**NASA DEVELOP National Program**

**2020 Fall Project Proposal**

**Massachusetts – Boston**

**Charles River Basin Water Resources**

*Assessing Water Quality and Flooding Vulnerability to Assist High Water Intervention and Urban Planning Programs in the Charles River Basin*

**Project Overview**

***Project Synopsis*:** Communities in the Charles River Basin of Massachusetts named flooding as one of their greatest environmental concerns. This has been attributed to local impervious surface distribution and extreme weather events. DEVELOP will partner with the Massachusetts Audubon Society (Mass Audubon), the City of Natick’s Office of Sustainability, and the Charles River Watershed Association (CRWA). The team will use Landsat 5 and 8, Sentinel-1 and -2, and ancillary datasets, to map impervious surface cover, water quality, and local flood vulnerability and susceptibility. The provided products will help partners better understand how remotely-sensed factors contribute to flooding as well as identify key areas in need of increased resiliency efforts.

***Community Concern:*** In recent years, Massachusetts communities have seen an increase in high water events, specifically related to flooding and increased surface runoff. This has been attributed to increased development, impervious surfaces, and extreme precipitation events, especially in Eastern Massachusetts. When surveyed at community workshops, a majority of Charles River Basin town representatives identified flooding events as the greatest environmental impacts felt in their communities. Many local governments in Massachusetts and organizations like Mass Audubon are interested in assessing their area’s vulnerability to climate change impacts and have thus sought out vulnerability assessments from state run programs. However, these assessments currently do not incorporate remote sensing data.

***Source of Project Idea:*** After working with DEVELOP in the spring of 2020, Mass Audubon was interested in partnering for an additional project. The topic of focusing on flooding and increased surface runoff due to impervious surfaces to assist mitigation programs was specifically requested by both Mass Audubon and the City of Natick.

***National Application Area Addressed:*** Water Resources

***Study Location:*** Charles River Basin, MA

***Study Period:*** January 2000 – September 2020

***Advisor:*** Dr. Cedric Fichot (Boston University)

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Charles River Watershed Association** | Julie Wood, Deputy Directory | End User | Yes |
| **City of Natick, Office of Sustainability** | Jillian Wilson Martin, Sustainability Coordinator | End User | No |
| **Massachusetts Audubon Society** | Elissa Landre, Sanctuary Director of Broadmoor Wildlife Sanctuary; Tom Lautzenheiser, Central/Western Regional Scientist; Danielle Perry, Statewide Climate Adaptation Ecologist; Joshua Rapp, Regional Scientist | End User | Yes |

***End User Overview***

***End User’s Current Decision-Making Process:***The City of Natick and the CRWA are looking into assessing their vulnerability to impacts from climate change, and Mass Audubon is interested in assessing the potential vulnerabilities for the lands they manage. The main focus for all partners is preparing for and managing flooding events, especially in the most vulnerable areas. However, both of these groups currently do not utilize remote sensing data in their vulnerability assessments, decision-making, or climate preparations. All partner organizations are in the process of establishing climate preparedness plans for flooding due to weather extremes and are interested in incorporating cost-efficient, remotely-sensed data into their management.

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

*Charles River Watershed Association –* The partner POC has an introductory understanding of NASA Earth Observations, however, the organization currently does not use any remote sensing in their decision-making. The partner is excited to gain a working knowledge of how Earth observations can be included in their environmental planning.

*Massachusetts Audubon Society* – The partner POCs have working knowledge and understanding of NASA Earth observations. However, the organization does not currently use NASA Earth observations or other remote sensing products in its decision-making. Mass Audubon is excited to incorporate remote sensing data into their future decision-making and overall environmental planning.

*City of Natick, Office of Sustainability* – The partners do not currently use and have limited knowledge of NASA Earth observations and remote sensing data. Currently, remote sensing products are not employed for its decision-making. The City of Natick is looking forward to increasing their understanding of how remotely-sensed data can be used to aid their environmental intervention and planning.

***Collaborator & Boundary Organization Overview***

***Dissemination by Boundary Organizations*:**

*Charles River Watershed Association –* The CRWA is one of the country’s oldest watershed protection organizations. They work closely with groups from 35 different towns in the watershed. The CRWA is looking to develop a watershed-wide flood-risk model, which products from this project would contribute to. The partner is hoping to share results from this project to their network of government groups and organizations in order to create a watershed-wide plan to prepare for future flood events.

*Massachusetts Audubon Society* – Mass Audubon is one of the largest providers of environmental education in Massachusetts. Its network of partner organizations from past and current community outreach extends from local government to national environmental groups. Mass Audubon plans to share the knowledge and results from the project beyond its wildlife sanctuaries to the neighboring communities it works closely with as well as the general public via its website. Mass Audubon is hoping to share results from the project with local communities to inform their vulnerability planning.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The partners will meet with the Massachusetts – Boston DEVELOP team via video conferencing on a bi-weekly basis throughout the fall term. The main DEVELOP POC for all communications will be the project lead. If needed, the Fellow will assist.

***Transition Plan*:** The partner hand-off will take place during week 10 of the term. The event will take place virtually over Google Meet. The project team will present the term’s methods and results as well as answer questions. Products not requiring software release will be immediately delivered to partners for policy and research integration. Deliverables will be sent to partners after completing export control.

**Earth Observations Overview**

***Earth Observations:***

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| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 5 TM** | Surface Reflectance | Landsat 5 data will be used to obtain vegetation data and estimate recent flooding events. |
| **Landsat 8 OLI** | Surface Reflectance | Landsat 8 data will be used to obtain vegetation data and estimate recent flooding events. |
| **Sentinel-1 C-SAR** | Backscatter | Sentinel-1 data will be used to estimate flood frequency. |
| **Sentinel-2 MSI** | Surface Reflectance | Sentinel-2 data will be used to estimate flood frequency. |

***Ancillary Datasets:***

* FEMA Flood Insurance Rate Map (FIRM) – Define FEMA hazard areas and high-risk zones in the study area
* NASA Socioeconomic Data and Applications Center (SEDAC) Population Count v4.11 – Estimates of population data for vulnerability mapping, as well as an input for NOAA’s Impervious Surface Analysis Tool (ISAT)
* NOAA Office for Coastal Management 2016 High Res Land Cover: Massachusetts – Land cover data will be incorporated into the ISAT analysis and susceptibility maps
* NOAA Office for Coastal Management Coastal Inundation Digital Elevation Model: Massachusetts – Elevation and slope data will be incorporated into the susceptibility map, as well as used to calculate a topographic wetness index and height above the nearest drainage
* Planet Ortho Scene Data – Classifying impervious surfaces at a higher resolution than the National Land Cover Database and incorporating into ISAT
* USDA Gridded Soil Survey Geographic (gSSURGO) Database – Soil geographic data at 10m resolution, such as hydrologic conductivity, will be incorporated into susceptibility maps to represent soil infiltration rate
* USGS Charles River, New Charles River Dam at Boston, MA Gage Height (feet) – Measuring river height for the Charles River from 2007 to 2020
* OpenStreetMap Road Vectors – Estimating road density in the susceptibility mapping

***Software & Scripting:***

* Esri ArcGIS Online – StoryMap creation
* Esri ArcGIS Pro – Data visualization and mapping
* Google Earth Engine – Data processing and analysis of Sentinel data
* NOAA ISAT – calculating the percentage of impervious surface area
* R – Data processing and timeseries analysis

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Watershed Water Quality Maps** | Partners will use these maps to visualize spatial variations of hydrology, runoff, and water quality in the watershed in order to plan for future weather extremes and high-water events. | The team will be running NOAA’s ISAT to look at runoff degradation and water quality in the watershed. This will use ancillary datasets as the primary inputs, notably Planet data for identifying high-resolution impervious surfaces. | II |
| **Flood Frequency, Susceptibility, and Vulnerability Maps** | Susceptibility and vulnerability maps will help partners pinpoint areas of highest risk for future flooding events. This will allow for more specific delegation of resources and aid from mitigation or recovery programs. | Landsat and Sentinel data will be used to determine flood frequency. Landsat, Sentinel, and ancillary data will be combined to analyze multi-factor indicators such as land cover, slope, vegetation health, and height above nearest drainage, that influence the chance of flooding. Additional socioeconomic factors will be incorporated to assess vulnerability. Together, these data will detail approximate flood risk for the area. | II |
| **ArcGIS Online StoryMap** | The StoryMap will illustrate the project background, methods, and results. This product will act as a way of communicating the project’s goals to the general public, as well as other organizations or communities interested in applying the same strategies. | The ArcGIS StoryMap will incorporate data from the above maps as well as additional information on the project community concerns, partners, and NASA Earth observations involved. | N/A |

***End User Benefit*:** The provided maps and information will help partners advance their environmental decision-making and understanding of local flood events due to weather extremes. Education about remote sensing resources will allow these groups to better understand how remotely-sensed environmental factors contribute to high water events, identify vulnerable areas in need of immediate resiliency efforts, and assist communities in planning for high water mitigation. Overall, the products will assist the partner agencies by improving their environmental management, as well as be distributed to other Massachusetts communities to provide resources and assistance.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: 2020 Fall

***Related DEVELOP Work:***

2020 Summer (LaRC) – Riley County Water Resources: Comparing Curve Calculation Methods to Inform Local Resiliency Initiatives in Riley County, Kansas

2020 Spring (LaRC) – Toa Baja Disasters: Mapping Tropical Storm Susceptibility in Puerto Rico’s ‘Underwater City’ Using NASA Earth Observations to Assist the Municipality’s Intervention Efforts

2019 Spring (LaRC) – Providence & Elizabeth Urban Development: Utilizing NASA Earth Observations to Explore Heat and Flood-Related Vulnerabilities in Urban Settings

2019 Spring (MA) – Niagara Falls Disasters: Employing Remote Sensing Techniques to Evaluate Flood Extent and Environmental Parameters that Contribute to High Water Levels in Lake Ontario’s Coastal New York Communities

2019 Summer (GSFC) – Ellicott City Disasters: Applying NASA Resources to a Statistical Flood Risk Model to Improve Early Warning Systems and Public Safety

**References:**

DeVries, B., Huang, C., Armston, J., Huang, W., Jones, J., & Lang, M. (2020). Rapid and robust monitoring of flood events using Sentinel-1 and Landsat data on Google Earth Engine. *Remote Sensing of Environment, 240*, 1-14. <https://doi.org/10.1016/j.rse.2020.111664>

Samanta, S., Kumar Pal, D., & Palsamanta B. (2018). Flood susceptibility analysis through remote sensing, GIS and frequency ratio model. *Applied Water Science, 8, 66.* <https://doi.org/10.1007/s13201-018-0710-1>

Shen, X., Wang, D., Mao, K., Anagnostou, E., and Hong, Y. (2019, April 11). Inundation Extent Mapping by Synthetic Aperture Radar: A Review*.* *Remote Sensing*, *11,* 879. <https://doi:10.3390/rs11070879>