**New York City Urban Development**

*Mapping Hotspots using NASA Earth Observations to Inform Future Green Initiatives in New York City*

**Project Team**

***Project Team*:**

Scott Harrison (Project Lead)

Josi Robertson

Luis Garcia Falcon

Brianna McCardle

***Advisors & Mentors*:**

Dr. Kenton Ross (NASA Langley Research Center)

Sydney Neugebauer (NASA Langley Research Center, DEVELOP Fellow)

**Project Overview**

***Project Synopsis*:** Urban heat islands pose a significant risk to human health. The identification of hotspots in New York City is reliant upon historical temperature data. NASA Earth observation data from the Landsat series and land use data from the National Land Cover Database (NLCD) was used to create a geodatabase of historical hotspots and land cover. This geodatabase, combined with demographic and zoning data, will help our partner organizations, the City of New York Mayor’s Office of Resiliency and the NYC Department of Health and Mental Hygiene, design effective green initiatives. Furthermore, an ArcGIS workflow will create a map of historically at-risk areas in New York City.

***Abstract*:**

The effect of urban hotspots is a growing public health concern. In the face of climate change and urbanization, city dwellers are at increasing risk for heat-related illness and mortality. New York City (NYC) is especially vulnerable to heat-related illness because of extreme population density and projected population growth. A plan to mitigate the dangers of future heat-related illness is paramount. This project utilized NASA Earth observations to identify hotspots from 1990-2019 within the five boroughs of NYC and create geodatabases of hotspot locations, land use, and land cover. Earth observations utilized included Landsat 5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper (ETM+), and Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS). Location of hotspots were spatially and temporally mapped in conjunction with land use and land cover change obtained from the National Land Cover Database (NLCD). Both hotspot location and intensity changed throughout time, and occurrence of temperature hot spots tended to match zonal features. Results show that higher than average temperatures correlated to increased development while lower than average temperatures were associated with vegetation, bare land, and open water. Our partners at the City of New York Mayor’s Office of Resiliency and NYC Department of Health and Mental Hygiene will utilize the results to inform green initiatives, helping to reduce the incidence of heat-related illness in the most at-risk neighborhoods.

**Keywords:** Landsat, temperature hotspots, New York City, Public Health, heat vulnerability, Urban Heat Islands

***National Application Areas Addressed:*** Urban Development, Health & Air Quality

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

***Study Period:*** 1990 to 2019 (May to October)

***Community Concerns:***

* Urban hotspots, or localized increases in temperature, are a common occurrence within cities due to the high degree of urbanization and lack of vegetative cover.
* Variation in the distribution of vegetation, building types, and surface materials results in disparate neighborhood-level heat risks within the city.
* Extreme heat is the number one cause of extreme weather mortality in New York City with approximately 130 deaths each year.
* Projected increases in temperature due to increased urbanization are likely to put even more people at risk.
* It is critical to identify urban hotspot locations and take mitigating action in order to increase community resilience.

***Project Objectives:***

* Use satellite imagery to measure and map the temporal and spatial changes of urban hotspots in New York City and generate a geodatabase of hotspot locations and land-use changes
* Analyze the correlation between land-use change, zoning classification, and major transportation corridors to hotspot location
* Overlay hotspot locations with NYC’s heat vulnerability index (HVI) to identify the most vulnerable communities

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **City of New York, Mayor’s Office of Resiliency**  | Daphne Lundi, Senior Policy Advisor | End User | Yes |
| **New York City Department of Health And Mental Hygiene** | Sarah Johnson, Executive Director, Air Quality Program | Collaborator | No |

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

Columbia University and the NYC Department of Health and Mental Hygiene (DOHMH) utilized socio-economic and environmental metrics to develop a Heat Vulnerability Index (HVI) in order to determine the relative heat-related risk facing NYC neighborhoods. As a result, the City of New York Mayor’s Office of Resiliency (MOR) developed and implemented the Cool Neighborhoods program in order to address the heat-related issues faced by communities in an effort to keep New Yorkers safe during hot weather and protect against the impacts of rising temperatures. One goal of the program is to mitigate the effects of urban hotspots in areas identified as most at risk by the HVI through the implementation of green infrastructure. The MOR and the DOHMH currently lack tools for measuring the distribution and intensity of hotspots within the city.

***Project Benefit to End User***:

By creating a geodatabase that will allow the city to analyze historical locations for hotspots and vulnerable communities, the city will be able to prioritize those areas for intervention. Additionally, compiling a database of land use and land use changes over time will allow the city to explore the relationship between development, hotspots, and heat vulnerability. The project will culminate in an ArcGIS Model Builder Workflow that the city will be able to use to identify hotspots within the city. They will be able to utilize this to incorporate and assess future datasets and to create new images to identify vulnerable populations.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 4 TM** | Land cover, temperature | Classify land use / cover and daytime surface temperature from 1990-1993. |
| **Landsat 5 TM** | Land cover, temperature | Classify land use /cover and daytime surface temperature from 1990-2011. |
| **Landsat 7 ETM+** | Land cover, temperature | Classify land use / cover and daytime surface temperature from 2011-2013. |
| **Landsat 8 OLI** | Land cover | Classify land use / cover from 2013-2019 and in future analysis. |
| **Landsat 8 TIRS** | Temperature  | Calculate daytime land surface temperature for 2013-2019 and in future analysis.  |

***Ancillary Datasets:***

* New York City Heat Vulnerability Index (HVI) data – Heat index that accounts for vulnerability based on social and environmental factors used to locate vulnerable population
* New York City LiDAR Capture (2017) – High resolution LiDAR for land cover/use validation
* New York City Zoning and Land Use Map – Analyze correlation between zoning and land use with identified hotspots
* US Geological Survey National Land cover Data Base (NLCD) – Land use / cover maps from 2001, 2006, 2011, 2016 used to create geodatabase
* NOAA Coastal Change Analysis Program (CCAPS) Land use / cover maps – Land cover and use from 1996, 2001, 2006, 2011 used to create geodatabase

***Software & Scripting:***

* Esri ArcGIS – Image processing and end product generation
* R – Batch processing for ArcGIS analysis

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category**  |
| **Geodatabase of Hotspots from 1990 - 2019** | Landsat 4 TM, Landsat 5 TM, Landsat 7 ETM+, Landsat 8 TIRS | The city will use this database to analyze historical hotspot locations throughout the city, explore spatial relationships over time, and identify vulnerable communities that may be prioritized for intervention. | N/A |
| **Geodatabase of Land Use Change from 1990 - 2019** | Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI | The city will use this database to analyze historical land-use patterns and identify areas of significant change to explore how this relates to hotspots and heat vulnerability. | N/A |
| **ArcGIS Model Builder Workflow for Identifying Hotspots** | Landsat 4 TM, Landsat 5 TM, Landsat 7 ETM+, Landsat 8 TIRS | This workflow will allow city officials to easily incorporate land cover data with surface temperature information when new images are available. This end product will also integrate that information with demographic data to visualize hotspots and identify vulnerable populations that could benefit from interventions. | IV |
| **ArcGIS StoryMap** | N/A | This StoryMap will be used to communicate the results of the project to partners and community members. This will help partners relay information about hotspots and urban heat vulnerability to other decision makers, city officials, and the public. | N/A |

**Project Handoff Package**

**Transition Plan:**

The team handed off the end products in a virtual meeting with the partners in Week 10. During this meeting, the team gave a methodology tutorial of the project and an overview of the model builder in ArcGIS. This included a geodatabase of historical hotspots and land cover change.

**Team POC**: Scott Harrison: sdharris@colby.edu

***Software Release POC:*** Josi Robertson: josi.robertson@gmail.com

**Partner POC**: Daphne Lundi: dlundi@cityhall.nyc.gov

Sarah Johnson: sjohnso5@health.nyc.gov

**Handoff Package:**

* Geodatabase of Hotspots from 1990-2019
* Geodatabase of Land Use Change from 1990-2019
* ArcGIS Model Builder Workflow for Identifying Hotspots
* Arc StoryMap
* Technical Paper

**References:**

The City of New York. (2015). Cool Neighborhoods NYC: A Comprehensive Approach to Keep Communities Safe in Extreme Heat [PDF]. Retrieved October 1, 2019 from https://www1.nyc.gov/assets/orr/pdf/Cool\_Neighborhoods\_NYC\_Report\_FINAL.pdf

Urban Land Institute. (2019). Scorched: Extreme Heat and Real Estate [PDF]. Washington, DC. Retrieved October 1, 2019 from https://americas.uli.org/wp-content/uploads/sites/2/ULI-Documents/Scorched\_Final-PDF.pdf