Title: Methane Fluxes from the Salt Marsh Accretion Response to Temperature eXperiment (SMARTX)

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BER Program: TES

Project: University project

Project Website: https://serc.si.edu/gcrew/warming

Project Abstract: The land component of the Energy Exascale Earth System Model (ELM) simulates fully coupled processes and interactions between water, energy, carbon (C) and nutrient cycles (N, P) through the ELM-PFLOTRAN interface. ELM, like most land surface models, uses soil moisture as a proxy for O₂ presence and does not track salinity, pH, or iron and sulfur cycles which are important in coastal wetlands.¹⁻³ Using PFLOTRAN (an open source reactive transport code), we incorporated the missing chemical interactions, plant-mediated transport of O₂, and interactions between terminal electron acceptors (e.g., aerobic and anaerobic oxidation of methane (CH₄)). To test model performance, we used CH₄ emissions and porewater data collected from the Salt March Accretion Response to Temperature eXperiment (SMARTX). SMARTX was established in 2016 in the Smithsonian’s Global Change Research Wetland to understand the ecosystem-scale effects of warming and elevated CO₂ on biogeochemical cycling. Year-round heating treatments range from ambient controls to 5.1 °C above ambient. Summer CH₄ fluxes from sedge-dominated areas averaged 491 μmol CH₄ m⁻² d⁻¹ in control plots, compared to 539, 571, and 1071 μmol CH₄ m⁻² d⁻¹ in plots heated to 1.7, 3.4, and 5.1 °C above ambient temperature, respectively. In grass-dominated areas, summer CH₄ fluxes also doubled with 5.1 °C of warming, from 747 to 1742 μmol CH₄ m⁻² d⁻¹. Porewater CH₄ concentrations followed similar trends. Based on these data, we expected CH₄ emissions and dissolved CH₄ concentrations to increase exponentially with warming. However, the data from SMARTX indicate that plant-mediated transport of O₂ can mitigate warming effects, reducing CH₄ emissions. Warming effects were strongest in the grass-dominated zone, indicating effects of C substrate availability. We were able to simulate the positive influence of warming on CH₄ production while the addition of sulfate and O₂ decreased CH₄ emissions, with O₂ having the strongest influence. We found that the model was particularly sensitive to C availability. Since ELM-PFLOTRAN incorporates C processes based on terrestrial data, characterization of coastal C pool structure and decay rates are necessary to improve model simulations.

¹ Tang et al. (2016) Geoscientific Model Development 9: 927-946