Tidal-scale flow routing and sediment deposition in mangroves; a combined observational-numerical approach

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Short-term bio-physical interactions in coastal mangroves contribute to coastal stabilization and coastal safety. Spatial explicit observations (or simulations) of sediment deposition rates in mangroves related to gradients in elevation and vegetation and to tidal-scale hydrodynamics are unprecedented. We studied the tidal-scale bio-physical interactions in coastal mangroves by (i) unravelling contributing processes through numerical modelling based on field observations and (ii) simulating system behaviour for conditions beyond the observed field settings.

This study is based on observations obtained in an elevated mangrove forest dissected by tidal creeks, fringing an estuary at the Thai Andaman coast. A process-based 3D numerical model was set-up in Delft3D, explicitly accounting for vegetation induced drag and turbulence. The 3D model and a depth-averaged (2DH) version thereof were calibrated and validated successfully with the observed flow routing and sediment deposition patterns. The 2DH model proved to be an efficient and accurate tool for computing the tidal-scale dynamics at the study site.

According to field data and numerical simulations, the creeks are a major pathway for tidal inflow during the lower tides, while the sheltered interior of the forest is an effective sediment sink during the higher tides. A sensitivity analysis of the initial system response to instantaneous environmental change shows that the studied mangrove system is rather stable: deposition rates are quite independent of the vegetation density, while counteracting adjustments of the topography and relative elevation. Sediment trapping rapidly reduces with diminishing sediment inputs and a loss of mangrove area, e.g. due to river damming or conversion to aquaculture. Deeper inundations of the mangroves would enhance flow routing through the forest while deposition rates diminish when vegetation densities decrease simultaneously. These results stress the sensitivity of mangroves' sediment trapping capacity to environmental change.

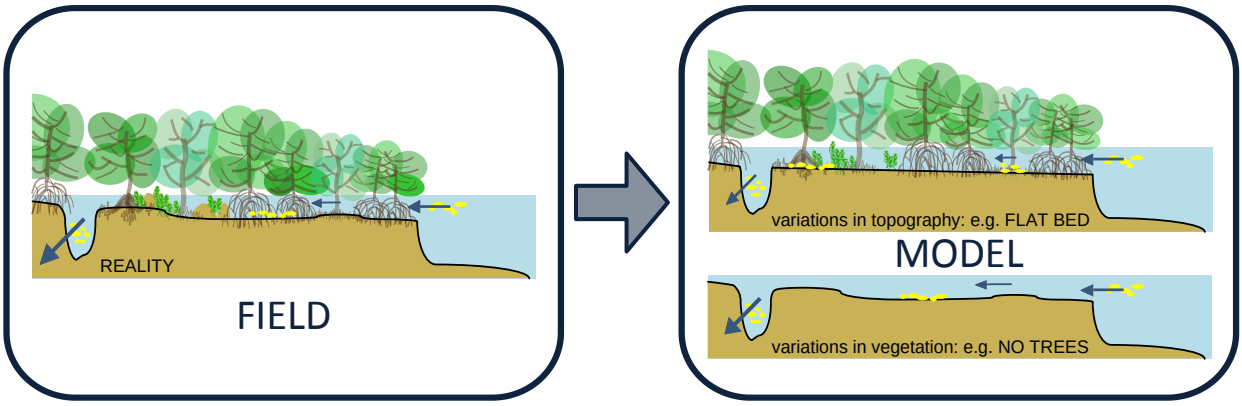

Figure 1. A combined observational-numerical approach to tidal-scale mangrove dynamics.