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

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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 O_2 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 O_2, and interactions between terminal electron acceptors (e.g., aerobic and anerobic oxidation of methane (CH_4)). To test model performance, we used CH_4 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 CO_2 on biogeochemical cycling. Year-round heating treatments range from ambient controls to 5.1 °C above ambient. Summer CH_4 fluxes from sedge-dominated areas averaged 491 µmol CH_4 m^{-2} d^{-1} in control plots, compared to 539, 571, and 1071 µmol CH_4 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 CH_4 fluxes also doubled with 5.1 °C of warming, from 747 to 1742 µmol CH_4 m^{-2} d^{-1}. Porewater CH_4 concentrations followed similar trends. Based on these data, we expected CH_4 emissions and dissolved CH_4 concentrations to increase exponentially with warming. However, the data from SMARTX indicate that plant-mediated transport of O_2 can mitigate warming effects, reducing CH_4 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 CH_4 production while the addition of sulfate and O_2 decreased CH_4 emissions, with O_2 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

[2] Thornton et al (2009) Biogeosciences 6: 2099-2120

[3] Bianchi (2007) The Biogeochemistry of Estuaries