UK Coastal Research Conference
Liverpool 2025

MODELLING THE IMPACTS OF SEA-LEVEL RISE ON SOIL CARBON DYNAMICS IN MANGROVE FORESTS

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Mangrove forests provide essential ecosystem services as biodiversity hotspots, coastal protections, and significant carbon reservoirs. However, their future carbon sequestration is uncertain because sea-level rise may drown these ecosystems, leading to tree mortality, ceasing carbon sequestration, and releasing stored carbon. Anthropogenic disturbances, such as damming that limits sediment supply, further reduce the potential for sediment accumulation necessary for mangrove soil accretion.

To investigate these complex dynamics, we developed a robust numerical model that couples hydrodynamic and morphodynamic processes, mangrove forest dynamics, and soil carbon dynamics. This integrated model allows two-way feedback among these processes and is capable of reproducing carbon distributions over soil depth and typical carbon sequestration rates in mangrove ecosystems. We applied the model to an idealized tropical tidal embayment and explored the impacts of sea-level rise under various IPCC RCP scenarios.

The results show strong spatial variations in carbon stocks due to variations in hydrodynamics and sediment dynamics that affect habitat suitability for mangrove growth. Our findings also emphasize the critical role of channel network dynamics in determining mangrove survival and the long-term fate of stored carbon. Overall, our modeling framework reveals multiple potential responses of carbon dynamics to changing environmental conditions. This eco-carbon-morphodynamic model offers valuable insights into the long-term sustainability of key ecosystem services in mangrove environments and underscores its potential as a tool for predicting ecosystem resilience under future climate scenarios.