**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*

**VPS Title:** Going With the Overflow: Assessing Flood Extent in Niagara Falls, New York

**Project Team**

***Project Team:***

Christine Fleming (Project Lead)

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***Advisors & Mentors:***

Dr. Cédric Fichot (Boston University)

***Other Contributors:***

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**Project Overview**

***Project Synopsis:*** Lake Ontario coastal communities were severely impacted by high water levels during the spring of 2017. The state of New York allocated 95 million dollars in relief funds for impacted residents. Niagara Falls, NY, city management required further assessment of maximum flood extent and regional impacts in order to determine high-risk areas. The Niagara Falls Disasters team used NASA Earth observations to create a map indicating flood extent and to provide tools for assessment of environmental parameters relevant to flood risk evaluation.

***Abstract:***

Approximately 11 million people reside in the Lake Ontario watershed. Extreme high water levels in the spring of 2017 caused severe flood damage to communities off the coast of Lake Ontario. Niagara Falls drainage infrastructure did not accommodate floodwater inundation, which led to the destruction of property and unsafe conditions for residents. City management required further assessment of maximum flood extent and regional impacts in order to determine high flood risk areas. The Niagara Falls Disasters team partnered with the City of Niagara Falls, the Great Lakes and St. Lawrence Cities Initiative, Cornell University, and University of Michigan to map flood extent and create tools to assess relevant environmental parameters used inflood risk evaluation. The team used Google Earth Engine to identify river and coastline changes in the Niagara Falls, NY region. Additionally, the team evaluated various environmental parameters derived from NASA Earth observations, including snow and ice cover, precipitation, and soil moisture, and generated time series analyses for the months prior to and during the 2017 flood event. These products will allow the partners to better prepare at-risk communities for future extreme weather events.

**Keywords:**

remote sensing, flood extent mapping, disaster relief, inundation

***National Application Areas Addressed:*** Disasters, Water Resources

***Study Location:*** Niagara Falls, NY

***Study Period:*** April 2015 to February 2019

***Community Concerns:***

* Extreme high water events in 2017 caused flooding and damage to homes, recreational areas, and businesses along the coast of Lake Ontario.
* Niagara Falls, NY, was unable to accommodate floodwater inundation during the worst of these events, resulting in property damage and dangerous conditions for residents.
* Niagara Falls communities and management require further assessment of the flood extent and regional impacts in order to determine high-risk areas.

***Project Objectives:***

* Determine the feasibility of using satellite remote sensing techniques for urban flood extent mapping
* Create flood extent maps that display the extent of high water levels prior to and including the 2017 flood
* Demonstrate how specific environmental parameters that contribute to flooding can be measured using satellite remote sensing

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **City of Niagara Falls, Department of Planning and Economic Development**  | Tom DeSantis, Director of Planning and Economic Development; Alan Nusbaum, Environmental Planner and GIS Coordinator | End User | No |
| **Great Lakes and St. Lawrence Cities Initiative** | Melissa Soline, Program Manager | End User | Yes |
| **Cornell University** | Dr. Scott Steinschneider, Assistant Professor | Collaborator | Yes |
| **University of Michigan** | Dr. Drew Gronewold, Associate Professor | Collaborator | Yes |

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

The City of Niagara Falls currently uses GIS to record and distribute environmental information to city residents and state government agencies. GIS is included in their responses to queries regarding the Federal Emergency Management Agency Flood Zones and the National Flood Insurance Program. However, the direct use of satellite imagery and remotely sensed environmental parameters is limited. Most environmental decision-making is completed using data collected directly from the field and information provided by the National Weather Service. Flood management decisions are largely based on impacts observed during past flood events and regional weather forecasting. Niagara Falls is in the process of responding to community concerns related to future flood risk. On a wider scale, the Great Lakes and St. Lawrence Cities Initiative is interested in incorporating NASA Earth observations data into the cooperative management of many Great Lakes communities. A coalition of 130 mayors and municipalities work together to manage their vast freshwater resources. They do not have consistent flood extent and forecasting procedures, and their use of remotely sensed data is limited.

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

The project end products will enhance flood management practices and forecasting efforts. Mapping flood extent and identifying areas that were impacted during the flood events of 2017 will allow our end users to target high-risk areas for future flood mitigation and warnings. The estimation of environmental parameters that contribute to flooding over a greater spatial and temporal scale will allow our partners to incorporate more data into ongoing risk analysis and forecasting, thus saving time and limiting costs of environmental monitoring. The products will also inform Lake Ontario community members about the applications of NASA Earth observations to localized flood management practices.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **Terra MODIS** | Surface reflectance | Surface reflectance was used to estimate snow cover. |
| **GPM IMERG** | Precipitation | Precipitation data were used to quantify precipitation in the years leading up to 2017 flood events. |
| **SMAP L-band Radiometer** | Soil moisture | Soil moisture measurements were used to infer soil porosity. |
| **SRTM** | Digital elevation model | The digital elevation model was used to map and predict flood extent in relation to land topography. |
| **Landsat 7 ETM+**  | Surface reflectance | Surface reflectance was used to evaluate river and coastline change as well as assess flood inundation. |
| **Landsat 8 OLI** | Surface reflectance | Surface reflectance was used to evaluate river and coastline change as well as assess flood inundation. |

***Ancillary Datasets:***

* United States Geological Survey (USGS) Lake Ontario Watershed Shapefile – Establish the study area and extent of the Lake Ontario drainage basin

***Software & Scripting:***

* Esri ArcGIS Pro – Data processing and production of maps
* QGIS – Data processing and production of maps
* Google Earth Engine API – Imagery processing and generation of a watershed observation tool
* TerrSet Geospatial Monitoring and Modeling System – Data processing and production of maps

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **Flood Extent Maps** | Landsat 8 OLI | The partners will use the flood extent map to bring awareness to communities that may become flooded by identifying vulnerability in the region. | I |
| **Coastline Annual Land Cover Change (CALCC) Tool** | Landsat 7 ETM+Landsat 8 OLI | The partners can use the tool as a reference to inform decision-making related to shoreline loss and identify areas of concern.  | V |
| **Hydrologic Inputs Tool (HIT)** | GPM IMERGTerra MODISSRTMSMAP L-band Radiometer | As a means of understanding current and historical hydrologic cycles, partners can use this Google Earth Engine tool to create charts and maps of variables that influence flooding during years of interest. | IV |
| **Snow and Ice Cover, Precipitation, and Soil Moisture Time Series** | GPM IMERGTerra MODISSMAP L-band Radiometer | The partners will use this time series to identify how snow cover, precipitation, and soil moisture changed from 2015 to 2019. Visualizing these parameters will help partners understand how environmental factors that affect water balance may contribute to flooding events. | I |
| **HIT and CALCC Tutorials** | N/A | The HIT tool pdf and video tutorials and the CALCC tool pdf tutorial will be used to help partners understand how to use the Google Earth Engine platform. | N/A |

**Project Handoff Package**

*Transition Plan:* The Niagara Falls Disasters team handed off project materials to partners during Week 10 of the term via a WebEx video conference. The team presented a PowerPoint presentation detailing final maps and figures as well as a tutorial of Google Earth Engine tools. Deliverables and end products not included in the Software Release process were shared with partners via Google Drive after the video conference. Additionally, the team provided supplemental materials in support of the provided tools, which included detailed PDF and video tutorials that were shared with the partners once the Software Release Process was completed.

*Software Release Plan:* The team provided the partners with a detailed tutorial of the Google Earth Engine code and answered questions during the virtual handoff presentation. The Team POC will continue to provide updates during the Software Release Process as necessary.

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**Handoff Package:**

* Poster
* Presentation
* Project Video
* Technical Paper
* Project Summary
* Study Area Shapefiles
* Flood Extent Map
* Snow and Ice Cover, Precipitation, and Soil Moisture Time Series
* HIT and CALCC tutorials
* Screenshots of the CALCC Tool (no code displayed)
* Screenshots of the HIT user interface (no code displayed)

**References:**

City of Niagara Falls, New York. (2016). *Planning and environmental*. Retrieved from

<http://niagarafallsusa.org/government/city-departments/planning-and-environmental/>

New York State (n.d.). *Lake Ontario relief and recovery*. Retrieved from

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