**Bridgeport Urban Development**

*Leveraging NASA Earth Observations and Sociodemographic Data to Assess Urban Heat Vulnerability and Inform Cool Corridors in Bridgeport, Connecticut*

**Project Team**

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**Project Overview**

***Project Synopsis:***

Groundwork Bridgeport is concerned about the Bridgeport’s resiliency to urban heat as the climate crisis intensifies, as well as the disadvantaged East Side communities’ heightened vulnerability to this environmental hazard. By combining satellite data from Landsat 8 TIRS and Landsat 9 TIRS-2 with sociodemographic and socioeconomic data, our team analyzed the city’s urban heat distribution and created urban heat vulnerability maps. Ultimately, these end products will support Groundwork Bridgeport in identifying areas to connect with residents for their Cool Corridors project and other cooling interventions.

***Abstract:***

Urban environments face hotter temperatures than suburban and rural areas due to higher concentrations of impervious surfaces, heat-retaining buildings, and lack of green space. Bridgeport, Connecticut, which was formerly a national manufacturing hub, is now the densest and most populous city in the state. Bridgeport experiences hotter temperatures, exposing its residents to more extreme temperatures than the surrounding affluent suburbs. Extreme heat affects the health of those exposed to it and intensifies energy demands. Understanding temperature differences is the first step in effectively directing mitigation efforts. Our partner, Groundwork Bridgeport, along with the Yale Urban Design Workshop, are planning a “cool corridors” project, implementing cooling infrastructure to combat urban heat. We used Landsat 8 Thermal Infrared Sensor and Landsat 9 Thermal Infrared Sensor-2 data to conduct a Land Surface Temperature analysis in Google Earth Engine for the county of Fairfield. A Principal Component Analysis was performed to identify indicators of social vulnerability in Bridgeport. We used the SOlar and LongWave Environmental Irradiance Geometry model to identify felt heat on the block level to inform where the partner should locate their cooling interventions to ensure they are most effective and equitable. We focused on the East Side of Bridgeport, which we found was 10 degrees hotter than other areas of Bridgeport and the neighboring town of Fairfield. We integrated our findings using Earth observations and additional sociodemographic and climate data into final communication products for our partners which will facilitate their selection of candidate locations for their Cool Corridors project.

***Key Terms:***

Urban Heat, Land Surface Temperature, Remote Sensing, Social Vulnerability Index, Principal Component Analysis, SOLWEIG Modeling, ArcGIS Pro

***Application Area:*** Urban Development

***Study Location:*** Bridgeport, CT (focus on the East Side with census tracts 735, 736, 738, 739, and 740)

***Study Period:*** 2013 to 2023 (June to September)

***Community Concerns:***

* As global temperature highs increase year after year due to anthropogenic climate change, urban areas face disproportionately hotter temperatures compared to rural and suburban environments due to their lack of green space and higher density of impervious surfaces. In Bridgeport, Connecticut, increasing summer temperatures over the past decade have resulted in increasingly and disproportionately high-temperature extremes compared to the surrounding Fairfield County.
* Extreme heat can be deleterious to human health, particularly when individuals face extended exposure or have pre-existing health vulnerabilities. Extreme heat causes an increase in total morbidity and cardiovascular and respiratory hospital visits. The elderly, youth, individuals with mental illness, and people with pre-existing cardiovascular and respiratory illnesses are more sensitive to a dramatic increase in temperature.
* Hotter temperatures lead to more energy use, particularly in peak hours, stressing power grids and potentially causing rolling blackouts or brownouts. This increased energy use also leads to more spending, a particular concern for Connecticut residents given that the state has the fourth most expensive energy in the country.
* Compared to the rest of Fairfield County, the East Side neighborhood of Bridgeport faces uniquely high rates of poverty and a majority of the residents are non-white. Community members in the East Side have been vocal about their concern with extreme heat in their neighborhood and the Cool Corridors project will mitigate temperatures in areas that are best suited for the intervention, restoring comfort to an underserved area during the summer months.

***Project Objectives:***

* Quantify Median Land Surface Temperature (LST) for Fairfield County and the city of Bridgeport at the Tract and Block Group levels
* Create a social vulnerability index (SVI) at the Block Group level with partner oversight
* Quantify Heat Vulnerability Scores (HVS) for the city of Bridgeport at the Block Group level using SVI and Principal Component Analysis
* Combine the Median LST for Bridgeport with the HVS to select specific Block Groups for analysis
* Analyze urban heat using SOlar and LongWave Environmental Irradiance Geometry (SOLWEIG) modeling

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **Contact (Name, Position/Title)** | **Partner Type** | **Sector** |
| **Groundwork Bridgeport** | Christina Smith, President and CEO/Executive Director  | End User | Non-profit |
| **Yale Urban Design Workshop** | Andrei Harwell, Faculty Director | Collaborator | Non-profit/University |

***Decision-Making Practices & Policies:***

Groundwork Bridgeport’s decision-making is rooted in multi-level, community-driven planning processes. For the Cool Corridors project, they are hosting multiple public gatherings with the community to identify highly traveled routes and public opinion about resiliency and intervention techniques (of present and potential future). Groundwork Bridgeport remains in the planning phase of its Cool Corridors project. In prior proposals for the project, Groundwork Bridgeport indicated that they would place their cooling interventions between parks, though there was little explanation on how these corridors between parks would be identified, prioritized, or deployed. Groundwork Bridgeport has a volunteer base that conducts neighborhood surveys about forthcoming projects to incorporate community feedback in their plans, but there was no heat assessment within the East Side in their decision-making process before this project began.

**Earth Observations & End Products Overview**

***Earth Observations:***

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| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 8 TIRS** | Land surface temperature (for temperature anomaly) | TIRS will provide thermal analysis data for daytime land temperatures. |
| **Landsat 9 TIRS-2** | Land surface temperature (for temperature anomaly) | TIRS-2 will provide thermal analysis data for daytime land temperatures. |

***Ancillary Datasets:***

* USGS 3DEP LidarExplorer LiDAR Digital Elevation Models – Input for SOLWEIG modeling
* USGS 3DEP LidarExplorer LiDAR Point Clouds – Calculate Digital Surface Model (DSM) for SOLWEIG modeling
* National Solar Radiation Database Meteorological Data – Input weather and climate data for SOLWEIG modeling
* Connecticut ASOS (ASOS-AWOS-METAR) – Input precipitation data into SOLWEIG modeling
* US Census Bureau American Community Survey Data, 2021 5-Year Survey – SVI factors for Principal Component Analysis

***Models:***

* SOLWEIG (Contact: Dr. Mehdi Heris, Hunter College) – Model outdoor thermal comfort through the mean radiant temperature at a high-resolution scale
* UHEAT (Contact: Char Tomlinson, Participant) – Compile and average surface temperatures

***Software & Coding Languages:***

* Google Earth Engine JavaScript API – Acquire data and calculate daytime LST
* ESRI ArcGIS Pro 3.0.0 – LST analysis, Bivariate Mapping
* R 4.3.2 – Adapted UHEAT 1.0 to conduct a Principal Component Analysis
* QGIS 3.34.2 – Used SOLWEIG, Urban Multi-scale Environmental Predictor (UMEP) plug-in

***End Products:***

|  |  |  |
| --- | --- | --- |
| **End Products** | **Earth Observations Used**  | **Partner Benefit & Use** |
| **Urban Heat****Assessment Map****Package** | Landsat 8 TIRS and Landsat 9 TIRS-2 | These maps and visualizations displaying empirical urban heat distribution in Bridgeport will assist partners in their urban heat analysis and help inform their outreach initiatives to decide on cooling intervention strategies and locations. |
| **Urban Heat****Vulnerability****Map Package** | Landsat 8 TIRS and Landsat 9 TIRS-2  | This bivariate map builds upon theurban heat assessment maps bycreating and integrating a vulnerabilityindex, which includes sociodemographic and socioeconomic indicators relevant topartner interest. This will support the partners in the assessment of vulnerability and prioritization of certain areas for cooling interventions and advocacy. |
| **Urban Heat****Intervention****Modeling or Case****Study** | USGS LiDAR Point Clouds and Digital Elevation Models | This modeling will produce large-scale maps that visualize how heat is felt and experienced in the East Side’s most vulnerable areas to inform cooling intervention strategies and locations. |
| **Creative****Communication****Deliverable – Two-Page Impact Flyer** | Landsat 8 TIRS, Landsat 9 TIRS-2, USGS LiDAR Point Clouds and Digital Elevation Models | Two-page impact flyer about urbanheat and vulnerability willsupport the partners in their community engagement and education efforts. |

***Product Benefit to End User:***

The ultimate benefit that these products will provide to the end user is an assessment of urban heat on the Block Group level that can inform the location of their Cool Corridors project. After analyzing social variables that relate to heat vulnerability in Bridgeport and integrating this with an LST analysis, the products indicate which areas have the greatest need for cooling interventions. Beyond this, the LST analysis at the Block Group level for the city and at the Tract level for the county can be distributed publicly to educate the public and inform additional heat interventions in the region, addressing where there are deficits to enhance equity. The end user expressed interest in using these maps in continued advocacy efforts that do not yet have an associated project.

**References**

Bark, N. (1998). Deaths of Psychiatric Patients During Heat Waves. *Psychiatric Services*, *49*(8), 1088–1090. <https://doi.org/10.1176/ps.49.8.1088>

Klein Rosenthal, J., Kinney, P. L., & Metzger, K. B. (2014). Intra-urban vulnerability to heat-related mortality in New York City, 1997–2006. *Health & Place*, *30*, 45–60. <https://doi.org/10.1016/j.healthplace.2014.07.014>

Larson, Andrew. (2024, February 28). Study: CT ranks 4th for most expensive electricity in U.S. *Hartford Business Journal*. <https://www.hartfordbusiness.com/article/study-ct-ranks-4th-for-most-expensive-electricity-in-us#:~:text=A%20new%20study%20from%20Texas,followed%20by%20Maine%20and%20Florida>

United States Environmental Protection Agency. (2023). *Heat Island Impacts*. EPA. <https://www.epa.gov/heatislands/heat-island-impacts>