Flood Mapping of Recent Major Hurricane Events with Synthetic Aperture Radar, Commercial Imaging, and Aerial Observations

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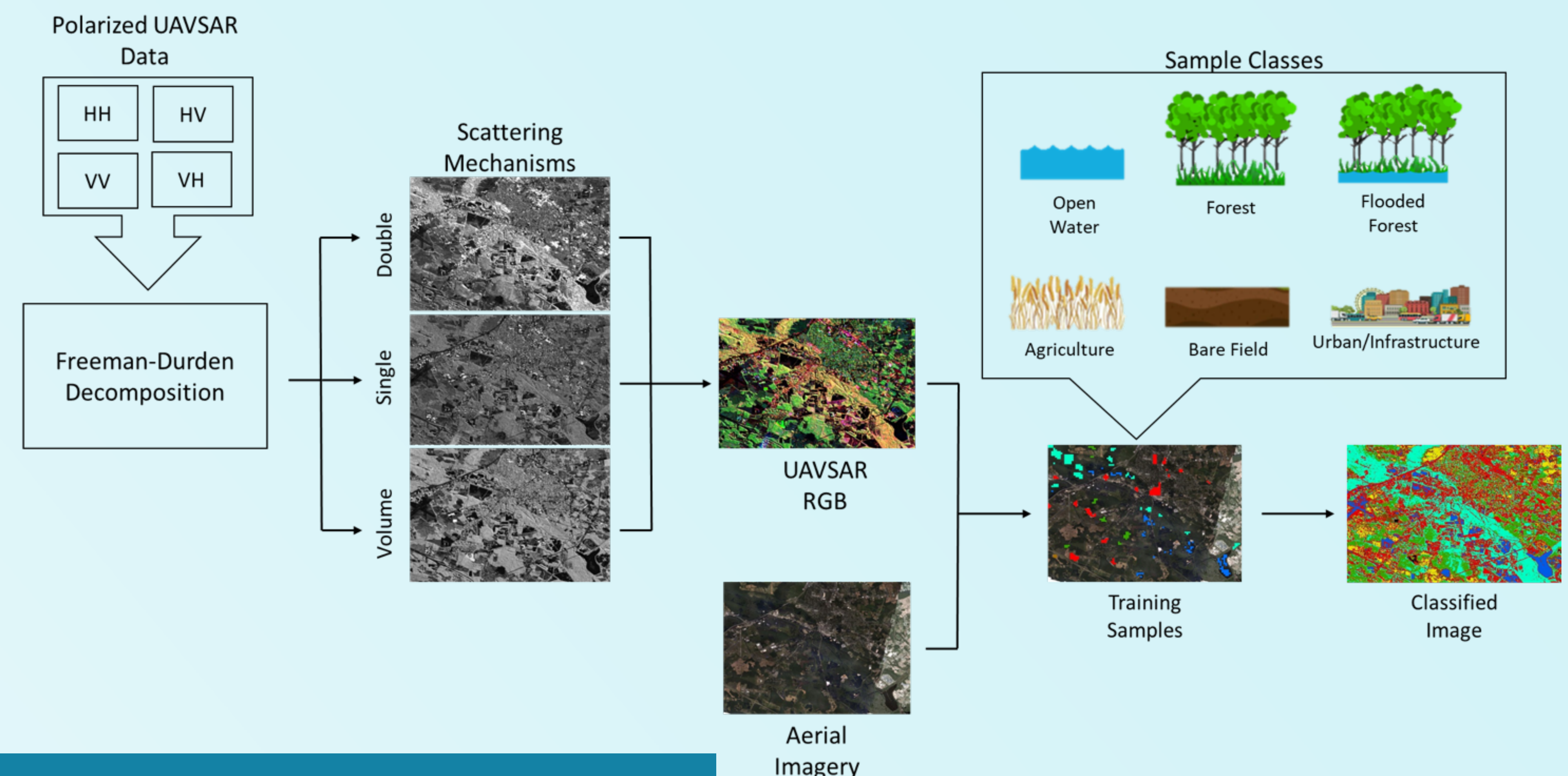
Introduction

Floodwater mapping is an important remote sensing process that is used for disaster response, recovery, and damage assessment practices. Developing a system to read in Synthetic Aperture Radar (SAR) data and perform land cover classification will allow for the production of near real-time inundation mapping, enabling government and emergency response entities to get a preliminary idea of the situation.

SAR is a unique remote sensing tool. Data in this project was obtained by NASA Jet Propulsion Laboratory's Uninhabited Aerial Vehicle SAR (UAVSAR), an L-band radar mounted to a Gulfstream III jet. Data collected by UAVSAR is similar to what will be available from the NASA-Indian Space Research Organization (NISAR) mission starting in early 2022.

Using Python and ArcGIS applications, a model was developed using training samples taken from NOAA post-event aerial photography and UAVSAR data gathered in the aftermath of Hurricane Florence in September 2018.

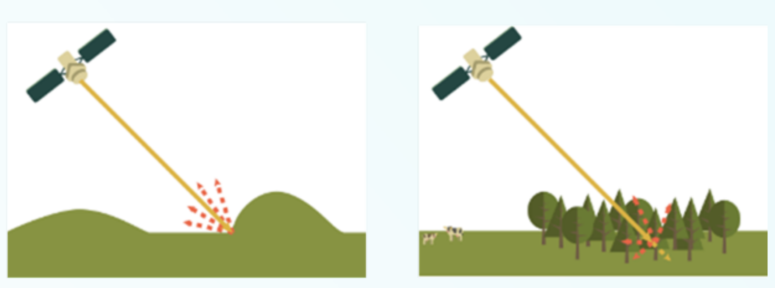
Methodology



Legend

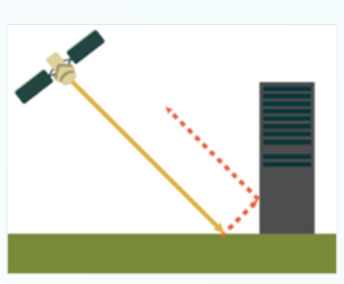
Scattering Mechanisms

Image source: NASA's Applied Remote Sensing Training Program



Surface/Single

Volume



Double

Figure 1: The Freeman-Durden Decomposition allows us to display the reflectivity (backscatter) values associated with scattering mechanisms

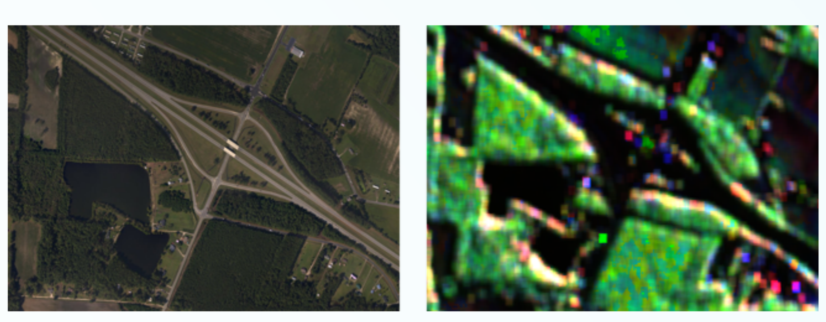


Figure 2: A comparison between NOAA aerial imagery and UAVSAR RGB showing the similar backscatter signatures of open water and roads.

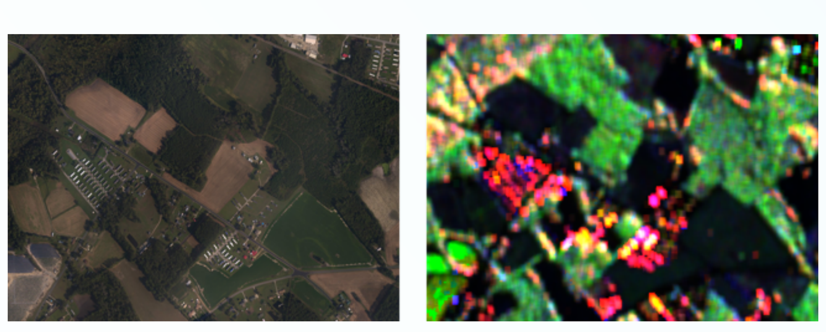


Figure 3: A comparison between NOAA aerial imagery and UAVSAR RGB showing similar backscatter signatures of bare and agricultural fields.

Lumberton, North Carolina – Hurricane Florence

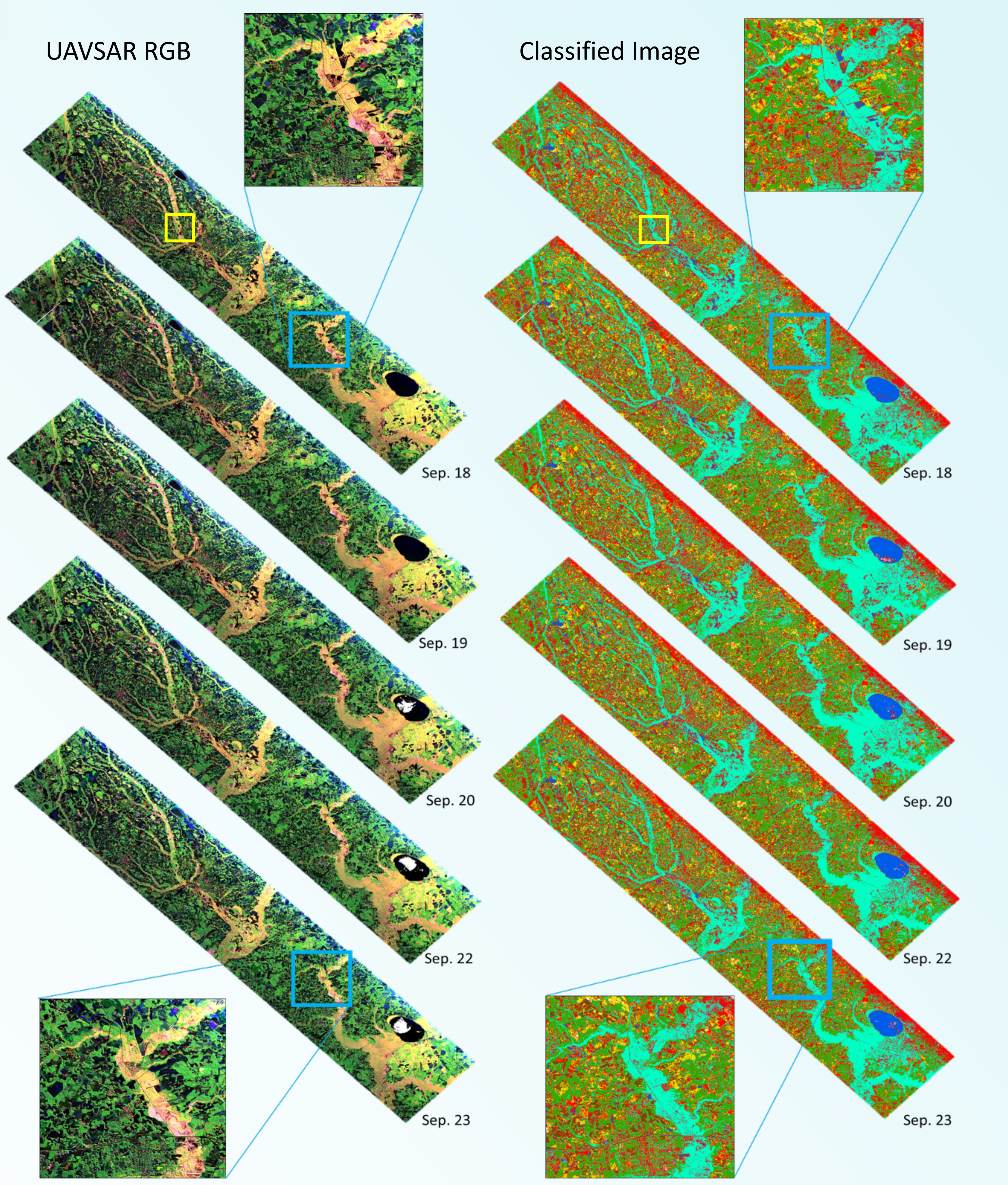


Figure 4: A time series comparison between UAVSAR RGB imagery (left) and the classified image created by the model (right). Blue boxed portions show a noticeable decrease in inundation extent from the beginning to end of the time period.

Results

	Overall Accuracy	61.4%
(blue)	Open Water	35.9%
(green)	Forest	75.0%
(aqua)	Inundated Forest	81.8%
(yellow)	Agriculture	59.8%
(brown)	Bare Field	49.5%
(red)	Urban/Infrastructure	64.8%

*Individual class values are calculated user accuracy values

Class Probabilities

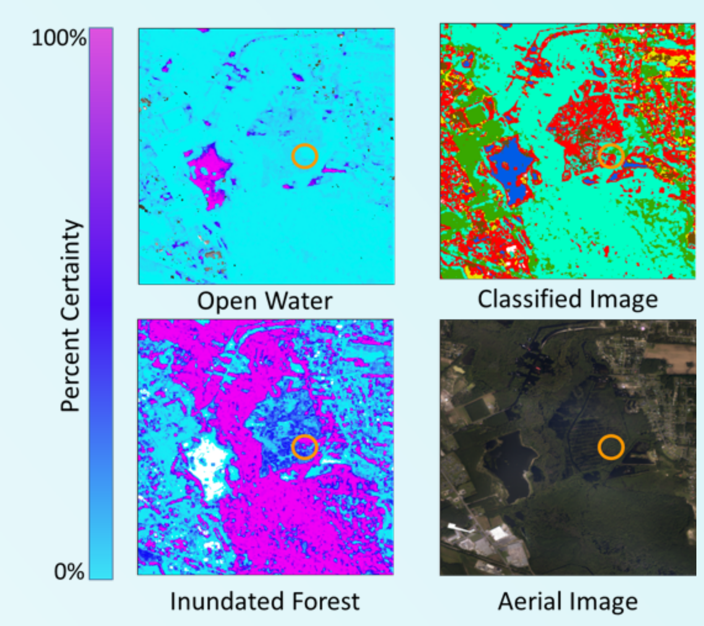


Figure 5: A closer look at the yellow boxed portions from Fig. 4 showing a comparison between class probabilities and the aerial image from Sep. 18.

Class	Percent Certainty
Open Water	3.8%
Forest	0.3%
Inundated Forest	42.6%
Agriculture	5.2%
Bare Field	5.0%
Urban/Infrastructure	43.1%
Classification	Urban/Infrastructure

Figure 6: Table of class certainties for area within orange circle of Fig. 5.

Users may find that probabilities are more useful than deterministic classes for decision making.

For example, the orange circled area in Fig. 5 is classified as "urban" despite being surrounded by water and inundated forest. A user may be able to infer that this area is likely inundated as well. Fig. 6 shows that there was only a 0.5% difference between the pixel being classified as "urban" or "inundated forest" – something that can be discounted for the sake of continuity.

Conclusions

- Floodwaters extending below the forest canopy have high backscatter values in the double component, making them easily discernable in L-band imagery
- The model's rapid classification of the swath offers a reasonable depiction of floodwater extent in a short runtime, making it useful for near-real time applications
- Similarities in backscatter signatures for different classes leads to model "confusion," as in the misclassification of roads as open water and similar issues
  - Swath data should be constrained by radar incidence angle in order to reduce noise and retain highest quality data

Future Work

- Overall and individual class accuracy may be improved with a merging of the Agriculture and Bare Fields classes, which often get confused for each other
  - Must look closely at what classes are best characterized by radar (i.e. a unique backscatter signature) as well as complementary information to improve final mapping
- Assessment and improvement of reference data points, which are misaligned due to a discontinuity in spatial resolution between NOAA aerial imagery and UAVSAR data
- Collaboration with partners to estimate depth of floodwaters

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