Flood Vulnerability Mapping Using Sentinel-1 SAR and GIS

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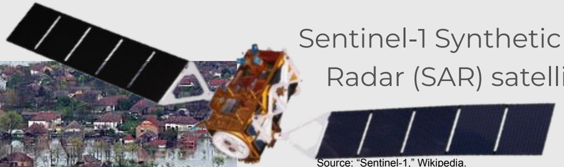
Flood Mapping with Satellite Radar

- Floods are one of the most significant natural disasters, affecting communities, homes, and lives
- **Objective** - Identify flooded areas, exposed buildings, and populations
- **Research Question:**
  Can mapping radar signal changes effectively highlight flooded areas?



Sentinel-1 Synthetic Aperture Radar (SAR) satellite data

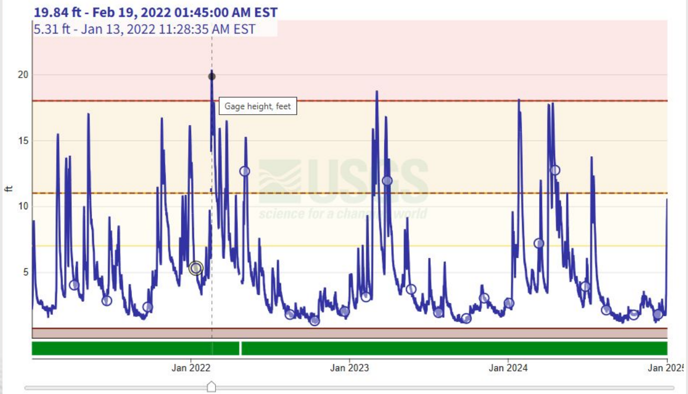
Source: “Sentinel-1,” Wikipedia.

Source: “Local banks lead on physical climate risk,” Federated Hermes Limited, EOS Insight.

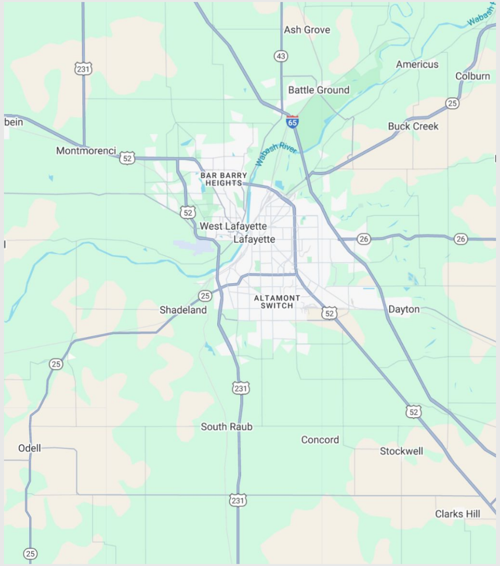
Unlike normal photos, SAR sends radar signals to create images. SAR is especially useful because it can operate in clouds and dark.

Experimental Design

- Used Sentinel-1 SAR radar images from before and during a flood event
- Independent variables: VV, VH radar polarizations, elevation, slope, distance to river
- Dependent variable: Flood classification
- Machine learning (Random Forest) and GIS mapping
- Two trials:
    - 8 bands- Used only SAR features
    - 12 bands- SAR data with ancillary data

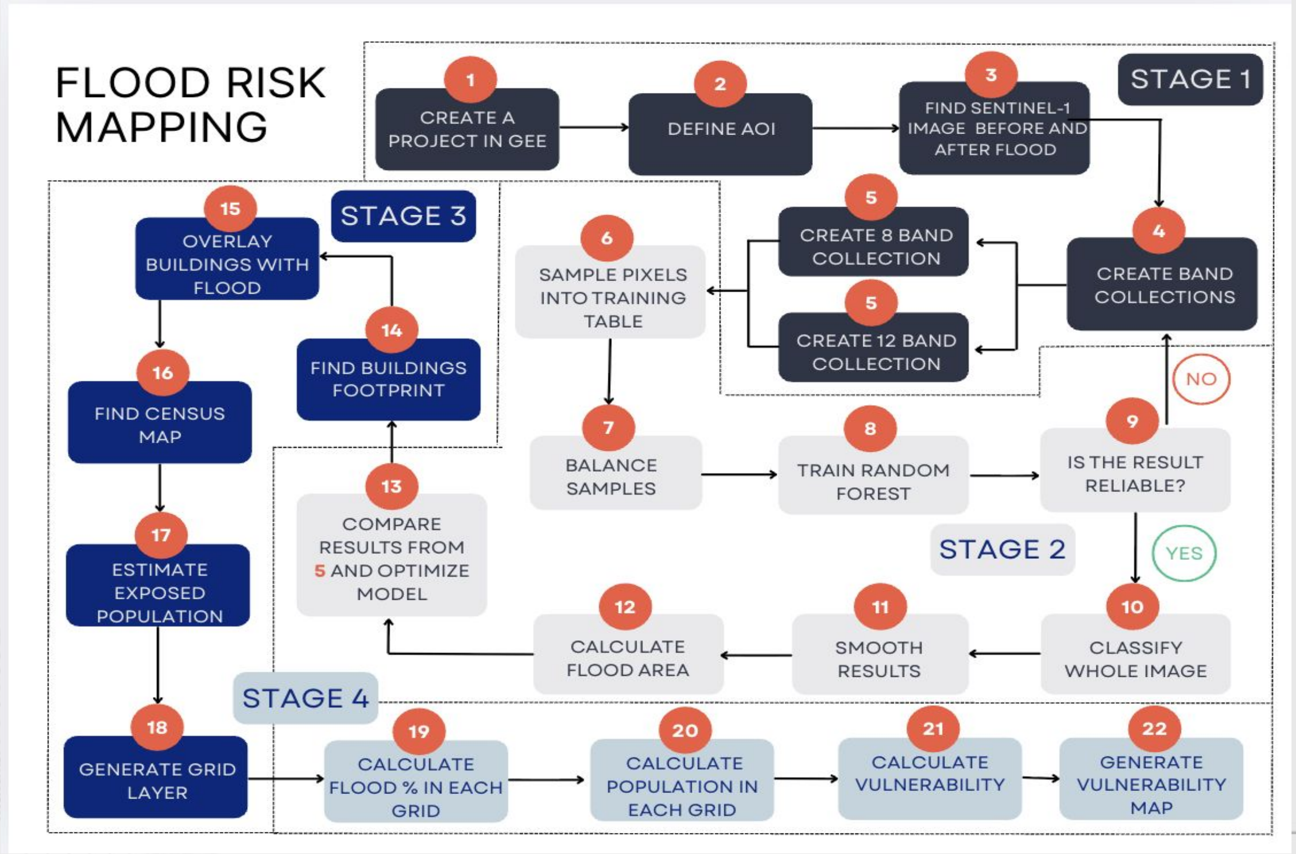


February 2022 flood; USGS stream gage 03335500, at Wabash River, Tippecanoe County



Tippecanoe County, Indiana along the Wabash River

Methods and Data Processing



Stage 1- Identify Sentinel-1 SAR image for flood mapping in Google Earth Engine.

Stage 2- Use Machine Learning method to classify flood areas.

Stage 3- Analyze the buildings and population that were exposed to flood.

Stage 4- Create a flood vulnerability map

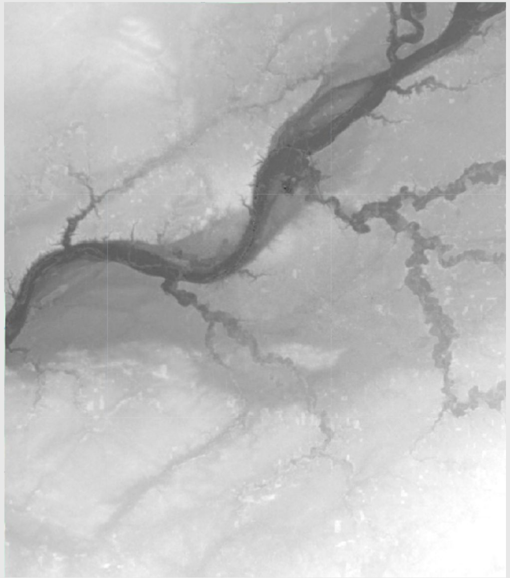
Flood Mapping

VV Pre-flood

VV Flood

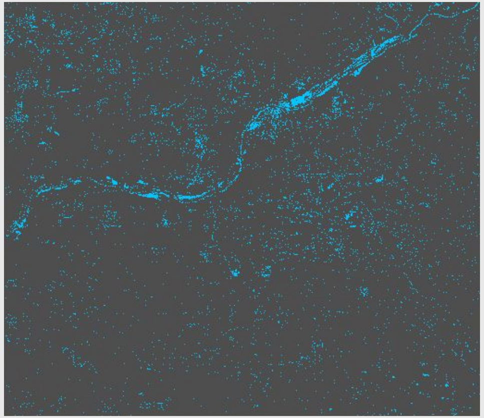
DEM

A 3D representation of terrain, shows slope, relative elevation, and distance to river



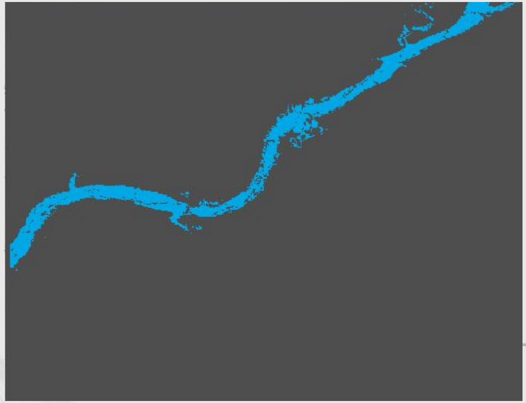
Bright areas mean rough surfaces eg. cities, forests. Dark areas are smooth surfaces, meaning water and flat fields.

Accuracy and Impact



Flooded area mapped with 8 bands

- SAR and GIS mapping can provide accurate results to detect floods
- 8 bands:
  - Detected flood broadly across scene
  - Identified wet areas that aren't directly related to river
- 12 bands:
  - Flooding identification relied heavily on ancillary instead of SAR
  - Detection clustered heavily on top of the river



Flooded area mapped with 12 bands

Confusion matrix:
[[1789,8],[5,1812]]

Overall accuracy:
0.9964028776978417

Kappa:
0.9928054689584055

Producers accuracy:
[[0.9955481357818586],[0.9972482113373693]]

Users accuracy:
[[0.9972129319955407,0.9956043956043956]]

Accuracy calculated with 8 bands

Confusion matrix:
[[1852,0],[0,1843]]

Overall accuracy:
1

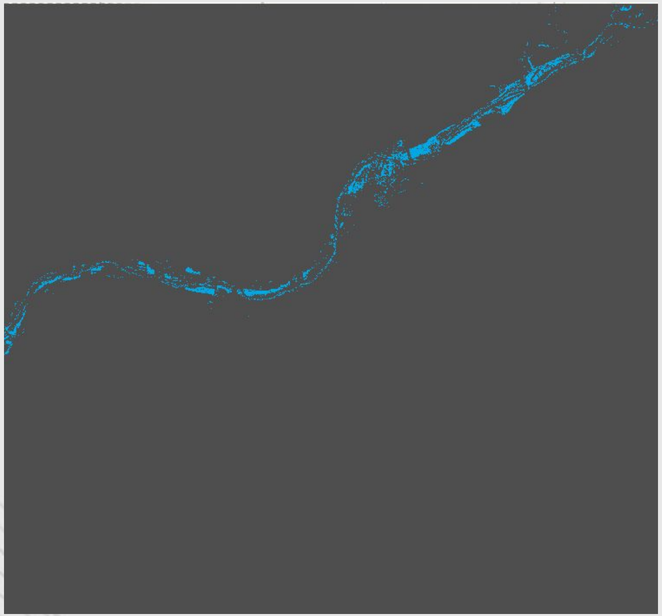
Kappa:
1

Producers accuracy:
[[1],[1]]

Users accuracy:
[[1,1]]

Accuracy calculated with 12 bands

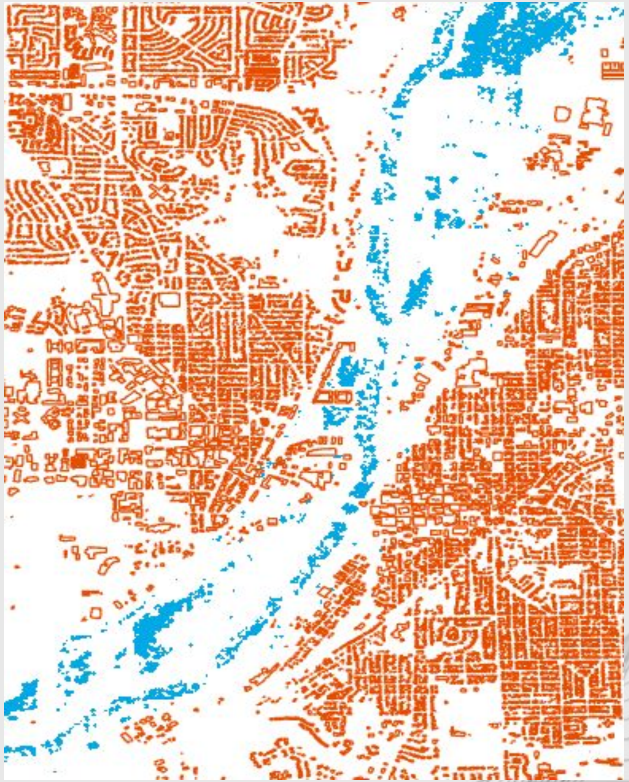
Data Interpretation and Conclusion



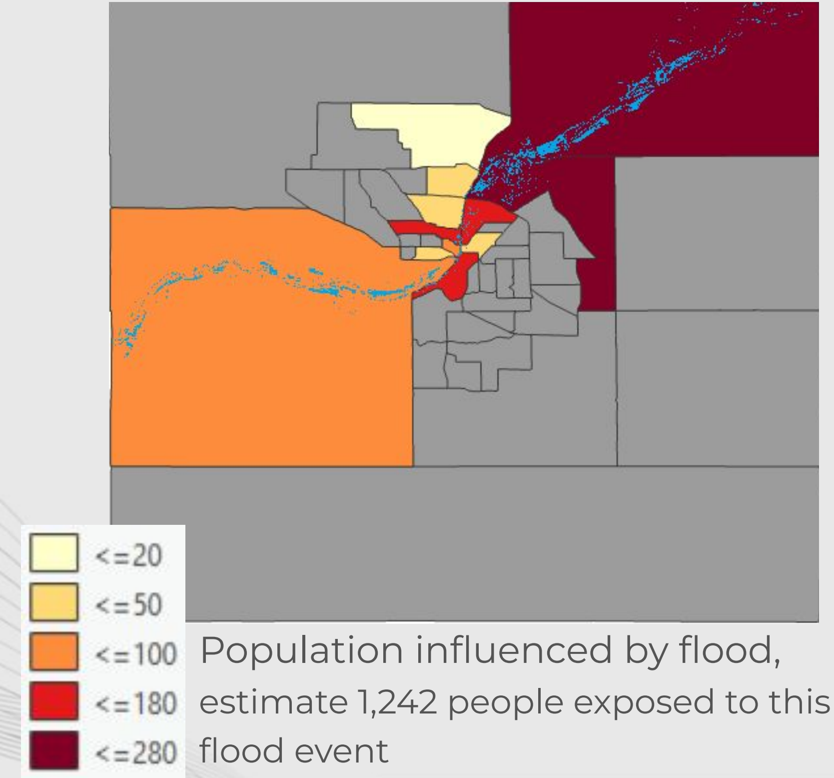
Final flood map; 8-band result combines with 12-band result

Buffer zone	Buildings affected
0 meter	15
20 meter	59
50 meter	191
100 meter	511

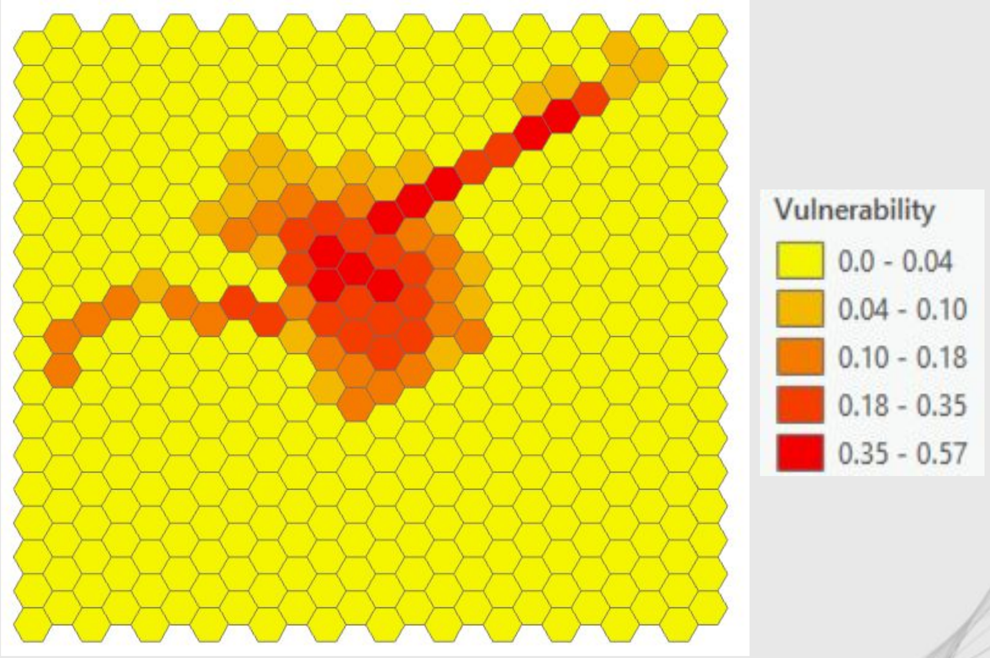
Building footprint overlapped with flooded area



Vulnerability Calculation



Population influenced by flood, estimate 1,242 people exposed to this flood event

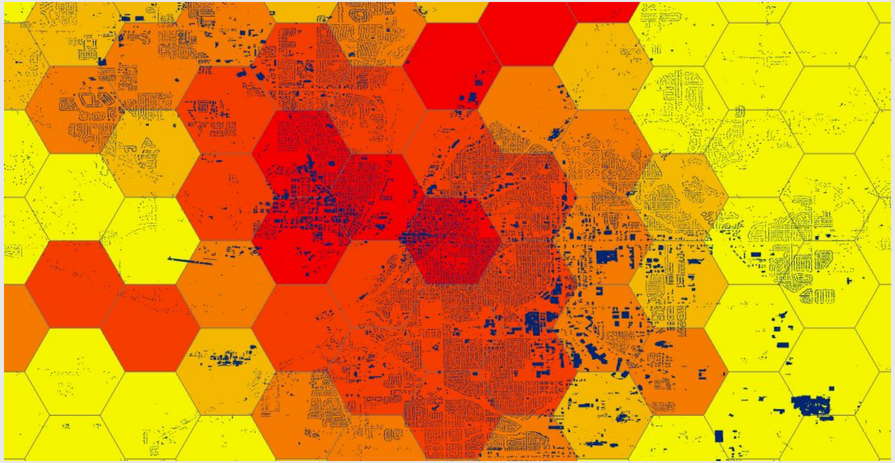


The vulnerability in each cell is calculated by:

flood% (normalized) * 0.5 + population (normalized) * 0.5

Significance and Future Steps

- This method can map floods rapidly during emergencies
- Useful for risk assessment and urban planning
- Can be applied to other flood events and regions
- In the future, test more events and improve modeling



Enlarged photo of vulnerability grid overlaid with building footprints

References

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