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Mangrove interaction with tidal flow, waves & long term sedimentation: mechanisms governing adaptation

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Abstract

The uncertainty surrounding the impact of sea-level-rise (SLR) and storms, which threaten the coastal hinterland, heightens the need for design guidelines on mangroves adaptation and their use in coastal safety. This research seeks to quantify the bio-physical processes governing the geomorphological evolution of mangrove-mudflat systems utilizing spatially explicit observations of mangrove population dynamics with process-based modelling. For calibration purposes and increased insight into the interactions between hydrodynamics, sediment dynamics and mangroves, field observations were collected along Guyana's coast.

A quadrant, 1km wide and 6km in length, was established along the mangrove-mudflat coastline at Chateau Margot. This stretch of coastline is subject to a semi-diurnal tidal regime with maximum tidal range of 3.5m during spring tide. Using the data, we developed a 2D high-resolution depth-averaged model of the field site using Delft3D-Flexible Mesh. We coupled this model with a mangrove dynamics model capturing the development of the Avicennia germinans and Laguncularia racemosa species under suitable inundation and competition regimes. The coupled model stimulates the geomorphological development from the interaction between the intertidal flow, waves, sediment transport and the temporal and spatial variation in the mangrove growth, drag and bio-accumulation over 100 years.

Waves are critical for the transport of mud into the mangrove belt during high tide. Inundation of the inner fringe occurs during spring tides, so the calm conditions allow for a heightened platform and species establishment. The deeper channels form the major path for the tidal inflow during the lower tides, while the interior of the forest is an effective sediment sink during the higher tides. RCP 4.5 and 8.5 SLR scenarios simulate the retreat and decay patterns, with modeled tipping points realized after 1.5m.

Results indicate mangrove adaptability hinges on the long term sedimentation responses and system conditions to promote the establishment of belt widths exceeding 300m.

Keywords

mangroves, adaptation, sea level rise, field measurements