TH53E - Advancing Coastal Research in the Southeast United States: Insights from a DOE Environmental System Science Workshop

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Overview

- Background on DOE
- Southeast Coastal Workshop
- Highlights
  - Defining characteristics
  - Key gaps and uncertainties
  - Research Priorities and Opportunities
- Q&A

Link to download this presentation

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Our Mission:

Deliver scientific discoveries and major scientific tools to transform our understanding of nature and advance the energy, economic, and national security of the United States.

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Steward **10** of the 17 DOE national laboratories

More than **37,000** users of **28** Office of Science scientific user facilities

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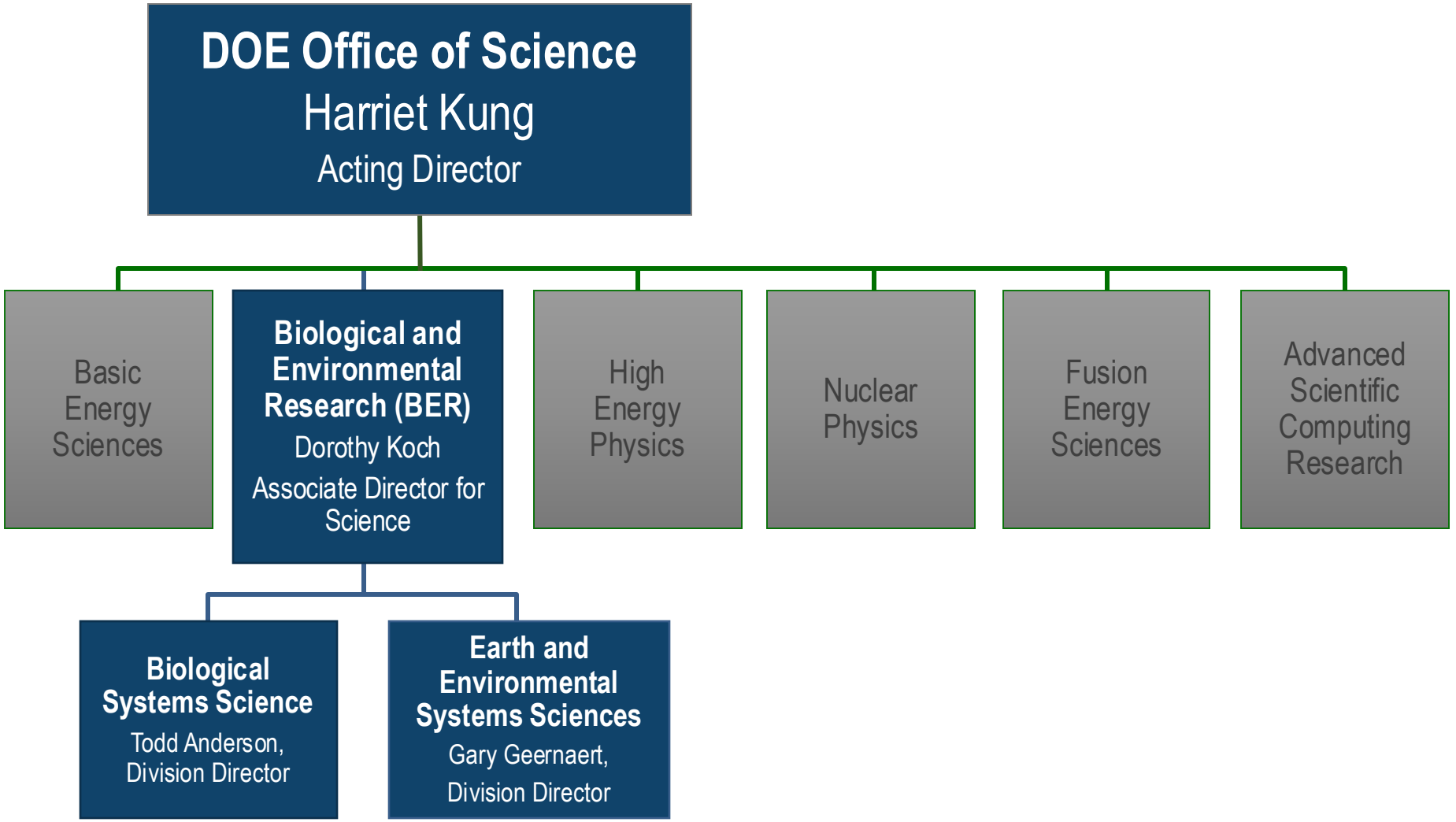
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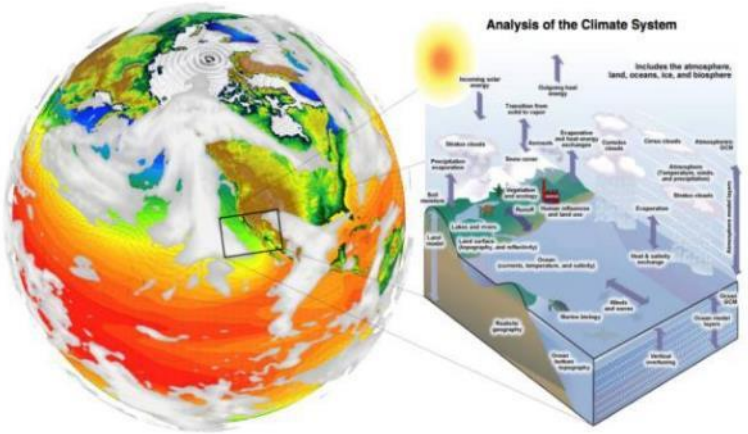


Atmospheric System Research

- Atmospheric Process Science
- Atmospheric Radiation Measurement (ARM) facility

Earth and Environmental Systems Modeling

- Earth System Model Development
- Regional and Global Model Analysis
- Multisector Dynamics

Environmental System Science

- Ecosystem and Watershed Sciences
- Environmental Molecular Sciences Laboratory (EMSL)

Data Management for Earth and Environmental Sciences

https://science.osti.gov/ber/Research/eessd

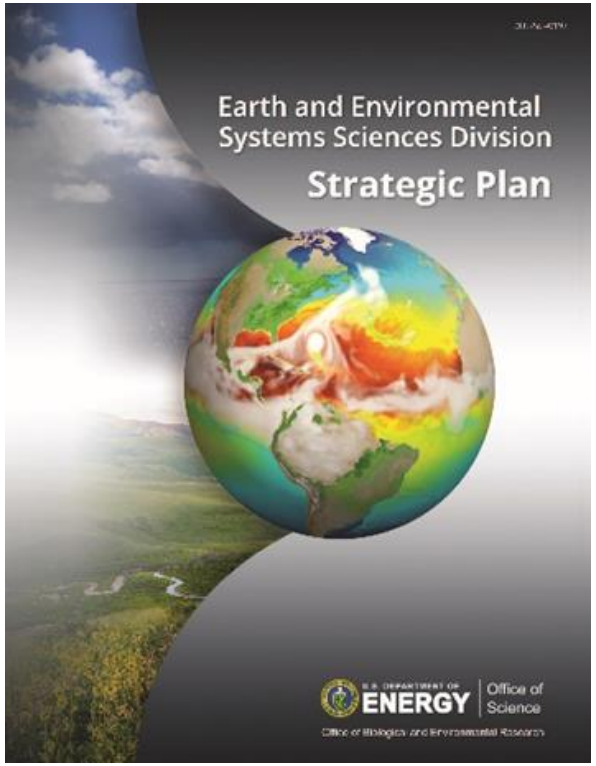
2018-2024 EESSD Strategic Plan

EESSD's Mission: To enhance the seasonal to multi-decadal scale predictability of the Earth system using long term field experiments, DOE user facilities, modeling and simulation, uncertainty characterization, best-in-class computing, process research, and data analytics and management in order to inform the development of advanced solutions to the Nation's energy challenges.

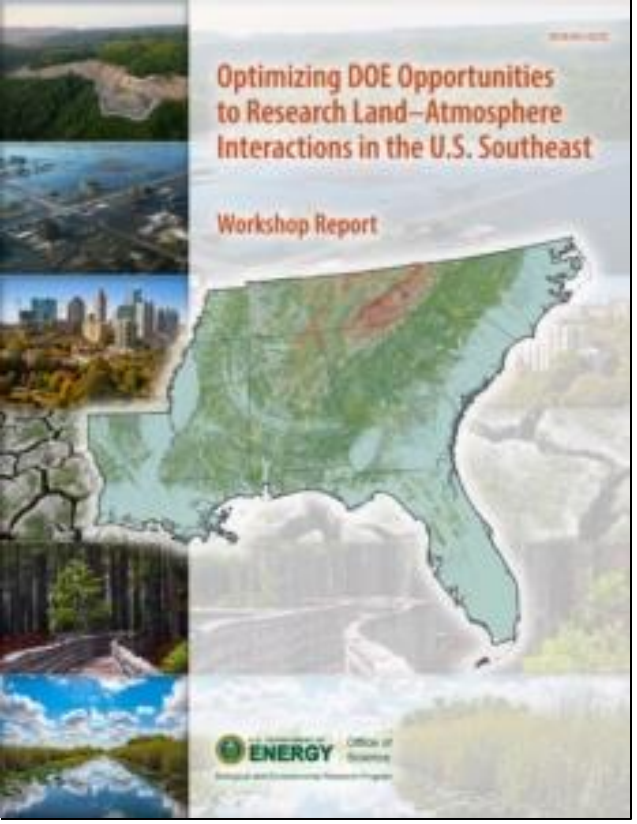
Vision: An improved capability for Earth system prediction on seasonal to multi-decadal time scales to inform the development of resilient U.S. energy strategies.

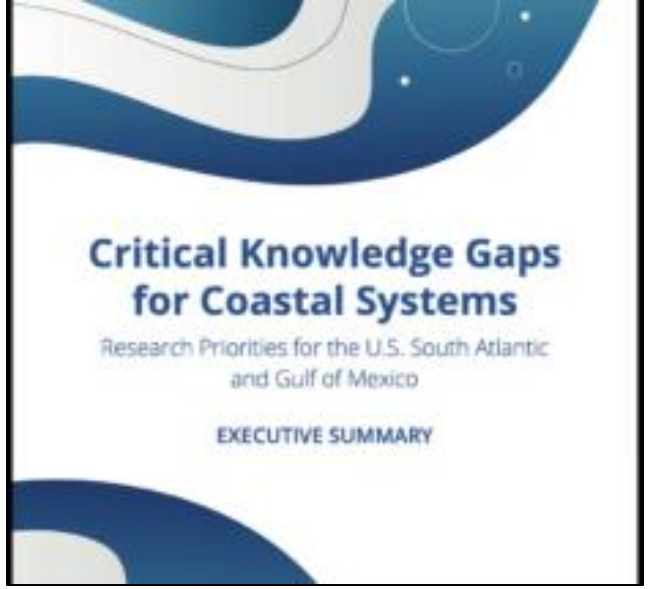
Strategic Plan Grand Challenges

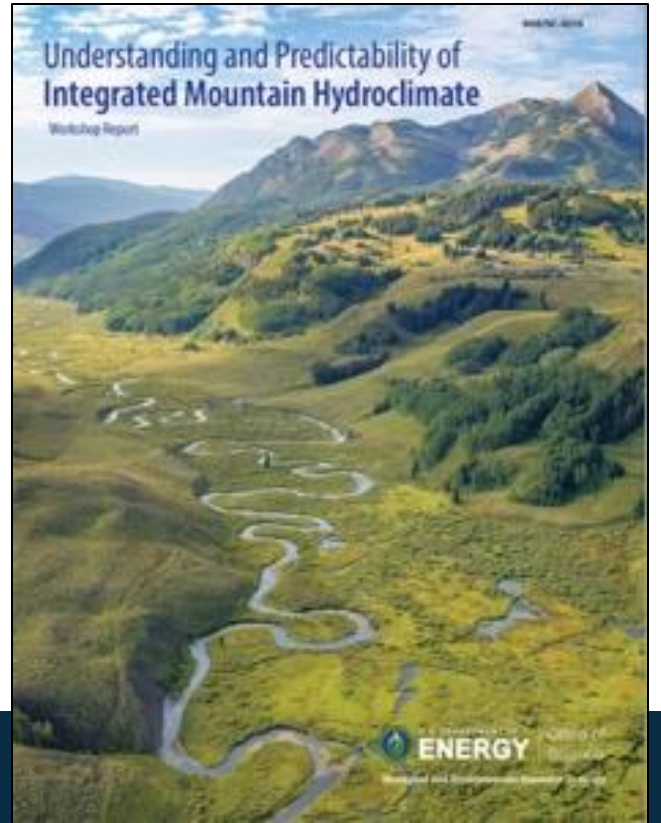
- Integrated water cycle
- Biogeochemistry
- High Latitudes
- Drivers/Responses in the Earth System
- Data-Model Integration



https://science.osti.gov/-/media/ber/pdf/workshop-reports/2018_CESD_Strategic_Plan.pdf







Recent Workshops to Inform Priorities

- ***Critical Knowledge Gaps for Coastal Systems (March 2024)***
- Southeastern Land-Atmosphere Research Opportunities (Aug 2023)
- Artificial Intelligence for the Methane Cycle (March 2023)
- Understanding and Predictability of Integrated Mountain Hydroclimate (January 2022)
- Understanding Decision-Relevant Regional Climate Data Products Workshop (Nov 2022)
- AI for earth system modeling (Dec 2024)
- Lessons Learned from Ecosystem-Scale Experimental Field Studies (January 2025)
- Designing Future Ecosystem Experiments (Summer 2025)

Environmental System Science

ESS
Environmental
System Science

Goal: advance an integrated, robust, and scale-aware predictive understanding of terrestrial systems and their interdependent microbial, biogeochemical, ecological, hydrological, and physical processes.

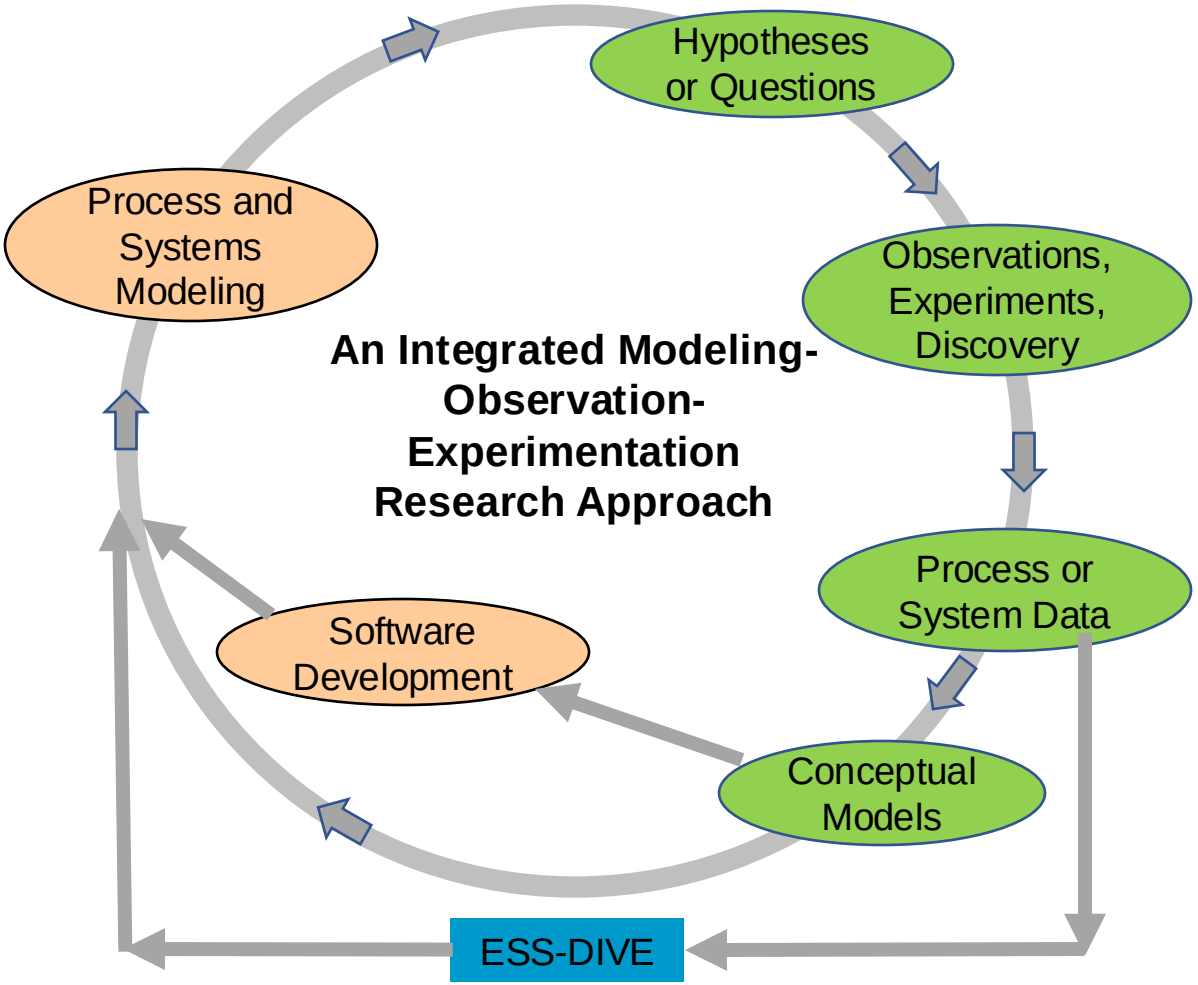
Objectives:

- Develop an integrated framework using a **systems approach**, emphasizing **ecological and hydro-biogeochemical linkages** among system components
- Elucidate the complex processes and controls on the structure, function, feedbacks, and dynamics of **terrestrial ecosystems and watersheds**
- Advance **foundational process knowledge** to address key knowledge gaps and uncertainties across a range of spatial and temporal scales, and
- Incorporate those **scientific findings into process and system models** and use model outputs to inform experiments.

Scope:

- From the **bedrock through the soil, rhizosphere, and vegetation to the atmosphere**
- From **molecular to global scales** and nanoseconds to decades, with an emphasis on understudied ecosystems and characterizing processes across interfaces (**e.g., coastal systems**)

The Model- Experiment (ModEx) Paradigm

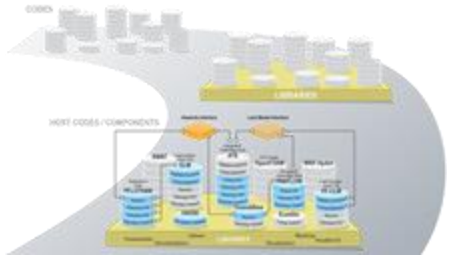


- Our **"predictive understanding"** is encapsulated in process, ecosystem, watershed and Earth System models over vast spatial and temporal scales (molecular to global)
- **Identified needs and gaps in state-of-the-art models help motivate ESS research** on ecological and hydro-biogeochemical processes
- Coupling modeling needs with process investigation **generate research hypotheses** that ESS researchers interrogate with lab, field, and observational research.
- Results of ESS process research are incorporated into **new model developments and simulations**
- Comparing model improvements and predictions against observations or field experiments identify uncertainties that need further observational/field research (***not a one-way street***).

ESS Open Data and Open Science Philosophy

AMERIFLUX MANAGEMENT PROJECT

ESS-DIVE
Deep Insight for Earth Science Data



IDEAS- Watersheds

WHONDRS
Worldwide Hydrobiogeochemistry Observation Network for Dynamic River Systems

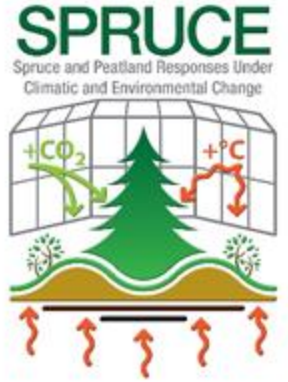
LeafWeb

FRED
Fine-Root Ecology Database

Field Research in Critical Systems

COMPASS
Coastal Observations, Mechanisms, and Predictions Across Systems and Scales

SPRUCE
Spruce and Peatland Responses Under Climatic and Environmental Change



Watershed Testbeds

Why Southeast U.S. Coastal Systems?

- **Coastal systems are areas of high hydro-biogeochemical activity and predictive uncertainty** in local to global environmental and Earth system dynamics and are home to significant human populations and energy infrastructure.
- **Complex feedbacks, drivers, and stressors present challenges for transferrable and scale-aware predictive understanding** of coastal system processes, their role in the Earth system, and the impacts of and feedbacks to future environmental change.
- Southeast coastal systems have characteristic physical, ecological, hydrological, and climatic conditions that result in **mechanisms and processes distinct and unique from those of other U.S. coastal regions**.

Critical Knowledge Gaps for Coastal Systems: Research Priorities for the U.S. South Atlantic and Gulf of Mexico Workshop

- Held in Gaithersburg, MD on March 26-27, 2024
- Objective of the workshop was to solicit feedback from the research community on major gaps and research priorities in knowledge, data, and modeling relevant to coastal ecosystems in the southeastern United States.
- 48 participants representing 34 institutions and 19 states/territories

Workshop participants and observers

Workshop Attendees

Amanda Spivak**	Clint Dawson**	**Jesus Gomez Velez**	Katrina Bennett	Tiffany Troxler**
Andre Rovai	Deepak Mishra	Jianqiu Zheng	**Ken Krauss****	Tom O'Halloran**
Angelia Seyfferth	**Devon Eulie**	Joel Rowland**	Margaret Torn	Vanessa Garayburu-Caruso
Anna Armitage	**Elizabeth Herndon**	**John White**	Melanie Mayes**	**Victoria Congdon****
Ariane Peralta	Eric Ward**	Jorge Villa	**Nick Ward****	Wei Wu
Ashley Smyth	Greg Noe	Joseph Quansah	**Pamela Weisenhorn****	Xavier Comas
Ben Sulman**	**Havalend Steinmuller****	Josh Breithaupt	**Peter Thornton****	**Xi Yang****
Bradley Christoffersen**	Holly Michael**	Julia Cherry	Sophie Lafond-Hudson	**Xingyuan Chen****
Brita Jessen**	Jeff Chanton	**Julia Guimond**	Susannah Tringe	Brian Benscoter and Gil Bohrer
Camilo Rey-Sanchez	Jessica O'Connell	Kaizad Patel	Tana Wood**	ORISE Staff

plenary speaker **writing team for pending workshop report

Workshop Objectives

Inform development of a workshop report to:

1) Identify unique and/or critical needs and gaps that require coordinated observations and manipulative experiments advance the predictive process-based understanding of the region;

2) Identify collaborative and synergistic research opportunities in the regions; and

3) Discuss opportunities for coordinated, integrated ESS research that leverage DOE resources and capabilities and those of other agencies and stakeholders.

Southeast U.S. Coastal Domain

- Atlantic coast from Virginia/North Carolina border south to Florida
- U.S. Gulf of Mexico coast from Florida to Texas

- "Boots, not boats"
  - Terrestrial side of the coastal domain

- Ecosystems directly influenced by and with direct influence upon the coastal terrestrial-aquatic interface

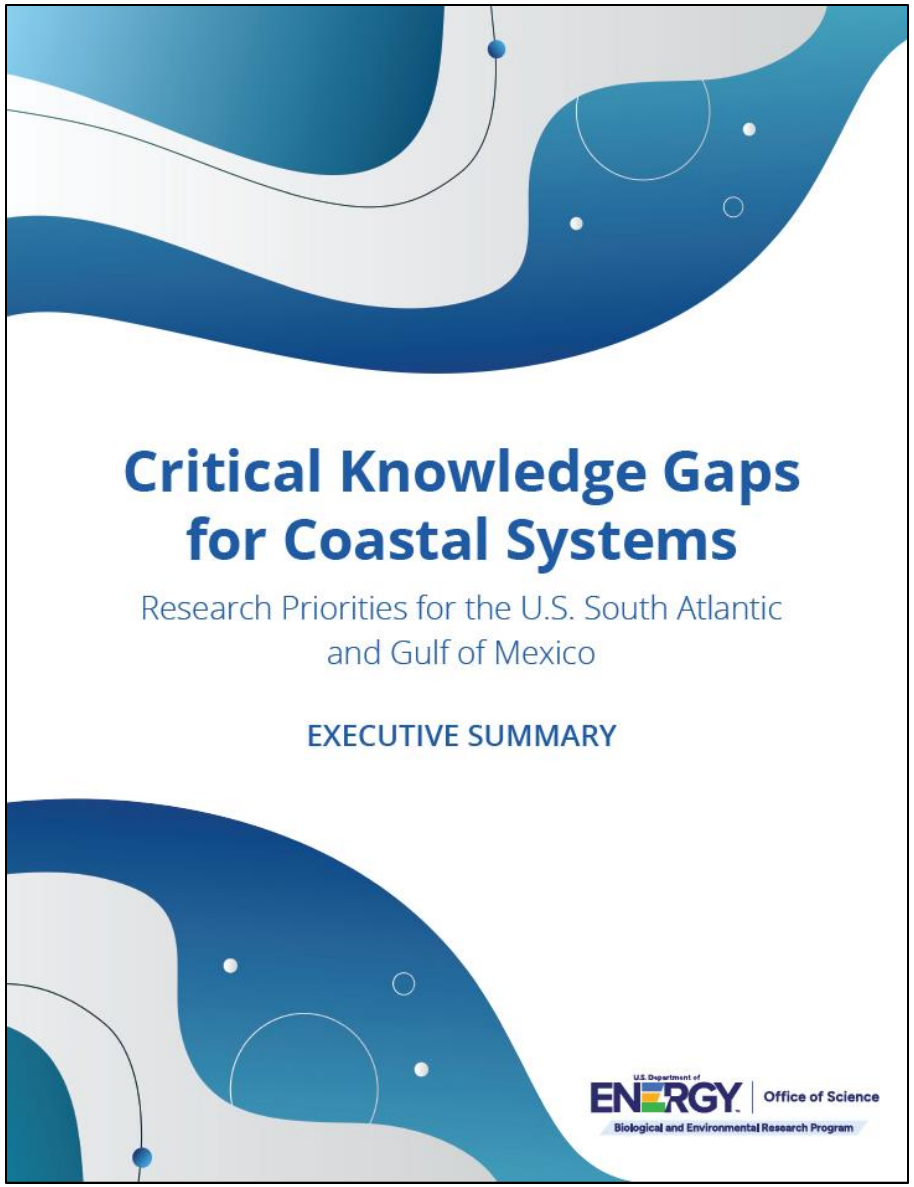
Workshop Products

Full workshop report in progress

- Early 2025

Executive Summary released last month

Synthesis topic in FY25 ESS solicitation



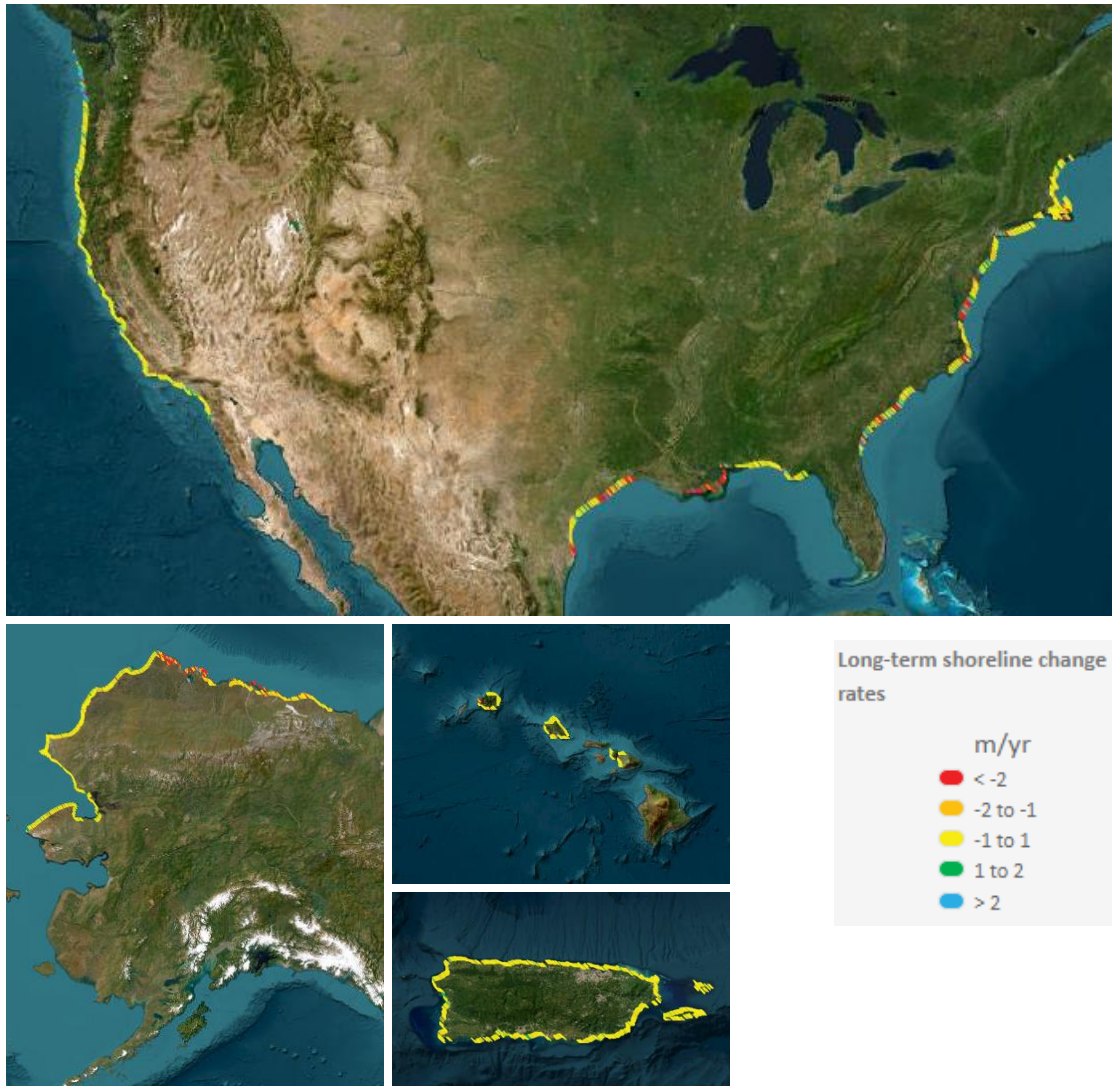
https://ess.science.energy.gov/southeast-coastal-systems-report/

Characterizing southeastern coastal zones

What characteristics of the southeastern U.S. are similar to or distinct from other coastal regions of the U.S.?

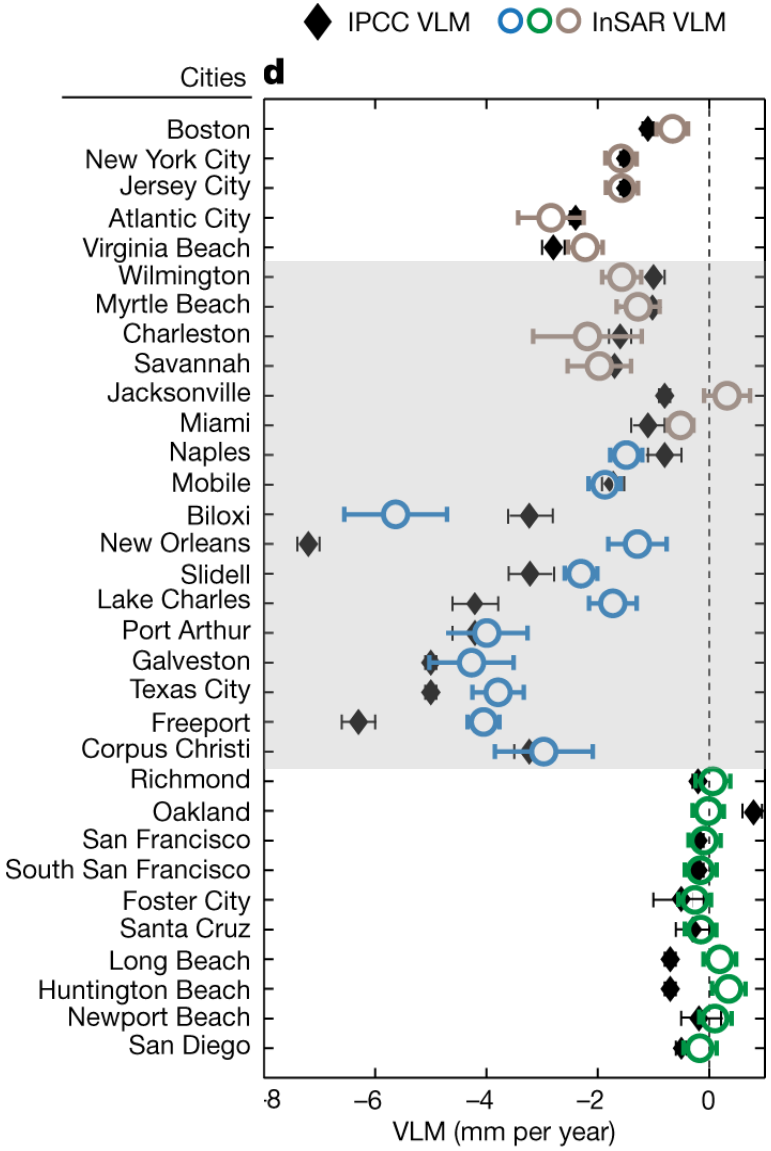
USGS Coastal Change Hazards

Long-term Shoreline Change Rates



Gulf and South Atlantic coastal ecosystems have **similar** features and challenges as other coastal regions:

- Tides that induce variability in salinity and inundation
- Extreme weather events (e.g. Hurricanes and storm surges)
- Human infrastructure, development, and industry
- Sea level rise and saltwater intrusion



South Atlantic and **Gulf Coast** cities experience widespread negative vertical land motion

Figure adapted from Ohenhen et al. (2024) Nature

Gulf and South Atlantic coastal ecosystems also have ***unique*** features and challenges that warrant focused research and model representation:

- Hot and humid climate
- Unique and diverse ecosystems and ecotones
- Micro- to mesotidal regimes
- Low elevation gradients
- High rates of subsidence and relative sea level rise
- Frequent extreme storms

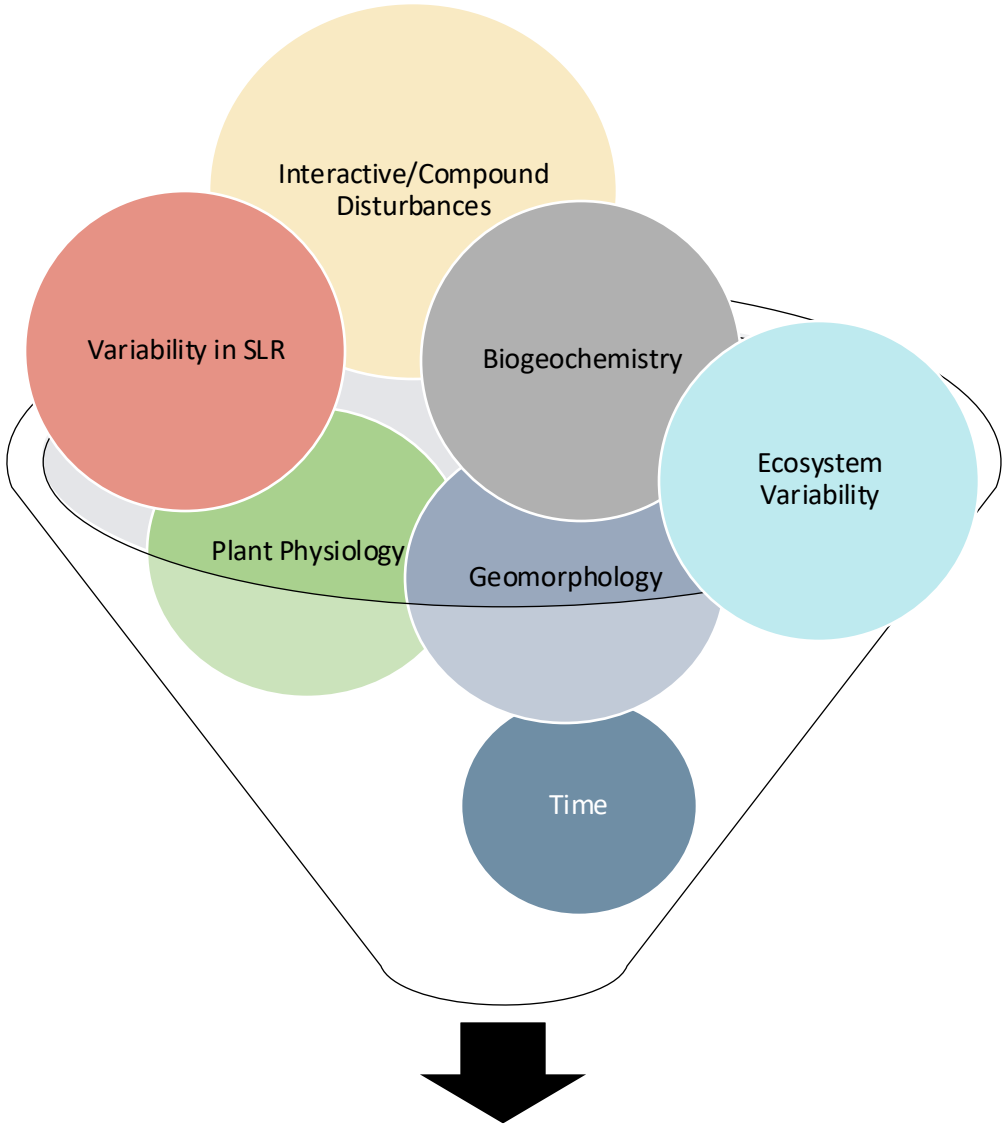
Atmospheric: rising temperatures, more frequent temperature and precipitation extremes, tropical storms

Seaward: sea level rise, storm surge and extreme tides, ocean water temperature and composition

Terrestrial: changing river inputs, urbanization, agriculture, fire, invasive species, subsidence

- (Compound) flooding
- Drought
- Salinization and contamination
- Vegetation damage and die-off
- Shifting ecosystem distribution
- Belowground impacts
- Climate feedbacks
- **Human vulnerability to storm damage, flooding, and poor water quality**

Efforts to understand southeast U.S. coastal vulnerabilities are hampered by the complexity of the situation



Modified from slide presented by Havalend Steinmuller

Critical gaps in knowledge, data, and modeling

- **Distribution and Connectivity of Coastal Systems**
- **Biogeochemical Processes Underlying Ecosystem Function**
- **Response to Compounding Stressors and Disturbances**

Critical gaps in knowledge, data, and modeling

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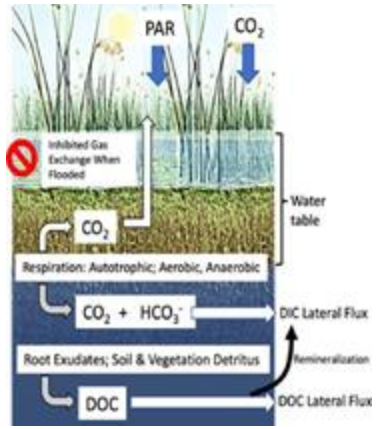
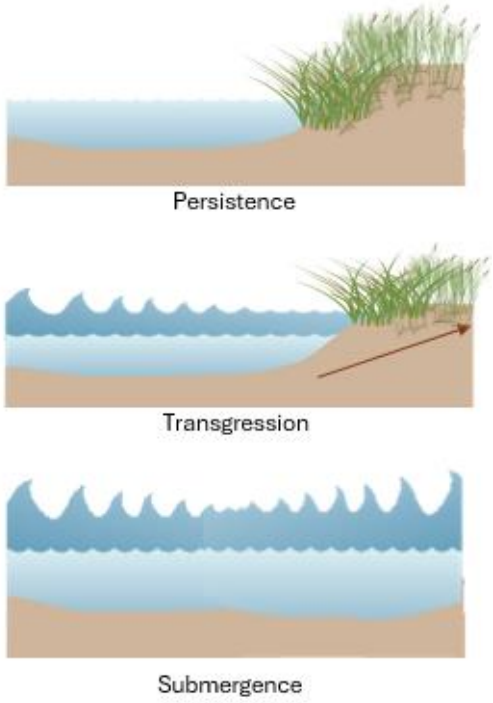
Mangroves

Ken Krauss



Eric Ward



Havalend Steinmuller

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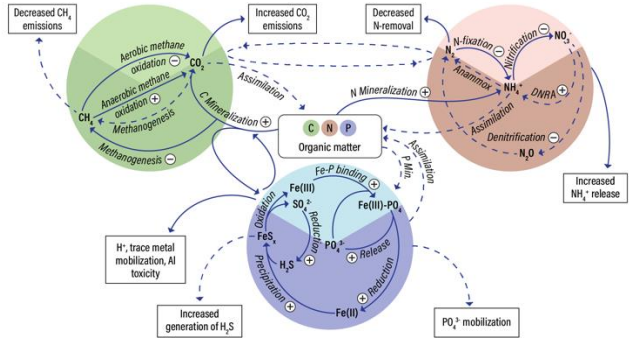
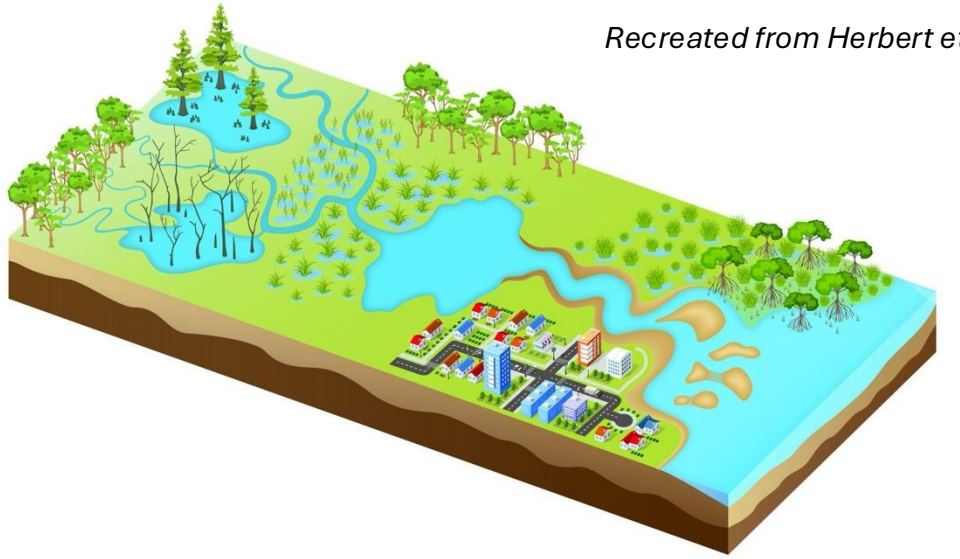


Recreated from Herbert et al. (2015)



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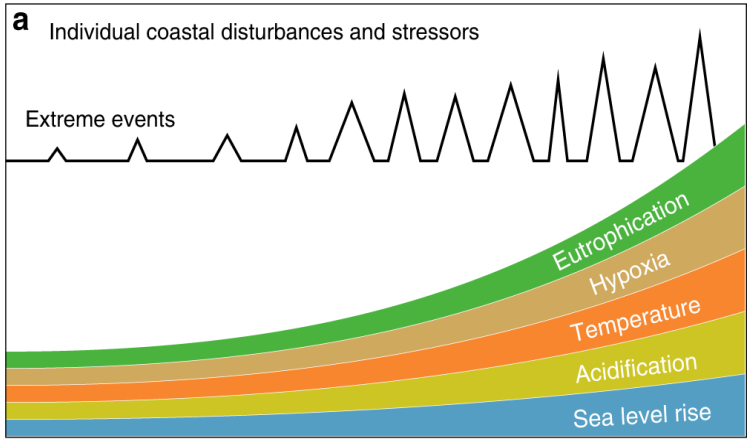
- **Response to Compounding Stressors and Disturbances**

Tom O'Halloran

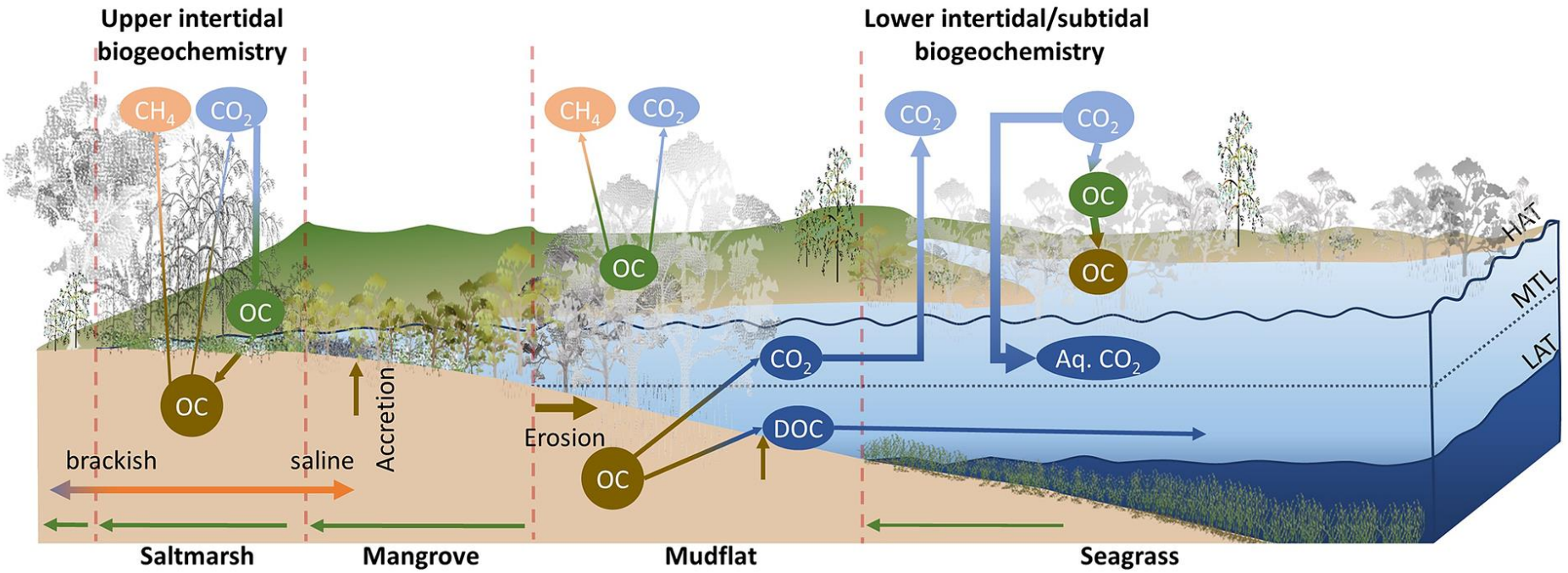


Ward et al. (2020)

Science priorities and research opportunities

- **Understand effects of individual and compounding stressors and disturbances**
- **Impacts of ecosystem state change on associated biotic communities and biogeochemical processes**
- **Representation of integrated inland-to-estuary watershed processes**

Advance predictive understanding of how ecosystem structure and function respond to relative sea level rise, emphasizing the belowground and climate impacts of shifting vegetation distributions.



from Rogers et al. (2023)

Partner with ongoing projects and monitoring networks to leverage existing data that will clarify historical and ongoing trends, inform model development, and identify remaining data/knowledge gaps.

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NATIONAL ESTUARINE RESEARCH RESERVE

Coastal Carbon Network

SWISLR RCN

Coastal Critical Zone Network

SCIENCE AND MANAGEMENT ADVANCES
FORESTED WETLANDS
OF THE UPPER ESTUARY

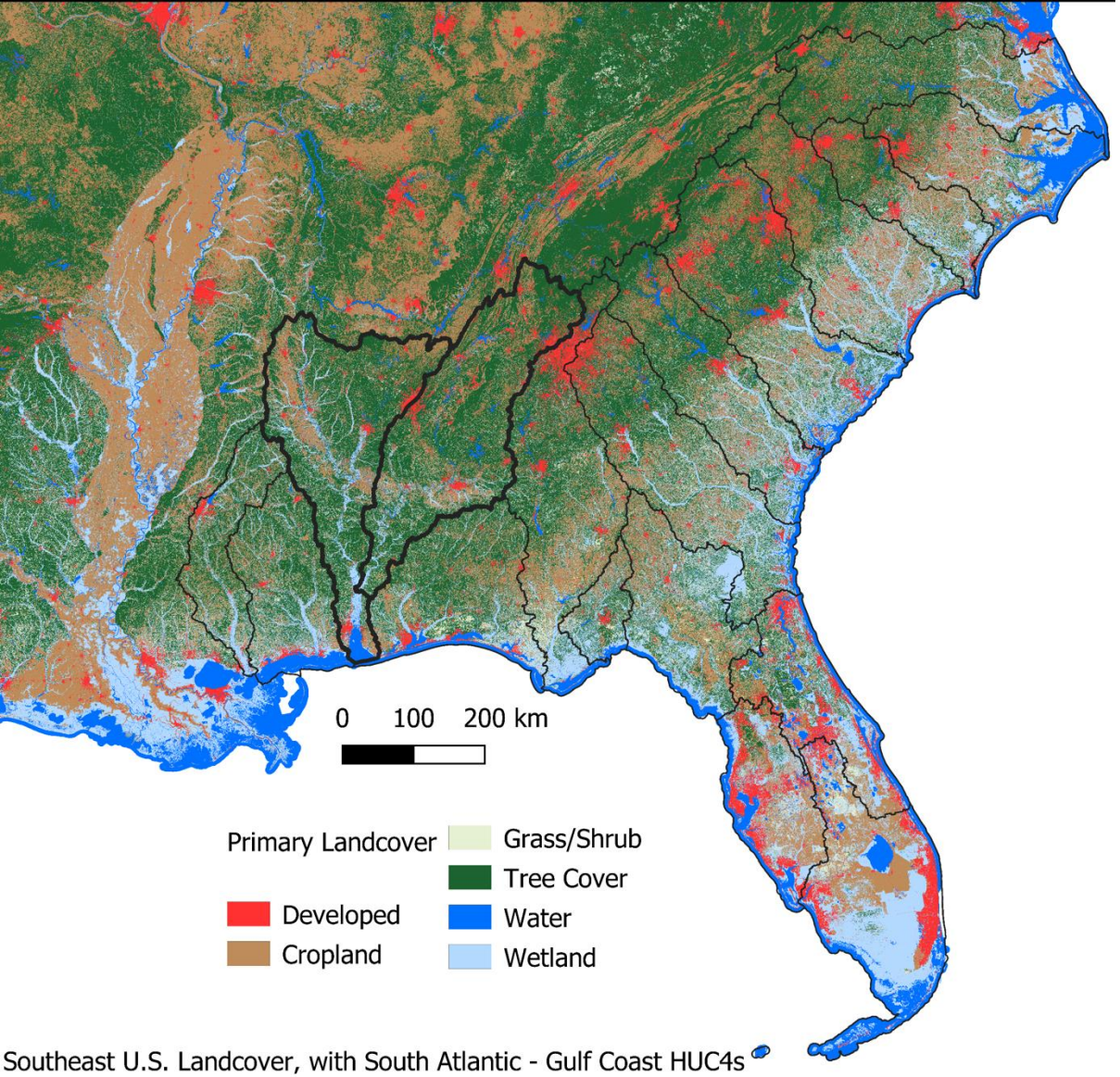
FCE LTER

Sea Grant

COMPASS | FIELD, MEASUREMENTS, AND EXPERIMENTS
Coastal Observations, Mechanisms, and Predictions Across Systems and Scales

Georgia Coastal Ecosystems LTER Project

National Estuarine Research Reserve System Science Collaborative



Southeast U.S. Landcover, with South Atlantic - Gulf Coast HUC4s

Figure courtesy of Peter Thornton

Summary

- Anticipate release of the full workshop report in early 2025
- Coastal systems of the southeast U.S. have both parsimonious and unique characteristics with other coastal regions
- Cascading influence of compound stressors and disturbances result in large and key uncertainties in Earth system processes
- Integrated experimental and modeling framework critical for representation of coastal systems

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