Urban Heat Island (UHI) Mapping and Tree Disparities in Laredo, Texas

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Urban Heat Island, Extreme Heat, Green Spaces, Tree Canopy, Environmental Justice, Climate Resilience

RioGrande International Study Center
RGISC

SCIENCE INFLUENCERS

TEXAS A&M INTERNATIONAL UNIVERSITY

Introduction and Background

- Extreme heat is the deadliest weather hazard in the United States, causing more deaths than hurricanes, floods, and tornadoes combined.
- Climate change intensifies the frequency and severity of extreme heat events, especially in urban areas lacking green infrastructure.
- Urban Heat Islands (UHIs) are caused by dense development, limited vegetation, trap heat, and elevated temperatures. Underserved communities are at higher risk of heat-related illnesses due to these UHIs.
- In 2022, Laredo had two heat-related deaths, a staggering increase of 15 heat-related deaths in 2023.

The CALOR Campaign

- In partnership with NOAA, the Rio Grande International Study Center (RGISC) launched Laredo's first Urban Heat Island (UHI) Mapping campaign as one of fourteen cities nationwide.
- The CALOR Campaign (Climate Action for Laredo to Organize Resilience) involved over 100 volunteers collecting 47,000 temperature and humidity data points across 70.4 square miles in nine routes.
- Environmental ground-level data was recorded at 1-second intervals in three collection times to understand heat distribution.
- RGISC's report will propose solutions and outline steps for climate resilience and environmental justice in Laredo and nearby communities in South Texas.

Objectives

- The campaign's objectives were to map heat distribution across residential, commercial, and industrial areas and capture daily temperature fluctuations in three collection times: 6-7 AM, 3-4 PM, and 7-8 PM.
- Aimed to create high-resolution heat maps to inform city planning and public health policy.
- Engage citizen scientists in a unique community science event to understand and advocate the dangers of excessive heat.
- Focused on promoting environmental justice in areas with limited green spaces and higher heat exposure.

Study Date

August 3rd, 2024

70.4 mi²
Study Area

110
Volunteers

9
Routes

47,647
Measurements

106.7°F
Max Traverse Temperature

11.0°F
Max Temperature Differential

HEAT WATCH

Data Collection – Campaign Day

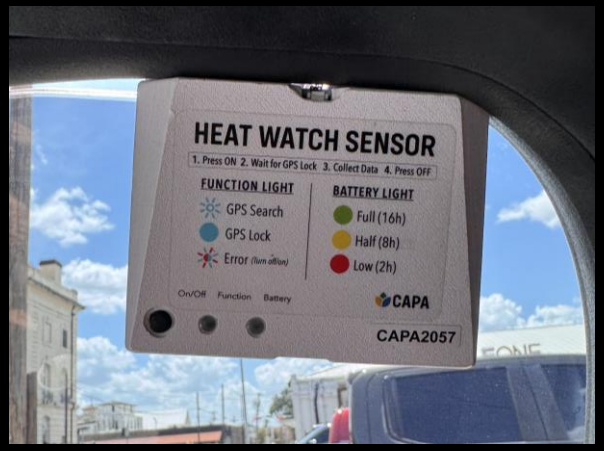
- Citizen scientists met at their assigned starting point in one of the nine routes and collected data for one hour following their predetermined route.
- Citizen scientists were trained in the data collection procedure, sensor setup on their vehicle, and sensor troubleshooting a week before the campaign.
- Each vehicle had a designated driver, a navigator, who provided directions of the route to the driver, and a note keeper to document observations during the route.

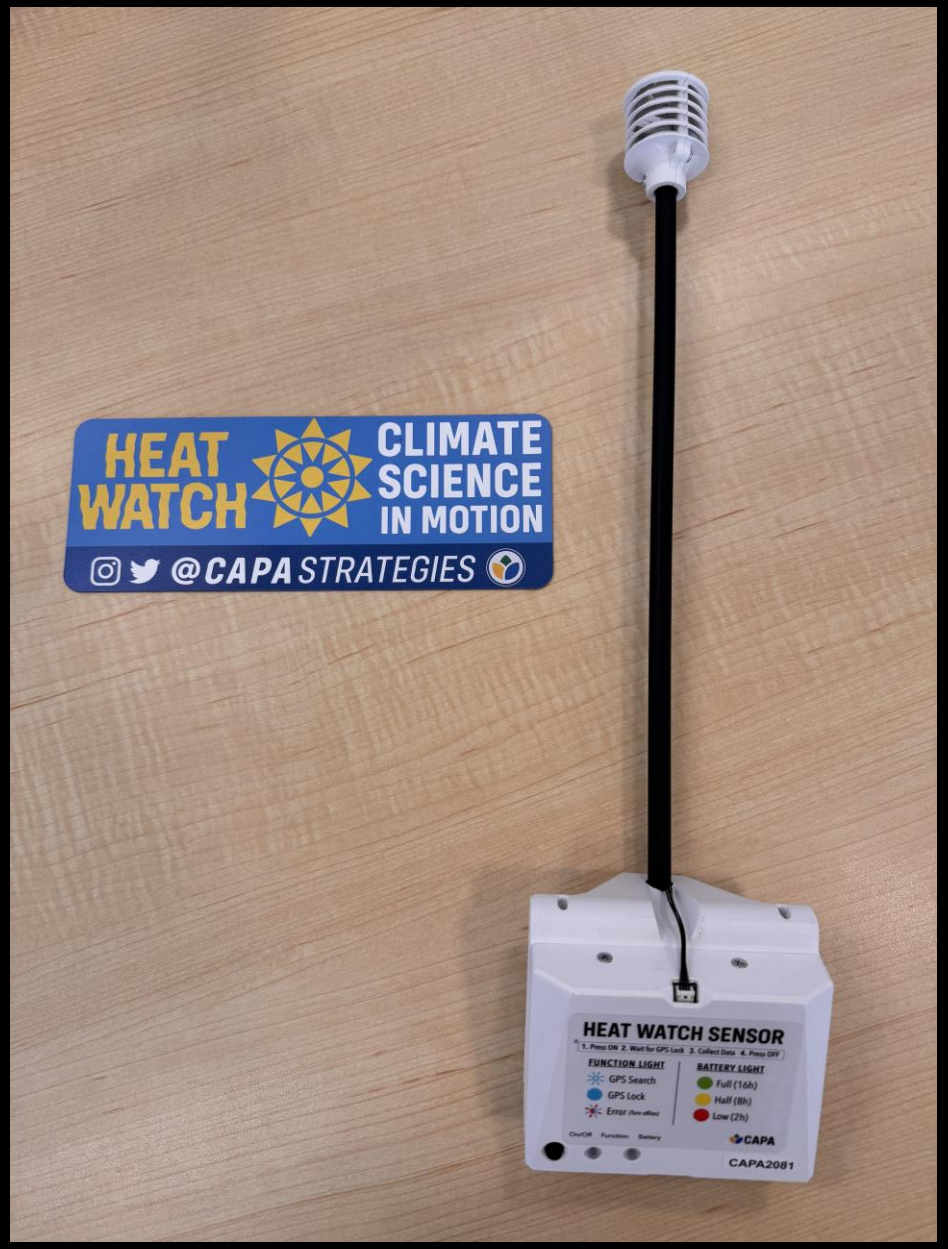
Sensors

- The sensors provided by CAPA Strategies collected temperature, humidity, and GPS data at 1-second intervals.
- Diurnal temperature changes and hyper-local heat patterns were recorded during the three collection times

  of 6-7 AM, 3-4 PM,

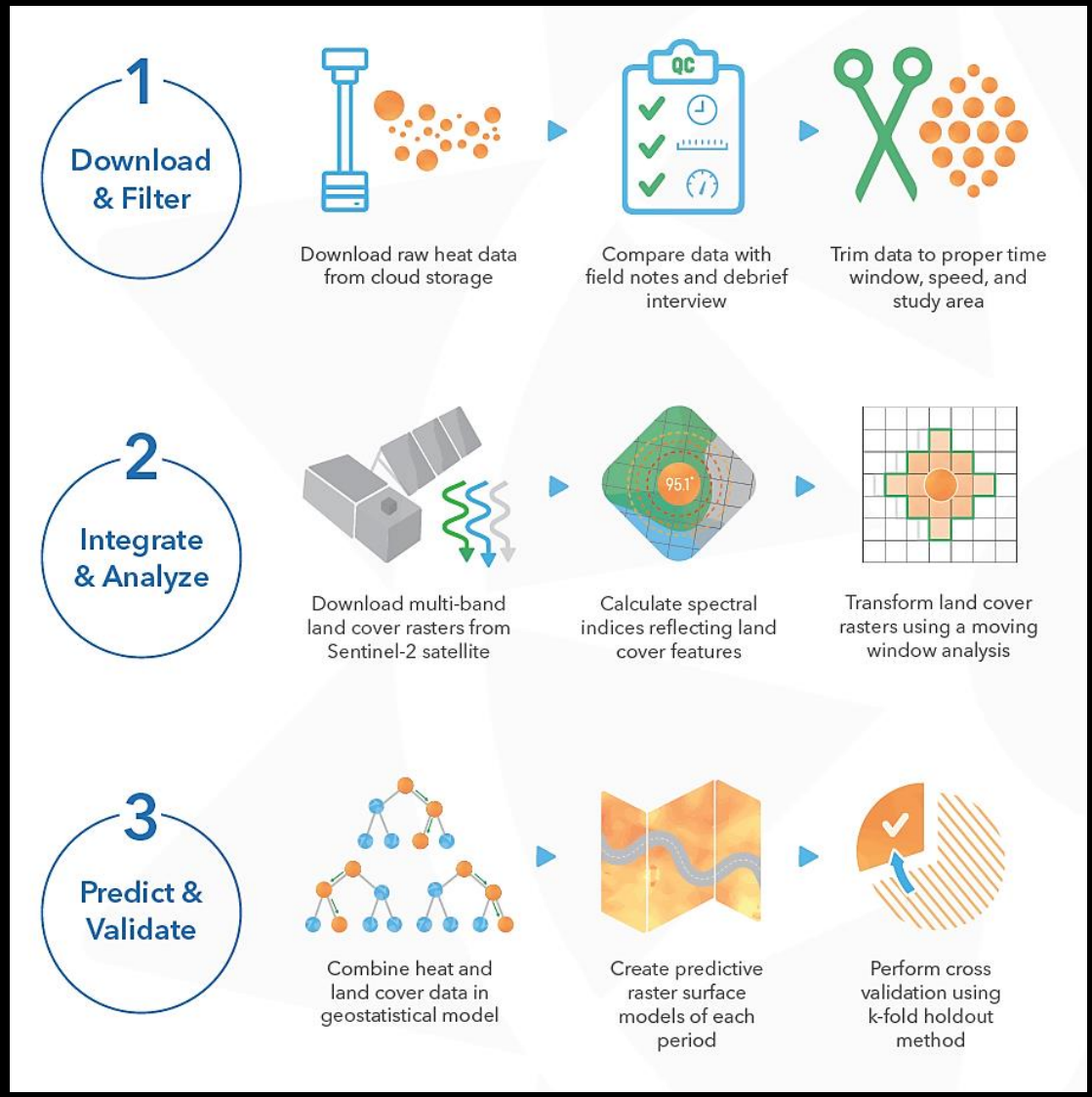
  and 7-8 PM.





Data Analysis

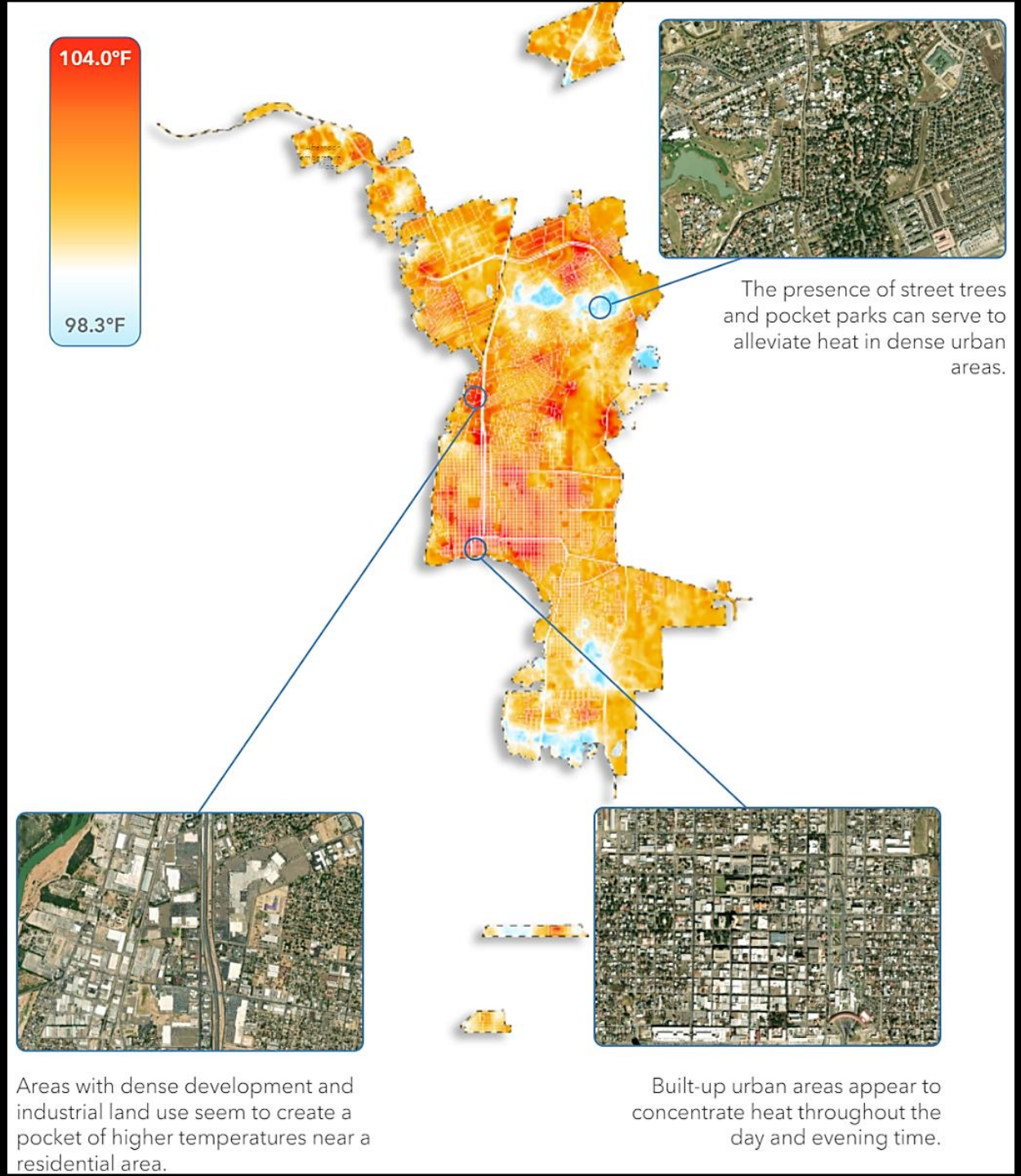
- CAPA Strategies used a geospatial modeling process to create high-resolution temperature maps from raw data in three steps:
- Step 1: Downloaded and filtered raw heat data, aligning with field notes and study parameters.
- Step 2: Integrated multi-band land cover data from Sentinel-2 satellites to calculate vegetation and surface features, identifying fine-scale urban heat patterns.
- Step 3: Combined heat and land cover data in a geostatistical model, using machine learning to generate predictive surface maps. Model accuracy was validated with k-fold cross-validation for reliability in planning and policy.



Results

- The study's results demonstrated the concentration of hotspots, especially in industrial zones and densely urbanized neighborhoods with minimal green infrastructure.
- These areas consistently experienced higher temperatures due to impervious surfaces such as concrete and asphalt, which absorb and retain heat.

Map of the afternoon heat distribution in Laredo from the 3-4 PM collection time, highlighting areas of concentrated heat in dense urban and industrial zones, with cooler pockets near street trees and parks.

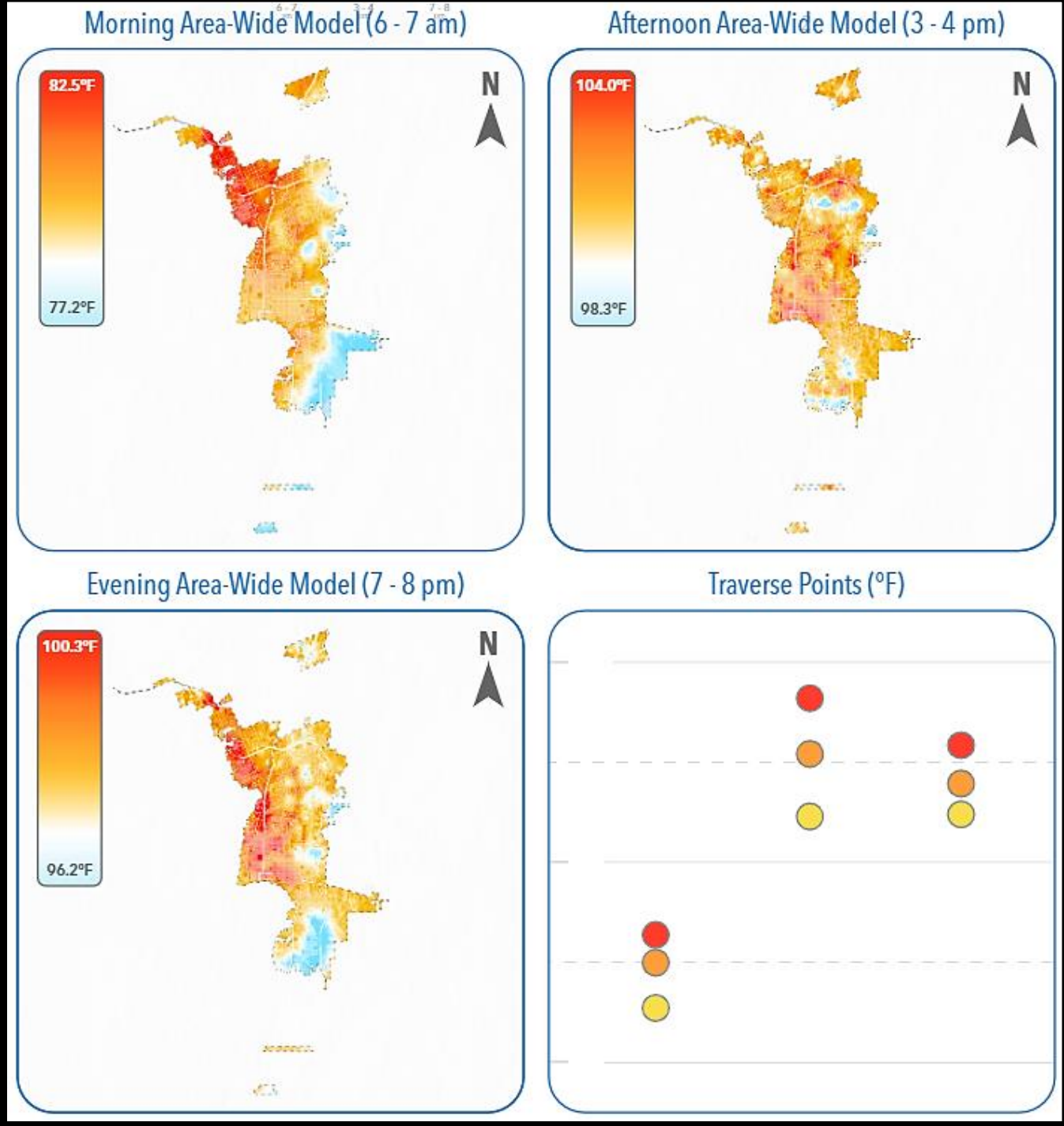


Accuracy Assessment*	
Model Period	Adjusted R-Squared
6 - 7 am	0.95
3 - 4 pm	0.58
7 - 8 pm	0.80

- CAPA strategies implemented a 70:30 holdout cross-validation method to ensure the predictive temperature model’s reliability.
- 70% of the data was for model training, while the remaining 30% was reserved for testing the model’s predictive accuracy.
- The model's performance is measured using an Adjusted R-squared value, which indicates the strength of the predictions. An Adjusted R-squared value of 1.0 reflects perfect predictability, while 0 signifies no predictive power.

Conclusions and Applications

- The CALOR campaign produced high-resolution heat maps, identifying heat hotspots in residential, commercial, and industrial zones in Laredo, Rio Bravo, and El Cenizo.
- Data from these maps will guide city planners in developing targeted climate strategies for vulnerable communities.
- Proposed urban design strategies include reflective building materials, cool pavements, and expanding Laredo's tree canopy to reduce heat and improve livability, especially in marginalized areas.



Conclusions and Applications

- Citizen scientists' involvement raised community awareness and fostered ownership, supporting long-term public engagement in climate initiatives.
- CALOR’s data provides a baseline for ongoing monitoring, enabling adaptation of strategies to ensure Laredo’s climate resilience through evidence-based approaches.