From tides to seasons: How cyclic tidal drivers and plant physiology interact to affect carbon cycling at the terrestrial-estuarine boundary

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Project Abstract: Our overarching goal is to improve mechanistic process understanding and modeling of tidal wetland hydro-biogeochemistry in coastal Terrestrial-Aquatic Interfaces. Key characteristics that distinguish coastal wetlands, such as tidal oscillation, sulfur biogeochemistry, and plant structural adaptations to anaerobic soil, are beginning to be incorporated in land surface models such as the E3SM Land Model (ELM) through coupling with reactive transport code (ELM-PFLOTRAN). There remains large uncertainty in their parameterization. Particularly challenging are: 1) the small-scale, dynamic, heterogeneous redox conditions in wetland soils; 2) the aerenchyma tissue in wetland plants that greatly facilitate gas fluxes into and out of sediment; and 3) the temporal and spatial variability in salinity, which is a key determinant for plant species distribution and productivity, as well as organic matter decomposition.

Working in a brackish marsh, we will combine intensive and new spatially-explicit sediment redox measurements with continuous sediment redox, salinity, and water table data, and then test relationships between these sediment variables and atmospheric fluxes of carbon and energy. Measurements will be guided by, and will inform, new developments in ELM-PFLOTRAN designed to capture critical features of diverse coastal TAI functions. We plan integrated measurements and modeling at two locations with contrasting hydro-biogeochemistry in an oligohaline marsh in the Parker River estuary, MA. We will use field measurements to help inform ELM-PFLOTRAN development designed to improve simulations of brackish marsh biogeochemistry under fluctuating oxygen availability and salinity influenced by tides, diel and seasonal changes in plant physiology and river discharge.

Ultimately, we will be poised to combine our new process understanding and model formulation with existing long-term data already in hand from two more saline salt marsh sites in the Parker Estuary. As sea level rises, saline conditions will become more common in many coastal TAIs, but they will also potentially be exposed to more flashy freshwater riverine input from intense, sporadic, storms. By having information from marshes at both ends of the full salinity gradient, we will be able to better constrain biogeochemical reactions in ELM-PFLOTRAN, validate ecosystem-scale modeled fluxes with eddy covariance measurements, and simulate present and

future hydrological variations and resulting carbon dioxide and methane fluxes in tidal wetlands in the face of expected global change.