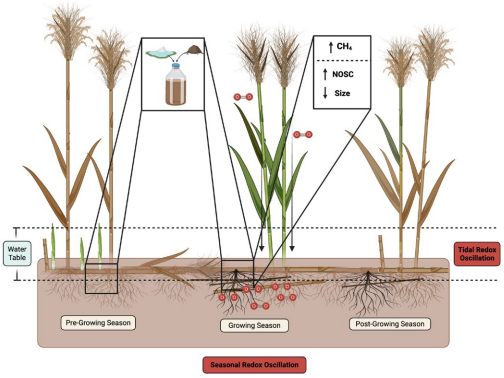
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Linking Transient Changes in Dissolved Organic Chemistry to Wetland Carbon Emissions

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Wetlands form a massive reservoir of soil carbon (C) that is disproportionately impacted by climate change and displays extreme variability in C cycling. The biogeochemical pathways underpinning this variability remain a critical knowledge gap due in part to the oversimplification of soil organic matter (SOM) transformations. To address the chemical complexity of these SOM transformations, we studied changes in the mass and nominal oxidation state of SOM, soil microbial communities, and C emissions affected by changes in elevation (relevant to sea level rise and wetland migration) and transient redox perturbations (i.e., plant mediated radial oxygen loss (ROL)). Soil was sampled across a *Phragmites*-dominated tidal marsh before and during the growing season. The SOM chemistry under redox perturbation was further characterized in the lab during a time-series incubation of soil using high-resolution Fourier transform mass spectrometry (FTICR-MS), microbial community composition using 16S sequencing, and corresponding methane (CH4) and carbon dioxide (CO2) emissions. Differences were observed in the SOM molecular profiles by mass and nominal oxidation state of C (NOSC) depending on the combination of transect position (from the wetland interior to the wetland-forest edge) and transient oxygenation. We find that (1) the most inundated portion of the wetland interior is most susceptible to spikes in CH4 emissions following plant-mediated oxygenation, corresponding with relatively large changes in mass and NOSC compared to less-inundated sites and (2) that highly-oxidized high-molecular-weight compounds and less-oxidized low-molecular-weight compounds each signal high C emission potential. The general framework for SOM transformations, based on thermodynamics, is that as organic molecules become more processed by microbes, the molecules become smaller and more oxidized (more energy yielding). Our work shows that this framework holds well during transient redox perturbations and helps to explain C emissions in wetlands, but is less adequate to describe strong variation in wetland C emissions without accounting for how changes in SOM mass (or size) and NOSC independently correspond to this variation.