**NASA DEVELOP National Program**

**Arizona – Tempe**

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*Project Summary – Fall 2017*

***Phoenix Health & Air* Quality II**

*Utilizing NASA Earth Observations and Ground Measurements to Reduce Extreme Heat Experiences by Transit Riders in Phoenix, Arizona*

**VPS Title:** Throwing Shade: Monitoring Surface Temperatures at Transit Stops in Urban Phoenix

**Project Team**

***Project Team*:**

Lance Watkins (Project Lead), lance.e.watkins@nasa.gov

Elizabeth Dyer

Dean Blumenfeld

Yalin Qu

Mario Chavez

***Advisors & Mentors*:**

David Hondula (Arizona State University)

Ariane Middel (Temple University)

Yuliya Dzyuban (Arizona State University)

***Past or Other Contributors*:**

Tamara Dunbarr

McKenzie Murphree

**Project Overview**

***Project Synopsis*:** The goal of this project was to provide the City of Phoenix Public Transit Department with information they may utilize to prioritize locations for shade structure infrastructure investment. Landsat derived land surface temperature (LST) and *in situ* measurements of air temperature and LST at several City of Phoenix bus stops, along with data on vegetation cover and secondary shading, will give the City of Phoenix Transit Department a better understanding of the current heat and shade conditions of stops lacking these structures. The team also integrated demographic and socioeconomic data to provide an assessment of heat vulnerability of residents.

***Abstract*:**

Phoenix, Arizona, a city with 1.5 million residents, experiences extreme heat every year from May through October, with summer daily maximum temperatures regularly rising over 100°F and a record high temperature of 122°F. Residents are prone to thermal discomfort during these summer months, especially those who rely on public transportation, making environmental heat a significant public health concern. The City of Phoenix Public Transit Department is heavily invested in addressing this concern through infrastructure development aimed at reducing riders’ heat exposure at bus stops. The department’s previous method of determining priority for improvements such as shade structures was based solely upon ridership. The NASA DEVELOP team provided the transit department with an analysis of the thermal environment at city bus stops, data which may be used when prioritizing the installation of new shade structures at unshaded stops. Land surface temperature (LST) from Landsat 8 Operational Land Imager (OLI) and *in situ* LST and air temperature measurements were collected to provide a better understanding of the thermal environment at transit stops. LiDAR data were used to extract building heights in order to examine secondary shade potential within the thermal environment. We also created an assessment of the vulnerability of riders based on a selection of demographic and socioeconomic characteristics of the surrounding area. These results will contribute to the Phoenix Transit Department’s efforts to reduce the risk of heat-related illness for transit riders across the city and promote the viability of public transportation to achieve long-term health and sustainability goals.

**Keywords:**

Land surface temperature, Landsat, heat vulnerability assessment, remote sensing, LiDAR

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

***Study Location:*** Phoenix, AZ

***Study Period:*** 2005 – 2017 (May – October)

***Community Concern:***

* Extreme urban heat that leads to thermal discomfort and health risks
* Intense heat experienced while traveling to and waiting at unshaded stops
* Efficient and effective use of investment in public transit system in Phoenix

***Project Objectives:***

* Provide partners with information that will allow them to better prioritize the deployment of shade structures at currently unshaded bus stops across the City of Phoenix
* Expand analysis to include the conditions faced by transportation riders both while on pedestrian pathways leading to, and while waiting at, transit stops
* Validate satellite LST by conducting site visits to sampled bus stops
* Assess the vulnerability of the residents around unshaded bus stops using demographic and socioeconomic characteristics from US Census data
* Combine existing LiDAR data products with Landsat imagery to estimate shade along our specific routes and bus stops

***Previous Term:*** Spring 2017 (Tempe, AZ) – Phoenix Health & Air Quality I

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **City of Phoenix, Public Transit Department** | Joe Bowar, Deputy Manager  Herb Munoz, Engineer  Jorie Bresnahan, Data Specialist | End User | No |
| **Arizona State University, Urban Climate Research Center** | David Sailor, Professor | Collaborator | No |
| **Arizona State University, Center for Policy Informatics** | Erik Johnston, Professor | Collaborator | No |

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

Prior to engaging with the DEVELOP program (Phoenix Health & Air Quality I), decisions regarding deployment of shade structures in the next 5 years were going to be based primarily on ridership. This has been the primary prioritization metric for the city. Additional criteria for site eligibility include ADA compliance, safety concerns, right of way, utility clearance, and land ownership. To the best of our knowledge, this project represents the first time this particular division of the city government has engaged with remote sensing data. After the first term of Phoenix Health & Air Quality, the end user had a chance to be aware of the thermal environments of unshaded bus stops throughout the city of Phoenix.

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

Incorporating NASA Earth observations will enable the partner to more comprehensively evaluate bus stops and the experiences of transit system users through the addition of information about the thermal environment, vegetative cover, secondary shading, and heat vulnerability of residents. The City of Phoenix Public Transit Department will be able to utilize land surface temperature values taken from Landsat 8 to better understand how LST values differ across the city, which will better inform them on their shade structure prioritization at bus stops. *In situ* LST collection will validate Landsat 8 LST values to provide the city more confidence in adding temperature to their prioritization process. The partner will also be able to see how natural and secondary shading from vegetation and buildings surrounding the stops can affect the LST. Heat vulnerability assessment of the city will allow them to address which stops have the potential of servicing those more vulnerable to extreme heat.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 8 OLI** | LST, NDVI | This dataset was used to estimate a land surface temperature time series for bus stops and specific bus routes. This dataset was also be used to estimate vegetation prevalence at bus stops and along routes. |
| **Landsat 8 TIRS** | LST | This dataset was used to estimate a land surface temperature time series for bus stops and specific bus routes. |
| **Landsat 5 TM** | LST, NDVI | This dataset was used to estimate a land surface temperature time series for bus stops and specific bus routes. This dataset was also be used to estimate vegetation prevalence at bus stops and along routes. |

***Ancillary Datasets:***

USGS 3D Elevation Program – land surface model

City of Phoenix Public Transit Department bus stop attributes database– daily ridership and bus stop characteristics

United States Census Bureau 2010 Census & 2015 American Community Survey – demographic and socioeconomic data

NASA DEVELOP and ASU UCRC *in situ* meteorological measurements – air temperature, relative humidity, land surface temperature

***Software & Scripting:***

R – data processing and statistical analysis

Google Earth – data visualization

ESRI ArcGIS – map creation and image processing

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used** | **Partner Use** | **Software Release Category** |

|  |  |  |  |
| --- | --- | --- | --- |
| **Bus Stop & Route LST Assessment** | Landsat 8 TIRS, Landsat 5 TM | Partners will use this product to understand how LST values vary along some routes and transportation corridors in addition to bus stops. This will inform their decision in prioritizing shade improvements along certain routes. | I |
| **Bus Stop & Route Shade Assessment** | N/A | This product will help partners understand how potential natural shade provided by vegetation and buildings is distributed along specific routes and transportation corridors. Partners will utilize this layer to identify the most and least shaded bus stops and routes throughout Phoenix, which will inform the prioritization of shade enhancements. | I |
| **Bus Stop & Route Heat Vulnerability Assessment** | N/A | End users are able to view this layer alongside the other end products to identify which routes and stops have the potential for servicing areas where they are regularly used by riders more vulnerable to extreme heat. This information will be useful in prioritizing shade structure installation. | I |
| **LST Ground Based Validation** | Landsat 8 OLI & TIRS, Landsat 5 TM | This is a ground-based validation of the satellite LST with *in situ* LST was requested by our partners at the end of the first term. This will help our partners estimate confidence they can give to the satellite based LST values. | I |
| **Satellite – Ground Measurement Analysis** | Landsat 8 OLI & TIRS, Landsat 5 TM | The Landsat based LST measurements were related to ground based measurements of air temperature. This will help our partners better understand how LST measurements might relate to the thermal environment riders experience, which will help to determine where shading structures should be placed. | I |

**Project Handoff Package**

**Transition Plan:**

At the end of this term, the team will have a meeting with the City of Phoenix Public Transportation Department, where they will present the end products in a Google Earth environment. At the same time, the team will hand off the other end products, assessment materials and necessary data to the client.

**Team POC:** Lance Watkins (Project Lead), lance.e.watkins@nasa.gov

**Partner POC**: Joe Bowar, joseph.bowar@phoenix.gov

**Handoff Package:**

* Satellite – Ground Measurement Analysis
* LST Ground Based Validation Result
* Bus Route LST Assessment
* Bus Route Shade Assessment
* Bus Route Heat Vulnerability Assessment

**References:**

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