**NASA DEVELOP National Program**

**2020 Spring Project Proposal**

**Arizona – Tempe**

**Philadelphia Health & Air Quality**

*Assessing Land Surface Temperature, Vegetation Cover, and Compounding Vulnerability Factors to Identify High Priority Areas for Cooling Initiatives in Philadelphia, Pennsylvania*

**Project Overview**

***Project Synopsis*:** The partners for this project include the Philadelphia Department of Public Health and Office of Sustainability, who both work to maintain the overall environmental health of the city to better serve the health of its citizens. This work will focus on evaluating the land surface temperature (LST) and overall greenness (NDVI) of Philadelphia, Pennsylvania, using the NASA Earth observations Aqua MODIS, Terra MODIS, and ISS ECOSTRESS. Connecting the results of these analyses with local tree inventory, air quality, and socioeconomic data will allow the project team to conduct a multivariate decision analysis about where new trees or cooling adaptations are most needed. Rooftops will be specifically evaluated in the decision process as potential for green-roofs or cool-roofs. The partners will use the project’s resulting maps of tiered selected localities to prioritize greenness and cooling initiatives throughout Philadelphia.

***Community Concern:*** Philadelphia environmental health groups are cognizant that their city experiences urban heat effects and elevated air pollution, and that groups of lower socioeconomic status are disproportionately affected by these issues. Urban heat can lead to heat-related illnesses or deaths, which often occur at higher rates in areas with little green space, extensive impervious surfaces, and low albedo. The city’s goal is to mitigate these issues by planting trees and reducing sources of air pollution. The Philadelphia Department of Public Health and the City’s Office of Sustainability would like to determine how to most effectively prioritize cooling initiatives to reduce urban heat and most impactfully improve the health and safety of Philadelphia residents.

***Source of Project Idea:*** This project originated from an initial contact between Jason Hammer of the Philadelphia Department of Public Health and the Arizona – Tempe node’s science advisor, Dr. David Hondula, regarding his past research on heat vulnerability in Philadelphia. Dr. Hondula connected Jason with the Fellow, Crystal Wespestad, to determine whether his group would be interested in partnering with NASA DEVELOP to do further analysis of related environmental health topics. A project design was generated during a phone discussion between DEVELOP and the Philadelphia Department of Public Health.

***National Application Areas Addressed:*** Health & Air Quality

***Study Location:*** Philadelphia, PA

***Study Period:*** January 2018 – December 2019

***Advisors:*** Dr. David Hondula (Arizona State University)

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Philadelphia Department of Public Health** | Jason Hammer, Public Health Preparedness Planner;  Jessica Caum, Program Manager, Bioterrorism & Public Health Preparedness Program;  Alexandra Skula, Preparedness Analyst | End User | Yes |
| **City of Philadelphia, Office of Sustainability** | Saleem Chapman, Deputy Director | End User | No |

***End User Overview***

***End User’s Current Decision-Making Process:***The Philadelphia Department of Public Health (PDPH) leads city preparedness planning and outreach initiatives to reduce the health impacts of climate change. The City of Philadelphia, Office of Sustainability, also works to prepare for climate change by working with partners around the city to reduce carbon emissions and prepare for hotter future environments. To inform this work, PDPH convenes the Climate Change & Health Advisory Group (CCHAG), which is comprised of stakeholders from City agencies such as the Office of Sustainability and Office of Emergency Management, as well as community-based organizations. CCHAG meetings allow for bidirectional feedback between PDPH and stakeholders throughout the decision-making process for projects and initiatives through presentations and data-sharing.

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

*Philadelphia Department of Public Health –* The partner’s only exposure to NASA Earth observations thus far has been through the utilization of Dr. Dave Hondula’s 2012 research on heat-related mortality in Philadelphia County, which analyzed land surface temperature from Landsat 7. The department does have some employees that utilize GIS in their work, but they may not be directly involved with the NASA DEVELOP project.

*City of Philadelphia, Office of Sustainability –* Similar to the PDPH, the partner’s only exposure to NASA Earth observations has been through the utilization of the afformentioned 2012 research on heat-related mortality in Philadelphia County. The Office of Sustainability does have some employees that utilize GIS in their work, but they may not be directly involved with the NASA DEVELOP project.

***Collaborator & Boundary Organization Overview***

***Dissemination by Boundary Organizations*:**

*Philadelphia Department of Public Health* – The project results will be shared directly with CCHAG, made up of at least 40 stakeholders. This group will then provide feedback to the PDPH and other groups, utilizing the results to aid their decision-making process. Some products from the project may also be shared on the public data-sharing website (OpenDataPhilly.org) and used to update the Philadelphia Heat Vulnerability Index web map, which currently includes an outdated temperature map and a separate vulnerability assessment based on socioeconomic/demographic and health status data.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The NASA DEVELOP project team will meet with the partners weekly over video chat. There will also be ongoing communication via email. The main POC will be the Project Lead once the Fellow has introduced the team to the partners.

***Transition Plan*:** A handoff will be conducted virtually in the last week of the term via Google Hangouts or Zoom. All processed data products and end products will be sent to the partners by email or NASA Large File Transfer. Software release is not anticipated. The products will be mainly in the form of an easily shareable geodatabase or static map files and will be utilized for decision making in urban heat reduction initiatives.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Terra MODIS** | Albedo, Normalized Difference  Vegetation Index (NDVI), and emissivity | MODIS data will allow the team to create a high resolution albedo, NDVI, and surface emissivity maps for Philadelphia, especially focusing on rooftops and impervious surfaces. |
| **Aqua MODIS** | Albedo, NDVI, and emissivity | MODIS data will allow the team to create a high resolution albedo, NDVI, and surface emissivity maps for Philadelphia, especially focusing on rooftops and impervious surfaces. |
| **ISS ECOSTRESS** | Plant evapotranspiration and Land Surface  Temperature (LST) | ISS ECOSTRESS data will be used to generate a map of the geographic distribution of plant evapotranspiration and LST within Philadelphia. |

***Ancillary Datasets:***

* United States Census Bureau TIGER census shapefile – To select for population vulnerability variables within the priority site selection analysis
* City of Philadelphia Street Tree Inventory shapefile – To use for density measurements of current trees within selection process for future greening locations
* City of Philadelphia Building Footprints shapefile – To use for selection of rooftops
* City of Philadelphia Parks and Recreation Districts (PPR) raster – To use within priority site selection analysis and tree placement recommendation decisions
* City of Philadelphia Land Cover raster – To use as an additional parameter for organizing selected priority locations for future outreach efforts to different groups

***Software & Scripting:***

* Esri ArcGIS – Data processing, geodatabase creation, image and map creation
* Google Earth Engine API – Imagery processing, calculation of NDVI, LST, and albedo maps

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Geodatabase of Heat Susceptibility Index Variables** | This collection of feature classes will be used to determine which urban heat or vulnerability factors should be addressed within the high priority areas for cooling initiatives, in accordance with the Philadelphia Heat Vulnerability Index. They may also be used to update the current Philadelphia Heat Vulnerability Index web map. | All utilized sensors (Aqua &Terra MODIS, ISS ECOSTRESS) and select ancillary datasets will be used to make individual map layers showing the areas for each data value deemed to be at a detrimental level for urban heat vulnerability, as determined by the partners and literature review. | N/A |
| **Cooling Initiative Priority Map** | This static map will be an organizational tool for the partners when prioritizing the implementation of cooling initiatives for Philadelphia. | This static map will depict which areas are deemed to be high, medium, and low priorities for cooling initiatives. This selection will be determined from a weighted suitability analysis of the magnitude of the urban heat vulnerability variables derived from all the utilized sensors (Aqua & Terra MODIS, ISS ECOSTRESS) and ancillary datasets. The provided street tree inventory dataset will be an overlay on this map. | N/A |
| **Roof Specific Cooling Initiative Priority Map** | This static map will be an organizational tool for the partners when prioritizing the implementation of green-roofs or cool-roofs and organizing outreach efforts to building owners. | This map will be a variation of the Cooling Initiative Priority Map clipped to the boundaries of building footprints and organized by city, commercial, or private residence land use. | N/A |

***End User Benefit*:** With limited staff capacity and scientific expertise internally to employ NASA Earth observation data, this collaboration with the NASA DEVELOP Program will significantly advance the City’s heat mitigation initiatives. Given the intersectoral impacts of the urban heat island effect, the data produced by this project will inform both short-term heat relief planning and a long-term, multi-agency heat response strategy as part of the City’s Climate Change Adaptation Plan. Particularly, this project will inform the development of the PDPH’s Climate Change and Health Adaptation Plan, as well as direct community engagement and outreach activities.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: 2020 Spring

***Related DEVELOP Work:***

2019 Fall (LaRC) – New York City Urband Development: Mapping Hotspots using NASA Earth

Observations to Inform Future Green Initiatives in New York City

2019 Summer (LaRC) – Hampton Roads Urban Development II: Assessing Urban Tree Canopy and Impervious Surface Distribution to Inform Urban Planning in Hampton, Virginia

2019 Summer (JPL) – Douglas County Energy: Identifying Areas with High Solar Power Potential in Kansas via NASA Earth Observations and LiDAR

2018 Fall (AZ) – Tempe Urban Development: Utilizing NASA Earth Observations to Assess Thermal Landscapes and Prioritize Greening Initiatives in Tempe, Arizona

2018 Summer (LaRC) – Richmond Health & Air Quality: Synthesizing Temperature, Reflectance, and

Socioeconomic Data to Provide Spatial and Temporal Temperature Analyses in Richmond, Virginia

2018 Spring (ARC) – Richmond Urban Development: Quantifying Changes in Urban Tree Canopy Cover and Land Surface Temperature to Understand Their Impacts on Neighborhoods throughout Richmond, California

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

**Notes & References:**

***Notes*:**

* The City of Philadelphia already has a heat vulnerability index web map at the census tract level, where vulnerability based on socioeconomic/demographic and health status is mapped separately from heat exposure data, largely based on Dr. David Hondula’s 2012 heat study: <https://phl.maps.arcgis.com/apps/webappviewer/index.html?id=9ef74cdc0c83455c9df031c868083efd>
* NASA’s Socioeconomic Data and Applications Center (SEDAC) may be an alternative to TIGER for data on population vulnerability.
* There is a plethora of potentially useful open source data, including the number of trees planted along the street or in yards since 2009, for the area here: <https://www.opendataphilly.org/>
* There is aerial photography and 3D building model data for Philadelphia on the Pennsylvania Spatial Data Access website: <https://www.pasda.psu.edu/uci/SearchResults.aspx?Shortcut=aerial>
* There are high resolution LiDAR for Philadelphia from 2018 that could be used for roof selection and shading analysis, especially if building footprint data are not sufficient

***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.

Hondula, D. M., Davis, R. E., Leisten, M. J., Saha, M. V., Veazey, L. M., & Wegner, C. R. (2012). Fine-scale

spatial variability of heat-related mortality in Philadelphia County, USA, from 1983-2008: a case-

series analysis. *Environmental Health*, *11*(1), 16.

Mushore, T. D., Mutanga, O., Odindi, J., & Dube, T. (2018). Determining extreme heat vulnerability of

Harare Metropolitan City using multispectral remote sensing and socio-economic data. *Journal of*

*Spatial Science*, *63*(1), 173-191.

Santamouris, M. (2014). Cooling the cities–a review of reflective and green roof mitigation technologies to

fight heat island and improve comfort in urban environments. *Solar Energy*, *103*, 682-703.

Tan, Z., Lau, K. K. L., & Ng, E. (2016). Urban tree design approaches for mitigating daytime urban heat

island effects in a high-density urban environment. *Energy and Buildings*, *114*, 265-274.