08.08.24

Flooded Area Assessment using KMeans clustering technique

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Story

Context

- Flooding -> damage, such as infrastructure destruction and water system pollution;
- The New England Region - challenges from coastal and inland flooding;
- Crucial to quantify the impacts of flood events.

Problem

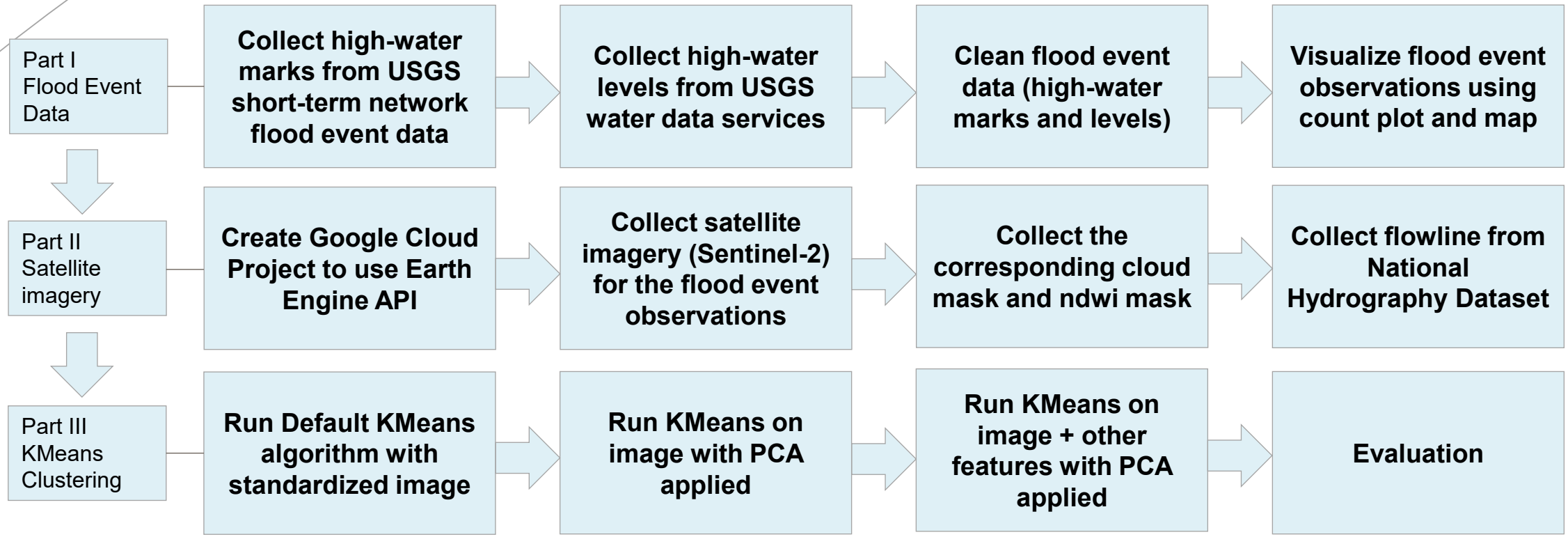
- Precisely assessing the extent of flood can be challenging.

Proposal

- Satellite images – straightforward and comprehensive
- Develop an approach to help automatically identify the flooded area

* Image from The Great Vermont Flood of July 2023

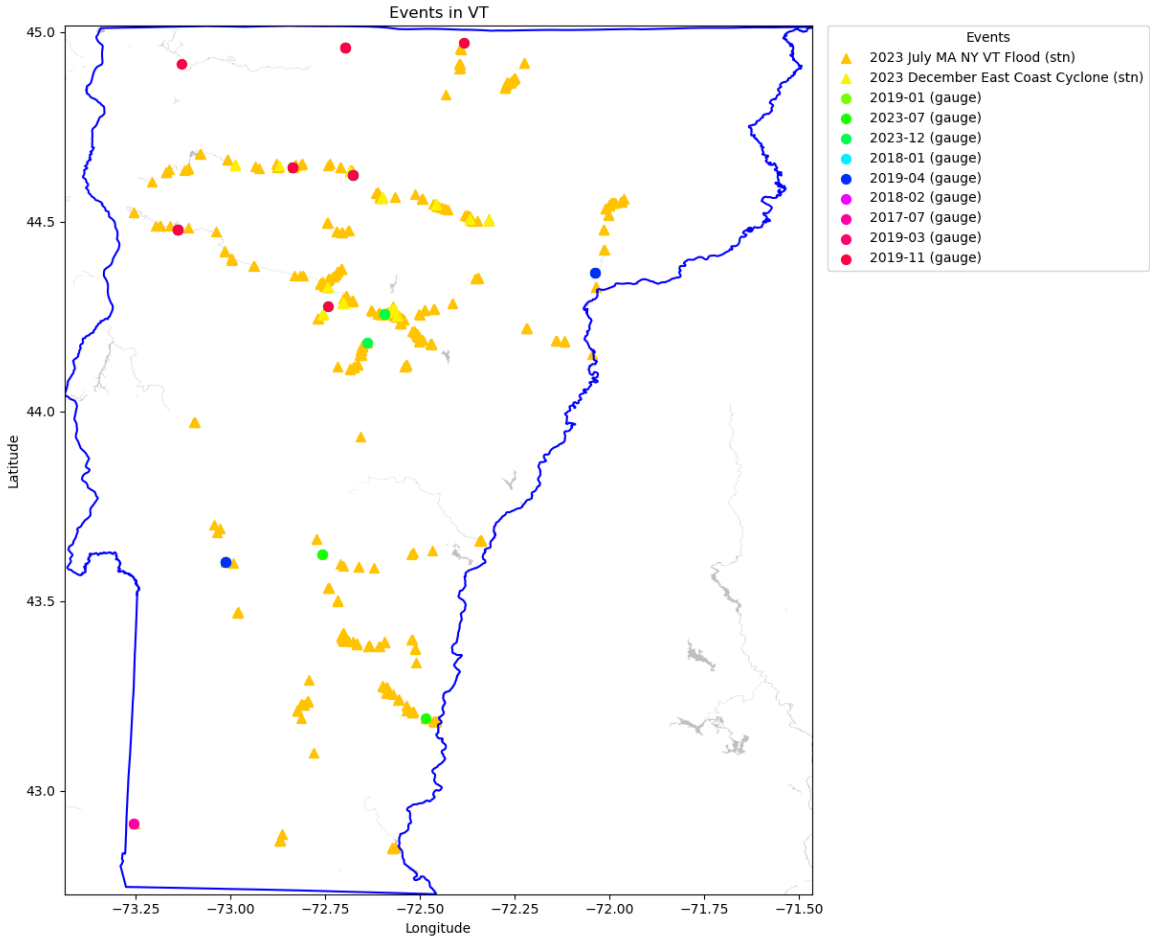
Workflow



- USGS: United States Geological Survey
- High-water marks: Visual clues of peak stream height or surveying equipment
- High-water level: Real-time water level above moderate flood stage value for specified gauges from USGS Water Data Services (e.g., https://water.noaa.gov/gauges/ASTM1)

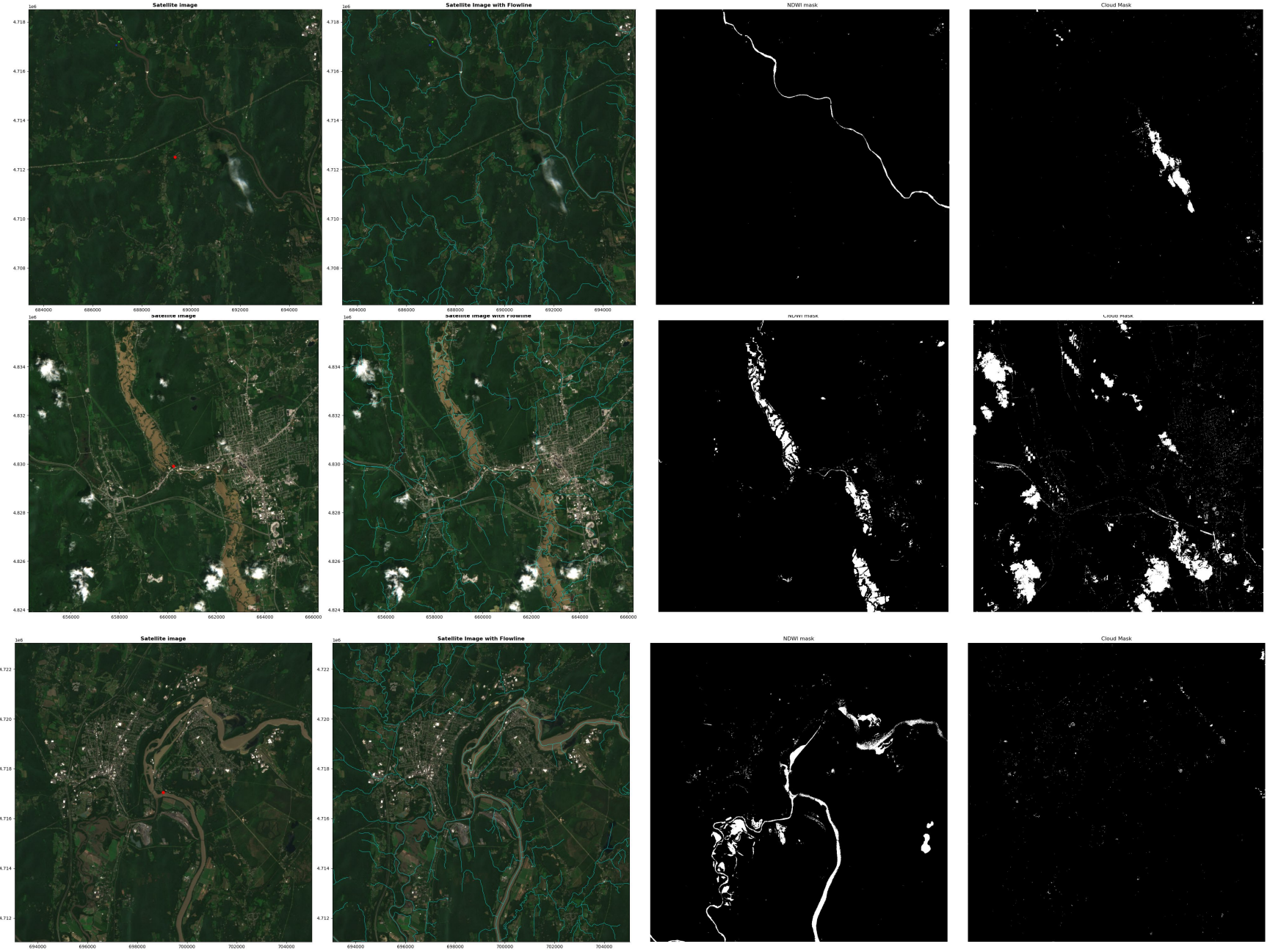
Part I Flood Event

	High-water marks	High-water levels
Original Shape	53 x 3502	11 x 8326
Modified Shape	7 x 889	9 x 218
Top 3 Flood events	• 2023 July MA NY VT Flood : 641 instances • 2018 March Extratropical Cyclone : 115 instances • 2018 January Extratropical Cyclone : 81instance	• 2023-12 : 64 • 2023-07 : 27 • 2024-01 : 18
Top 3 States	• VT : 590 • MA : 262 • CT : 15	• CT : 57 • VT : 56 • ME :40
Note	Based on the counts, the majority of collected images will be from 2023-07.	



Part II Satellite Image 2023-07

1. Sentinel -2 satellite image: 25 images during flood events (8 notable)
2. Flowline from National Hydrography Dataset
3. Normalized Difference Water Index (NDWI): threshold set to -0.1
4. Cloud Mask based on s2cloudless: urban area and high reflectance



Part III
KMeans Clustering algorithm with PCA and other features combined

Default

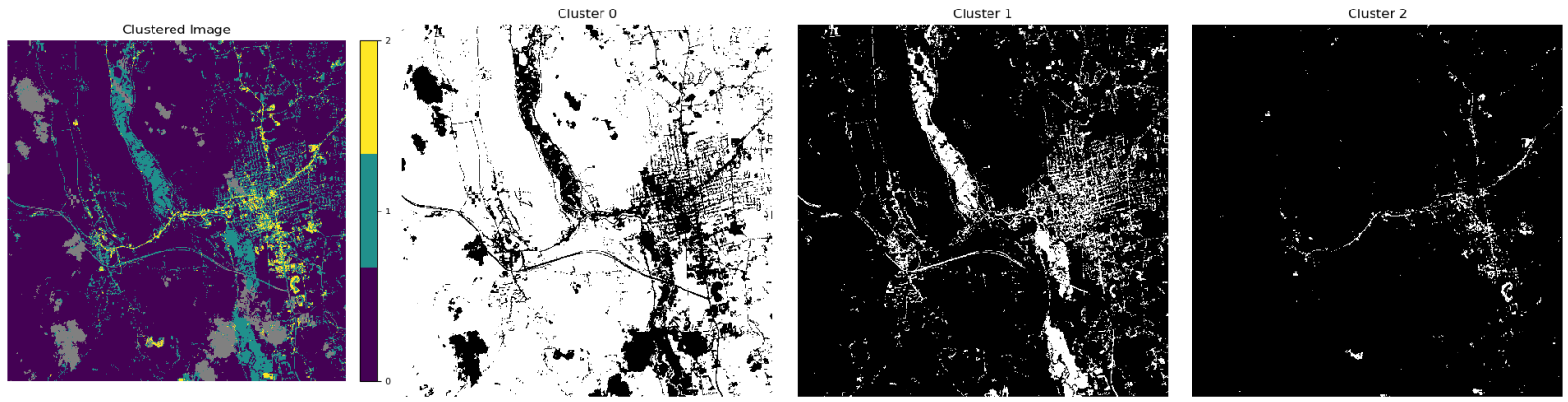


Image -> PCA

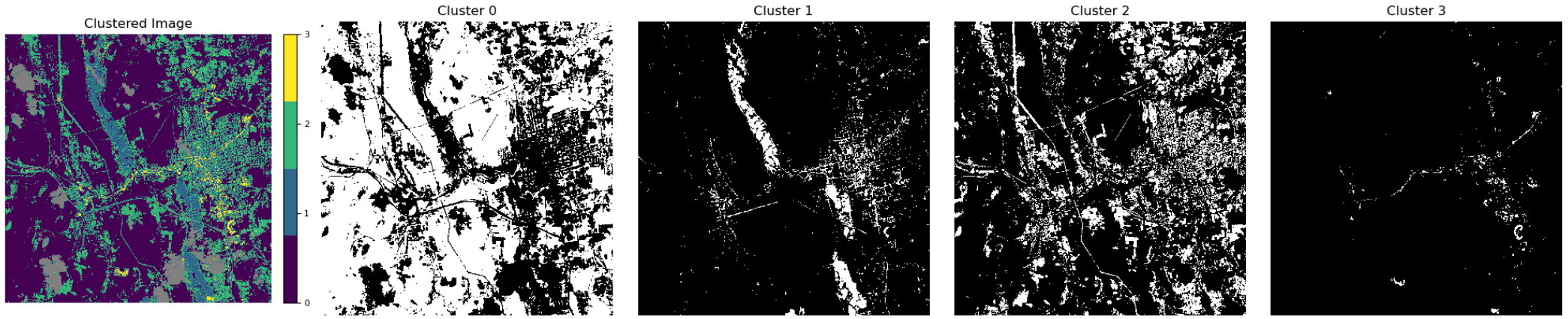
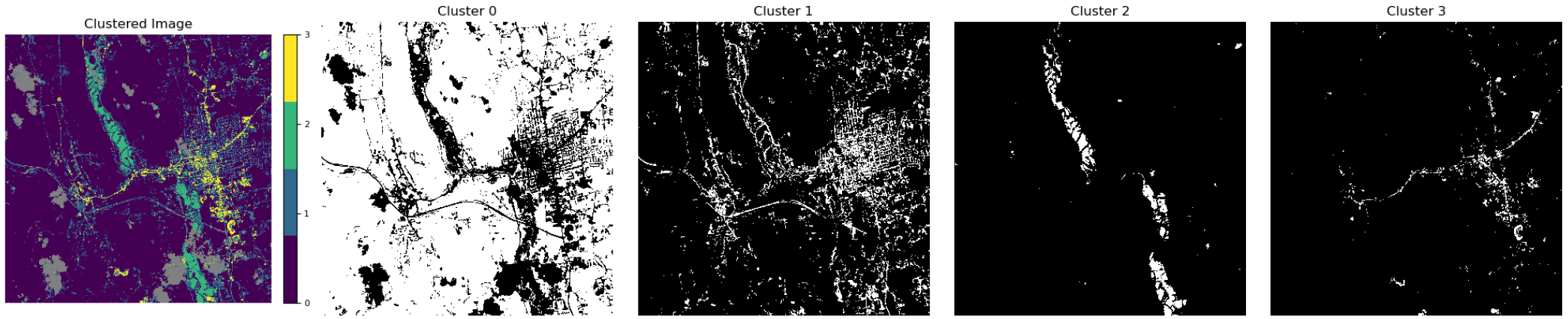
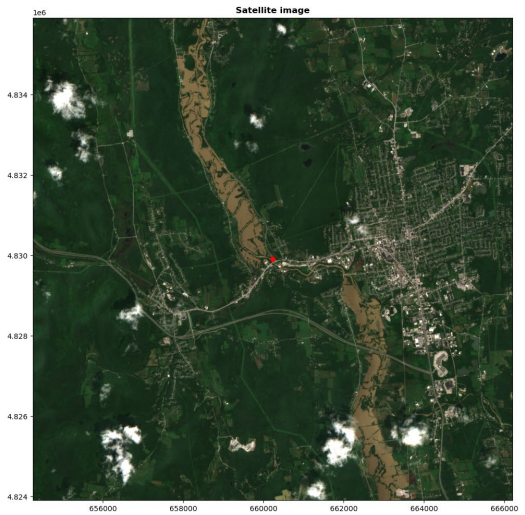


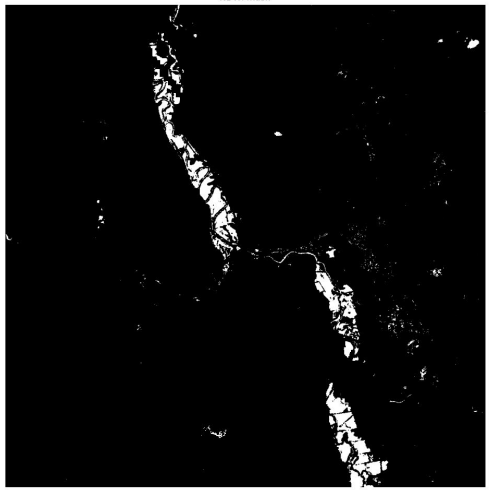
Image with NDWI feature -> PCA

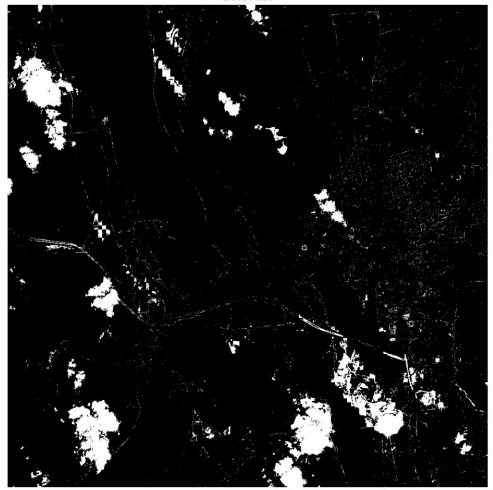


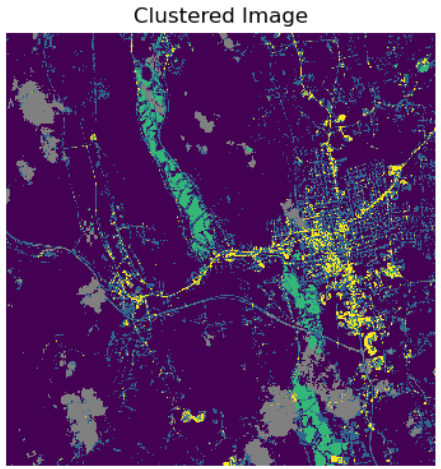
SUMMARY - Optimal KMeans Clustering Result

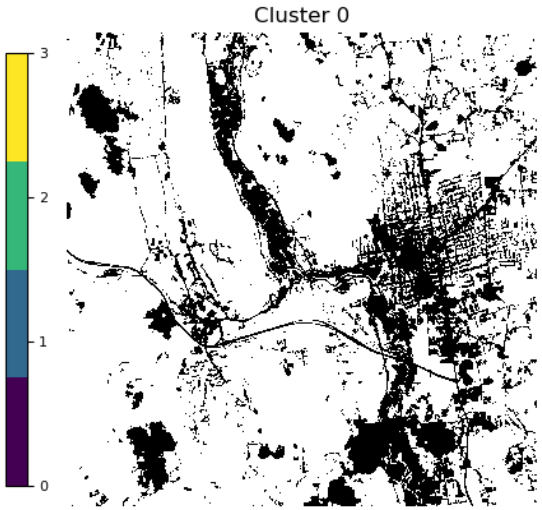
- Reduced noise

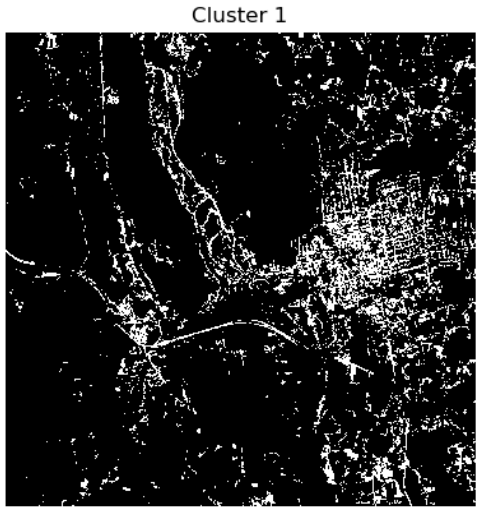


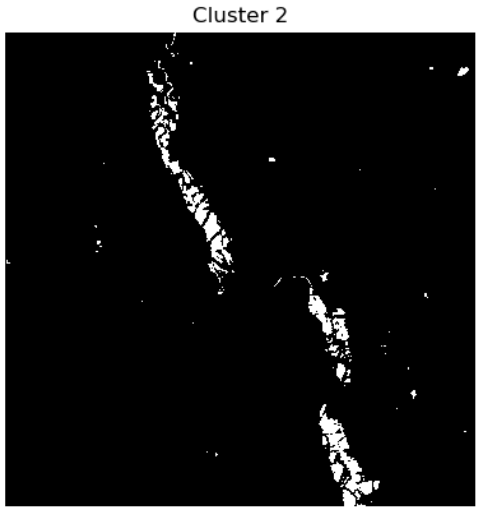


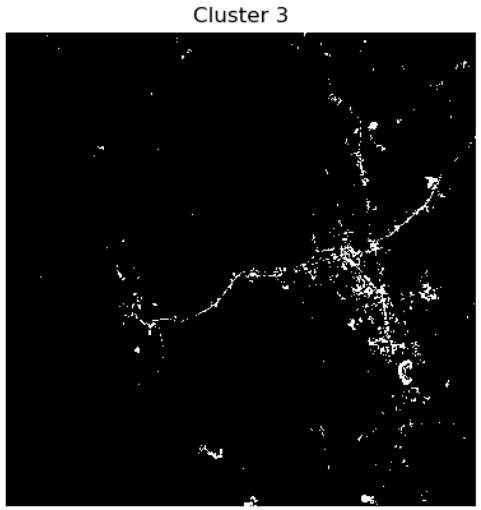












Discussion

- Satellite imagery can be a straightforward way to check the flooding situation in a specific area; however; not all flood events can be caught.
- Combining the satellite imagery and NDWI (Normalized Difference Water Index) helps the clustering algorithm.

Future work

- Flowline data from NHD includes all flowing water features -> noise.
- At the current stage, the evaluation part focuses on visual inspection -> quantitative evaluation.
- Ensure the reproducibility.
- Algorithm improvement: K-means clustering process is being killed (the process is running out of memory)

THANK YOU!

Acknowledgements

- Prof. Bogden (Supervisor)
- Sam from USGS (Stakeholder)