EP31C-1021
also see talk
Wedn afternoon
EP34B-04

Turning the tide: estuarine bars and mutually evasive ebb- and flood-dominated channels

Maarten Kleinhans, Jasper Leuven, Maarten van der Vegt, Anne Baar, Lisanne Braat, Laura Bergsma, Steven Weisscher

Universiteit Utrecht
Faculty of Geosciences
River and delta morphodynamics
m.g.kleinhans@uu.nl
www.geo.uu.nl/fg/mkleinhans

PI: Maarten Kleinhans

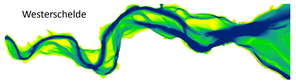
Problem definition

No descriptive taxonomy and forecasting model for perpetually changing and interacting channels and shoals formed by ebb and flood currents in estuaries.

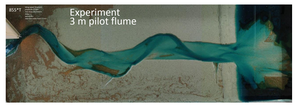
- Bar dimensions explained by width-depth ratio as river bars?
- Apparent stability of ebb- and flood channels explained by the inherent instability of symmetrical channel bifurcations as in rivers?

Methods

- Remote sensing data of bars in estuaries
- Linear stability model for tidal (and river) bar dimensions

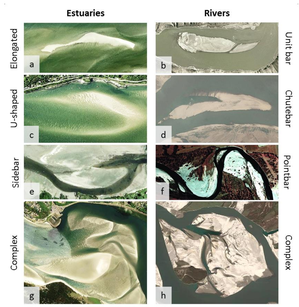


- Numerical modelling (Delft3D)
- Experiments in a novel tidal facility: the Metronome



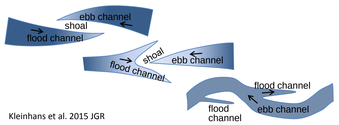
Measured bar dimensions

- Bar length/width has universal ratio in rivers+estuaries
- Complex bars are amalgamated elongated bars with ebb/flood-dominated channels

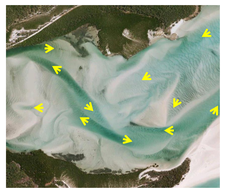


Ebb- and flood-dominated channels

- Mutually evasive channels
- Channels often end in shoals
- Periodic behaviour?

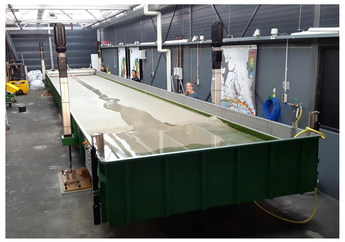


Kleinhans et al. 2015 JGR

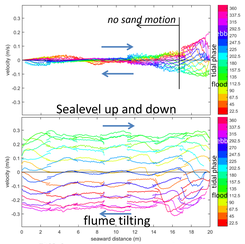


The Metronome tidal facility... why it works

Raising and dropping sealevel to generate tides gave poor experiments in the past 130 years because the tide does not get far upstream. By tilting the flume, ebb and flood flows move the sand all along the experimental estuary, just like in nature.



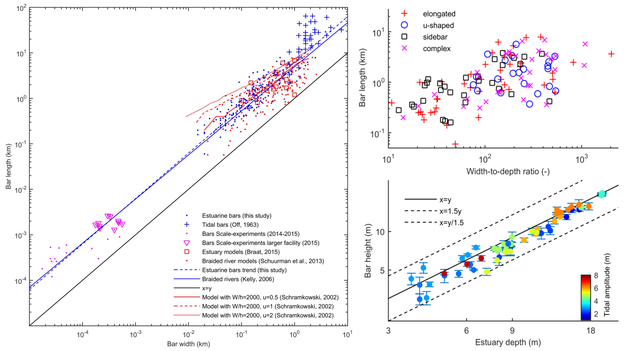
Dimensions: 20 m long, 3 m wide



PIV measurements

Bar theory compared to measurements

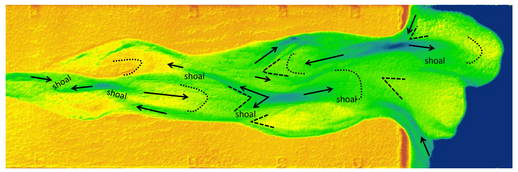
- Theories: Schramkowski & al. (2002), Seminara & Tubino (2001), and Struiksma et al. (1985) for rivers
- Their hypotheses: bar braiding scales best with width/depth ratio; bar length determined by tidal excursion length (peak velocity)
- Our findings: bar length scales best by estuary width; braiding index also depends on width/depth ratio; secondary effect of tidal flow velocity
- Bar height from bathymetries approximates average water depth



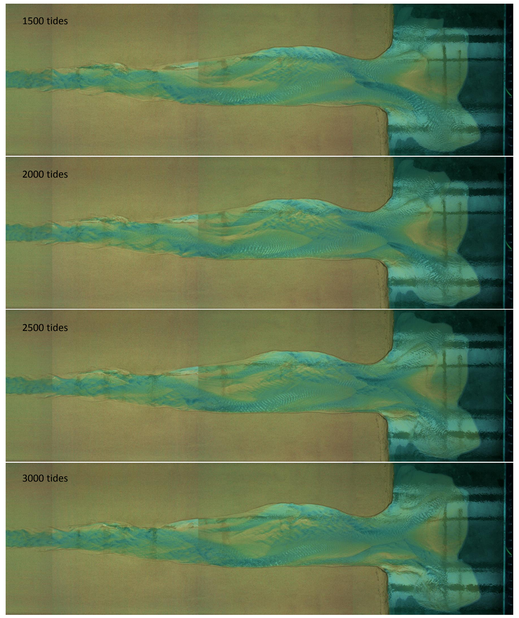
Channel-shoal interactions

From experiments in the Metronome:

- Mutually evasive ebb- or flood-dominated channels ubiquitous in all conditions with mobile sediment
- Two styles of formation:
  * flood-channel cutoff (like a chute) through ebb-dominated bend
  * scoured channel forms U-shaped / lobate bar, which is sharpened by the opposite current bifurcating around it
- Periodic behaviour: small bars shed from large bar as sediment pulse fed by bar erosion by opposite current



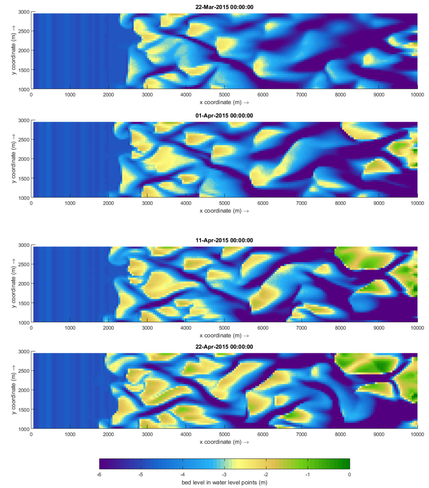
Experiment: 0.01 m/m slope, 30 s period



Channel-shoal interactions

From idealised scenarios in Delft3D (3m amplitude):

- System width determines braiding index
- flood channels form U-shaped / lobate bars; more so when sourced by scouring channels
- Some flood channels are chute cutoffs
- U-shaped / lobate bars are channel termini; direction depends on / cauyses flood/ebb dominance?



A look forward

- ERC and STW projects 2014-2020
- 6 PhDs, 4 Postdocs, technicians, PI
- Themes:
  - channel-shoal interactions, also with mud
  - eco-engineering species
  - Holocene development of NW European estuaries
- Approaches:
  - model improvement+extensions Delft3D
  - experimentation in the Metronome
  - querying geological data and reconstructions
  - pattern characterisation in remote sensing data
- Dissemination:
  - primary education outreach with experiments
  - stakeholders involved
  - annual Christiaan Brunings Lecture www.uu.nl/bruningslecture

funding:
STW Enabling new technology
erc European Research Council Supporting top researchers from anywhere in the world