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Modeling Tidal Marsh Carbon Cycling Under Sea Level Rise and Elevated CO_2

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Coastal marsh, mangrove, and seagrass ecosystems are of global importance in terms of carbon cycling despite occupying just 2.5% of worldwide land area. These systems account for almost half of total marine carbon burial and sequester carbon at extremely high rates, thus we must work towards predicting the dynamic responses of coastal carbon pools to shifts in climate and rising sea levels. Complex interactions between the biotic and abiotic constituents of coastal ecosystems shape carbon cycling processes, but modeling efforts to date have not fully captured the feedbacks that control carbon burial and organic matter accumulation under global change scenarios over decades to centuries. We present a new point-based soil cohort model that captures the ecogeomorphic feedbacks between flooding, organic matter accumulation, sediment deposition, and marsh surface elevation under scenarios of accelerated sea level rise and elevated CO_2. Our model incorporates the differential effects of inundation and resource supply on primary production of two coastal plant types (C3 & C4), and couples this with organic matter decomposition in the soil as a function of age, carbon quality, depth, and carbon priming by roots. This allows us to predict dynamic changes in surface elevation and carbon burial over annual to decadal time scales, and to predict how accelerating sea level rise rates and alterations in mineral sediment supply will alter these feedbacks over decadal to centurial time scales. Preliminary results indicate that coastal marsh elevation can reach an equilibrium with rising sea levels via organic accretion even with limited mineral sediment inputs, and that elevated levels of atmospheric CO_2 can further enhance carbon sequestration and subsurface organic accretionary processes through effects on belowground primary production. However, under scenarios of accelerated sea level rise, the model indicates a point at which the reduction in primary production is not compensated by increased mineral deposition, leading to the drowning of the marsh. Our work highlights the importance of organic accretion in future marsh survival.