**NASA DEVELOP National Program**

**2017 Fall Project Proposal**

**Arizona – Tempe**

**Phoenix Health & Air Quality II**

*Enhancing Strategic Shading for Public Transportation with NASA Earth Observations*

**Project Overview**

***Project Synopsis*:** The objective of this project is to help the City of Phoenix Public Transit Department prioritize locations for installation of shade structures at public bus stops. Partnering with the Maricopa County Department of Public Health and the ASU Urban Climate Research Center, the DEVELOP team will build on prior work using Landsat and ASTER NDVI and Land Surface Temperature products to enhance a decision-support tool for city staff. The team will generate new information about the thermal environment along specific transit routes and pedestrian corridors to add to existing knowledge of the thermal condition at specific bus stops. The integration of route- and corridor-based data, as well as new ancillary data sets including socioeconomic and demographic data, will help the City identify locations for infrastructure investment that make the provisioning of shade more effective and equitable for transit users.

***Community Concern:*** Residents of the City of Phoenix passed a more than 30 billion dollar transportation tax in 2015 from which significant improvements to public transportation are planned and expected. Among those investments, $10,000,000 is allocated to installing new shade structures at bus stops over the next five years. Lack of sufficient shade at bus stops is among the most frequent concerns that residents and visitors of the city voice to public transportation staff, and heat-related illness is a significant public health concern in the region each summer. The effective deployment of new shade structures will not only reduce community complaints about bus stops, but could also lead to a greater overall return on the significant investment in public transportation city residents voted to support and fund and reduced incidence of symptoms of heat illness.

***Source of Project Idea:*** ASU researchers have been working with the City of Phoenix Public Transit Department through the development and implementation of the transportation tax initiative known as T2050. As a result of those conversations, city staff became aware of the opportunity to systematically characterize the thermal environments used by public transportation users and recognized the potential to validate or enhance their decision-making process for shade structure deployment.

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

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

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

***Advisors:*** David Hondula (Arizona State University), Ariane Middel (Temple University), Yuliya Dzyuban (Arizona State University)

**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 |

***End-User Overview***

***End User’s Current Decision-Making Process:***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. Incorporating NASA EO enables the partner to more comprehensively evaluate bus stops and the experiences of transit system users through the addition of information about the thermal environment and vegetative cover. 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.

***End-User’s Capacity to Use NASA Earth Observations:***

*City of Phoenix, Public Transit Department* – Public transit staff were introduced to Landsat and ASTER products during spring 2017 through the Phoenix Health & Air Quality I DEVELOP project. This projectwill continue to build capacity among end users by expanding the analytical framework from one that was point-based (bus stops) to one that is oriented toward networks (roads, pedestrian paths). This term will also help partners understand more specifically the extent to which land surface temperature and NDVI data provide a realistic representation of the near-surface atmospheric conditions experienced by transit users.

***Collaborator & Boundary Organization Overview***

***Collaborator Support:***

*Arizona State University, Urban Climate Research Center* – The UCRC at ASU will support the project through the provision of meteorological equipment that team members will use to measure near surface atmospheric conditions at transit stops and along pedestrian corridors that access transit routes. These data will help validate and contextualize NASA EOs for thermal comfort assessment.

*Arizona State University, Center for Policy Informatics* – CPI provides the team access to state-of-the-art visualization resources at the university, including the Decision Theater on ASU Tempe Campus and the Policy Analytics Lab at the ASU Phoenix Campus. CPI has been one of the primary academic homes for collaboration between public transportation staff and the university for the past five years and engagement with CPI will help support this mutually beneficial relationship.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The DEVELOP team will hold weekly teleconference or video conference meetings with city staff throughout the project term and meet in person with city staff at least three times during the project (approximately weeks 2, 6, and 10). The main point of contact will be Joe Bowar. The DEVELOP team will directly e-mail with city staff more frequently (following the working relationship developed in the first project term).

***Transition Plan*:** The transition will be facilitated by an in-person close-out meeting at ASU near the end of the term. Final datasets, the decision support tool, and other resources will be electronically sent to the public transit data specialist. Tools will be used by the partners beginning in week 6 of the project, when we anticipate the first live demonstration, and continually used through the end of the project. Ideally, we anticipate the tool will be continually used by end users over the next 3-5 years as locations are considered for shade structure deployment.

**Earth Observations Overview**

***Earth Observations:***

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| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Landsat 8, Operational Land Imager (OLI)** | Land surface temperature, NDVI | This dataset will be used to estimate a land surface temperature time series for bus stops and specific bus routes. This dataset will also be used to estimate vegetation prevalence at bus stops and along routes. |
| **Landsat 5 Thermal Infrared Sensor (TIRS)** | Land surface temperature | This dataset will be used to estimate a land surface temperature time series for bus stops and specific bus routes. |

***Ancillary Datasets:***

City of Phoenix Public Transit Department – Ridership & boardings data – included as an additional layer in decision support viewer

City of Phoenix Public Transit Department – Bus stop attributes – included as an additional layer in decision support viewer

United States Census Bureau – 2010 Census & 2015 American Community Survey (5-year rolling average) demographic and socioeconomic indicators, census tract scale – included as an additional layer in decision support viewer

NASA DEVELOP and ASU UCRC – *In situ* meteorological measurements – NASA EO validation

Socioeconomic Data and Applications Center (SEDAC) – Gridded Population of the World (GPW) – The team will use the GPW products to address concerns of population density

***Software & Scripting:***

R – data processing and statistical analysis

Google Earth – data visualization

Esri ArcGIS – map creation and image processing

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product(s)** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| Bus Route LST Assessment | Partners will use this product to understand how LST values vary along specific routes and transportation corridors in addition to bus stops. This will inform their decision in prioritizing shade enhancements. | Building off of the previous team’s work, the team will use ASTER, Landsat 5, and Landsat 8 to estimate land surface temperature (LST) along specific routes and corridors identified by the partners. LST will be related to air temperature and classed to improve interpretation of LST values. | I |
| Bus Route NDVI Assessment | Partners will use this product to understand how vegetation prevalence varies along specific routes and transportation corridors. This will inform their decision in prioritizing shade enhancements. | Building off of the previous team’s work, the team will use Landsat 8 to estimate vegetation prevalence along specific routes identified by the partners. The NDVI data will be classed from low vegetation to high vegetation to improve interpretation of NDVI values. | I |
| Bus Route Heat Vulnerability Assessment | End users will be able to view this layer alongside the other end products to ensure that the bus stops and routes being prioritized in areas where they are regularly used by those vulnerable to extreme heat. | Census, ridership, and SEDAC data will be used to summarize the characteristics of those riders who are more vulnerable to extreme heat. | I |
| LST Ground Based Validation | This is a ground-based validation that 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. | The team will be using thermal sensors from ASU’s Urban Climate Research Center to collect in-situ data of specific routes and stops identified by the end users. These data will then be compared with the satellite based LST. | I |
| Hot Stops Decision Support Viewer | Partners will be able to use this tool to explore the previously listed end products to determine which bus stops and routes they will prioritize shade structure enhancements. | The datasets and sensors listed in the previously mentioned end products will be brought together in Google Earth. Google Earth is a readily available software for viewing spatial data. Google Earth also provides the advantage of allowing partners to view street level images throughout the City of Phoenix. | III |

***End-User Benefit*:** End products will enable the project partners at the City of Phoenix to include a wider array of variables in their decision-making criteria for strategic shading within the public transportation system. Specifically, the DEVELOP team will enable city staff to consider information about the physical environment at bus stops and along walking routes that support those bus stops when deciding where shade may be most beneficial. Partnering with DEVELOP, ASU, and MCDPH also gives city staff additional validation and credibility when rationalizing their decision making to city leadership, elected officials, and the public at large.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 2Terms: 2017 Spring to 2017 Fall

***Multi-Term Objectives:***

* **Term 1:** 2017 Spring (AZ) – Phoenix Health & Air Quality I
  + The spring 2017 Phoenix Health & Air Quality DEVELOP team obtained and processed all available land surface temperature data from Landsat and ASTER over a ten-year period as well as relevant NDVI data. The term linked these datasets to transit system locations (bus stops) and created a positive relationship with end users from which new questions and opportunities emerged. The team successfully built a simple decision support environment based in Google Earth and Microsoft Excel from which City staff could evaluate different prioritization metrics for bus stop shading. The team met with city staff virtually or in person at least five times throughout the term and had more regular e-mail communication.
* **Term 2 (Proposed Term):** 2017 Fall (AZ) – Phoenix Health & Air Quality II
  + The second and final term of the project will expand the geographic domain of analysis from individual bus stop point locations to networks of transit routes as well as pedestrian corridors that support the transit system. This will provide a broader perspective on conditions that transit riders experience while walking to and waiting at bus stops. The team will also collect *in situ* measurements to validate NASA EOs at the scale of interest for analyzing pedestrian thermal comfort and advance understanding of the association between land surface type and air temperature. Partner interaction will be more frequent and analysis-oriented than in the first term. The first term team identified best practices for handoff of datasets and resources to city staff that will be followed this term.

***Previous Terms:***

2017 Spring (AZ) – Phoenix Health & Air Quality I

**Notes & References:**

***References:***

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