

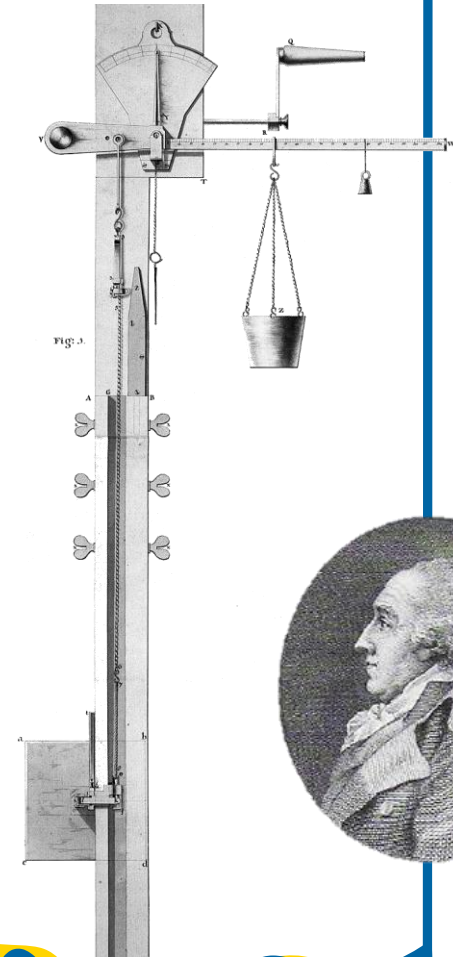
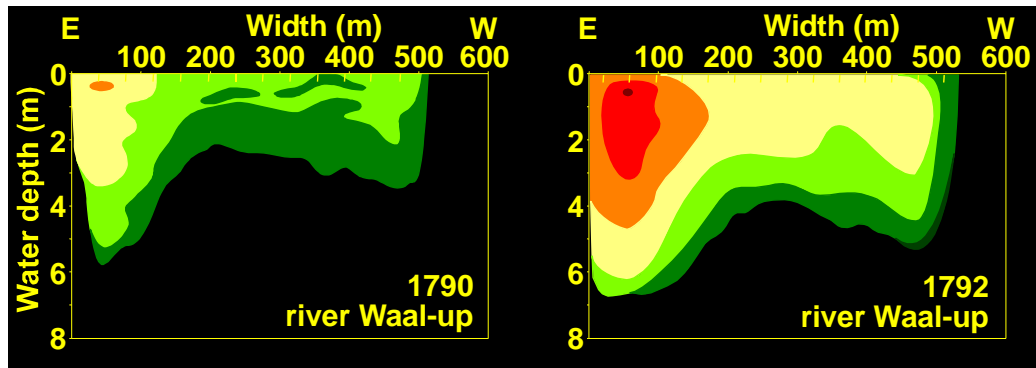


welcome at the 2020 Brunings Lecture



Why Christiaan Brunings?

- 1736-1805
- 1st president Rijkswaterstaat 1798
- Precursor of ADCP invented 1789
- Worked on discharge division at the Pannerdensche Kop



www.uu.nl/bruningslecture

2016: mud

■ Jim
Best



2017: saltmarsh

■ Sergio
Fagherazzi



2018: channels

■ Andrea
D'Alpaos



2019: sea-level rise

Friederike
Bungenstock



■ Jelmer
Cleveringa



■ Tjeerd
Bouma



■ Bas
van Maren



Aimée
Slangen



Marjolijn
Haasnoot





والذي مات البراء وحلف عشرة اولاد وكور من حملتهم والذي ذكروا لهم ذلك
وتزوجوا العشرة وتزوج والذي من ردة الله انا ولحونك الفسحة لم يزر فوا
من ابن الادلاد كبرت انا من عمومي **واذرك** شهر اذ اصبحت
فكنا عن الحديث فقالت ديار ساد يا اخنا ما اطيع محمد بن قاريه قالت
ابن هذا ما احذركم به في الليلة القليلة ان عشت افاقا في الملائكة

الليلة الثانية في الاقرب من حديث الف ليلة و ليلة

فلما كبرت وبلغت سابع الرجال يوم من الايام انا في جامع الموصل يوم الجمعة
والذي معنا فضيلة صلاة الجمعة وخجبت الناس لحسن الذي وعملي كمنع
وتعدوا خلقه فجاء في حال السلطان وعز الجبلون فذكر امدينه مدينه
الى المنبوذ الى قديم رسلها فقالت عمومي قالت المستافين انما لي وجد لا اكره
اجتنب من اقليم مصر يعني خاطري في مدينه مصر فقالت اعلمني بعد ادعيه في السلطان
وامر الدنيا فقال الذي ذكرا الجبر من ابي مصر ما ابي الدنيا تراها ذهبت
ومناها لعدس ما عجب ما هو خفيف عذب وطيبه ليله وظ

فما قال القائل **شعر**
بهنكم اليوم وفانكم ومعددا انا لكم بالهنا
ما الليل الاذاعي عودكم لكم نعم وما المفرد الا انا
فلو نظرت عكم خصر ارضها وتخليها بالارها ووسيتها باساق النور
وان عاينهم جبهة السيل وكم بها من مغير جليل وان ردتهم العري في كفة
البحر ارجعت ابحارهم فليله من الدهش المزم والذلك المنظر الحسن وقد
احد فت كحشا مقطعا سليل كانه درجده تصح بيبايك فصد والله
در القالب بنا هذه الايات **شعر**
لله يومى جوده الجشب ومن من الصيا والعشب

ولما سخطا لبيان بحسبه لصاريم في عن من عشرين
ومن في مدينه موقفة قد طرب بالبور عطفها ووس
قد سخطها يد العيون لنا فكن من سخطها على فوس
خاطبي الروح ان ما كفاها من سورة الفم غير شعث
وسفتني العار موعده فانكم ادوي لسرة العطر

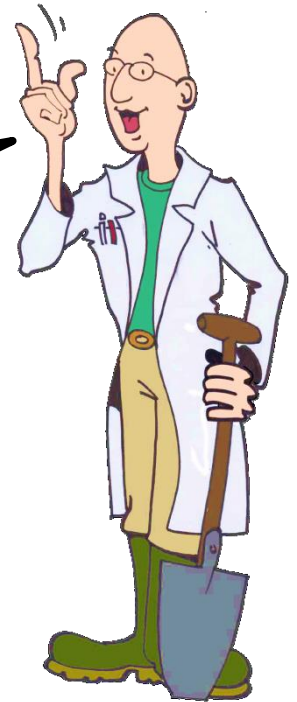
واذرك شهر اذ اصبحت فقلت عن الحديث فقال ديار ساد ما اطيع
محمد بن قاريه قالت ابرهه ما احذركم به في الليلة القليلة ان عشت
واقا في الملائكة

الليلة الثالثة وتلاق من حديث الف ليلة و ليلة

قالت لمعني ان الشاب قاله سريع والذي بوصف مصر ولما فرغ من وصف
الليل ووصف بركة الشمس قاله انك من الرصد ومحا شنه عنده يقول الشاعر
اذا استشرقت من غد خض هذا ما نوع الطرف وان ذكرت ليلة الوفا فاعط
القوس ناوها واحرق الماء في محارها ولورات الروصد بالاصال والظلم
عليها ما لم تشاهد عجا ولملت لها طربا وان كنت سنا حل مصر وقد
حلت التمر ظلمعا ولبن الجبر من اوابه ذردا ودرعا اجبال منسية
الغسل وطلعة الوافر الظليل ولما سعت انا هذه الوصف لمصر في ش
خاطري منها وما منت لكان الليلة وفي بعض الايام فاستعوسني بغير المتحد
افهم مصر محبت الخرابي وكتبت عليه حتى جهر لي بصاعه وسير في حجة
عمومي وقال لهم لا بدقوه واخل مصر وميعوا متعده في مسق ثم تحضرنا
وسافرنا وخرجنا من الموصل ما كان استافين حتى وصلنا مدينت
فالما بعض ايام ولم تستقر في مدينه دمشق فاستعاضها مدينه طيبة امية
ما كبر ان نعيمه دنائها وانفخار واهيار وهي ما حاجته من الجنان اق
روصد من رياض رضوان منها من كل فاكهه ورحان فترنا نعيم الحان

Lustrum lecture: our own work

- '1001' great results make a greater story
 - PhDs and Postdocs present their work in π minutes
 - and...



Programme

■ Patterns in the sand

- Your questions
- Break
- Historic maps

■ Living waterscapes and land level rise

- Your questions
- A brief look ahead
- Drinks in the new Metronome lab



Patterns in the sand: questions about bends, bars, channels and dynamics

Maarten Kleinhans

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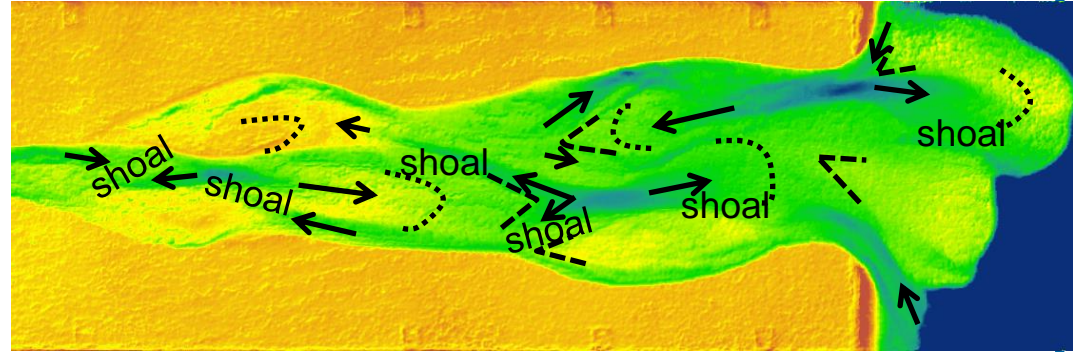
1001 questions

- Mutually evasive ebb- and flood-dominated channels
- Big tidal meanders and tidal bars
- Floodplain formation: mud flats and tidal marsh
 - Mud
 - Bio-stabilizers and bio-turbators
- Sizes of estuaries
- Effects of evolving plant life 400 Ma
- Pattern recognition, modelling, experiments
- Human interference



Ebb/flood channels

- Like fluvial bars
- But sill formation!
instability mechanism?

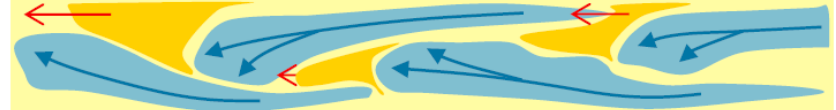


Fluvial bars (Jang & Shimizu, 2005)

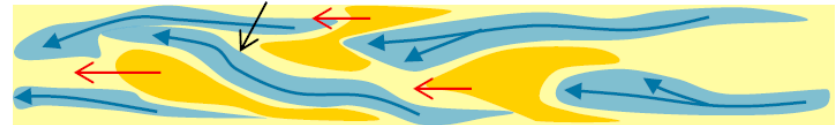
d, Asymmetric alternate bars, 'sills' are remnants of alternate bars

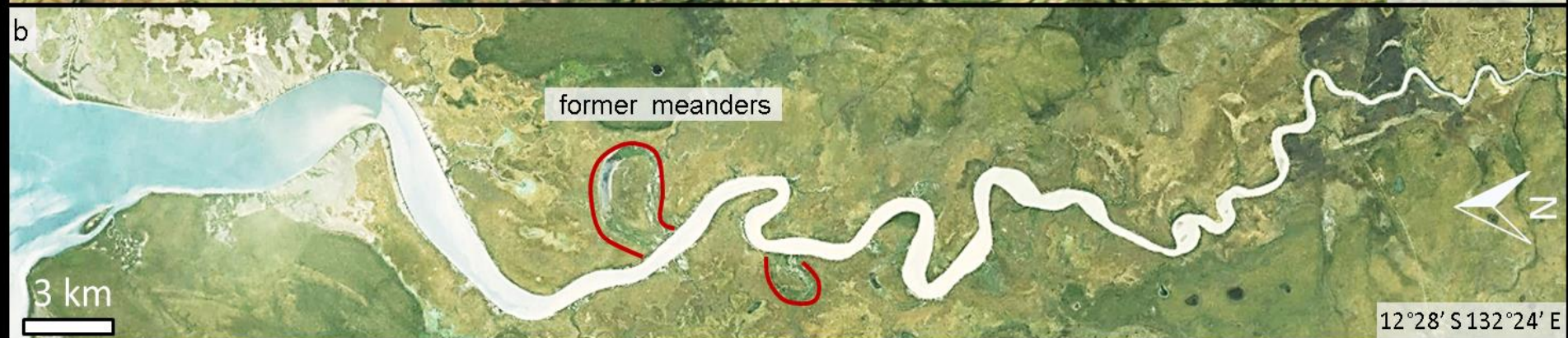
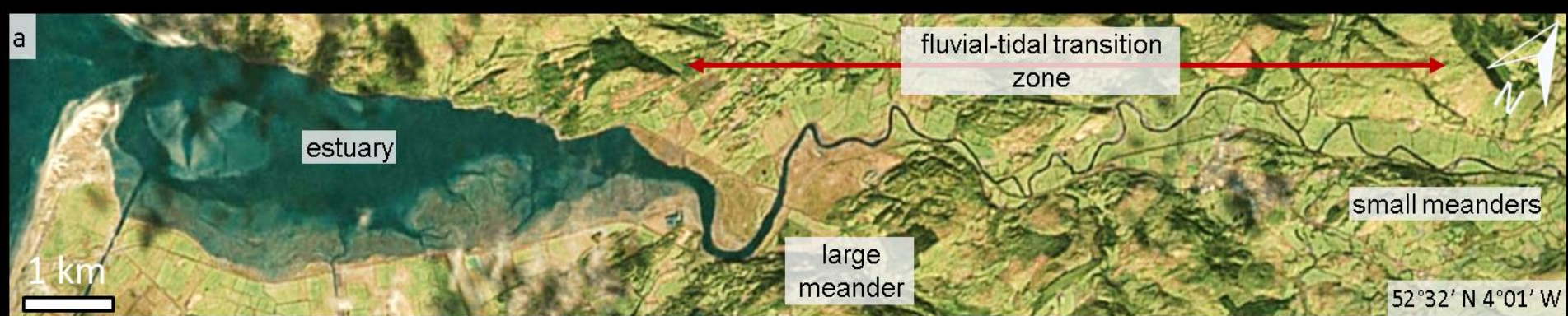


e, Downstream migration

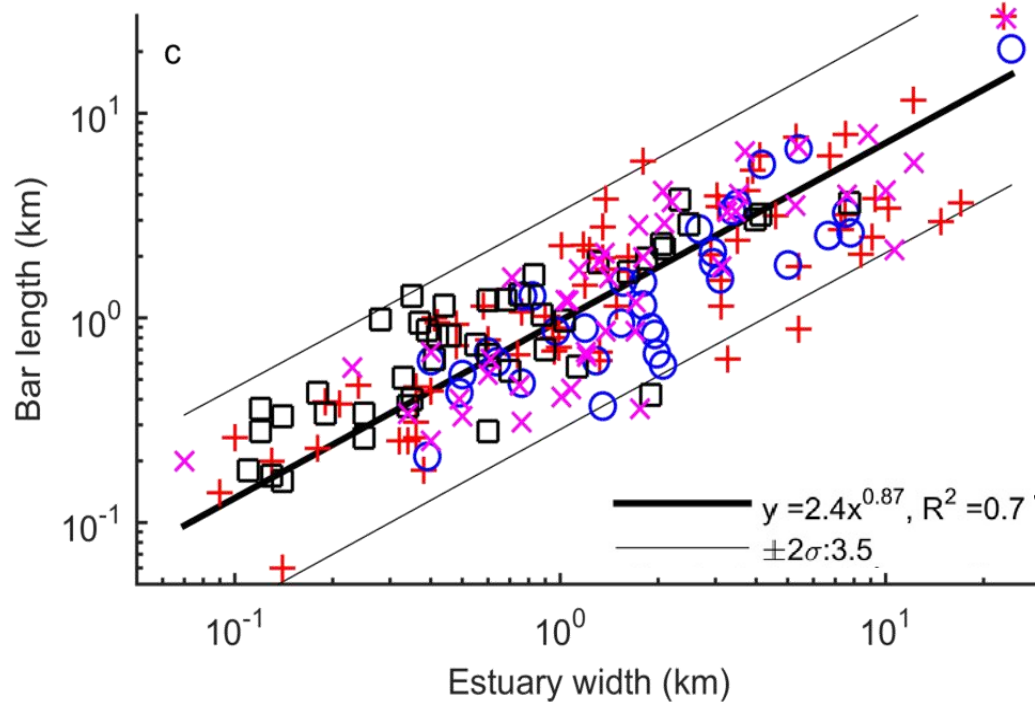


f, Former sills are cut off



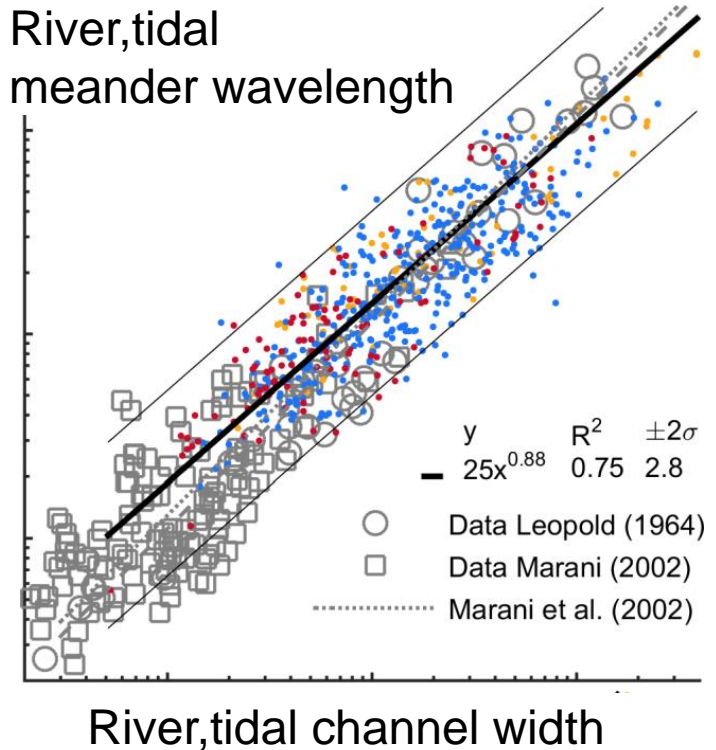


Bends bars etc.



Leuven et al. 2016 Earth-Science Reviews

River, tidal
meander wavelength



Leuven et al. 2018 Geology

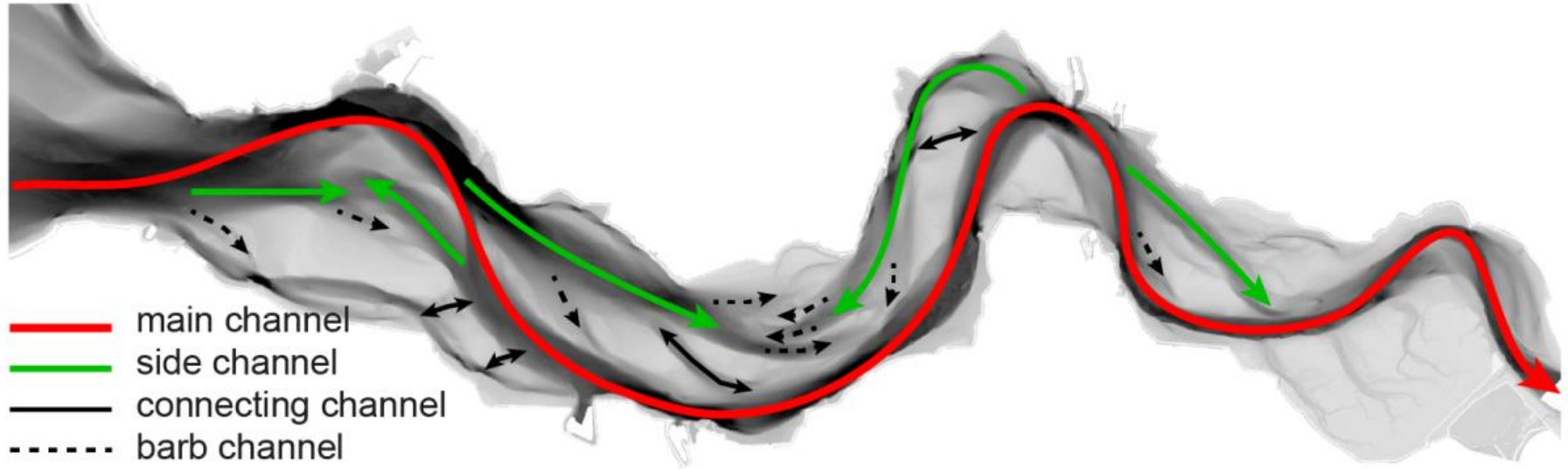


Perturbations in the Western Scheldt

(de-)stabilizing of the multi-channel character

Wout van Dijk

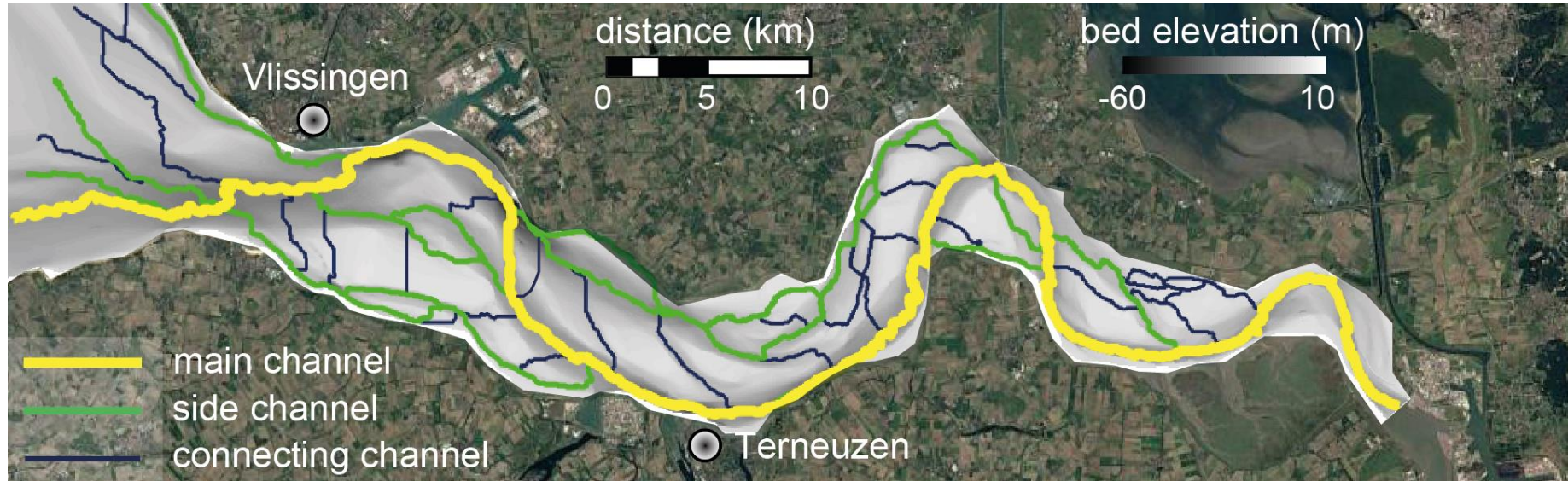
Channels in the Western Scheldt



Multi-channel network including a main channel, side channels and connecting channels between them

Channel network extraction

Thanks to Matt Hiatt, Willem Sonke, Bettina Speckmann et al. TU/e
Hiatt et al. (2020) – JGR - ES

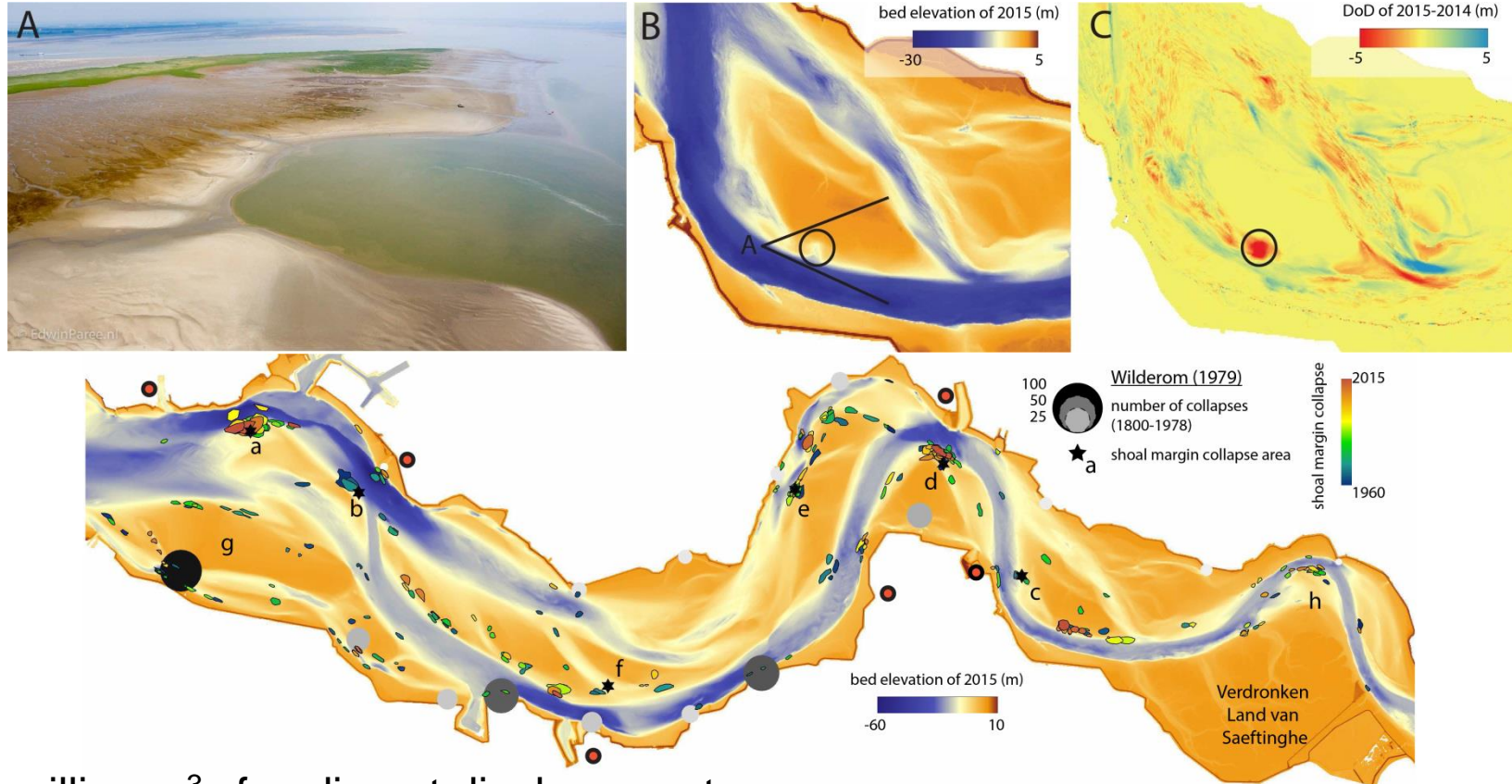


Automatic selection of the significant channels of the Western Scheldt

Natural perturbations

Van Dijk et al. (2018) – ESPL

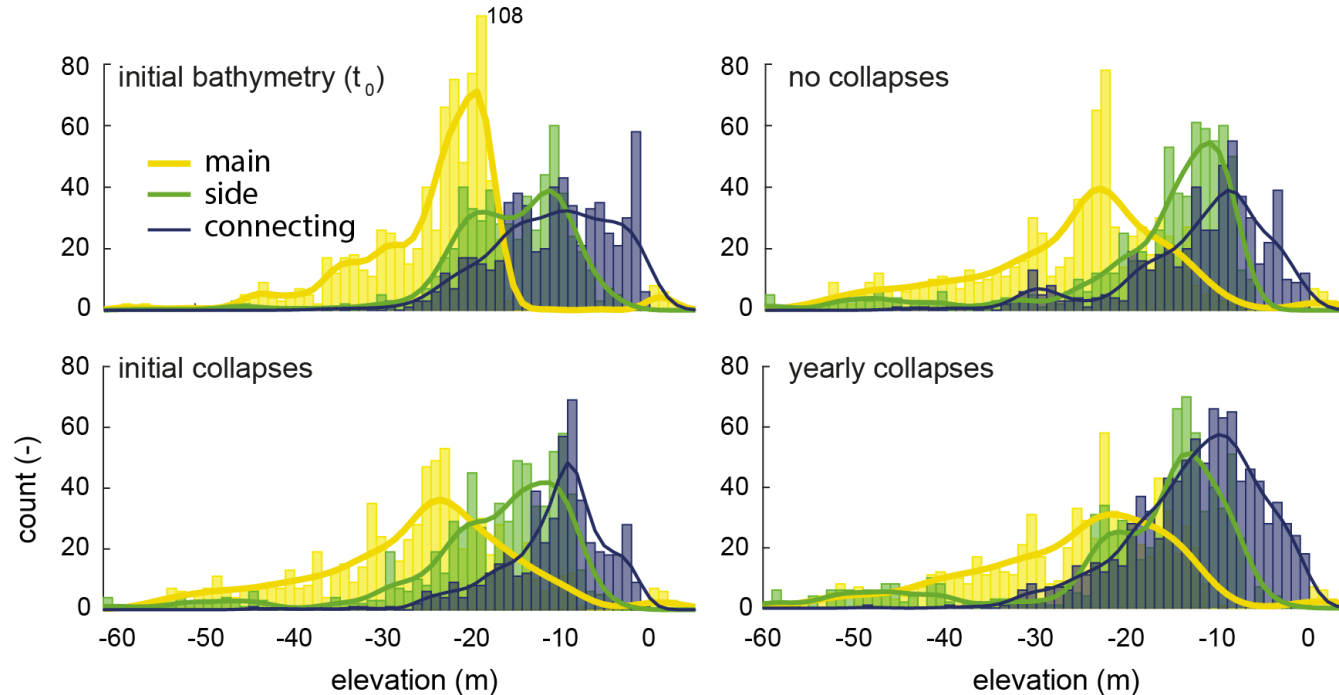
Shoal margin collapses



> 1 million m³ of sediment displacement

Effect on the channel network

Van Dijk et al. (2019) – JGR - ES



Shallowing of the main channel depth,
main and side become equally important!

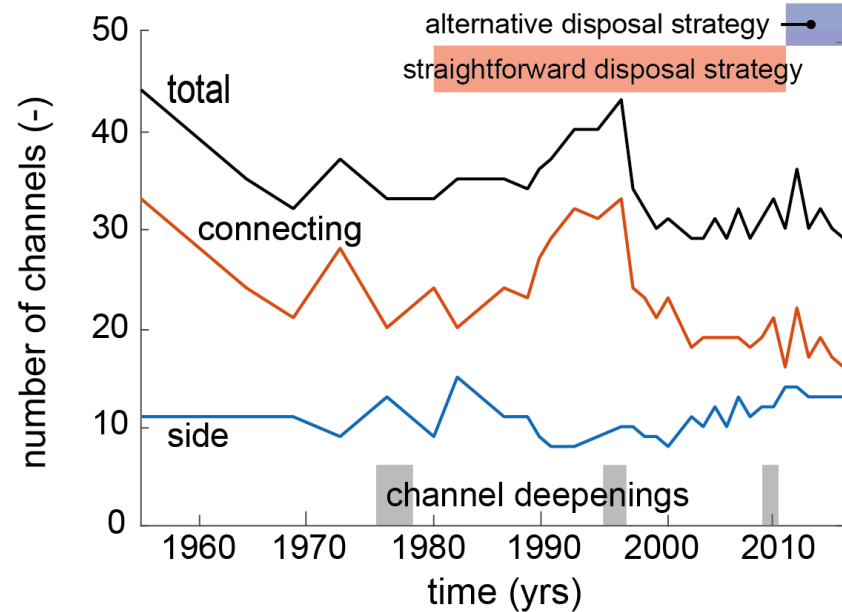
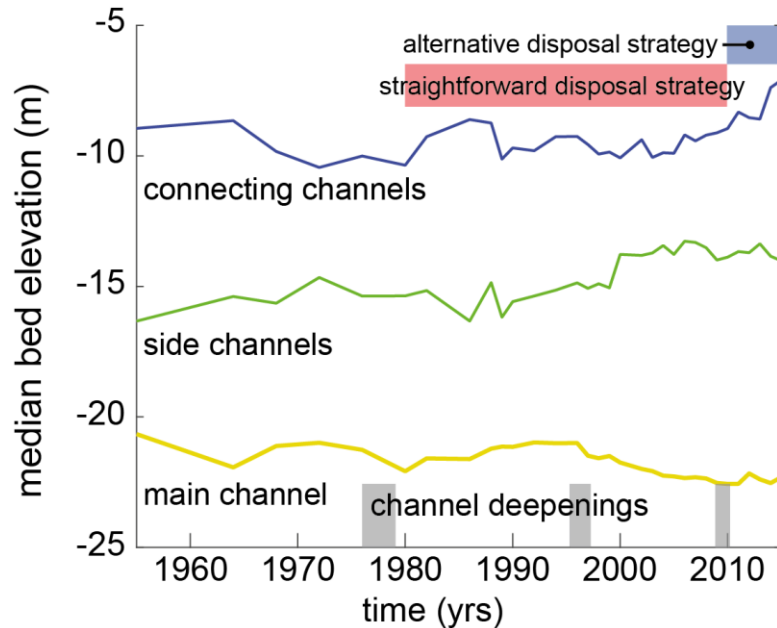
Human-induced perturbations



> 10 million m³ of sediment displacement per yr

Accessibility of the harbors,
continuous dredging and disposal is needed

Effect on the channel network



Jeopardizing the number of channels, channel dynamics
Increase shoal size and elevation differences between channels

Perturbations and the multi-channel system of the Western Scheldt

- Natural perturbations have a positive effect on the multi-channel character
- Human-induced perturbations such as fairway dredging reduce the dynamics of channels and ecological valuable tidal flats



How To Make Pretty Models

Anne Baar

NWO

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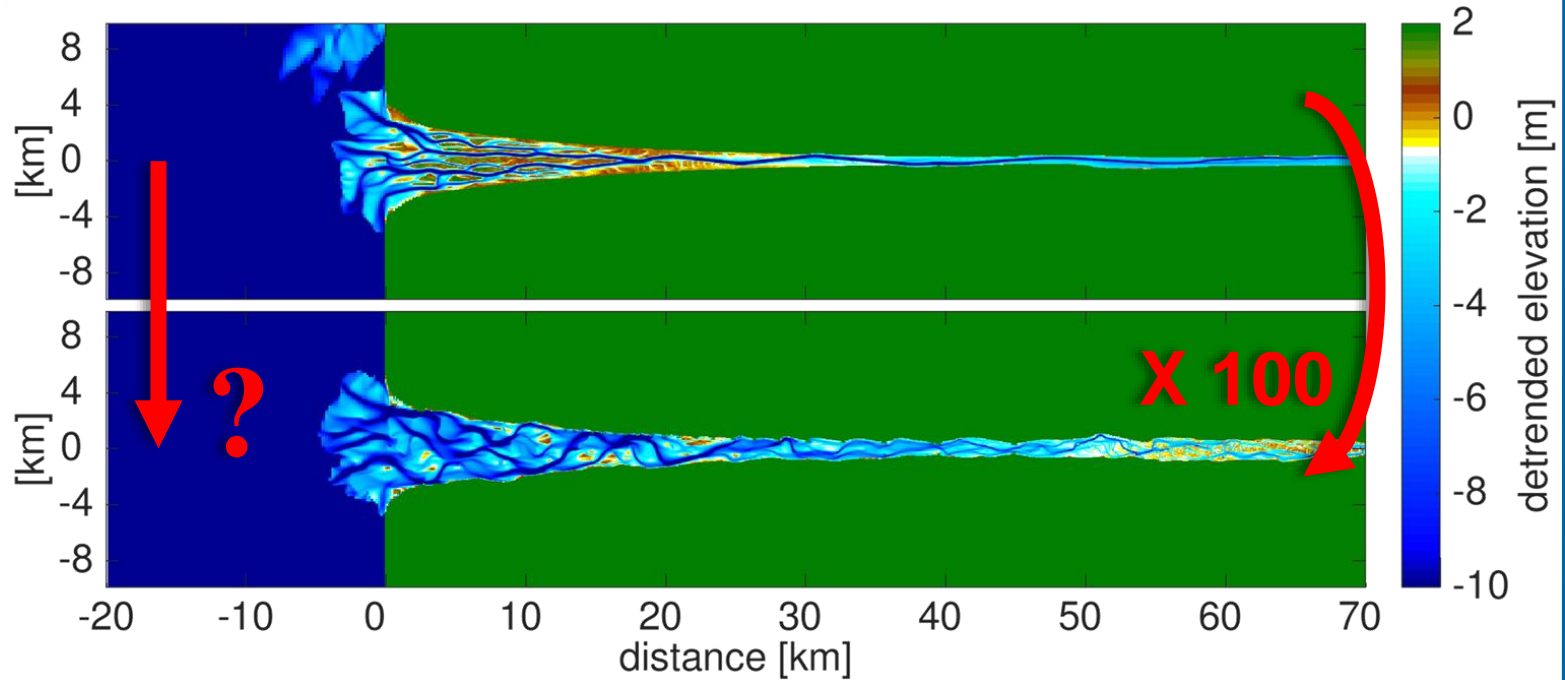


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OF HULL

ENERGY AND
ENVIRONMENT INSTITUTE

Transverse slope effect

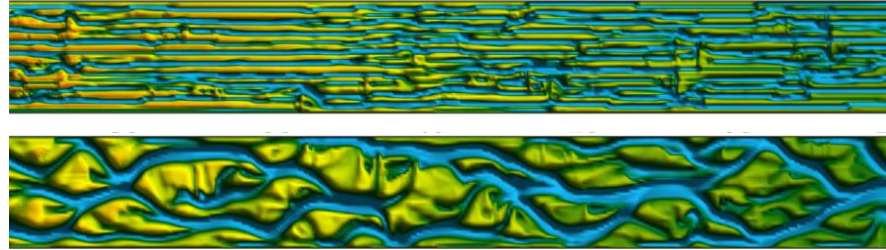
physically
default
correct



increased

1. Suspended transport

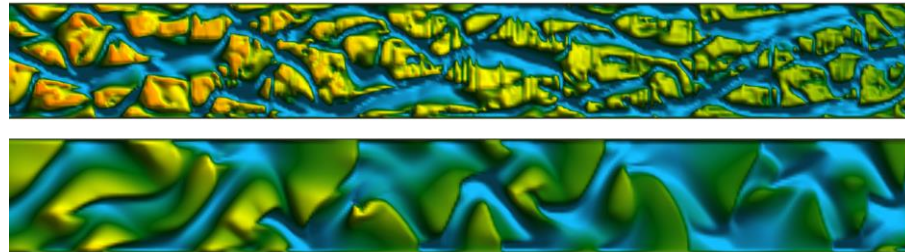
Van Rijn



default

X 100

Engelund-Hansen

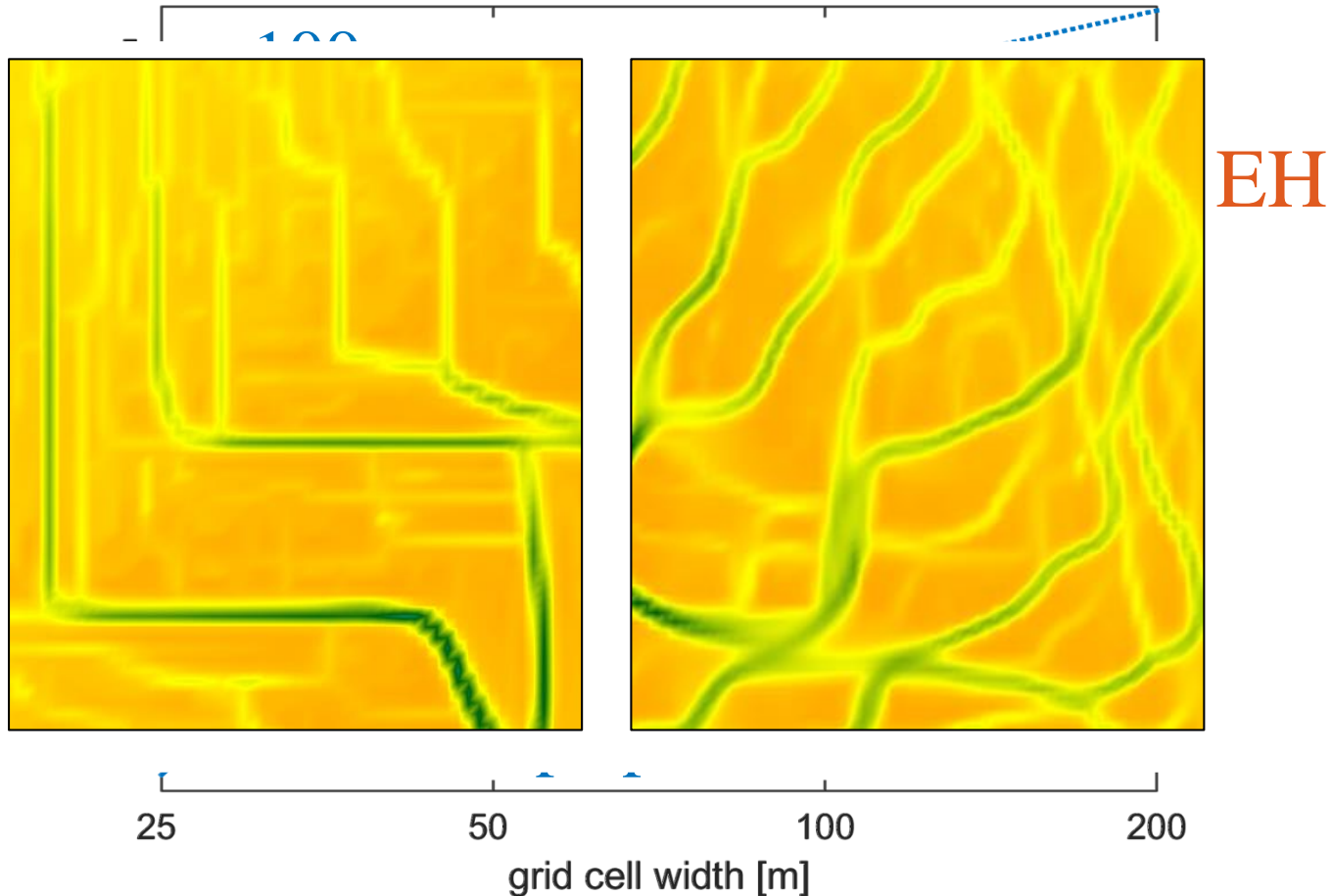


default

X 7

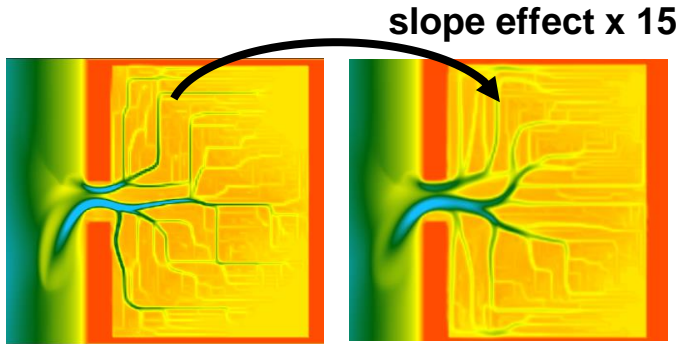
2. Grid size-dependent incision

Van Rijn

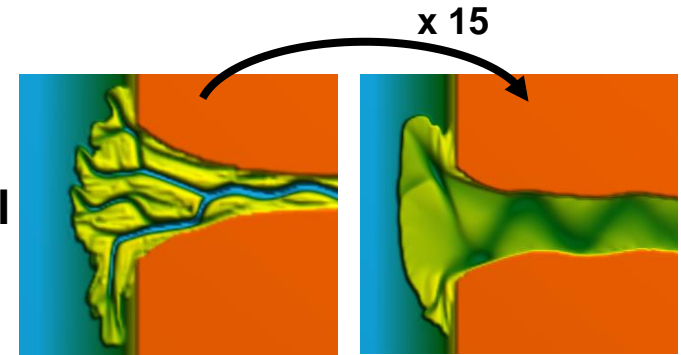


Impact on large-scale morphology

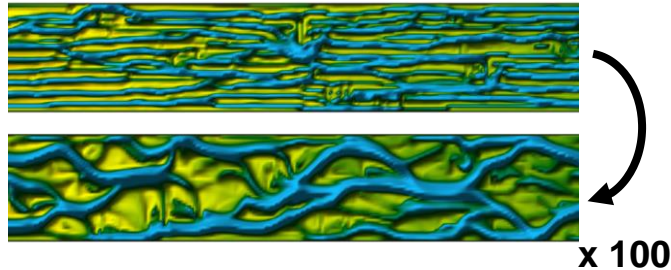
Erosional



Depositional

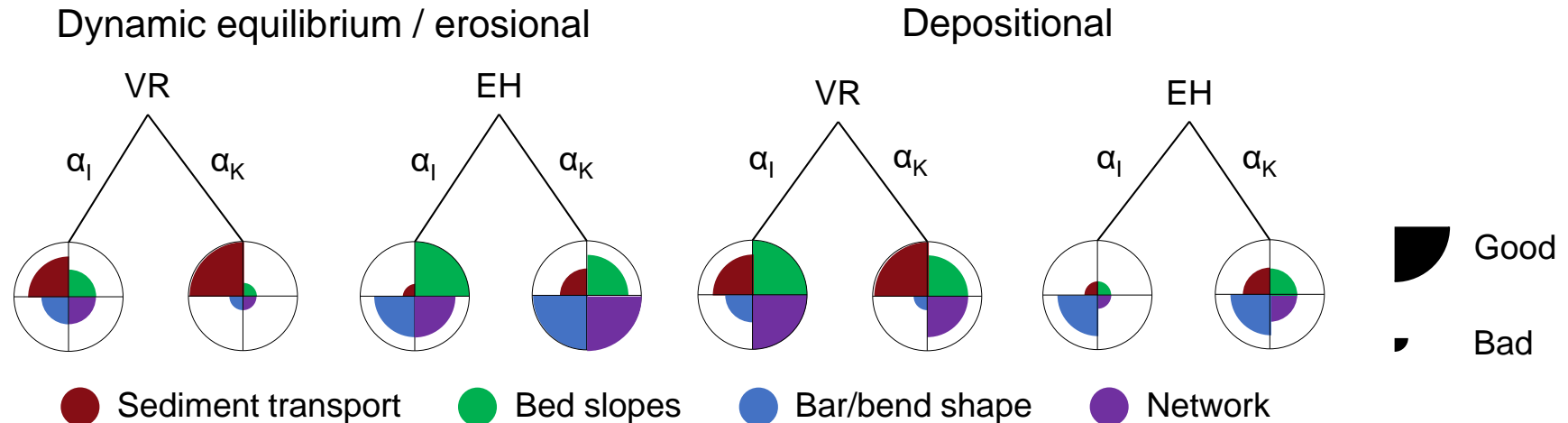


Balanced



Which model do you want?

- Depends on research objective
 - What environment?
 - Realistic sediment transport or morphology?
- Slope parameterization: bar/channel stability





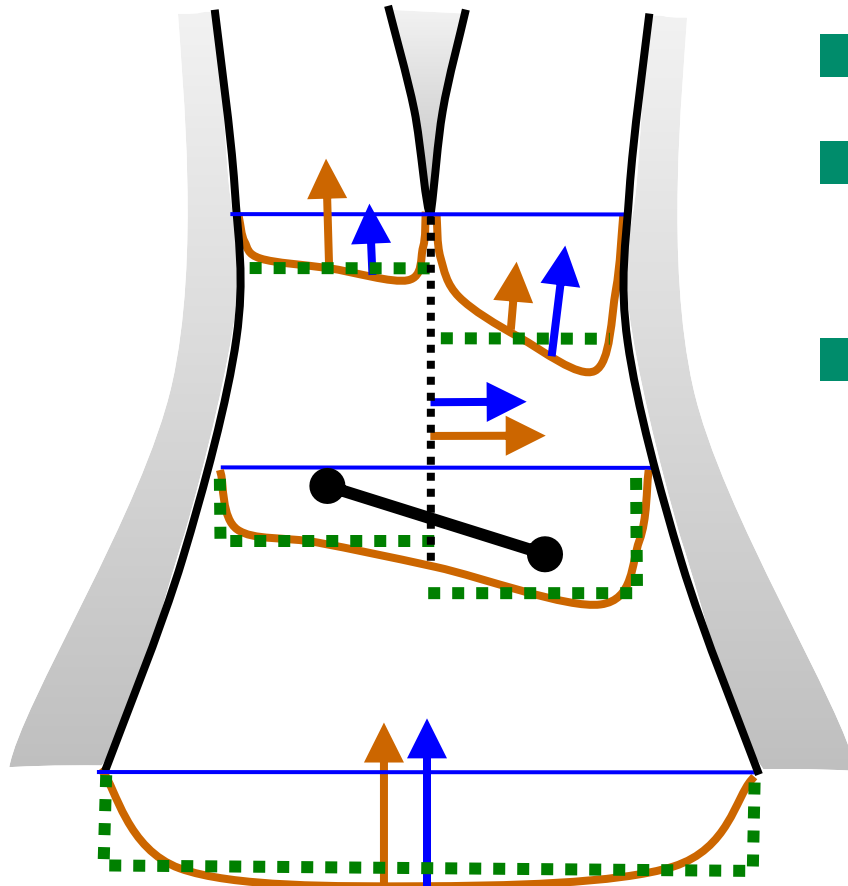
Morphodynamic evolution of tidally-influenced bifurcations

Arya Iwantoro

Maarten van der Vegt and Maarten Kleinhans

Stability mechanism rivers

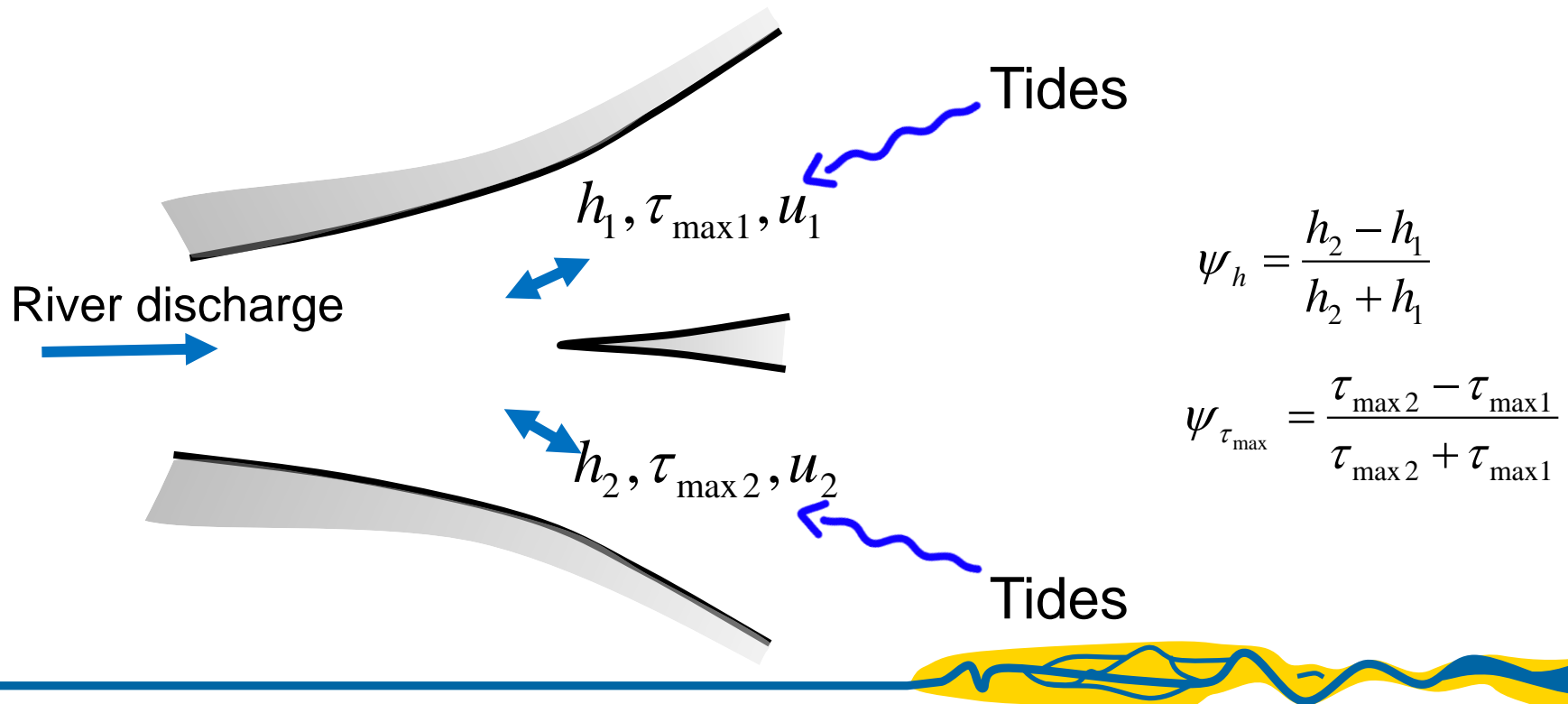
- Perturbation
- Sediment transport is nonlinear function of flow
- Bedslope effect compensates the unbalance



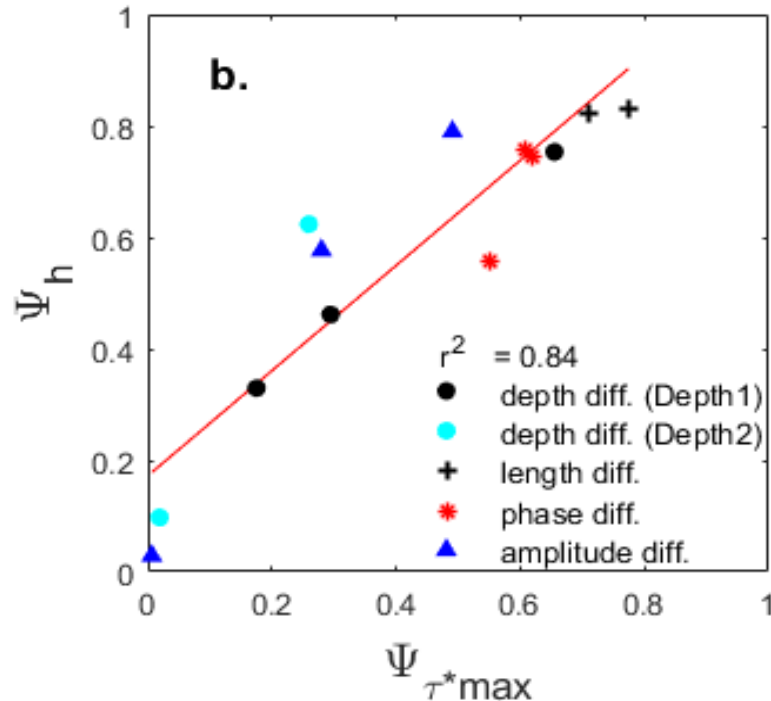
—→ Sediment transport
—→ River flow

Valid for tidal systems?

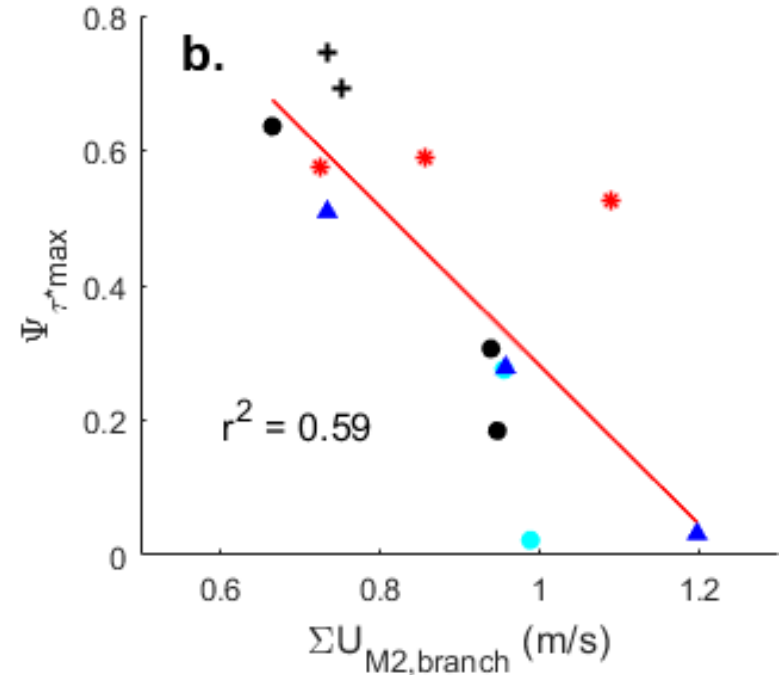
- Delft3D simulations: asymmetry final equilibrium
- Developing and applying 1D model: stability



Increasing tides \rightarrow less asymmetric

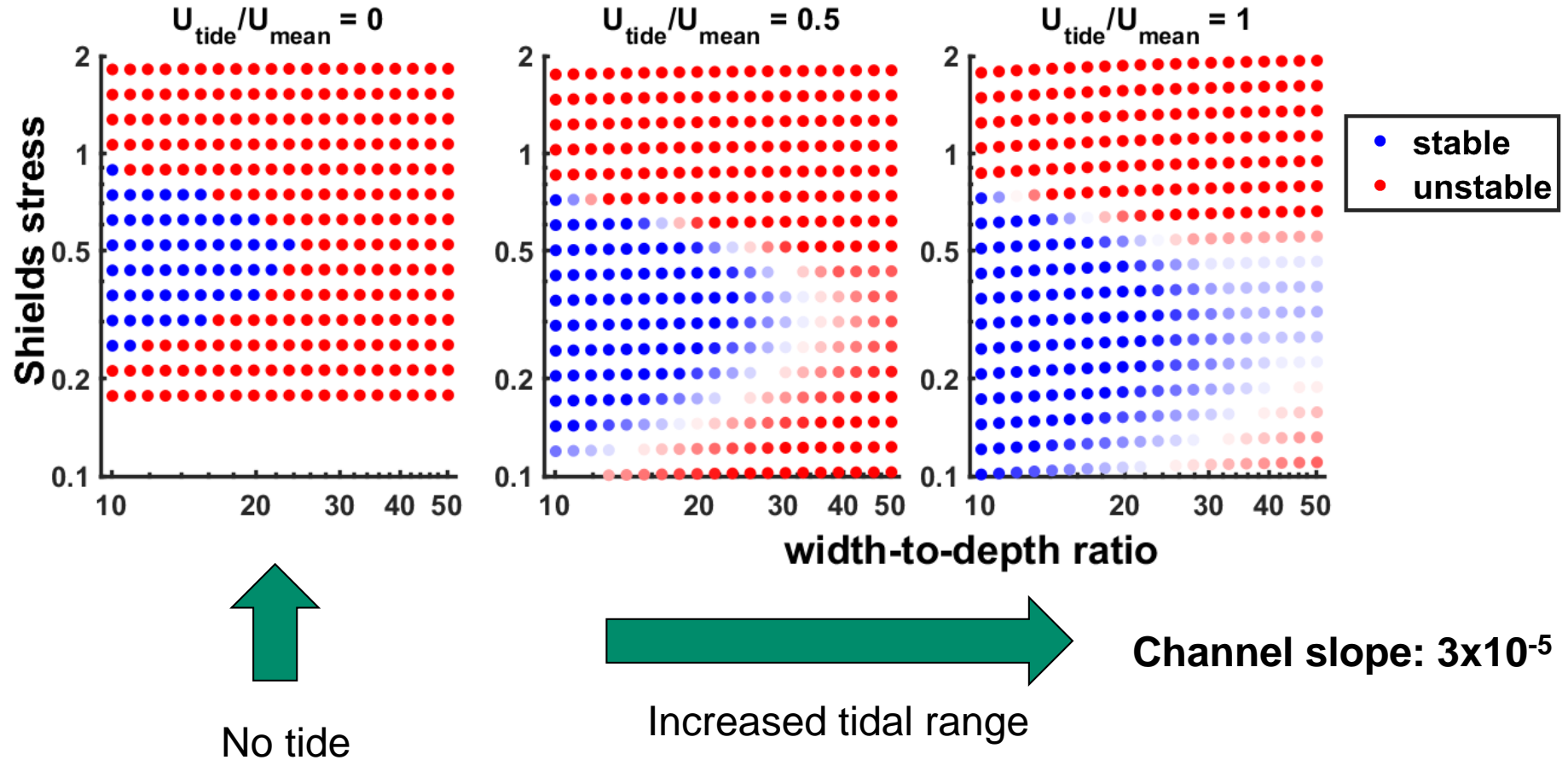


More asymmetric depth
means more asymmetric flow



Increased tides results in less
asymmetric flows

Tides stabilize bifurcations



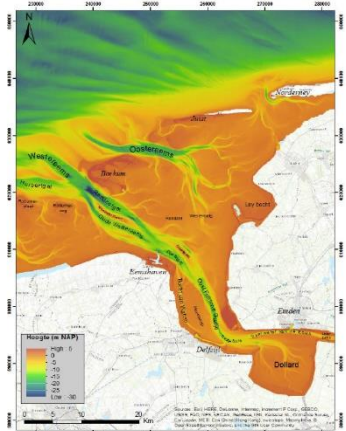
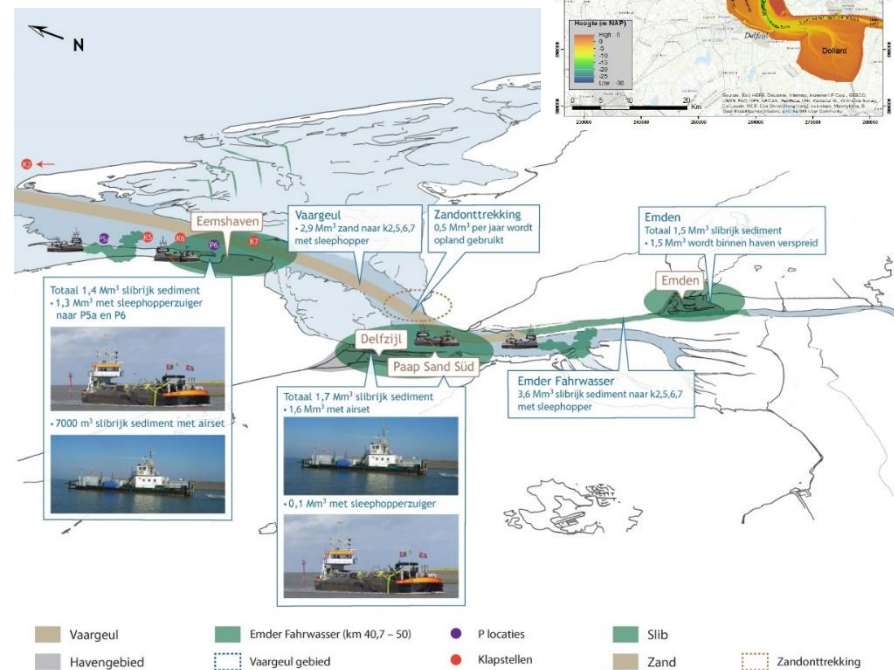
The Ems Estuary

An inspirational place for research and innovation

Dr. Petra Dankers
14 januari 2020

The Ems Estuary – Declining ecological state

- The Ems estuary is experiencing
 - Increased tidal range
 - Increased turbidities in the lower Ems river and the Ems estuary
 - Decrease of biomass at many places in the food pyramid
- Many reasons
 - Loss of intertidal areas
 - Dikes and polders
 - Dredging and fairway deepening



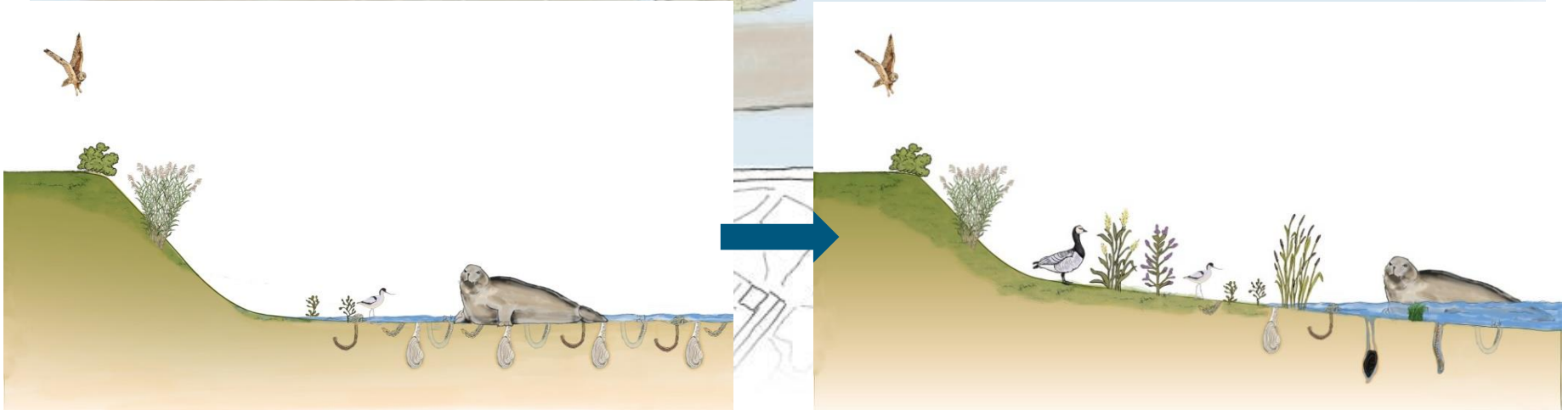
What happens if we do nothing

- With business as usual (ongoing dredging, sea level rise and land subsidence) we expect:
 - Slow deepening of sandy channels
 - Slow drowning of part of tidal flats
 - Muddier tidal flats
 - Growing tidal flats in the Dollard
 - Ongoing decline in biomass
 - Possible outflow of fine sediments from the Ems river towards the estuary
 - On the long term – high water safety issues



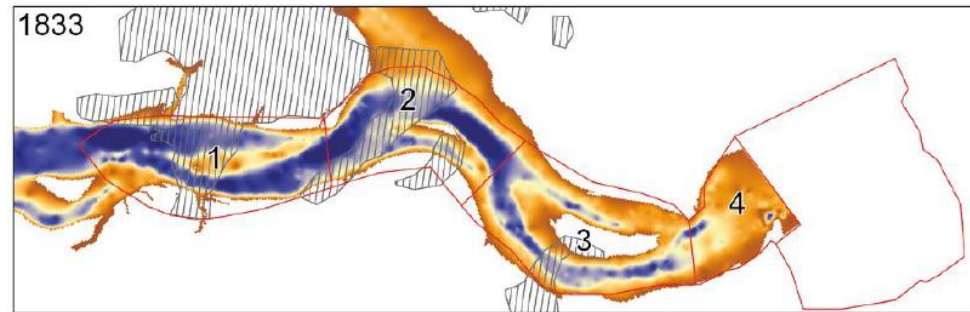
Where do we want to go

A healthy ecosystem with large, partly vegetated, tidal flats that grow with sea level rise.
And ideally also hinterland that grows with sea level rise.



How?

- Learning from research
- Results from the Eems-Dollard 2050 program in cooperation with Utrecht University
 - Improvement of understanding the (historical) development of the system
 - The importance of hard layers in the subground and the effect of dredging
 - Hard layers shape the estuary
 - The estuary is a net sedimenting system (except during the years of extensive dredging/deepening of channels)
- Thus: use the sediments to grow with sea level rise (in the estuary and behind the dikes of the estuary)



Pierik et al., 2019

How?

Field experiments and pilot projects

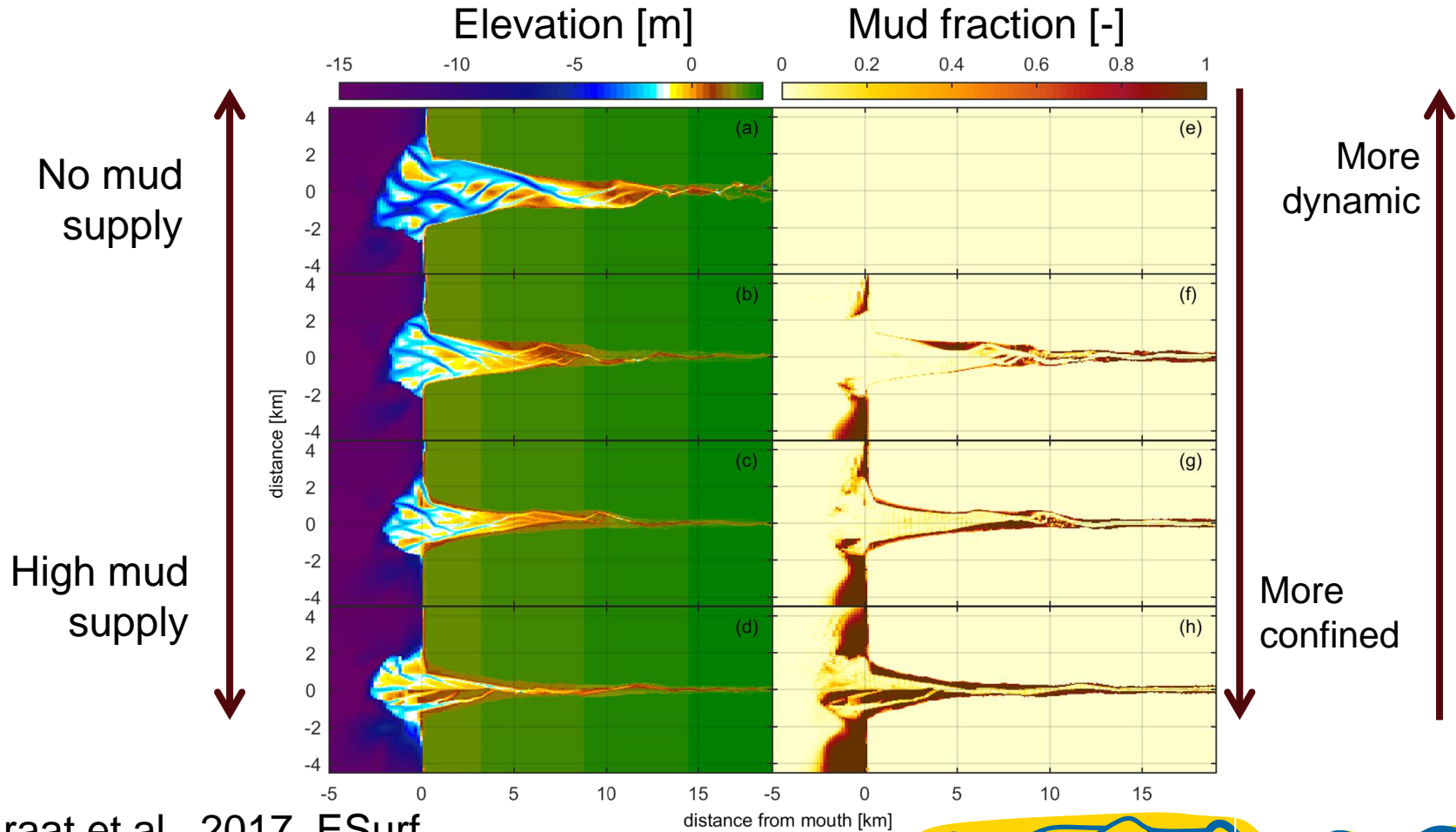
Large pilot in the Dollard in order to learn how to promote salt marsh development, how to create ecological interesting land/water boundaries and how to provide for sedimentation of fine sediments and decrease the turbidity



Effects of Mud on Morphology

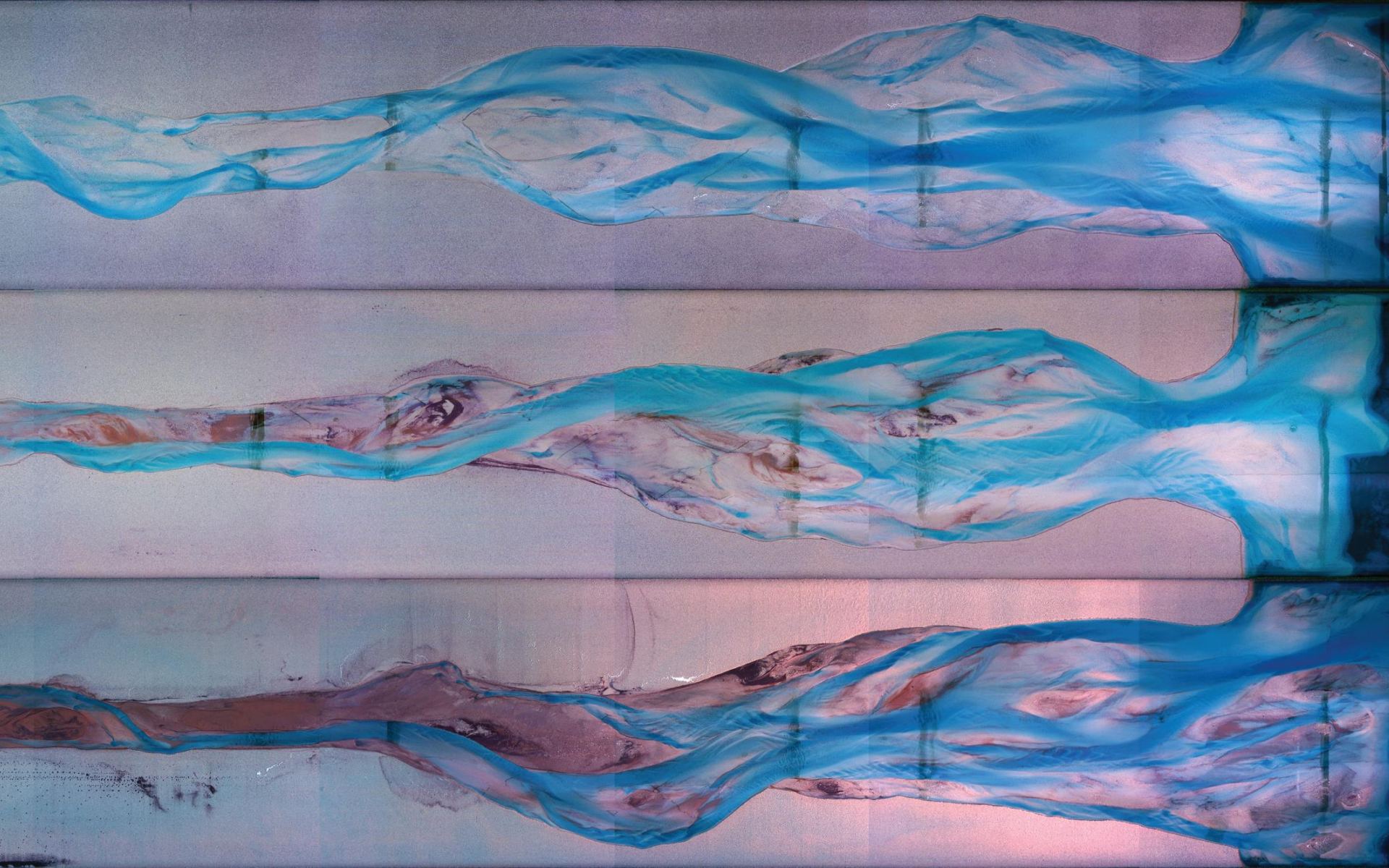
Lisanne Braat

Mud confines estuaries



Shorter and Narrower

- See movies at
Braat, L., J.R.F.W. Leuven, I.R. Lokhorst and
M.G. Kleinhans (2019), Effects of estuarine
mudflat formation on tidal prism and large-scale
morphology in experiments, Earth Surf. Process.
Landforms 44, 417-432,
<http://dx.doi.org/10.1002/esp.4504>



PS: Scaling of the experiments

- Tilting: sand mobility & tidal excursion length
- Coarse sand: no scours
- Nutshell: suspension
- Plants:
 - Settling elevation, no growth, rooting, flow resistance

Kleinhans et al. 2014 Earth-Science Reviews

Kleinhans et al. 2015 Geomorphology, JGR

Kleinhans et al. 2017 ESurf

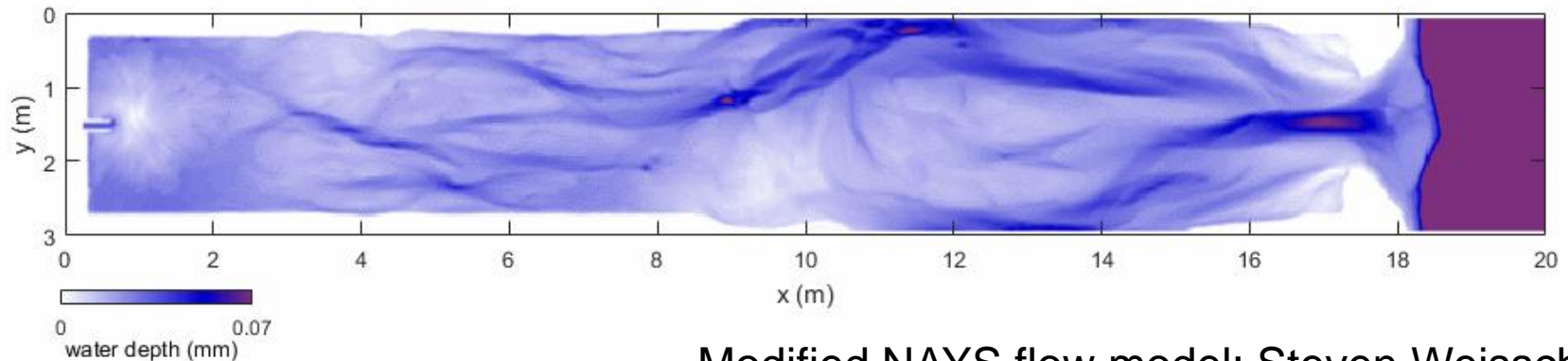
Kleinhans et al. 2018 Sedimentology

Braat et al. 2019 ESPL

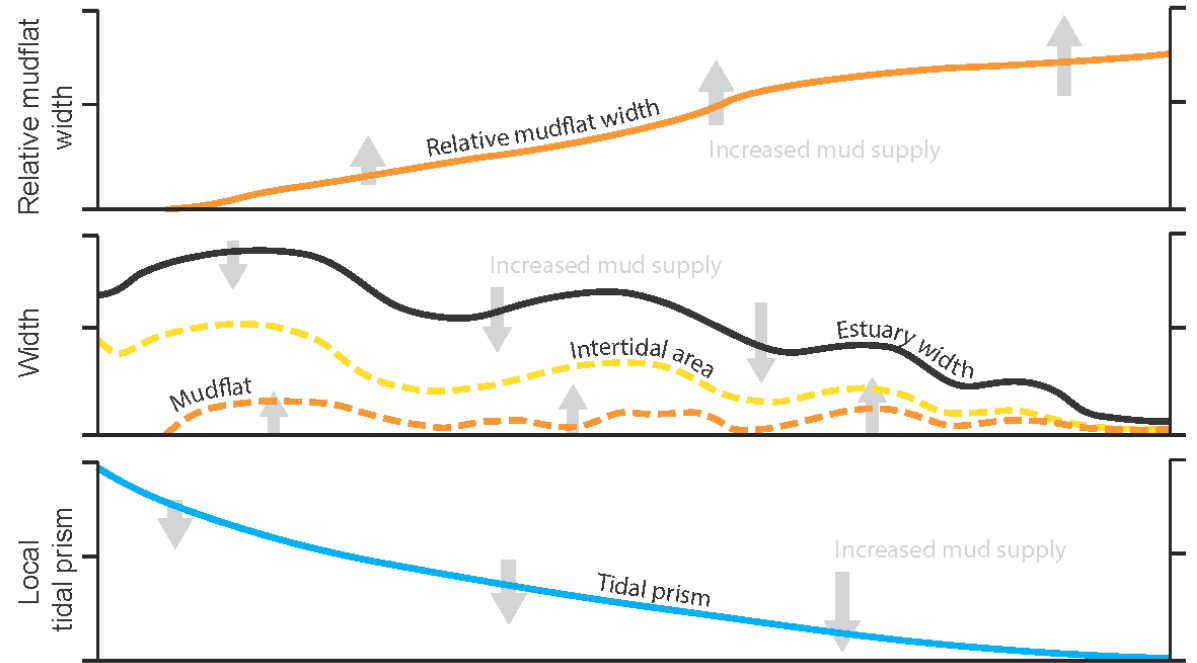
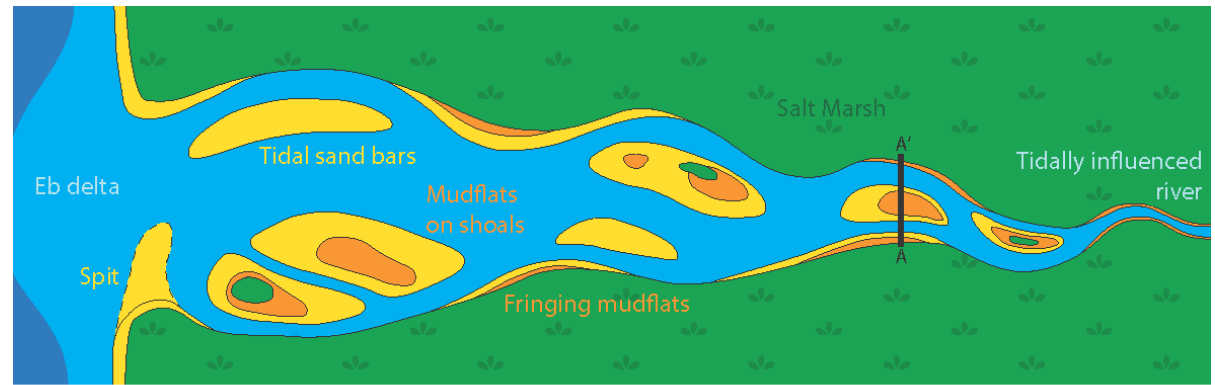
Lokhorst et al. 2019 ESPL

PS: Scaling of the experiments

- Tilting: sand mobility & tidal excursion length
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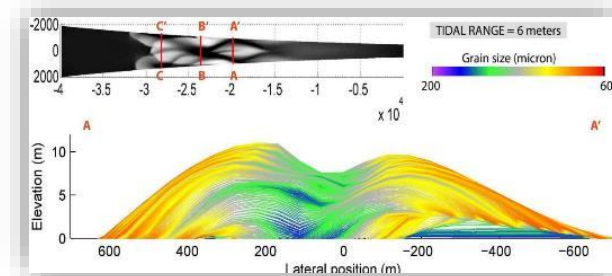
Modified NAYS flow model: Steven Weisscher





Controls on mud distribution and architecture along the fluvial-to-marine transition

- *where is the mud?* -



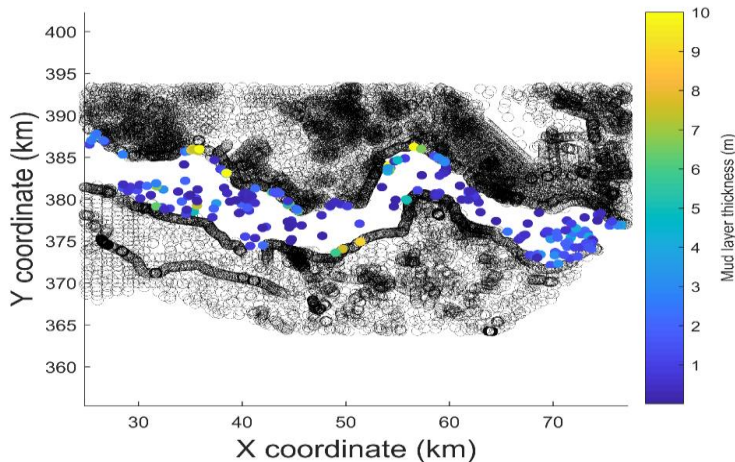
Wietse van de Lageweg

Field observations: Scheldt estuary



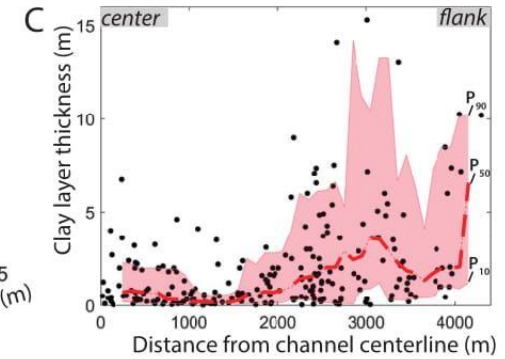
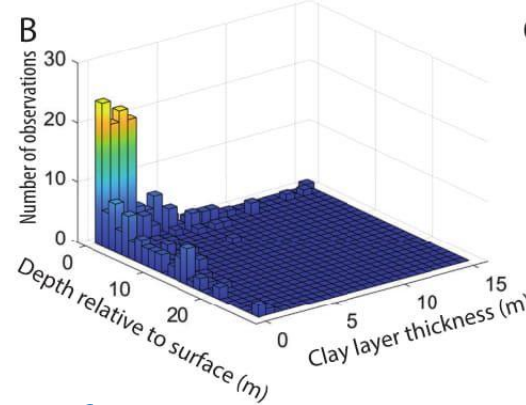
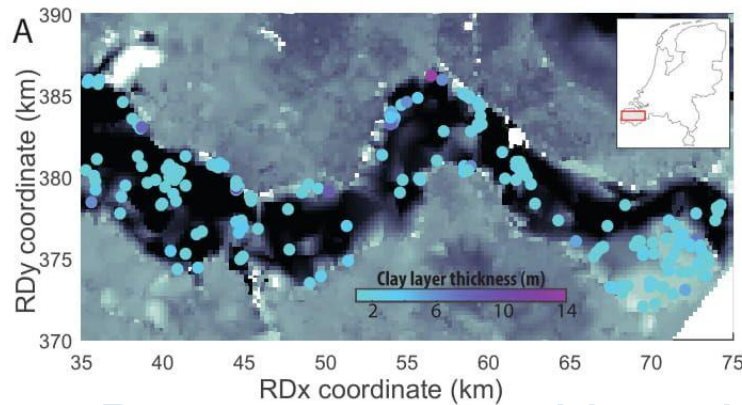
TNO DINO Database

- In total: 14717 corings
- Region of Interest: 756 corings
 - Within modern Western Scheldt
- Naaldwijk formation: 574 corings
 - Holocene deposits
- With clay: 227 corings



Sandy system: ~5-10% mud content at surface [Van Maldegem et al. 1993]

Large-scale patterns in mud deposits



■ **Percentage mud in subsurface:** $\frac{\text{Total clay thickness}}{\text{Total core thickness}} = \frac{447 \text{ m}}{8704 \text{ m}} \cdot 100 = 5.1 \%$

■ Consistent with surface observations

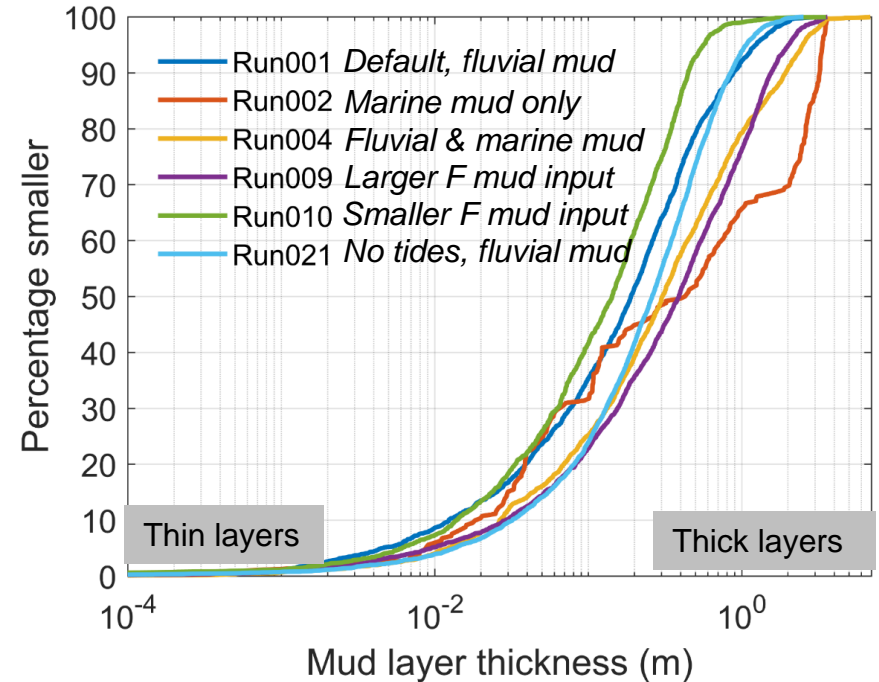
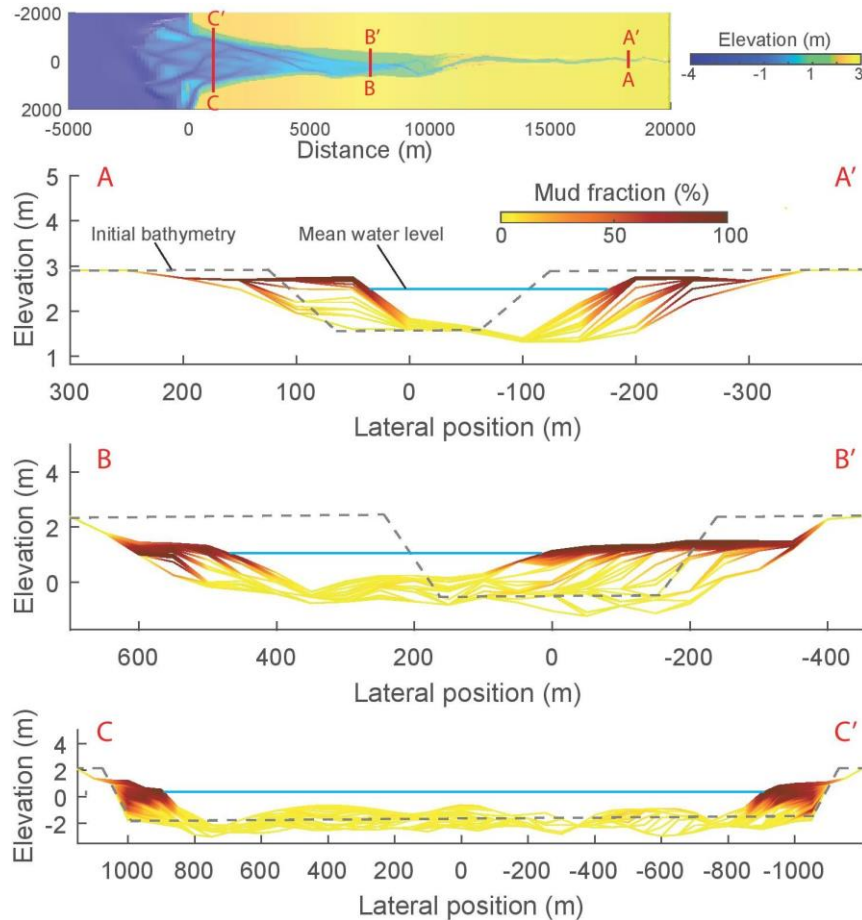
■ **Mud typically (85%) organised into a single layer**

■ 80% of mud-layer thicknesses between 6 cm and 3.1 m

■ 50% of mudlayers thicker than 0.5 m

■ **Thickening of mud deposits towards flanks**

Virtual (mud) sedimentology



So, where is the mud?

■ Processes

- **River-dominated**: muddier & more heterogeneous deposits
- **Tides**: tend to separate sands and muds with mud deposits towards flanks
- (Low-energy) **waves**: prevent mud deposition in mouth area

■ Spatial trends (D3D & Scheldt consistent)

- Mud deposits predominantly towards flanks of system
- Typically a single (1) mud layer in core

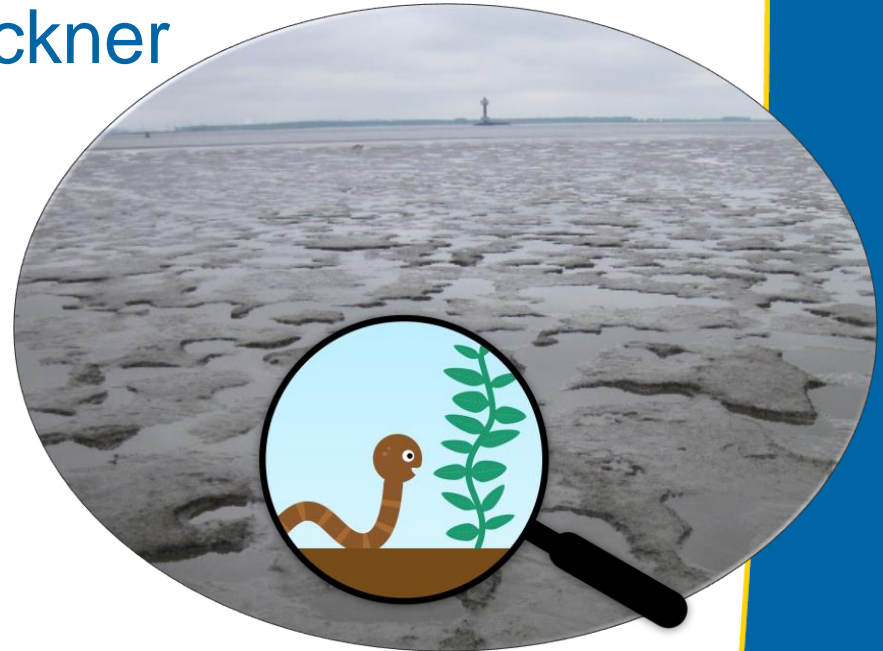
■ Implications

- Mud deposits determine degree of lateral confinement (thus bar pattern)
- Heterogeneity determines scales of predictability in geological models



Biostabilizers and mud

Muriel Brückner



NWO

Applied and
Engineering Sciences

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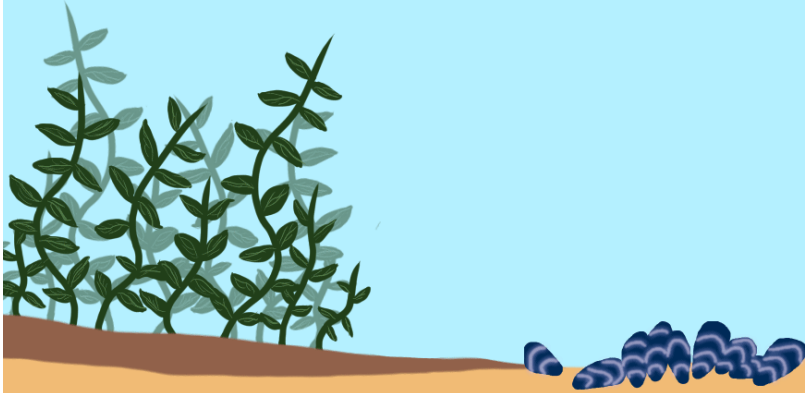
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erc

What if organisms live in the mud?

Biostabilizers



Bio-destabilizers



Credit: Lisanne Braat

What if organisms live in the mud?

Biostabilizers

Saltmarsh

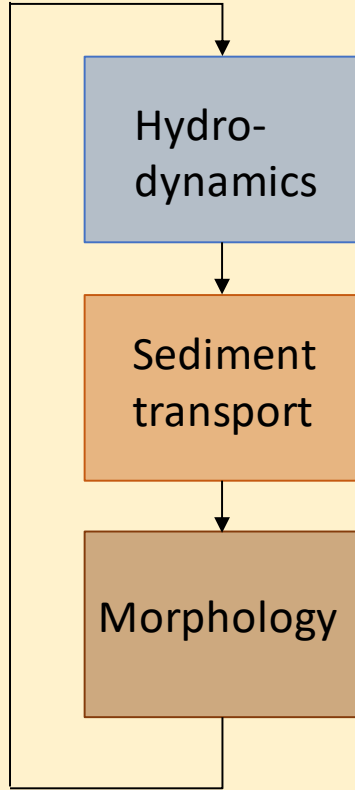
Microphytobenthos

Bio-destabilizers

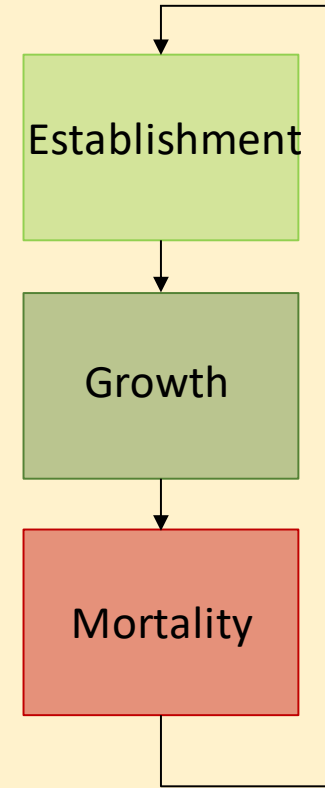
Credit: Lisanne Braat

Eco-morphodynamic model

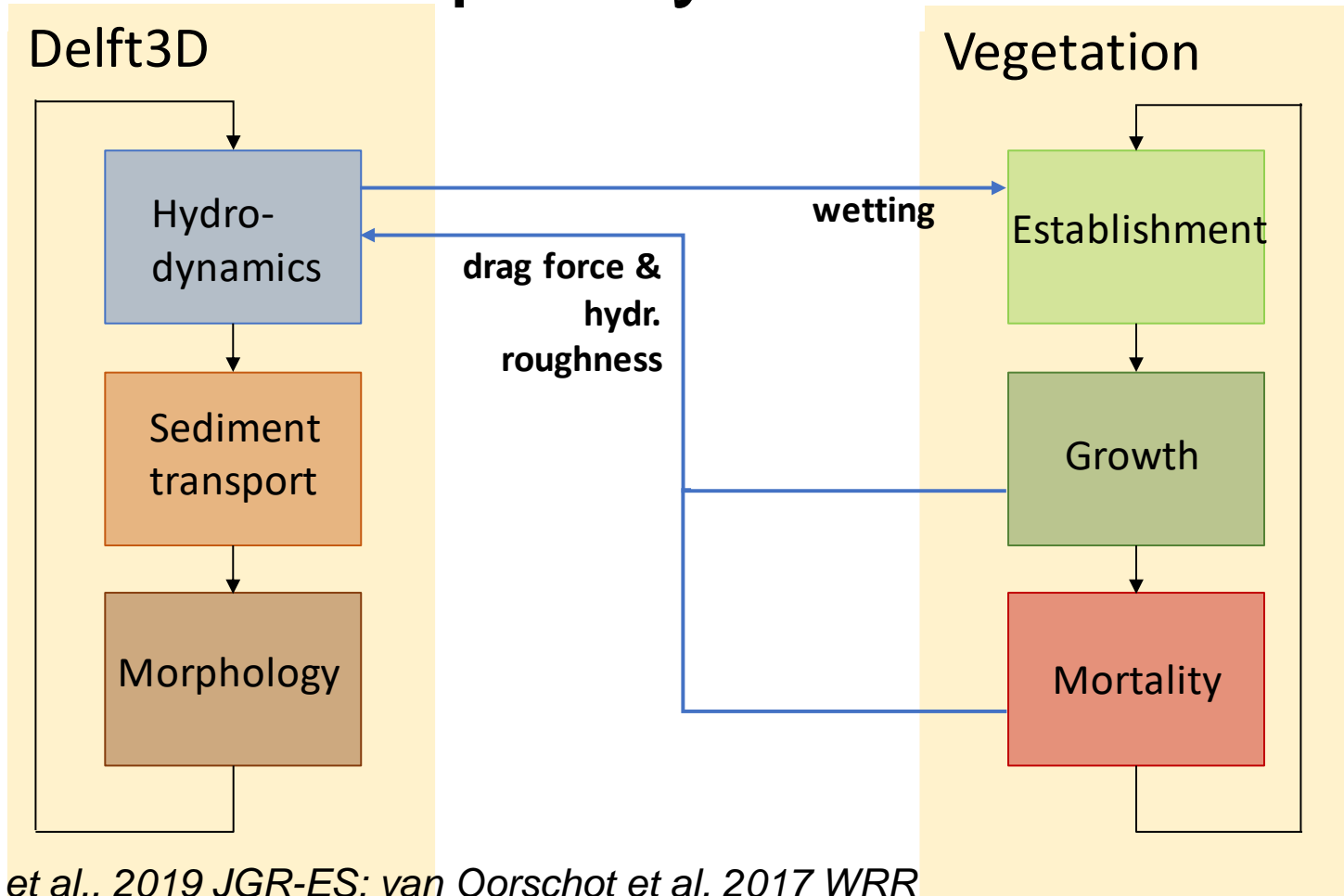
Delft3D



Vegetation

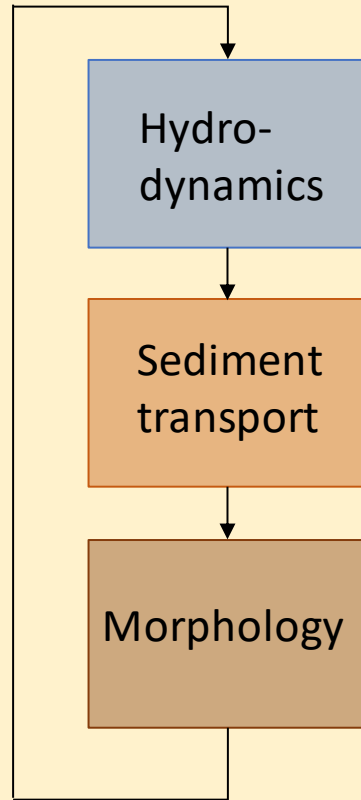


Eco-morphodynamic model

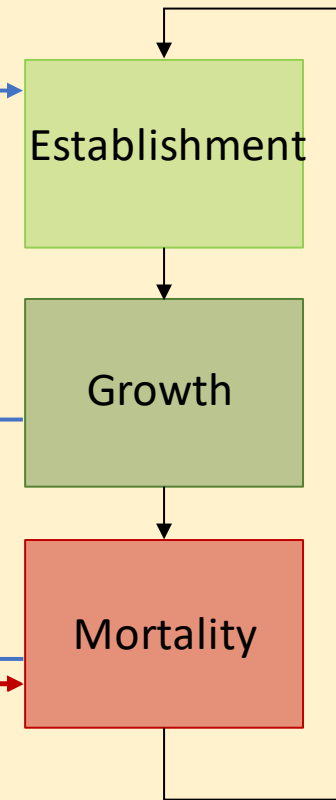


Eco-morphodynamic model

Delft3D



Vegetation



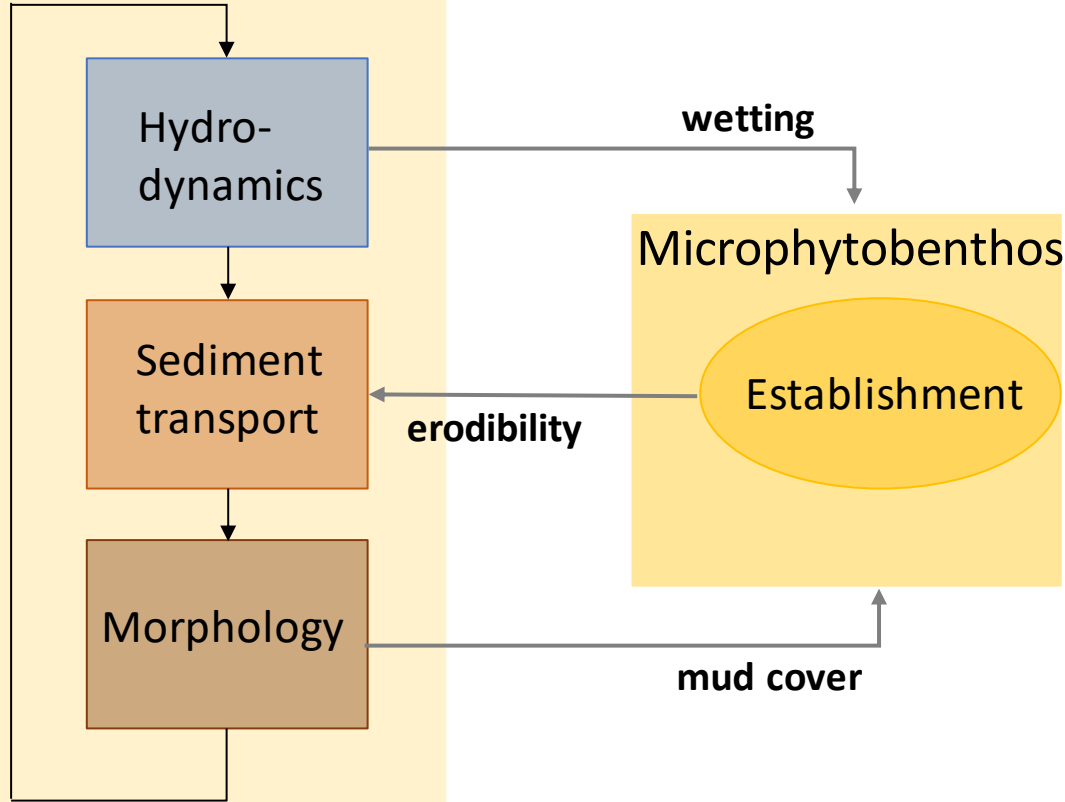
drag force &
hydr.
roughness

wetting

uprooting
drowning
burial
erosion

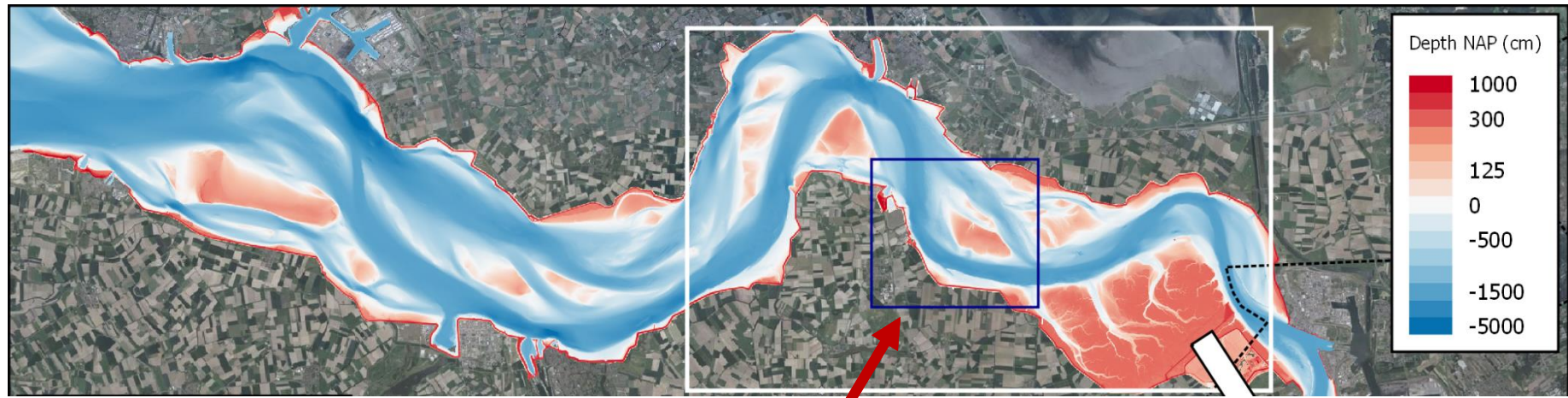
Eco-morphodynamic model 2

Delft3D



The model domain

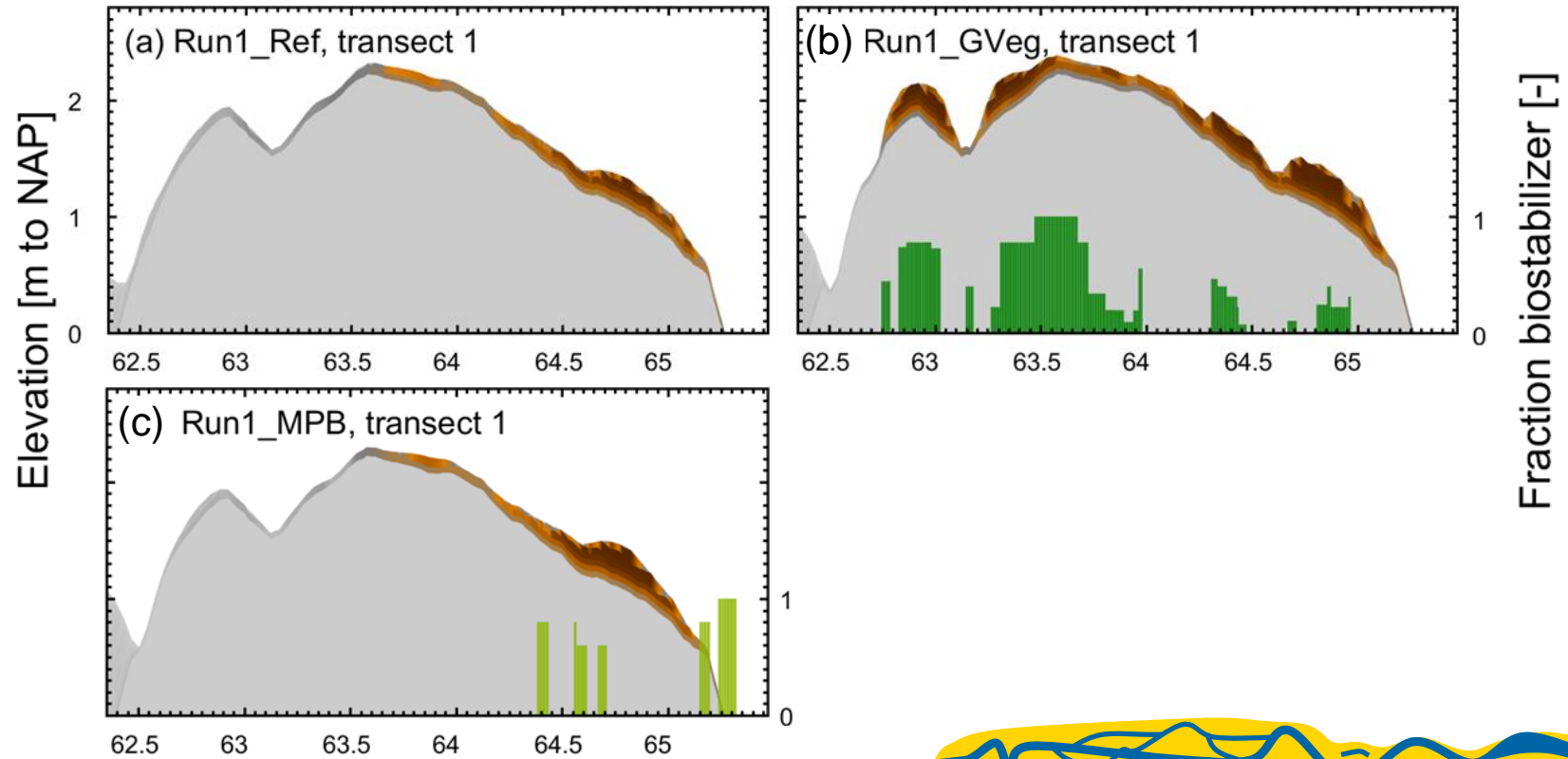
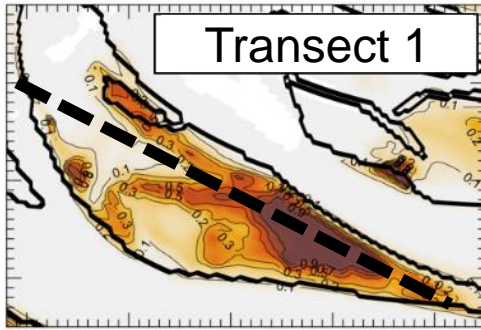
■ Calibrated NeVla-model (Dutch-Flemish)



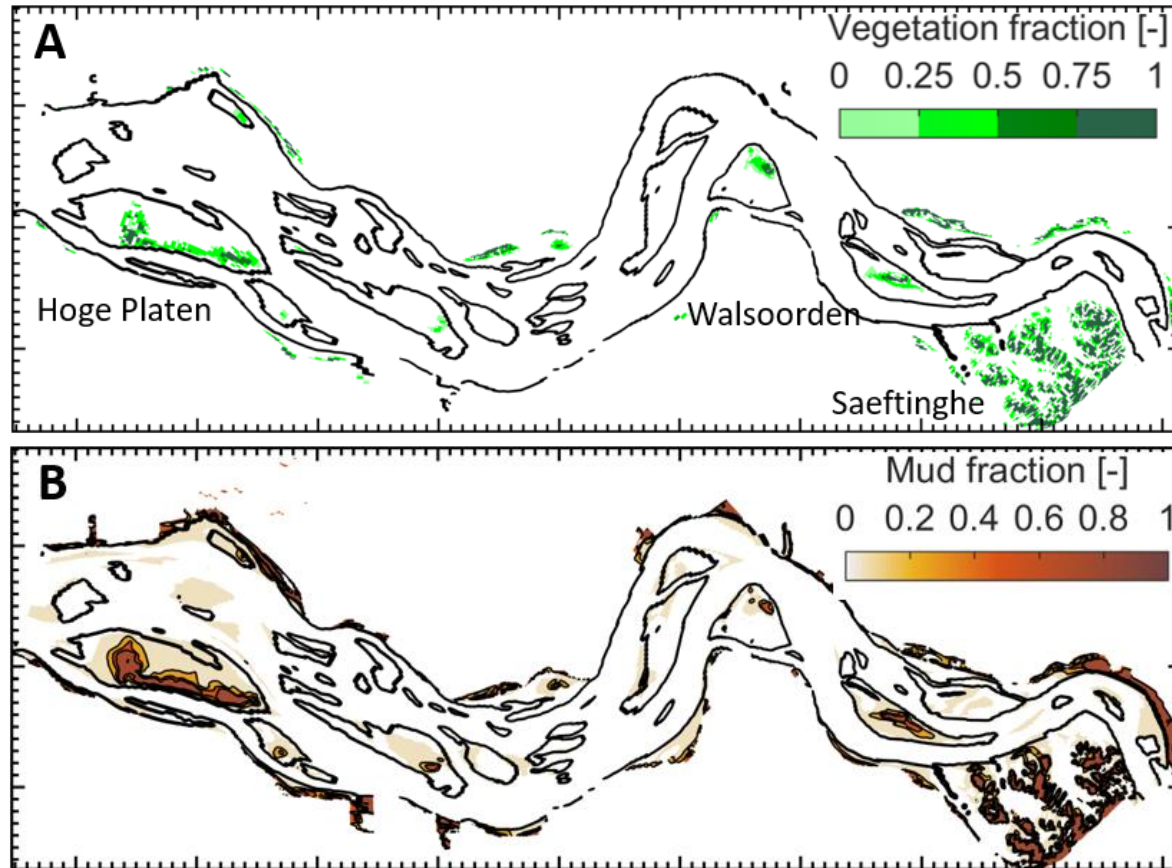
Tidal shoal of Walsoorden

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

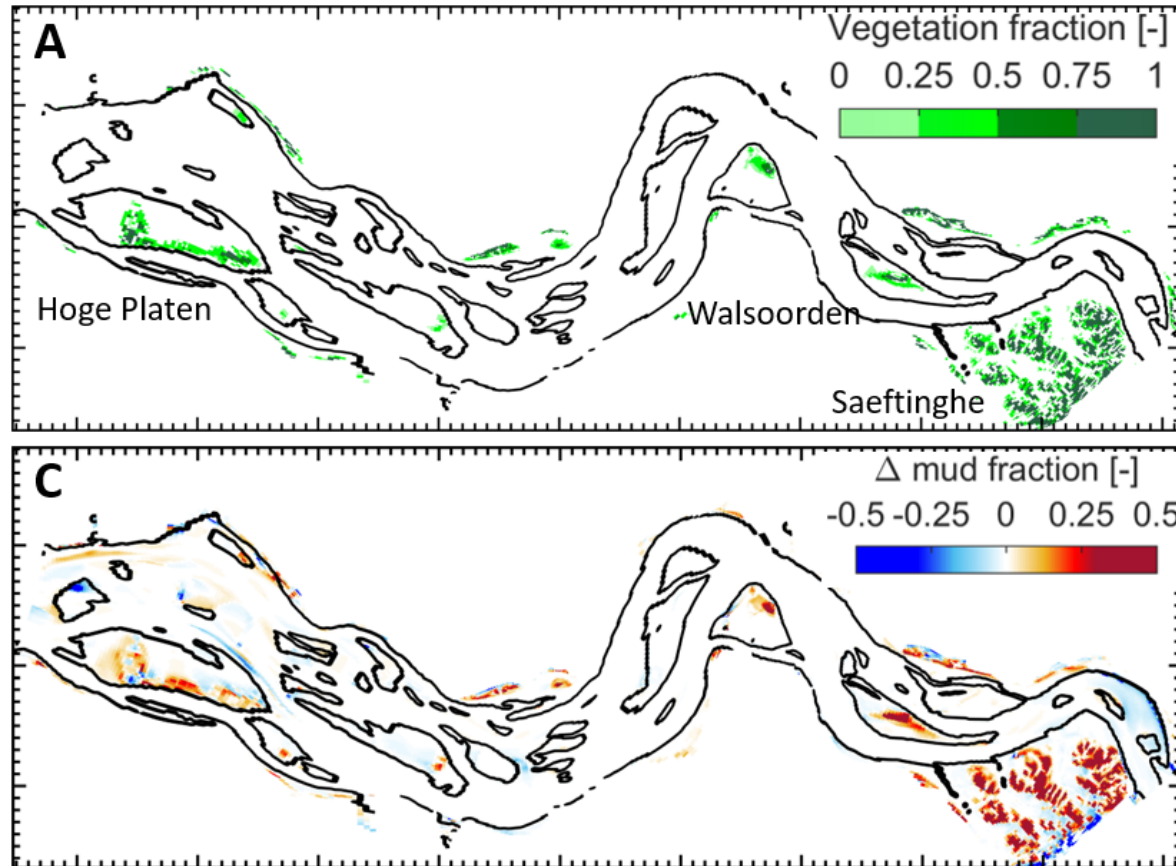
Long-term mud accretion



Large-scale mud distribution



Large-scale mud distribution



Biostabilizers affect mud distribution

- Mud captured in the season by microphytobenthos and saltmarsh
- Supply-limitation:
Large-scale mud scarcity at higher elevations through mud deposition at lower elevations
- Erosion at margin of vegetation

Work in progress: macro-benthic bioturbation



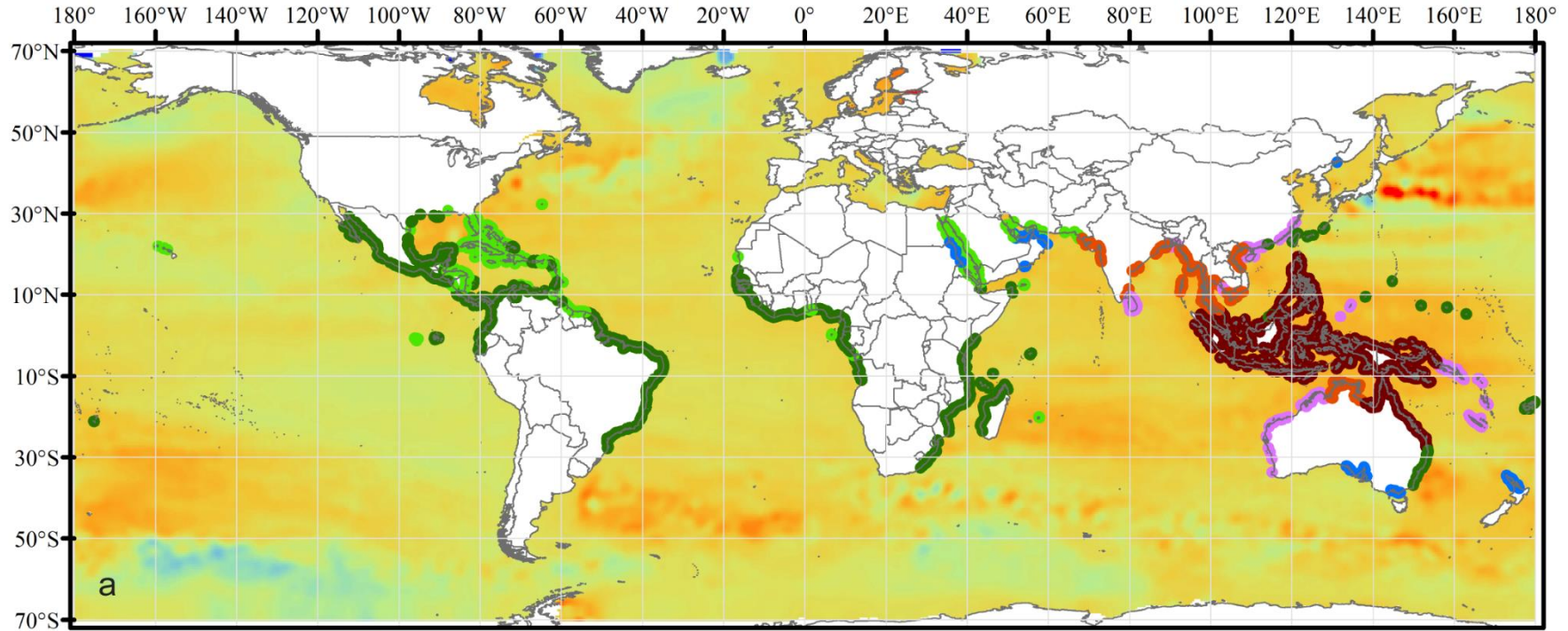
Mangrove response to SLR

Danghan Xie

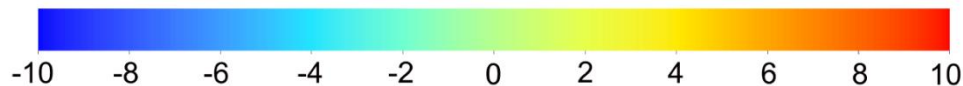
(with Barend van Maanen and Christian Schwarz)



Present sea level rise



Sea Level Rise Rate (mm/yr):

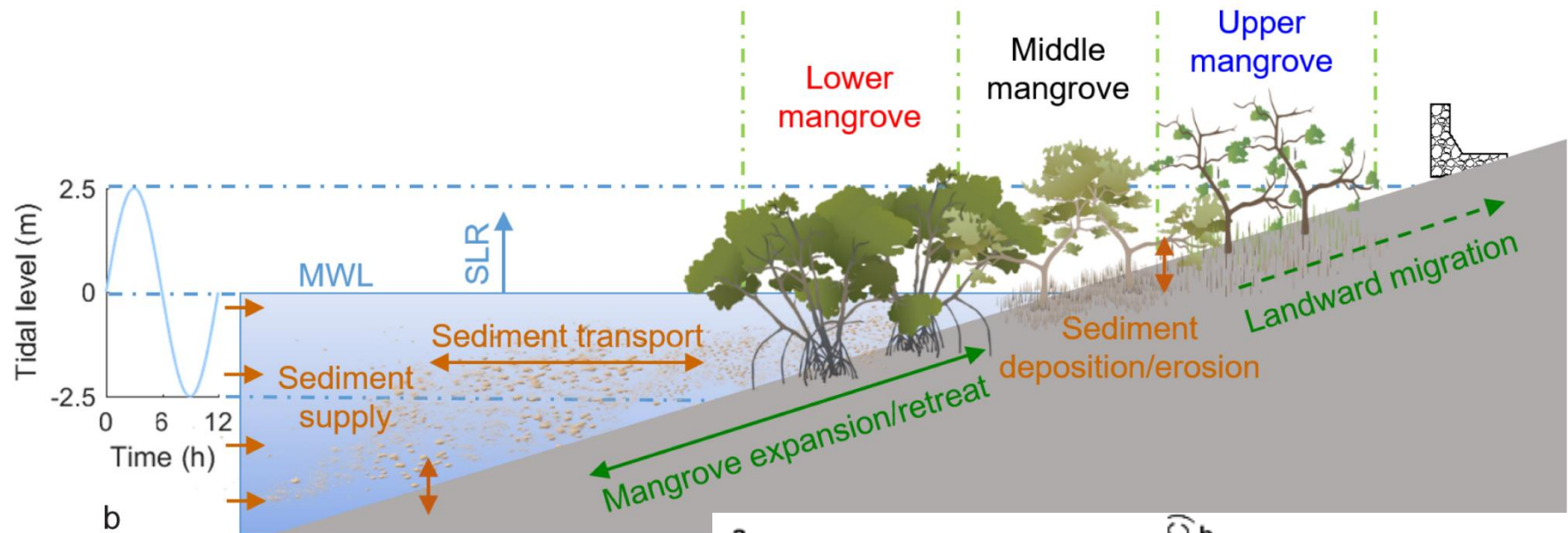


Mangrove Species:

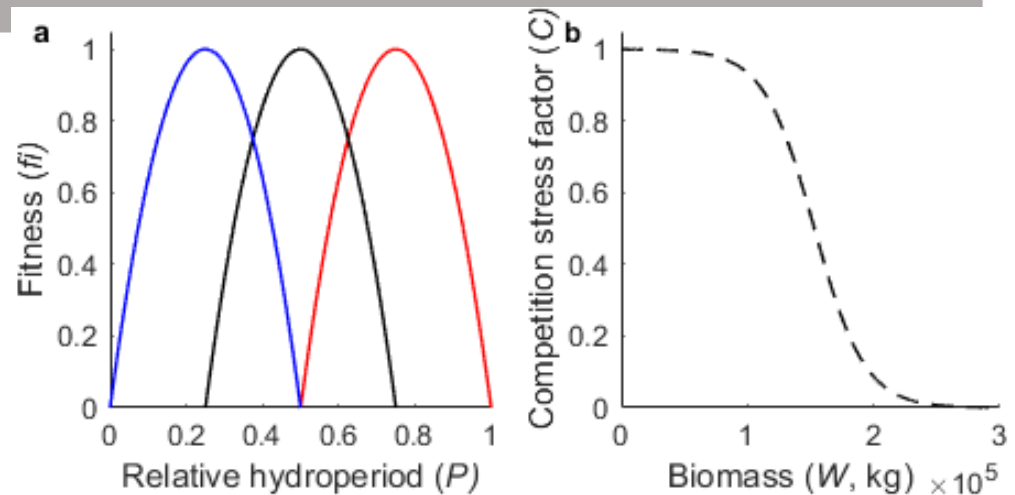


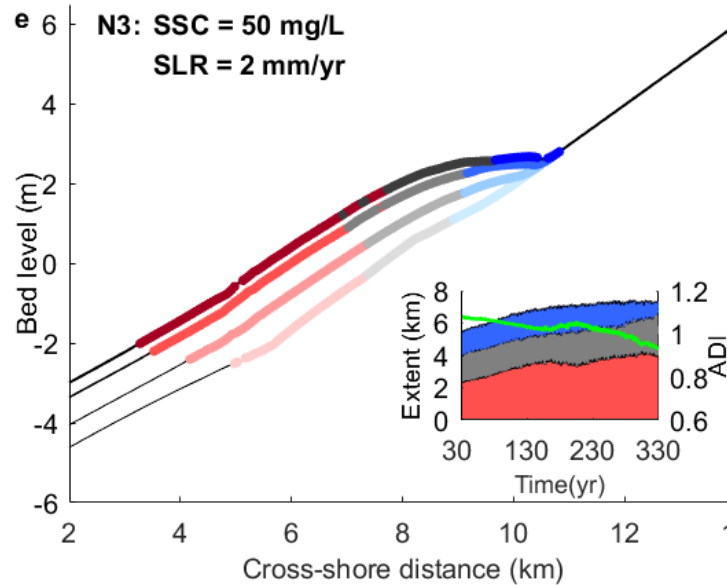
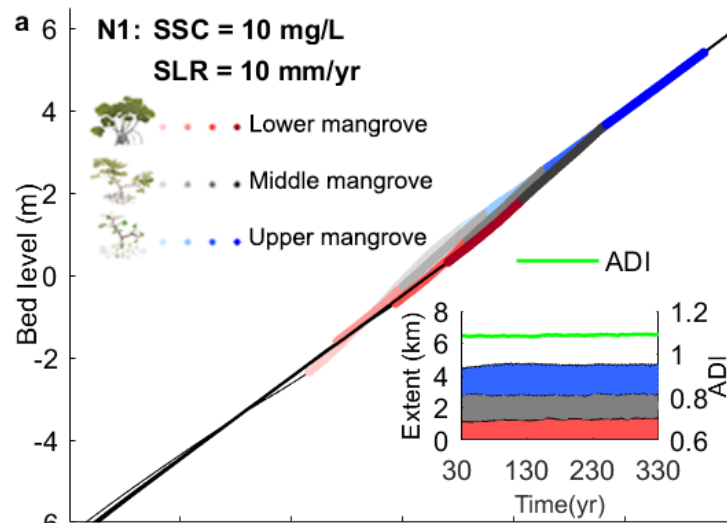
TOPEX/Poseidon and Jason satellite altimetry data

Adapted from Spalding et al. 2010



Muriel Brückner's model, +





Conclusions

- Do mangroves keep up with sea level rise?
 - Depends more on sediment concentration than on sea level rise
 - Sea wall enhances sedimentation
- Species diversity depends on space
 - Sea wall may cause coastal squeeze in case of insufficient sedimentation



Patterns in the sand

Our conclusions and your questions



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- Bars & bends (Jasper, Maarten)
- Channel network perturbations (Wout)
- Slope effects and beautiful models (Anne)
- Tidal bifurcations (Arya / Maarten)
- Eems-Dollard (Petra)
- Mud and morphology (Lisanne / Maarten)
- Mud and geology (Wietse)
- Salt marsh vegetation (Muriel)
- Mangrove survival (Danghan / Maarten)



Historic map exhibition

Dr. Marco van Egmond
Boothzaal & map library

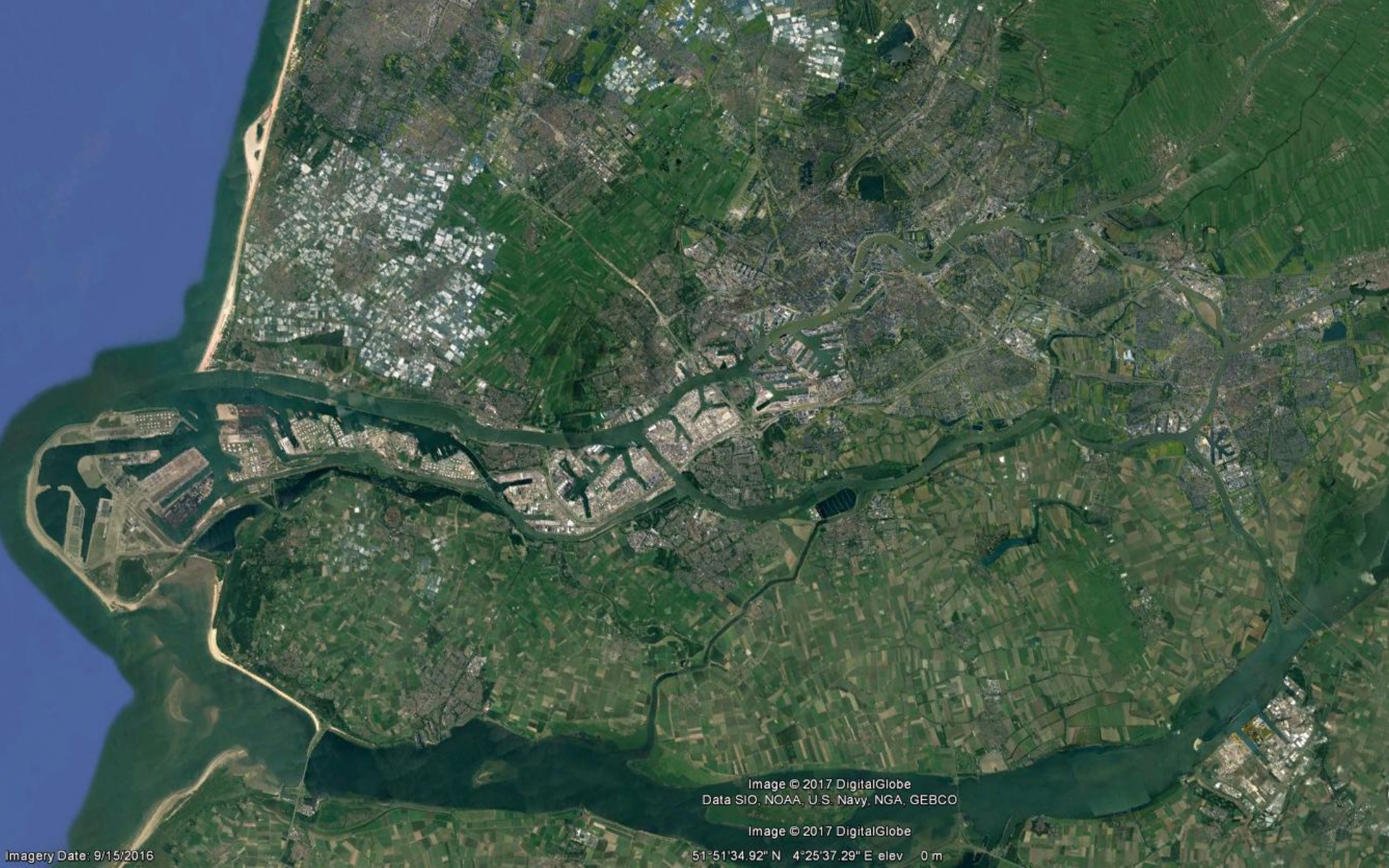


Image © 2017 DigitalGlobe
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Image © 2017 DigitalGlobe

51°51'34.92" N 4°25'37.29" E elev 0 m

Imagery Date: 9/15/2016

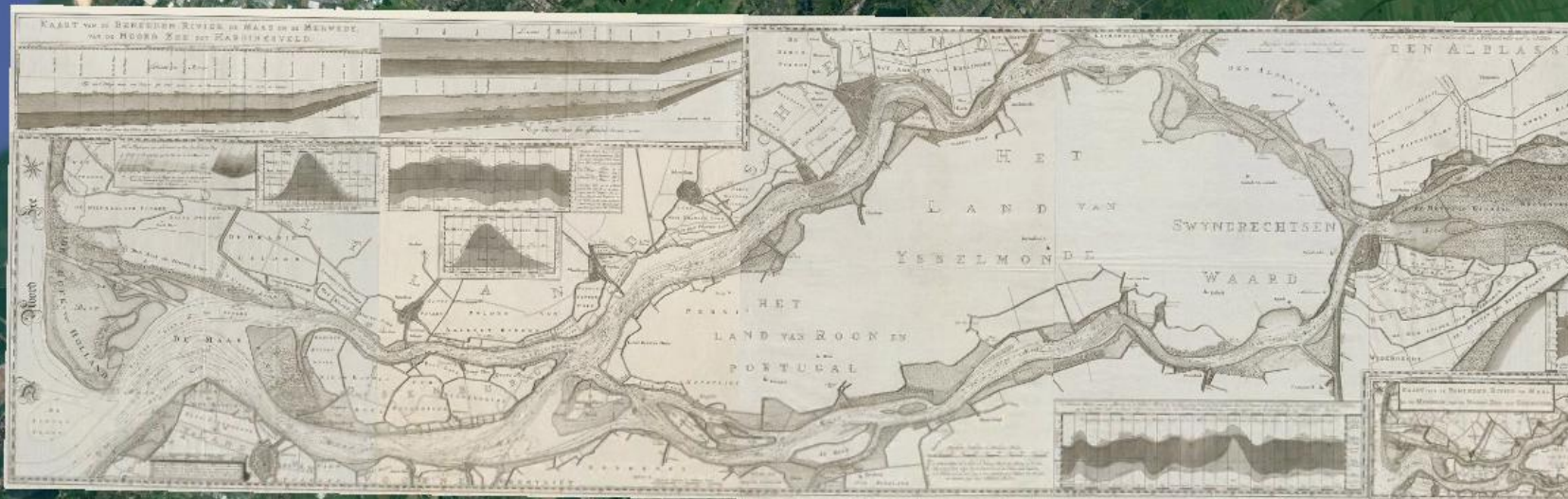


Image © 2017, DigitalGlobe
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Image © 2017 DigitalGlobe

51°51'34.92" N 4°25'37.29" E elev 1 m

Imagery Date: 9/15/2016



Historic map exhibition

- **Here, and 6th floor** of this Library
- No bags, no drinks/food
- Be back by 3 pm for the next session
- Curator: Dr. Marco van Egmond
 - www.uu.nl/library/specialcollections



Part 2. Living waterscapes and land level rise

Followed by:

- Your questions
- A brief look ahead
- Drinks - new Metronome lab



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www.uu.nl/bruningslecture

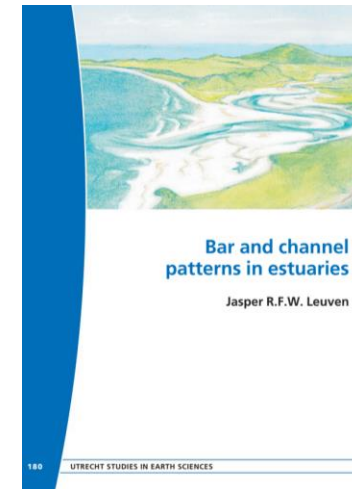
@MetronomeUU



Sea-level rise effects in estuaries

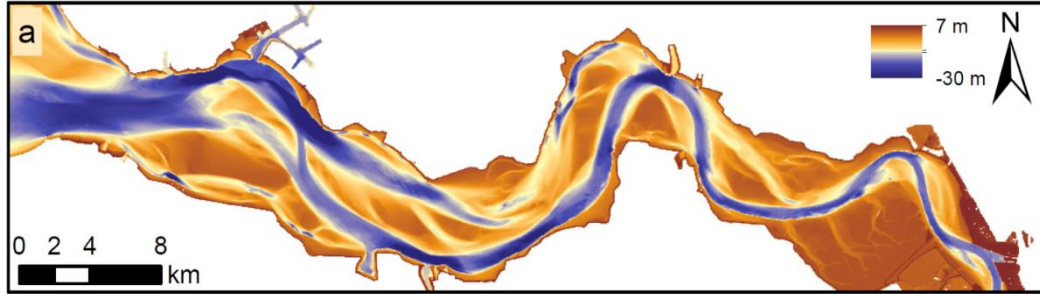
Jasper Leuven

jasper.leuven@rhdhv.com



Patterns predictable

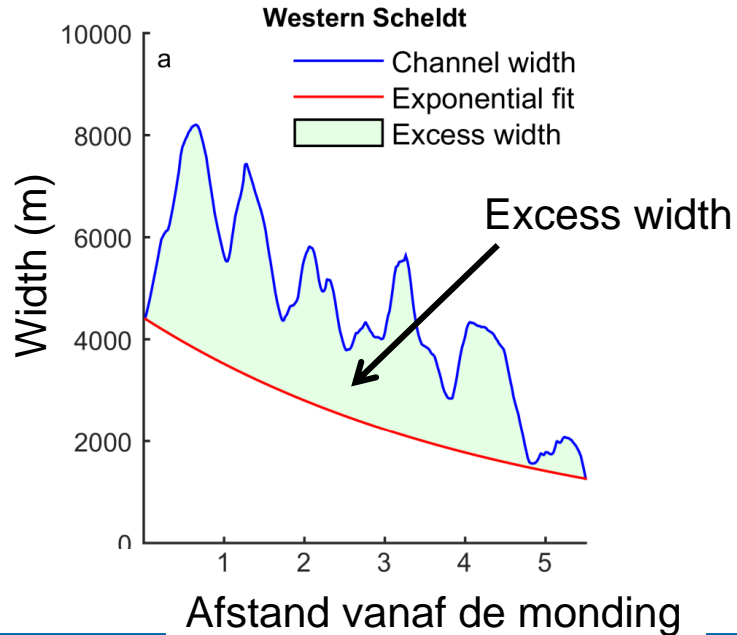
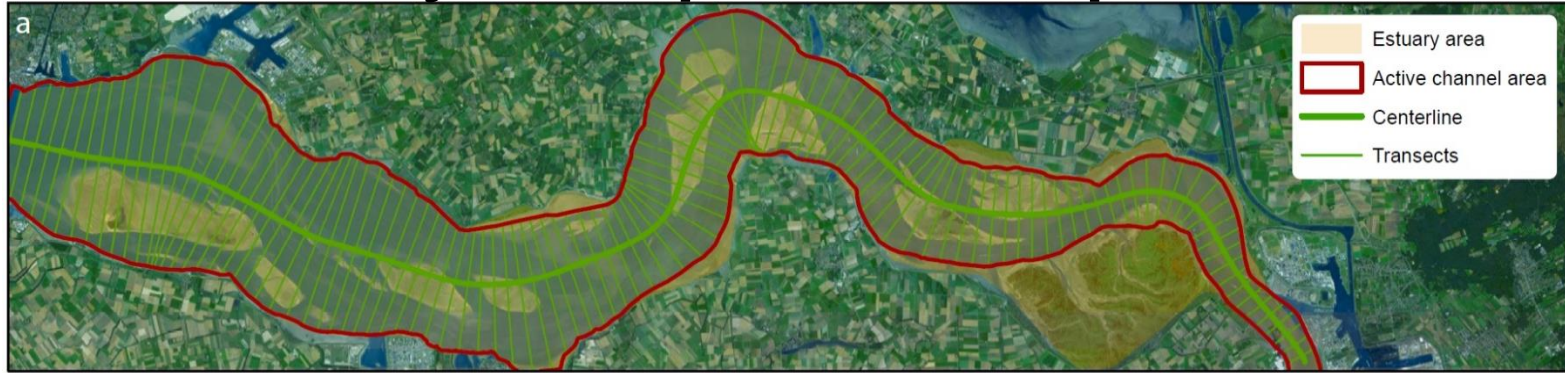
Disturbed
Large
Natural
Small



Data
No data



Estuary shapes and patterns



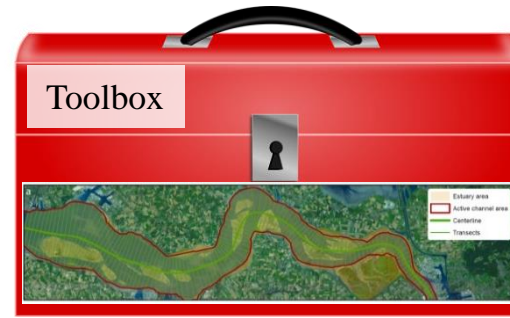
Leuven et al., 2018, ESPL

Obtain bathymetry

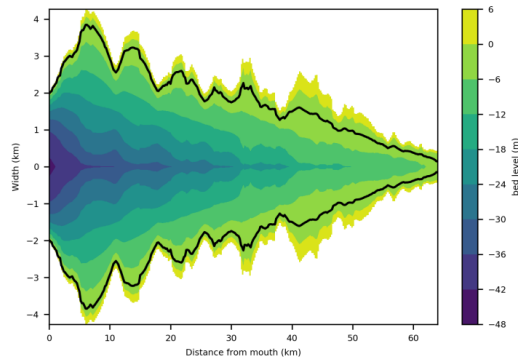


+ amplitude
+ discharge

Rapid estimate
for bathymetry



Leuven et al., 2018, *Rem. Sensing*



Gives:

- input 1D model
- equilibrium sediment volume

Sea-level rise effects?

■ (1) Effect SLR on water levels in estuaries?

■ Potential flood risk?



■ (2) Effect on sediment balance?

■ Drowning?

■ Loss of intertidal area?

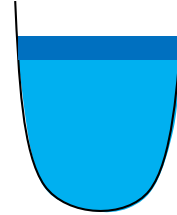


Size matters

■ + 1 meter SLR



small



large



■ Friction ↓

Water level effect:

+++

0

Pickering et al. (2017); Idier et al. (2017)

■ Δ amplitude

Sediment effect:

0

+++

Conclusions

- Estuarine morphology predictable
- Future effects SLR
 - Increased MSL
 - Δ amplitude
- Small, shallow, damping estuaries
 - Flood risk by reduced friction
- Large, deep, amplifying estuaries
 - Drowning if amplitude decreases

Leuven et al. (2016), ESR

Leuven et al. (2018), E-surf

Leuven et al. (2019), Nature CC

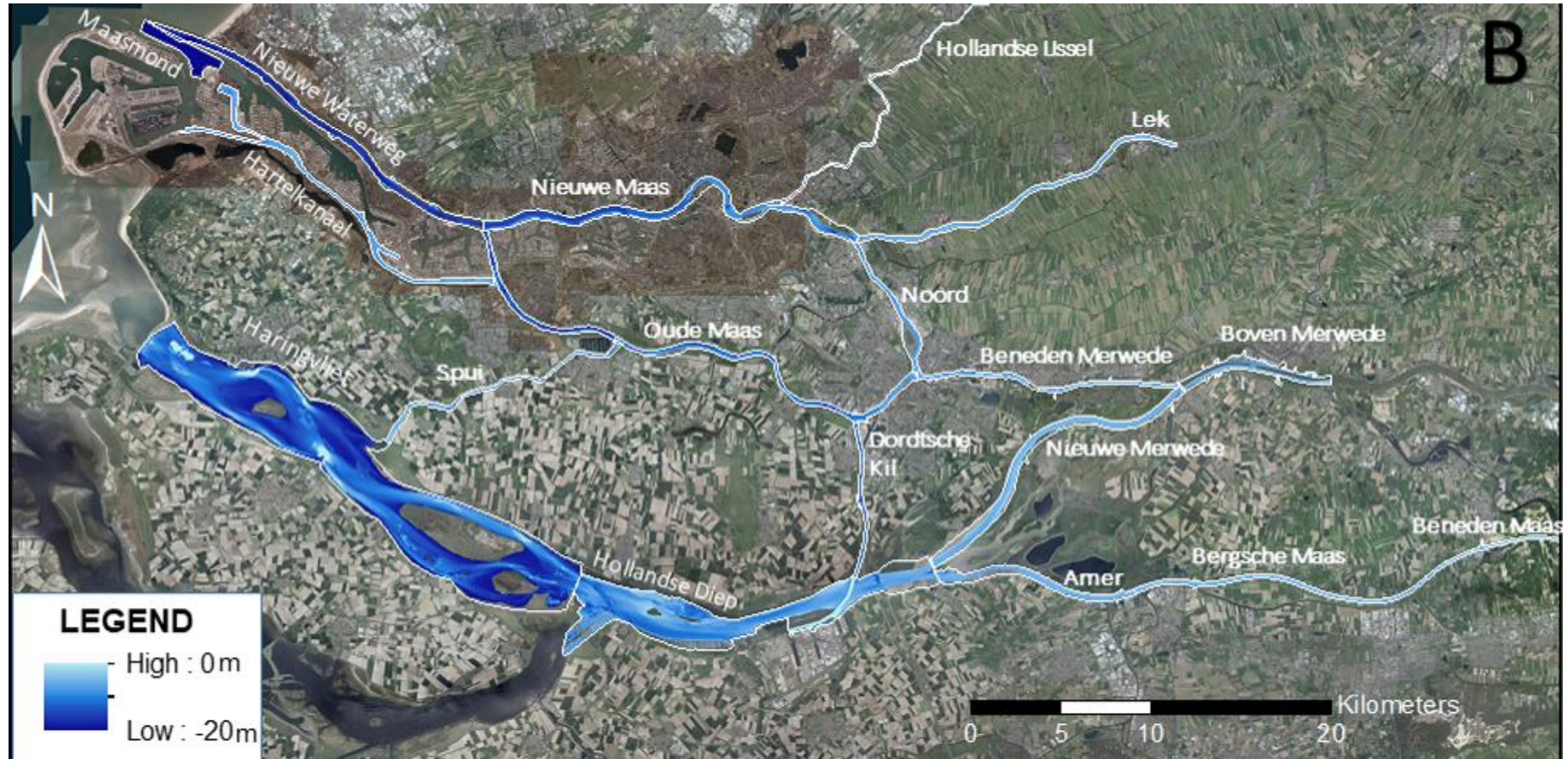


Exploring the Rhine-Meuse Delta / Estuary / Benedenrivieren

Jana Cox

j.r.cox@uu.nl

The Rhine-Meuse Estuary



Problems in the RME

- Deeper channels to open up shipping routes
- More flow → faster water
- Increased flood risk
- Threatened ecology



Where is the
sediment and what
can we do with it?

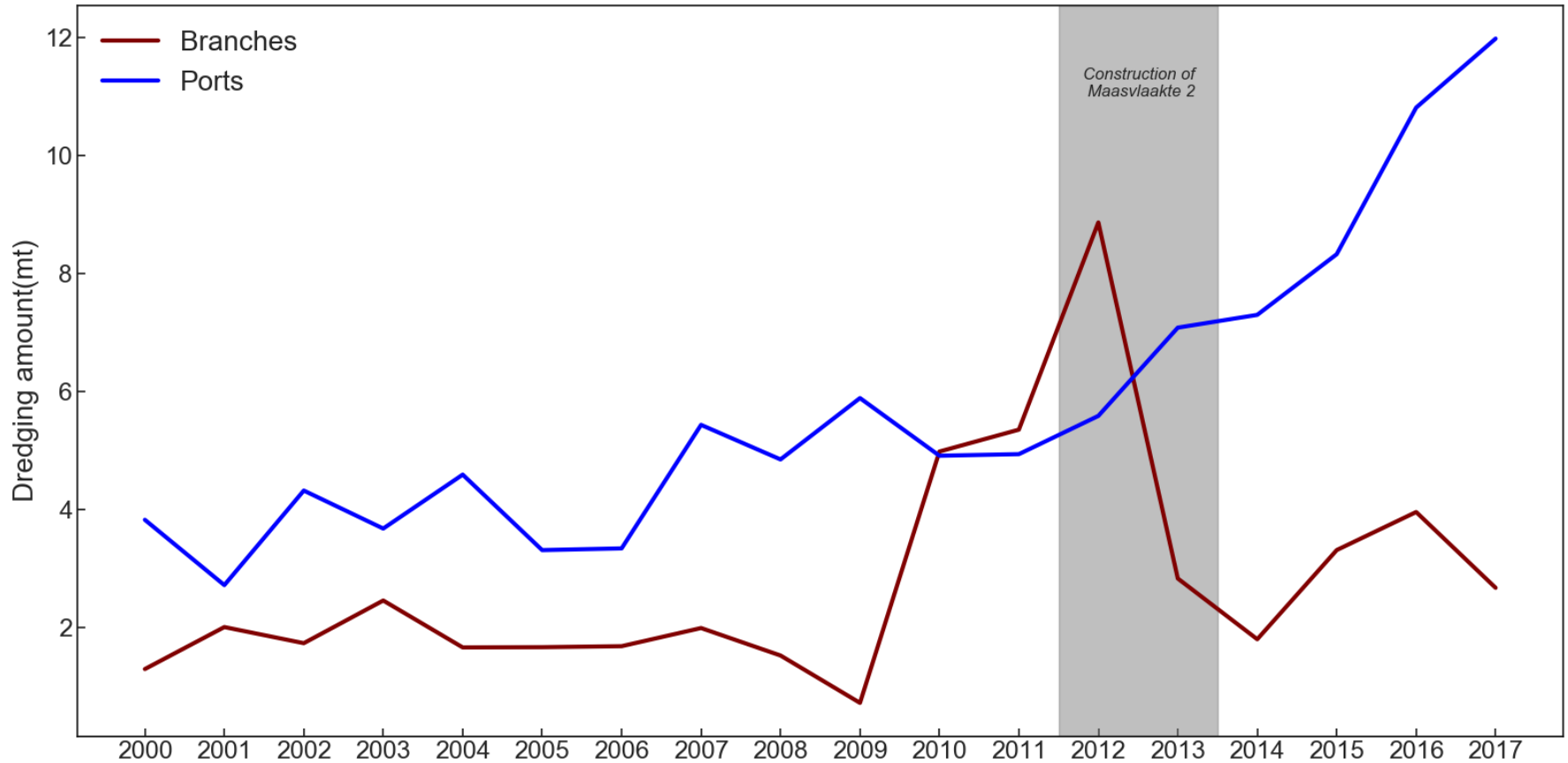


Making a sediment budget



$$\Delta_{dredging} + \Delta_{suspended} + \Delta_{bedload} = \Delta_z$$

Dredging



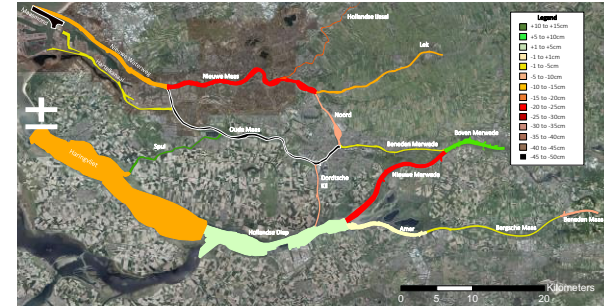
Where does it go?



Fluxes in and out

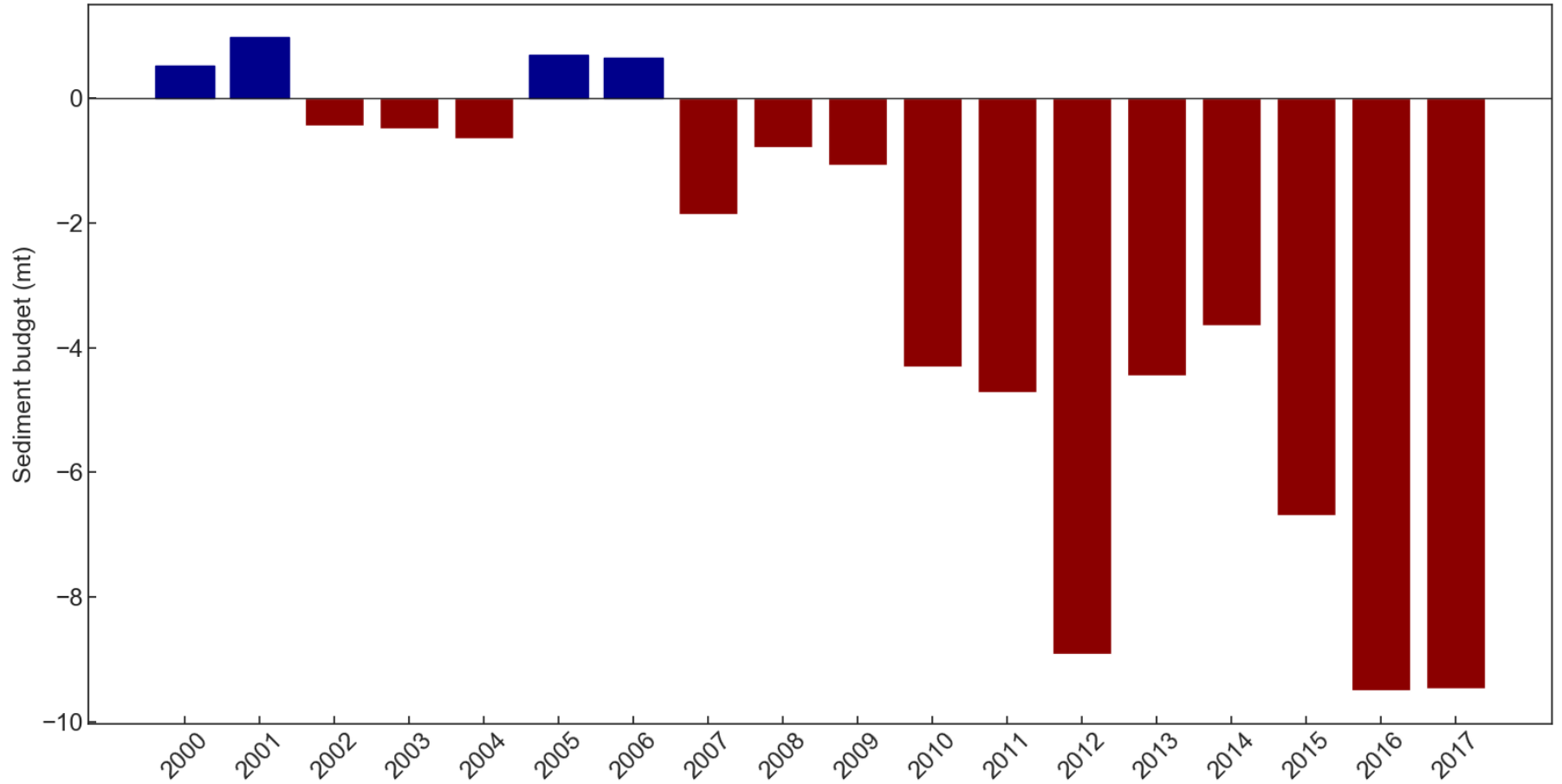


Preliminary numbers, work in progress

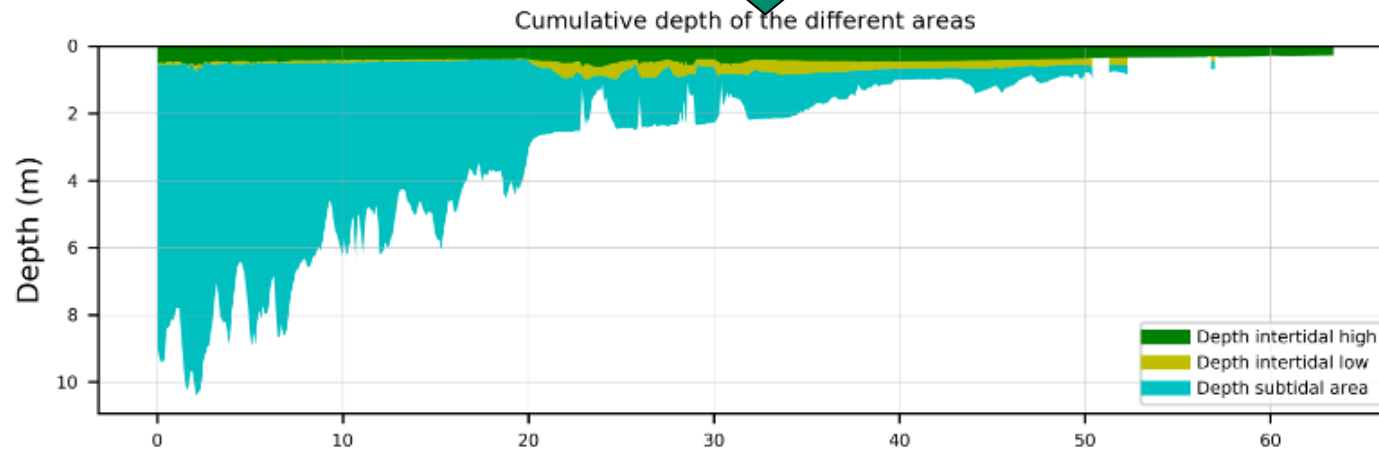
[illegible]



Outcome

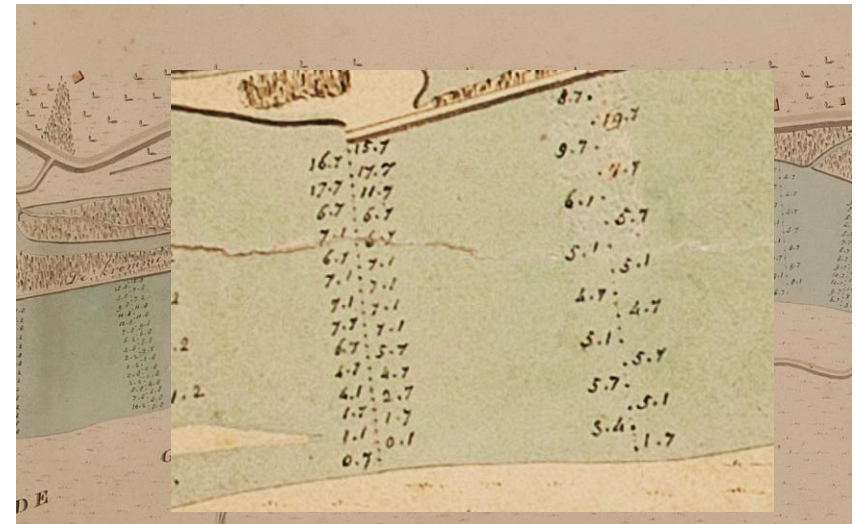
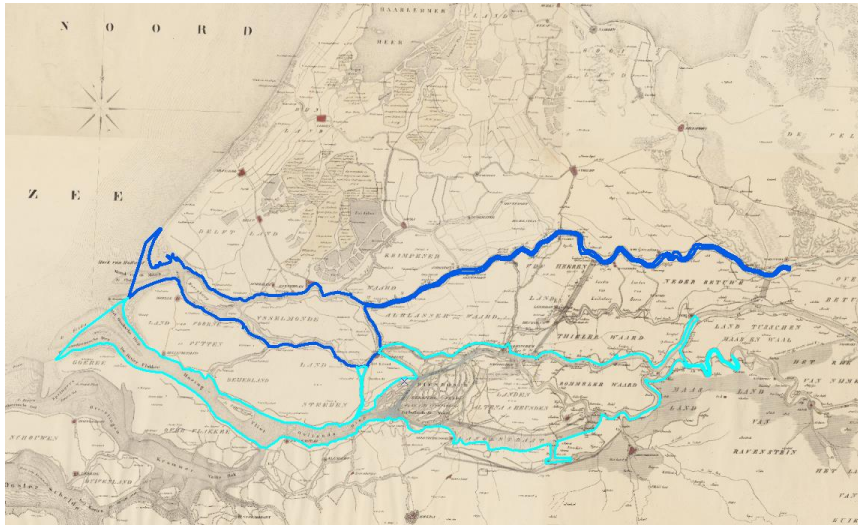


Historical maps – making budget for the past



Using historical maps and charts

- Estuary outline (derived from maps)
- Depth at the upstream & seaward boundary (depth charts + estimates)





Long-term evolution of tidal systems

lessons from the Holocene evolution of the Dutch coast

Tjalling de Haas

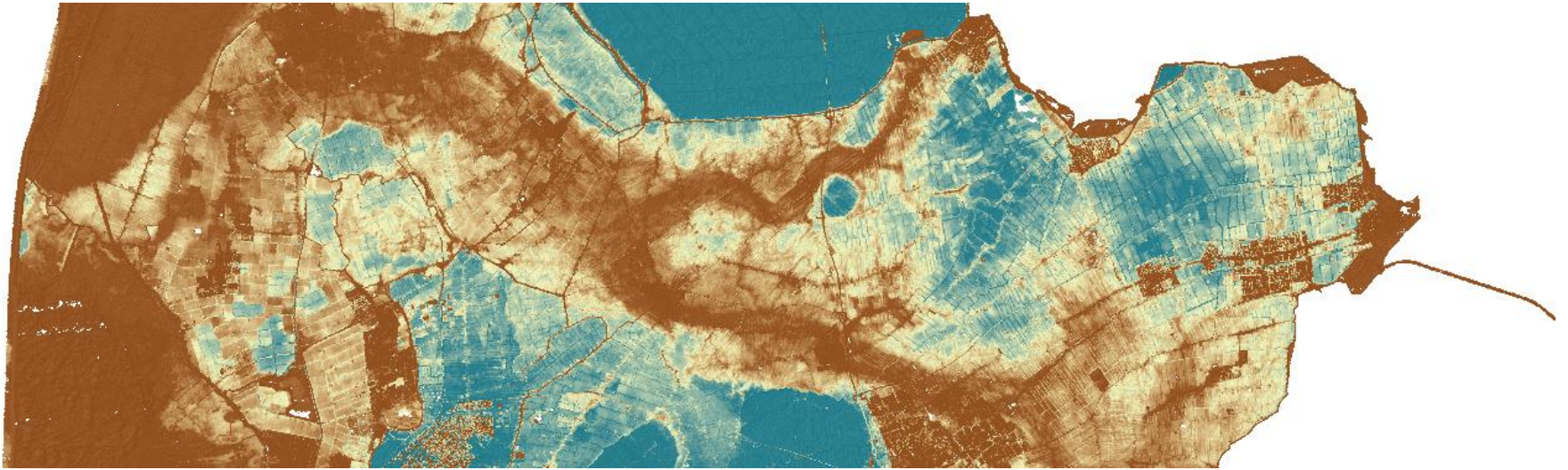


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Many abandoned tidal systems

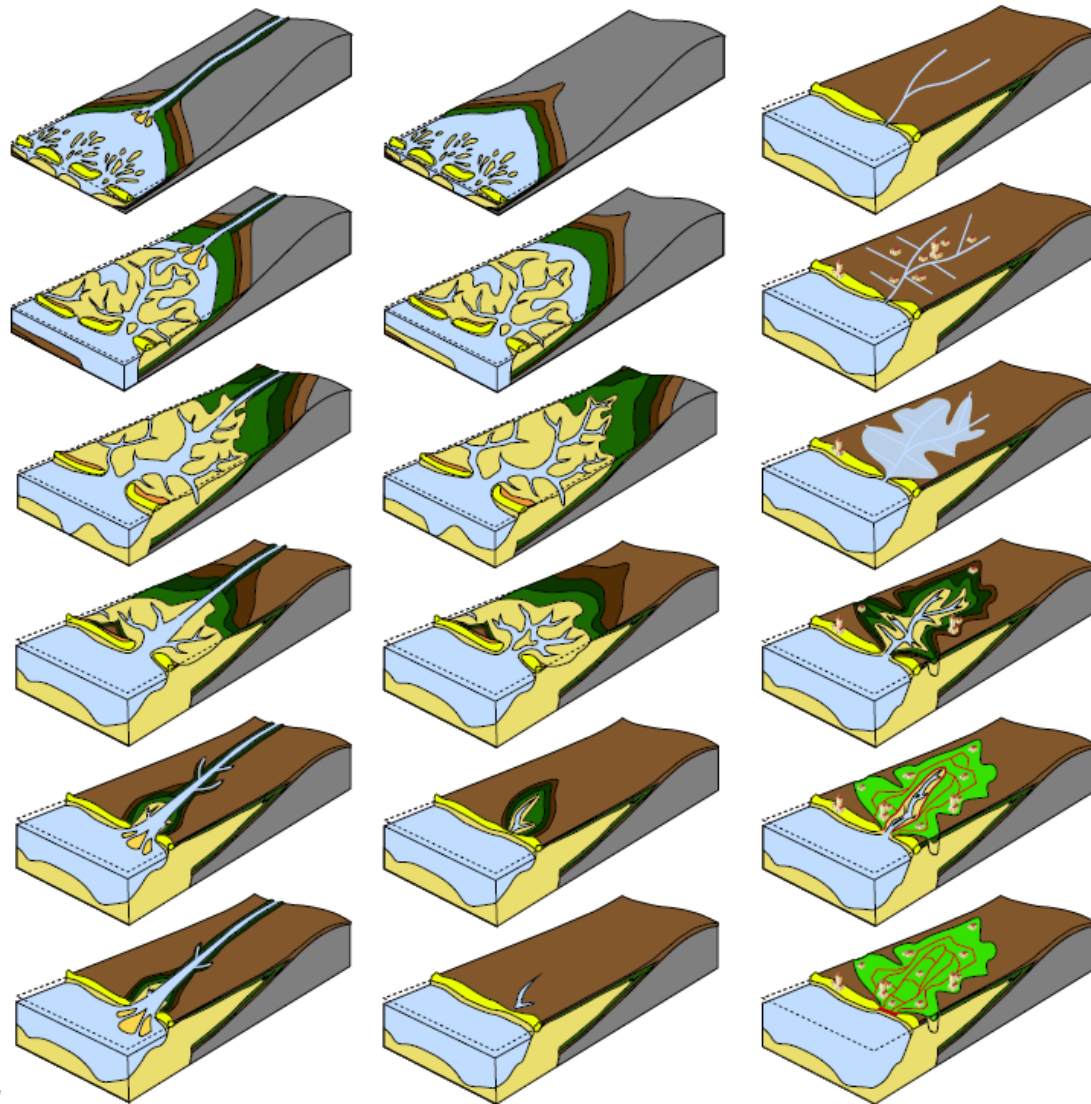


(1a) Estuary

(1b) Tidal embayment

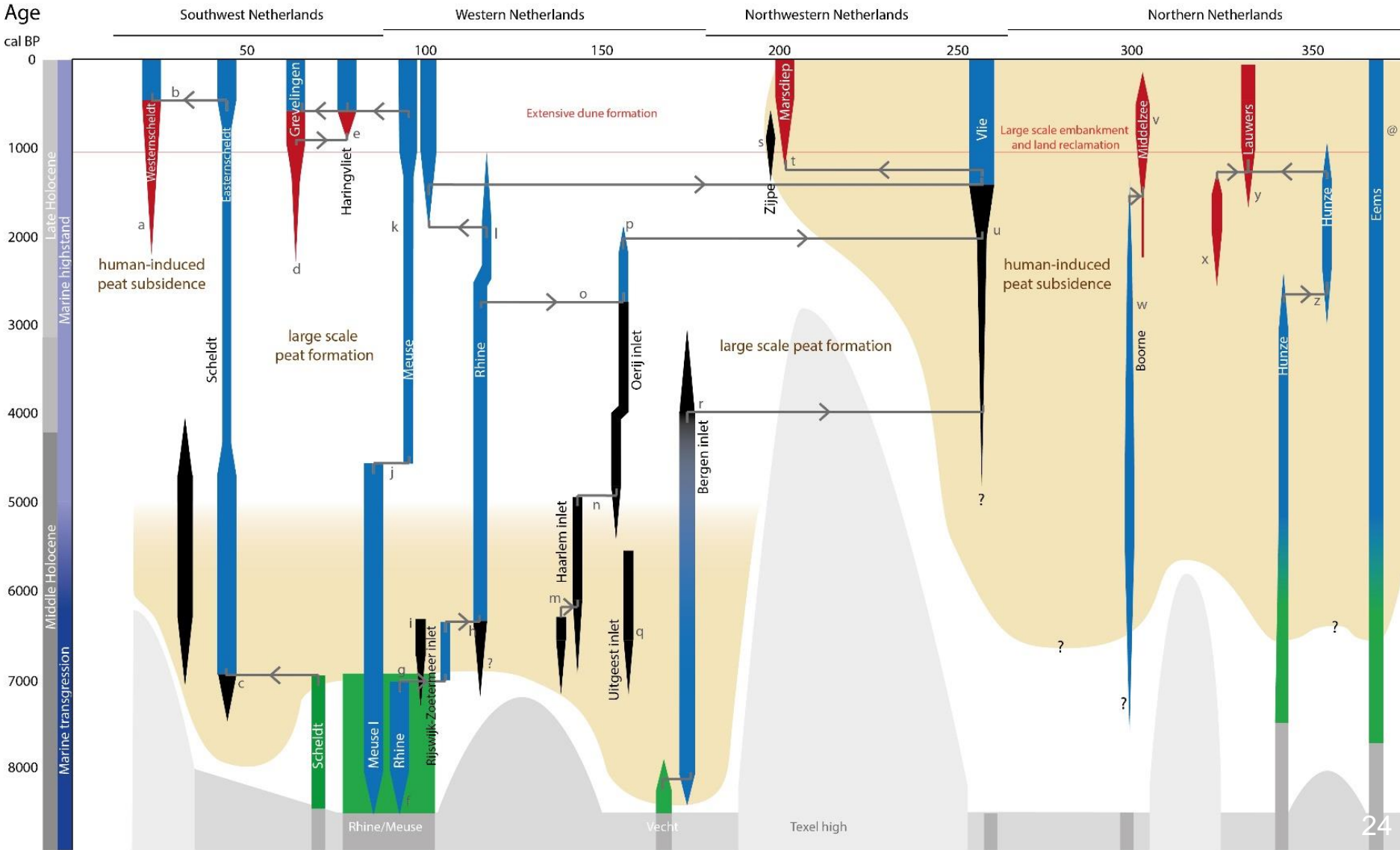
(2) Ingressive inlet

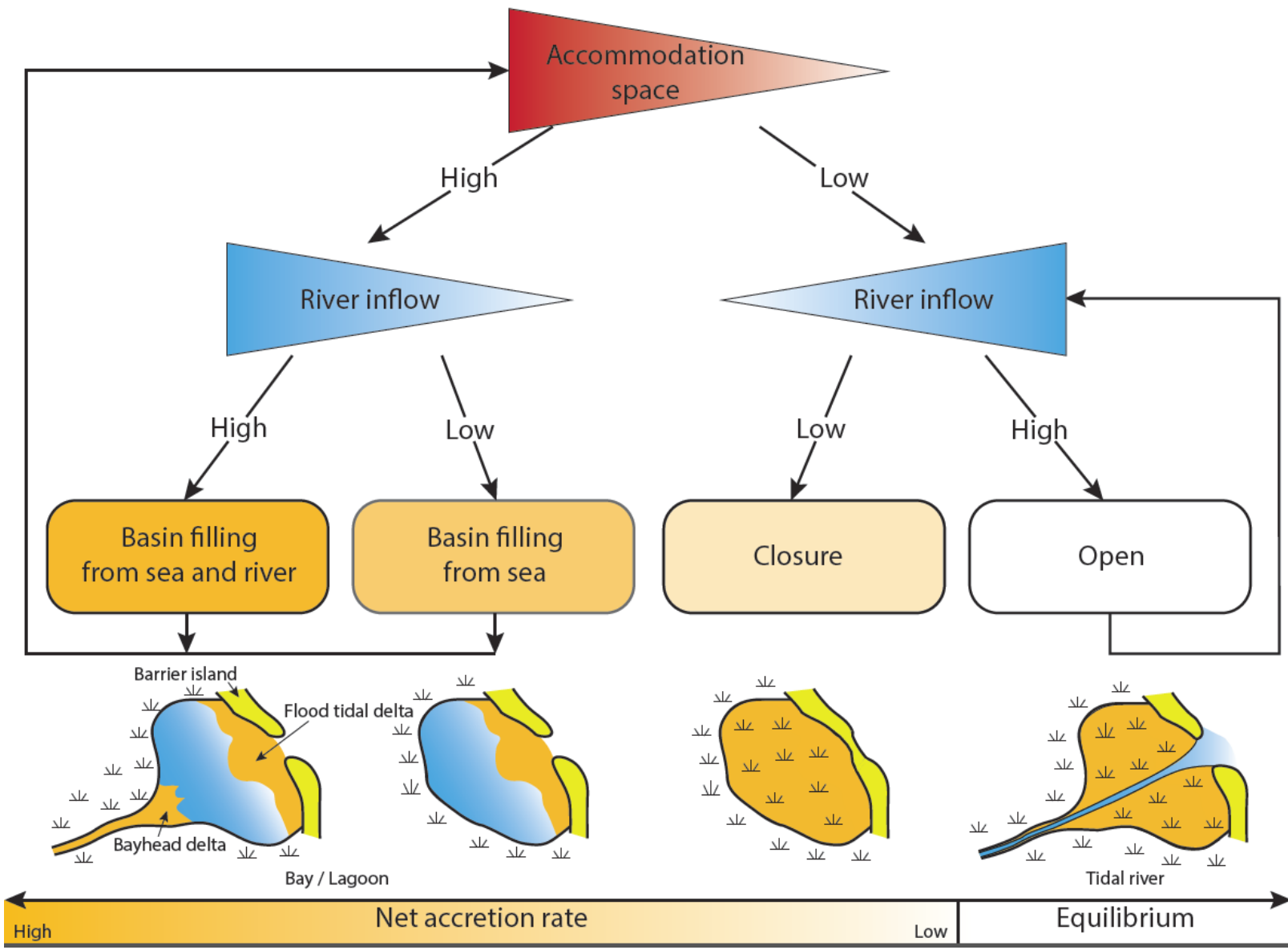
Time



Age

cal BP
0







How estuaries filled

Harm Jan Pierik



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How did Holocene estuaries fill?

- Overbanks and floodbasins:
 - levees, crevasses

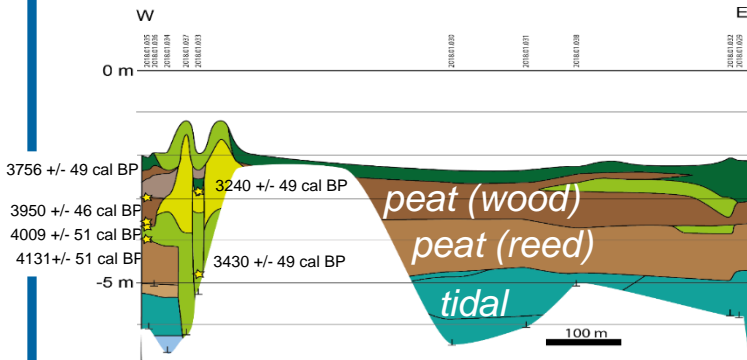
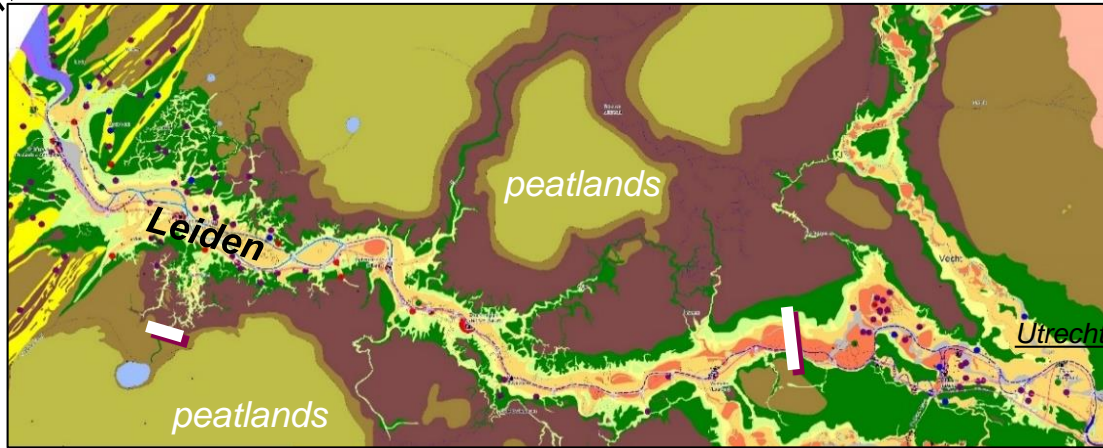
How does this work ?



Cumberland marshes, Canada. Photo: Maarten Kleinhans

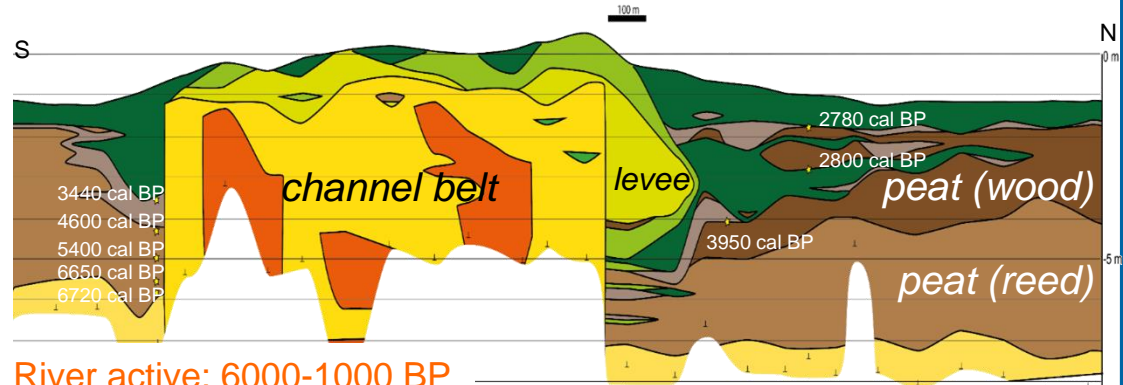
Overbanks Old Rhine

North Sea



River active: 6000-1000 BP

Crevasse active: ca. 4200-3250 cal BP



River active: 6000-1000 BP

Levee active: 3900-2800 BP

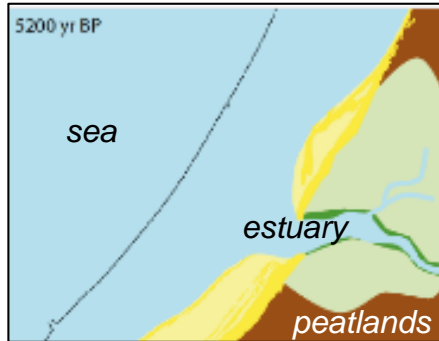
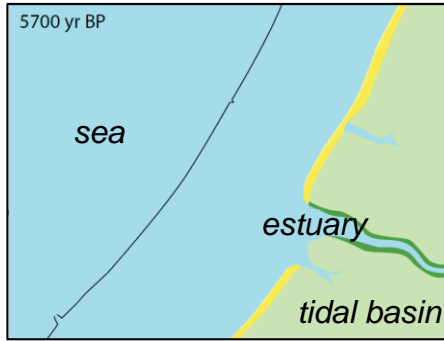
After: Stouthamer 2001; Van Asselen 2009



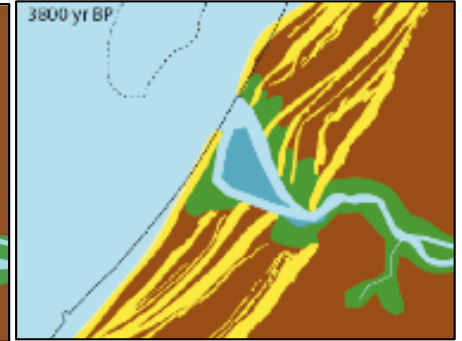
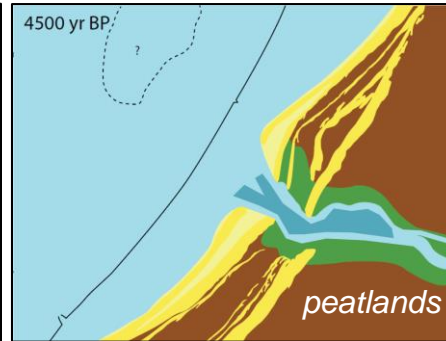
Estuary mouth evolution

From tidal basin to closing tidal river

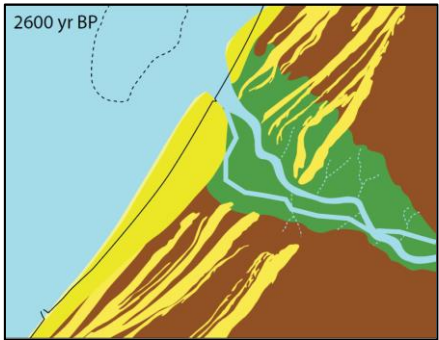
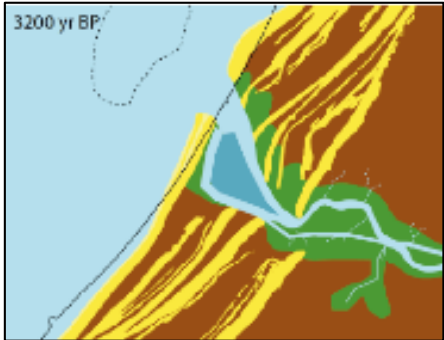
peat formation + barrier progradation



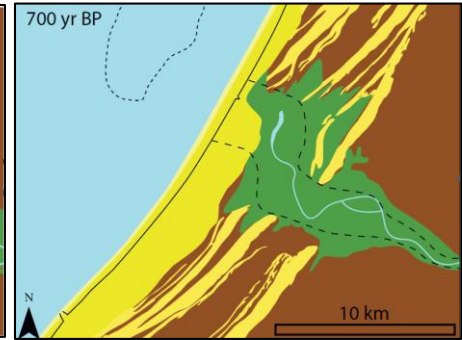
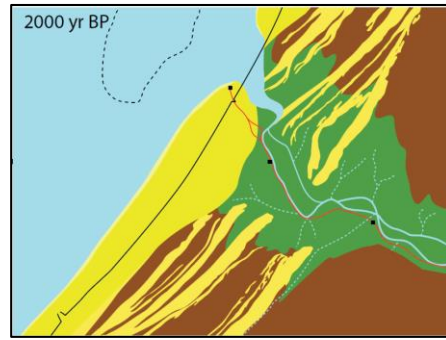
barrier progradation + estuary infilling



estuary infilling

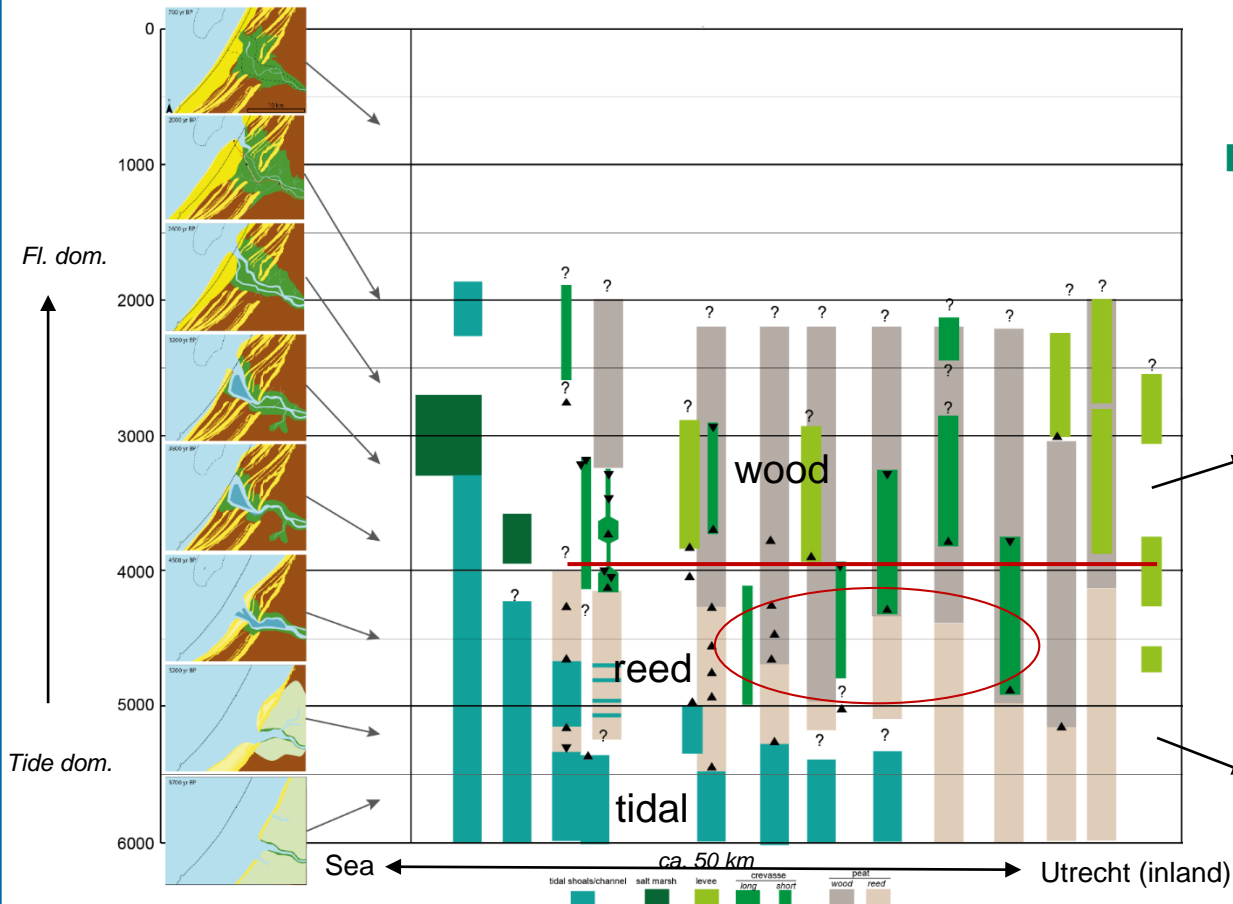


estuary closure



Modified after De Haas et al. (2019)

Time-space overview



- **Crevasses** mainly in **woods** and start when **tides** are strongest (i.e. mouth most open)
- Wide **levees** when fluvial **Q** increases



Conclusions

- Tidal → fluvial
- Tidal back-barrier → reed → wood
 - Reed peat: push the tides out
 - Wood peat: facilitates overbanks
- It is all about feedbacks and interactions...
 - Tidal sedimentation → peat formation → narrow the system,
 - SLR → type of vegetation → type of crevasse
- Geological cases, numerical and experimental models help better understand feedbacks





Long-term biogeomorphology

Márcio Boechat Albernaz

m.boechatalbernaz@uu.nl

[@coastal_biker](https://twitter.com/coastal_biker) 



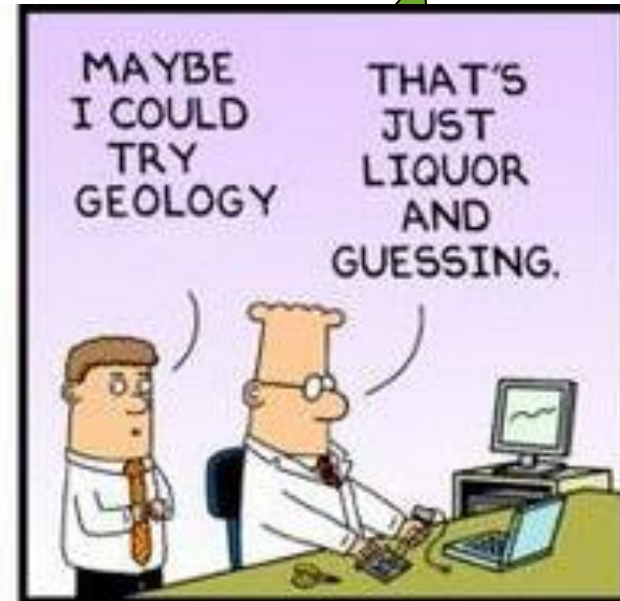
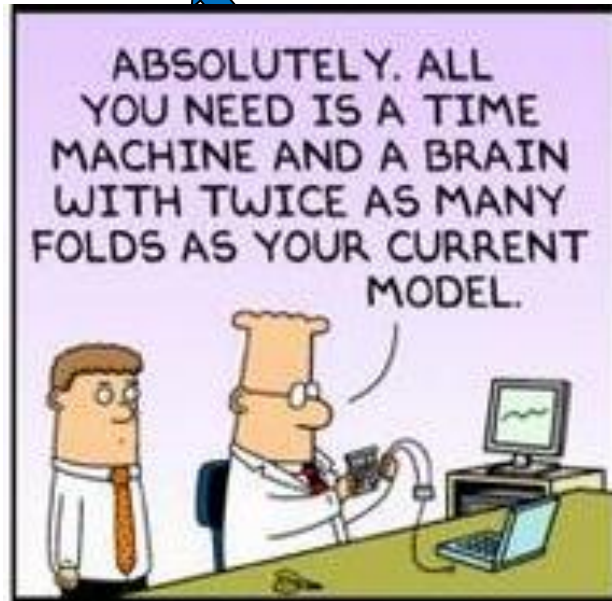
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Boundary
Conditions

Initial
Conditions

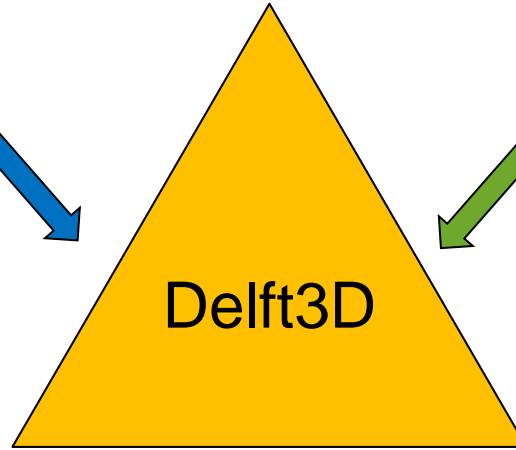
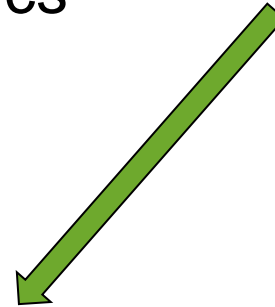
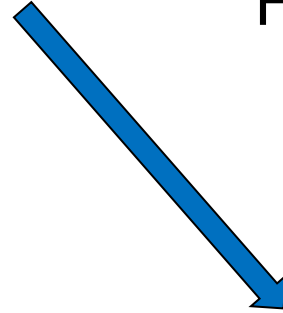


Final Condition (preserved)

Boundary
Conditions

Initial
Conditions

Hydrodynamics



Delft3D

Morphology

Transport

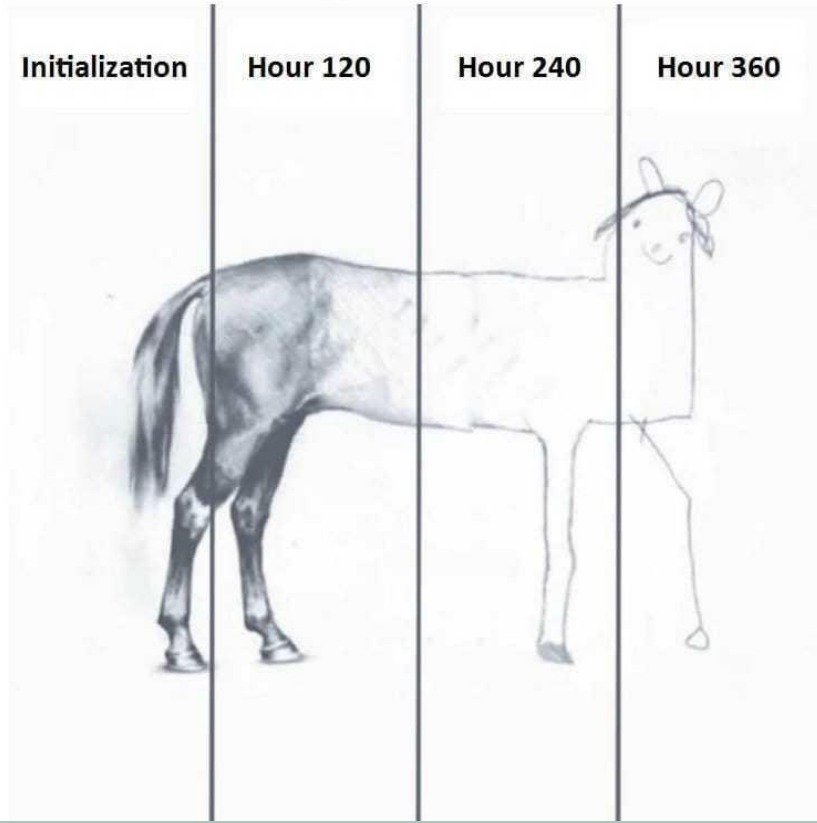


Final Condition (reconstructed)

Tides
Waves
River
WL
Sed. Comp.

Accom space
Sed. Comp.

Typical progression of the GFS

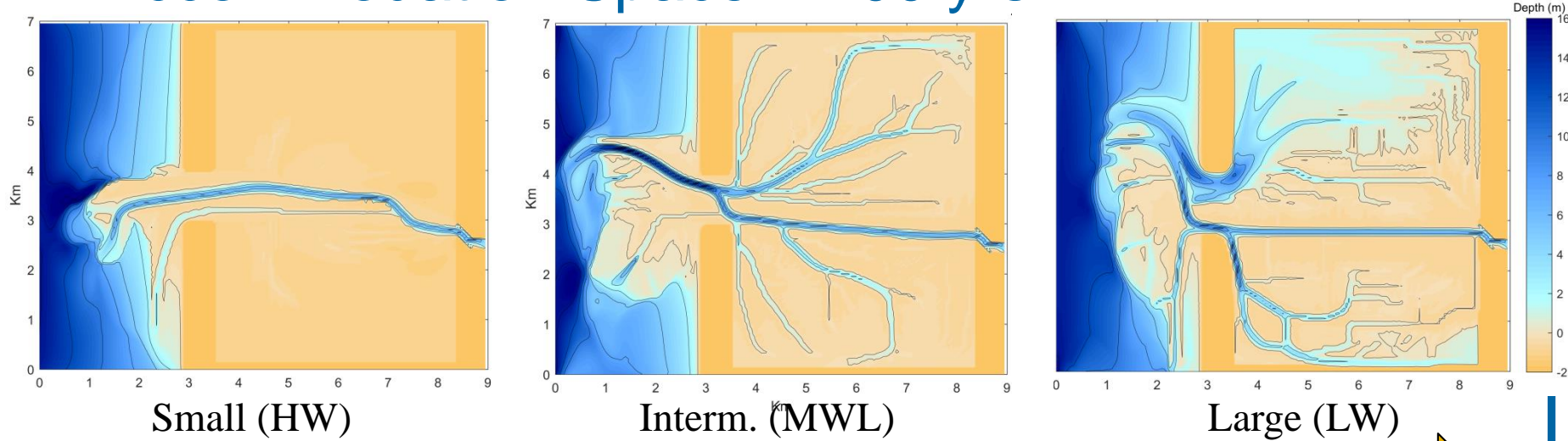


Morpho

sport

Geological heritage - Initial condition

■ Accommodation Space – 400 yrs

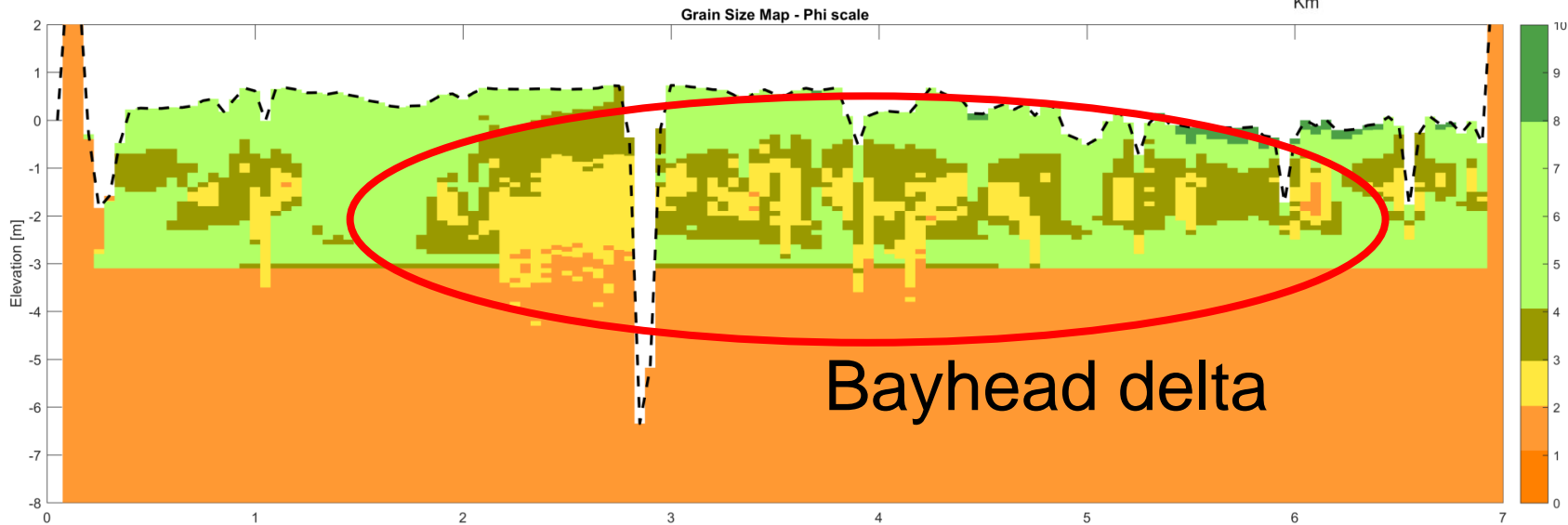
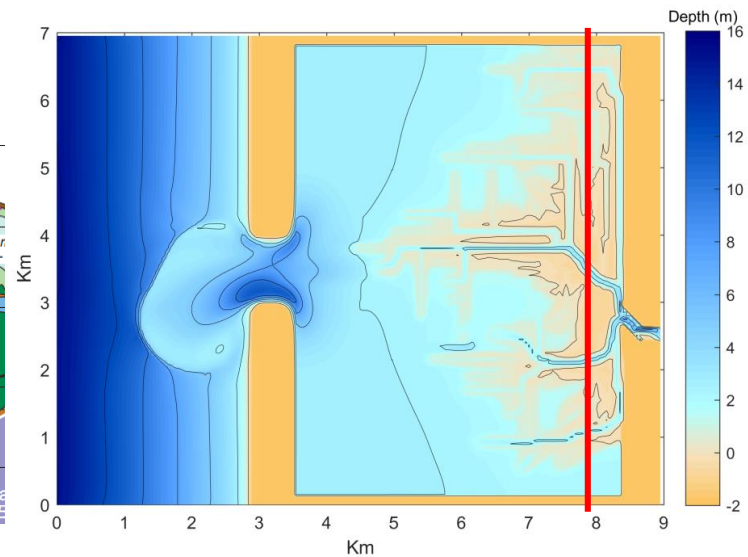
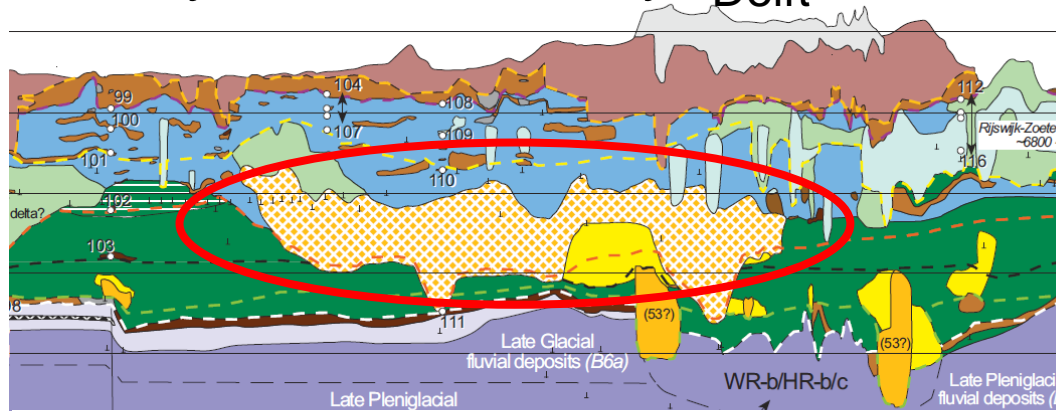


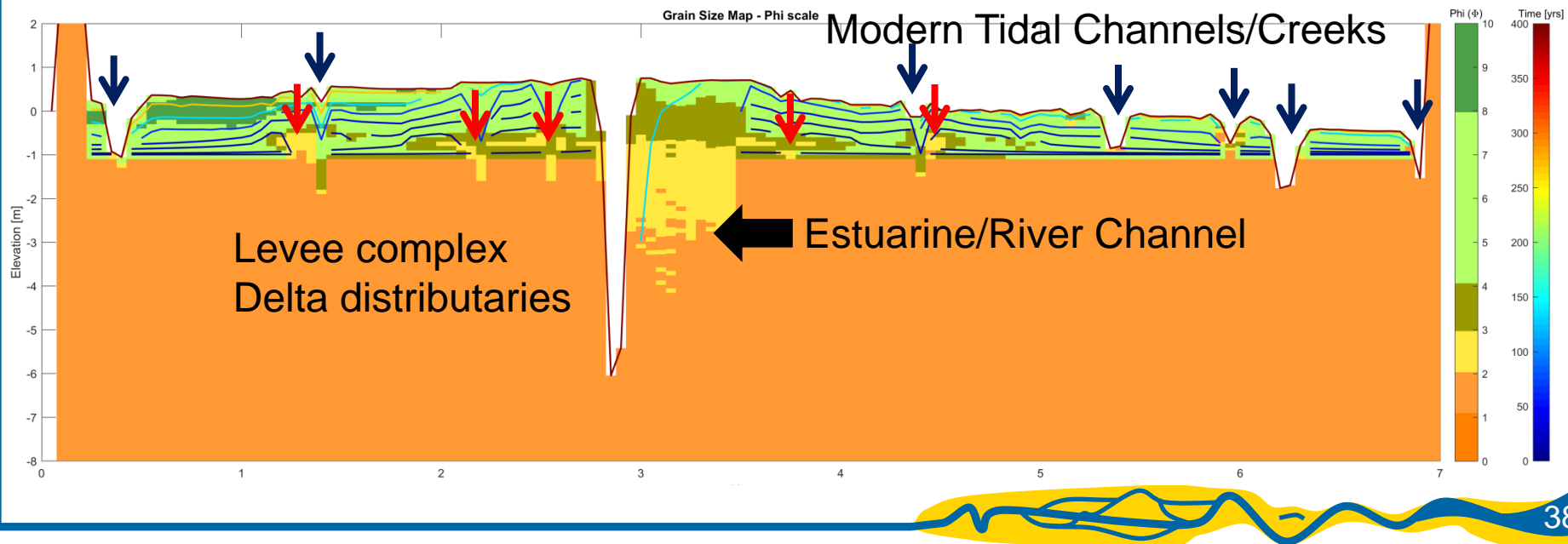
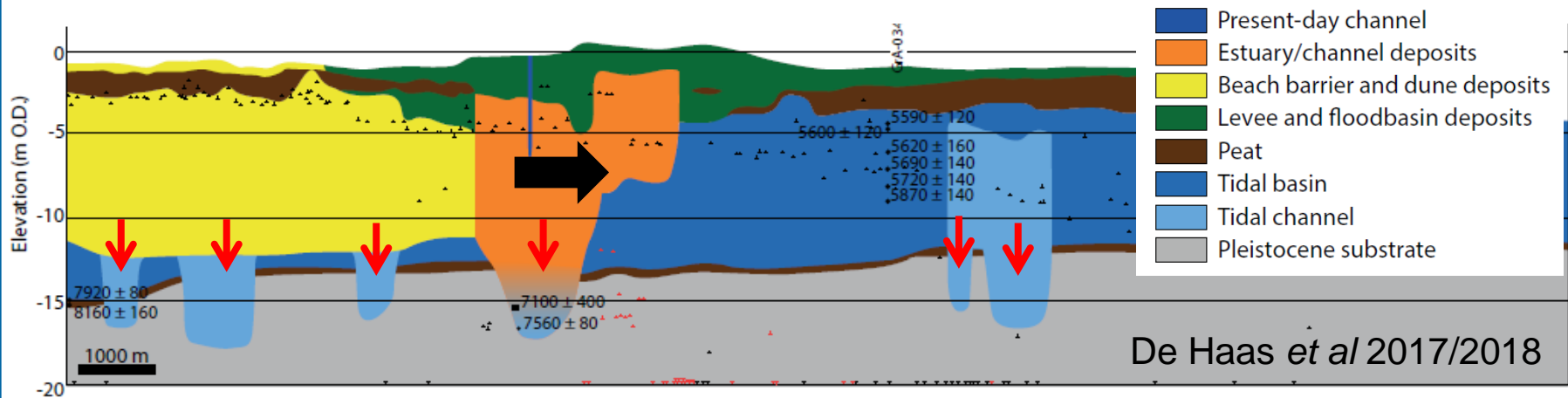
Accommodation Space

Tidal system

Fluvial system

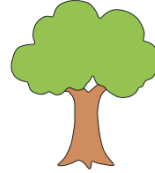
Reality: Meuse estuary Delft



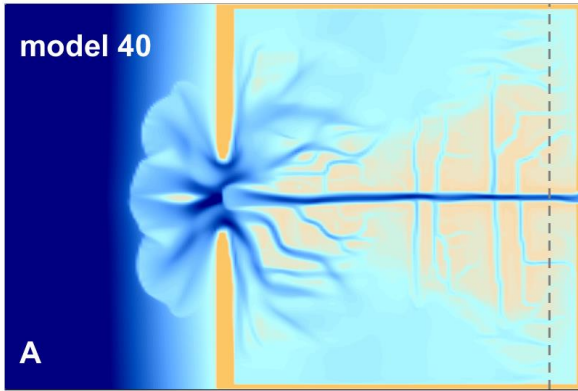


Tidal-Fluvial Levees & Crevasses

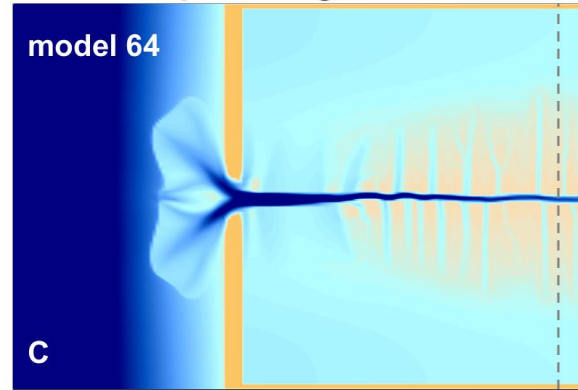
■ Effects of Vegetation



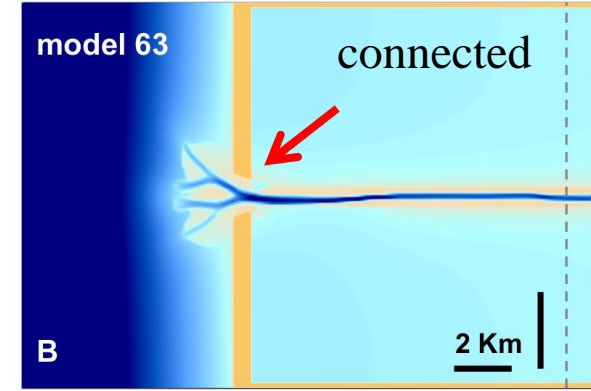
reference



sparse vegetation



dense vegetation



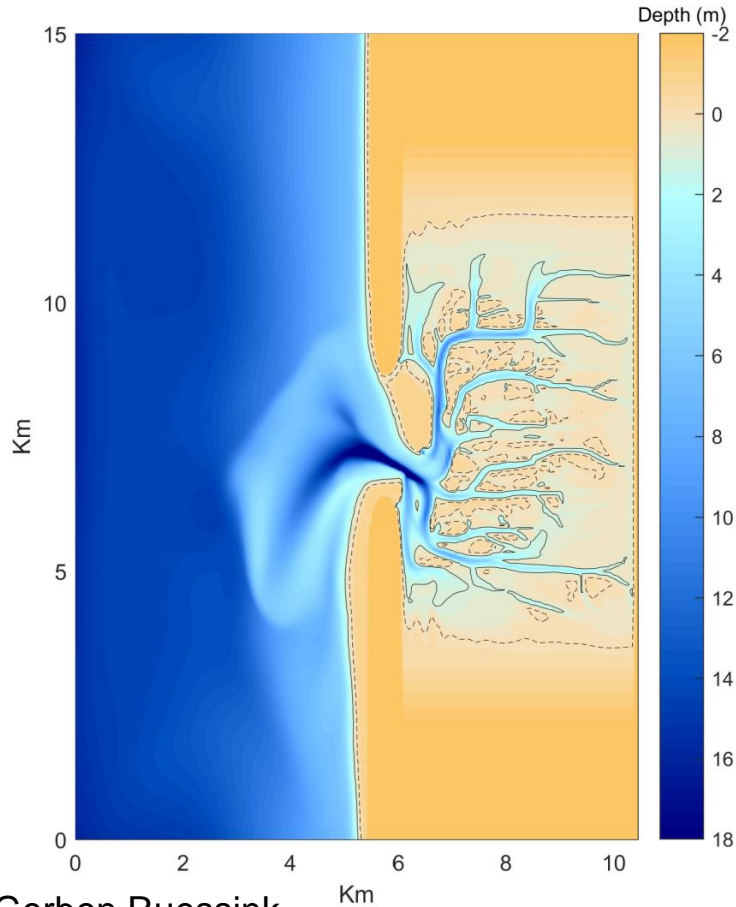
Accommodation Space

Tidal system

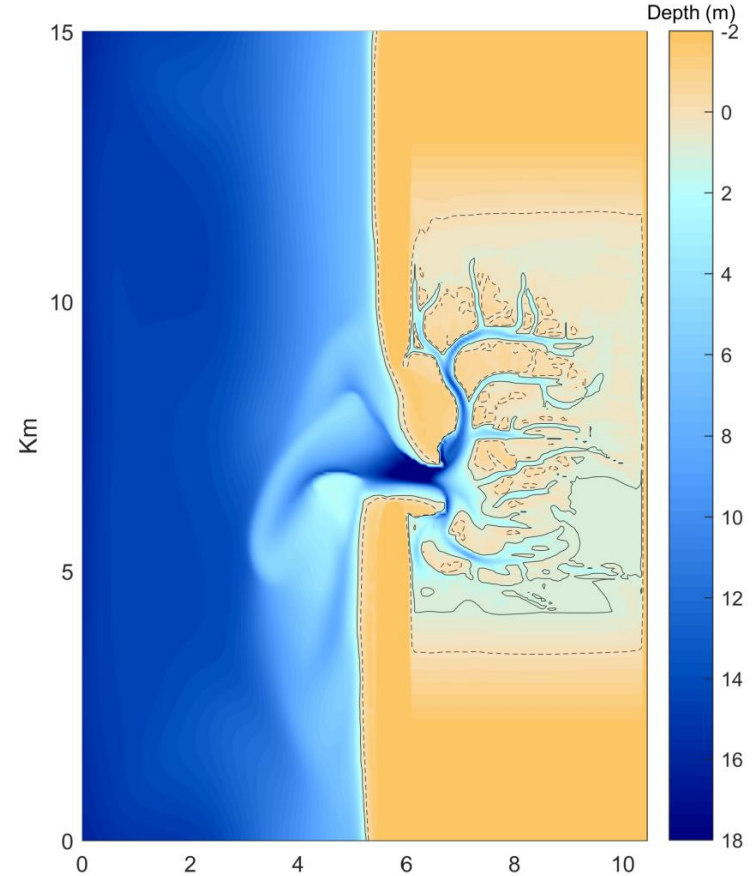
Fluvial system

Drowning tidal basins (100 yrs)

Waves + no SLR



Waves + SLR



Conclusions

- Accommodation Space determines the large scale architecture of deposits
- Vegetation changes the tidal-fluvial balance and affects the (bio)geomorphological evolution of levees/crevasses and floodbasins
- Sediment supply + vegetation are key components to infill the waterscapes vs SLR



Building and raising land: infilling estuaries on a laboratory scale

Steven Weisscher

s.a.h.weisscher@uu.nl



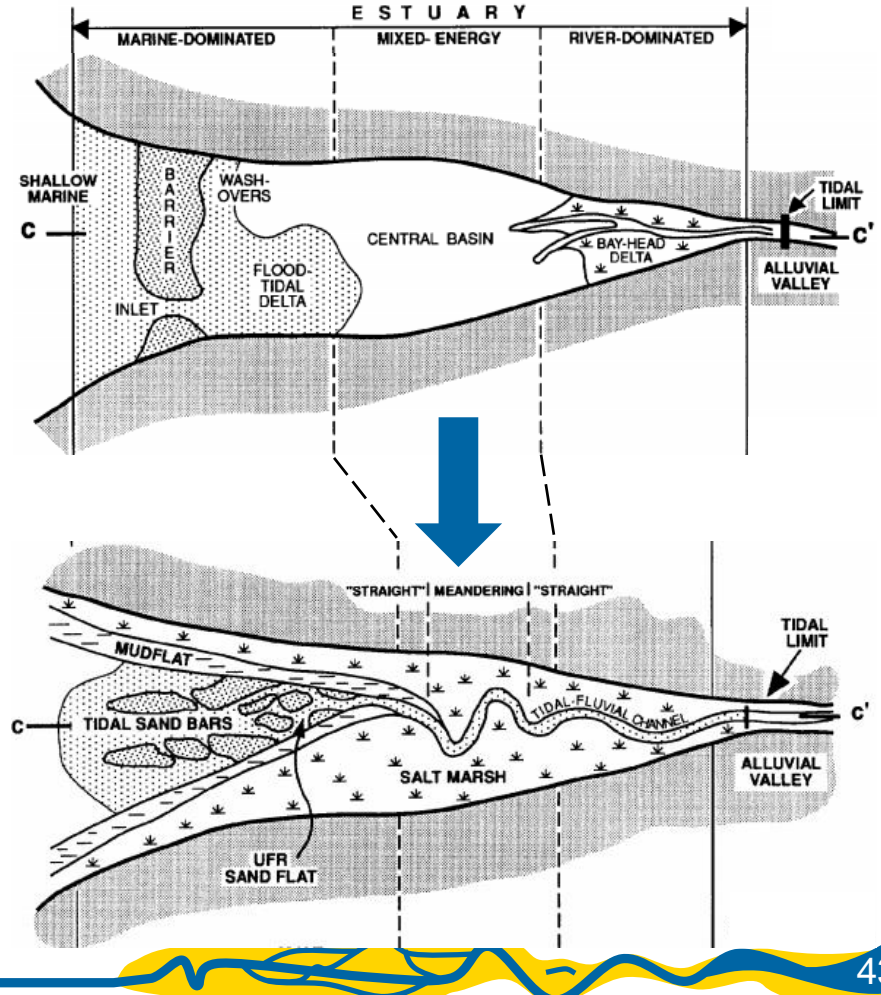
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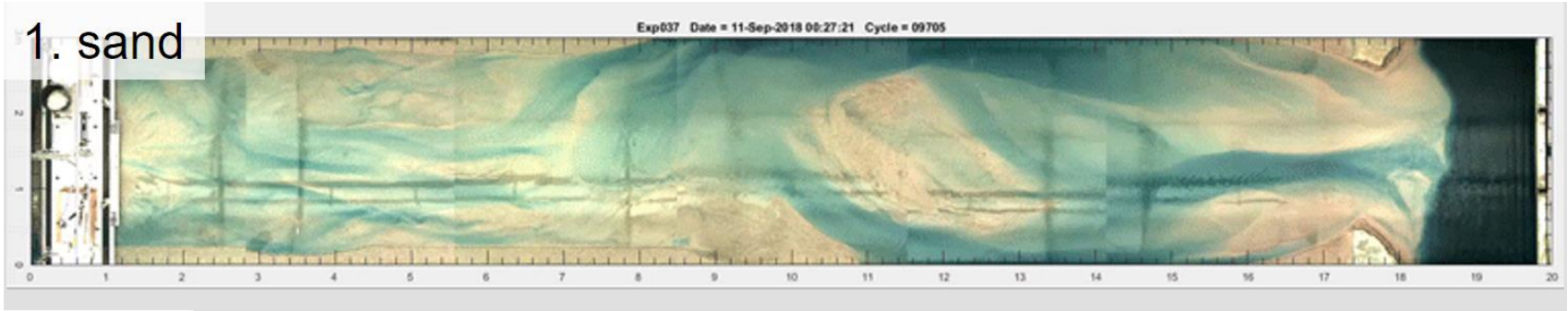
Building and raising land?

- Infilling feedback
 - Where does it start?
 - Which patterns?
- Mud and vegetation
- Experiments

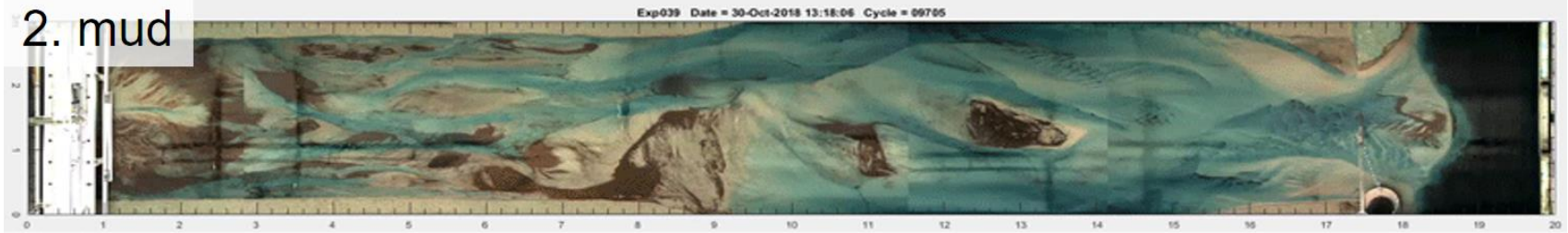


Morphological development

1. sand



2. mud



3. mud + veg

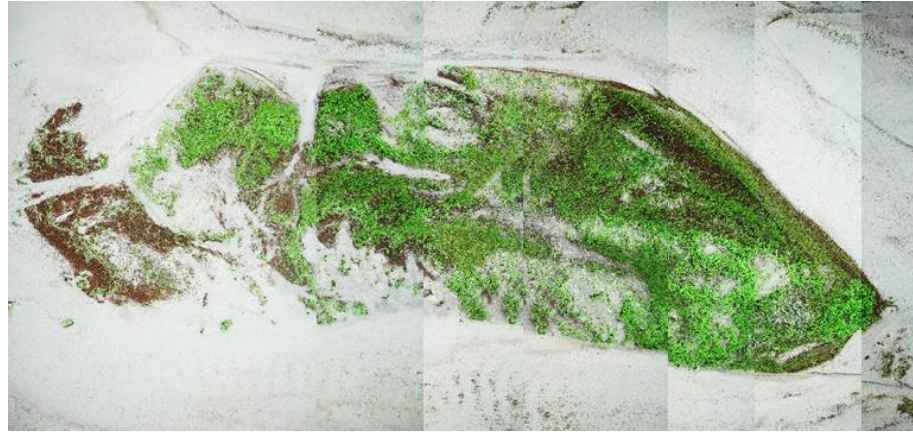


(work in progress, no movies online yet)

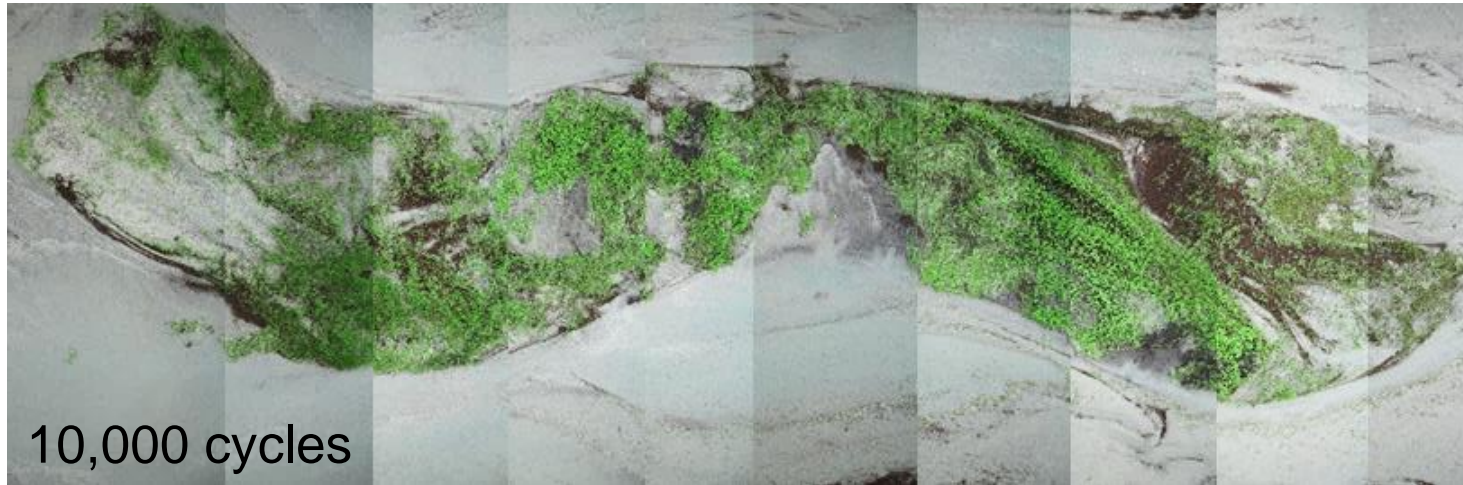
Growing vegetated bar

land/river

sea



9,000 cycles

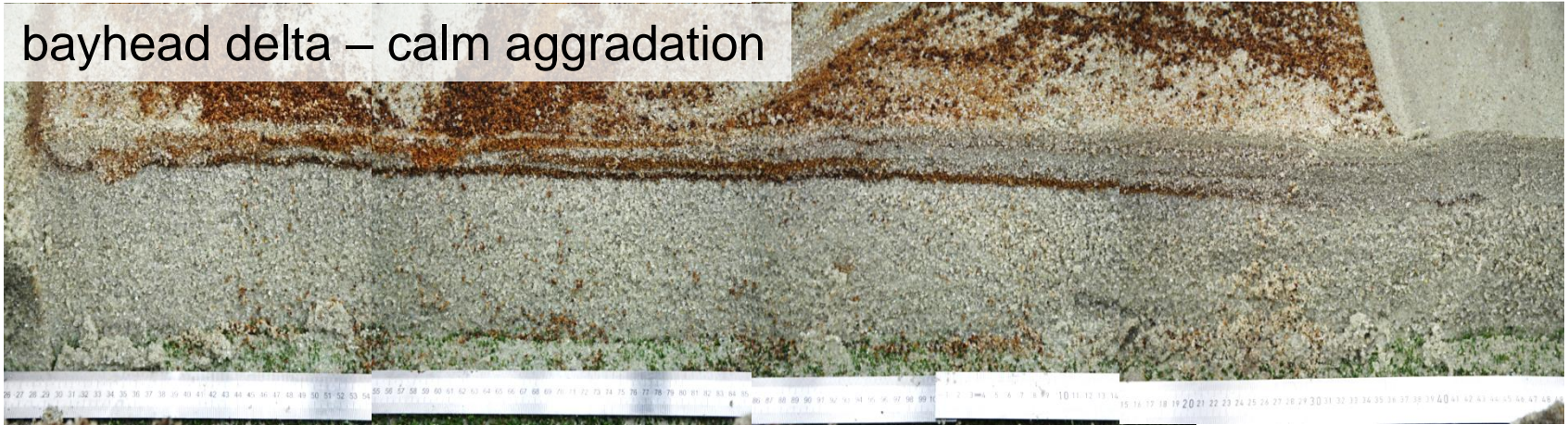


10,000 cycles



In the subsurface

bayhead delta – calm aggradation



middle estuary – high dynamics



Conclusion

- Landward side
 - Bayhead delta
 - Low dynamics
- Middle of estuary
 - Channel-bar pattern
 - High dynamics
- Building/raising land?
Let's go **green**





Early life in ancient estuaries

William McMahon



European Research Council

Established by the European Commission

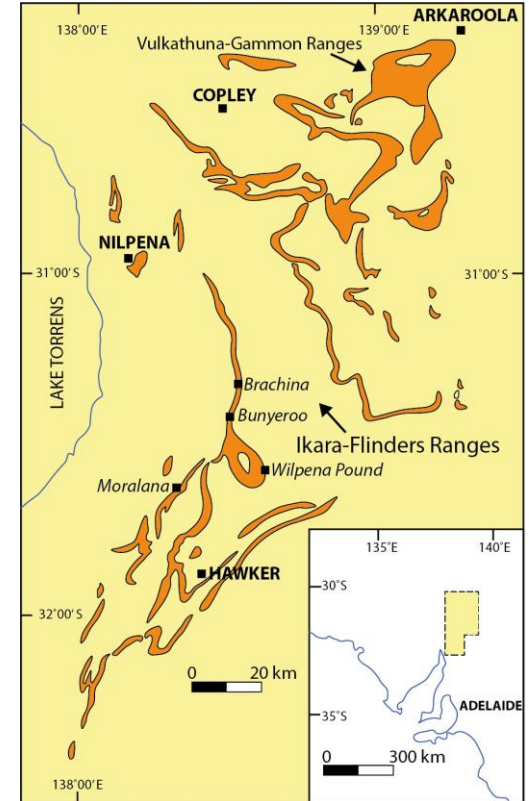
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Rawnsley Quartzite

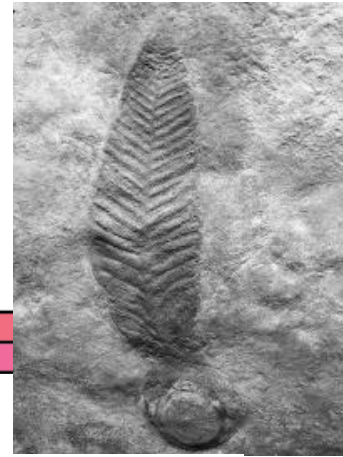


- ~**555** million years old
- Sandstone **dominated** stratigraphy
 - Subtract plants = Less mud?
 - **Early macroscopic life**

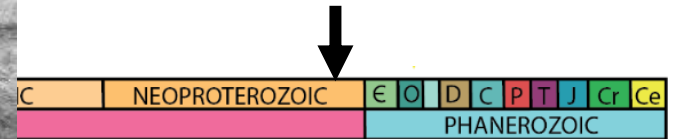


RAWNSLEY QUARTZITE = ALWAYS INTERPRETED AS PRODUCT OF **SHELF**
AND **SUBMARINE CANYON** ENVIRONMENTS

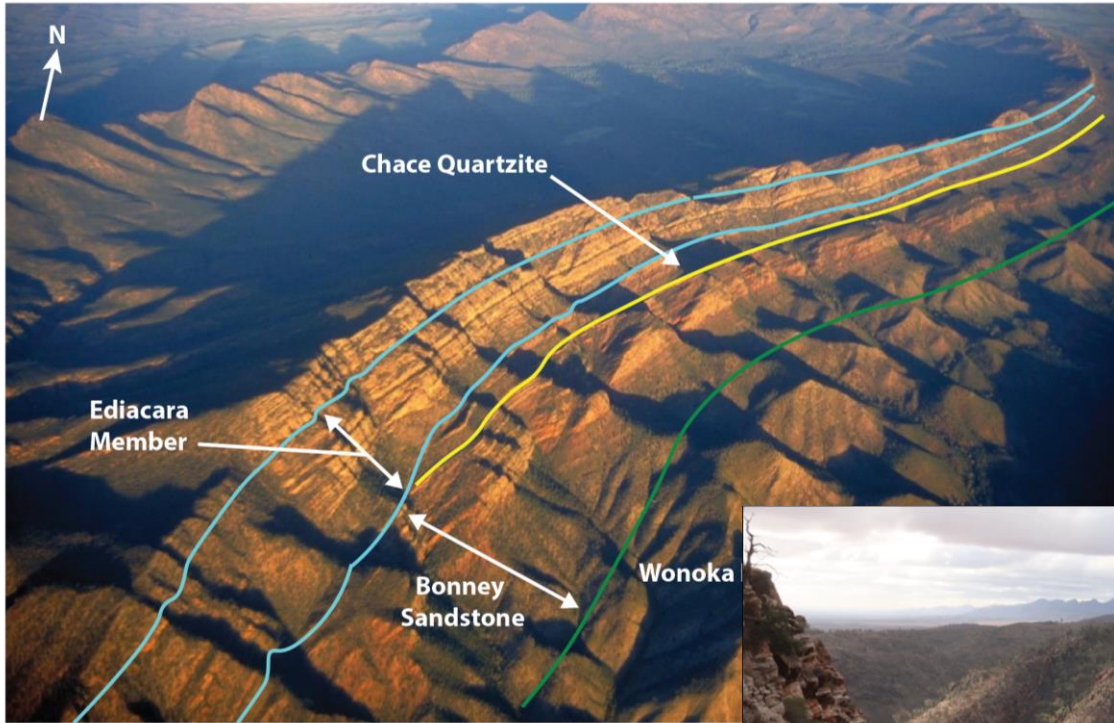
Ediacara Biota



ARCHEAN



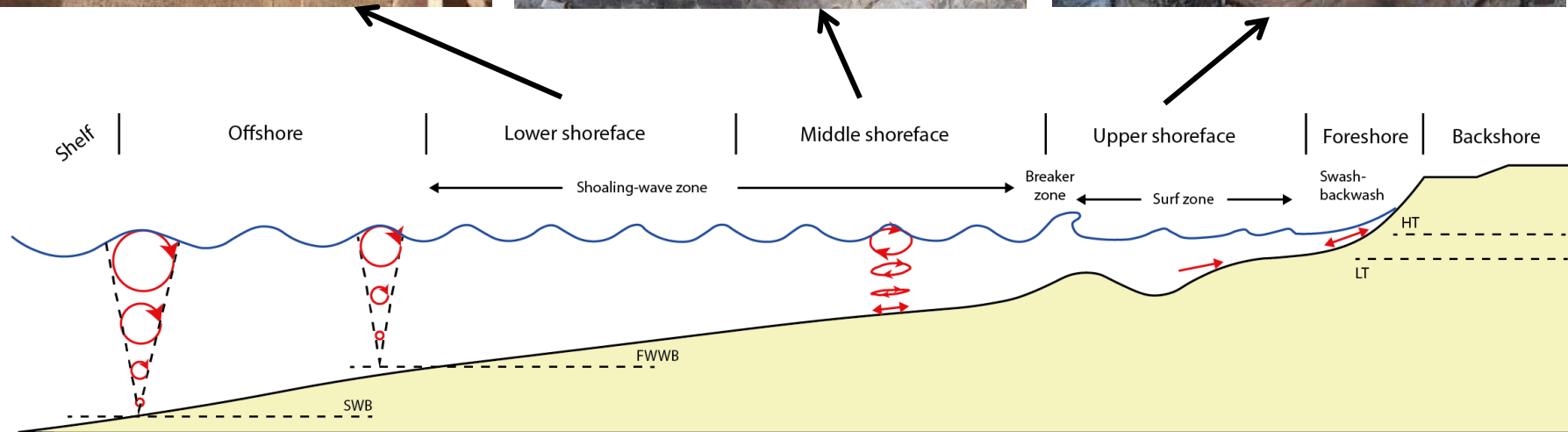
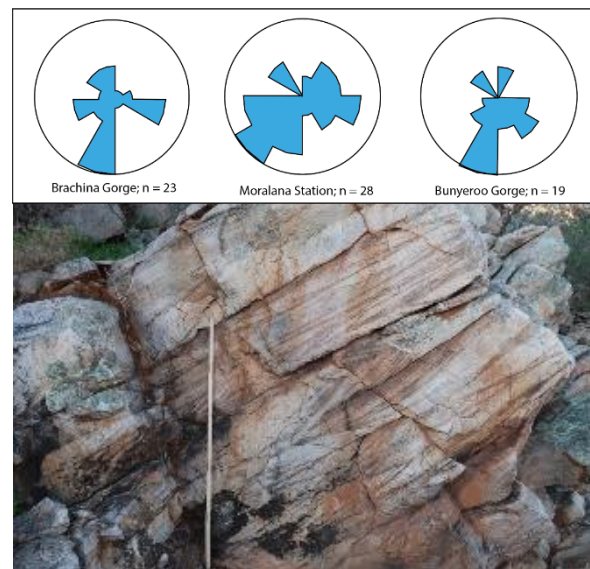
Incised valleys



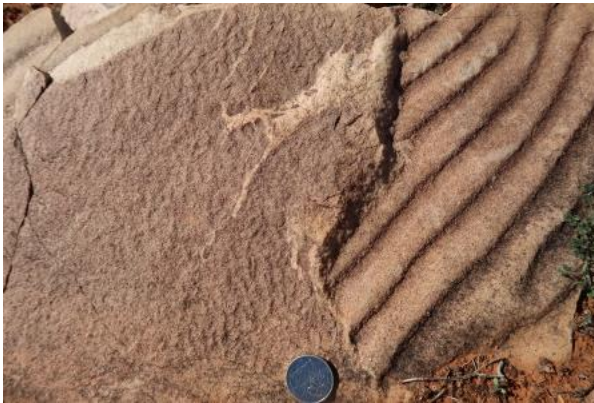
Estuarine deposits



Shoreface deposits

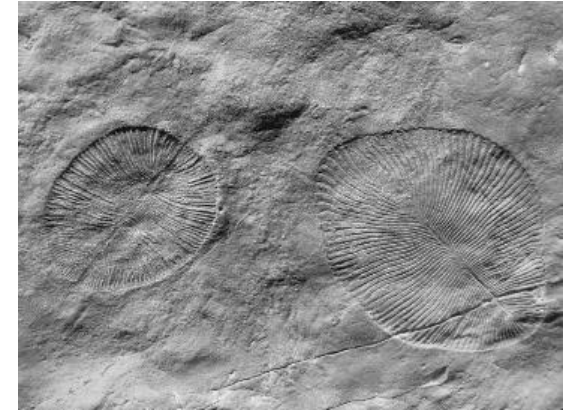
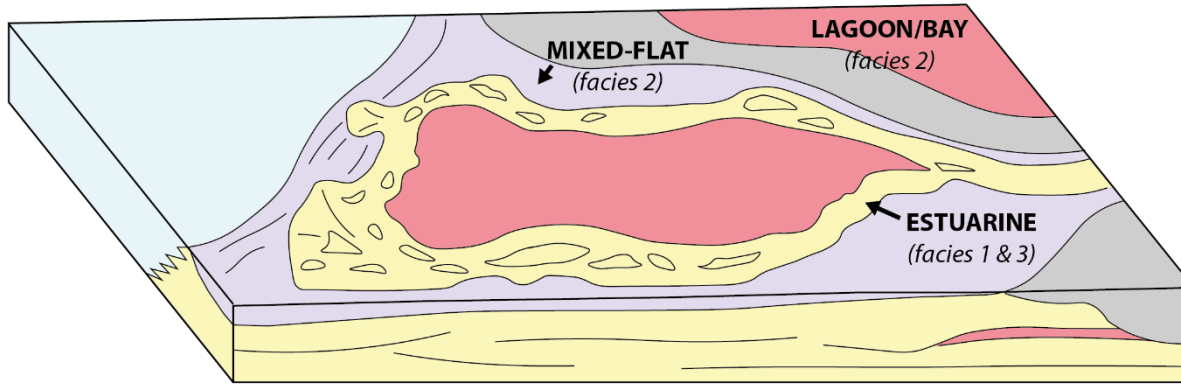


Tidal flat deposits

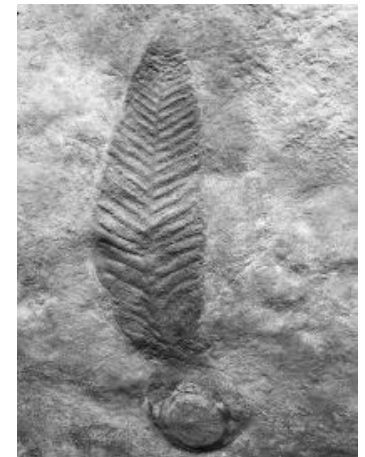
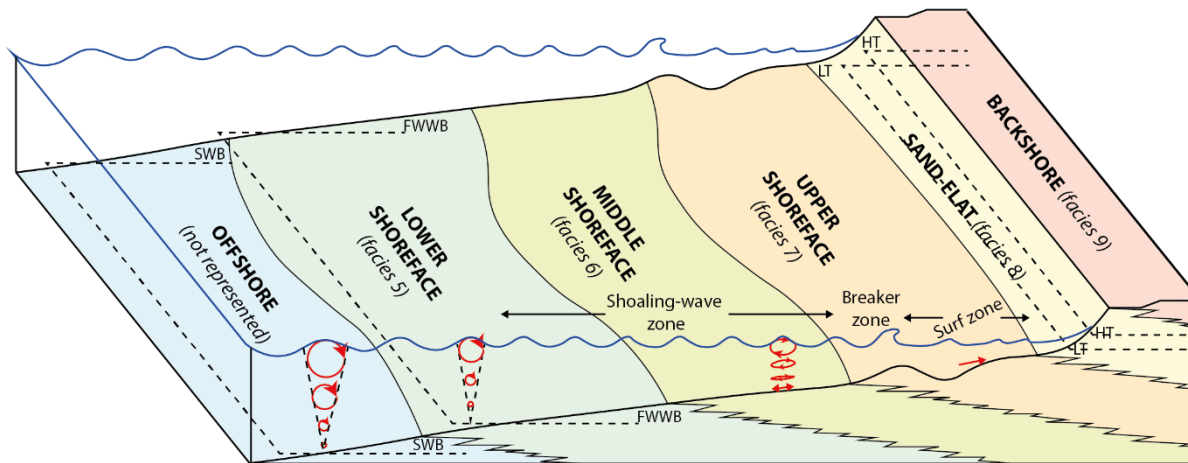


Earliest known evidence of mobile organisms in emergent environments

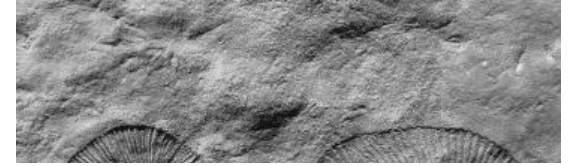
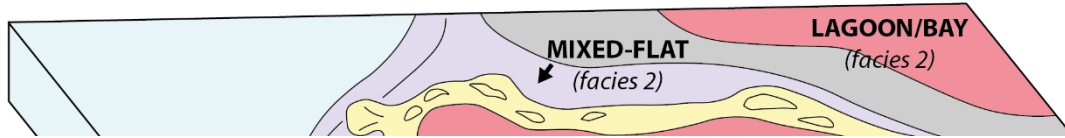
COMPLEX 1



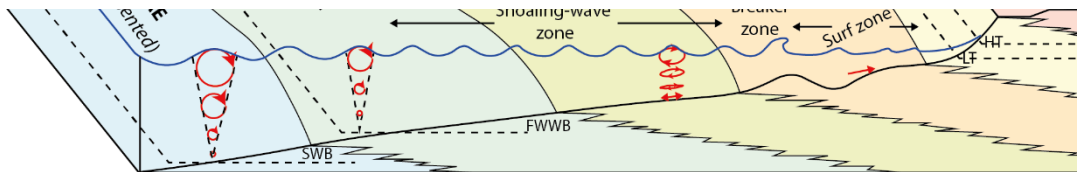
COMPLEX 2 & 3



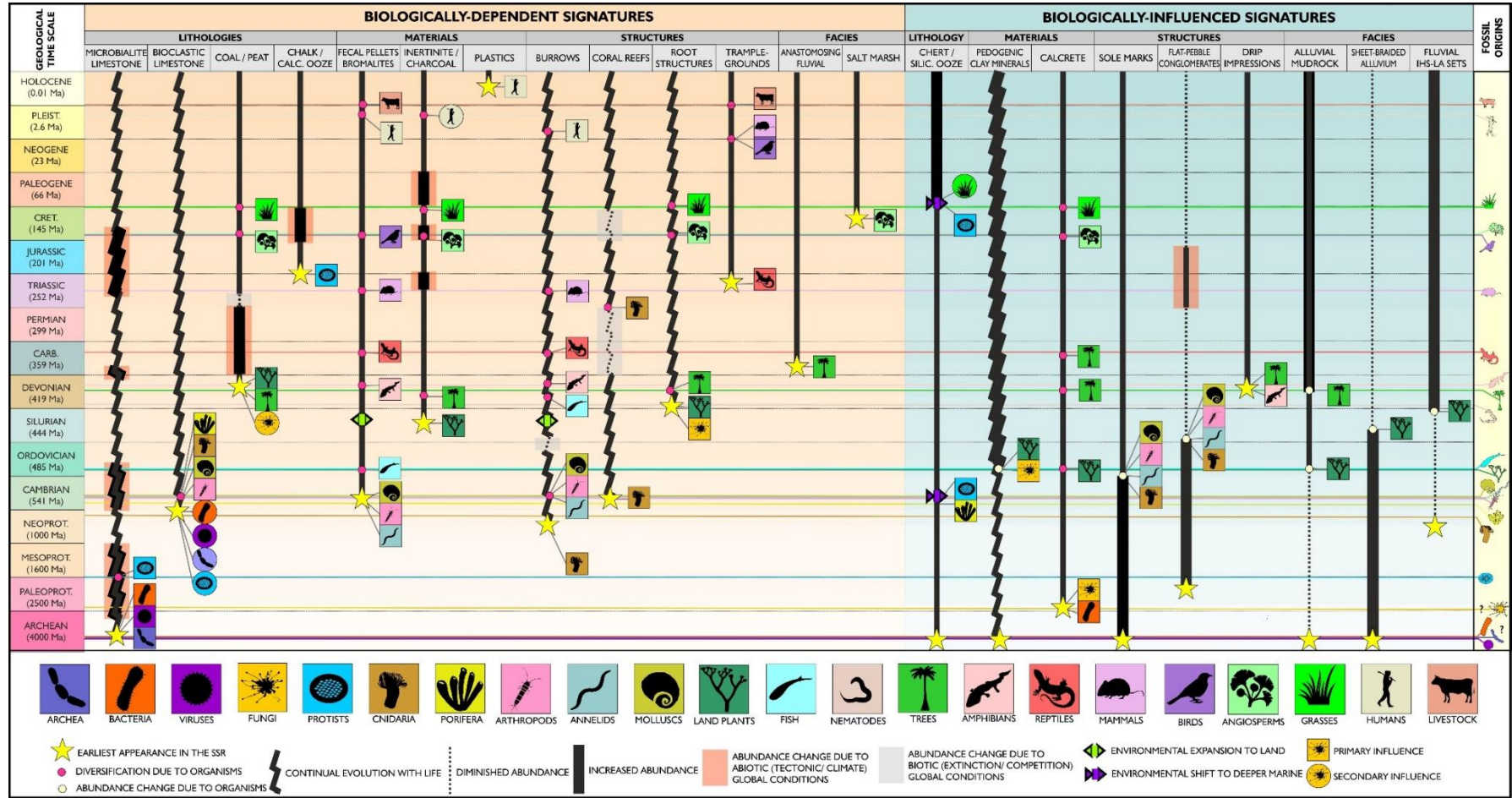
COMPLEX 1



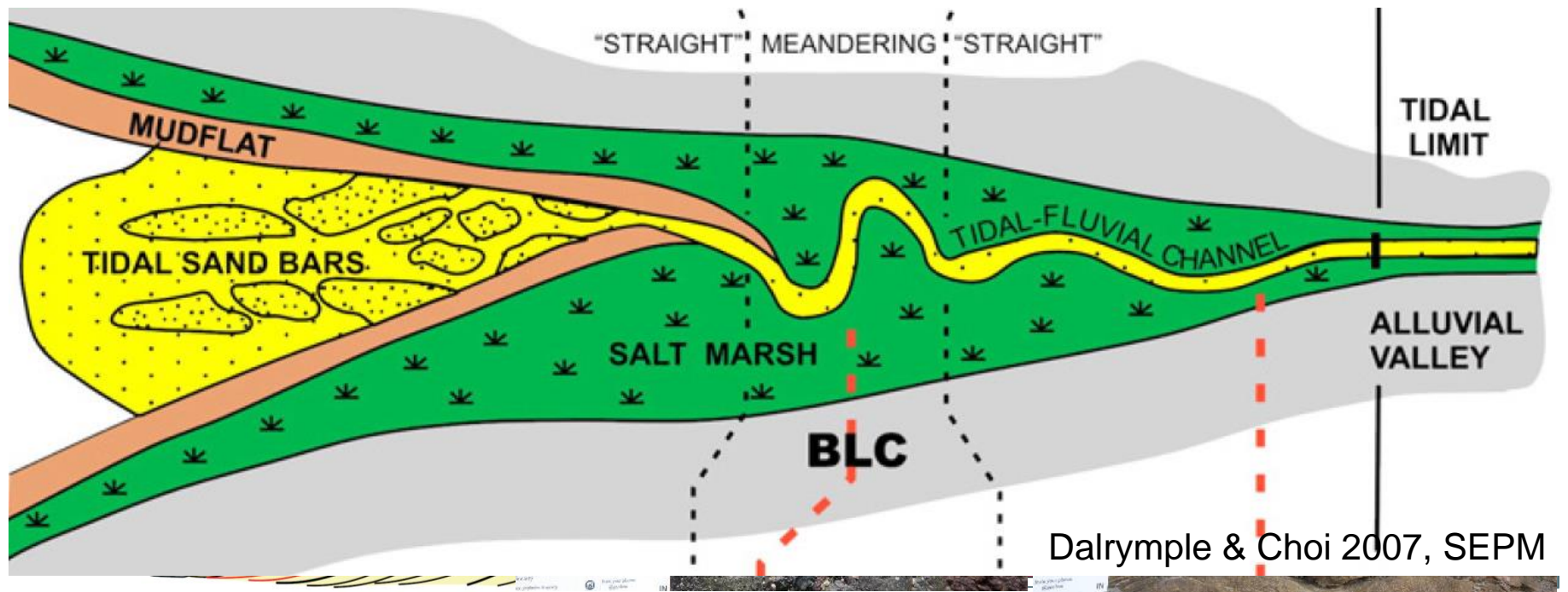
- Composition of fossil assemblages is tied to facies, so comprehension of these facies is fundamental to our understanding of early ecosystems
- Estuarine and shoreface environments account for all fossiliferous facies



A caveat.....rocks play by biology's rules



Davies et al., 2019, ESR





Living waterscapes and land level rise

Our conclusions and your questions



- Bars, estuary shape and sea level rise (Jasper)
- Sediment management Rhine-Meuse (Jana)
- Holocene Rhine-Meuse delta (Tjalling)
- Holocene Rhine estuary (Harm Jan)
- Filling estuary models (Marcio)
- Filling estuary experiments (Steven)
- Early life in ancient estuaries (Will)

■ next: putting on the thinking hat



Future causes and effects *a moral of the fairy tale*

Maarten Kleinhans

NIAS



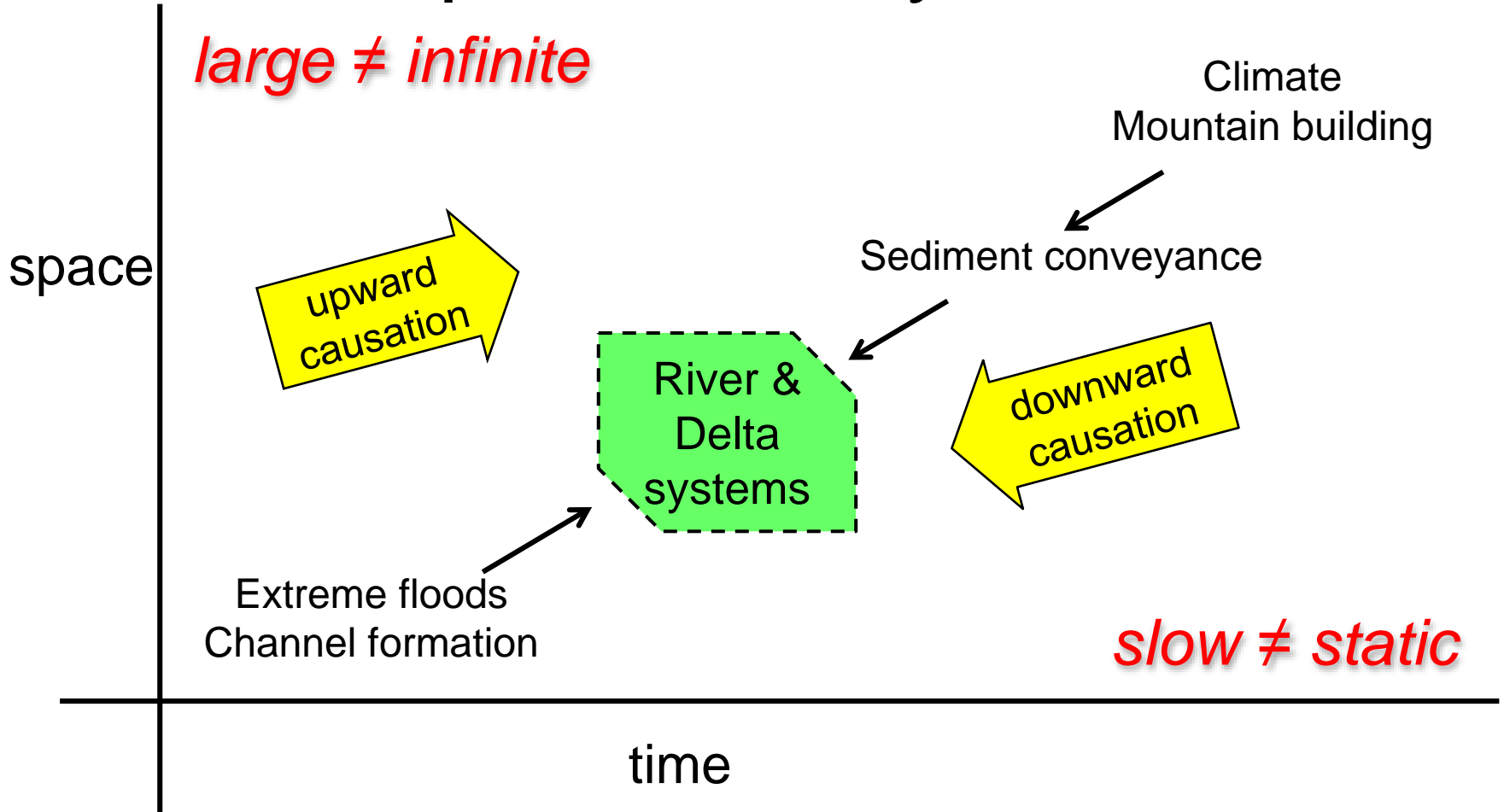
Netherlands Institute
for Advanced Study
in the Humanities and
Social Sciences

Open systems are **processes**

- Rivers and deltas:
 - A process, rather than a thing
- Analogy: a living organism:
 - A process, rather than a thing
- Present policies, politics and practice:
 - Economic growth, change processes, building with nature, 'sustainable' development
 - on a **STATIC, infinite** planet

Open Earth systems

large \neq infinite





Everything we do has consequences

- Objective science = value-free = zero impact ...
 - E.g. a dike: protection
 - barrier for ecosystems
 - long-term cause of floods / salinity intrusion
- 'Building with nature', 'Sustainability', ...
 - fairy tales of utopic solutions ('maakbare wereld')
(inflated excuses for further inaction?)
- Or germs of radical system change?

***Are we academics
mere tools
serving today's politics
that increase over-exploitation***

or

***are we critical intellectuals
thinking, debating and investigating
how to achieve an inhabitable Earth
after the 21st century ?***



Storylines

[Program](#)

[Storylines](#)

[Research team](#)

[Previous Brunings lectures](#)

[Associated movies](#)

[Christiaan Brunings](#)

Brief videos will become available on the 14th of January 2020 (on the day of the Brunings lecture). Follow the storyline of your interest and see below for brief introductions:



www.uu.nl/bruningslecture

Patterns in data



Movies, people, links...

- Movies, storylines with publication links
- PhD theses
- Open Access publications (squirrelled on my site)
 - Plus work in progress



- Older movies; soundscapes of the sea

- <https://soundcloud.com/user-293141304>



A high-angle, wide-lens photograph of a young woman with brown hair tied back, smiling at the camera. She is wearing a dark green hoodie with 'REAL NetherWester' printed on it and dark pants. She is holding a selfie stick in her right hand and a blue bucket with an orange shovel handle in her left. She is standing on a sandy beach with some footprints visible. The background shows the vast expanse of the beach and the ocean in the distance.

Multi-talented
director and producer
of the Brunings website
and the movies

→ LISANNE BRAAT
GEOMORPHOLOGIST

Rubicon grant laureate

Metronome and drinks: where to go?

■ *Earth Simulation Lab:*

- towards Botanical Gardens,
- go on to the far north-west (left): Princetonlaan 4



the end