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

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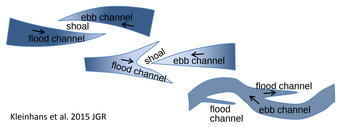
## Problem definition

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

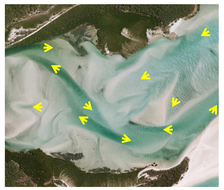
- Are bar dimensions explained by width-depth ratio as river bars?
- Is the apparent stability of ebb- and flood channels explained by the inherent instability of symmetrical channel bifurcations as in rivers?

## Ebb- and flood-dominated channels

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

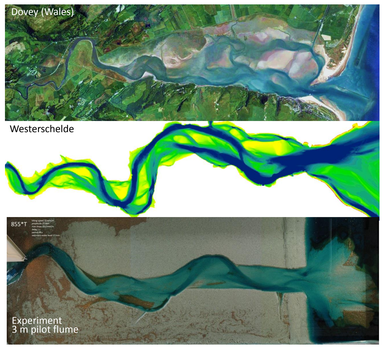



Kleinhans et al. 2015 JGR



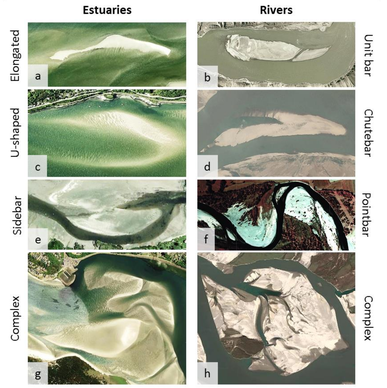
## Methods

- 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



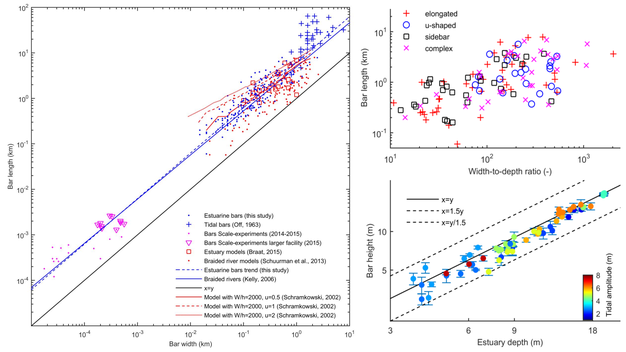

## Measured bar dimensions

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




## 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

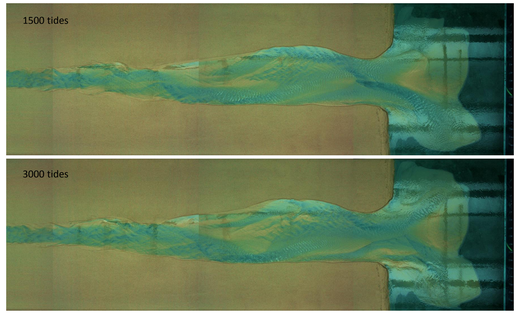


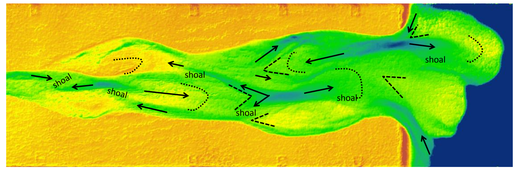

## Pilot scale-experiments

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


Experiment: 0.01 m/m slope, 30 s period




## Channel-shoal interactions

- Mutually evasive ebb- or flood-dominated channels ubiquitous in all conditions with mobile sediment
- Two styles of formation:

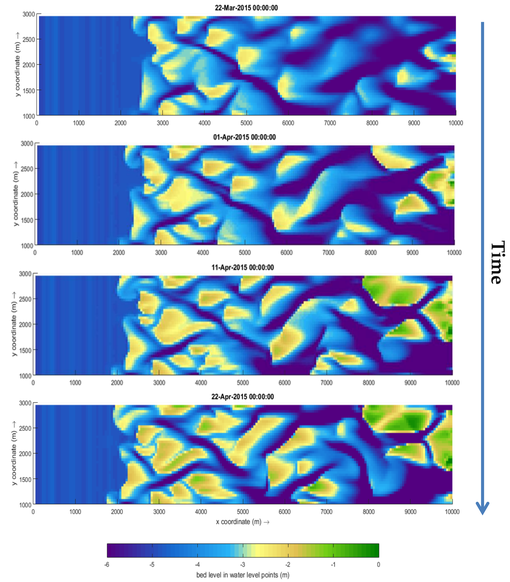
1. Channel cutoff through ebb-dominated bend

2. Channel forms U-shaped bar, which is sharpened by the opposite current bifurcating around it

## Numerical modelling

From idealised scenarios in Delft3D (3m amplitude):

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




## A look forward

- How do bar patterns relate to estuary shape?
- How can we predict bar dimensions?
- Scale bar dimensions with estuary dimensions and/or tidal properties?
- Are similar results found for experiments and models as for natural systems?
- What drives the dynamics of channels and shoals, such as the occurrence of mutually evasive ebb- or flood-dominated channels?

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