Advancing Resilience Measures for Vegetated-Mudflat Coastlines under Climate Change Impacts: Sea Level Rise & Storms

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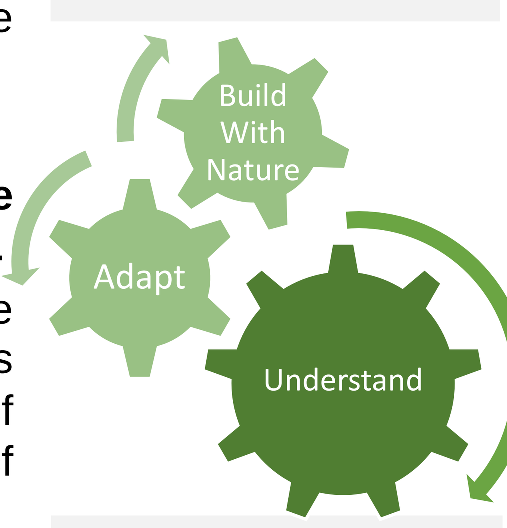
1 Background

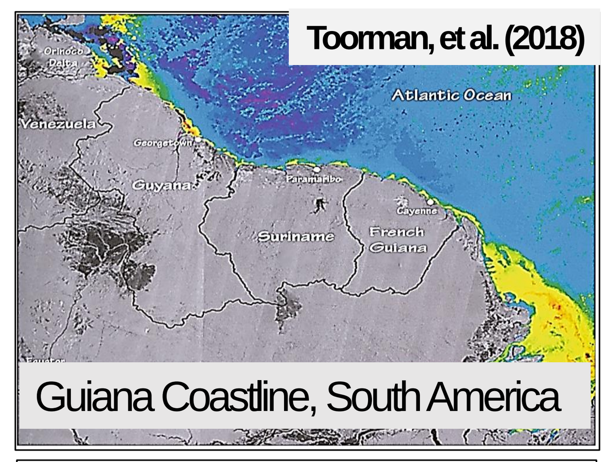
- Vegetated foreshores, e.g. mangroves and salt marshes, are critical towards reducing flooding risk.
- They maintain valuable ecosystem services.
- They allow for a flexible and adaptive response to climate change by:
  - **Attenuating wave energy,**
  - **Stabilizing and heightening the foreshore** at a rate that matches or exceeds that of SLR.
- However over the next 100 years, they will be impacted by **sea level rise (SLR)** scenarios >2.0m, intensified magnitude and frequency of storms and the anthropogenic influences of humans.

Questions are posed concerning the **resilience of these vegetated foreshores,** the **vulnerability of associated coastal environments** and **how best to design hybrid coastal protection measures.**

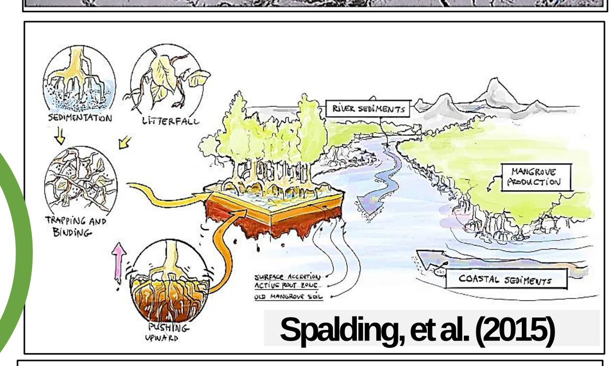
The Survival of the Mangrove System = Healthy Sediment Budget



Increasing Extreme Events = Need for Hybrid Coastal Protection Measures



Guiana Coastline, South America

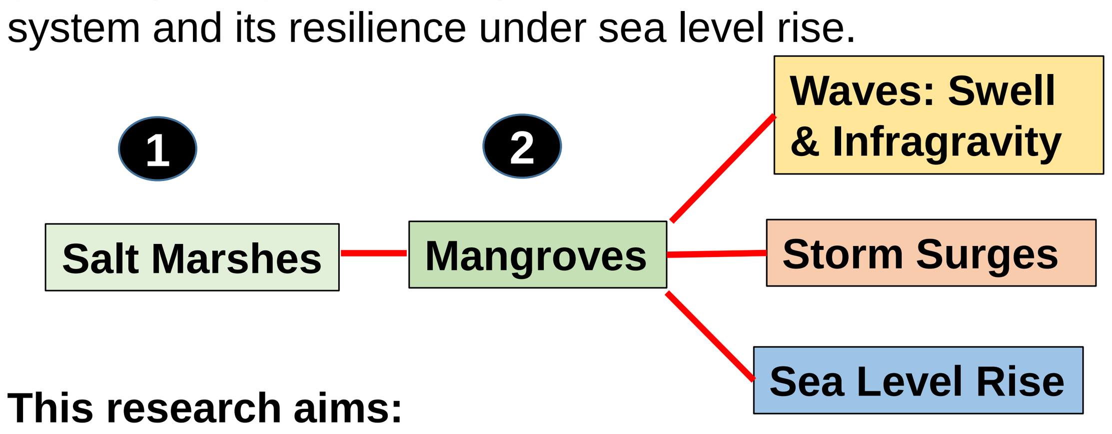


Spalding, et al. (2015)

Mangrove Coast, Guyana, South America

2 Research Objectives & Methodology

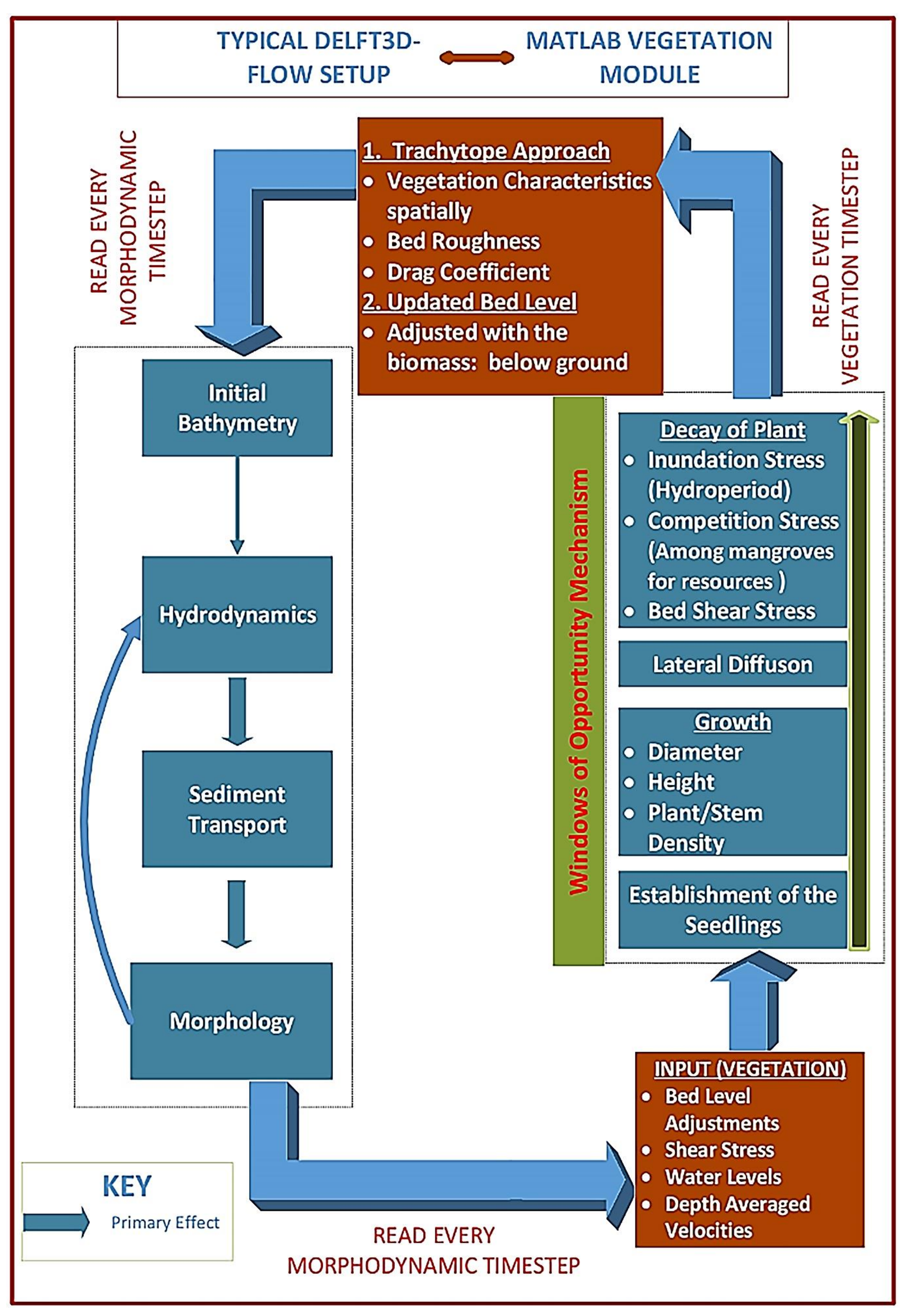
The first phase investigated the governing process for the geomorphological development of a salt marsh-mudflat system and its resilience under sea level rise.



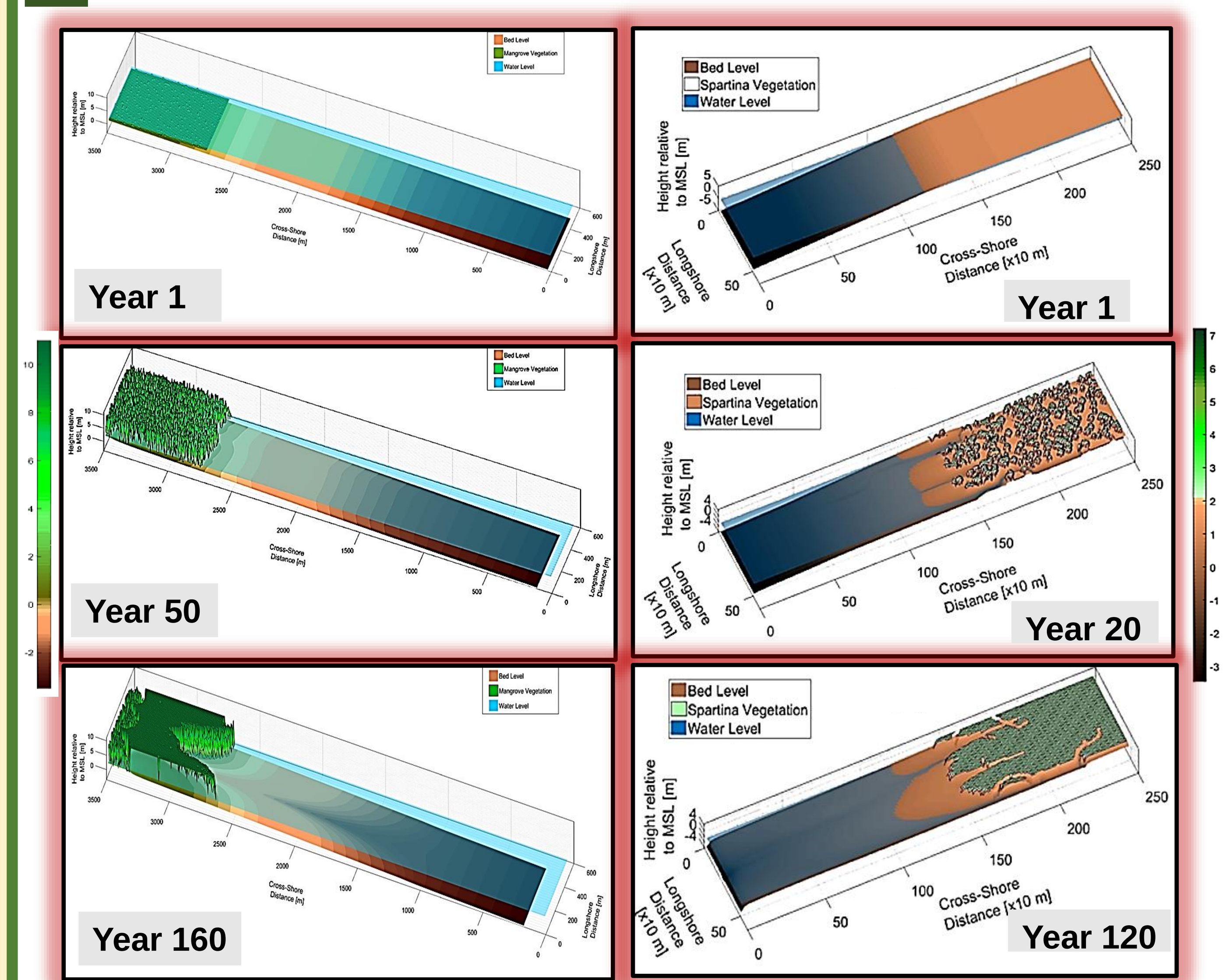
This research aims:

1. To examine the resulting **spatial dynamics of the sediment gradient** under swell and infragravity waves,
2. To determine the temporal dynamics of **constant vs. extreme wave forcings** on the mangrove functionality and recovery rates,
3. To determine the **tipping points of the mangrove systems** under a range of projected sea level rise rates, and
4. To create a **vulnerability index for combined structural solutions** with mangrove foreshores, e.g., reduction in overtopping, adaptability under SLR, maintenance of critical width, allowance for retreat.

For the storm & wave analysis, SWAN and / or XBeach will be used in an approach with Delft3D-Flexible Mesh BMI with XBeach.



3 Model Development Morphology



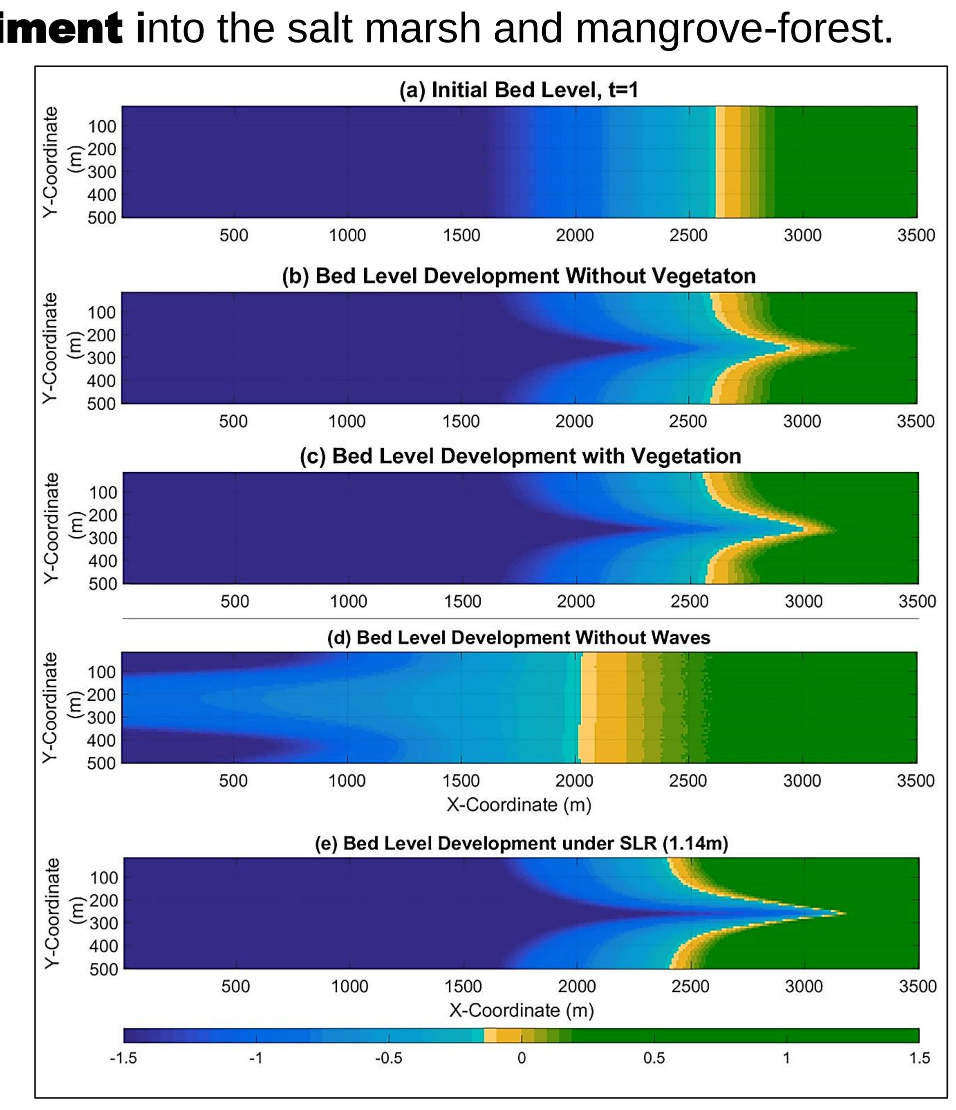
Mangroves | Salt Marshes

Once conditions are suitable for colonization the vegetation establishes. For **salt marshes they attain dynamic equilibrium in 120 years** with **bio-accumulation and sediment deposition** being **pivotal for survival**.

After **160 years for mangroves, the morphology and biomass continue to evolve** with a satisfactory spatial layout of the mangrove-belt and underlying channel-shoal pattern.

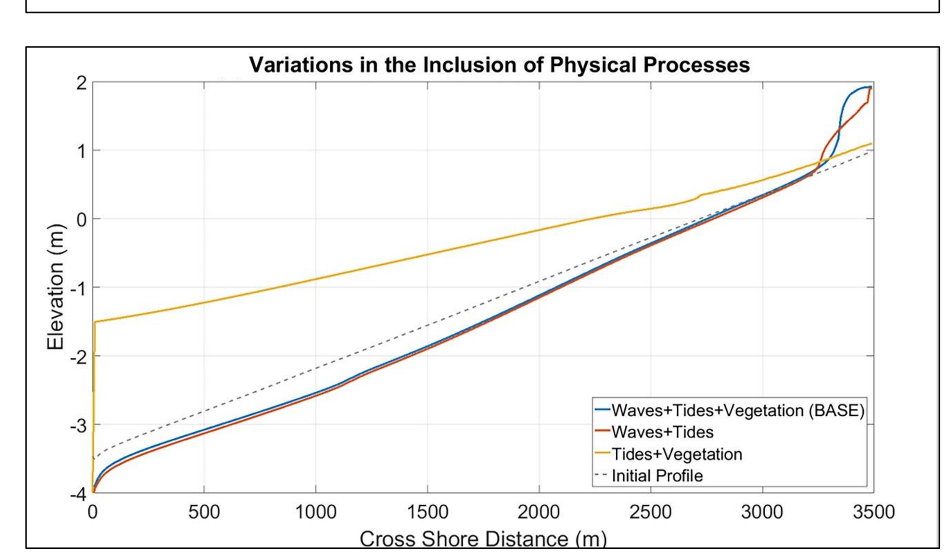
4 Critical Processes in the Mangrove Development

- For both vegetated systems, **wave action is critical for transporting sediment** into the salt marsh and mangrove-forest.
- Without mangrove vegetation, the **channels are narrower and incise the platform more** as the presence of vegetation adds stability along the banks.
- This stability allows for the **heightening of the mangrove interface** with the mudflat.



Validation

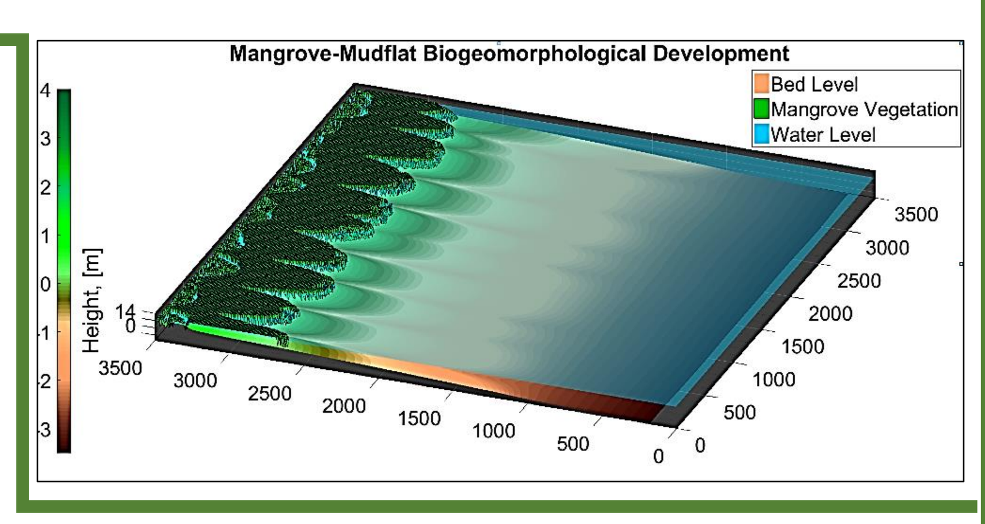
- **Boundary effects are not an issue.**
- The model is validated by trends from satellite imagery and results of van Maanen, et al. (2015) as the growth process is similar.



Future Works

The model will :

- Study **minimum mangrove-belt widths** required to withstand different SLR & storm scenarios.



- Explore **potential measures taken in reducing the vulnerability** (susceptibility to flooding and the capacity to cope and adapt) of mangrove-mudflat coastlines to SLR and storms.

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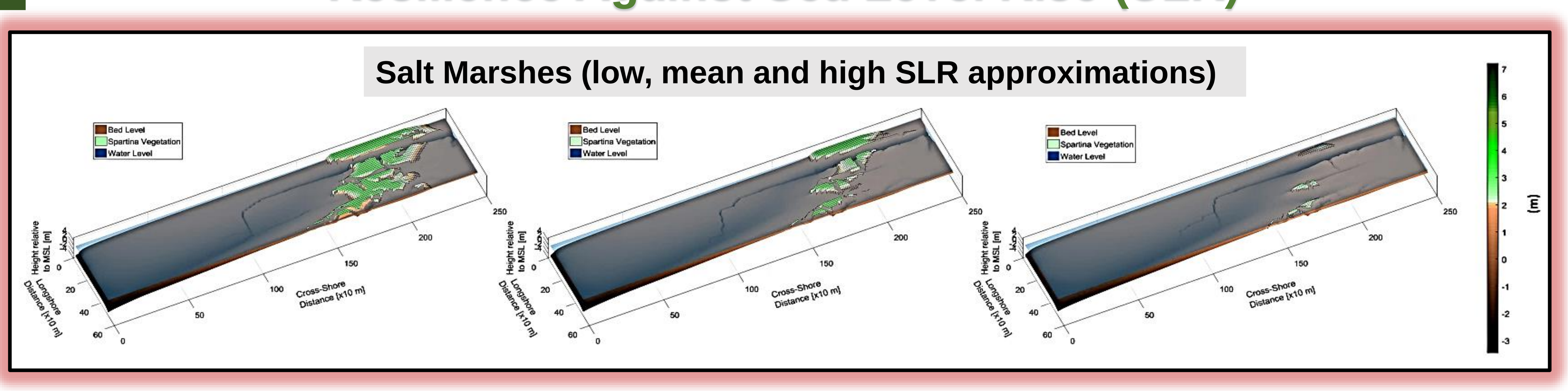
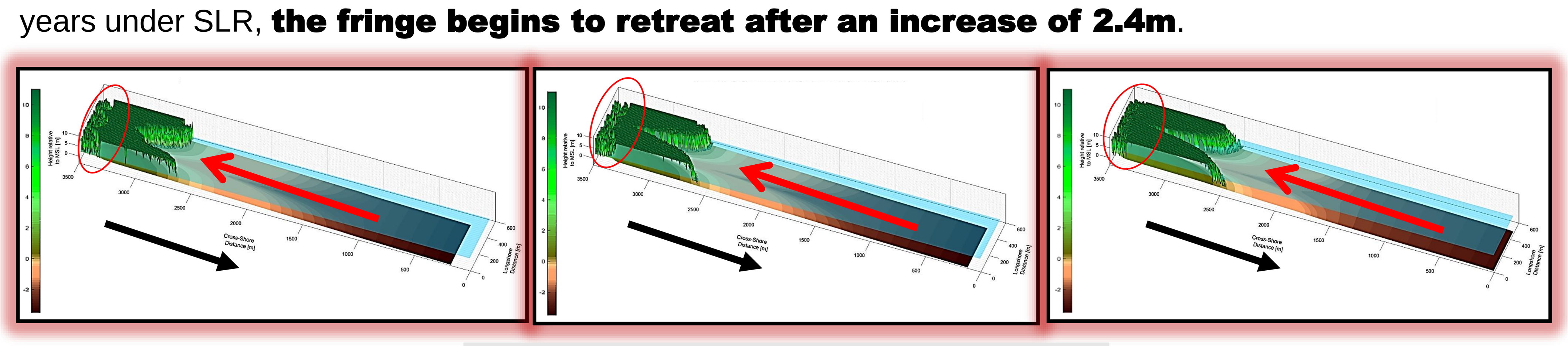
5 Resilience Against Sea Level Rise (SLR)



- **100 years of SLR** showed that **high bio-accumulation rates lead to marsh survival and heightening (50-60 years)**. But the marsh system eventually drowns under all IPCC 8.5 climate change scenarios to varying degrees. **Levee areas are the last to drown. Only exponential increases showed extended periods in which salt marshes survive, linear increases did not.**
- With an exponential increase in sea-level (1.14m/century) after 160 years, the **mangroves are resilient. Bed levels increase at a rate that matches SLR although channels incise more and widen.** The model is able to define **SLR tipping-points**, after which the mangrove-belt starts to retreat. When extended for 200 years under SLR, **the fringe begins to retreat after an increase of 2.4m**.



Mangroves (high SLR approximation)

References

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