**NASA DEVELOP National Program**

****NASA Marshall Space Flight Center

*Spring 2017*

**Short Title: Mississippi River Basin Disasters II**

**Subtitle:** Utilizing NASA Earth Observations to Create an Automated Flood Probability Map in the Mississippi River Basin

**VPS Title:** Python Learns to Swim: Automating Flood Probability Algorithm

**Project Team & Partners**

**Project Team:**

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**Advisors & Mentors:**

Dr. Jeffrey Luvall (NASA Marshall Space Flight Center)

Dr. Robert Griffin (University of Alabama in Huntsville)

Dr. Andrew Molthan (NASA Short-term Prediction Research and Transition Center)

Leigh Sinclair (University of Alabama in Huntsville, Information Technology and Systems Center)

**Past or Other Contributors:**

Chris Ploetz

Olivia Callaway

**Partner Organizations:**

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

**Project Details**

**Applied Sciences National Applications Addressed:** Disasters

**Study Area:** Mississippi River Basin: AL, AR, CO, GA, IL, IN, IA, KS, KY, LA, MD, MI, MN, MO, MS, MT, NC, ND, NE, NM, NY, OH, OK, PA, SD, TN, TX, VA, WI, WV, and WY

**Study Period:** September 2013 – March 2017

**Earth Observations & Parameters:**

Landsat 8 Operational Land Imager (OLI) – Surface Reflectance

WorldView-2, 3, and 4 – Surface Reflectance

Terra Moderate Resolution Imaging Spectroradiometer (MODIS) – Land-water mask

**Ancillary Datasets Utilized:**

* USGS National Land Cover Database (NLCD) – Land cover data
* Oak Ridge National Laboratory LandScan – Population data
* Homeland Infrastructure Foundation-Level Data (HIFLD) – Infrastructure Data

**Software Utilized:**

* ESRI ArcGIS – Raster manipulation and analysis, image enhancement, and map creation of Landsat 8 OLI and WorldView-2, 3 and 4
* Python – Scripting and automation of the previous term’s probability algorithm

**Project Overview**

**80-100 Word Objectives Overview:**

The Mississippi River Basin is home to millions of Americans, encompassing portions of 31 states from Louisiana to Minnesota. This area is prone to frequent flooding at various intensities, causing both social and economic damages to impacted communities. Disaster response and relief organizations require more precise data and maps to use in their decision making process for prioritizing aid in the area. To enhance the understanding of flooding and the communities affected in this area, this project automated the flood probability algorithm.

**Abstract:**

The Mississippi River Basin is the fourth largest drainage basin in the world, and is susceptible to multi-level flood events caused by heavy precipitation, snow melt, and changes in water table levels. Conducting flood analysis during periods of disaster is a challenging endeavor for NASA’s Short-term Prediction Research and Transition Center (SPoRT), Federal Emergency Management Agency (FEMA), and the US Geological Survey’s Hazards Data Distribution Center (USGS HDDS), due to heavily-involved research and lack of manpower. During this project, an automated script was generated that performs high-level flood analysis to relieve work load for end-users. The script incorporated Landsat 8 Operational Land Imager (OLI) tiles and utilized computer-learning techniques to generate accurate water extent maps. The script referenced the Terra Moderate Resolution Imaging Spectroradiometer (MODIS) land-water mask, to isolate areas of flood induced waters. These areas were overlaid onto the National Land Cover Database’s (NLCD) land cover data, the Oak Ridge National Laboratory’s LandScan data, and Homeland Infrastructure Foundation-Level Data (HIFLD) to determine the classification of areas impacted and the population density affected by flooding. The automated algorithm was tested on multiple flood events within the Mississippi River Basin, and focused on the September 2016 flood event that occurred in Upper Mississippi River Basin. This script allows end-users to create their own flood probability and impact maps for disaster mitigation and recovery efforts.

**Keywords:**

Mississippi River Basin, disaster relief, Landsat 8 OLI, NDWI, flood impact, flood probability, Python

**Community Concerns:**

* Floods have cost Americans $34 billion in damages within the Mississippi River Basin since 2010.
* The September 2016 flood event that affected northern Iowa, southern Minnesota, and western Wisconsin caused an estimated $22 million of infrastructure damage in the city of Cedar Rapids, Iowa alone.
* In Iowa, a flood event in June 2008 left approximately 16 percent of crop land and pasture underwater, and the September 2016 event was estimated to have affected thousands of acres of soybeans, corn and pasture.
* An estimated 10,000 people were evacuated from Cedar Rapids, Iowa, with others evacuated from the cities of Mason City, Clarksville, and Palo in Iowa, and Ferryville in Wisconsin due to the September 2016 flooding.
* During the winter 2015 and 2016 flood events, thousands of homes were destroyed and as many as 20 people lost their lives in Louisiana alone.

**Current Management Practices & Policies**:

Currently, USGS uses Earth observations to provide data and maps to first responders and researchers to monitor flood events. While FEMA uses maps created through the Flood Risk Project, these maps take 3 to 5 years to produce and focus on building flood “resilient” communities. When planning disaster relief efforts, FEMA currently relies on flood detection models and uses products created by other partners, such as the USGS. These models lack predictive and near real-time ability, and tend to overestimate flooded areas due to poor spatial resolution. NASA SPoRT utilizes NASA Earth observations to help locate floods, but it is a manual process that is time intensive.

**Decision Support Tools & Benefits:**

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| --- | --- | --- | --- |
| **End-Product** | **Earth Observations Used** | **Benefit & Impact** | **Software**  **Release** |
| Automated Flood Map | Landsat 8 OLI, WorldView-2, 3, and 4, Terra MODIS | The Automated Flood Map will enhance the project partners’ decision making process by determining the probability of flooding within a given area as new satellite imagery becomes available. | III |
| Automated Flood Impact Map | Landsat 8 OLI, WorldView-2, 3, and 4, Terra MODIS | The Automated Flood Impact Map will aid in the project partner’s decision-making process by pinpointing areas that have been heavily exposed to flooding and will require the most disaster relief. | III |