**NASA DEVELOP National Program**

**2019 Fall Project Proposal**

**Arizona – Tempe**

**Louisville Urban Development**

*Observing Impervious Surface Area and Tree Canopy Cover with Optical and Radar Imagery in Louisville, Kentucky*

**Project Overview**

***Project Synopsis*:** This project’s partners at the New York University School of Medicine’s City Health Dashboard (CHD), and University of Louisville Envirome Institute, which works closely with the Louisville Department of Public Health and Wellness, are working to include physical environment metrics on their Dashboard that impact public health. The partners aim to incorporate tree cover measurements and impervious surface locations into their website since there has been research in showing the relationship between green spaces with the health of communities. The Arizona – Tempe node will collaborate with the partners to create tree cover and impervious surfaces maps using Landsat 8 OLI, Sentinel-1 C-SAR, and Sentinel-2 MSI imagery for Louisville, KY. The project’s end products may help in changing the way public policy may function to improve the health of the cities by identifying potentially vulnerable areas.

***Community Concern:*** The partners’ goal is to provide actionable data for city leaders and public health practitioners to create healthier and more equitable communities. The CHD team has developed close relationships with city and community leaders across the country, including Louisville, KY. These city leaders frequently request that the CHD team add a metric related to the impact of climate on health to their site, as cities are vulnerable to the physical, financial, and health effects of changes in climate and are significant contributors of greenhouse gas emissions. Leaders and politicians in the cities have the opportunity to shape programs and policies for sustainable and resilient urban living and growth, but to do so, they need access to strong climate-related data. There is a large body of evidence that urban green infrastructure is associated with extreme weather resilience and improved health outcomes. With this in mind, the CHD seeks to develop a green health benefit data layer derived from land use measures to help cities identify health-improving interventions, such as planting more trees or expanding or improving access to parks.

***Source of Project Idea:*** This project idea came directly from Benjamin Spoer from the City Health Dashboard team; he submitted a project request form to the DEVELOP National Program Office via the project idea form. DEVELOP Projects Manager Amanda Clayton shared the idea with Arizona –Tempe node leadership as a potential project for the node. Arizona – Tempe Center Lead Erika Higa continued the conversation with Benjamin and his team to discuss the idea in detail and the feasibility of including metrics created from NASA Earth observations data for use in the City Health Dashboard application.

***National Application Area Addressed:*** Urban Development

***Study Location:*** Louisville, KY

***Study Period:*** April 2013 – September 2019

***Advisors:*** Dr. David Hondula (Arizona State University), Dr. Kenton Ross (NASA Langley Research Center)

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **City Health Dashboard** | Dr. Benjamin Spoer, Manager of Data and Analytics | End User | Yes |
| **University of Louisville, Envirome Institute** | Dr. Ted Smith, Deputy Director | End User | Yes |

***End-User Overview***

***End User’s Current Decision-Making Process:***The CHD analytic staff uses the following metric inclusion criteria to evaluate the addition of a climate-related metric to the site. The metric must be at the city level or below, scalable to and comparable across 500 cities, utilize regularly updated and publicly available underlying data sources, and be actionable at the city level. The staff’s Primary Investigators and City Advisory Board review possible metrics to see if they meet these criteria. The team does not use any remote sensing beyond the dashboard’s air pollution metric, which is powered by the Community Multiscale Air Quality model through the EPA. The CHD group spends a large amount of time and resources working on the selected metrics shared on the website. The University of Louisville Envirome Institute measures and assesses domains of the environment, develops new models for healthy urban living, and communicates scientific knowledge to policy makers and stakeholders.

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

*City Health Dashboard –* The CHD does not have extensive experience working with NASA Earth observations and have only using remotely sensed data for the air pollution metric on the site.

*University of Louisville Envirome Institute –* The Envirome Institute has experience using NDVI, EVI, and ambient air pollution data for epidemiological studies but lacks access to NASA science teams to identify other environmental datasets that NASA may have to provide more complete health risk metrics. The Louisville Department of Health and Wellness does not have direct experience with using NASA Earth observations for policy and decision making. Partners at the department are only familiar with Earth observations from a research standpoint and not in applied work.

***Collaborator & Boundary Organization Overview***

***Dissemination by Boundary Organizations*:**

*City Health Dashboard –* The CHD shares its metrics in a publicly available site, and the group has close relationships with city and community leaders across the country. They provide these data to 500 cities within the U.S. This project will focus on Louisville, KY, and the methods will be applied to other cities after the project ends so that the CHD team can have the data ready on its dashboard to the remaining cities of focus.

*University of Louisville Envirome Institute –* The University of Louisville Envirome Institute is a US founding member of the United Nations Sustainable Development Solutions Network, as well as the leaders of the Green Equity for Health Equity Initiative for the Louisville Department of Health and Wellness. This work ties directly to the Mayor of Louisville's interest in working to change to the built environment to reduce health inequity while also combating climate change. Additionally, Louisville Mayor Greg Fischer is the incoming president of the US Conference of Mayors and will thus be able to share the outcome of this project broadly.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** Arizona node leadership will help facilitate the first meeting; from there, the Project Lead will be the main point of contact with the partners. During the term, the team will have weekly or biweekly telecon meetings to update the partners on the project’s status. Email communications will occur as needed.

***Transition Plan*:** A formal end-user handoff will take place at the end of the term in the form of a WebEx teleconference. The project results will be sent via NASA’s Large File Transfer. The partners will review the products and methods and replicate the process with other cities in their network. This project may require a software release depending on the codes the team will use to create the end products.

***Letters of Support*:** Benjamin Spoer, Manager of Data and Analytics, City Health Dashboard

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 8 OLI** | NDVI, NDISI | Normalized Difference Vegetation Index (NDVI) will be used to map tree coverage in the study area, while the Normalized Difference Impervious Surface Index (NDISI) will be used to create impervious surface maps. |
| **Sentinel-2 MSI** | NDVI, NDISI | NDVI will be used to map tree coverage in the study area, while the NDISI will be used to create impervious surface maps. |
| **Sentinel-1 C-SAR** | Backscatter | Radar signatures will be used to map land cover, mainly impervious surfaces and tree coverage, based on the different backscatter properties from Earth’s surface. |

***Ancillary Datasets:***

* USDA National Agriculture Imagery Program (NAIP) – This will be used for supervised classification for impervious surfaces.
* USFS Urban Forest Data for Kentucky – This spreadsheet contains percent Urban Tree Canopy cover and a planting priority index for each city which will be used to differentiate possible tree planting opportunity sites in Louisville.
* USGS National Land Cover Dataset (NLCD) – This will be used to compare its impervious surface classifications with the team’s product.

***Software & Scripting:***

* Esri ArcGIS – Used for image production, analysis, and processing indices
* ESA Snap Toolbox – Used to process and analyze radar imagery
* Google Earth Engine API – Used to automate the indices output

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Canopy Cover Time Series Maps** | This product will help the partners identify gains and losses in tree cover over time. This will help them identify regions that constantly have less tree coverage and thus help them to see how this could relate to the health of communities.  | The team will use Landsat 8 OLI, Sentinel-1 C-SAR, and Sentinel-2 MSI data to create NDVI maps. Along with using NAIP imagery, the team will use supervised classification to detect tree cover.  | I |
| **Impervious Surface Time Series Maps** | This product will help the partners see where they are gaining and losing impervious surfaces over time. This will help them identify regions have more impervious surfaces and thus help them to see how this could relate to the health of communities. | The team will use Landsat 8 OLI, Sentinel-1 C-SAR, and Sentinel-2 MSI data to create NDISI maps. Along with using NAIP imagery, the team will use supervised classification to detect impervious surfaces. | I |
| **Tutorial of Methods for End Products** | This will be a document that explains how the end products were created. It will be a step-by-step guide so partners can reproduce the analysis and create the same products for their other cities of interest. | This will include the datasets and analysis mentioned above. | N/A |

***End-User Benefit*:** This project will introduce the partners to the capabilities of NASA Earth observations which will help them to identify areas that are lacking in green infrastructure as well as to identify a viable climate-influenced metric. This metric can be incorporated within the City Health Dashboard, using this pilot study of Louisville, KY, as an example. With the tutorials and assistance provided by NASA DEVELOP team, the CHD team hopes to expand this methodology to generate metric estimates for its additional 499 cities. The work completed by this project will help improve the partner’s efficiency and help them save time and money by recreating the team’s products and create a new health metric for their partner cities. The end products have the potential to change public policy related to improving the health of cities across the country by increasing the visibility of these metrics, such as seeing the importance of increasing tree coverage for better health.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: 2019 Fall

***Related DEVELOP Work:***

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

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

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*:**

* City Health Dashboard: <https://www.cityhealthdashboard.com/>
* Project partner Ted Smith at theUniversity of Louisville Envirome Institute leads the Louisville Green Equity Initiative of the Louisville Department of Public Health and Wellness.
* The CHD team has not used any remote sensing beyond its air pollution metric seen here: <https://www.cityhealthdashboard.com/metric/21>
* Louisville just completed the 100 Resilient Cities program (<http://www.100resilientcities.org/>) from the Rockefeller Foundation and has identified extreme weather and air pollution as key health risks to the population.

***References:***

Chen, J., Yang, K., Chen, S., Yang, C., Zhang, S., & He, L. (2019). Enhanced normalized difference index for impervious surface area estimation at the plateau basin scale. *Journal of Applied Remote Sensing*, *13*(1), 016502.

Guo, H., Yang, H., Sun, Z., Li, X., & Wang, C. (2014). Synergistic use of optical and PolSAR imagery for urban impervious surface estimation. *Photogrammetric Engineering & Remote Sensing*, *80*(1), 91-102.

Sun, Z., Wang, C., Guo, H., & Shang, R. (2017). A modified normalized difference impervious surface index (MNDISI) for automatic urban mapping from Landsat imagery. *Remote Sensing*, *9*(9), 942.