**NASA DEVELOP National Program**

**2019 Spring Project Proposal**

**Virginia – Langley**

**Providence & Elizabeth Urban Development**

*Exploring Heat- and Flood-related Vulnerability in Urban Settings via NASA Earth Observations*

**Project Overview**

***Project Synopsis*:** Groundwork USA is a network of nonprofit organizations focused on promoting environmental, economic, and social well-being within marginalized communities through the regeneration, improvement, and thoughtful management of urban spaces. One aspect of Groundwork USA’s mission is to understand and address localized vulnerabilities to urban heat and flooding. This project will apply Landsat 8 TIRS, Suomi NPP VIIRS, Terra ASTER, Terra and Aqua MODIS land surface temperature and emissivity (LST&E) data to monitor and understand the effects of urban heat islands. The project team will also use Landsat 8 OLI and Sentinel-2 MSI data to derive land cover products that can be combined with flood extent indices derived from Sentinel-1 C-SAR data to generate a comprehensive flood extent analysis. The goal of this project is to update and refine methodologies for both urban heat and flood extent analyses and apply them to two of Groundwork USA’s partner cities, Providence, RI, and Elizabeth, NJ.

***Community Concern:*** Providence, RI, and Elizabeth, NJ, are both densely populated urban environments in low-lying areas proximal to bodies of water. These conditions make the communities that live in these cities vulnerable to extreme urban heat and potential flooding. Groundwork USA directors, alongside personnel from community-based local trusts Groundwork Rhode Island and Groundwork Elizabeth, hope to build local capacity for city- and neighborhood-specific resilience planning. They want to use Earth observations to implement a vulnerability assessment methodology that they can eventually apply across the Groundwork USA network to give their local trusts consistent and reproducible map products.

***Source of Project Idea:*** Previous DEVELOP projects partnered with local Groundwork USA trusts (Groundwork Richmond, Groundwork RVA, and Groundwork New Orleans) and successfully explored the feasibility of using NASA Earth observations to assess vulnerabilities related to urban heat and flooding. The results of those projects led to the formation of a two-year Groundwork USA project focused on using remote sensing techniques to support similar efforts. Other Groundwork USA officials then reached out to the DEVELOP NPO and Virginia – Langley node leadership to explore further partnership. The current project formed from those discussions.

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

***Study Location:*** Elizabeth, NJ & Providence, RI

***Study Period:*** May 2013 – October 2018

***Advisor:*** Dr. Kenton Ross (NASA Langley Research Center)

**Partner Overview**

***Partner Organization:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Groundwork USA** | Steve Burrington, Executive Director of Groundwork USA; Lawrence Hoffman, GIS Program Manager of Groundwork USA; Amelia Rose, Executive Director of Groundwork Rhode Island; Jonathan Phillips, Executive Director of Groundwork Elizabeth | End User | Yes |

***End-User Overview***

***End User’s Current Decision-Making Process:***Groundwork USA is a non-profit leader in community-based environmental work. The network operates in partnership with twenty localized trusts and undertakes projects aimed at transforming the environment of marginalized communities. Groundwork USA personnel acquire data and prioritize projects through a variety of means. As evidenced by past DEVELOP collaborations, some local trusts already incorporate Earth observations in their work, but this is inconsistent across the entire Groundwork USA network. Currently, no standardized mapping procedure exists to assess urban heat and flood risk across all of their locations, including Providence, RI, and Elizabeth, NJ.

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

*Groundwork USA* – Groundwork USA is able to aggregate and capitalize on the strengths of its various local trusts. Across the network, there are multiple GIS professionals who are familiar with spatial data visualization and manipulation. These professionals mostly specialize in the use of social and demographic data rather than remote sensing products, and they do not currently incorporate NASA Earth observations into their regular decision-making processes. Their background and expertise will allow Groundwork USA officials to rapidly incorporate the results of this project, alongside social and demographic variables, into their decision-making processes. The results of this work and the associated project methodology tutorial will build the end user’s capacity to use remote sensing and Earth observation data.

***Collaborator & Boundary Organization Overview***

***Dissemination by Boundary Organizations*:**

*Groundwork USA* – The results of this project are intended to support a broader Groundwork USA initiative aimed at generating a consistent and reproducible set of mapping products that can be used in multiple Groundwork USA trust cities across the country. Upon completion of the project, the Groundwork USA GIS Manager will compile project results into aggregated map products that incorporate appropriate social and demographic variables alongside the urban heat and flood risk maps. Groundwork USA officials plan to replicate the project methodology across multiple cities and disseminate project results as part of that broader effort. They are well situated to disseminate project results in a manner that will ensure high potential for impact.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The DEVELOP team will communicate with project partners weekly or biweekly throughout the project term. The Project Lead will coordinate regular partner meetings via teleconference and maintain recurring email correspondence with Groundwork USA officials. The primary in-term POC will be Lawrence Hoffman, the Groundwork GIS Program Manager, who is well suited to relay the partner organization’s GIS preferences and project needs.

***Transition Plan*:** The Project Lead will coordinate a final teleconference or WebEx to transition all products to the end user. The team will hand off all final maps, data products, and a standard operating procedure/tutorial document on the mapping methodology via NASA LFT. The project methodology is of particular importance because the partner has expressed a discrete desire to replicate the approach in other Groundwork USA trust cities.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Landsat 8 OLI** | Surface reflectance  | Landsat 8 OLI data will serve as the primary underpinning of the land cover classification.  |
| **Landsat 8 TIRS** | LST  | Landsat 8 TIRS LST data products will serve as the primary means to evaluate urban heat.  |
| **Suomi NPP VIIRS** | LST&E  | Suomi NPP VIIRS LST&E data from the LP DAAC will be a secondary means by which to evaluate urban heat, if time allows. |
| **Sentinel-1 C-SAR** | Backscatter values | Sentinel-1 C-SAR data will be used to generate Normalized Difference Flood Index and Normalized Difference Flood in Vegetated Areas Index values to assess flood risk. Initial radar preprocessing will involve the ESA’s SNAP toolbox.  |
| **Sentinel-2 MSI**  | Surface reflectance | Sentinel-2 MSI data will serve as a secondary underpinning to the land cover classifications in the years for which the data are available.  |
| **Terra ASTER** | LST&E, top of atmosphere reflectance | ASTER data will be references to compare monitored land surface temperatures and emissivity with calculated land surface temperature from Landsat data. |
| **Terra MODIS** | LST | Terra and Aqua MODIS MOD11A1 and MOD11A2 data products will be additional references and validation data sources used as points of comparison to Landsat-derived temperature and emissivity products. |
| **Aqua MODIS** | LST | Terra and Aqua MODIS MOD11A1 and MOD11A2 data products will be additional references and validation data sources used as points of comparison to Landsat-derived temperature and emissivity products. |

***Ancillary Datasets:***

USGS National Land Cover Database (NLCD) – As of December 2018, the NLCD is available for 2016. NLCD layers, such as the percent tree cover, percent impervious surfaces, and other high resolution products, will be points of comparison to the team’s Landsat- and Sentinel-derived land cover products

NOAA Coastal Change Analysis Program (C-CAP) Coastal Land Cover and Land Change Dataset – This dataset will be used as a reference point for the team’s Landsat- and Sentinel-derived land cover products

USDA National Agricultural Imagery Program (NAIP) – The high resolution aerial imagery available from NAIP will help the team create reference training points for accuracy analysis of the land cover product

USDA Cropland Data Layer – The land cover dataset tailored to agricultural regions will be used as a point of comparison to the team’s land cover products

Dartmouth Flood Observatory Surface Floodwater Records – These data will be used to assess the accuracy of flood extent products

FEMA Flood Map Service Center Flood Maps – These products will be used to compare historical flood extent and assess the flood extent products

NOAA NCEI Local Climatological Data (LCD) – Local weather and climatological data will be used to better define flood risk assessments

***Software & Scripting:***

ERDAS IMAGINE – Raster manipulation, land cover classification of Landsat and Sentinel imagery, and map product generation

Esri ArcGIS Pro – Raster manipulation, land cover classification of Landsat and Sentinel imagery, and map product generation

ESA SNAP Toolbox 6 – Radar data preprocessing

Python – Landsat, Sentinel, MODIS, ASTER, and VIIRS data processing

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **2014 to 2018 Urban Heat Maps**  | These basic urban heat distribution maps will be the partner’s primary way to understand heat distribution.  | Landsat 8 TIRS, Suomi NPP VIIRS, Terra ASTER, Terra MODIS, and Aqua MODIS data will be used to generate this end product. | I |
| **2014 and 2018 Heat Vulnerability Assessment Maps**  | Surface temperature maps overlaying land cover maps will demonstrate the relationship between land cover type and heat distribution. Groundwork USA will use these maps to target adaptation and management strategies.  | Landsat 8 OLI, Sentinel-2 MSI, Landsat 8 TIRS, Suomi NPP VIIRS, Terra ASTER, Terra MODIS, and Aqua MODIS data will be used to generate this end product. | I |
| **2018 (and other selected years) Flood Distribution Map(s)**  | These basic urban flood distribution maps will be the partner’s primary way to understand flooding and inundation.  | Sentinel-1 C-SAR data will be used to generate this end product. | I |
| **2014 and 2018 Flood Risk Assessment Maps**  | Flood risk maps overlaying land cover maps will demonstrate to the partner the distribution of vulnerable areas and their relationship to land cover type.  | Landsat 8 OLI, Sentinel-2 MSI, and Sentinel-1 C-SAR data will be used to generate this end product. | I |
| **Project Methodology Standard Operating Procedure Document**  | A detailed document outlining the project procedure and methodology will allow Groundwork USA to replicate this analysis for other trust cities. | N/A  | N/A |

***End-User Benefit*:** In the short term, the results of this work will allow Groundwork USA, Groundwork Rhode Island, and Groundwork Elizabeth to better understand heat- and flood-related vulnerabilities in Providence, RI, and Elizabeth, NJ. In the long term, the refined project methodology will allow Groundwork USA to generate a consistent and reproducible set of map packages that can be applied to any of its local trusts. Groundwork USA officials will aggregate the results of this project with their other mapping efforts to build consistency across their network and facilitate the continued use of NASA Earth observations in their decision-making processes.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: 2019 Spring

***Related DEVELOP Work:***

2018 Summer (LaRC) – Richmond Health & Air Quality: Synthesizing Temperature, Reflectance, and Land Change to Provide Spatial and Temporal Temperature Analysis in Richmond, Virginia

2018 Summer (AL) – New Orleans Urban Development: Utilizing Earth Observations to Assist Groundwork New Orleans to Reduce Flood Vulnerability in the New Orleans, Louisiana, Metropolitan Area

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

**Notes & References:**

***Notes*:** Team members should anticipate using Landsat 8 TIRS data as their primary means of assessing urban heat. However, their methodology may be highly dependent on the upcoming distribution of new surface temperature data products from the USGS (Landsat Level-2 Surface Temperature Science Product). Although they are not yet available, these products could become available soon, and their release will affect the project methodology. Without the surface temperature product, the team will need to use emissivity data to convert TOA brightness temperature to surface temperature, which will pose an initial challenge that the previous projects listed above had to address. Additionally, while the Suomi NPP VIIRS LST&E dataset is potentially a good option for calculating surface temperature, it is not a gridded and will need to be prior to data processing. Finally, the Sentinel-1 C-SAR imagery will require preprocessing through the ESA SNAP toolbox before it can be stacked and incorporated into the flood indices. The team should be mindful of time constraints and understand that these datasets will require a certain amount of time-consuming preprocessing. If possible, it would benefit project partners from Groundwork Providence to include two towns north of Providence (Pawtucket and Central Falls) in the analysis. Groundwork USA has begun operating in these areas as well.

***References:***

Cian, F., Marconcini, M., & Ceccato, P. (2018). Normalized Difference Flood Index for rapid flood mapping: Taking advantage of EO big data. *Remote Sensing of Environment, 209*, 712-730.

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