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Stability of OM-bearing Fe and Mn oxides impacted by fresh and saltwater flooding

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Coastal forested ecosystems are experiencing more frequent and severe storm events, resulting in tree mortality driven by increased soil salinity and reducing soil conditions. These changes in soil conditions also threaten the stability of organic matter (OM)-bearing Fe and Mn oxides, either through mineral reduction or cation competition with OM for mineral exchange sites. We used a field-scale experiment to investigate the effects of changing redox and salinity on OM-bearing minerals. The Terrestrial Ecosystem Manipulation to Probe the Effects of Storm Treatments (TEMPEST) experiment utilizes large-scale (2,000 m^2) manipulations to simulate one or more 10-hour pulse storm events with fresh or saltwater in an upland coastal forest. In the second year of treatment (two 10-hour treatments on two consecutive days), we observed a delayed substantial and sustained increase in porewater dissolved organic carbon (DOC) concentrations 60 days after the saltwater treatment, which coincided with increased porewater Fe(II) concentrations. This suggests a role of Fe oxide minerals in the stability of carbon in these soils. To further investigate the role of OM-bearing minerals in response to saline water flooding, we employed a combination of targeted soil extractions and temporal changes in mineral-coated sands. Soils collected before and after flooding treatments were subjected to sequential extractions targeting soluble, OM-bound, poorly-crystalline, and crystalline Fe and Mn oxides. Extracts were analyzed for Fe, Mn, and DOC. Additionally, ferrihydrite and hydrous Mn oxide-coated sands, with and without OM incorporated, were buried in mesh bags before treatment and removed after treatment at dates corresponding to soil and porewater sampling. Synthetic minerals were analyzed using X-ray absorption near-edge structure (XANES) and extended X-ray absorption fine structure (EXAFS) spectroscopy to determine changes in Mn oxidation state and Fe and Mn mineralogy, respectively. XANES and EXAFS analyses were paired with near-edge X-ray absorption fine structure (NEXAFS) spectroscopy of synthetic minerals and soils to determine corresponding changes in OM functional groups. Together, these analyses connect DOC pulses to shifts in both broad classes of mineral-associated OM and to fine-scale mineral transformations caused by fresh and saltwater flooding in a coastal forest, providing insight into OM stability in transitional coastal ecosystems.