High-resolution Measurement of Transit Riders' Extreme Heat Exposure across U.S. Cities

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Center Name: Center for Equitable Transit Oriented Communities (CETOC)

Research Priority: Preserving the Environment

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Project Description: Extreme heat events, exacerbated by climate change and urban heat island effects, pose severe risks to public health and urban infrastructure. Public transit riders, especially in densely populated urban areas, are disproportionately affected by heat due to factors such as extended outdoor times, high urban temperatures, and inadequate heat-mitigating infrastructure. Transit based heat exposure is a critical social equity issue, as it disproportionately affects vulnerable and marginalized population due to disparities in access to cooling, housing, mobility, and workplace conditions. However, very few studies focus on the heat exposure of public transit riders. The challenges are twofold. First, prior studies do not consider exposure time as a factor in the calculation of heat exposure. With the longer walking and waiting time due to public transit's low reliability and first/last-mile problem, exposure time can be as important as the temperature. Second, there is a lack of high-resolution thermal comfort data at the individual level to sustain this measurement. Prior studies largely use air or ground temperature as the proxy of personal thermal comfort, which is not accurate enough to represent public transit riders' experience. To calculate a high-fidelity, high-resolution exposure during each transit trip, we need to calculate the fine-grained transit time and the corresponding thermal comfort temperature. To address these gaps, we propose a new system – Transport Heat Exposure Index (THEI) – as a comprehensive approach to quantify and analyze heat exposure across public transit systems. With high-performance computation and deep learning techniques, we will process high-resolution (1 meter) historical meteorological data, public transit General Transit Feed Specification (GTFS) schedule and real-time data, and urban 3D built environment

data, including bus stops shelter, street-level tree canopy, buildings, and sidewalk inventory. The objective of this research is to develop a state-of-the-art framework to gauge high-resolution heat exposure of transit riders when accessing different destinations with urban microclimate modeling and detailed transit network routing techniques. With the empirical findings and the methods, researchers and policymakers can more effectively understand heat exposure nuances and devise strategies to mitigate its public and urban impacts. Such insights will foster targeted interventions and informed planning, enhancing community resilience and social equity against escalating extreme heat events.

USDOT Priorities: *Infrastructure*: Measuring and mitigating heat exposure in public transit systems is critical for developing heat-resilient infrastructure. The use of advanced urban microclimate simulation techniques and the consideration of tree canopies and building shades in our analysis contribute to designing infrastructure that can withstand the impacts of extreme heat and climate change. *Environmental Sustainability*: By tackling the increasing challenge of extreme heat events exacerbated by climate change and improving our understanding of heat exposure in public transit systems and developing strategies to mitigate this exposure, our project supports efforts to adapt to climate change and enhance environmental sustainability. *Equity*: By focusing on public transit riders, especially vulnerable communities without reliable transportation alternatives and aiming to reduce heat exposure for these populations, our project contributes to achieving mobility equity and ensuring that transportation systems serve all communities fairly. *Engaging Transformative Research*: The development of the THEI and the comprehensive analysis of heat exposure sources represent significant advancements in the field and offers practical tools for policymakers and urban planners to develop targeted interventions.

Outputs: 1. A new methodology to measure transit-based heat exposure by analyzing GTFS, high-resolution meteorological data, and built environment data. 2. A new framework to guide planners and transit authorities understand heat exposure and simulate the effects of potential changes in infrastructure or service patterns. 3. A comprehensive transit heat exposure database available to the public. 4. A technical report 5. Manuscript(s) for publication and presentation.

Outcomes/Impacts: The THEI could lead to new guidelines or standards for managing heat exposure in public transit systems, influencing local and national transportation policies. Data-driven insights into the impact of heat on vulnerable populations could drive legislative efforts to allocate funding for climate adaptation strategies in public transit and urban infrastructure. The THEI system could aid in bus shelter and transit stops redesigns, potentially including features like solar-powered fans or water mist systems. The insights can also improve route and schedule planning, increasing ridership, safety and comfort. The system can encourage the integration of tree canopies and vertical gardens in urban transit corridors to naturally reduce ambient temperatures and enhance the urban microclimate. By reducing the risk of heat-related illnesses among transit users, the project enhances the overall safety and health of the public transit environment. The system can improve thermal comfort and increase ridership and satisfaction, thereby enhancing the reliability and quality of transit services. Effective heat mitigation strategies can also lead to cost savings by reducing the healthcare burden from heat-related illnesses and lowering energy costs through more efficient infrastructure design.

Final Research Report: (Link to be provided after project completion).