Title: **Multiscale Data Synthesis and Analysis for Understanding Coastal Ecosystems**

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Project: COMPASS-FME
Project Website: https://compass.pnnl.gov/fme

Project Abstract: This multipronged data synthesis effort involved five key areas clearly and traceably linked with the main COMPASS-FME hypotheses and/or goals, and highly relevant for the project's modeling and/or experimental goals. These areas are to (i) assemble and synthesize disparate coastal datasets relevant to the project; (ii) use a meta-analysis to understand how top-of-column root- and/or microbe-generated greenhouse gas fluxes are affected by changes in water availability, experimental length, and ecosystem type; (iii) examine how inundation changes alter vegetation dynamics and lead to the formation of 'ghost forests' worldwide, and the mechanisms driving these changes; (iv) use machine learning to probe how estuarine and lacustrine water biogeochemistry and quality vary through time and space, and the effects of press and pulse disturbances; and (v) understand the degree to which coastal marsh plant production is driven by growing season phenology, tidal flooding, and species-specific effects. Finally (vi), a 'functional zonation' task focusing on spatial synthesis and inference is being used to scale results and models within COMPASS-FME as well as to the larger-scale companion project COMPASS-GLM.

We summarize progress in these areas, including initial results, the manuscripts submitted and published to date, and how this work links with other project MODEX efforts. Key results include the construction of a meta-analysis statistical pipeline for (ii), and ingestion of over 100 studies reporting soil water manipulation experiments; a completed literature review in (iii) that provides the foundation for a testable framework regarding ghost forest formation under changing inundation levels; extensive dataset assembly and analysis in (iv) working to identify linkages between water quality, ephemeral ecosystem control points, and disturbances; and an ongoing belowground traits meta-analysis (v) focusing on how these factors control coastal marsh productivity in the Chesapeake Bay (CB) region. Finally, the functional zonation team has assembled and co-registered spatial datasets across the CB and Lake Erie regions (vi), constructed maps of the functional zones in which the project's synoptic sites sit, and finalized regression models predicting peak plant productivity.

Title: **Multiscale Observations and Modeling for Improved Prediction of Coastal Wetland Processes**

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Project Abstract: COMPASS-FME has established field sites for intensive synoptic studies in two distinct geographies: in brackish marsh systems of the Chesapeake Bay, and in freshwater wetlands of the Western Lake Erie Basin. Within each region, three sites were selected to establish transects that span elevation gradients consisting of coastal upland forests, forest-wetland transitions, wetlands, and nearshore open waters. The sites also lie along regional gradients in salinity in the case of Chesapeake Bay and gradients in nutrient loading and geomorphology in both regions. Measurements that are being made now and are planned for the coming season include observations of subsurface and surface biogeochemical, plant physiological, hydrological, and geophysical processes. Modelers and observationalists are working together to define multi-scale measurements and simulations to elucidate processes at each site. Modeling is being conducted at point, column, and transect scales using a hierarchy of process-resolving models. Simulations of biogeochemistry at the scale of the soil pore space are capturing microbial dynamics, redox reaction networks, organic matter decomposition, and gas flux. Simulations in single vegetation/sediment/soil columns include those pore-scale dynamics, and introduce variability along vertical gradients in temperature, moisture, oxygen concentration, salinity, and organic matter composition. Two-dimensional transect simulations integrate pore-scale and vertical dynamics along the horizontal transition from wetland to upland conditions, including the effects of inundation from the wetland side and freshwater flooding from the upland side. Here we present results from simulations at each of the three scales (pore, column, transect), based on preliminary observations from COMPASS-FME synoptic sites. These results have helped to refine COMPASS-FME field activities, prioritizing measurements to be gathered in the upcoming field season. For example, we are prioritizing physical characterization of soils, quantifying interactions between iron and sulfur cycles, and extending measurements of plant physiology across all the synoptic sites.

Title: The Exploration of Coastal Hydro-biogeochemistry Across a Network of Gradients and Experiments Consortium (EXCHANGE)

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Project Abstract: The EXCHANGE Consortium aims to improve understanding of how the two-way exchange of water between estuaries or large lake lacustuaries and the terrestrial landscape influence the state and function of ecosystems across diverse coastal interfaces. Our overarching goal is to develop a community-driven, regionally distributed sampling network to examine how spatial variations lead to ecosystem control points at the coastal terrestrial-aquatic interface (TAI). We are using a combination of bulk measurements, molecular level analyses, and laboratory experiments on soil, sediment, and water samples collected across transverse gradients (from upland to estuarine waters – the coastal terrestrial-aquatic interface) at geographically distributed sites around two major coastal regions—the Mid-Atlantic and the Great Lakes. These geographically distributed measurements and experiments will enable us to elucidate how organic matter (OM) cycling dynamics vary between saline and freshwater coastal TAIs, respectively. We are studying the spatial variability in coastal ecosystem dynamics through a series of targeted campaigns. Campaigns developed via workshops with regional partners follow ICON-FAIR principles from conception to data analysis and publication. The first EXCHANGE campaign (EC1) focuses on baseline understanding of the chemical forms and distribution of carbon and nutrients across research sites in both regions. During the Fall of 2021, participants in EC1 collected samples from 52 coastal TAIs using standardized sampling kits. Experiments were performed on samples from a subset of sites to evaluate the response of soil and sediment greenhouse gas production to inundation. Spatial variation across regions was apparent across multiple data types, with variability in surface water chemistry (e.g. dissolved organic carbon, nitrate/nitrite) greater in the Mid-Atlantic compared to the Great Lakes. Spatial variations in terrestrial and aquatic biogeochemical properties and processes studied as a part of EXCHANGE are the product of a range of different environmental conditions, geomorphic settings, and inundation history. For example, total carbon in transition zone soils was lower in soils with visually observed iron oxidation. The data produced by EXCHANGE increase our understanding of how OM processing and transport is coupled to depth and duration of soil saturation and the abundance of redox-sensitive elements, which is essential to the parameterization of reactive transport modeling across spatial scales.

Title: **The Terrestrial Ecosystem Manipulation to Probe the Effects of Storm Treatments Experiment**

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Project Abstract: Coastal upland forests are facing widespread mortality as sea-level rise accelerates and precipitation and storm regimes change. The loss of coastal forests has significant implications for the coastal carbon cycle; yet, predicting the likelihood of mortality is difficult due to our limited understanding of disturbance impacts on coastal forests. The manipulative, ecosystem-scale Terrestrial Ecosystem Manipulation to Probe the Effects of Storm Treatments (TEMPEST) experiment is designed to address the potential for extreme freshwater and seawater disturbance events to alter tree function, species composition, and ecosystem processes in a deciduous coastal forest in Maryland, USA. The experiment uses a large-unit (2,000 m^2), un-replicated experimental design, with three 50-m x 40-m plots serving as control, freshwater, and seawater treatments. Transient saturation (5 hours) of the entire soil rooting zone (0-30 cm) across a 2,000 m^2 coastal forest is attained by delivering 300 m^3 of water through a spatially distributed irrigation network at a rate just above the soil infiltration rate. Our water delivery approach also produces extensive, low-level (≤ 8 cm above ground) inundation and elevates the water table, which is typically ~5 m below ground. A TEMPEST simulation approximates a 15-cm rainfall and based on historic records, is of comparable intensity to a 10-year storm for the area. Treatment application frequency will increase over a decade to quantify tipping points where plant and microbial communities and biogeochemical cycles begin to change rapidly. Pre-treatment data collection began in 2019 and the first full simulation is scheduled for June 2022. This experimental framework provides us with an unparalleled opportunity to control disturbance frequency and intensity and disentangle the effects of saturation and salinity under in-situ conditions and at an ecosystem-scale.