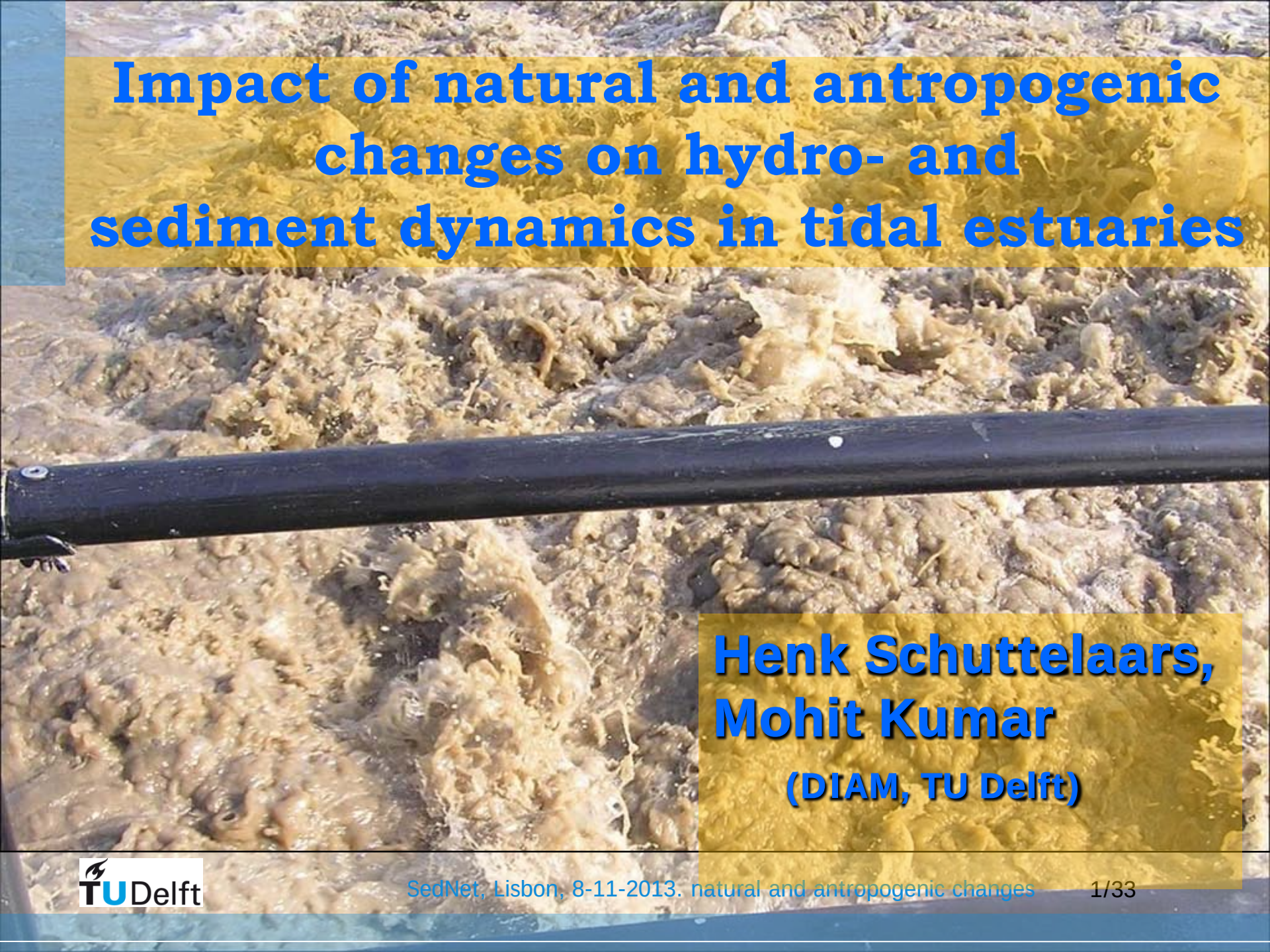
Impact of natural and antropogenic changes on hydro- and sediment dynamics in tidal estuaries



Henk Schuttelaars, Mohit Kumar

(DIAM, TU Delft)

Introduction (1)

In this talk: - influence of the length of the estuary on trapping location

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In this talk:
- influence of the length of the estuary on trapping location
- influence of the retention basins on water motion and sediment transport

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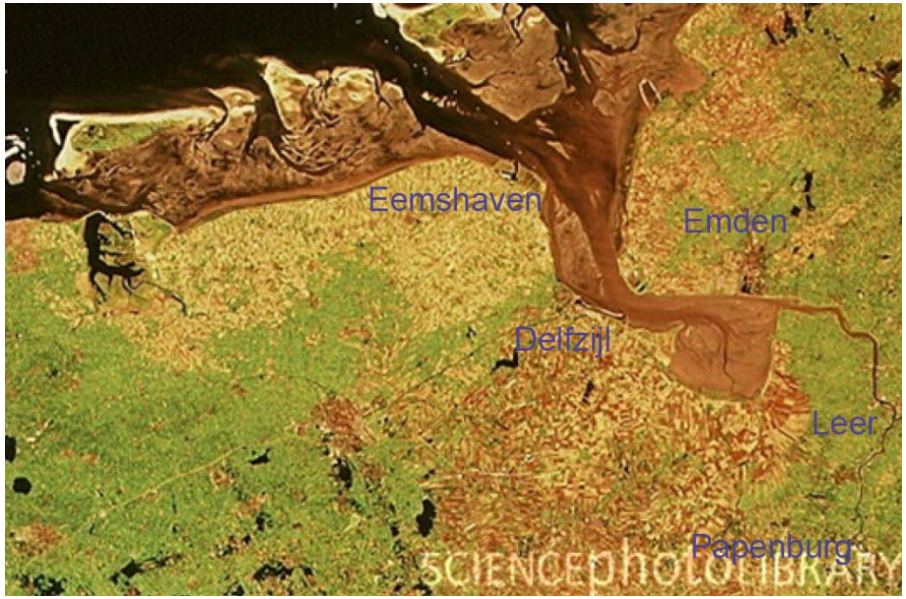
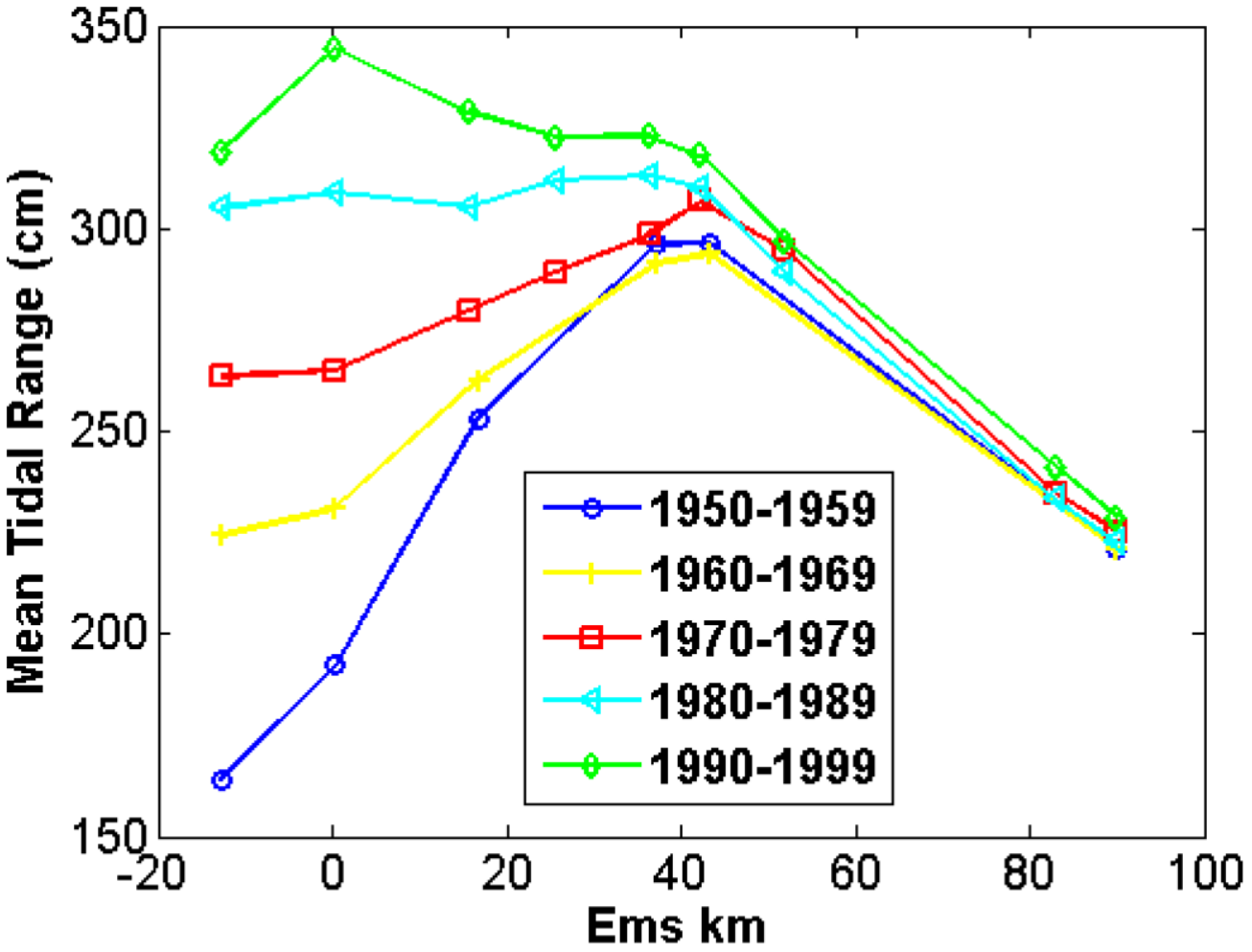
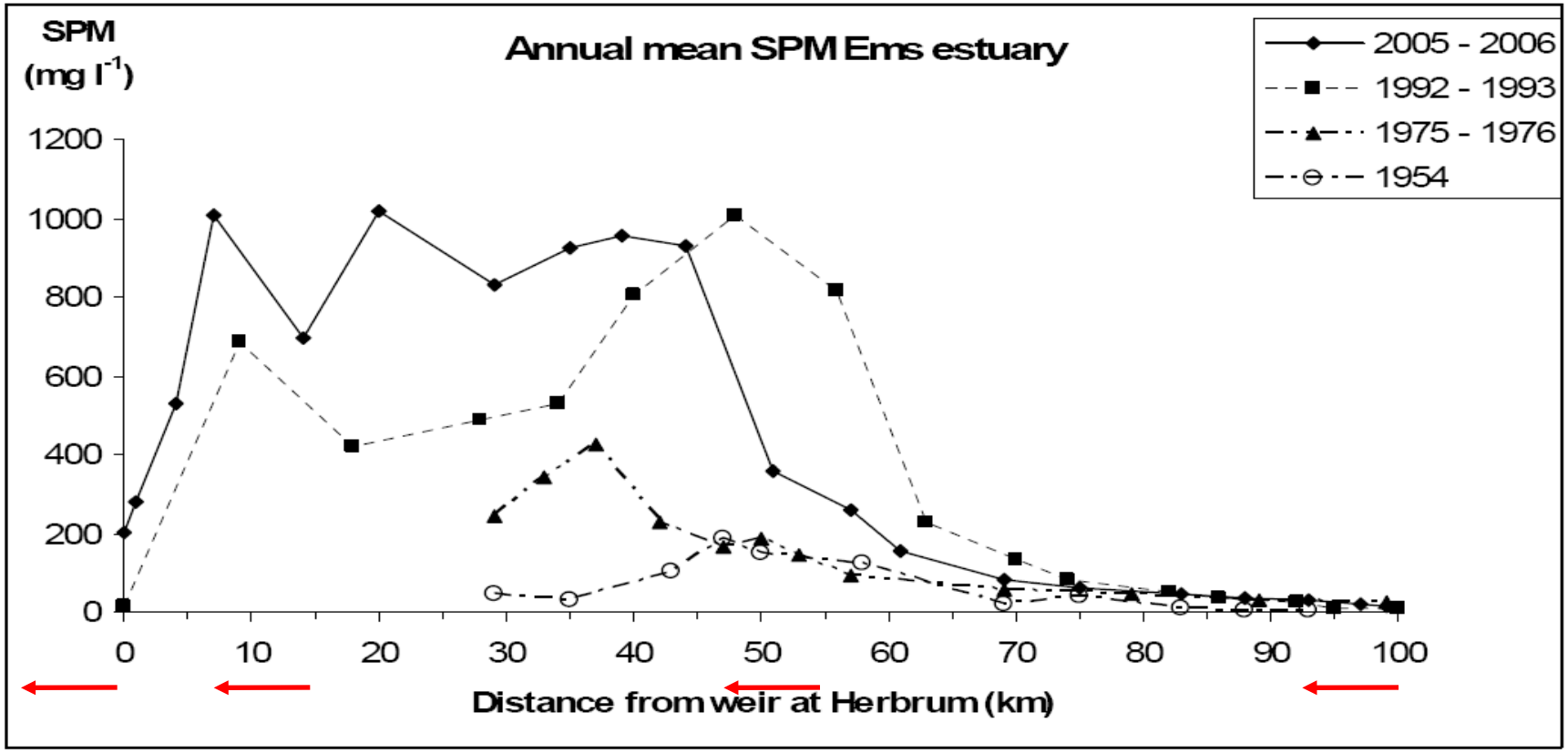
Motivation: **Ems estuary**



Introduction (2)



Introduction (3)



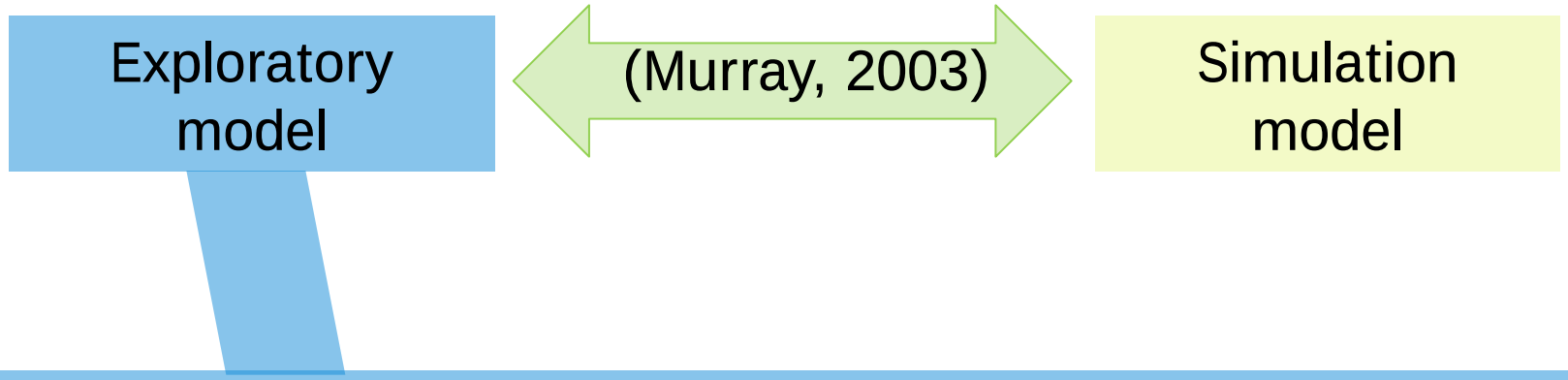
Herbrum Papenburg Emden

Borkum

Landward side

Seaward side

Model Formulation (1)



Exploratory models arise when trying to discover what processes or interactions are essential to produce specific phenomena and their sensitivity—when searching for a clear explanation

Model Results

Two experiments:

1 – influence of the length of the estuary on tidal trapping

2 – influence of retention basins on water motion and sediment transport

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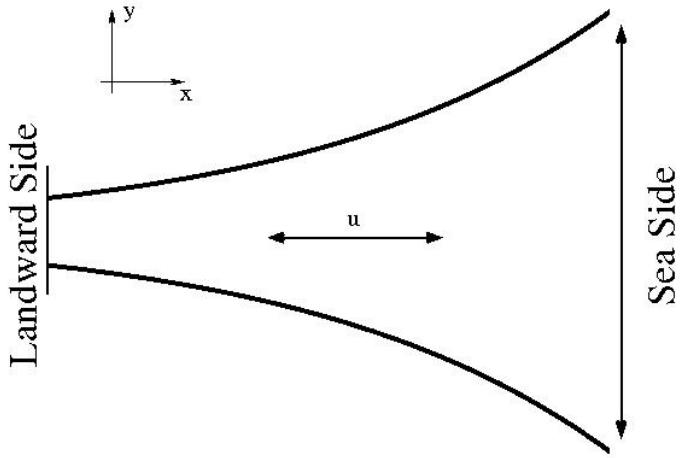
Model Formulation (2)

The system of equations we use:

- Width-averaged shallow water equations
- Width-averaged concentration equation
  (Advection-diffusion equation with erosion and depostion)
- Morphodynamic equilibrium condition

Geometry

exponential converging



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This system of equations will be solved using an idealized modelling approach...

...as this allows us to separate the individual transport mechanisms in a straightforward way

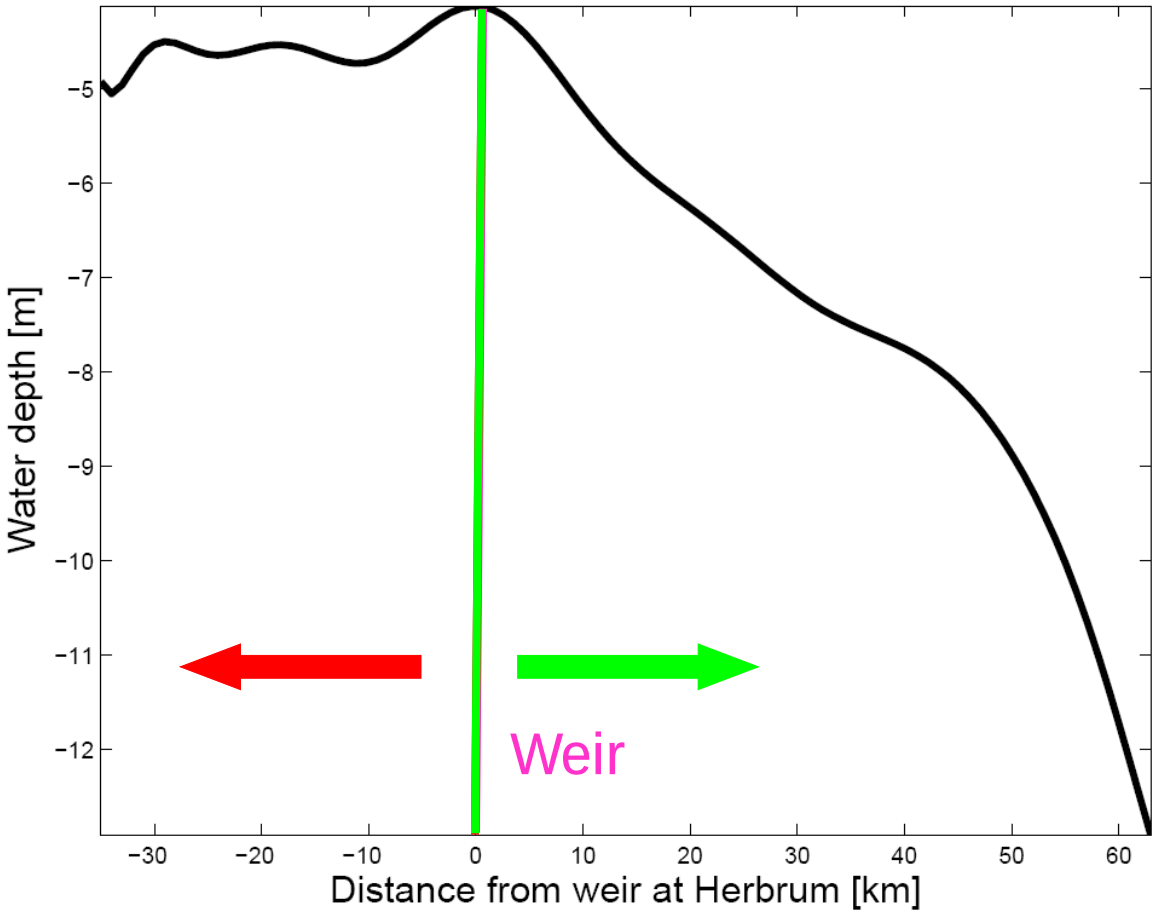
Influence of length on sediment trapping

Geometry

Water depth

Current length

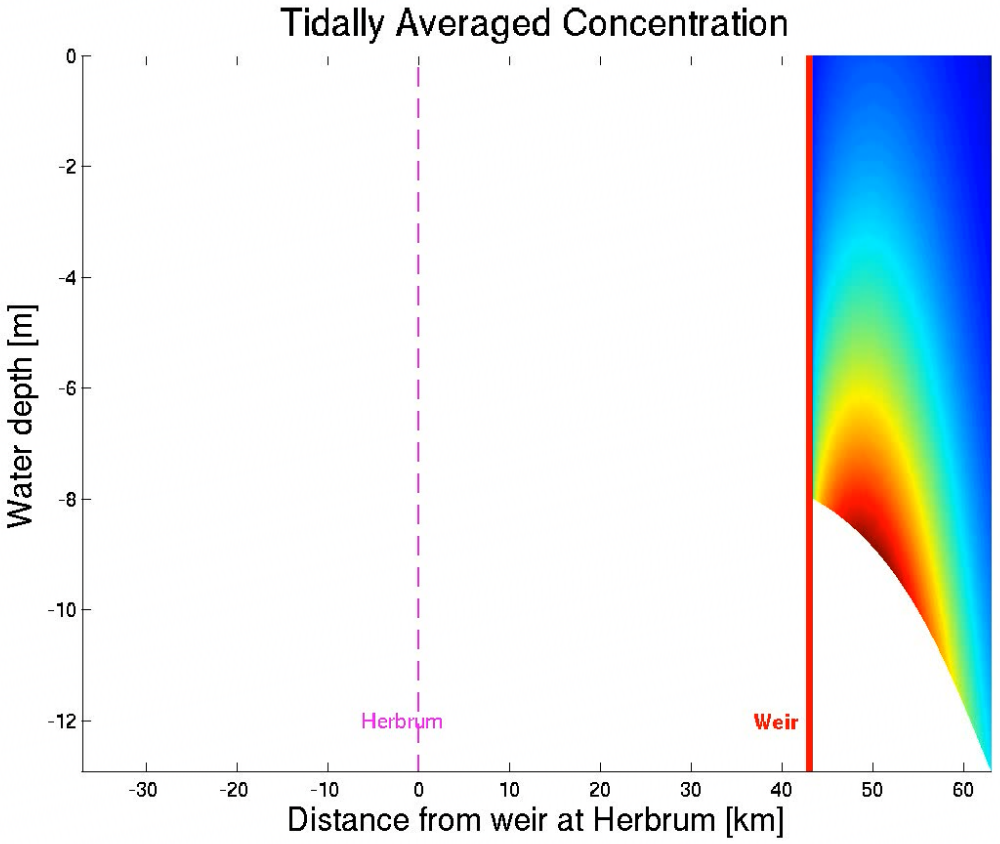
- Increasing length
- Reducing length



Influence of length on sediment trapping

Varying length of the estuary

Lenght: 60 km
70 km
90 km



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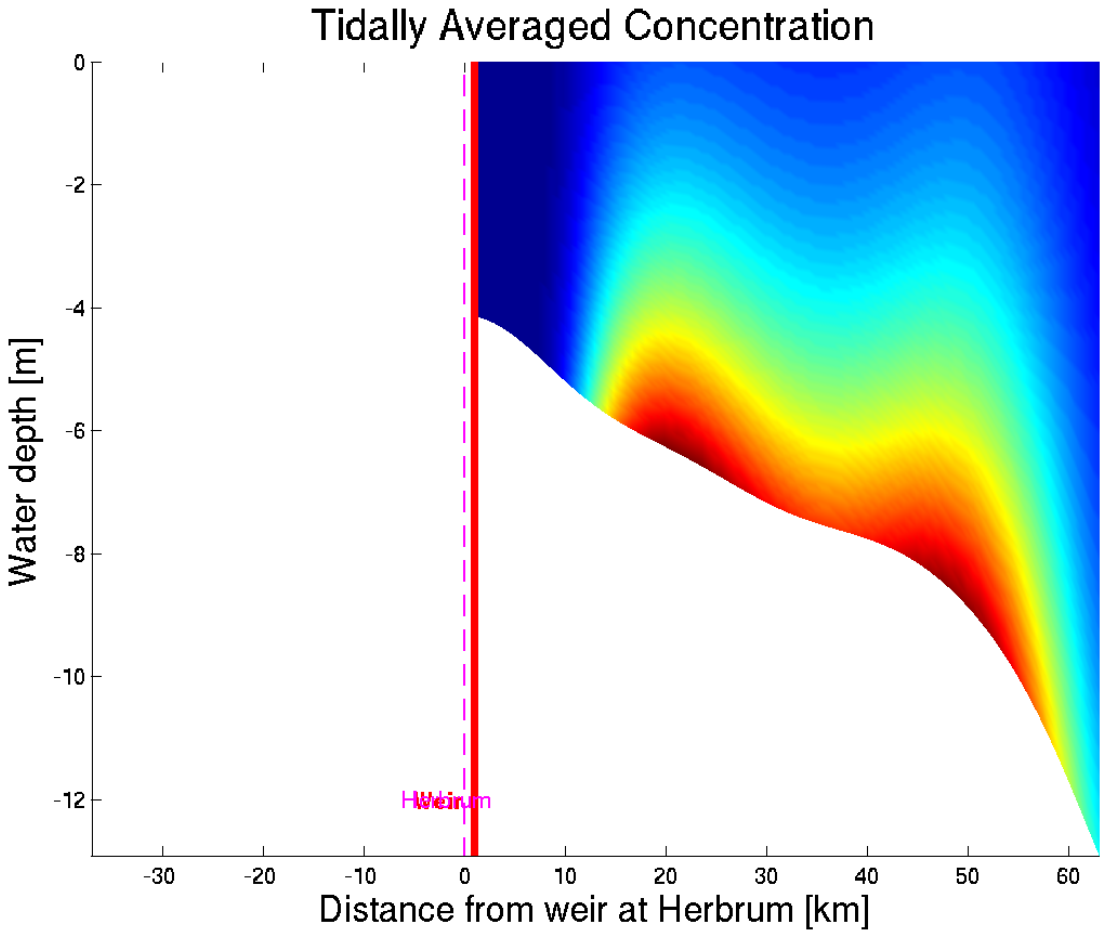

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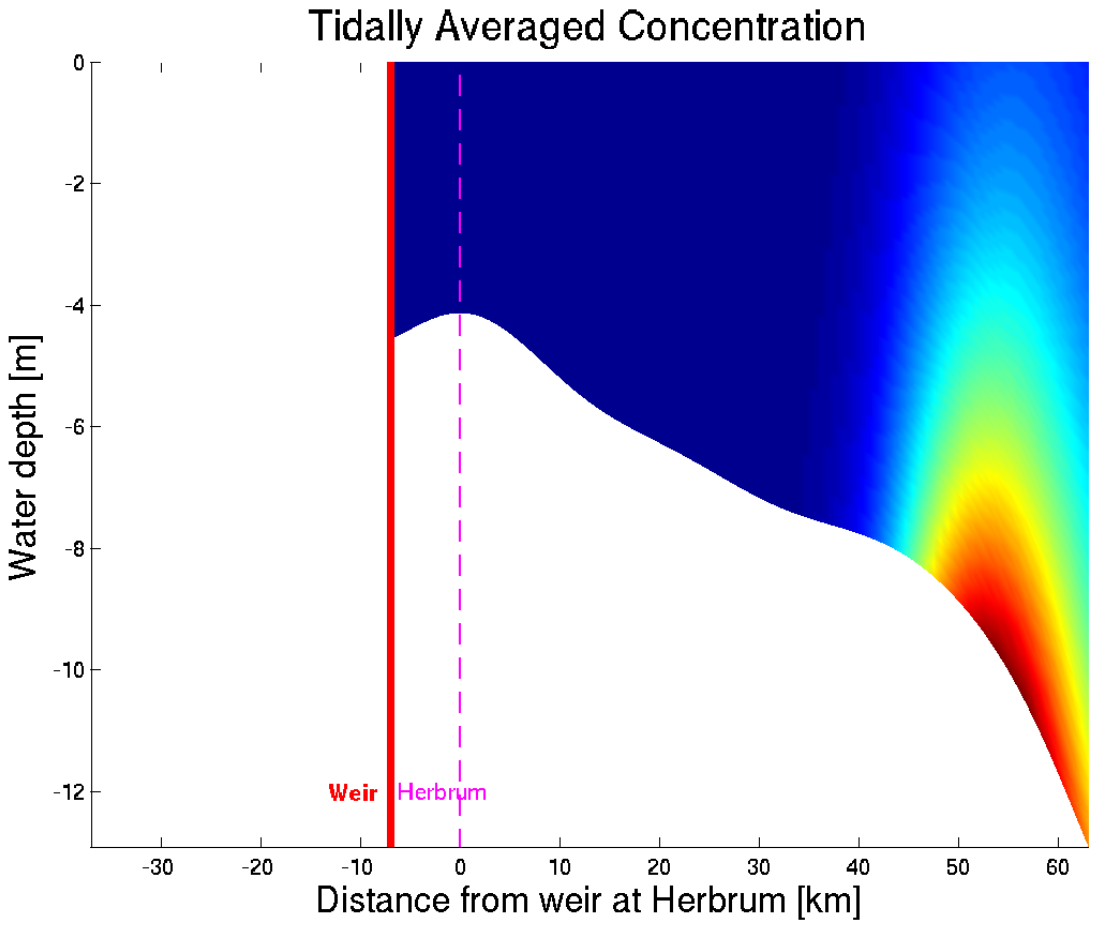

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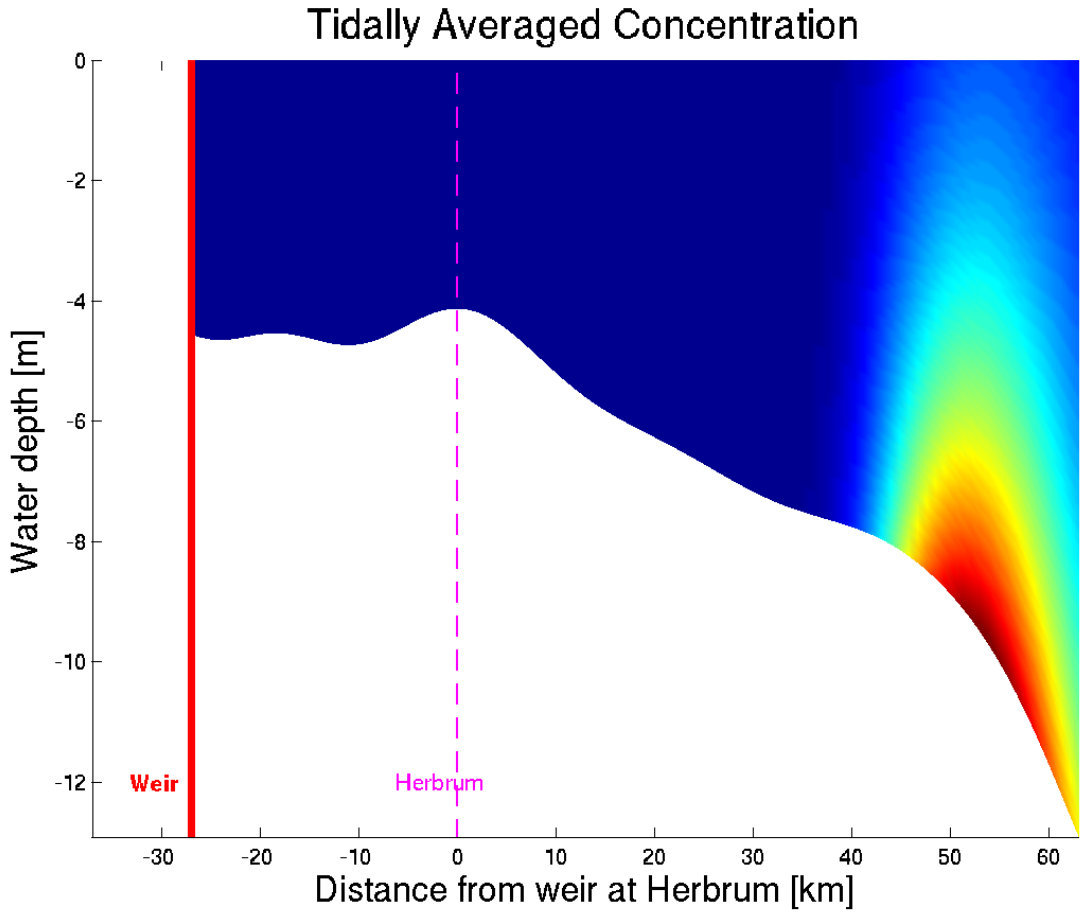
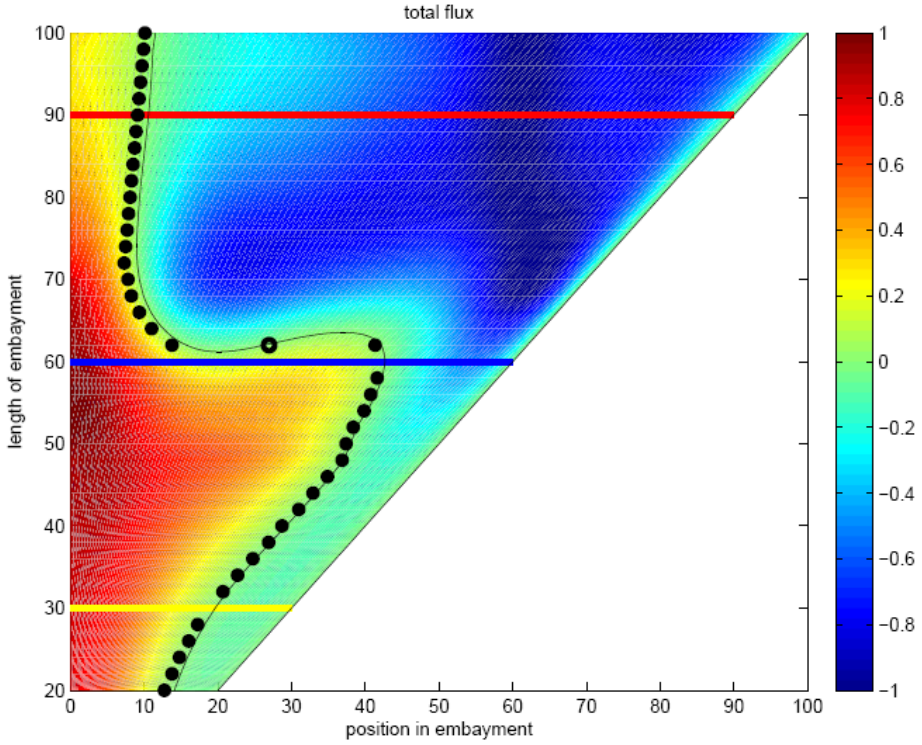
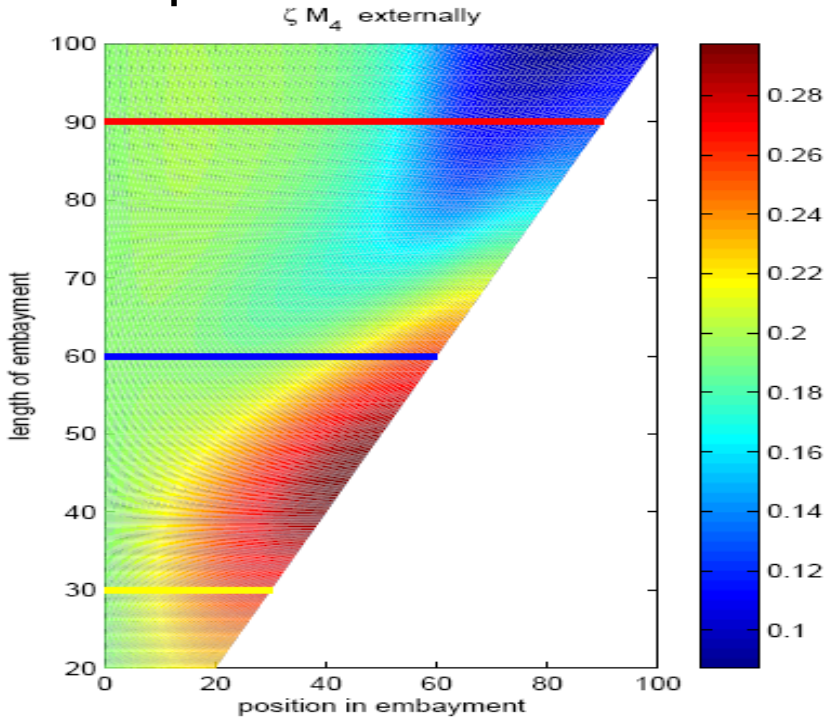


Influence of length on sediment trapping

Tidally averaged transport



Amplitude of externally prescribed overtide



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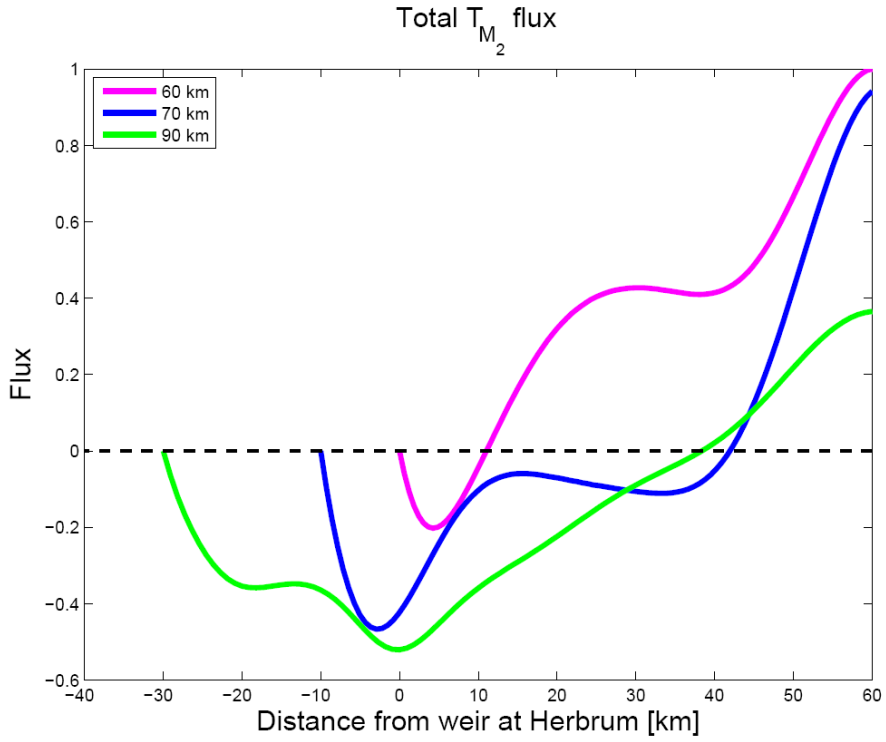
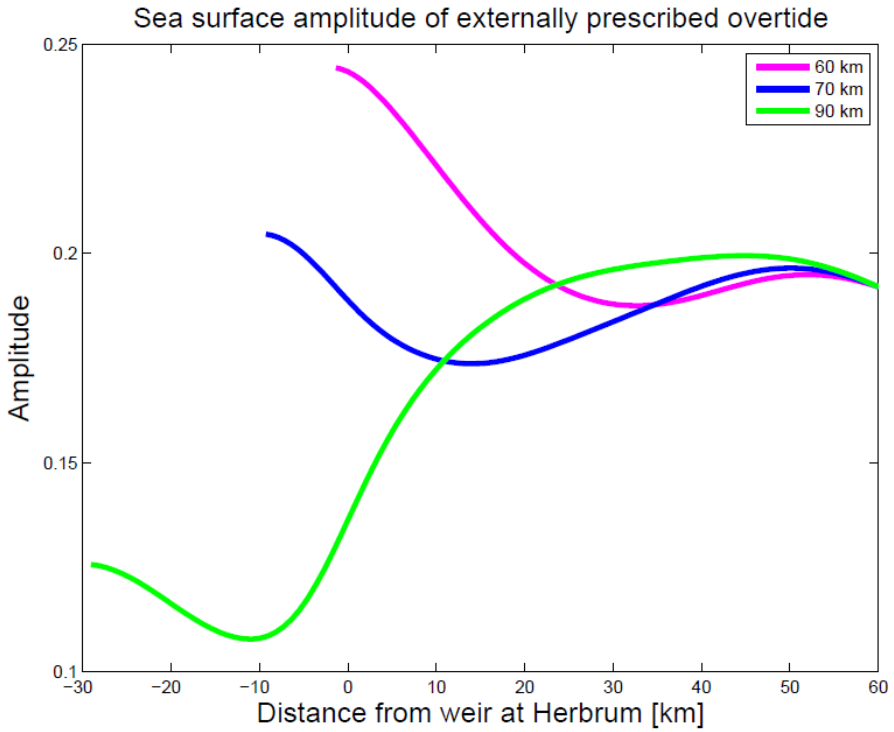




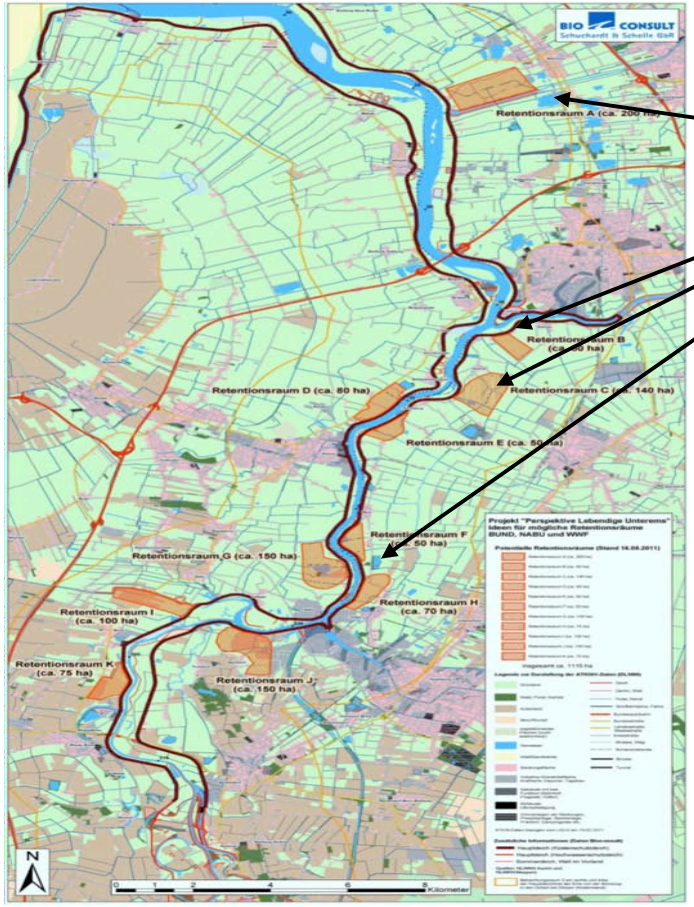
Model Results

Two experiments:

1 – influence of the length of the estuary on tidal trapping

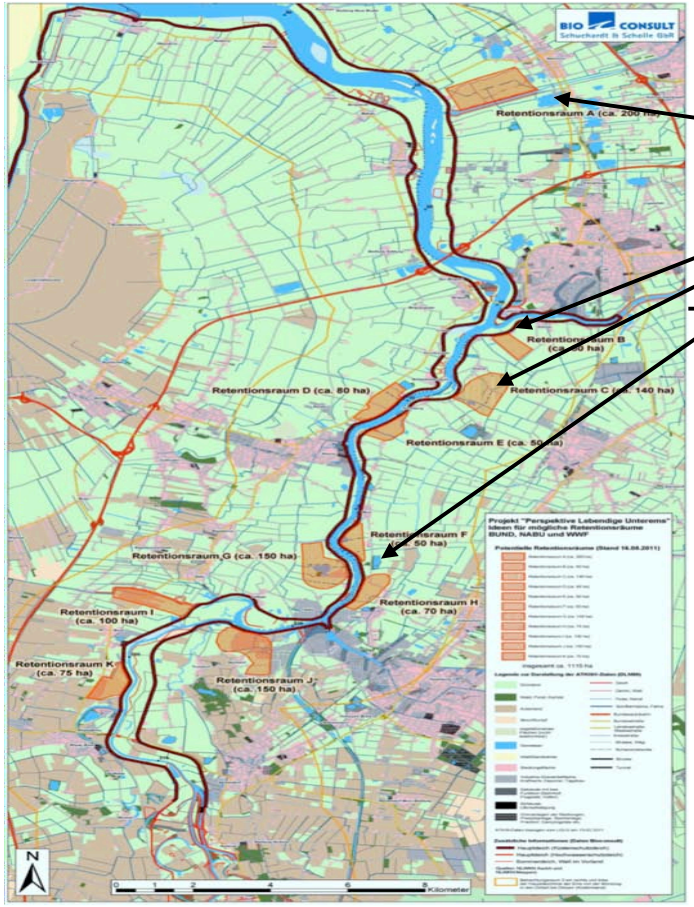
2 – influence of retention basins on water motion and sediment transport

Retention Basins



Possible locations
of retention basins

Retention Basins

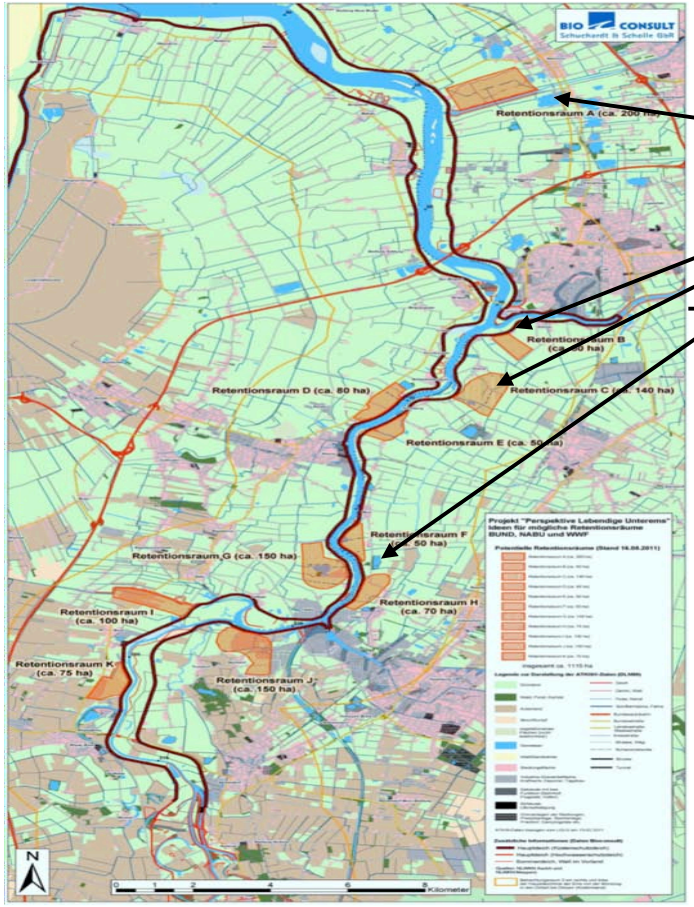


Possible locations
of retention basins

What is the influence of location and geometry of the RB on:

- sea surface amplification
- (initial) sediment transport

Retention Basins



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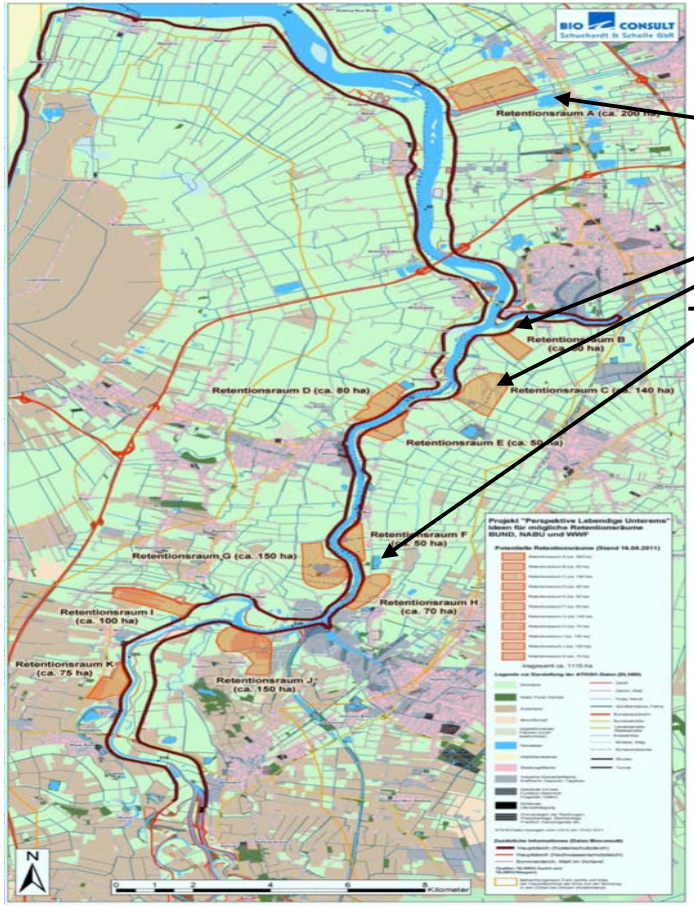
Alebregtse et al (2013)

Retention Basins



Possible locations
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What is the influence of location and geometry of the RB on:

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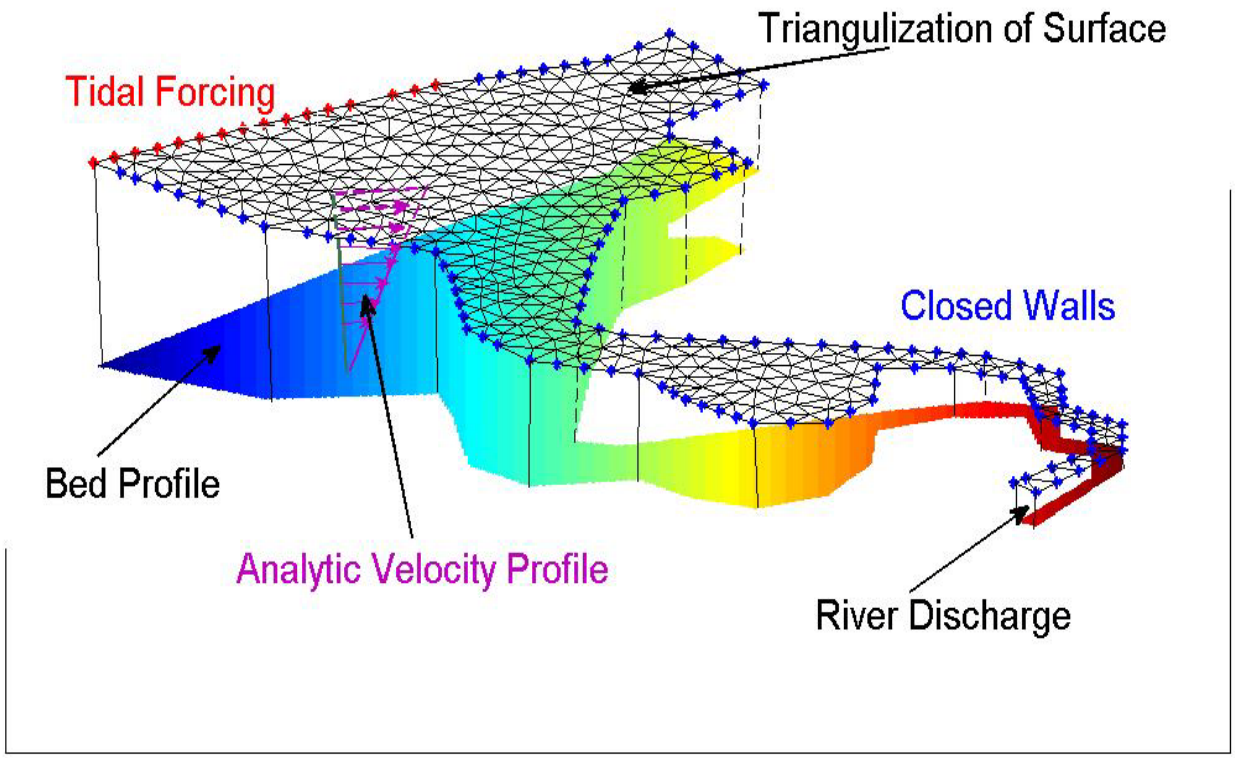
Need a 3D model

Retention Basins

The system of equations we use:

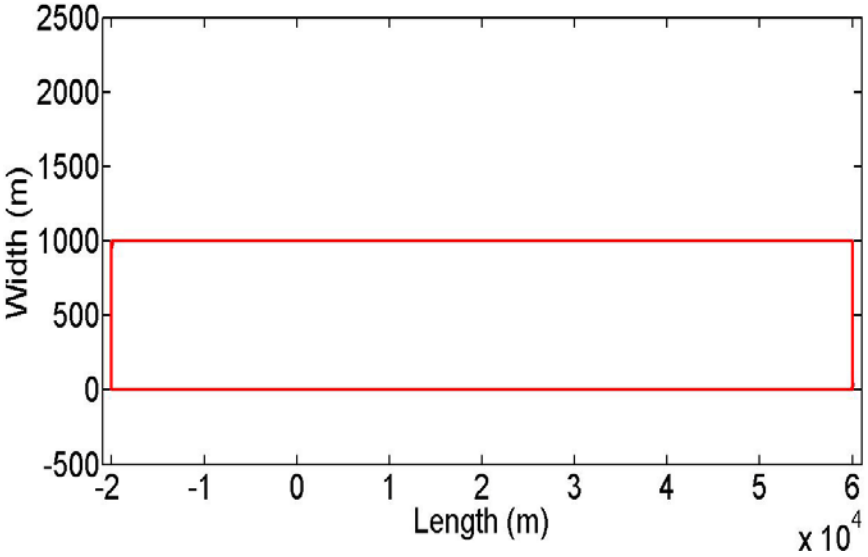
- 3D shallow water equations, extension of Winant (2007) for arbitrary domain and bathymetry
- Transport ~ $\langle u^3 \rangle$

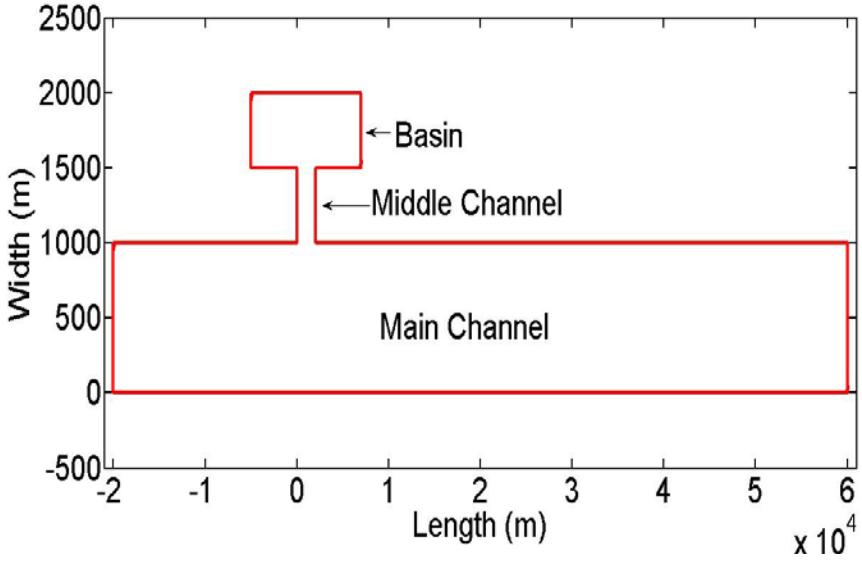
Retention Basins



Retention Basins

Influence on SSE (amplification):





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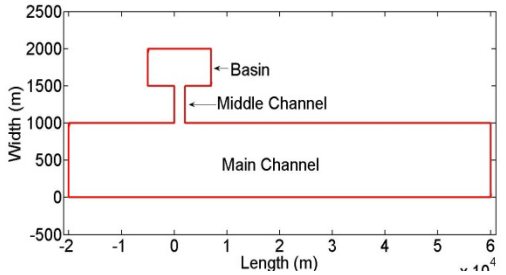
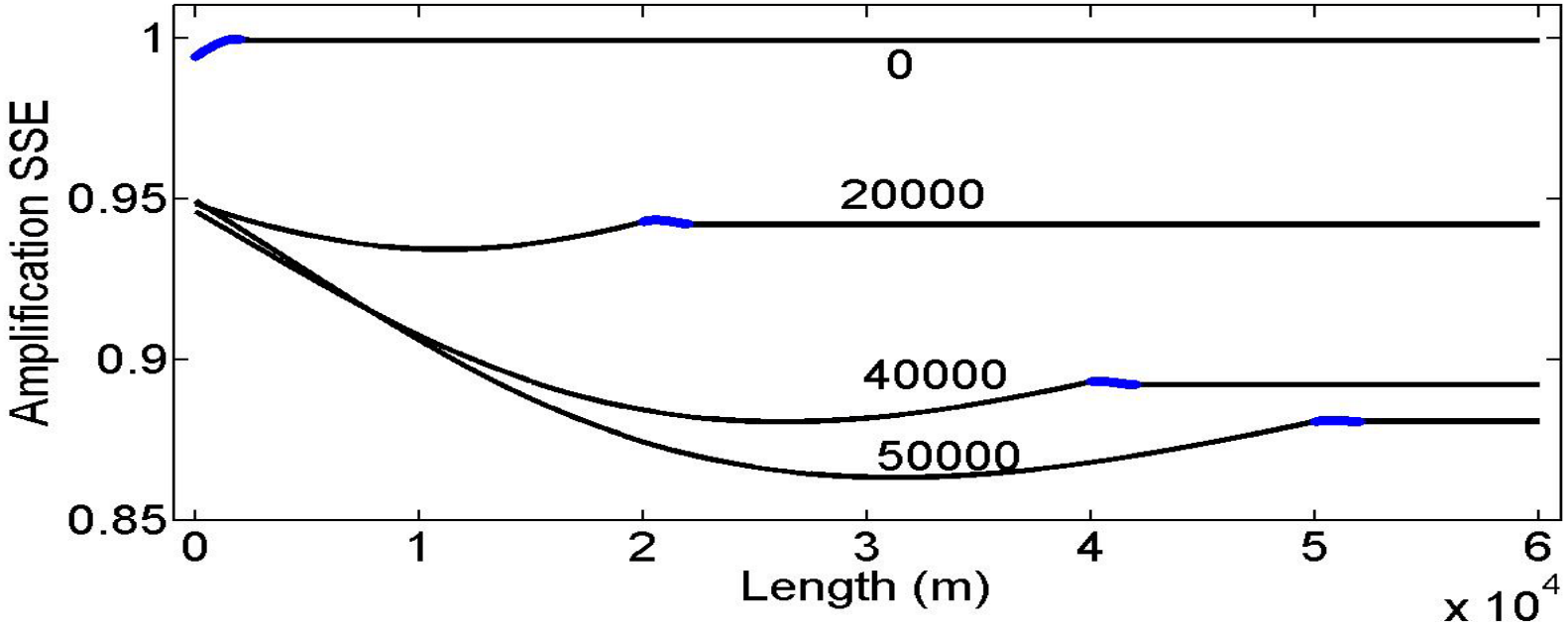
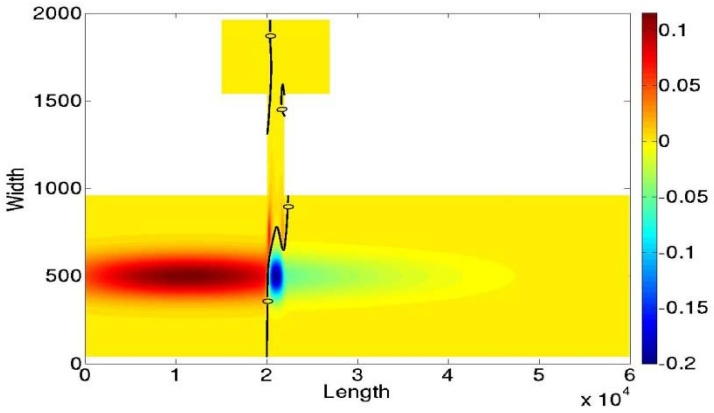




Retention Basins

Influence on sediment transport – system is flood dominated



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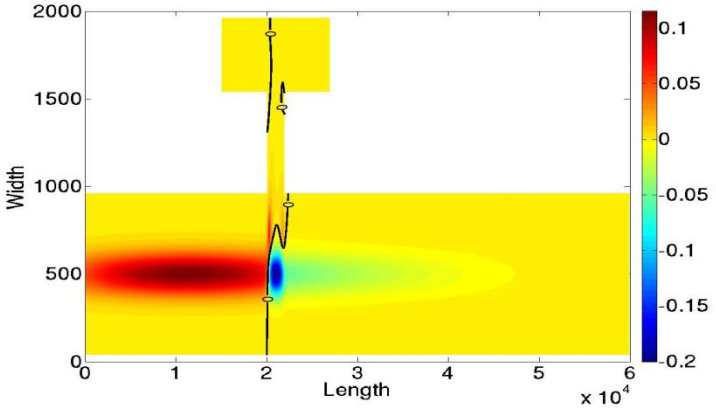

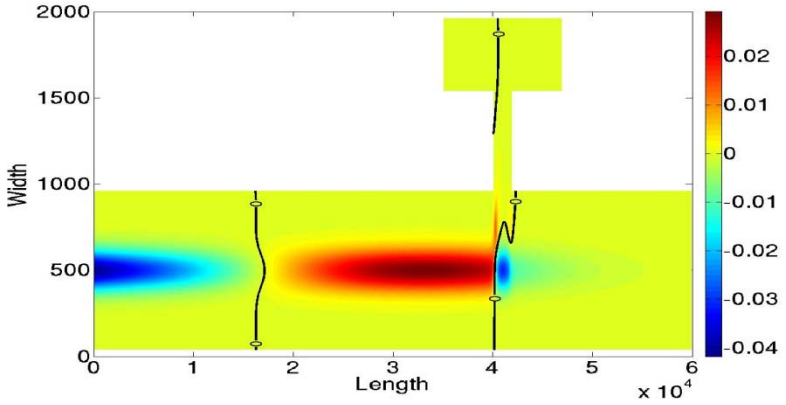

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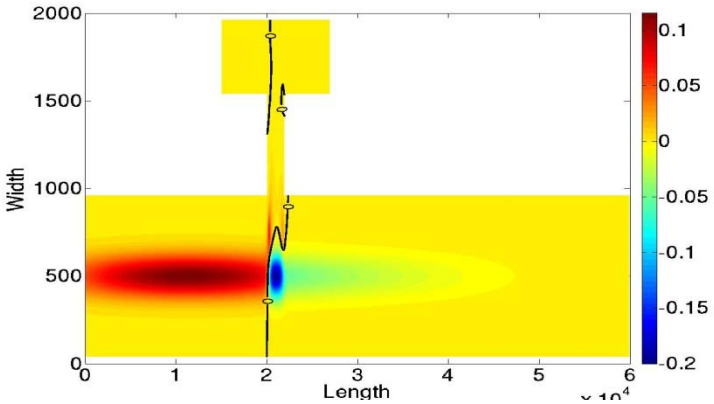

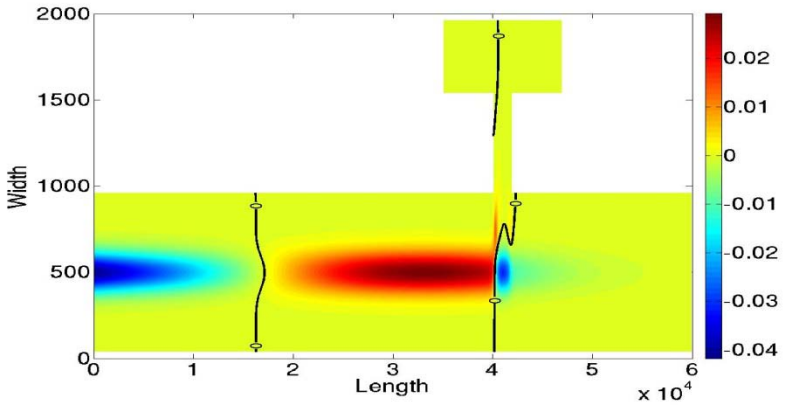

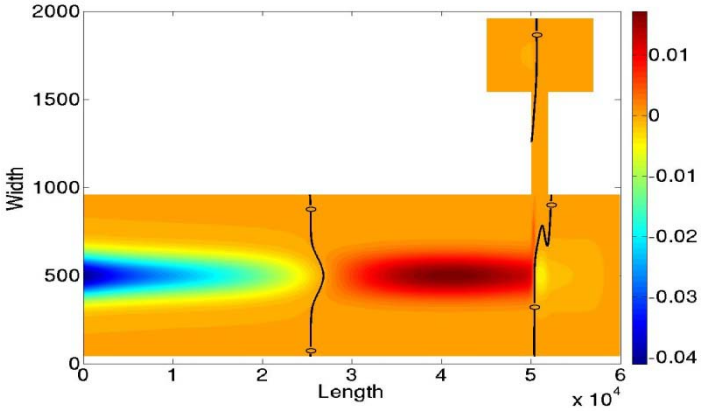

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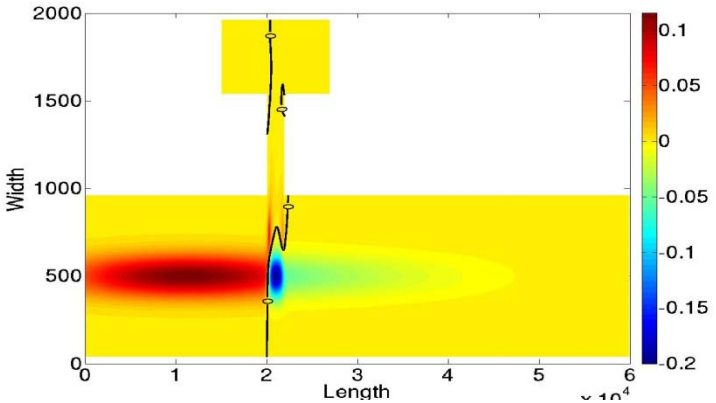

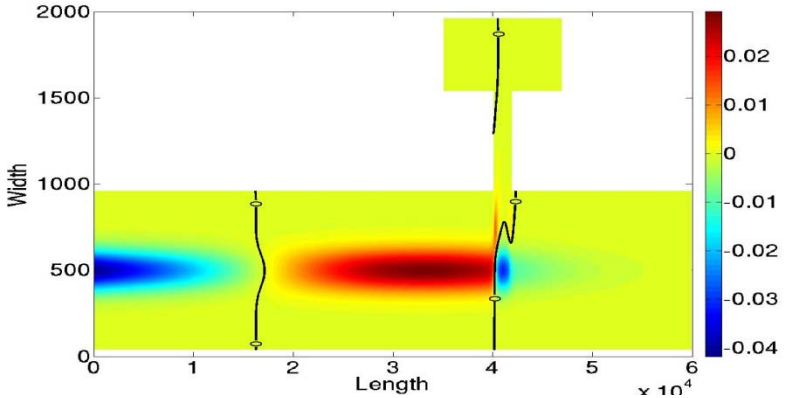

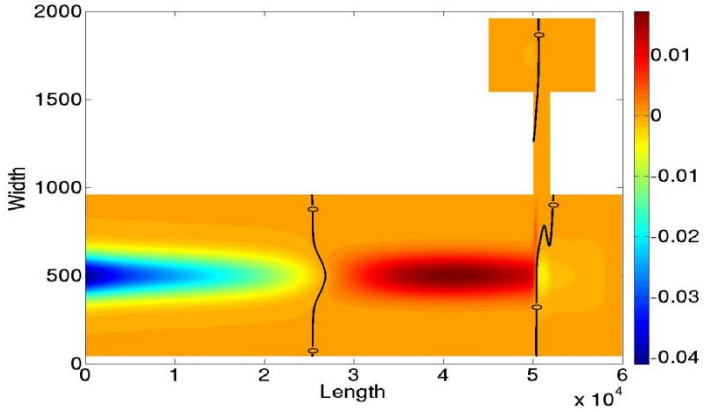

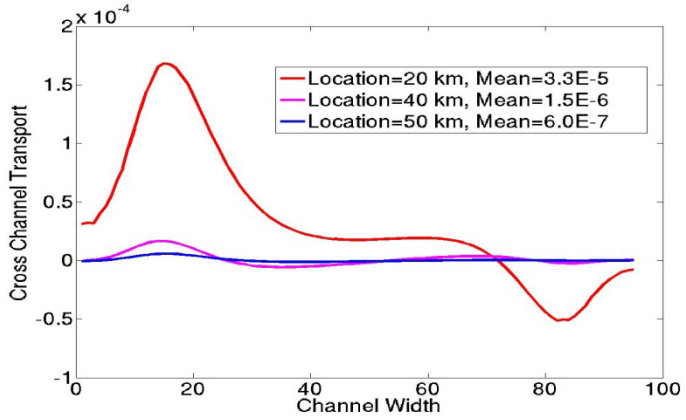

Conclusions – changing length

Increasing the length will result in:

- Water Motion:
  - A damping of the M_4 tidal wave
  - The same will happen by making the estuary shallower.
- Sediment Transport:
  - Trapping moves towards the entrance since the transport due to tidal asymmetry decreases dramatically

Conclusions – retention basins

- Water Motion:
  - Most effective close to the end
- Sediment transport for RB close to entrance:
  - Enhanced import at entrance
  - Reduced import to landward side
- Sediment transport for RB close to end
  - Reduced import at entrance
  - Enhanced import to landward side