Coastal Wetland Carbon Sequestration in a Warmer Climate

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Coastal wetlands are global hotspots of carbon storage. Marshes, mangroves, and seagrass meadows account for about half of the total marine soil carbon budget and bury carbon at rates roughly equivalent to terrestrial forests despite occupying just 2.5% of Earth's land area. Such extremely high rates of carbon sequestration are attributed to interactions among three primary factors: high rates of plant production, low rates of decomposition, and sea level rise. As rates of sea level rise accelerate, coastal wetlands have the potential to sequester soil carbon at increasingly rapid rates as long as plants survive flooding and contribute to soil building. Compared to upland soils, the sequestration potential of tidal wetland soils is extremely high because rising sea level increases the potential soil volume over time, and therefore reduces carbon saturation effects typical of upland soils. Coastal wetlands have only recently been recognized as important carbon sinks, and therefore the response of carbon cycling to global change in this ecosystem is virtually unexplored. The future sink strength and carbon stock stability of these systems is uncertain because global change drivers such as temperature and elevated CO_2 perturb the complex biotic and abiotic feedbacks that drive high rates of soil carbon sequestration. Despite the extraordinary leverage these ecosystems exert over the global carbon cycle, the dynamics of coastal wetland carbon pools are not presently represented in earth system models.

Our objectives are to quantify how warming affects the stability of large coastal wetland soil carbon pools, the ability of coastal wetlands to maintain contemporary rates of carbon sequestration, and to quantify interactions between temperature, elevated CO_2 and inundation frequency on soil carbon dynamics. Specifically, we will (i) initiate the first *in situ*, active aboveground and belowground warming experiment in a coastal wetland, and examine the interaction between warming, elevated CO_2 and inundation frequency, (ii) test the overarching hypothesis that warming will increase both plant production and decomposition, but that the net effect will be an increase in soil carbon sequestration rate, (iii) modify a well-established marsh carbon model to incorporate new insights gleaned from the warming experiment, including the impact of warming on productivity and decay, and potential interactions between inundation, warming, and elevated CO_2 that vary with plant species across real-life wetland landscapes. (iv) migrate this refined marsh carbon model into the new wetland-enabled Community Land Model (CLM), producing the first attempt to capture tidal wetland dynamics in a fully prognostic land surface model with coupled water, energy, carbon and nutrient cycles.

The experiment has a gradient design with air and soil warming treatments ranging from 0 to +3.9 ^{o}C, to a soil depth of 1 m. Elevated CO_2 will be crossed with temperature at the extremes (0, +3.9). Replicate transects (n=3) will be located in each of two plant communities yielding a plant community treatment that corresponds to changes in inundation across the wetland landscape. The design emphasizes plant and soil biogeochemical measurements that will be used to test and further develop a marsh carbon model. In addition, we will migrate new coastal wetland carbon cycle processes from our refined marsh carbon model into the wetland-enabled CLM framework to evaluate performance of the coastal wetland carbon model in a broader terrestrial ecosystem context, with fully coupled water, energy, carbon, and nutrient cycles.