Automating sediment budgets with channel recognition

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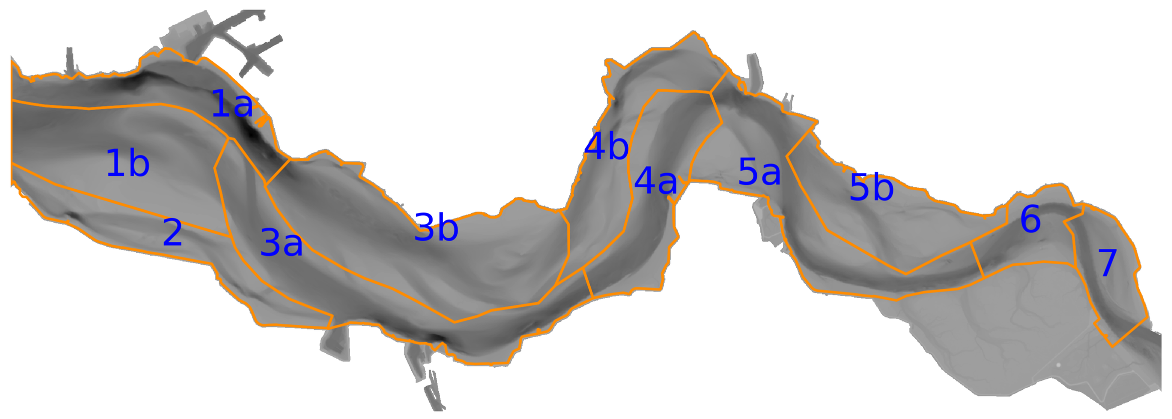
Introduction

Aim: Develop an automated, objective method for sediment budgeting in tidal basins.
Case study: Western Scheldt estuary.

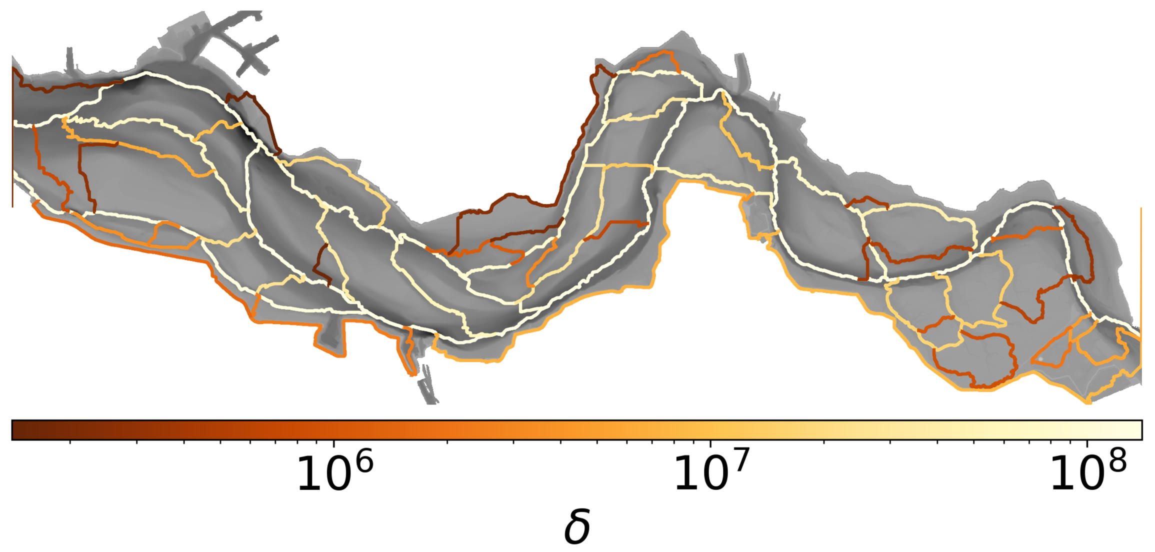
Methods

1. Divide basin into subunits,
2. Quantify sediment volume change per subunit over time,
3. Assess net flow direction in/ out of each subunit.

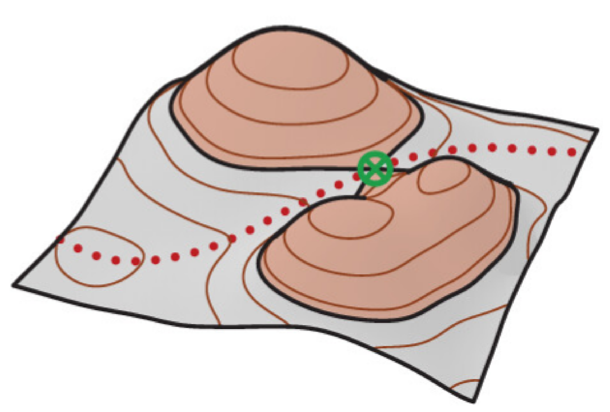
Current method: Divide *manually* into static macrocells [1].



New method: Divide *automatically* using autodetected channel networks [2, 3] per timestep.



Computing the channel network for a given value δ will result in channels that are separated by volume at least δ. Below, the smaller volume is used (Adapted from [2]).

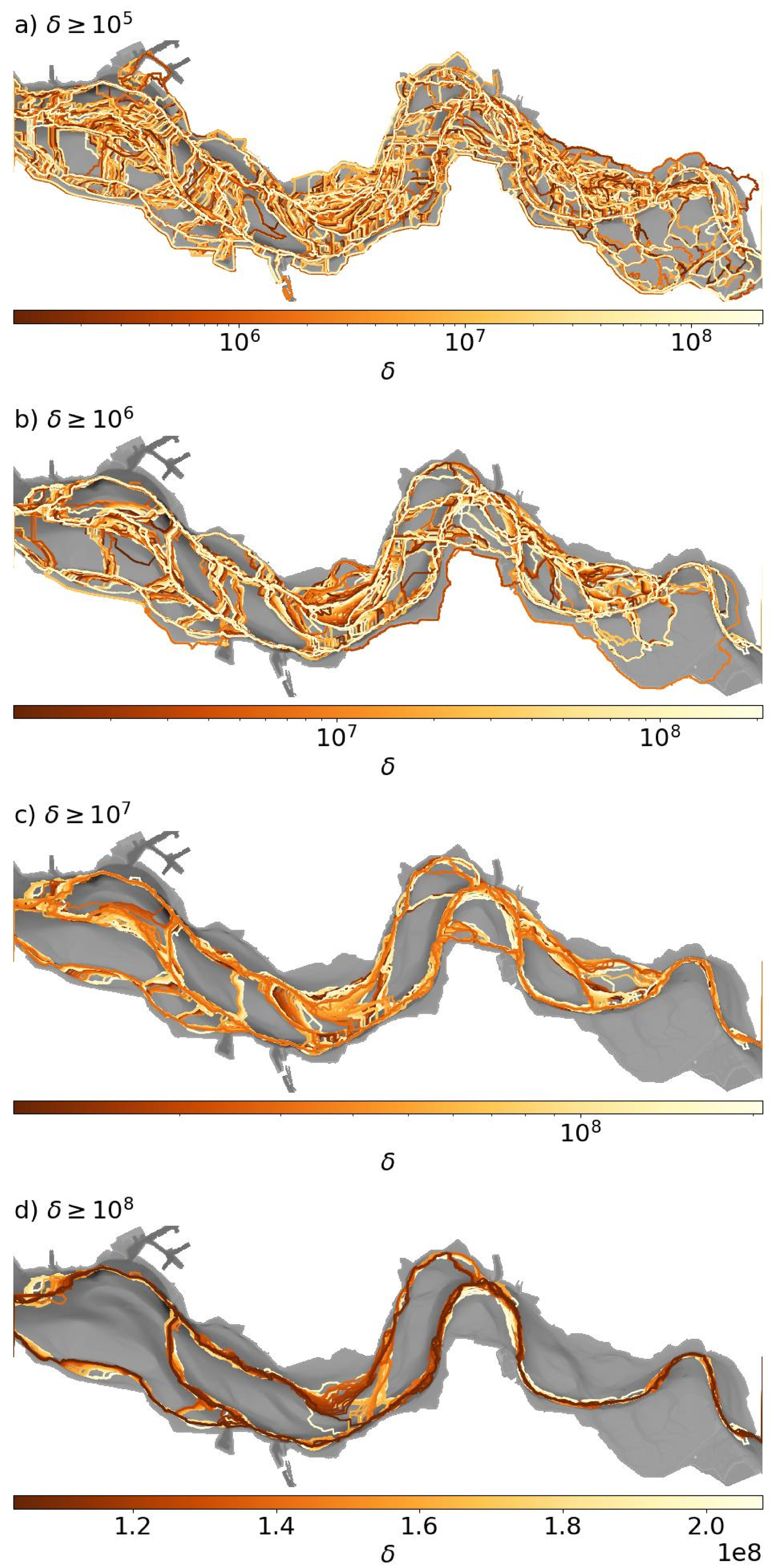


Q1: What network detail needed?

Approach:

1. Combine channels from all timesteps to find areas swept over by channels,
2. Merge channel-dense areas into channel polygon,
3. Remaining polygons are bars.

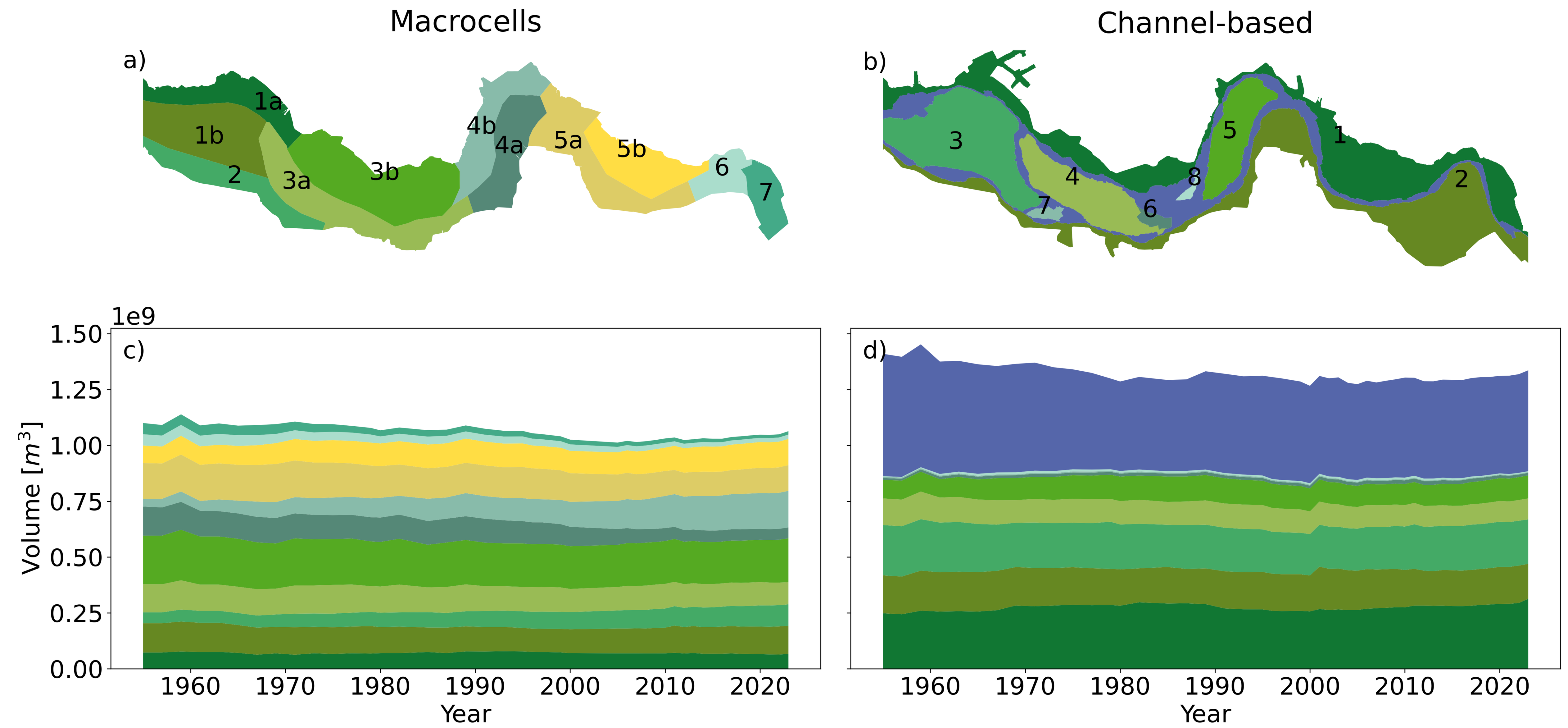
Combined channel networks for different δ thresholds:



Finding: Only $\delta \geq 10^8$ preserves the islands observed at low tide.

Q2: Compare sediment budgets

Comparing sediment budget methods. Top row: subdivision of the Western Scheldt in to **a)** macrocells, and **b)** channel-based polygons (channel area coloured in blue). Bottom row: Sediment volume change over time for **c)** macrocells, and **d)** channel-based polygons; colours correspond to **a)** and **b)**, respectively.



Period	Observation	Discussion
1970-1990	Volume shift from channel to polygon 1, also observed in macrocell 3b	Channel migrating south
2000-2001	Volume increase in polygon 2, absent from macrocells	Shift occurs in Saeftinghe, excluded from macrocells*
Throughout	Volume shift from macrocell 4a to 4b, less obvious in channel-based	Localised investigation needed around polygon 5

*1955 Bathymetry used for Saeftinghe until 2000, the observed change is thus cumulative.

Conclusion

- Channel migration drives many observed changes,
- Increased bar elevation compensated by area decrease [4] = little change in volume,
- Very long bars in channel-based method pose challenge for localising observed changes.

Next Steps

- Quantify changes involved in lateral channel dynamics vs. vertical bar dynamics,
- Compare temporal variation in budgets as a function of δ,
- Quantify channel network properties.

References

[1] E. P. L. Elias, A. J. F. V. d. Spek, Z. B. Wang, J. Cleveringa, C. J. L. Jeuken, M. Taal, and J. J. V. d. Werf, "Large-scale morphological changes and sediment budget of the Western Scheldt estuary 1955–2020: the impact of large-scale sediment management," *Netherlands Journal of Geosciences*, vol. 102, Jan. 2023.

[2] W. Sonke, M. G. Kleinhans, B. Speckmann, W. M. van Dijk, and M. Hiatt, "Alluvial connectivity in multi-channel networks in rivers and estuaries," *Earth Surface Processes and Landforms*, vol. 47, no. 2, pp. 477–490, 2022.

[3] W. Sonke, "tue-alga/topotide: 2.1.0," Apr. 2025.

[4] W. M. van Dijk, J. R. Cox, J. R. F. W. Leuven, J. Cleveringa, M. Taal, M. R. Hiatt, W. Sonke, K. Verbeek, B. Speckmann, and M. G. Kleinhans, "The vulnerability of tidal flats and multi-channel estuaries to dredging and disposal," *Anthropocene Coasts*, vol. 4, pp. 36–60, Jan. 2021.