



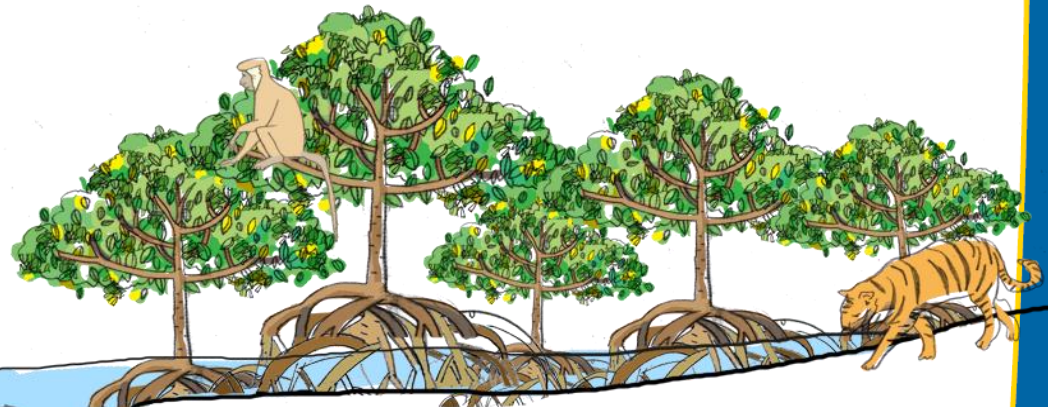
# A bio-morphodynamic modelling study to determine how environmental conditions control mangrove vulnerability to sea-level rise

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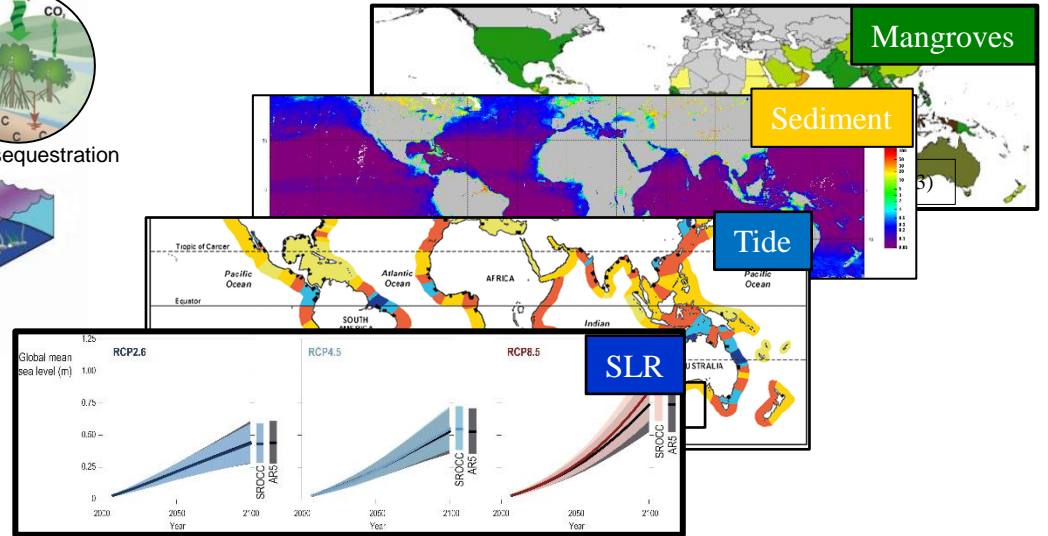
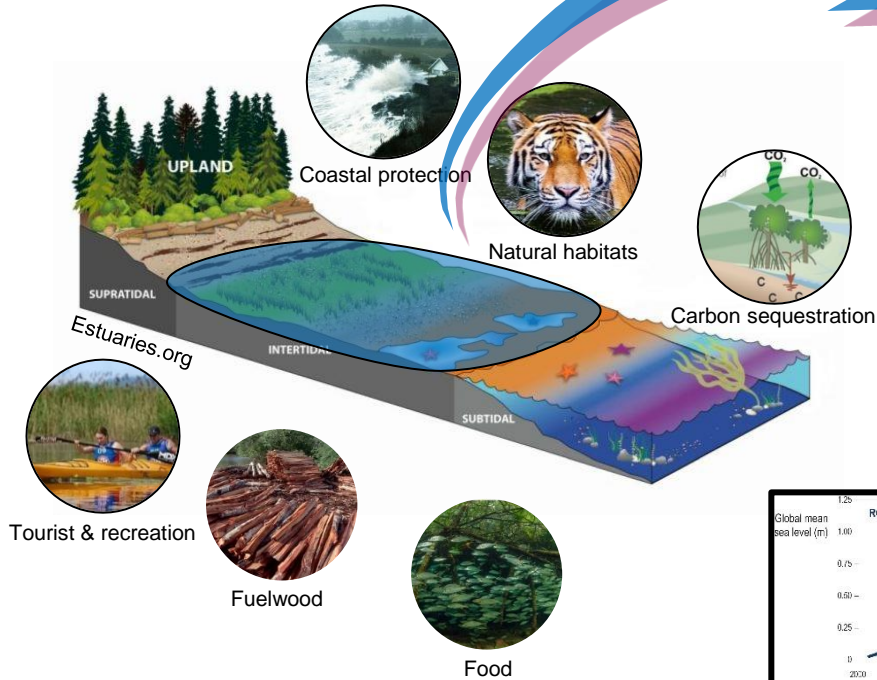
**Co-authors:**

Christian Schwarz,  
Maarten G. Kleinhans,  
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and Barend van Maanen



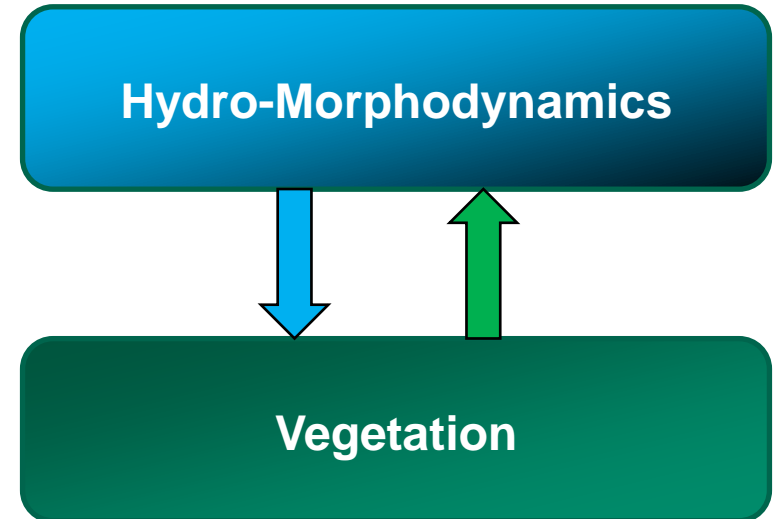
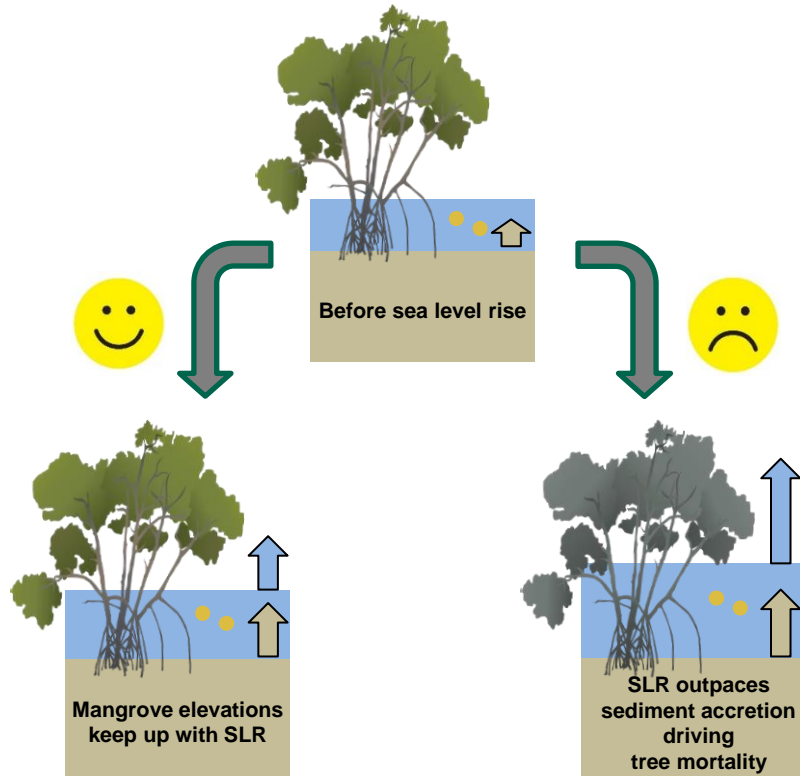
# Mangrove habitats

A multifunctional coastal ecosystem:



How do mangroves in various environmental settings respond to accelerating sea-level rise?

# Importance of biophysical feedbacks



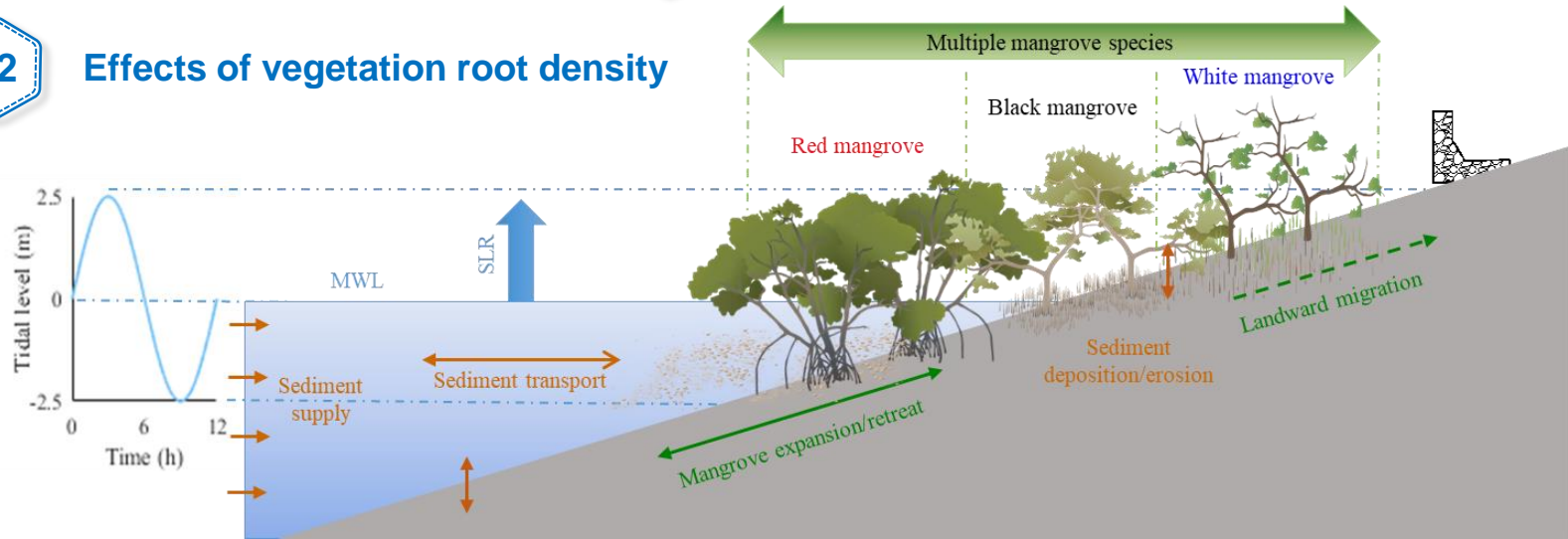
**Sediment accumulation is typically dependent on inundation period**

- What is the impact of coastal conditions on SLR resilience of bio-morphodynamic systems?
- What processes control the movement of the seaward mangrove edge?
- How does sediment accretion respond to SLR?

# New bio-morphodynamic model development

01 One or multiple vegetation species

02 Effects of vegetation root density

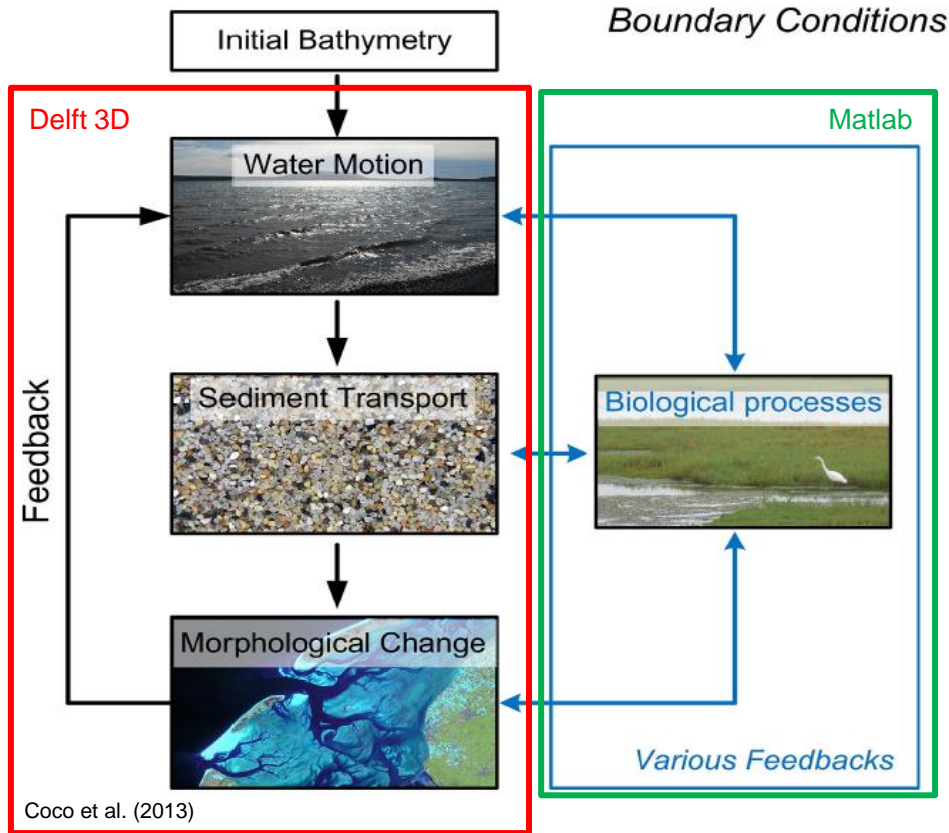


03 Tides, waves & sea-level rise

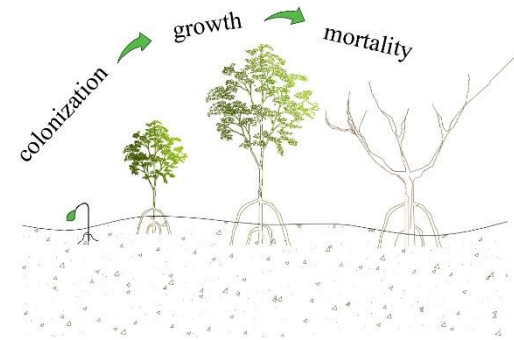
04 Comprehensive treatment of sediment process

05 1D thus fast and effective

# Working structure of mangrove model



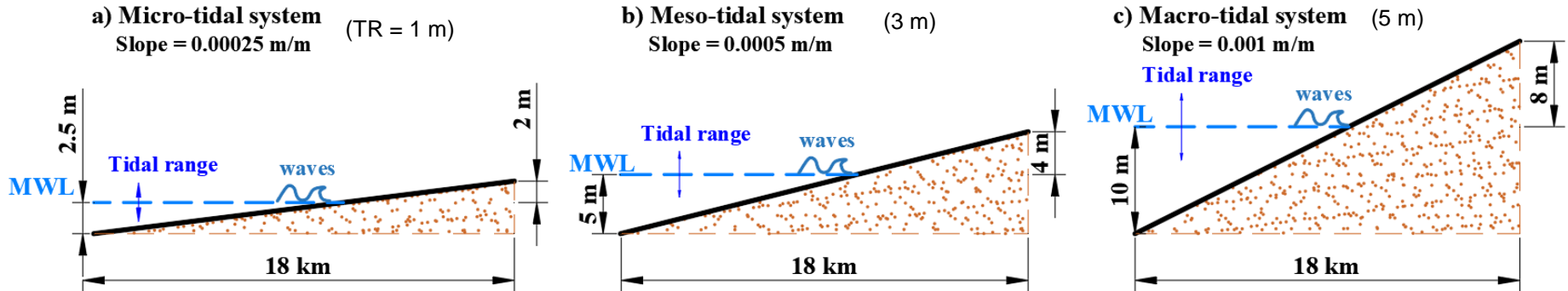
Vegetation life processes:



- 1) Colonization constraints:**  
suitable inundation regime and limited flow strength
- 2) Mangrove mortality:**  
inundation and competition

# Model settings and Simulation arrangement

## 1) Initial bathymetry

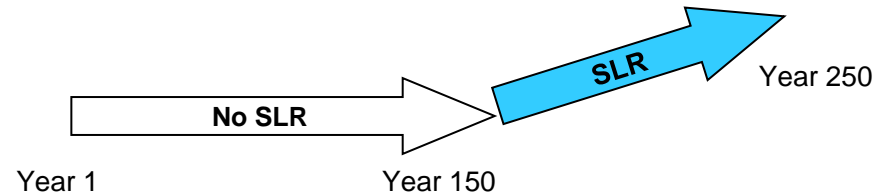


## 2) Boundary conditions

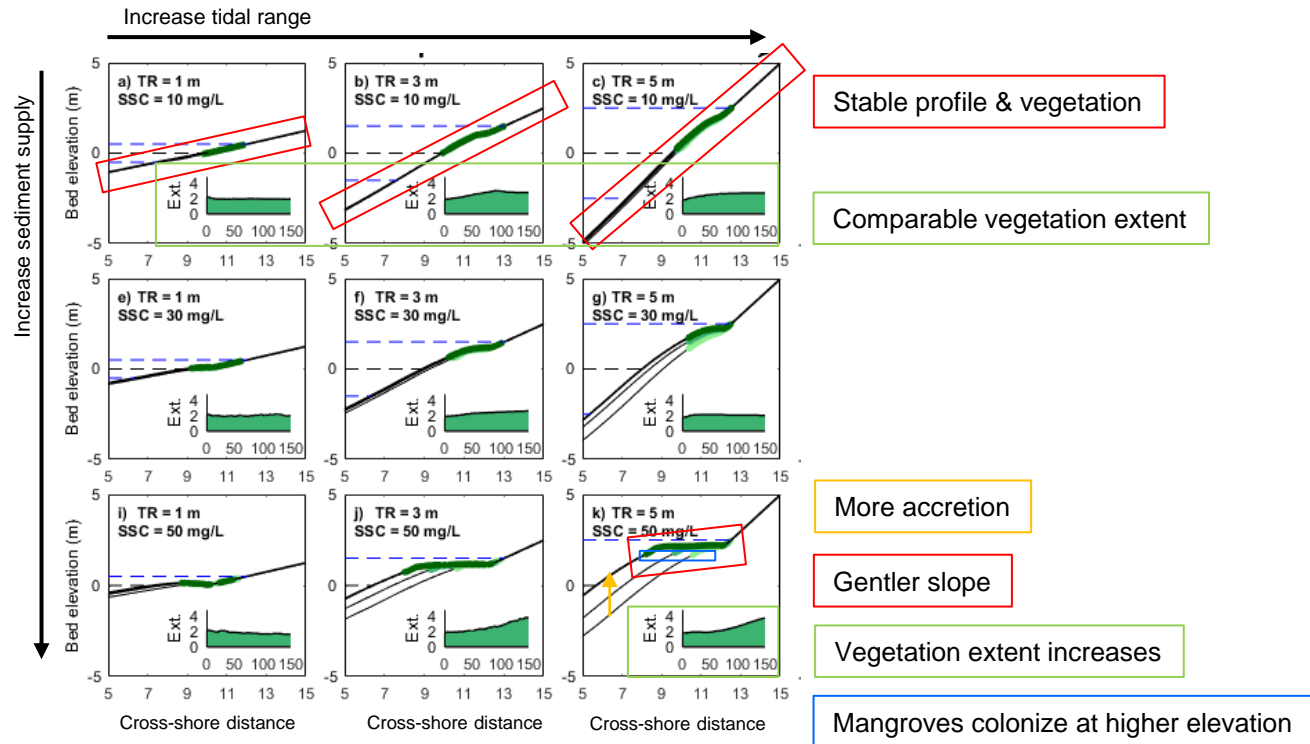
- Sediment supply {
  - Low: 10 mg/L
  - Med.: 30 mg/L
  - High: 50 mg/L

- Wave conditions {
  - No waves
  - Moderate wind waves

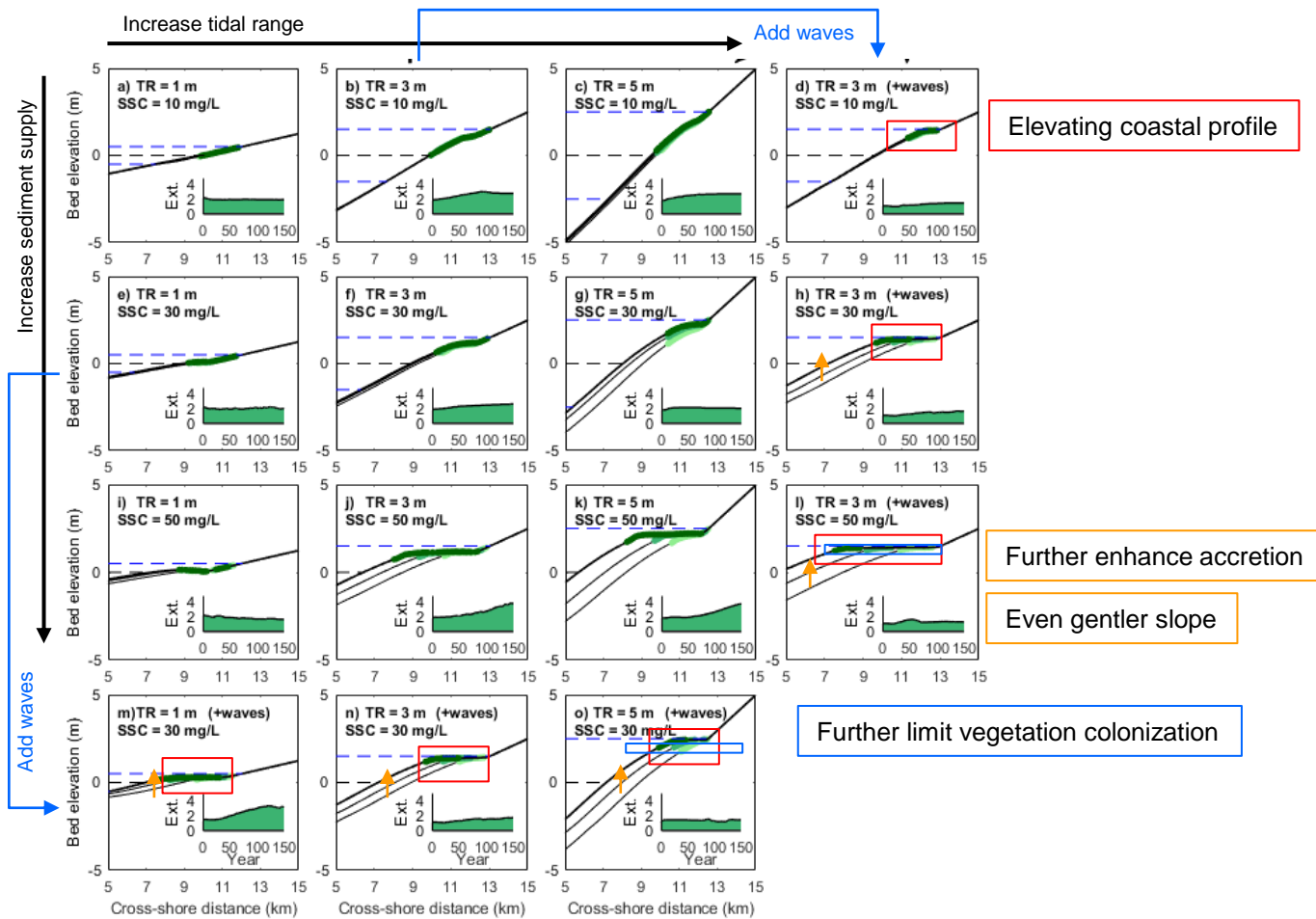
## 3) Simulation periods



# Impacts of varying environmental conditions: *without* SLR



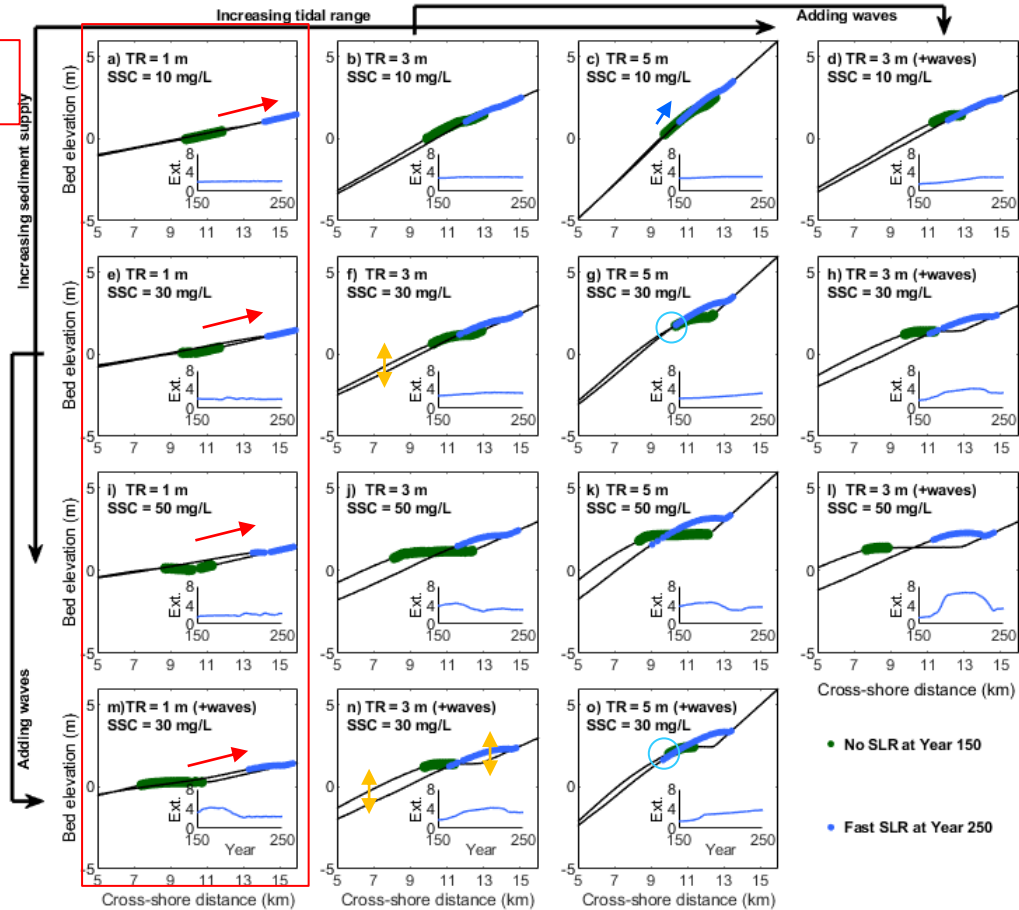
# Impacts of varying environmental conditions: *without* SLR





# Impacts of varying environmental conditions: *with* SLR

Mangrove development:  
SLR dependent

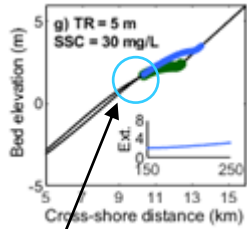


Little landward retreat

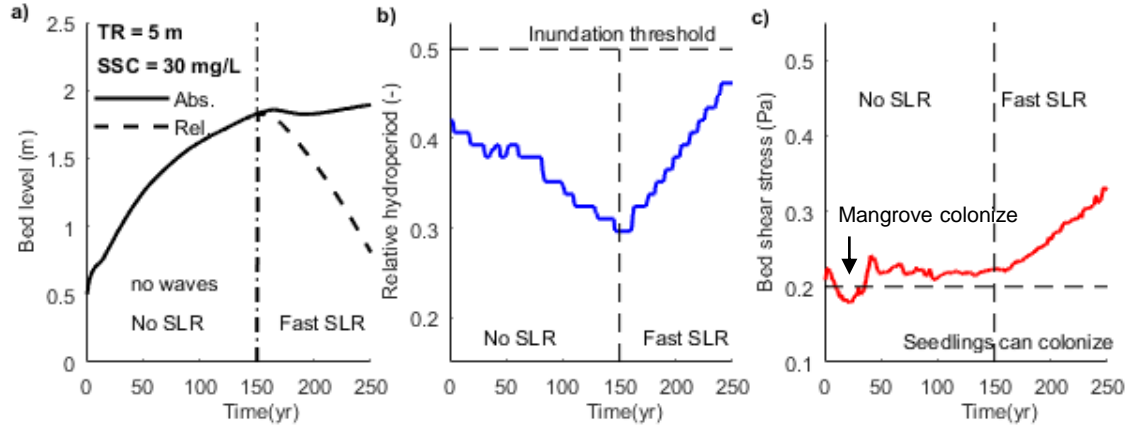
Stable vegetation seaward

Waves enhance erosion offshore but accretion onshore

# Impacts of buffer space during SLR



What happened here?

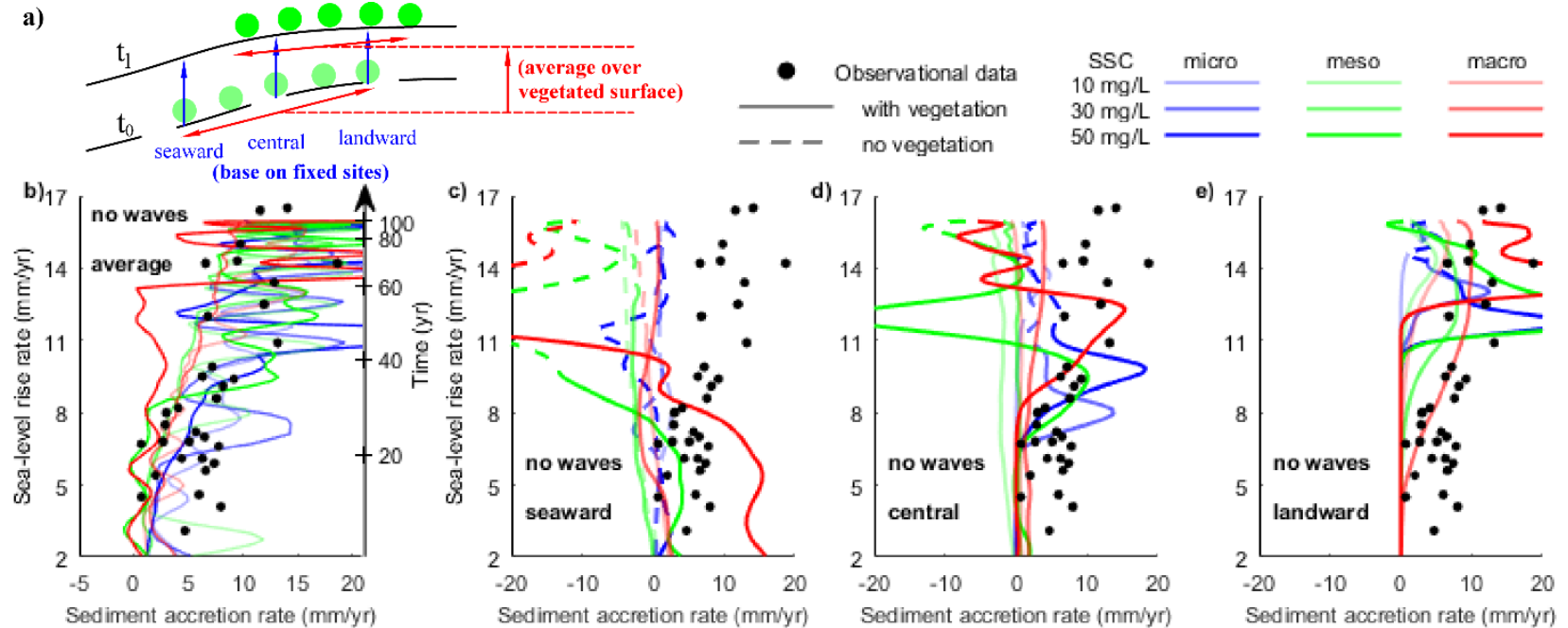


Before SLR:      Increase bed level      Decrease inundation      Changes in flow strength

During SLR:      Small accretion with a decreasing rel. bed level      Increasing inundation but still remains lower than threshold      Enhanced flow strength

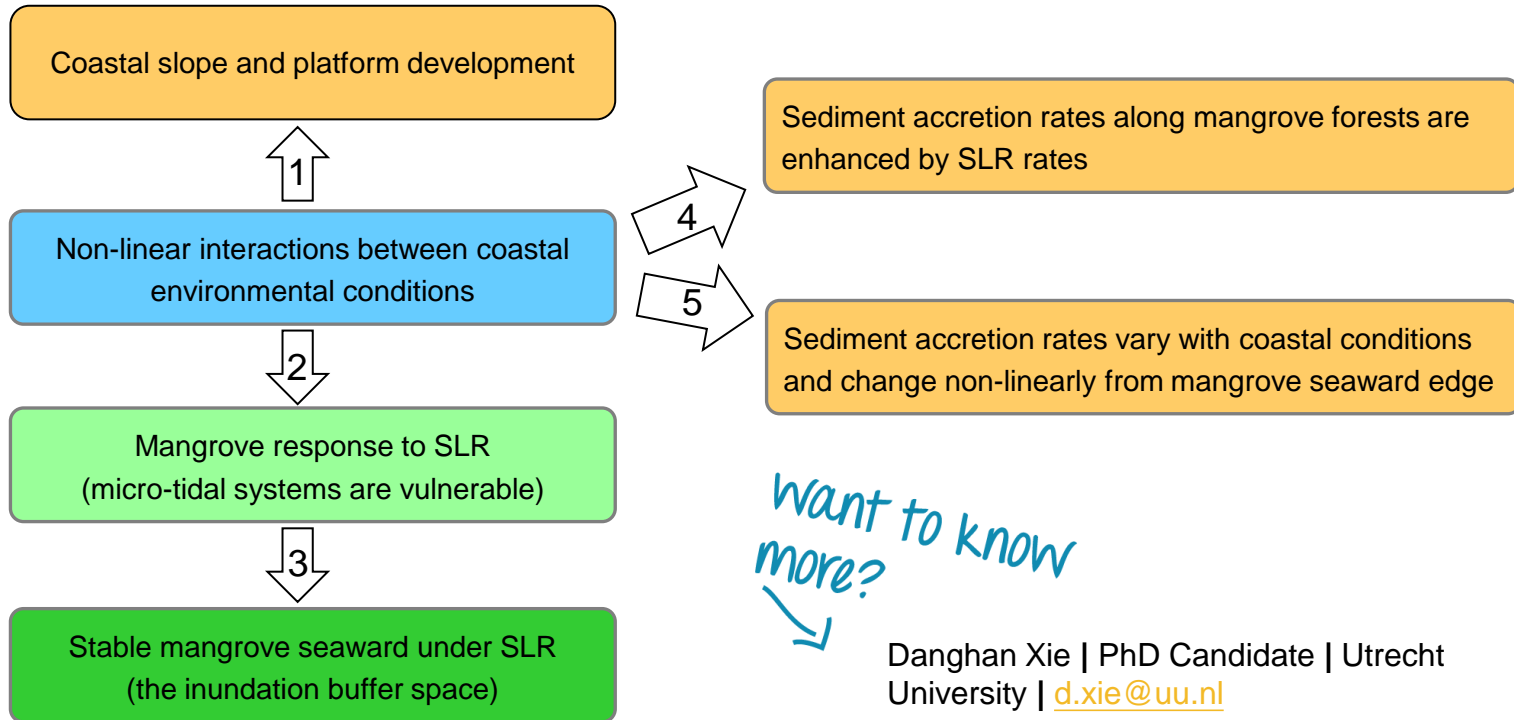
Inundation buffer forms because of colonization restrictions, such that the inundation threshold of mangrove trees is not immediately exceeded during rising sea levels

# Comparison with the field data showing Nonlinear relations between SLR and sediment accretion rates



Sediment accretion indeed increases with SLR, but that the timing and magnitude of change depends on coastal conditions and position within the forest.

# Key messages



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## Earlier publication that describes model development:

Xie, D., Schwarz, C., Brückner, M. Z. M., Kleinans, M. G., Urrego, D. H., Zhou, Z., and van Maanen, B. (2020), Mangrove diversity loss under sea-level rise triggered by bio-morphodynamic feedbacks and anthropogenic pressures, *Environmental Research Letters*, 15(11), 114033.