**NASA DEVELOP National Program**

**2018 Fall Project Proposal**

**Arizona – Tempe**

**Tempe Urban Development**

*Utilizing NASA Earth Observations to Assess Thermal Landscapes and Prioritize Greening Initiatives in Tempe, Arizona*

**Project Overview**

***Project Synopsis*:** This project uses NASA Earth observations to aid the City of Tempe in an effort to improve the thermal environment of their parks and greens spaces through the implementation of tree canopy cover and reduction of impervious spaces. The team will assess spatiotemporal trends in land surface temperature and land cover (including tree canopy cover) throughout the city using Landsat 5 TM, Landsat 8 OLI, Landsat 8 TIRS, and Sentinel-2 MSI. A focused analysis will be conducted on the Rio Salado–Tempe Beach Park to assess the influence of land cover, tree canopy cover, and land surface temperature on residents’ use of the park. This work will help inform the implementation of the city’s Urban Forestry Masterplan and Rio Salado and Beach Park Masterplan to improve the quality of the park for Tempe residents.

***Community Concern:*** Tree canopy cover can greatly influence the outdoor thermal environment through the processes of evapotranspiration and shading. The City of Tempe has a strategic goal of achieving 25% tree canopy cover and to reinforce principles of the Urban Forestry Master Plan, which include providing equitable tree shading to provide cooler pathways for pedestrian activity. City officials are actively working to meet this goal by focusing on the parks and green spaces throughout the city; one such area that the city is focusing its effort on is the Rio Salado – Tempe Beach Park. The city is currently working on the Rio Salado and Beach Park Masterplan which will outline the development of the area for the next 20 - 30 years. By improving the thermal environment and overall appeal of the park, the efforts made by this project would encourage greater use by Tempe residents.

***Source of Project Idea:*** This project idea stemmed from ongoing collaboration between the City of Tempe, Arizona State University Urban Climate Research Center, and the Central Arizona Long-Term Ecological Research Program to strategically implement urban tree canopy to reduce extreme heat and improve the quality of Tempe parks. Our science advisors, Dr. Hondula and Dr. Middel, is actively engaged with this work.

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

***Study Location:*** Tempe, AZ

***Study Period:*** 2000 – 2018 (May – October)

***Advisor:*** Dr. David Hondula (Arizona State University), Dr. Ariane Middel (Arizona State University)

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **City of Tempe** | Bonnie Richardson, Architect & Urban Planner | End User | No |
| **Arizona State University, Urban Climate Research Center**  | Dr. David Sailor, UCRC Director | Collaborator | No |

***End-User Overview***

***End User’s Current Decision-Making Process:***The City of Tempe has several ongoing projects related to improving the thermal conditions throughout the city. The city’s Urban Forest Master Plan outlines several goals and strategies relating to tree and shade management throughout the city. Some of these goals relating to tree management and improved thermal conditions overlap with goals outlined in the Rio Salado and Beach Park Master Plan and Urban Core Master Plan. The Urban Forest Master Plan, however, outlines the cities interest in targeting new tree planting in parks and open spaces intended for pedestrian or civic activity, including neighborhoods with low canopy cover. The use of remote sensing has been limited to specific projects that involve direct collaboration with academic research units.

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

*City of Tempe* – The city of Tempe has had some exposure to Earth observations through existing academic collaborations, but does not directly process NASA Earth observations themselves. This project will build the capacity of the partners by increasing their exposure to relevant NASA Earth observations.

***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 existing data of thermal comfort surveys, behavioral observations, *in situ* tree measurements, and thermal measurements throughout the Rio Salado Tempe Beach Park.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** Prior to the term, the AZ Center Lead will be the POC. Once the term begins, the Project Lead will be the designated POC. The team will conduct biweekly meetings with the partners through a combination of in-person meetings and teleconferences.

***Transition Plan*:** The results and end products will be presented to partners at an end of term closeout event. Afterward, all processed data products will be sent to the partners via NASA Large File Transfer (LFT). Currently, there is no need for software release. The end products will be implemented by partners at the end of 2018 and into 2019, in coordination with their tree planting initiatives.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 5 TM** | Vegetation indices, land use cover, land surface temperature | This dataset will be used to assess current and past land surface temperature, tree canopy cover, and land cover. |
| **Landsat 8 OLI** | Vegetation indices, land use cover, land surface temperature | This dataset will be used to assess current and past land surface temperature, tree canopy cover, and land cover. |
| **Landsat 8 TIRS** | land surface temperature | This dataset will be used to assess current and past land surface temperature. |
| **Sentinel-2 MSI** | Vegetation indices, land use cover | This dataset will be used to assess current and past tree canopy cover and land cover. |

***Ancillary Datasets:***

USDA National Agriculture Imagery Program (NAIP) – High-resolution imagery for more accurate estimates of tree canopy coverage and percent impervious surface

The United States Geological Survey (USGS) – LiDAR data of the Greater Phoenix area will be used to help estimate tree coverage and shadow coverage

ASU Urban Climate Research Center – A variety of *in situ* temperature measurements taken at various locations throughout the Rio Salado Tempe Beach Park

***Software & Scripting:***

Google Earth Engine API – Processing of Landsat 5, Landsat 8, and Sentinel-2 data

Esri ArcGIS – Image and map creation, object based classification

R – Statistical analysis

ERDAS Imagine – Sub-pixel analysis, object based classification.

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Baseline: LST, Tree Canopy, Vegetation Time Series** | The partners will use this time series to identify how temperature, tree canopy cover, and vegetation has changed from 2000 – 2018. They will be able to identify areas throughout Tempe that have experienced increase in temperature and decrease in tree canopy cover and vegetation. This will allow our partners to better target tree planting initiatives. | Landsat 5 TM, Landsat 8 OLI, Sentinel-2 MSI, and Landsat 8 TIRS will be used to assess land surface temperature, tree canopy cover, and vegetation prevalence. A spatiotemporal analysis will identify how these variables have changed throughout time as well as identifying anomalous values throughout space. | N/A |
| **Park Thermal Performance Metrics** | These end products will include a set of performance metrics relating to temperature, tree canopy, and shade prevalence throughout the Rio Salado Tempe Beach Park. These metrics will allow our partners to interpret the distribution and magnitude of temperature, tree canopy cover, and shade throughout the park. It will also enable them to better target tree planning and shade structure installations.  | Landsat 8 OLI and Landsat 8 TIRS will be combined with ancillary datasets (*in situ* measurements, NAIP, and LiDAR datasets) to produce a shade analysis, land surface temperature assessment, and tree canopy cover for present conditions throughout the Rio Salado Tempe Beach Park.  | N/A |
| **Tempe Thermal Performance Metrics** | These end products will include a set of performance metrics relating to temperature, tree canopy, and shade prevalence throughout the Tempe Urban Core and along the proposed Tempe Street Car routes. These metrics will allow our partners to assess thermal conditions, duration and timing of shade, and tree canopy cover along Tempe street car routes and throughout the city so tree planting and shade structure installation can be targeted.  | Landsat 8 OLI and Landsat 8 TIRS will be combined with ancillary datasets (*in situ* measurements, NAIP, and LiDAR datasets) to produce a shade analysis, land surface temperature assessment, and tree canopy cover for present conditions throughout the Tempe Urban Core.  | N/A |

***End-User Benefit*:** The end products will enable our partners to establish several performance measures that can be used to better track greening initiatives and efforts to reduce the thermal burden residents experience throughout the City of Tempe. The performance metrics will enable the end user to implement the greening interventions outlined in the Rio Salado Tempe Beach Park Masterplan, Tempe Urban Core Masterplan, and the Tempe Urban Forestry Masterplan.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: 2018 Fall

***Related DEVELOP Work:***

2018 Spring (AZ) - Ajax Urban Development: Utilizing NASA Earth Observations to Assess Urban Forests as an Adaptation Strategy for Extreme Heat in Ajax, ON, Canada

2017 Fall (AZ) – Phoenix Health & Air Quality II: Utilizing NASA Earth Observations and Ground Measurements to Reduce Extreme Heat Experienced by Transit Riders in Phoenix, AZ

**Notes & References:**

***Notes*:**

Tempe Urban Core Master Plan:

 <https://www.tempe.gov/city-hall/community-development/urban-core-masterplan>

Rio Salado Arts Park Thermal Comfort Assessment: <https://www.dropbox.com/s/bosyumk7pqbmre8/Spring2018%20Progress%20Report.pdf?dl=0>

Tempe Urban Forest Grants and Demonstration Projects:

<https://www.tempe.gov/city-hall/community-services/parks/urban-forest/urban-forest-grants-and-demonstration-projects>

Urban Forest Master Plan:

<https://www.tempe.gov/city-hall/community-services/parks/urban-forest-master-plan>

***References:***

Harlan, S., Declet-Barreto, J., Stefanov, W., & Petitti, D. (2013). Neighborhood effects on heat deaths:

social and environmental predictors of vulnerability in Maricopa County, Arizona. *Environmental Health Perspectives, 121*(2), 197–204. <https://doi.org/10.1289/ehp.1104625>

Middel, A., Selover, N., Hagen, B., & Chhetri, N. (2016). Impact of shade on outdoor thermal comfort—a

seasonal field study in Tempe, Arizona. *International Journal of Biometeorology, 60*(12), 1849–1861. https://doi.org/10.1007/s00484-016-1172-5

Reid, C., O’Neill, M., Gronlund, C., Brines, S., Brown, D., Diez-Roux, A., & Schwartz, J. (2009). Mapping

community determinants of heat vulnerability. *Environmental Health Perspectives, 117*(11), 1730-1736. <https://doi.org/10.1289/ehp.0900683>

Uejio, C. K., Wilhelmi, O. V., Golden, J. S., Mills, D. M., Gulino, S. P., & Samenow, J. P. (2011). Intra-urban

societal vulnerability to extreme heat: The role of heat exposure and the built environment, socioeconomics, and neighborhood stability. *Health & Place, 17*(2), 498–507. https://doi.org/10.1016/j.healthplace.2010.12.005

Turner II, B. L. (2016). Land system architecture for urban sustainability: new directions for land system

science illustrated by application to the urban heat island problem. *Journal of Land Use Science*, *11*(6), 689-697.