Vici project Turning the tide: dynamics of channels and shoals in estuaries with sands and mud

Maarten G. Kleinhans, Lisanne Braat, Anne W. Baar, Jasper R. F. W. Leuven
m.g.kleinhans@uu.nl, l.braat@uu.nl, a.w.baar@uu.nl, j.r.f.w.leuven@uu.nl

Universiteit Utrecht
Faculty of Geosciences
Research group
River and delta morphodynamics



Project summary

Tidal systems such as the Scheldt, Humber and Columbia estuaries and Wadden seas in Florida and the North Sea, have perpetually changing and interacting channels and shoals formed by ebb and flood currents. Current models fail to forecast these natural dynamics. Yet main channels are economically important shipping fairways, whilst shoal areas that emerge and submerge daily are ecologically valuable habitats under threat of dredging, dumping and sea level rise. Our aim is to investigate and forecast how channel-shoal dynamics in estuaries result from geomorphological processes and human interference.

Figure 1. Aerial photograph Dovey (Dyfi) estuary

Hypotheses

- **Channel- and shoal-margin collapses and current-driven sand transport on sloping channel beds cause the dynamics of channels and shoals,**
- **whilst break-down of shoals is balanced by resistant cohesive mud layers.**
- **bifurcating channel network propagates and possibly amplifies small-scale disturbances by collapses and dredging through the system into neighbouring reaches.**

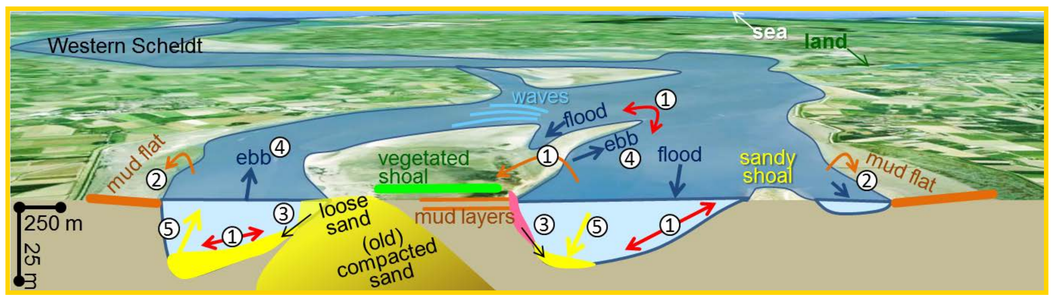

Figure 2. Local-scale processes: **1**) Bed slope effect on sediment transport by currents, modified by waves, and effect on channel bifurcations. **2**) Mud deposition on shoals, mud flats and marsh. **3**) Channel margin collapse by bank failure, liquefaction of loose sand, or dense sand breaching. Large-scale channel-shoal interactions: **4**) Formation of mutually evasive ebb- or flood-dominated channels in the network. **5**) Large local perturbations propagate to adjacent reaches.

Understanding channel-shoal dynamics in estuaries

How are large-scale morphodynamics of tidal channels and shoals caused by the small-scale balance of local slope processes and mud settling?

PhD – Anne Baar

Aim 1: Transverse slopes
Effects of bedforms, suspension and particle sizes

Experiments in annular flume

Submodel transverse bed slope effects

PhD – Lisanne Braat

Aim 2: Mud layers
Effects of cohesive mud layer formation

Experiments in tilting flume

Numerical modelling in Delft3D

PhD – Jasper Leuven

Aim 3: Channel network
Effects of disturbances by dredging, dumping and river input

Analysis toolbox

Aim 4: Bank and shoal margin collapses

Models and scenarios

Utilisation

- Ecology
- Petroleum industry
- Dredging industry

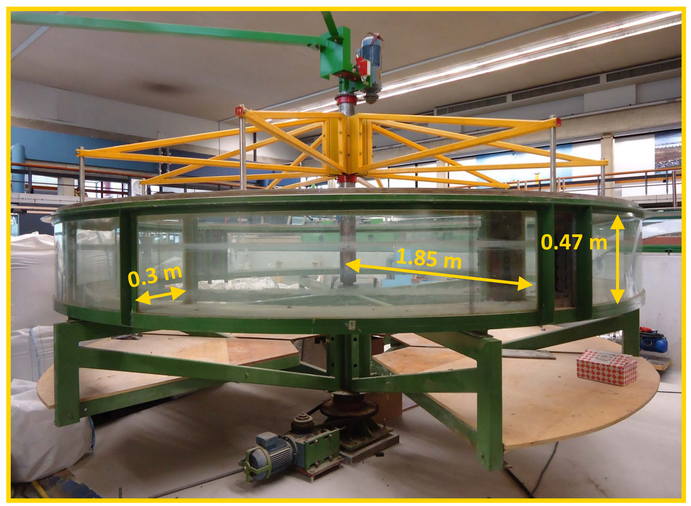

Figure 3. Annular flume at TU Delft

Figure 4. Placing of the 'Metronome', a novel experimental tilting flume to create dynamic tidal systems

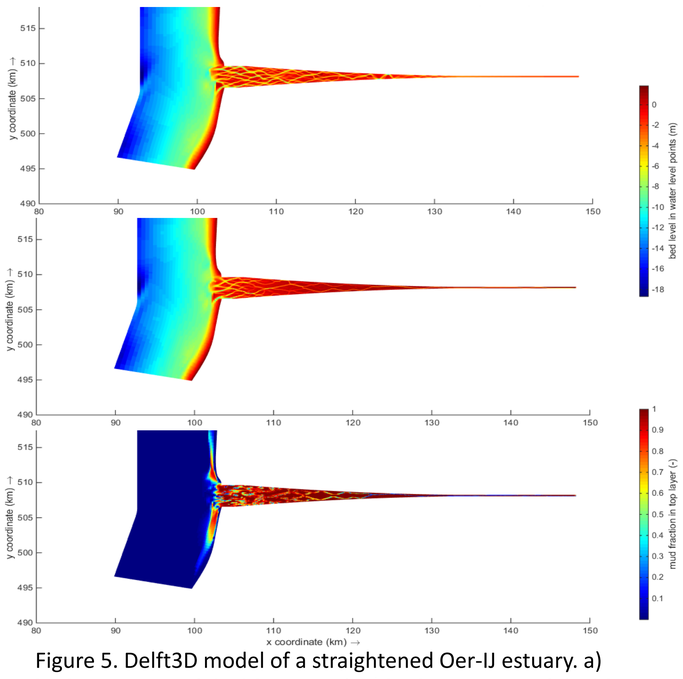

Figure 5. Delft3D model of a straightened Oer-IJ estuary. a) bathymetry, model without mud, b) bathymetry, model with mud influx, c) mud fraction top layer, model with mud influx

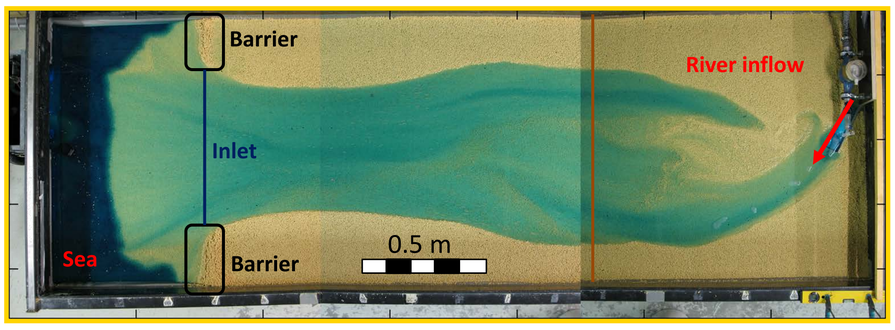

Figure 6. Pilot experiment in small tilting flume

Figure 7. Arrival of the Metronome

Funding

Vici grant (2014), 5 year funding from the Netherlands Organisation of Scientific Research (NWO, STW), Innovational Research Incentives Scheme, www.nwo.nl/vi
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Design and construction of the Metronome: Fysisch Geografisch Laboratorium, Consmema, Variodrive

Collaboration

Deltares, Netherlands Center for Coastal Research (NCK), Rijkswaterstaat Zeeland, NOIZ (Yerseke), Bureau of Economic Geology, University of Texas (USA)
TU Delft University of Technology, University of Genova (Italy), University of Cantabria (Spain), University of Antwerp (Belgium)
Wetenschapsknooppunt for elementary school children (Science Hub), www.uu.nl/wetenschapsknooppunt

Enabling new technology

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