**Ohio River Valley Transportation & Infrastructure**

*Utilizing Synthetic Aperture Radar and NASA Earth Observations to Identify Optimal Transportation Routes to Assist Emergency Responders after Flood Events in the Ohio River Valley*

**VPS Title:** Bridge over Troubled Water

**Project Team**

***Project Team*:**

Kane Cook (Project Lead), fkcook12@gmail.com

Christine Evans

Sara Miller

Alex Younger

***Advisors & Mentors*:**

Dr. Jeffrey Luvall (NASA Marshall Space Flight Center)

Dr. Robert Griffin (University of Alabama in Huntsville)

Dr. Franz Meyer (University of Alaska Fairbanks)

Suravi Shrestha (NASA Short-term Prediction Research and Transition Center)

Maggi Klug (University of Alabama in Huntsville)

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

**Project Overview**

***Project Synopsis*:** The Ohio River is a major contributor to the environmental and economic security of the Midwest region. The river is utilized for several industrial purposes; however, the valley is prone to frequent flooding that disrupts surface transportation. In partnership with the Federal Emergency Management Agency (FEMA), the NOAA National Weather Service (NWS) Ohio River Forecast Center (OHRFC), the Kentucky Division of Water, and NASA Short-term Prediction Research and Transition Center (SPoRT), the team aimed to identify areas susceptible to floods, provide optimal routes during flood events, and strengthen flood resilience.

***Abstract*:**

The Ohio River provides the 13-state region of the Ohio River Valley with economic and social benefits through power generation, industrial manufacturing, drinking water, and recreational uses. While the river is an important environmental and economic resource, the valley is prone to numerous flood events that damage the environment, residential areas, and important infrastructure. The fall 2018 NASA DEVELOP Ohio River Valley Transportation and Infrastructure team utilized Landsat 8 Operational Land Imager (OLI) and Sentinel-1 C-band Synthetic Aperture Radar (SAR) data to identify flood events and their intensities and develop flood risk maps of the area. The Global Precipitation Measurement (GPM) Integrated Multi-Satellite Retrievals for GPM (IMERG) and the Shuttle Radar Topography Mission (SRTM) provided precipitation and elevation data used in flood analysis. The team partnered with the Federal Emergency Management Agency, the NOAA National Weather Service Ohio River Forecast Center, the Kentucky Division of Water, and the NASA Short-term Prediction Research and Transition Center (SPoRT) to investigate flood risk throughout the Ohio River Valley, identify key infrastructure at risk, and provide favorable transportation routes during these events. The team found that during a 2018 flood event, 667 miles of major highways were impassible and 16% of all hospitals within the study area were inaccessible. The results of this project will assist forecasters and emergency responders by providing a detailed report of vulnerable populations, at risk infrastructure, and historical impassible route systems.

**Keywords:**

Remote sensing, Sentinel-1, Landsat 8, flooding, transportation routes, Normalized Difference Flood Index, Normalized Difference Water Index

***National Application Areas Addressed:*** Transportation & Infrastructure, Disasters

***Study Location:*** Western portion of the Ohio River Valley; IL, IN, KY

***Study Period:*** February 2015 – March 2018

***Community Concern:***

* While the Ohio River contributes to social, economic, and environmental prosperity in the region, it is prone to frequent flood events.
* In February 2018, the most disastrous flood event since 1997 occurred, affecting over 50% of the river, costing Louisville alone over $3.5 million in damages to infrastructure.
* These frequent events disrupt surface transportation, limit disaster response, and prevent relief organizations from providing aid to those in need.

***Project Objectives:***

* Detect regions within the valley that are most susceptible to flooding
* Provide optimal routes for transportation during flood events
* Identify important infrastructure impacted during flood events
* Strengthen partner organizations’ flood resilience efforts and reduce emergency responder times
* Display results using an ArcGIS Online Story Map to show the effectiveness of using NASA Earth observations for flood mapping

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **NOAA National Weather Service, Ohio River Forecast Center** | James Noel, Service Coordination Hydrologist | End User | No |
| **Federal Emergency Management Agency** | Christopher Vaughn, Geospatial Information Officer | End User | No |
| **Kentucky Division of Water, Energy and Environment Cabinet** | Carey Johnson, Program Manager | End User | No |
| **NASA Short-term Prediction Research and Transition Center (SPoRT)** | Jordan Bell, Research Associate II | Collaborator | No |

***Decision Making Practices & Policies***:

The NWS focuses on providing weather, water, and climate forecasts and warnings to communities across the United States. These forecasts and warnings are necessary to protect lives, property, and enhance the national economy. Covering territory within 11 states, the NWS OHRFC makes flooding prediction forecasts. The local NWS Weather Forecast Offices issue advisories and warnings based on those forecasts. They include statements on how those forecasts and advisories consist of different flood event aspects such as passable and impassable roads, precipitation amounts, outlooks, etc. FEMA, consisting of 10 regional offices across the United States, provides disaster support through advising, training, and funding of individuals and local organizations. The agency focuses on improving disaster preparedness, protection, and response of citizens and first responders. By incorporating Earth observations in their decision-making processes, these organizations can provide disaster response more easily on a large scale.

***Project Benefit to End User***:

The NWS OHRFC, FEMA, and the Kentucky Division of Water will use the Ohio River Valley Flood Risk Map and Disaster Response Optimal Road Map to enhance flood resilience in the Ohio River Valley. Earth observations will identify vulnerable regions within the study area and allow end users to determine the most effective and efficient transportation systems to take when responding to a disaster, potentially reducing response times across the region and allowing more targeted flood warning messages. The results will also help the OHRFC identify flood extent from previous floods within the study area.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Sentinel-1 C-SAR** | Backscatter,Normalized Difference Flood Index (NDFI) | Sentinel-1 C-SAR data were used to identify floodwater using the NDFI. |
| **Landsat 8 OLI** | Surface reflectance,Normalized Difference Water Index (NDWI) | Landsat 8 OLI data were utilized to identify flood water and current bodies of water by calculating the NDWI. |
| **GPM IMERG** | Precipitation | GPM IMERG data were used to derive precipitation amounts during the study period. |
| **SRTM** | Elevation | SRTM elevation data were used to derive aspect and slope during flood risk analysis. |

***Ancillary Datasets:***

USDA Cropscape, 2016 – create a land cover classification

Oak Ridge National Laboratory LandScan, 2016 Population Dataset – determine population density for the

 flood impact analysis

Homeland Infrastructure Foundation-Level Data (HIFLD) – identify important infrastructure including schools, daycares, retirement homes, hospitals, emergency medical services, fire stations, police stations, chemical plants, dams, airports, and water treatment plants for the flood impact analysis

USDA National Resources Conservation Service (NRCS) US General Soil Map (STATSGO2), 2003 –

 identify different soil types within the Ohio River Valley

US Census Bureau TIGER dataset, 2017 – identify primary and secondary roads throughout the study area

Agency for Toxic Substances and Disease Registry (ATSDR) Social Vulnerability Index (SVI) – identify vulnerable populations based on income and poverty

***Software & Scripting:***

Esri ArcGIS – raster manipulation and analysis, imagery processing, and map creation

Sentinel Application Platform (SNAP) – imagery preprocessing

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **Ohio River Valley Flood Risk Map** | Sentinel-1 C-SARLandsat 8 OLIGPM IMERGSRTM | The Flood Risk Map detects areas susceptible to flooding and identifies the vulnerable populations within the Ohio River Valley. Project partners can use this map to warn residents of the region of high-risk areas before flood events to encourage evacuation. | N/A |
| **Disaster Response Optimal Road Map** | Sentinel-1 C-SARLandsat 8 OLI | This analysis considers the areas and roads that are at higher flood risk and determines the best routesfor disaster responseorganizations based on previous flood events. | N/A |
| **Disaster Response Optimal Road Map Tutorial** | Sentinel-1 C-SARLandsat 8 OLI | Network Analyst tools in ArcMap, including “Find fastest Route” and “Find Closest Facility” were demonstrated to partners to build capacity. | N/A |
| **Infrastructure Impact Analysis** | Sentinel-1 C-SARLandsat 8 OLI | Impacted infrastructure in the region was analyzed. Partners were informed about which services and facilities were operational or inoperable during a given flood event.  | N/A |
| **Bridge Over Troubled Water: Ohio River Valley Story Map** | Sentinel-1 C-SARLandsat 8 OLIGPM IMERGSRTM | Earth observations and ancillary datasets were integrated into an online map highlighting the concerns of the community and addressing the capacity of Earth observations for flood mapping. Partners will be able to use this visually-appealing product in presentations and outreach when discussing flood navigation. | N/A |

**Project Handoff Package**

**Transition Plan:**

The team conducted a handoff during week ten of the term via video conference for our remote partners and an in-person meeting for our local partners at SPoRT. All products in the handoff package were transferred via Google Drive.

**Team POC:** Kane Cook, fkcook12@gmail.com

**Partner POC**: James Noel, james.noel@noaa.gov

 Christopher Vaughn, christopher.vaughan2@fema.dhs.gov

 Carey Johnson, carey.johnson@ky.gov

 Jordan Bell, jordan.r.bell@nasa.gov

**Handoff Package:**

* Project Summary
* Tech Paper
* Poster
* Presentation
* Project one-pager
* Ohio River Valley Flood Risk Map
* Disaster Response Optimal Road Map
* Disaster Response Optimal Road Map Tutorial
* Infrastructure Impact Analysis
* Bridge Over Troubled Water: Ohio River Valley Story Map

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