OPTIMIZING MANGROVE CARBON SEQUESTRATION WITH A MECHANISTIC MANGROVE HYDRO-MORPHODYNAMIC MODEL

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INTRODUCTION

The 6th IPCC reports anthropogenic activities have led to 1°C global warming with widespread and intensifying impacts. Investigating sustainable mitigation and adaptation measures are deemed necessary to address and respond to climate change.

The global target of climate change is to achieve net zero emissions by 2050. It has been recognized that ocean and coastal ecosystems have the largest potential to sequester carbon and simultaneously provide many services as part of the adaptation. These ecosystems are referred to as Blue Carbon Ecosystems (BCE). BCE consists of tidal marshes, seagrass meadows, and mangroves, where the latter has the highest carbon sequestration rate and economic value per hectare (Macreadie et al., 2019).

Mangrove conservation has been considered one of the global high-priorities, e.g., by the UN or nations with their national determination contribution. Even though the global coordinated efforts have been conducted, many mangrove conservation and restoration projects (about 80-90%) experienced failures. The main reason is the lack of understanding of the mangrove ecological requirements and the mismatch of the mangrove species.

Acknowledging mangroves as the forefront of climate change solutions requires a well-defined conservation-restoration strategy. Even though knowledge of mangrove ecology is well appreciated, their feedback loop interactions with the changing environment are still lacking. The combination of the high failure rate of conservation-restoration and the lack of mechanistic understanding of mangroves' response to the environment may hinder the wide adoption of mangroves as a climate change solution. Therefore, our work introduces the mechanistic modelling of mangrove-hydro-morpho-dynamic to explore strategic mangrove planting on an idealized open coast mudflat setting.

METHODS

We apply a new coupled individual-based-hydro-morphodynamic model DFMFON (Beselly et al., 2023). This coupled model allows us to include spatiotemporal physical-environmental processes (water level, flow, wave, sediment availability, and salinity) with species-specific mangrove interactions. DFMFON model describes mangrove-mudflat dynamics, including the life stage progression (mangrove establishment, growth, and mortality) along with the systems' morphodynamic evolution conditioned by physical-environmental forcings. We tested 12 scenarios by varying mangrove placement at different tidal water levels. We used a combination of two mangrove species (Rhizopora spp. and Avicennia spp.) on a large block of mangrove planting and patched with the gap. The simulations were forced with spring-neap tides and constant wave forcing.

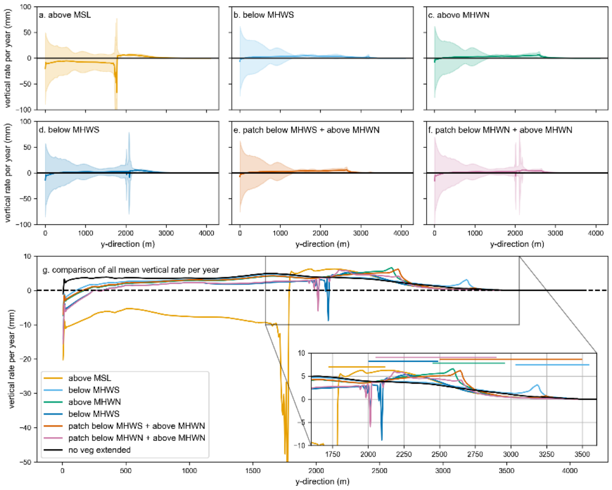

Figure 1 – Annual vertical erosion/ sedimentation rate.

RESULTS

The model results show counter-intuitive results of mangroves to morphology when the restoration is close to the mean sea level. On the contrary, mangroves located above the mean high-water neap accumulated more sediment. In correlation with that, we observe mangroves above mean high-water neap benefitted from the additional accommodation space and developed larger biomass. Patched scenarios gained significant bed level and biomass, potentially having the highest carbon stocks from biomass and soil organic carbon.

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