3-14-2024

Webinar: Assessing Cool Corridor Heat Resilience Strategies for Human-Scale Transportation

Ladd Keith
University of Arizona

Kristina Currans
University of Arizona

Assessing Cool Corridor Heat Resilience Strategies for Human-Scale Transportation

Ladd Keith, PhD, Assistant Professor of Planning
Kristi Currans, PhD, Associate Professor of Planning

| March 14, 2024

The University of Arizona

Presenters

Ladd Keith

Assistant Professor
Urban Planning
University of Arizona

MS in Planning
PhD in Arid Lands Resource Sciences

Kristina Currans

Associate Professor
Urban Planning
University of Arizona

BS, MS, PhD Civil Engineering
(Transportation)

The University of Arizona

Learning outcomes

- An understanding of planning for urban heat resilience;
- The ability to recognize and differentiate heat mitigation and management strategies;
- An understanding of the impacts of heat on transportation users and systems;
- An ability to explain the challenges of evaluating local impacts of strategies.

Impacts of extreme heat

- Public health
- Quality of life
- Economy
- Energy and water usage
- Infrastructure and urban systems
- Urban landscapes
- Agriculture
- Rural and natural lands

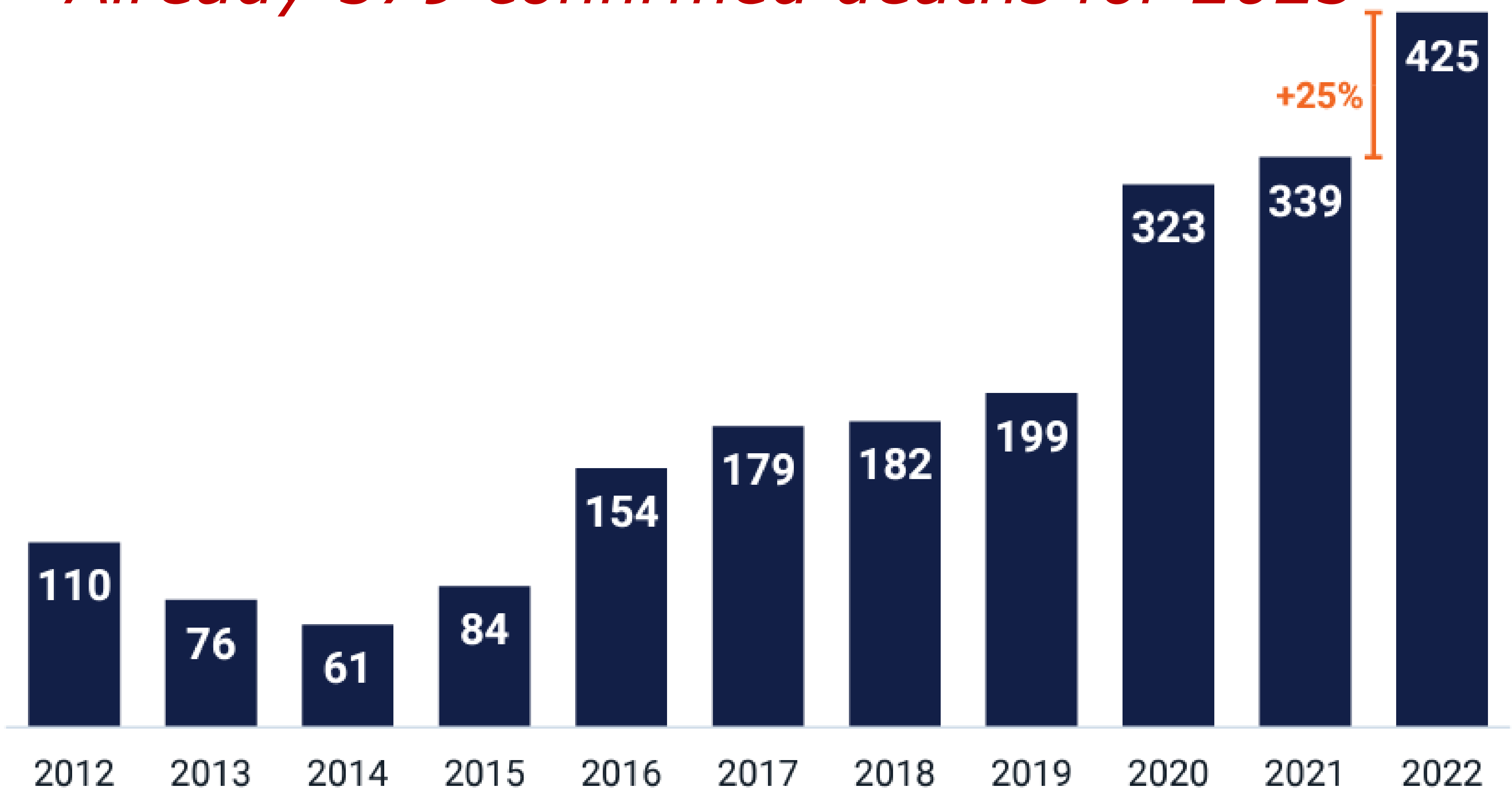
THE UNIVERSITY OF ARIZONA

Public health impacts of heat

- Heat is the #1 weather-related cause of death in the U.S.
- Heat illnesses and deaths are widely acknowledged to be underreported
- 12,000 deaths estimated per year in 2010s, could increase to 110,000 by 2100 (Shindell et al., 2020)

Heat-Associated Deaths in Maricopa County, AZ

Already 579 confirmed deaths for 2023



(Maricopa County, 2023)

THE UNIVERSITY OF ARIZONA

Economic impacts of heat

Nationally, heat already results in $100B in economic losses every year, anticipated to reach $200B by 2030, and $500B by 2050 (Atlantic Council, 2021)

- Labor safety and productivity
- Economic development efforts
- Tourism
- Increased costs to healthcare, energy/water, infrastructure, etc.

Extreme heat could result in an average annual economic loss of between $1.9 billion and $2.3 for the Phoenix metro area alone if no further action is taken (The Nature Conservancy / AECOM, 2022)

Transportation impacts of heat

- Transportation infrastructure
  - Functionality
  - Lifespan and maintenance
- Transportation mode choices
- Health and safety of transit users, pedestrians, bicyclists

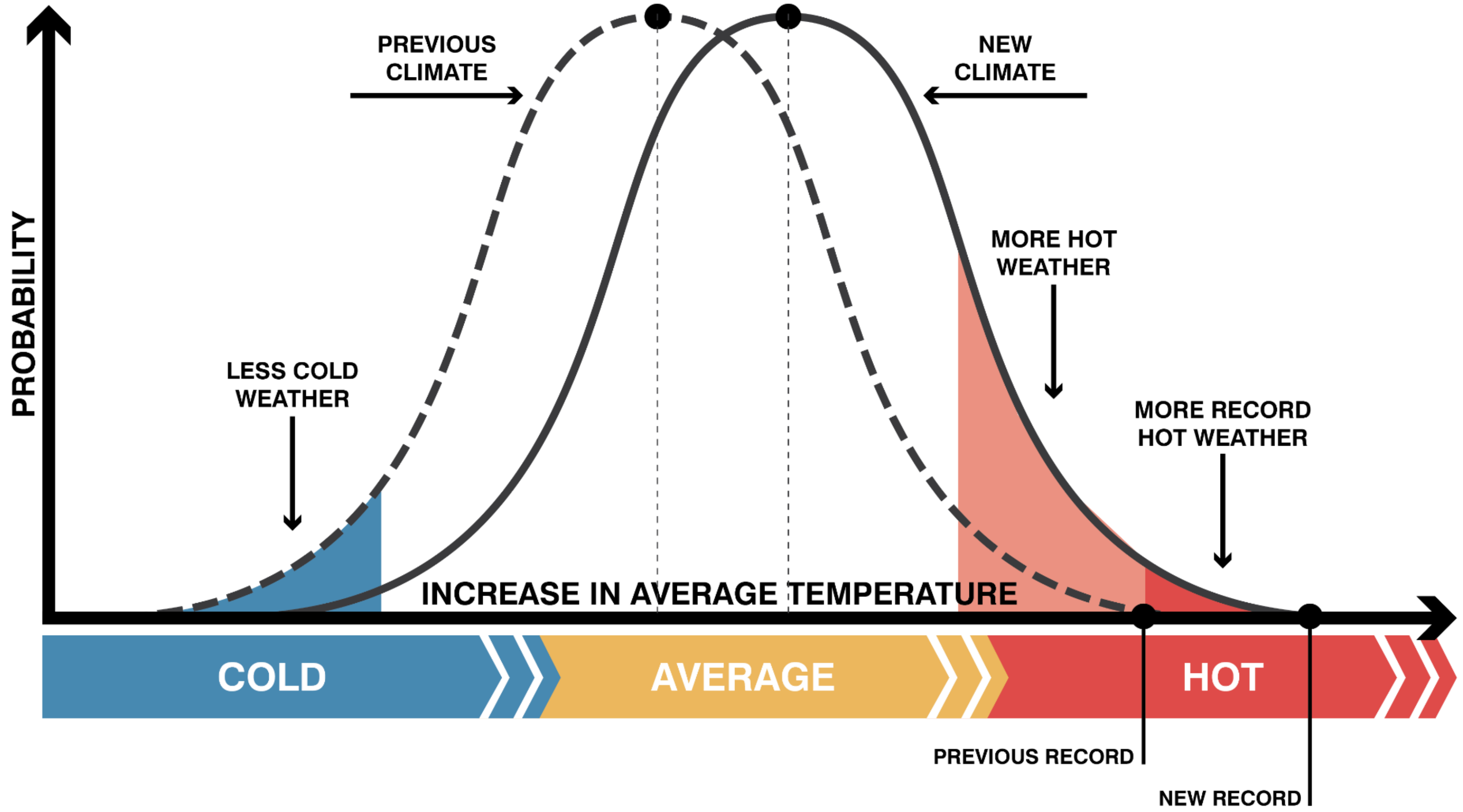
(Portland Streetcar, 2021)

THE UNIVERSITY OF ARIZONA

Heat: An increasing climate risk

Continued increases in the intensity, duration, and frequency of extreme heat events and continual rise in average temperatures

- Weather
- Climate change
- Urban heat island (UHI) effect

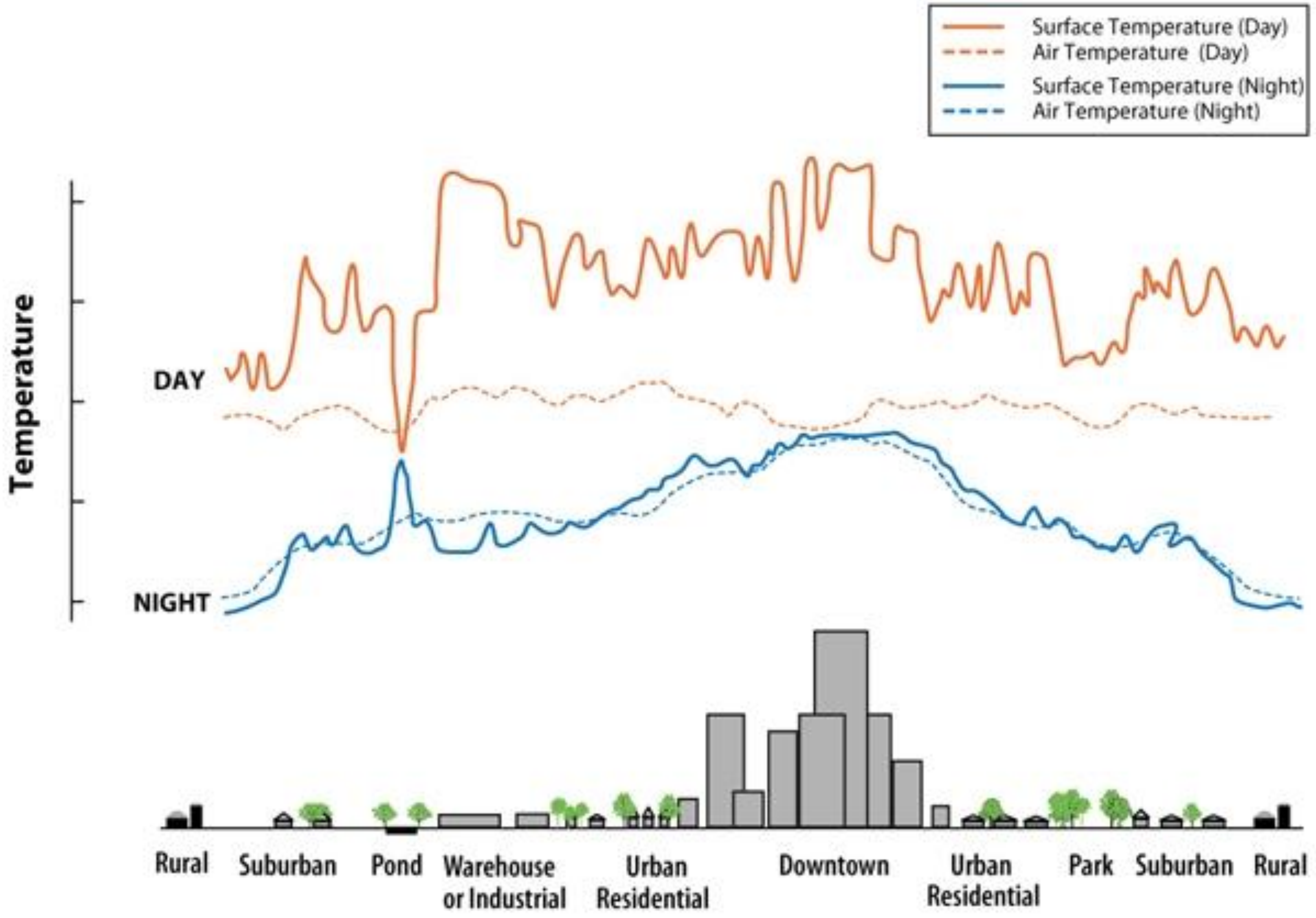


(Keith & Meerow, 2022, adapted from U.S. EPA)

THE UNIVERSITY OF ARIZONA

Urban heat island (UHI) effect

- Land use and cover change
- Urban form
  Building height, density, and arrangement
- Building materials and reflectivity
- Vegetation and humidity
- Waste heat emissions
- Air pollution

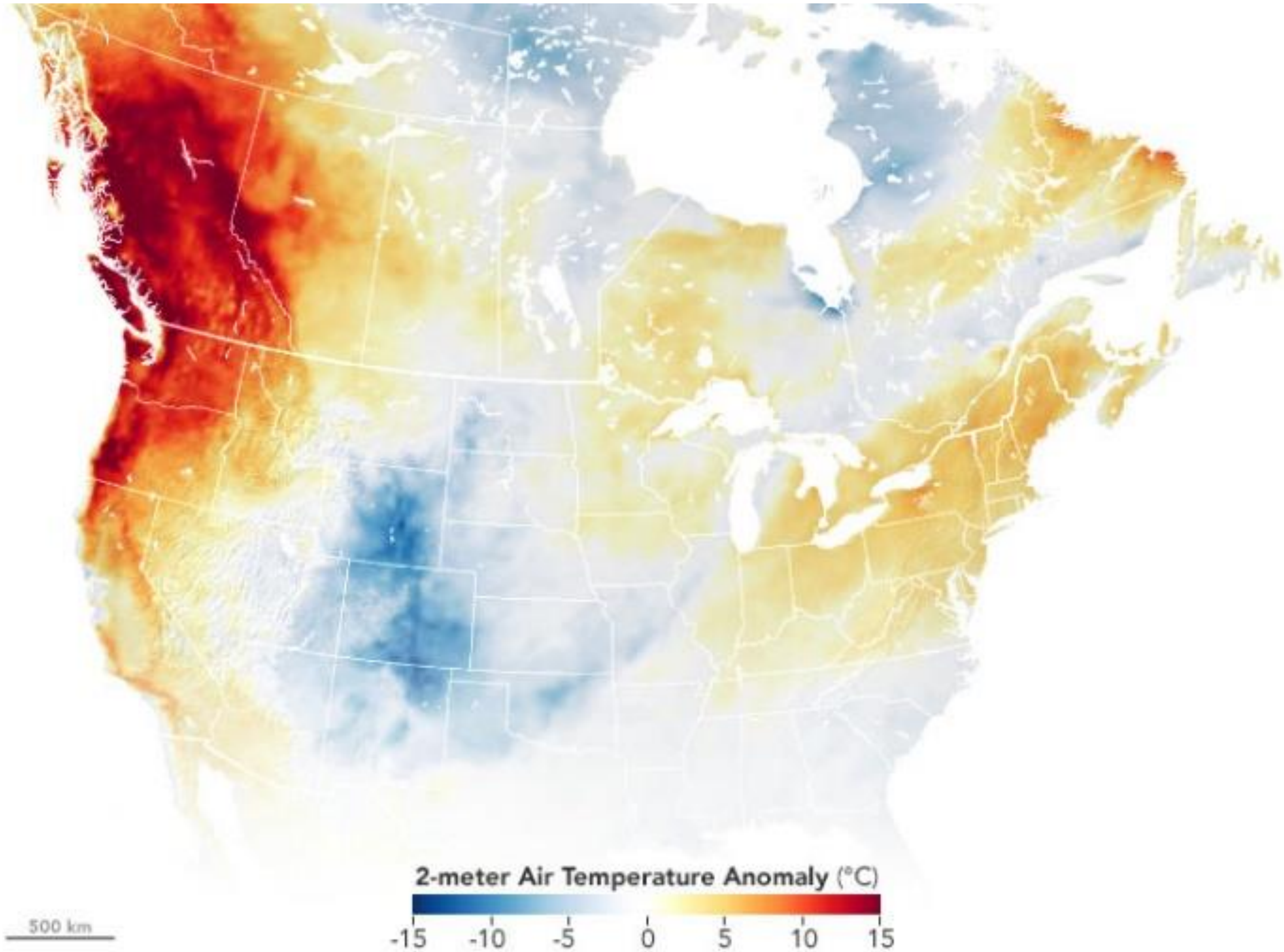


(U.S. EPA)

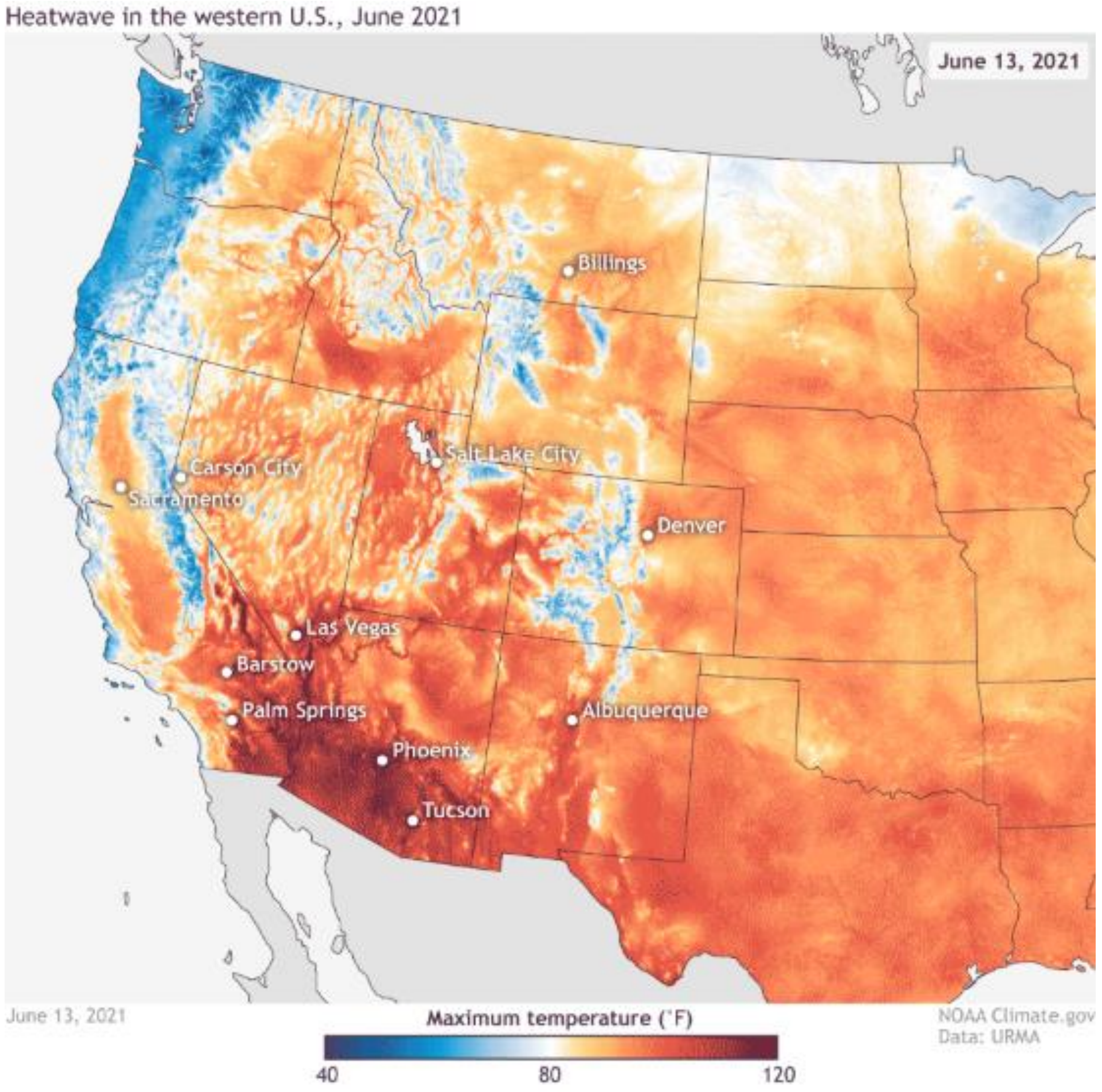
THE UNIVERSITY OF ARIZONA

Heat: A chronic and acute climate risk

2021 Pacific Northwest Heatwave



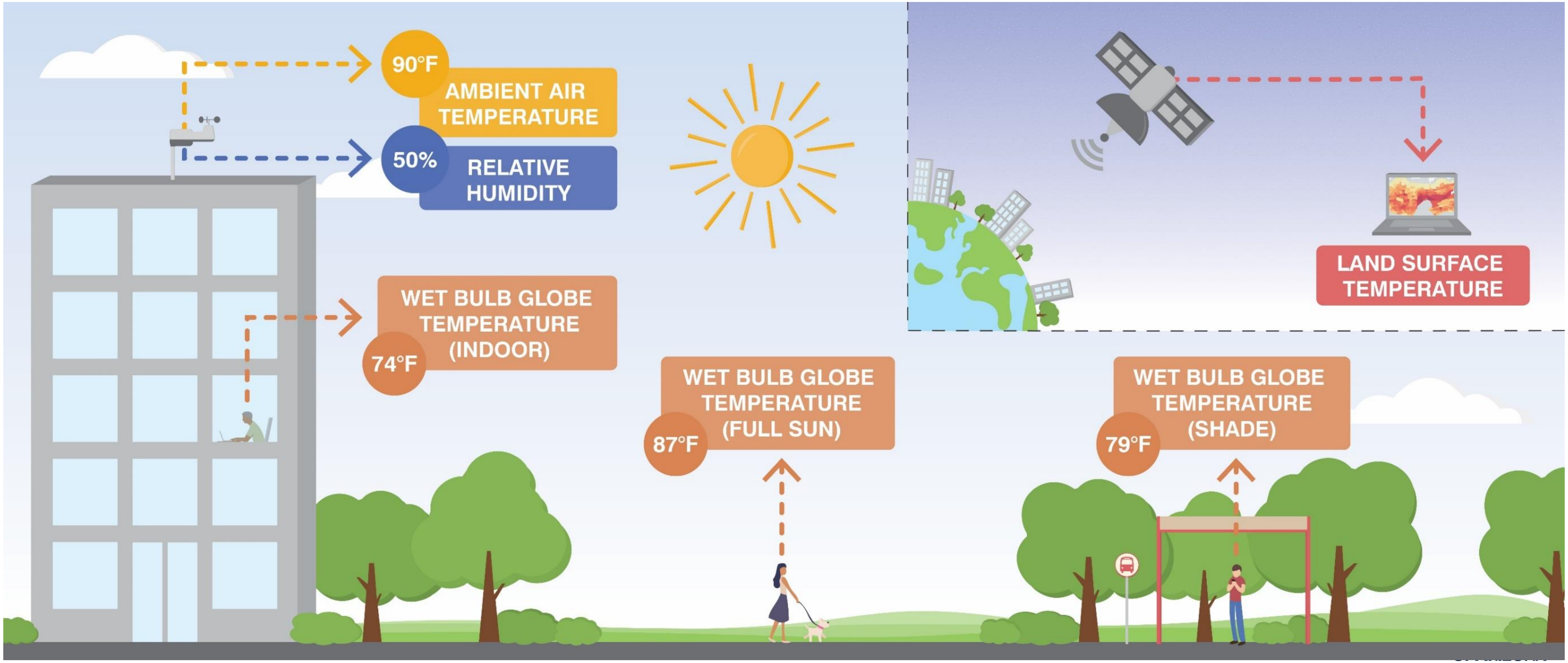
2021 Southwest Heatwave



(U.S. NOAA)

THE UNIVERSITY OF ARIZONA

Complexity of heat



(Keith & Meerow, 2022)

Urban heat inequities

- Urban heat is not equally distributed, lower-income and minority neighborhoods are often the hottest areas in cities
- Affordability and accessibility of:
  - Healthcare
  - Housing and quality housing
  - Energy for indoor cooling
  - Transportation

Sam Hughes, Tucson, AZ

Southside, Tucson, AZ

(Google)

THE UNIVERSITY OF ARIZONA

Deploy heat officers, policies and metrics

Heat governance

"The actors, strategies, processes, and institutions that guide decision-making for mitigating and managing heat as a hazard."

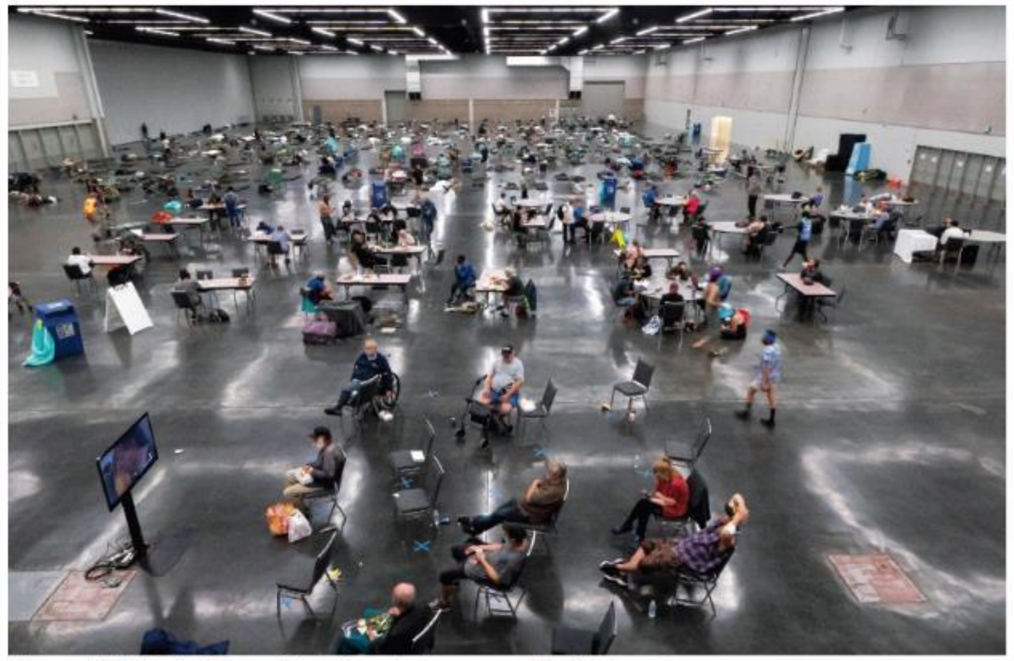
Six guiding principles for researchers and decision-makers

- Advance heat equity
- Mitigate heat
- Manage heat
- Develop metrics
- Coordinate initiatives
- Build heat institutions

Setting the agenda in research

nature

Comment



In June, residents in Portland, Oregon, fill a cooling centre to escape record-breaking temperatures.

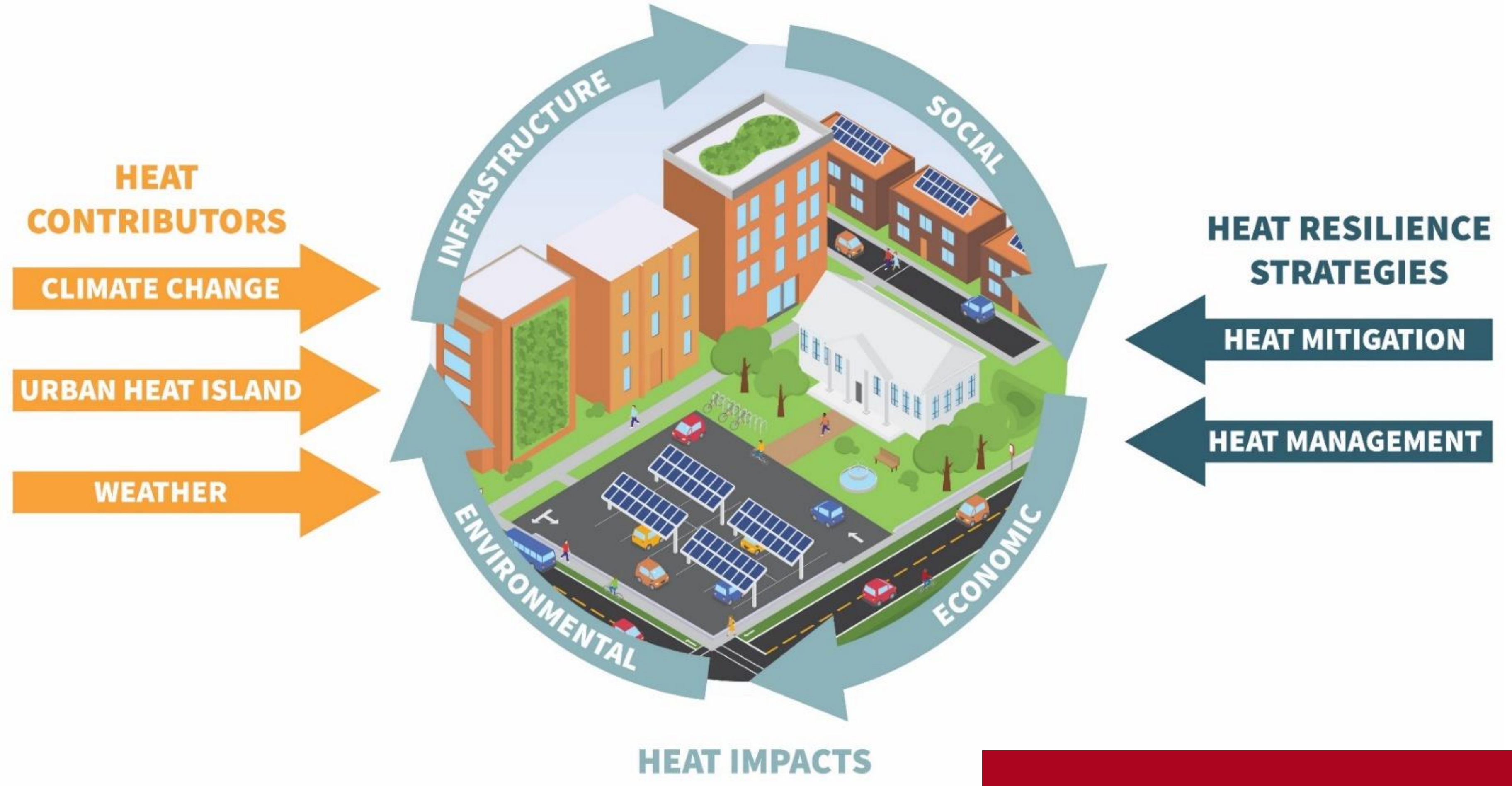
Deploy heat officers, policies and metrics

Ladd Keith, Sara Meerow, David M. Hondula, V. Kelly Turner & James C. Arnott

Planning for Urban Heat Resilience

Urban heat resilience

“Proactively mitigating and managing urban heat across the many systems and sectors it affects.”



THE UNIVERSITY OF ARIZONA

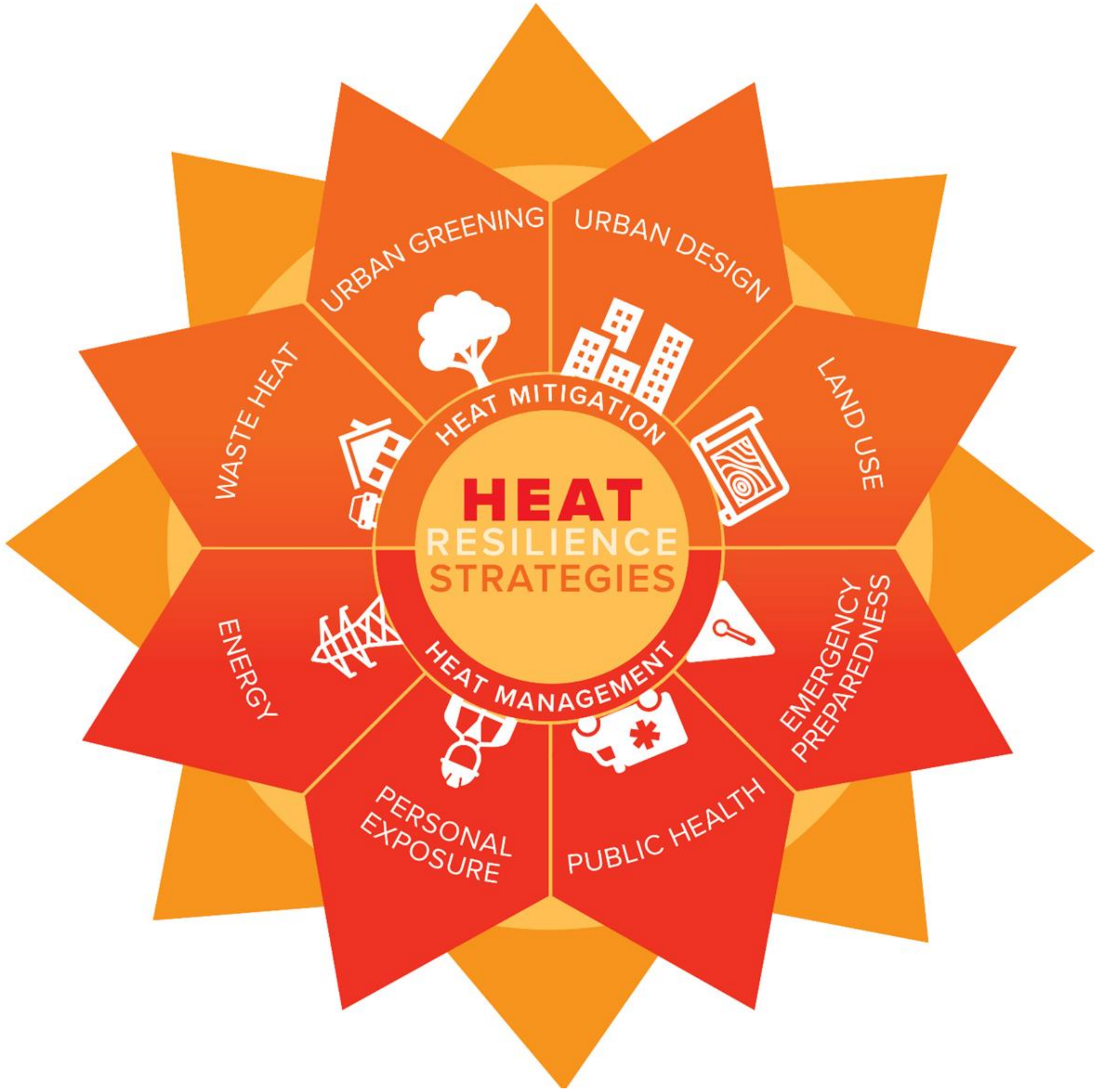
Heat resilience strategies

Heat mitigation

Strategies that reduce the built environment's contribution to urban heat.

Heat management

Strategies that prepare and respond to chronic and acute heat risk.



(Keith & Meerow, 2022)

THE UNIVERSITY OF ARIZONA

Heat mitigation strategies

- Land use
  urban development, land conservation, transportation
- Urban design
  shade structures, cool materials
- Urban greening
  urban forestry, parks, green infrastructure
- Waste heat
  buildings, vehicles

(Keith & Meerow, 2022)

THE UNIVERSITY OF ARIZONA

Heat management strategies

- Cooling centers / resilience hubs
- Weatherization and energy assistance programs
- Early warning systems
- Heat education and awareness campaigns
- Occupational safety guidance and regulations
- Energy grid resilience

(Keith & Meerow, 2022)

Heat resources and information

Extreme Heat Network

- U.S. National Integrated Heat Health Information System (NIHHIS)
- U.S. EPA's Heat Island Reduction Program
- U.S. Fifth National Climate Assessment
- Global Heat Health Information Network (GHHIN)

NITC Project No. 1483

Assessing Cool Corridor Heat Resilience Strategies for Human-Scale Transportation

Ladd Keith
Assistant Professor
UArizona

Kristina Currans
Associate Professor
UArizona

Nicole Iroz-Elardo*
Assistant Professor,
Willamette University

Students: Ash Avila, Lauren Heath, Ethan Wissler, Andrew Birkelbach, and Brenden Little.
** Majority of these slides were developed by Prof. Iroz-Elardo*

THE UNIVERSITY OF ARIZONA

What are cool corridors

- Streets targeted for heat mitigation strategies
- Reduce the UHI effect and improve thermal comfort
- Examples:
  - Decreasing asphalt
  - Increasing vegetation
  - **Cool pavements**
  - Increasing shade

(Photo: Ladd Keith, 2021)

THE UNIVERSITY OF ARIZONA

Cool corridor study overview

- The City of Tucson was chosen as part of pilot program for an asphalt cool pavement product
- Lab measurements suggest less heat is absorbed in the pavement, like a sunscreen, but what is the impact on human comfort (pedestrian-scale)?
- Before-after, case-control quasi-experimental design to evaluate the impacts of the cool pavement product on various heat metrics of the area

NITC NATIONAL INSTITUTE for TRANSPORTATION and COMMUNITIES

Read the full NITC report at the link above

THE UNIVERSITY OF ARIZONA

Treatment Used: PlusTI

- Pavement Technology Inc (PTI) PlusTi asphalt rejuvenator (Installed Fall 2021)
  - https://www.pavetechinc.com/plus-ti/
  - Mechanism: UV-reflective TiO2 nanoparticles
  - At the time of our study, the PlusTI treatment reported a target Solar Reflectance Index (SRI) reading of 40 (most roads estimated at 5-10).

- Since our study, these treatments continue to evolve. I believe the current version of this rejuvenator is now called ARA-1 Ti.
  - https://www.pavetechinc.com/uhi-mitigation/
  - https://www.pavetechinc.com/wp-content/uploads/2021/03/PlusTi-ARA-1Ti-Asphalt-Rejuvenator-Sealer-0721-LB350.pdf

- Other resources:
  - **Global Cool Cities Alliance**: https://globalcoolcities.org/cool-roadways-partnership

THE UNIVERSITY OF ARIZONA

Personal heat exposure measurements

Ambient Air Temperature

- Measured by standard thermometer
- Analogous to the weather station readings

Thermal Comfort

- Wet Bulb Globe Temp. (WBGT) Index
- Comfort of people at pedestrian level
- Ambient air temperature + humidity, wind, and solar radiant heat.

Surface Temperature

- Temperature collected of a surface
- Sidewalks, gravel, vegetation, etc.
- Sun and Shade

THE UNIVERSITY OF ARIZONA

Tucson Cool Pavement Project

Before/After, Case/Control Sites

- 6 test sites
- 3 control sites
- 3 test days per segment

Before: Oct. 2021
After: Apr. 2022
- 10AM-4PM

GIS Mapping to Match Sites

- 7 land cover types:
  - Water, Trees/Shrubs, Irrigated Land, Desert, Barren/Bedrock, Impervious, Structures
- Street Design
- Street Orientation

THE UNIVERSITY OF ARIZONA

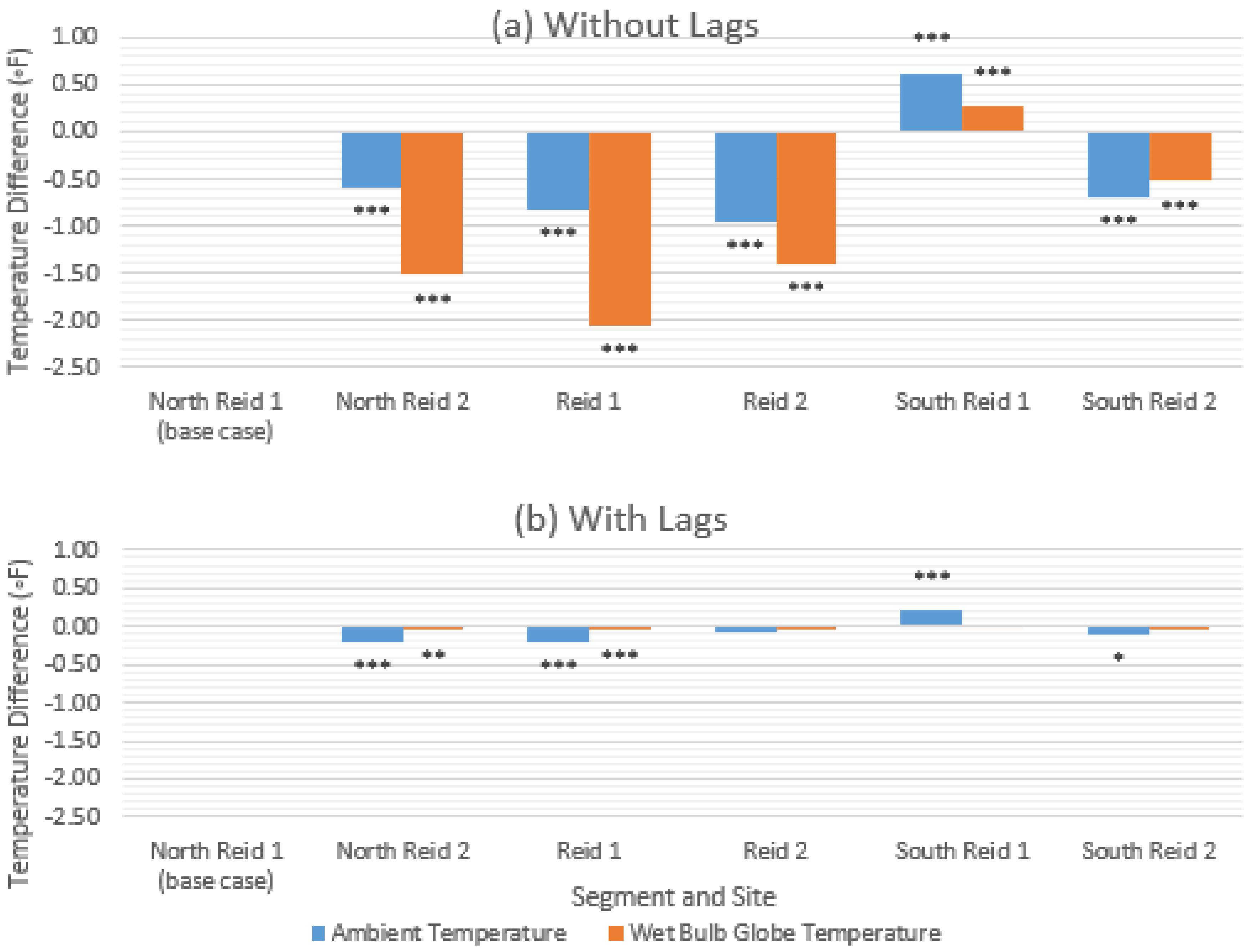
Summary of findings

Focusing on Before/After, Treatment Only

Controlling for temporal autocorrelation

Centerline Analysis

	Ambient (ºF)	WBGT (ºF)
Autocorrelation one-min. lags	1	3
Shade	-0.3	-0.08
Wind	-1.0	-0.04
After (vs. Before)	-0.3	*Not sig.*



Notes: ***: p-value < 0.001; **: p-value < 0.01; *: p-value

Figure 11 Temperature differences (°F) for ambient air temperature and wet bulb globe temperature by segment and site (a) without and (b) with temporal lags

Summary of findings

Experimental UVB/UV Index

UVIndex – reflection higher on concrete (sidewalk) than asphalt (road)

	Highest Range of Measurement	Proportion Reflected (average)
UV Index	7.7-8.1 “Very High”	4%
UVB	0.22-0.26 mW/cm^2	3%

Summary

Surface Temperatures

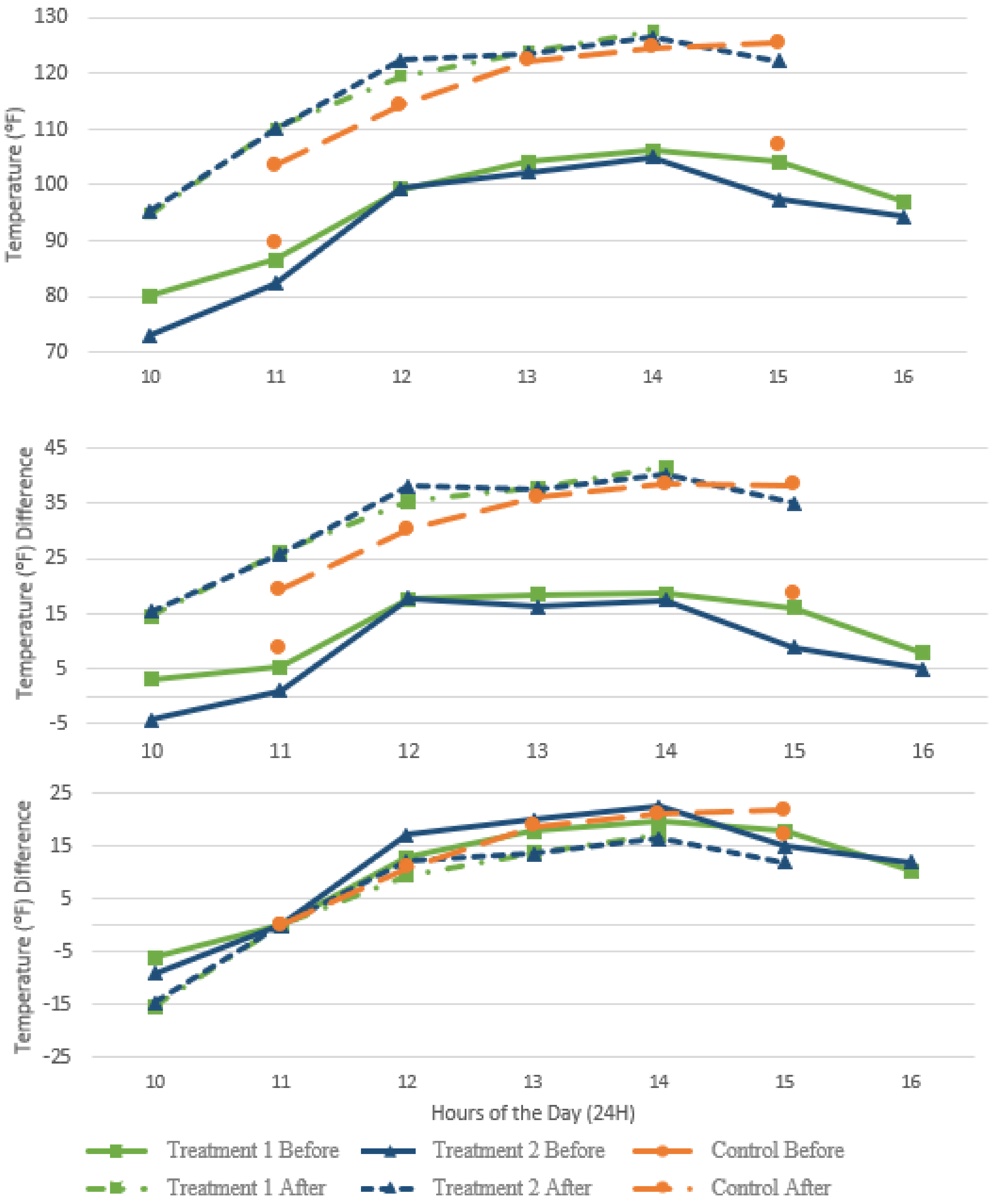
- Collected hourly

Complications in case/control with micro-climates

Temperature (^{o}F)

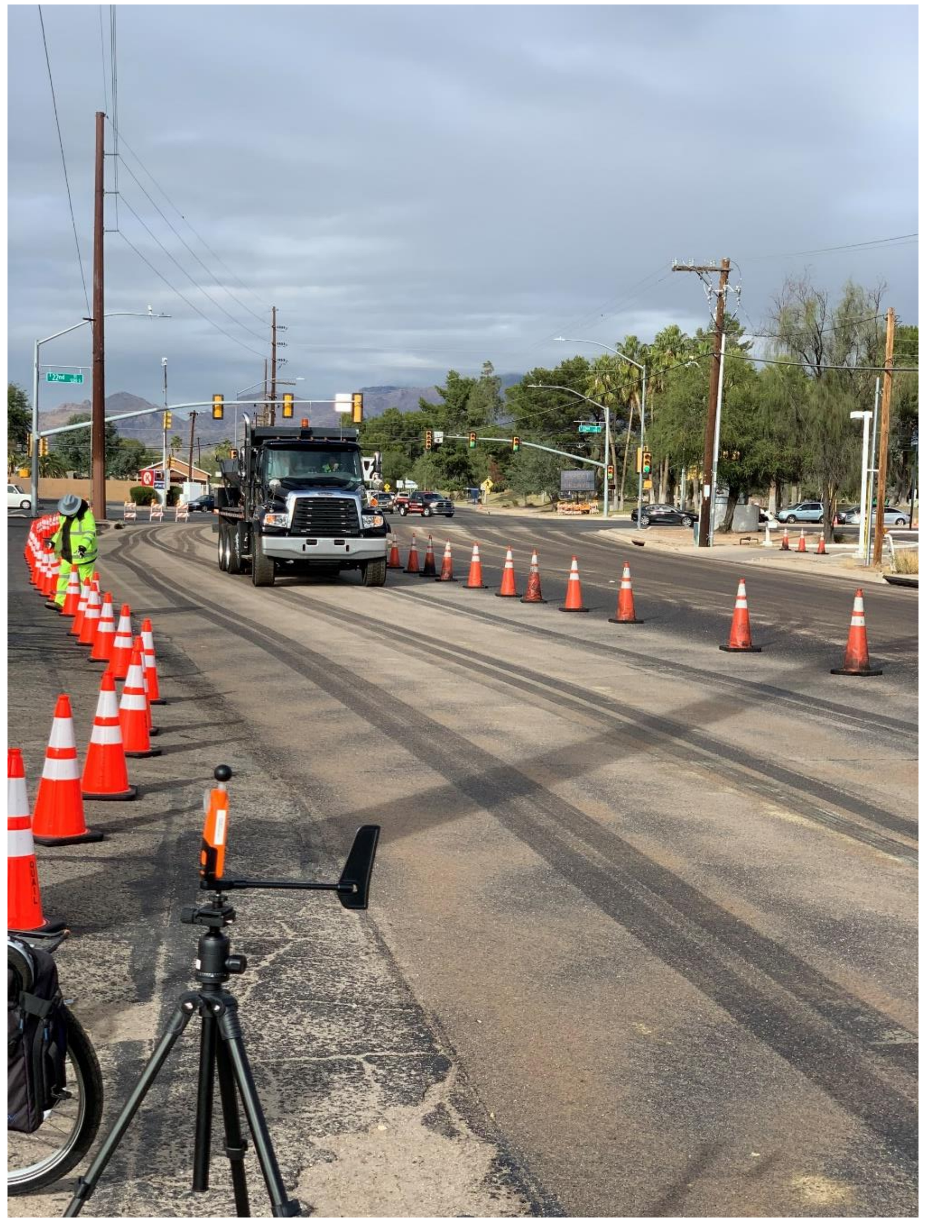
Temperature (^{o}F) Difference with Airport Ambient

Temperature (^{o}F) Difference with Surface Temperature



Research challenges

- Translating climate science and research to practice
  - Cool Pavement: improves surface longevity but might increase heat implications on pedestrians.
- Lab environment vs. natural environment studies
  - NITC Cool Corridors study
  - NITC Vehicle heat study
- Difficulty teasing out effects from micro-planning decisions
  - Locations with shade
  - Pavement applications
  - Urban heat island effect



The University of Arizona

Thank you

ladd@arizona.edu
curransk@arizona.edu

This project was funded by the National Institute for Transportation and Communities (NITC; grant number 1483), a USDOT University Transportation Center.

NOAA

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

NIH

NITC
NATIONAL INSTITUTE for TRANSPORTATION and COMMUNITIES

THE UNIVERSITY OF ARIZONA