THE CONDITIONS FOR SEDIMENT ACCRETION ON SALT MARSHES

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INTRODUCTION

Salt marshes are vegetated intertidal wetlands that evolve over time. They provide valuable ecosystem services in the form of coastal protection, carbon sequestration and as a habitat for flora and fauna (Temmerman et al., 2023). These benefits are affected by the expansion and retreat of salt marshes (Fagherazzi et al., 2020). A resilient marsh attracts sufficient sediment to keep up with sea level rise. Tidal currents and waves transport sediment to the marsh, where the interaction between currents, waves, sediment and vegetation can lead to accretion. However, morpho-dynamic models often employ transport equations that were developed for bare beds and may not accurately simulate transport and accretion over vegetated beds.

In this study, we aim to identify the conditions under which sediment accretion can occur. We introduce a new sediment transport equation for vegetated beds under combined wave-current flows in a morphodynamic model. The model is then applied to simulate accretion patterns on two contrasting field sites. The outcomes support the assessment of salt marsh resilience and the design of management interventions that benefit accretion.

METHODS

We developed a new equation for sediment transport over vegetated beds under wave-current flows based on flume experiments at the Massachusetts Institute of Technology (MIT; Figure 1). We measured sediment resuspension, bedforms, and hydrodynamics within emergent wooden dowels, which represent stiff salt marsh vegetation. Our conditions included wave, current, and combined wave-current flows at three vegetation densities and two sediment grain sizes. Our new sediment formula bridges the small-scale understanding from experiments to estuary-scale salt marsh morphodynamics in the field.

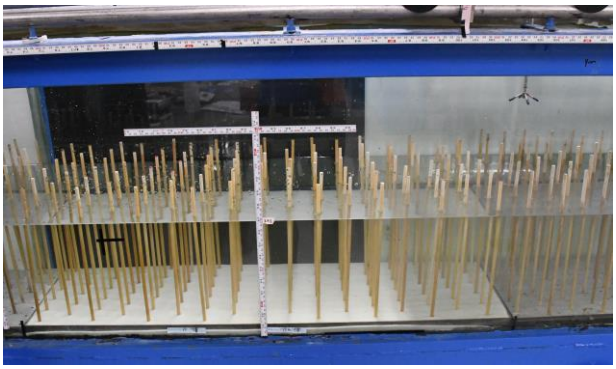

Figure 1 - Artificial vegetation and sediment bed during the experiments in the wave-current flume at MIT.

Next, we set up morphodynamic models for the Taf Estuary (based on Bennett et al, 2020) and the Marconi Marsh (based on Baptist et al., 2021) using the new sediment transport equation. These sites have been selected for their contrasting vegetation characteristics, locations and tidal ranges. We include the marshes and the mudflats found at both locations in our model

The Taf Estuary (Figure 2) is located in the south of Wales, UK, where the spring tidal range is 7.5 m (Bennett et al., 2020). Salt marshes have rapidly expanded in the twentieth century and now cover approximately 299 Ha with *Atriplex Portulacoides* as the most common species. The Marconi marsh is located in the Ems-Dollard Estuary in the Netherlands, where the spring tidal range is 3.4 m. It is a semi-natural marsh that was created by raising the bed elevation, sowing seeds in sections, and protecting it with brushwood dams before leaving it to natural development (Baptist et al., 2021). *Salicornia spp.* has emerged as the most common species.

Figure 2 - Satellite photo of a section of the Taf Estuary (Google Earth, 2018). Salt marshes can be seen along the banks. The red lines denote the transects that are used in the analysis. The frame in the top right shows the location of the Taf Estuary in the British Isles (Background map by Hellerick, 2013).

We run our model for calm weather and storm conditions. We initially study accretion patterns along selected transects (Figure 2). The calm weather simulations only include tidal flow. They aim to identify spatial and temporal accretion patterns over a tidal cycle. The storm conditions feature waves and currents. They show how wave-current interactions affect the accretion patterns.

RESULTS

We have developed a new sediment transport equation for vegetated beds under wave-current flows, and introduced this in a morphodynamic model. Our model results are expected to show which tidal and wave conditions are most favourable to salt marsh accretion at the two field sites. Our outcomes can be applied to understand resilience of existing marshes, predict the effect of interventions on salt marsh accretion, or identify promising locations for salt marsh establishment.

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