Oak Ridge National Laboratory

Simulating Estuarine Wetland Function in the E3SM Land Model

Benjamin Sulman

Sophie LaFond-Hudson,
Jiaze Wang, Shannon Jones, and
Kewei Chen

U.S. DEPARTMENT OF ENERGY

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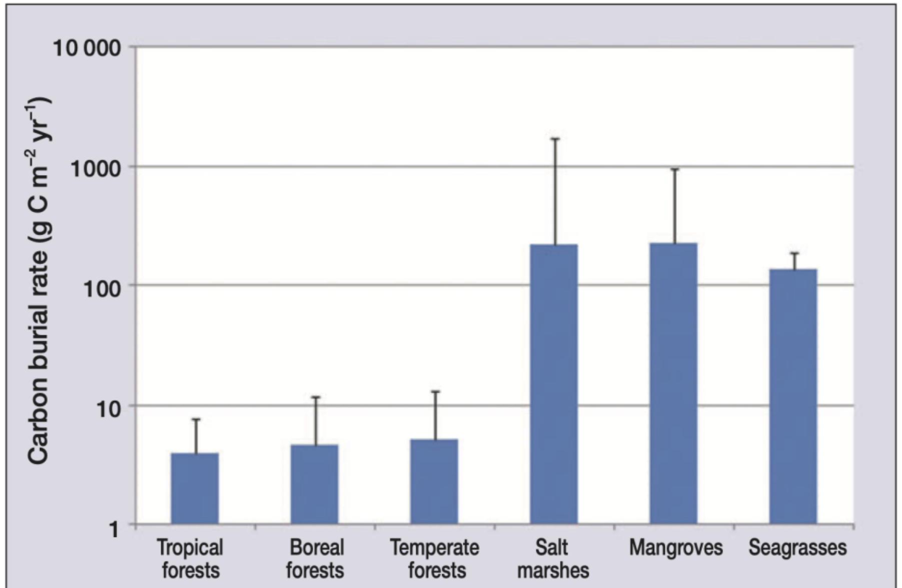
Rationale:

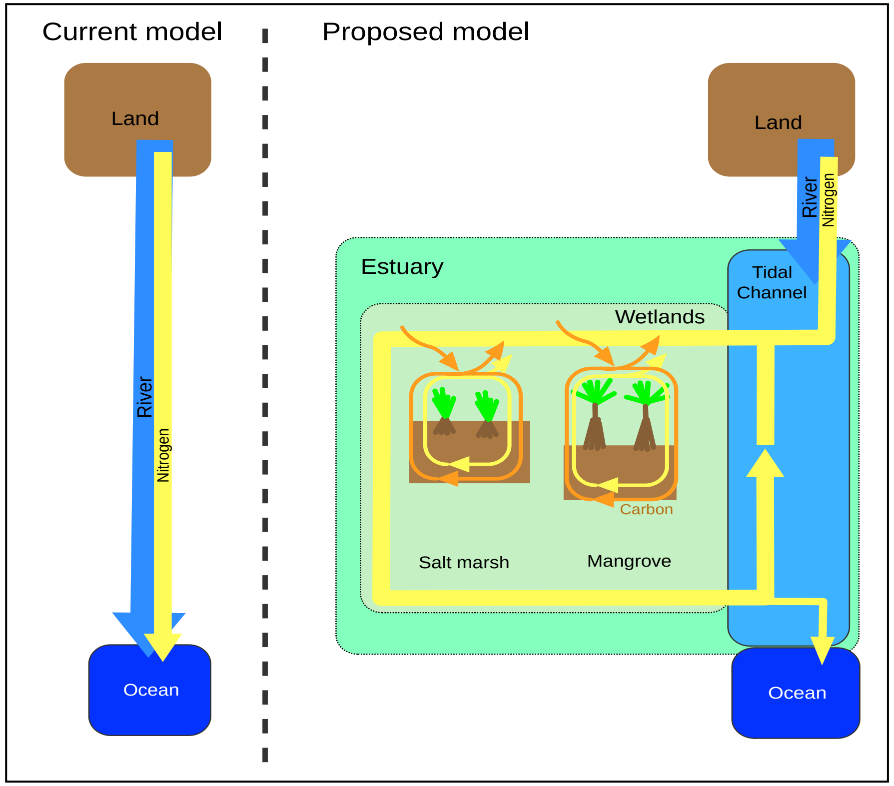
- Coastal wetlands are some of the most productive terrestrial ecosystems on Earth
- Hot spots of biogeochemical cycling due to salinity and hydrological gradients
- Can remove a large fraction of nitrogen from river flows
- E3SM lacks representation of coastal wetland vegetation, biogeochemistry, and hydrological exchanges. This could drive errors in C and N balance of wetland-rich coastal regions

Project goals:

- Develop estuarine wetland vegetation and biogeochemistry functionality in ELM
- Integrate estuarine wetlands into E3SM river-ocean flows



McLeod et al., 2011



Coastal wetland vegetation

The Challenge:

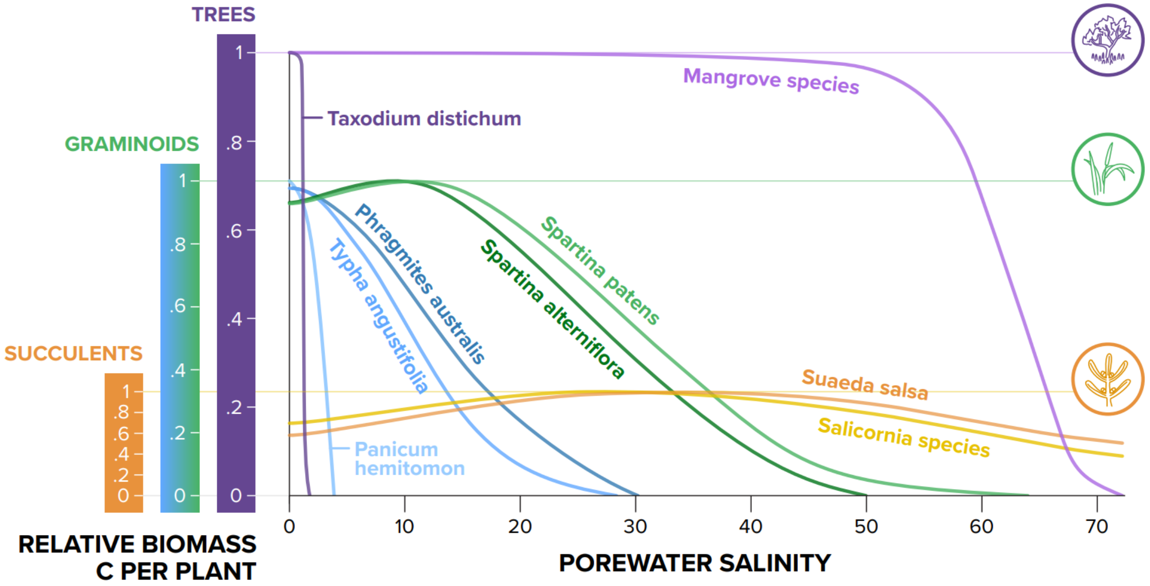
Coastal wetlands have specialized vegetation adapted to flooding and salinity

Key questions:

- How do key traits of wetland-adapted vegetation vary from existing ELM plant functional types?
- What is the impact of salinity, inundation, and other coastal factors on vegetation function?

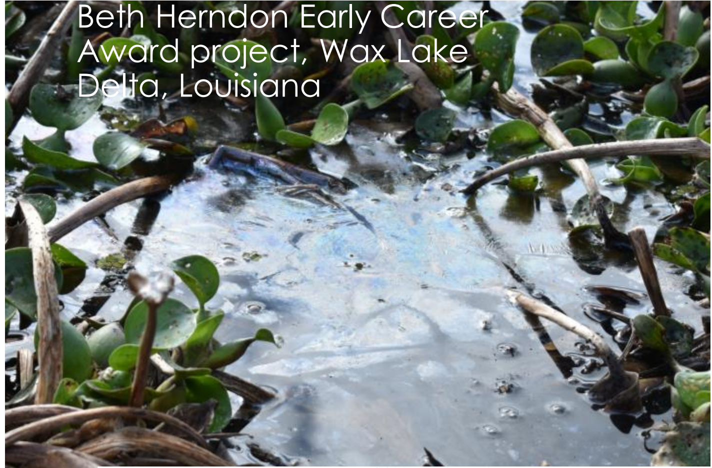
Modeling approaches:

- Defining salt marsh and mangrove plant functional types in ELM
- Introducing salinity and inundation response functions



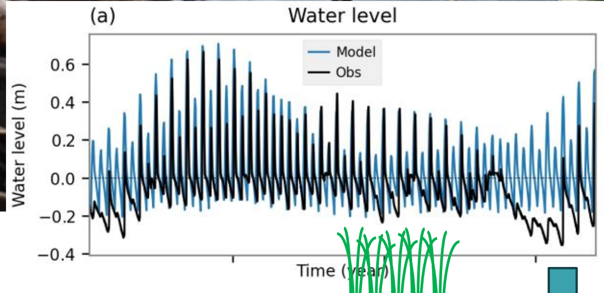
LaFond-Hudson and Sulman, 2022, New Phytologist

Coastal wetland biogeochemistry



The Challenge:

Biogeochemical regimes vary across hydrology and salinity gradients

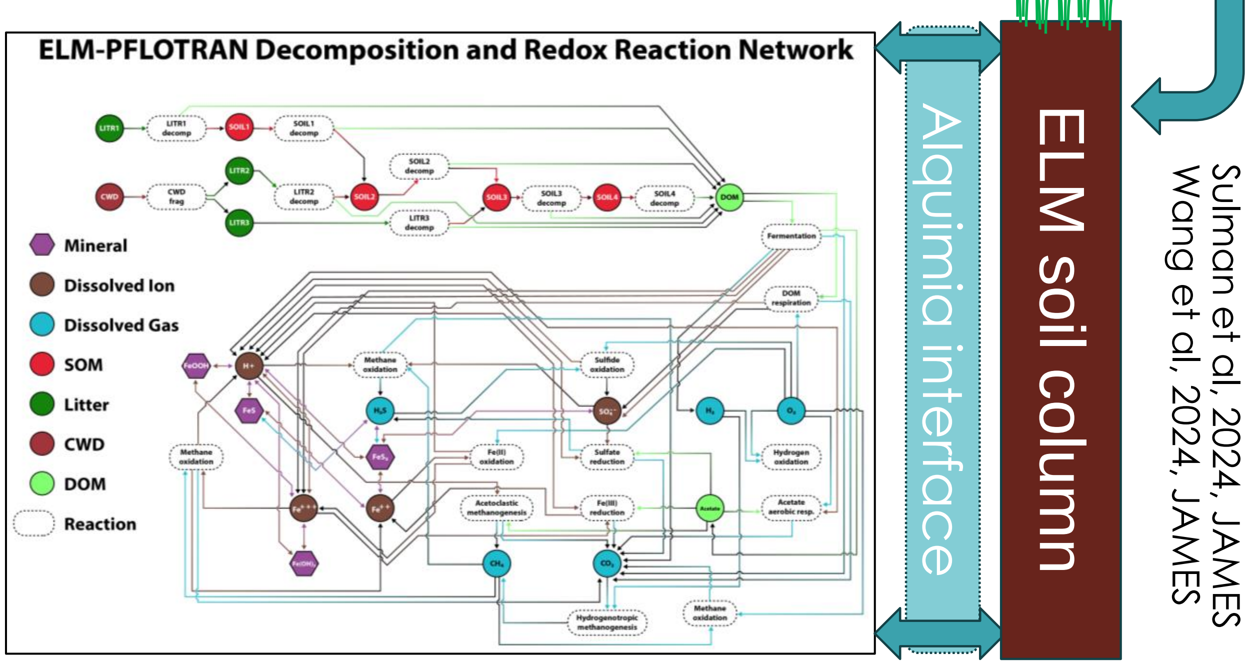


Key question:

- How do carbon cycling and greenhouse gas fluxes vary across salinity gradients and tidal patterns?

Modeling approaches:

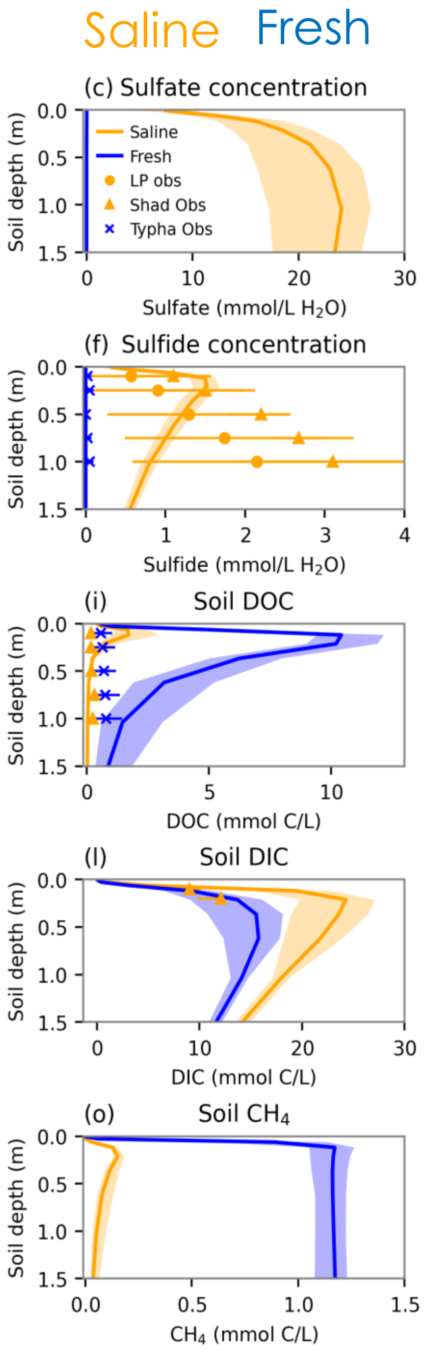
- Coupling PFLOTRAN reaction network model with ELM
- Introducing tidal hydrology and solute boundary conditions



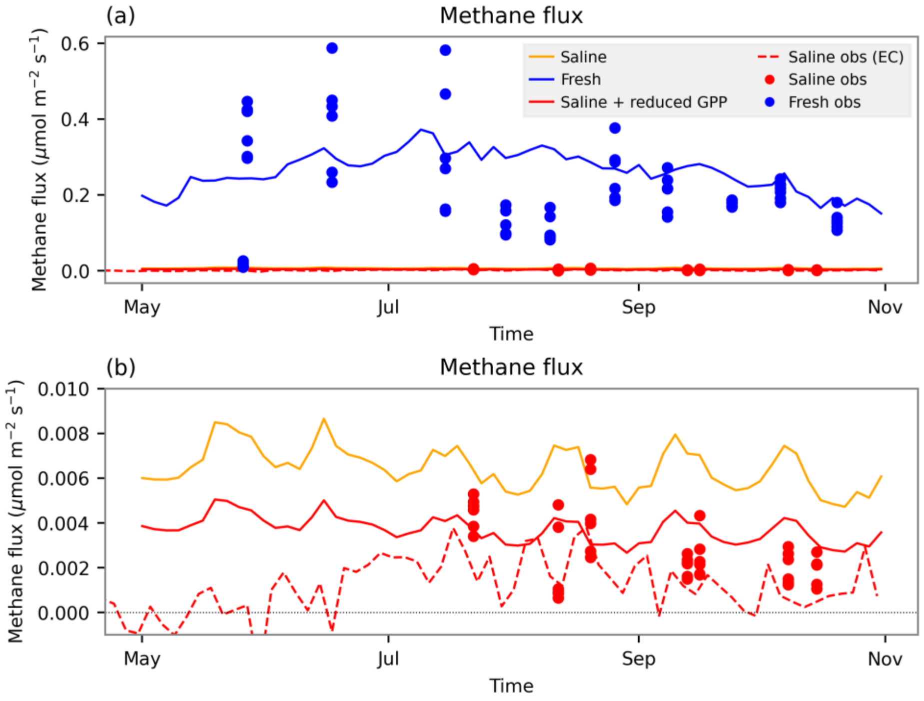
Sulman et al, 2024, JAMES
Wang et al, 2024, JAMES

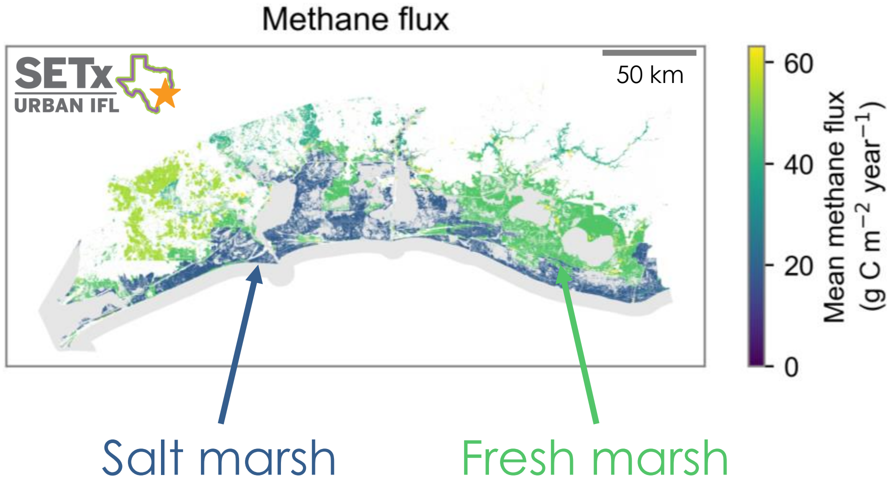
ELM-PFLOTRAN results: Biogeochemistry in fresh and saline simulations

- High sulfate in saline simulation
- Sulfate reduction produces sulfide deeper in profile
- DOC concentrations lower due to sulfate reduction
- Higher DIC due to sulfate reduction
- Sulfate reduces methane via substrate and methane oxidation



Sulman et al., 2024, JAMES





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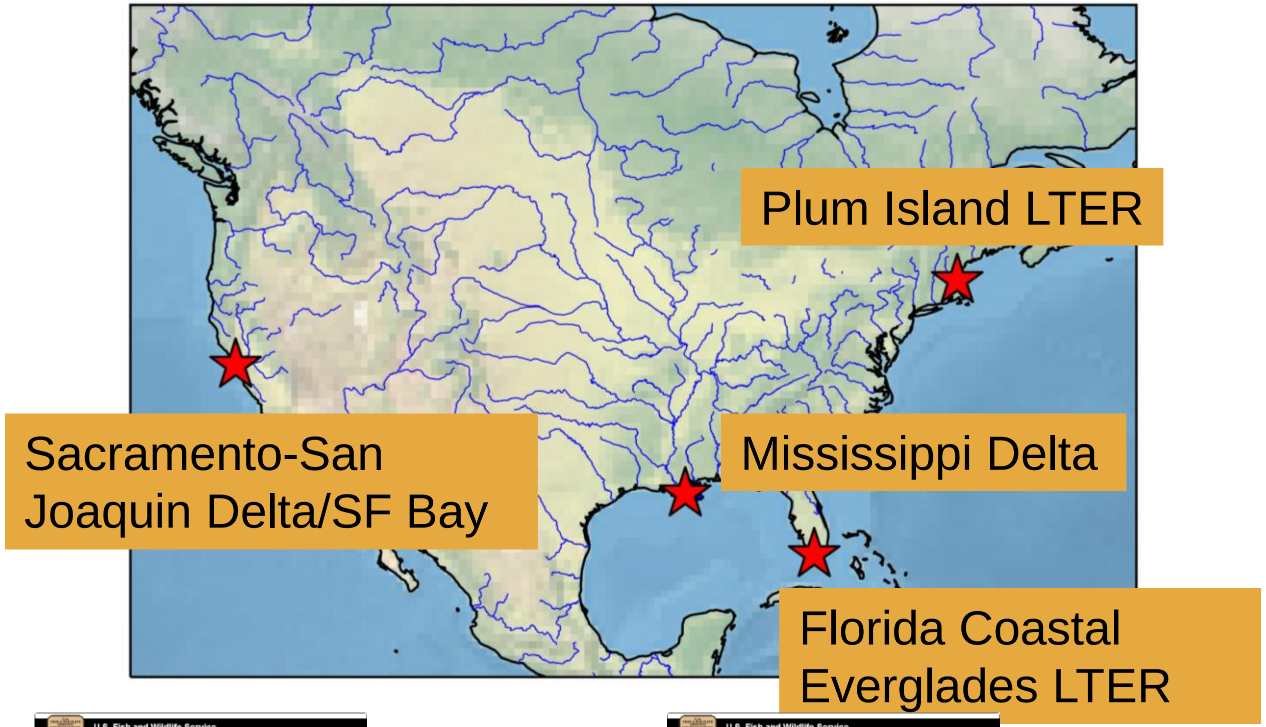
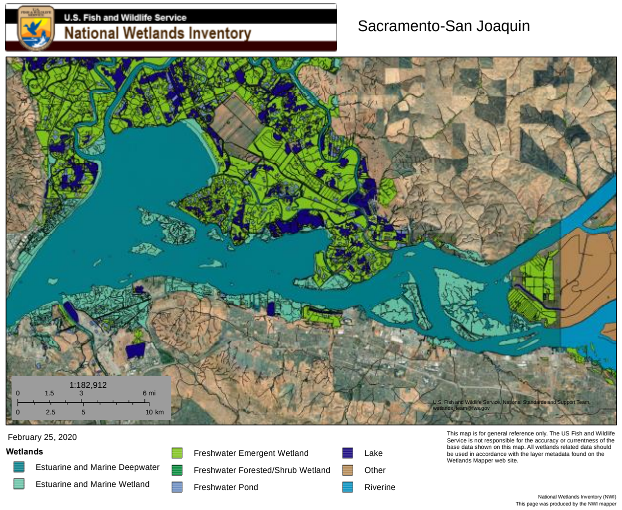
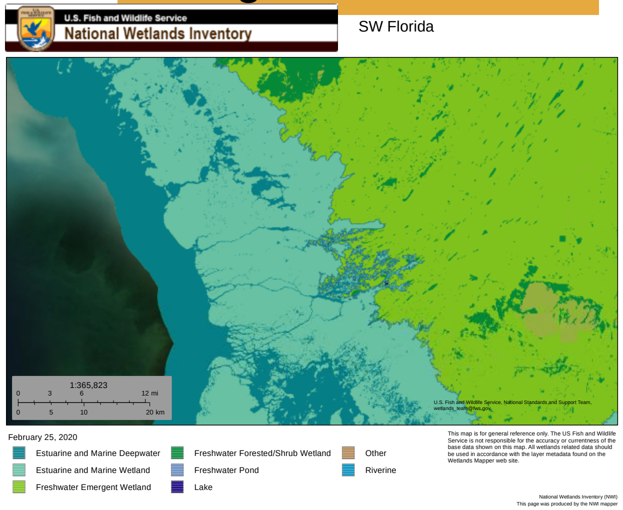
Upcoming plans to close out the project

- Spatially explicit simulations in multiple estuary regions
  - Plum Island (MA)
  - Georgia LTER
  - Florida Coastal Everglades LTER
  - Mississippi Delta
  - Sacramento-San Joaquin Delta
- Full coastal transect simulations covering Gulf Coast and Atlantic Coast







Connections beyond this project

- ELM wetland capabilities and PFLOTRAN coupling connect with roles in several related projects:
  - NGEE Arctic
  - Southeast Texas Urban IFL
  - COMPASS-FME
- Multiple collaborations including Beth Herndon Early Career Award project, Marine Biological Laboratory
- DOE-sponsored and community-led workshops and conferences focusing on coastal ecosystems

Lessons learned

Postdoc Shannon Jones

Postdocs Sophie LaFond-Hudson and Jiaze Wang
Collaborators Anne Giblin, Zoe Cardon, Inke Forbrich, and Yongli Zhou

- Building collaborations with measurement and experimental groups is essential for modeling-focused projects
- Connecting processes across multiple model components is a challenge
- Taking advantage of proposal opportunities benefits from a flexible tool set that can apply to multiple systems and research questions