

# Machine Learning Classification of Flood Waters from Hurricanes Harvey and Florence as Captured by Synthetic Aperture Radar and Optical Remote Sensing

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# What is Synthetic Aperture Radar?

- ▶ Synthetic Aperture Radar (SAR) is an active remote sensing instrument that relies on reflected energy from Earth's surface (backscatter)
  - ▶ Microwave radiation emitted by the radar can penetrate clouds and vegetation, available day or night
- ▶ SAR data for this project was obtained by NASA JPL's UAVSAR instrument
  - ▶ Side-looking L-band synthetic aperture radar mounted on a Gulfstream-III jet
  - ▶ Quad-pol radar outputs data according to its transmitted and received orientation
    - ▶ HH - Horizontal transmit, Horizontal receive
    - ▶ HV - Horizontal transmit, Vertical receive
    - ▶ VV - Vertical transmit, Vertical receive
    - ▶ VH - Vertical transmit, Horizontal receive



Images: NASA Jet Propulsion Laboratory



# Visualizing UAVSAR Data

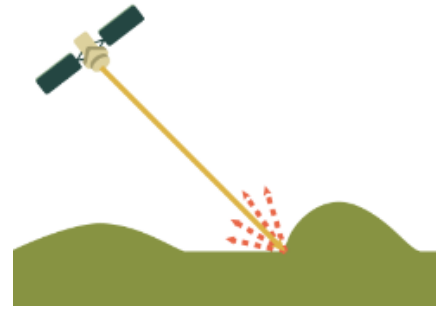
▶ UAVSAR and other quad-pol data can be visualized through many different decomposition methods. The **Freeman-Durden** decomposition method is used here.

- ▶ Produces layers that show the fraction of returned radar power resulting from single, double, and volume scattering mechanisms

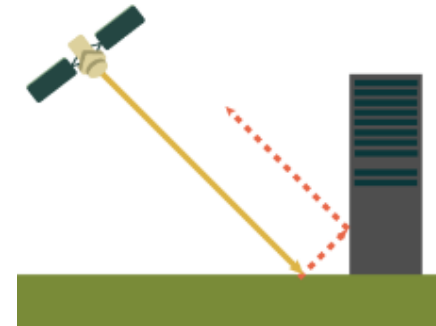
**Single** scattering - smooth, relatively flat surfaces (e.g. open water, paved areas, bare/sparsely-vegetated ground)

**Double** scattering - perpendicular vertical structures (tree trunks in standing water, buildings, power poles)

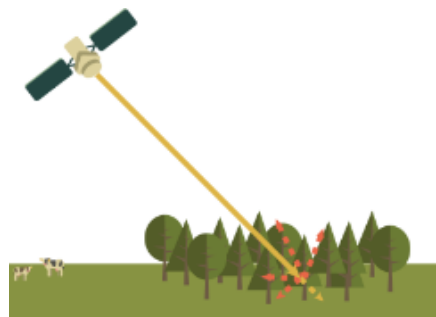
**Volume** scattering - vegetative canopies, sometimes urban areas



Single

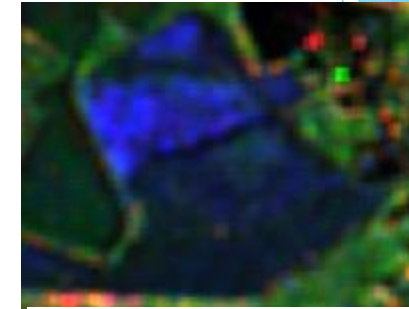


Double



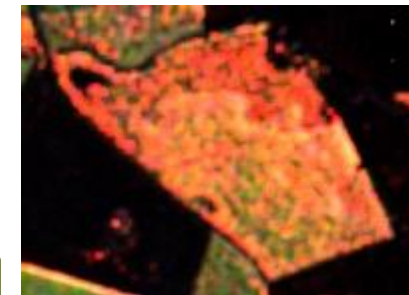
Volume

UAVSAR



A field with short/sparse vegetation cover

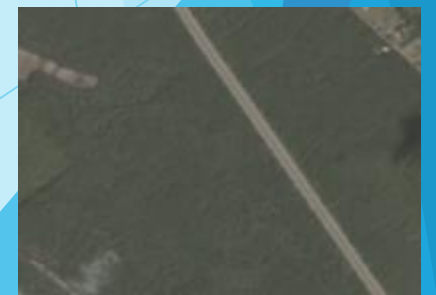
Visible



An area of inundated forest

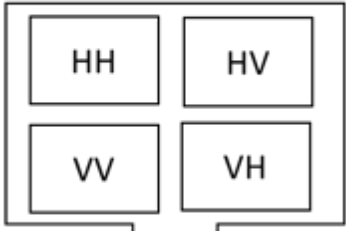


An area of dry forest



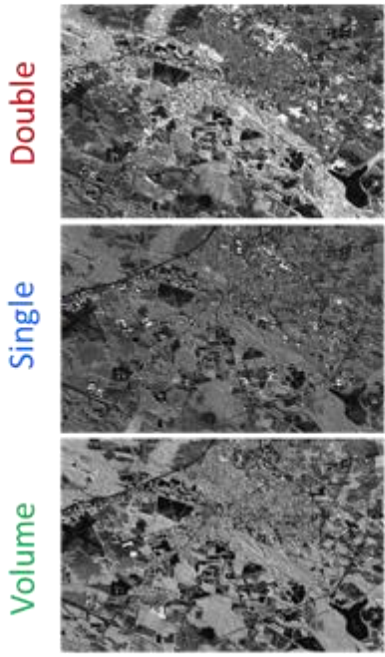
# Methodology

Polarized UAVSAR Data



Freeman-Durden Decomposition

Scattering Mechanisms

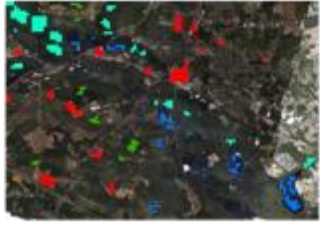
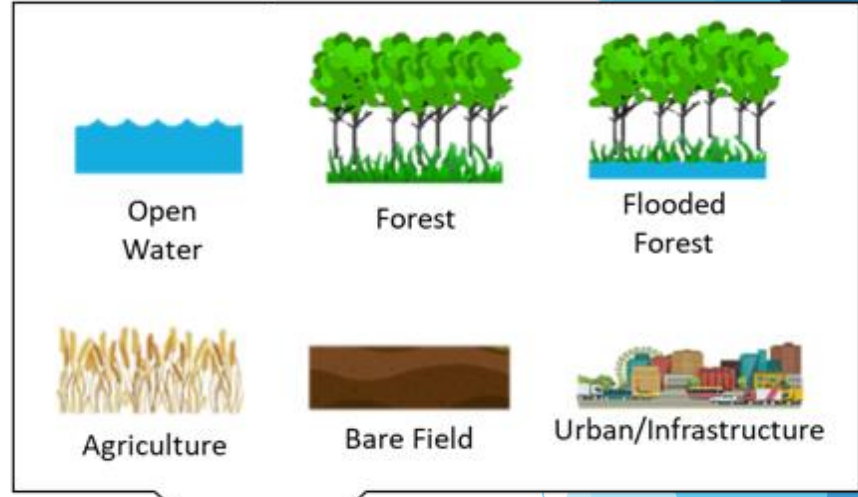


UAVSAR RGB

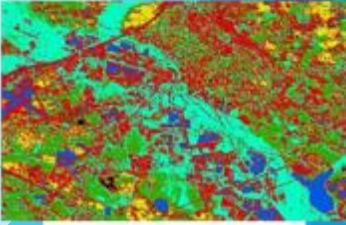


Aerial Imagery

Sample Classes



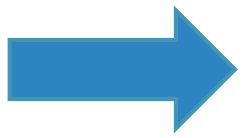
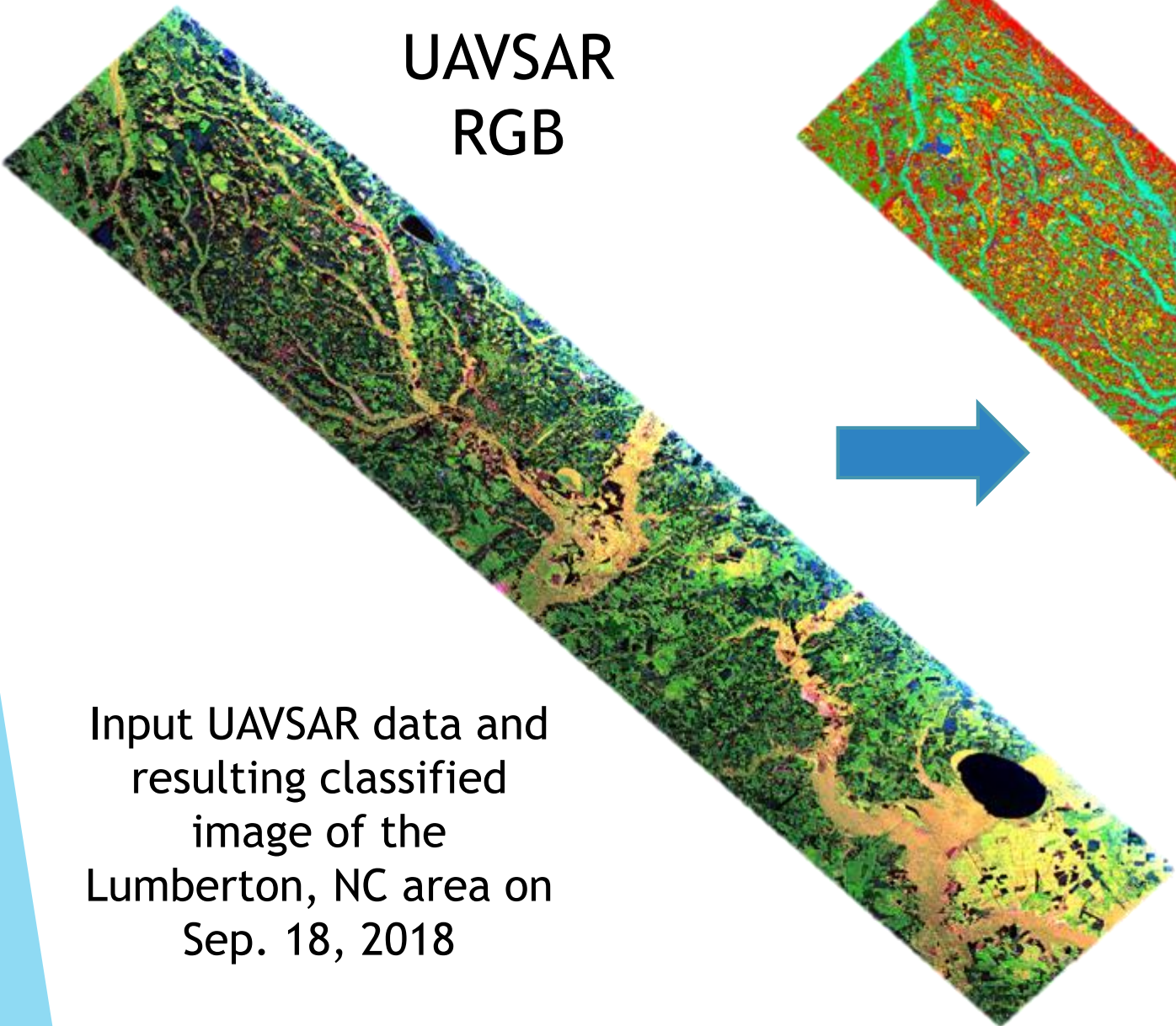
Training Samples



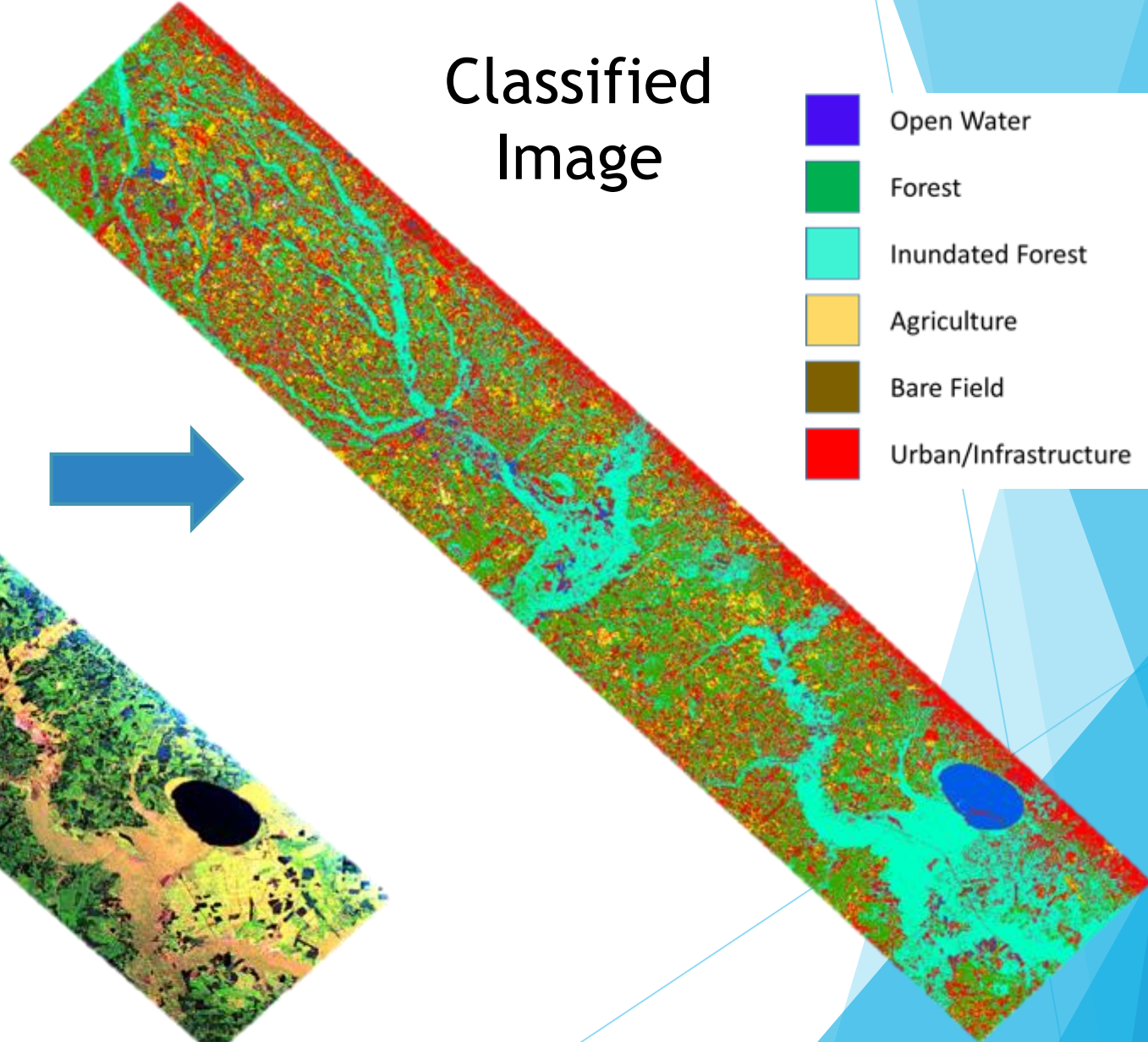
Classified Image

# Data Input/Output Example

UAVSAR  
RGB



Classified  
Image



- Open Water
- Forest
- Inundated Forest
- Agriculture
- Bare Field
- Urban/Infrastructure

Input UAVSAR data and resulting classified image of the Lumberton, NC area on Sep. 18, 2018

# Results - Florence

## Classified Points

Reference Points		Open Water	Dry Forest	Inundated Forest	Agriculture	Bare Field	Infrastructure	Total	
	Open Water		<b>37</b>	6	25	1	6	28	103
	Dry Forest	1		<b>81</b>	9	8	2	7	108
	Inundated Forest	0	13		<b>90</b>	1	0	6	110
	Agriculture	1	3	6		<b>64</b>	19	14	107
	Bare Field	0	1	8	19		<b>54</b>	27	109
	Infrastructure	1	7	13	10	6		<b>68</b>	105
	Total	40	111	151	103	87	150		642

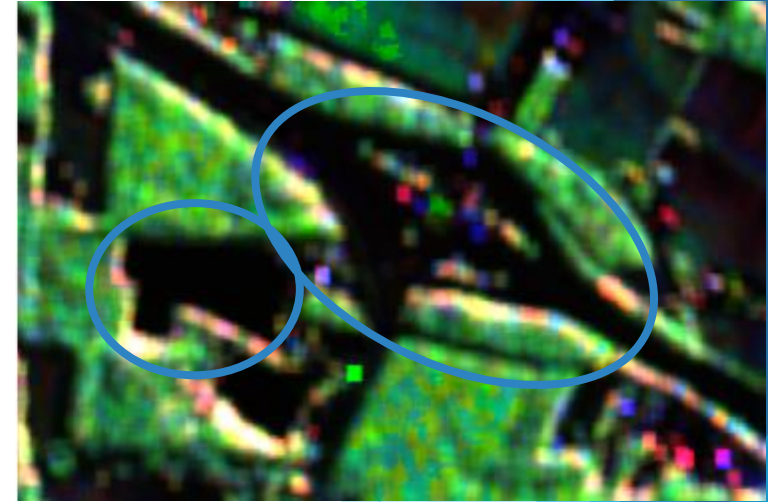
Overall Accuracy:  
61.37%

Kappa Coefficient:  
.536

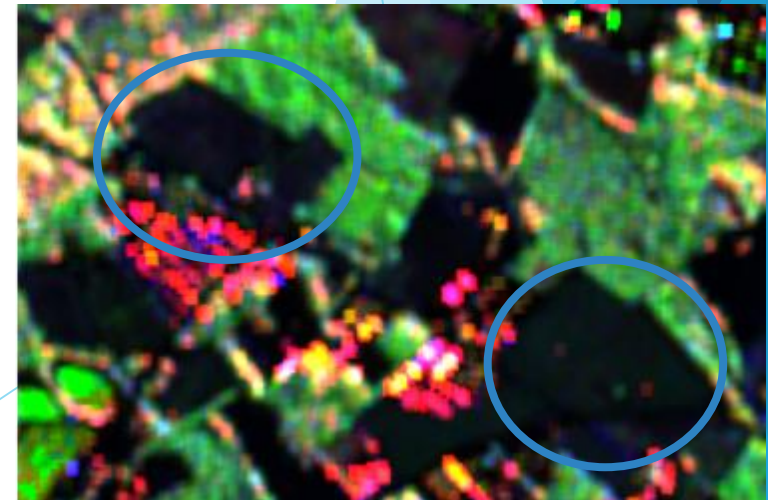
# Limitations

- ▶ Since UAVSAR provides a measure of surface roughness, different land cover types with similar textures tend to look similar in the imagery.
  - ▶ Creates many opportunities for the classifier to be confused

- ▶ An example of the similarity of water and road networks in SAR imagery, both relatively smooth/flat surfaces



- ▶ Bare and vegetated fields can also look similar in the SAR image, more room for classifier error



# Conclusions/Future Work

- ▶ This method allows for the rapid classification of UAVSAR swaths with reasonable accuracy, making it potentially useful for near-time applications
- ▶ Moving forward, the main goal is to increase the accuracy of the classifier through a combination of methods:
  - ▶ The adjustment of classes and their respective training samples by focusing on classes with a distinct backscatter signature in the SAR image
  - ▶ Differing spatial resolutions between UAVSAR, NOAA aerial imagery, and Planet visible imagery cause a misalignment of accuracy assessment points, likely influencing the results of the assessment
  - ▶ Addition of a building mask may eliminate the need for an Urban/Infrastructure class, also eliminating the confusion associated with the class