Universiteit Utrecht
Faculty of Geosciences
River and delta morphodynamics

Modelling the effects of dynamic saltmarsh ~~and microphytobenthos~~ growth on the large-scale morphology of estuaries

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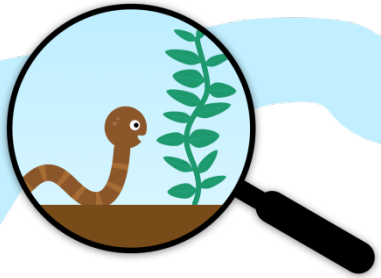
C.S. Schwarz, L. Braat, M.G. Kleinhans



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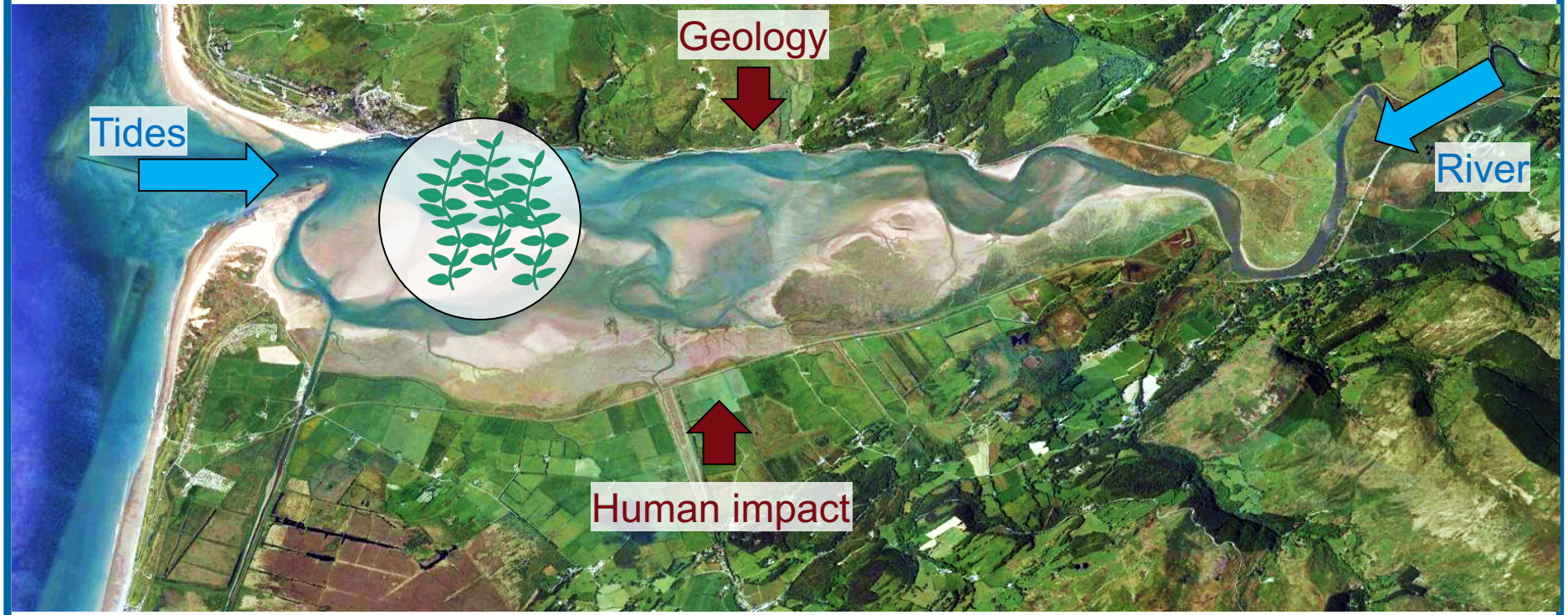
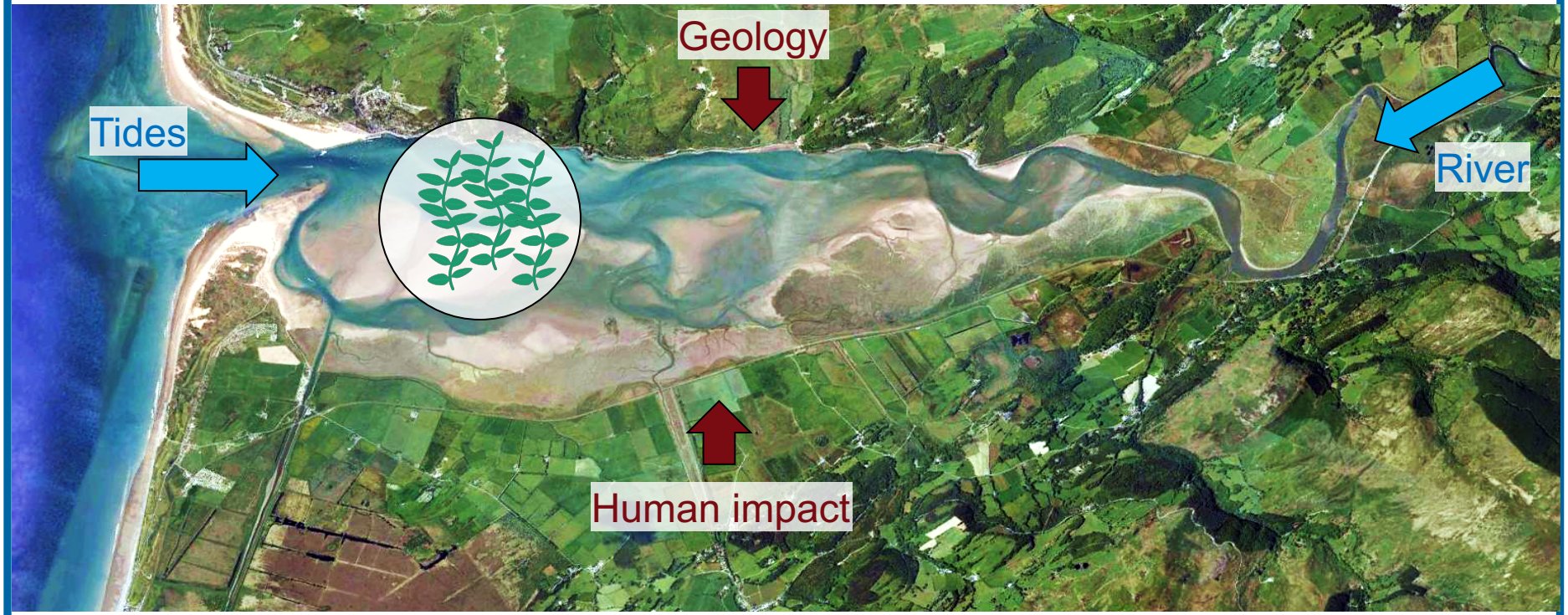
Estuarine morphology mediated by biostabilizers



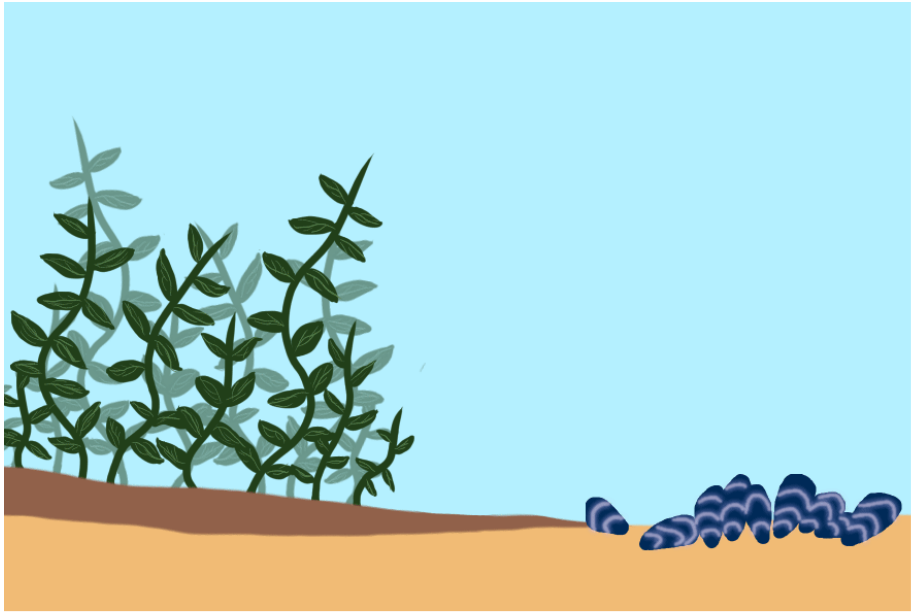
Dovey estuary, UK

Estuarine morphology mediated by biostabilizers



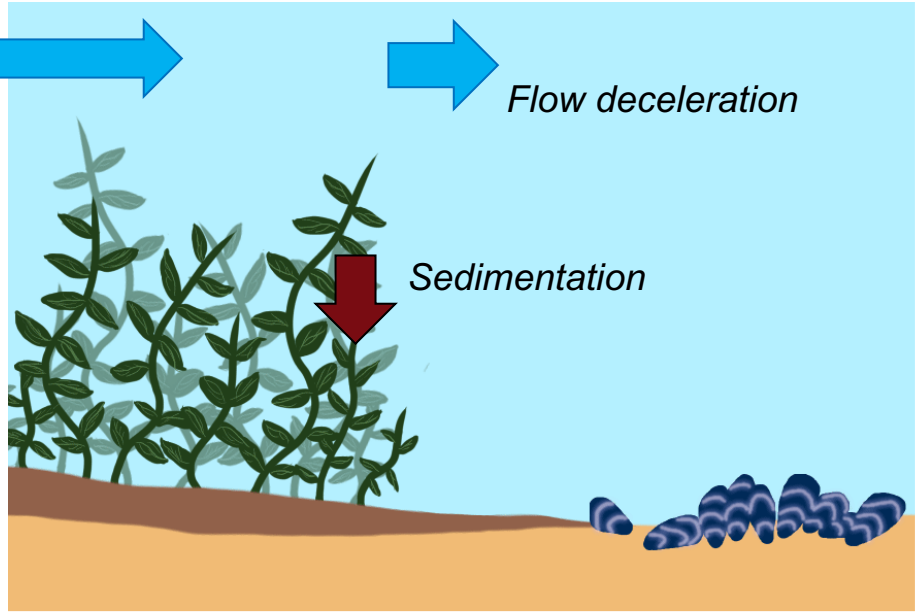
How do biostabilizers determine estuarine morphology?

Biostabilization - saltmarsh



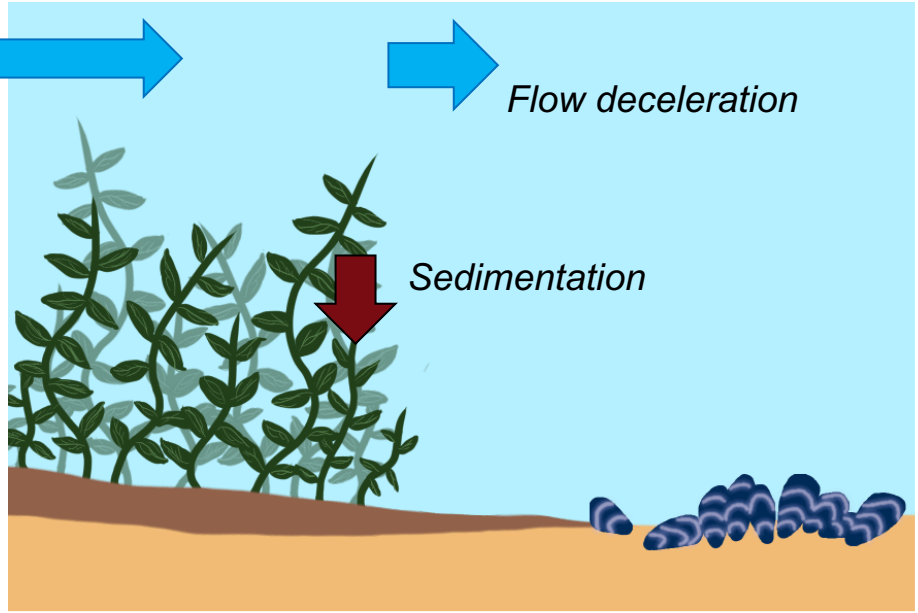
- Vegetation – flow reduction and soil stabilization

Biostabilization - saltmarsh



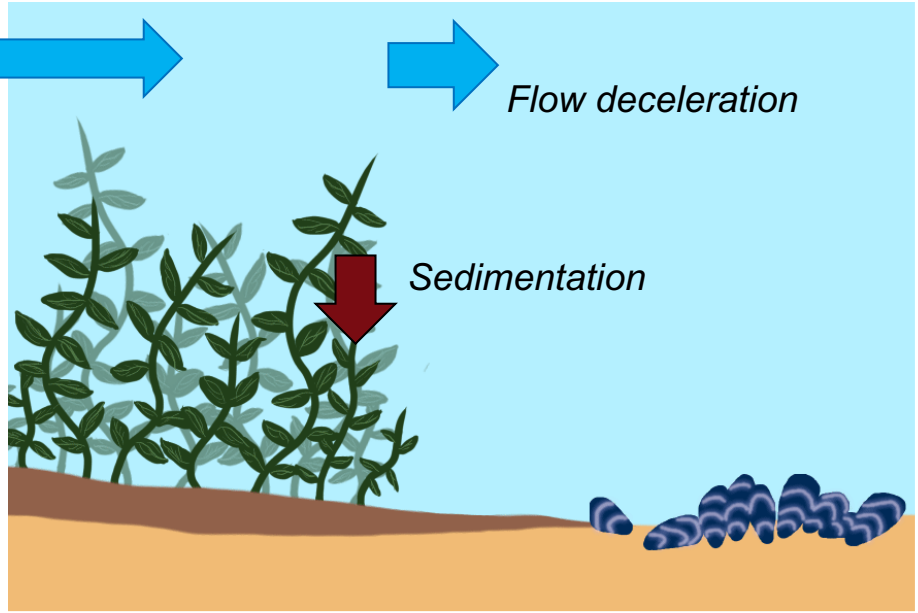
- Vegetation – flow reduction and soil stabilization

Biostabilization - saltmarsh



- Vegetation – flow reduction and soil stabilization
- Changes in flow and morphology affect vegetation

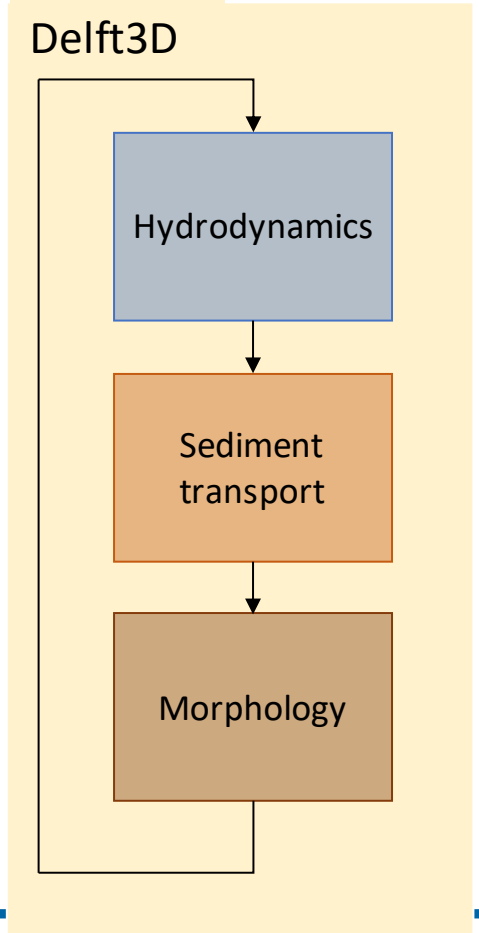
Biostabilization - saltmarsh



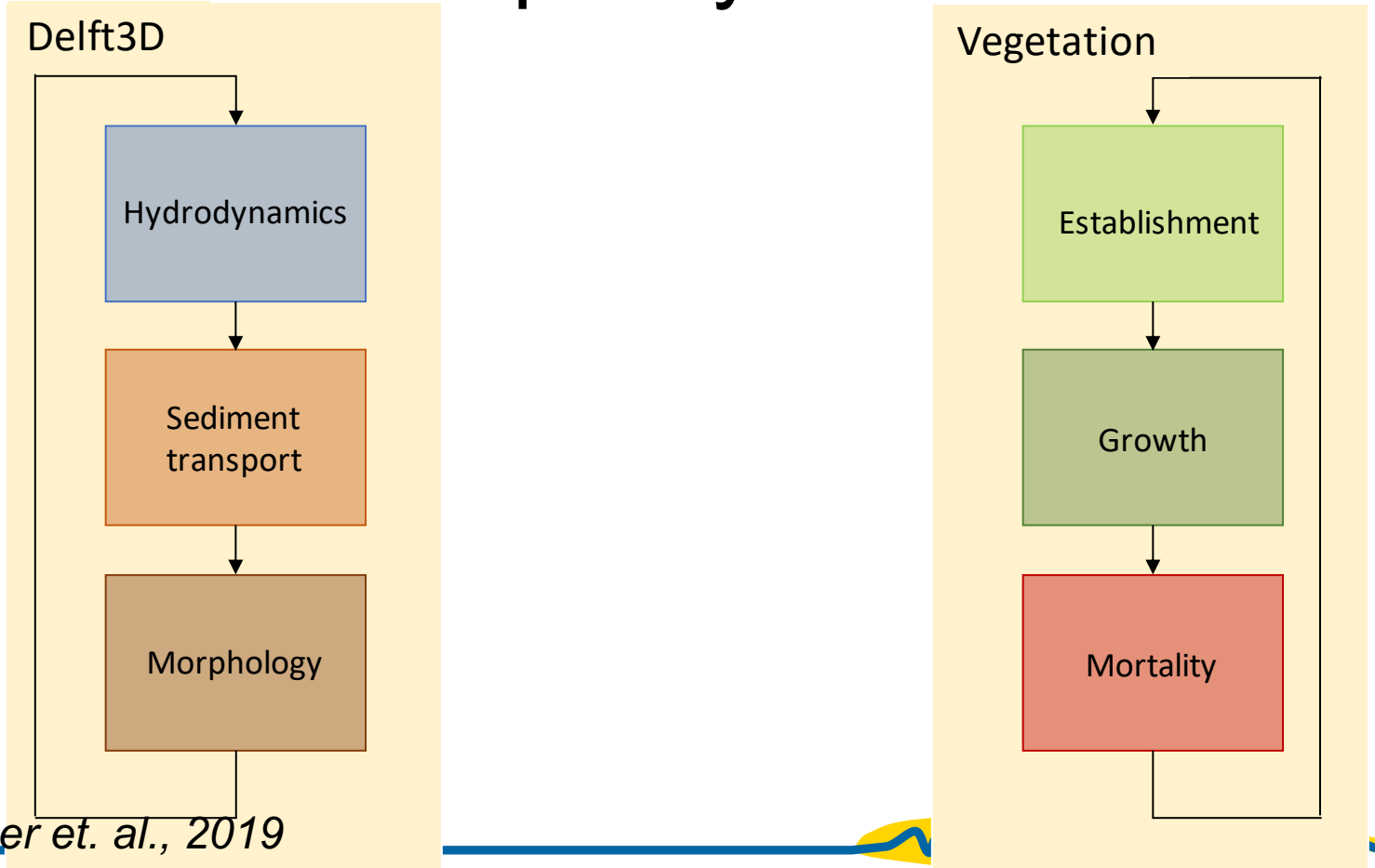
- Vegetation – flow reduction and soil stabilization
- Changes in flow and morphology affect vegetation

We need capture of the feedback-loop between eco-engineering effects and vegetation response

Eco-morphodynamic model

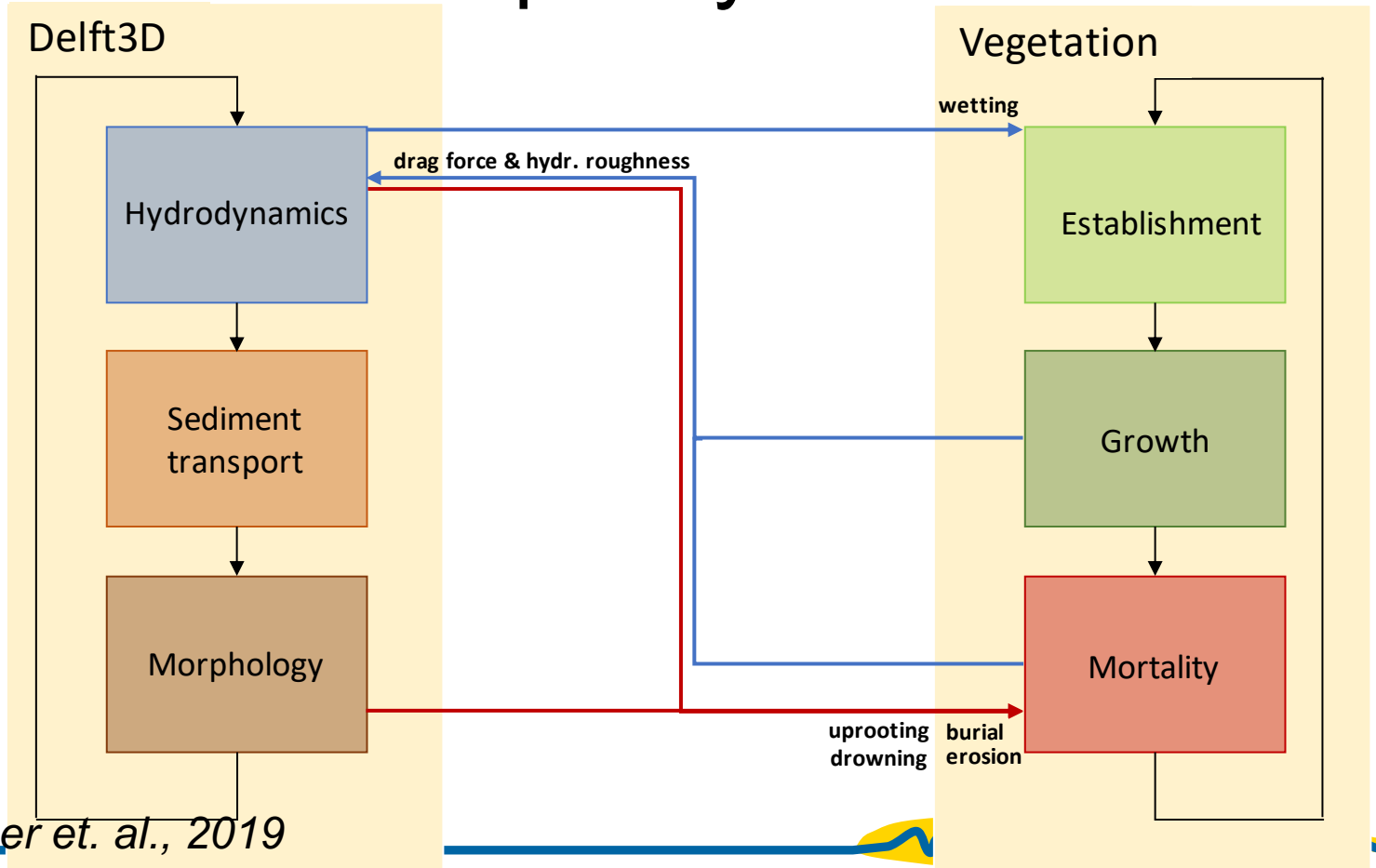


Eco-morphodynamic model



Brückner et. al., 2019

Eco-morphodynamic model



Brückner et. al., 2019

Eco-morphodynamic model

What makes the model novel:

- Literature-based vegetation parameters
- Several life-stages – aging of vegetation
- Several species combined
- Good representation of saltmarsh establishment (Brückner et. al., 2019)

Mud as a stabilizer

- Mud can develop cohesive cover along the estuary

Mud as a stabilizer

- Mud can develop cohesive cover along the estuary

Research question

What establishes first – saltmarsh or mud?

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What establishes first – saltmarsh or mud?

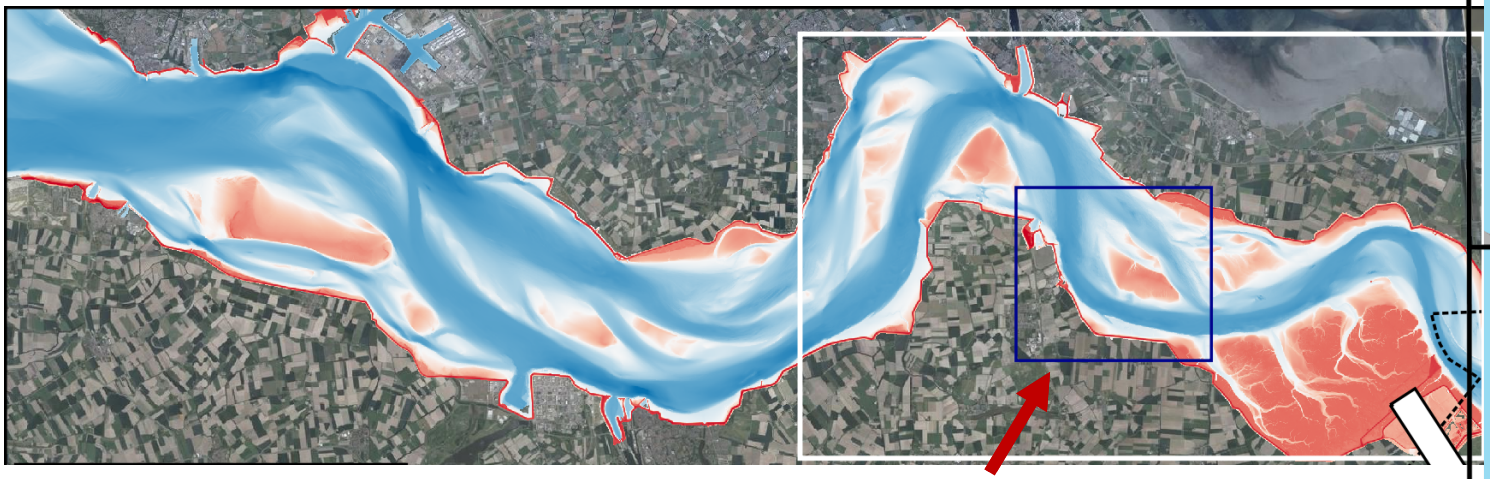
- Reference without vegetation
- Generic saltmarsh species with sand
- Generic saltmarsh species with sand + mud
- Mud-dependent saltmarsh species

The Western Scheldt estuary

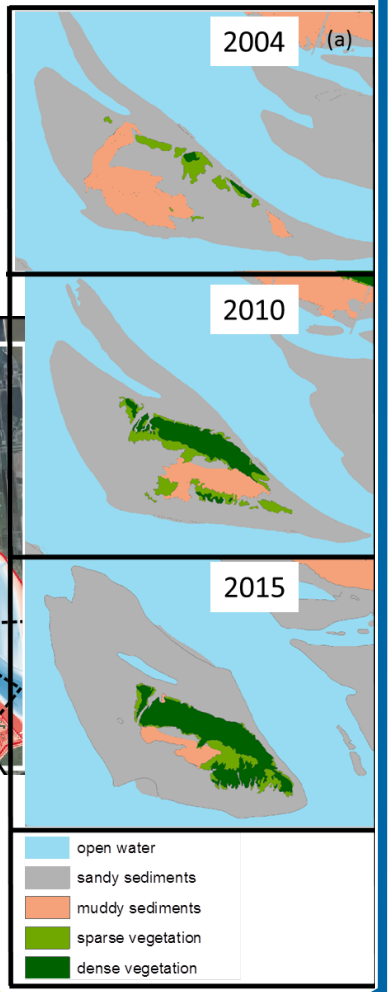
- dynamic, sandy estuary
- Meso/macro-tidal
- Heavily dredged

The model domain

- Calibrated Nevla-model (Dutch-Flemish)



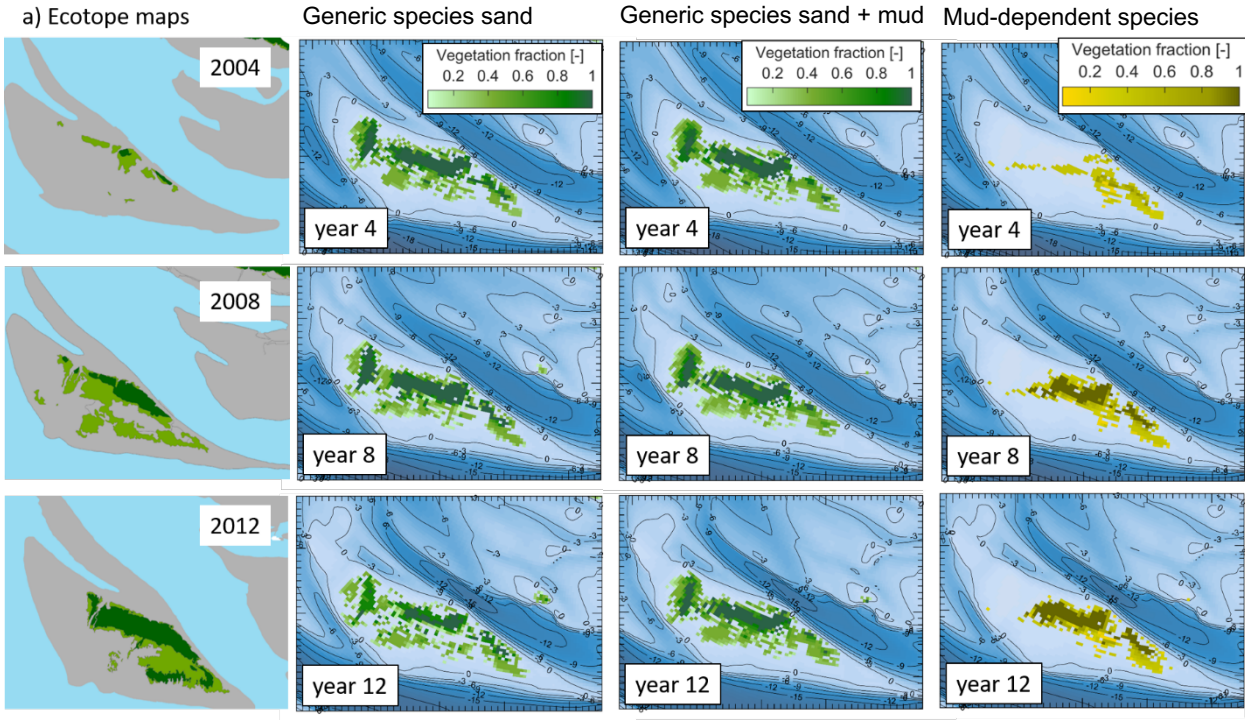
Tidal shoal of Walsoorden



Vroom et al., 2015; Schrijvershof & Vroom, 2016

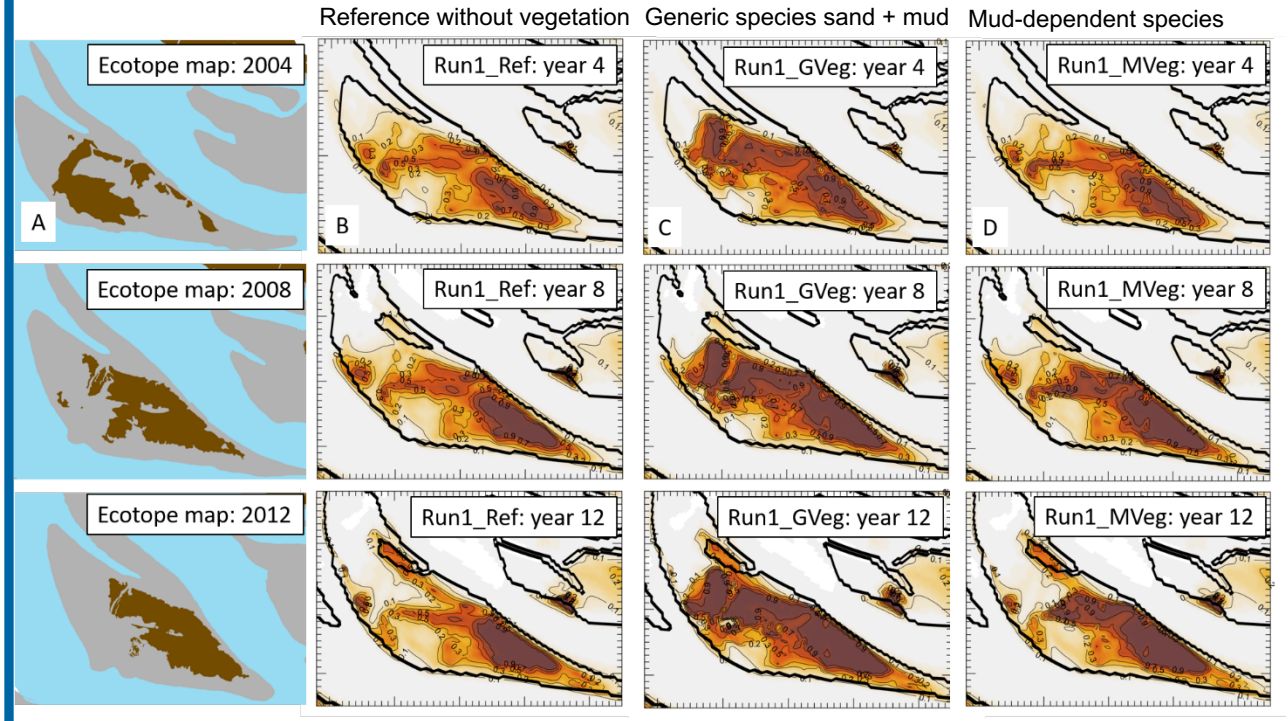
Ecotope maps (Dutch Water Authorities)

Species pattern on a tidal bar



- Generic species on sand and mud similar pattern
- Mud-dependent species expands with time
- Generic species cover overpredicted while mud-dependent species cover underpredicted

Species pattern on a tidal bar



- Mud settling occurs without vegetation
- Vegetation enhances mud
- Various species affect mud pattern differently

Conclusions

What establishes first – saltmarsh or mud?

- Depending on the species vegetation can promote mud accretion where otherwise no mud settles
- Calm areas allow for mud settling prior to vegetation establishment

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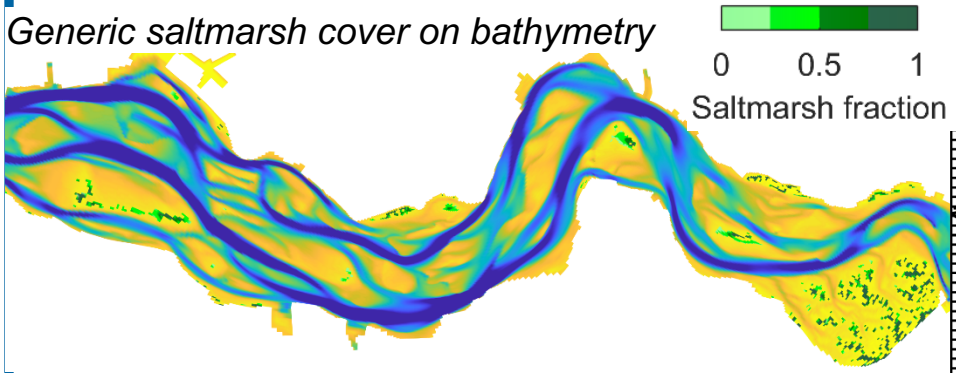
What establishes first – saltmarsh or mud?

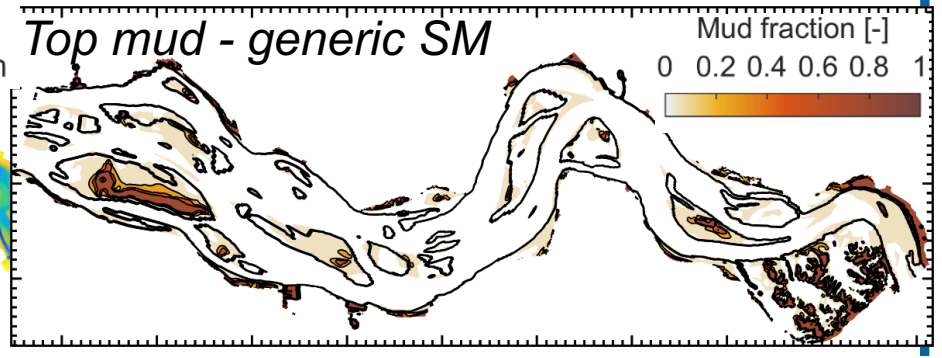
- Depending on the species vegetation can promote mud accretion where otherwise no mud settles
- Calm areas allow for mud settling prior to vegetation establishment
- Vegetation establishment is partly determined by the sediment in the bed that is controlled by hydro-morphology

The Western Scheldt Estuary

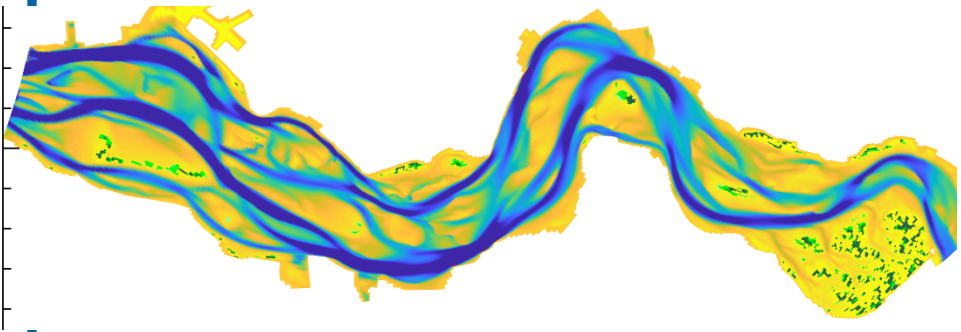
Generic saltmarsh cover on bathymetry



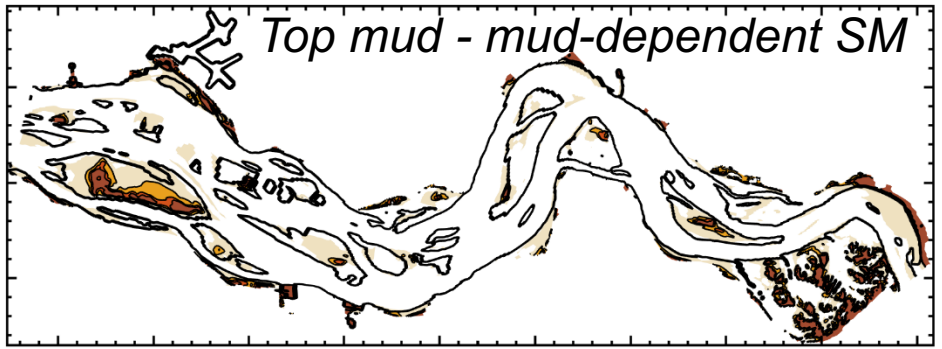
Top mud - generic SM



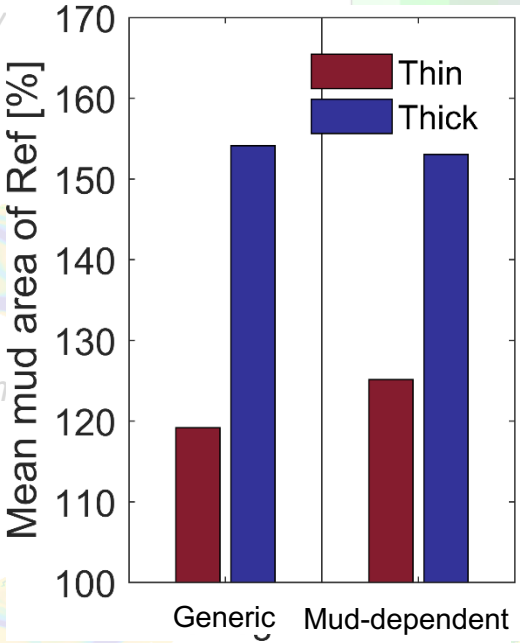
Mud-dependent saltmarsh cover

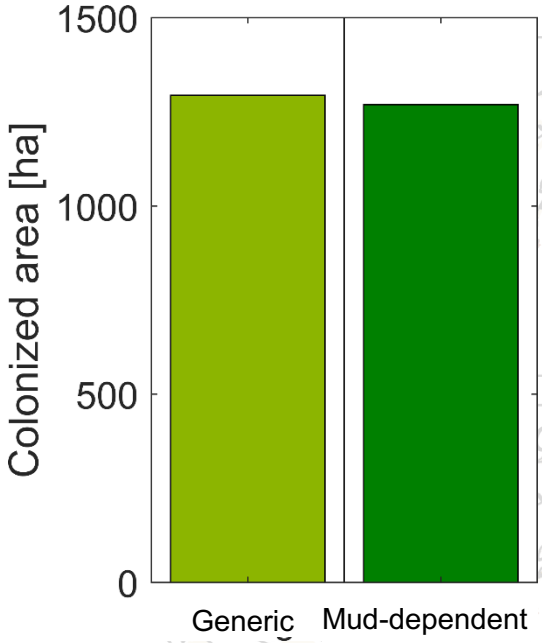


Top mud - mud-dependent SM



The Western Scheldt Estuary



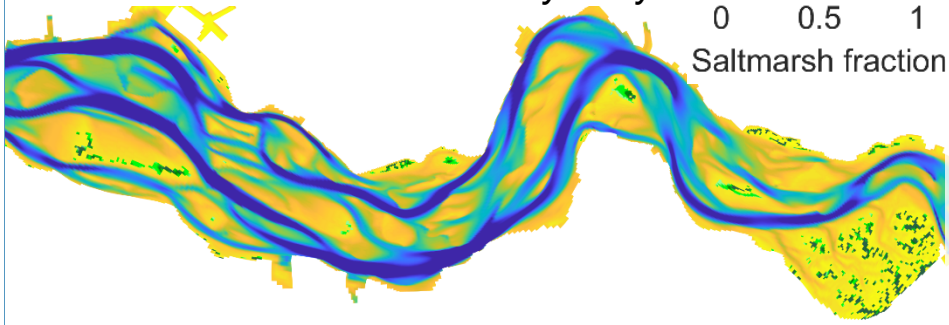


Conclusions

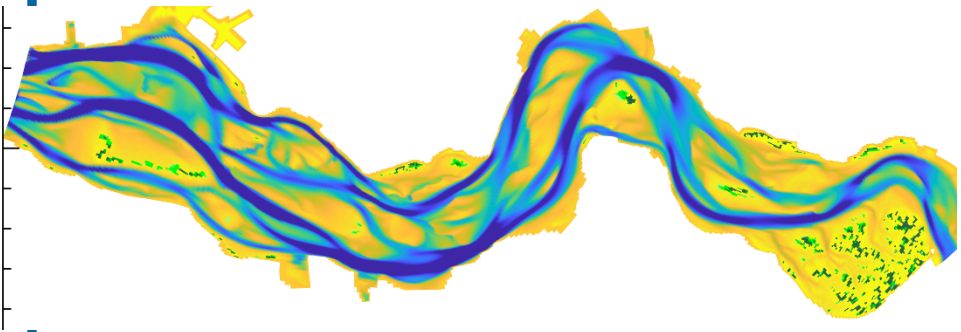
- Depending on the species vegetation can promote mud accretion where otherwise no mud settles
- Calm areas allow for mud settling prior to vegetation establishment
- Vegetation establishment is partly determined by the sediment type in the bed that is controlled by hydro-morphology
- Also on the large scale, mud layers are mediated by species type

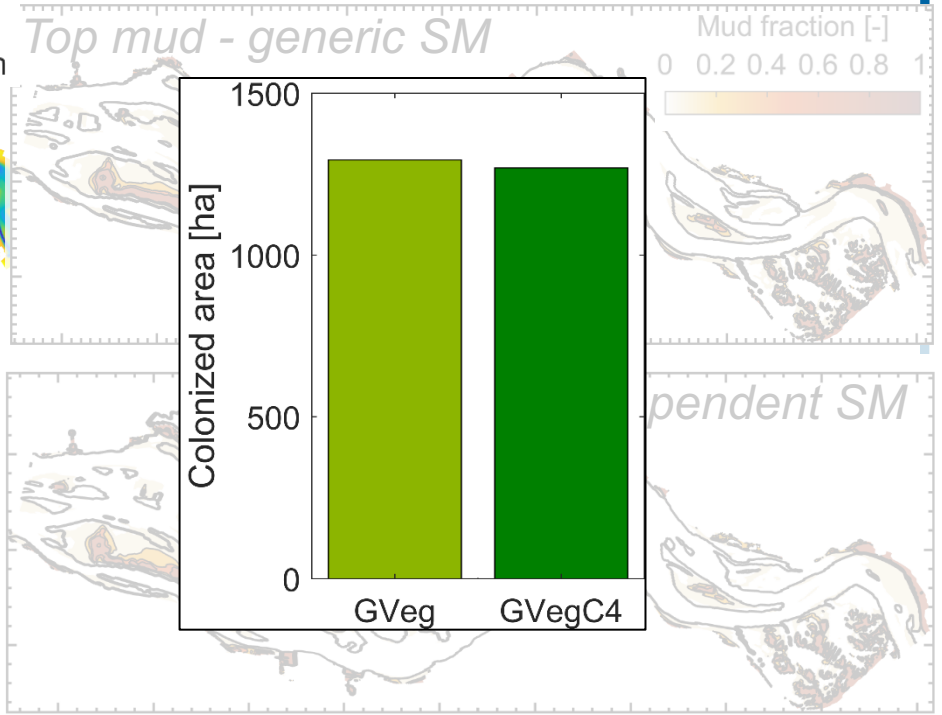
The Western Scheldt Estuary

Generic saltmarsh cover on bathymetry

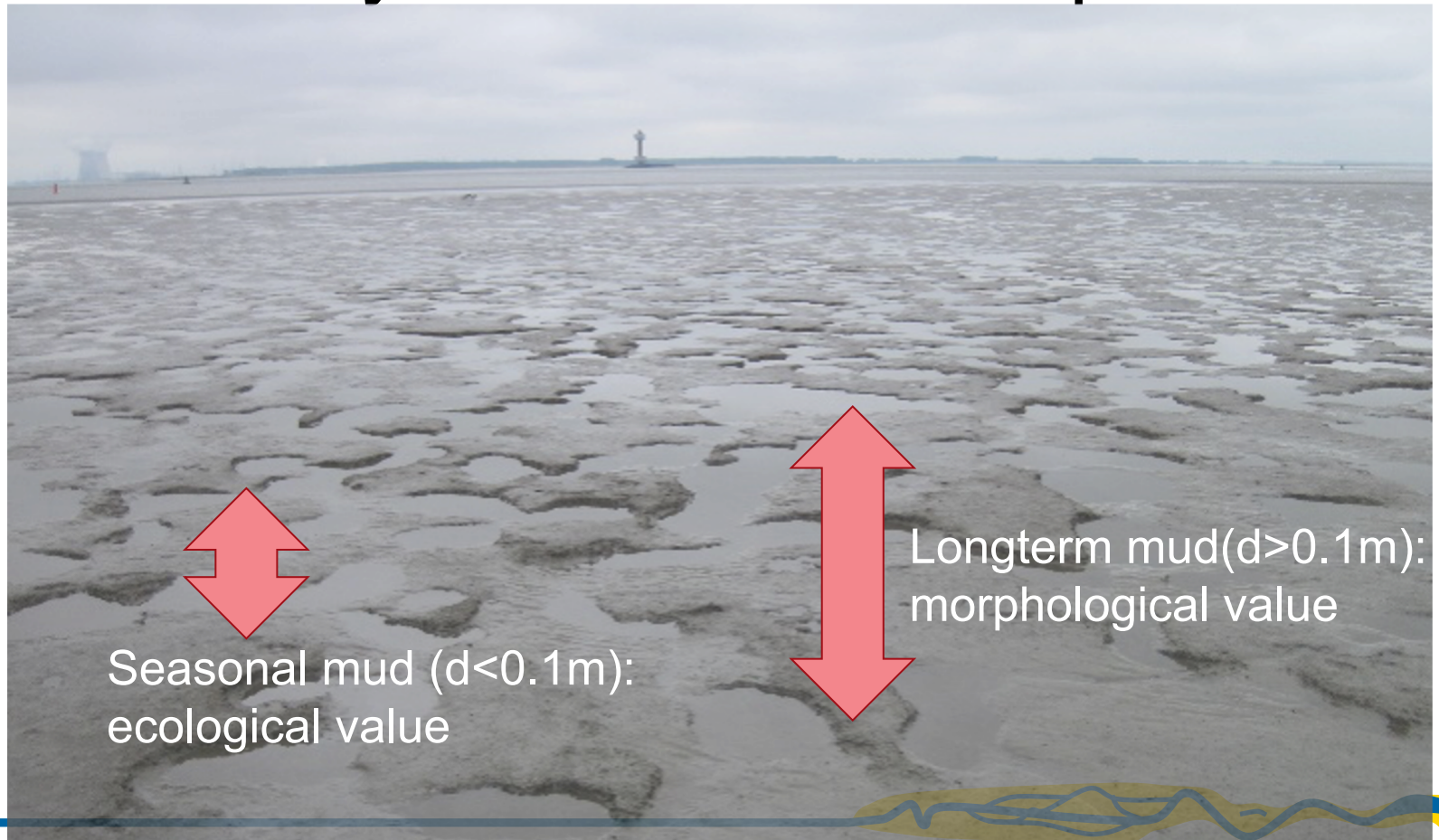


Mud-dependent saltmarsh cover

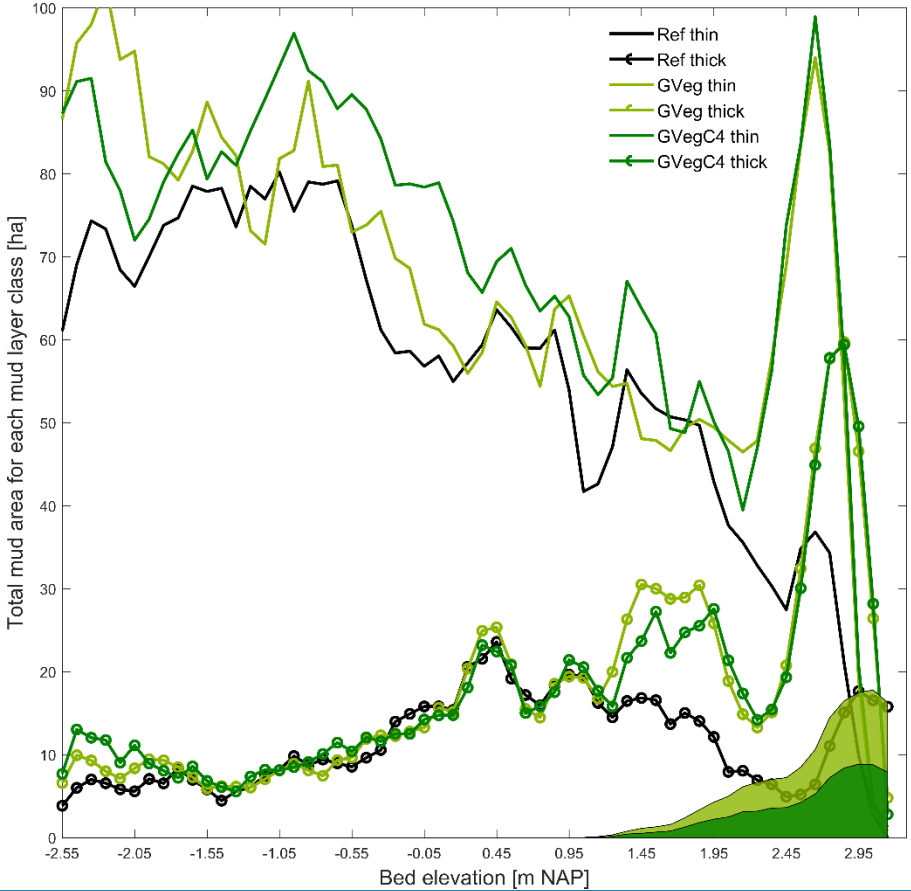


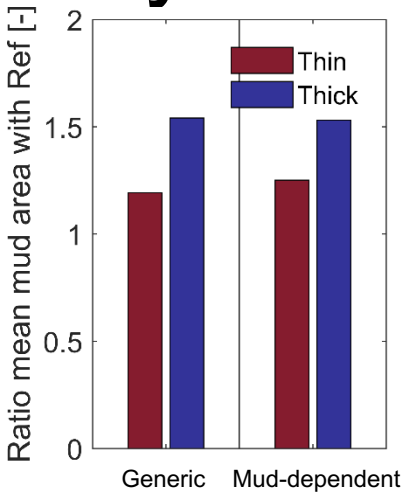


Mud layer thickness is important



Thick and thin mud layers along z





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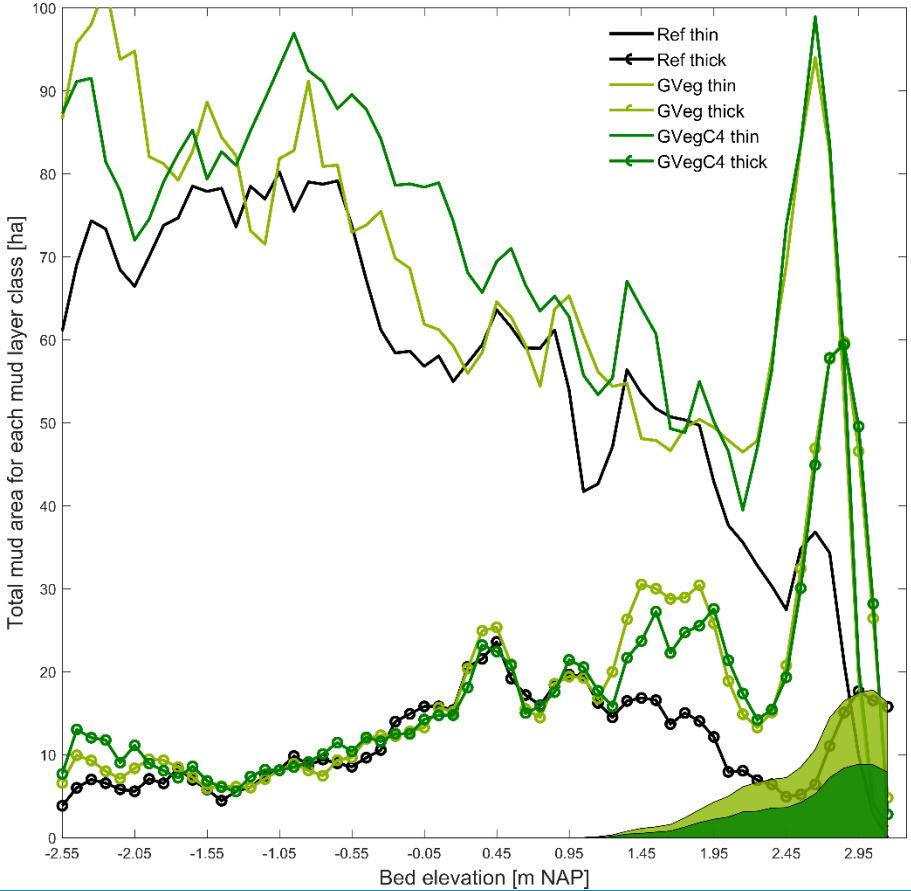
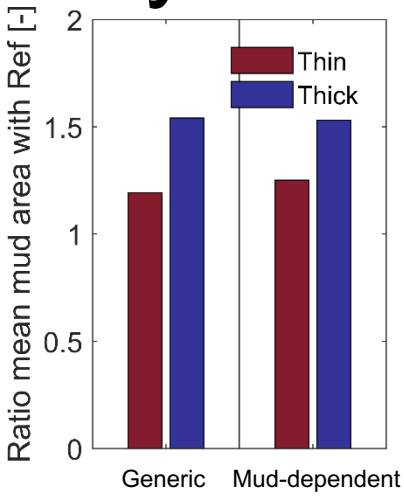
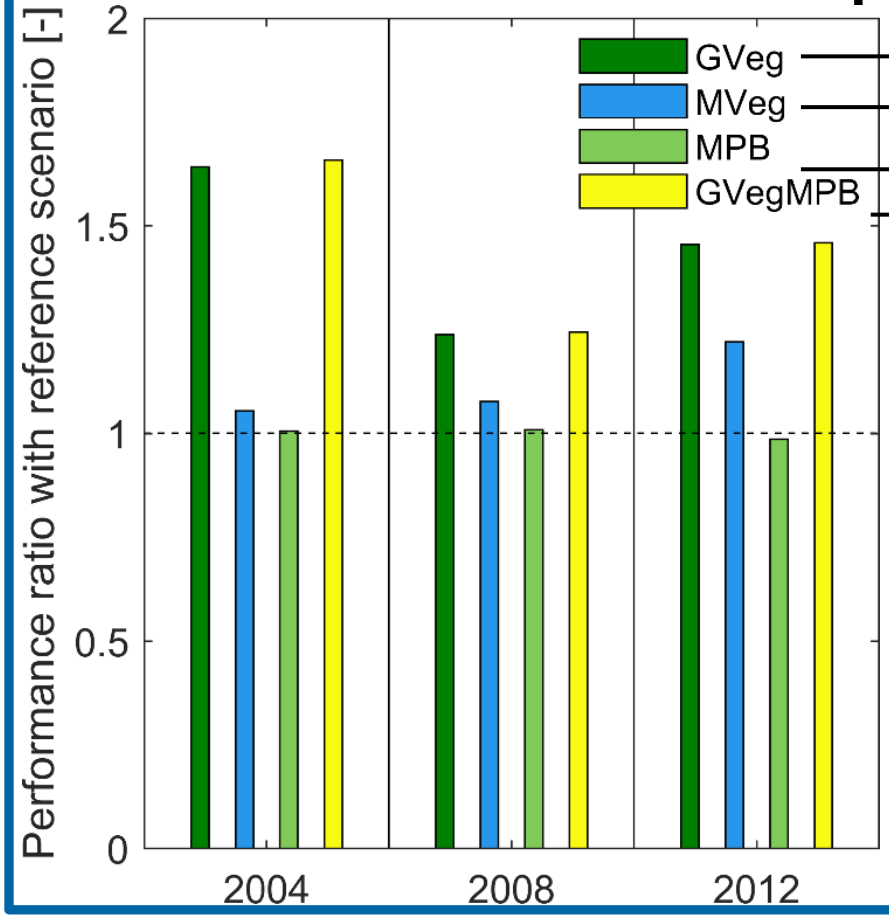




- Larger mud extent with gradually spreading vegetation
- Thin layers enhanced by mud-dependent species while thick layers expand with generic species

Good representation



Generic saltmarsh: better

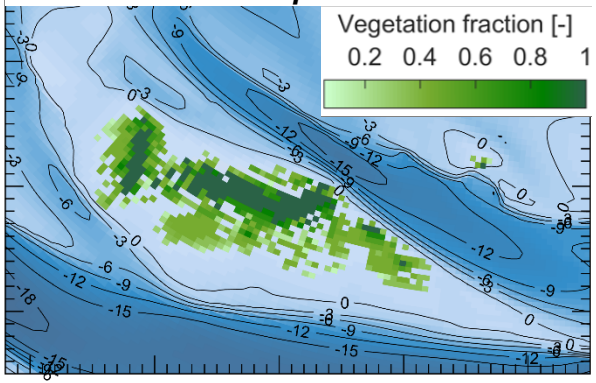
Mud-dependent saltmarsh: better with time

Microphytobenthos: neutral

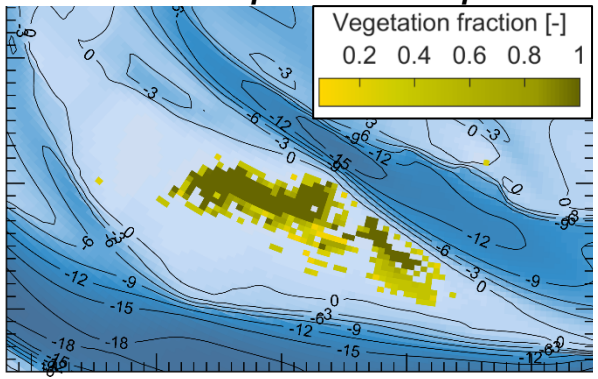
Generic saltmarsh + microphytobenthos: better

Pattern representation

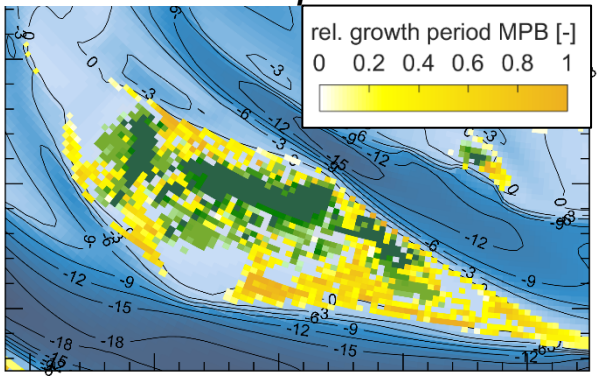
A – Generic species



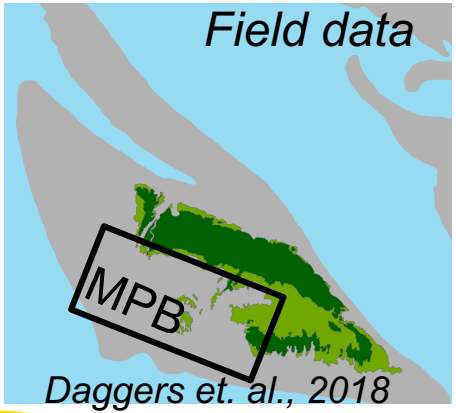
B – Mud-dependent species



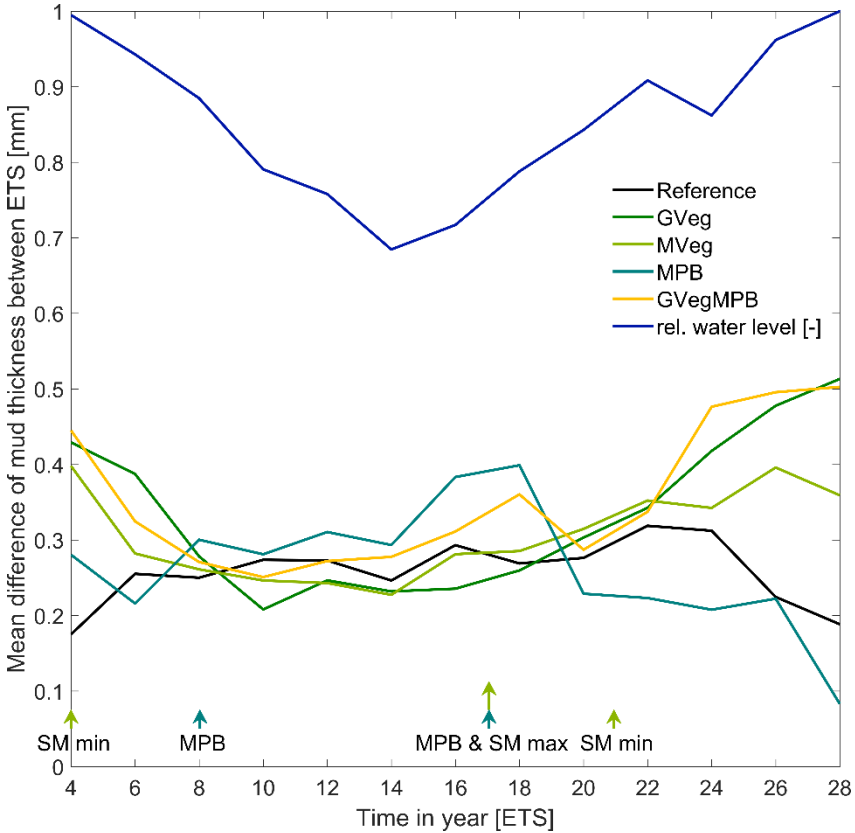
C – Generic species + MPB

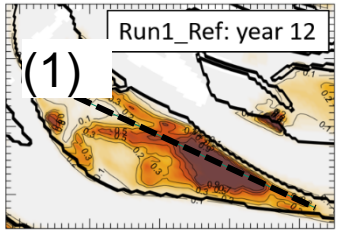


- Generic species overestimates while mud-dependent species underestimates coverage

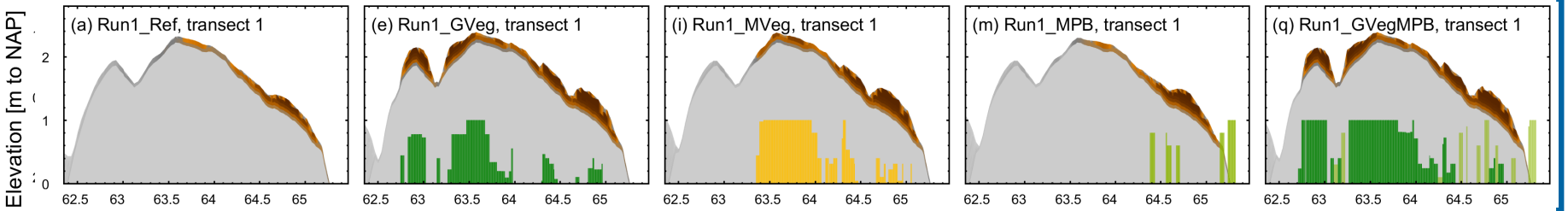


Seasonal mud on Walsoorden





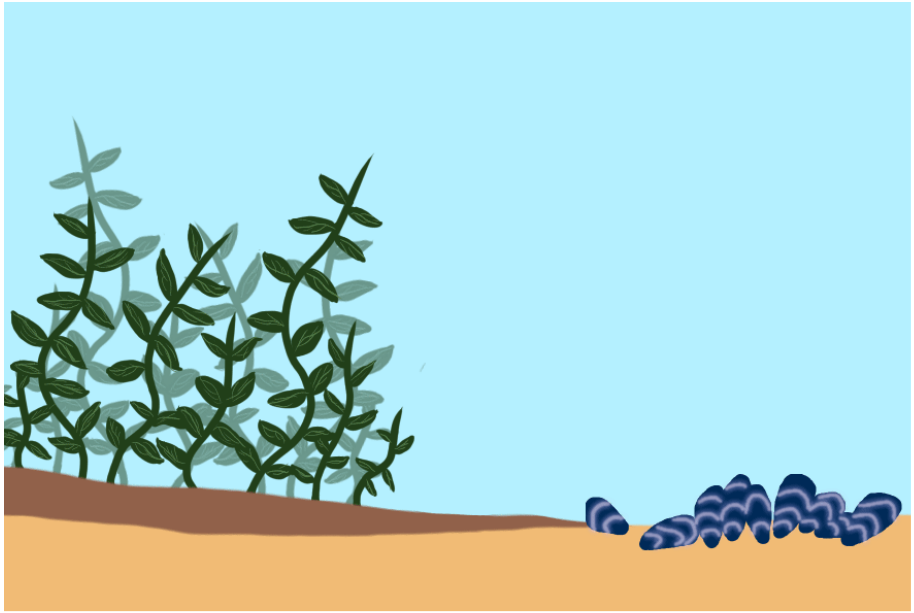
Long-term mud



- Mud thickness is enhanced through biostabilization
- Thickness is governed by a regional feedback rather than biota fraction
- Combined species facilitate each other and mud accretion

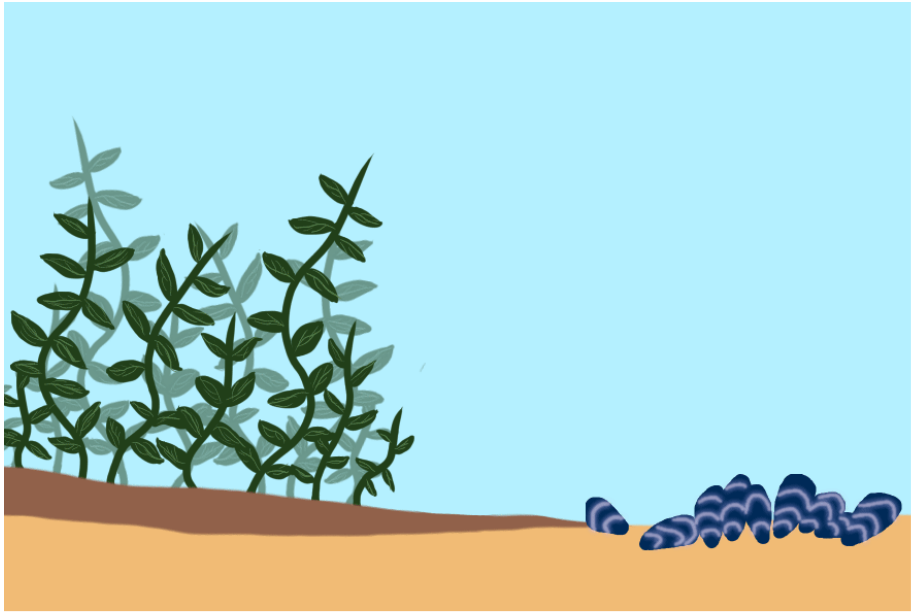
Longterm effects induced by biostabilization

Biostabilization - microphytobenthos



- Microphytobenthos (biofilm) – soil stabilization
- Secretion of extracellular polymeric substances (EPS)

Biostabilization - microphytobenthos

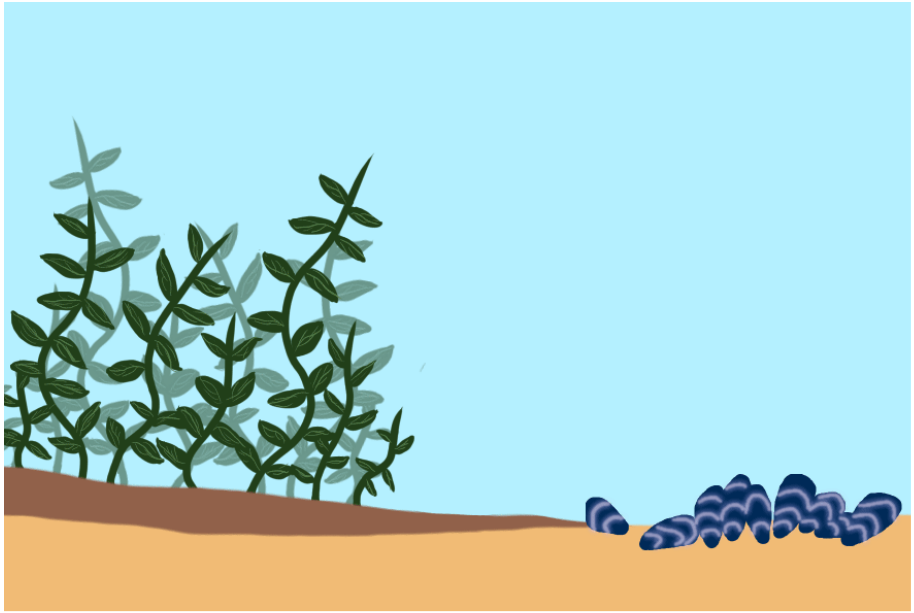


- Microphytobenthos (biofilm) – soil stabilization
- Secretion of extracellular polymeric substances (EPS)
- Affect sediment properties: increase of beginning of motion

(1) $E_m = \mathrm{MS}(\tau_{CW}, \tau_{cr,e})$

(Partheniades, 1965)

Biostabilization - microphytobenthos



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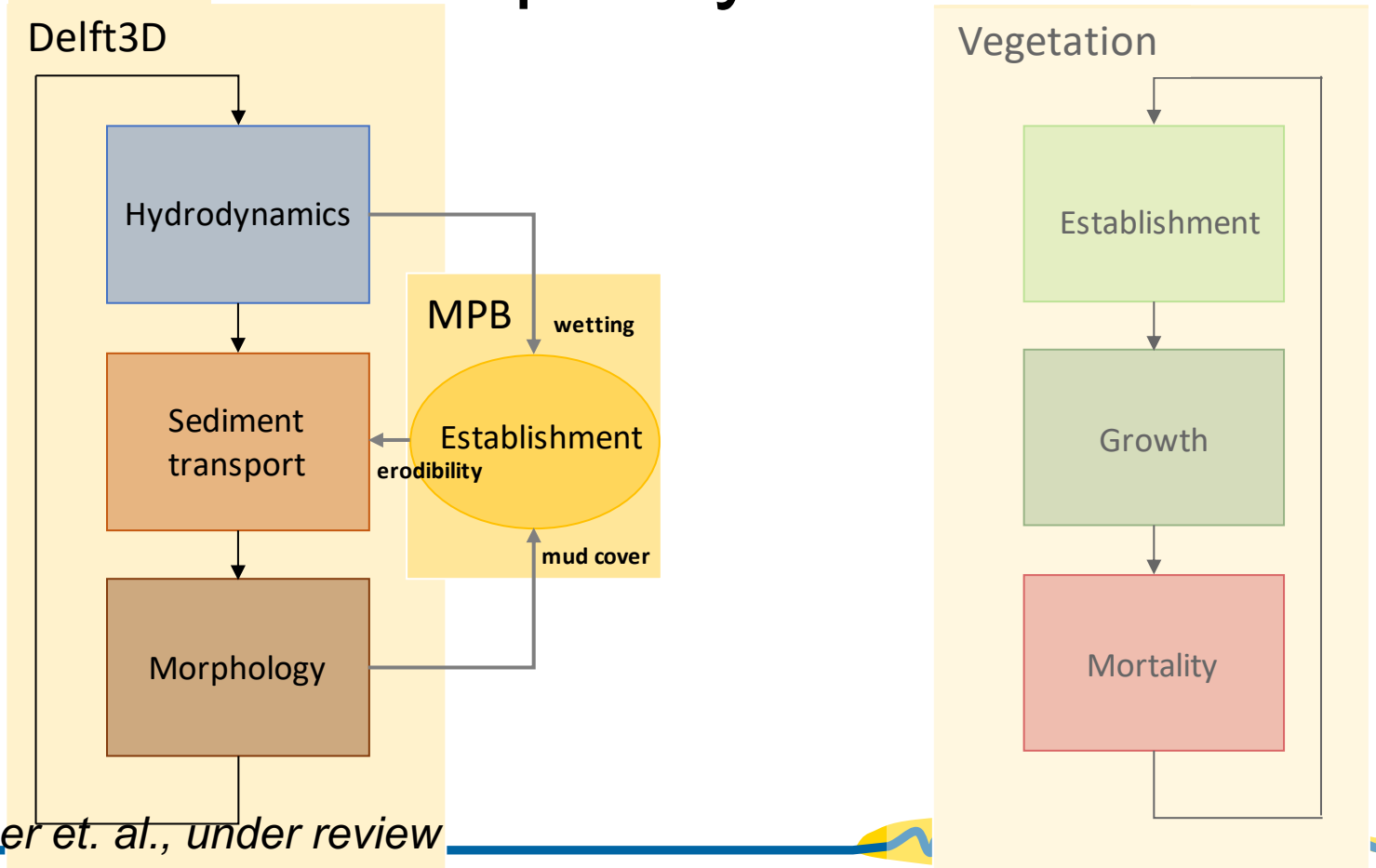
- Secretion of extracellular polymeric substances (EPS)
- Affect sediment properties: increase of beginning of motion

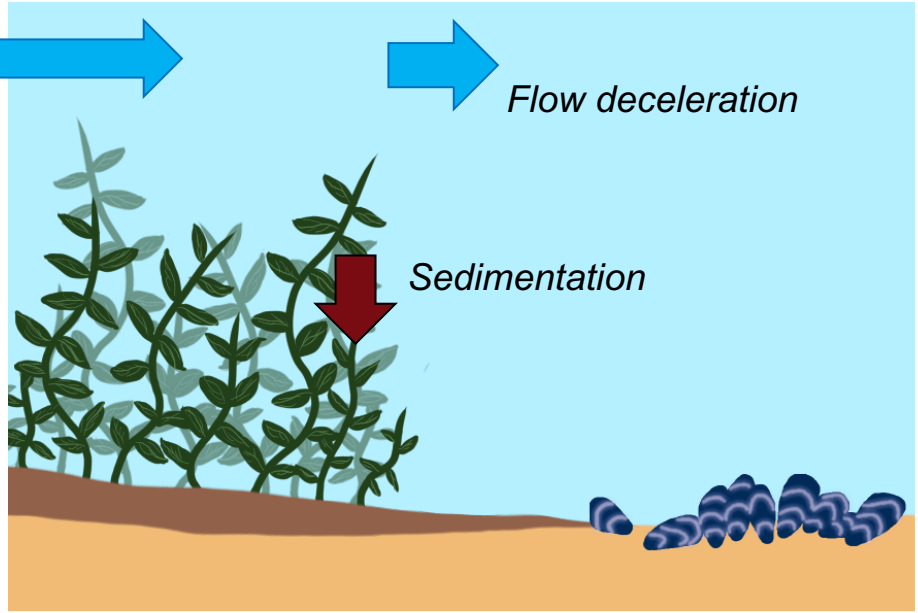
→ Seasonal and dynamic behaviour needs to be captured

Eco-morphodynamic model



Brückner et. al., under review

Biostabilization - saltmarsh



- Vegetation – flow reduction and soil stabilization

$$(1)\quad C = C_b + \frac{\sqrt{g}}{\kappa}\ln\left(\frac{h}{h_v}\right)\sqrt{1 + \frac{C_D n h_v C_b{}^2}{2g}}$$

(Baptist, 2007)

$$(2)\quad F = C_D n \frac{h_v}{h}\frac{C_b^2}{C^2}$$