Department of Geography and the Environment
Villanova University

Project: September 2021 Tropical Storm Ida Flooding Manayunk/East Falls, Philadelphia
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Background:

On September 1st 2021, intense rainfall associated with Tropical Storm Ida resulted in catastrophic flooding throughout the Philadelphia region. Portions of the Manayunk and East Falls neighborhoods in Northwest Philadelphia were inundated with greater than 1 foot of river water, which left behind sediment layers up to 10cm in depth. In the days following the storm, sediment samples were collected from >30 locations consisting of roadways, parking lots sidewalks, and playgrounds. These samples will be analyzed for both bacteria assemblages and heavy metal (e.g., Cadmium, copper, nickel, lead, and zinc) concentrations to assess public health risk. To fully assess exposure risk, we also need to understand the spatial extent of floodwaters within these neighborhoods. This 2021/22 PA View grant allowed us to secure satellite imagery from the following morning (September 2nd 2021) when flood waters reached their highest levels.

The use of the grant imagery has proven valuable beyond the Remote Sensing Course. This project and the imagery will also be utilized for the Disasters Course as well as the Geotechniques Course and Environmental Studies courses.

Total Budget: $1000.

Summary of PA View Grant Imagery Use:

Imagery was acquired from multiple sources (Planet Lab and SPOT-6 1.5m pan-sharpened, orthorectified imagery) to piece together data of the City of Philadelphia before and after Hurricane Ida hit. One neighborhood in particular was used as a case study in this research which had reported significant impacts from flooding during Hurricane Ida as well as a previous tropical storm that occurred in 2020, Tropical Storm Isaias. Each image included RGB and Near-Infrared bands that allowed researchers to utilize the Normalized Difference Water Index (NDWI), a calculation which enhances open water features while reducing the reflectance of soil and vegetation features (see equation below). This reveals a range of values from -1 to 1 in which positive values reveal water features or saturated areas, while anything less than or equal to 0 are estimated to be vegetation or soil.

$$NDWI = (NIR - Green) / (NIR + Green)$$

The NDWI calculation was applied to the two mosaiced images of pre and post Hurricane Ida and then a difference calculation was done on the two images.

<div align="center">Difference = (Post-Hurricane – Pre-Hurricane)</div>

       Any cell with a positive difference calculation was estimated to be an area where moisture likely increased due to the hurricane. This allowed researchers to gain an estimate of where across the city inundation had occurred, helping to identify areas that are not already listed within the floodplain. The figure below shows the pre (A) and post (B) Hurricane Ida in Manayunk (neighborhood outlined in red). Map C reveals the results of the NDWI calculation, with blue symbolizing cells with a positive output and estimated moisture increase, with darker blue signifying cells of greatest moisture increases.

These results indicate that Hurricane Ida caused widespread moisture increases, and likely areas of stormwater inundation, especially within the neighborhood of Manayunk.
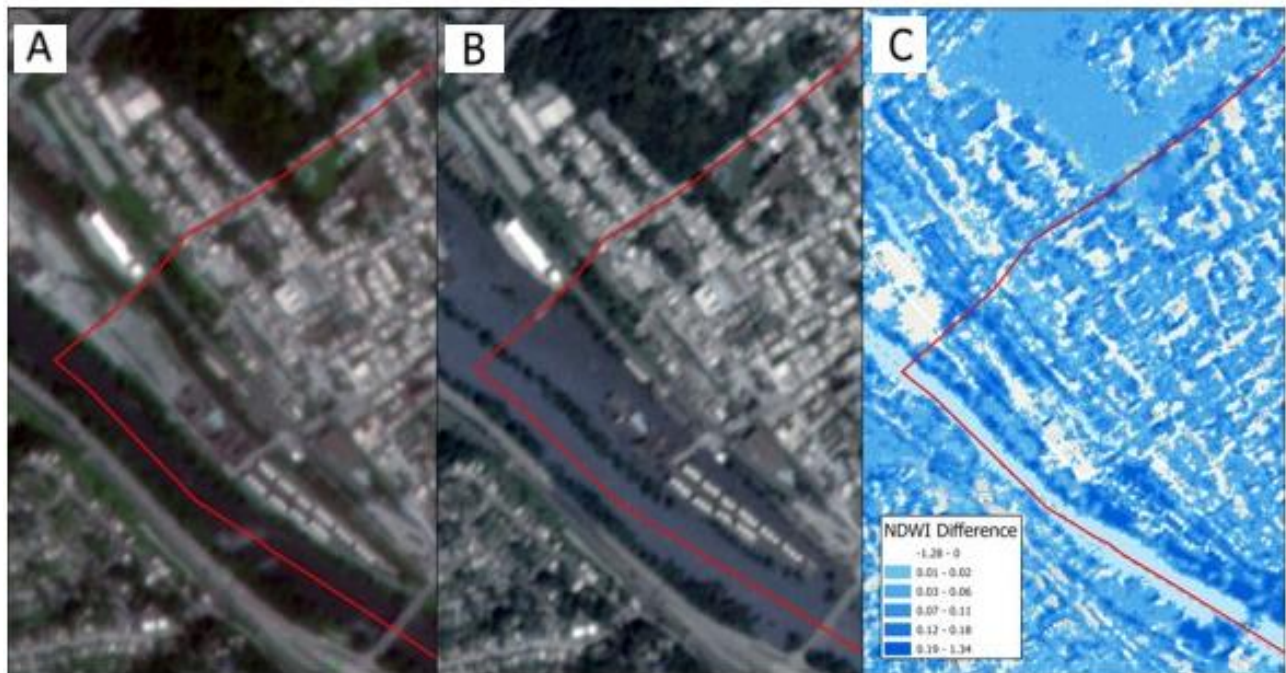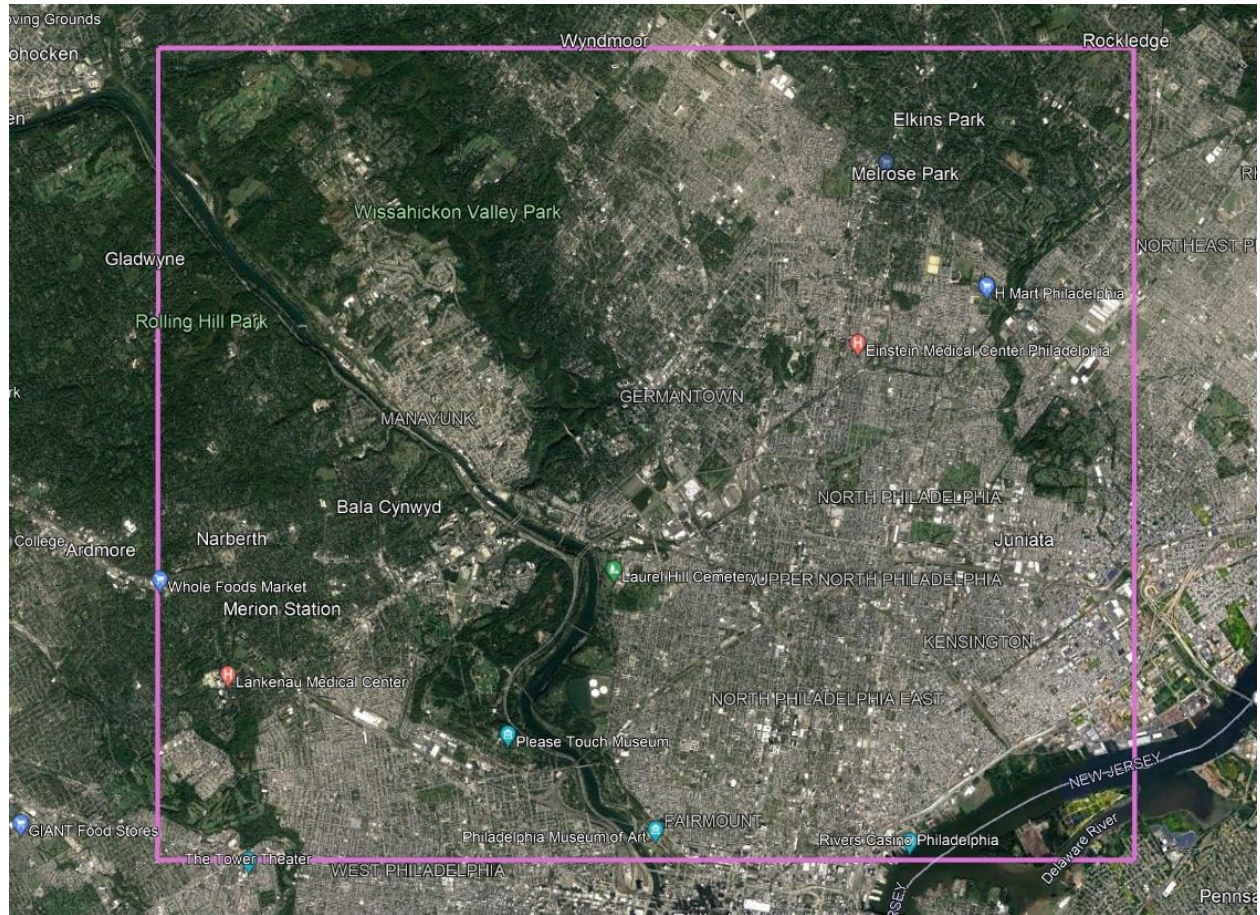
SPOT Imagery Extent for Manayunk Study Area.

Grant Purchased SPOT-6 Archive Satellite Imagery:

- **AOI:** Manayunk, Philadelphia, PA 1.5m RGB and 1.5m CIR: 09/02/2021
- **Products:** Custom ortho with pan-sharpening
  - SPT ID: DS_SPOT6_202109021520366_FR1_FR1_SV1_SV1_W075N40_02845
- **Bit Depth:** 8-bit
- **Band Combination:** Natural Color and False Color
- **Projection/Datum:** UTM / WGS84
- **Image Processing:** Custom Ortho
- **Radiometric Correction:** Display

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