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The fate of mangrove assemblages in the face of changing coastal systems

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As one of the dominant ecosystems present along tropical and subtropical shorelines, mangroves provide valuable ecological and economic functions, including carbon sequestration, provision of habitats for various organisms and coastal protection. At the same time, these ecosystems are increasingly threatened by relative sea level rise and human activities. Existing models and projections generally focus on the importance of biophysical feedbacks in controlling vertical accretion and inland migration as a way for mangroves to survive future pressures. However, the possibility of mangroves to expand seaward under coastal progradation is still poorly understood and the impacts of environmental and human stresses on forests with multiple mangrove species are rarely studied.
This study, for the first time, investigates the development of mangrove assemblages in response to external drivers such as sea level rise, sediment availability and coastal barriers. We present a new eco-morphodynamic model that captures the interactions between mangrove assemblages consisting of red, black and white mangroves, hydrodynamics, sediment transport and coastal evolution on centennial time scales.
We find that total mangrove coverage across the coastal gradient can increase despite sea level rise because of both landward and seaward expansion. Inland migration of trees is controlled by the increase in inundation of previously dry areas contingent on the availability of allocation space (i.e. absence of coastal barriers). Seaward expansion is dominated by the balance between sea level rise and sediment availability and only possible through coastal progradation under sufficiently high sediment supplies. Furthermore, under the absence of coastal barriers, mangrove forest diversity remains relatively stable despite changes in sea level or sediment availability.
Simulations including coastal barriers constraining the inland migration of mangroves show a decrease in both total forest coverage and mangrove diversity, especially in the case of low sediment supply and high sea level rise. Additionally, mangrove species only able to survive under short inundation regimes may eventually fully disappear. On the other hand, it is surprising that the presence of a coastal barrier can accelerate sediment accumulation under high sea level rise rates. As a result, coastal progradation is boosted facilitating the survival of existing mangroves in comparison to the scenarios without barriers. Finally, we show how spatio-temporal variations in accretion rates can further drive species-specific responses under sea level rise. Our modelling results highlight the sensitivity of mangrove forests to external pressures and the complex biophysical feedbacks that govern the evolution of these valuable ecosystems.