

Geospatial Data Fusion for Coastal Environmental Applications

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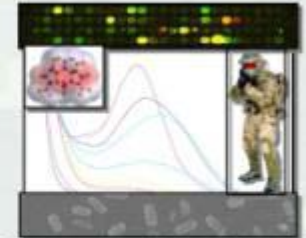


Ecosystem Restoration



Remediation and Munitions Response

Impacts of Climate Change



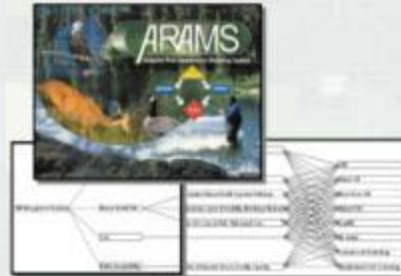
Sustainable Materiel and Processes



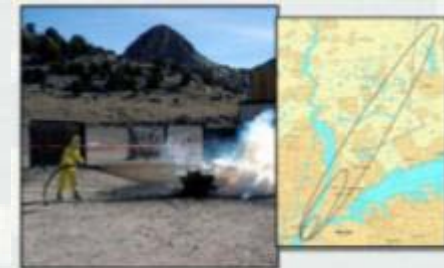
Environmental Resources



Environmental Sensing



Risk and Decision Science



Environmental Security



Environmental Forecasting



Research Focus Areas

Wetlands



Ecosystem Restoration



Invasive Species



Endangered Species



Environmental Characterization

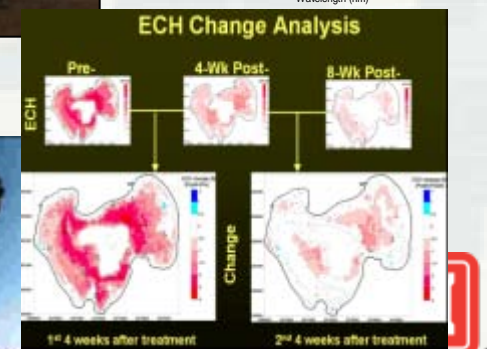
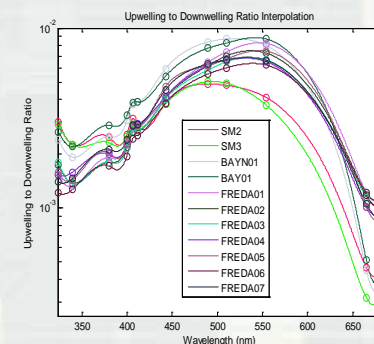
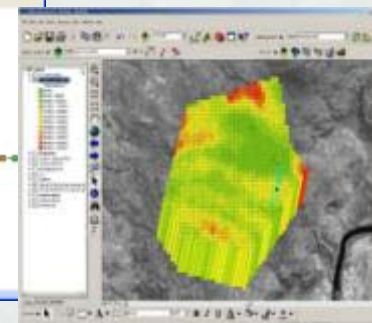
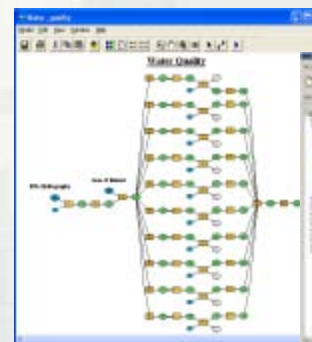
Natural Resource Management

Navigation Dredging



Environmental Systems Branch

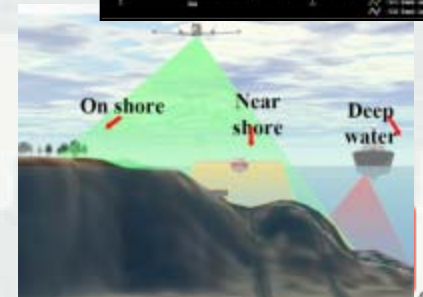
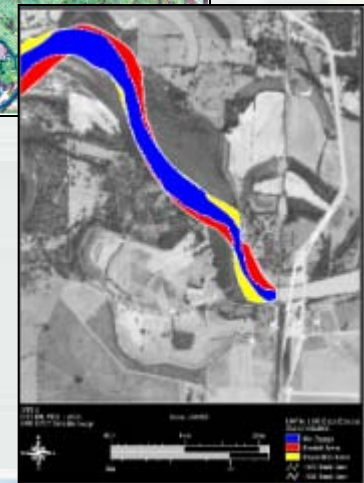
- **MISSION:** Identification, mapping, and modeling of environmental conditions in support of diverse military and civil requirements. Development of environmental sensing, characterization, and monitoring capabilities necessary to quantify environmental site conditions. Model development for the prediction and visualization of dynamic environmental characteristics for civil and military applications.



Geospatial Data Analysis Facility

FOCUS: Application of Geospatial Technologies Toward Civil and Military Environmental Applications

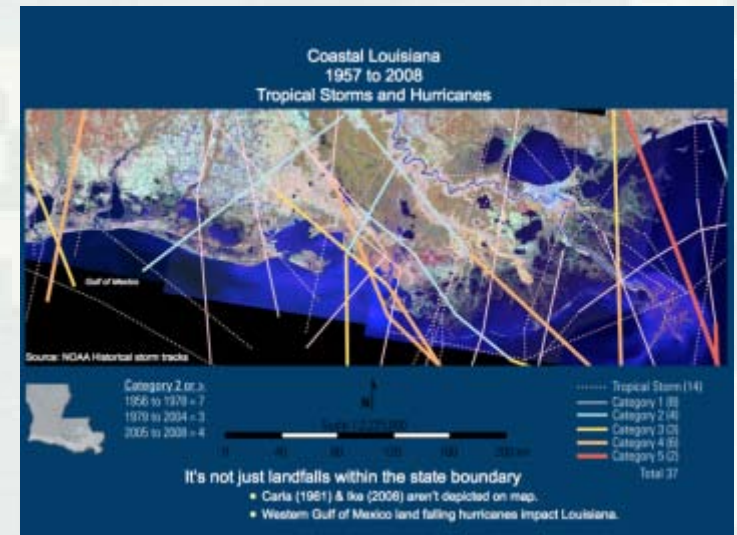
- Custom Geospatial Model Development
 - *ESRI Model Builder Expertise*
- Image Processing and Analysis
 - *Unclassified to Top-Secret*
 - *Multispectral and Hyperspectral Platforms*
 - *Active and Passive Systems*
- Custom Database Development
 - *SDSFIE Experts*
- Serving Geospatial Data Via Web Interface
 - *Improvised Explosive Device Defeat Organization (SIPRNET)*
- Development of Innovative Applications of Combined Lidar and Hyperspectral Imagery
 - *CHARTS system*



Wetland Environmental Technologies Research Facility (WETRF)

FOCUS: Application of geospatial technologies to address issues of specific concern to coastal Louisiana and northern Gulf of Mexico wetlands

- Scope
 - ▶ *Wetland science data integration*
 - ▶ *Geospatial analyses*
- Impact
 - ▶ *Informs coastal restoration and protection planning and management*
- Capabilities
 - ▶ *Expert technical staff stationed at LSU campus*
 - ▶ *Relationship with USGS NWRC and LA OCPR*
 - ▶ *Interdisciplinary team*



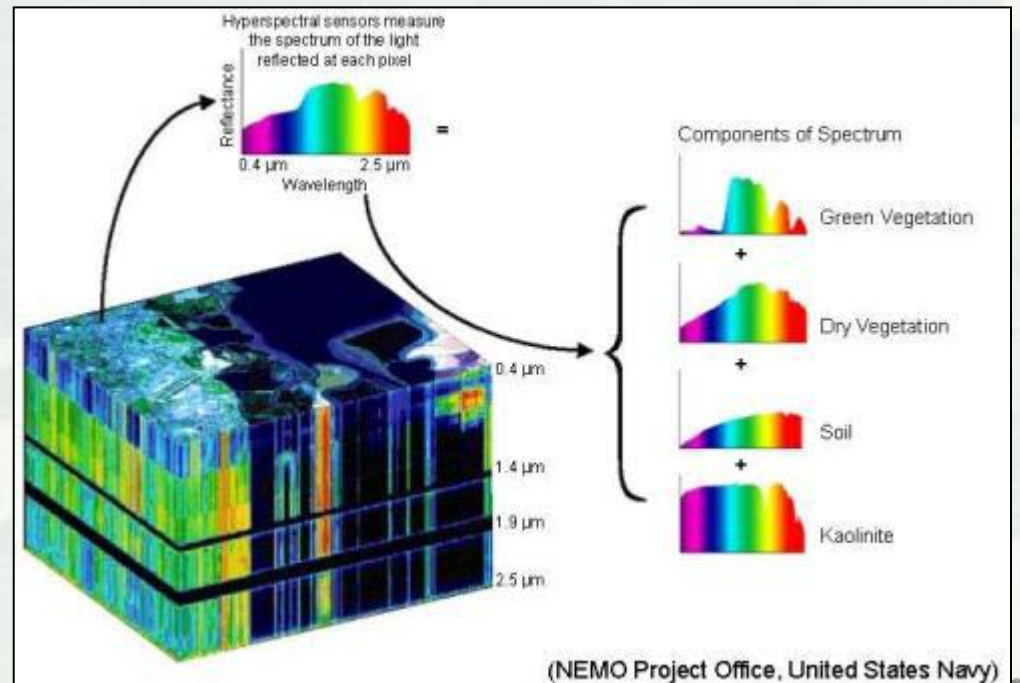
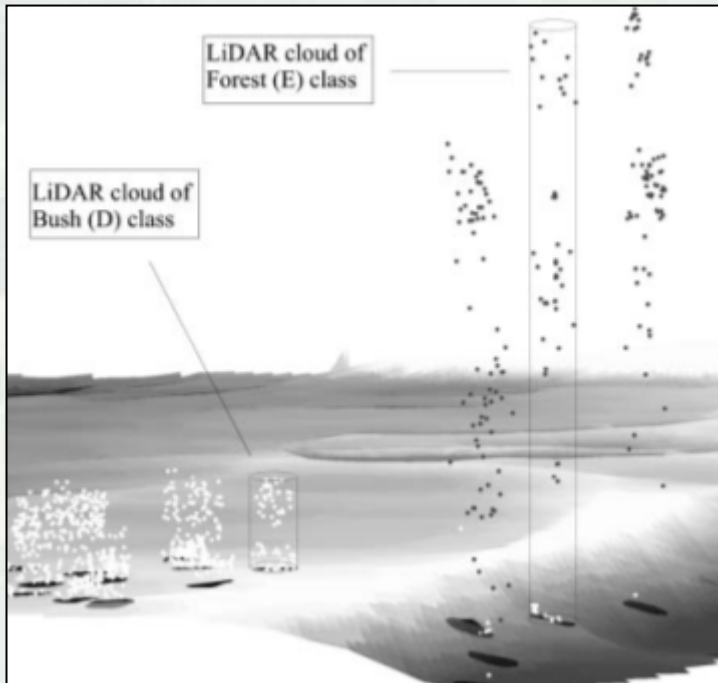
EL and JALBTCX

- EL has teamed up with JALBTCX to assist with the development and expansion of environmental data products
- **GOAL:** identify/expand environmental data products, utilizing (1) imagery resources of JALBTCX and (2) environmental expertise in EL to address environmental/geospatial needs of the coastal districts.



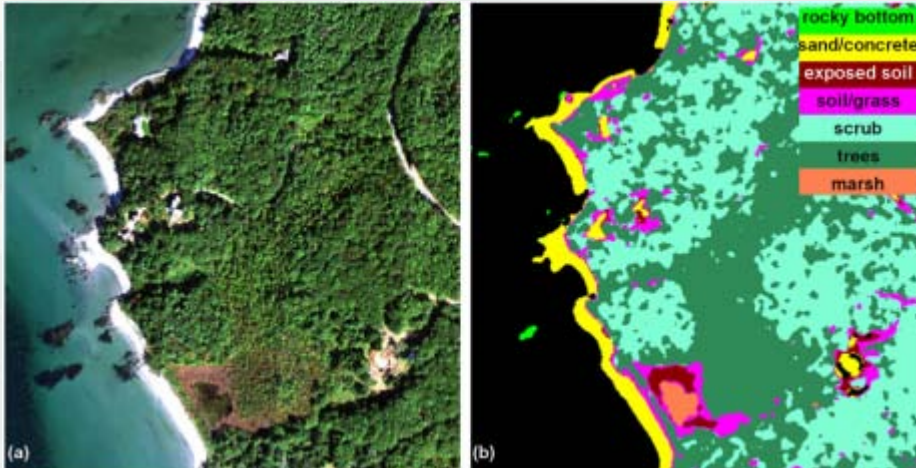
Objective

- Target features **spectrally** with hyperspectral and **structurally** with lidar through image fusion



Landuse/Landcover and Species Composition

- Landuse/landcover, Species Composition/Distribution, and Habitat Mapping
 - basic groups or categories of landcover
 - specific plant species or species assemblages/groups
 - critical habitats using standard classification systems



Portsmouth Harbor, New Hampshire.
(a) True color image extracted from hyperspectral mosaic. (b) Basic image classification.



Landuse/Landcover and Species Composition

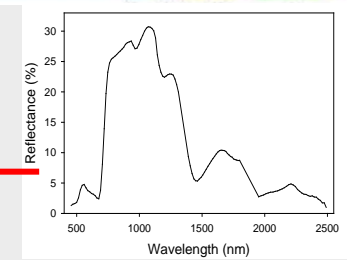
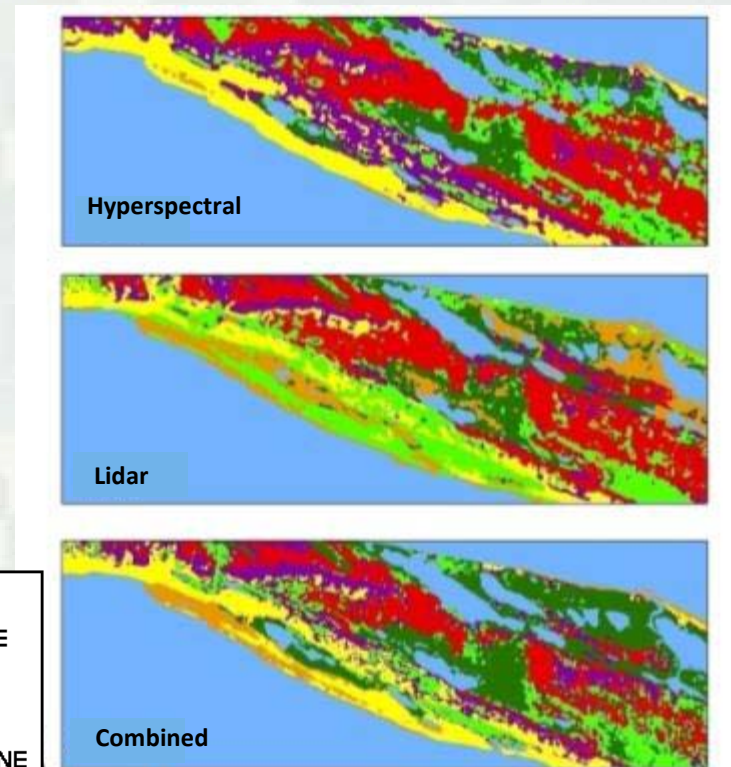
- Landuse/landcover, Species Composition/Distribution, and Habitat Mapping

Coastal Habitats - Spain



Chust, G. et al 2008. Coastal and estuarine habitat mapping, using lidar height and intensity and multi-spectral imagery. *Estuarine, Coastal and Shelf Science*. 78:633-643.

Barrier Island Habitats – Horn Island



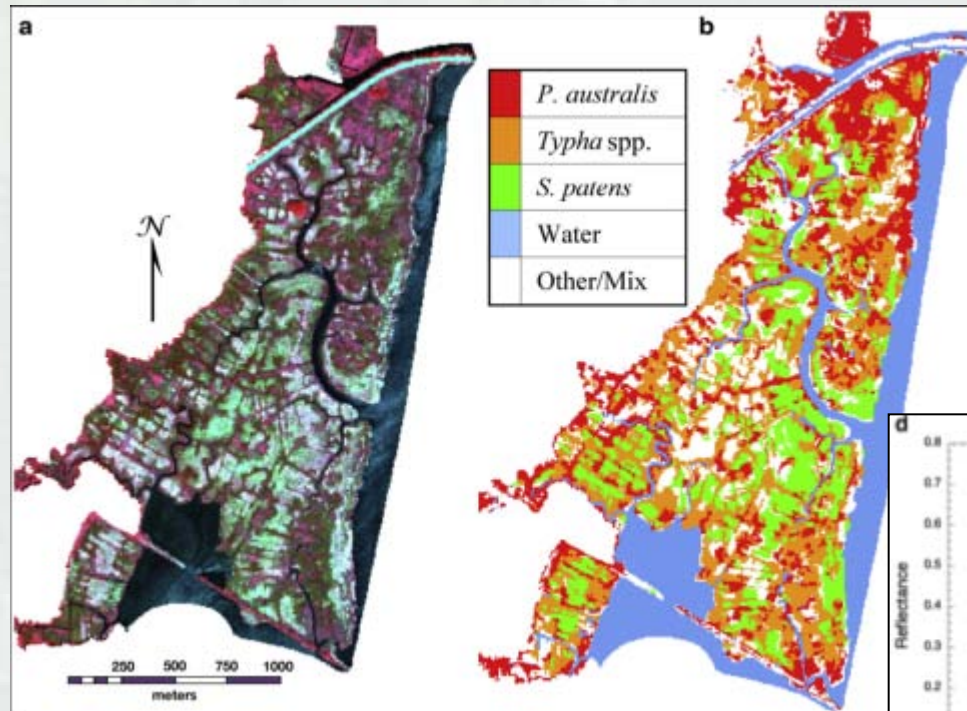
Lucas and Carter. 2009. Decadal Changes in Habitat-Type Coverage on Horn Island, Mississippi USA. *Journal of Coastal Research*, In Press.

Invasive Species Detection

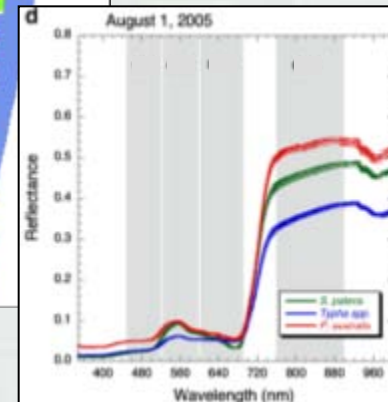
- Mapping Invasive and Indicator Species
 - Spectrally and structurally target species of interest
 - Emphasize changes in composition, structure and function in ecosystems caused by invasives



Common Reed



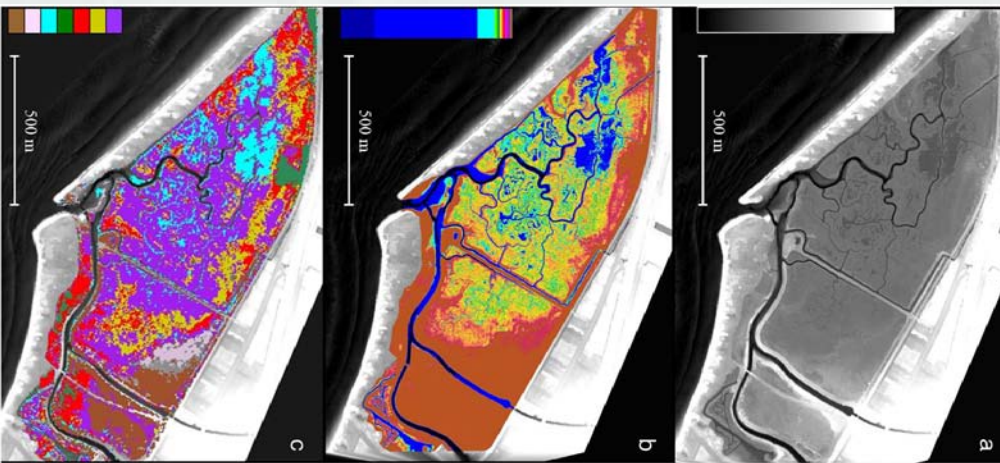
Gilmore, M.S. et al. 2008. Integrating multi-temporal spectral and structural information to map wetland vegetation in a lower Connecticut River tidal marsh. *Remote Sensing of Environment*. 112:4048-4060.



Wetlands and Beach Characterization

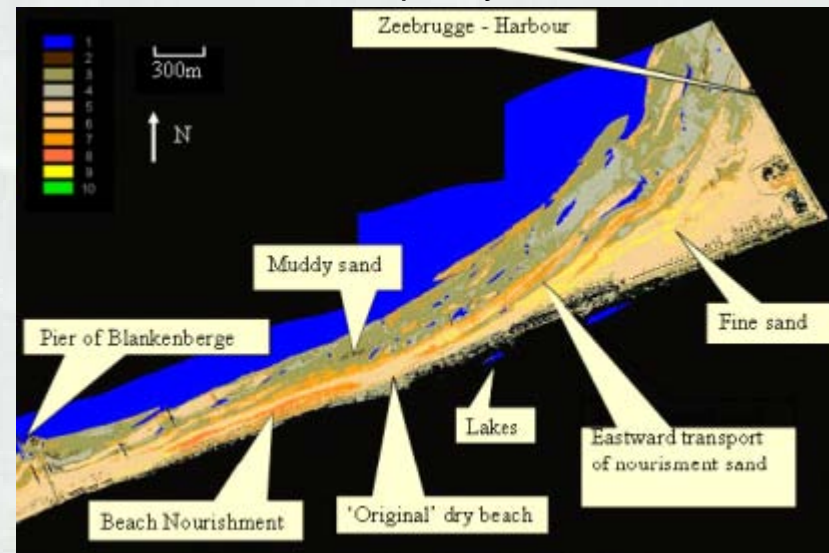
- Mapping Wetland Habitats and Beach Morphology
 - Spectrally and structurally target wetland species (distribution and condition)
 - Emphasize species pattern characterization and zonation related to elevation gradients
 - Characterize erosion/sedimentation and beach types for monitoring

Wetland Habitat Zonation



Sadro, S. et al. 2007. Characterizing patterns of plant distribution in a southern California salt marsh using remotely sensed topographic and hyperspectral data and local tidal fluctuations. *Remote Sensing of Environment*. 110:226-239.

Beach Morphodynamics



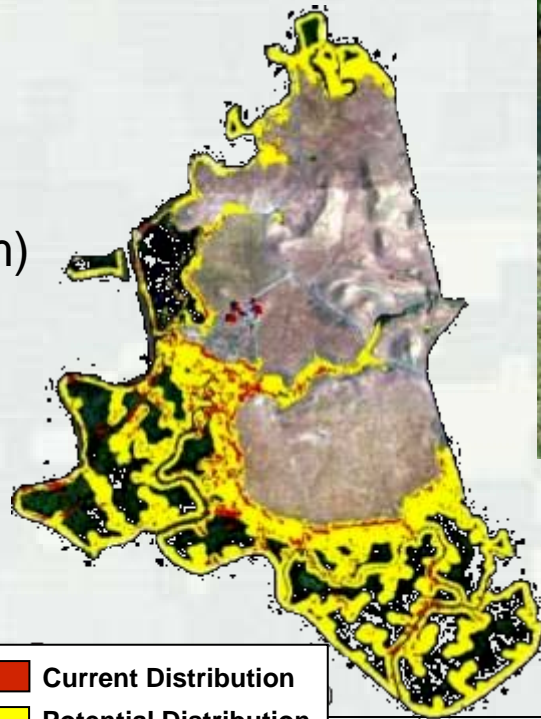
Deronde, B. et al. 2006. Use of airborne hyperspectral data and laserscan data to study beach morphodynamics along the Belgian coast. *Journal of Coastal Research*. 22(5):1108-1117.



Ecosystem Characterization

- Mapping ecosystem characteristics
 - Identify unique characteristics in landscape parameters/attributes
 - Model habitat for invasive/threatened/endangered species and restoration/conservation
 - Model habitat changes to examine trade-offs

Potential habitat for
invasive species (Lepidium)



■ Current Distribution
■ Potential Distribution

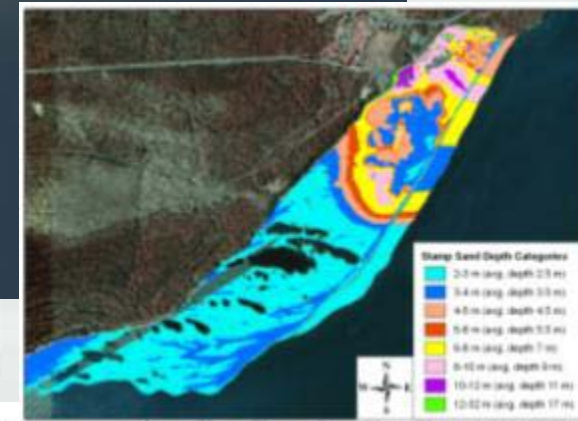
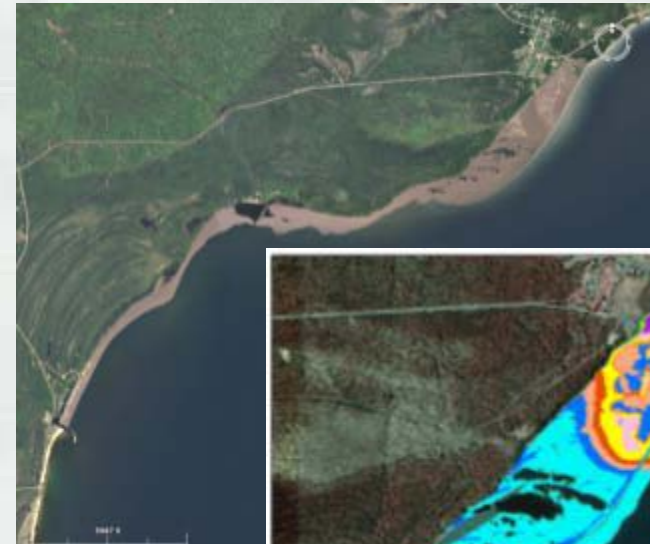


Ustin, S.L. and Hestir, E.L. Hyperspectral & Lidar Sensing of the Delta. (presentation). Center for Spatial Technologies & Remote Sensing (CSTARS). UC Davis.

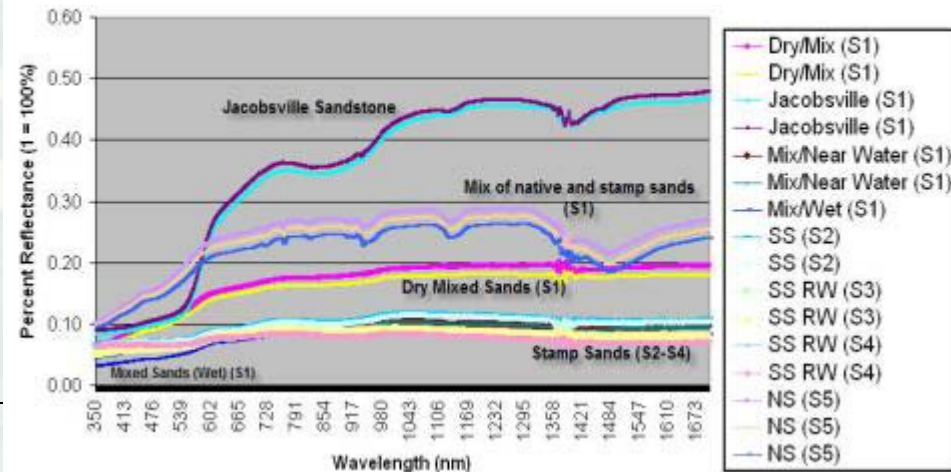
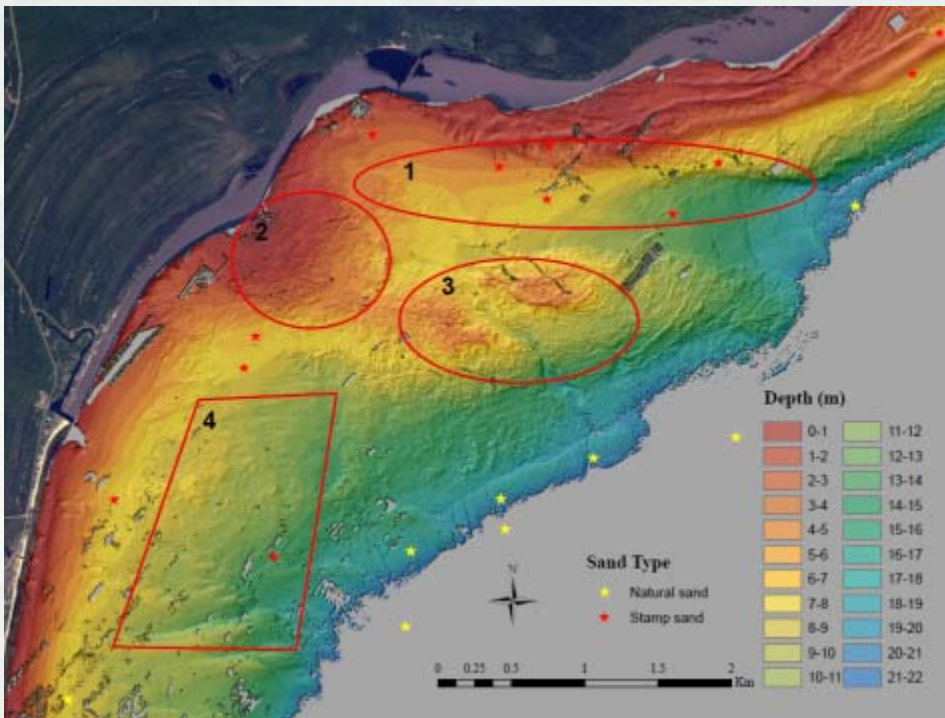


Heavy-metal Stamp Sands Migration in Lake Superior

Purpose: Classify submersed lake bottom surfaces using hyperspectral and lidar bottom reflectance. Map stamp sands distribution and estimate movement and loss of stamp sands to lake.



Stamp Sands and Background Spectra Collection

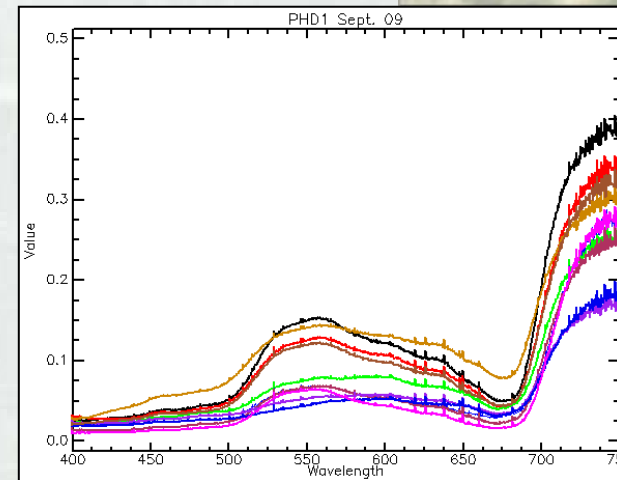


Discrimination of Submerged Aquatic Vegetation Species

Purpose: evaluate and demonstrate the use of fused airborne hyperspectral and bathymetric lidar data to detect and discriminate species of estuarine SAV and macroalgae in two representative small-craft dredged harbors

Background: Dredging impacts to SAV vary by species; CWA lists SAV as a Special Aquatic Site; Mapping species is important for:

- Planning dredging operations
- Mitigating ecological damage
- Monitoring SAV



Submersed Eelgrass spectra,
Plymouth Harbor, MA



Study Sites

Plymouth Harbor, MA



Buttermilk Bay, MA

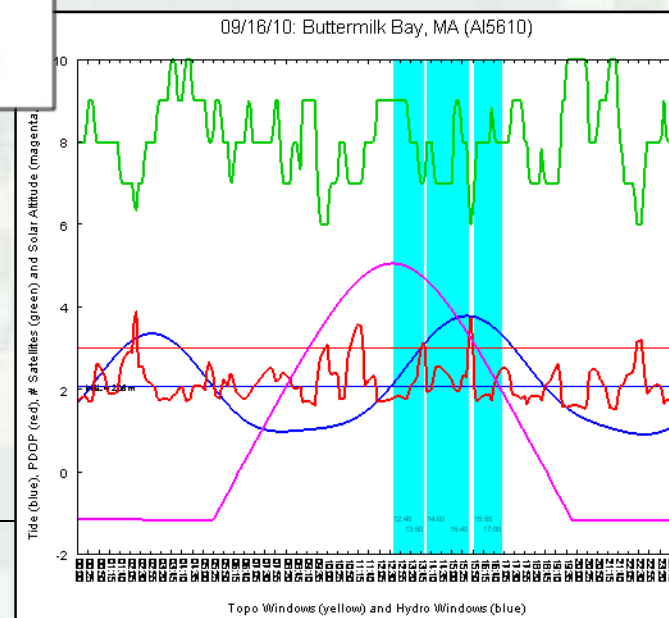
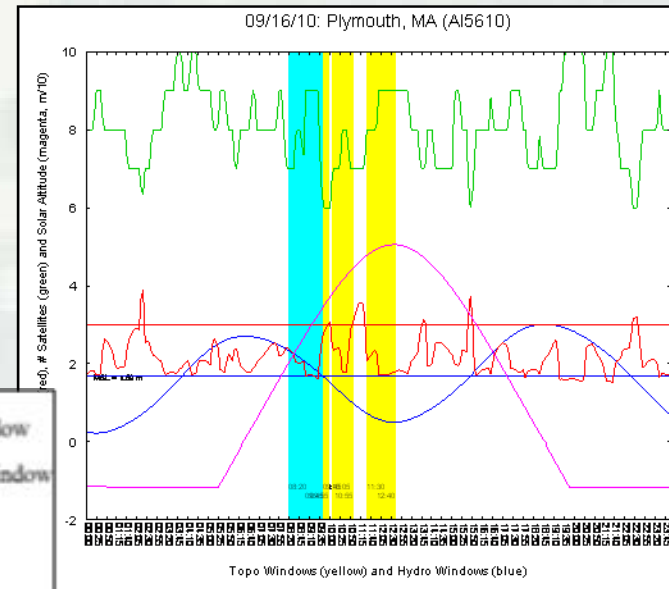
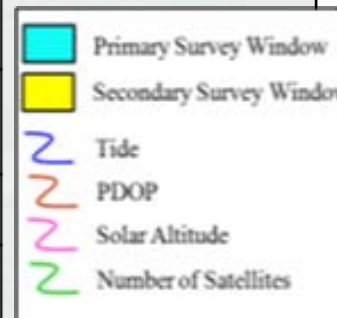


Mission Planning

- Sept 15 – 16, 2010

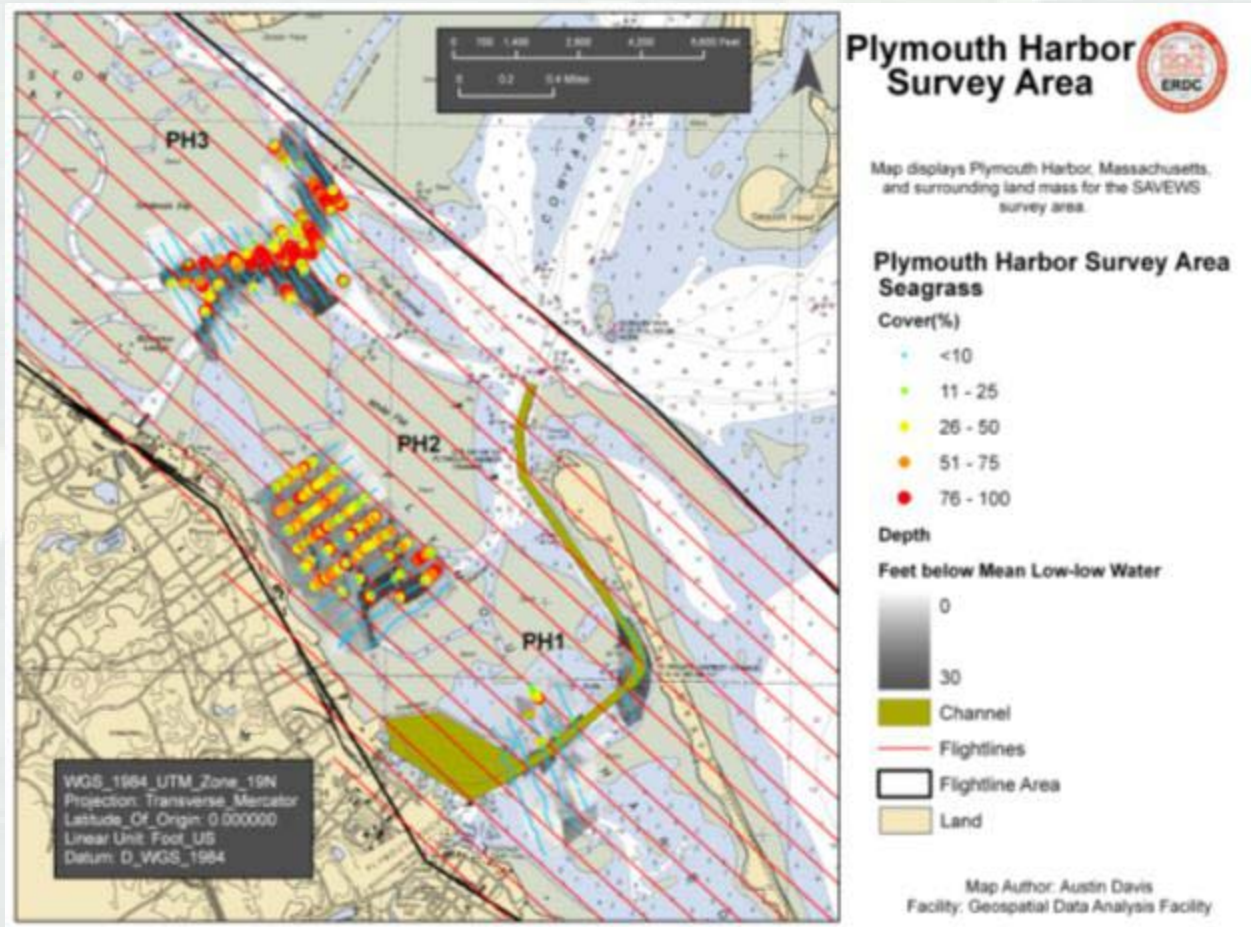
Factor	Level/condition	Criticality	Notes
GPS PDOP ¹	<3.0	Mandatory	Required for image geo-rectification
Solar Elevation	>30 degrees and <50 degrees above horizon	Mandatory	Required for hyperspectral data
Solar Azimuth	Into/out of sun; away from sun is preferable	Highly desirable	Light penetration and return to sensor
Cloud Cover	<10%	Mandatory	Required for hyperspectral data
Sea State	Minimal white capping	Highly desirable	
Tide	Above mean and rising or high	Highly desirable	Required for water clarity and coverage of shallow flats
Wind	<30 knots	Mandatory	Required for flight safety; less white capping

Note: 1. Position Dilution of Precision



Spatial Ground Truth

- Acoustic Survey (ERDC, SAVEWS), Sept 7 - 8



Spatial Ground Truth

- In-situ hyperspectral measurements of SAV/sediments and onshore features (Optech/ERDC, Divespec and ERDC, ASD FieldSpec Pro), Sept 9 - 14
- Underwater video imagery (NAE/ERDC, drop camera), Sept 13 - 14
- Diver observation and sampling (EPA), Sept 14 - 16

Divespec Instrument



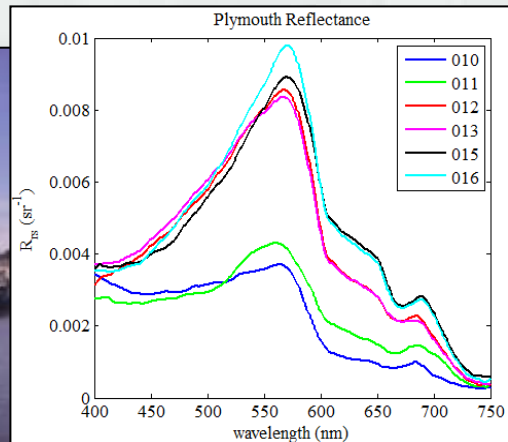
Drop Camera in viewing frame

ASD measurement of SAV



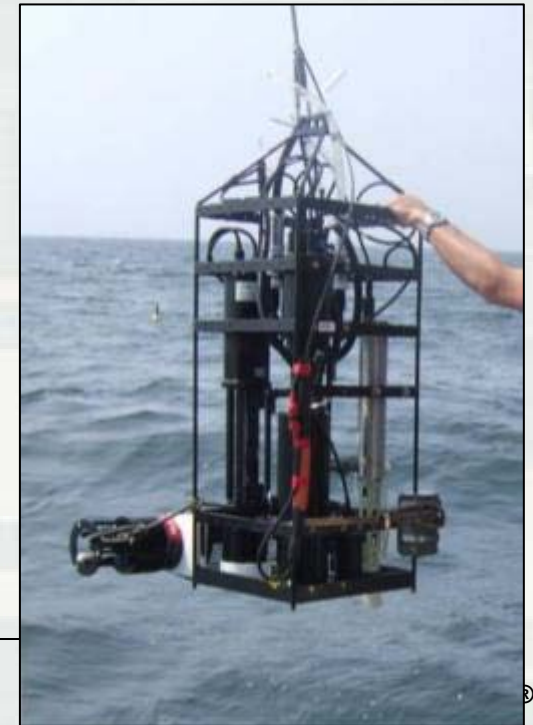
Dynamic Ground Truth

- Spectral irradiance (ERDC, ASD Field Spec Pro)
- Tidal Height (Xtides software and Real-time)
- Water column optical properties: Chl a, absorption, backscattering, attenuation, etc. (Univ. of Connecticut)



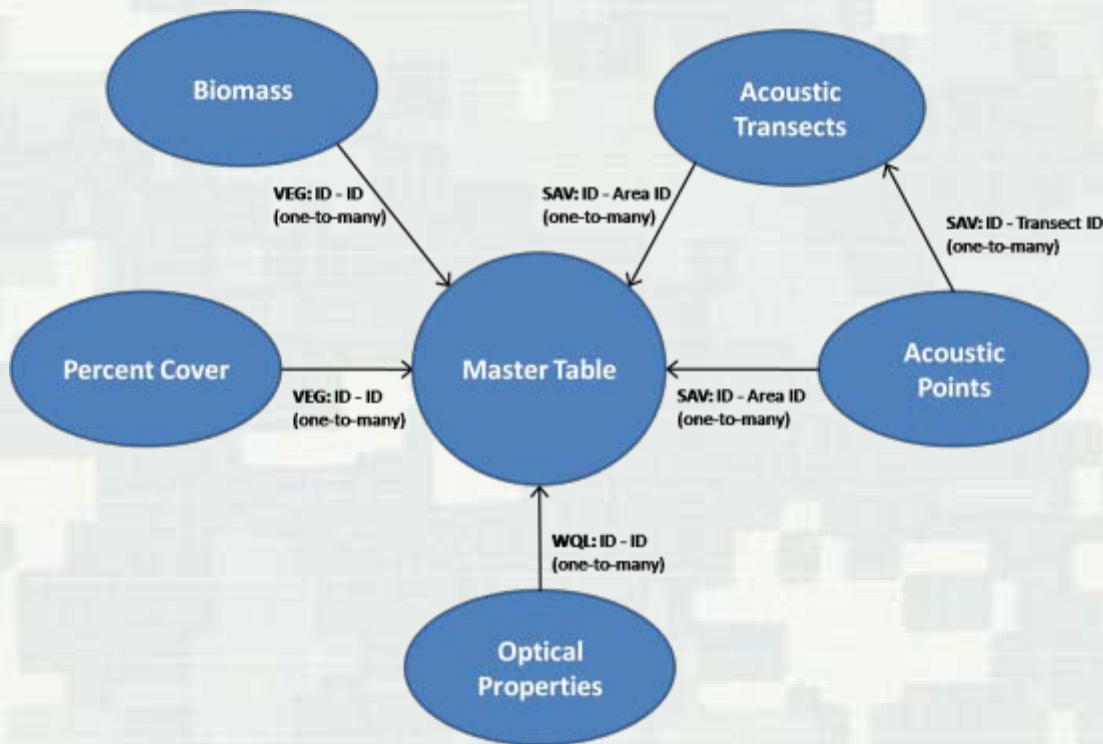
Hyperspectral water-leaving reflectance, Plymouth Harbor, MA

AC-9 Instrument for Optical Measurements



Ground Truth Database

- All ground truth data are compiled in a Microsoft Access database
- Available soon: <http://www.coastalamericafoundation.org/>



Preliminary CHARTS Data

- Google Earth KMZs: preliminary CHARTS data and ground truth site locations also available online soon



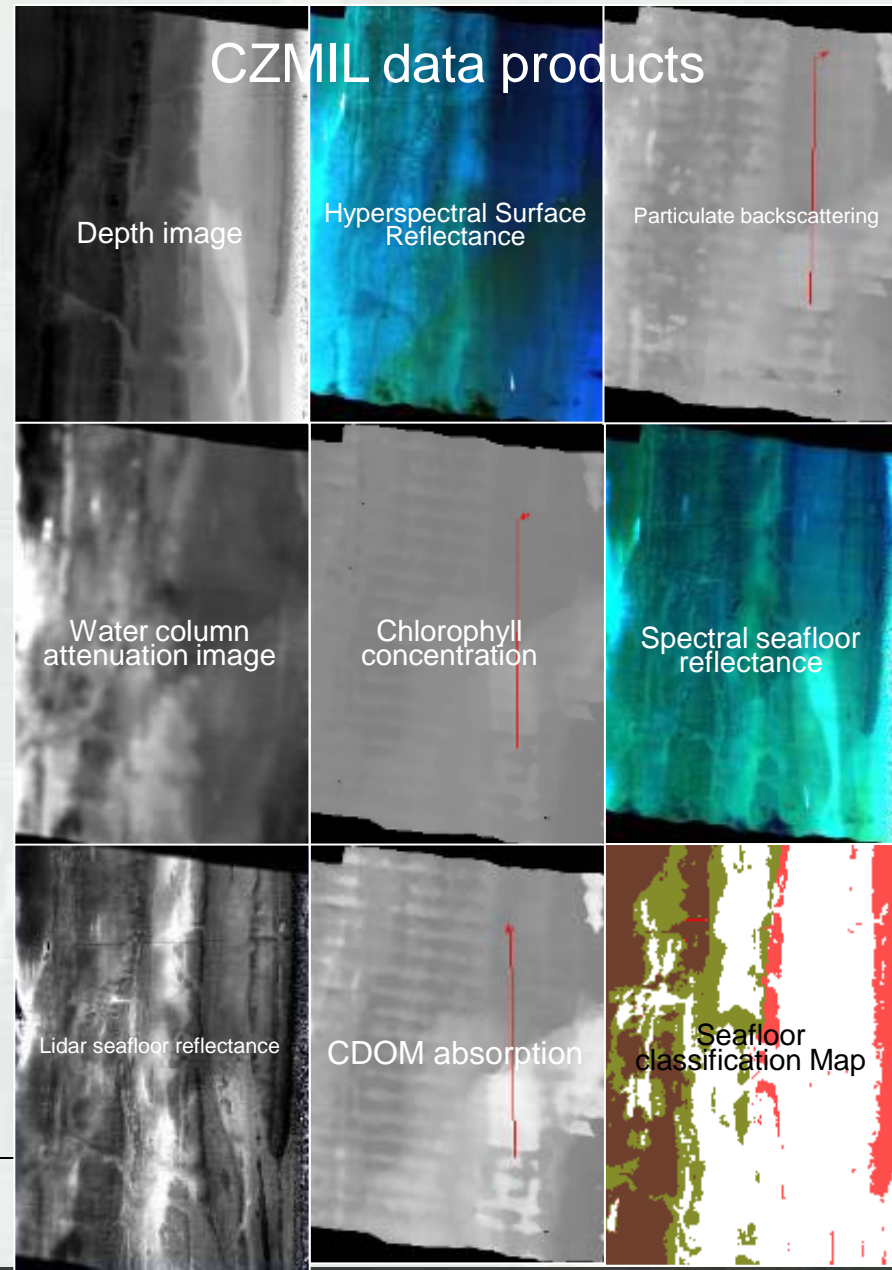
- Lidar elevation data
- Survey polygons
- Flight lines
- Ground truth sites

Buttermilk Bay, KMZ



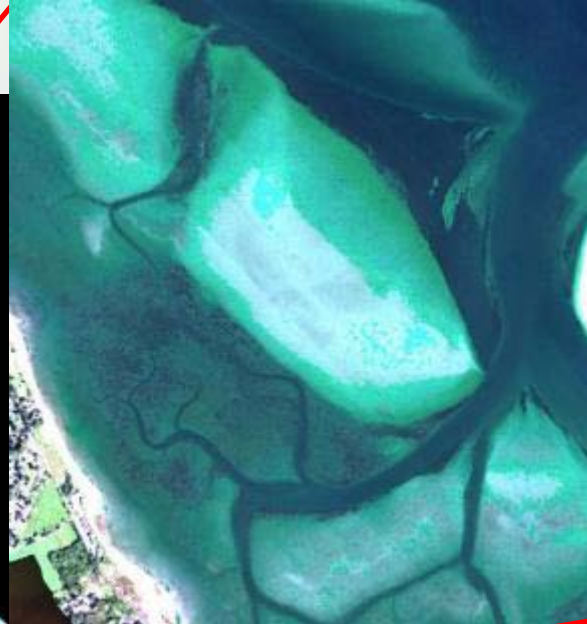
Image Processing Methods

- Coastal Zone Mapping and Imaging Lidar (CZMIL) Data Processing System
 - DPS with *Spectral Optimization* to characterize seafloor and water column constituents
 - * Invert the hyperspectral image with bathymetric lidar depth as constraint to obtain bottom, reflectance, IOPs, etc.
 - Classification of seafloor reflectance to solve for species



Imaging Processing: DPS

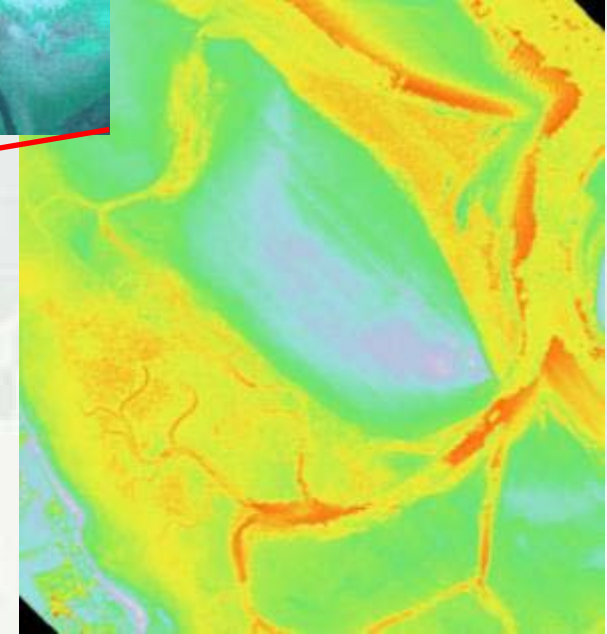
Plymouth Harbor, MA



Hyperspectral water-leaving reflectance

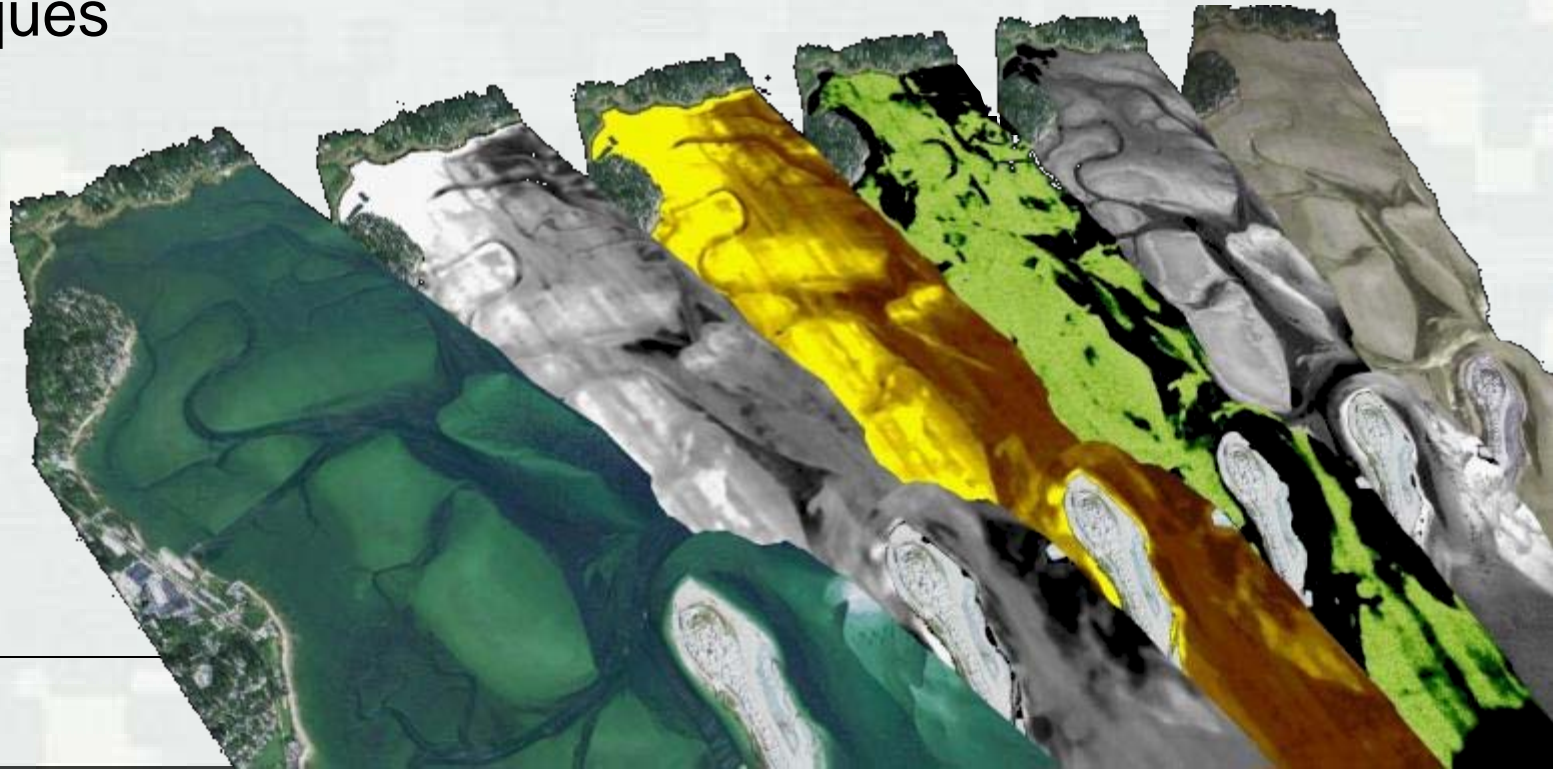


Lidar bottom reflectance



Future Steps

- Continue image processing
- Classification iterations (supervised and unsupervised) using hierarchical approach
- Accuracy assessment and comparisons to other techniques





Joint Airborne Lidar Bathymetry
Technical Center of eXpertise

Questions?

Molly Reif

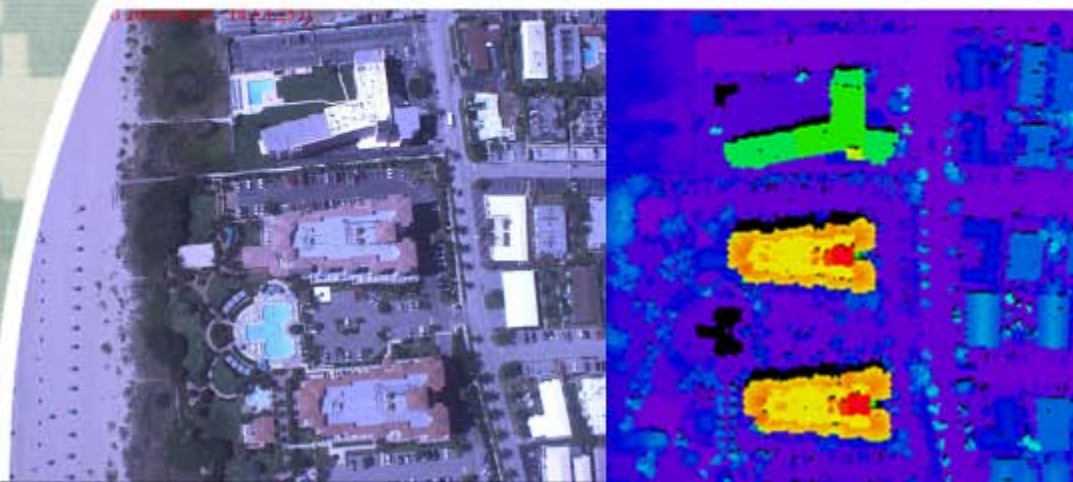
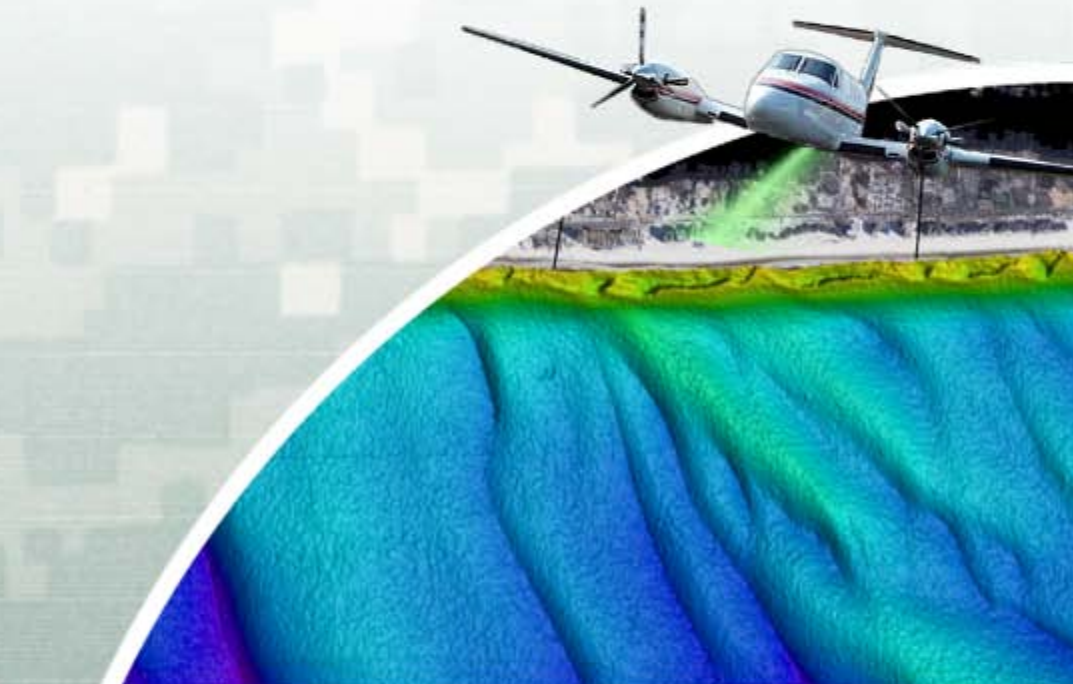
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