Multi-Scale Ground Filtering of Dense Lidar Point Clouds for Modeling Shrub Mangrove Canopies in Coastal Environments

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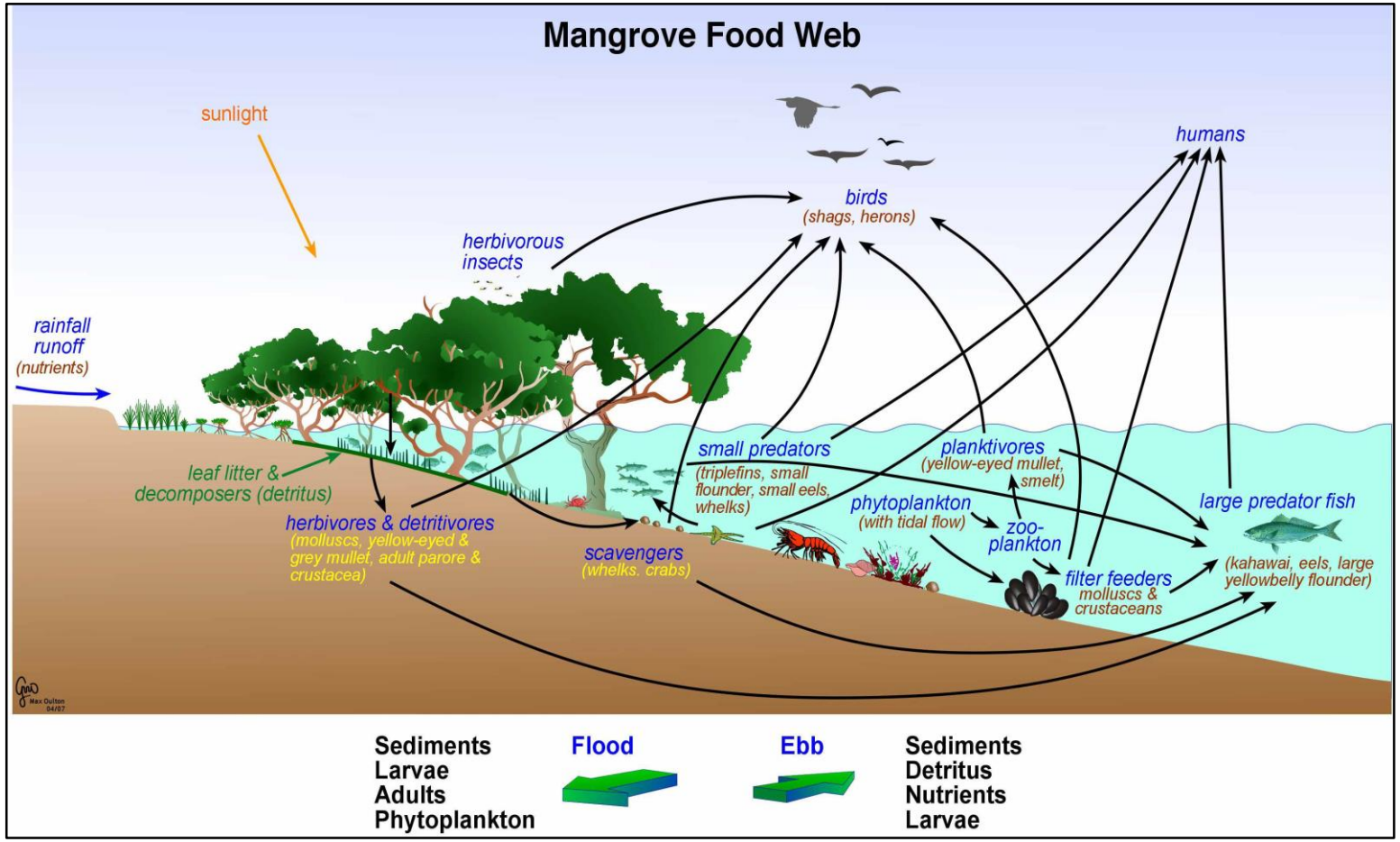
Presentation Outline

- Why Mangroves Are Important
- Research Issues
- Project Goals
- Study Area & Data
- Methodology & Workflow
- Results & Deliverables
- Q & A

Why Mangroves?



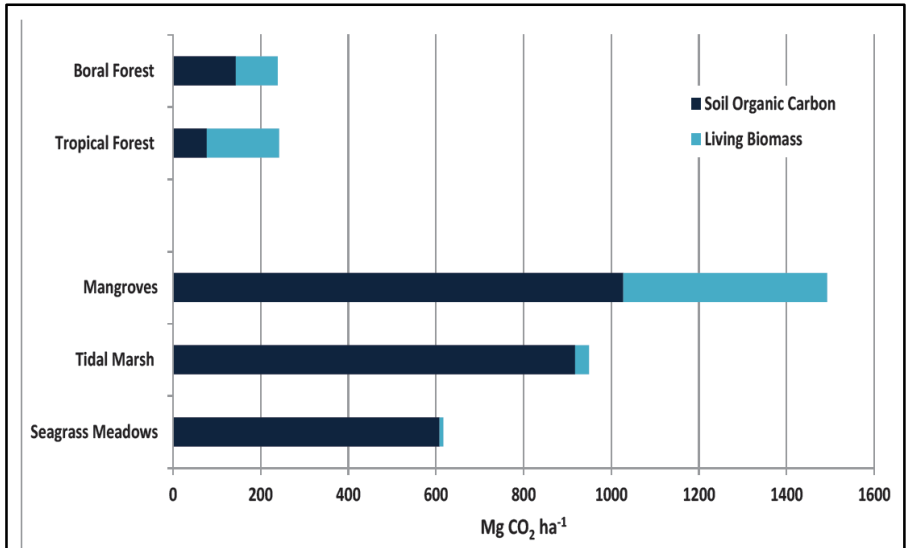
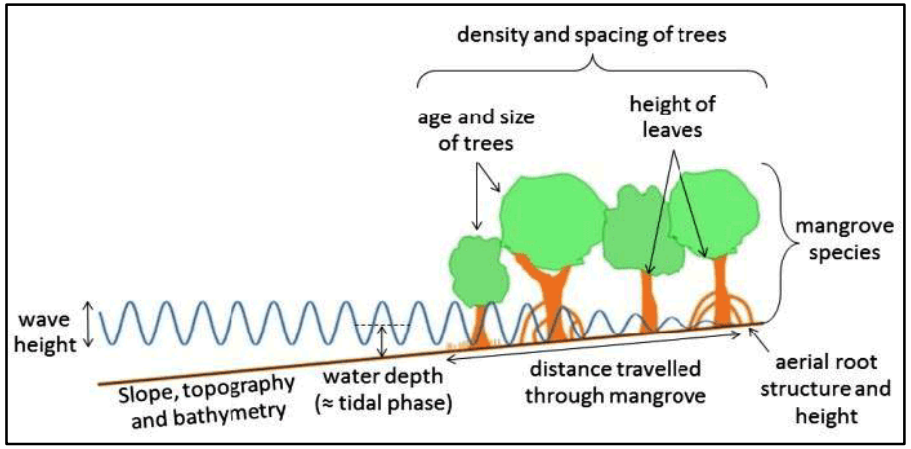
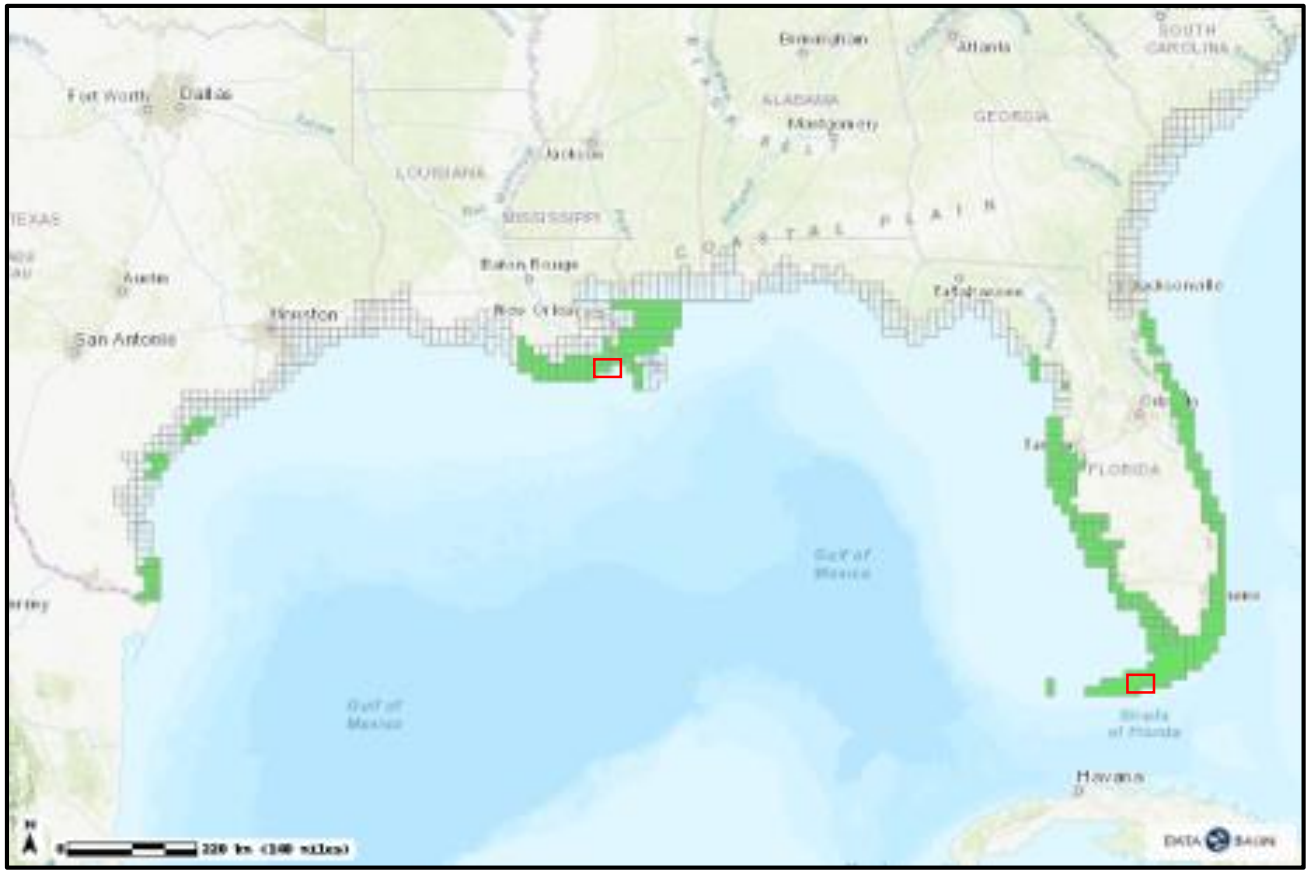


Figure 2. Mean carbon storage above and belowground in coastal ecosystems versus terrestrial forest (Fourqurean et al. 2012; Pan et al. 2011; Pendleton et al. 2012).



Shrub Mangrove Locations in the US

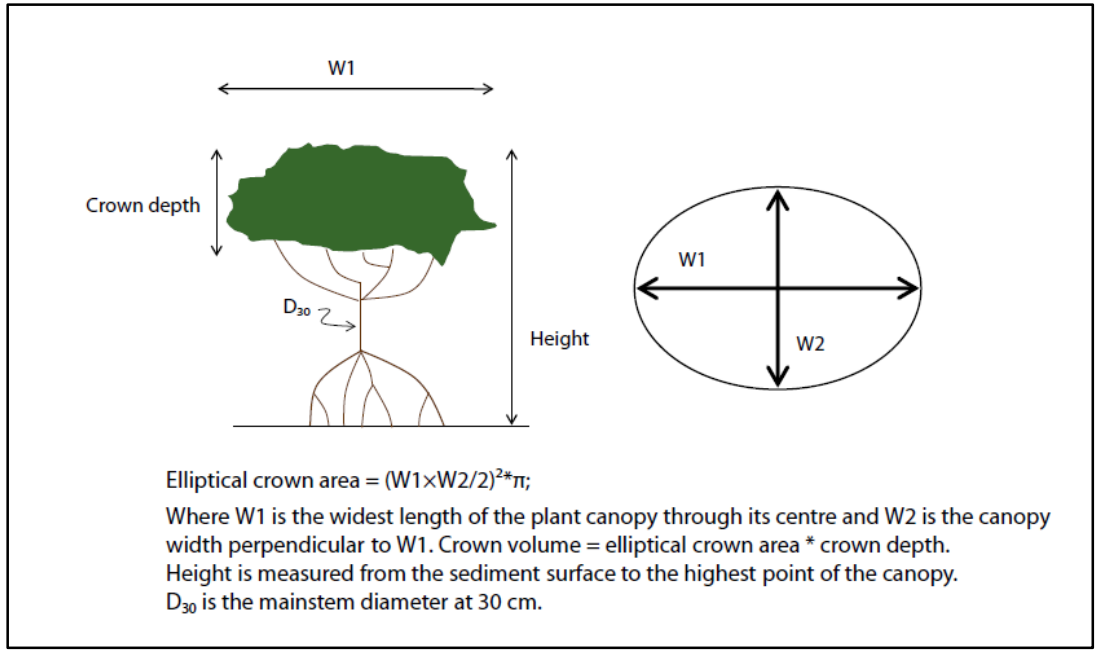
Locations of Shrub Mangroves in Southeastern US



Map Source: https://databasin.org/maps/new#datasets=6ec804f5250a483abd9bdb200939247f
Data for map derived from "Increase in Black Mangrove Abundance in Coastal Louisiana," Michot, et. al (2010)
https://www.researchgate.net/publication/319573839_Increase_in_black_mangrove_abundance_in_coastal_Louisiana

Research Issues

Carbon Stock Monitoring for Coastal Mangroves

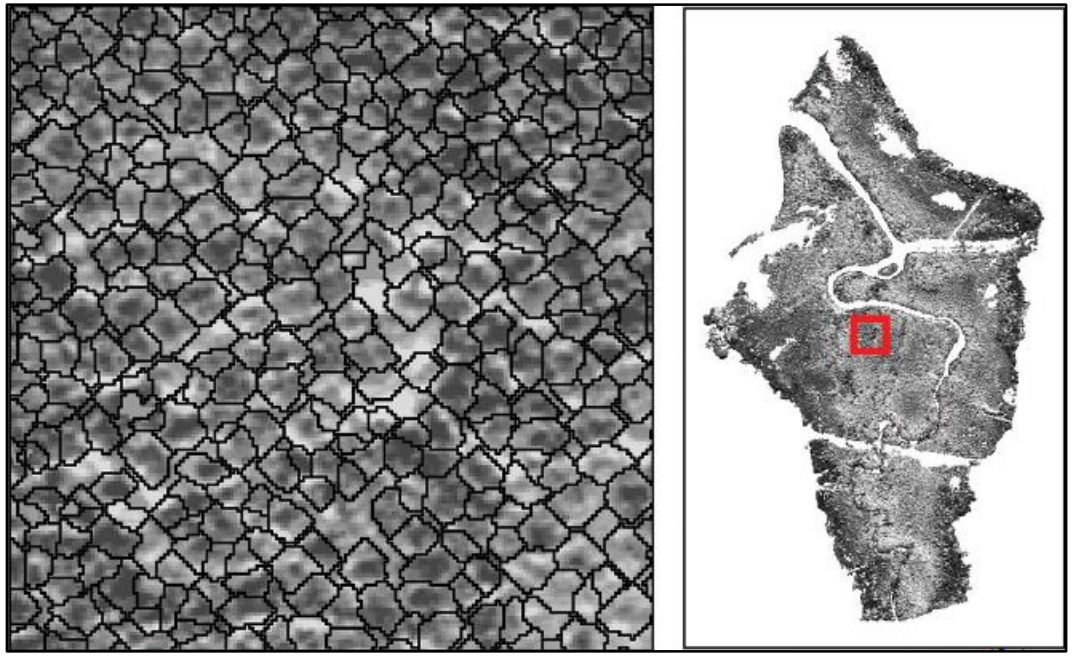


Elliptical crown area = $(W1 \times W2/2)^2 * \pi$;

Where W1 is the widest length of the plant canopy through its centre and W2 is the canopy width perpendicular to W1. Crown volume = elliptical crown area * crown depth.
Height is measured from the sediment surface to the highest point of the canopy.
D_{30} is the mainstem diameter at 30 cm.

Allometric measurements commonly used by Biologists & Ecologists studying shrub mangroves in the wetlands. (Image Source: CIFOR)

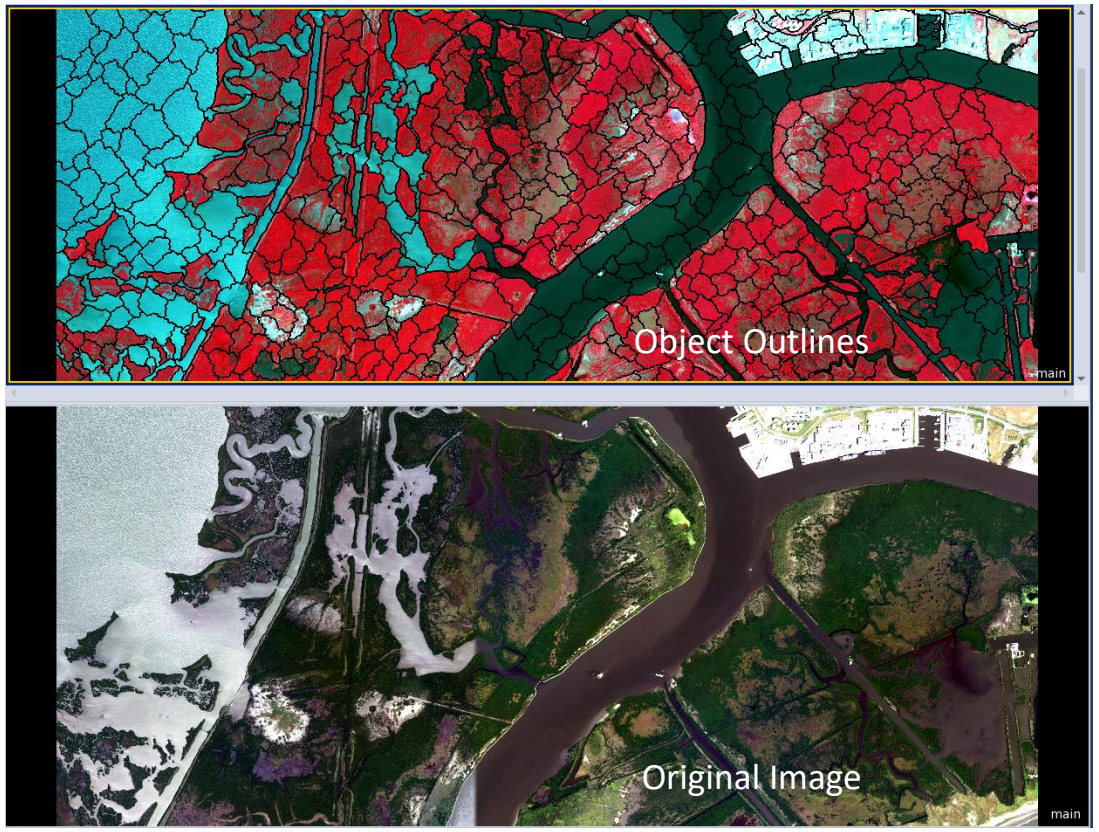
Allometric Measurements Collected at Large Scale



Automated feature extraction methods can potentially allow researchers to collect allometric data remotely at large scale for regional analyses of mangrove stocks. (Image Source: Heenkenda, et al., PE&RS, 2015)

Object-Based Image Classification

Object-Level Image Segmentation



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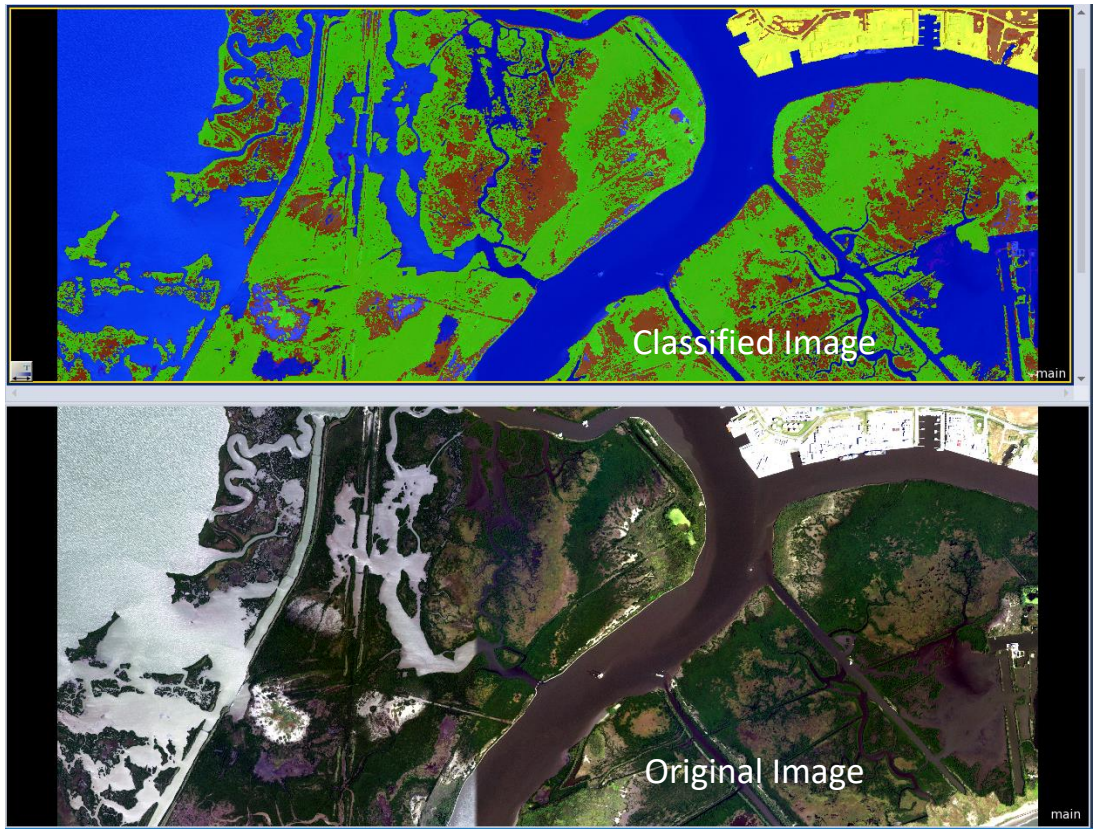
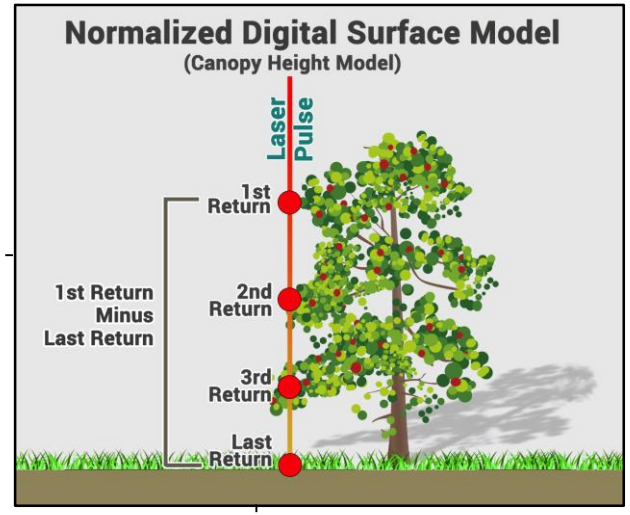
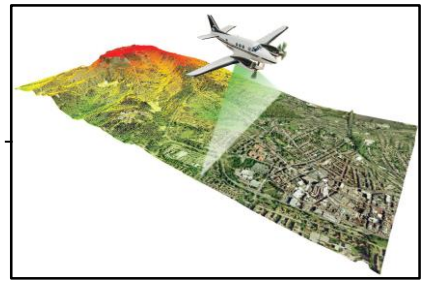


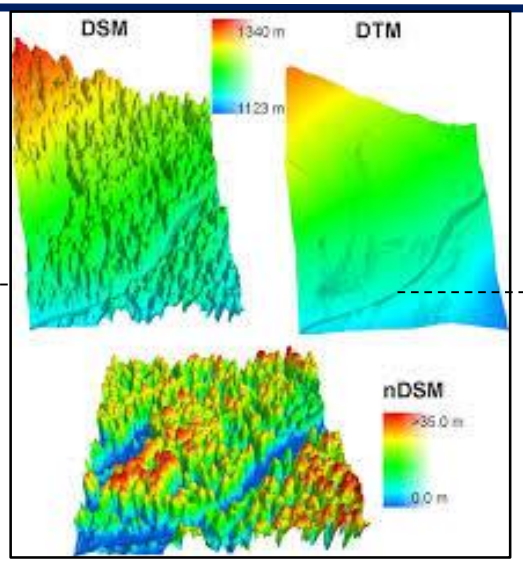
Canopy Height Models

Lidar point cloud over vegetated area collected



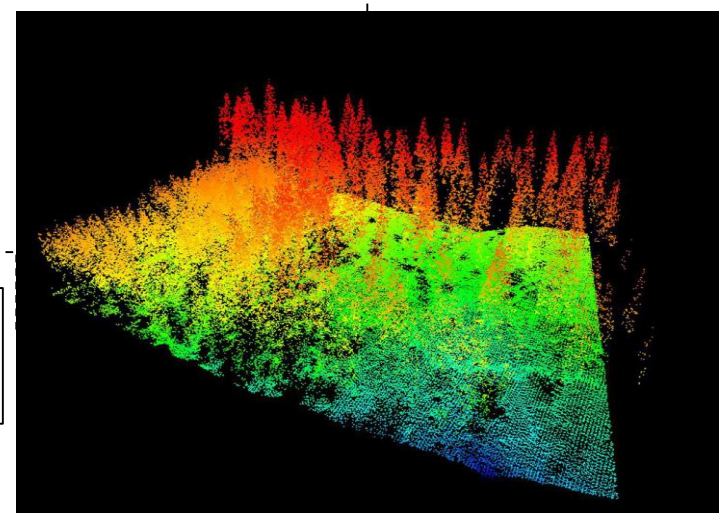


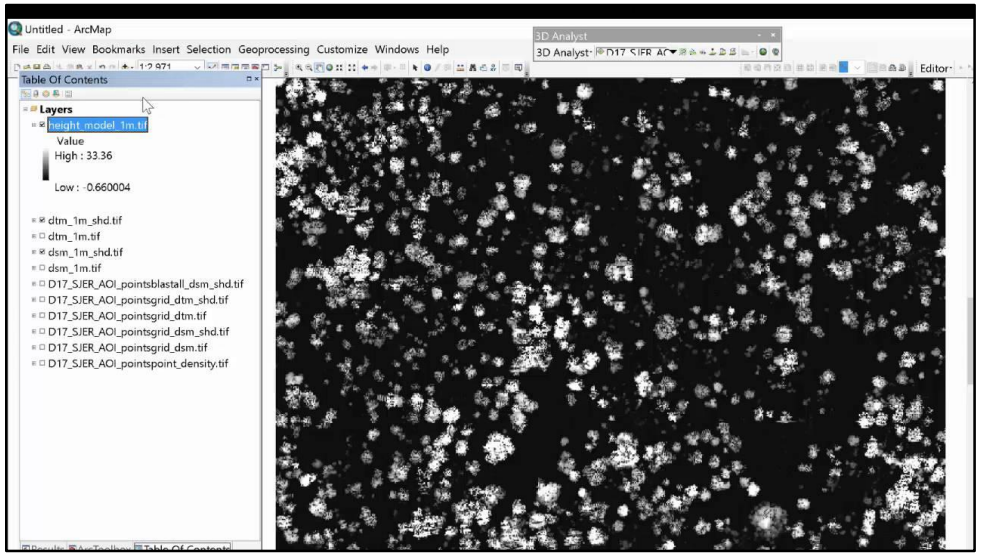
Digital Surface Model (DSM) and Digital Terrain Model (DTM) created



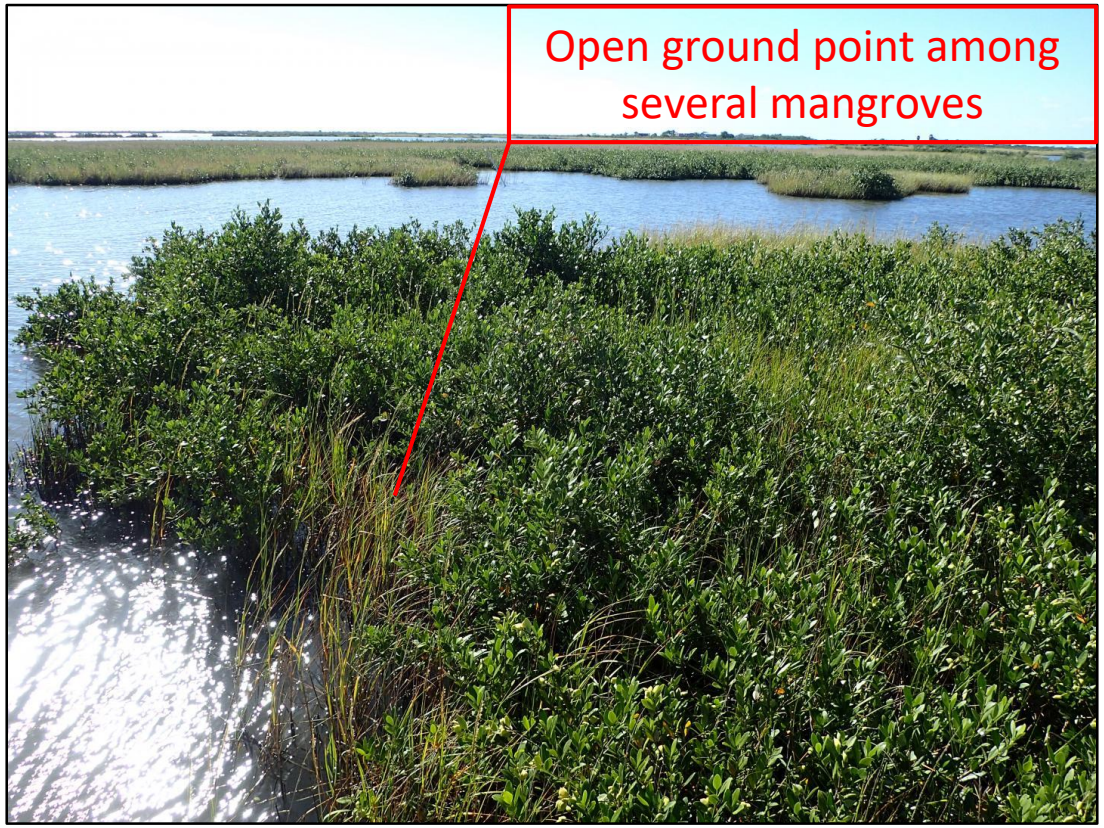
DTM subtracted from DSM to create a Canopy Height Model (CHM)

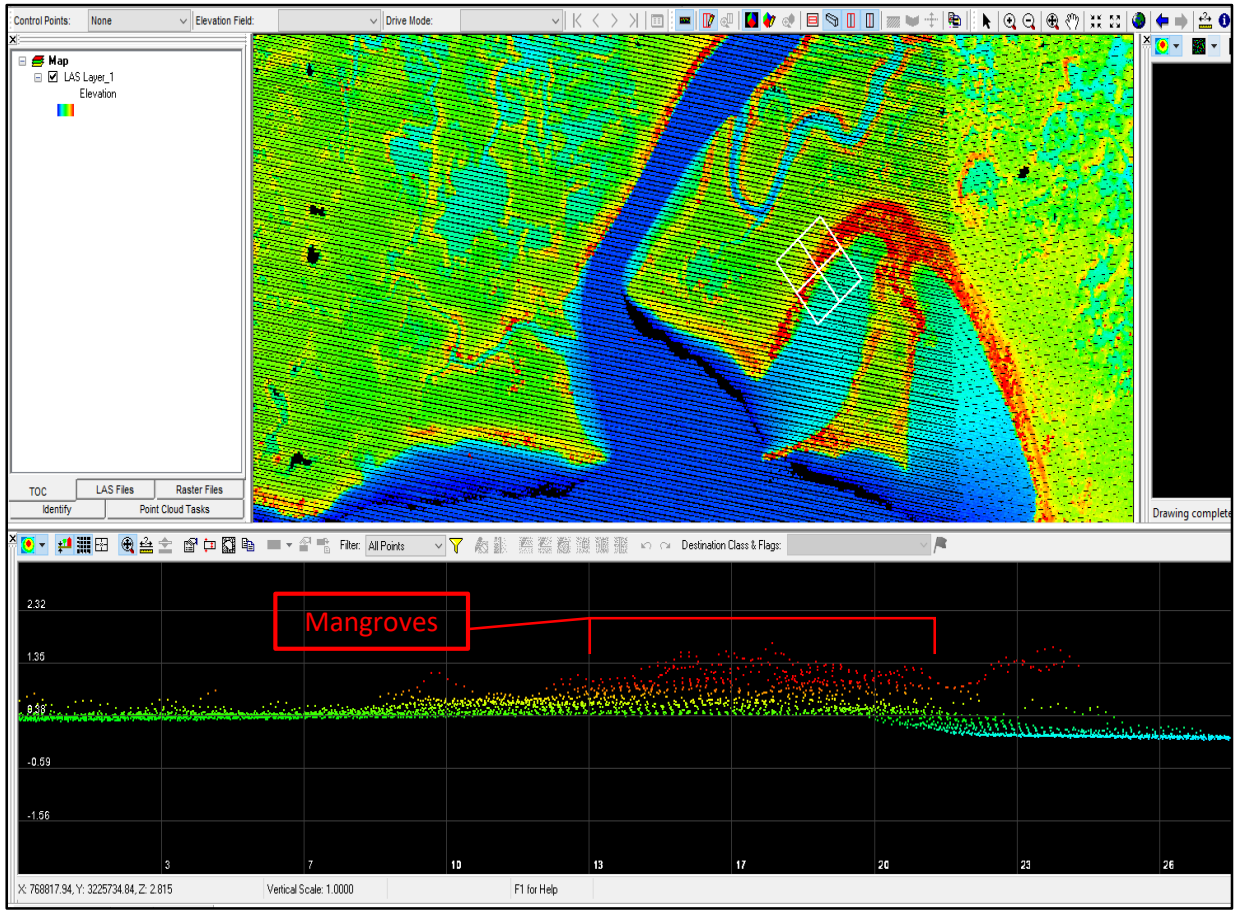
Lidar point cloud processed and classified





Vertical Return Structure Issues





Goals of the Project

- Goals of the Project:
  - Develop an accurate method for extracting mangrove features over coastal wetlands using Object-Based Imagery Analysis (OBIA) in eCognition Developer.
  - Develop an accurate method for creating Canopy Height Models (CHM) of shrub mangroves using feature extraction tools and lidar data in LP360.
  - Determine the degree of influence that scale plays in OBIA image classification and point cloud classification of shrub mangroves.
  - Determine if these methods could be used to improve the study of global carbon budget estimates for coastal environments.

Study Area

Coastal Louisiana

Image Source: Google Earth

Port Fourchon AOI

Image Source: USDA NAIP

Data Sources

NAIP Imagery	
Collection Date:	20150430
Sensor:	Leica ADS100
Platform:	Cessna Conquest / Cessna 414
Altitude:	16,000ft AGL
Ground Sample Distance (GSD):	1-meter
Spatial Reference System:	NAD83 UTM Zone 15N
Bands:	4, R/G/B + NIR
Bit Depth:	8-bit, 0-255
Data Format:	JPEG 2000

Lidar Point Cloud	
Collection Date:	20150213
Data Format:	LAS v1.2
Assigned Classes:	1, 2, 7, 9, 10, 17, 18
Nominal Point Spacing:	0.39 meters
Nominal Point Density:	6.36 pts / square meter
Spatial Reference System:	NAD83 UTM Zone 15N
Vertical Datum:	NAVD88 (Geoid 12B)
Sensor:	Leica ALS70-HP
Vertical Accuracy Class:	9.25cm (ASPRS ’14 Standard)

Software Packages & Tools

ArcGIS Desktop v10.6

- Reclassify Raster
- Raster to Polygon Conversion
- Raster Calculator
- Surface Volume

eCognition Developer v9.3

- Multi-Resolution Segmentation
- Image Object Classification
- Object Merge
- Region Grow
- Threshold Class Assignment
- Export Vector Layer

LP360 Advanced

- Point Cloud Task (PCT) Macro
- Classify by Feature PCT
- 2D/3D Breakline Tools
- Classify by Statistics PCT
- Conflation PCT
- Filtering PCTs
- Export Wizard (DSM/DEM Products)

Workflow Overview

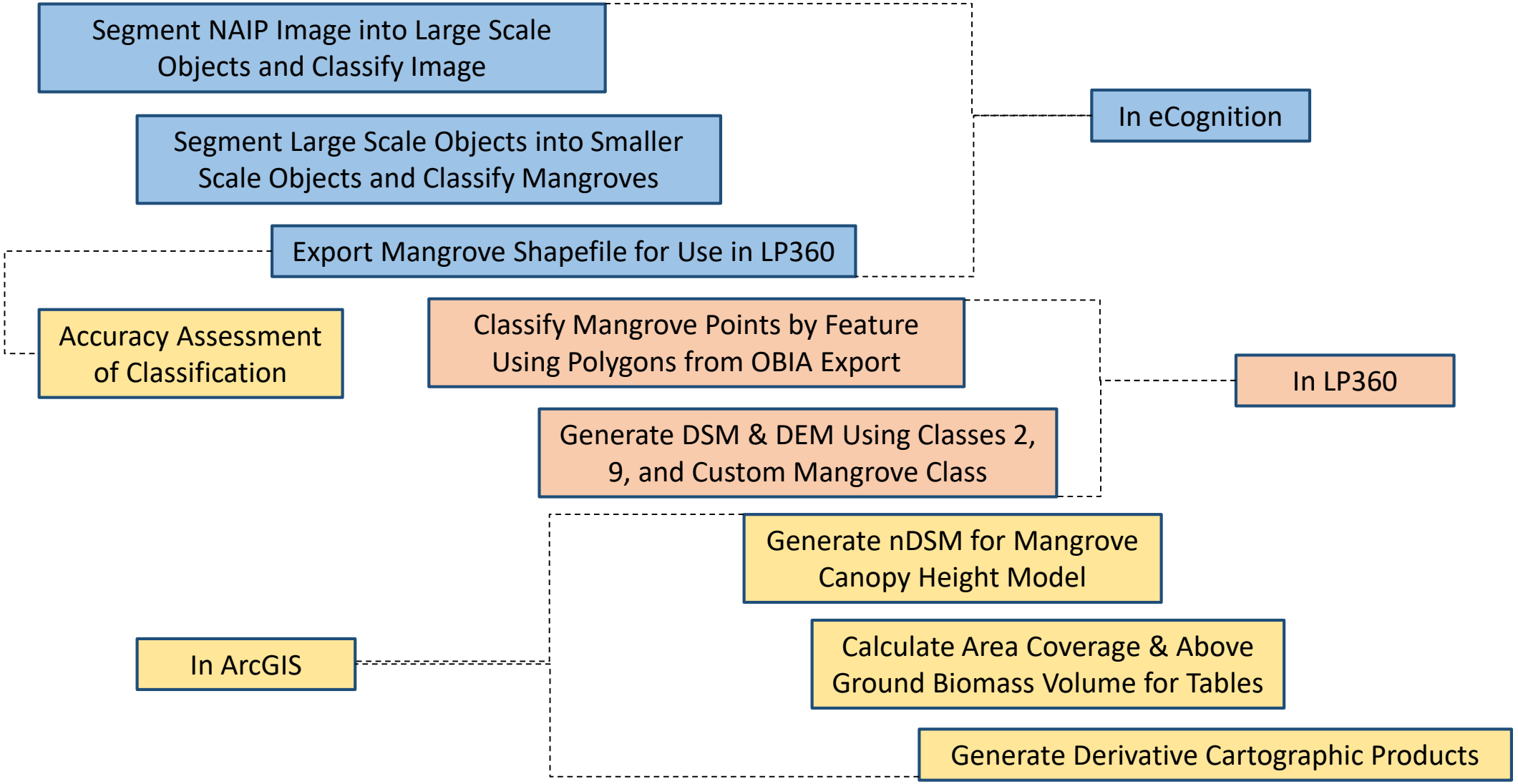
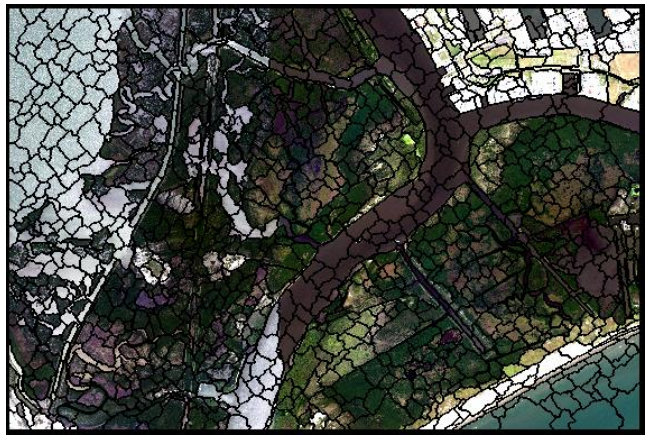


Image Classification Methodology

Multi-Resolution Segmentation (Initial Objects)



1

In eCognition | In ArcGIS

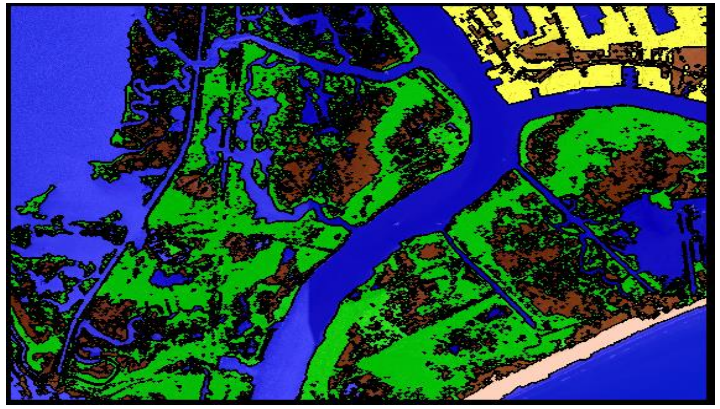
Classify Initial Objects

2

Multi-Resolution Segmentation (Wetland Objects)

3

Classify Second-Order Objects



4

Export Classified Polygons:
Final Merged Objects Exported as Polygon Shapefile

Import Polygons in ArcGIS

5

Classification Accuracy Assessment

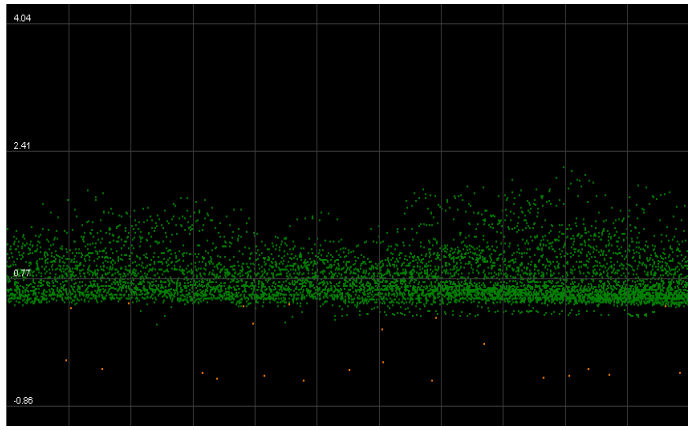
Preliminary Classification Accuracy

		Reference Class						
	Class Value	**Beach**	**Built**	**Earth/Grass**	**Mangrove**	**Water**	**Total**	**User's Accuracy**
Mapped Class	Beach	29	0	1	0	0	30	96.67%
	Built	0	39	1	0	0	40	97.50%
	Earth/Grass	0	0	51	2	7	60	85.00%
	Mangrove	0	0	2	57	1	60	**95.00%**
	Water	0	0	0	2	58	60	96.67%
	Total	29	39	55	61	66	250	**94.17%**
	Producer's Accuracy	100.00%	100.00%	92.73%	**93.44%**	87.88%	**94.81%**	**Overall Accuracy**
								93.60%

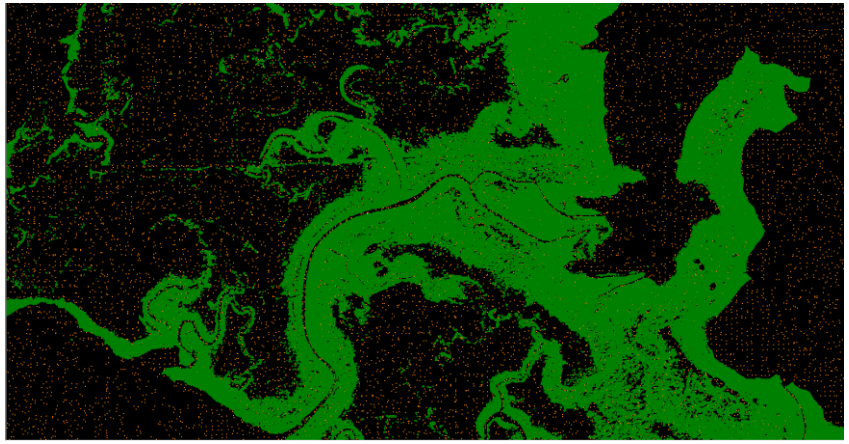
Canopy Extraction Methodology

LP360 | In ArcGIS

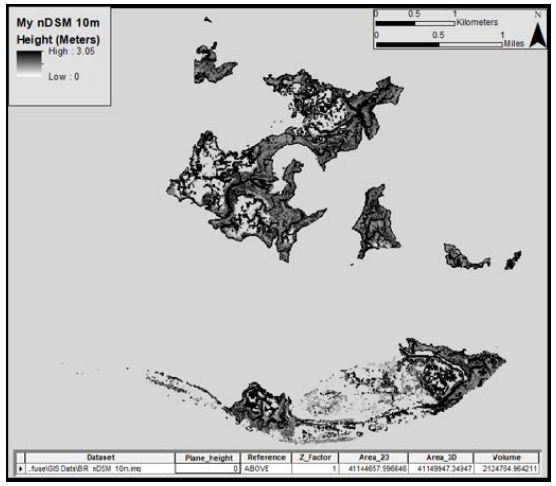
Classify Ground Seed Points 1



Classify By Feature



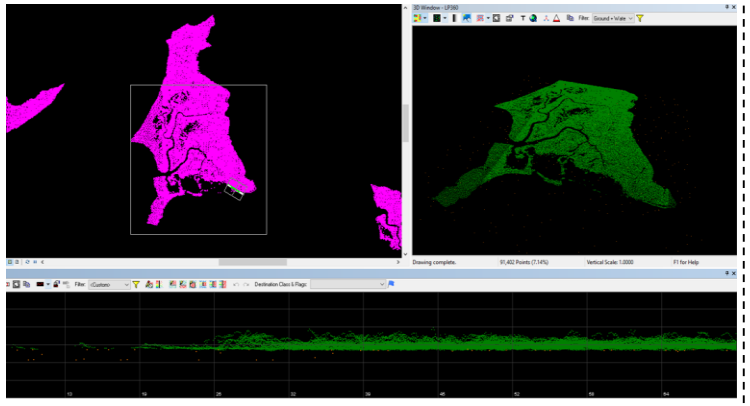
Generate Canopy Height Model 5



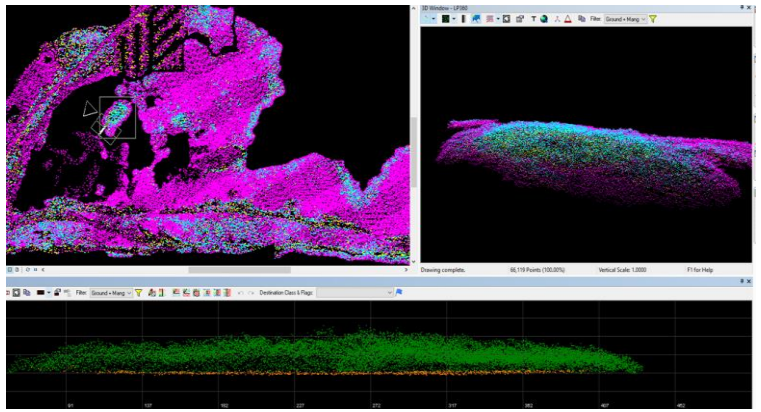
Export Elevation Models
Export DEM & DSM in .img format

Import to ArcGIS

Generate DSM 2



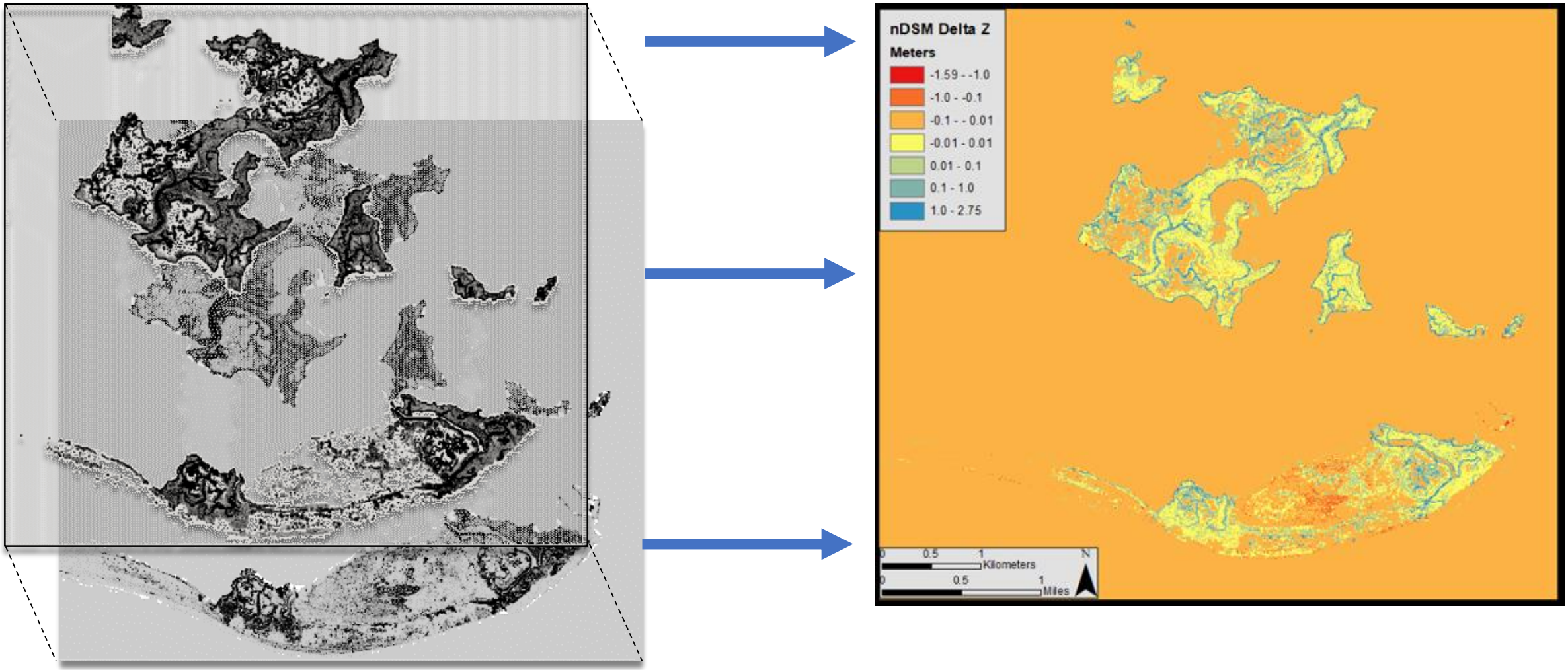
Generate DEM 4



3

Canopy Height Model Comparison

Surface Volume Differencing Operation in ArcGIS



Results & Deliverables

Develop an accurate method for extracting mangrove features over coastal wetlands using ground filtering of dense point clouds and OBIA.

- *Expectation: The methods developed will successfully extract mangroves.*

Define the degree of influence that scale plays in generating an accurate CHM.

- *Expectation: Unknown*

Define the degree of influence that scale plays in generating an accurate CHM.

- *Expectation: Unknown*

Determine if these methods could be used to improve the study of global carbon budget estimates for coastal environments.

- *Expectation: In theory, these methods should indeed improve the study of global carbon budget estimates for coastal environments.*

Questions?

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OBIA & Mangrove Forests

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Above-Ground Biomass Estimation

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