EGU21-7537
https://doi.org/10.5194/egusphere-egu21-7537
EGU General Assembly 2021

Multi-Time Scale Mangrove-Mudflat Modelling: Exploring Guyana's Unique Dataset & Numerical Modelling

Uwe Best[1,3], Mick van der Wegen[1,2], Jasper Dijkstra[2], Johan Reyns[1,3,2], and Dano Roelvink[1,3,2]
[1]IHE Delft Institute for Water Education, Coastal & Urban Risk & Resilience, Netherlands
[2]Deltares, Delft, Netherlands
[3]Delft University of Technology, Delft, Netherlands

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. Mangrove forests, well known as coastal ecosystem defences, attenuate the hydrodynamic forces, reduce coastal erosion and foster conditions for increased sedimentation. However, the mechanistic understanding of the feedbacks between the vegetation and the morphodynamics and, the processes which result in the long term erosion- sedimentation during extreme wave events has been limited (Horstman 2014, Best 2017).Therefore, 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 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 in the mangrove-mudflat coastline at Chateau Margot. This stretch of coastline is subject to a semi-diurnal tidal regime with a 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 Avicennia germinans and Laguncularia racemosa species under suitable inundation and competition regimes. With the dynamic vegetation interface linked via the Basic Model Interface (BMI) with Delft3D-FM, the initial establishment is randomized over the computation grid cells, followed by the growth, diffusion and decay of the mangroves in areas of high stresses. The coupled model simulates 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.

A combination of 1D and 2D simulations to analyze the equilibrium behavior of the system as well to identify the mechanistic feedbacks critical for the development of stable belt widths. 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 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 SLR scenarios, liner and exponential, reinforce behavioral trends for mangrove retreat and decay, with modelled tipping points realized after 1.5m increases. Results indicate mangrove adaptability hinges on the long term sedimentation responses and system conditions to promote the establishment of belt widths exceeding 300m.