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

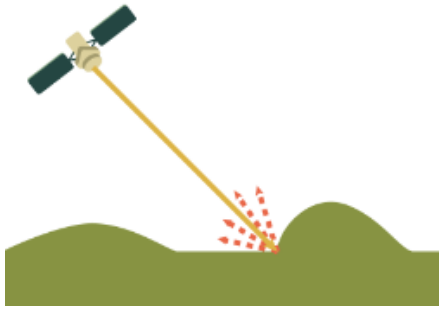
Visualizing UAVSAR Data

- 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

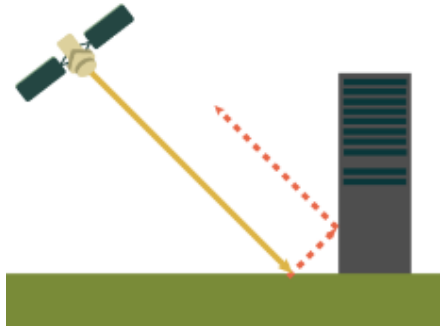
Single scattering – smooth, relatively flat surfaces (e.g. open water, paved areas, bare/sparsely-vegetated ground)

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

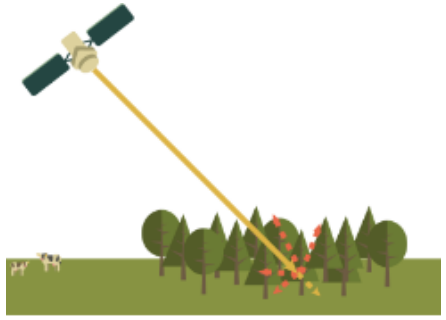
Volume scattering – vegetative canopies, sometimes urban areas



Single

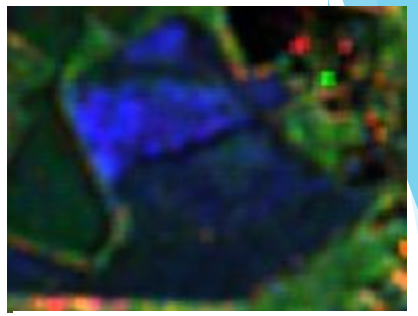


Double

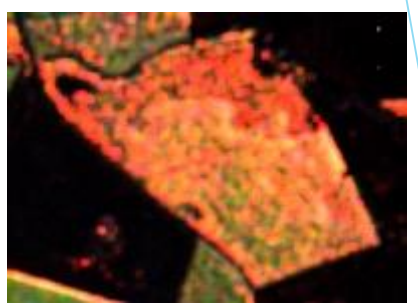


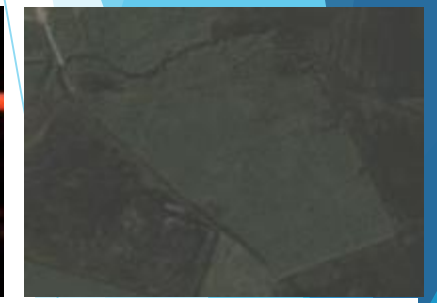
Volume

UAVSAR | Visible

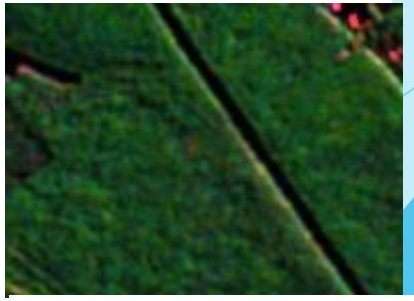


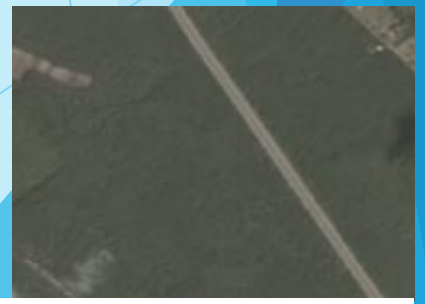
A field with short/sparse vegetation cover





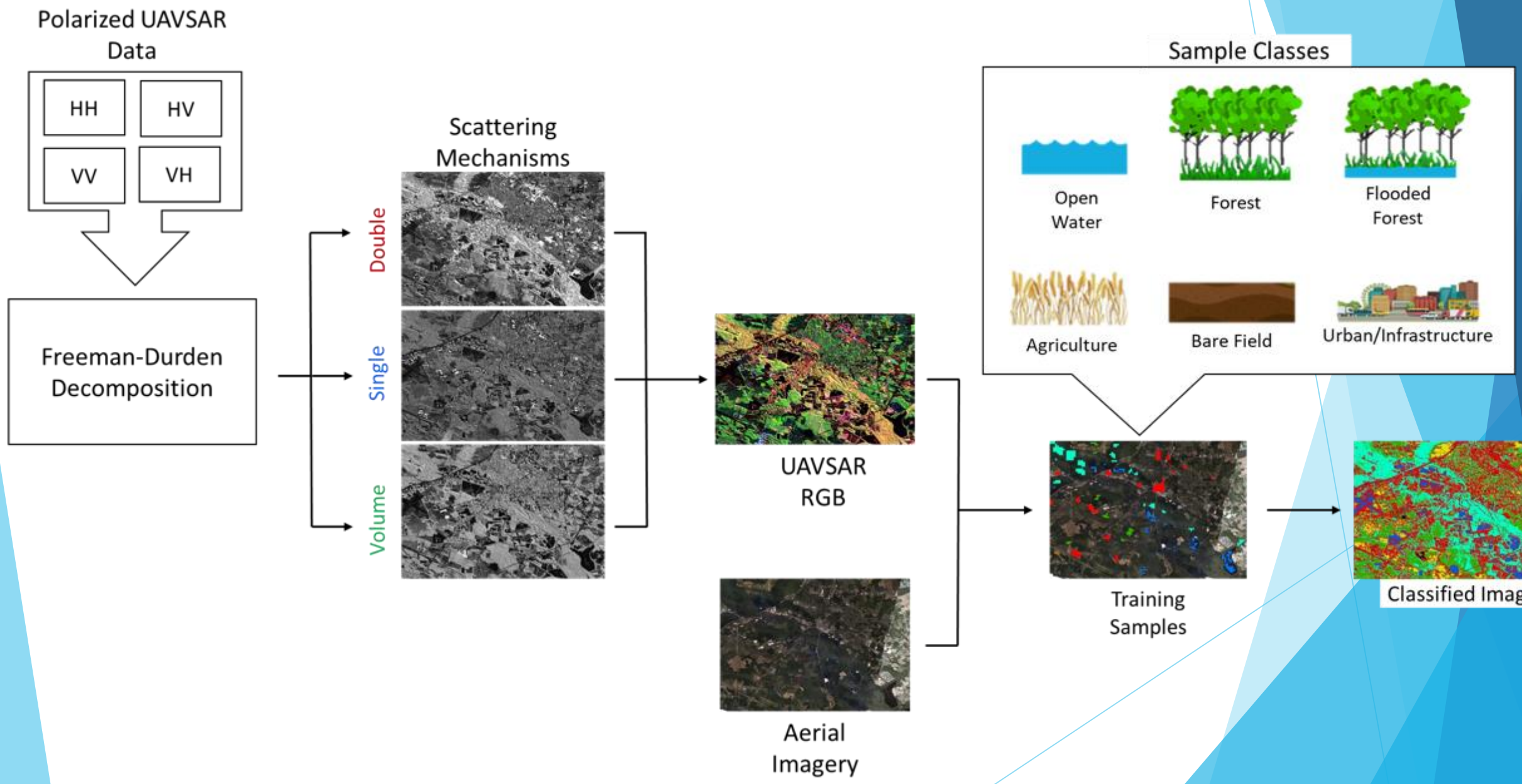
An area of inundated forest





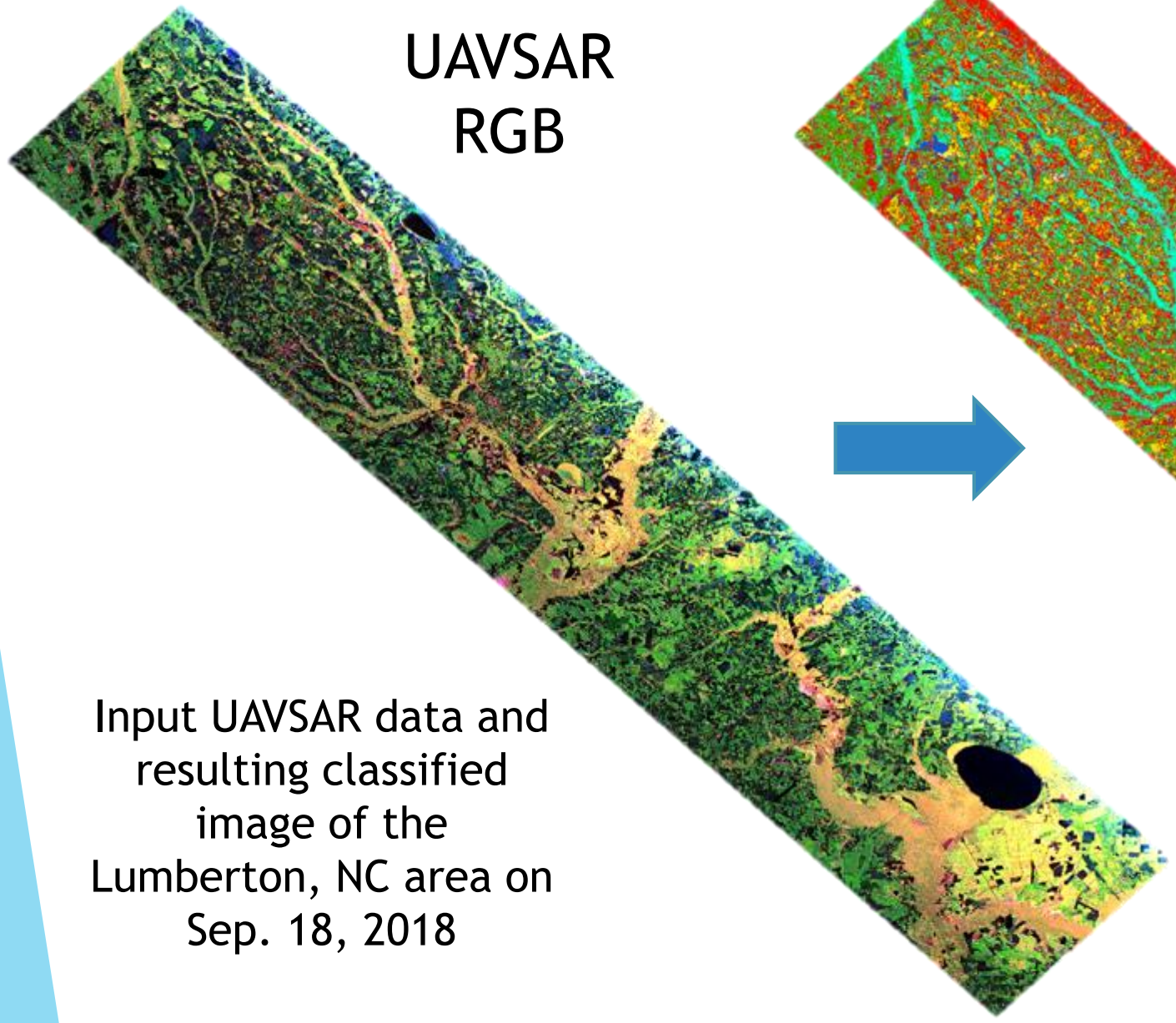
An area of dry forest

Methodology

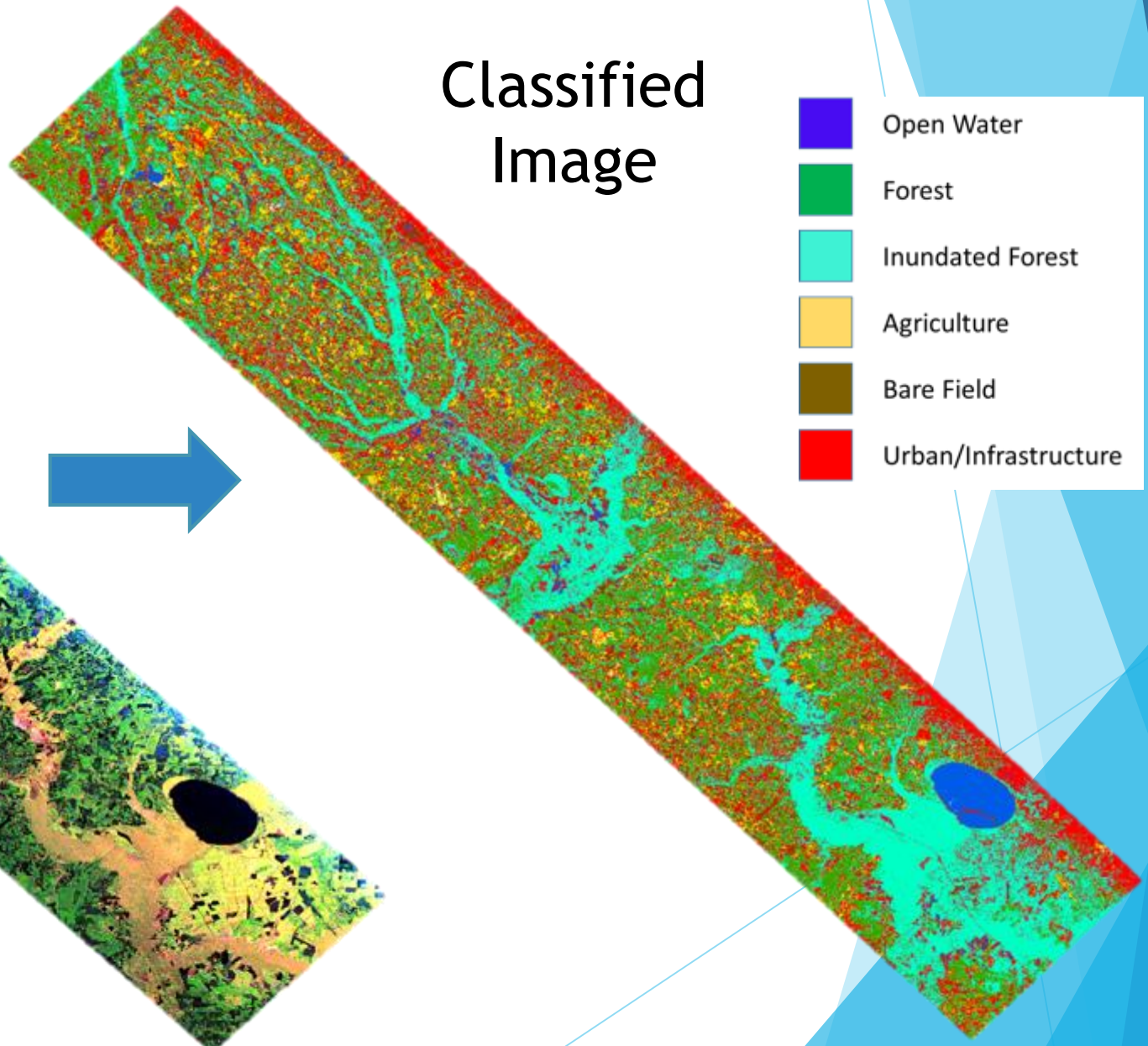


Data Input/Output Example

UAVSAR RGB



Classified Image



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

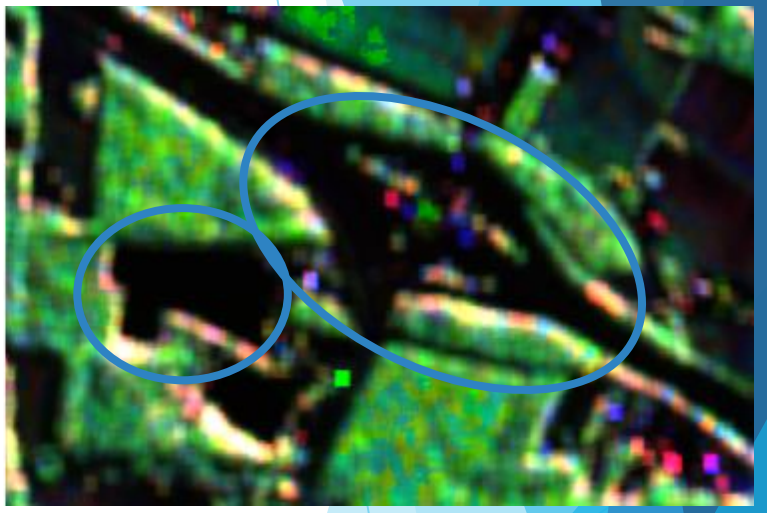
Overall Accuracy:
61.37%

Kappa Coefficient:
.536

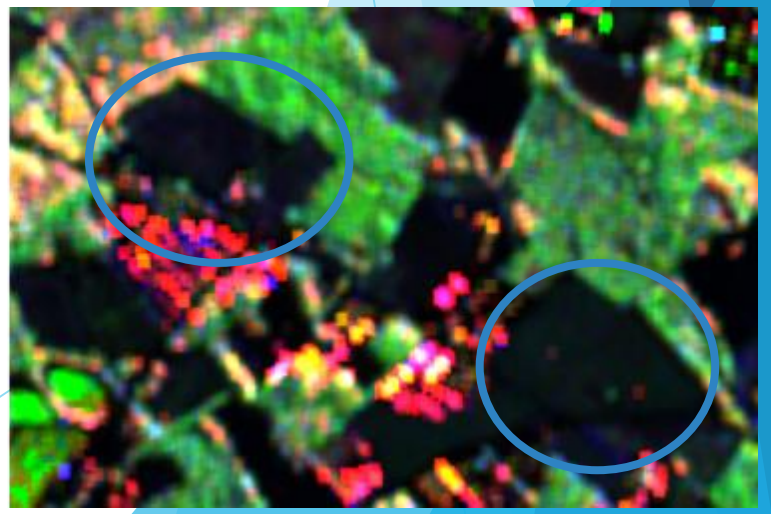
Limitations

- 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