Biophysical Controls on Ecosystem-Scale CO₂ Exchange in a Tidal Marsh in Northern California

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Carbon (C) cycling in coastal wetlands is difficult to measure and model due to dynamic atmospheric (vertical) and hydrologic (lateral) fluxes, as well as sensitivities to dynamic land- and ocean-based drivers. To date, few studies have reported on continuous measurements of vertical and/or lateral C exchanges in these systems and as such, our understanding of the key drivers of carbon cycling in coastal wetlands including inundation, temperature, radiation, and salinity remains limited. Increasing the number of direct measurements of vertical and lateral C fluxes is a critical first step to developing a better understanding of the drivers and sensitivities of C sequestration and greenhouse gas (GHG) mitigation potential of coastal wetlands. Here we present 2.5 years of near-continuous eddy covariance measurements of CO₂ and CH₄ fluxes from a brackish tidal marsh in Northern California. We used a combination of wavelet analysis and information theory to analyze the interactions between whole ecosystem CO₂ flux and biophysical drivers.

CO₂ fluxes showed significant interannual variability, with low net CO₂ uptake in the first year of the study (67 g C m⁻² yr⁻¹; March 2014 – March 2015), and considerably higher uptake the following year (295 g C m⁻² yr⁻¹; March 2015 – March 2016). Conversely, annual CH₄ fluxes were similar between years (1.2 and 1.3 g C m⁻² yr⁻¹ in the first and second year, respectively). With respect to the net atmospheric GHG budget (assuming a sustained global warming potential of 45), the wetland was a net GHG sink of 172 g CO₂eq m⁻² yr⁻¹ in 2014–2015, and a sink of 1004 g CO₂eq m⁻² yr⁻¹ in 2015–2016. Our results also showed that tides significantly influenced CO₂ fluxes across multiple timescales; ecosystem respiration was approximately 25% lower during spring tides relative to neap tides, and flooding resulted in an overall increase in photosynthesis by 9 to 27%. While there are several mechanisms that can potentially contribute to the suppression of respiration following flooding, our results suggest tidal effects may largely be due to the suppression of CO₂ efflux from the soil as the water creates a physical barrier to gas diffusion. In this case, it is critical to consider lateral fluxes as flooding may also coincide with increased dissolved inorganic carbon loss from the marsh. Further research on lateral C transport is key to investigating the influence of tides on the role of coastal wetlands as C sinks or sources.