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Novel environmental conditions stimulate organic carbon reactivity along the terrestrial-aquatic continuum

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Rivers export substantial amounts of organic carbon to the ocean in particulate and dissolved forms (POC and DOC, respectively). A fraction of river-derived POC and DOC persists for millennia in coastal sediments or the deep ocean, respectively, while more reactive fractions are actively decomposed and drive CO_2 emissions from riverine and estuarine waters to the atmosphere. Several major challenges complicate our understanding of the fate of river organic carbon in the coastal ocean: 1) processes occurring along the tidally-influenced reaches of rivers are typically not evaluated in the context of fluvial carbon fluxes and 2) interactive effects that occur when diverse substrates and microbial communities mix can drastically change organic carbon reactivity from refractory to highly labile. This presentation highlights research aimed at addressing these two challenges based on studies in the largest river on Earth, the Amazon, as well as smaller watersheds around the conterminous US coastline.

Across these diverse studies, a common theme has emerged—organic carbon reactivity can be rapidly stimulated when exposed to novel physical, chemical, or biological conditions. Such novel conditions may include mixing a body of water with biogeochemically distinct tributary or coastal waters, changing water flow velocity, resuspending or eroding sediments or soils into the water column, or exposing previously anoxic sediments to oxygen. For example, degradation of terrestrial plant litter leachates in the lower Amazon River occurred >3 times more rapidly in the presence of algae near the river mouth and tributary confluences while bulk microbial respiration was shown to be directly linked to tidal variability in river velocity. Incubation studies performed around the US coastline have also shown that the response of surface water respiration to soil erosion or sediment resuspension varies as a function of previous exposure of the soils/sediments to surface water; the highest rates of CO_2 production occurred with the most novel water-soil mixtures (e.g., upland soils a substantially larger response than aquatic sediments when mixed with water). Further elucidating the mechanisms underlying organic carbon reactivity along the terrestrial-aquatic continuum is critical for improving global models and carbon budgets.