Adapting Urban Infrastructure for Local and Global Climate Change: Climate action planning for extreme heat in urban environments

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Please note: all temperatures shown in Fahrenheit for ease of understanding by City staff.

Overview

The Health Impact Project with the city of Tempe is an effort to address the threat of extreme heat through informed design guidelines and action projects for Tempe's first Climate Action Plan. Findings will inform future investment in city infrastructure, to be more resilient, by identifying and reducing residents' exposure to extreme heat and ultraviolet (UV) radiation created by city infrastructure. This effort is to develop a suite of heat assessment tools to inform design and decision-making. Assessments will allow the city to understand how parks, playgrounds, multi-use paths, arterial walls, and parking lots currently perform on extreme heat days. In 2019, the city of Tempe, Arizona initiated its Health Impact Project as a pilot for reducing extreme heat along four types of infrastructure: public parks, multi-use paths, walls, and parking lots. A cross-sectional team of researchers, residents and city officials collaborated to conduct a variety of capacity building activities including:

- citywide heat and health survey to understand social differences between Tempe character areas;
- microclimate assessments to measure surface, air, and mean radiant temperatures across various sun exposures, materials, and times of day of the four infrastructure types;
- a participatory heat assessment conducted by residents and researchers to measure temperatures across various infrastructure, and learn how perceptions and preferences intersect with those measurements; and
- a climate action design workshop, where researchers and city officials explored findings to began co-creating design and policy guidelines

Key Questions

- *In what ways is heat connected to City staff's responsibilities with the City and with their department?*
- *How would City staff use this microclimate and social information in their different City roles to improve decision-making or to create policy?*
- *How could this information be improved and made more usable for the City and for residents to build climate literacy and action round extreme heat?*

Overall Goals

- Clarify the health threats of extreme heat with Tempe staff and residents
- Identify infrastructure that enhances or reduces extreme heat
- Develop design guidelines for capital improvement investments
- Develop policy guidance
- Provide the Mayor and Council with clear next steps

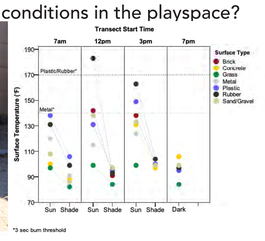
Infrastructure types assessed:

1.Parks & Playspaces

Questions:

- What are the hottest materials in the playground?
- What are the mean radiant temperatures at ground level under various conditions in the playspace?

Figure 1a: Surface temperate sensor



*3 sec burn threshold

Figure 1b: Hand-held surface temperatures ("touch-scale") at Kiwanis South Playground on August 25, 2019. Sky Harbor daytime high air temperature 103F and morning low air temperature 85F, Sunrise: 5:57 am and Sunset: 7:02 pm.

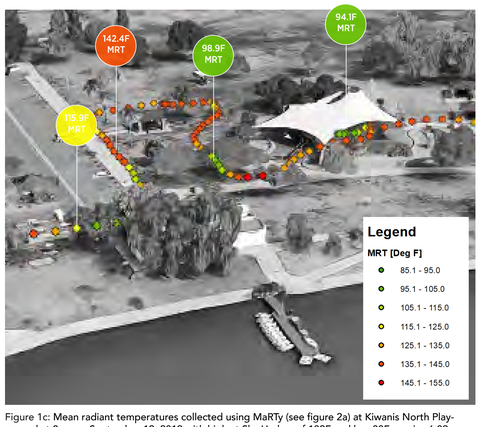


Figure 1c: Mean radiant temperatures collected using MaRTy (see figure 2a) at Kiwanis North Playground at 8am on September 12, 2019 with high at Sky Harbor of 102F and low 80F, sunrise 6:09am and sunset 6:38pm.

Findings:

- Tension between accessibility and surface temperature hazards with rubberized surfaces (can reach +170F)
- Trees and shade structures can reduce MRT by 30-50F at 8am
- Focus on creating more usable playspaces for more hours each day and longer season - shade

2.Multi-Use Paths

Questions:

- What are the mean radiant temperatures at ground level under various conditions on multi-use paths?

Figure 2a: We conducted hourly microclimate transects using the mobile human-biometeorological weather station "MaRTy" (Figure 2a) to measures air temperature, relative humidity, horizontal wind speed and direction, six-directional radiation flux densities, and GPS location. Transects were conducted during daylight hours on hot, clear, calm summer days. MRT observations were analyzed across all sites, transects, measurement days, and observation times to determine shade coverage efficacy.

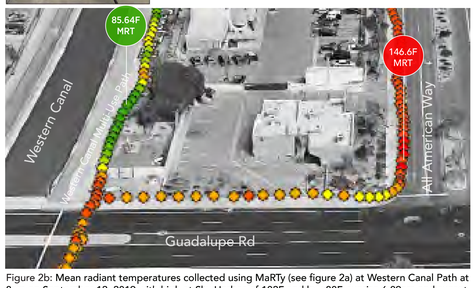


Figure 2b: Mean radiant temperatures collected using MaRTy (see figure 2a) at Western Canal Path at 8am on September 12, 2019 with high at Sky Harbor of 102F and low 80F, sunrise 6:09am and sunset 6:38pm.

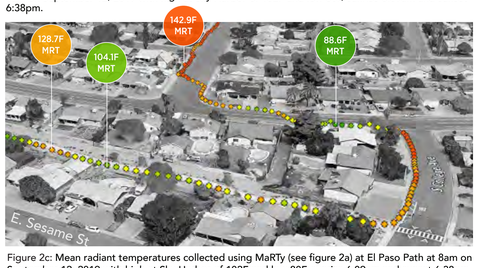


Figure 2c: Mean radiant temperatures collected using MaRTy (see figure 2a) at El Paso Path at 8am on September 12, 2019 with high at Sky Harbor of 102F and low 80F, sunrise 6:09am and sunset 6:38pm.

Findings:

- At 8am commute time, shaded parts of North-South Western Canal path were up to 60F cooler (MRT) than All American Way
- East-West El Paso Path MRT was 10-40F cooler than adjacent College Ave
- Heat walks help align thermal experience, MRT, and surface temperature data and promote learning

3. Arterial Walls

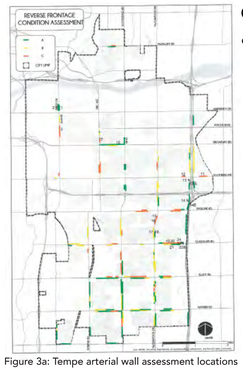


Figure 3a: Tempe arterial wall assessment locations

Questions:

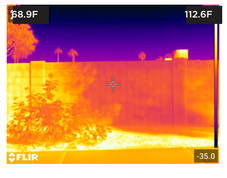
- What is the thermal contribution of different arterial wall designs by orientation?

Wall 24

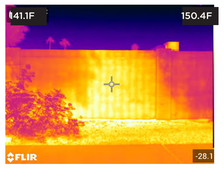
Figure 3b: Wall 24. south facing

Wall 24, thermal photos:

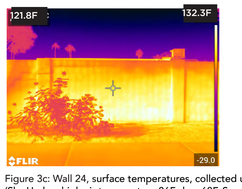
900 (9am)



1200 (12pm)



1500 (3pm)



2000 (8pm)

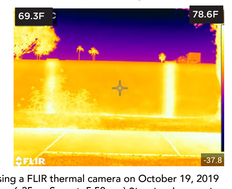


Figure 3c: Wall 24, surface temperatures, collected using a FLIR thermal camera on October 19, 2019 (Sky Harbor high air temperature 86F, low 60F, Sunrise: 6:35am Sunset: 5:50pm.) Structural concrete columns and ground beams showed highest night time temperatures

Findings:

- Shade, thermal capacity, and orientation impact on surface temperatures
- Thermal performance varied depending on hour of day
- Structural concrete columns and ground beams showed highest night time temperatures
- The effect of wall surface roughness, as in smooth versus rough masonry, was not thermally visible

4. Parking Lots

Questions:

- What is the impact of PV shade in parking lots during different times of day?

Figure 4a (Left): We conducted hourly microclimate transects using the mobile human-biometeorological weather station "MaRTy" (left) to measure air temperature, relative humidity, horizontal wind speed and direction, six-directional radiation flux densities, and GPS location. Transects were conducted during daylight hours on hot, clear, calm summer days. MRT observations were analyzed across all sites, transects, measurement days, and observation times to determine shade coverage efficacy.

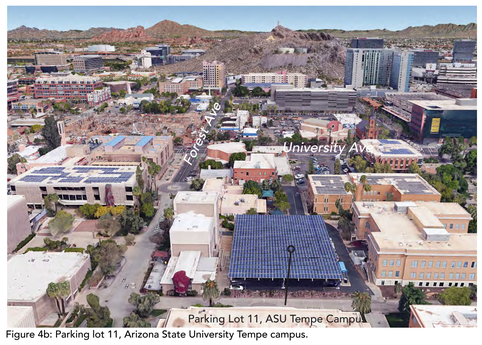


Figure 4b: Parking lot 11, Arizona State University Tempe campus.

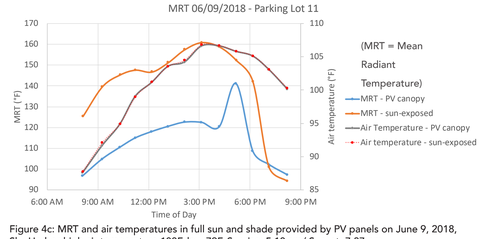


Figure 4c: MRT and air temperatures in full sun and shade provided by PV panels on June 9, 2018, Sky Harbor high air temperature 108F, low 79F, Sunrise: 5:18 am/ Sunset: 7:37 pm.

Findings:

- Strong differences between sun-exposed and PV shaded areas, MRT of up to 40F
- Strong differences in the surrounding surface temperature underneath the instrument, up to 30F
- For surface and MRT areas, differences are much lower or non-existent during the night hours

5. Community Activities

5.1) Conversations with City Staff:

From June through November 2019, the team had several meetings with City staff to discuss potential cooling strategies for each infrastructure type. City staff also suggested we document ideas that have been tried with lessons learned so as to not to repeat past mistakes. If old ideas were revisited, the City should approach with eyes open as to past barriers and issues as to why the strategy was not successful.

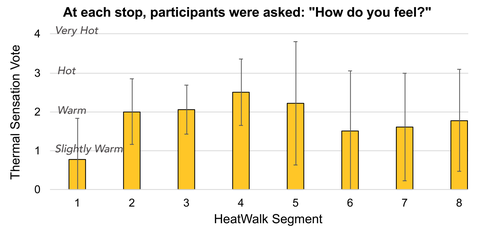
5.2) Heat Walk in Kiwanis Park:

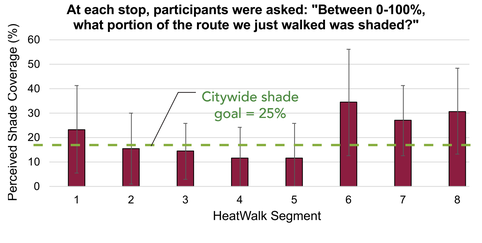
The heat walk occured on September 21, 2019 with Sky Harbor daytime high air temperature 96F, low 70F with sunny skies, light winds low; Sunrise: 6:15 am/ Sunset: 6:26 pm

Participant Info: 40 participants; 20 community members; 20 researchers, city staff, volunteers; 2 mile route through neighborhoods near Kiwanis Park; Walkers began at 1:00pm; Participants were interviewed along the route and completed short surveys at eight predetermined stops; Most participants were between 25 and 64 years old, 12 men, 8 women; 75% of participants live in Tempe, 50% live within a 20-minute walk of Kiwanis Park; 85% of participants said that they are very concerned or extremely concerned about; health risks from extreme heat to people in Tempe.

Figure 5a: Participants at the first Tempe Heat Walk event on September 21, 2019 at Kiwanis Park, Tempe, AZ.

Figure 5b (above): Tempe Heat Walk route through a variety of infrastructure.
Figure 5c (Below): Thermal sensation vote and perceived shade coverage for each segment. For example Segment 4 is the results of participants answers walking from stop 3 to 4 on College Avenue.





Findings:

- Data collection can be an engagement activity (such as informal questions from public, or formal Heat Walk)
- Heat walks help align thermal experience, MRT, and surface temperature data, and promote learning
- During mid-day, southern segment of College Ave was perceived as the hottest where it had the lowest amount of shade

Overall Lessons Learned & Next Steps:

- Create shared understanding of metrics and terminology
- Address and leverage better coordination between past, present, and future research-policy activities
- We don't understand enough about residents' thermal experience, and also need translate our thermal information
- City staff's perceived role in how heat is in their area of concern and action
- Need to build in time at end of project to reflect on past efforts, how to coordinate with new efforts, and passing the research forward

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