Southwest Integrated Field Laboratory (SW-IFL) and the Tucson Testbed

Kristina Currans, PhD, University of Arizona

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Katia Lamer, PhD, Brookhaven National Lab

Urban Heat Island Workshop

October 31, 2024

SW-IFL
Southwest Urban Corridor
Integrated Field Laboratory

ASU Arizona State University

Brookhaven National Laboratory

IBM Research

THE UNIVERSITY OF ARIZONA

NAU NORTHERN ARIZONA UNIVERSITY

OAK RIDGE National Laboratory

Department of Energy Biological and Environmental Research Program

Earth and Environmental Systems Sciences Division (EESSD)

"…to advance the science underpinning our understanding of the predictability of urban systems and interactions with the climate system, and to provide the knowledge and information necessary to inform equitable climate and energy solutions that can strengthen community-scale resilience across urban landscapes."

DOE Urban IFL: https://ess.science.energy.gov/urban-ifls/

DOE Urban Integrated Field Labs (UIFL)

Southwest (Arizona)

David Sailor
Arizona State
University

Baltimore

Benjamin Zaitchik
John Hopkins

Chicago

Cristina Negri
Argonne National Laboratory

Southeast Texas

Paola Passalacqua
University of Texas, Austin

Vision

The **Southwest Urban Corridor Integrated Field Laboratory** (SW-IFL) seeks to engage stakeholders and provide scientists and decision makers with high-quality, relevant knowledge capable of spurring and guiding responses to environmental concerns.

SW-IFL

Expected Outcomes

- Integration of high-resolution observations, diagnostic and predictive models, and civic engagement
- New knowledge and deliver next-generation predictive tools that are regionally specific and translatable to other arid regions
- Empower the public to respond to extreme heat
- Informing the development and deployment of policies and solutions that are effective, equitable and generalizable

Institutions

Arizona State University

University of Arizona

Northern Arizona University

Oak Ridge National Laboratory

Brookhaven National Laboratory

IBM

Testbeds

Resilient Solutions

Observations

Modeling

Related Subprojects

- Neighborhood plan evaluation
- Mobile Home evaluation
- Travel behavior survey
- Studio projects
- Education projects (K12)

SW-IFL - A Team of 80+

Tucson Testbed Coordination

- Malini Roy, Post doc, University of Arizona *
- Irene Ogata, City of Tucson (stakeholder)
- Amanda Grant, MSUP GRA
- Amanda Lucero, MSUP GRA

Developed some of the slides I'll share with you.

Leadership

- **Leadership Team:** David Sailor and Jean Andino, ASU
- **Resilient Solutions**: Patricia Solis, ASU; Ladd Keith, UA
- **Observations Team**: Enrique Vivoni, ASU; Ted Schuur, NAU
- **Modeling Team** : Matei Georgescu, ASU; Kevin Gurney, NAU
- **Brookhaven National Lab**: Katia Lamer *
- **Oak Ridge National Lab**: Joshua New
- **IBM Research**: Mukul Tewari
- **Evaluation**: Wendy Barnard

Southwest Integrated Field Lab
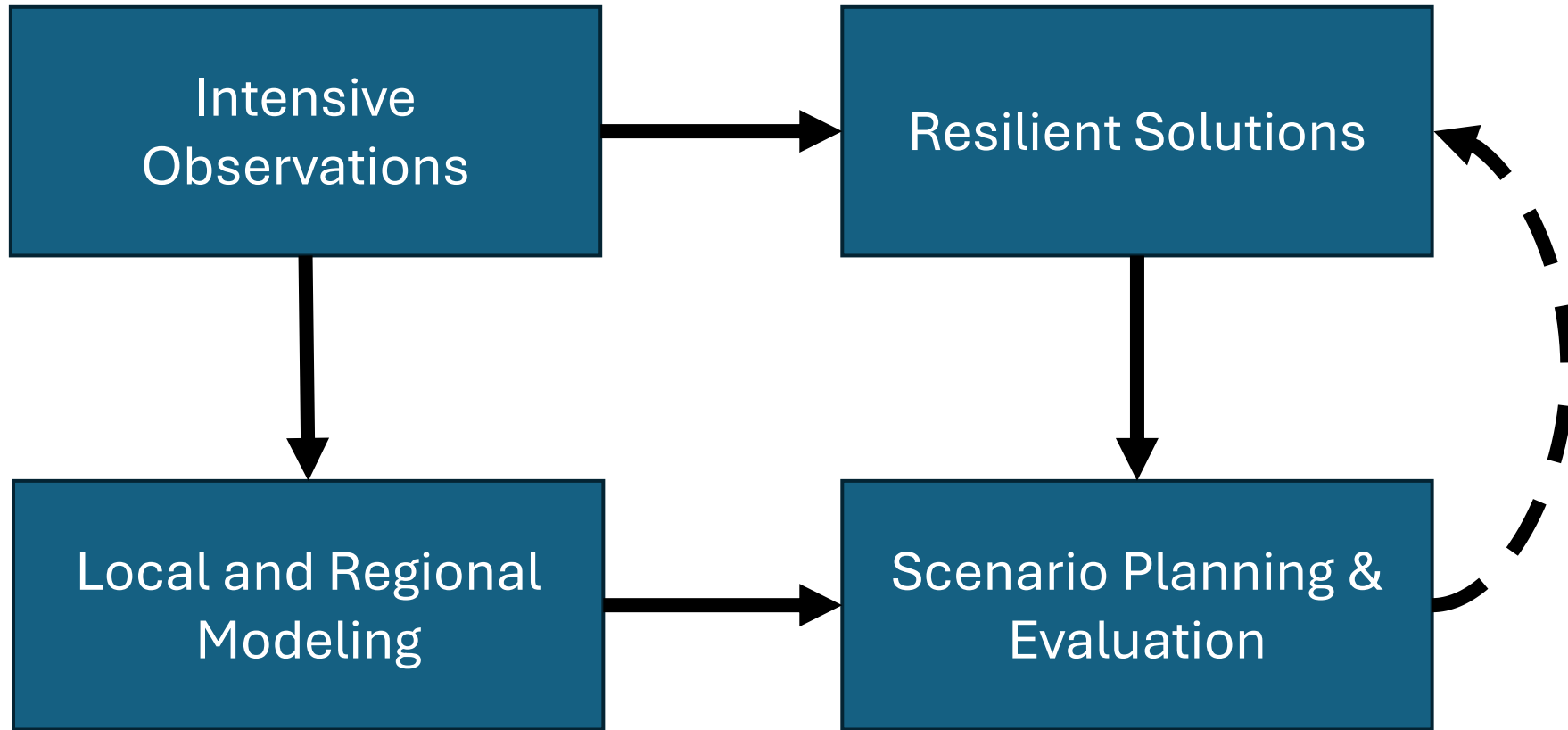
Testbeds & Intensive Observation Period (IOP)

What is a "testbed"?

- Area of unspecified geography where data observations and modeling are intensified
- Target evaluation
  - interventions
  - Differences/changes in the built or natural environment
- Passively and actively collected observations

Regional NAU's Flagstaff Scenario/ Policy Evaluation

Corridor UArizona's Oracle Road Testbed

Site-Specific ASU's Jackson St. Unhoused Population
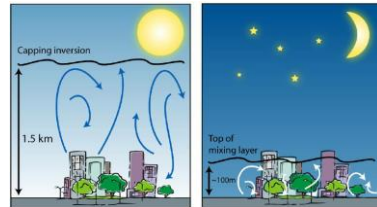
Understanding the urban climate of Arizona

Research directions:

1. Links between the extreme heat, air chemistry, urban/agricultural irrigation, and socioeconomic clustering.

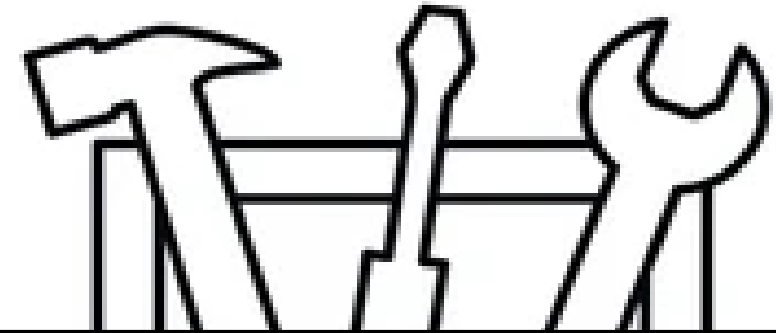2. Impact of urban planning strategies on the urban climate.

The built environment   The climate   People

Research tools:

- Data from pre-existing networks and databases
- Data from new instrument networks and apps
- Data from new field campaigns

Considerations for the data:

- Distributed in space to capture diversity
- Street-level and upper-level to capture the whole lower atmosphere
- Long term to see robust behaviors and trends

Data from pre-existing networks and databases

Model of America digital twin of buildings
Generated statistics of building
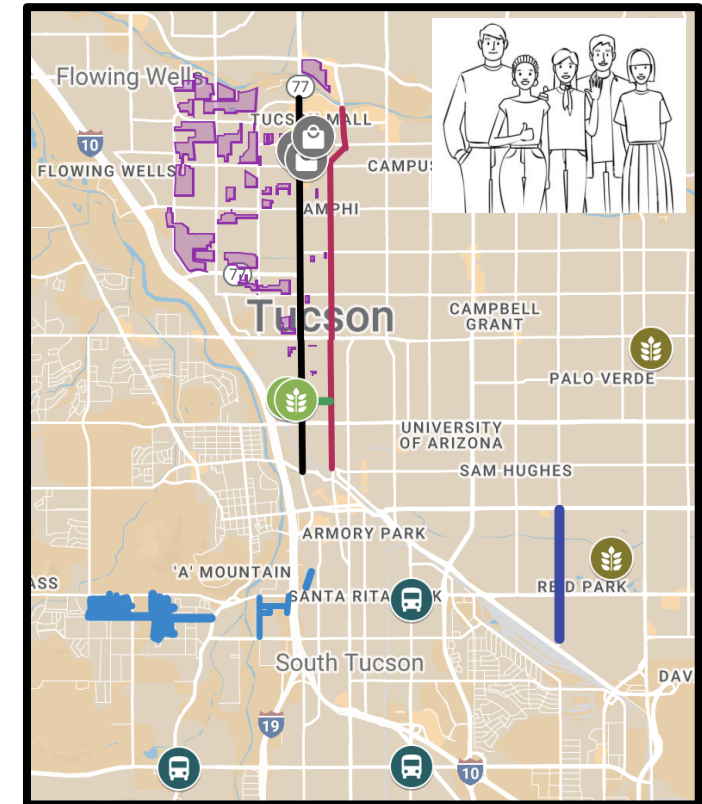morphology in regions of any size.

National Household Travel Survey
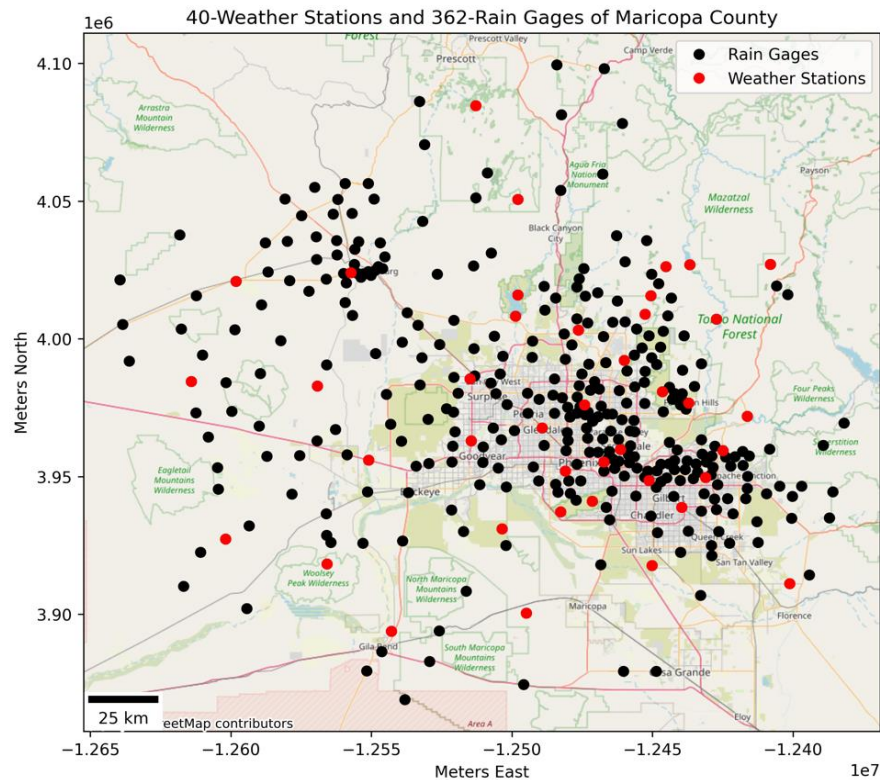Gathered travel behavior
and weather data.

Stakeholders' insights
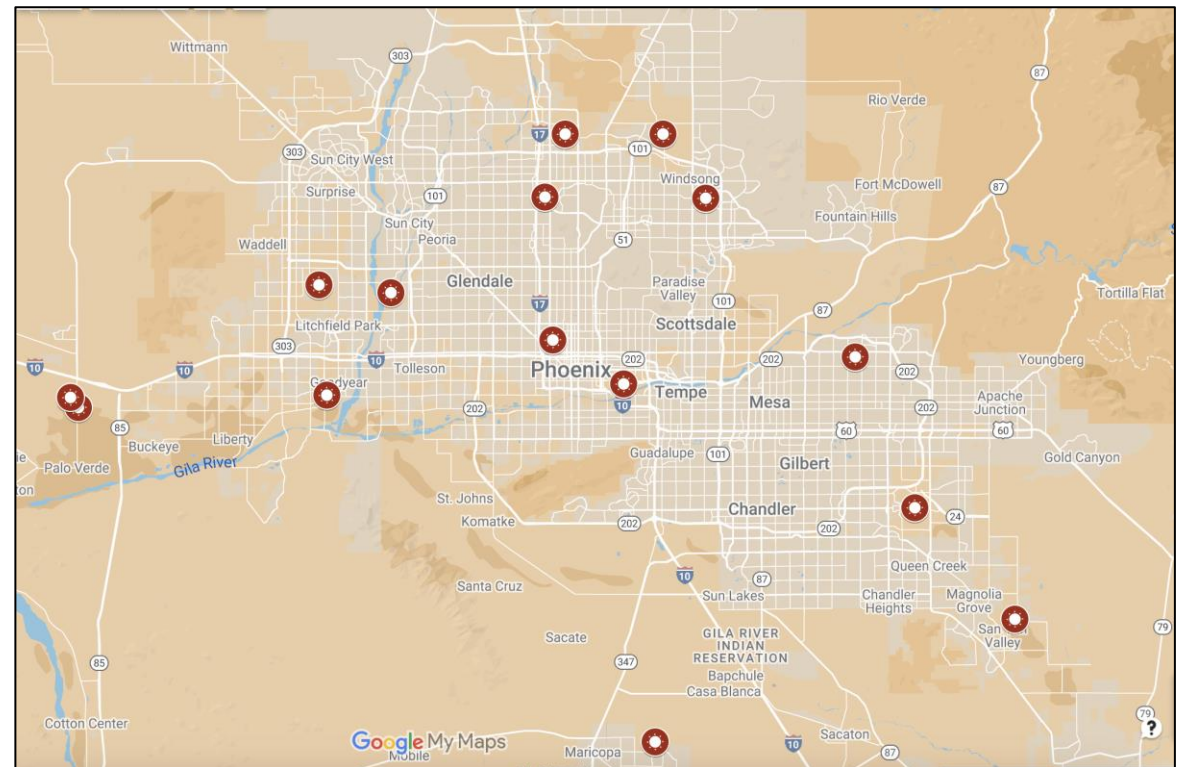Mapped planned resilience solutions.

Data from pre-existing networks and databases

Flood District of Maricopa County
Identified rain gage and weather dataset.
Prepared code to extract this data.

ASOS and AZMET weather station networks
Mapped the locations of each station.
Identified areas with sparse coverage.

Data from new measurement networks

3 Eddy covariance towers
(now registered w/Ameriflux)
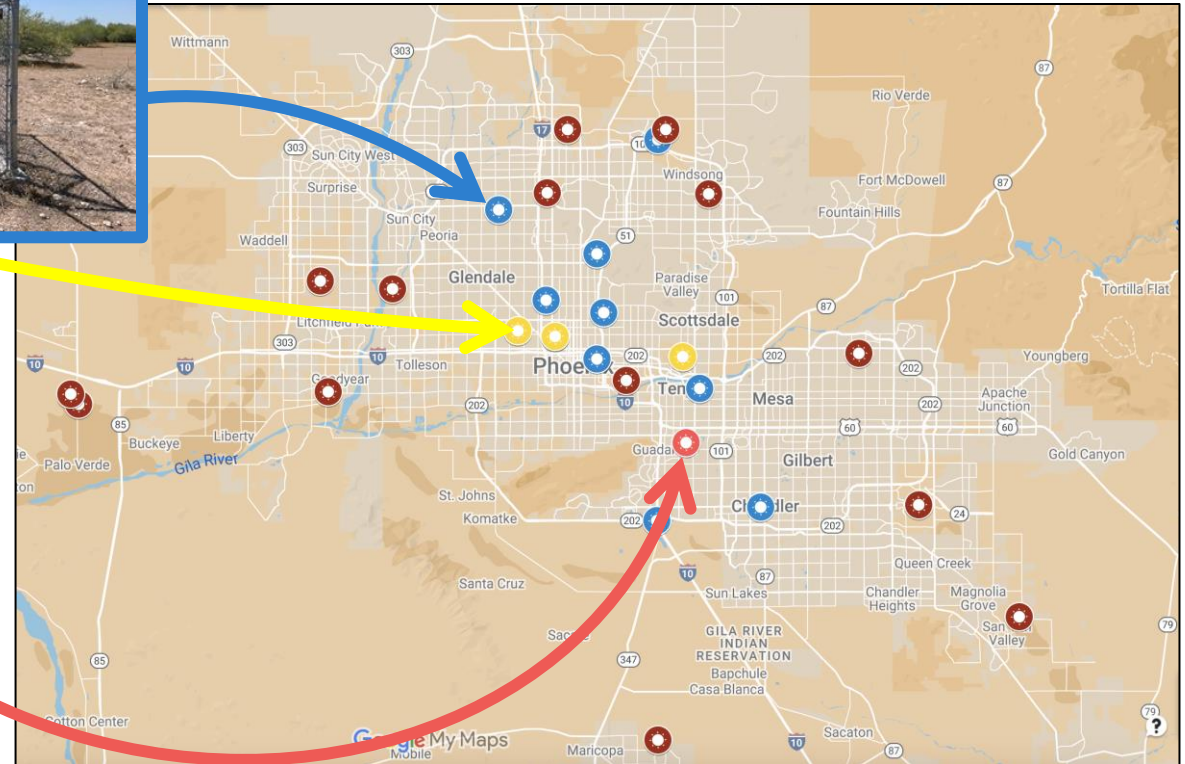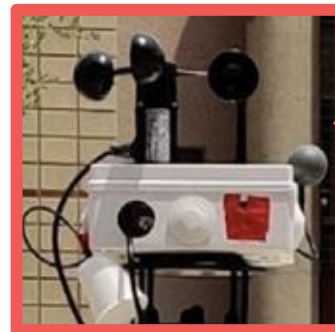Measure the exchange of energy, particle and gases from different land uses

12 Weather stations
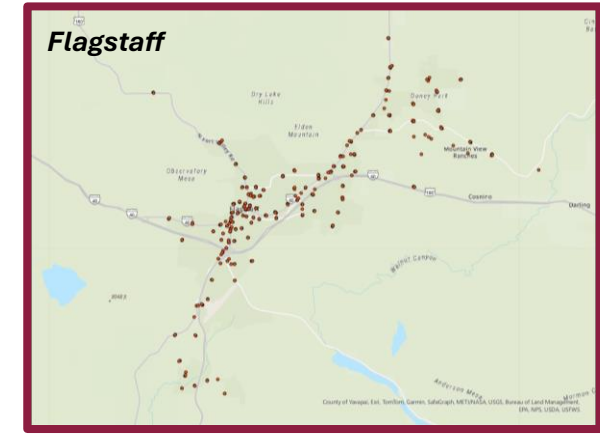In neighborhoods rather than airports

3 MaRTiny
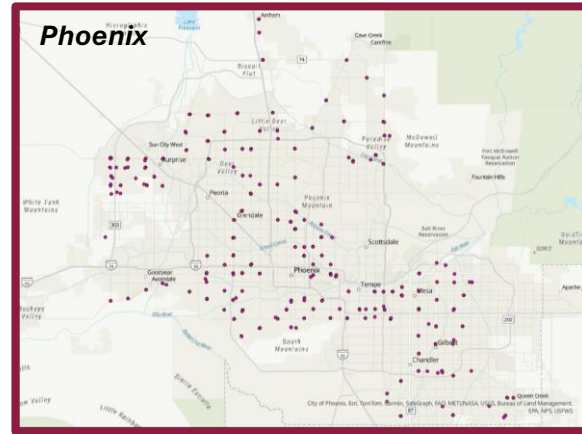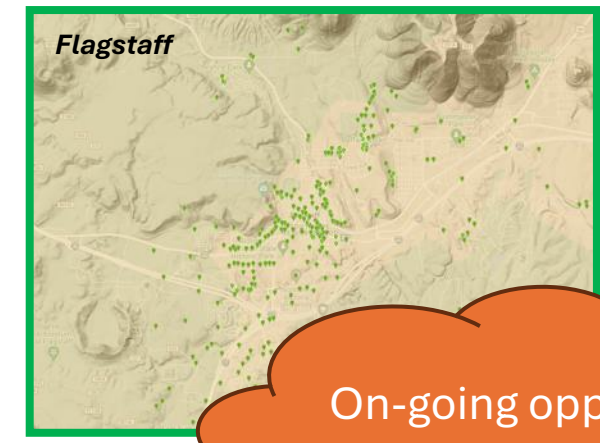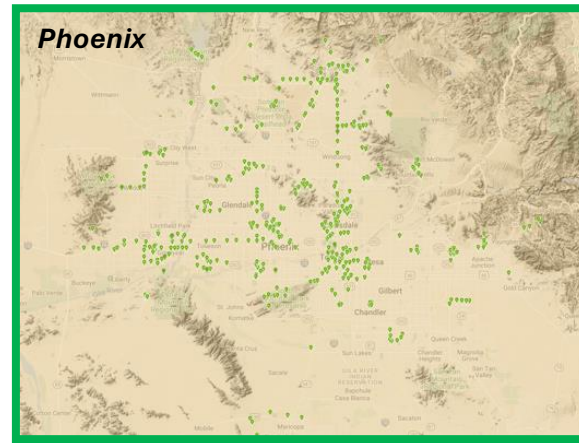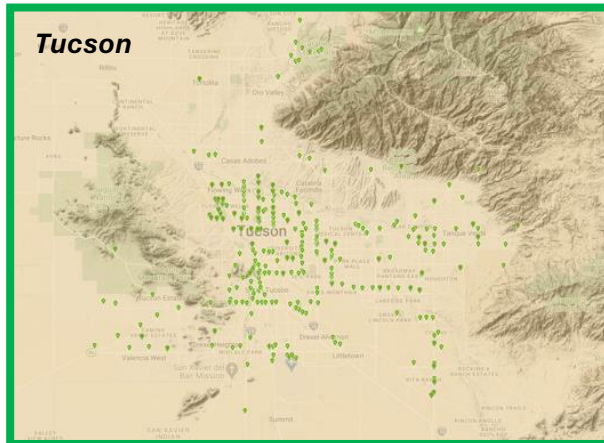Collects weather data, and counts the number of people in the shade and sun

Creating/leveraging apps for use by citizen scientists

Traffic records app
Increase density of traffic data. Related to CO_2, quality, and anthropogenic heat emissions.

Plant radiocarbon sampling
Monitoring CO_2 emissions through analysis of annual plants.

On-going opportunities to contribute!

2024 IOP Field Campaign

- Co-designed 4 science objectives and specific research questions with SWIFL members across teams and with stakeholders.

- Deployed all our campaign instruments.

- Employed several of our "tools" simultaneously.

- Main window: 28 days between June 3-July 3.

- Data will be released to the entire community before the end of the project.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
	3-Jun	4-Jun	5-Jun	6-Jun	7-Jun	8-Jun	9-Jun
Location	Phoenix	Phoenix	Phoenix	Phoenix	Phoenix	Phoenix	Phoenix
Coment					LandSat overpass	LandSat overpass	
Exp type	Arrival	9am Training on car held thermometers 1pm-5pm scouting	9am test radiosonde launch 1am-5pm scouting	Intra-neighborhood Variability 11am - 3pm first sampling session 5pm - 8pm second sampling session	Intra-neighborhood Variability 11am - 3pm first sampling session 5pm - 9pm second sampling session	Down Day	Intra-neighborhood Variability 4am - 7am first sampling session 8am - 12pm second sampling session
	10-Jun	11-Jun	12-Jun	13-Jun	14-Jun	15-Jun	16-Jun
Location	Phoenix	Phoenix	Phoenix	Phoenix	Phoenix	Phoenix	Phoenix
Comment						LandSat overpass	LandSat overpass
Exp type	Intra-neighborhood Variability 3am - 6am first sampling session 7am - 10am second sampling session	Intra-neighborhood Variability 3am - 7am first sampling session 7am - 11am second sampling session	Down Day	Cool Air Advection 10pm- 2am first sampling session 1pm - 5pm second sampling session * Windsond launch every 2 hrs	Unmanned data collection at fixed site	Unmanned data collection at fixed site	Cool Air Advection 7pm- 3am sampling session * Windsond launch every 2 hrs
	17-Jun	18-Jun	19-Jun	20-Jun	21-Jun	22-Jun	23-Jun
Location	Phoenix	Phoenix	Phoenix	Phoenix	Phoenix	Phoenix	Phoenix
Comment					Journalist visit		
Exp type	Cool Air Advection 7pm- 3am sampling session * Windsond launch every 2 hrs	Cool Air Advection 7pm- 3am sampling session * Windsond launch every 2 hrs	Unmanned data collection at fixed site	Urban dome 5am launch radiosonde from center 7am-9am first sampling session 9am launch windsond from each B point 9am-11am second sampling session 1pm launch radiosonde from center	Urban dome 12pm launch radiosonde from center 1pm-3pm first sampling session 3pm launch windsond from each B point 3pm-5pm second sampling session 6pm launch radiosonde from center	6pm-8pm outreach event at Desert Botanical Garden	Down Day
	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun	29-Jun	30-Jun
Location	Phoenix	Phoenix	Phoenix	Phoenix/Tucson	Tucson	Tucson	Tucson
Comment	LandSat overpass			Transit day	Visits		
Exp type	Urban dome 5am launch radiosonde from center 7am-9am first sampling session 9am launch windsond from each B point 9am-11am second sampling session 12pm launch radiosonde from center	Urban dome 5am launch radiosonde from center 7am-9am first sampling session 9am launch windsond from each B point 9am-11am second sampling session 11am launch windsond from each B point 1pm launch radiosonde from center	Urban dome 12pm launch radiosonde from center 1pm-3pm second sampling session 3pm launch windsond from each B point 3pm-5pm first sampling session 6pm launch radiosonde from center	CMAS in transit to Tucson	Oracle Road Testbed Characterization 10am radiosond launch [outreach launch] 4-8 pm sampling session [outreach drive alongs]	10pm Windson launch [outreach launch]	Down day
	1-Jul	2-Jul	3-Jul	4-Jul		6-Jul	7-Jul
Location	Tucson	Tucson	Tucson				
Comment			LandSat overpass				
Exp type	Orable Road Testbed Characterization 4-8 pm sampling session [outreach drive alongs]	Orable Road Testbed Characterization 6am media outreach 9am-1pm sampling session	Orable Road Testbed Characterization 11am-12pm first sampling session 12pm Windsond launch 1pm-4pm second sampling session	Wrap up/Transit Day			

2024 IOP Field Campaign

See presentation materials for CMAS Fact Sheet!

2 CMAS mobile observatories
(based in New York)
- Each carry ~11 climate instruments that sample while stationary and while driving.
- Off-the-grid sampling
- Measure air temperature, winds, humidity, cloudiness, aerosols, air quality at street-level and throughout the lower atmosphere.

Onboard data visualization

Meteo. station

Doppler lidar & backscatter lidar

WindSond

MRR-Pro & disdrometer

Modulair & fisheye camera & radiosonde

Temperature profiler

* Slide modified from Katia Lamer, Brookhaven National Lab

2024 IOP Field Campaign

1 Transportable Eddy covariance tower
Measure the exchange of energy, particle and gases.
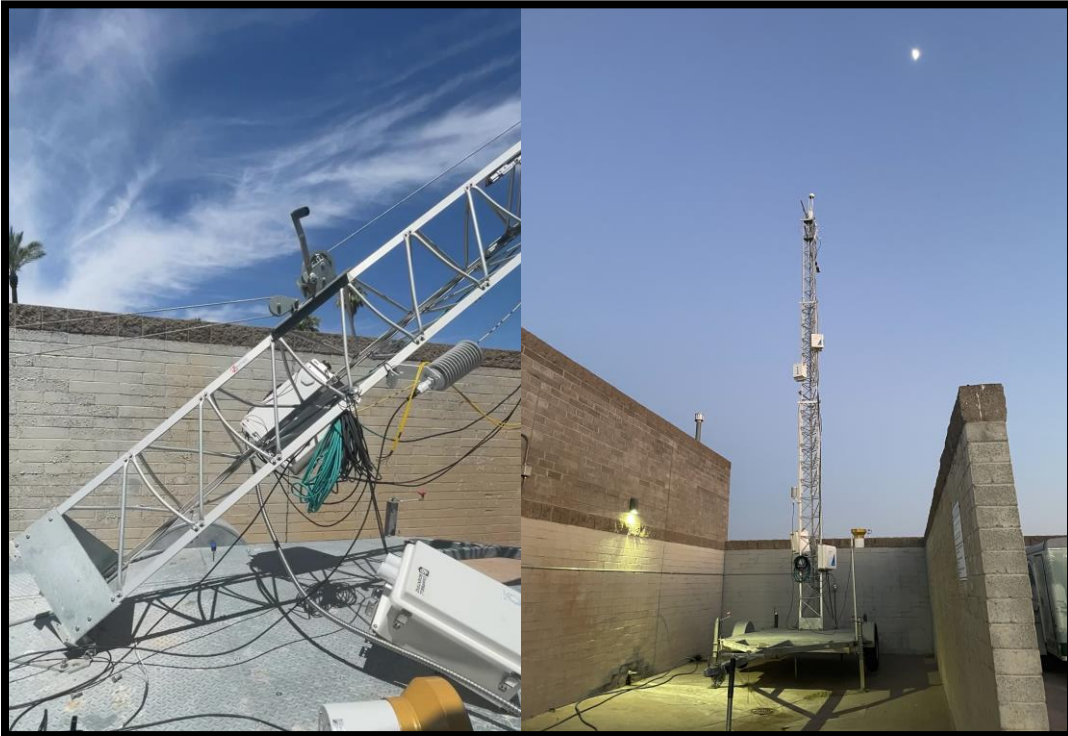
9 car-held temperature sensors
Measure land surface temperature and 2-m air temperature.

Science objective 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. Does climate variability correlates with building variability?

Approach:

- Mapped 1kmx1km regions matching **WRF model** grid.
- Used **Model of America digital** twin to select regions with different levels of building variability.

   Used **stakeholders' insight** to select underserved neighborhoods.

   Collected data (air quality, air and surface temperature, vertical wind, etc.) with the **2 CMAS mobile labs** and **cars with temperature sensors** while driving 1h transects through each region, several simultaneously.

*~45hrs of data spanning 12 neighborhoods, mixture of day and night measurements*
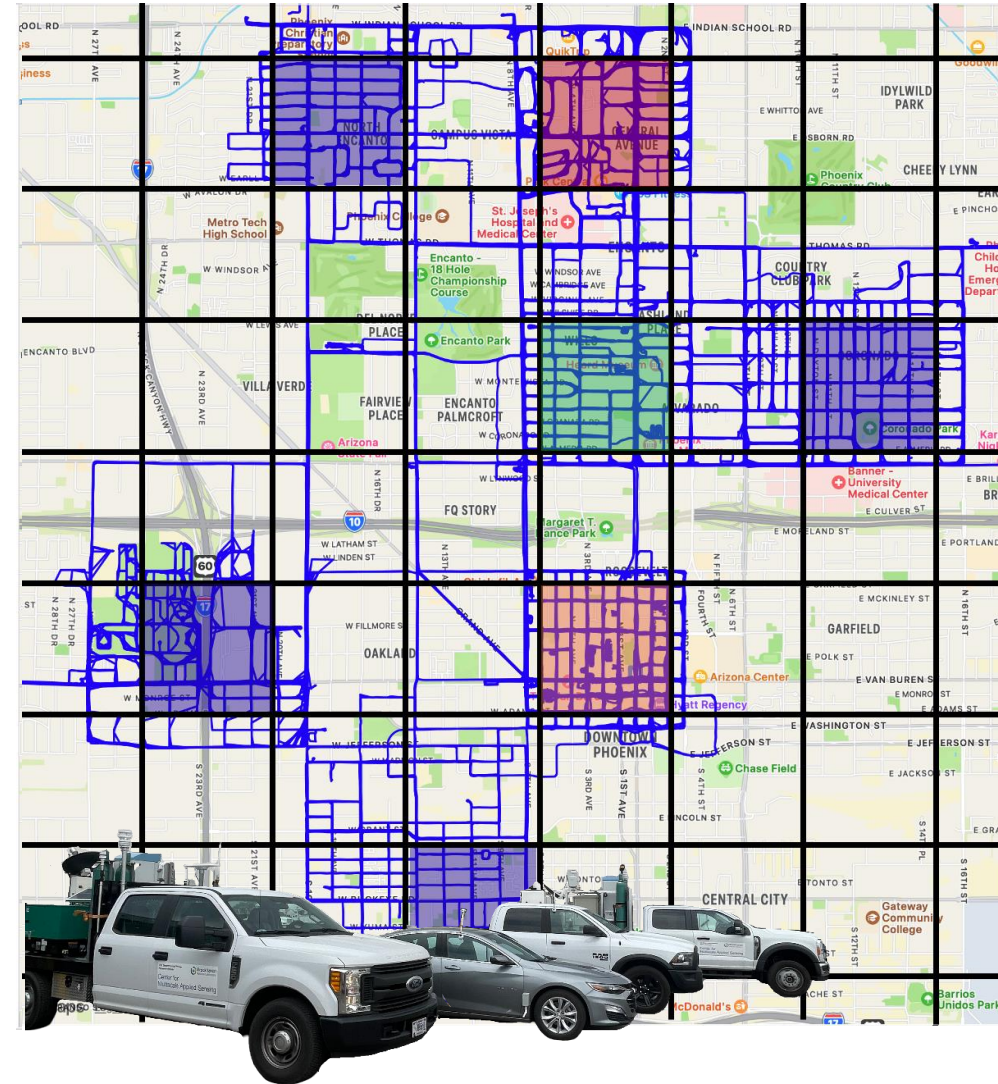
Science objective 2: Cool Air Advection

1. How much can a large green space cool the air?
2. If any, can the cool breeze travel downwind, and how does this change with wind speed and direction?

Approach:

- Selected and got access to a green space with our **project stakeholders.**

- Deployed **mobile eddy covariance tower** at the edge of the golf course.

  Used **car temperature sensors** to map air and surface temperature.

- Use temperature profiler on **CMAS2 mobile lab** to collect air temperature profiles within neighborhoods.

- Launch 3 simultaneous weather Windsond every 2 hrs.
  32 hrs of data, mixture of day and night
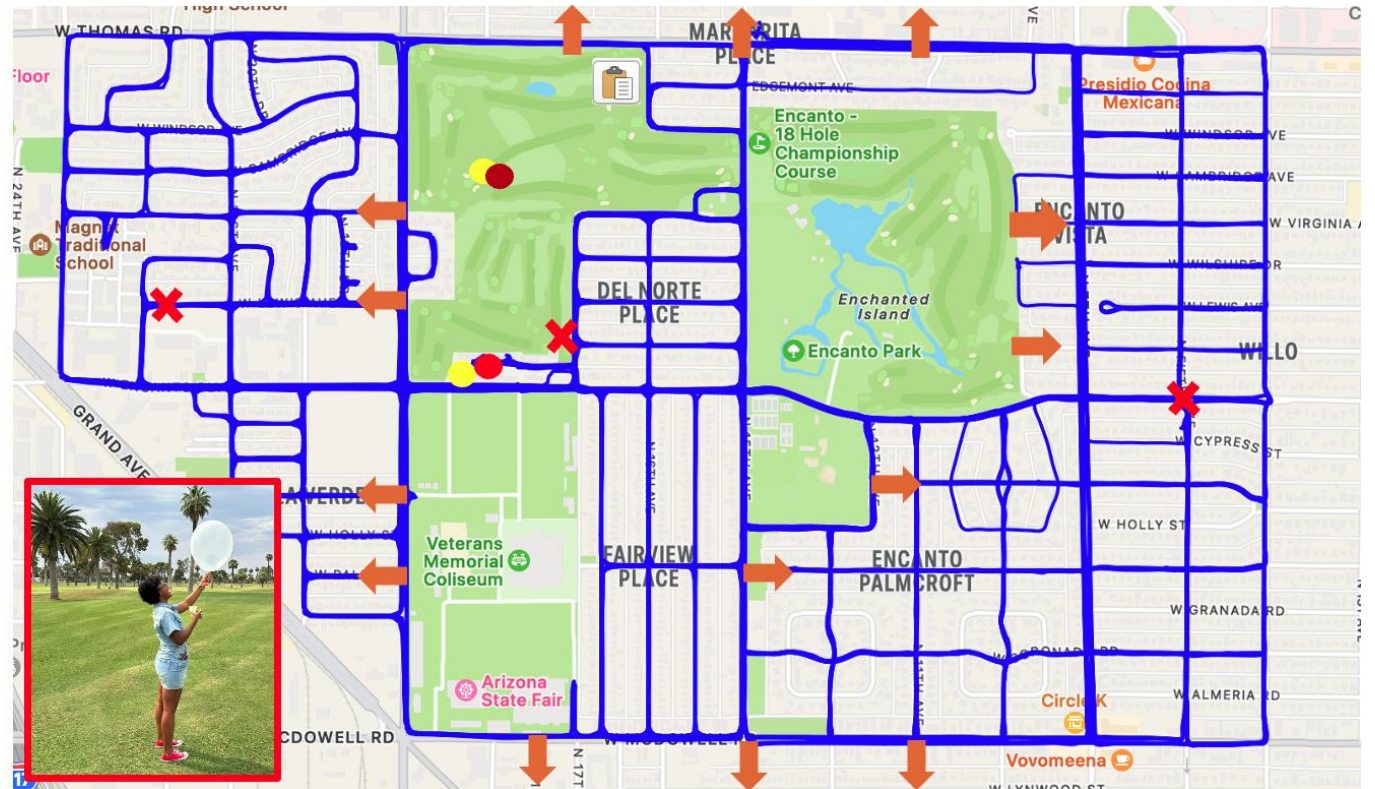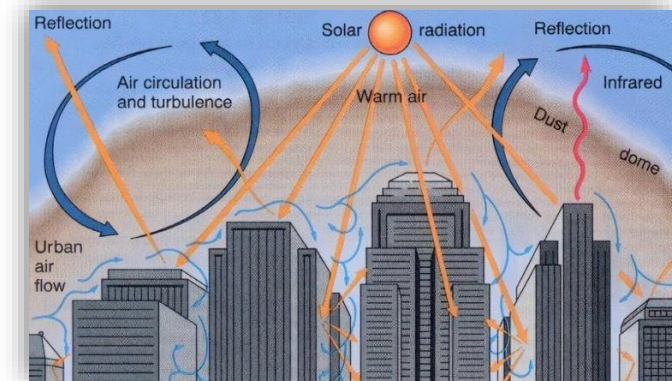
Science objective 3: Urban Dome

1. Map the vertical extent of Phoenix's Atmos. Boundary Layer (ABL):
   - Aerosol/pollution particles
   - Temperature and humidity
   - Vertical winds
2. Determine if the ABL structure varies with distance away from the city center

Approach:

- Select transects based on past **Weather Research and Forecasting (WRF) model** study
- Have each of the **CMAS mobile labs** drive a transect through Phoenix
- Launch 2 simultaneous Windsonds on the outskirts of the city and 1 radiosondes in the city center

10 transects, mixture of day and night
11 Windsond launches
10 radiosonde launches

Height a.g.l.

Lidar backscatter "concentration of particles"
Collected 9:45am-10:55am LT

1.2 miles
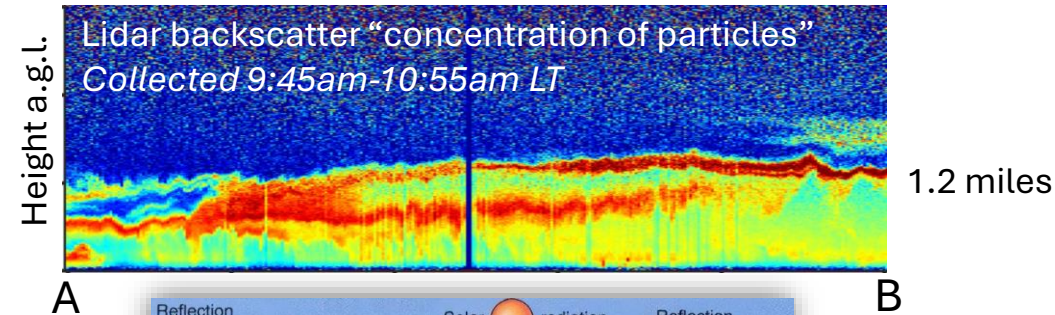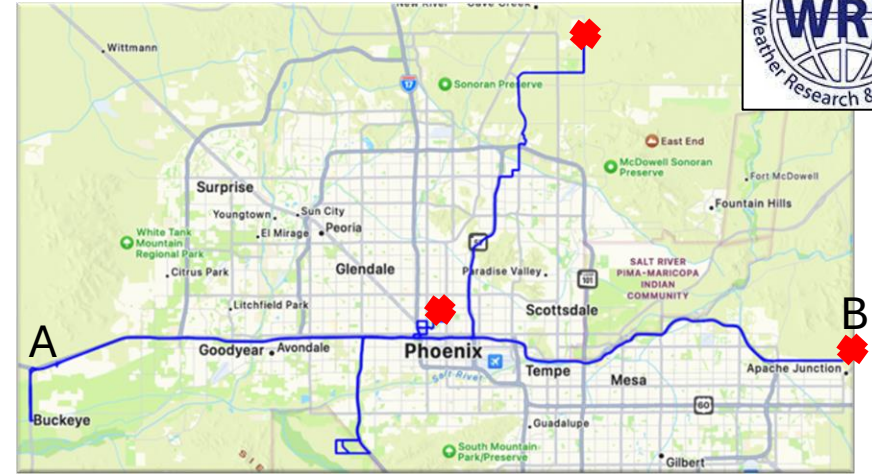
Science objective 4: Heat Resilient Solutions

1. Map the current state of Tucson's urban climate.

Approach:

- Work with **stakeholders' information** to plan a route passing through (1) houses participating in the "home thermal security" survey, and (2) locations with planned infrastructure changes.
- Have the **CMAS1 mobile lab** collect data along the route
- Launch sondes and radiosondes daily

13 hrs of data, daytime
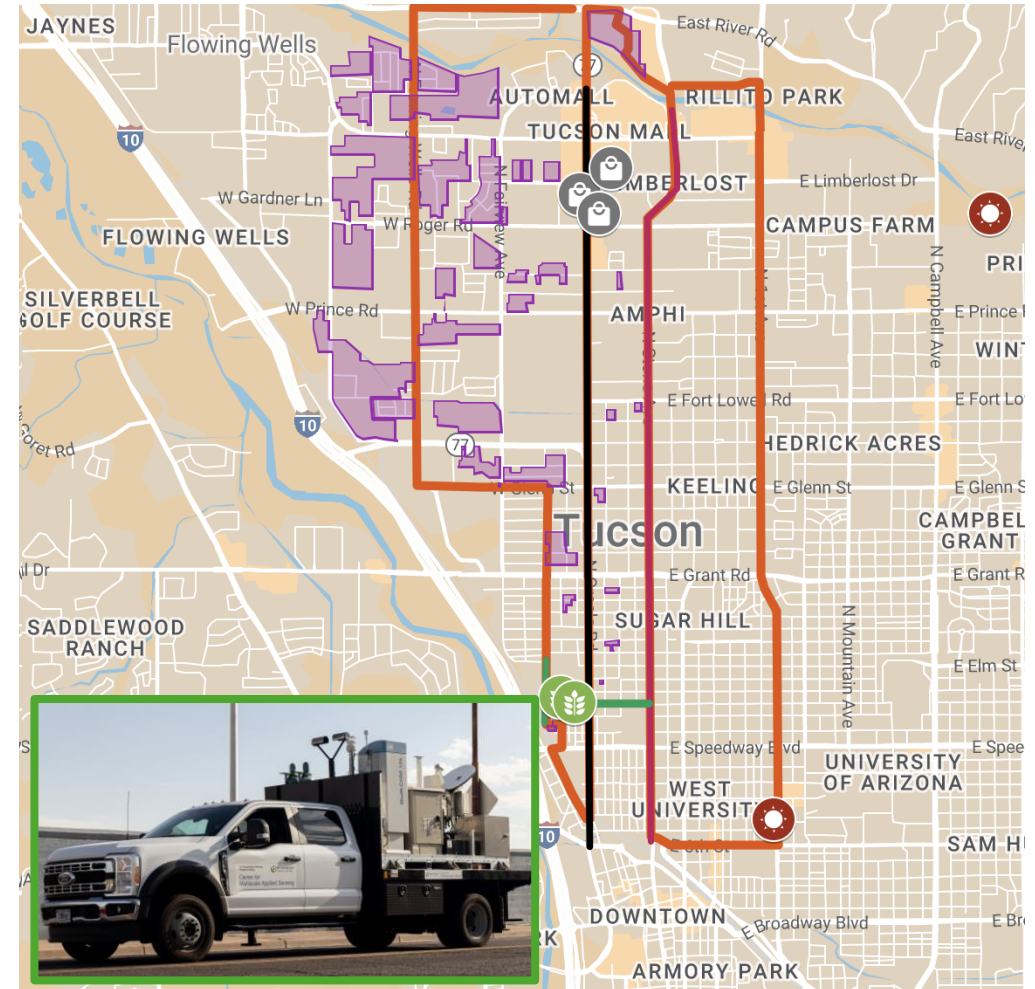
Tucson Testbed: Oracle Corridor

Why Oracle?

- 4-mile north-south transit corridor

- High social vulnerability characteristics

- Gap in terms of meteorological data collection instruments

- A variety of land use typologies, vacant land
  - Dense with mixed-use development
  - Strip malls
  - Single-family (low-income and middle-income) housing
  - Tucson house
  - Open spaces, cemetery
  - Schools
  - Industries
  - Offices

Oracle Road on CDC 2020 SVI

Oracle Road Zoning

CDC 2020 Social Vulnerability Index by Tract for Arizona

Overall SVI Score

High (0.7501 - 1.0000)

Medium-High (0.5001 - 0.7500)

Low-Medium (0.2501 - 0.5000)

Low (0.0000 - 0.2500)
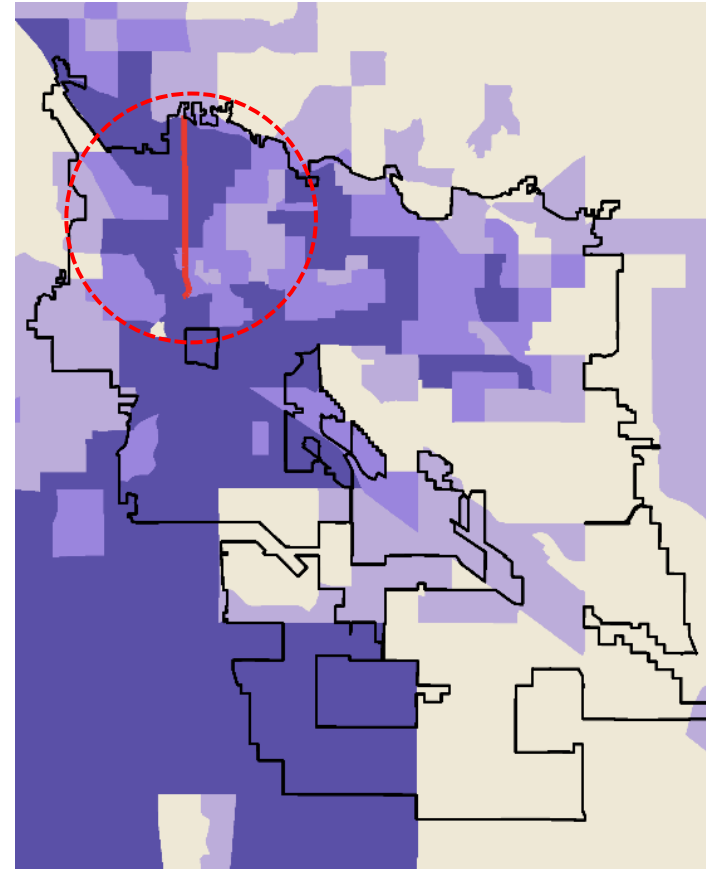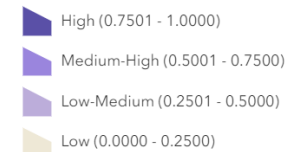
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CDC 2020 S...
Tract for Arizona

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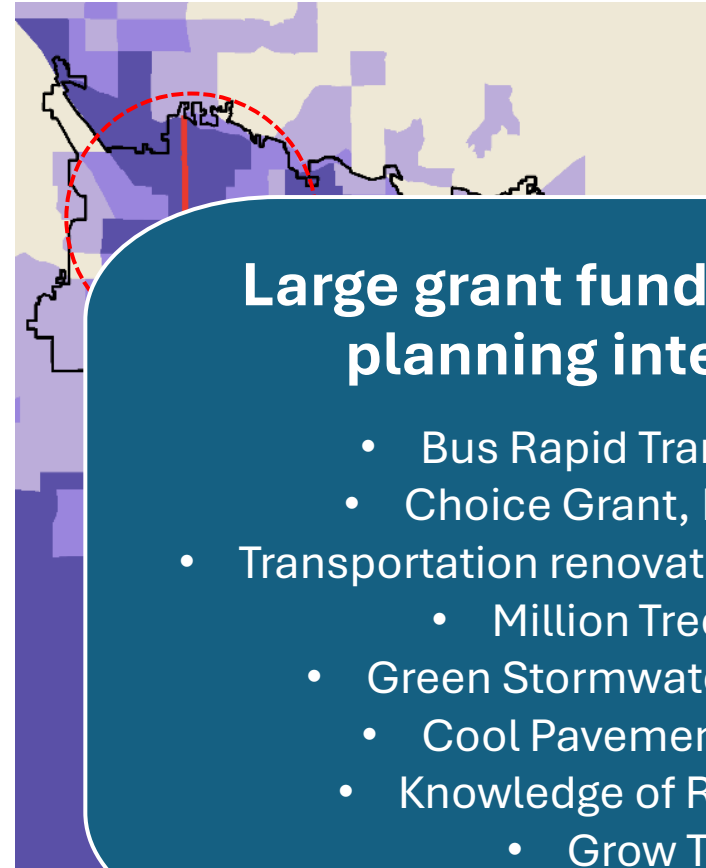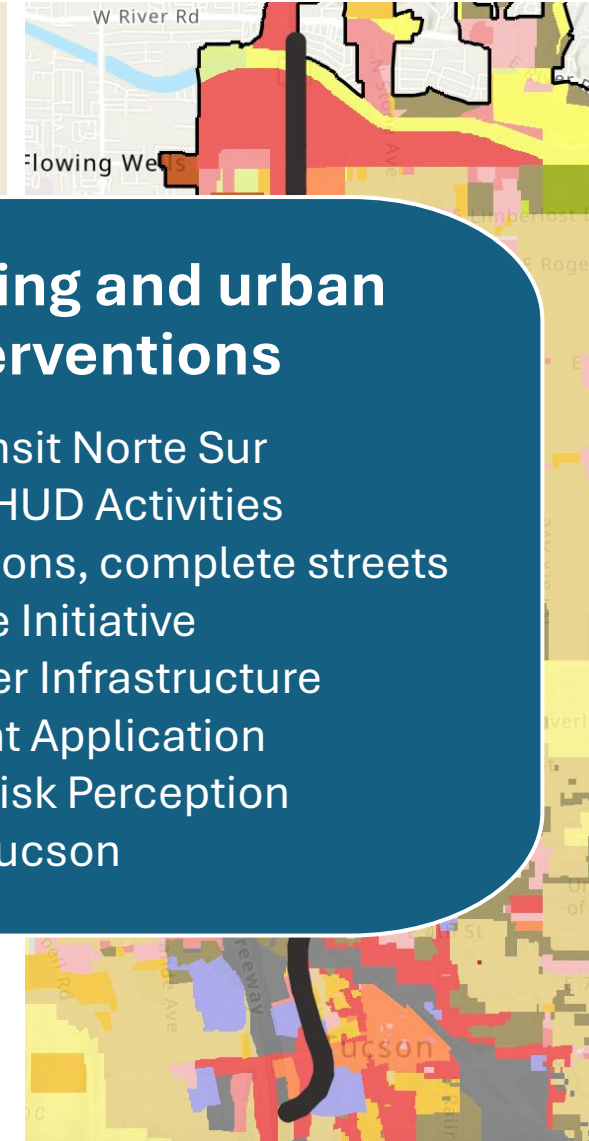
Large grant funding and urban planning interventions

- Bus Rapid Transit Norte Sur
- Choice Grant, HUD Activities
- Transportation renovations, complete streets
- Million Tree Initiative
- Green Stormwater Infrastructure
- Cool Pavement Application
- Knowledge of Risk Perception
- Grow Tucson

Engagement

Stakeholders engaged:
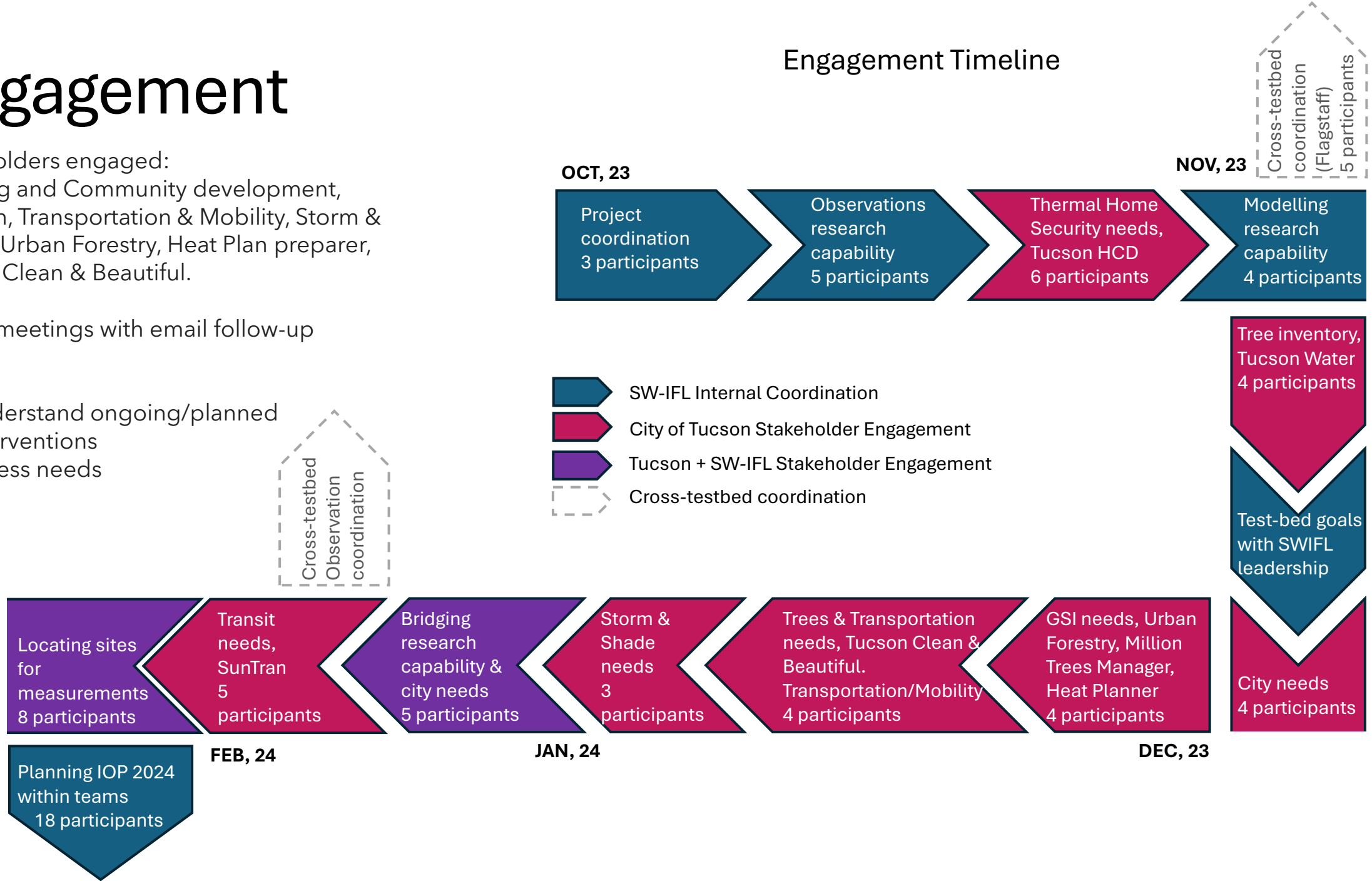Housing and Community development, SunTran, Transportation & Mobility, Storm & Shade, Urban Forestry, Heat Plan preparer, Tucson Clean & Beautiful.

Virtual meetings with email follow-up

Goal:
- Understand ongoing/planned interventions
- Assess needs

Engagement Timeline

OCT, 23

Project coordination
3 participants

Observations research capability
5 participants

Thermal Home Security needs, Tucson HCD
6 participants

NOV, 23

Modelling research capability
4 participants

Cross-testbed coordination (Flagstaff)
5 participants

Tree inventory, Tucson Water
4 participants

Test-bed goals with SWIFL leadership

City needs
4 participants

Legend

- SW-IFL Internal Coordination
- City of Tucson Stakeholder Engagement
- Tucson + SW-IFL Stakeholder Engagement
- Cross-testbed coordination

Cross-testbed Observation coordination

Locating sites for measurements
8 participants

FEB, 24

Transit needs, SunTran
5 participants

Bridging research capability & city needs
5 participants

JAN, 24

Storm & Shade needs
3 participants

Trees & Transportation needs, Tucson Clean & Beautiful. Transportation/Mobility
4 participants

DEC, 23

GSI needs, Urban Forestry, Million Trees Manager, Heat Planner
4 participants

Planning IOP 2024 within teams
18 participants
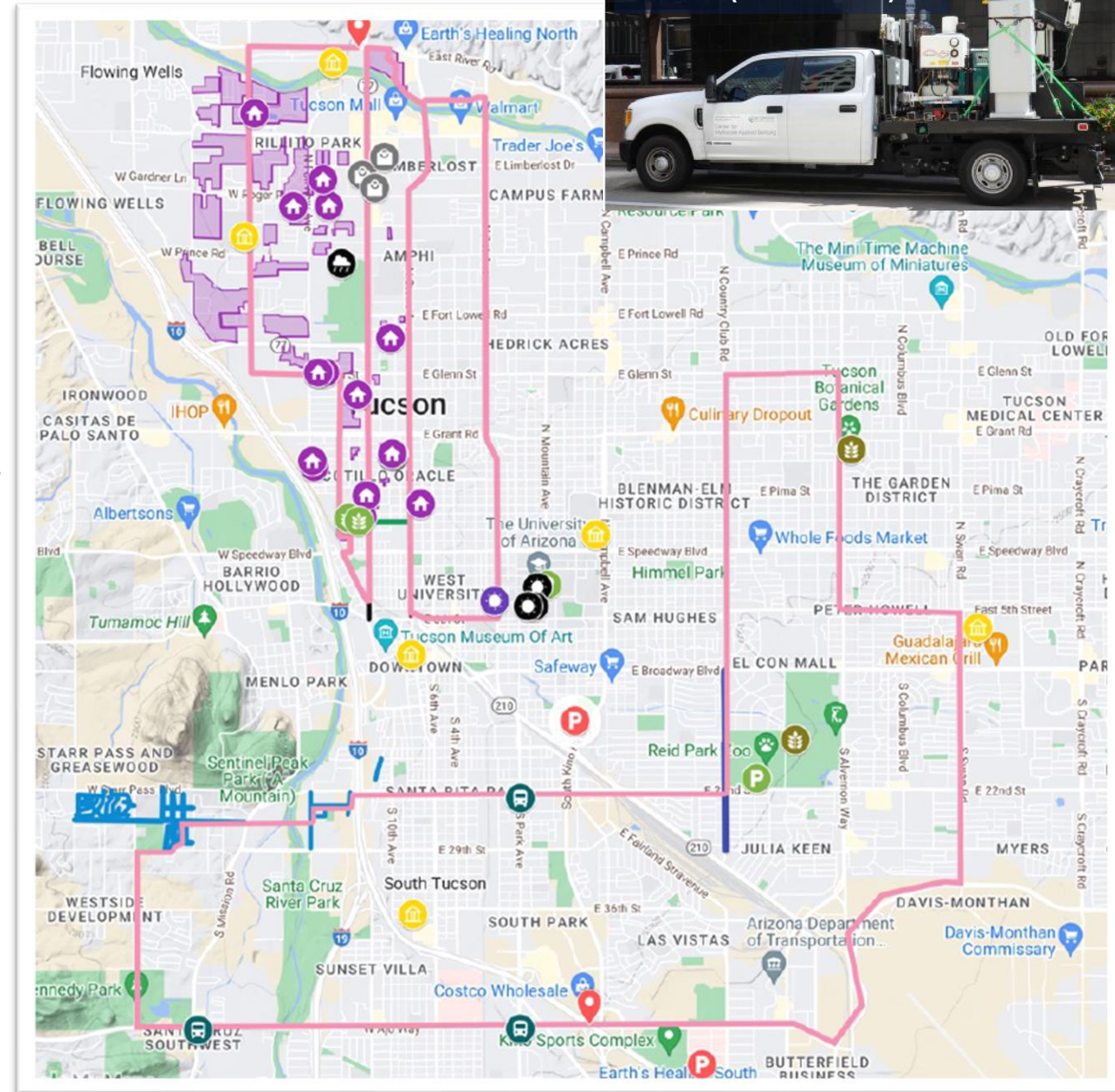
Oracle/Tucson Testbed

Short-term IOP:

- <u>HOUSING</u>: Home Thermal Security analysis in public housing, and manufactured housing along Oracle Road
  - Data Collection: Logger + MaRTy measurements + interviews

- <u>GREEN INFRASTRUCTURE</u>: Performance of GSI interventions in Parks, Complete Street
  - Data Collection: CMAS + Weather station

- Performance of <u>COOL PAVEMENT</u> application
  - Data Collection: Case + Control sites; not in Oracle

- Comparison of <u>AIR POLLUTION</u> in K-12 schools in Tucson with a focus on schools along the Corridor
  - Data Collection: Purple Air Sensors + CMAS

CMAS1 (Brookhaven)

Oracle/Tucson Testbed

CMAS1 (Brookhaven)

Long-term IOP:

- Meso-scale analysis of imprint of the evolving built environment along Oracle Road on Heat, Precipitation, Air pollution, Emissions, Urban dome
  - Data Collection: CMAS

- Addressing climate data gaps in formerly underinvested Oracle Road
  - Data Collection: Weather station + CMAS

- Analysis of return on investments by the city in GSI, housing, complete street, cool pavement interventions.
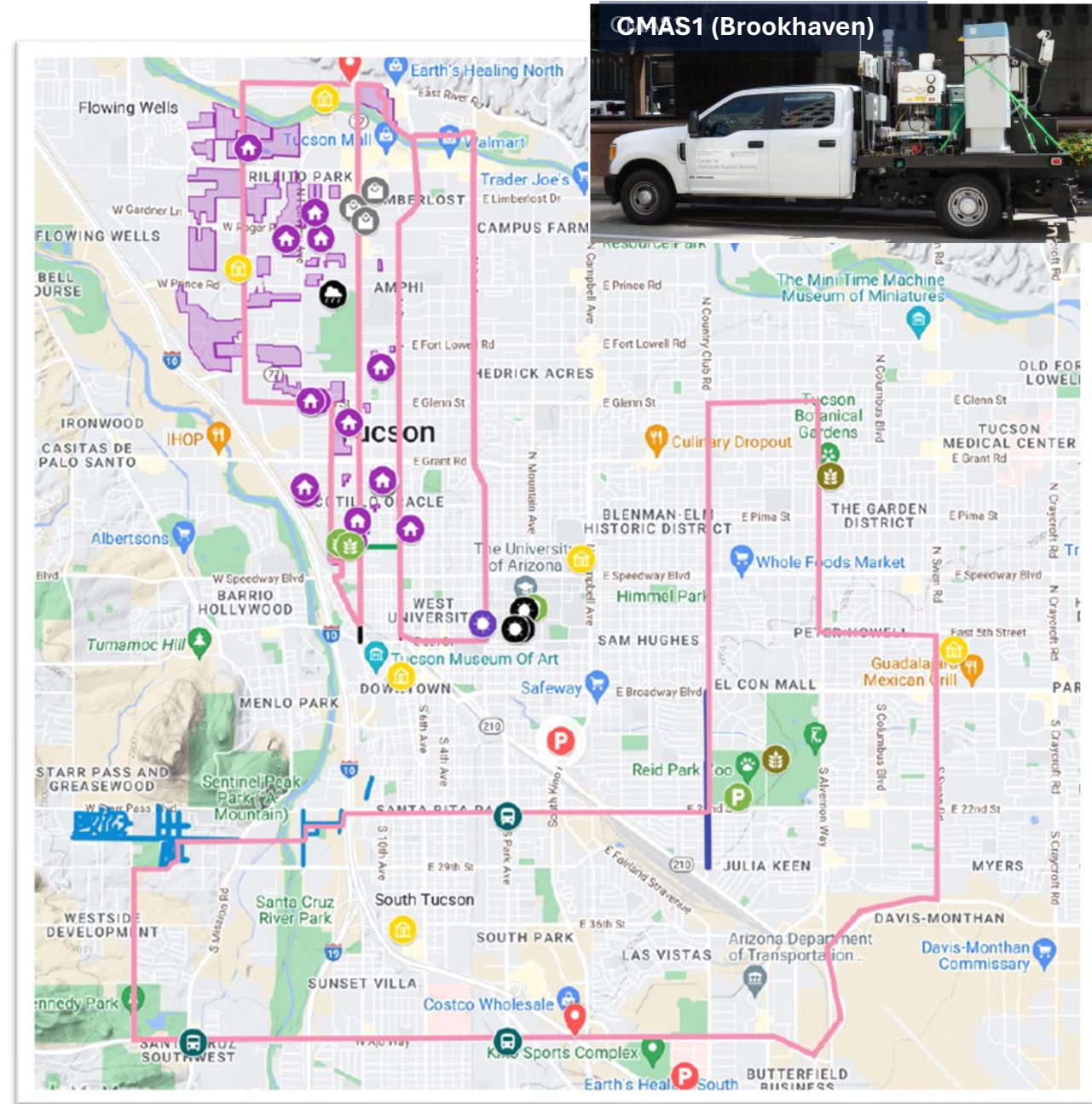
Next Steps

5-year Project Duration: December 2022 – December 2027

Currently at the end of Year 2

On-going and Up-coming Activities

Intensive Observations Periods (IOPs)

- Analyze all that data!
  - CMAS trucks (Lamer)
  - Home thermal security (Kear)
  - Air Quality "Purple" sensors (Lim)

- Summer 2025 – **In planning progress**
  - Currently developing CMAS truck observation plans
  - Advocating to bring an Eddy covariance tower and MaRTy Carts to Tucson!

- Summer 2026
  - CMAS trucks return to Arizona, planning to repeat activities to measure change over time
  - Revisit Tucson's routes and observe changes

Related Activities

- Neighborhood plan evaluation (Keith, Roy)

- Design competition (Kokroko)

- Working with the City to install weather stations with precipitation sensors and purple air quality sensors (Currans)
  - One location in progress north of downtown near Oracle
  - Looking for another spot

- Working with modeling group to being scenario planning (Currans and others)

- Mobility discovery (Currans)
  - Summer 2025: Heat + Travel Survey, General Population of Arizona
  - Summer 20256: Special populations, qualitative work, and/or choice experiments?

- Science of Science Evaluation (Meadow)

Citizen Science Opportunities

MaRTy Cart, ASU

iNaturalist app screenshot

- Seeking interested community collaborators for Discovery Fellowship
  - learn MaRTy cart data collection
  - collect local data corresponding with green infrastructure and tree shade (e.g., transit stations, parking lots)

- iNaturalist app plant collection for radiocarbon analysis
- expanding plant data collections to Phoenix and Tucson (NAU, more info to come)

HESTIA TRAFFIC APP

CITIZEN SCIENCE APP TO IMPROVE CO2, AIR QUALITY, AND HEAT EMISSIONS

FOR APPLE DEVICES, READY TO USE

FOR ANDROID DEVICES, NEED TEST SUBJECTS

Questions?

Kristina Currans, PhD

Associate Professor, Urban Planning

University of Arizona

curransk@arizona.edu

For more information and updates, check out our newsletter!

- https://sw-ifl.asu.edu/news

THE UNIVERSITY OF ARIZONA

LINKS
- SW-IFL SharePoint Page
- SW-IFL Team Google Calendar
- SW-IFL Monthly Updates Submission/Feedback Form
- SW-IFL Photo Form

SW-IFL UPDATES
SEPTEMBER 2024

Arizona Project WET Water Festival

THIS ISSUE
Message from Dr. Sailor
SW-IFL All Hands Meeting
2024 DOE Urban PI Meeting

UPCOMING EVENTS
- Sep 20: Call for Presentations from Urban Working group due
- Sep 26-27: SW-IFL 2024 All Hands Meeting in Tempe, Arizona
- Sep 30: DOE Urban IFL Poster Abstracts due
- Oct 10: Leadership Team Meeting
- Oct 8: Team submissions due for October External facing newsletter
- Oct 10: Leadership Team Meeting
- Oct 10: Resilient Solutions Team Meeting
- Oct 11: Modeling Team Meeting
- Oct 18: Observation Team Meeting
- Oct 28-29: DOE Urban IFL Principal Investigators' Meeting in Rockville, MD

Don't forget: the SW-IFL Google Team Calendar is available for you to add your project related events to keep everyone in the loop. Check it out for listed times and points of contact

MESSAGE FROM THE DIRECTOR

SW-IFL colleagues,

Welcome to our September newsletter!

We've got a lot going on over the next month, including our All-Hands meeting to be held here in Tempe on September 26th - 27th, and then the U.S. Department of Energy's PI meeting to be held in Washington DC October 28-29.

I really appreciate everyone's hard work in helping us prepare for these two very important meetings.

We are simultaneously working on our Year 2 public-facing annual report which we will make available on our website toward the end of the year. It is truly impressive how much we have all accomplished together this year.

Looking forward to sharing the report and seeing you at the meeting!

Dave

2023 SW-IFL All Hands Meeting at NAU