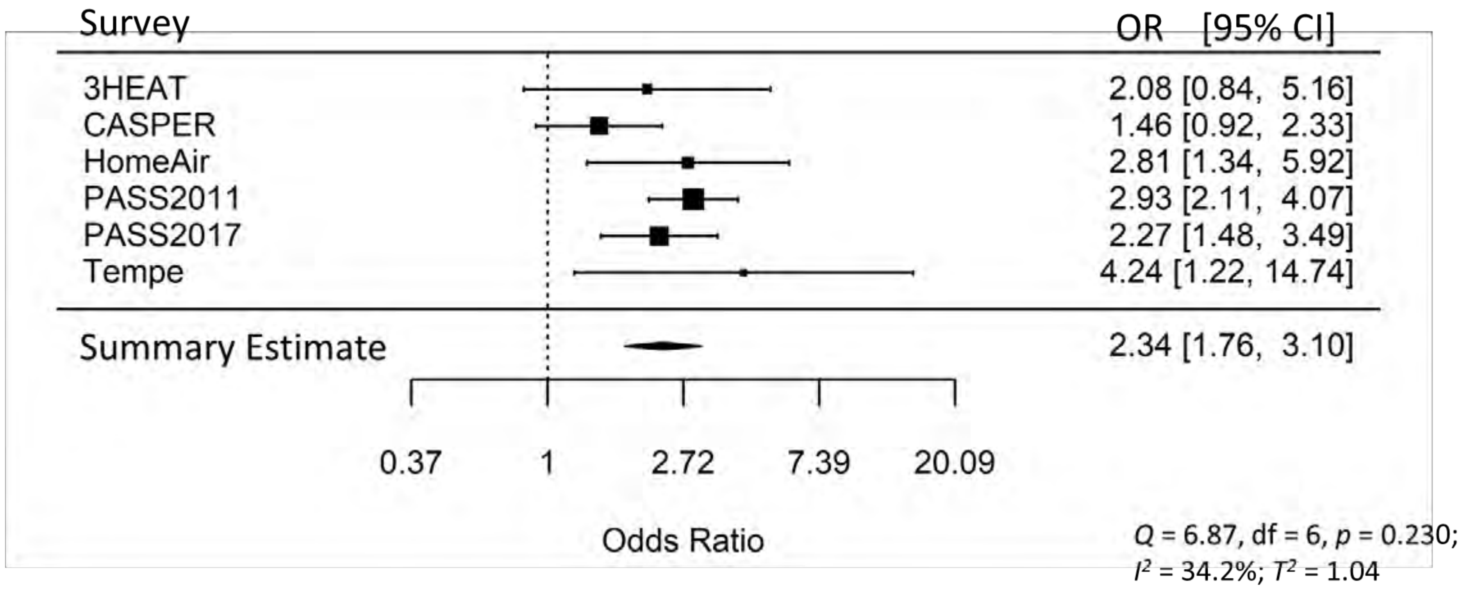
Logistic regression model

$$log\left(\frac{Y}{1-Y}\right) = b_o + b_1x_1 + b_2x_2$$

Odds of HRI~survey question + HH size

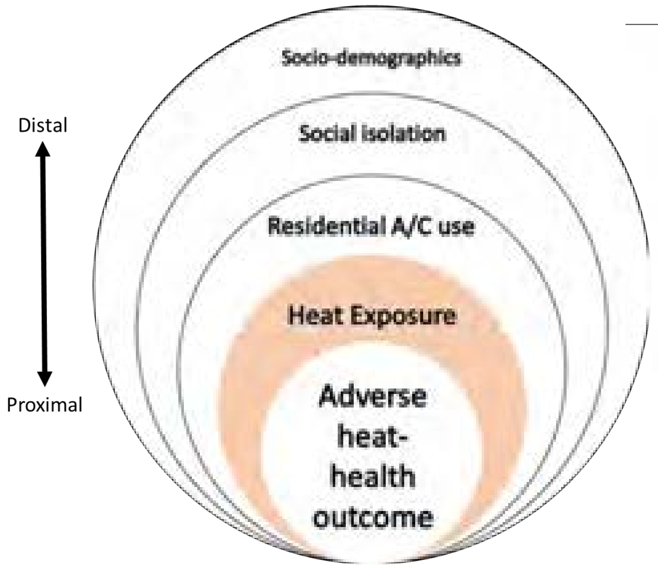
Meta-analysis

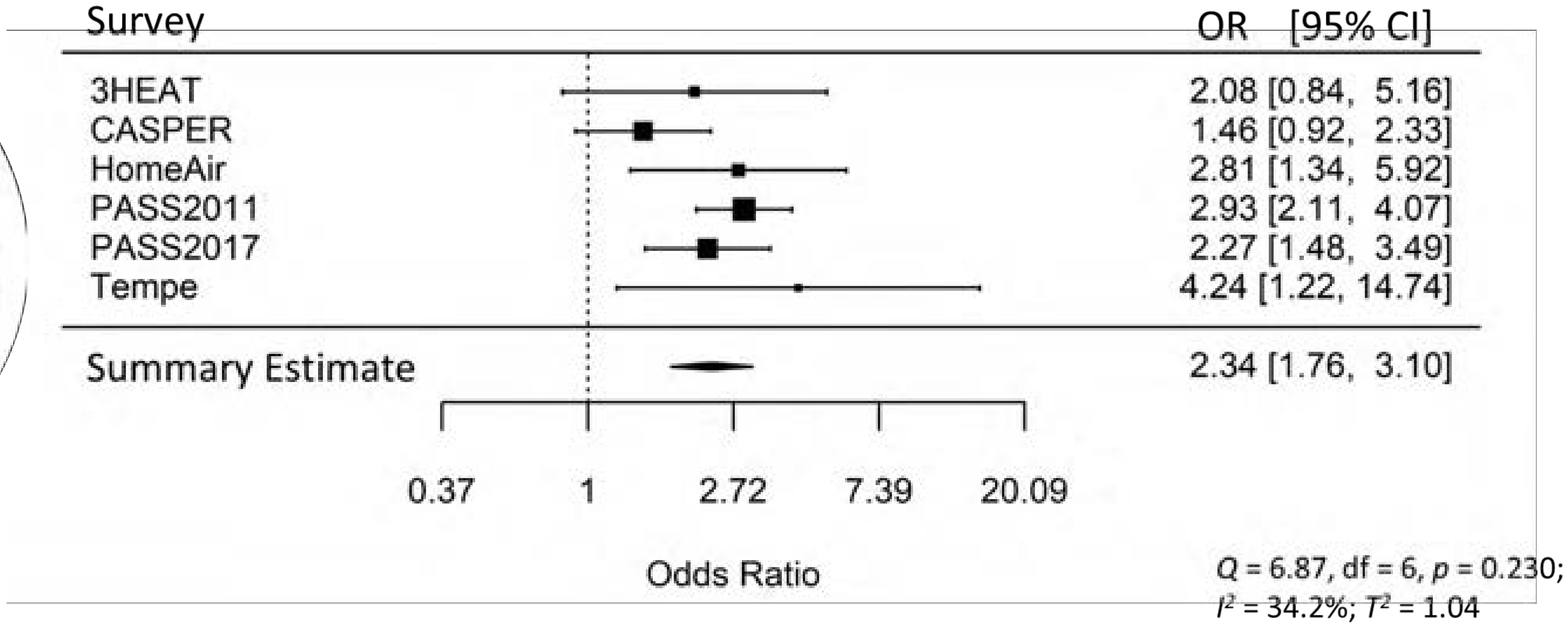
Are you or members of your household ever too hot in your home?



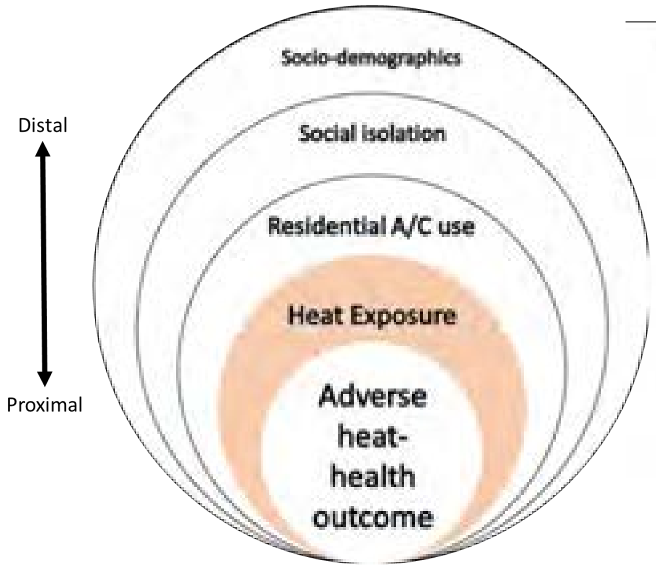
- Synthesize effect sizes → summary effect
- In a random-effects model, individual studies are weighted to minimize both **within study variance** and **between study variance**
- Can quantify heterogeneity of effect sizes between studies:
  - T^2 – estimated between studies variance
  - I^2 – proportion of observed variance that reflects real differences in effect size
  - Q – test statistic to assess certainty of apparent heterogeneity
- We used a random-effects meta-analysis model with restricted maximum-likelihood (REML) to estimate T^2

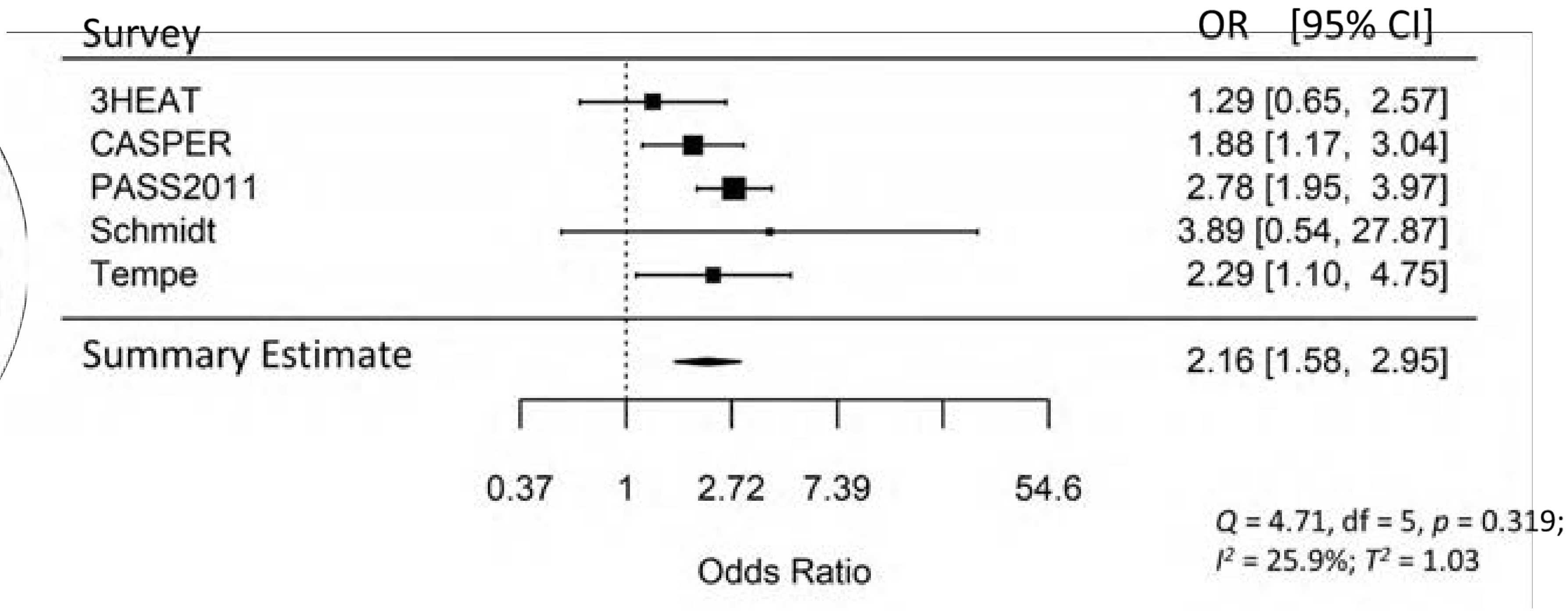
Are you or members of your household ever too hot in your home?



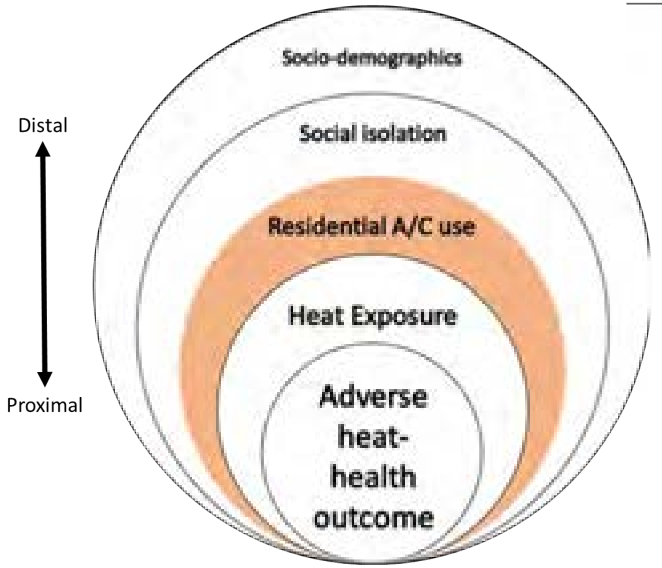


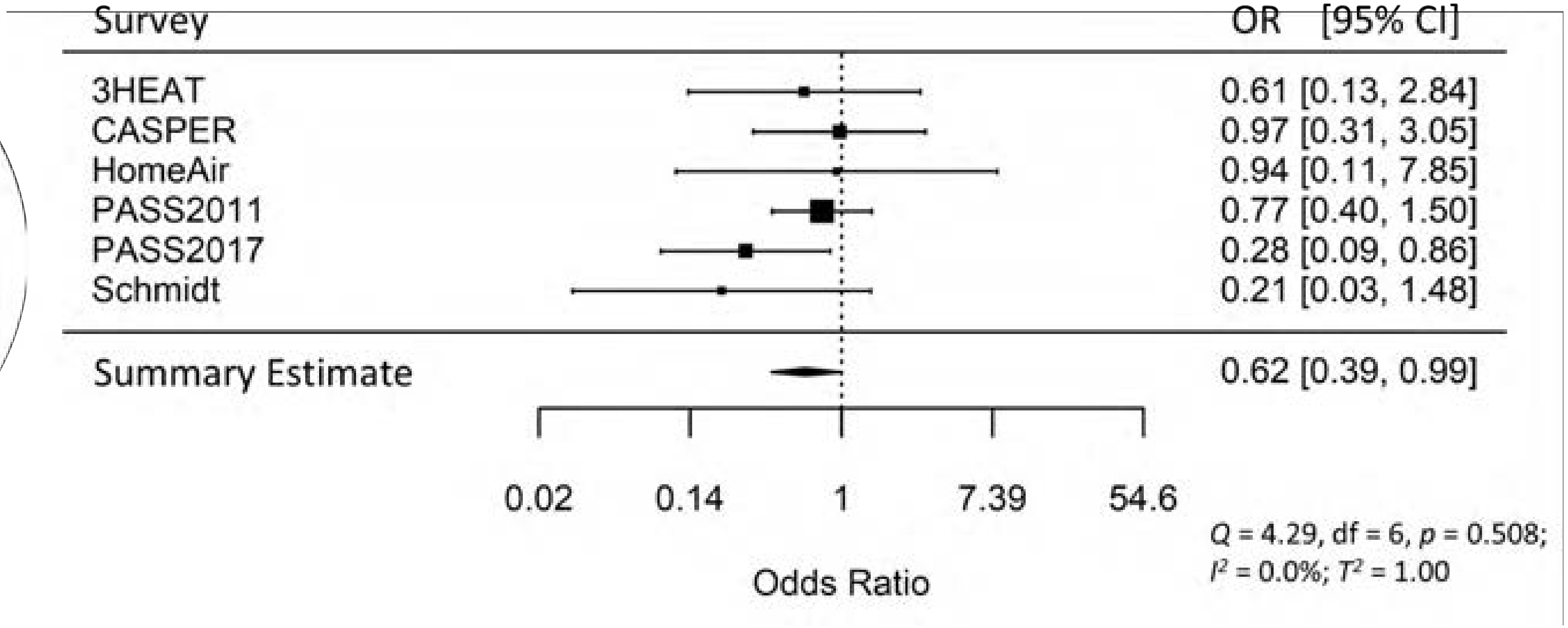
Do you or does any member of your household work outdoors?



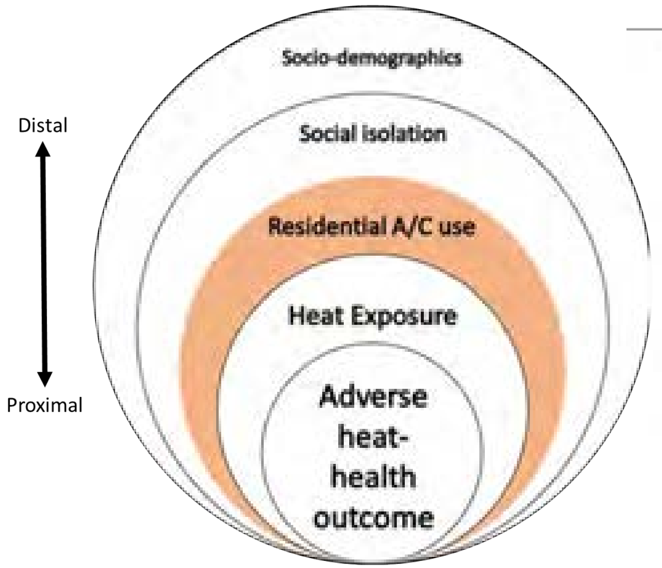


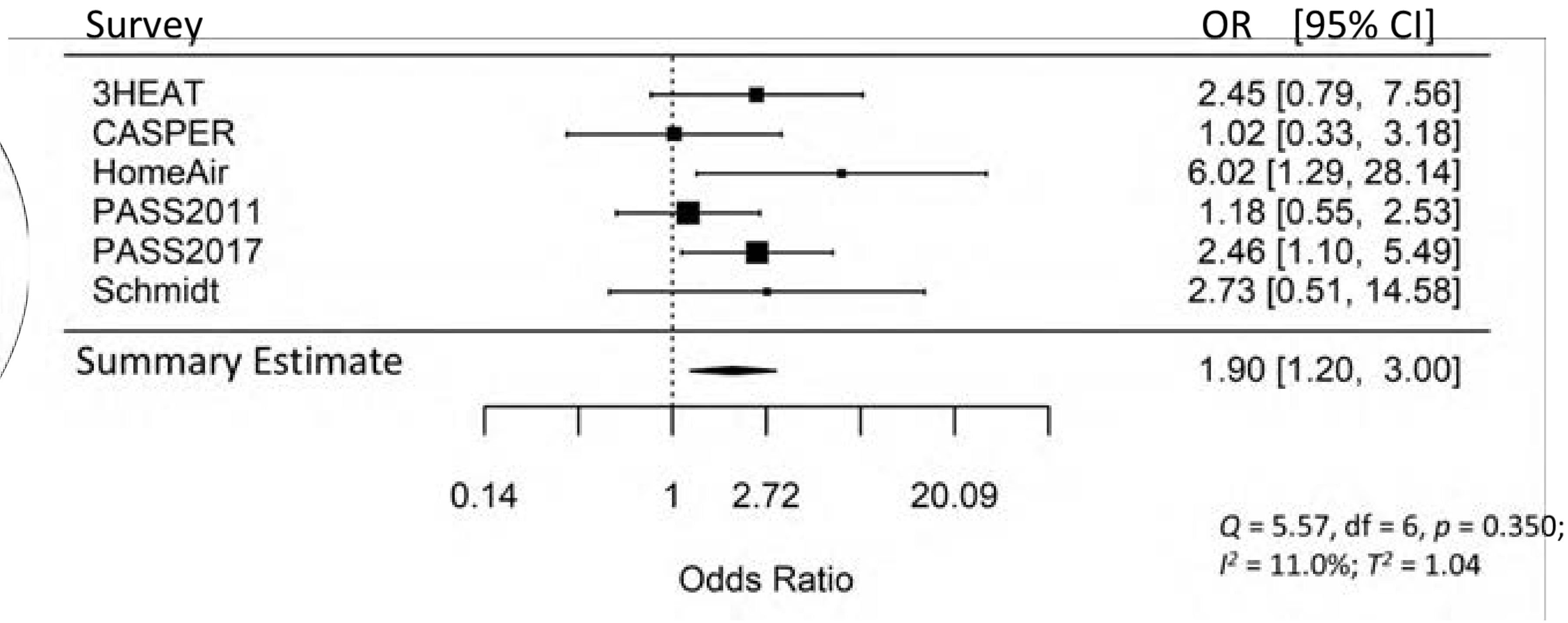
Do you/and or your household use central air-conditioning to cool your home?



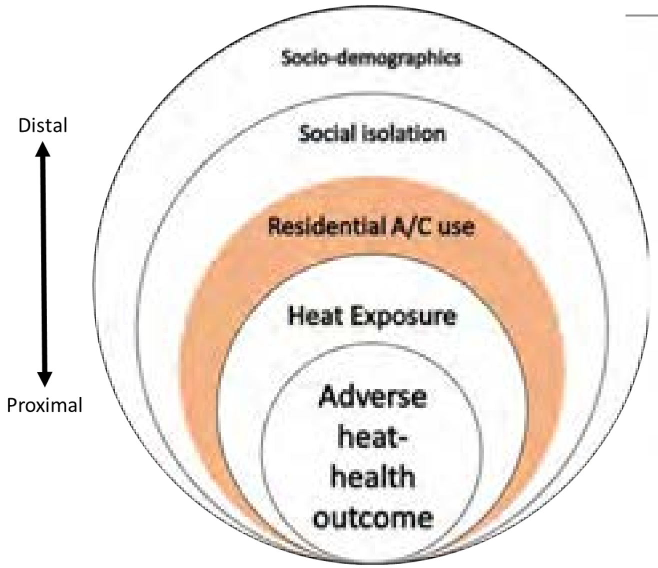


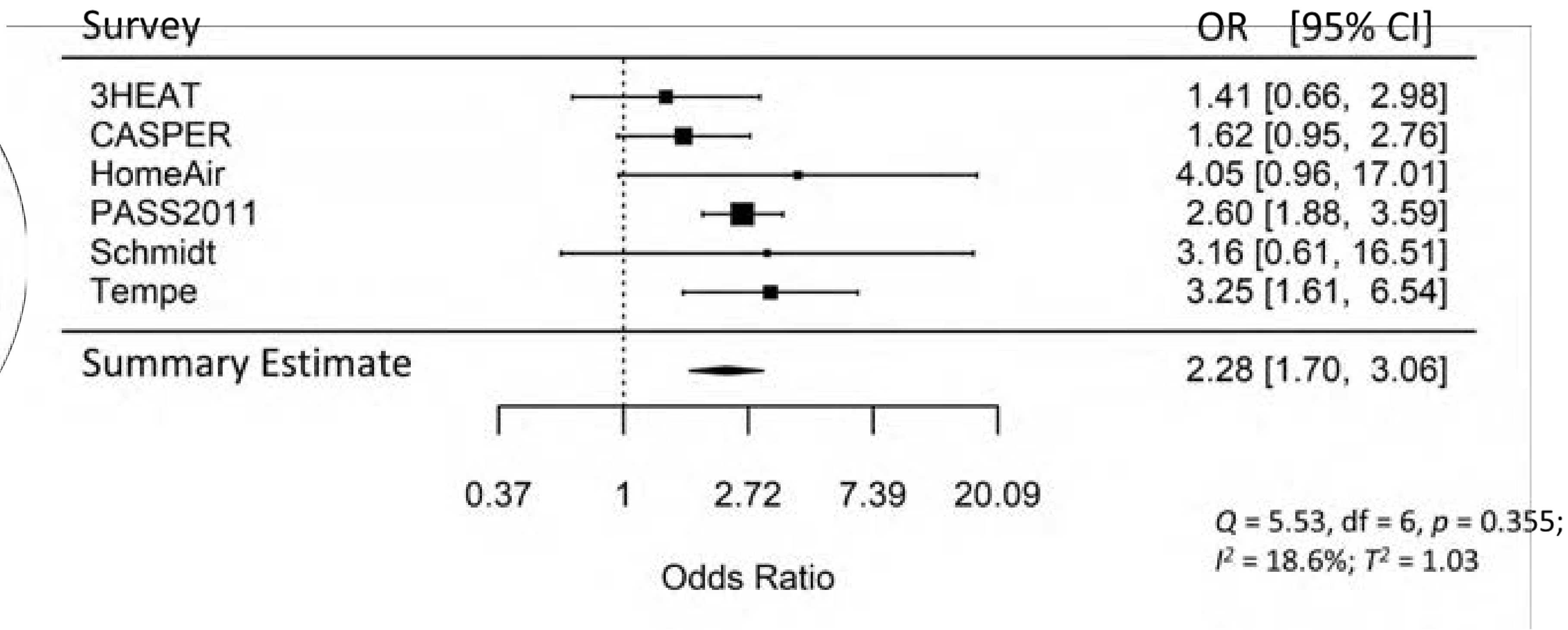
Do you/and or your household use window air-conditioning to cool your home?



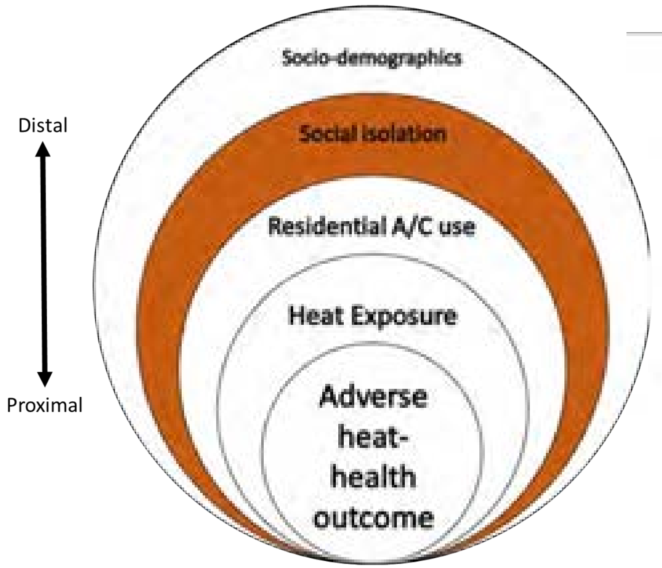


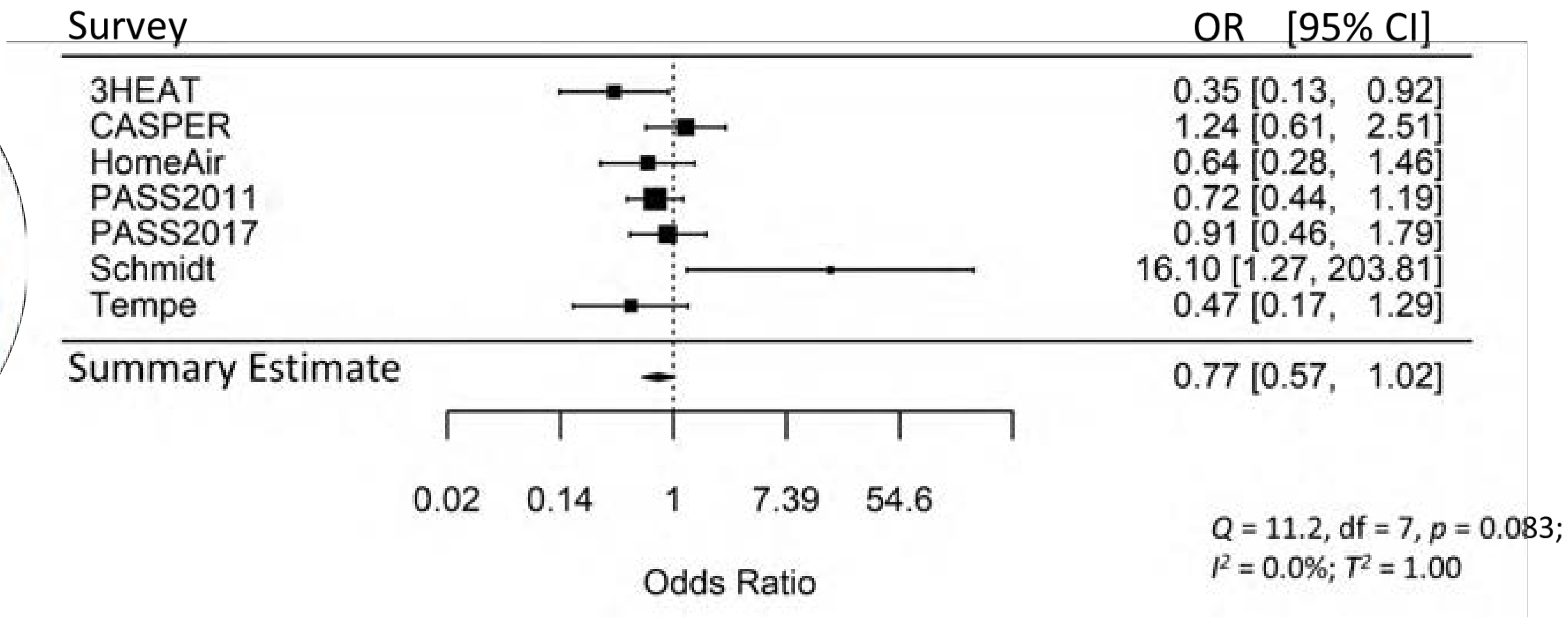
Do you restrict air-conditioning use in your home due to concerns about cost?



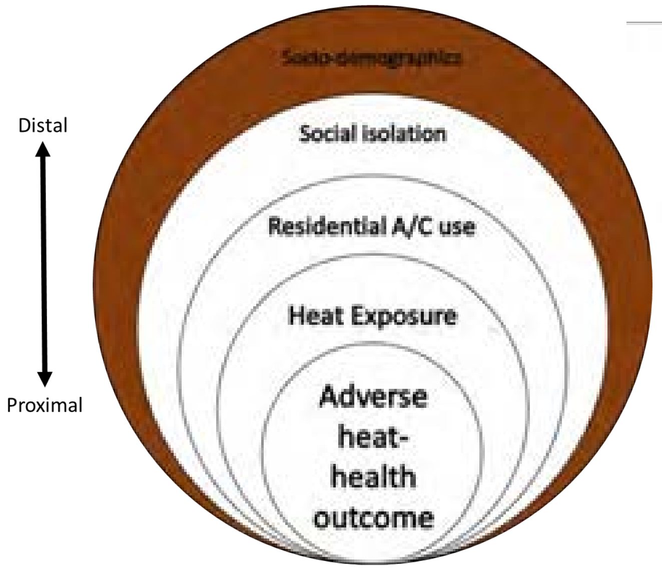


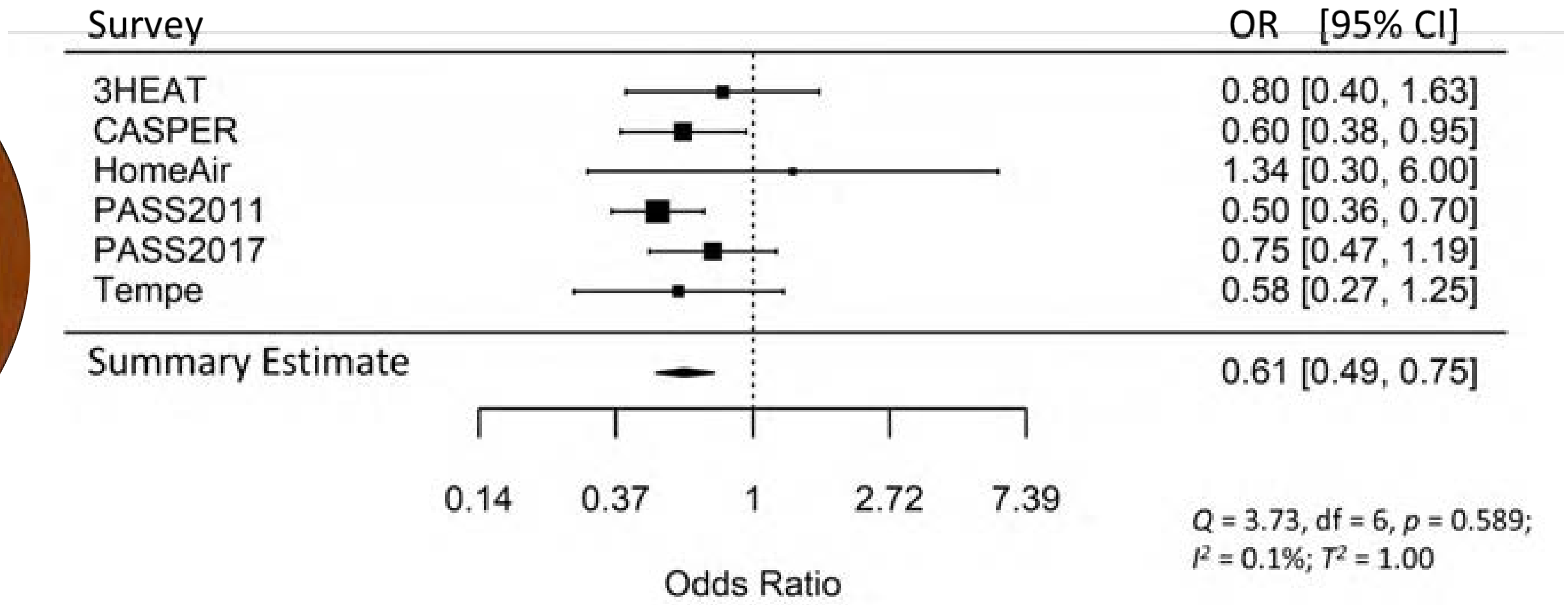
Do you live alone?



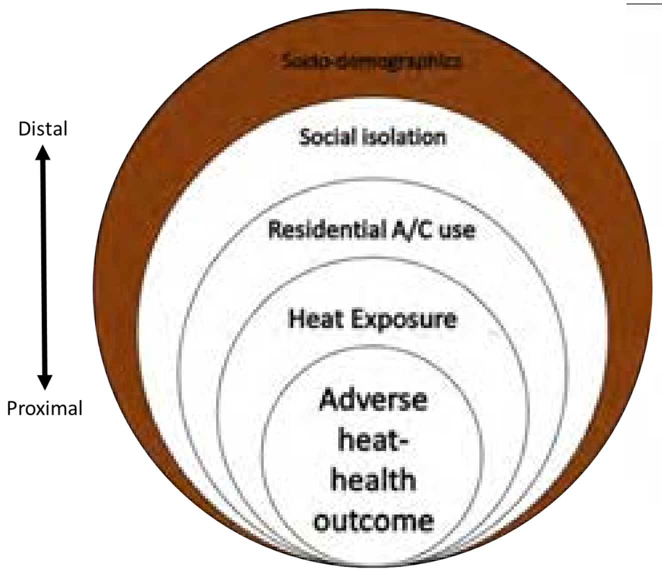


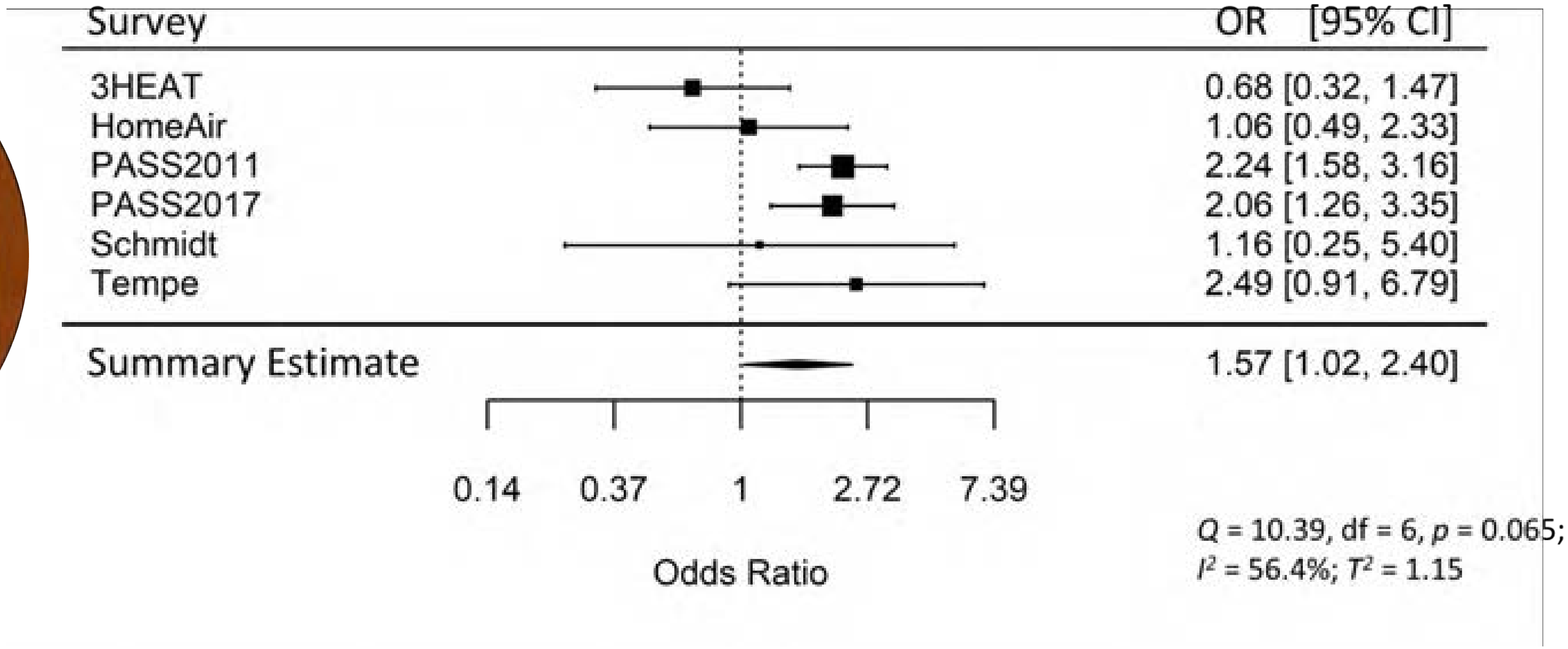
Do you or someone you live with own your home?



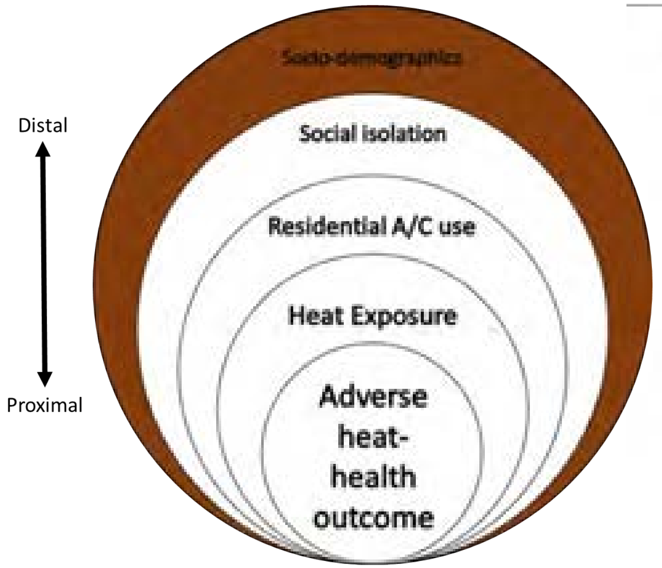


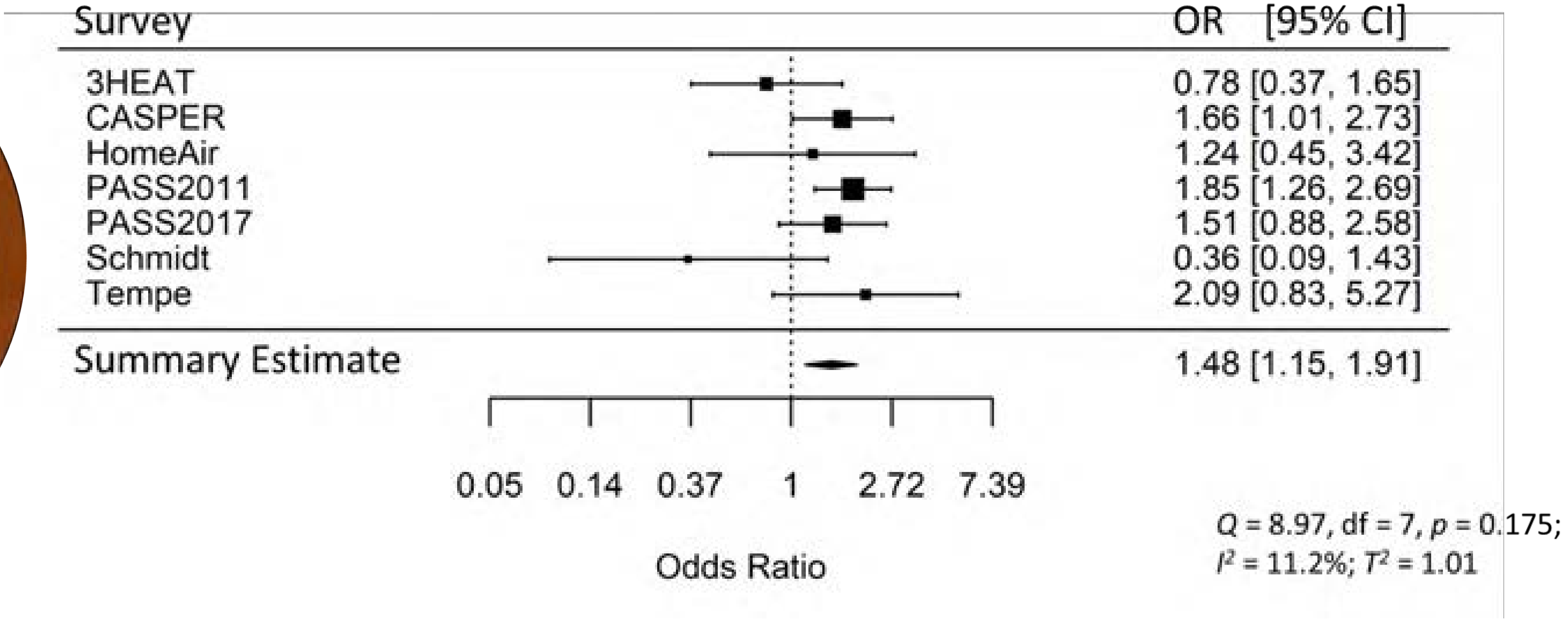
Is your annual household income less than $40,000 USD?



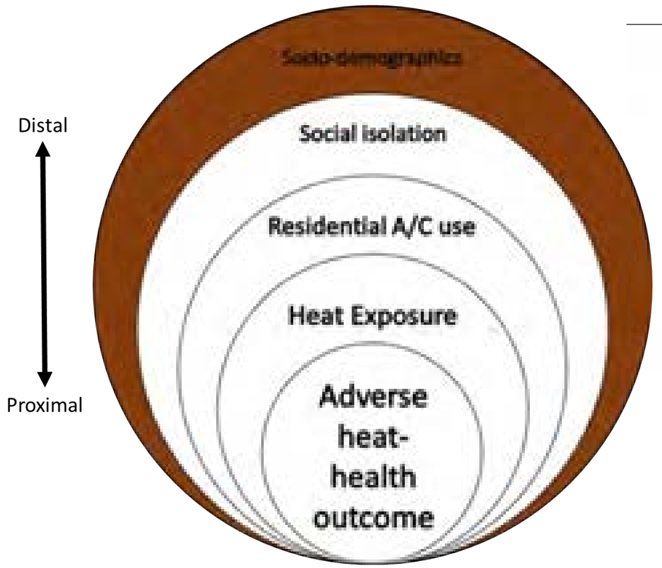


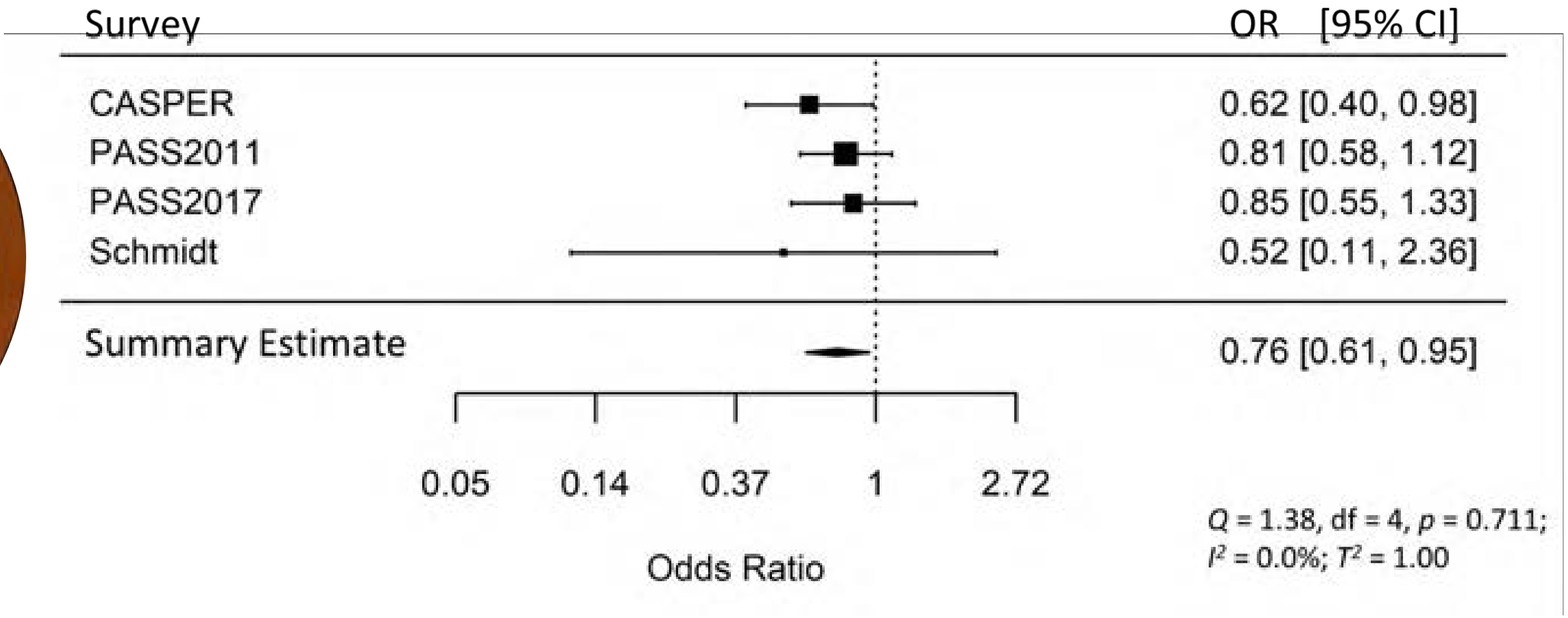
Do you identify as Hispanic, Latino, Mexican, Mexican-American, or Spanish?



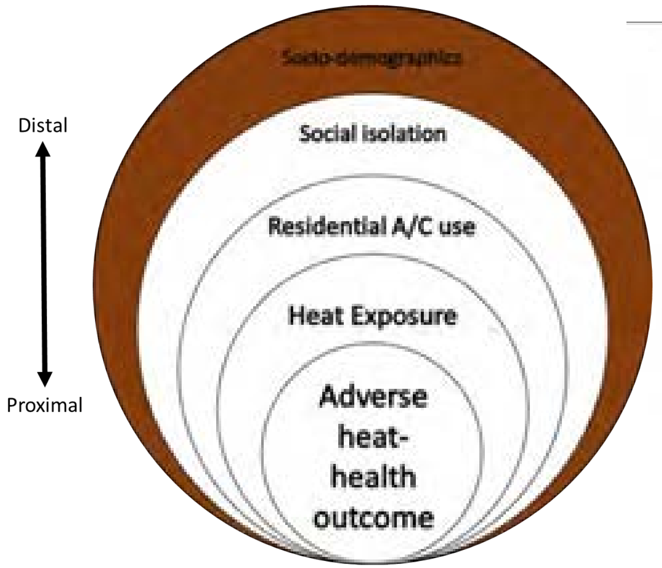


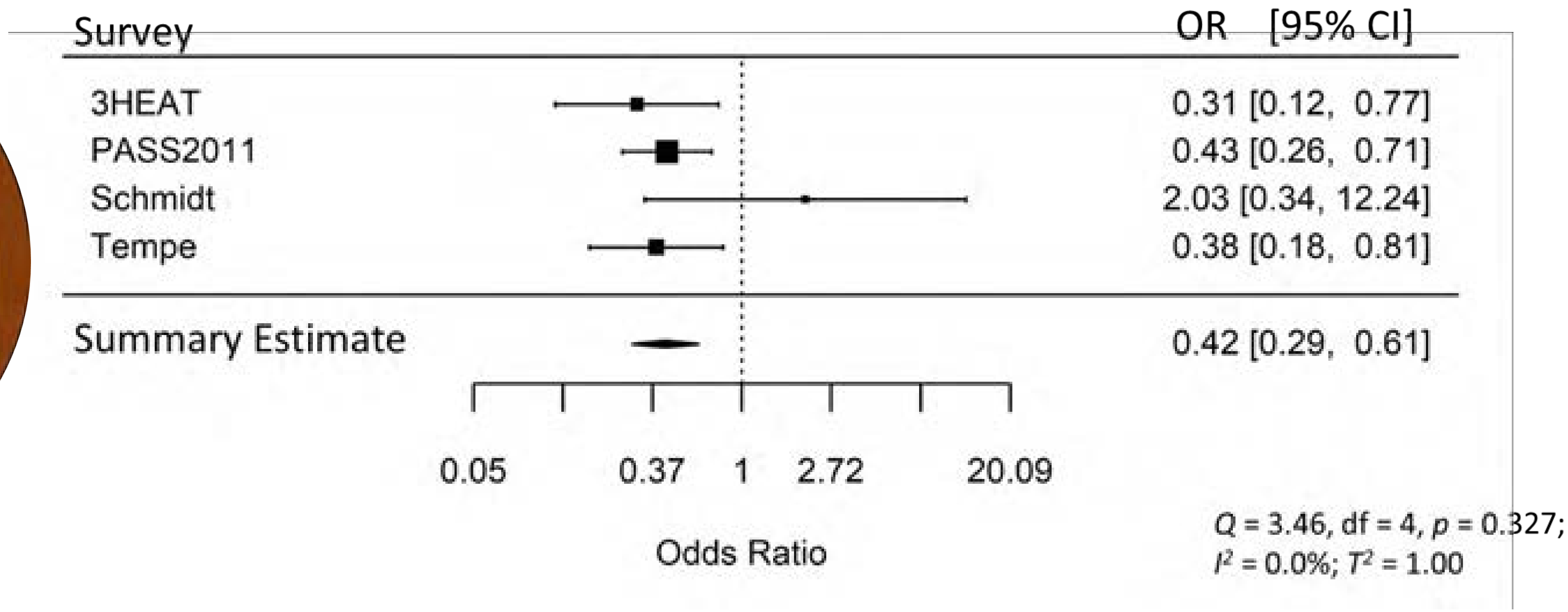
Do you have a Bachelor's degree or equivalent?





Are you over the age of 64?





Conclusion

- Indoor environment plays significant role
- Home ownership and indoor environment?
- In general, household/individual level measures match anticipated relationships from previous research
- Limitations
  - Small sample size of surveys: T^2 precision sensitive to sample size and a small sample limits use of techniques that could explain excess between study variance (like subgroup analysis or meta-regression).

Acknowledgments

- National Science Foundation under grant number DEB-1832016, Central Arizona-Phoenix Long-Term Ecological Research Program (CAP LTER).
- 3HEAT: NSF SES-1520803
- Maricopa County Department of Public Health
- City of Tempe
- ASU Knowledge Exchange for Resilience

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Thank you!

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Researcher, Georgia Institute of Technology, Urban Climate Lab

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Assessing the Cooling Potential of Tree Canopy and Cool Roofing on Indoor Heat Exposure in Concurrent Heat Wave and Blackout Events

Assessing the Cooling Potential of Tree Canopy and Cool Roofing on Indoor Heat Exposure in Concurrent Heat Wave and Blackout Events

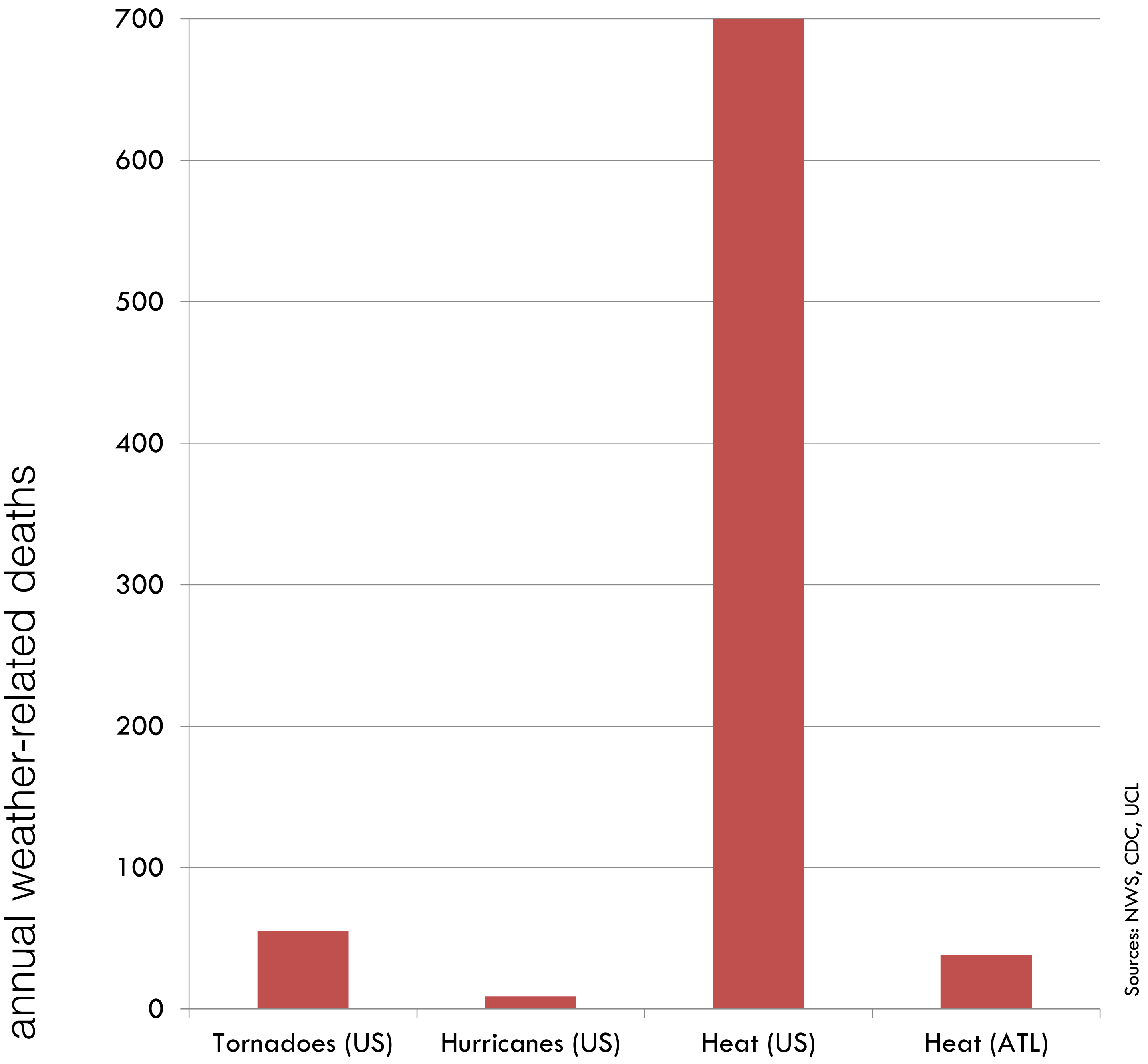
Evan Mallen, Mayuri Rajput, Brian Stone, Fried Augenbroe, Ashley Broadbent, Scott Krayenhoff, Mattei Georgescu

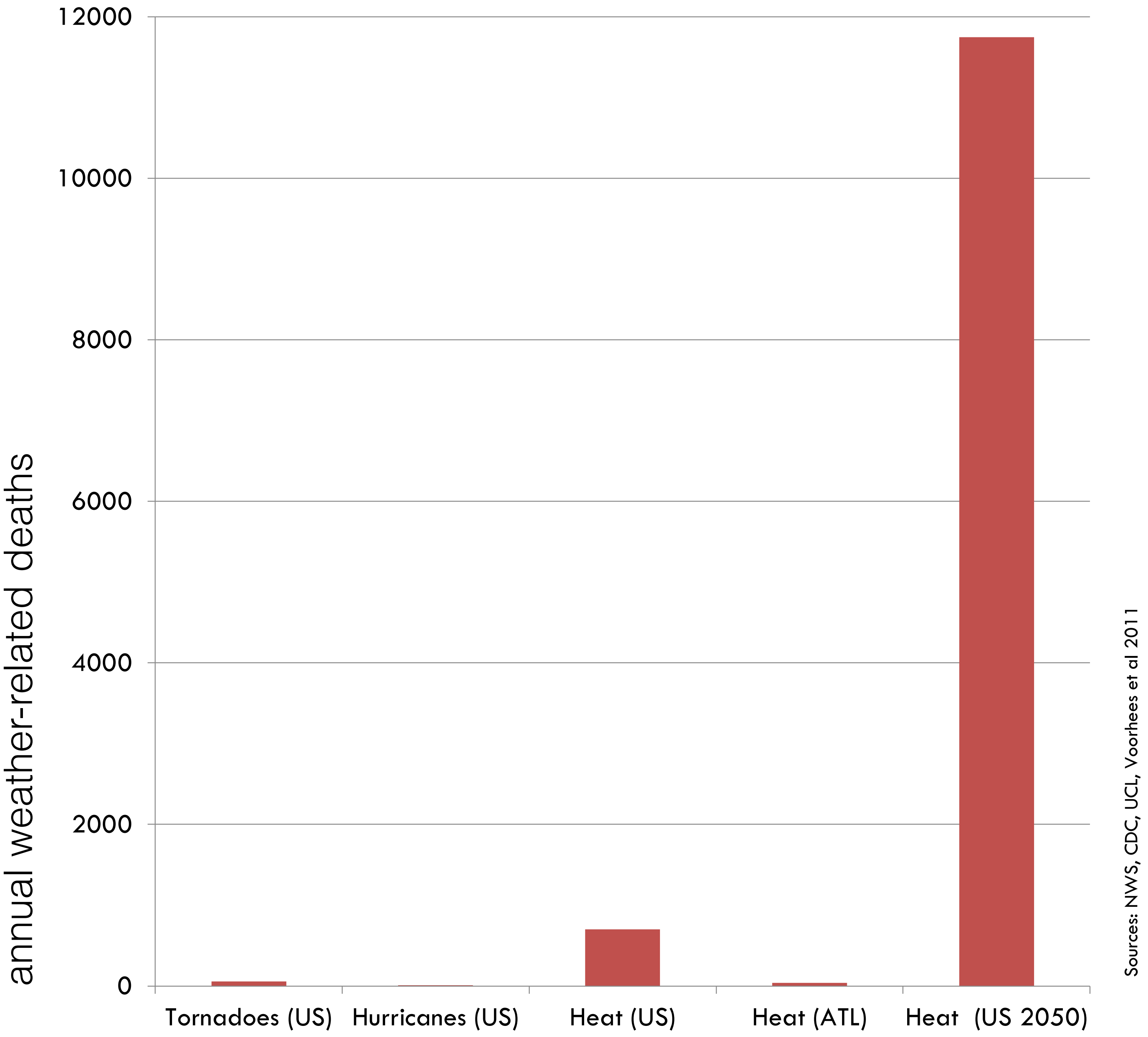
Luskin Climate Adaptation Research Symposium

September 8, 2021

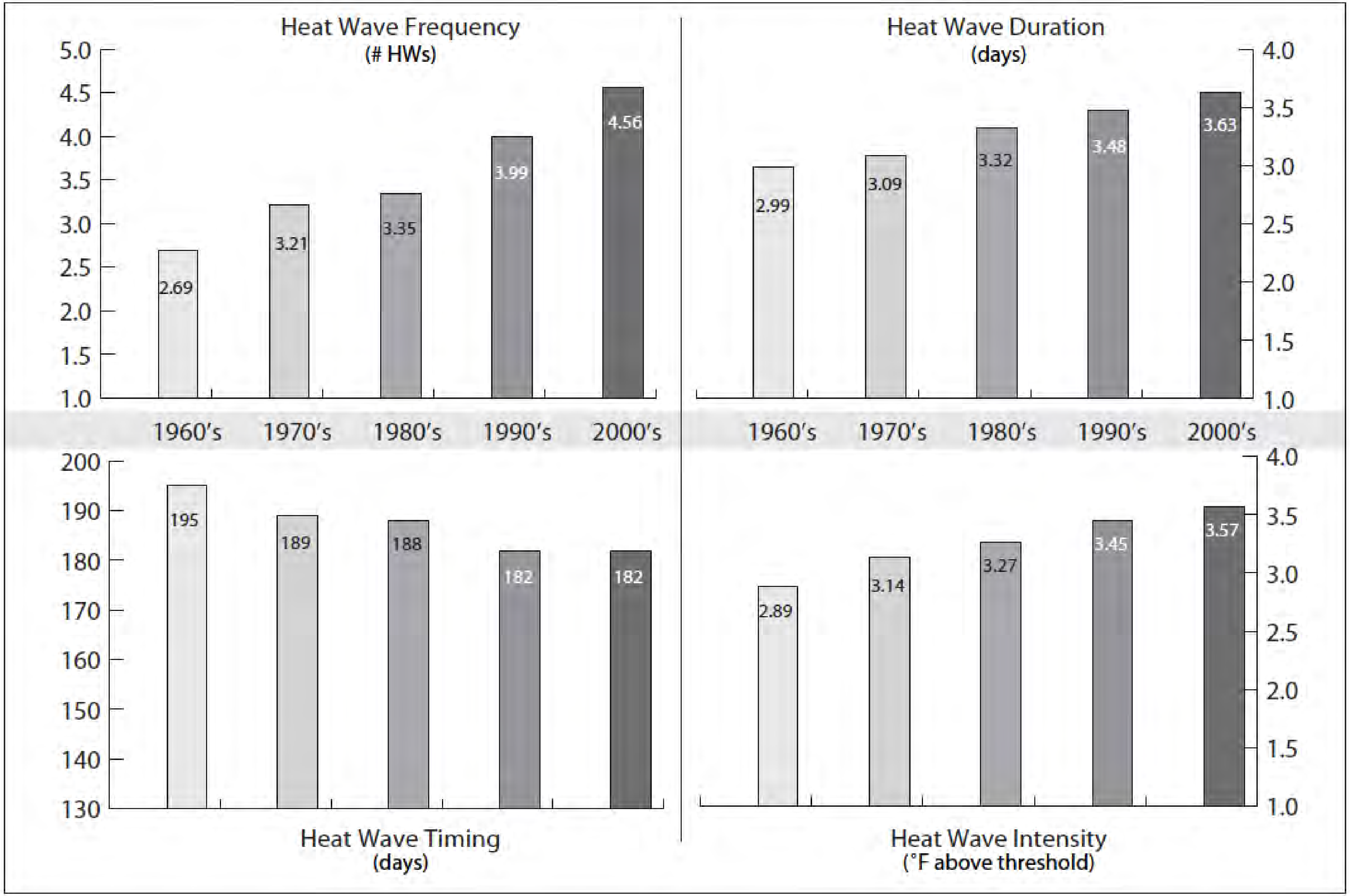
Georgia Tech School of City & Regional Planning
College of Design

urban climate lab


annual weather-related deaths
700
600
500
400
300
200
100
0
Tornadoes (US)
Hurricanes (US)
Heat (US)
Heat (ATL)
Sources: NWS, CDC, UCL

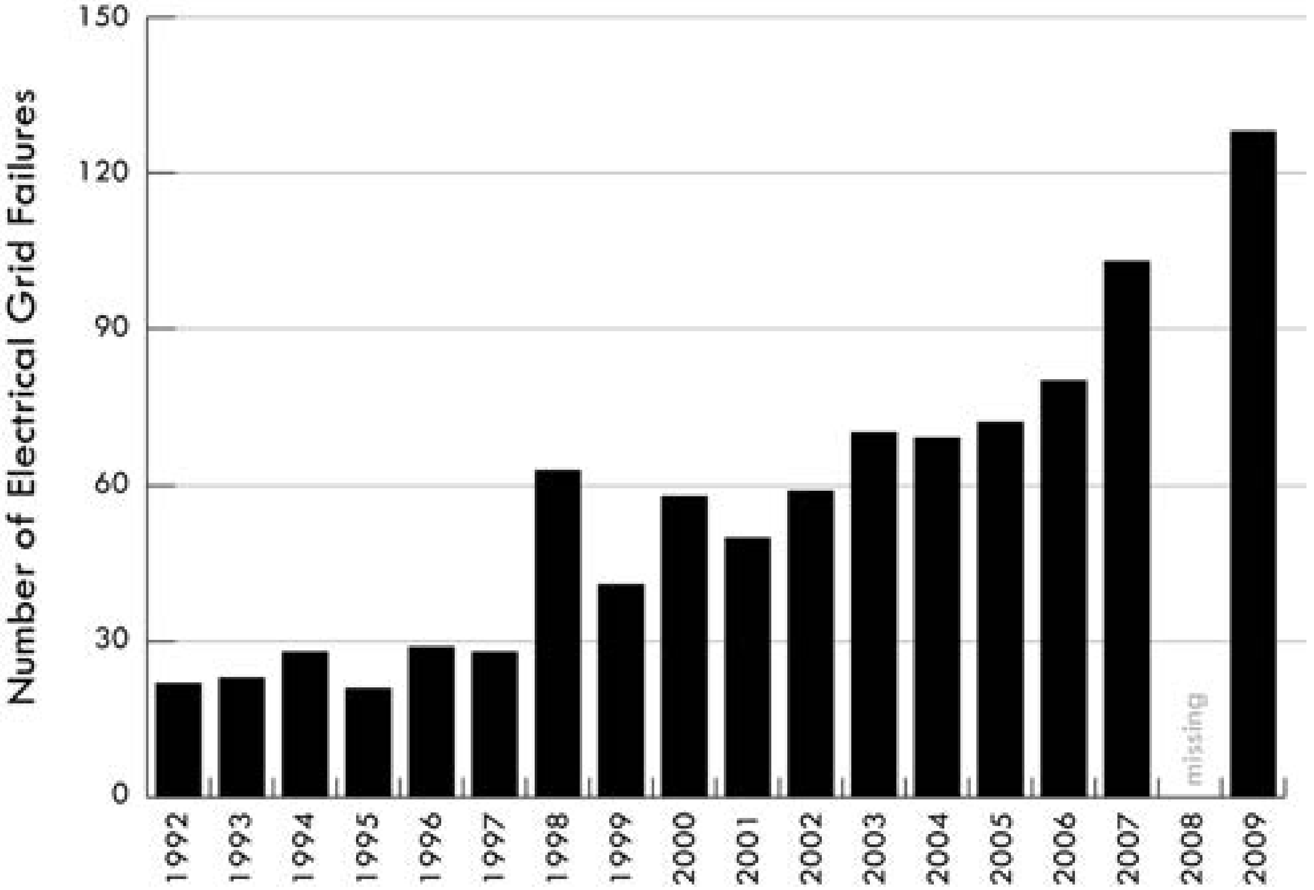

annual weather-related deaths
12000
10000
8000
6000
4000
2000
0
Tornadoes (US)
Hurricanes (US)
Heat (US)
Heat (ATL)
Heat (US 2050)
Sources: NWS, CDC, UCL, Voorhees et al 2011

Rising Heat Wave Trends

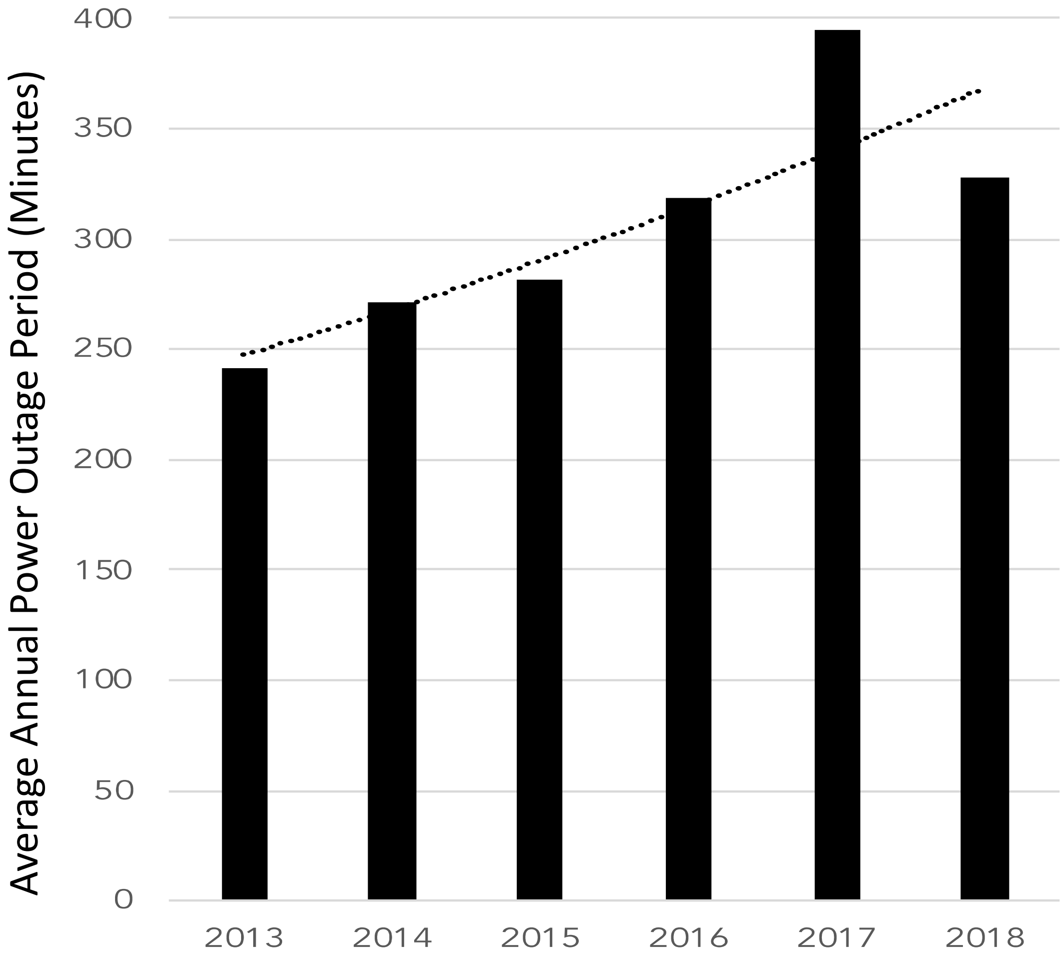


Habeeb et al., 2015

Rising Power Outages

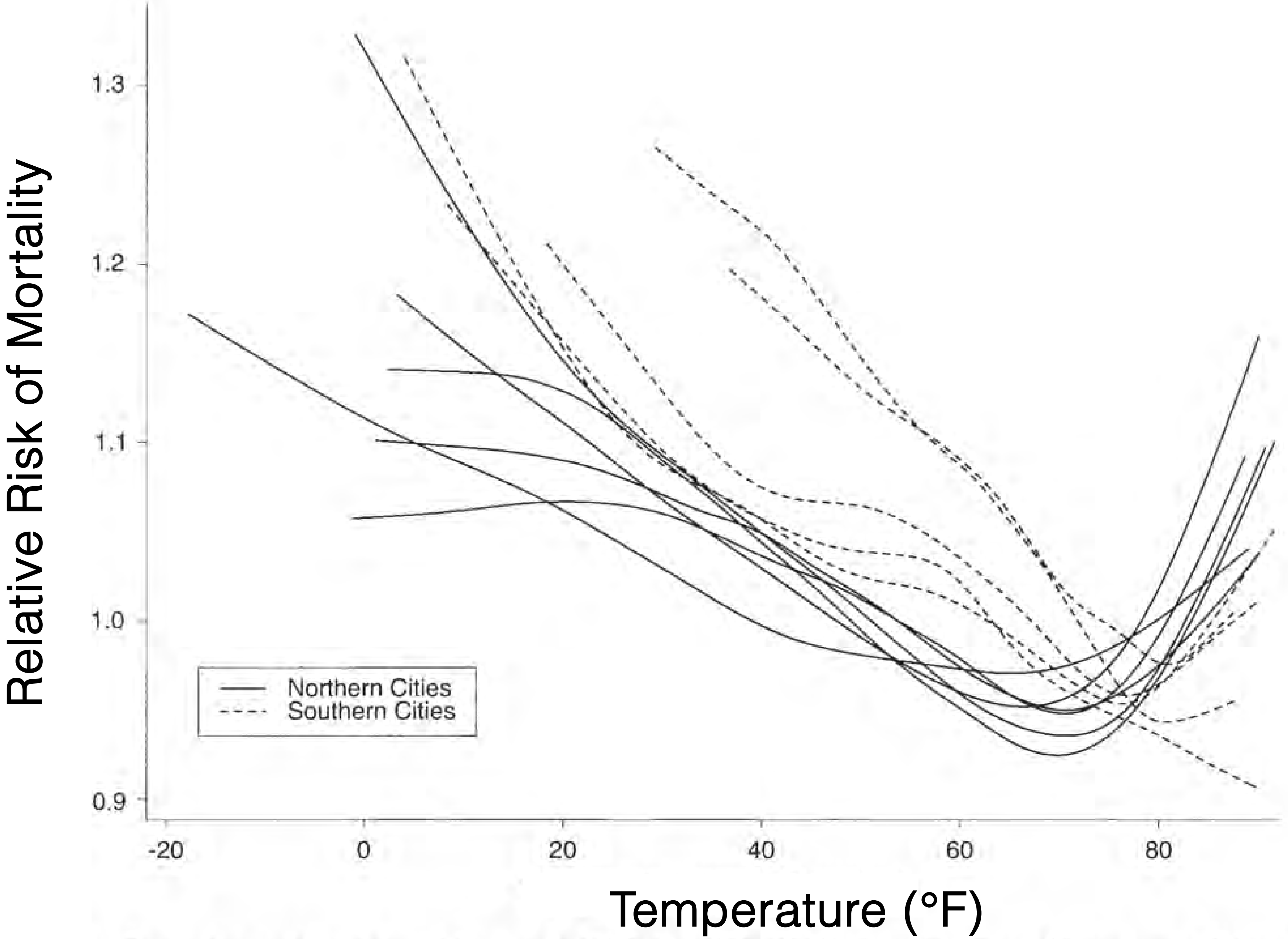


NERC



Systems Average Interruption Duration Index (SAIDI)

USEIA, 2019



1. Temperature-mortality relative risk functions for 11 US cities, 1973–1994. Northern cities: Boston, Massachusetts; Chicago, Illinois; New York; Philadelphia, Pennsylvania; Baltimore, Maryland; and Washington, DC. Southern cities: Charlotte, North Carolina; Atlanta, Jacksonville, Florida; Tampa, Florida; and Miami, Florida. °C = 5/9 × (°F − 32).

Curriero et al. (2002)

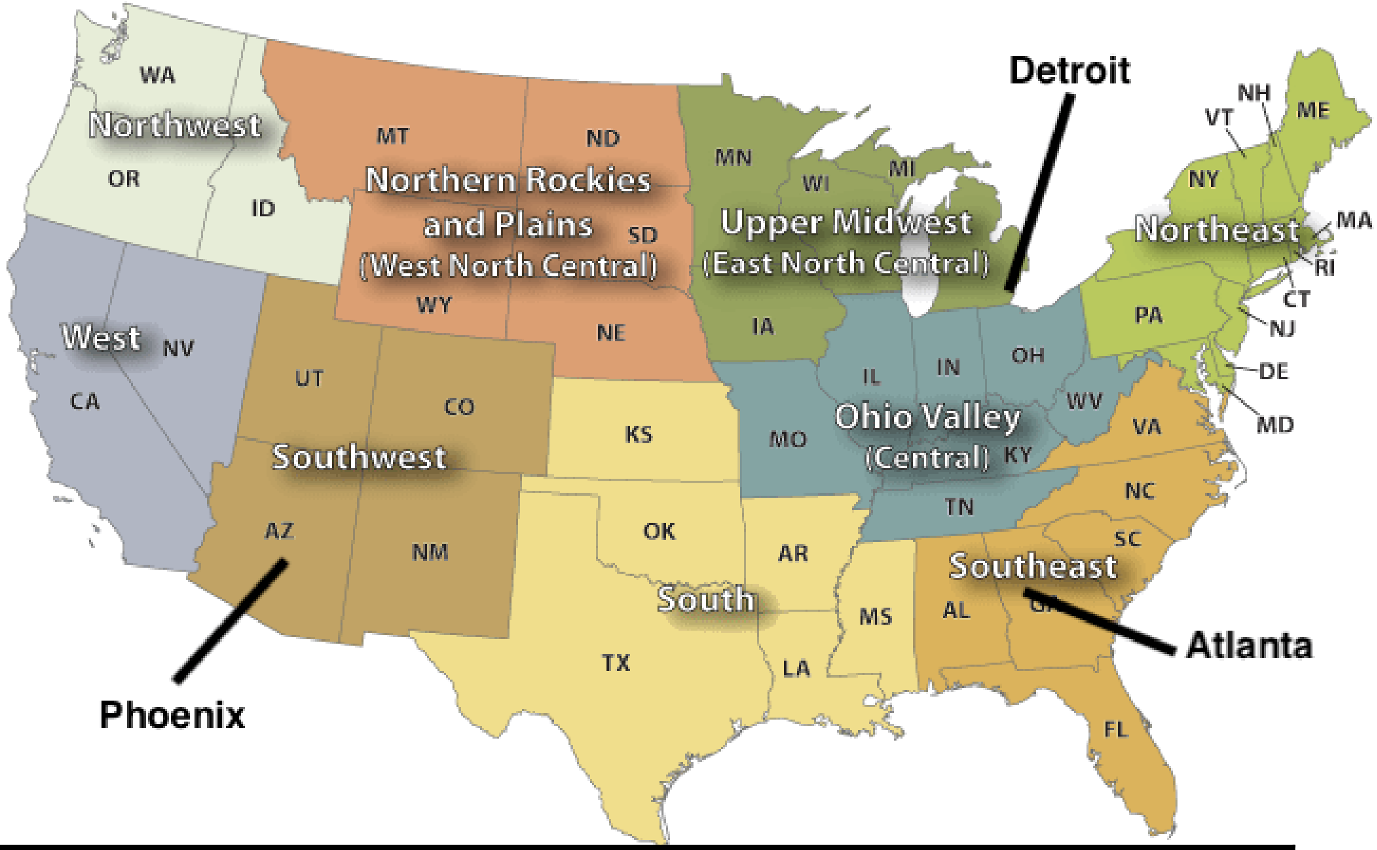
Research Questions

1. How do building-interior heat exposures change during a concurrent heat wave and blackout event for different residential building types?

2. How effective are cool roofing and tree canopy in reducing building-interior heat exposures?

3. How do building-interior temperatures vary with the spatial intensity of the urban heat island?

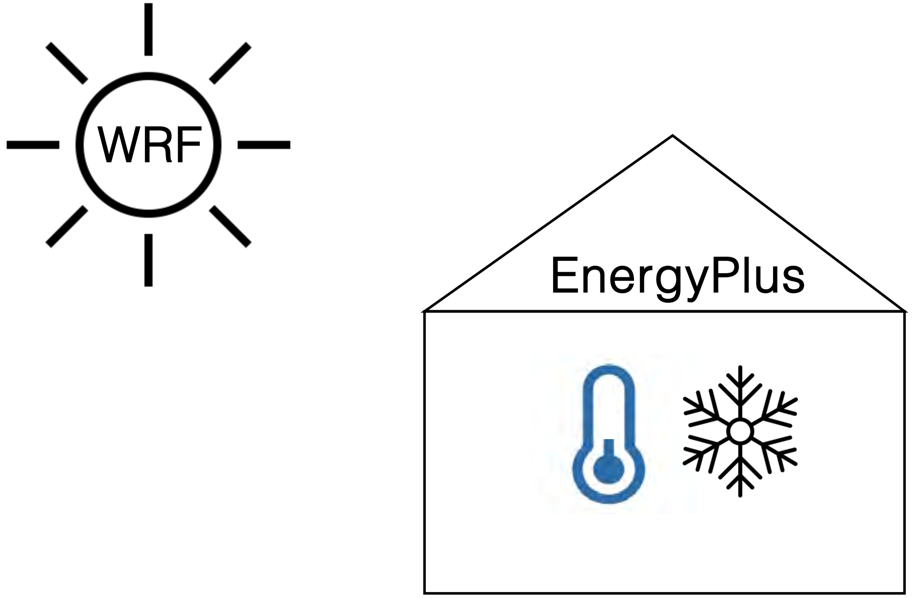
Study Population



	Atlanta, Georgia	Detroit, Michigan	Phoenix, Arizona
Climate Region	Southeast	Upper Midwest	Southwest
Climate Type	Humid Subtropical	Humid Continental	Subtropical Desert
Mean Summer High Temperature (°F)	87.9	81.4	104.8
Population (2010)	420,003	713,777	1,445,632

Research Design

1. How do building-interior heat exposures change during a concurrent heat wave and blackout event for different residential building types?



Research Design

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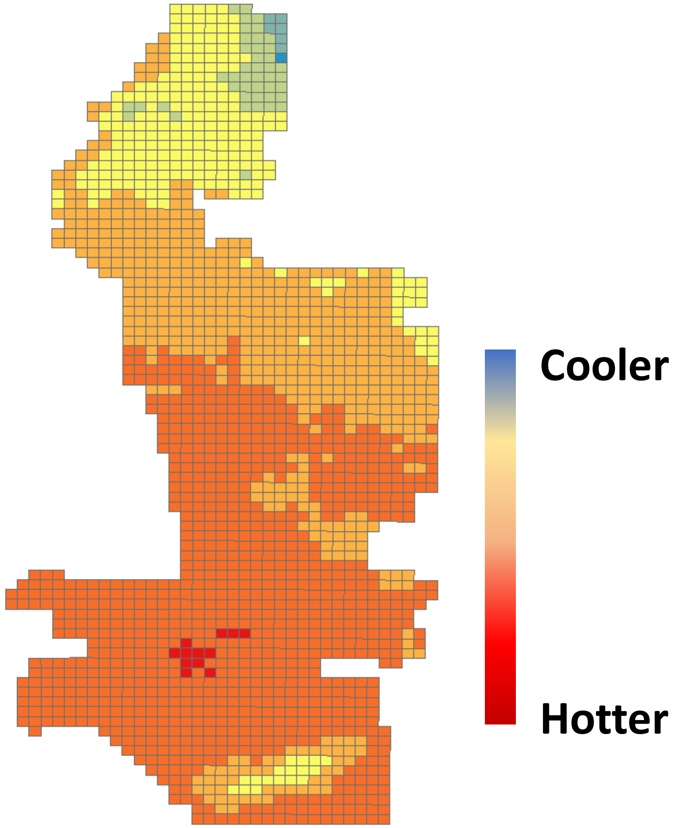
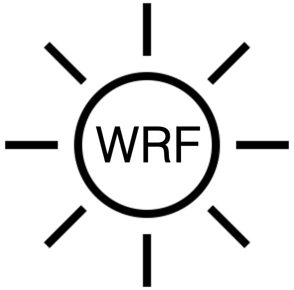
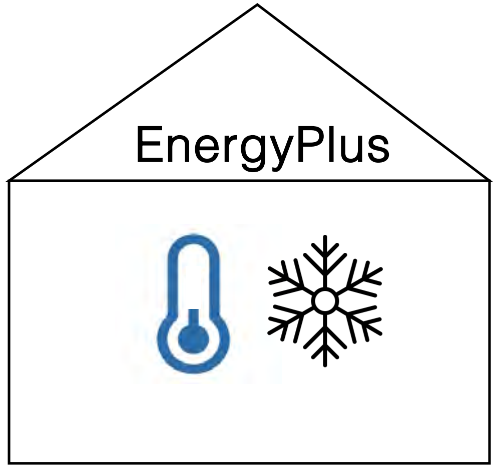


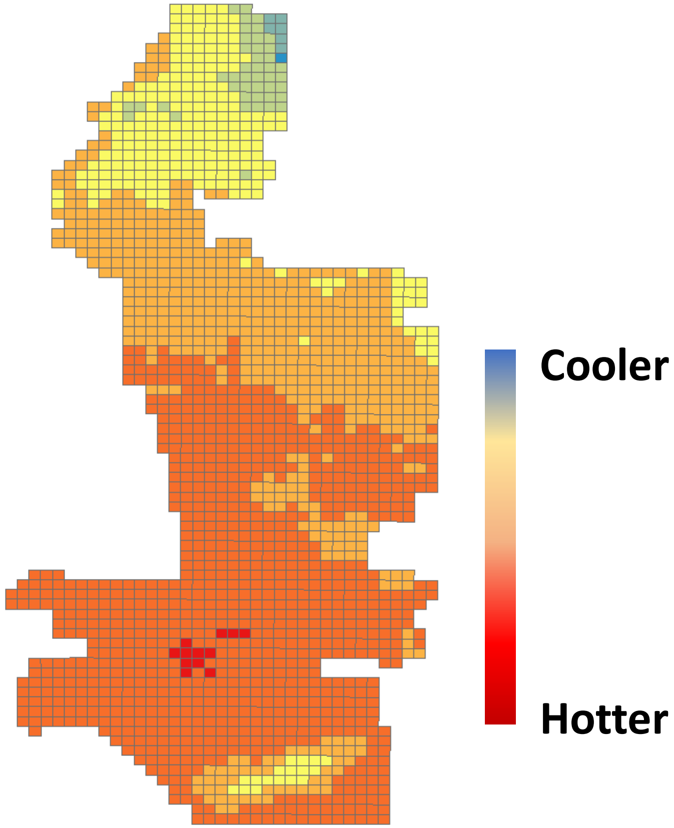


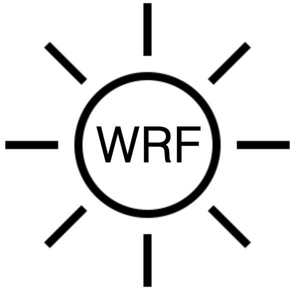


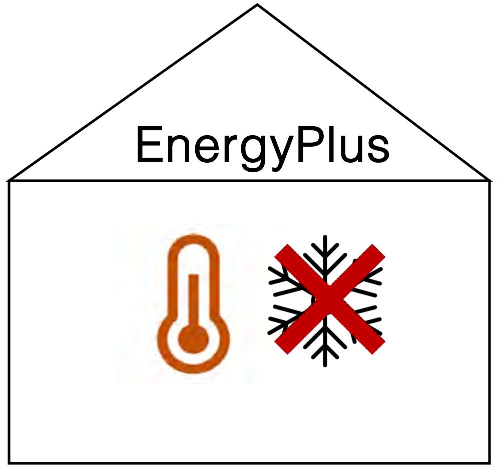
Target Period
2006-07-21
2006-07-22
2006-07-23
2006-07-24
2006-07-25

Research Design

1. How do building-interior heat exposures change during a concurrent heat wave and blackout event for different residential building types?

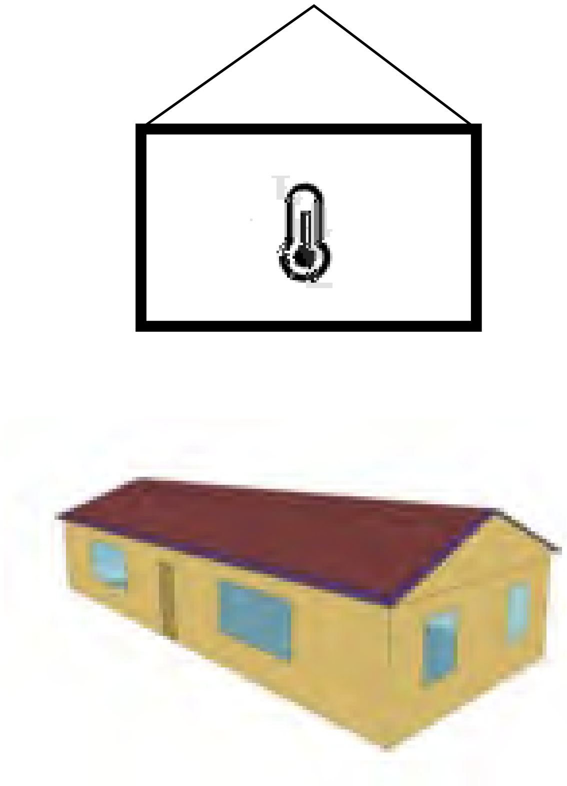




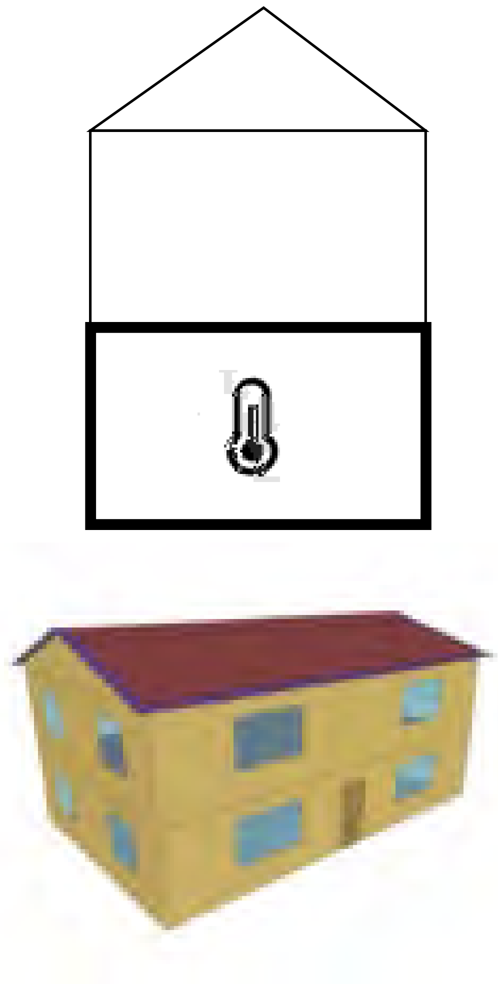


Target Period
2006-07-21
2006-07-22
2006-07-23
2006-07-24
2006-07-25

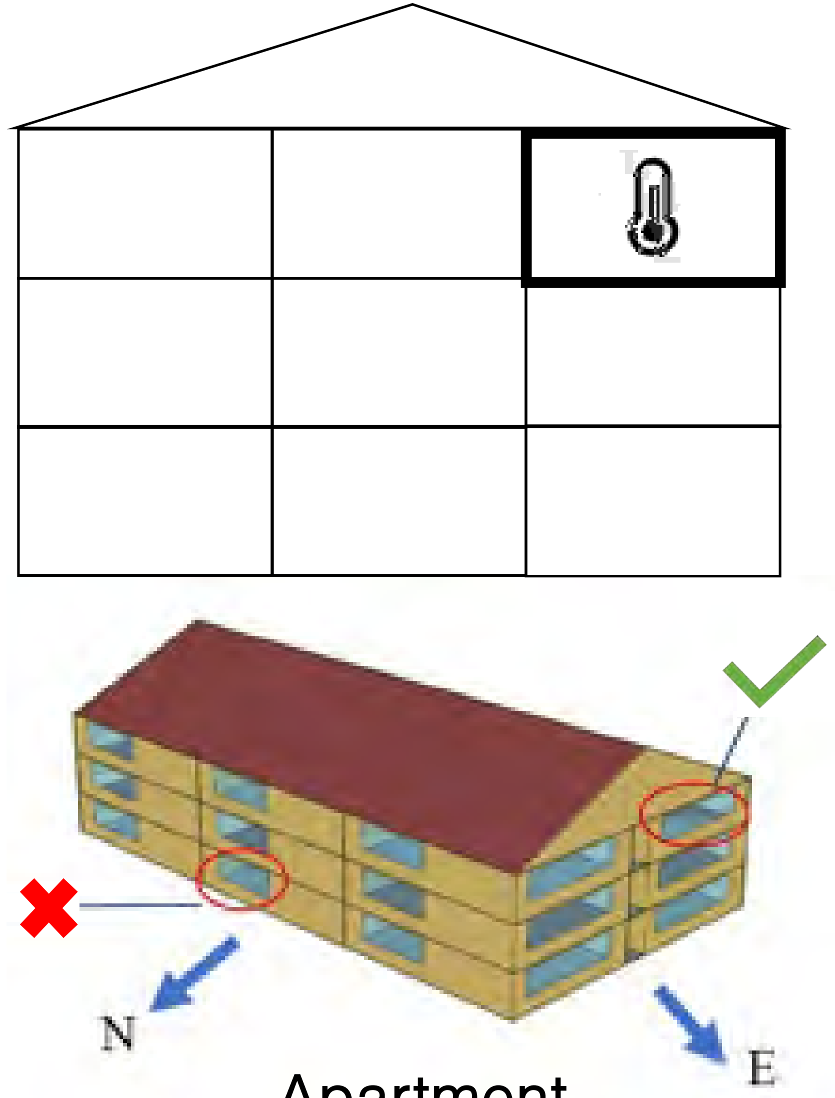
Residential Structure Prototypes



1-Story SF



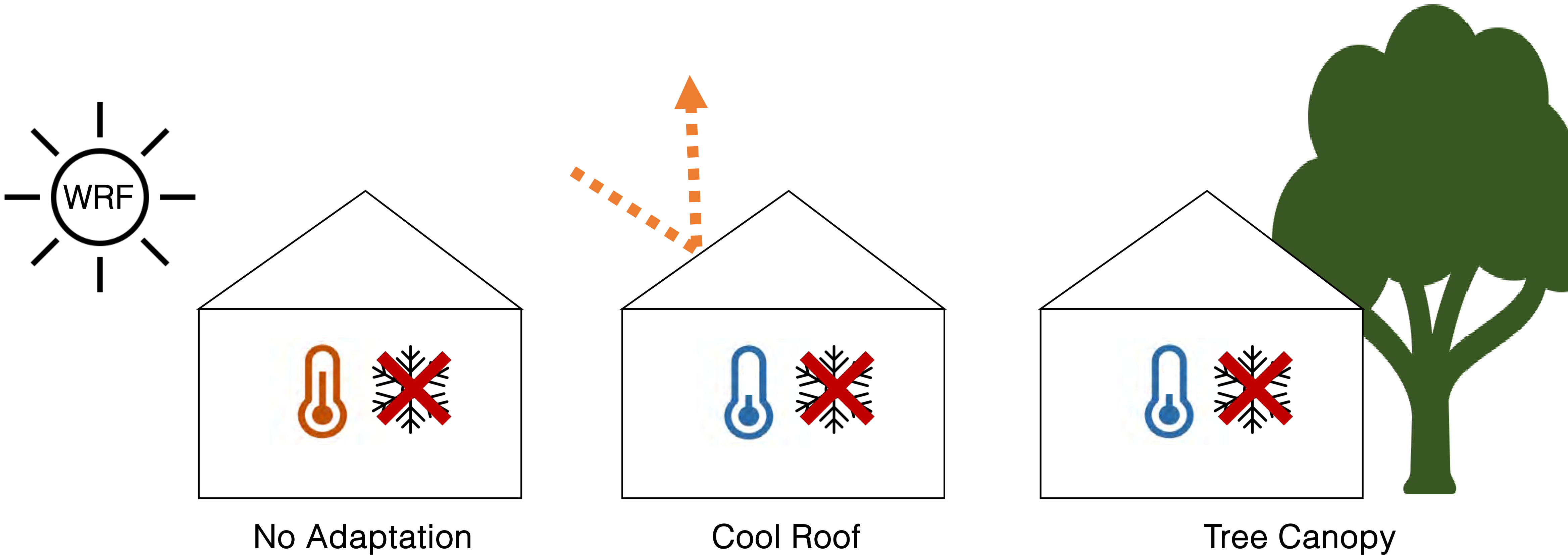
2-Story SF



Apartment

Research Design

2. How effective are cool roofing and tree canopy in reducing building-interior heat exposures?



Heat Management Strategies

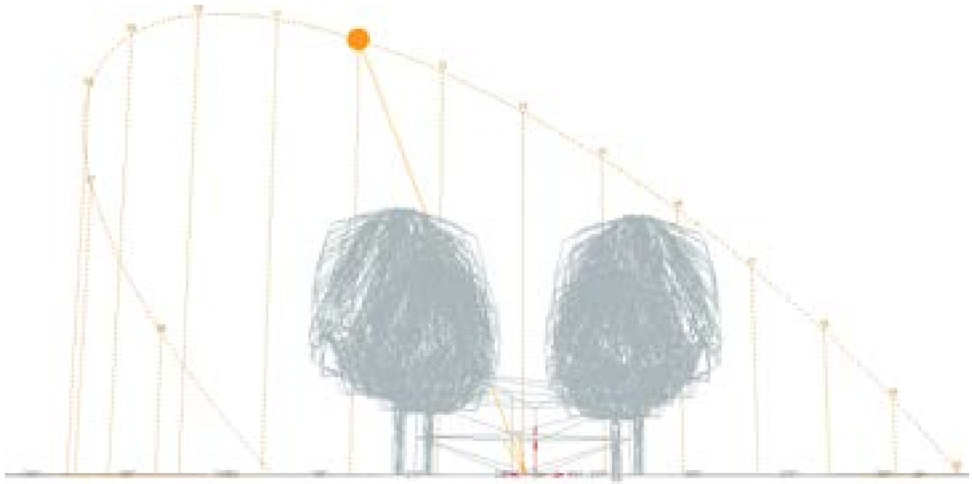
No Adaptation
Conventional roofing
Existing tree coverage

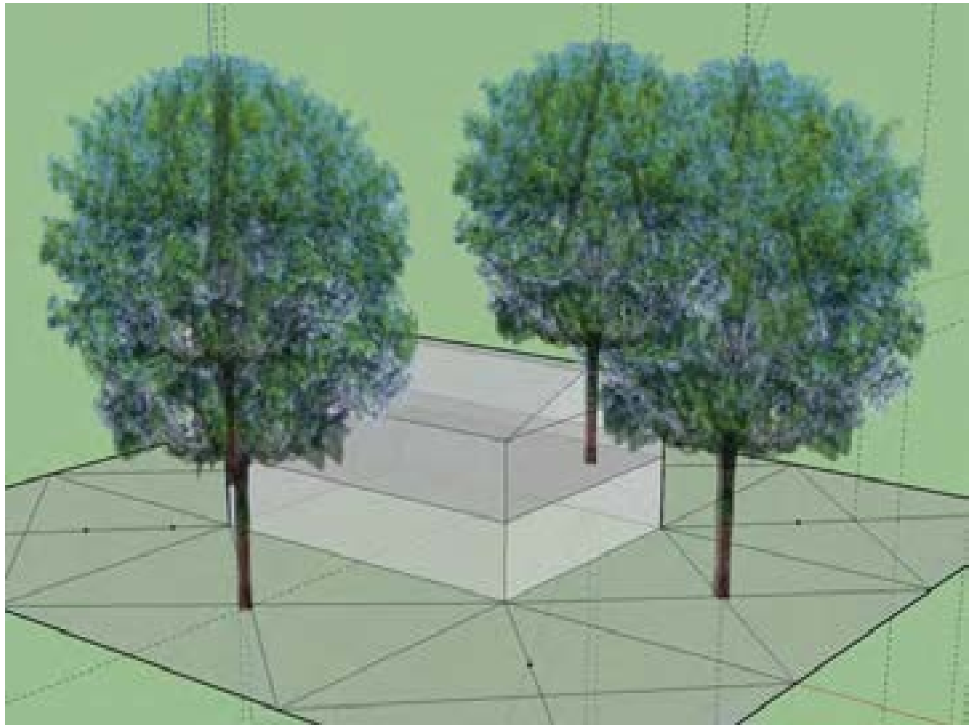
Cool Roof
100% conversion citywide

Tree Canopy
50% tree coverage
over road surfaces
with direct shading

Tree Modeling

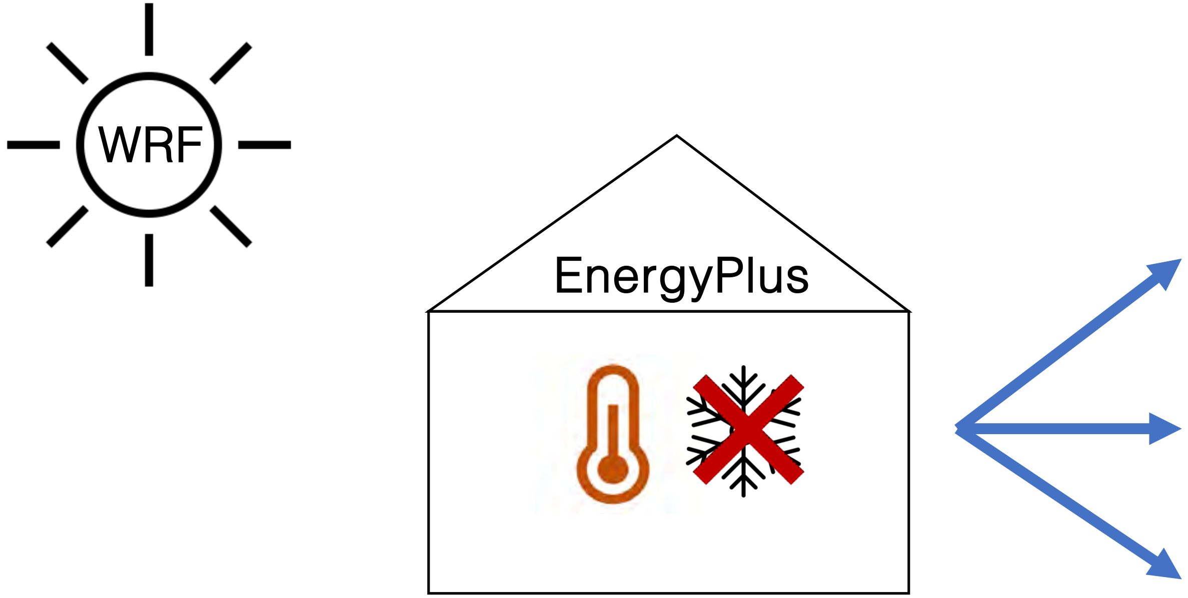
- Atlanta: Red Dawnwood (15 meter)
- Phoenix: Palo Verde (4 meter)
- Detroit: Honeylocust (15 meter)

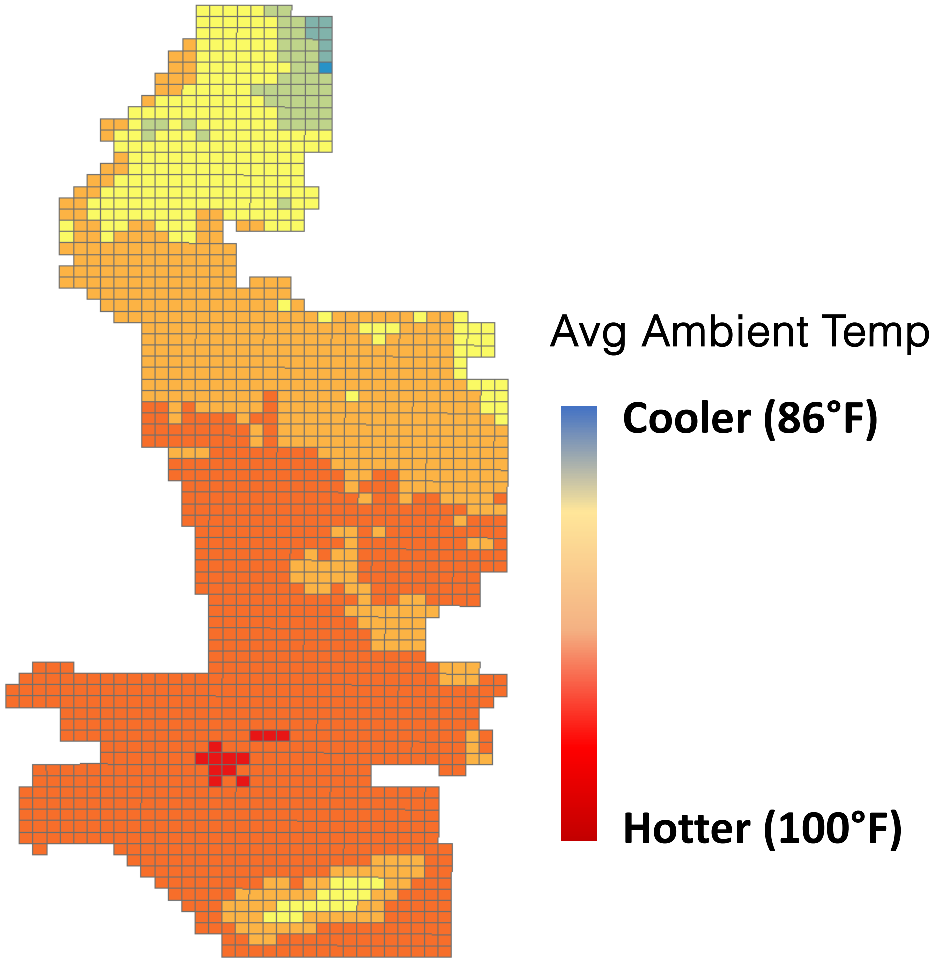




Research Design

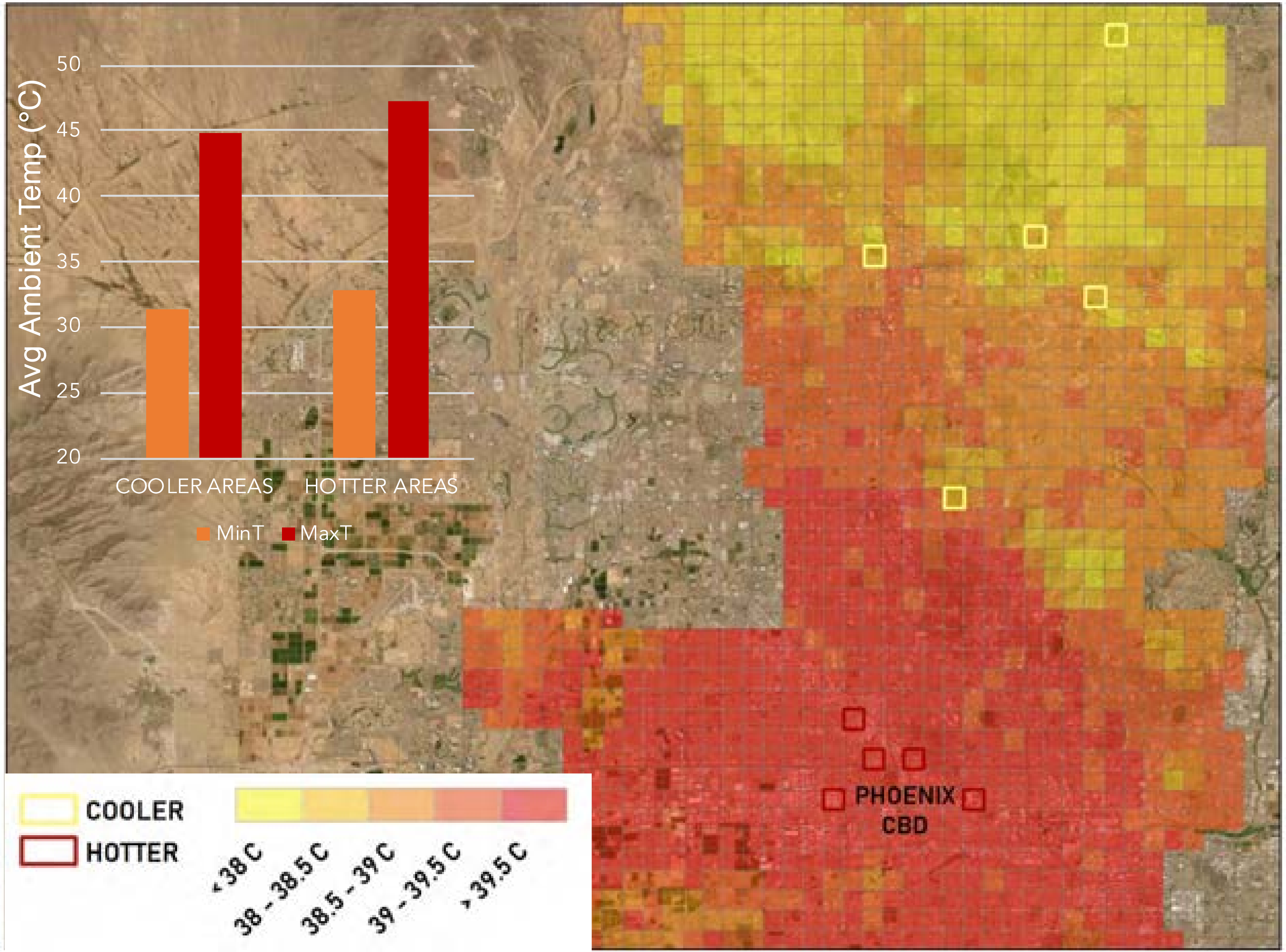
3. How do building-interior temperatures vary with the spatial intensity of the urban heat island?



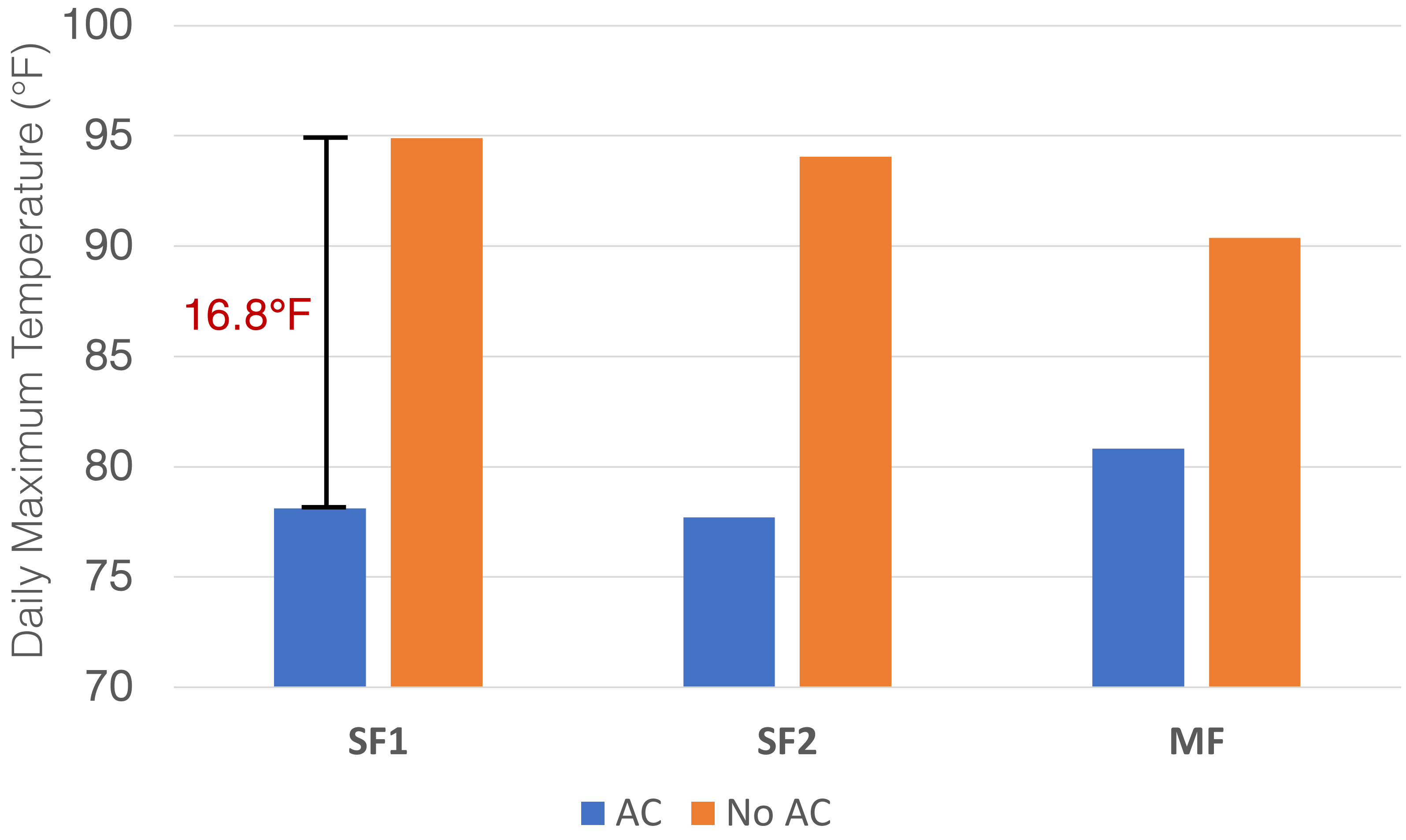


RQ3: Urban Heat Island Intensity

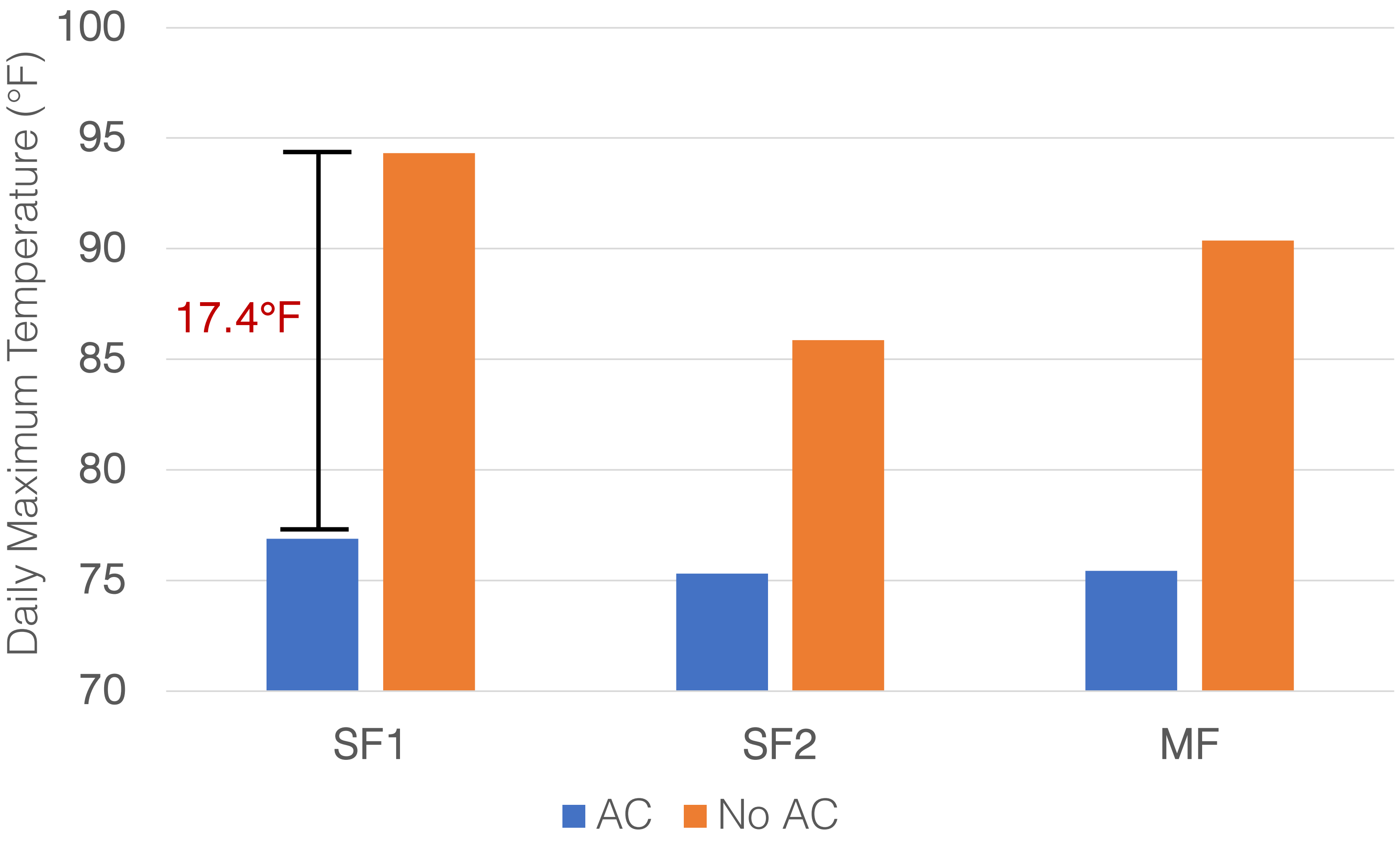
UHI Intensity:
4.5°F



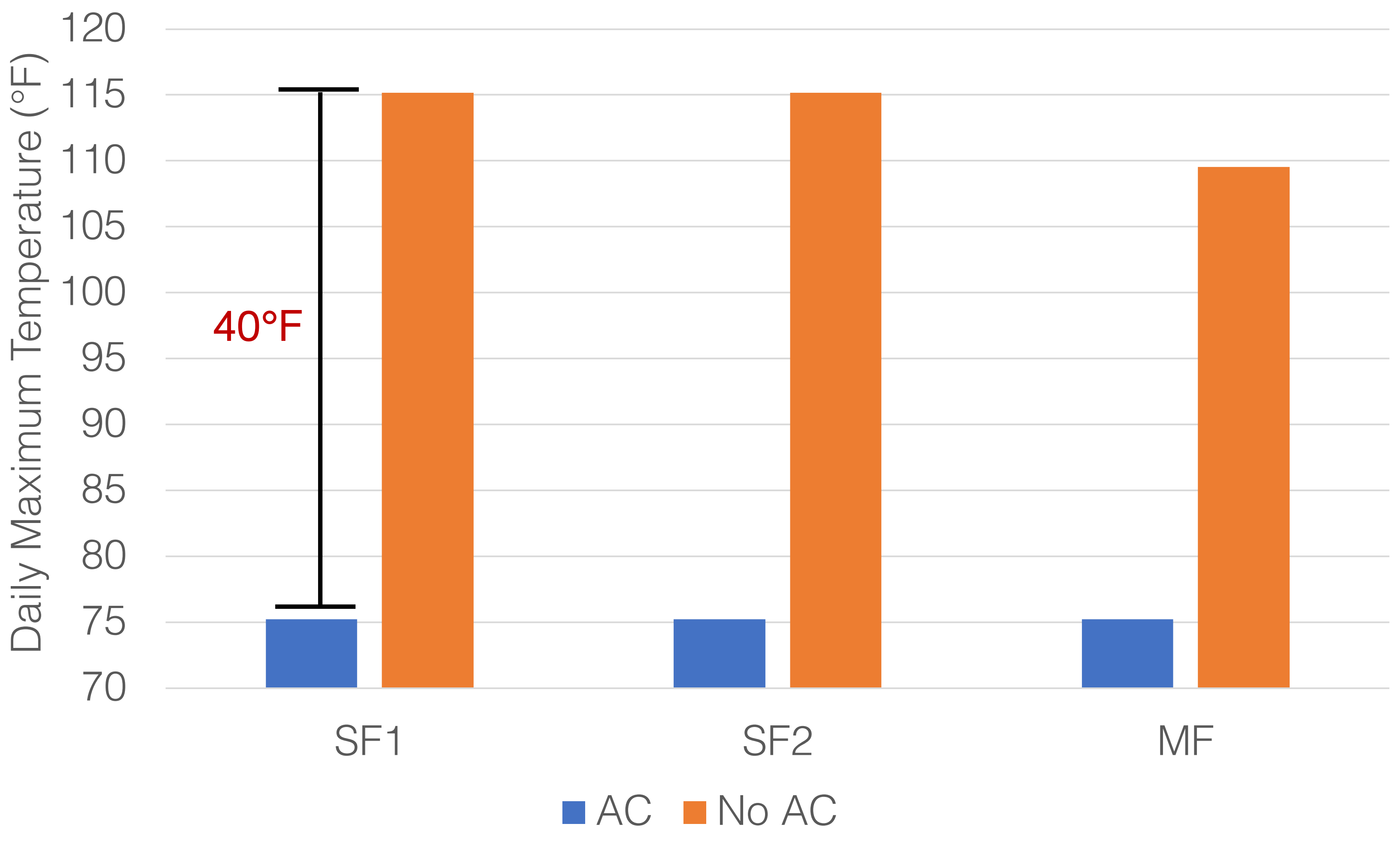
1. Blackout Impacts: Atlanta



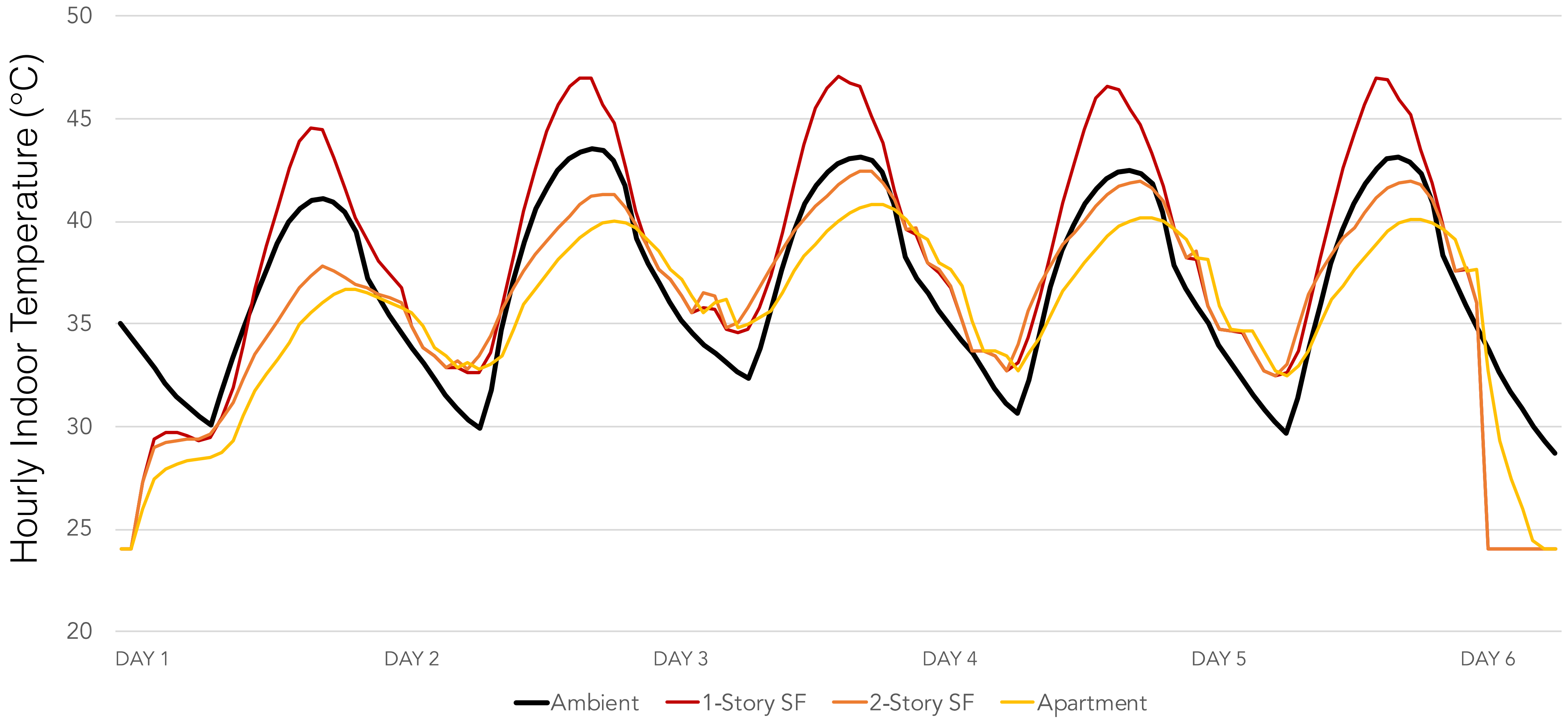
1. Blackout Impacts: Detroit



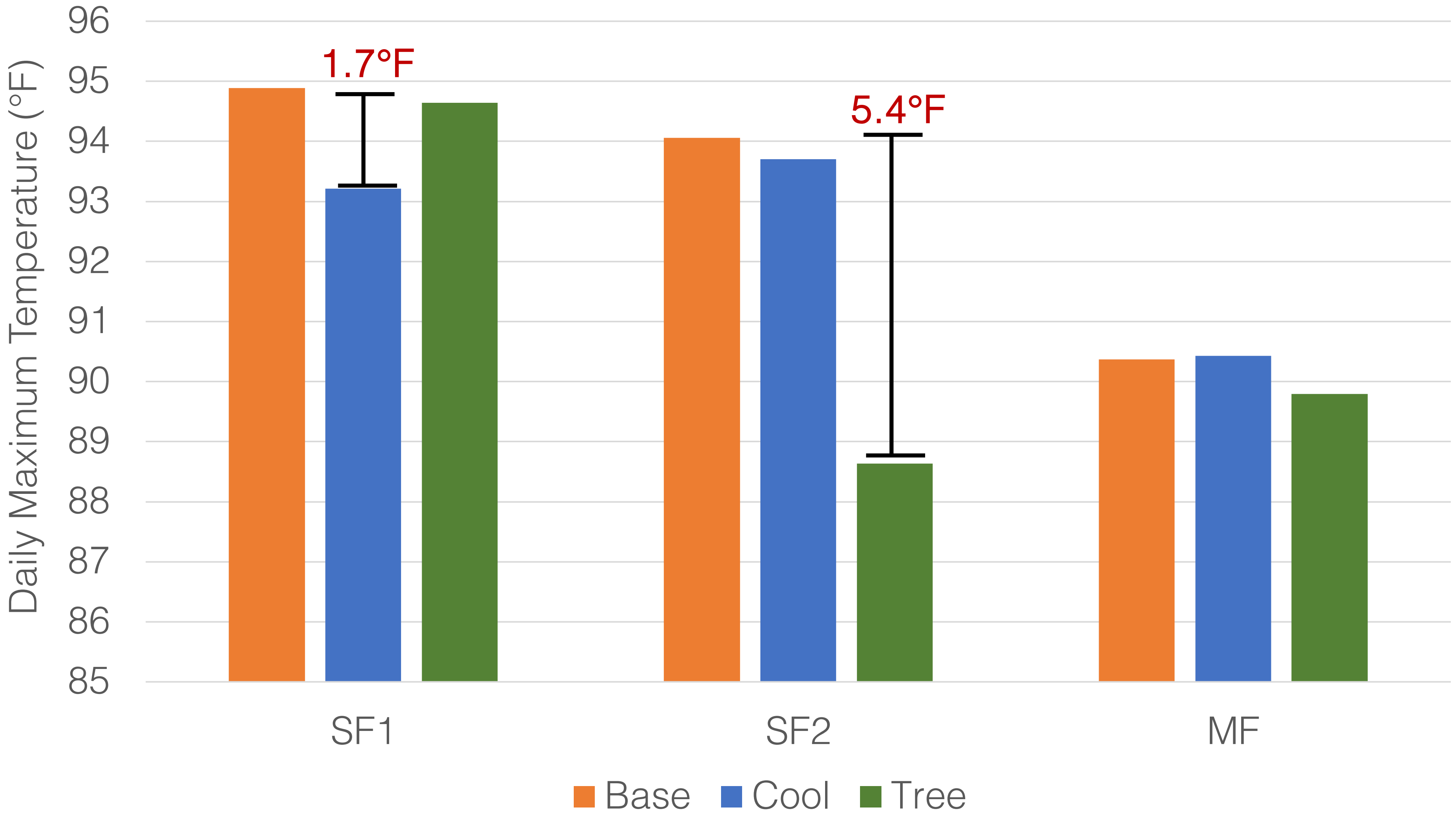
1. Blackout Impacts: Phoenix



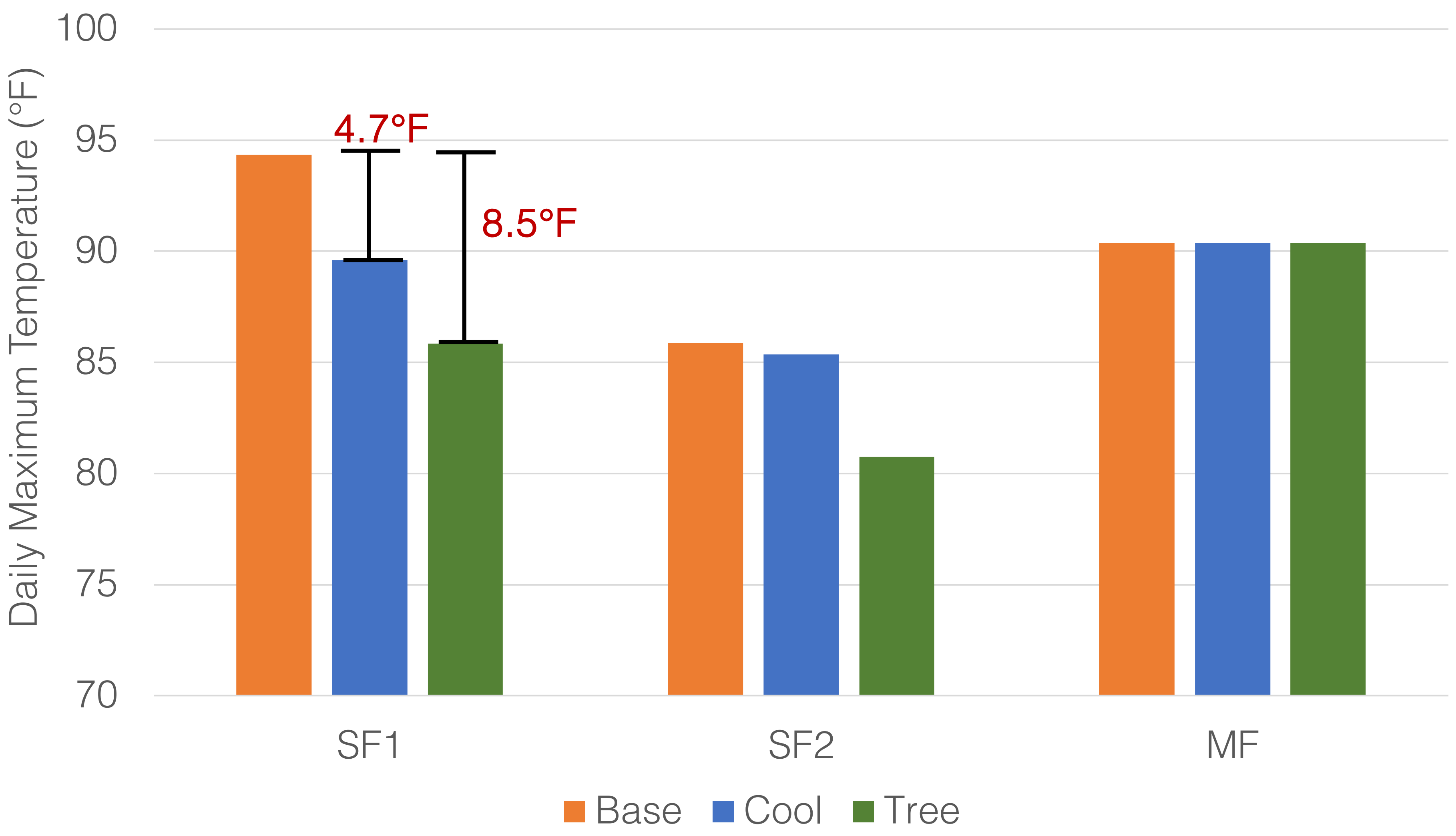
Diurnal Range



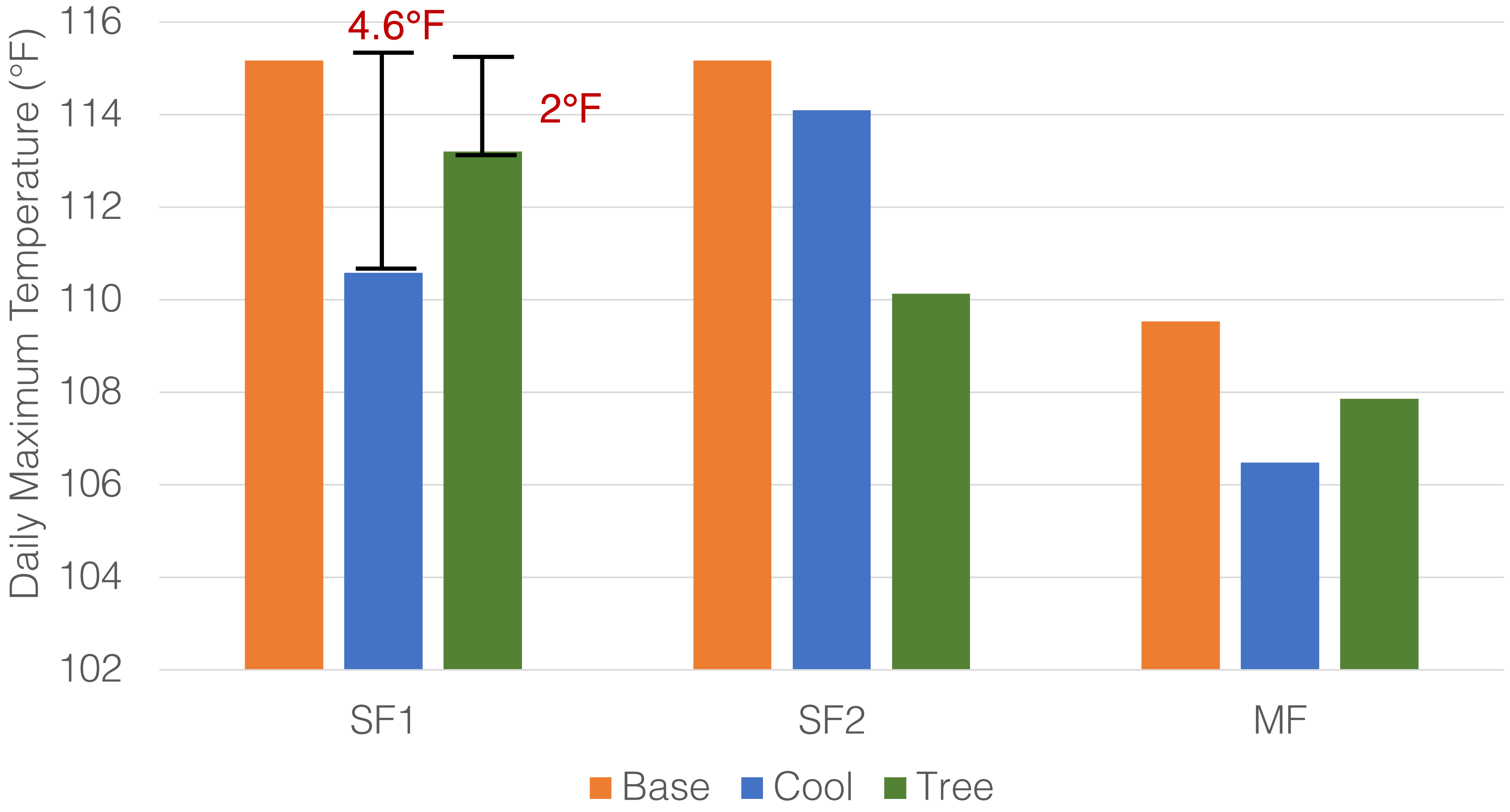
2. Heat Management Strategies: Atlanta



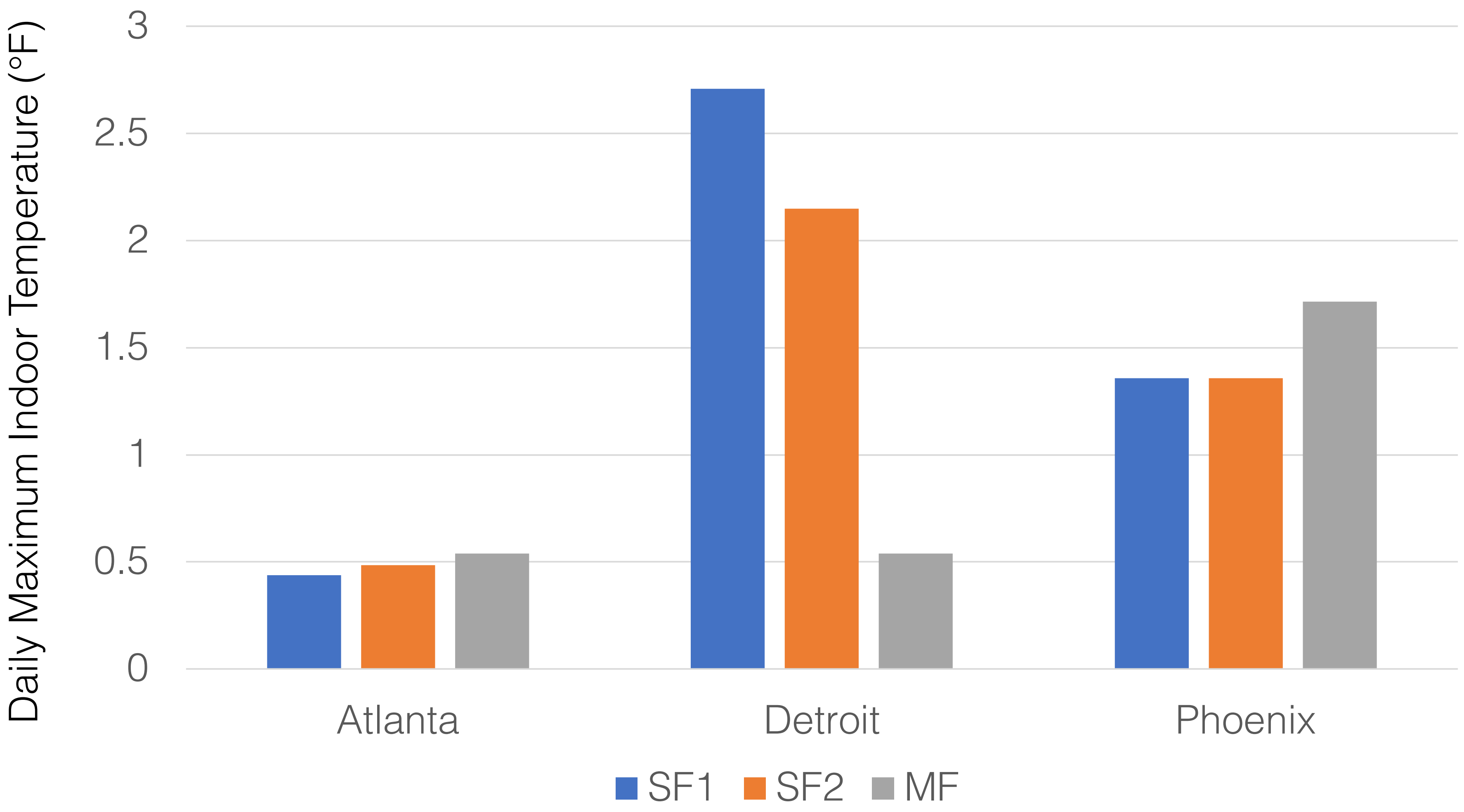
2. Heat Management Strategies: Detroit



2. Heat Management Strategies: Phoenix

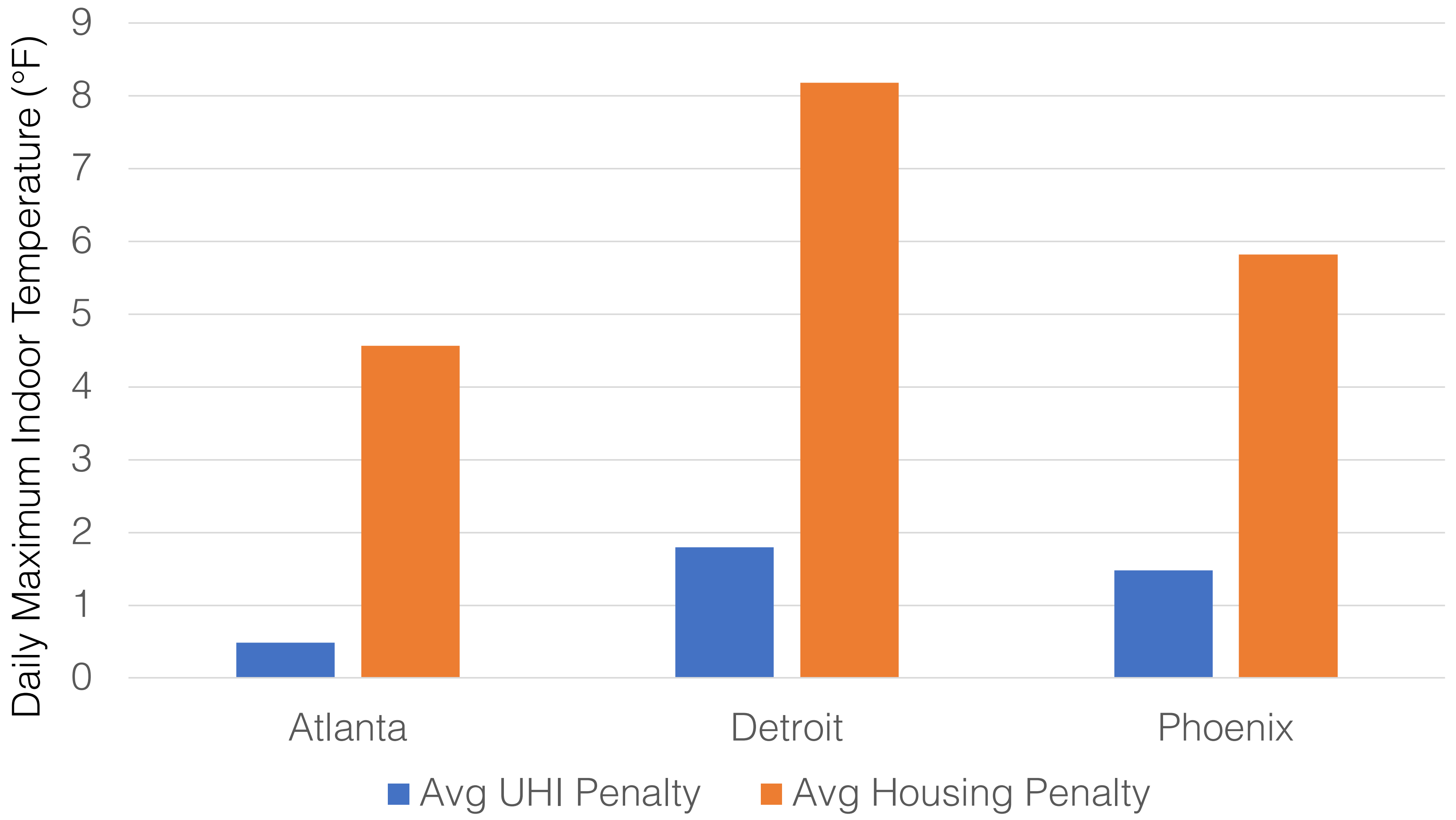


3. UHI Impact



UHI Penalty:
Difference in interior temperatures between warmest and coolest areas of city within housing type

3. UHI Impact



UHI Penalty:
Difference in interior temperatures between warmest and coolest areas of city within housing type

Housing Penalty:
Difference in interior temperatures between warmest and coolest building type for each city

Study Conclusions

- A concurrent heatwave and power outage can substantially impact indoor heat exposure, up to <u>40°F</u> for 1-story single family structures in Phoenix
    - Structure roof area and volume strongly influence interior temperature dynamics as compared to ambient temperatures

- Heat mitigation strategy effectiveness varies widely by city and housing type

- Housing penalty exceeds UHI penalty in all three cities

Recommendations for Policy

1. Prepare now

Cities should prepare now for concurrent heatwave and power outage events. Use both passive (cool roof and tree canopy) and active (personal adaptation) strategies

2. Housing matters

Identify vulnerable populations by housing type for most effective interventions

3. No "one-size-fits-all" solutions

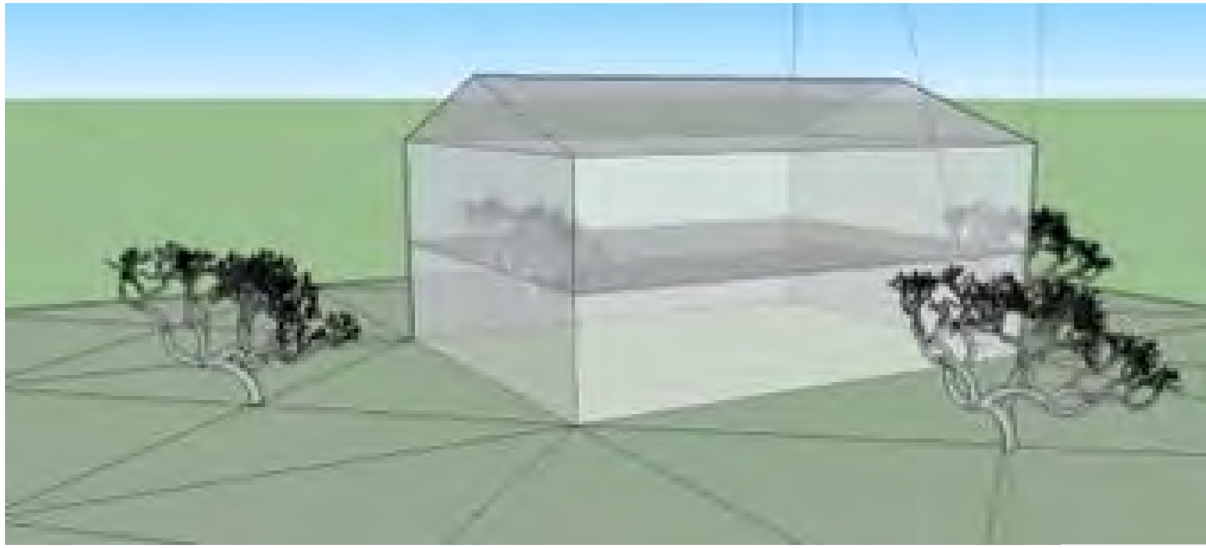
Heat mitigation strategies must be tailored to the local climate, as effectiveness may vary

4. Look beyond "hotspots"

Implement strategies in warm and cool areas of city, not just the "hotspots"

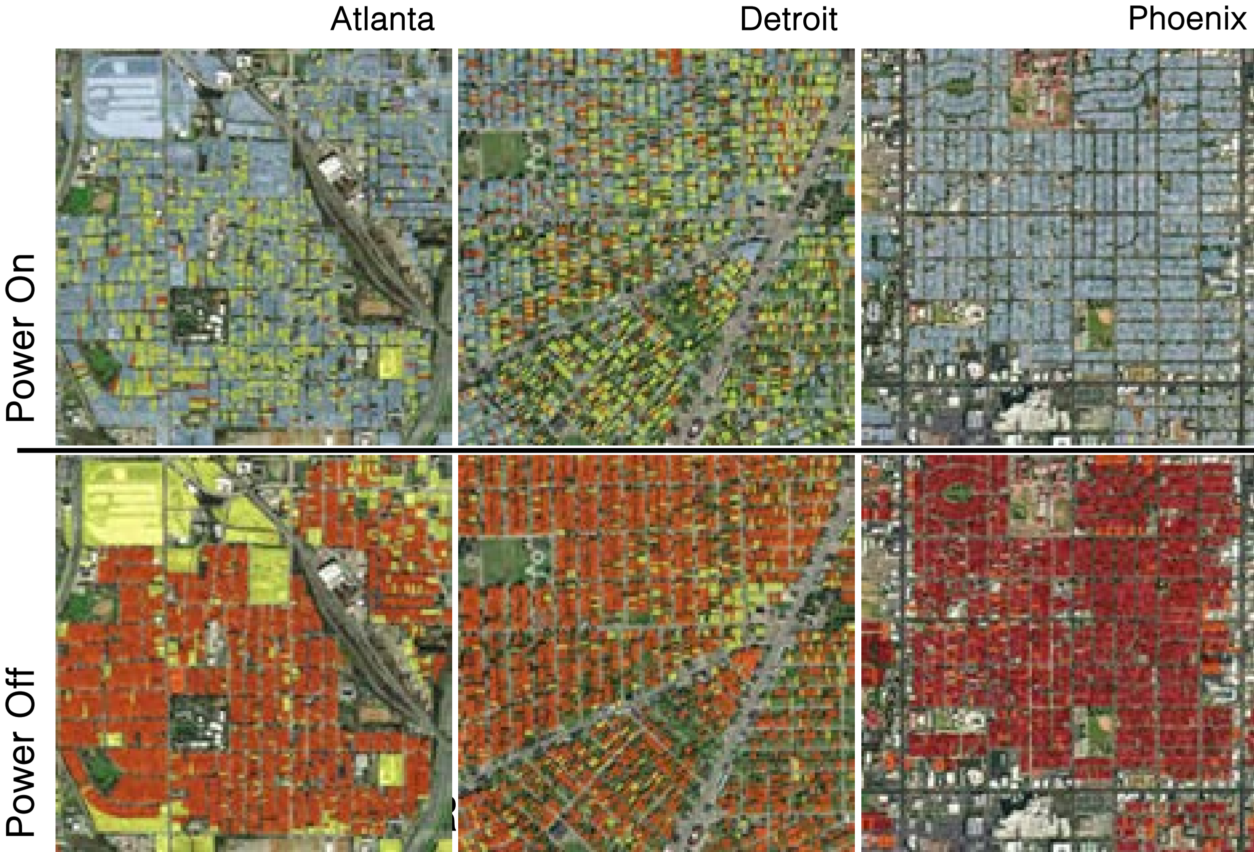
Further Research

1. Additional building prototypes and heat mitigation scenarios



2. Parcel-level risk analysis

3. Individually Experienced Temperature (IET) using synthetic population datasets



Thank You

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College of Design

urban climate lab

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Enhancing Schoolyard Resilience to Extreme Heat: Evaluating Pre Intervention Thermal Environments

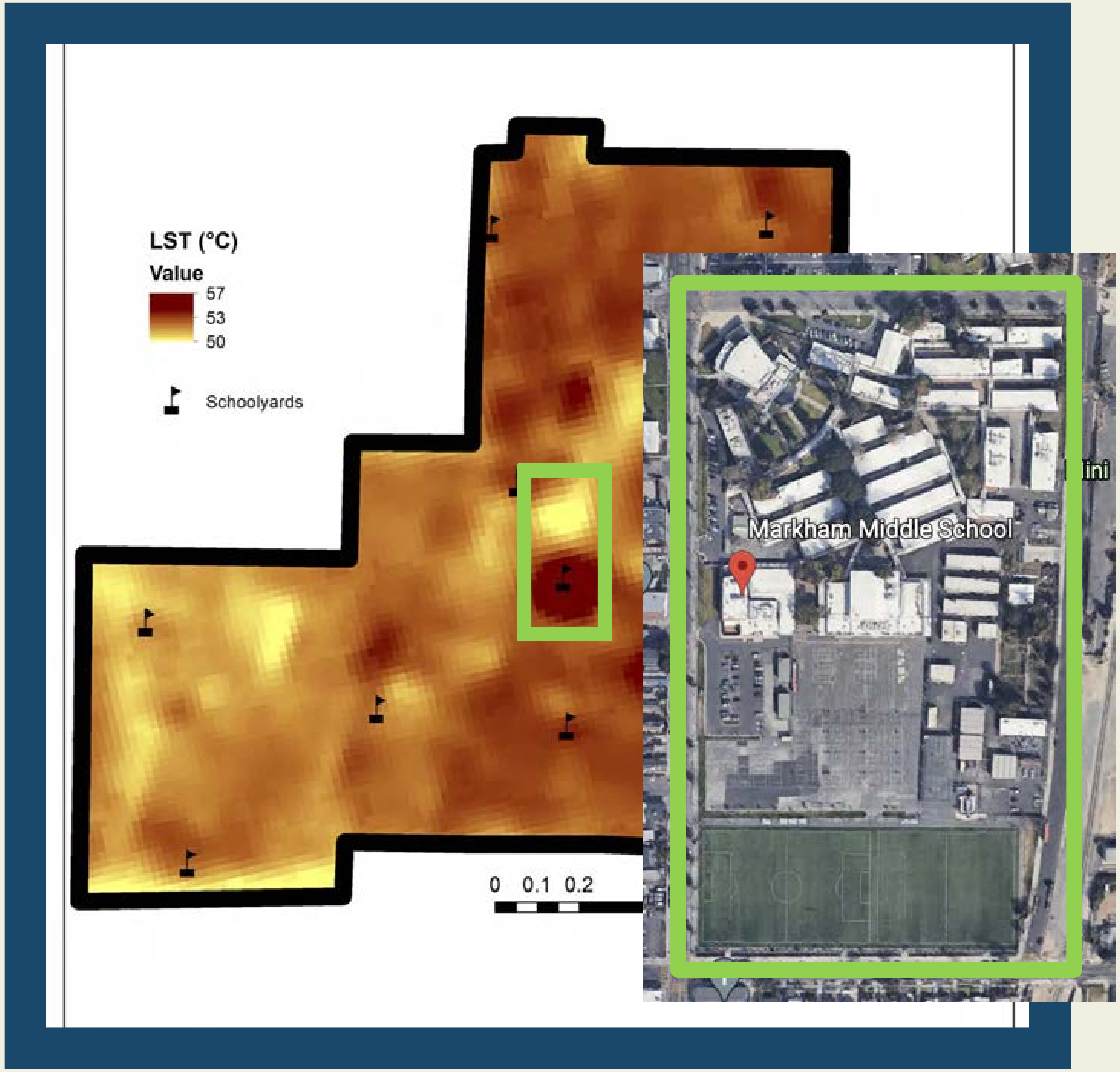
UCLA LCI 2021
Climate Adaptation
Research Symposium

Enhancing schoolyard heat resilience

Evaluating pre and post intervention thermal environments in Watts, Los Angeles, CA

Presented By

Morgan Rogers, University of California, Los Angeles
V. Kelly Turner, University of California, Los Angeles



Watts land surface temperature

49°C
Minimum Schoolyard LST

57°C
Maximum Schoolyard LST

51°C
Mean Schoolyard LST

1.8°C
Maximum Schoolyard LST

Source: Morgan Rogers, Watts, L.A., CA., Transformative Climate Community | Luskin Center for Innovation, 2021 | 2016 NAIP Imagery, LAUSD

Children are more vulnerable to heat stress & schoolyards are hot

Average surface temperature of unshaded schoolyards is 20°C more than shaded areas

52.8°C

Average surface temperature of unshaded schoolyard

Source: Moogk-Soulis, 2010

Urban climate assessments are well developed at the local and regional scales, but not at microscales and often do not measure thermal comfort

1 **SCALE**

Current mismatch

2 **HEAT INDICATOR**

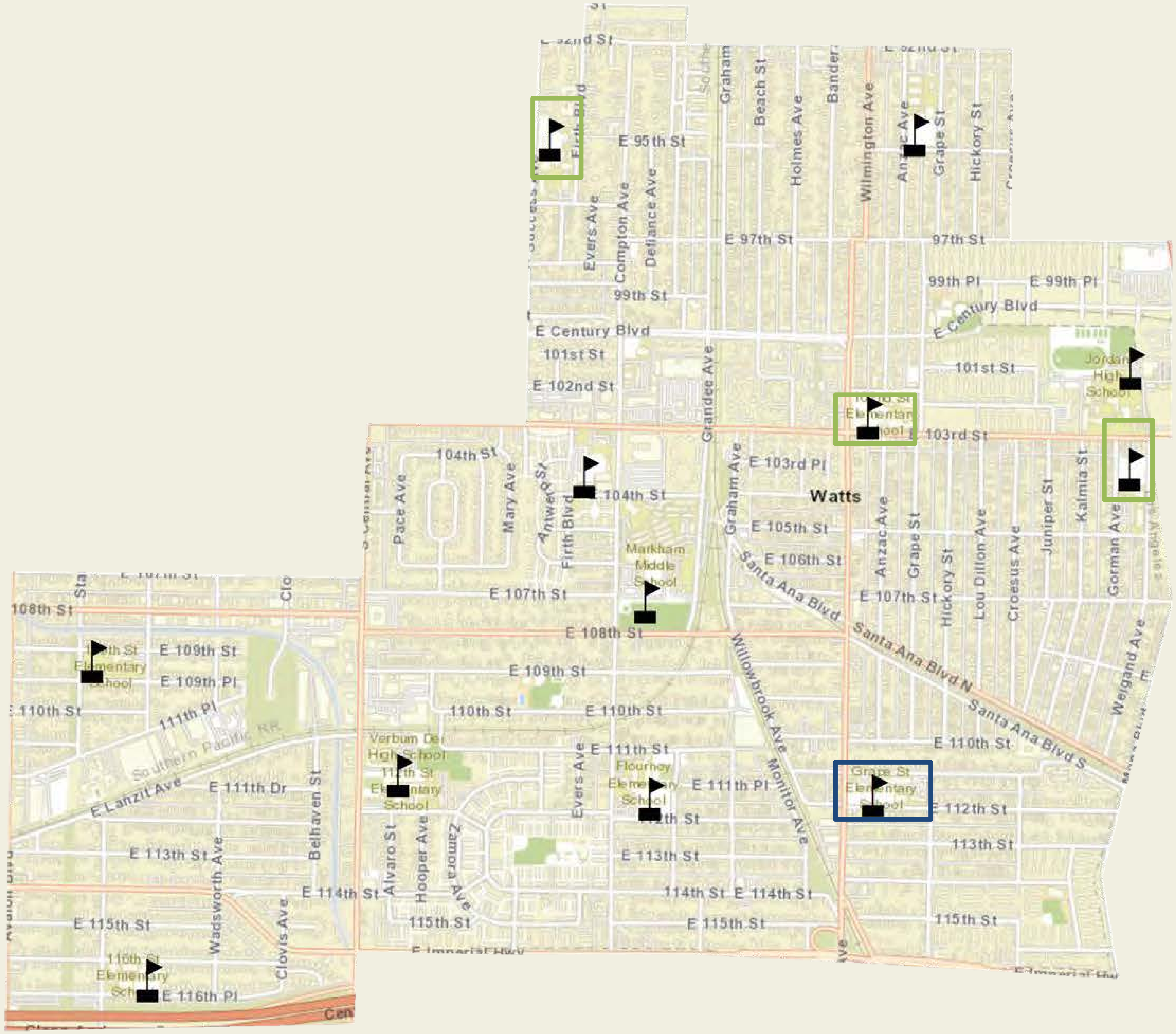
Need to measure thermal comfort (mean radiant temperature)

3 **URBAN EXPERIMENTS**

Need more data on how microscale design interventions influence thermal comfort

How do microscale design interventions influence thermal conditions in schoolyards?

Study Area
Watts, Los Angeles, CA



SCHOOLYARDS

Analyzing air, land surface, and mean radiant temperatures in 12 schoolyards

HEAT MITIGATION

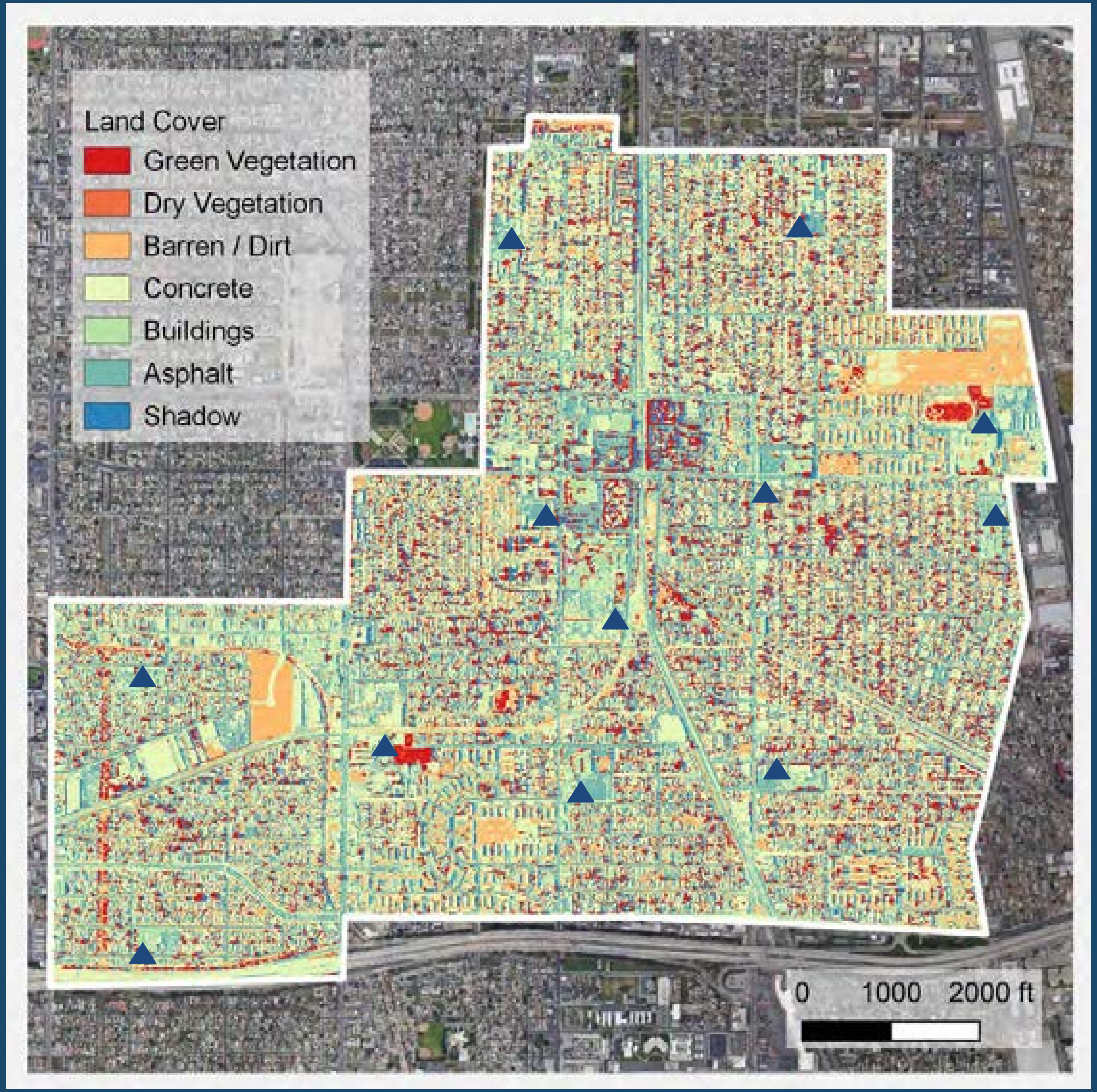
There are three LAUSD schools in the Watts Cool-Green Schools program

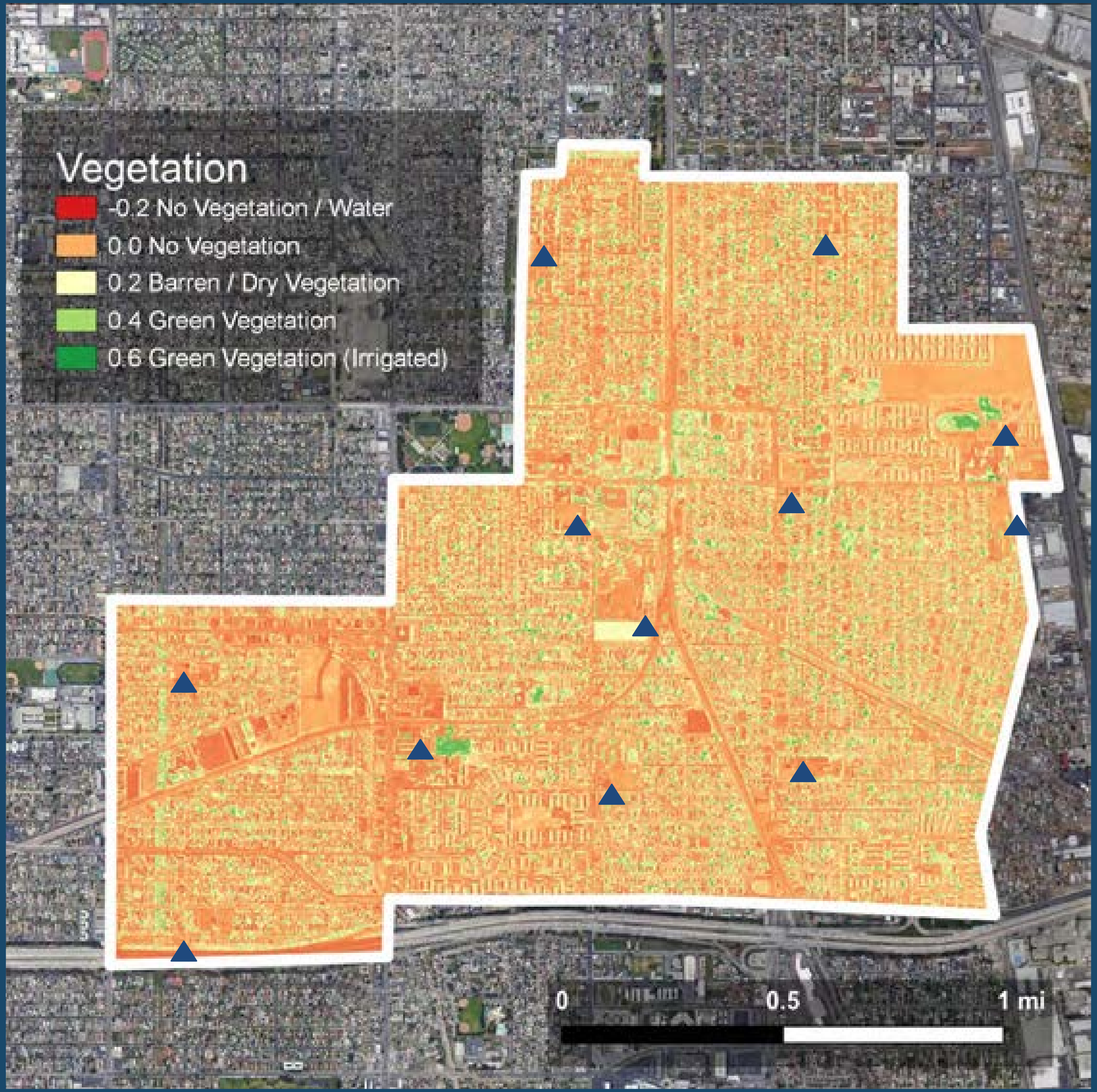
Source: Morgan Rogers, Watts, L.A., CA., Transformative Climate Community | Luskin Center for Innovation, 2021 | Watts Rising Collaborative

Methods

1. COMMUNITY ENGAGEMENT
2. REMOTE SENSING
3. IN SITU OBSERVATIONS
4. MICROCLIMATE MODELING

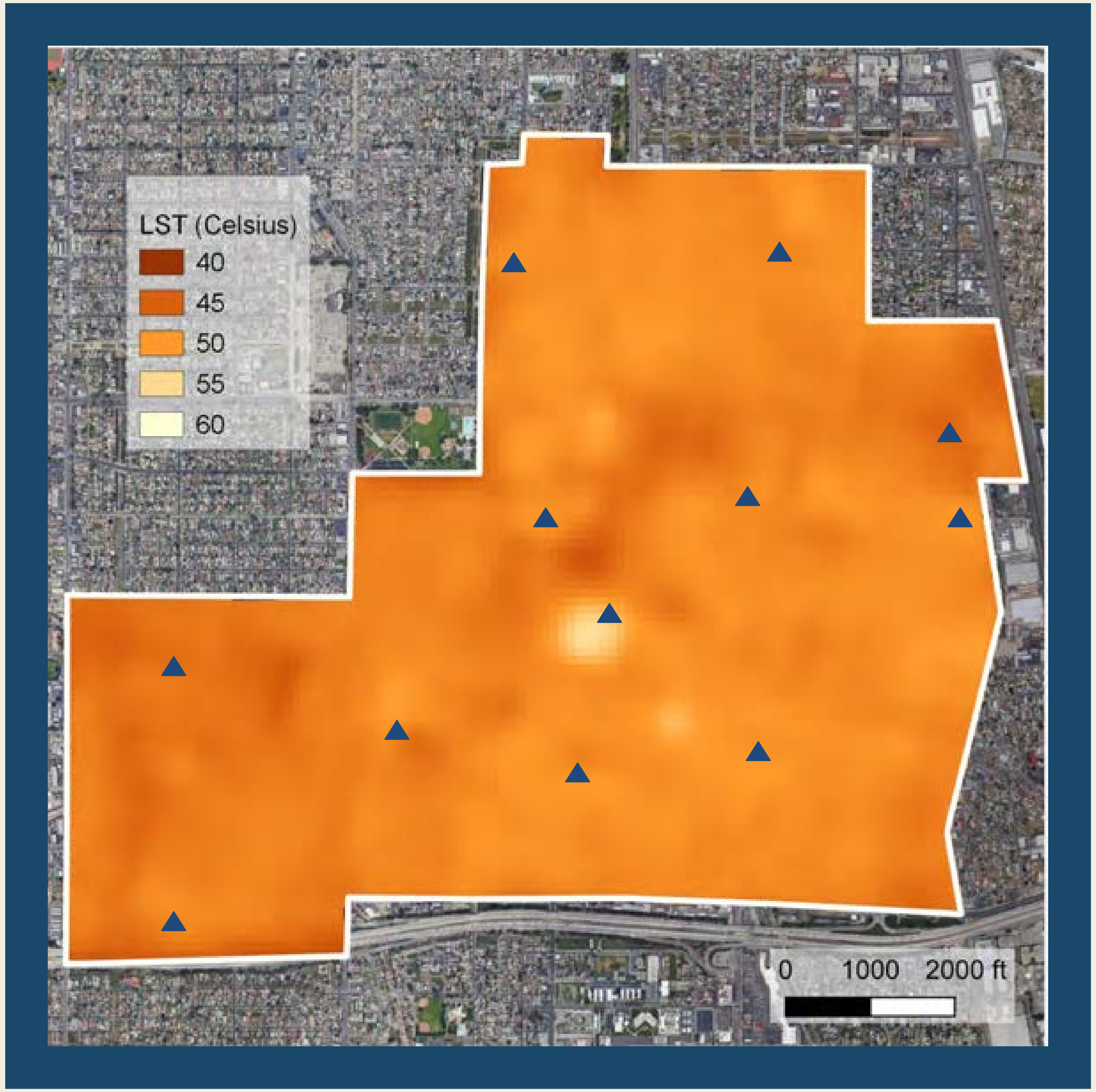
Land cover and vegetation





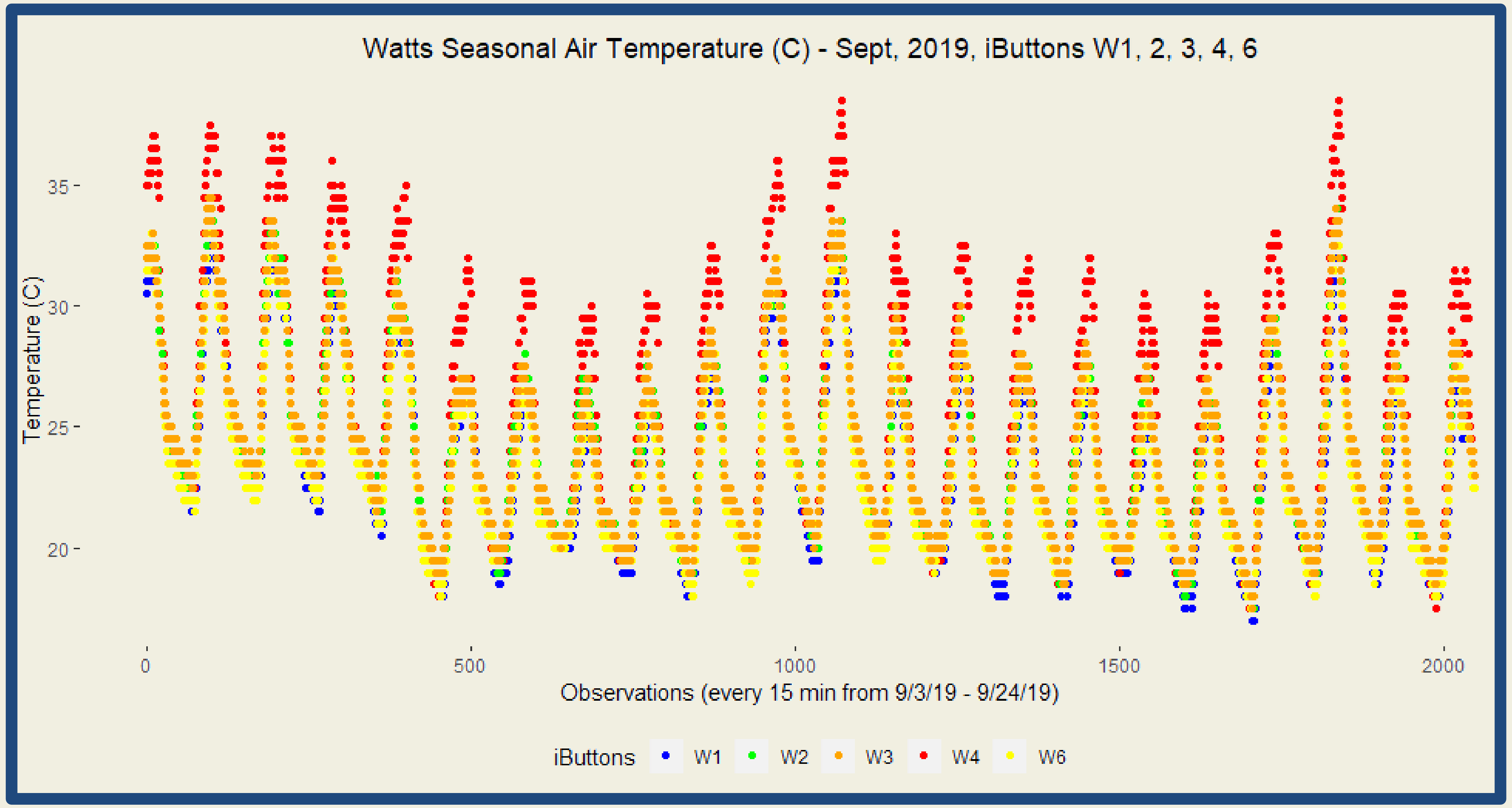
Source: Jon Ocon, Watts, L.A., CA., Transformative Climate Community | Luskin Center for Innovation, 2020 | 2016 NAIP Imagery

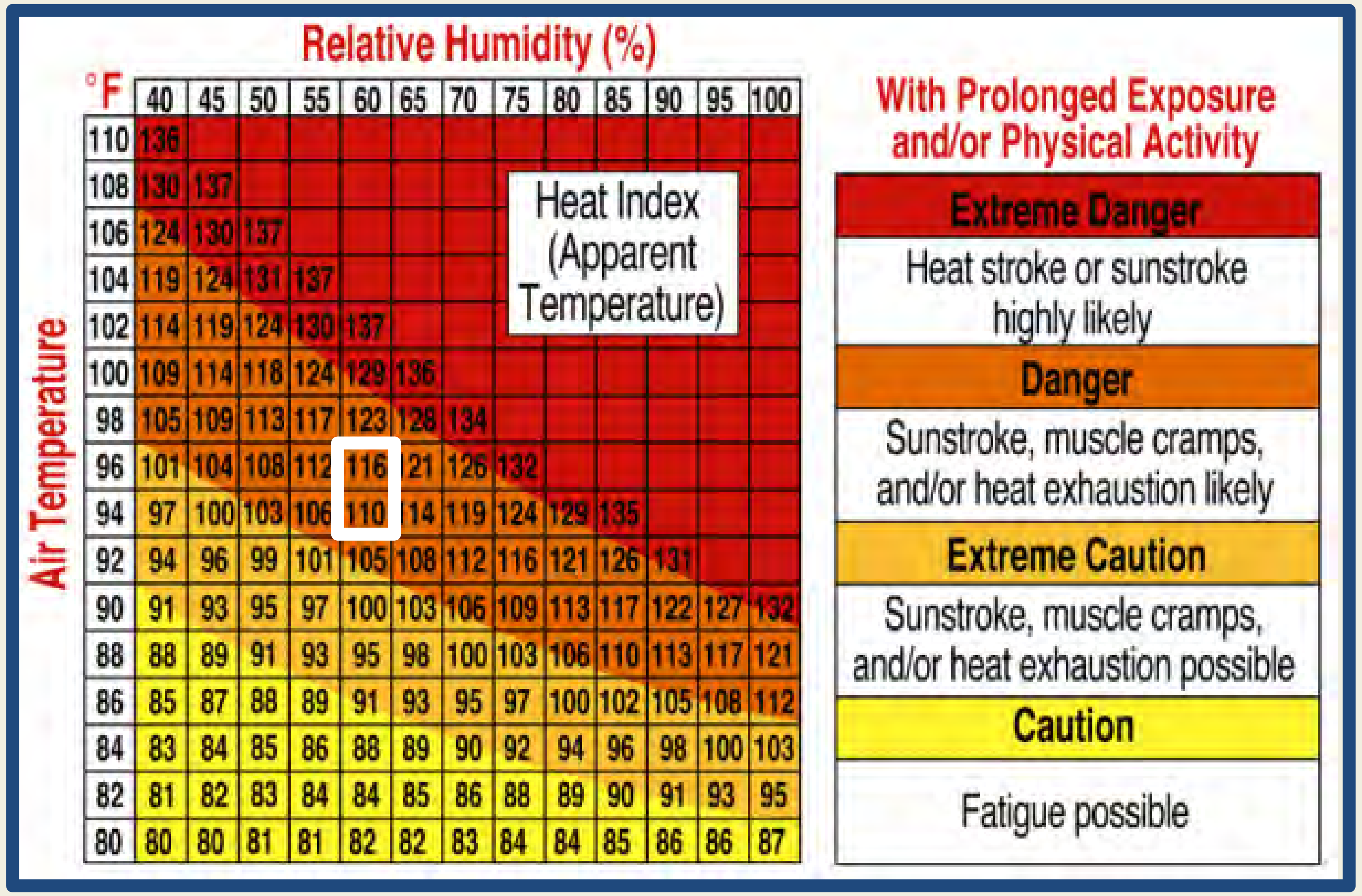
Land surface temperature and albedo



Source: Jon Ocon, Watts, L.A., CA., Transformative Climate Community | Luskin Center for Innovation, 2020 | 2016 NAIP Imagery

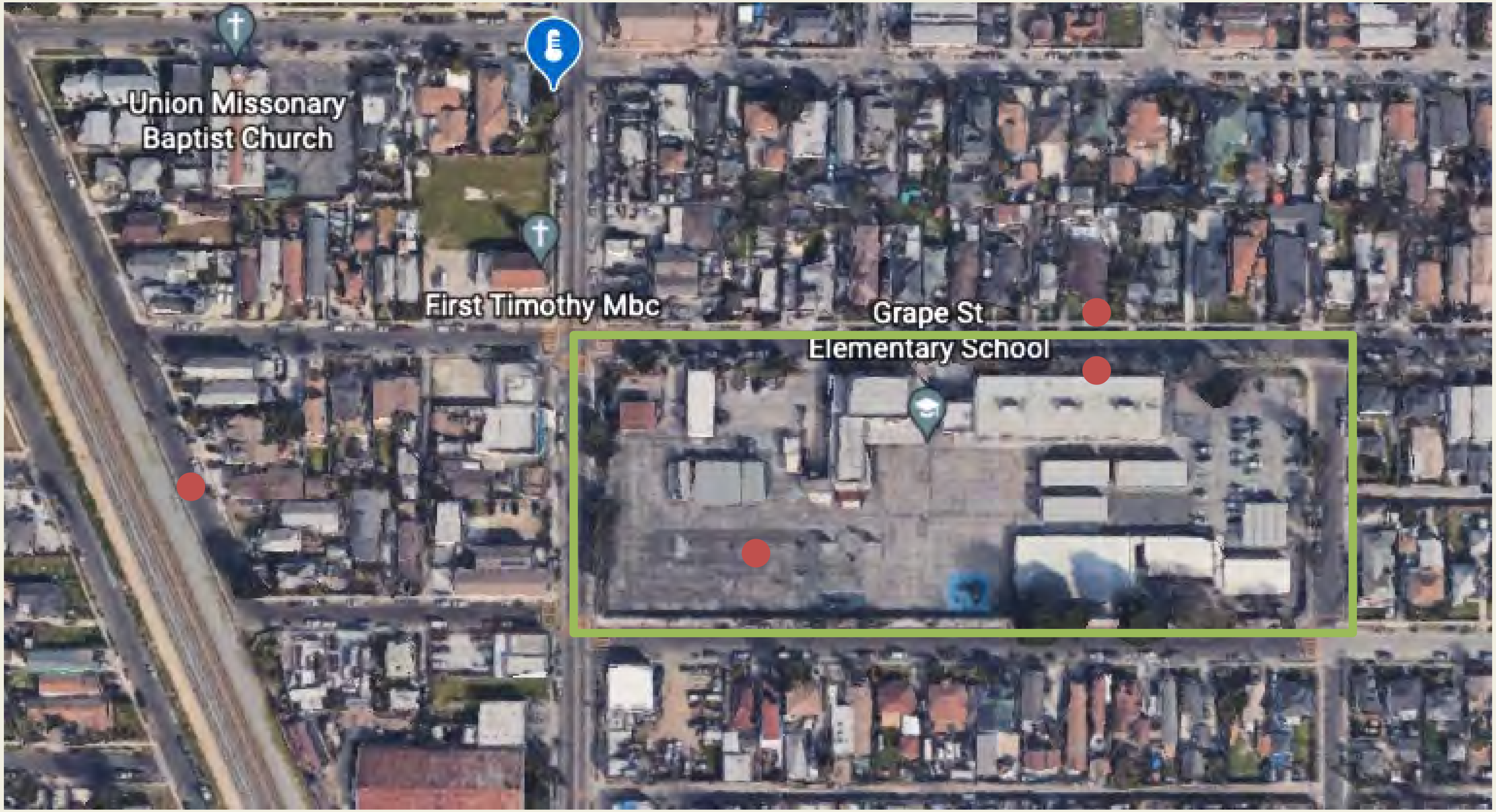
Air temperature often exceeds 35°C





°F	40	45	50	55	60	65	70	75	80	85	90	95	100
110	136												
108	130	137											
106	124	130	137										
104	119	124	131	137									
102	114	119	124	130	137								
100	109	114	118	124	129	136							
98	105	109	113	117	123	128	134						
96	101	104	108	112	116	21	126	132					
94	97	100	103	106	110	14	119	124	129	135			
92	94	96	99	101	105	108	112	116	121	126	131		
90	91	93	95	97	100	103	106	109	113	117	122	127	132
88	88	89	91	93	95	98	100	103	106	110	113	117	121
86	85	87	88	89	91	93	95	97	100	102	105	108	112
84	83	84	85	86	88	89	90	92	94	96	98	100	103
82	81	82	83	84	84	85	86	88	89	90	91	93	95
80	80	80	81	81	82	82	83	84	84	85	86	86	87

Grape Street Elementary

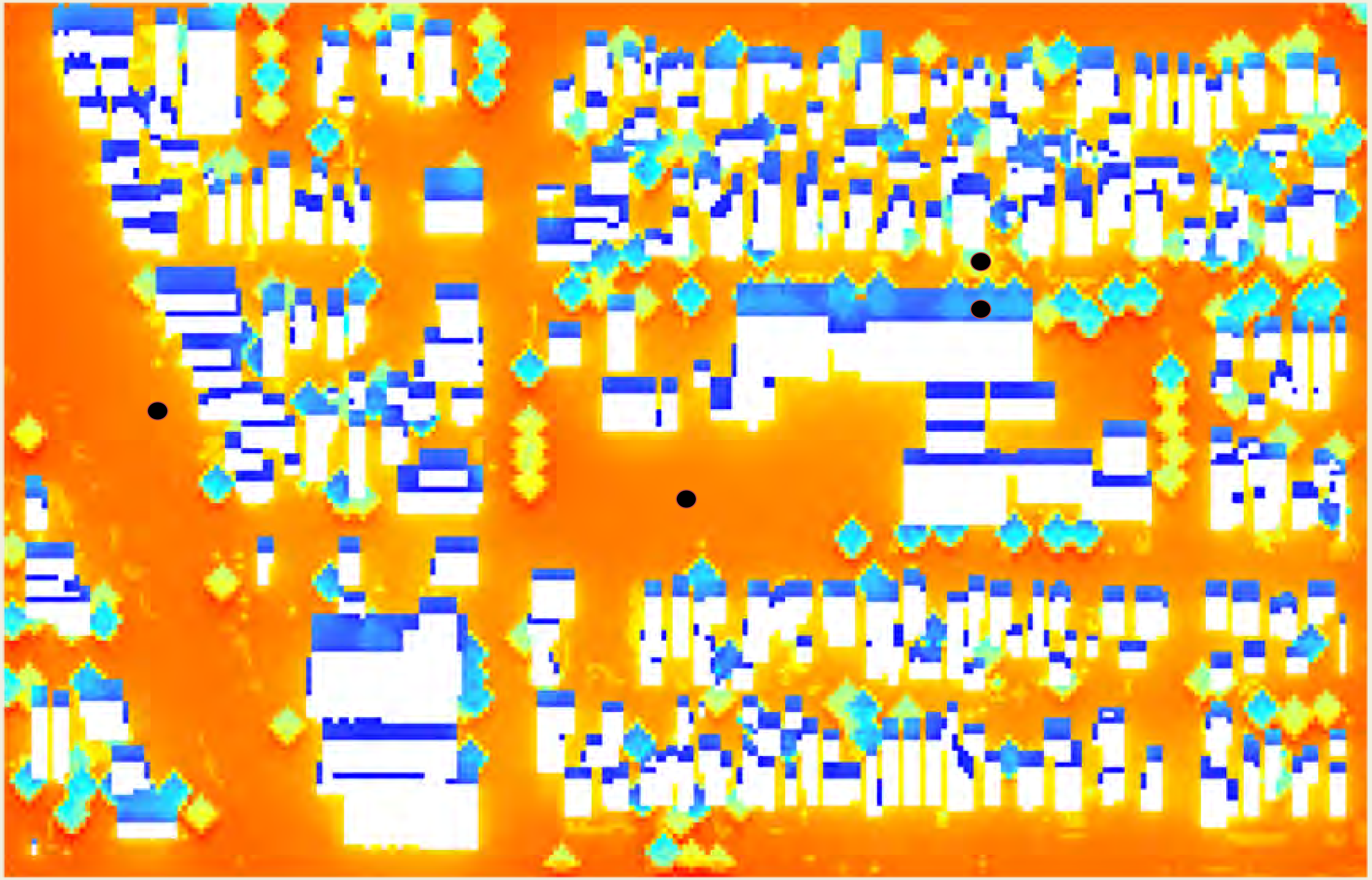


Time	Schoolyard			Roadway/ Metro Line			Shaded area			Residential yard		
	LST	AT	MRT	LST	AT	MRT	LST	AT	MRT	LST	AT	MRT
8:00	35	26	59	35	25	60	29	26	31	28	26	56
10:00	47	29	67	48	30	67	32	28	42	36	28	64
12:00	55	31	70	56	33	70	35	31	49	43	31	66
15:00	52	32	72	53	33	72	37	32	47	47	32	71

Source: Morgan Rogers, Watts, L.A., CA., Transformative Climate Community | Luskin Center for Innovation, 2021

Grape Street Elementary

Baseline ENVI-met model of mean radiant temperature at 12:00pm



Mean Radiant Temperature

Value

High : 73.8372

Low : 43.1321

Next Steps

BASELINE
MICROCLIMATE MODEL

PLANNED INTERVENTION
MICROCLIMATE MODEL

FUTURE SCENARIO
MICROCLIMATE MODEL

Acknowledgements

This project would not be possible without our collaborators, community stakeholders, and supporting organizations.

Collaborators

Ariane Middel, Arizona State University

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Forian A. Schneider, Arizona State University

Yujia Zhang, Arizona State University

Community Partners

Watts Rising Collaborative

Pacoima Beautiful

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UCLA LCI 2021
Climate Adaptation
Research Symposium

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Thank you for listening! Questions?

Up next – 10:45am-12:15pm PT

SESSION 2.1

International Lessons on Climate Adaptation

SESSION 2.2

Before the Storm: Responses to Forecasts

SESSION 2.3

Quantifying and Minimizing the Impacts of Wildfires

SESSION 2.4

Proactive Planning for Resilient and Equitable Communities

CLIMATE ADAPTATION
RESEARCH SYMPOSIUM

MEASURING & REDUCING SOCIETAL IMPACTS

Thanks for tuning in!

UCLA Luskin Center for Innovation