**NASA DEVELOP National Program**

**2017 Spring Project Proposal**

**NASA Marshall Space Flight Center**

**Mississippi River Basin Disasters II**

*Utilizing NASA Earth Observations to Create a Near Real-Time Flood Probability Map in the Mississippi River Basin*

**Project Overview**

***Project Synopsis*:** This project aims to automate a flood probability algorithm to better predict flooding in the Mississippi River Basin by extracting saturated pixels and modeling flood zones. Data will be collected using Landsat 8 OLI, and the Shuttle Radar Topography Mission Version 3 (SRTM v3). Near real-time flood probability and population exposure maps will enhance the end-users’ understanding of flooding in the Mississippi River Basin and its impacts on the affected communities. The partners of this project, NASA Short-term Research and Transition Center (SPoRT), Federal Emergency Management Agency (FEMA), and the United States Geological Survey (USGS), will use the end products of this project to help with disaster mitigation and recovery efforts.

**Community Concern:**

Flooding in the Mississippi River Basin has impacted thousands of lives in the immediate area. Since 2010, floods have cost Americans $34 billion in damages within the basin. During the winter 2015-2016 flood events, thousands of homes were destroyed and there were as many as 20 deaths in Louisiana alone. Disaster response and relief organizations need to gather data and maps to use in their decision-making process to prioritize areas requiring aid. Additionally, these data will be instrumental in to estimate damage and recovery costs post-disaster.

***Source of Project Idea:*** Discussions between Dr. Andrew Molthan, from NASA SPoRT, and NASA DEVELOP inspired desire for a collaborative endeavor to aid in flood monitoring throughout the Mississippi River Basin in the United States. It was expressed that disaster aid relief efforts could benefit from implementing automation techniques focused on the mapping of flood water from sensors with higher spatial resolution.

***National Application Area Addressed:*** Disasters

***Study Location:*** Mississippi River Basin: AR, KY, IL, IN, IA, LA, MN, MS, MO, TN, and WI

***Study Period:*** January 2017 to March 2017

***Advisors:*** Dr. Jeffrey Luvall (NASA at National Space Science and Technology Center), Dr. Robert Griffin (University of Alabama in Huntsville), Leigh Sinclair (UAH/ITSC), Dr. Andrew Molthan (NASA SPoRT)

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| USGS Hazards Data Distribution System (HDDS) | Brenda Jones, HDDS Manager (SPoRT collaborator) | End-User | Yes |
| Federal Emergency Management Agency (FEMA) | Christopher Vaughan, Geospatial Coordinator and Team Lead | End-User | Yes |
| NASA Short-term Prediction Research and Transition Center (SPoRT) | Dr. Andrew Molthan, NASA Research Meteorologist | Collaborator | Yes |

***End-User Overview***

***End-User’s Current Decision-Making Process:***

SPoRT is a NASA project that aims to transition observations and research capabilities to the operational weather forecasting community in order to improve short-term forecasts on a regional scale. SPoRT provides disaster-related products to NOAA’s National Weather Service to improve flood monitoring and response. In addition, SPoRT partners with the NASA Applied Sciences: Disasters Program and Disaster Response Plan to develop products from the USGS Hazards Data Distribution System during domestic and International Charter activations, generating products, and training for distribution to end users, including FEMA, which serves both federal and state Emergency Management Centers.

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

*USGS Hazards Data Distribution System (HDDS) –* The end-user currently utilizes Earth observations in their research. This project will build their capacity further by developing new products to model and assess flood probability.

*Federal Emergency Management Agency (FEMA) –* The end user used Earth observations to provide first response and damage assessments after natural disasters. The tools created by this project will enhance their capabilities to discern what areas need the greatest assistance after flooding events.

***Collaborator & Boundary Organization Overview***

***Collaborator Support:***

NASA Short-term Prediction Research and Transition Center (SPoRT) –SPoRT currently utilizes Earth observations from NASA, NOAA, and commercial land remote sensing imagers. This project will build their capacity by developing new products to map inundation and flood extent that will assist their partners with using imagery for flood mapping and inundation applications. Effective flood mapping can also support the validation and improvement of stream flow and flood and/or inundation forecasting models such as the National Water Model, developed by the National Water Center in Tuscaloosa, Alabama.

***Dissemination by Boundary Organizations*:**

NASA SPoRT – The created algorithms and methodologies from this project will be disseminated to various disaster relief organizations, such as FEMA and the USCG, through NASA SPoRT. From there, NASA SPoRT will perform additional validation of the product with DEVELOP team members and implement near real-time production of the algorithm to assist with future flood mapping activities in support of NOAA NWS and FEMA objectives, along with exploring the incorporation of the algorithm on other data sets provided by USGS HDDS. In addition, SPoRT will work with DEVELOP to produce and deliver relevant training and discussion. Improving the efficiency and timeliness of the resulting products will allow organizations to improve their decision making and focus efforts on disaster relief.

USGS HDDS – USGS HDDS provides data and maps to first responders and researchers to monitor flooding events, both historical and current. They would also benefit from a near real-time, synoptic product to complement the data they already have.

FEMA – It is FEMA’s mission to support citizens and first responders in the event of natural disasters and to improve the ability to prepare for, recover from, and mitigate all hazards including flooding. Currently they use products created by other partners to best respond to flooding disasters and are in need of a near real-time product. The products from this project will be distributed to first responders to properly prioritize areas that are in need of the most assistance.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:**

Communication will initiate the first week of the term to introduce the team and determine if there have been any changes to the desired end-products. The team will meet with NASA SPoRT team members (Dr. Andrew Molthan, and contractor(s) supporting training development) in person and/or or through email communications on a weekly basis to discuss progress of the project. At the conclusion of the project, DEVELOP team members will provide a documented algorithm approach that can be implemented by the SPoRT team as part of their near real-time production suite for further testing and evaluation on additional case events.

***Transition Plan*:**

For the first phase of this project, the end-products presented and handed off on a USB drive to NASA SPoRT at the completion of the term. During the second phase of this project, the objective will be to automate the previously created algorithm in the near real-time aspect. This end product will undergo the NASA software release process before being shared with partners.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 8 OLI** | Surface Reflectance | Landsat 8 OLI is a 30 m dataset that will be used in creating an algorithm to determine pixel saturation. |
| **Sentinel-2 MSI** | Surface Reflectance | Sentinel – 2 MSI will complement the Landsat 8 OLI sensor and increase the temporal resolution of the project. |
| **SRTM Version 3** | Digital Elevation Models | SRTM will provide DEMs that will be used to model the stream flows and other hydrologic data for use in the creation in a flood probability map |

***Ancillary Datasets:***

Oak Ridge National Laboratory – LandScan Data – Population data

***Modeling:***

Height Above Normal Drainage (HAND) Model (POC: Dr. Andrew Molthan, NASA SPoRT)

***Software & Scripting:***

ESRI ArcGIS – Raster manipulation and analysis, image enhancement and map creation of, Landsat 8 OLI, Sentinel-2 MSI, SRTM Version 3

Python 2 – Scripting an automation of the previous term’s probability algorithm

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| Near Real-Time Flood Probability Map | The Near Real-Time Flood Probability Map will enhance the project partner’s decision-making process by identifying the probability of a flood within a given area whenever new satellite data becomes available. | The Near Real-Time Flood Probability Map will be created using imagery from Landsat 8 OLI, Sentinel-2 MSI, and SRTM v3 | III |
| Near Real-Time Flood Exposure Map | The Near Real-Time Flood Exposure Map shows areas where the population is exposed to flooded areas. This will help decision makers know where to focus their resources in disaster aid. | The Near Real-Time Flood Exposure Map will complement the Flood Probability Map by adding Landscan population data to show the exposure of the population to the flooding risks | III |

***End-User Benefit*:**

Currently, the end-user strives to complement disaster relief organizations’ efforts for a more timely response to extreme flood events. The Flood Extent Map and Flood Probability Algorithm will be extremely useful to the project partner in this aspect. Having these products will allow for the project partner to respond to a flood event in a more timely fashion. In addition, since the disaster relief organizations currently contract out their data and maps, they will be able to create these data and maps, which will result in funds being allocated elsewhere in the organization.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 2 Terms: 2016 Fall (Start) to 2017 Spring (Completion)

***Multi-Term Objectives:***

* **Term 1:** 2016 Fall (MSFC) – Mississippi River Basin Disasters
  + The first term of this project created a Flood Probability Algorithm for detecting flood probable areas as well as exposure. The team generated static maps for the flood events of December 2015 to January 2016 for a subset of the river basin. This aided the project partners in understanding flood detection on a pixel-by-pixel basis.
* **Term 2 (Proposed Term):** 2017 Spring (MSFC) – Mississippi River Basin Disasters II
  + The focus of this term will be to automate the created Flood Probability Algorithm using python scripting. This will enable project partners to view up-to-date maps of probable flooded areas which will aid in flood inundation relief efforts.

***Previous Terms:***

2016 Fall (MSFC) – Mississippi River Basin Disasters: Utilizing NASA Earth Observations to Enhance Flood Monitoring Throughout the Mississippi River Basin

***Related DEVELOP Work:***

2016 Spring (WC) – Wise Disasters: Utilizing NASA Earth Observations to Identify and Predict the Extent of Flooding and to Mitigate its Risks in Wise County, Virginia

2014 Spring 2014 (GSFC) – Mekong Disasters: Utilizing NASA Earth Observations to Enhance Flood Impact Products and Mitigation in the Lower Mekong Water Basin

**Notes & References:**

***References:***

Lower Mississippi River Basin flood events below Red River Landing, LA http://www.srh.noaa.gov/lix/?n=ms\_flood\_history

“The World’s Largest Floods, Past and Present: Their Causes and Magnitudes” by the USGS http://pubs.usgs.gov/circ/2004/circ1254/pdf/circ1254.pdf

USGS Flood Information http://water.usgs.gov/floods/

National Weather Service River Watch Mississippi River Basin http://www.riverwatch.noaa.gov/l\_mississippi.shtml

Historical floods from the USGS http://water.usgs.gov/floods/events/2016/winter/

https://www.arcgis.com/home/item.html?id=fb983e14e5ef4f2fb2336b77e8a9f638

http://www.tandfonline.com/doi/pdf/10.1080/02626667.2010.543087

http://download.springer.com/static/pdf/183/art%253A10.1007%252Fs11707-009-0023-7.pdf?originUrl=http%3A%2F%2Flink.springer.com%2Farticle%2F10.1007%2Fs11707-009-0023-7&token2=exp=1461615947~acl=%2Fstatic%2Fpdf%2F183%2Fart%25253A10.1007%25252Fs11707-00900237.pdf%3ForiginUrl%3Dhttp%253A%252F%252Flink.springer.com%252Farticle%252F10.1007%252Fs1170700900237\*~hmac=3b5b78efb442e0e89c2c392190cadcd1070426352257ec6599e8a437735680b4