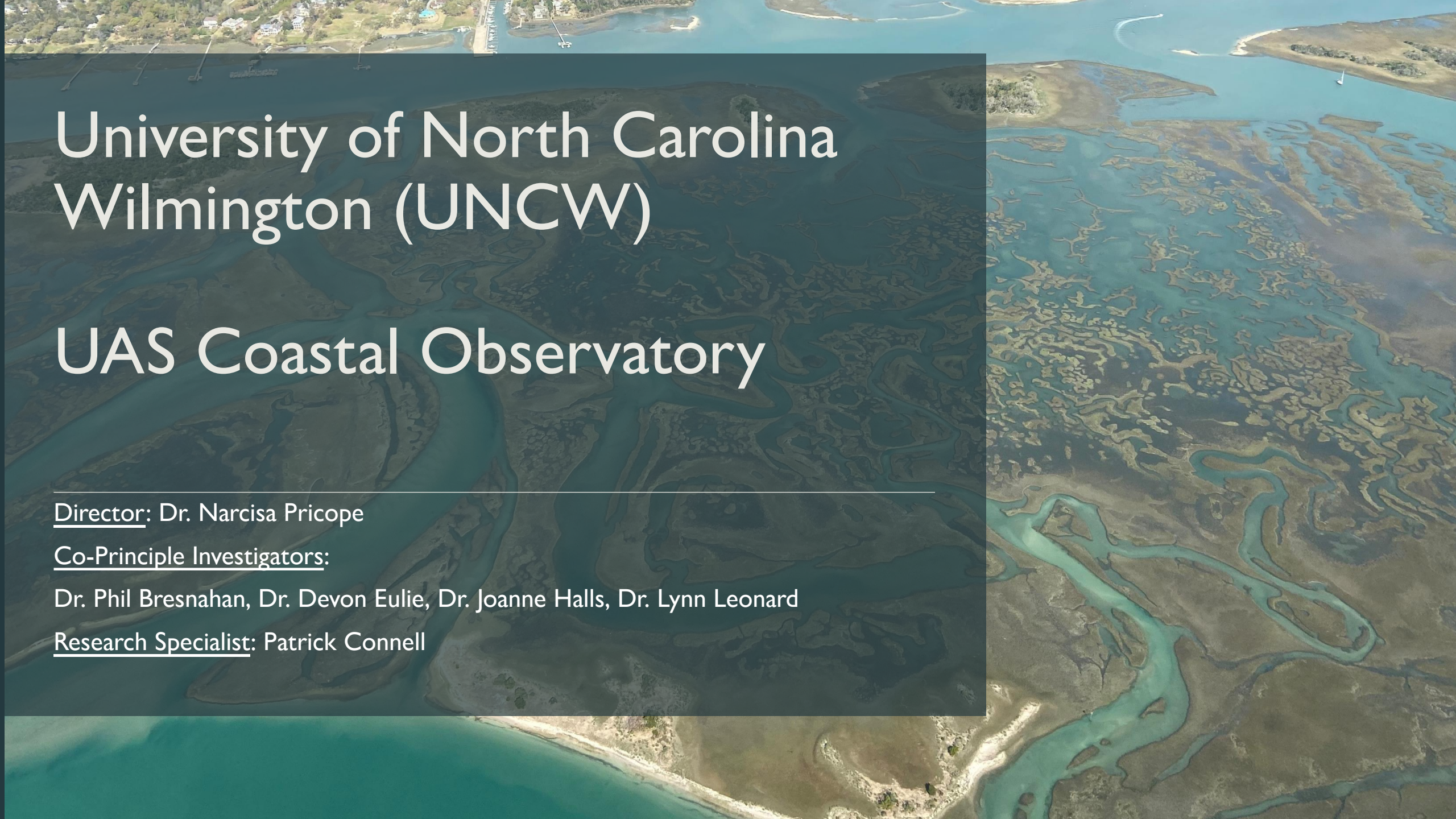


University of North Carolina Wilmington (UNCW)

UAS Coastal Observatory

Director: Dr. Narcisa Pricope

Co-Principle Investigators:

Dr. Phil Bresnahan, Dr. Devon Eulie, Dr. Joanne Halls, Dr. Lynn Leonard

Research Specialist: Patrick Connell

About Us

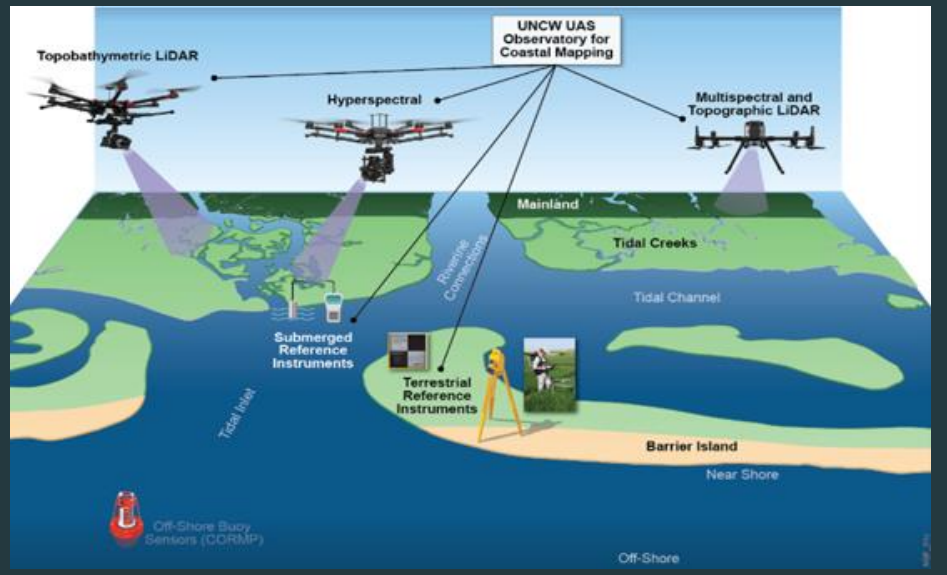
Headquartered at UNCW Center for Marine Science (CMS)

Lab contains on-demand integrative UAS platforms with hyperspectral and LiDAR sensors enabling us to quantify, map, monitor and model complex coastal ecosystems and socio-environmental dynamics.

Making contributions to nationwide efforts to establish baseline ecological conditions in coastal communities.

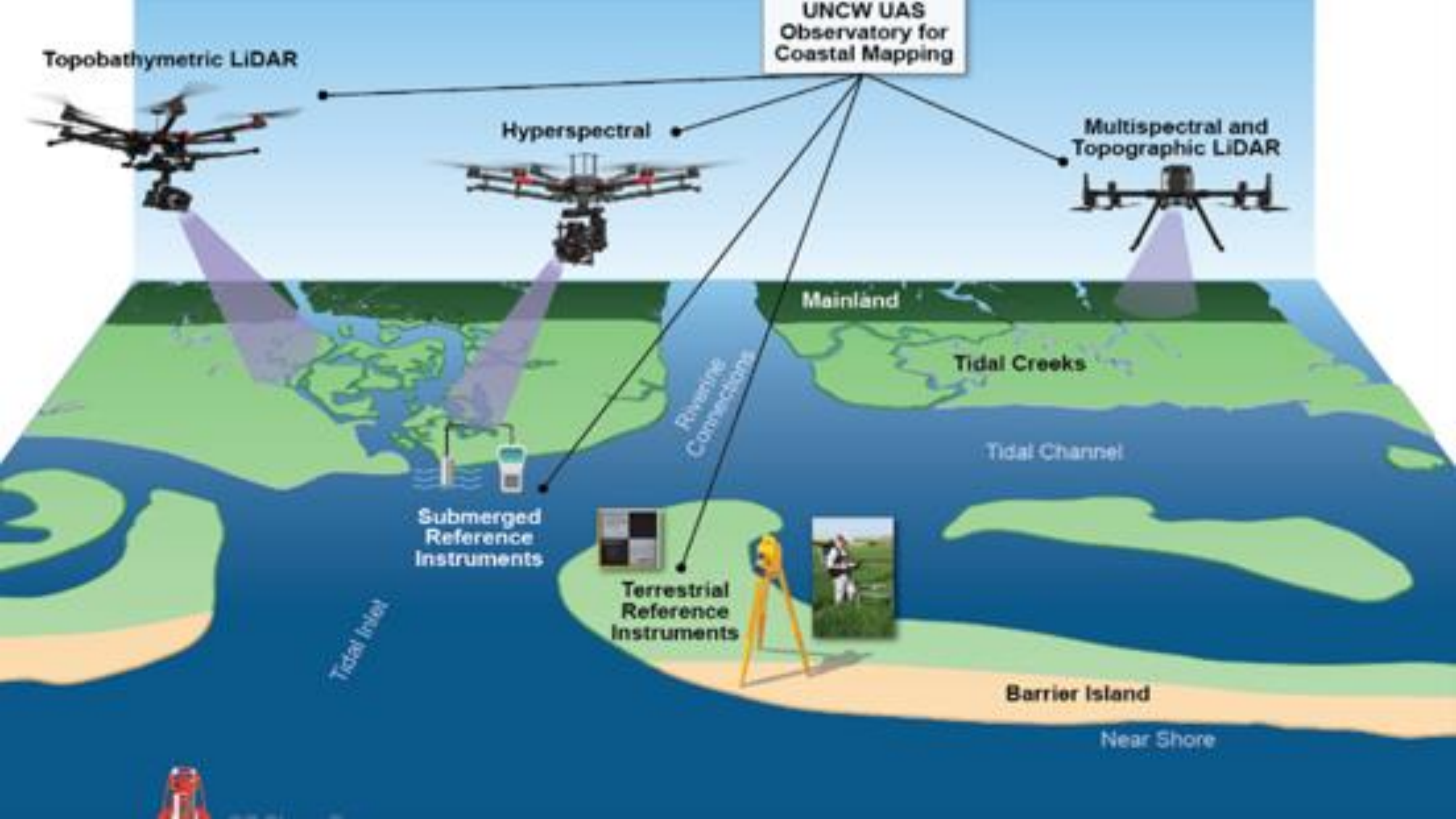
Equipment

- → Malvern Panalytical Spectroradiometer
- → YSI EXO2
- → DJI Matrice 300 RTK
  - → MicaSense Dual RedEdge MX- Multispectral Sensor
  - → YellowScan LiDAR Mapper
- → FreeFly Alta X
  - → LiteWave Edge Topo-bathy LiDAR System
  - → ITRES microCASI-1920 Hyperspectral Mapping System



DJI Matrice 300 RTK- UAS

- 55-Minute Max Flight Time
- Max Payload Capacity- 5.8 lb.
- Skyport system
  - → MicaSense RedEdge-MX Multispectral Sensor
  - → YellowScan LiDAR Mapper


UNCW UAS Observatory for Coastal Mapping
Topobathymetric LiDAR
Hyperspectral
Multispectral and Topographic LiDAR
Mainland
Tidal Creeks
Riverine Connections
Tidal Channel
Submerged Reference Instruments
Terrestrial Reference Instruments
Tidal Inlet
Barrier Island
Near Shore

Micasense RedEdge-MX Dual Camera

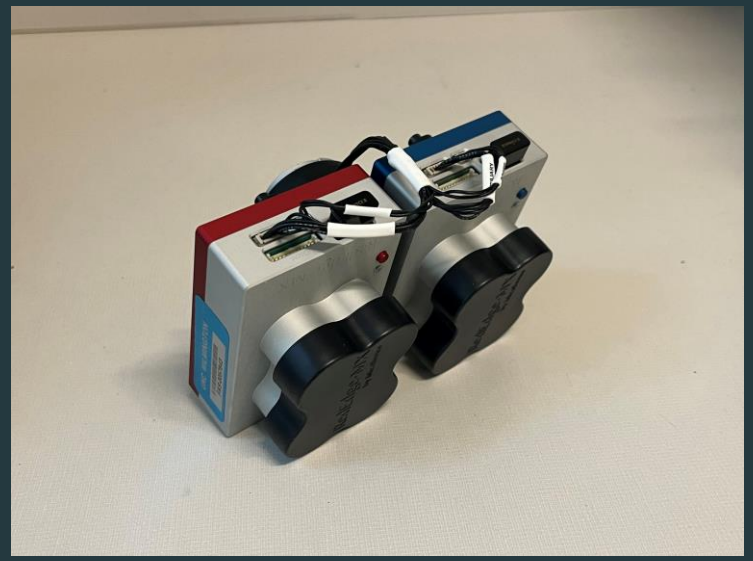
DJI Matrice 300 RTK Skyport Compatible

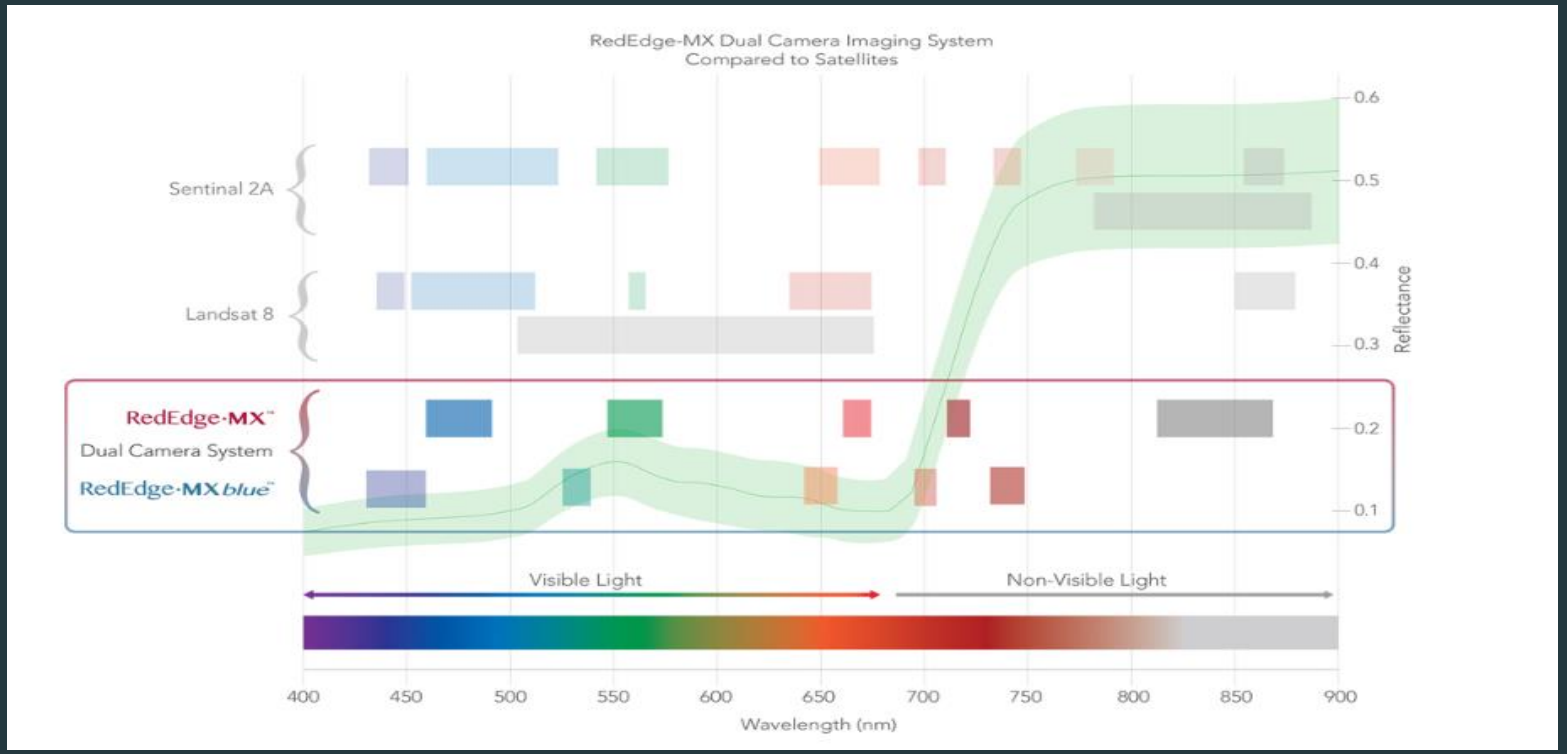
Two 5 Band Cameras (10 Bands Total)

- RedEdge-MX
- RedEdge-MX blue

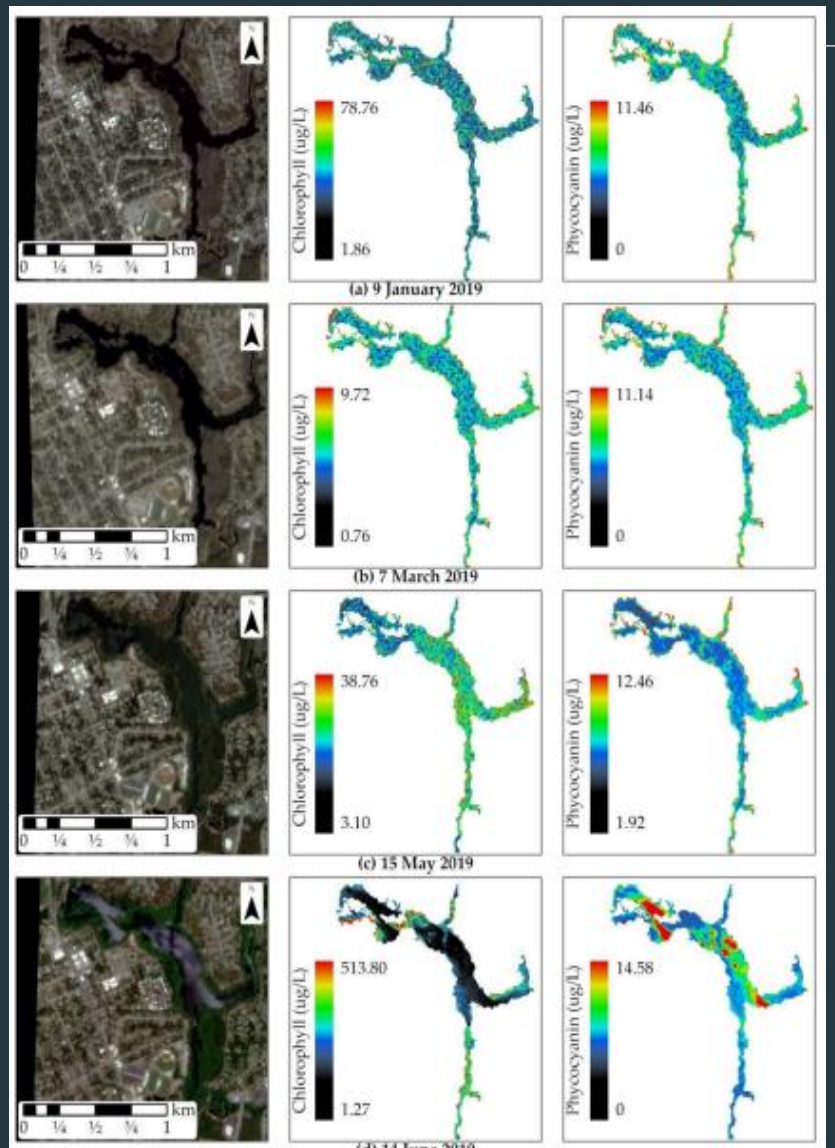
8 cm Ground Sampling Distance

Field of View: 47.2 HFOV





UAS- Multispectral Imaging Applications

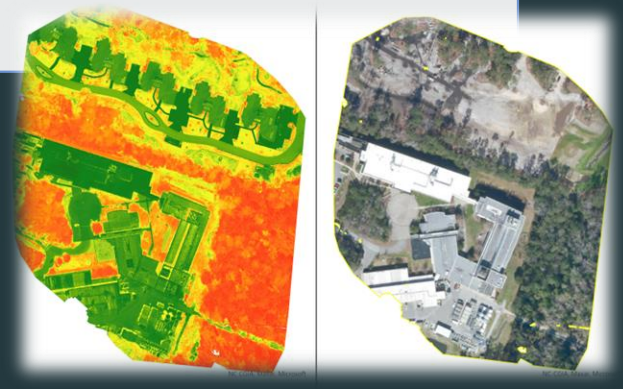


General Applications:

- High resolution imaging
- Vegetation health assessment
- Invasive species ID
- Harmful algal blooms monitoring
- Water resource management
- Wildfire assessments

Planned Applications:

- Mapping transition from tidal freshwater wetlands to salt marsh
- Wildfire effects on vegetation recovery rates in coastal fire-adapted ecosystems
- Wetland prediction modeling



YellowScan Mapper- Topographic LiDAR

- DJI Matrice 300 RTK Skyport Compatible
- Multi-echo Livox Horizon Laser Scanner

Mapper LiDAR system

Scanner	Livox Horizon
Wavelength	905 nm
Precision[1][3]	2 cm
Accuracy[2][3]	3 cm
Shots per second	240 k
Echoes per shot	Up to 2
Scanner field of view	81.7 °

GNSS-Inertial solution	Applanix APX-15 UAV
Weight [4]	1.5 kg (3.3 lbs) battery included
Size	L 14.3 x W 9.5 x H 15.4 cm
Autonomy	1 hour typ.
Power consumption	19 W
Operating temperature	-20 to +40 °C

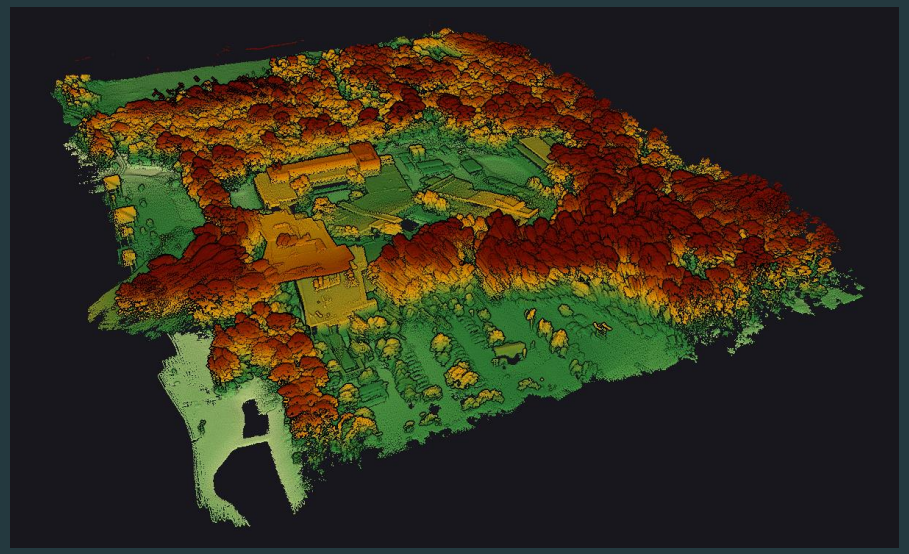
(1) Precision, also called reproducibility or repeatability, accounts for the variation in successive measurements taken on the same target.

(2) Accuracy is the degree of conformity of a measured position to its actual (true) value.

(3) One σ @ 50 m, nadir.

(4) Weight battery excluded: 1.3 kg (2.9 lbs)

UAS- Topographic LiDAR Applications

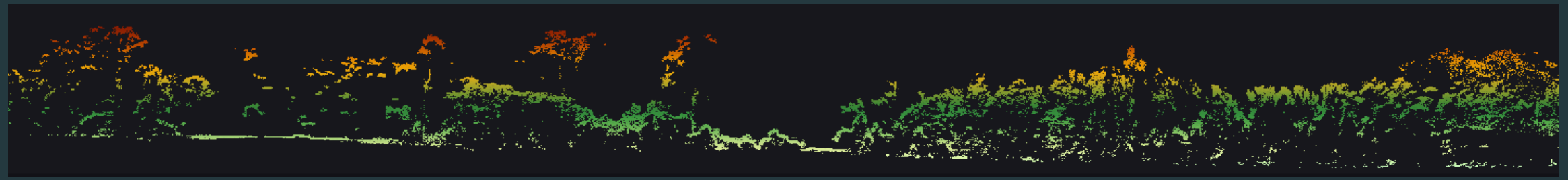


General Applications:

- High resolution & dense point cloud generation
- Digital elevation/surface models
- Land cover assessments
- Archeology- lost civilizations?
- Urban planning
- Flood risk assessments

Planned Applications:

- Sea level rise modeling
- Mapping transition from tidal freshwater to salt marsh wetlands
- Shoreline management and coastal resilience strategies



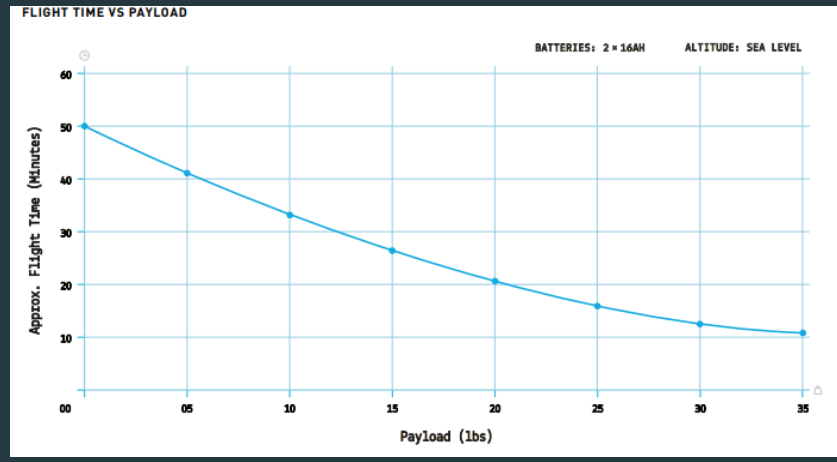
FreeFly Alta X- UAS

50 Minute Max Flight Time

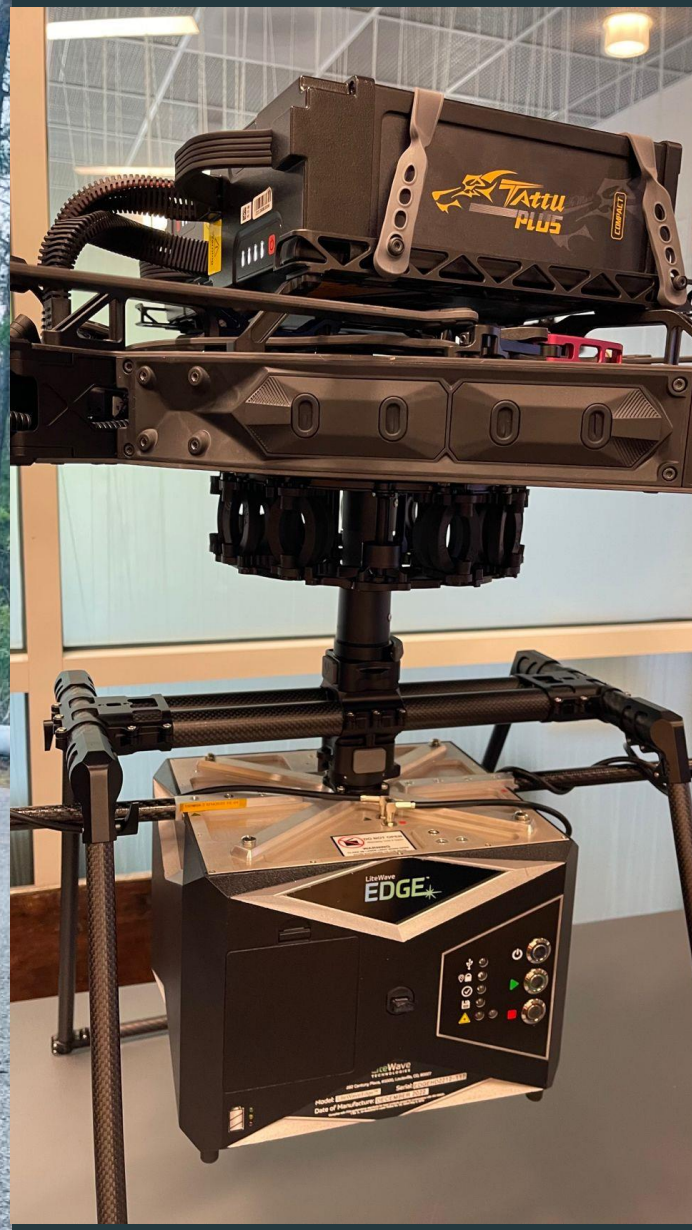
35 lb. Max Payload

LiteWave EDGE Topobathy LiDAR System

ITRES microCASI-1920 Hyperspectral Mapping System

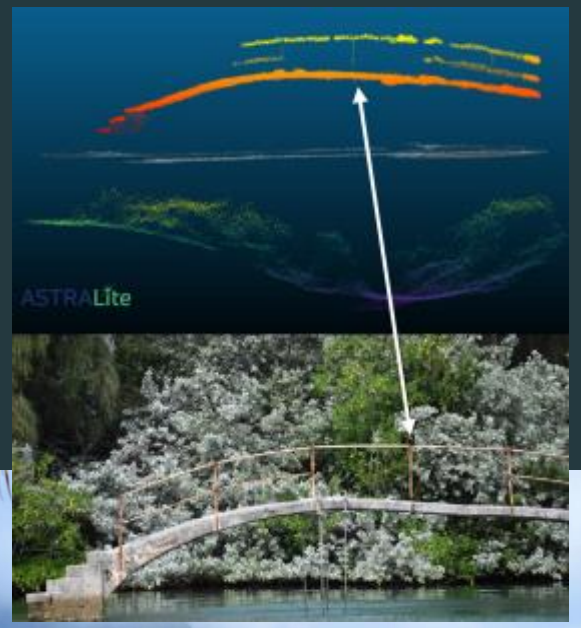



EDGE


Tattu
PLUS
EDGE

LiteWave EDGE- Topo-bathy LiDAR

- Alta X Compatibility
- 2-in-1 Topo-bathy LiDAR System
- Streams, Rivers, Ponds, Lakes
- Near-Shore / Coastal Environments



System Specifications

Weight	5 kg
Dimensions	27 cm x 23 cm x 19 cm
Power Supply	Internal LI-Ion Battery - 1-hour lifetime
Data Interface	USB Flash Drive
Data Volume	1 GB / 10 Minutes
Laser Class	Class 3R Laser Product according to IEC 60825-1:2014
Nominal Ocular Hazard Distance (NOHD)	5.5m (Eye Safe at >5.5m from output aperture)

LiDAR Performance

Accuracy	1 cm
Precision	0.5 cm
Laser Wavelength	532 nm
Typical Altitude	20m - Bathy; 40m - Topo
Depth Penetration	> 1.5 Secchi Depth
Pulse Repetition Rate	20 kHz (design option)
Laser Beam Footprint	33 cm at 30 m (11 mrad divergence)

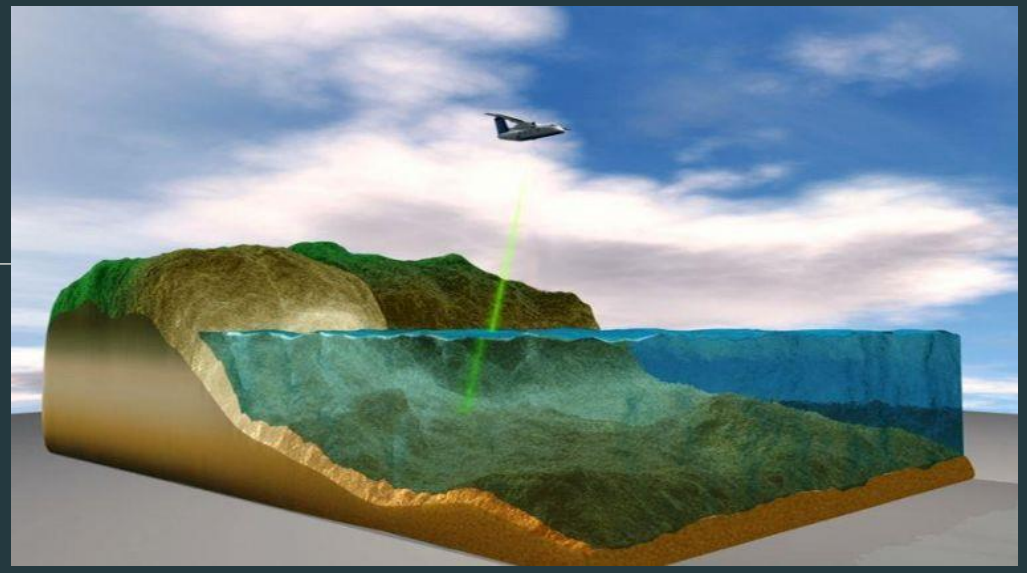
UAS Topo-Bathy LiDAR- Applications

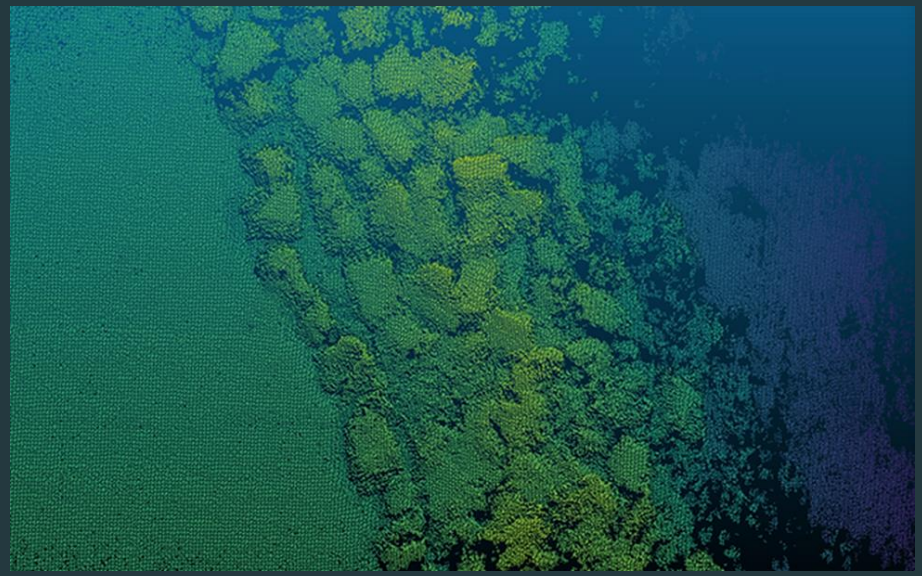
General Applications:

- High resolution & dense point clouds of land and underwater terrain
- Underwater structure mapping
- Coastal engineering
- Navigation

Planned Applications:

- Archaeological detection of ephemeral encampments for enslaved Africans in the naval stores industry
- Coastal wildlife vulnerability assessments
- Wetland prediction modeling
- Quantifying coastal change hazards related to storms, sea-level rise, and anthropogenic activities





ITRES microCASI-1920 Hyperspectral Mapping System

- Alta X Compatibility
- Micro imaging system
- Air/Ground
- Internal Radiometric Correction

SENSOR TYPE

VNIR Pushbroom Sensor
Compact Airborne Spectrographic Imager

PERFORMANCE

Spectral Range (Continuous Coverage)	400 – 1000nm
# Spectral Channels	288
# Across-Track Pixels	1920 (1840 effective)
Total Field of View	36.6 Degrees
IFOV	0.36 mRad (0.021°)
F/#	F/2.5
Spectral Width Sampling/Row	2.1nm (Average)
Spectral Resolution (FWHM)	<5nm
Pixel Size	5.86x5.86 Microns
Dynamic Range	12-Bits
Detector Full Well	32,500 Electrons
Maximum FPS	280 fps (Full frame)
Spectral Smile/	0.5 pixels
Keystone Distortion	0.5 pixels
Data Recording Capacity	480GB (SSD, SATA III)
Data Recording Capacity(hr)	3 hours (@ 40fps)

DIMENSIONS, WEIGHTS, AND POWER

ITEM Control, Recording	W / H / D(CM) / WT. (KG)
SHU, POWER	19 / 19.2 / 10.2 / <2.5KG Sensor Head 24-32VDC , ~45W

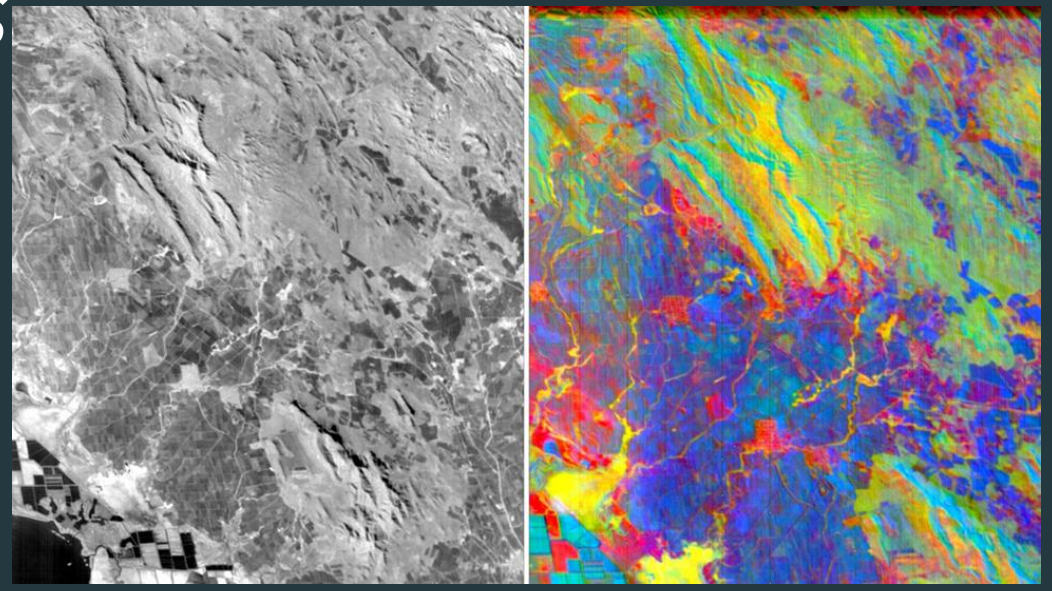
Hyperspectral Imaging- Applications

General Applications:

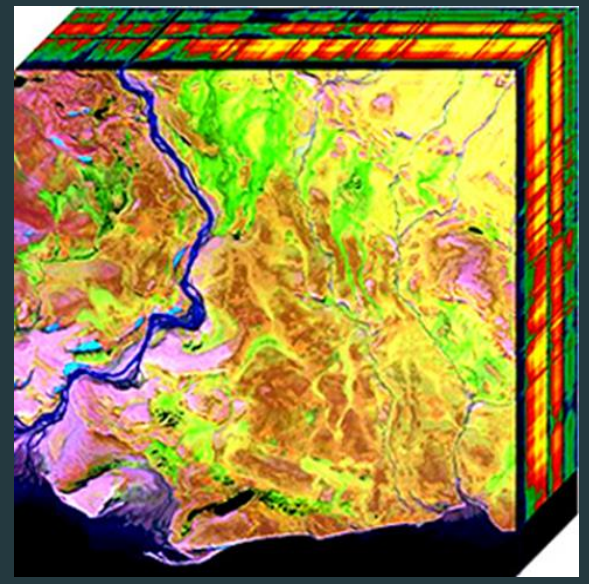
- Agriculture
- Mining and resource management
- Environmental assessments and health monitoring
- Detailed vegetation characterization
- Hazard waste response

Planned Applications:

- Differentiating seagrass and microalgal communities
- Comparisons between planktonic and benthic algae-dominated aquatic systems
- Develop machine learning methods using hyperspectral imagery



Hyperspectral imagery comparison from Pixxel hyperspectral sensors onboard SpaceX Transporter4



Malvern Panalytical Spectroradiometer

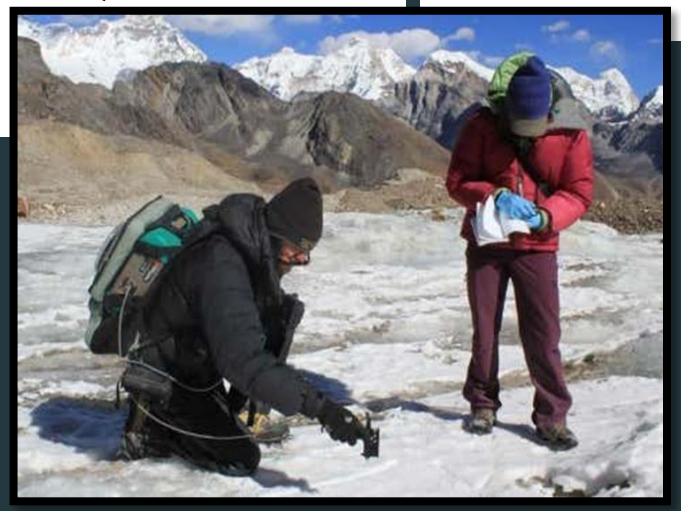
Specifications:

FieldSpec 4- Standard
- Spectral reflectance
- Radiance & irradiance

- Wavelength range of 350 – 2500 nm
- Spectral resolution of 3 nm at 700 nm & 10 nm at 1400/2100 nm
- Scanning time: 100 milliseconds
- Detectors:
  - VNIR (visible near infrared)
  - SWIR 1 (short-wave infrared 1)
  - SWIR 2 (short-wave infrared 2)

Applications:

- Measuring
  - Reflectance
  - Absorbance
  - Radiance and irradiance
- Multispectral ground-truthing
- Sensor calibration
- Imagery analysis
- Precision agriculture



XYLEM YSI EXO2

Specifications

- Multi-parameter water quality sonde capable of measuring:
  - PH
  - Conductivity
  - Total Algae- Phycocyanin & Phycoerythrin
  - Chlorophyl
  - FDOM
  - Dissolved Oxygen

Applications:

- Water quality monitoring
- Water quality profiling & logging
- Algal bloom ID
- Water quality assessments
- Education

Current Progress

EQUIPMENT

- Received:
  - DJI Matrice 300 RTK
  - MicaSense RedEdge Dual MX- Multispectral
  - YellowScan Mapper- LiDAR
  - Trimble r12i
  - LiteWave ASTRAEdge- Topobathy LiDAR
  - FreeFly ALTA X

- Awaiting:
  - ITRES Hyperspectral
  - YSI EXO2
  - Malvern Panalytical Spectroradiometer

TRAININGS

- Trimble R12i Training
  - Static Surveys
  - GCP

- DJI Matrice RTK 300

- YellowScan LiDAR Training
  - Flight Planning
  - In-field checks
  - Post processing

- MicaSense RedEdge Dual MX

- Freefly Alta X
  - Flight planning and data collection

- ITRES Hyperspectral Training
  - Initial POSPac Training
  - Training Continued (Late May 2023)

- LiteWave Bathymetric Topo LiDAR
  - May 9th and 10th

Research Plan

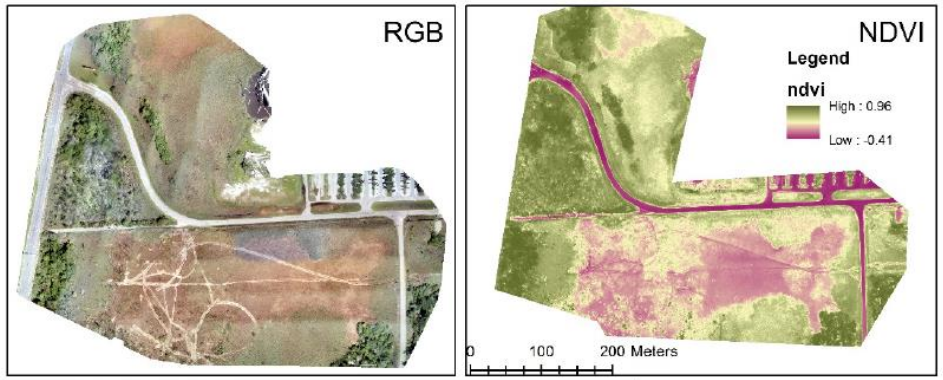
- Currently, 10 research plans are proposed under grant, spanning a wide range of disciplines.
- Disciplines range from archeology, machine learning, and ecological impacts of a large variety of drivers.
- 16 outside organizations provided LOS.

Investigator(s)	Institution(s)	Departments	Topic	Funding Support	Students (indicate UG or G)
Pricope[PI], Evans[SP], Mainali*[SP] & Hitchcock*[SP]	UNCW, Stetson University, Clemson University	Earth and Ocean Sciences	Natural and Nature-based Features (NNBF) for Resilient Coastal Transportation Systems	National Sea Grant (NOAA) and the Office of Coastal Management	4G, 2UG
Eulie*[PI], Urbanek[SP], & Danner*[SP]	UNCW	Environmental Sciences	Vulnerability of Coastal Wildlife in the Face of Changing Climate	NC Sea Grant (in preparation)	1 G, 1 UG
Halls[PI] & Pricope[PI]	UNCW, Stroud Water Research Center	Earth and Ocean Sciences	Mapping the transition from tidal freshwater wetlands to salt marsh	NCDOT RP2020-04	2 G
Leonard[PI], Halls[PI], Long J.*[SP], Hawkes[SP], & Posey[SP]	UNCW	Earth and Ocean Sciences, Center for Marine Science, Biology and Marine Biology	Time varying geomorphic responses to short- and long-term natural and anthropogenic forcings of barrier islands	NOAA Integrated Ocean Observing System; DOD A21-0041; NERRS Science Collaborative (pre-proposal in review)	6 G, 4 UG
Bresnahan*[PI,] Mallin[SP] & Cahoon[SP]	UNCW	Earth and Ocean Sciences, Center for Marine Science, Biology and Marine Biology	Water quality in shallow natural waters and comparisons between planktonic and benthic algae dominated aquatic systems	City of Wilmington Contract no. S6-0720.2	2 G, 4UG

Previous UAS coastal work by PI Pricope

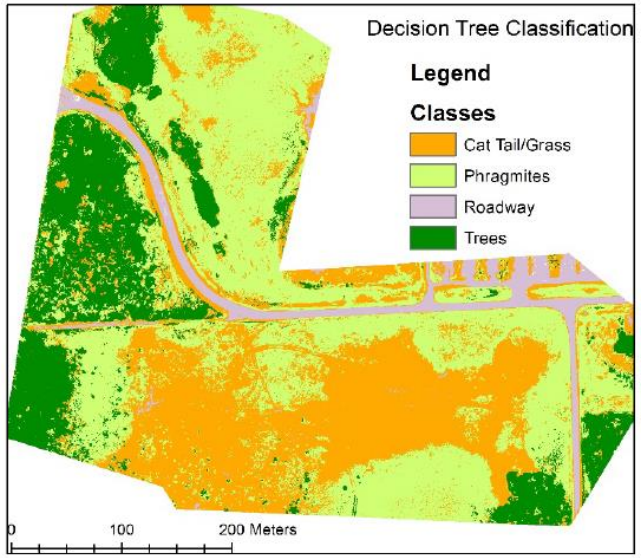
NC DOT RP 2020-04 Contract

Fusing multi-source UAS-derived data to improve project planning and the NCDOT wetlands prediction model

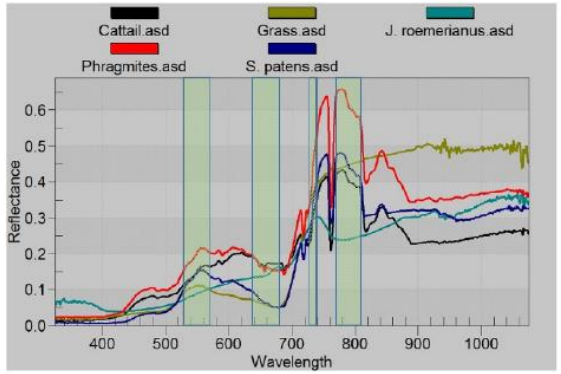


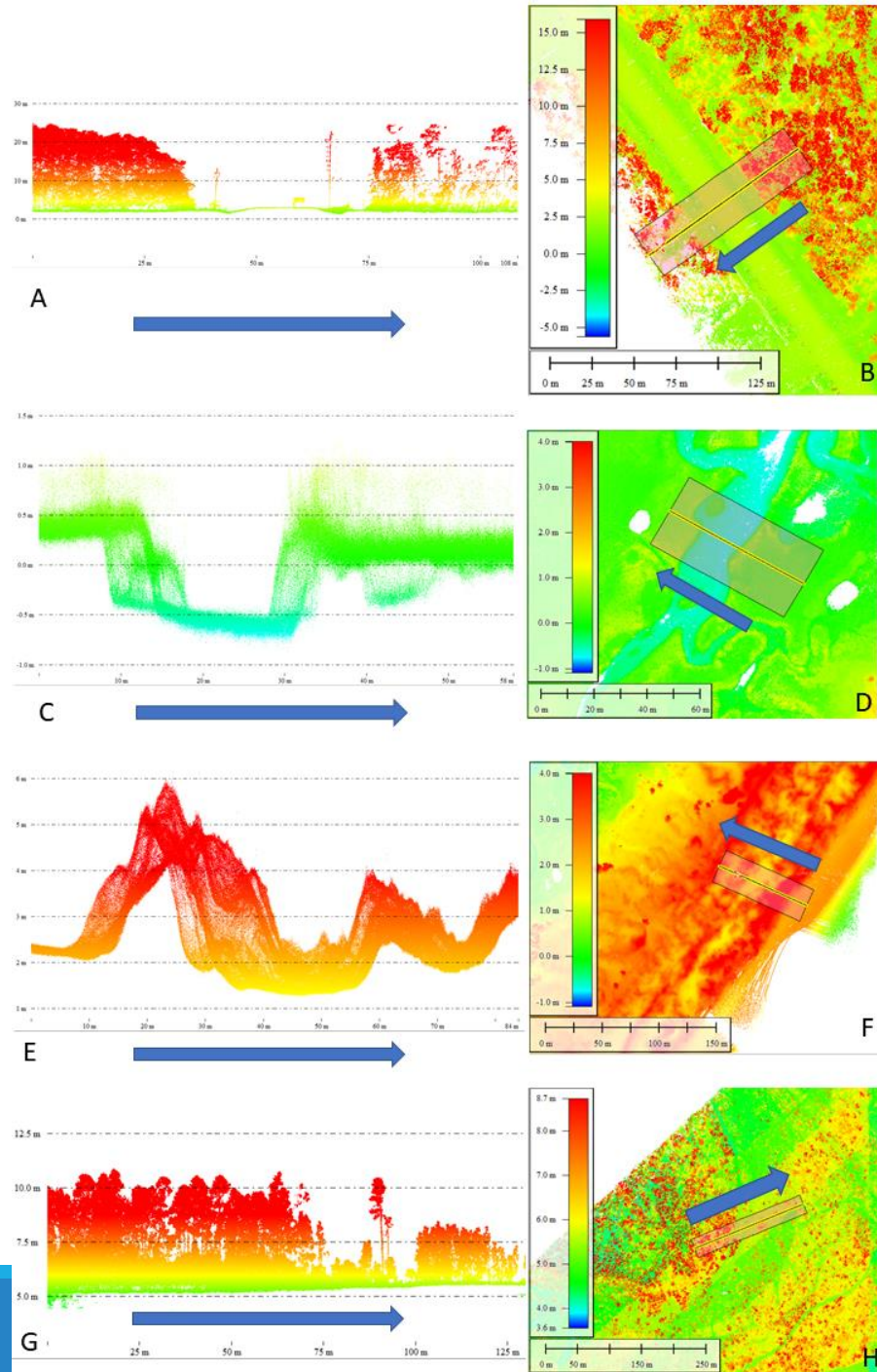
Band Ranges

Green: 530-570
Red:640-680
Red Edge: 730-740
NIR: 770-810



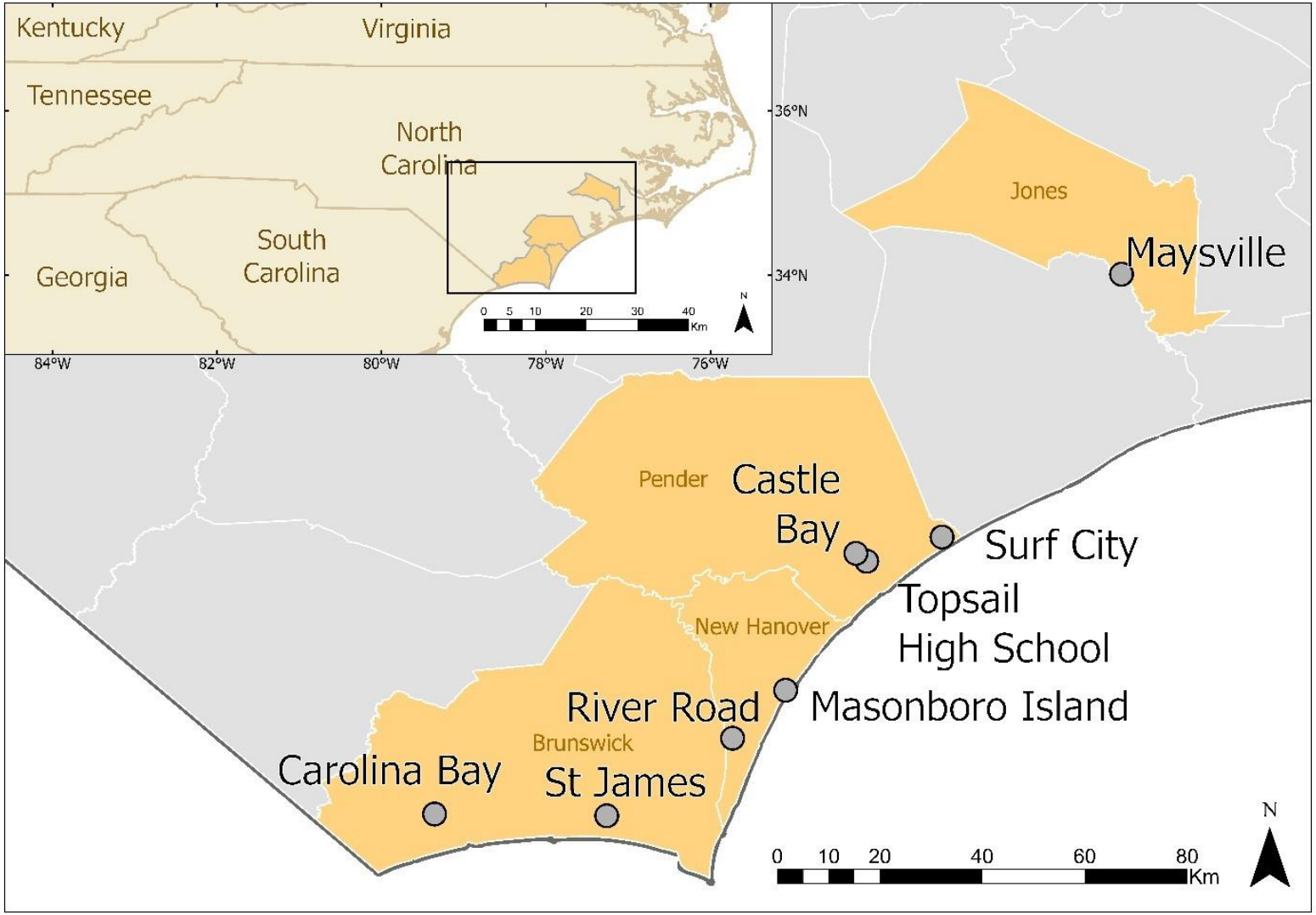
Spectral Curves





NCDOT RP2020-04 STUDY SITES:

10 sites surveyed across four NC counties along a gradient of palustrine to estuarine wetland types



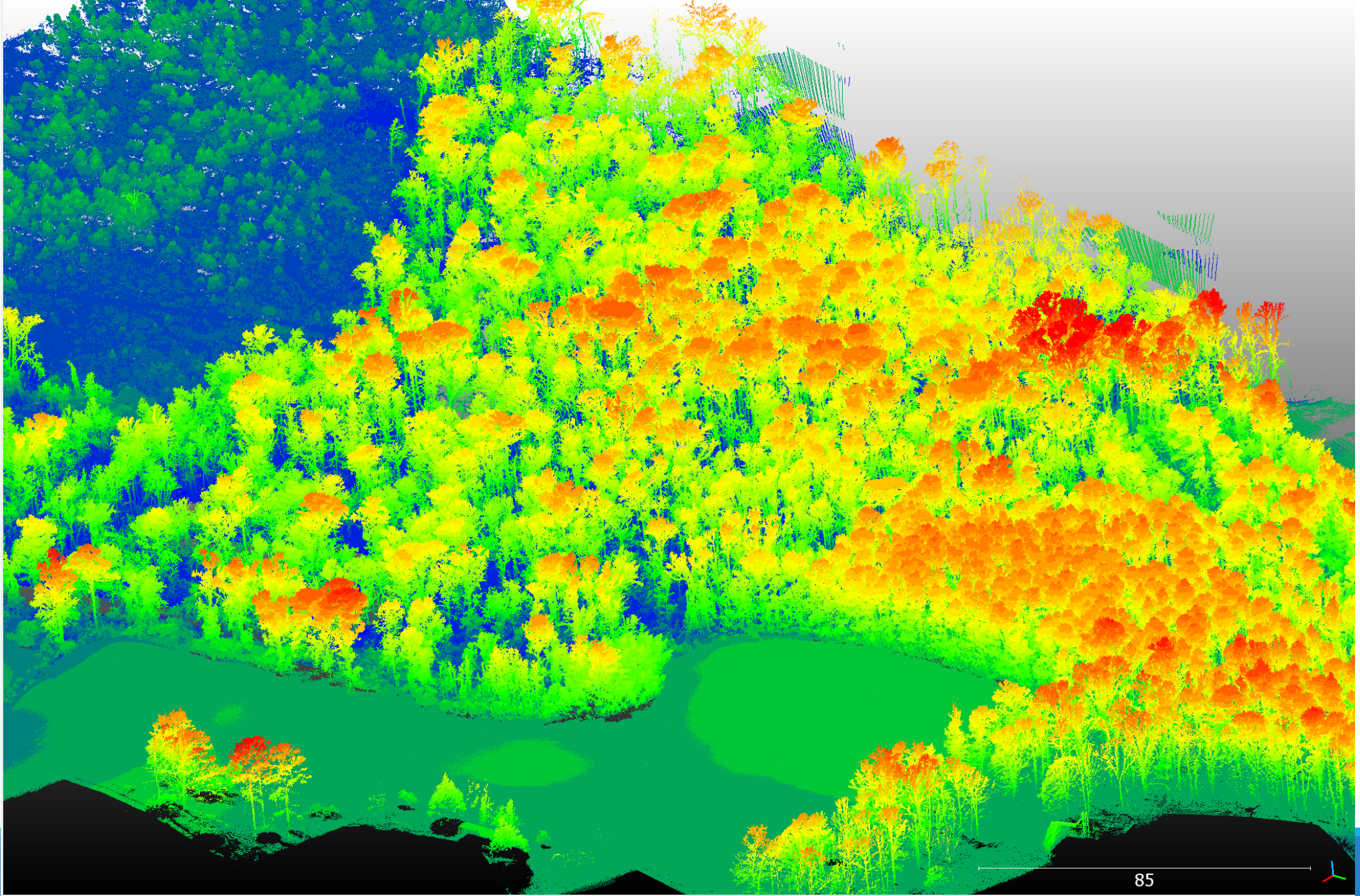
UAS LIDAR AND UAS MULTISPECTRAL DATA COLLECTION

- UAS Quanergy LiDAR M8 on DJI Matrice 600 Pro
  - Ground Control Points (GCPs, Trimble R10 RTK)
  - Static Survey (Trimble R8 RTK)
  - Check points (Trimble R8/10 RTKs)
- UAS Parrot Sequoia+ Multispectral sensor mounted on an eBee Plus RTK

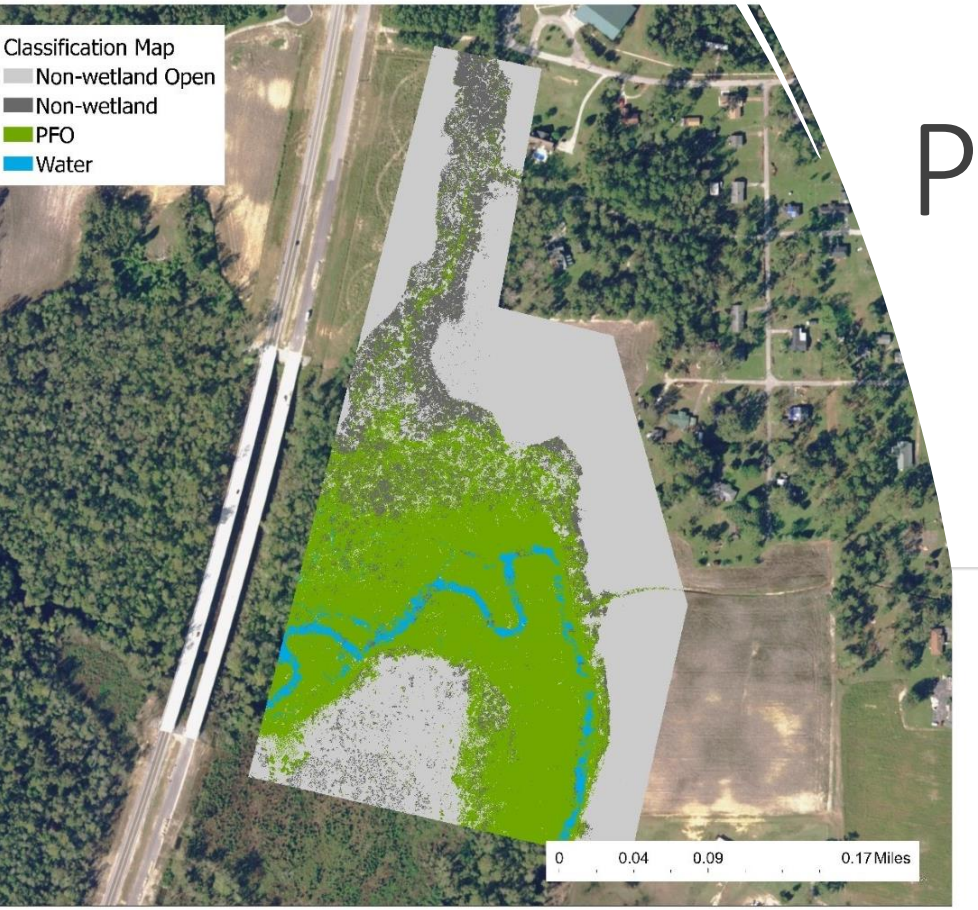
Matrice 600

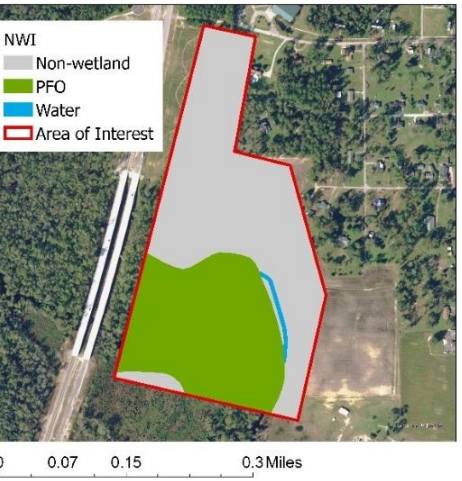
eBee Plus RTK
https://tecnitop.com/en/ebee-plus-en/

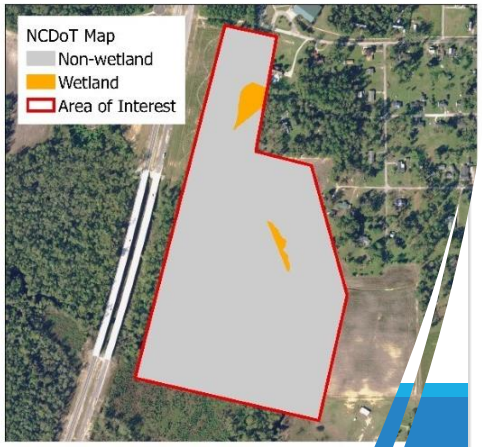
Static Survey (left) and GCP collection (right)

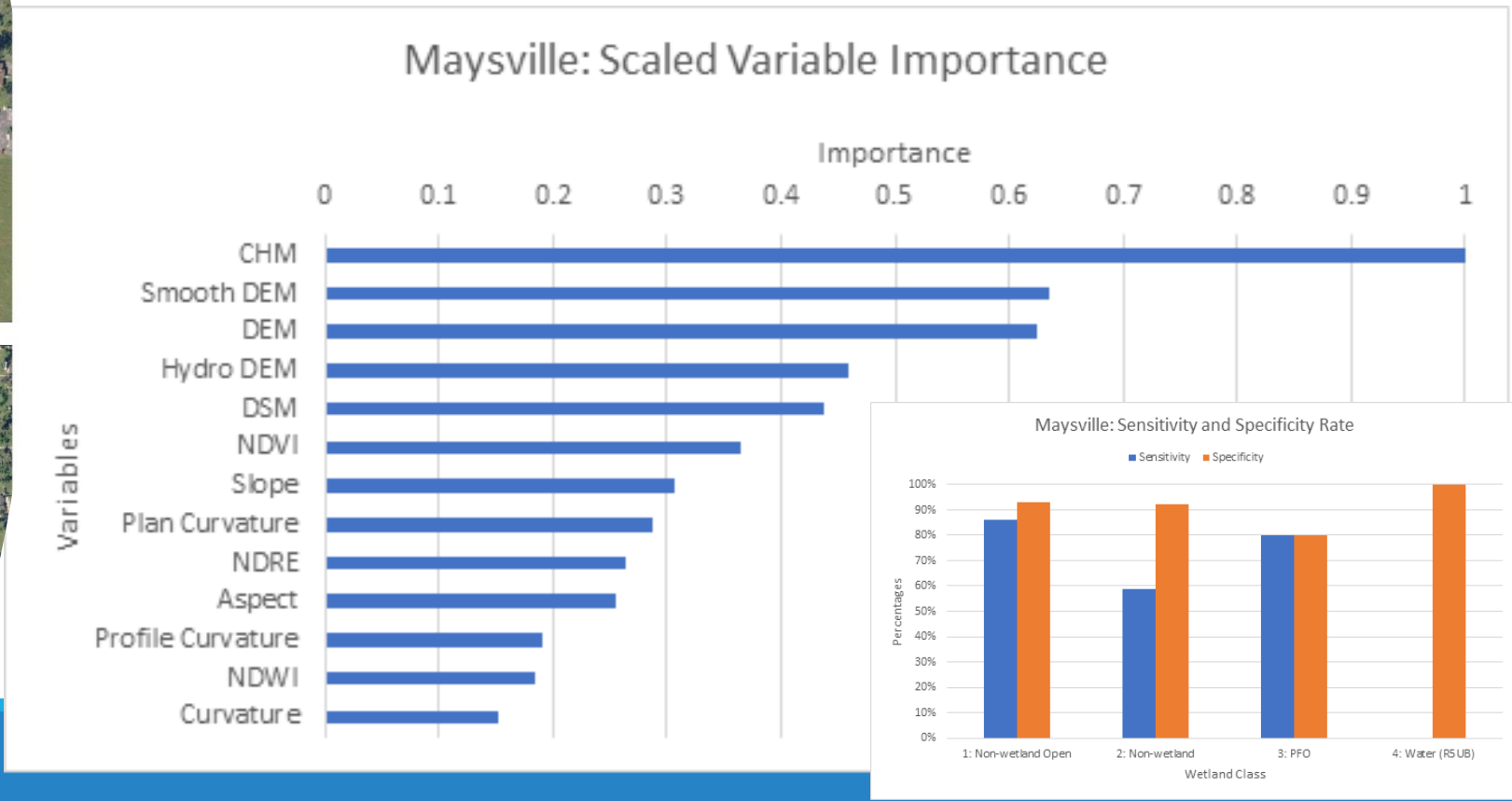

85

Palustrine forested wetlands

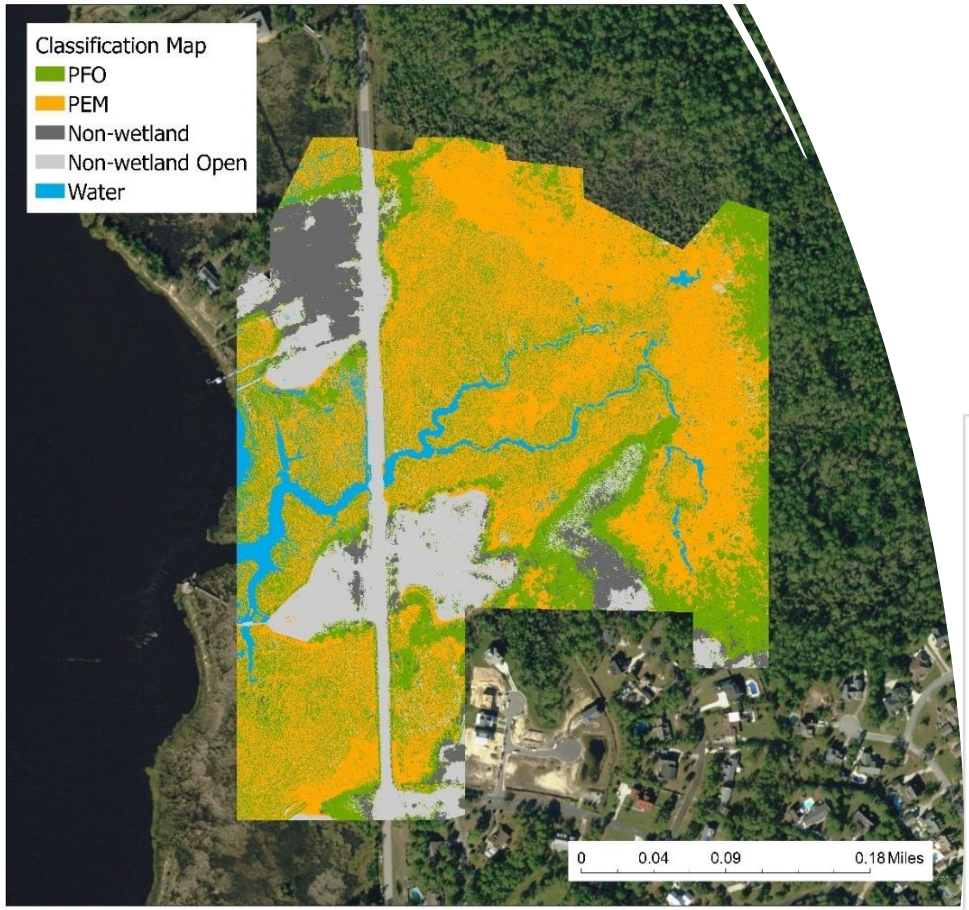


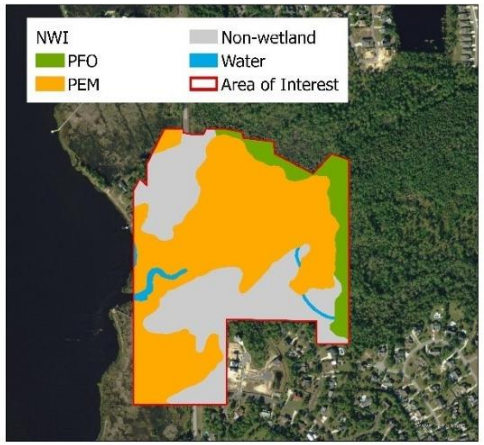


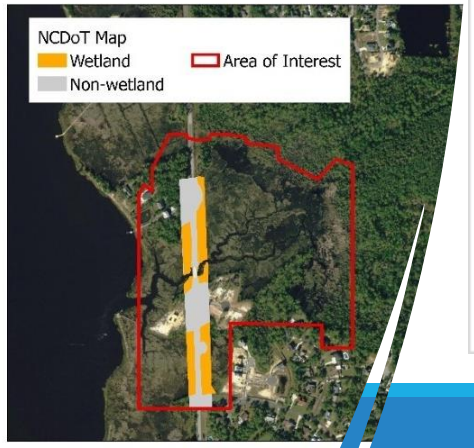




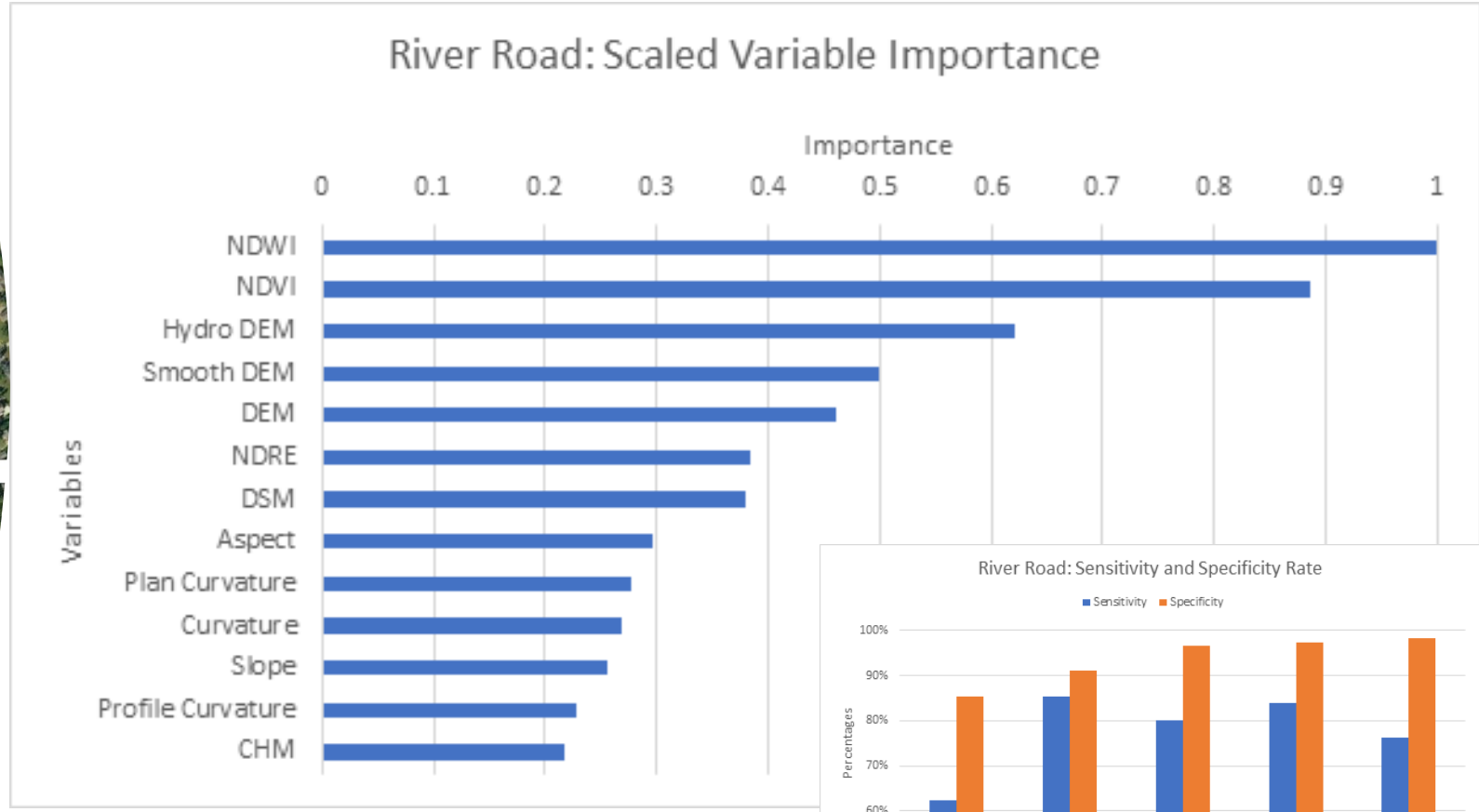
Palustrine emergent wetlands







0 0.13 0.25 0.5 Miles



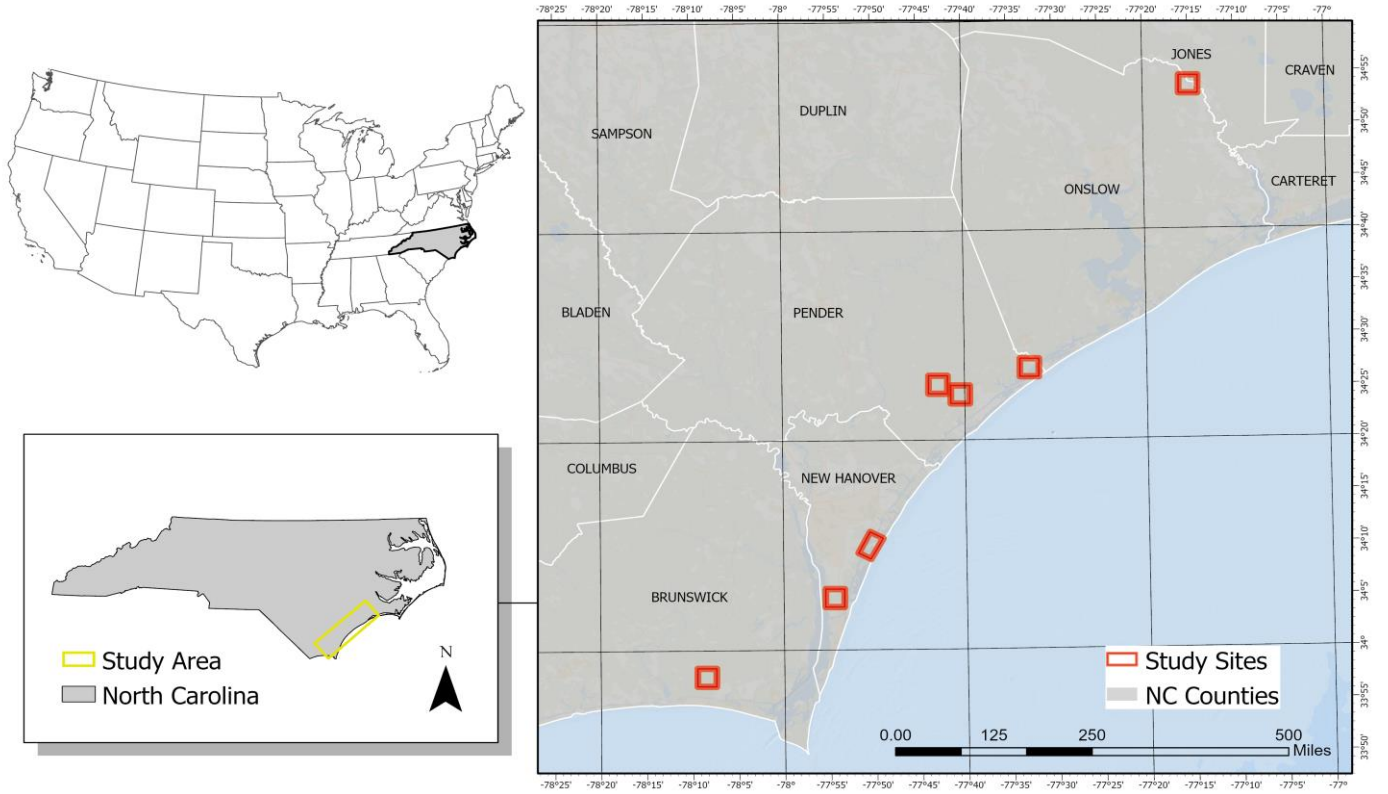
QL1 LiDAR and NAIP

7 Study Sites

- Coastal plain of North Carolina
- 2500 acres per site
- Existing response data

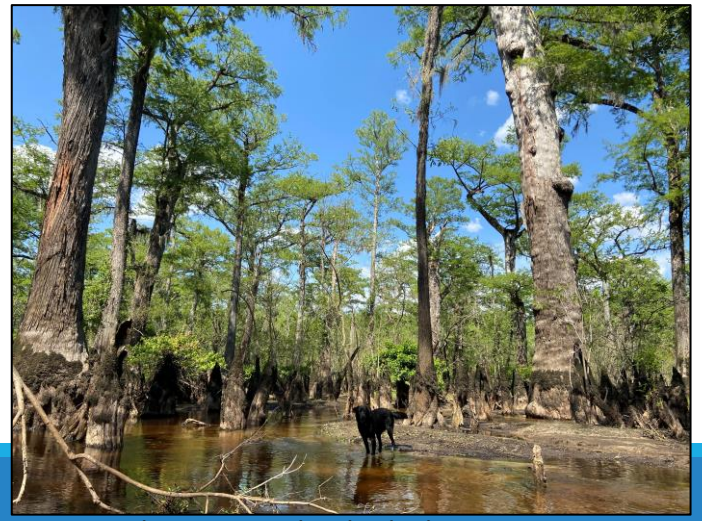
Palustrine and estuarine dominated

Sites incorporated urban areas, vegetated zones, waterbodies, and wetland systems

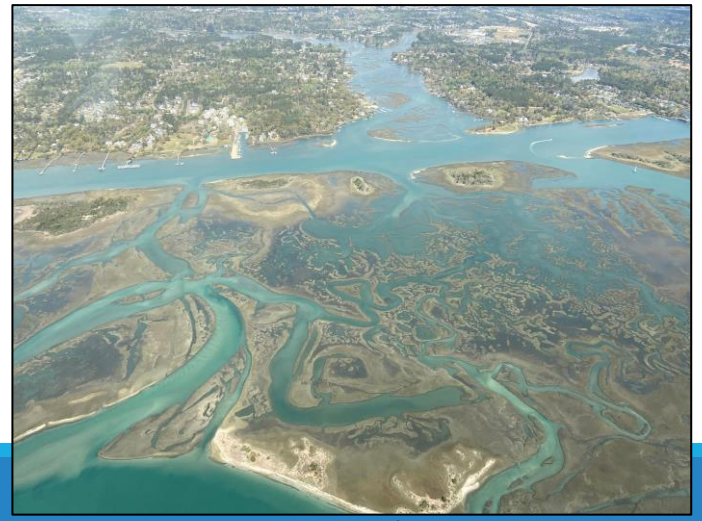


Selected study sites

Study Site	Wetland System Present
Maysville	Palustrine
Surf City	Palustrine, Estuarine
Castle Bay	Palustrine
Topsail	Palustrine
Masonboro	Palustrine, Estuarine, Marine
River Road	Palustrine
St. James	Palustrine



Palustrine Wetland- Black River, NC



Estuarine Wetland- S.E. of Figure 8 Island

MS THESIS by PATRICK CONNELL, 2022

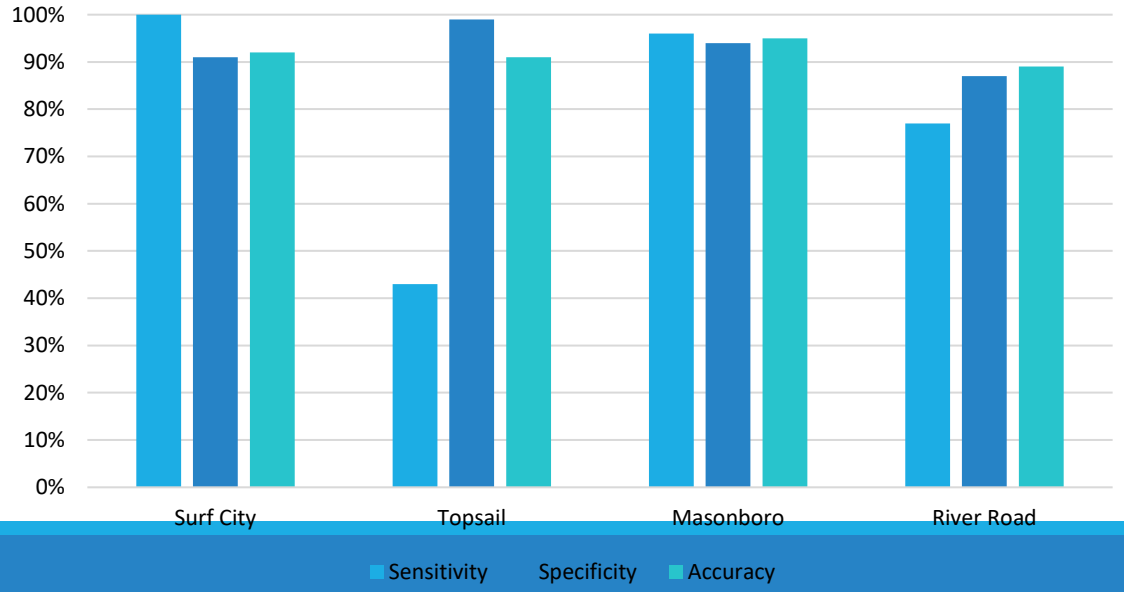
Example Results- Class Level Assessments - Emergent

Results

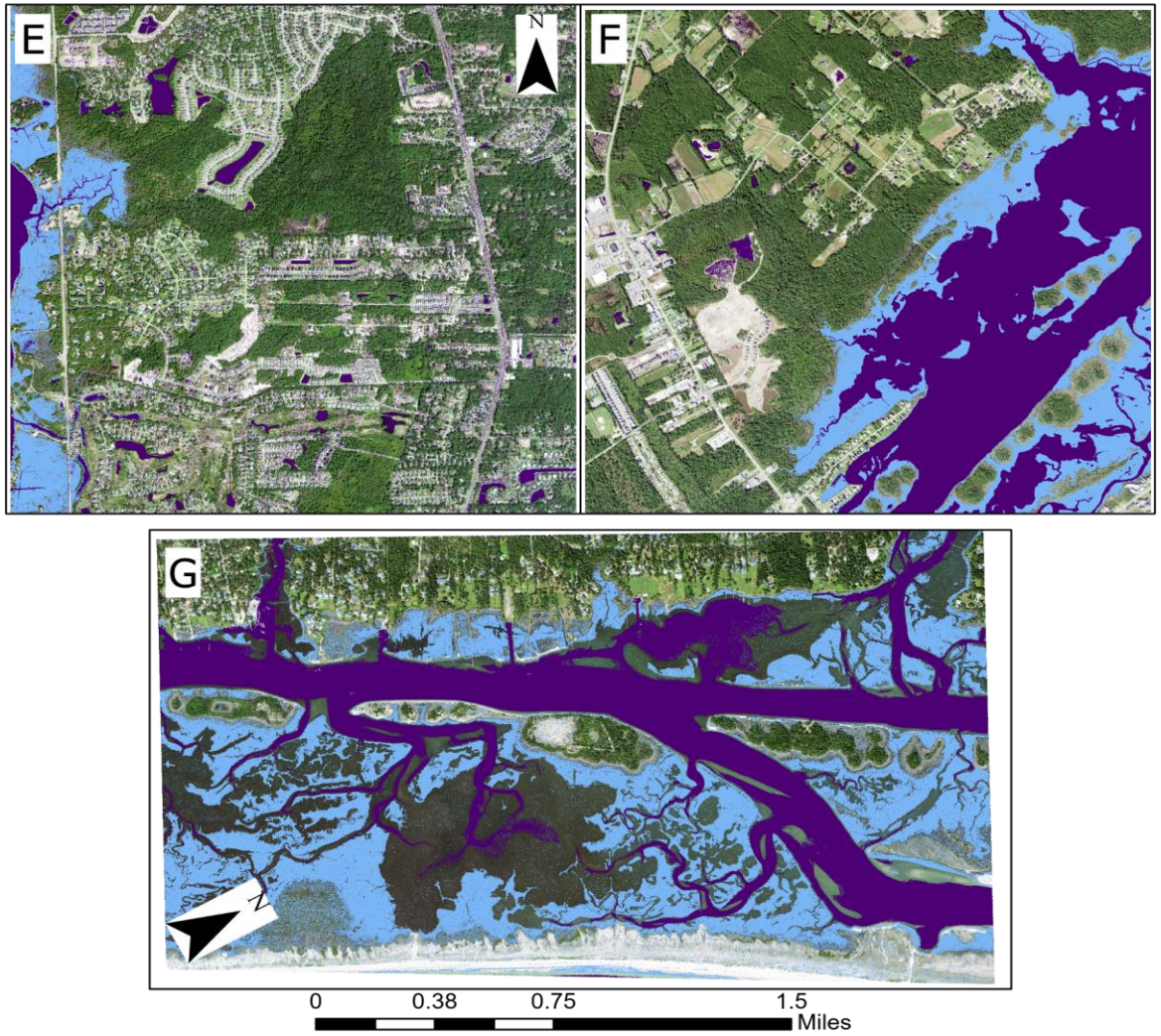
- Emergent wetlands
  - Best performing classification
- Average overall accuracy – 92%
- Sensitivity: 78% – 96%
- Specificity: 89% – 95%

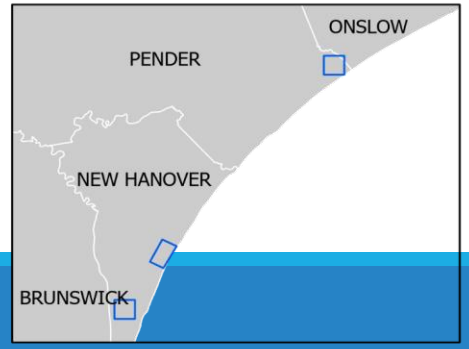
Top Variables of Importance

- DSM
- NDVI



Quantitative model results for individual emergent wetland classes per model





E: River Road
F: Surf City
G: Masonboro

Class
EM (Emergent)
Water

Emergent wetland and water predictions for sites: River Road, Surf City, and Masonboro

Thank you!
Questions?

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Research Plan Continued

Jarvis*[SP], Kenworthy[C], & Puckett[C]	UNCW, NC NERR	Biology and Marine Biology	Hyperspectral applications to differentiate seagrass and microalgal communities	NC Department of Environmental Quality award # 2019-H-074	1 G, 2 UG
Reber[PI] & Ewen[C]	UNCW	Anthropology	Archeology and coastal resources		15 UG
Pricope[PI] & Weatherford[C]	UNCW, NCDOT, U Nacional Agraria La Molina and Universidad de Cusco (Peru)	Earth and Ocean Sciences	Fusing multi-source UAS data for wetlands prediction modeling	NSF GSS-1560700; NCDOT RP2020-04; World Bank (Peru work); NCDOT Technical Assist.	7G, 3UG
Eulie*[PI], Long A, Posey[SP], Gittman*[C], Narayan*[C], Smith*[C], Scyphers[C], & Johnson[C]	UNCW, East Carolina U, Duke U, Northeastern U, US Naval Academy	Environmental Sciences and Center for Marine Science	Biogeomorphic impacts of shoreline management and coastal resilience strategies	NCDCR-2613; USCRP W912HZ-20-2-0006; NSF CoPe (in review); NOAA ESLR (in review)	6 G, 2 UG
Halls[PI]	UNCW	Earth and Ocean Sciences	Assessment of flood risk and simulations of wetland change in Pender County, NC	NC Sea Grant 18-CCRG-02	1 G
Halls[PI] & Darrow[C]	UNCW, Bald Head Island Conservancy	Earth and Ocean Sciences	Dune characteristics in relationship to sea turtle nesting		1 G
Hawkes[SP]	UNCW, WHOI, UAF	Earth and Ocean Sciences	Bering Sea storminess	NSF pending	1G, 2UG
Long Z[SP] & Danner*[SP]	UNCW	Biology and Marine Biology	Invasion rates of Beach vitex (Vitex rotundifolia)		1G, 4UG
Rother*[SP] & Peng*[SP]	UNCW	Environmental Sciences and Earth and Ocean Sciences	Wildfire effects on vegetation recovery rates in coastal fire-adapted ecosystems	North Carolina Division of Parks and Recreation/ NC State Parks	2G, 3UG

Enabled Coursework

Course	# Students/ Semester	Equipment Used	Purpose	Instrument time required
EVS 455/555 Geospatial Analysis for Coastal Management	14	Trimble R12i TSC7 Rover, DJI Matrice 600 Pro, ASTRALiTe EDGE Topo-Bathy LiDAR system, RBR sensors	Intertidal surveys of estuarine and backbarrier sites	10 hours
EVS 456/556: Land Survey Tech for Natural Resource Management	14	Trimble R12i TSC7 Rover, DJI Matrice 600 Pro, ASTRALiTe EDGE Topo-Bathy LiDAR system, RBR sensors	Intertidal surveys of estuarine and backbarrier sites, survey technology training	10 hours
EVS 457/557: Intro to Drone Operations	14	DJI Matrice 300 RTK	UAS and survey technology training	5 hours
GGY 281: Introduction to GIS	80	Trimble R12i TSC7 Rover, DJI Matrice 300 RTK	Introduction to geospatial technologies	3 hours
GGY 429/529: Aerial Drone Applications in Geosciences	22	DJI Matrice 300 & 600 Pro, uCASI-1920 hyperspectral, Altum multispectral sensor, and the Livox LiDAR	UAS mission planning, execution, data collection;3D and vegetation models	25 hours
GGY 522: Remote Sensing in Env. Analysis	16	DJI Matrice 600 Pro, uCASI-1920 hyperspectral sensor, ASD spectrorad., Trimble R12i TSC7 Rover	Vegetation mapping and classification algorithms using hyperspectral data	10 hours
GGY 524: Advanced GIS	18	Trimble R12i TSC7 Rover, DJI Matrice 300 RTK	Barrier island vegetation surveys	10 hours
OCN/GLY 390: Oceanographic/Geo-science Field Methods	12	DJI Matrice 600 Pro, uCASI-1920 hyperspectral, Altum multispectral sensor, and the Livox LiDAR; Trimble R12i TSC7 Rover, DJI Matrice 300 RTK	Coastal/estuarine water quality surveys, beach surveys	6 hours
GLY 553: Ocean Technology	15	DJI Matrice 600 Pro, uCASI-1920 hyperspectral, Altum multispectral sensor, and the Livox LiDAR	UAS and survey technology training, sensor development and testing	5 hours
ANT 311: Archaeological Field Methods	15	DJI Matrice 300 & 600 Pro, Livox LiDAR, Altum multispectral sensor	Archaeological mapping and site detection	10 hours

The UAS Coastal Observatory will also provide for additional coursework availability for students.

The availability of state-of-the-art instrumentation will provide students with ample opportunity in the realm of geospatial technologies.