Assessing Greenhouse Gas Structural and Functional Resilience of Freshwater Coastal Wetlands Subject to Persistent Saltwater Intrusion Events

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Greenhouse gas production and fluxes in coastal wetlands are controlled by complex interacting hydrological and ecological processes whose dynamics are, in turn, modified by saltwater intrusion (SWI) events. In suburban and urban transition zones, the floodwalls and levee systems built to protect infrastructure and urban development intensify the SWI events resulting from floods during storm surges. When the flood waves travel inland, they meet these barriers, and saltwater can remain stagnant for prolonged periods, increasing the exposure of adjacent coastal wetlands to salt stress (i.e., persistent SWI events). These stress conditions induced by SWI are rarely represented in biogeochemical models, limiting our capacity to predict and assess the long-term effects of SWI on coastal greenhouse gas production and fluxes. Moreover, significant knowledge gaps exist in how the ecosystem reorganizes after SWI disturbance. Specifically, what trajectories do biological components (ecosystem structure) and greenhouse gas production and emission (ecosystem function) follow after SWI? Also, it is not clear what the relevant scales to evaluate these trajectories are. Using an ecohydrological patch approach defined by plant functional types and water levels, this early-career proposal aims to understand better how ecosystem structure and function linked to greenhouse gas fluxes in freshwater coastal wetlands affected by the built environment are influenced by SWI in the short- (days to weeks) and long- (years to decades) term. This project will evaluate carbon dioxide and methane pools and fluxes before, during, and after simulated SWI events covering a wide range of salt exposure (salinity concentration, duration, and frequency). The measurements will be conducted on a multi-setting sampling approach composed of controlled mesocosm in greenhouses and experimental wetland ecosystem units and will be complemented with time-for-space replacements in coastal wetlands with a history of persistent SWI. Data collected will be used to produce and incorporate an explicit salinity-dependent function to the methane biogeochemistry module integrated into the E3SM Land Model (ELM v1). The improved module will then be used to assess the sensitivity of methane emissions to different scenarios of SWI, accounting for increased storm magnitude and frequency expected from climate change and sea-level rise and exacerbated by current and projected build environments.

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