The exciting influence of shoal margin collapses on the morphodynamics of the Western Scheldt Estuary

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Introduction

Channel bank failure and collapses of shoal margins have been recorded systematically in Dutch estuaries for the past 200 years (Wilderom 1961-1979). In many locations collapses reoccur at intervals of several years to decades. The effects of these collapses on the morphodynamics of estuaries are unknown.

Objective:

Investigate how **locations, probability, grain-size, type and volume** of channel/ shoal margin collapse affect the **morphodynamics** at the **channel-shoal scale**.
Analyse the **near-field morphodynamics** and **far-field** effects on **flow pattern** and **channel-bar morphology**

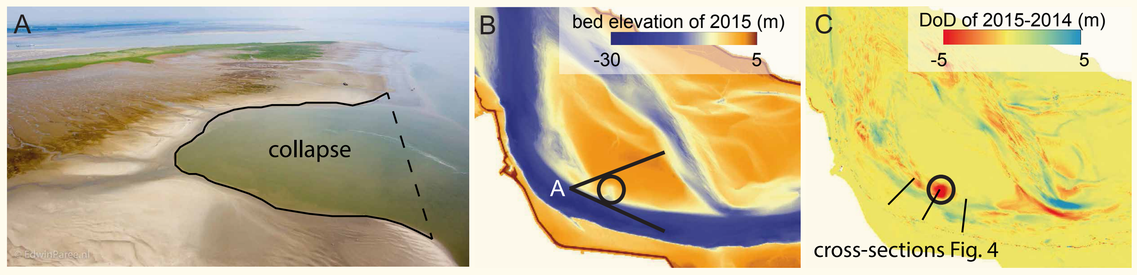


Fig. 1) Shoal margin collapse of July 2014 that eroded **800,000 m³** of the tidal flat of Walsoorden (A). Yearly bathymetry measurement of 2015 (B). DEM of Difference of 2014-2015 illustrates the location of the 2014 collapse (C).

Volume of shoal margin collapses

- Sediment from the **larger** collapses are spread **over longer distances**
- **Larger** collapses show **tens of centimeters variation** of the mean bed elevation, compared to **centimeters** for **smaller** collapses.

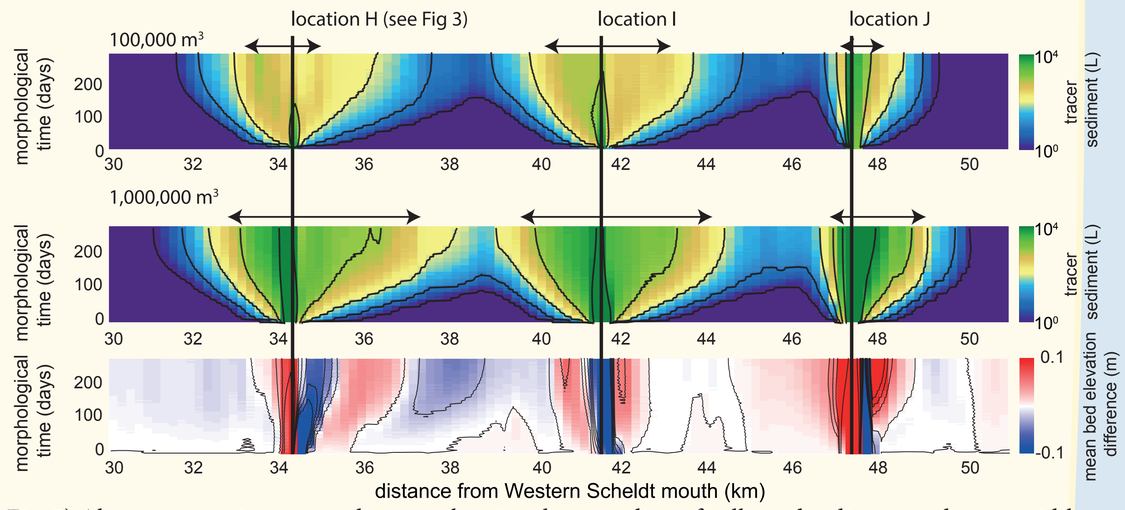


Fig. 5) Along estuary time-space diagram showing the spreading of collapsed sediment and mean width-averaged bed elevation difference between run with and without the large collapses.

The Western Scheldt estuary

- **Multi-channel** system (ebb- and flood-dominated channels)
- **Tidal prism 1 billion m³, tidal range 3.5-5 m**
- **Tidal assymetry**, slower but longer ebb flows
- Yearly-averaged **river discharge** of the Scheldt is **120 m³/s**
- Relative fine sediment, **150-300 µm**

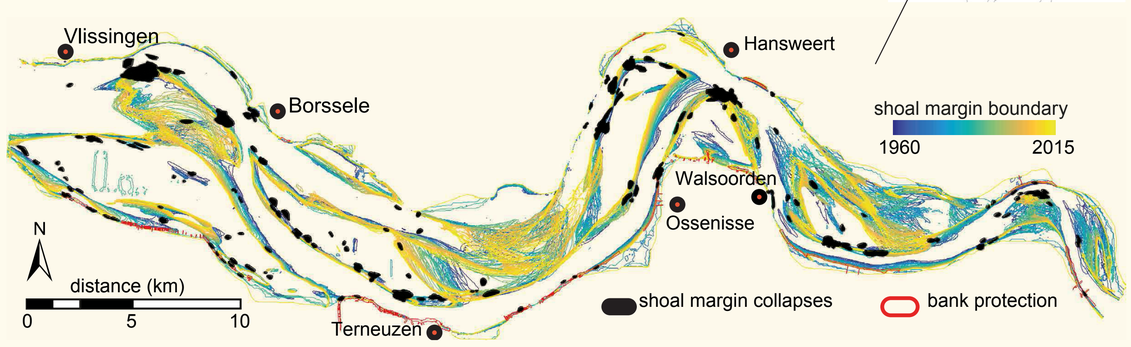
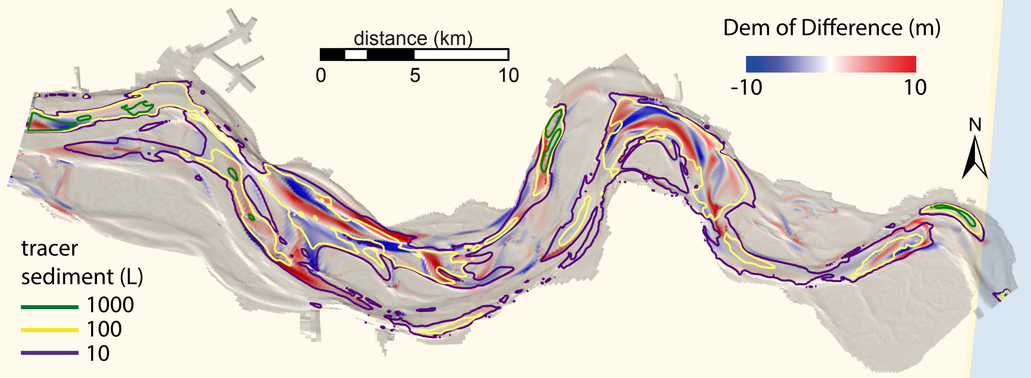


Fig. 2) **Shoal margin migration** map shows that shoal margin collapses occur at shoal margins that **do not migrate laterally (Van Dijk et al. Subm)**.

Location of shoal margin collapses

- **Spreading** of the collapsed material is **not throughout** the estuary (see 25 km).
- Even **without collapsed sediment** the morphology varies between the 2 runs.
- **Migration** of disturbance is dominant in **one direction,** depending on
  - **Flood**-dominated channel **(secondary channel), or**
  - **Ebb**-dominated channel **(main channel).**
- Less spreading in the secondary channel (e.g. locations E and F).



Methodology

- **Delft3D model** schematisation (nested from the NeVla model).
- **2 years** hydrodynamic simulation; morphological acceleration factor of **20**.
- Van Rijn et al. (2004) transport formula.
- Compare run **with** against a run **without** shoal margin collapses.
- Tested 3 scenarios: - **Grain-size** of the collapsed deposit (100, 200 and 300 µm)
  - **Volume** of the collapse (100,000 and 1,000,000 m³)
  - **Location** of the shoal margin collapse

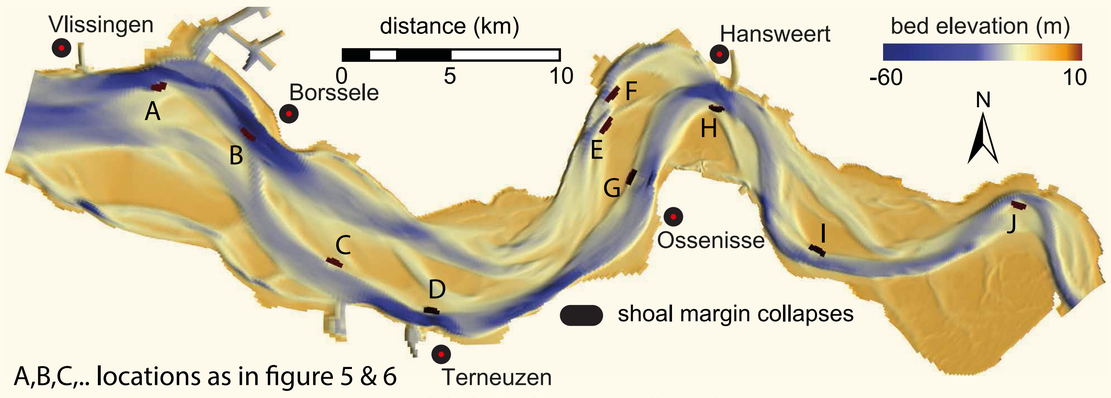


Fig. 3) **Modeled** shoal margin collapse locations

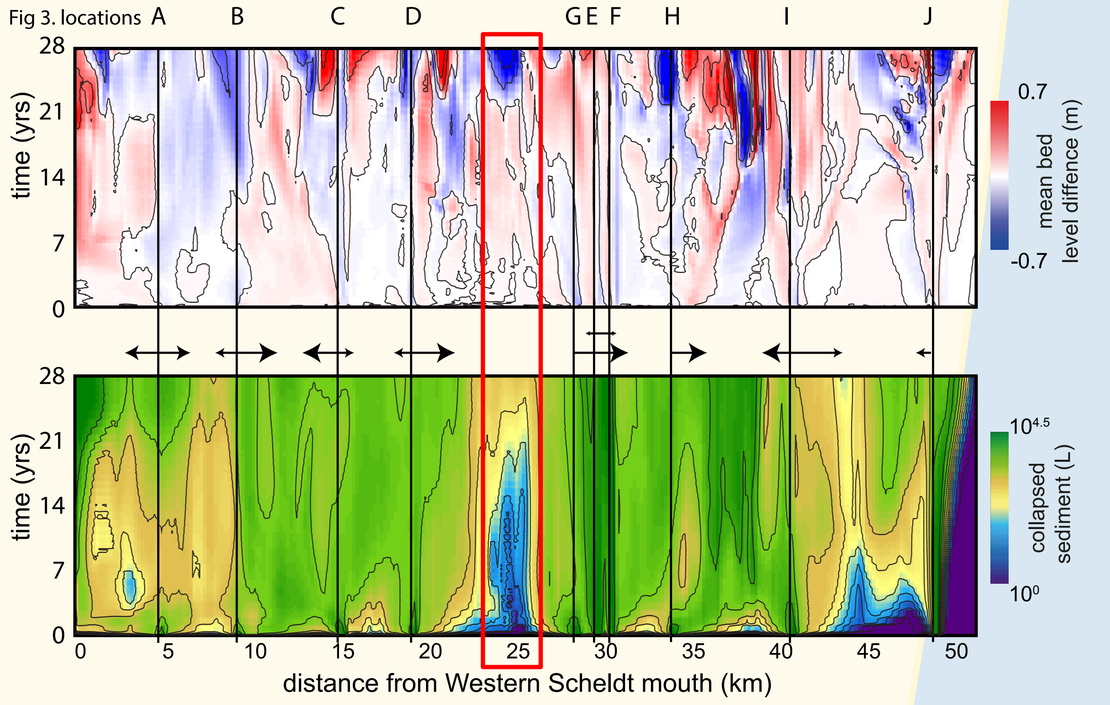


Fig. 6) DEM of Difference shows the difference between run with and without collapses after 28 yrs, and contours indicate distribution of the tracer sediment. Along estuary time-space diagram of the mean bed elevation and collapsed sediment spreading, with indicated disturbance direction for 10 locations.

Effect of deposited grain size in the channel

- Finer material **spreads faster** and **deposits** at the **channel flanks**.
- **Finer material** is predominantly transported **seaward** following the **residual current.**
- **Coarser material** is predominantly transported **landward** due to the **tidal asymetry.**

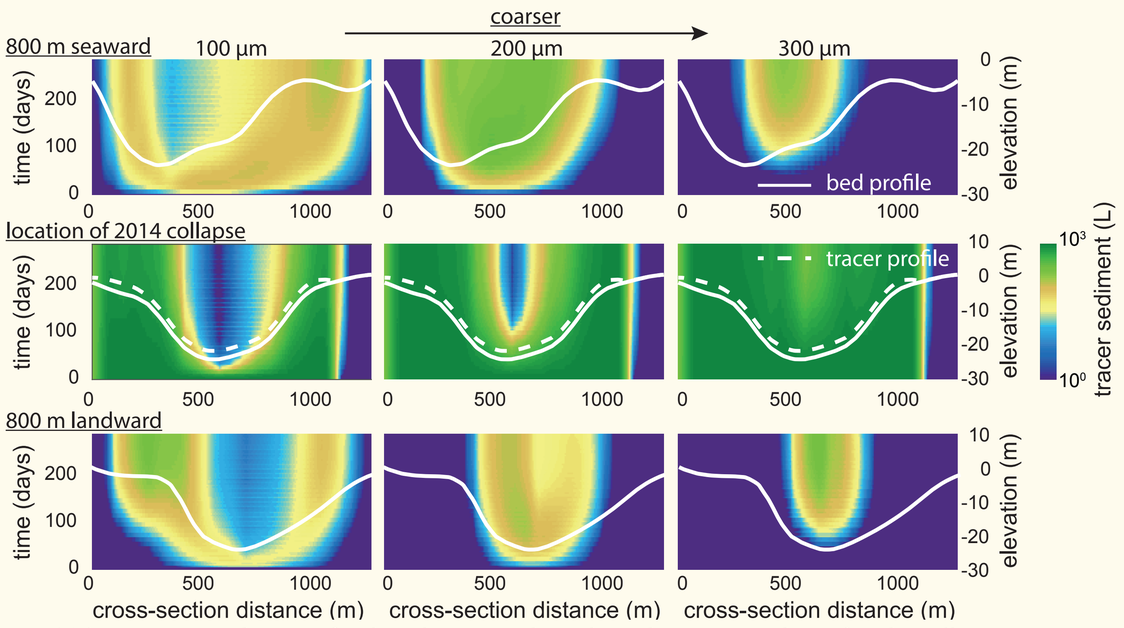


Fig. 4) The space-time diagram for three locations show the sediment spreading after the collapse.

Conclusions

Shoal margin collapses **excite the channel network** of sandy estuaries.
Volume of the collapse as well as **grain-size** determine **magnitude** and **direction** of the disturbance.
Short-term: the **morphodynamics** are affected by changing bed elevation in **longitidunal direction** but not in transverse direction. **Residual currents** were not affected by the collapses.
Long-term: the disturbance **stimulate** morphological changes, especially when the disturbance reaches a **channel junction** affecting the bed elevation in **transverse direction** as well.

Next: **Implementation of shoal margin collapse rules in Delft3D** to test if continuous collapses increase the dynamics of channel-shoal interactions.
Hypothesise that collapses **dynamices** the estuarine morphodynamics.

References & acknowledgements

Wilderom (1979), Resultaten van het vooroeverondervoor langs de Zeeuwse stromen (in Dutch). Technical report, Rijkswaterstaat, 1979. Nota 75.2.
Van Dijk et al. (Subm.), Probability and causes of shoal margin collapses in sandy estuary. to Earth Surface Processes and Landforms.
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