National Aeronautics and Space Administration

Airborne Imaging Spectrometer Products over Coastal Louisiana from NASA's Delta-X Campaign

Daniel Jensen[1] (Daniel.J.Jensen@jpl.nasa.gov),
Marc Simard[1], **David Thompson**[1], **Elena Solohin**[2], **Edward Castañeda-Moya**[2]
[1]NASA Jet Propulsion Laboratory, California Institute of Technology; [2]Florida International University

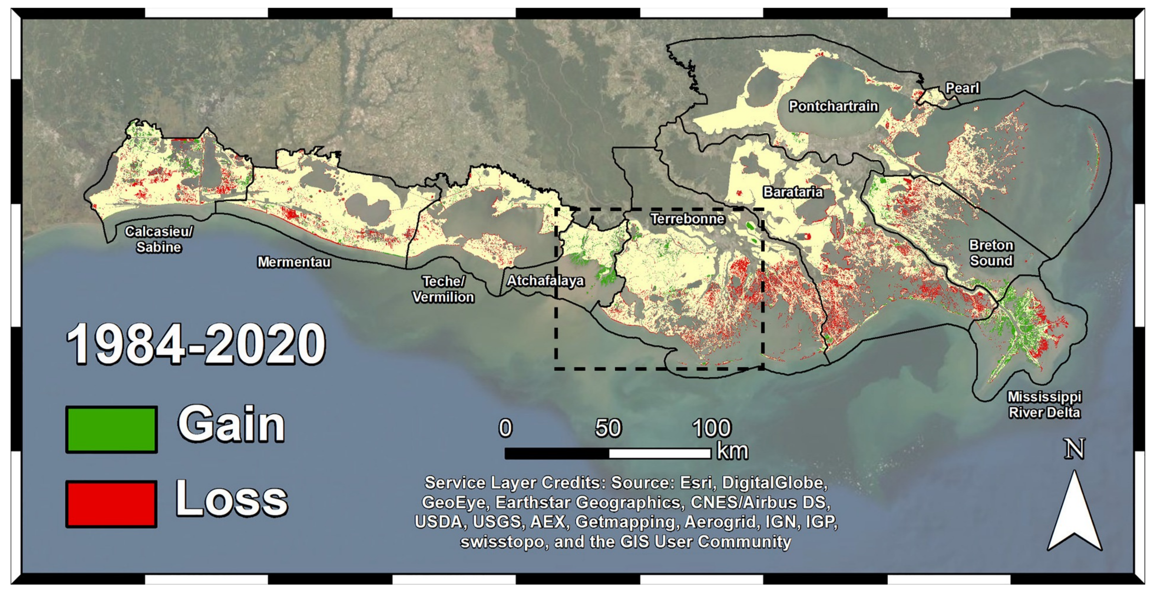


Figure 1: Study area in Louisiana's Atchafalaya and Terrebonne Basins. Map shows these basins' contrasting patterns of wetland gain and loss from 1984-2020 (Jensen et al. 2022).

Abstract

- Aboveground biomass (AGB) plays a critical functional role in coastal wetland stability, as high biomass vegetation contributes to organic matter production, sediment accretion potential, and carbon storage. Here we use Airborne Visible/Infrared Imaging Spectrometer—Next Generation (AVIRIS-NG) data from NASA's Delta-X mission in coastal Louisiana to map vegetation types and herbaceous AGB across the 2021 growing season.
- AVIRIS-NG imagery was obtained with a coincident herbaceous vegetation survey that harvested biomass (n=84) in April and August 2021 (Castañeda-Moya and Solohin 2022). We used these paired samples and reflectance spectra in a machine learning-based regression model that leverages visible-shortwave infrared reflectances. This model estimated seasonal AGB and carbon across the Atchafalaya and Terrebonne Basins' herbaceous wetlands.
- We additionally used the AVIRIS-NG data to map vegetation type across this domain. This classification scheme was based on the image-derived reflectance spectra from the Delta-X vegetation survey combined with 2021 Coastwide Reference Monitoring System (CRMS) survey plots coincident with the AVIRIS-NG imagery. We applied a Principal Components Analysis (PCA) to this compiled spectral library and trained a machine learning-based classifier on selected component responses. We applied the PCA rotation to the AVIRIS-NG imagery along with the classifier to map vegetation types.

Methods

AVIRIS-NG
- Spring and Summer mosaics produced for Atchafalaya and Terrebonne Basins

Field Samples
- 0.25 m^2 herbaceous vegetation plots (Castañeda-Moya and Solohin 2022).
- AGB harvested, dried, and weighed

CRMS Plot Data
- 2021 plot locations with vegetation species
  - Dominant species >50% cover

AGB Regression Model
- Developed machine learning model with Random Forests regression (Jensen et al. *in review*)
  - Independent Variable: AVIRIS-NG pixel reflectance spectra @ field plots
    - Conditional Gaussian Interpolation algorithm developed to correct AVIRIS-NG bands in 880-1000, 1080-1200nm wavelengths
  - Dependent Variable: AGB
  - **R^2 = 0.89, MAE = 109.30 g/m^2**

Vegetation Type Classifier
- Developed machine learning classification model with Random Forests
  - Combined 2021 Delta-X and CRMS vegetation field plots with coincident AVIRIS-NG reflectance spectra
    - N = 504
  - Principal Components Analysis of 300 reflectance bands calculated from sample spectra
    - 13 PCs used, 99.86% variance explained
    - PCA rotation applied to AVIRIS-NG mosaics

Herbaceous AGB and Carbon Maps
- **Herbaceous AGB**
  - Figure 2
  - **Validation**
    - Leave-One-Out-Cross-Validation
    - R^2 = 0.43
    - MAE = 257.30 g/m^2
- **Herbaceous AG Carbon Change**
  - Figure 3

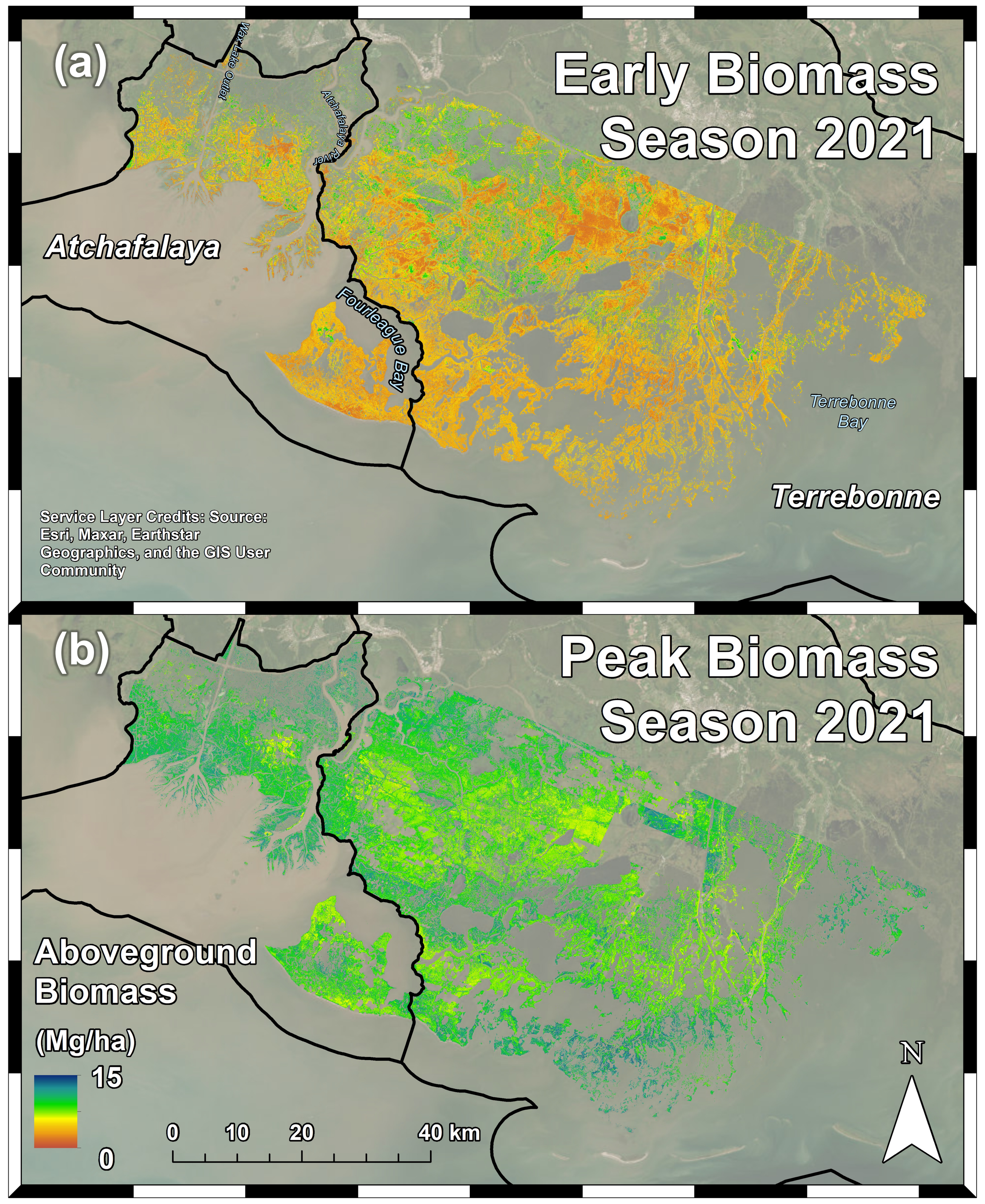
Vegetation Type Map
- Figure 4
- **Validation**
  - In situ dataset randomly subset into 2/3 Training and 1/3 Validation samples
  - Overall Accuracy = 85%
  - Overall Kappa = 0.81

Results

Figure 2 (right): Aboveground biomass (g/m^2) maps derived from the corrected AVIRIS-NG surface reflectance data and corresponding Random Forests model. Figure 2a shows herbaceous AGB in the early growing season. Figure 2b shows herbaceous AGB and total carbon estimates at the peak of the growing season.

Analysis from Jensen et al. (*in review*). Data available via ORNL DAAC (Jensen et al. 2023).

Figure 3 (below): Carbon (megagrams/hectare) allocated in herbaceous vegetation from early to peak growing season, 2021.



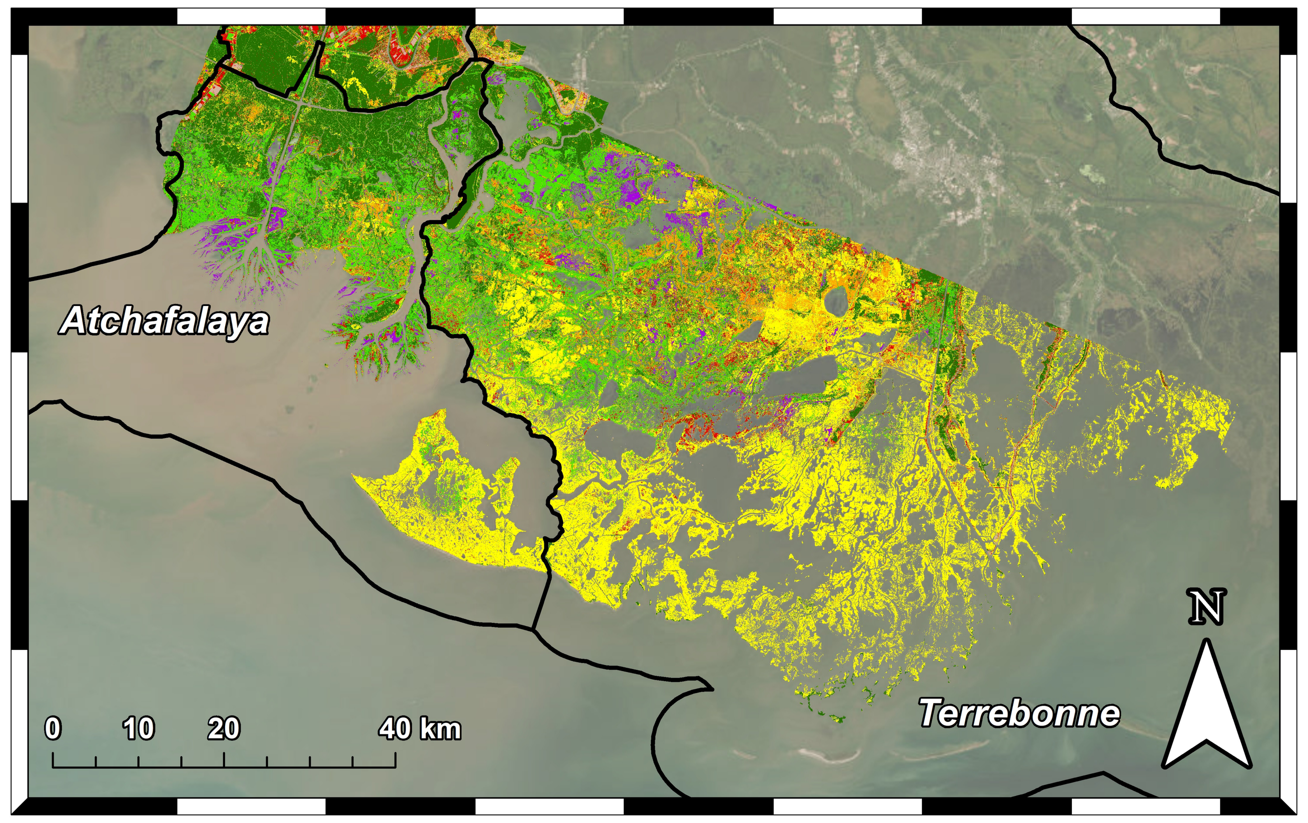
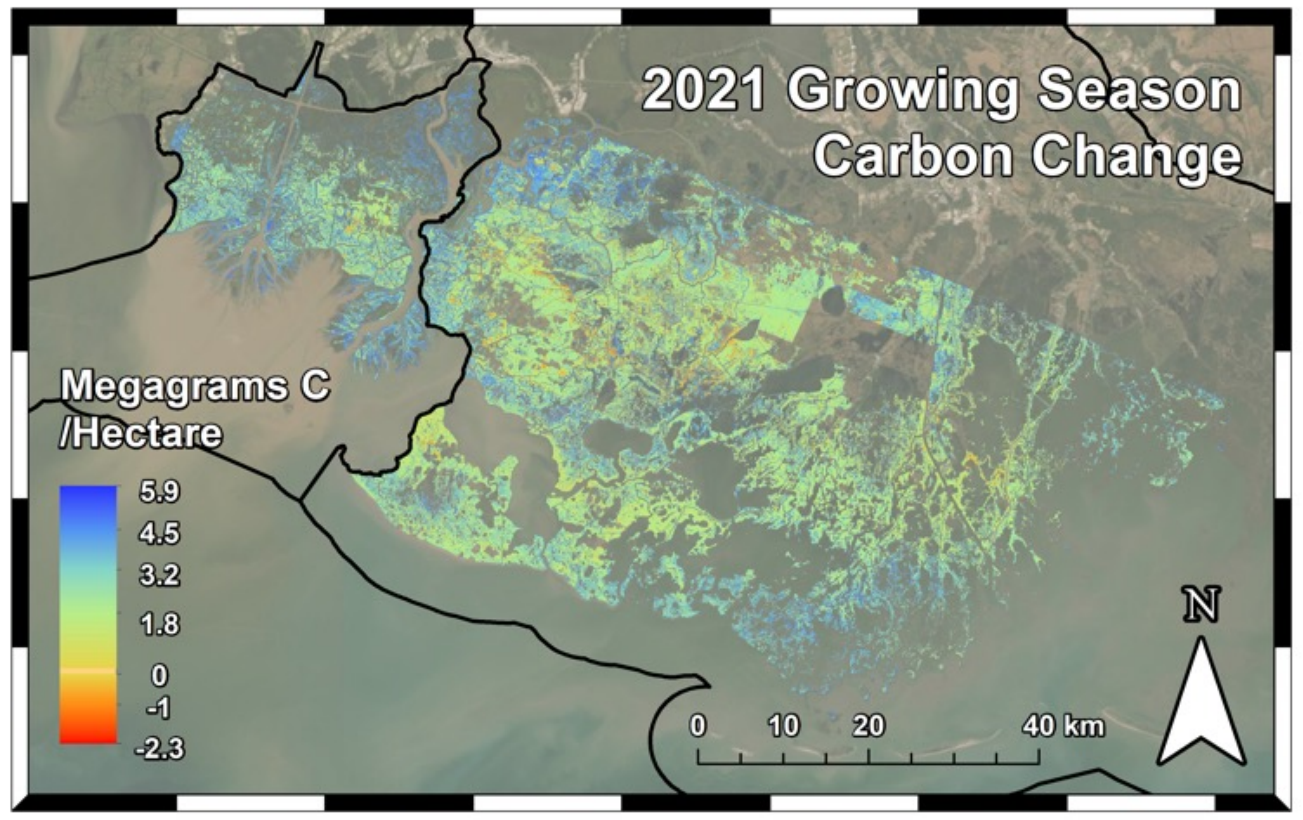


Figure 4 (above): Vegetation type map of the Atchafalaya and Terrebonne Basins

- **Forest**: *Acer rubrum, Salix nigra, Morella Cerifera, Nyssa aquatica, Triadica sebifera, Avicennia germinans*
- **Broadleaf Herbaceous**: *Sagittaria lancifolia, Vigna luteola, Colacasia esculenta, Polygonum punctatum, Murdannia keisak, Thelypteris palustris*
- **Saltmarsh Grasses**: *Spartina patens, Spartina alterniflora, Lythrum lineare, Spartina cynosuroides, Juncus roemarianus*
- **Freshwater/Brackish Grasses**: *Panicum hemitomon, Schoenoplectus californicus, Luziola peruviana, Eleocharis montana, Eleocharis R.*
- **Tall Grasses**: *Phragmites australis, Typha domingensis, Typha latifolia, Zizaniopsis miliacea*
- **Aquatic Vegetation**: *Ludwigia grandiflora, Nelumbo lutea, Eichornia crassipes*
- **Soil/Mudflat/Built**



Conclusions

- The Atchafalaya Basin overall sees more significant seasonal growth. Saltmarshes in the southern Terrebonne Basin see significant seasonal growth, while the brackish marsh interiors exhibit less aboveground productivity. This is consistent with ongoing observations that coastal Louisiana's brackish marsh interiors are less stable and seeing greater loss.
  - Mean carbon concentrations from April-August: Atchafalaya 0.94 → 4.00 Mg/ha, Terrebonne 1.54 → 3.60 Mg/ha
- Imaging spectroscopy/hyperspectral remote sensing provides effective data for accurately mapping vegetation types in wetland environments.
  - Overall Vegetation Type Accuracy = 85%, Kappa = 0.81
  - Future imaging spectroscopy missions such as NASA's Surface Biology & Geology will enable consistent trait maps for vulnerable wetland environments around the globe.

Acknowledgements and References:

- This project is part of JPL's Delta-X Earth Venture Suborbital mission (deltax.jpl.nasa.gov). This work was conducted at NASA's Jet Propulsion Laboratory.

- Castañeda-Moya, E., and E. Solohin. 2022. Delta-X: Aboveground Biomass and Necromass across Wetlands, MRD, Louisiana, 2021. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2000
- Jensen, D., Thompson, D.R., Simard, M., Solohin, E., & Castañeda-Moya, E. (in review). Imaging spectroscopy-based aboveground biomass and carbon estimation in Louisiana's coastal wetlands: Towards consistent spectroscopy for retrievals across atmospheric states. Submitted to Remote Sensing of Environment.
- Jensen, D.J., E. Castañeda-Moya, E. Solohin, A. Rovai, D.R. Thompson, and M. Simard. 2023. Delta-X: AVIRIS-NG L3 Derived Aboveground Biomass, MRD, Louisiana, USA, 2021, V2. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2138
- Jensen, D. J., Cavanaugh, K. C., Thompson, D. R., Fagherazzi, S., Cortese, L., & Simard, M. (2022). Leveraging the Historical Landsat Catalog for a Remote Sensing Model of Wetland Accretion in Coastal Louisiana. Journal of Geophysical Research: Biogeosciences, 127(6), e2022JG006794.

National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California
www.nasa.gov