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Mud transport under climate change
--- from 2013 to 2050

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Climate change

- Sea level rise is one of the main consequences of global warming
- The Antarctic ice sheet is potentially the largest contributor to future sea level rise
- Global mean sea level rise could range from 15 cm to 40cm by 2050 relative to the situation in 2013 (IMDC)

- *How it will affect cohesive sediment transport in the Scheldt by 2050? And the ecological impact to the system? (Integraal plan Boven-Zeeschelde)*

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3D Mud Transport Model

- Focus on the Upper Sea Scheldt
  (110km – 170km from the estuary mouth)
- Modelled with TELEMAC suite
- Based on the calibrated 3D hydrodynamic model (SCALDIS)
- Salinity is included
- Only has 1 class of fine sediment particles
- Sediment dumping is included

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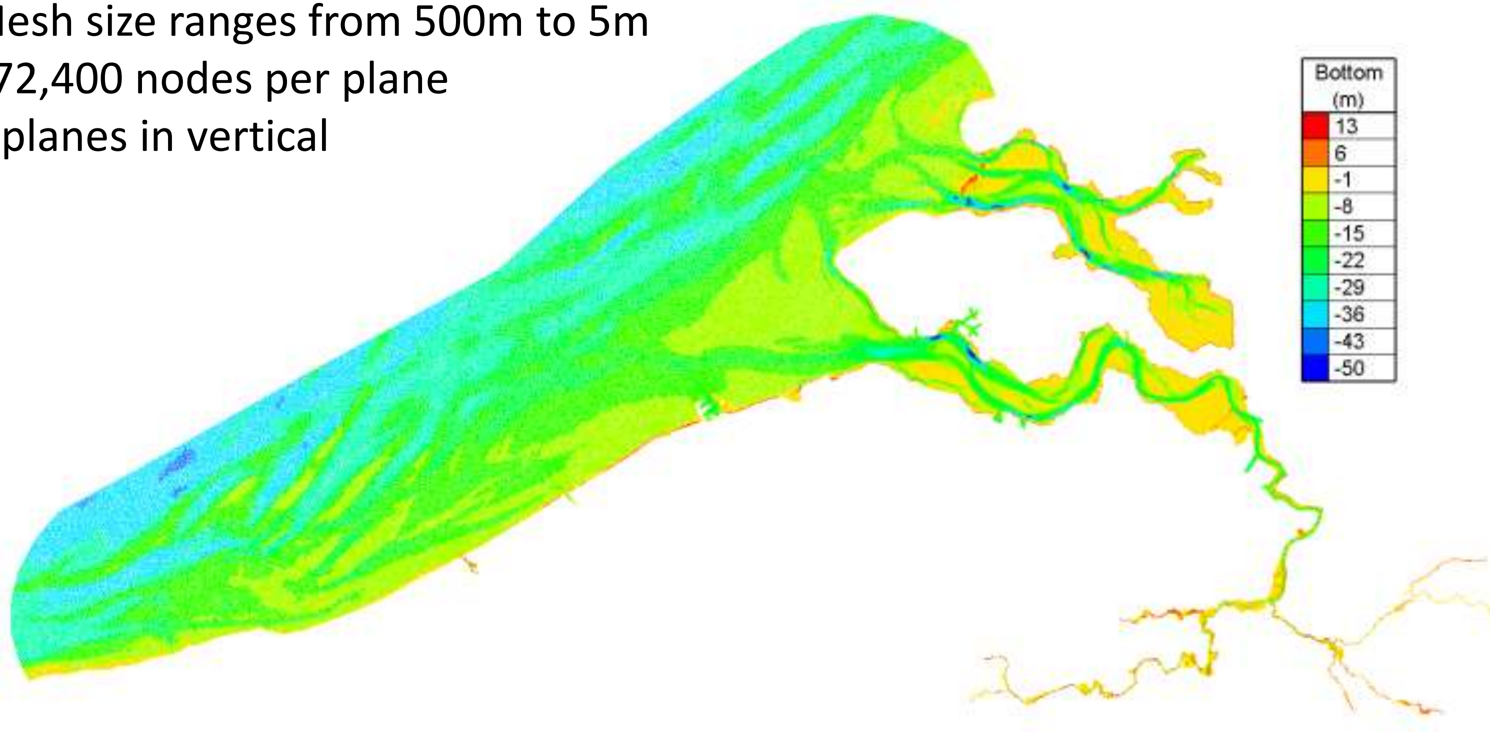
3D Mud Transport Model

- Unstructured mesh
- Mesh size ranges from 500m to 5m
- 472,400 nodes per plane
- 5 planes in vertical



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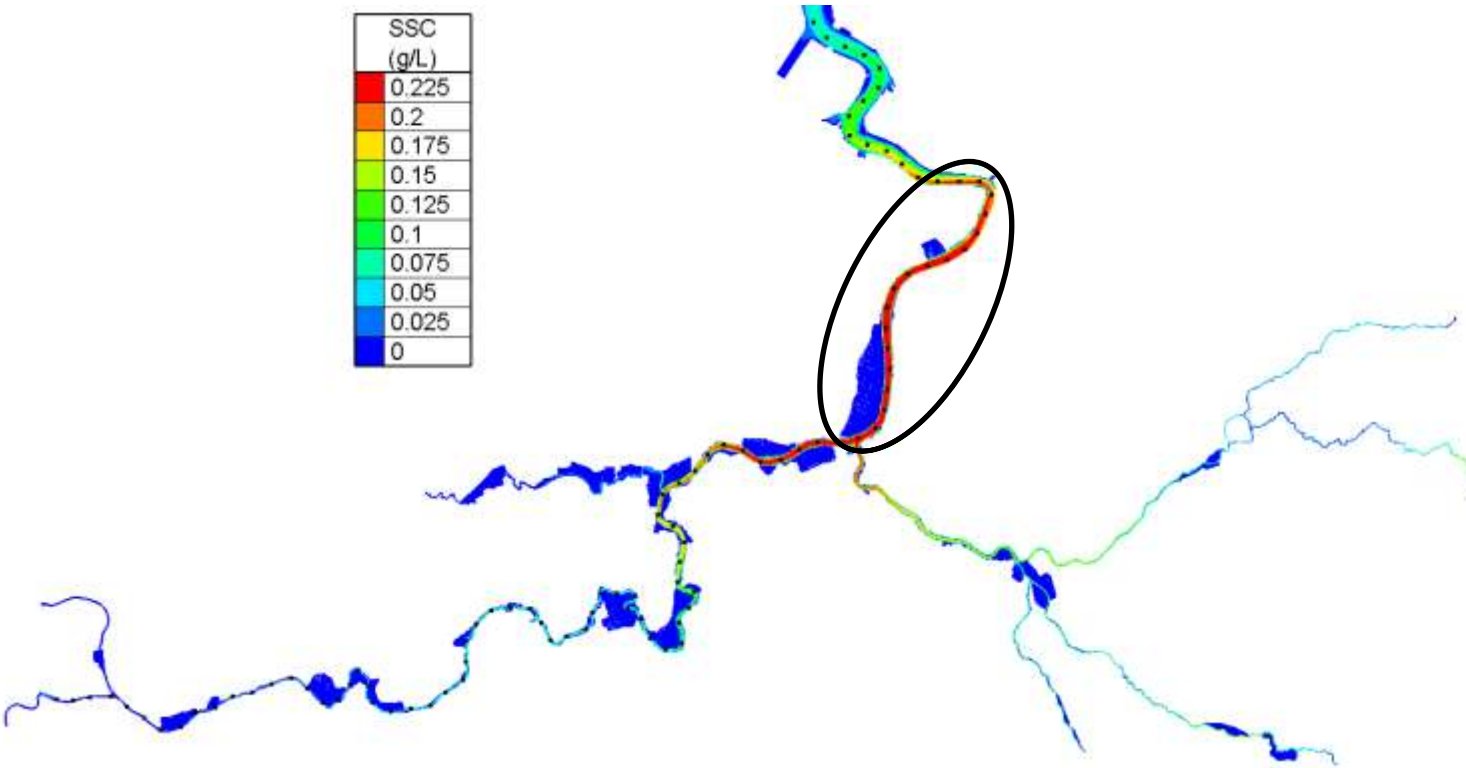
Model Results (SSC)

Mean sediment concentration showing a ETM zone near Antwerp



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Climate scenarios

- **Sea level rise**
  - The "current" situation (CN, +0 cm in 2013);
  - The "low" scenario (CL, +15 cm in 2050);
  - The "high" scenario (CH, +40 cm in 2050).
- **Change of tidal amplitude**
  - tidal amplitude at Schelle 5.40m (current situation A0)
  - tidal amplitude at Schelle 5.00m (future scenario A-)
  - tidal amplitude at Schelle 5.70m (future scenario A+)
- **Increase of the mean upstream discharge by 2050**

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Climate scenarios

Scenario	Discharge	Tidal amplitude	Sea level rise
2013_REF_A0CN	Q2013	A0	CN(2013)
2050_REF_AminCL	Q2050	A-	CL (2050)
2050_REF_AplusCH	Q2050	A+	CH (2050)

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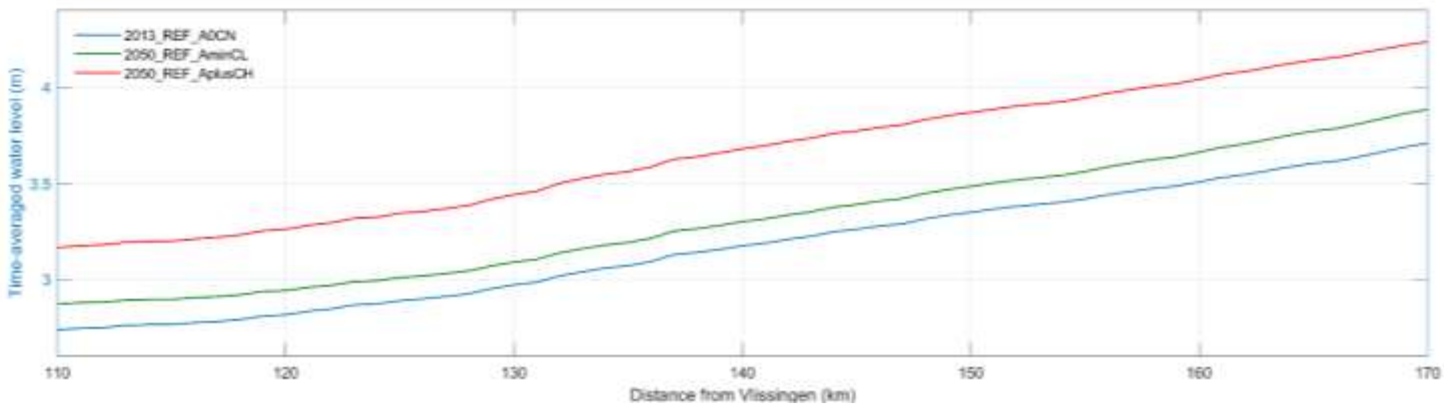
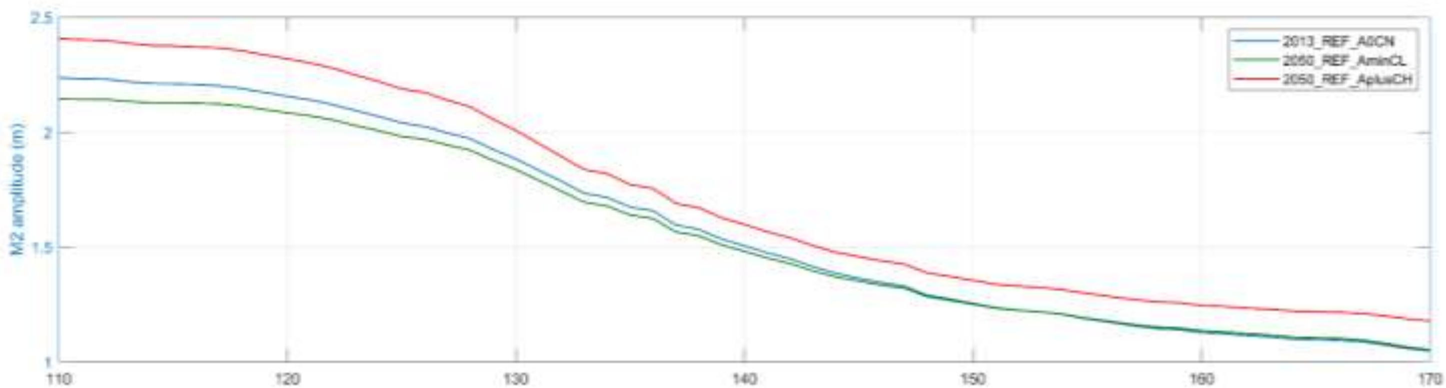
Scenario Analysis

- The sea level rise is well reproduced across the entire domain

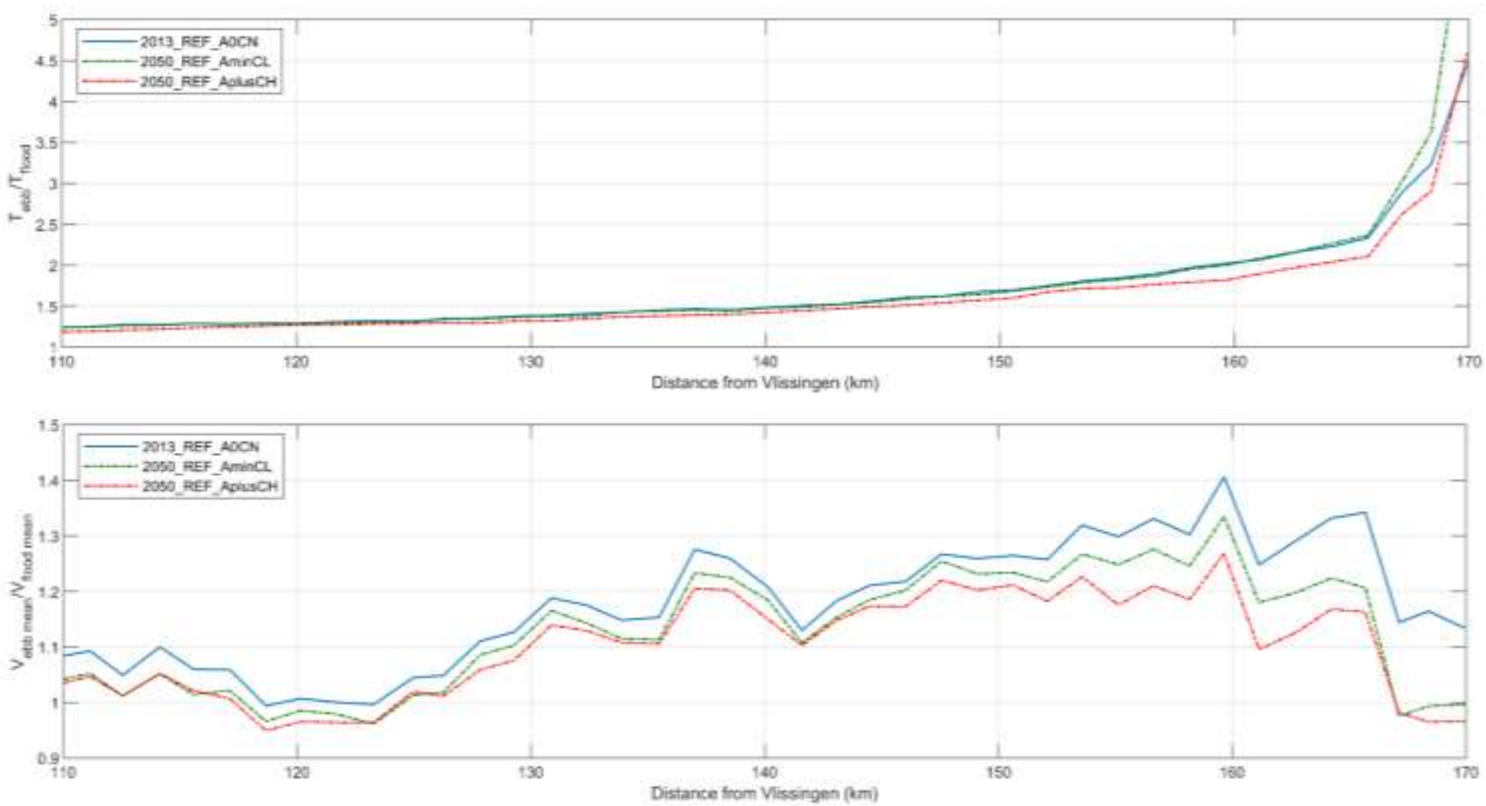


- The increase of Q also impact the tidal amplitude near the upstream boundary



Scenario Analysis

- Sea level rise makes the system less ebb dominant
- Increase of Q increases the ebb dominance near the boundary
- Increase of tidal amplitude makes system less ebb dominant



Scenario Analysis

- **Decomposed sediment transport/flux**
  (uses cross-sectionally averaged quantities for simplicity)

- **Tidally averaged transport** $\langle T \rangle = T_A + T_P + T_R$

- **Transport due to mean flow** $T_A = \langle C \rangle (\langle U \rangle \langle A \rangle + \langle U' A' \rangle)$

  due to tidal pumping $T_P = \langle U' C' \rangle \langle A \rangle$

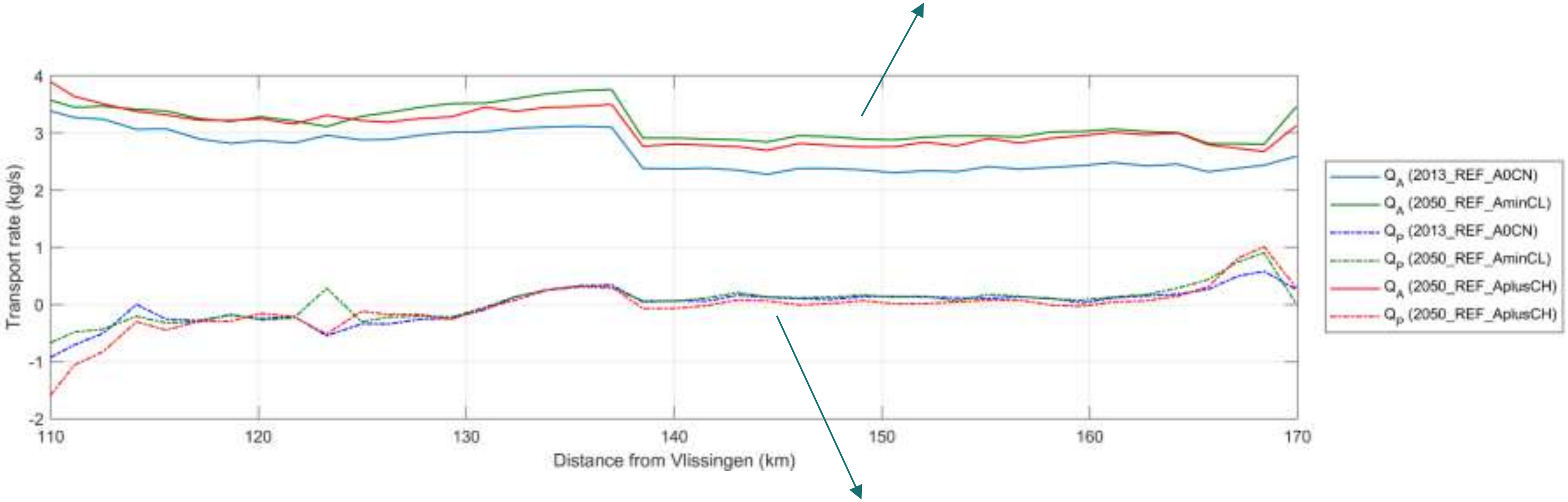
  residual part $T_R = \langle U \rangle \langle C' A' \rangle + \langle U' C' A' \rangle$

- **The decomposed flux** $\langle Q \rangle = Q_A + Q_P + Q_R = \dfrac{T_A + T_P + T_R}{\langle A \rangle}$

Scenario Analysis

- The main transport is through T_A, T_P is only a small fraction in this region
- T_A (and T_{total}) has direction towards downstream, suggesting an ebb system
- Q contributes to both T_A and T_P

T_A



T_P

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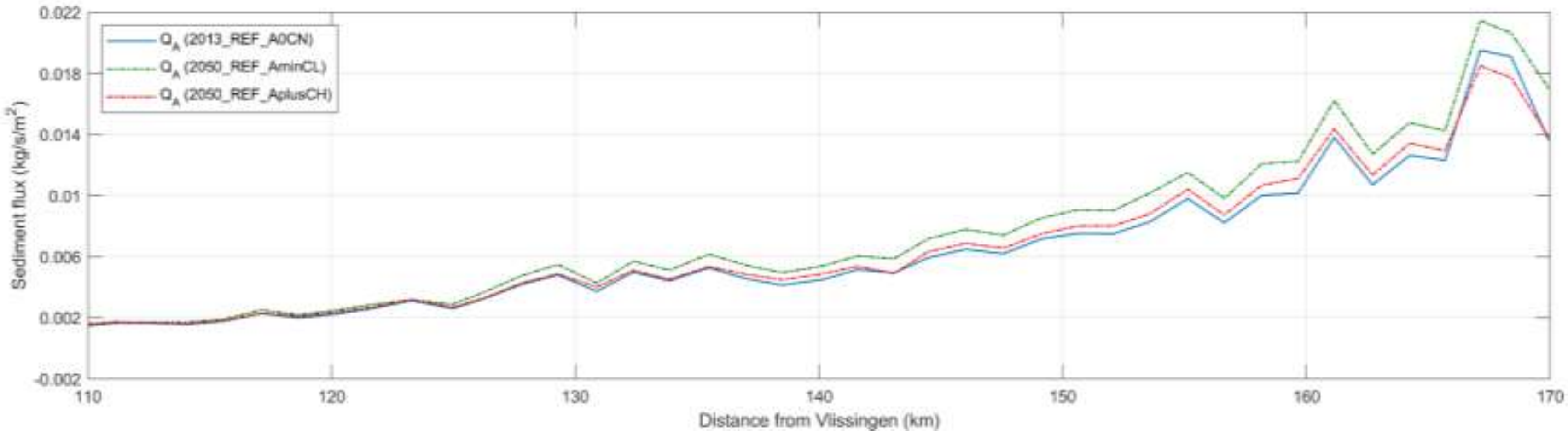
Scenario Analysis



- **Q_A indicates the transport efficiency**
  - Increase Q → more sediment transported downstream
  - Increase tidal amplitude → less sediment transported downstream
  - The effect of increasing Q decays towards downstream as the transect area increase

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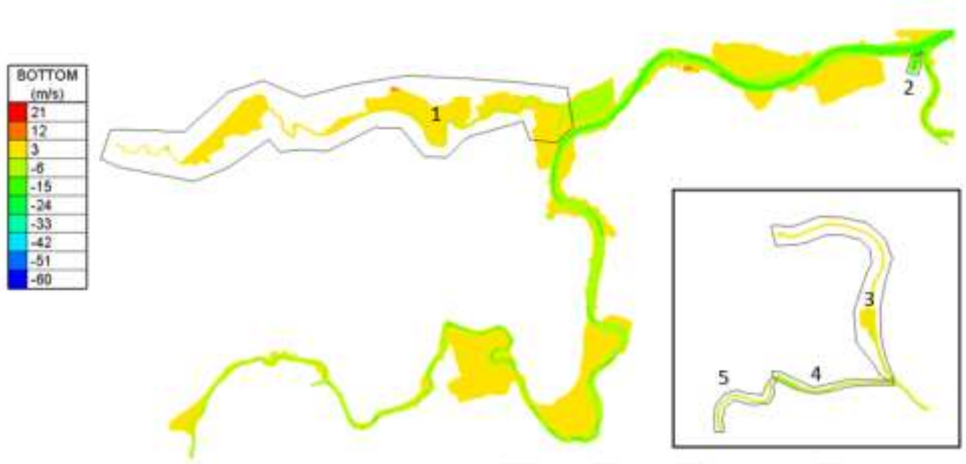
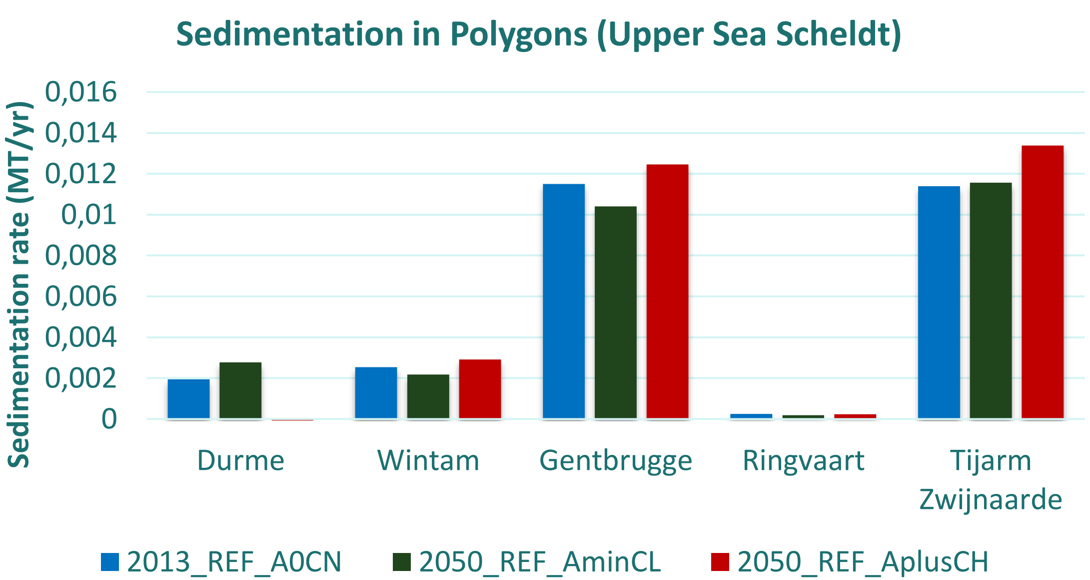
Scenario Analysis



1-Durme, 2-Wintam, 3-Gentbrugge, 4-Ringvaart and 5-Zwijnaarde

A- reduces the sedimentation while A+ increases it, suggesting higher tidal amplitude, less ebb dominant.



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Conclusions

- **Climate change has impact on the mud transport in the Upper Sea Scheldt**
  - Sea level rise tends to reduce the ebb dominance thus could reduce seaward mud transport (based on tidal asymmetry)
  - Increasing the upstream discharge could increase the ebb dominance and seaward mud transport
  - Increasing tidal amplitude could make the system less ebb dominant, reduce the seaward transport and more sedimentation in the upstream

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Thanks for your attention!