**New York City Transportation & Infrastructure**

*Assessing Urban Heat Island Effects at Bus Stops in New York City to Support Cooling Interventions*

**Project Team**

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**Project Overview**

***Project Synopsis:***

Urban heat in New York City (NYC), NY is exacerbated by the city’s built environment, leading to the urban heat island effect. Oppressive public policies have perpetuated inequities in shade distribution and heat exposure along lines of race and class, having serious implications on extreme heat exposure while taking the bus. Utilizing Landsat 8 TIRS and Landsat 9 TIRS-2 data, we mapped the Urban Heat Island Effect and created a Transportation and Heat Vulnerability Index using social, transportation, and environmental data for NYC. This analysis supports our partner Transportation Alternative’s efforts to increase transportation accessibility within the city.

***Abstract:***

New York City, the most populous city in the United States, is threatened by exacerbated heat exposure due to the urban heat island (UHI) effect induced by its heavily urbanized environment and limited tree canopy cover. Decades of racist policy and planning have led extreme heat to disproportionately impact people of color and low-income residents, especially in the context of public transportation by bus. This NASA DEVELOP project partnered with Transportation Alternatives to identify the most heat vulnerable populations in the city, characterize the extent of urban heat, and complete an individual bus stop analysis. We utilized NASA Earth observations, including Landsat 8 Thermal Infrared Sensor (TIRS) and Landsat 9 TIRS-2 to determine UHI extent and anomalies. Leveraging data from the City of New York and the American Community Survey (ACS), we constructed a transportation-specific heat vulnerability index to understand intersecting social and economic vulnerabilities by performing a Principal Component Analysis. After identifying major hotspots in the Bronx, Queens, and Brooklyn, we modeled mean radiant temperature at the hottest and highest ridership bus stops identified by our UHI analysis to estimate thermal comfort using the Urban Multi-scale Environmental Predictor’s SOLWEIG tool. Our end products will be incorporated into Transportation Alternative’s Spatial Equity NYC dashboard and inform their community engagement strategies as they organize with residents to advocate for cooling interventions.

***Key Terms:***

Environmental Justice, urban heat islands, public transportation, vulnerability, remote sensing

***National Application Area Addressed:*** Transportation & Infrastructure

***Study Location:*** New York City, NY

***Study Period:*** 2017 to 2022 (May to September)

***Community Concerns:***

* The urban heat island (UHI) effect in NYC is caused by the over-abundance of solar radiation-absorbing impervious surfaces, such as roads and buildings, and the lack of green space and canopy cover. Extreme heat and the UHI effect are health hazards, as overexposure cause heat stroke, cardiovascular disease, or even death.
* Due to a history of redlining in NYC, extreme heat and UHI effects disproportionately affect people along the lines of class and race.
* The UHI effect impacts transportation accessibility in NYC as people are exposed to extreme heat while walking to and waiting for buses.

***Project Objectives:***

* Analyze the extent of the UHI in NYC by comparing Daytime Land Surface temperatures with those of a rural reference
* Determine the most vulnerable districts of the city using a Principal Component Analysis (PCA) composed of social, transportation and environmental variables
* Determine the most vulnerable bus stops and routes within NYC city
* Create map layers of heat and vulnerability that can be used in Transportation Alternative’s Spatial Equity NYC dashboard
* Provide data for advocacy work for a just distribution of cooling measures as NYC redesigns bus routes

**Partner Overview**

***Partner Organization:***

|  |  |  |
| --- | --- | --- |
| **Organization** | **Contact (Name, Position/Title)** | **Partner Type** |
| **Transportation Alternatives** | Philip Miatkowski, Director of Research;  Em Friedenberg, Senior Research Associate | End User |

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

Transportation Alternatives (TA) is a non-profit organization with a fifty-year legacy of advocacy and community organizing for the reclamation of public space from cars in New York City. Originally focused on increasing bike accessibility, their mission has expanded to creating safer, more equitable streets and most recently addressing urban heat. TA has been involved in this cause by promoting awareness of urban heat and other issues to local policy makers, especially through their Spatial Equity NYC dashboard and the 25x25 projects that display transportation-justice data. TA only has a small and relatively new research team and are inexperienced with remote sensing and geospatial data. Because of this, many of their projects have been produced by working through contractors such as the Massachusetts Institute of Technology. TA can use Earth observations and geospatial data to create visualizations of transportation and heat within the city to support their grassroots advocacy efforts.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Landsat 8 TIRS** | Daytime land surface temperature (2017-2021) | Land surface temperature data from 2017 to 2021 were collected alongside data from Landsat 9 TIRS-2 data to calculate median land surface temperature for the study period and subsequently calculate the daytime UHI factor relative to a rural reference. |
| **Landsat 9 TIRS-2** | Daytime land surface temperature (2022) | Land surface temperature data from 2022 were collected alongside data from Landsat 8 TIRS data to calculate median land surface temperature for the study period and subsequently calculate the daytime UHI factor relative to a rural reference. |

***Ancillary Datasets:***

* National Land Cover Database (NLCD) Tree canopy cover – Average percent of tree canopy per census tract was included as a variable of physical/environmental vulnerability in the PCA
* US Census Bureau American Community Survey Demographics – Percent poverty, percent minority, percent work from home, population older than 65, median household income, commute by bus variables were included in the PCA to represent factors that may make populations more vulnerable to heat
* US Census Bureau Census tract boundaries – Geographic unit for the PCA
* City of New York Boroughs – Study shapefile
* City of New York City Council Districts – Used to create the bivariate maps at the level of city council districts
* City of New York Community Districts – Used to create the bivariate maps at the level of community districts
* City of New York Air Pollution Rasters – PM2.5 raster included as a variable of physical and environmental vulnerability in the PCA
* City of New York Bus Stop Shelters – Bus shelters, per Census tract, included in the PCA
* Bus Wait Times and Annual Bus Ridership, Metropolitan Transportation Authority – Used in the PCA to represent areas of high bus ridership

***Modeling:***

* Urban Multi-scale Environmental Predictor’s SOlar and LongWave Environmental Irradiance Geometry model (UMEP SOLWEIG) – Model mean radiant temperature (Tmrt) as a metric of human thermal comfort.

***Software & Scripting:***

* Google Earth Engine – Retrieve, cloud mask, and quality check daytime land surface temperature data from Landsat 8 TIRS and 9 TIRS-2
* Esri ArcGIS Pro 3.1.0 – Process data for the PCA, create the bivariate maps, and calculate the UHI effect using zonal statistics and raster calculator functions
* QGIS 3.28.3 – Use UMEP SOLWEIG plug-in to model mean radiant temperature
* R 4.2.2 – Process and collect variables for the PCA
* Google Colaboratory – Run the PCA

***End Product(s):***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Urban Heat Assessment Map Package** | Landsat 8 TIRS, Landsat 9 TIRS-2 | This map package will include a UHI factor map that highlights heat islands in the city and a vulnerability map that demonstrates the most heat sensitive districts. These visualizations will inform and support community advocacy in the most vulnerable districts. | N/A |

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

The UHI factor raster will highlight the UHIs in the city by comparing the city’s daytime temperatures with those of a rural reference. The heat vulnerability bivariate maps will highlight the districts with the most vulnerable populations and the highest temperatures. Both of these maps are easily comprehendible so that they can be used to inform community members and policy makers of the urban heat issue in the city. TA can include these analyses and map layers in their Spatial Equity dashboard, which will ultimately inform cooling interventions, community engagement strategies, and funding allocation. These results will also enhance TA’s ability to use Earth observations and geospatial data to support their advocacy.

**References**

US EPA. (2014, February 28). *Heat Island Effect* [Collections and Lists]. <https://www.epa.gov/heatislands>