Southwest Integrated Field Laboratory:
UIFL PI Meeting

October 28-29, 2024

U.S. DEPARTMENT OF ENERGY | Office of Science
Award Number DE-SC0023520

David Sailor, PI & Director
Arizona State University

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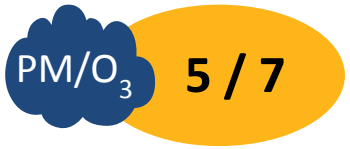
Arizona State University

Motivation

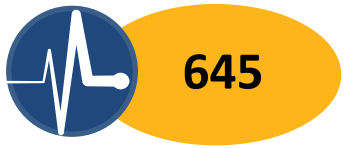
Arizona is fifth for year-over-year population growth in US. Current population is > 7.3M.

Average summer nighttime low temperature in Phoenix has increased by more than 5 °C over the past 60 years.

Arizona's current drought of 15 years is worst in more than 110 years of official recordkeeping, yet monsoon rains still create seasonal flooding.



Phoenix has 5th worst ozone pollution and 7th worst year-round PM2.5. Local air pollution is impacted by emissions, temperature, wildfires, and drought.



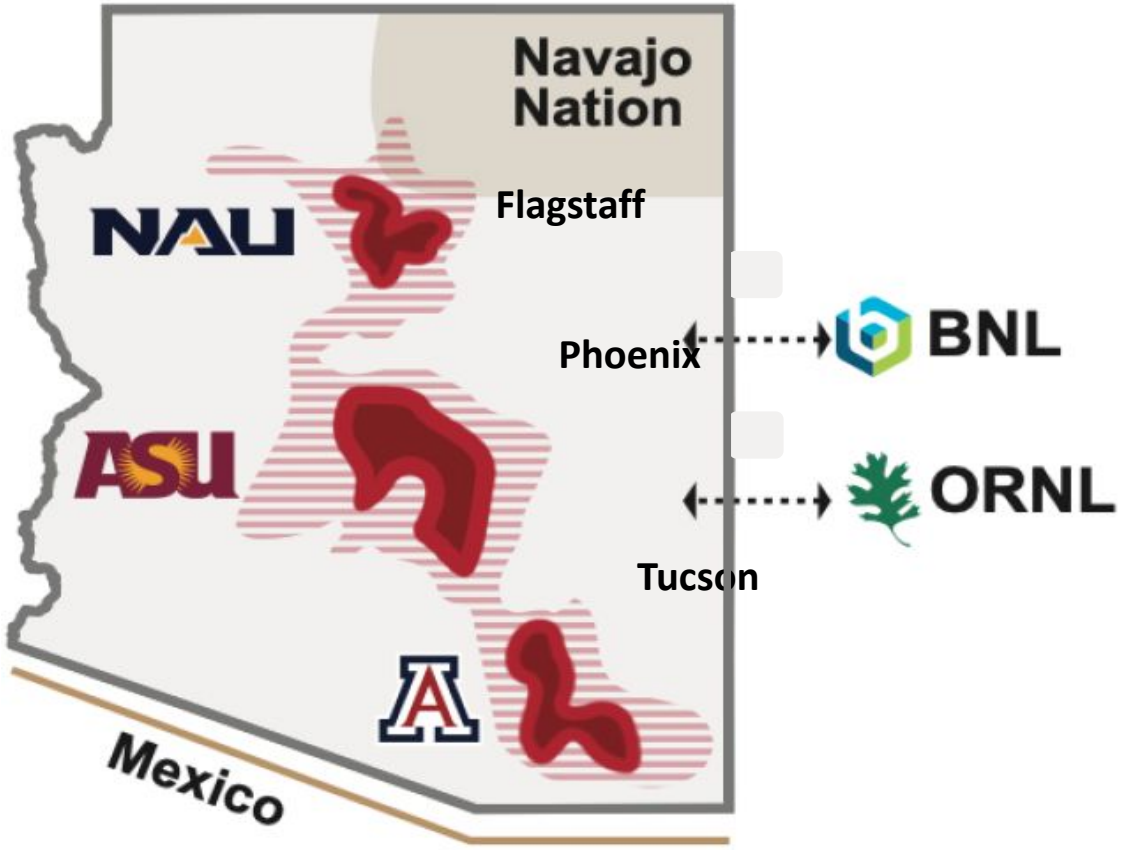
Heat caused 645 deaths in Maricopa County in 2023, a 52% increase over 2022, continuing a 10-year upward trend.

This summer: 113 days above 100 °F, 61 days above 110 °F, 39 nights above 90 °F !!!

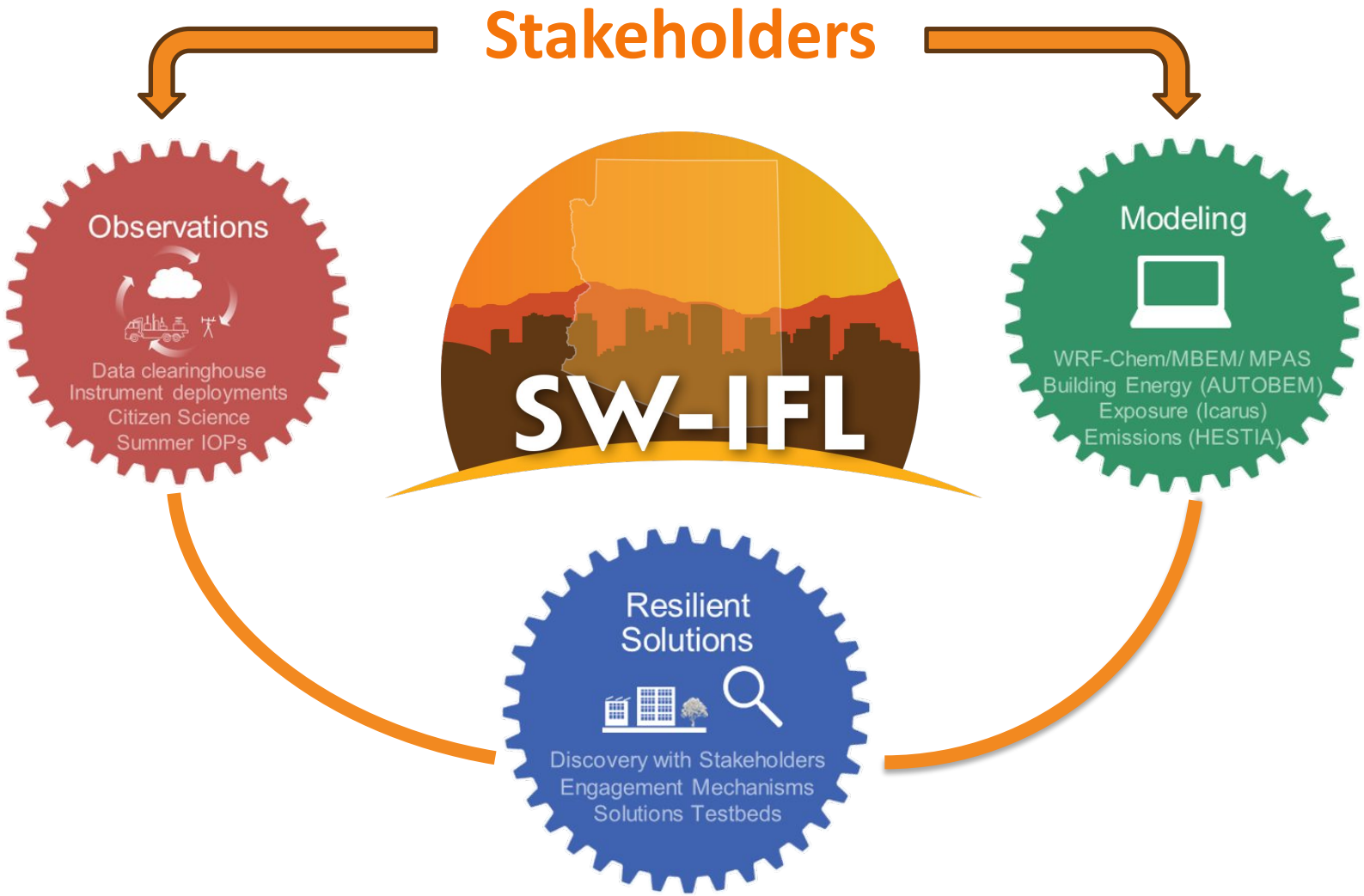
SW-IFL

Purpose and Objectives

To provide scientists and decision makers with high-quality, relevant knowledge capable of spurring and guiding responses to environmental challenges related to extreme heat across the state of Arizona.



Organization



Progress to date

1. Understanding Environmental Parameters and Drivers
   - Gathering historical and current data
   - Establishing measurement networks
2. Enabling Opportunities for Change
   - Solutions testbeds
   - Model/prediction infrastructure
3. Informing the Decision-Making Process
   - Engaging the public and local governments
   - Providing tools and resources for effective decision-making

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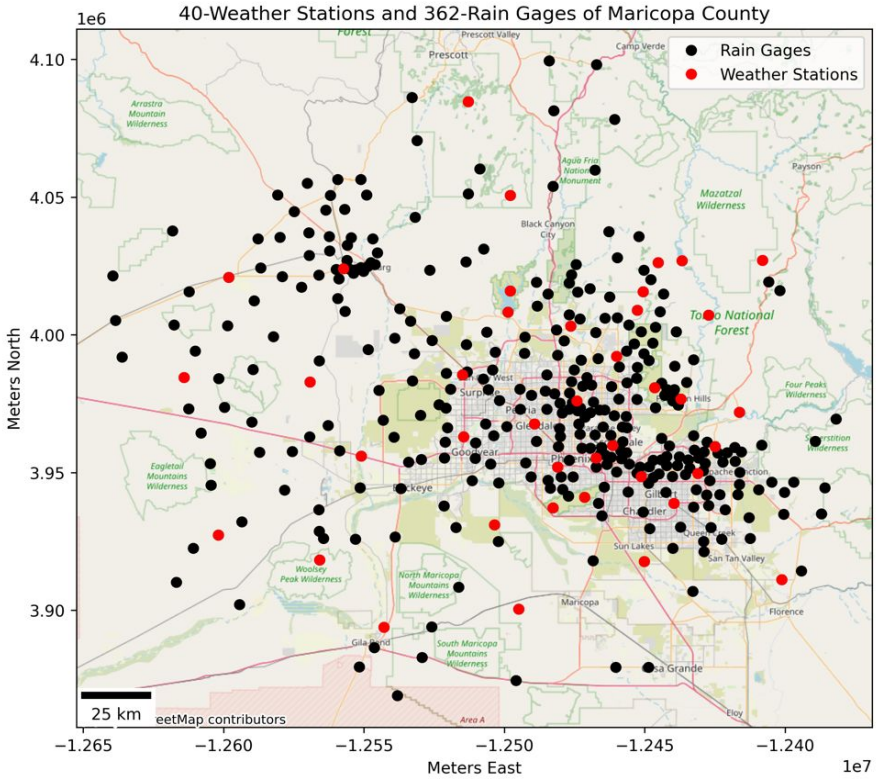
Data from pre-existing networks and databases

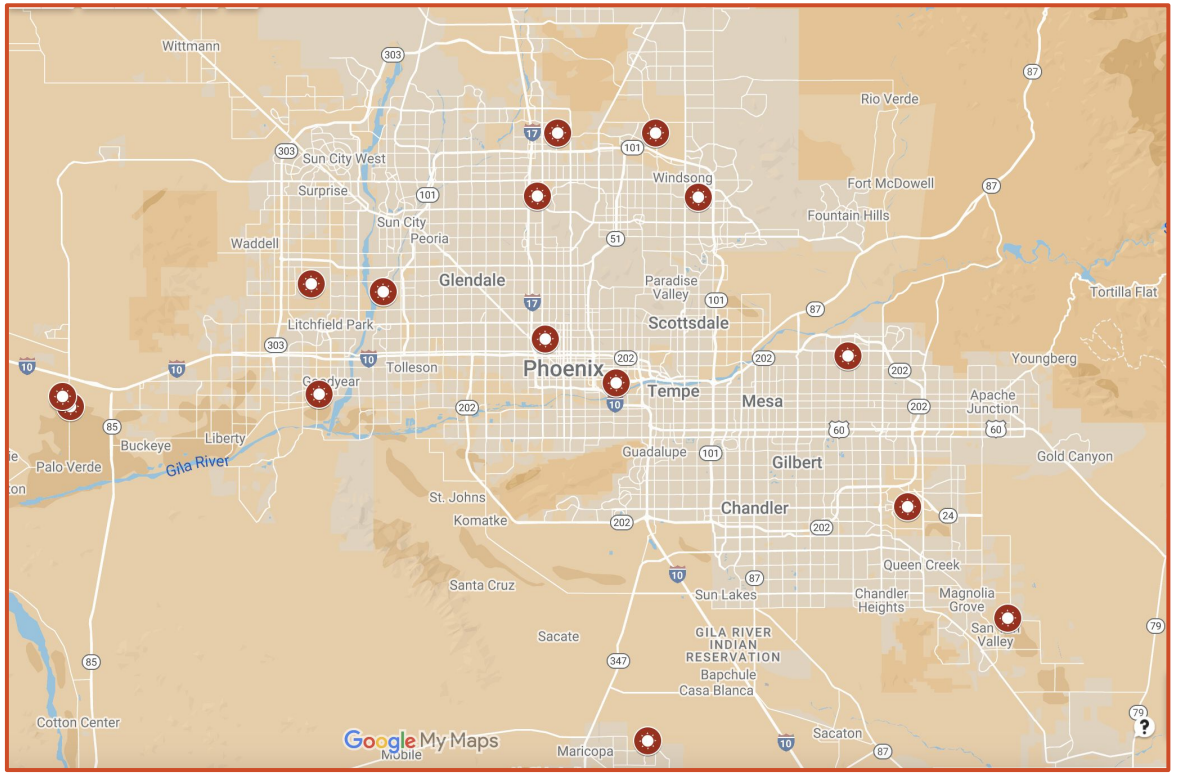
Flood District of Maricopa County

40 weather stations, 365 rain gages



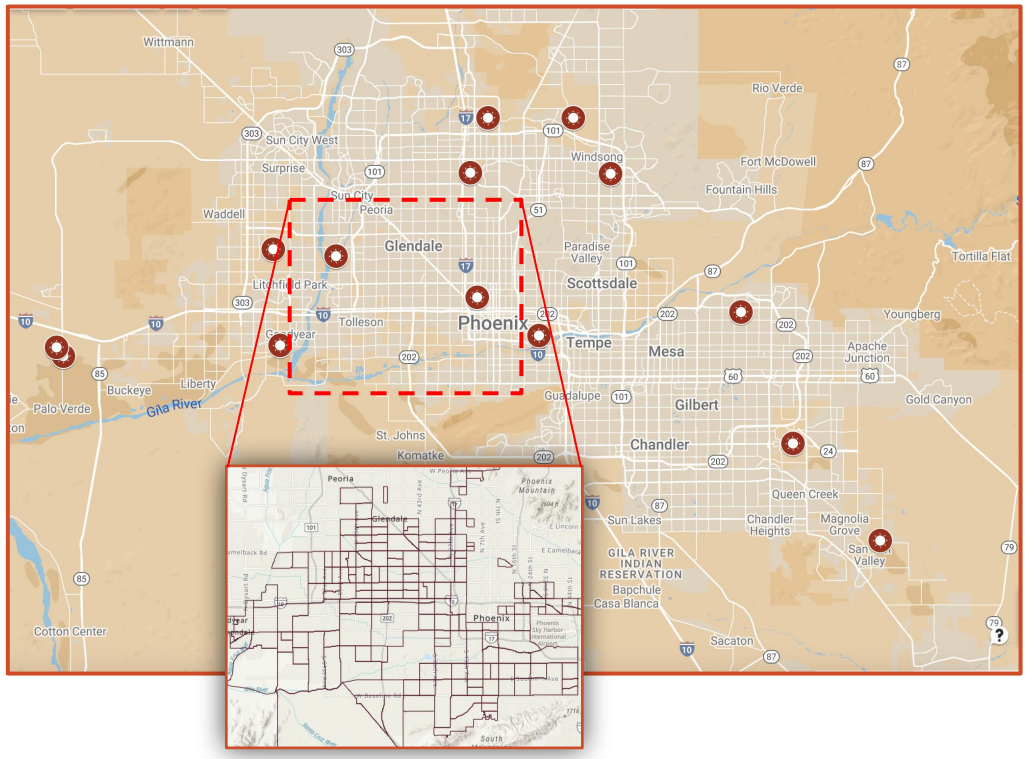
ASOS and AZMET weather station networks

79 weather stations across AZ



Data deserts are disproportionately in poor and minority communities

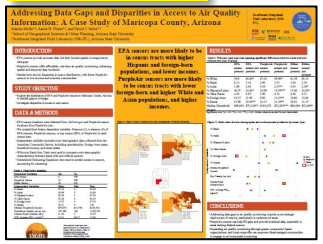
Weather networks



Census tracts (outlined) with
> 70% minority population

Air quality networks

Flores poster

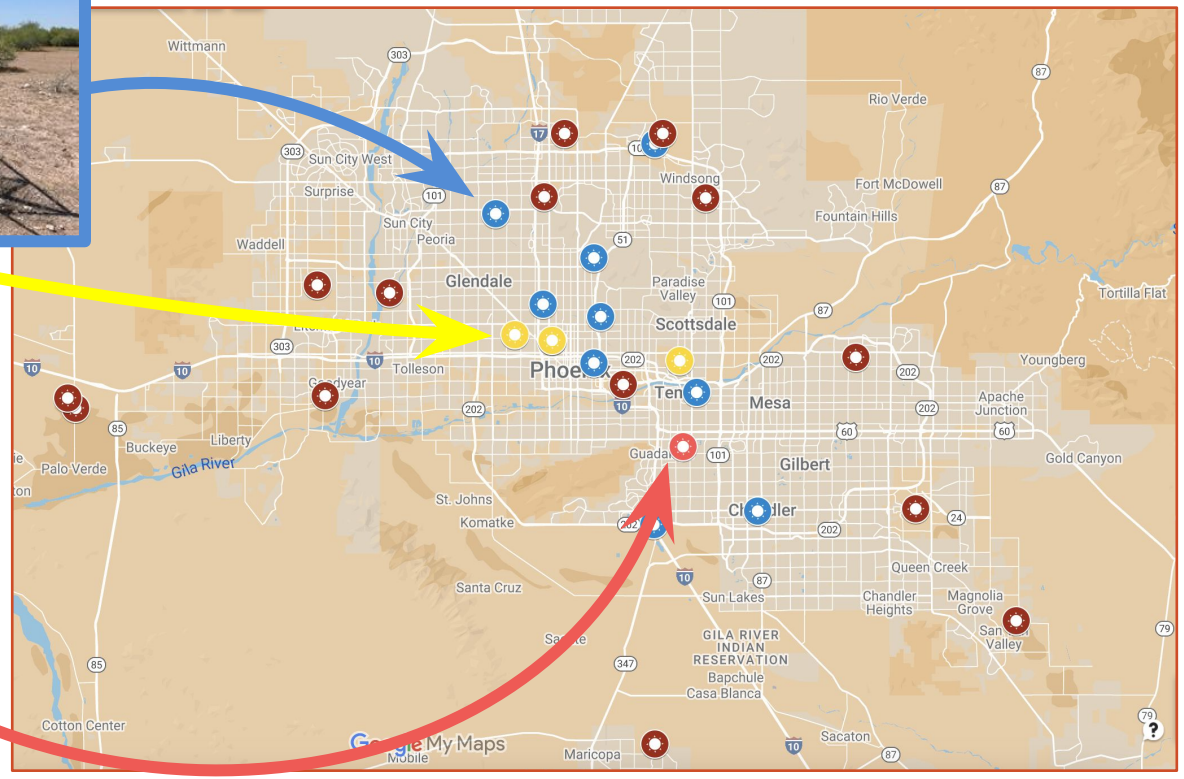


New measurement networks to fill gaps

12 Weather stations
In neighborhoods rather than airports

3 Eddy covariance towers
(registered w/Ameriflux)

3 MaRTiny
Collects weather data, and counts people in shade & sun

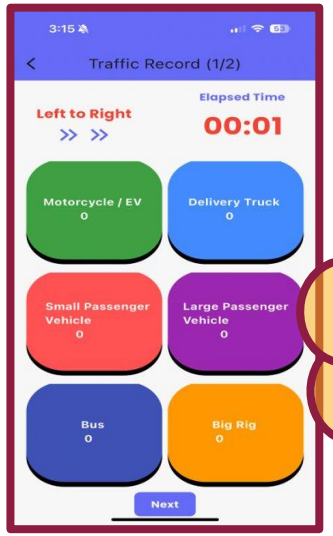


Citizen Science

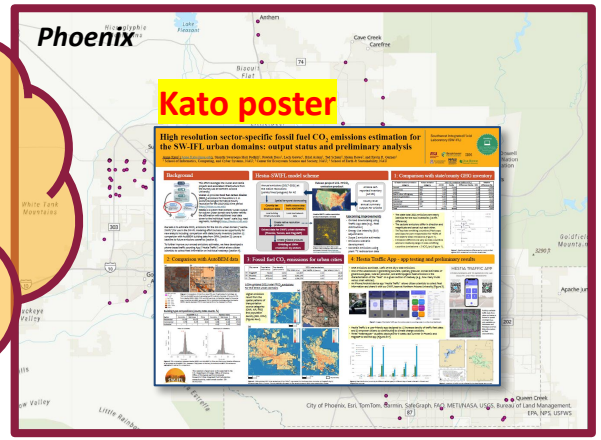
Traffic records app

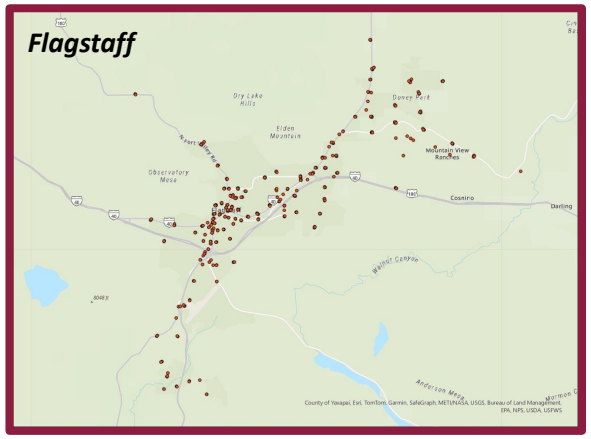
Traffic data for CO_2, air quality, and anthropogenic heat emissions

>74k vehicles in 4 weeks!



Download "Hestia Traffic" in the App Store to participate in data collection!

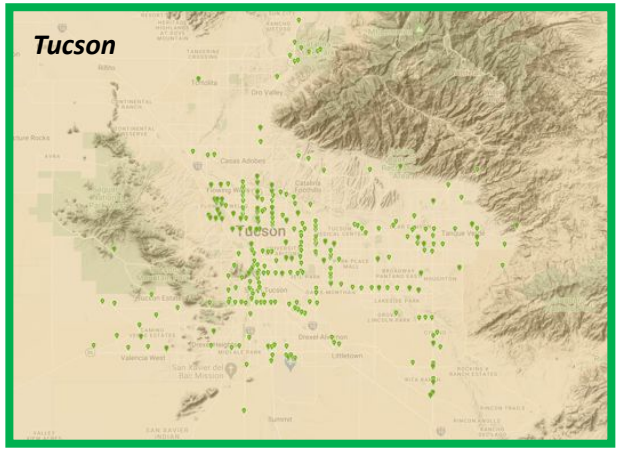


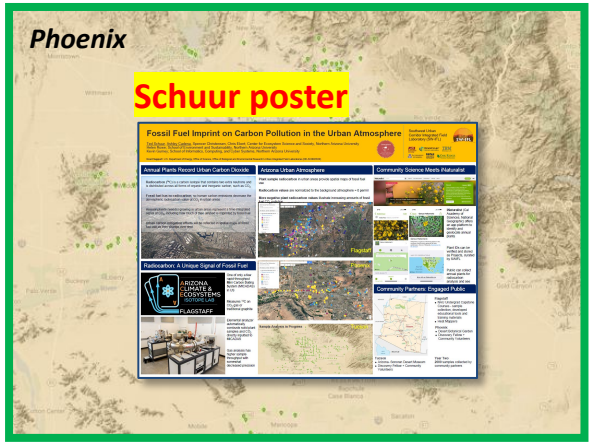


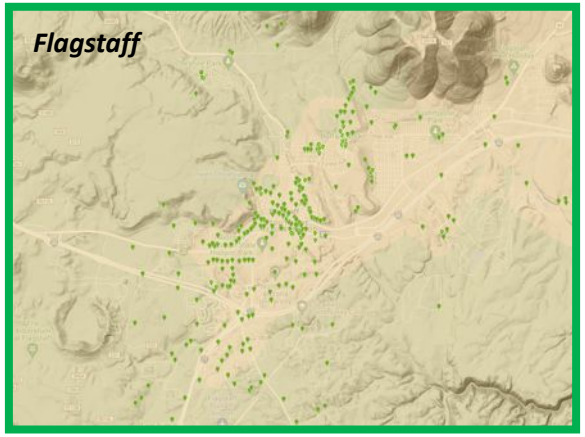
Plant radiocarbon sampling

Monitoring CO_2 emissions through analysis of annual plants.

>1700 obs by Spring 2024







Summer Intensive Observational Campaigns

- Supplement fixed measurement infrastructure with mobile observatories (CMAS) and car-mounted instrument packages

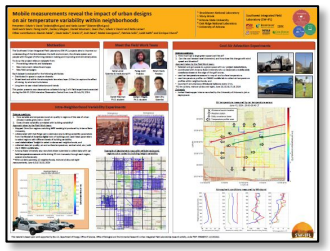
- Intensive measurements in summer (Aug-Sept 2023; June-July 2024)

Summer IOP Research Questions

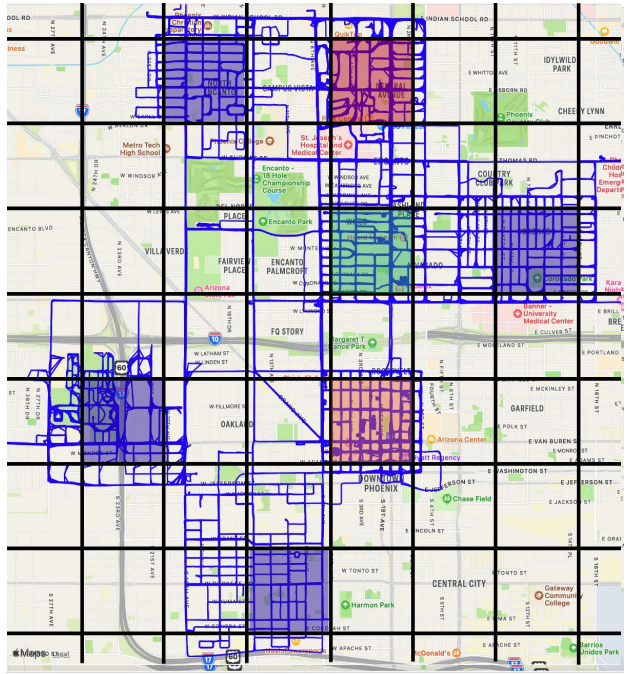
1. Intra neighborhood variability

1. How variable are temperature and air quality in regions of the size of urban climate models grids (1km x 1km)?
2. How well do LST and air temperature correlate (when/where/why)?
3. Does climate variability correlate with building variability?

Davis/Lamer poster



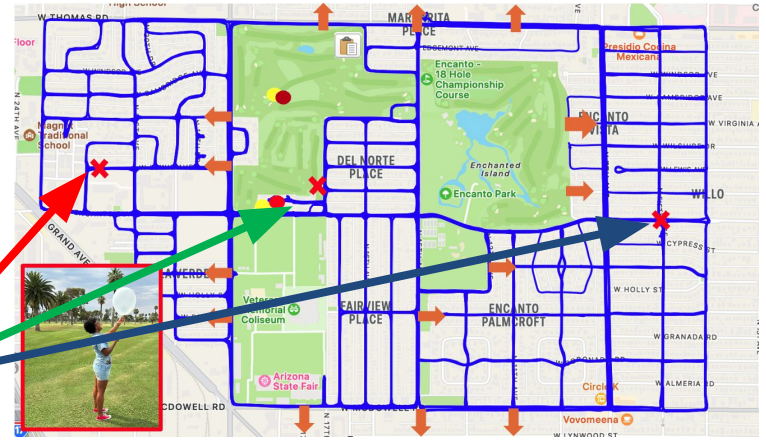
~45 hrs of data spanning 12 neighborhoods



2. Local and downwind effects of green and blue infrastructure

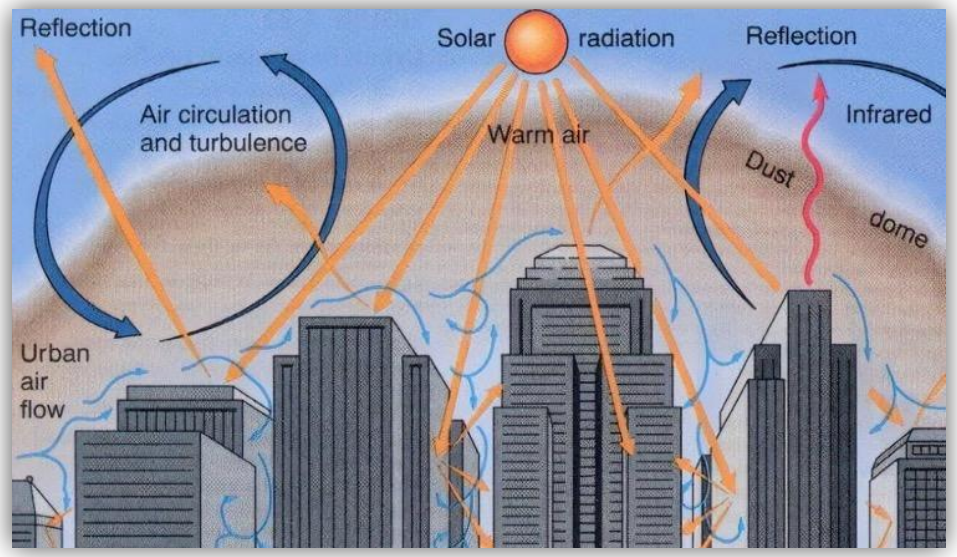
1. How much can a large green space cool the air and is the effect measurable downwind?
2. How do the cooling effects change with wind speed and direction?

32 hrs of data



Windsonds, 3 locations, every 2 hrs

Summer IOP Research Questions

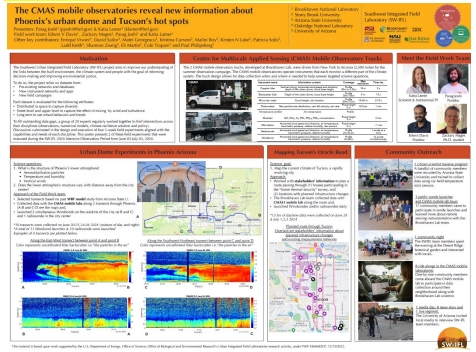


3.What is the structure of Phoenix's lower atmosphere?

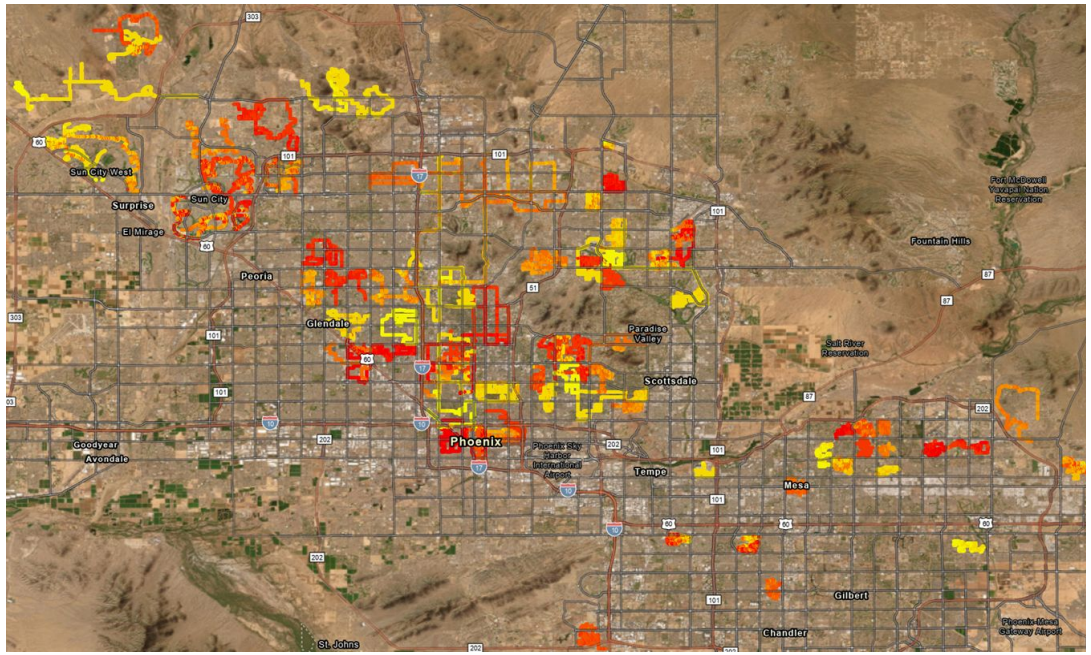
- Aerosol/pollution particles
- Temperature and humidity
- Vertical winds

4. Does the lower atmospheric structure vary with distance away from the city center?

Joshi/Lamer poster



Air temperature traverses across Phoenix in August 2023

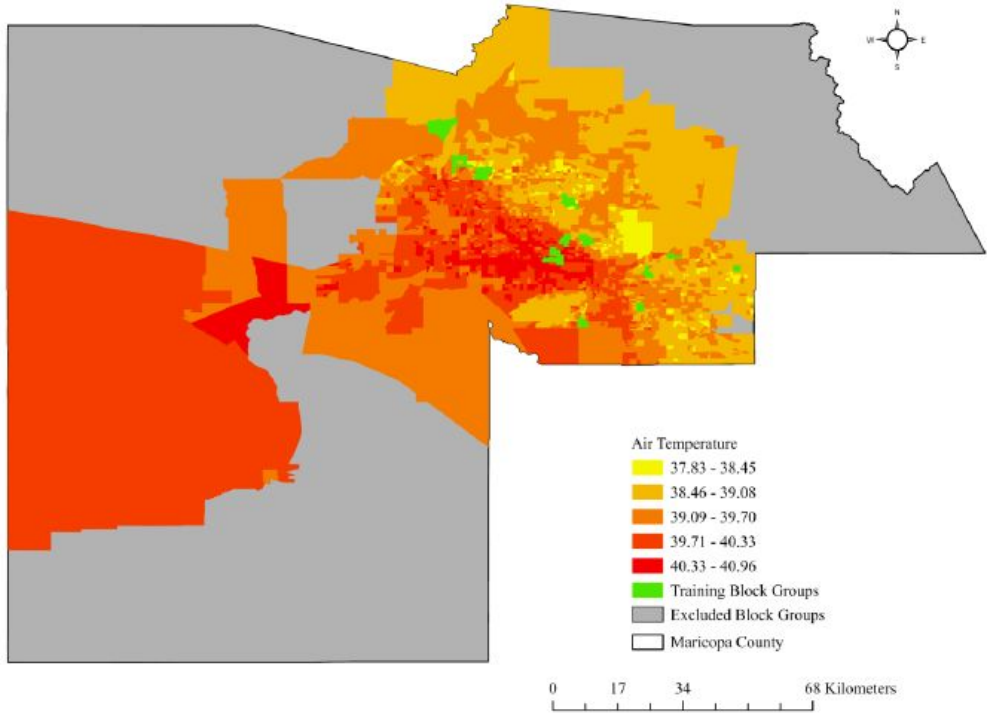


Land surface T, land use/cover, vegetation (% and height) elevation…

ML

ML model of afternoon air temperature across Phoenix

(census block group resolution)



Molla, A., D.J. Sailor, and A.B. Flores, "A Machine Learning Approach to Predict Near-surface Air Temperature and Explore Socio-demographic Inequalities in Exposure: A Case Study of Maricopa County, Arizona", in review *Urban Climate*.

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Test Beds and Predictive Activities

Research Question:
How effective will various solutions be at scale and into the future?

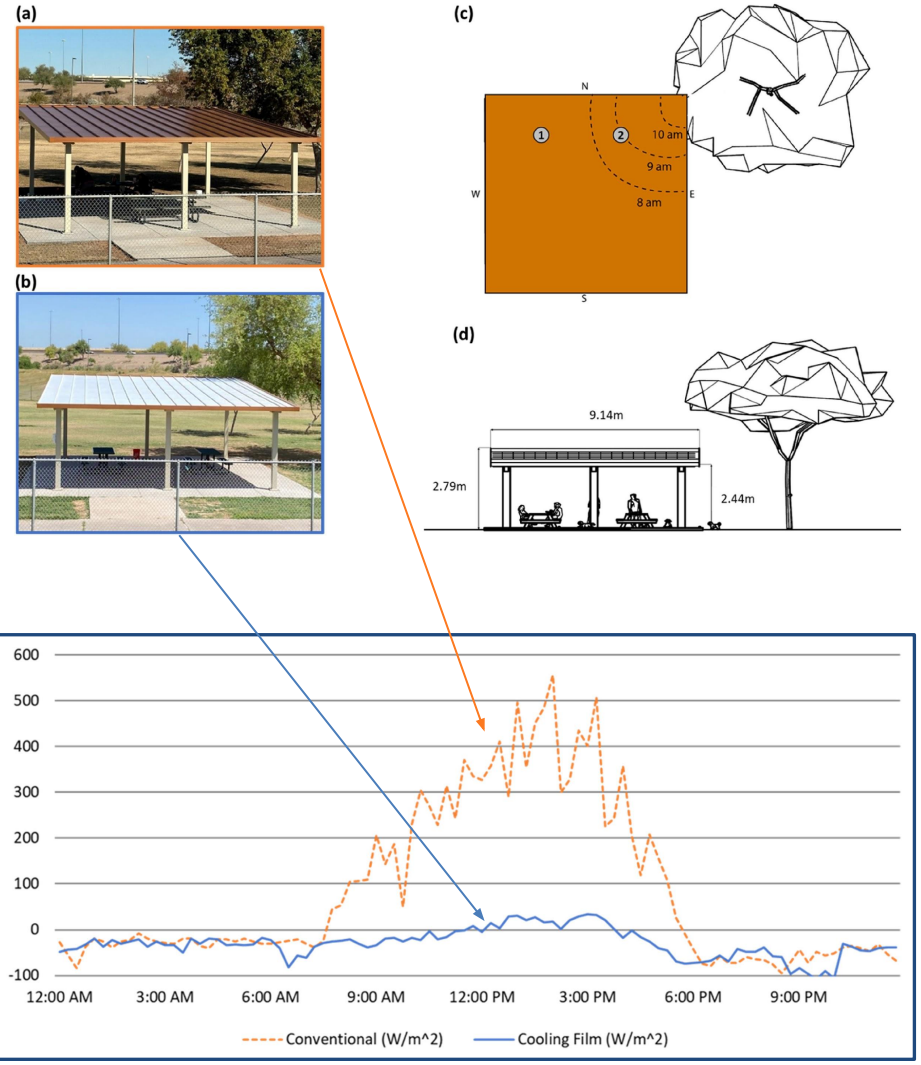
Technology Test Beds
Cool paving
Passive radiative cooling materials

Community Test Beds
Oracle Test Bed
Safe Outdoor Space Test Bed

Predictive Activities
Model of Models

Passive radiative cooling materials

- Tested a passive radiative cooling film on a park shade structure (ρ_{sw} = 0.95 ; $\varepsilon_{(8\text{-}13\mu m)}$ = 0.95)
- Structure surface temperatures cooler by 7 °C on average than control shelter
- Sensible heat flux into airshed reduced by 80%
- Summer daytime mean radiant temperature under shelter reduced by more than 3 °C



Sailor, Fagliarone, Hebrink, and Amaripadath, 2024. Field evaluation of the efficacy of passive radiative cooling infrastructure: A case study in Phoenix Arizona. *Building and Environment*, https://doi.org/10.1016/j.buildenv.2024.112226.

Safe Outdoor Space Community Test Bed

Site Goals

- Provide a safe outdoor camping option for the unhoused in Phoenix
- Introduce and evaluate cooling solutions including cool roofing films and site vegetation

Data Collection

- Reference weather station, surface temperature IR sensors and thermal environment measurements in/around the SOS shelter.

Left: Weather station at SOS site

Below: SOS urban camping for unhoused population

Above and right: SOS roof with 3M Film and installed IR sensor

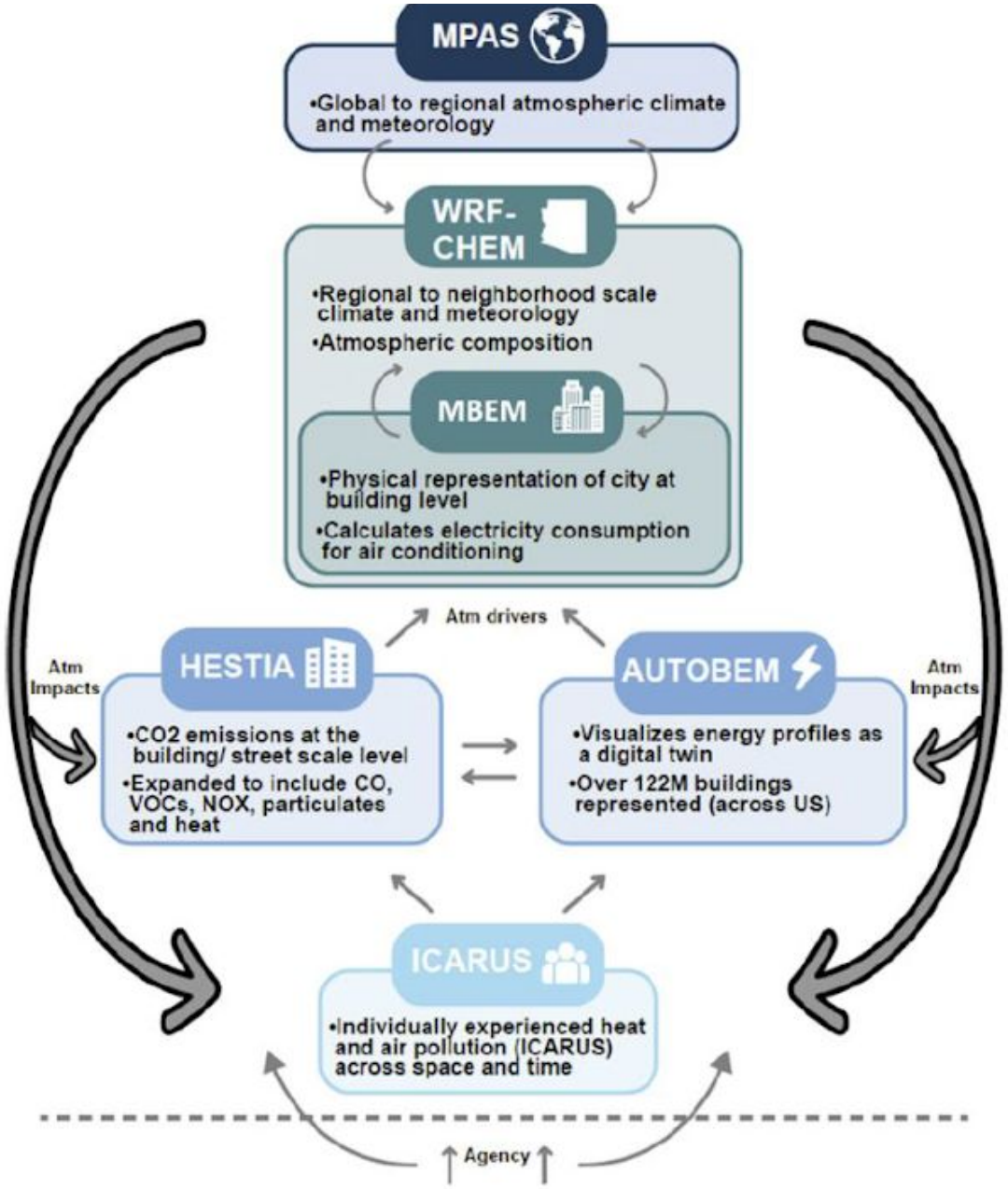
Model of Models (MoM) Overview

Building the diagnostic model

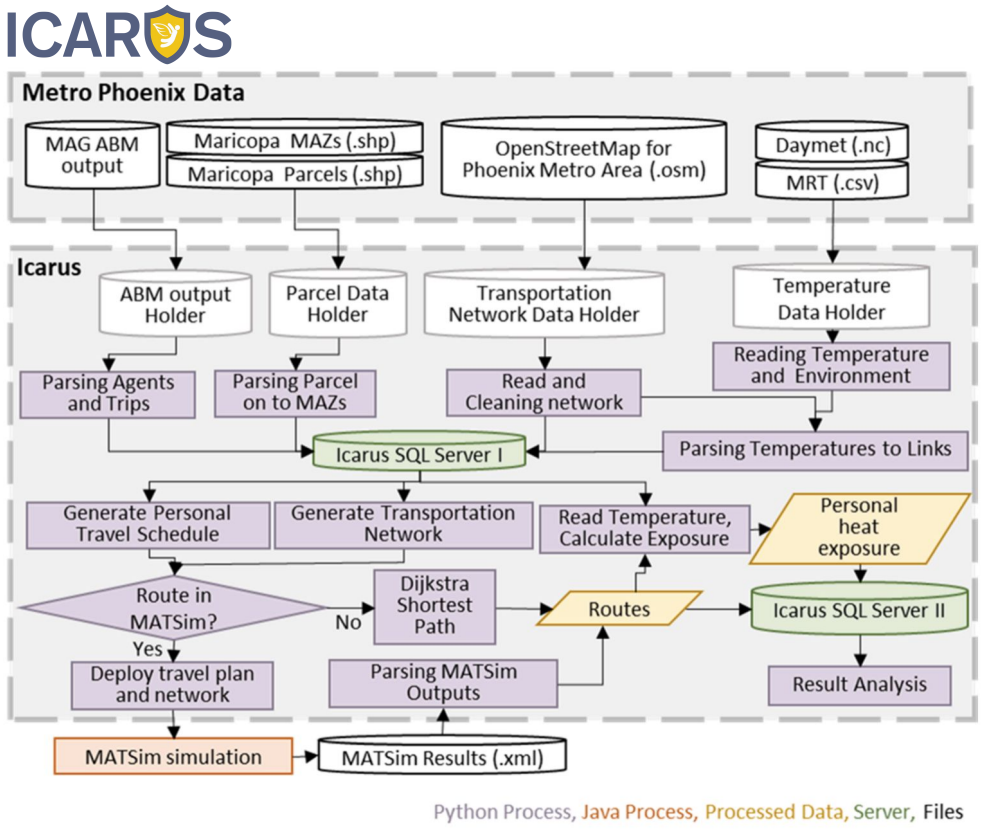
- Coupling global to local
- Coupling humans to technology
- Coupling drivers to atmosphere
- Coupling atmospheric impact to humans

Building the prognostic model

- Policy choices
- Behavioral change due to impact
- Growth
- Changing climate

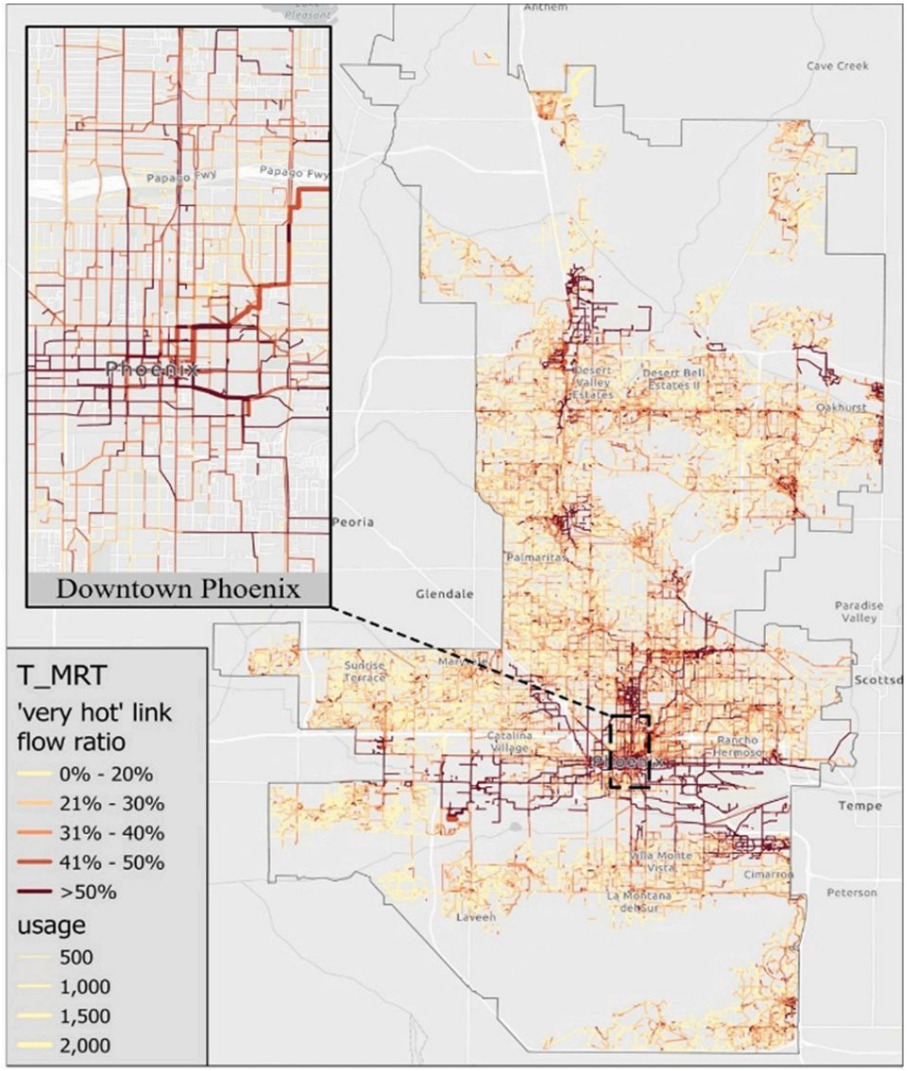


Behavior & Exposure

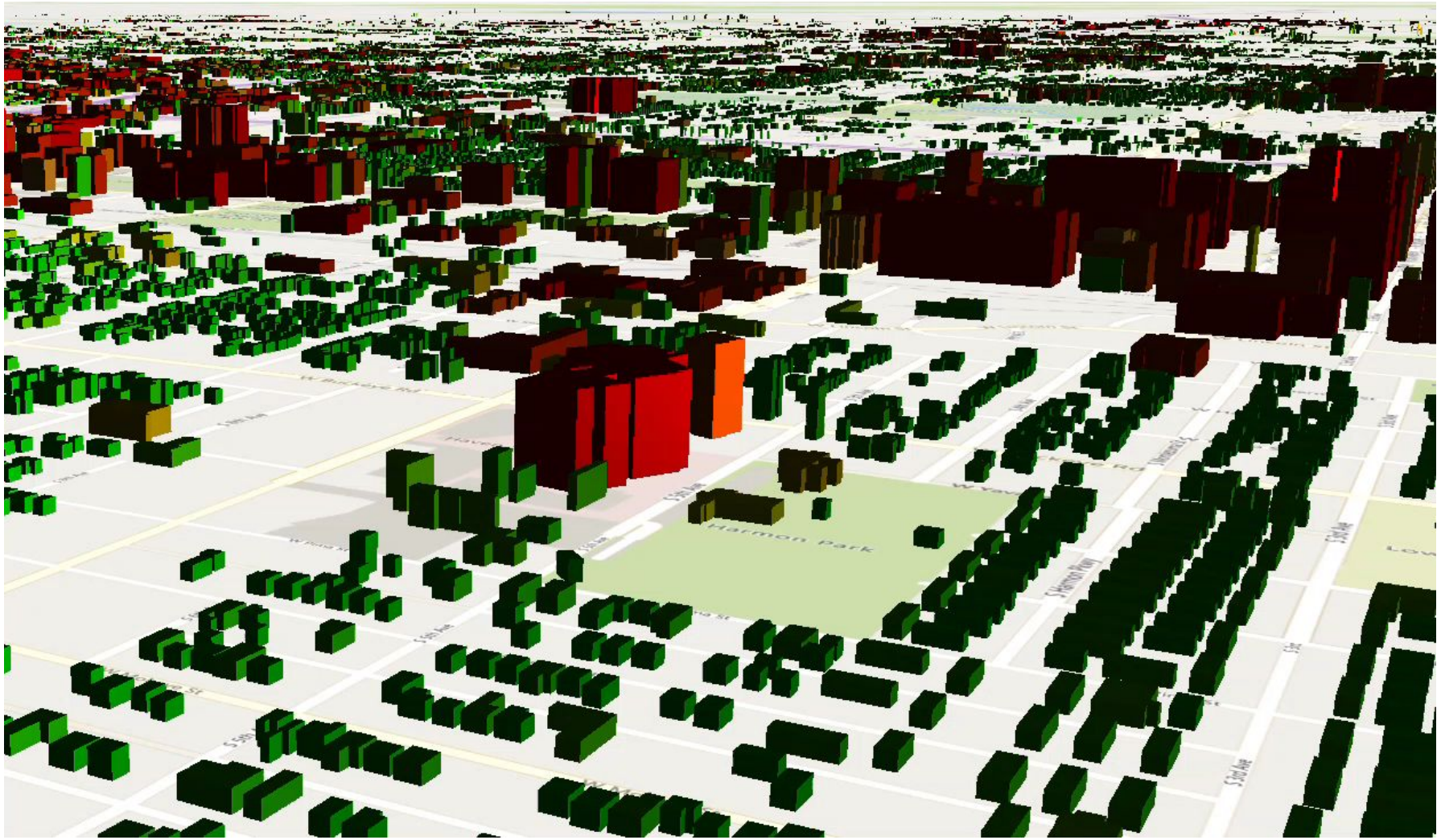


Repurposing Mesoscale Traffic Models for Insights into Traveler Heat Exposure, Li, Chester, Hondula, Middel, Vanos, Watkins, *Transportation Research Part D*, 2023, 114(103548), https://doi.org/10.1016/j.trd.2022.103548

T_{MRT} Very Hot Trips

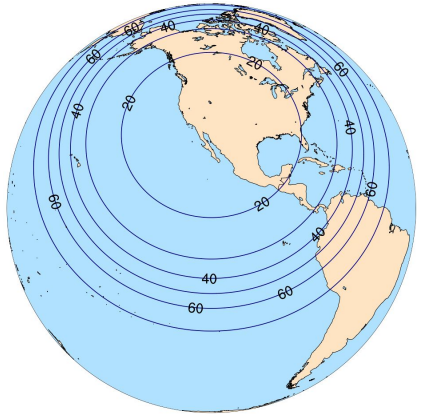


Digital Twin for Morphology and Energy Use Patterns



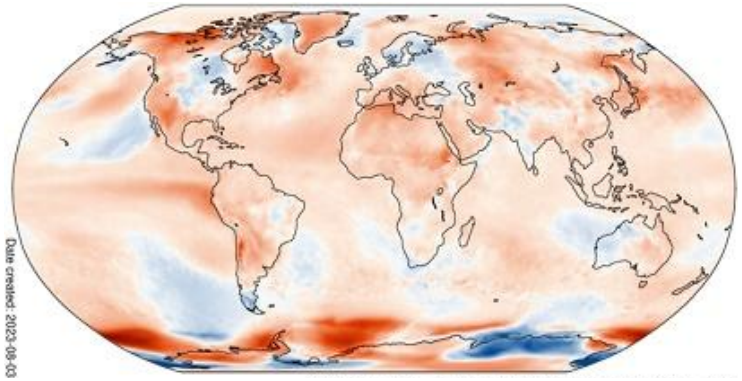
Autobem digital twin for all buildings in Arizona https://evenstar.ornl.gov/autobem/Maricopa/Maricopa.html

Atmospheric modeling across scales



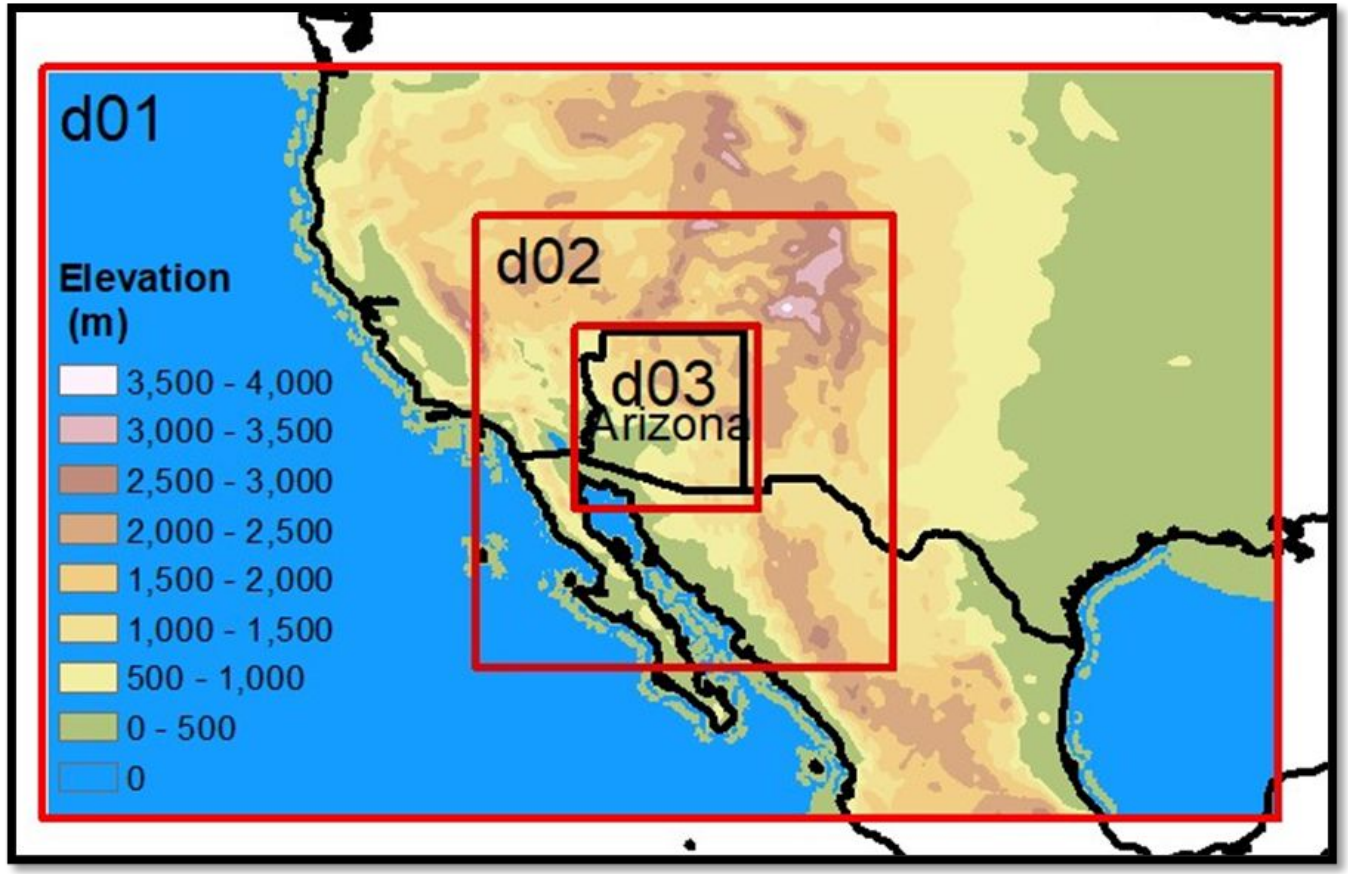
a) MPAS Mesh Configuration: 20km grid spacing across SW US.

ICs+LBCs



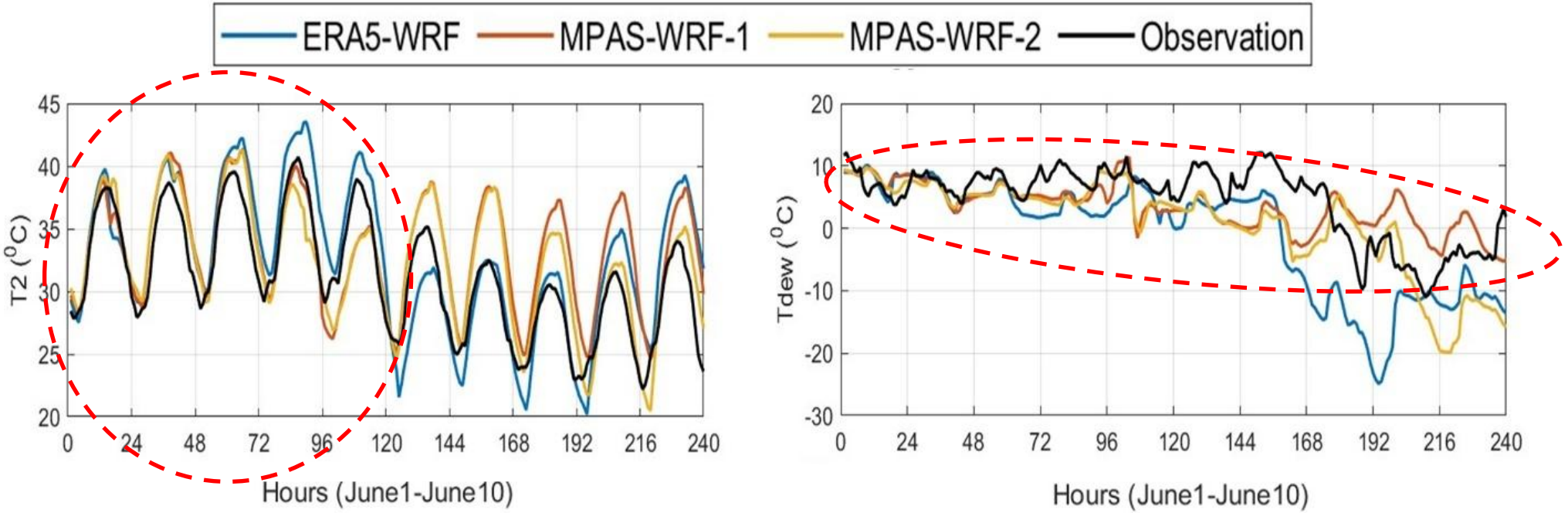
b) ERA-5 reanalysis at a resolution of 0.25 degrees

ICs+LBCs



c) WRF Domain: D01-D02-D03 are 18, 6, 2 km horizontal grid spacing, respectively.

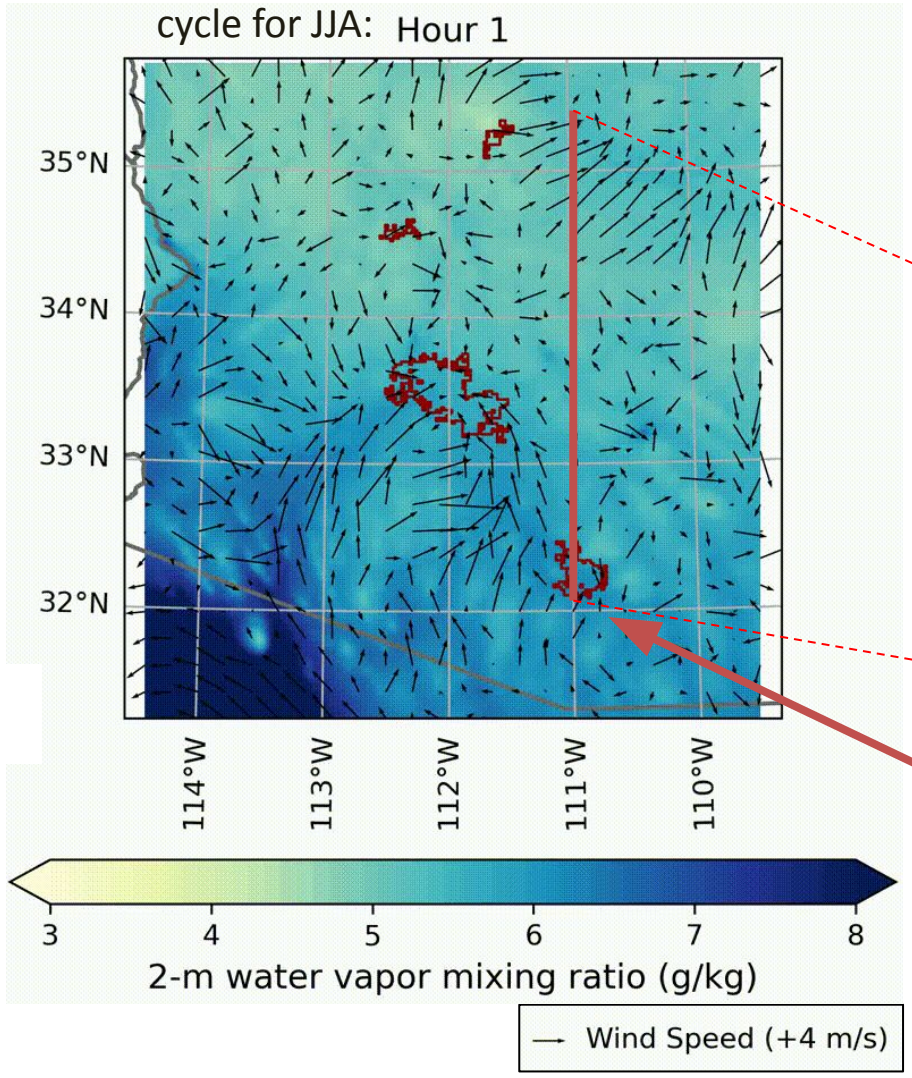
Atmospheric Model Evaluation



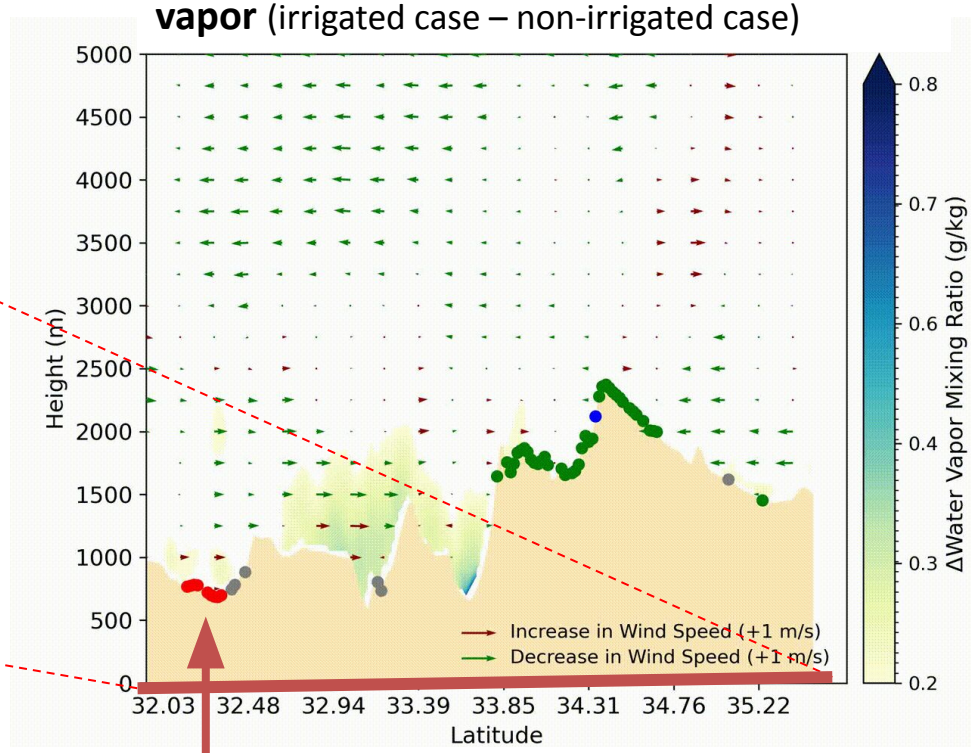
June 2020 test simulation

WRF simulations for Arizona with and without urban irrigation for summer 2023

Composite diurnal cycle for JJA: Hour 1



Differences in vertical wind and water vapor (irrigated case – non-irrigated case)



Tucson

Courtesy: Xiangwen Deng (ASU PhD Student) and M. Georgescu

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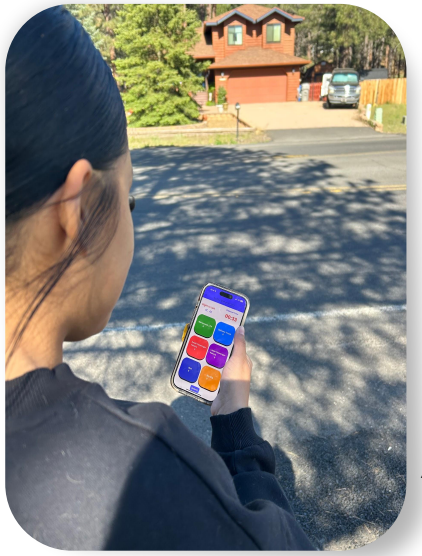
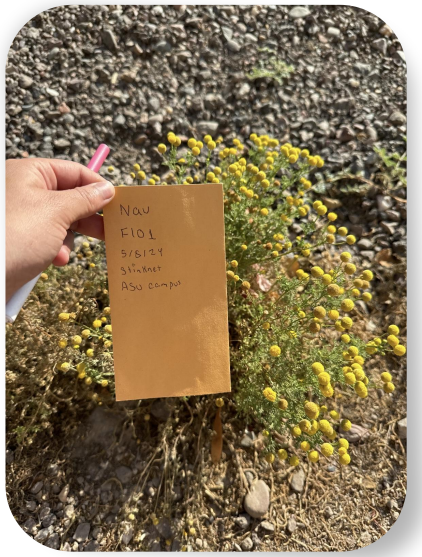
Engagement: K-12, Student HeatMappers, Fellows

- Household Thermal Security
  - Assessed the impact of heat on 40 households in Tucson through interviews and data collection
  - Home thermal security, energy equity and the social production of heat in manufactured housing, Kear et al., *Energy Res. and Soc. Sci.*, 2023, https://doi.org/10.1016/j.erss.2023.103318





Above: HeatMappers collecting plant samples. Left: Traffic app in action.

- Traffic CO_2 Emissions App
  - Support for models that estimate CO_2 emissions and air quality

- Vacant Land Assessment
  - Exploring potential impacts of development on heat and air quality

Sobhaninia poster

Below: HeatMappers Team.

Dissemination

- Outreach to community
  - Community Night with Desert Botanical Garden's Flashlight Night (Jun 22)
  - Media Day, Tucson (Jul 2)
  - OpenDoor Preview (Oct 11)
- SW-IFL Newsletters
- Cross UIFL Seminars
- Presentations and publications
- Extensive news media coverage

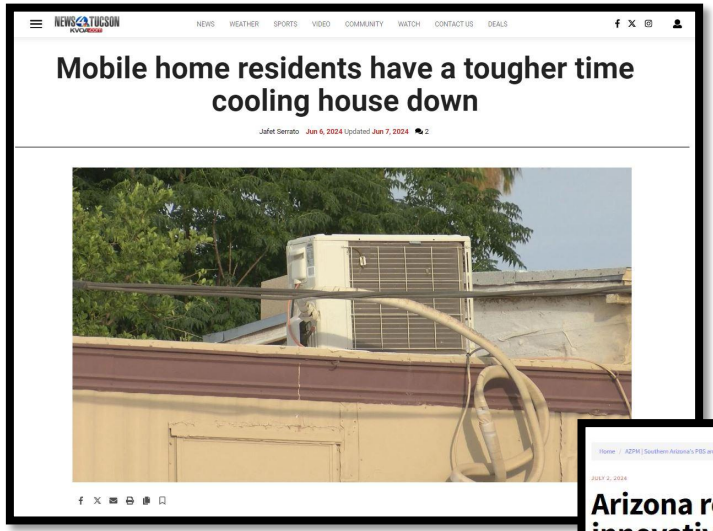




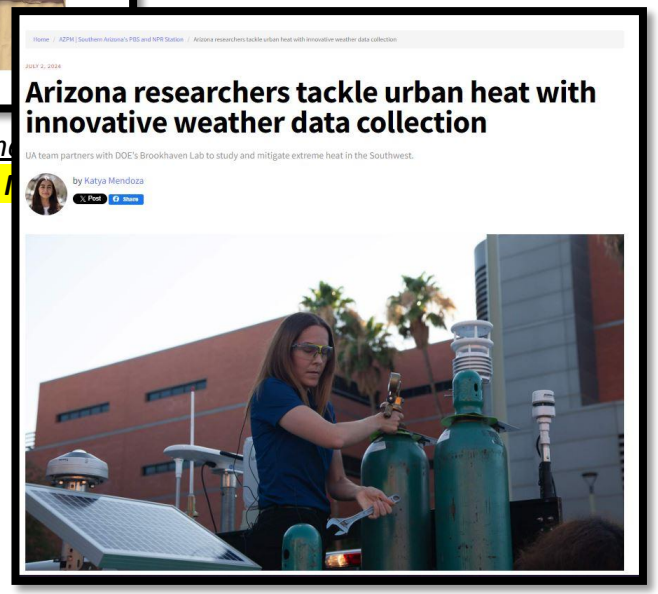
Photos from Community Night with Desert Botanical Garden, OpenDoor Preview, and Media Day.

Media coverage

From local

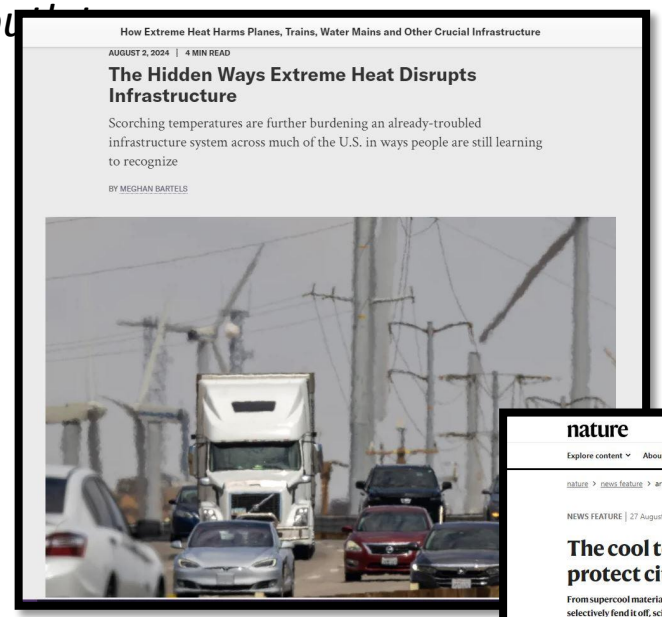


"Mobile home residents have a tougher time down". (June 6, 2024) Jafet Serrato, ***KVOA***

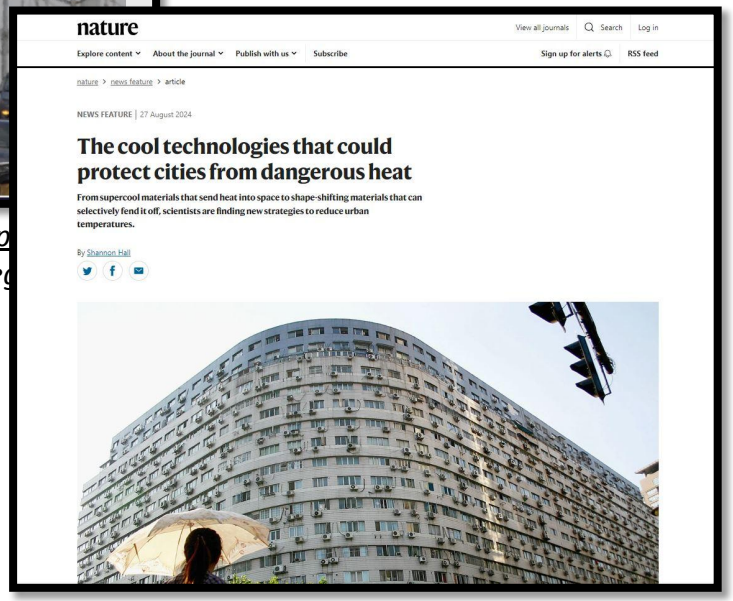


"Arizona researchers tackle urban heat with innovative weather data collection." (July 2, 2024) Katya Mendoza, ***AZPM News***

… to national/international ou



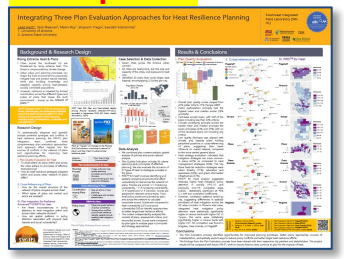
"The Hidden Ways Extreme Heat Imp Infrastructure." (August 2, 2024) Meg ***Scientific American.***



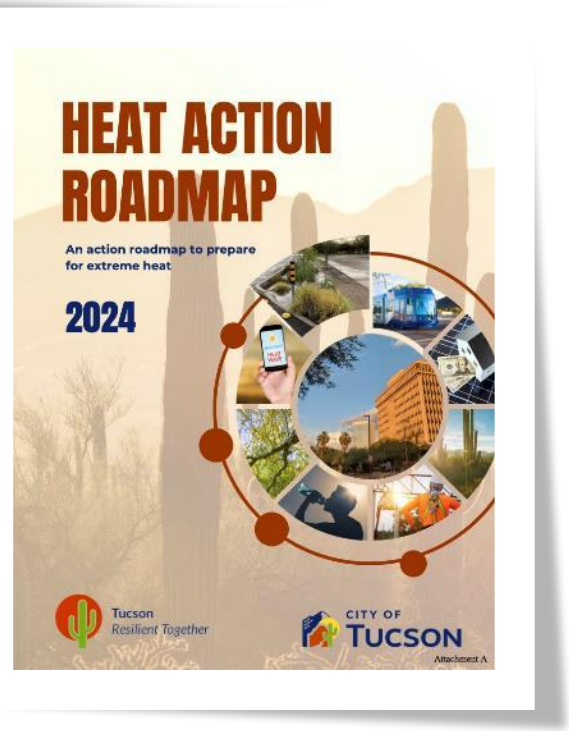
"The cool technologies that could protect cities from dangerous heat." (August 27, 2024) Shannon Hall, ***Nature News***

Solutions & Tools: Planning Discovery

Keith poster

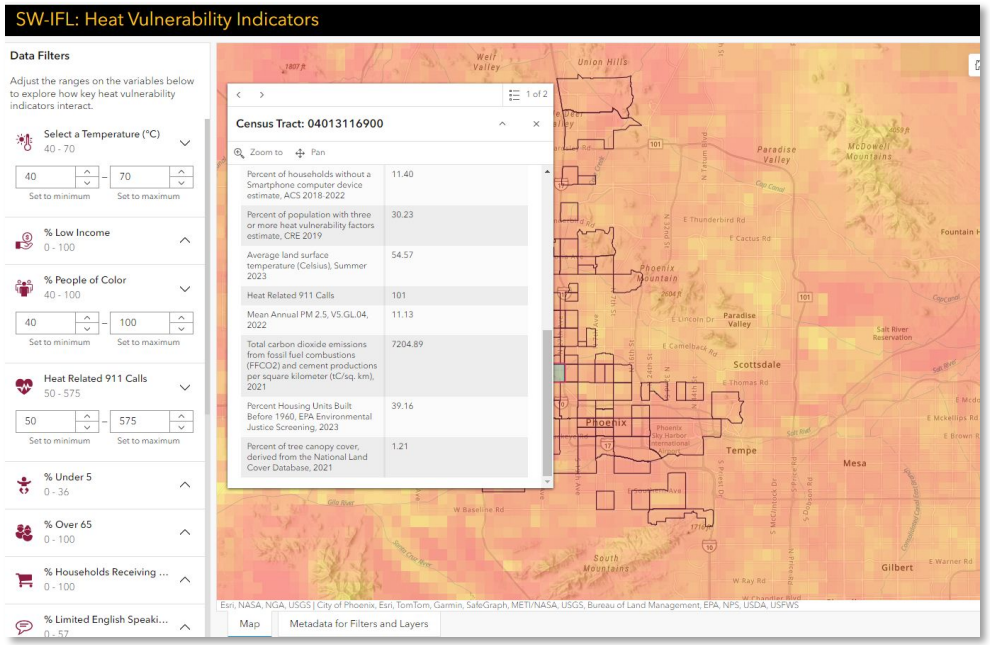


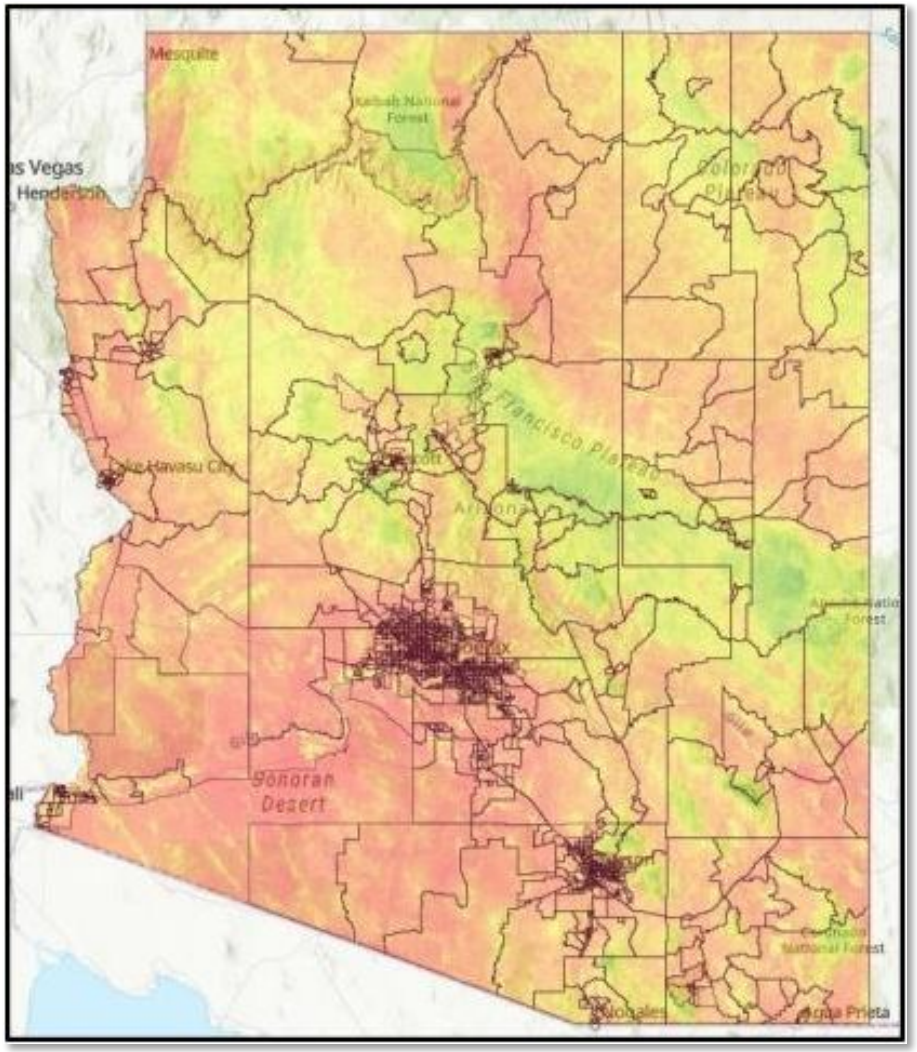
- Plan Evaluation for Heat Resilience Reports
  - Finalized and delivered reports for seven Arizona cities summarizing plan evaluation results (21 plans in total evaluated)
  - Plan evaluation for heat resilience: complementary methods to comprehensively assess heat planning in Tempe and Tucson Arizona, Meerow et al., *Env. Res. Lett.*, 2024, https://doi.org/10.1088/1748-9326/ad5d05
- City of Tucson Heat Action Roadmap
  - Ladd Keith, Sara Meerow, and Malini Roy served as technical experts for the City of Tucson's Heat Action Roadmap (adopted June 2024)
- Decision-support frameworks and tools
  - Multi-criteria decision support framework for outdoor heat stress management in urban environments, Amaripadath et al., *Sust. Cities and Society*, 2024, https://doi.org/10.1016/j.scs.2024.105799
- Center for Heat Resilient Communities
  - Ladd Keith and Sara Meerow are co-leads of the newly created national NOAA/NIHHIS center (www.heat.gov)



Solutions & Tools: Arizona Heat Exposure Dashboard

- Summary data products
- Filtering capability
- Useful for public, decision-makers, and researchers





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SW-IFL All Hands Meeting

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