From Data to Action: How Urban Heat Mapping Campaigns Can Expose Vulnerabilities and Inform Local Heat Policy

Christopher Fuhrmann,[a] Andrew Robinson,[a] Charles Konrad,[a] Abhishek Bhatia,[b]

[a] *NOAA's Southeast Regional Climate Center, Department of Geography and Environment, University of North Carolina at Chapel Hill, Chapel Hill, NC*

[b] *Carolina Health Informatics Program, University of North Carolina at Chapel Hill, Chapel Hill, NC*

Corresponding author: Christopher Fuhrmann, fuhrman1@email.unc.edu

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KEYWORDS:

Heat, Mapping, Communities, Health, Vulnerability

WORKSHOP:

Exploring Heat-Related Vulnerability Using NOAA's Urban Heat Watch Mapping Campaigns

WHAT:

This 90-minute virtual roundtable brought together local organizers from several Urban Heat Watch campaigns as well as representatives from NOAA and CAPA Strategies to discuss how the data and maps generated through these campaigns can be used to better understand heat-related vulnerability and inform effective heat mitigation strategies designed to capture those populations who are most vulnerable.

WHEN:

12 February 2024

WHERE:

Online

Background

Extreme heat poses a major hazard in urban areas due in large part to the urban heat island. Differences in observed temperatures and associated health effects between urban and surrounding rural locations are well-documented (Yadav et al. 2023; Cheval et al. 2024). However, the complex nature of cities results in significant intra-urban variability in temperature as well as variability in the underlying demographic and social characteristics of the urban population. The growing appreciation for intra-urban temperature variability has led to field campaigns to measure the fine-scaled patterns of extreme heat across the urban landscape. Many of these campaigns have been conducted under the Heat Watch Program (NOAA 2024), which was developed by CAPA Strategies and is currently funded by NOAA. Since 2017, over 60 cities and communities have participated in the Heat Watch program, resulting in detailed machine learning-generated thermal "fingerprints" using data collected by volunteers. While these maps reveal the geographic distribution of heat across a city, there

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remains a gap in applying these data to better understand and respond to local-scale inequities in heat exposure.

In February 2024, the Southeast Regional Climate Center conducted a 90-minute virtual roundtable with local Heat Watch organizers from several campaigns, mostly across the Southeast. Representatives from the National Integrated Heat Heath Information System (NIHHIS), the National Weather Service (NWS), and CAPA Strategies also participated in the discussions. Prior to the roundtable, we shared preliminary results of an effort to explore intra-urban vulnerability to extreme heat by linking the mapping data from 20 different campaigns with commonly cited demographic and social risk factors at the Census tract level (see example provided in Figure 1). We also asked participants to fill out a short Google form, which included their role and contributions to their campaign(s) and what their team has done (or is planning to do) with the mapping data. Responses to these questions were used along with information from the preliminary study to craft a series of discussion questions and prompts with the goal of gaining insight into how we can develop effective policies and alert systems that address the complex and localized heat hazard in urban areas.

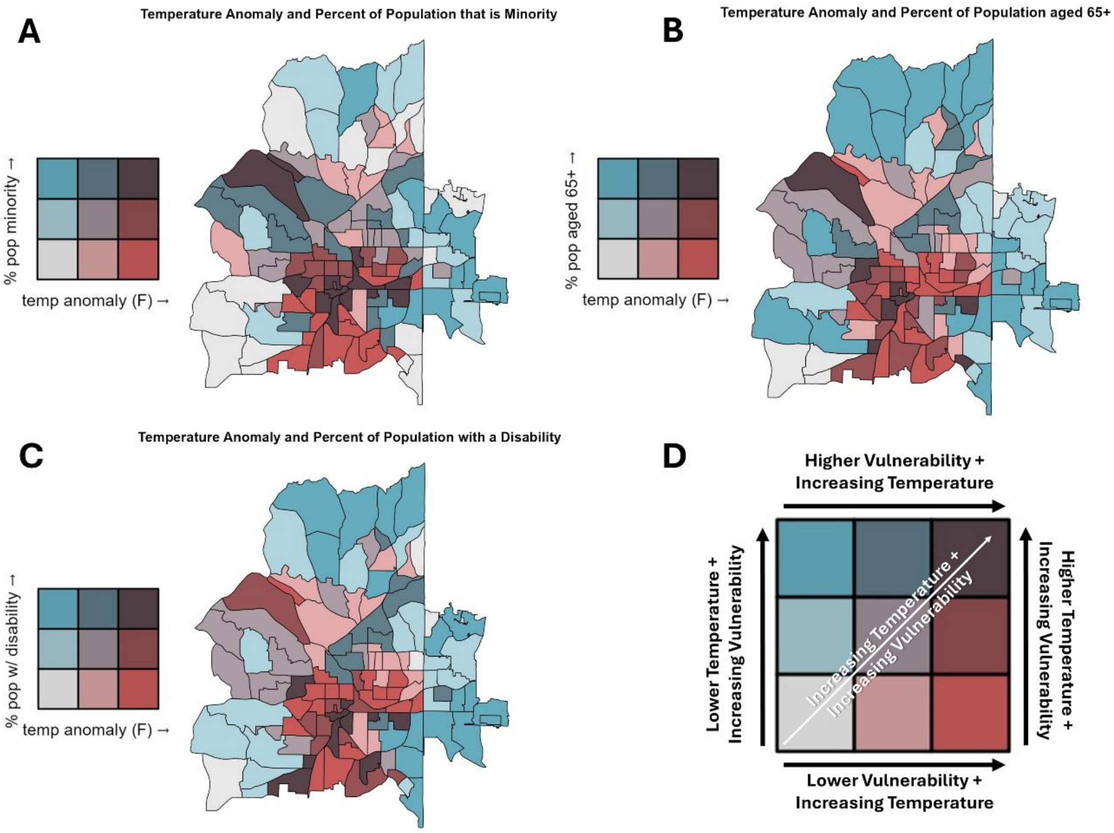

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Fig. 1. Bivariate maps showing the relationship between the average temperature anomaly calculated by combining mapping data and land cover information in a machine-learning model and (a) percent minority population, (b) percent elderly population, and (c) percent of population with a disability in Atlanta, GA using 2010 Census tract data. The 3x3 bivariate legend enlarged in (d) can be used by decision-makers to identify the geographic patterns of heat risk and visualize potential changes in temperature and vulnerability within the city.

Roundtable Discussion

The roundtable discussions were primarily guided by two overarching questions: how do we apply the mapping data to better understand and respond to local-scale inequities in heat exposure, and how can the data collected during these campaigns, combined with socioeconomic indicators, inform heat warnings and heat policies, particularly those that focus on more localized adaptation and mitigation strategies? Responses to these questions, as well as those posed in the preliminary study, yielded three themes (scale, engagement, and action), which are described below. We also identified several ideas for next steps in advancing progress on these themes.

Issues and considerations of scale

Heat risk is a growing concern in urban areas, and understanding the scale at which mitigation efforts are effective is crucial for developing comprehensive strategies. Tree planting programs are a common heat mitigation strategy, but their efficacy can vary depending on the scale of implementation. For example, assessing the impact of a single row of trees versus trees of different canopy types requires different approaches. The scale at which these programs are evaluated can influence the perceived benefits and inform future planning.

Census tracts are commonly used for assessing heat vulnerability (e.g. Hsu et al. 2021). They offer several advantages, such as providing a general picture of where disadvantaged populations reside in hot areas. Census tracts also align better with other datasets, particularly health data, making them more convenient for comprehensive analyses. However, Census tracts do not capture localized factors that contribute to heat risk, such as specific land use patterns or the presence of impervious surfaces and tree cover. Indeed, within a tract there can be significant localized variability in the capacity of communities and individuals to take action. In addition, while Census tracts are useful for obtaining funding, most scales of governance are not tied to these boundaries, limiting the actionability of the data generated at this scale.

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In cases where there are few tracts or exceptionally large tracts, Census blocks are used to more precisely identify vulnerable groups and the factors influencing heat risk. Analyzing data at the block level can result in more targeted interventions. However, even at this scale, pockets of vulnerability can exist beneath the block level, where most socioeconomic and health indicators are not available or discernible.

There are also issues of scale in heat risk communication. The NWS faces challenges in incorporating high-resolution mapping data and other census information into their alert systems, which are provided at the county level. Modifying forecast products to align with the sub-county resolution of the mapping data can lead to more effective communication of heat risks and the implementation of targeted mitigation efforts.

The temporal scale is also critical in heat risk mapping. Many heat mapping campaigns are conducted on just one day, and usually not on the hottest days, providing an incomplete picture of exposure. The information and tools needed for responding to acute heat events differ from those needed for long-term resiliency planning. Collecting data over time, rather than through "one-off" campaigns, is essential for developing baselines for heat exposure and quantifying potential benefits from mitigation programs like tree planting and cool roofs.

Communication and engagement

Effective communication and community engagement are crucial components in addressing the impacts of extreme heat on disadvantaged and vulnerable communities. Despite the availability of Census data to identify these communities, there remains a significant gap in awareness and understanding of heat risks among these groups.

As mentioned, Census data provide valuable insights into identifying disadvantaged and vulnerable communities. However, many community groups, while interested in addressing heat-related issues, do not recognize their own risks or possess the capacity to act. Part of this may be because they do not see heat as part of their organizational mission. This disconnect is further exacerbated by a lack of collaboration between heat watch organizers, city governments, and community organizations.

Effective engagement with communities requires building social capital, which involves establishing relationships and networks within the community. Community-based listening sessions have proven to be an effective method for engaging the general public, community leaders, and decision-makers. These sessions, conducted in collaboration with nonprofits, community centers, faith-based organizations, youth centers, school districts, and city

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governments, provide a platform for sharing information and identifying local leaders who are attuned to the community's experiences.

One major challenge is the disconnect between campaign organizers, city governments, and community organizations. This gap often results from differing scales of governance and priorities, as previously discussed. Campaigns that successfully bridge this gap are those that collaborate with boundary organizations, which link scientists, researchers, community leaders, and politicians. Building trust between these groups is essential, especially in communities that have experienced historical inequities such as redlining and gentrification.

Enhancing environmental and geographic literacy among community members is vital for effective engagement. Providing spatial context when presenting data, such as explaining the relationship between heat and landscape features, helps communities understand why certain areas are hotter than others. As an example, the use of bivariate mapping approaches, although potentially difficult for some audiences to interpret, can effectively visualize and illustrate heat vulnerability and disparities when properly explained (see Figure 1).

Relatedly, a significant barrier to self-identifying heat risks is the general lack of map literacy and resources to help communities interpret maps. Without spatial context, individuals may struggle to recognize their own risk simply by viewing a map. Developing tools or apps that link locational information with heat mapping data can help alert individuals to their risk, although this approach may introduce concerns related to surveillance and communication. Individual decision-making behaviors, priorities, and capacities also play a role in the effectiveness of communication. For instance, some NWS offices have started incorporating "calls to action" into their text products, specifying individual neighborhoods in their messaging and partnering with media and health communities to better convey localized heat risks.

Another barrier to effective communication is the potential disconnect between those obtaining information and the individuals they serve. For example, supervisors may discourage longer rest breaks despite employees' awareness of their heat-health risks. Addressing this barrier requires situational messaging that assigns specific thresholds and guidance to vulnerable populations, ensuring that actionable information is communicated effectively.

Taking action and prioritizing heat for policy

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Heat mapping products have become invaluable tools for cities and communities aiming to prioritize their limited resources effectively. Heat mapping data offer a clear visualization of temperature variations within urban landscapes, helping cities to pinpoint areas most affected by extreme heat. These maps enable local governments to allocate resources where they are most needed, enhancing the efficacy of their interventions.

Securing funding is essential for translating heat mapping data into actionable strategies. Various grants and funding sources, such as the Inflation Reduction Act (IRA), FEMA's Building Resilient Infrastructure and Communities (BRIC) grants, the U.S. Department of Housing and Urban Development (HUD), and the U.S. Forest Service (USFS), have supported communities in their heat mitigation efforts. These financial resources help build local capacity through community engagement and applied research.

Addressing heat effectively requires an understanding of how it intersects with other hazards and vulnerabilities. For instance, areas with compound hazards such as flooding, historical redlining, food deserts, and energy insecurity, often face exacerbated heat risks. Identifying these intersections allows for more comprehensive and effective mitigation strategies. Communities can prioritize heat through various practical measures:

- Integrating heat data into state hazard maps and resilience plans
- Implementing heating and cooling centers within school systems.
- Enhancing housing weatherization to better withstand extreme temperatures.
- Collaborating across health, social services, public transportation, urban agriculture, housing, parks, and recreation sectors

Different parts of a city may experience similar heat patterns but have vastly different resources. For example, a commercial district may be well-equipped to handle heat, while a neighborhood with high poverty levels may struggle. Additionally, some mitigation strategies face resistance due to cost and efficacy concerns, such as the debate between tree planting and building shade structures.

Mapping data can provide a foundation for future investments and opportunities, such as NOAA's National Strategic Plan for heat. However, challenges remain, particularly the discrepancy between the scales of actionable information and funding generation. For instance, while Census tracts may determine funding allocation, they may not provide the detailed data needed for precise interventions.

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Most funding opportunities and programs operate at higher levels than where individual actions can be taken. To bridge this gap, it is crucial to identify priorities that resonate with communities and decision-makers. Offering incentives and demonstrating clear benefits can encourage participation and ensure the success of heat mitigation strategies.

Next Steps

Integration of stationary and wearable sensors. To gain a deeper understanding of heat exposure and the effectiveness of mitigation strategies, incorporating stationary sensors into heat mapping campaigns is essential. Stationary sensors typically provide continuous, high-resolution data on local temperature variations. Wearable sensors, such as iButtons, could be used to measure personal heat exposure, offering insights into individual experiences of heat stress. By assessing the efficacy of mitigation strategies—such as the use of reflective materials to alter the local energy budget—these data can guide more effective interventions. For instance, tracking how reflective surfaces influence microclimates and personal comfort can help refine approaches to heat mitigation.

Expansion of heat metrics and thermal comfort measures. Current heat mapping efforts often rely on traditional metrics like air temperature, which may not fully capture the complexities of heat impacts. To enhance resilience planning, it is crucial to incorporate additional heat metrics such as the wet bulb globe temperature (WBGT), which accounts for temperature, humidity, wind speed, and solar radiation. Moreover, measures of thermal comfort that consider human energy balance are vital for a comprehensive understanding of heat stress. Integrating these metrics into heat assessments will provide a more nuanced view of how heat affects different populations and help tailor interventions to specific needs.

Enhancing spatial granularity in heat maps. Improving the spatial resolution of heat maps is critical for understanding temperature variations at a finer scale. By increasing granularity to sub-neighborhood and sub-block levels, we can account for localized differences in temperature, wind patterns, radiation, and moisture. This detailed spatial context enables more targeted and effective mitigation strategies, addressing heat disparities within communities and optimizing resource allocation.

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Extending the duration of mapping campaigns. To better evaluate the impact of mitigation measures and develop a robust baseline of urban heat, it is necessary to extend the duration of mapping campaigns. Conducting studies over several weeks or across multiple seasons allows for the observation of long-term trends and the effects of interventions such as cool roofs and urban greening projects. This extended timeframe will facilitate the tracking of temperature changes and energy burden reductions, providing useful data for forecasters and decision-makers to enhance heat warnings and resource distribution.

Aligning heat data with health indicators. Examining health indicators from the most recent National Climate Assessments (NCA) and state health assessments is crucial for aligning heat data with public health outcomes. Identifying health metrics that correlate with heat exposure and are relevant to specific communities will help prioritize interventions and tailor public health strategies. For example, linking heat mapping data with incidence rates of heat-related illnesses can inform targeted health advisories and preventive measures.

Establishing best practices for community engagement. Effective community engagement is key to the successful implementation of heat mitigation strategies. Establishing a set of “best practices” for engaging with communities involves understanding the appropriate scales for presenting heat data and fostering collaboration with local stakeholders. Engaging communities in meaningful ways ensures that heat mitigation strategies are well-received and tailored to local needs, enhancing their effectiveness.

Exploring funding opportunities and building social capital. Securing state and federal funding for community engagement and resilience building is essential for sustained impact. Exploring funding sources that promote community involvement and support social capital can facilitate the development of robust heat mitigation programs. These resources will enable the implementation of strategies that are both technically sound and community driven.

Integrating heat with other hazards. Finally, aligning heat data with other hazards tracked by federal and state agencies is critical for a holistic approach to urban resilience. Understanding the connections between heat and other environmental hazards, such as air quality or flooding, allows for more comprehensive risk management. Continued efforts to “build bridges” at the community level will enhance the effectiveness of hazard mitigation strategies and improve overall resilience.

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