Universiteit Utrecht

Faculty of Geosciences
River and delta morphodynamics

Responses of mangrove forests to sea-level rise and human interventions

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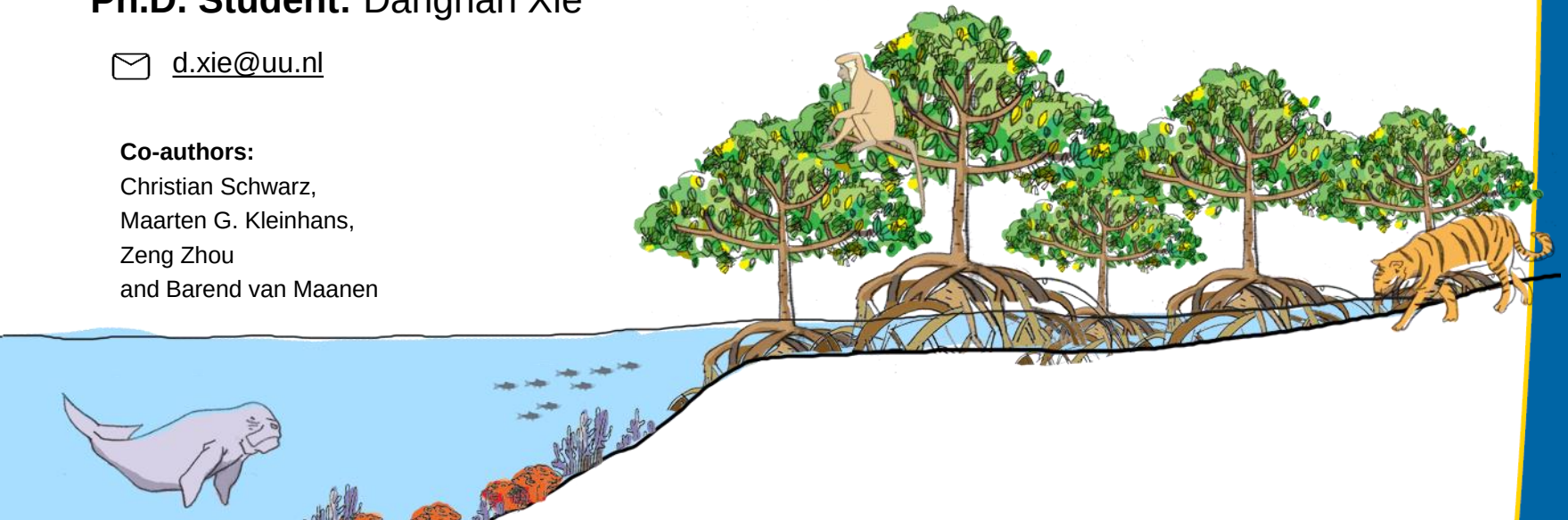
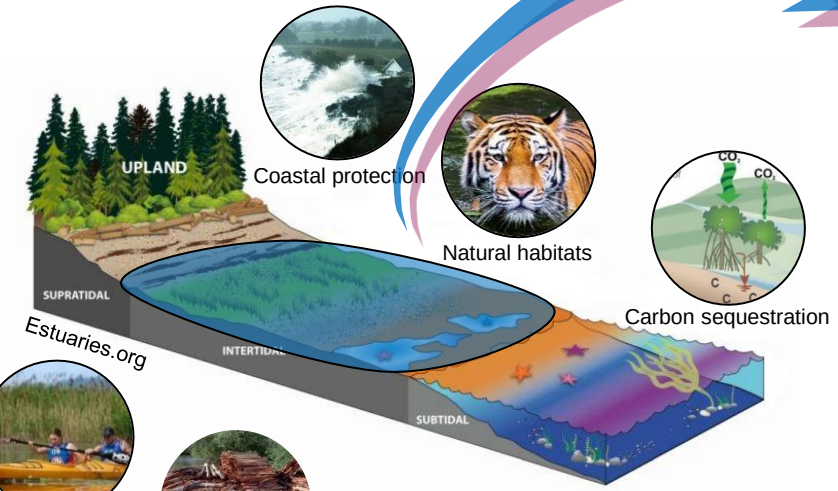
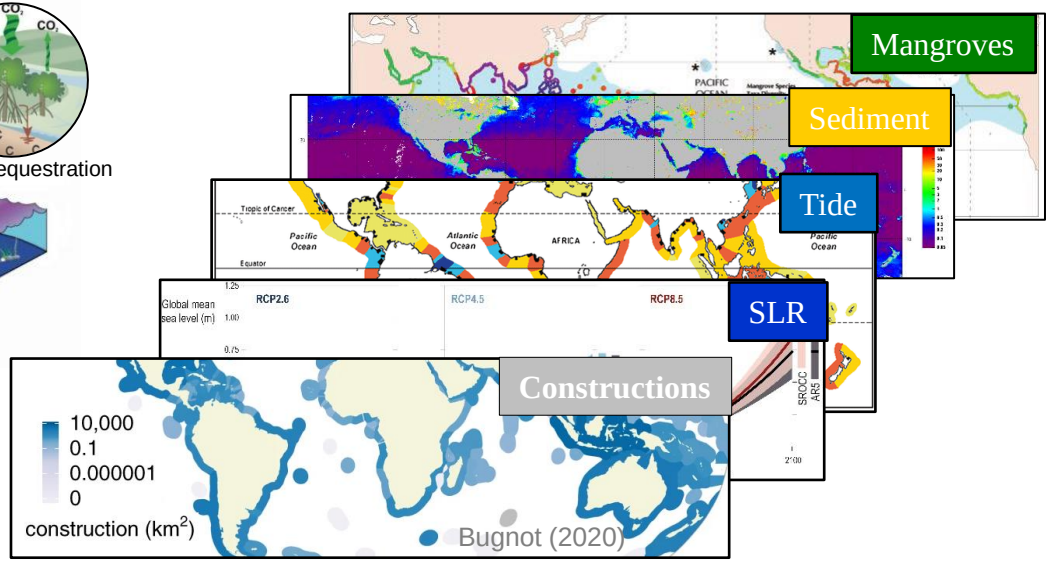


Mangrove habitats

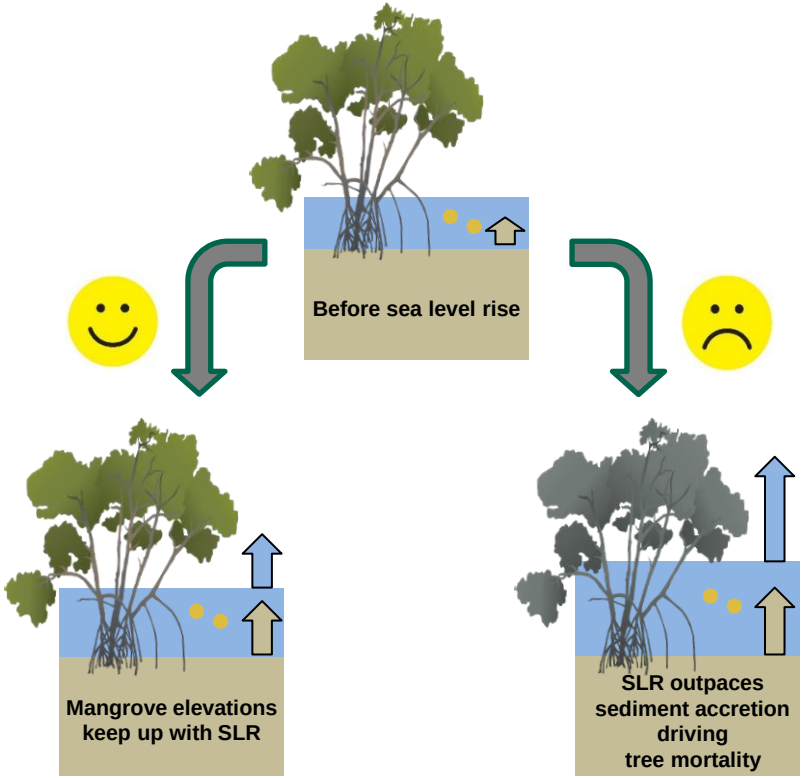
A multifunctional coastal ecosystem:

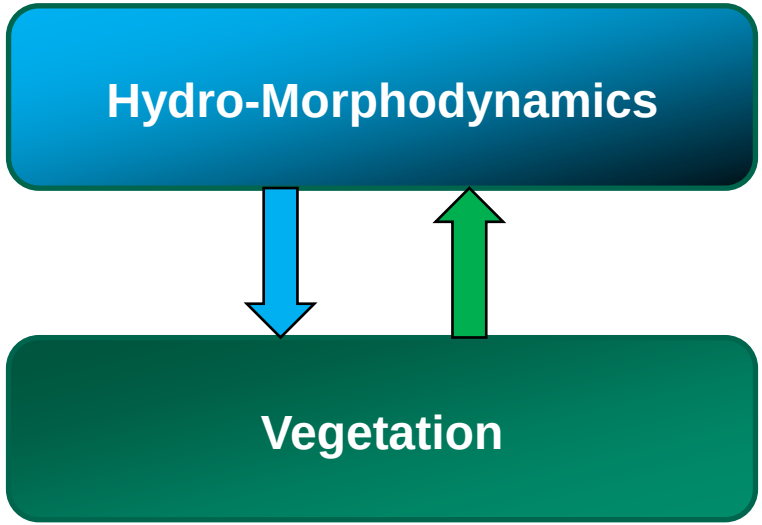




How do mangroves respond to accelerating sea-level rise and increasing human pressure?

Importance of biophysical feedbacks





Sediment accumulation is typically dependent on inundation period

Sediment dynamics

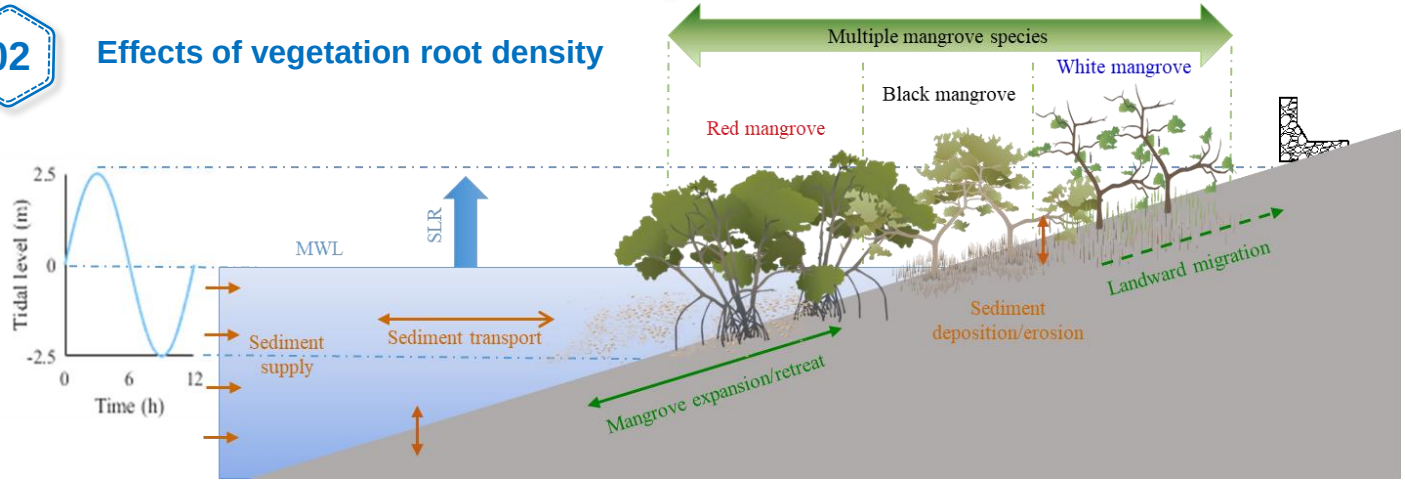
Vegetation dynamics (species difference, pneumatophore variations)

Various environmental conditions

New bio-morphodynamic model development

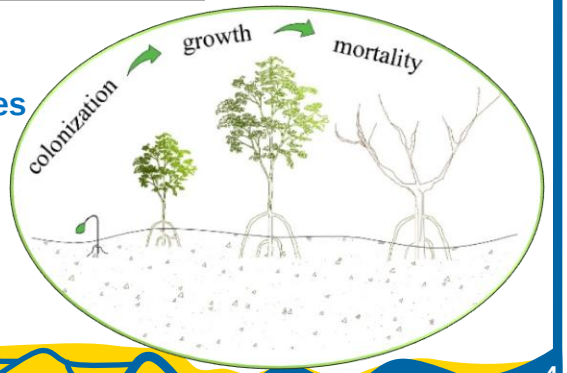
01 One or multiple vegetation species

02 Effects of vegetation root density



03 Tides, waves & sea-level rise

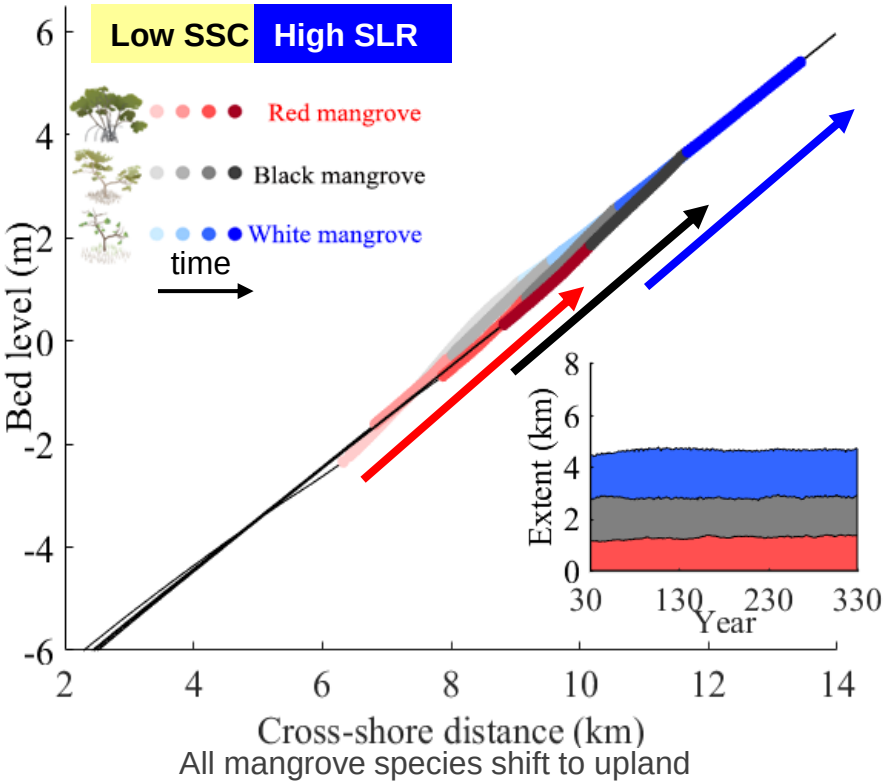
05 Dynamic vegetation processes



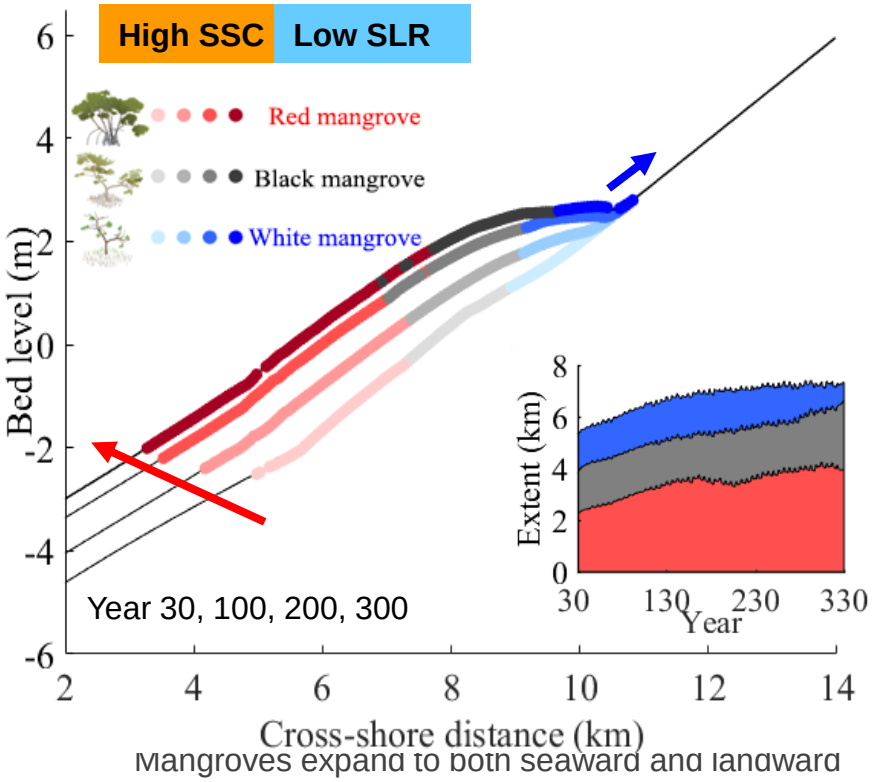
04 Comprehensive treatment of sediment process

Impacts of sediment supply concentration and sea level rise

Tidal range = 5 m (M2)



All mangrove species shift to upland

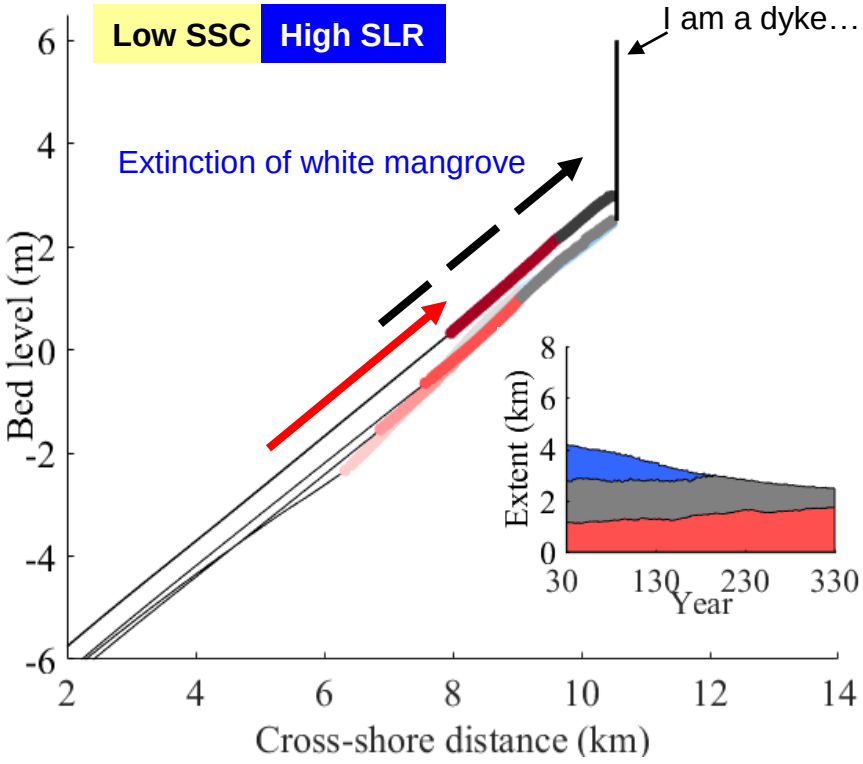


Mangroves expand to both seaward and landward

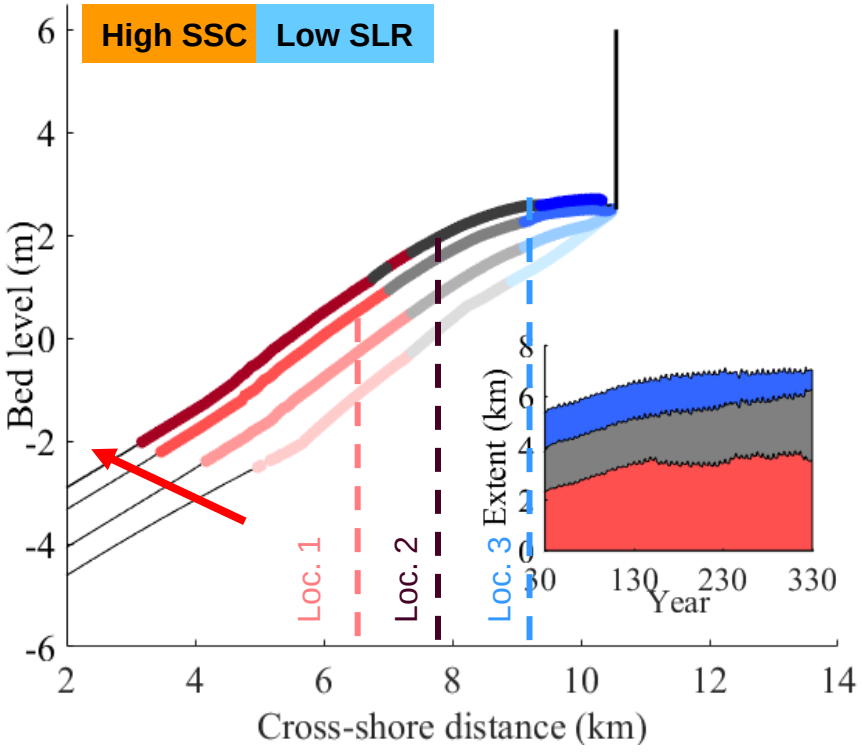
*** SSC= Sediment supply concentration; SLR=sea level rise**

Xie et al., 2020 Environmental Research Letters

Impacts of human barriers

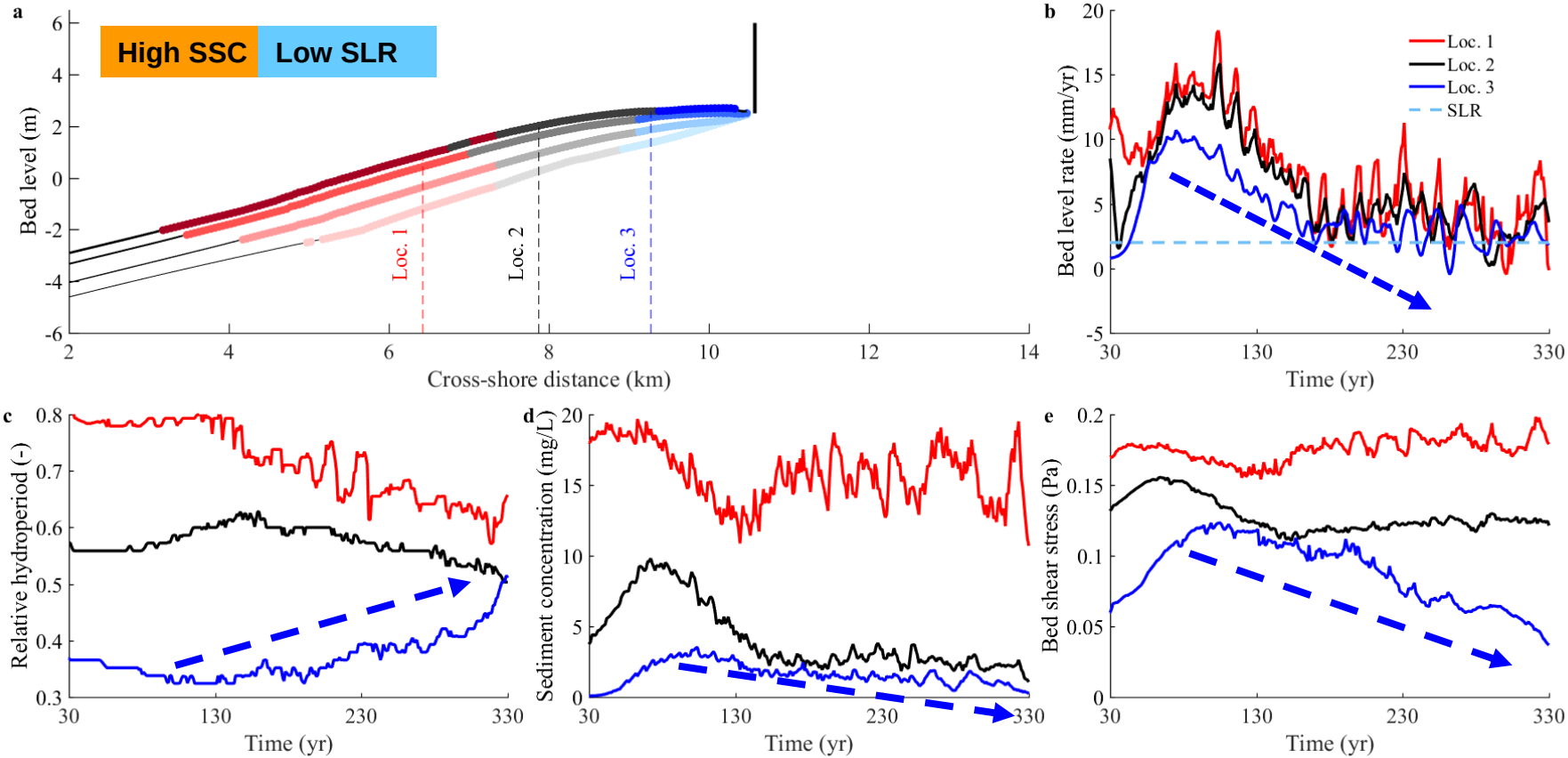


All mangrove species shift to upland, extinction happens



Mangroves expand to seaward but blocked on upland

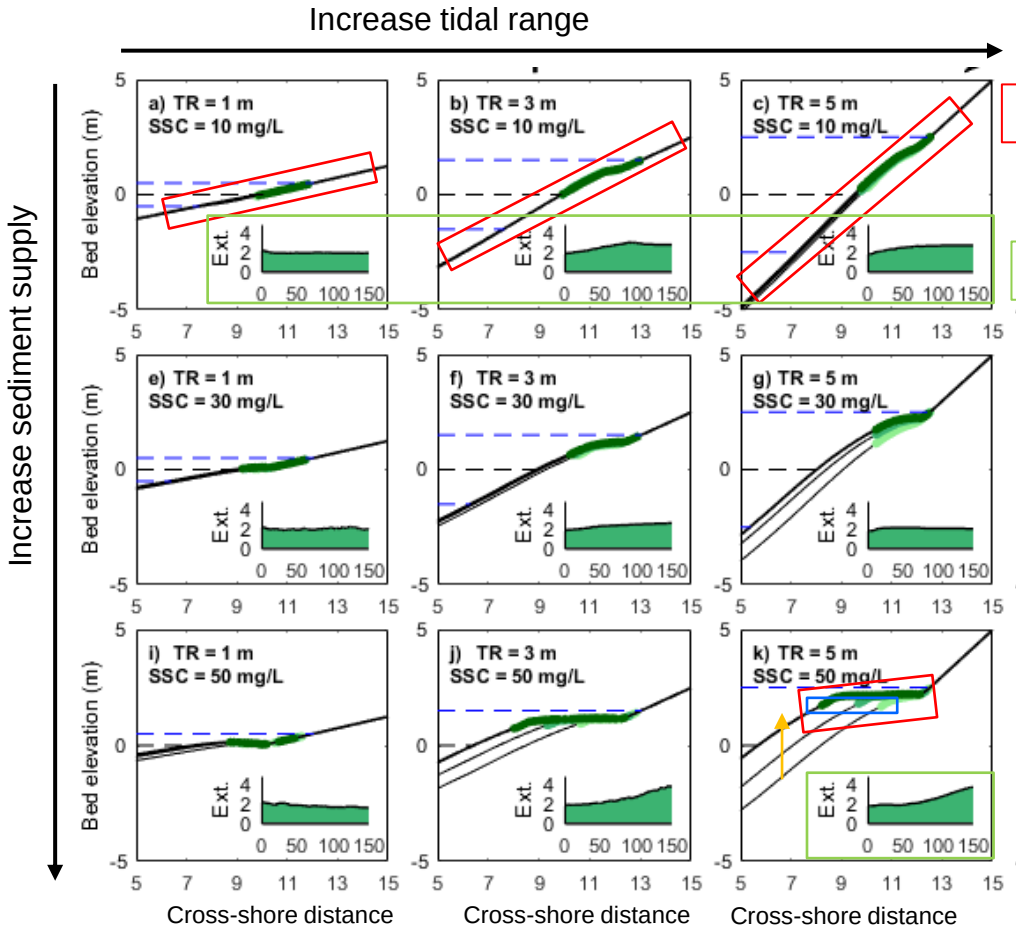
Species interactions arising from bio-physical feedbacks



Bed level accumulation rate decreases while inundation period increases → species are linked!!!

Xie et al., 2020 Environmental Research Letters

Impacts of varying environmental conditions: *without* SLR



Stable profile & vegetation

Comparable vegetation extent

More accretion

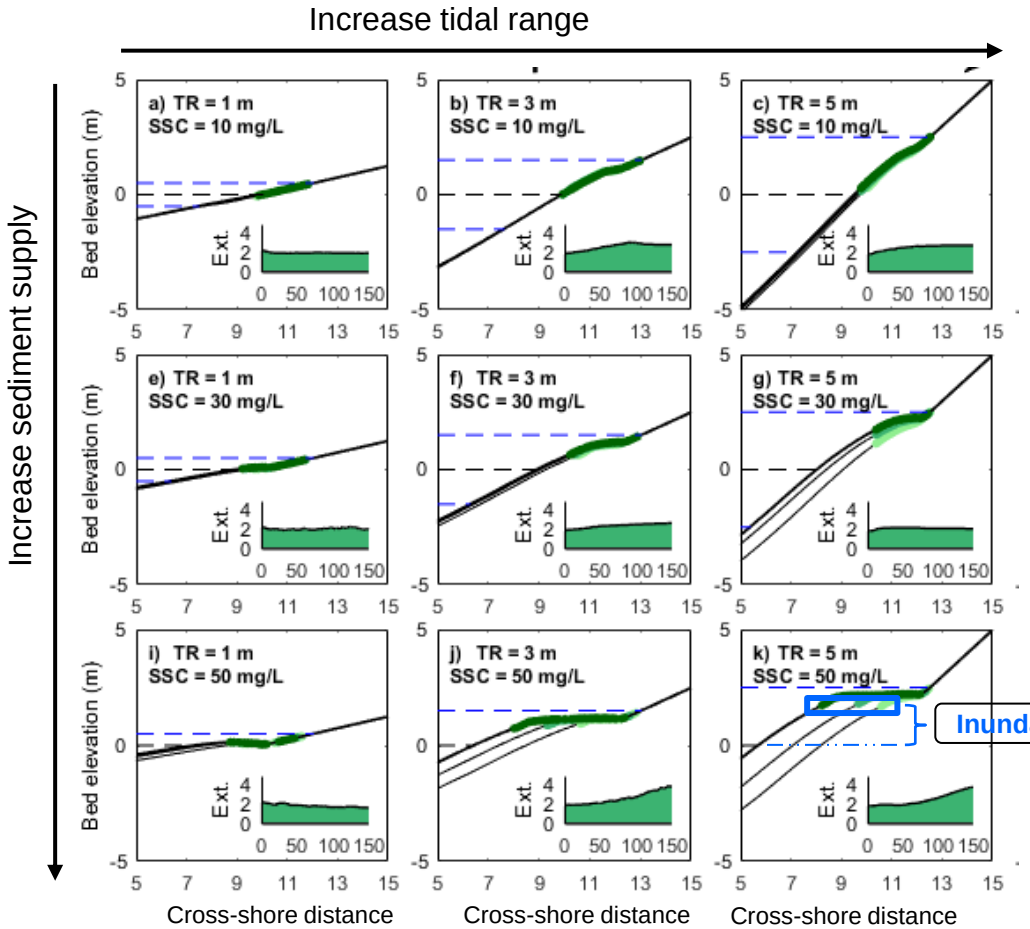
Gentler slope

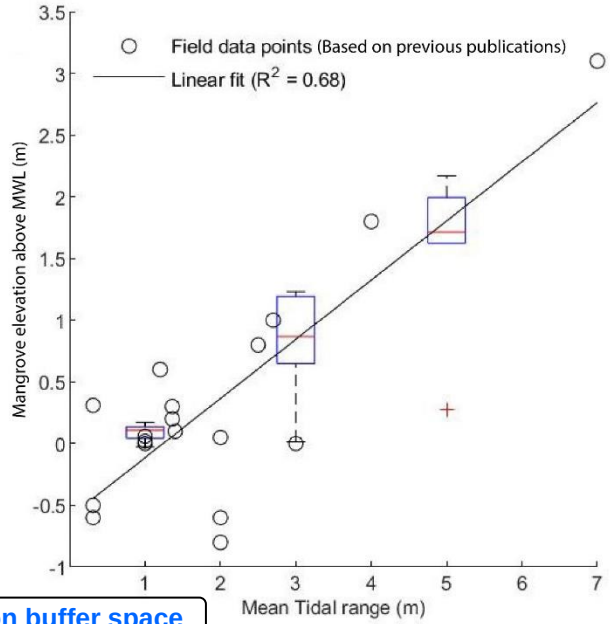
Vegetation extent increases

Mangroves colonize at higher elevation

Xie et al., Journal of Geophysical Research: Earth Surface (*in review****)***

Impacts of varying environmental conditions: *without* SLR





Inundation buffer space

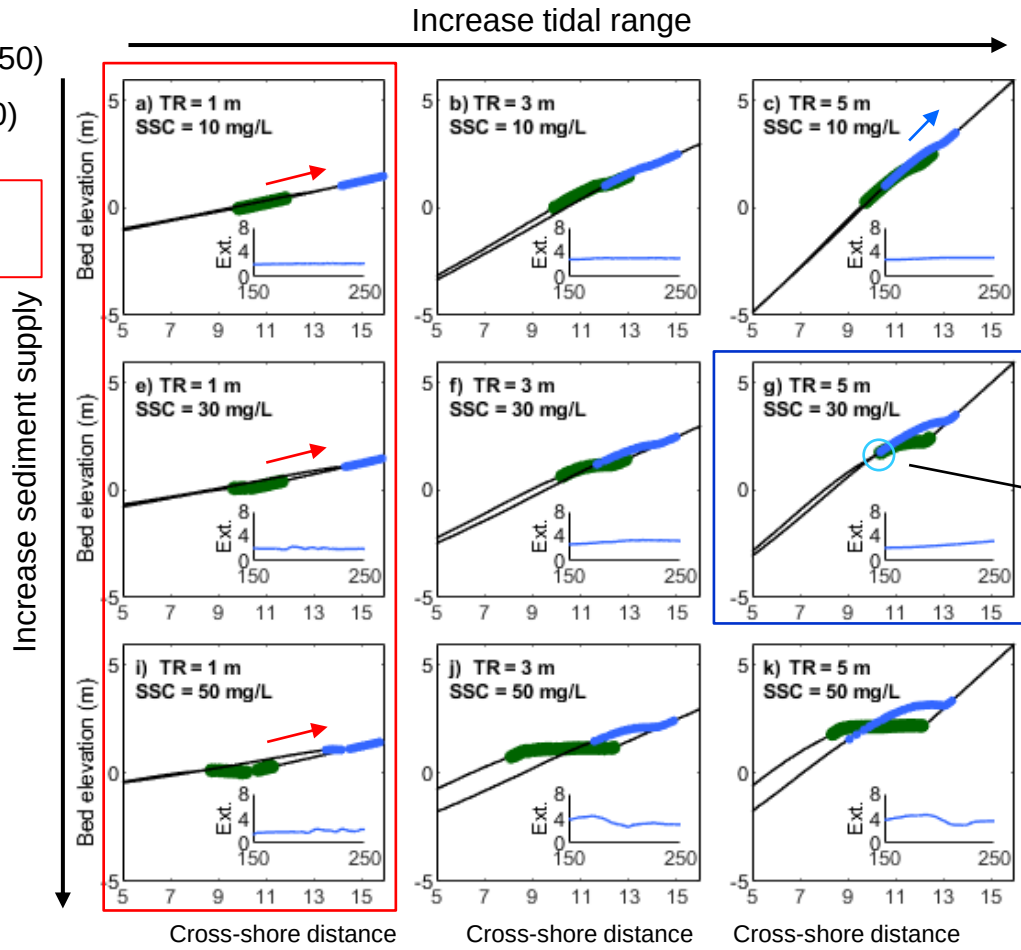
Limitation of mangrove seaward colonization increases with tidal range.

Xie et al., Journal of Geophysical Research: Earth Surface (in review)

Impacts of varying environmental conditions: *with* SLR

- Before SLR (year 150)
- After SLR (year 250)

Mangrove development: SLR dependent



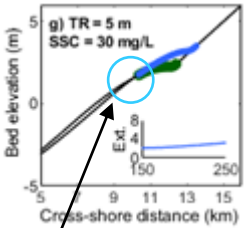
Little landward retreat

Stable vegetation seaward

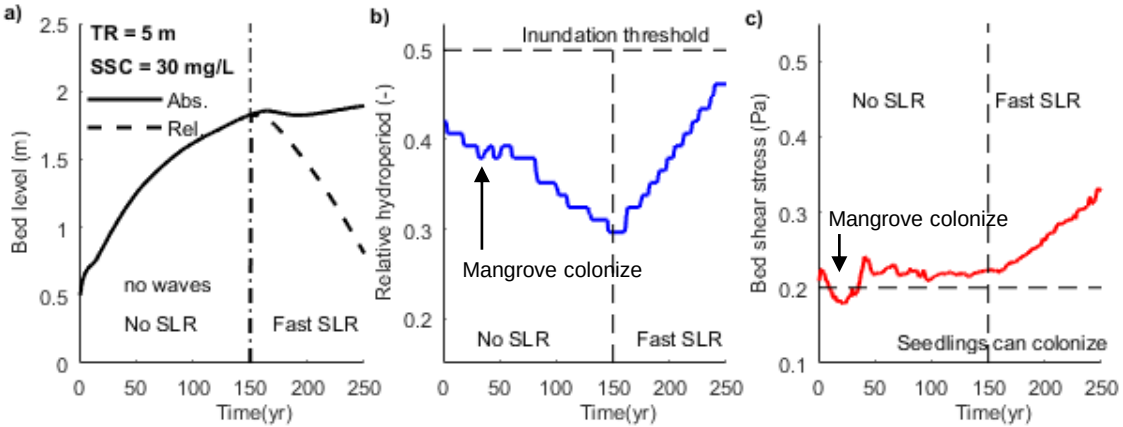
What happened here?

Xie et al., Journal of Geophysical Research: Earth Surface (in review)

Impacts of buffer space during SLR



What happened here?



Before SLR:

Increase | Decrease | Rel. constant

During SLR:

Decrease (rel.) | Increase but lower than threshold | Increase

Inundation buffer forms because of colonization restrictions, such that the inundation threshold of mangrove trees is not immediately exceeded during rising sea levels

Key messages

Different mangrove responses due to physical settings:

1- Mangroves can expand despite of SLR

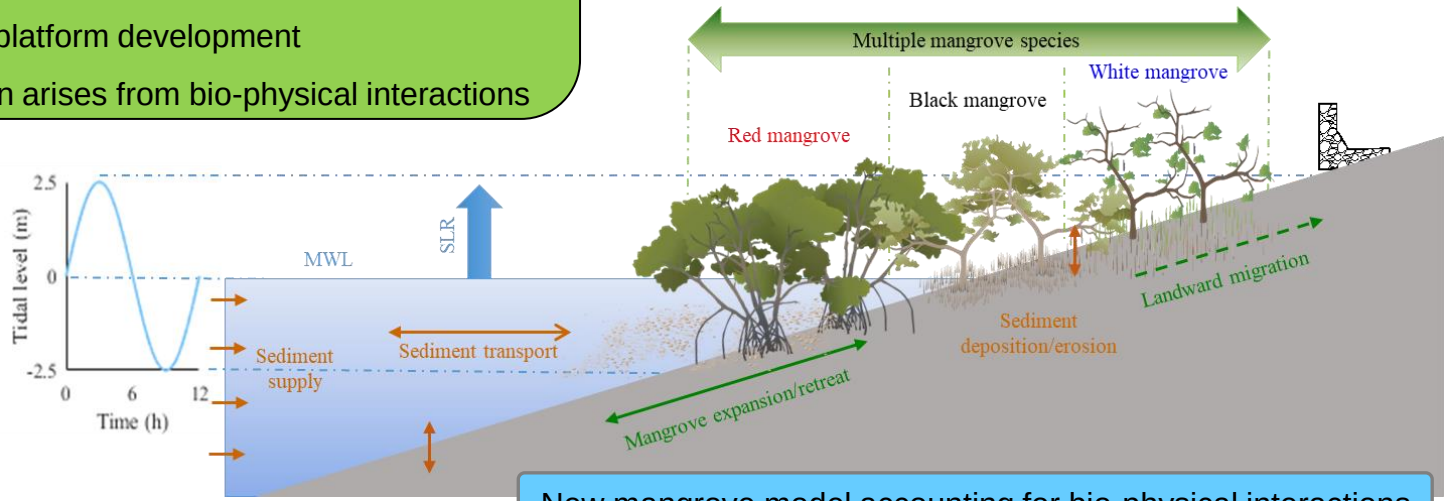
2- Stable mangrove seaward edge with SLR

3- Mirco-tidal system exhibited highest vulnerability

4- Coastal slope and platform development

5- Species substitution arises from bio-physical interactions

Human impacts, such as coastal barriers, limit mangrove inland migration and may threaten mangrove species



New mangrove model accounting for bio-physical interactions

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Xie et al., 2020 - Mangrove diversity loss under sea-level rise triggered by bio-morphodynamic feedbacks and anthropogenic pressures, *Environmental Research Letters*, *15*(11), 114033.

Xie et al., Implications of Coastal Conditions and Sea-Level Rise on Mangrove Vulnerability: a Bio-morphodynamic Modelling Study, *Journal of Geophysical Research: Earth Surface (in review)*