**NASA DEVELOP National Program**

**Virginia – Langley**

*Project Summary – Summer 2018*

**Richmond Health & Air Quality**

*Synthesizing Temperature, Reflectance, and Land Change to Provide Spatial and Temporal Temperature Analyses in Richmond, Virginia*

**VPS Title:** Un-Raising the Roof in Richmond, Virginia – An Urban Heat Analysis

**Project Team**

***Project Team*:**

Meg Fredericks (Project Lead), margaret.m.fredericks@nasa.gov

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***Advisors & Mentors*:**

Dr. Kenton Ross (NASA Langley Research Center)

**Project Overview**

***Project Synopsis*:** This project used NASA Earth observations to assess and illustrate the spatial and temporal distribution of urban heat in Richmond, VA. In addition to mapping land surface temperatures, our analysis interrogated the relationship between land use types and social vulnerability to extreme heat. The resulting maps were presented to our partners as a means to provide them with a greater understanding of the urban heat island effect throughout the city so that mitigation strategies and green-up projects can be developed and implemented.

***Abstract*:**

Cities around the world are adopting adaptation and mitigation strategies for extreme heat events, which are projected to increase in upcoming years. As Richmond, Virginia continues to grow, its residents are more likely to experience more extreme temperatures resulting from the urban heat island effect. An increase in impervious surfaces such as asphalt and concrete, which retain more heat energy than the natural environment, drive this effect. Efforts to alleviate these problems include supporting interventions by local non-profits, including Groundwork RVA, and working with the Richmond City Planning Office to prioritize increased tree cover in the area.In this project, we used Landsat 5 Thematic Mapper (TM), Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS), and Terra Advanced Spaceborne Thermal Emission and Reflection (ASTER) data to analyze these patterns in land surface temperature. To inform these patterns, we also examined the significance of the city’s infrastructure and land use choices. Land cover was assessed for selected years using data from the Virginia GIS Clearinghouse and the National Agriculture Imagery Program. Heat vulnerability indicators and land cover data were synthesized using US Census and health records and Centers for Disease Control (CDC) Social Vulnerability Indicators. These indicators depict the sensitivity of the population to extreme heat and identify where vulnerable demographics reside. Along with identifying these areas of concern, our results indicated that the urban heat profile of Richmond has dramatically increased and expanded in the last twenty years. Groundwork RVA can use temperature assessment maps along with these heat vulnerability indicators to establish, carry out and prioritize green infrastructure projects in the city.

**Keywords:**

Urban heat island, Landsat, MODIS, land surface temperature, heat vulnerability index, urban canopy, green infrastructure

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

***Study Location:*** Richmond, VA

***Study Period:*** 1994 – 2017 (May – September)

***Community Concern:***

* The urban heat island effect, which refers to the entrapment of heat radiation in cities due to the disproportionate amount of urban structures, is a phenomenon of increasing importance due to rising temperatures in the Southeast region of the United States.
* Due to the uneven spatial distribution of certain land cover types, such as trees, grass, and shrubs, specific neighborhoods are more at-risk to be negatively impacted by the urban heat island effect.
* Some populations, including the elderly and young children, low-income groups, and ethnic minority groups are more vulnerable to heat-related illnesses than others.

***Project Objectives:***

* Use satellite data and imagery to illustrate the temporal and geographic distribution of urban heat in Richmond, VA
* Illustrate the driving and mitigating variables of the urban heat island effect by classifying land types, such as impervious surfaces and the urban canopy within the city
* Incorporate a heat vulnerability index, to provide a greater spatial understanding of what populations are most vulnerable, and assist in determining where “greening” interventions should be made

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Groundwork USA, Groundwork RVA** | Giles Harnsberger, Executive Director | End User | Yes |
| **Science Museum of Virginia** | Dr. Jeremy Hoffman, Climate and Earth Science Specialist | Collaborator | No |

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

Currently, Groundwork RVA has no standard framework for making decisions related to temperature effects in Richmond.

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

End product maps will provide Groundwork RVA with an understanding of Richmond’s urban heat island with a broader temporal context stretching back into the 1990’s, and how these factors interact. By illustrating the relationships between these variables over time, Groundwork will be able to draw conclusions about what types of land cover drive and mitigate the urban heat island effect. They will use these conclusions to establish small-scale interventions for the most impacted neighborhoods, and in working with the Municipal Parks System as well as the Planning and Development Office in Richmond. Ultimately, Groundwork RVA aims to communicate that urban planning and design decisions have direct impacts on the quality of life within the city.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Landsat 8 OLI** | Top of atmosphere (TOA) reflectance | TOA reflectance was used to access land cover types, specifically, impervious surfaces and tree canopy cover. |
| **Landsat 8 TIRS** | Land Surface Temperature (LST) | TIRS data were used to estimate the spatial and temporal trends of surface temperature. |
| **Landsat 5 TM** | LST, TOA | TOA reflectance was be used to assess land cover type. LST wwasused to estimate extent, magnitude, and temporal trends in the surface temperature in Richmond, VA. |
| **Terra ASTER** | LST, TOA | ASTER was used as a reference to compare monitored land surface temperatures with calculated land surface temperature from Landsat data. |

***Ancillary Datasets:***

Virginia GIS Clearinghouse Land Cover Data – Assess vegetation prevalence to calculate NDVI and land cover.

USDA National Agriculture Imagery Program (NAIP) – Assess vegetation prevalence to calculate NDVI and land cover.

US Census American Community Survey (2010) – Develop heat vulnerability index based on demographic and socioeconomic indicators.

CDC Social Vulnerability Indicators (SVI) – Develop heat vulnerability index based on health, demographic and socioeconomic indicators.

***Software & Scripting:***

Esri ArcMap 10.5 – raster manipulation, map creation

Python – Landsat 5 and Landsat 8 data processing

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Extreme Heat Social Vulnerability Index** | N/A | This index will provide the partners with an understanding of what populations are most vulnerable to extreme heat events, as well as where these populations are located across the city. The partners will then be able to create outreach strategies and take preventative measures that focus on these populations. | N/A |
| **Landsat Surface Temperature Assessment Maps** | Landsat 5 TM  Landsat 8 OLI  Landsat 8 TIRS  ASTER | These maps will allow the partners to observe how surface temperatures in Richmond, VA have changed over time. By establishing trends in the distribution of land surface temperatures, the partners will be more equipped to target adaptation and mitigation efforts to improve the city’s extreme heat resiliency strategy. Land cover imagery will be overlaid on selected maps to demonstrate how land use choices influence local temperature. | N/A |
| **Heat Vulnerability Assessment Maps** | Landsat 5 TM  Landsat 8 OLI  Landsat 8 TIRS | This assessment will aggregate our heat vulnerability index, land cover, and land surface temperature data to demonstrate the combined impacts of vulnerability and vegetation, or lack thereof, on the spatial distribution of extreme heat throughout the city. | N/A |

**Project Handoff Package**

**Transition Plan:**

The team met with the partners in person on-site at the DEVELOP office, during the LaRC closeout on August 10th. The partners were present for the team’s presentation, which was followed by a final discussion and handoff of materials. During this meeting, partners had a chance to ask questions and any remaining issues were resolved. If our partners have additional questions for the team following our handoff, they will direct any further concerns to the point of contact for the project.

**Team POC:** Meg Fredericks, megfred.develop@gmail.com

**Partner POC**: Giles Harnsberger, giles@groundworkrva.org

**Handoff Package:**

* Landsat Surface Temperature Time Series Maps
* Heat Vulnerability Index Data
* Heat Vulnerability Assessment Maps
* Project Video
* Technical Paper
* Project Poster
* Project Presentation

**References:**

Harlan, S. L., Brazel, A. J., Prashad, L., Stefanov, W. L., & Larsen, L., (2006). Neighborhood microclimates and vulnerability to heat stress. *Social Science and Medicine,* *63*(11), 2847-2863.

Ingram, K., K. Dow, L. Carter, J. Anderson, eds. 2013. Climate of the Southeast United States: Variability, change, impacts, and vulnerability. *Washington DC: Island Press.*