FLORIDA STATE UNIVERSITY

DEPARTMENT OF
CIVIL & ENVIRONMENTAL
ENGINEERING

FAMU-FSU
College of Engineering

Integrating Remote Sensing and In-situ Data to Improve Understanding of Flood Events in the U.S.

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Presented By: Azizbek Nuriddinov

RIDER
Resilient Infrastructure & Disaster Response Center

Civil and Environmental Engineering, FAMU-FSU College of Engineering

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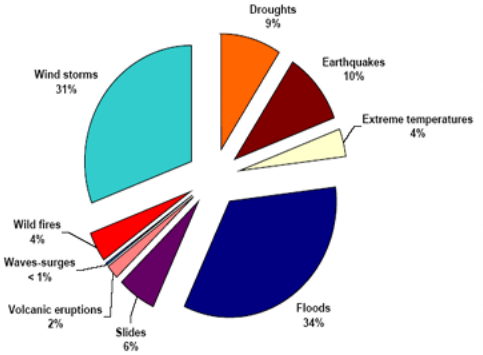
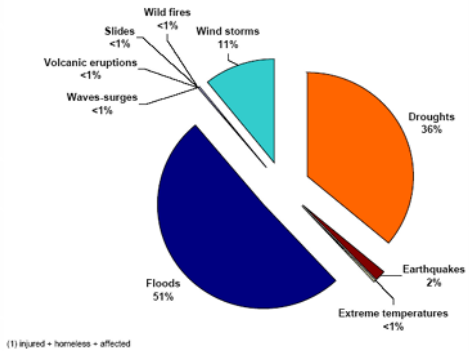
What is Flooding?

Overflowing of water from the normal confines of a river or stream



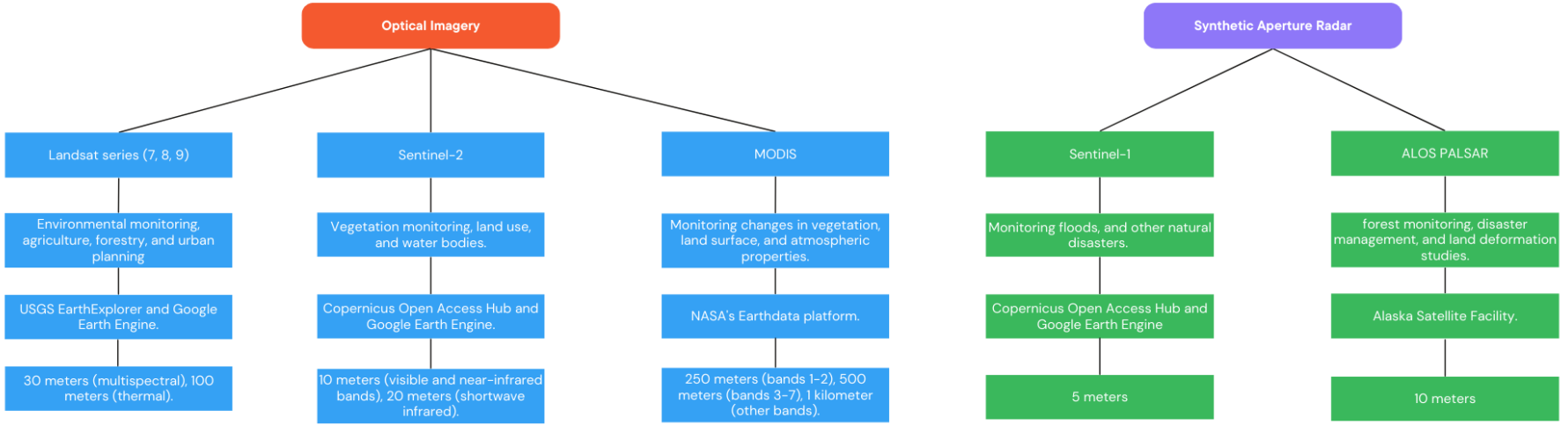


Floods: 34% world natural hazards between 1960-2015

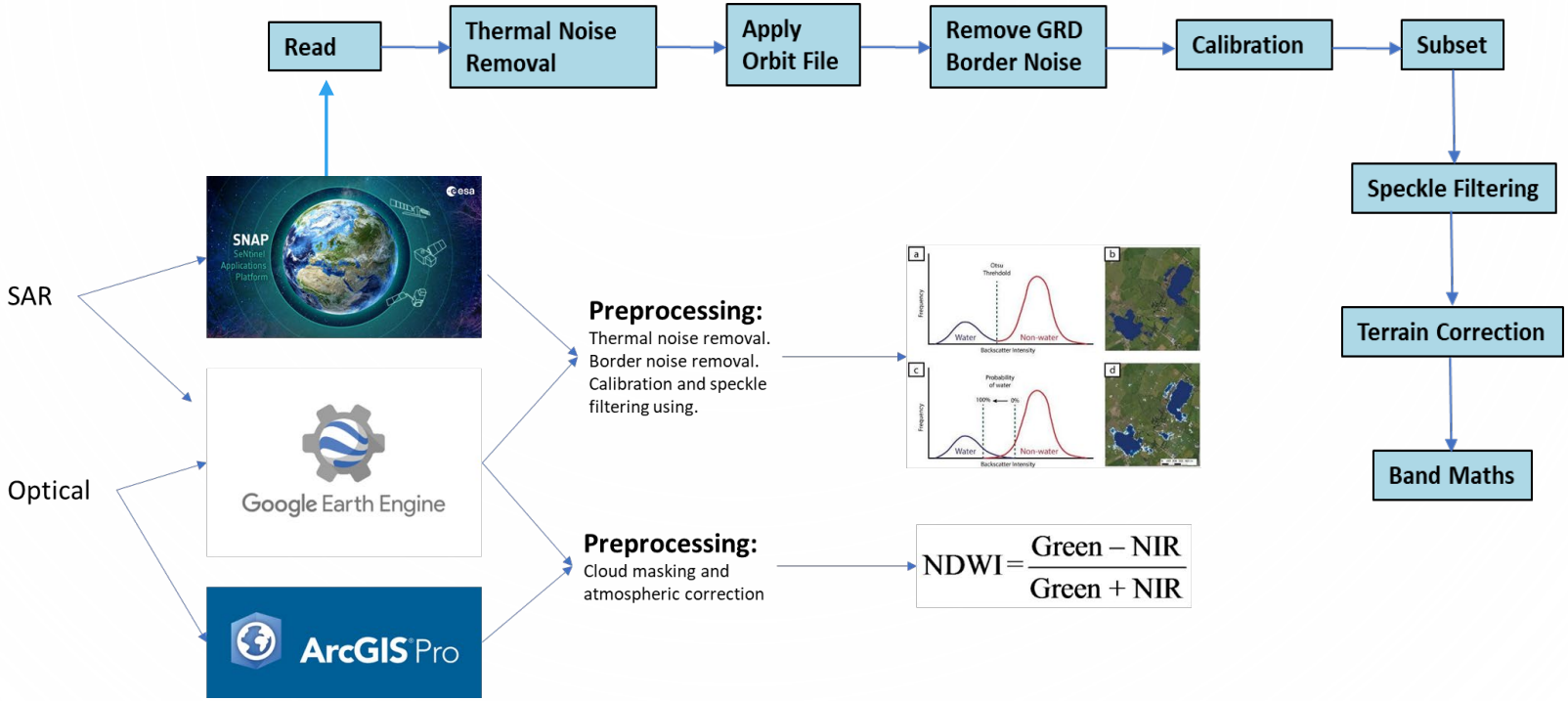
Half of affected people (200 million) related to flood events

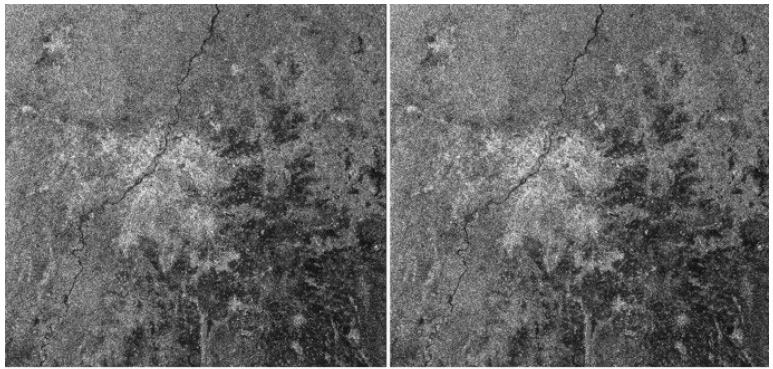
Source: EM-DAT-International Disaster Database (1960 to 2015)

Types of Available Satellite Imagery

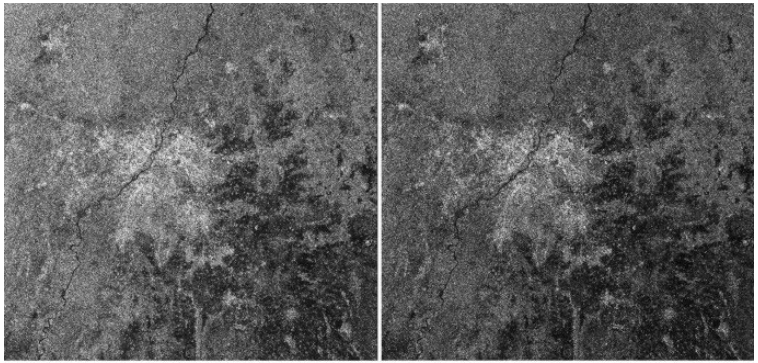


The traditional approach:

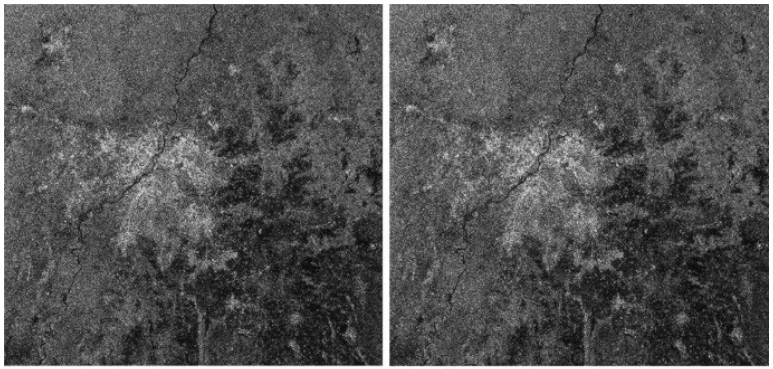




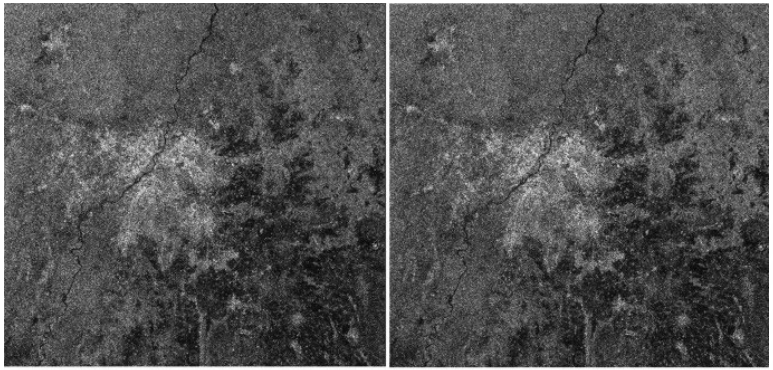
(a) *Image before orbit file update operation* **(b)** *Image after orbit file update operation*



(a) *Before thermal noise removal* **(b)** *After thermal noise removal*



(a) *Before border noise removal* **(b)** *After border noise removal*

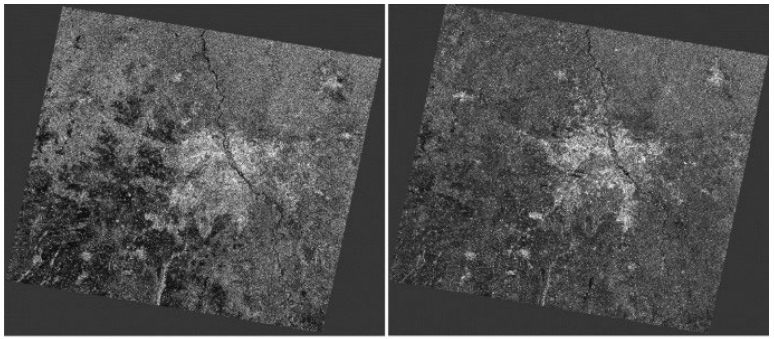


(a) *Before Radiometric Calibration* **(b)** *After Radiometric Calibration (Sigma0)*

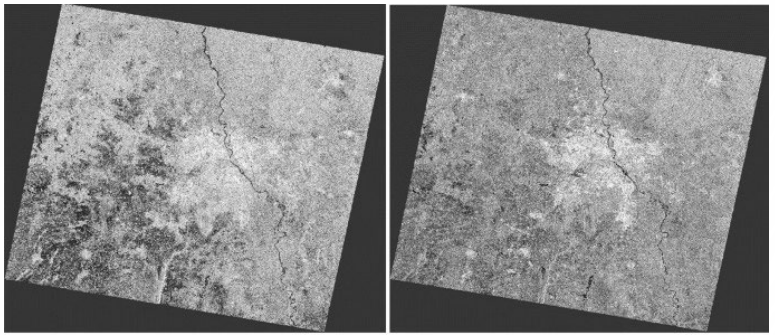
Speckle Filtering:

SAR images often contain **speckle noise**, which is a **granular** noise that can obscure details in the image.

In the VH polarized image, **water** features show a **dark color** tone; consequently, the VH polarized image envisages the river water bodies more predominantly compared to the VV image. It enables easier detection of water bodies from the C-band radar image due to no back-scattering behavior of the water surfaces.

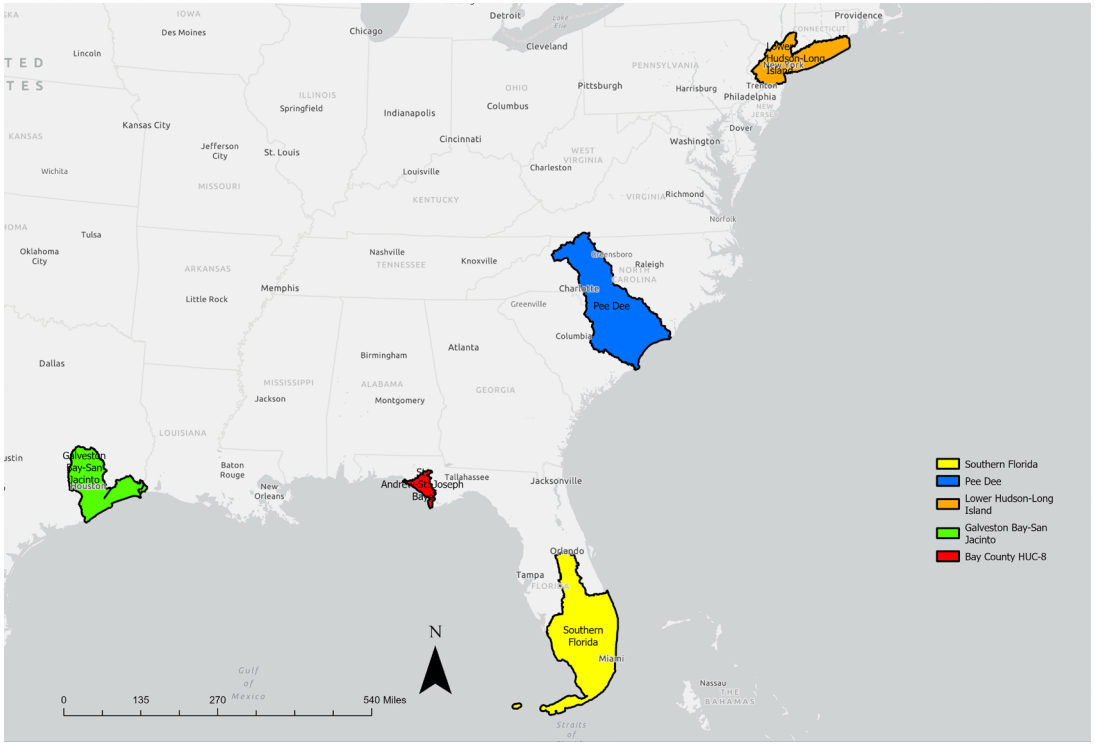


(a) *Before conversion to dB (VH)* **(b)** *Before conversion to dB (VV)*



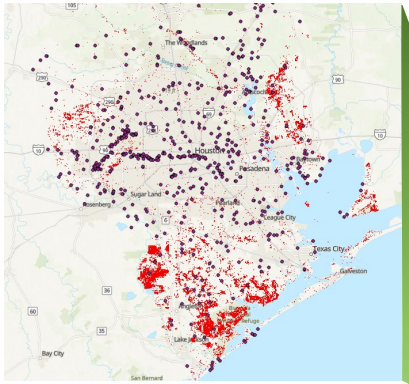
(a) *Image after dB Conversion (VH)* **(b)** *Image after dB Conversion (VV)*

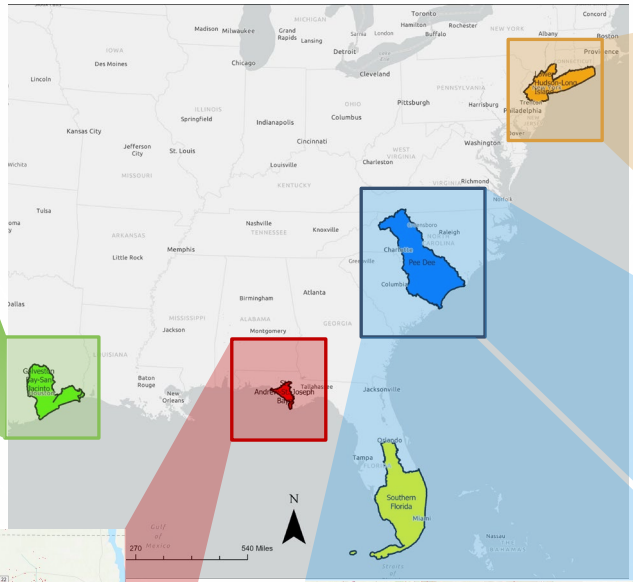
Study Areas Affected by Hurricanes

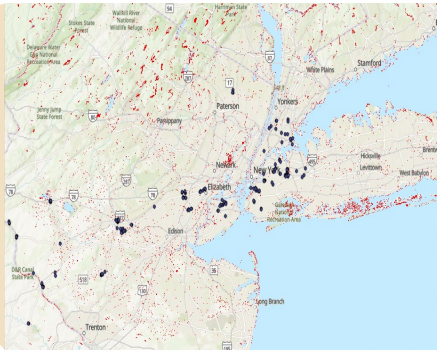


Hurricane	Affected Area
Ian (2022)	Southern Florida
Ida (2021)	Lower Hudson-Long Island
Florence (2018)	Pee Dee
Michael (2018)	St Andrew – St Joseph
Harvey (2017)	Galveston Bay-San Jacinto
Irma (2017)	Southern Florida
Matthew (2016)	Pee Dee

Hurricane Harvey

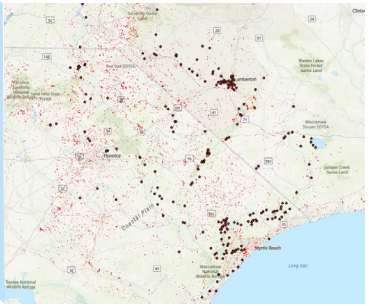




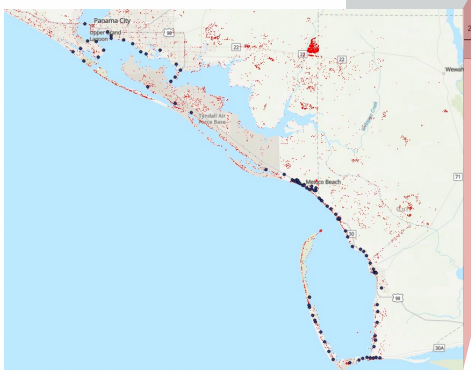


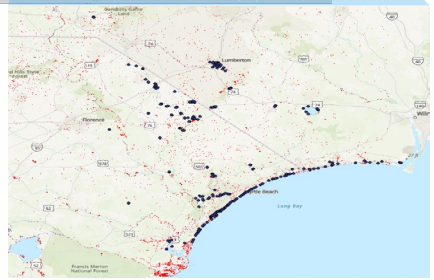
Hurricane Ida

Hurricane Florence

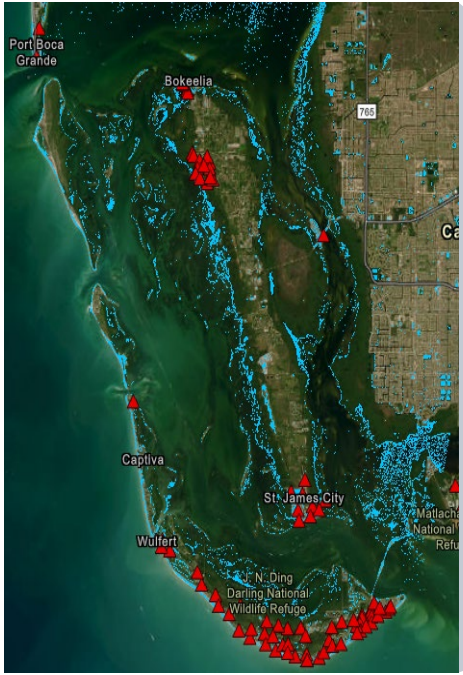


Hurricane Michael

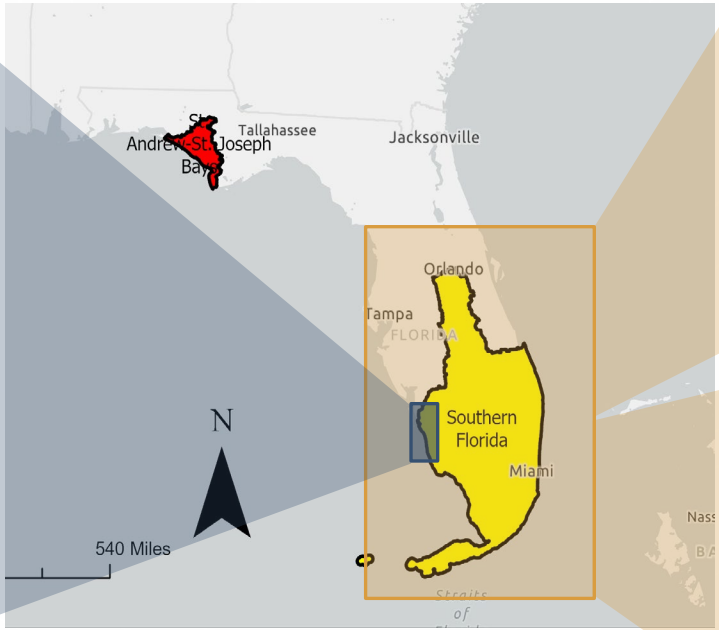


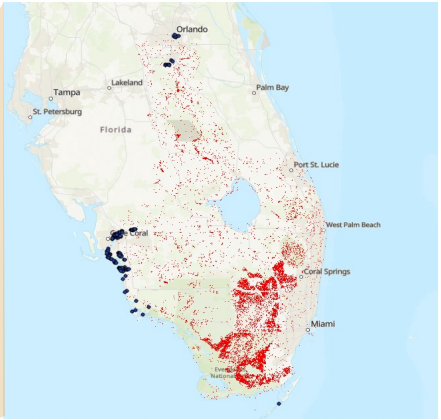


Hurricane Matthew

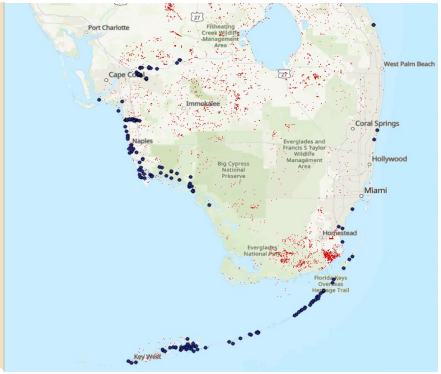


Optical Imagery: Planet



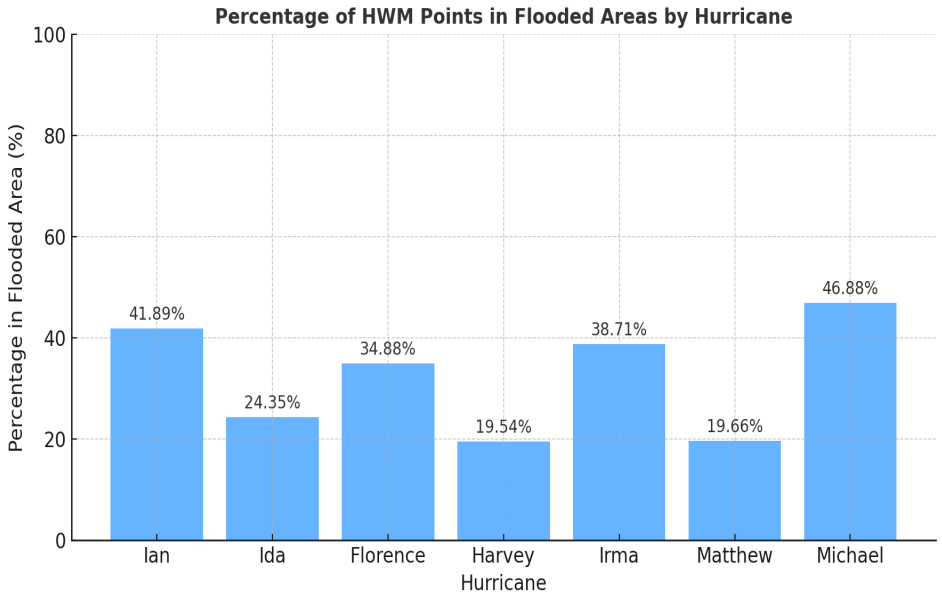


Hurricane Ian



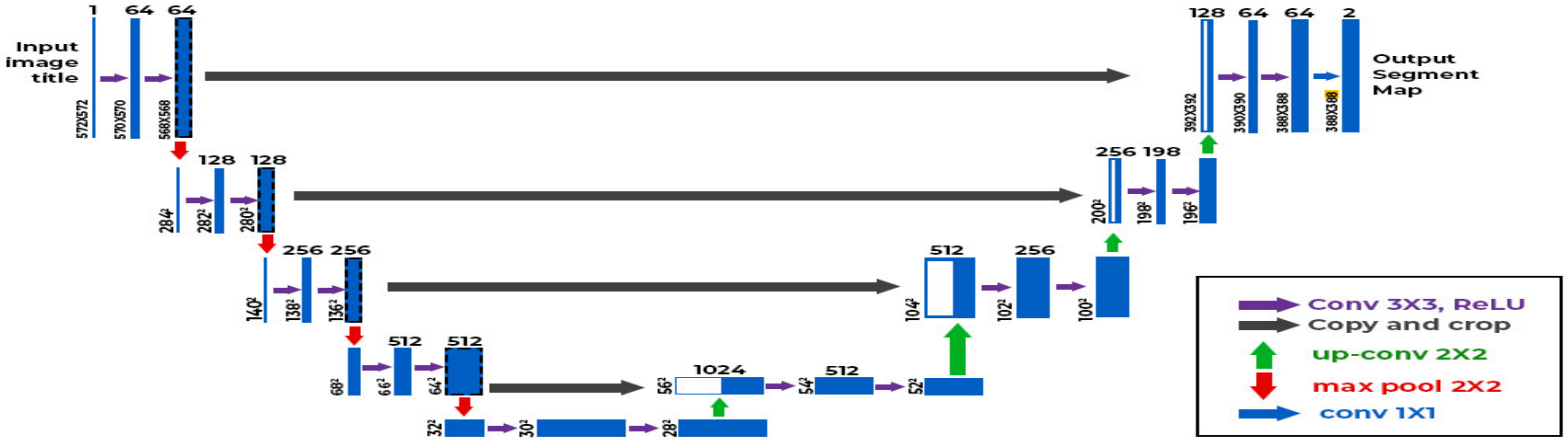
Hurricane Irma

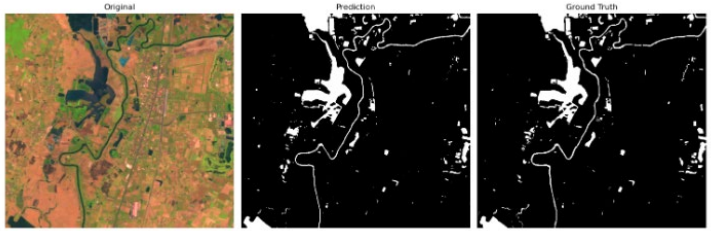
Comparison of HWM Points and Flooded Areas Across Hurricanes



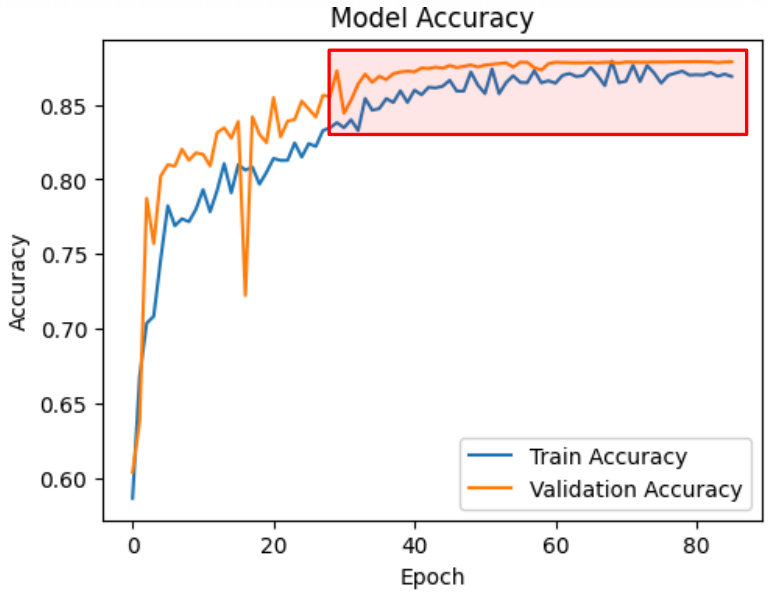
Hurricane	Affected Area	Total HWM points	Points in Flooded areas	Percentage in Flooded Area
Ian	Southern Florida	222	93	41.89%
Ida	Lower Hudson-Long Island	308	75	24.35%
Florence	Pee Dee	258	90	34.88%
Harvey	Galveston Bay-San Jacinto	967	300	31.02%
Irma	Southern Florida	248	96	38.71%
Matthew	Pee Dee	407	80	19.66%
Michael	Bay County	160	75	46.88%

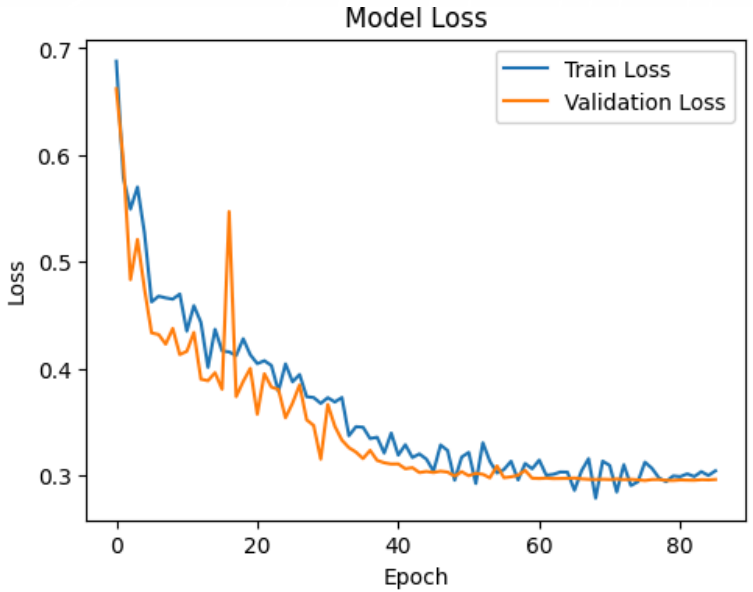
U-Net structure



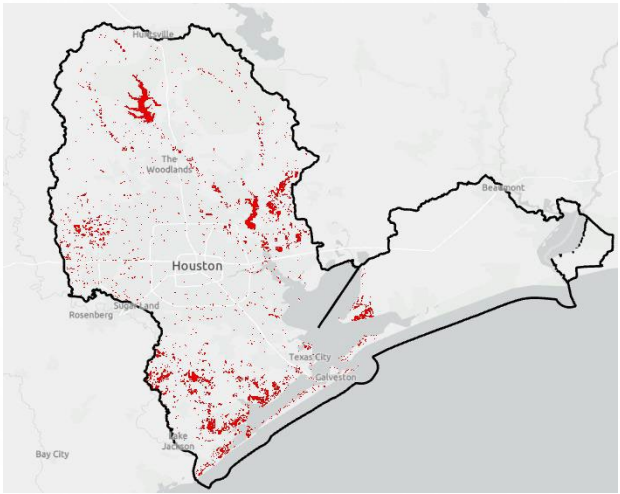


Model Accuracy:

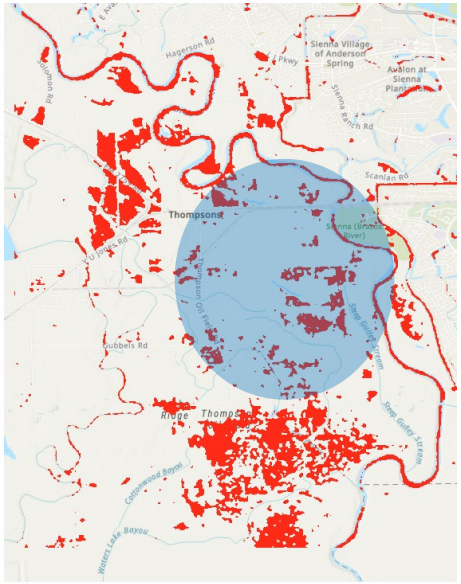




Case study | Hurricane Harvey (August 2017)

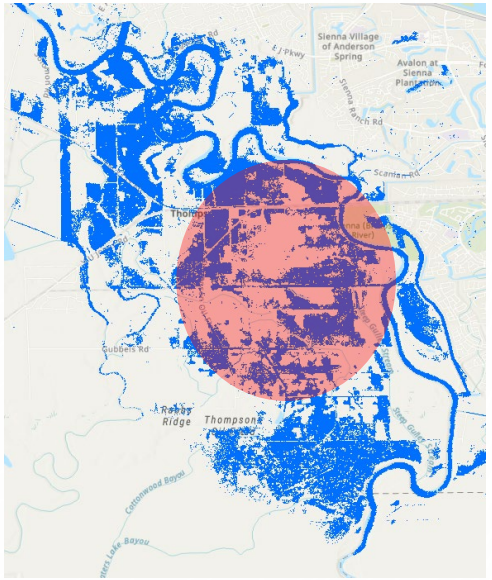


Affected area (Houston, Tx)



Traditional approach

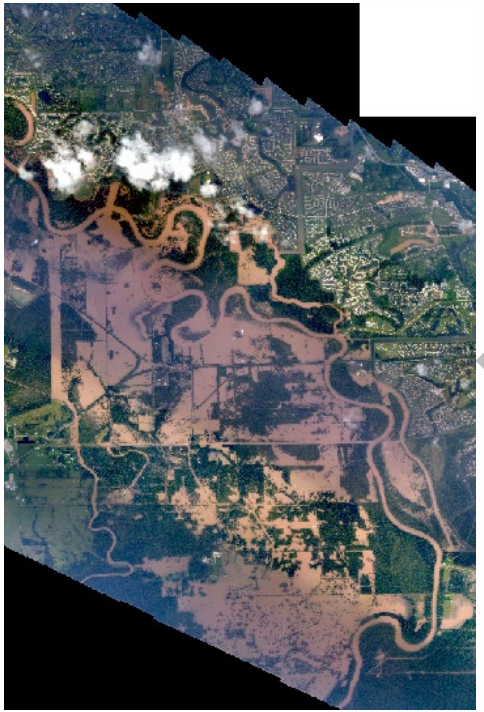
VS



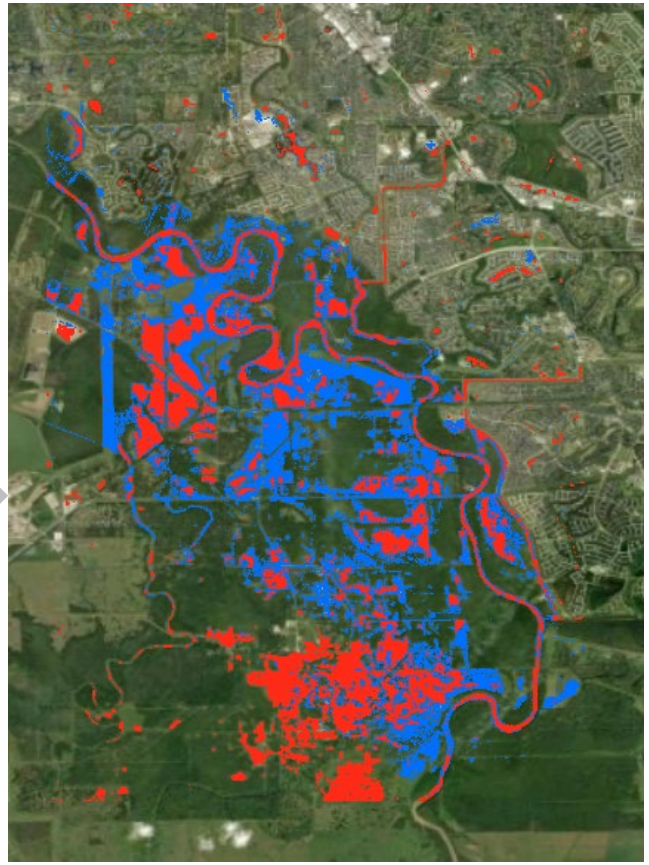
U-Net approach

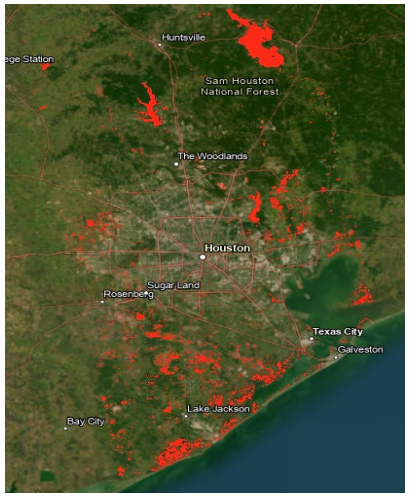
Case study | quick visual comparison

Drone image

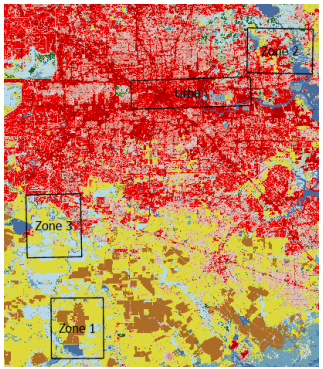


To validate our result, we visually compare it to drone images





U-Net model output



2017 NLCD map - to define validation zones

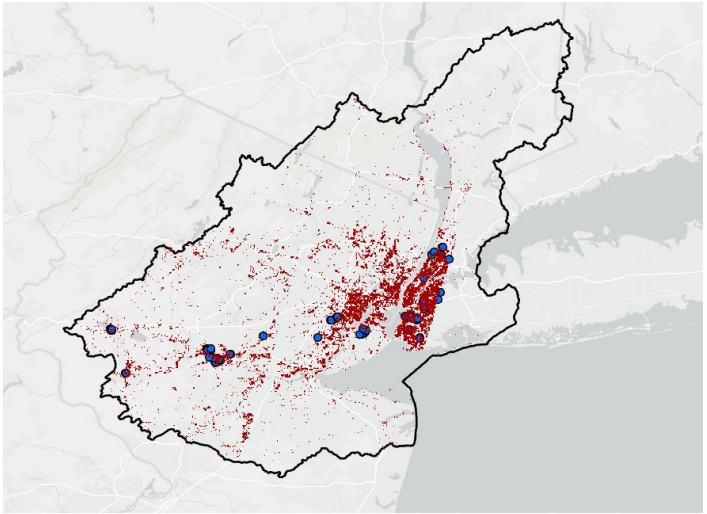
Case study | Close-up assessment:

Aerial images (ground truth) - to compare with

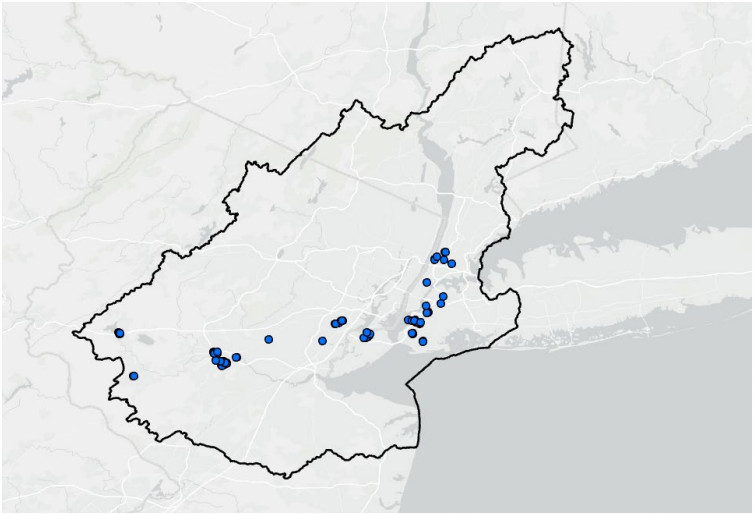
Class	Flooded	OA (%)	PA non-flood(%)	PA flood (%) Precision	UA non-flood (%)	UA flood (%) Recall	F1-score (%)	Kappa
Urban (High and Low Density, open water)	No	92.5	98.1	36.4	96.9	41.7	38.9	0.22
Zone_mixed1 (pasture, crops, woody wetlands, open water)	Yes	64.31	89.71	41.51	57.93	81.81	55.08	0.304
Mixed_zone2 (Urban, pasture, woody wetlands, forest, open water)	Yes	87.7	95.63	40.85	90.52	61.31	49.04	0.424
Zone_mixed3 (pasture, woody wetlands, low density urban, open water)	Yes	87.02	96.95	38.71	88.5	72.27	50.42	0.437
Weighted Mean (All Zones)	Yes	82.38	95.10	39.37	83.46	64.27	48.36	0.346

Case study | Hurricane Ida (2021)

U-Net model output



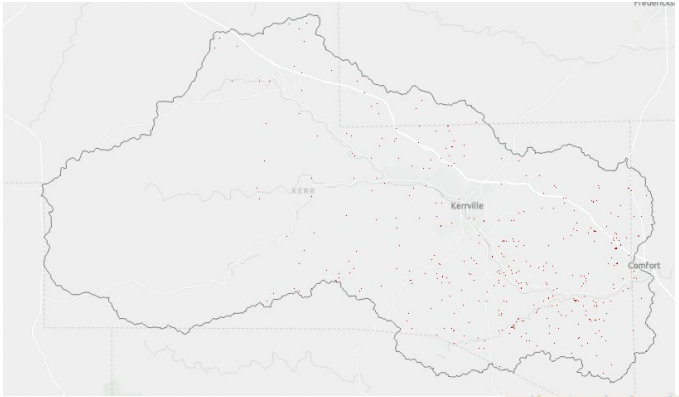
HWM points (ground truth)
- to compare with



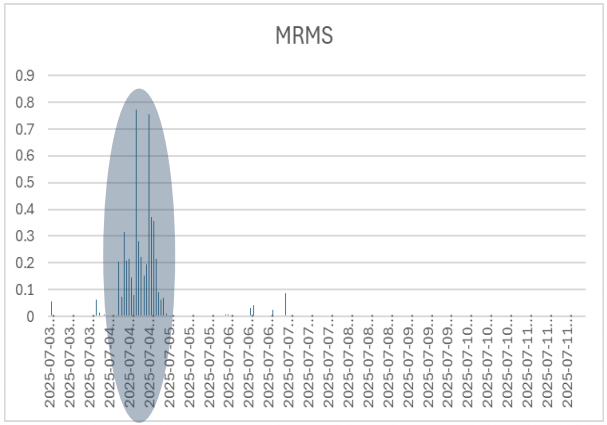
Validation: 70% compared to HWM (140 total points) within the area

Now our question is whether satellite images are always reliable?

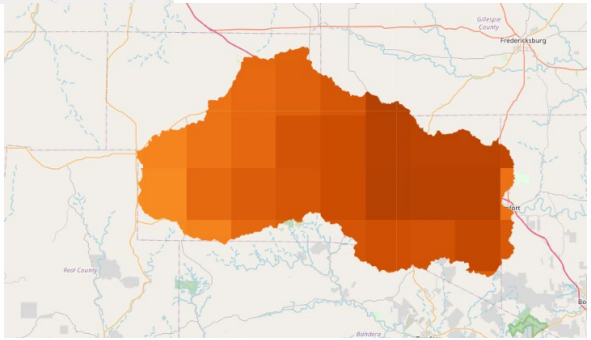
Case study | Texas flooding (4th-5th of July 2025)

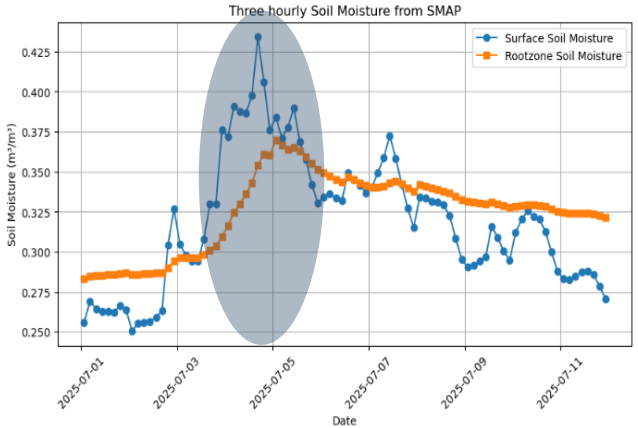


Planet imagery
(3 m resolution)
07/10/2025



Soil moisture map





Our next steps for improvement:

- Incorporate terrain information — add DEM, HAND, and Slope as extra features to improve terrain and reduce false positives on elevated or sloped areas.
- Leverage SMAP soil moisture and precipitation data to detect and simulate flooding during periods of limited optical or radar imagery, enabling better temporal continuity.
- Integrate in-situ HWM / gauge levels directly into training for improved ground-truth calibration.

Thank You

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