**Austin Health & Air Quality**

*Using NASA Earth Observations and Socioeconomic Data to Assess Urban Heat-Induced Health Risk in Austin, Texas*

**Project Team**

***Project Team:***

Margaret McCall (Project Lead)

Alexa Lopez

Will Peters

James Sanders

***Advisor:***

Dr. David Hondula (Arizona State University)

***Team POC:*** Margaret McCall, majemc@gmail.com

***Software Release POC:*** James Sanders, james.martin.sanders@gmail.com

***Partner POC:*** Marc Coudert, marc.coudert@austintexas.gov

**Project Overview**

***Project Synopsis:***

In this project, NASA DEVELOP partnered with the City of Austin to combine NASA Earth observations with socioeconomic data to better understand the spatial distribution of vulnerability to extreme heat in Austin, Texas. The team created a heat priority index to identify the areas of the City where residents are most at risk of adverse impacts from heat, which the City can use to prioritize green infrastructure investments and promote the equitable distribution of initiatives for reducing extreme heat, helping the City work towards its Community Climate and Climate Resilience Action Plans.

***Abstract:***

In recent years, Austin, Texas has experienced an increase in population and urban development. Additionally, the City’s climate continues to change and currently faces extreme heat and drought. As temperatures and demand for utilities and resources rise, the number of heat-related deaths and illnesses in socially vulnerable populations (e.g., older or lower-income populations) are expected to increase. The City of Austin, The University of Texas at Austin (UT Austin), and The University of Texas Health Science Center at Houston (UT Health) partnered with NASA DEVELOP to examine the distribution of urban heat throughout the City. This project utilized land surface temperature, greenness, plant water content, and urban surface material analysis parameters derived from NASA Earth observations from Landsat 8 Operational Land Imager (OLI), Landsat 8 Thermal Infrared Sensor (TIRS), and Aqua Moderate Resolution Imaging Spectroradiometer (MODIS). The DEVELOP team created a sharable geodatabase mapping heat exposure severity, areas of high social vulnerability, and an overall heat priority score. This overall score was determined with a weighted analysis of heat-related observations and socioeconomic data. The team tested the sensitivity of this score to a wide range of parameter decisions, such as which social variables were included. This heat priority index can be used to make informed infrastructure improvement plans in targeted areas (e.g., siting of cooling centers) and ensure equitable sustainable development.

***Key Terms:***

Remote sensing, urban heat islands, socio-economic vulnerability, land surface temperature, heat vulnerability

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

***Study Location:*** Austin, Texas

***Study Period:*** January 2015 to January 2021

***Community Concerns:***

* Urban heat is a major issue for the City of Austin. The influx of new residents contributes to the need for urban expansion and development within the City.
* Extreme heat poses a direct health risk to residents, decreases overall quality of life, and impedes the City’s ability to provide reliable access to power during periods of peak demand.
* As part of the City’s Climate Equity Plan, the City recognized those at a socio-economic disadvantage (e.g., low-income, people of color, poor to low English-speaking ability) will likely be the most affected by climate change.
* There is a need to define the most heat-vulnerable areas that are likely to experience the most negative effects from rising temperatures due to regional urbanization and global greenhouse gas emissions.

***Project Objectives:***

* Integrate environmental data from NASA Earth observations and socioeconomic and demographic data from the U.S. Census to help address urban heat and environmental equity in the City of Austin, Texas
* Enhance the robustness of the environmental component of the City’s current heat priority scoring approach using NASA Earth observation tools
* Create a heat exposure index (from 6 environmental variables such as land surface temperature), a heat vulnerability score (from 29 socioeconomic variables such as median income) and a heat priority score (from all variables), utilizing principal component analysis, and test the sensitivity of these indices to different parameter and variable choices
* Identify areas of vulnerability to urban heat islands (UHI, i.e., higher temperatures experienced by an urban area compared to the surrounding rural areas) within the City of Austin by highlighting communities in the top quintile of heat priority scores
* Develop a toolbox, including a StoryMap and online geodatabase, usable by the City of Austin to further map urban heat islands and locate the communities that are most vulnerable to the effects of heat exposure

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **City of Austin, Office of Sustainability** | Marc Coudert, EnvironmentalConservation Program Manager | End User | Yes |
| **The University of Texas at Austin, Jackson School of Geosciences** | Dr. Dev Niyogi, Professor,Department of Geological Sciences | Collaborator | No |
| **The University of Texas Health Science Center at Houston, School of Public Health** | Dr. Kevin Lanza, Postdoctoral Fellow | Collaborator | No |

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

The City of Austin has two climate action resiliency plans, one that is community-focused and one that is operations-focused. The operations-focused plan includes strategies on how to adapt to and mitigate the foreseen effects of climate change, including the effects of urban heat. To assess urban heat, the City currently works with local universities that utilize NASA Earth observation data to monitor and map the City’s canopy coverage and developed a City-wide, large-scale UHI map. The City has also collected *in situ* air temperature data via vehicle transects through an initiative with the National Oceanic and Atmospheric Administration (NOAA).

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
|  **Platform & Sensor**  | **Parameters** | **Use** |
| **Landsat 8 OLI** | Normalized Difference Vegetation Index (NDVI)AlbedoDry Built-Up Index (DBI)Daytime Land Surface Temperature (LST) | NDVI was used to map the existing vegetation coverage in the study area over a five-year period. Albedo was used to measure the reflection of light off a given surface. DBI was used to measure the extent of urban development for dry areas. LST was used as a proxy for ground level air temperature. NDVI was also used to calculate DBI and LST. |
| **Landsat 8 TIRS** | LSTDBI | DBI was used to measure the extent of urban development for dry areas. LST was used as a proxy for ground level air temperature.  |
| **Terra MODIS** | Normalized Difference Water Index (NDWI) | NDWI was used as a method to differentiate water from dry land. It is useful in mapping vegetation due to water content found in plants. |
| **Aqua MODIS** | Nighttime Land Surface Temperature (Night LST) | Nighttime LST was used as a proxy for nighttime ground level air temperatures, and was used to find the urban heat exposure at night. |

***Ancillary Datasets:***

* US Census Bureau American Community Survey by tract and block group 2015 to 2019 – Socioeconomic variables from the survey were used to create the heat vulnerability and heat priority indices
* Center for Disease Control PLACES Census Tract Data 2020 Release – Health data at the tract level on conditions that made populations more vulnerable to urban heat was used to create the heat vulnerability and heat priority indices
* City of Austin *in situ* meteorological measurements – Air temperature, relative humidity, and surface temperature at the street level were used. This includes data from the National Integrated Heat Health Information System (NIHHIS)- Climate Adaptation Planning Analytics (CAPA) Strategies campaign that used vehicles to collect meteorological data, as well as fixed-point weather stations. This was used to get more accurate estimates of heat exposure on the ground.
* City of Austin Tree Canopy Data – 2018 tree canopy data measured throughout the City in a raster format at 60-cm resolution. This was used to find areas with higher tree prevalence.
* Texas Natural Resources Information System Central Texas LiDAR – LiDAR point data was used to find areas with the most shading in Austin with a 60-cm resolution.

***Software & Scripting:***

* Google Earth Engine – Used to generate raster layers for relevant environmental variables derived from NASA Earth observations
* R v4.0.3 and RStudio 1.3.1073 – Used to pull the relevant social data and run the principal component analysis and sensitivity analysis to determine the heat exposure, social vulnerability, and heat priority indices
* Esri ArcGIS Online – Development of a reusable geodatabase for the Austin partners on an easy-to-use platform, and created a StoryMap to present results to the public
* Python v3.7 – Used to produce assorted graphs for the presentation
* Esri ArcGIS vPro2.7.0 – Used to produce assorted maps for the presentation from data compiled elsewhere

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations**  | **Partner Benefit & Use** | **Software Release Category** |
| **ArcGIS Online****Geodatabase of Data Layers, Ranked Heat****Severity Regions & Proposed Mitigation Project Locations** | Landsat 8 OLI/TIRSAqua MODIS | This online geodatabase will serve as a usable source of data for many decision-makers across different divisions of the City of Austin. It will help partners visualize urban heat impacts and can be used in later analyses with additional local measurements of experienced temperature. | III |
| **Texas Heat Environmental and Social Index of Sensitivity (THESIS)** | Landsat 8 OLI/TIRSAqua MODIS | The City of Austin will use this code, upon software release, to reproduce heat score maps and datasets as new satellite images and US Census data becomes available. | III |
| **ArcGIS Online****StoryMap** | Landsat 8 OLI/TIRSAqua MODIS | Partners can use the StoryMap to display various maps produced by the DEVELOP team to be put into context of vulnerable communities and help explain to the public and City partners the urban heat island effect in Austin. This StoryMap will be linked on Austin’s climate mitigation website. | N/A |
| **Code Training Tutorial** | N/A | This will walk through how to use the code from THESIS to reproduce heat score maps and relevant datasets as well as how to update the input datasets as new Earth observations and Census data becomes available. The City of Austin will use this to learn how to create the relevant heat score maps in future years with updated data.  | III |

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

This work will benefit the City of Austin by better informing their policy and infrastructure decisions, allowing them to target their mitigation efforts in the quantifiably hottest parts of the city and in communities understood to be the most vulnerable. By simplifying the factors that contribute to urban heat into a single metric, the City will be able to communicate prioritization needs more easily across city departments. The score validation analysis performed in this project will help the City understand how different decisions in the heat priority index process influence the outcome, and how certain the model is in the vulnerability of a given area.

**References**

Aminipouri, M., Knudby, A., & Ho, H. C. (2016). Using multiple disparate data sources to map heat vulnerability: Vancouver case study. *The Canadian Geographer / Le Géographe Canadien*, *60*(3), 356–368. <https://doi.org/10.1111/cag.12282>

Asadi, A., Arefi, H., & Fathipoor, H. (2020). Simulation of green roofs and their potential mitigating effects on the urban heat island using an artificial neural network: A case study in Austin, Texas. *Advances in Space Research*, *66*(8), 1846–1862. <https://doi.org/10.1016/j.asr.2020.06.039>

City of Austin. (2018, April). *Climate Resilience Action Plan for City Assets and Operations.* <https://austintexas.gov/sites/default/files/files/Sustainability/Climate_Resilience_Action_Plan.compressed.pdf>

City of Austin Office of Sustainability. (2020, September). *2020 Austin Climate Equity Plan.* <https://www.austintexas.gov/edims/document.cfm?id=347852>

Kim, J. H., Gu, D., Sohn, W., Kil, S. H., Kim, H., & Lee, D. K. (2016). Neighborhood landscape spatial patterns and land surface temperature: An empirical study on single-family residential areas in Austin, Texas. *International Journal of Environmental Research and Public Health*, *13*(9), undefined-undefined. <https://doi.org/10.3390/ijerph13090880>

Zhao, C., Jensen, J., Weng, Q., & Weaver, R. (2018). A Geographically Weighted Regression Analysis of the Underlying Factors Related to the Surface Urban Heat Island Phenomenon. *Remote Sensing*, *10*(9), 1428. <https://doi.org/10.3390/rs10091428>