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

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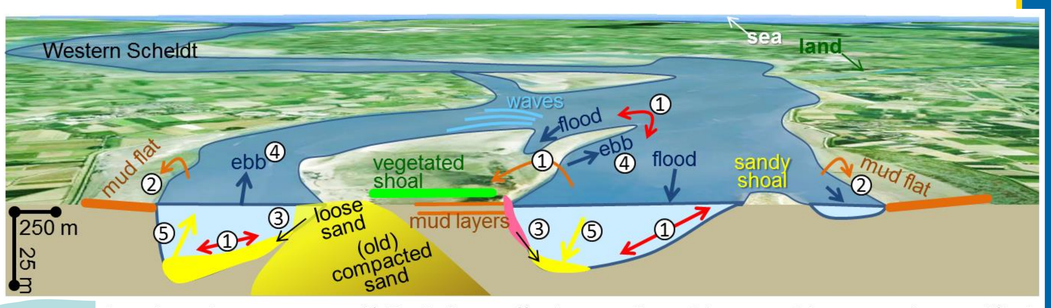
River and delta morphodynamics

## 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. My aim is to investigate and forecast how channel-shoal dynamics in estuaries result from geomorphological processes and human interference.

## Hypotheses

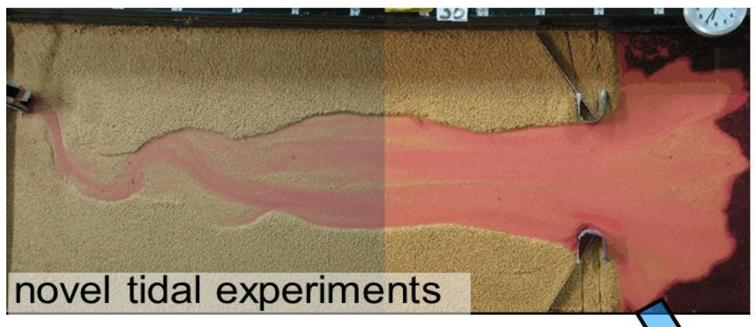
- channel- and shoal-margin collapses and current-driven sand transport on sloping channel beds cause the dynamics of channels and shoals,
- whilst break-down of shoals is balanced by resistant cohesive mud layers.
- bifurcating channel network propagates and possibly amplifies small-scale disturbances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

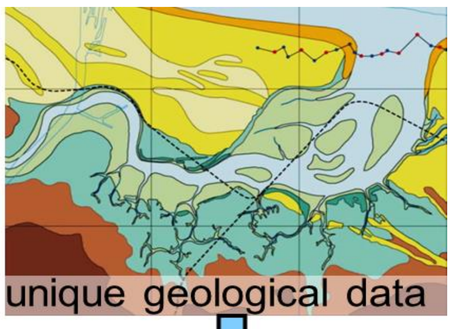


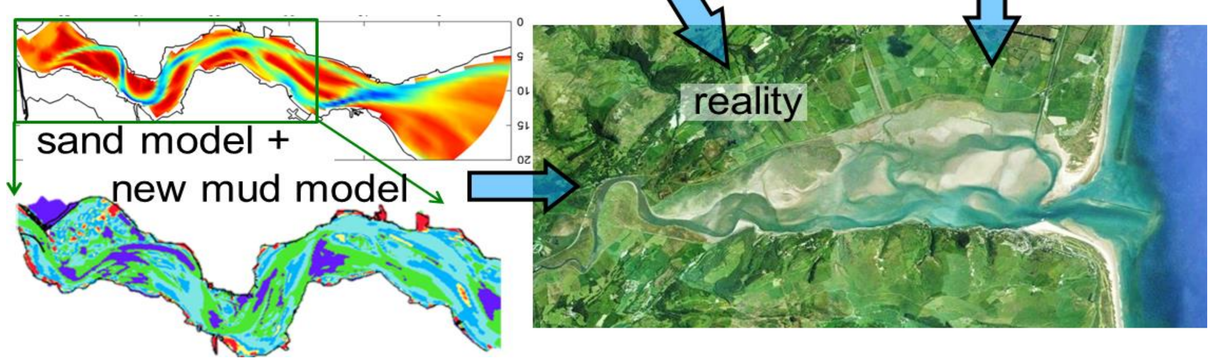

. Local-scale processes: **1**) Bed slope effect on sediment transport by currents, modified by waves, and effect on channel bifurcations. **2**) Mud deposition on shoals, mud flats and marsh. **3**) Channel margin collapse by bank failure, liquefaction of loose sand, or dense sand breaching. Large-scale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

## Complementary approaches

- create experimental scale models in a unique tidal laboratory facility based on my pilot setup that forms sustained-dynamic tidal channels and shoals
- develop three critical model components for a state-of-the-art numerical model and validate on detailed data of Western Scheldt and Wadden Sea:
  1) sand transport on gentle channel slopes, based on recent theory and new rotating-flume experiments,
  2) mud layer formation, based on recent model advances, and
  3) large bank collapses, based on geotechnical modelling and historical data.




## Project organisation for 2014-2020

Aims 4 and 5. **Large-scale dynamics in channel bifurcations in networks**

Aim 1. **Mud layers** | Aim 2. **Transverse slopes** | Aim 3. **Collapses**

PhD1: **slip-sliding away:** experiments in annular flume & geotechnical modelling

PhD2: **Channel-shoal interaction:** numerical modelling Delft3D

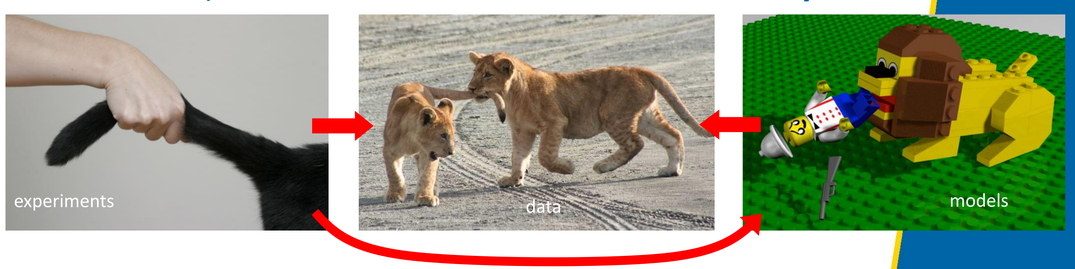
PhD3: **Channel-shoal interaction:** experiments in tilting flume

**Utilisation**

Postdoc2. *Petroleum industry:* **bar dimensions and stratification**

Postdoc1. *Dredging industry and ecology:* **test case dredging/dumping network propragation of disturbances**

### In other words, we "twist the lion's tail" in a non-lethal way



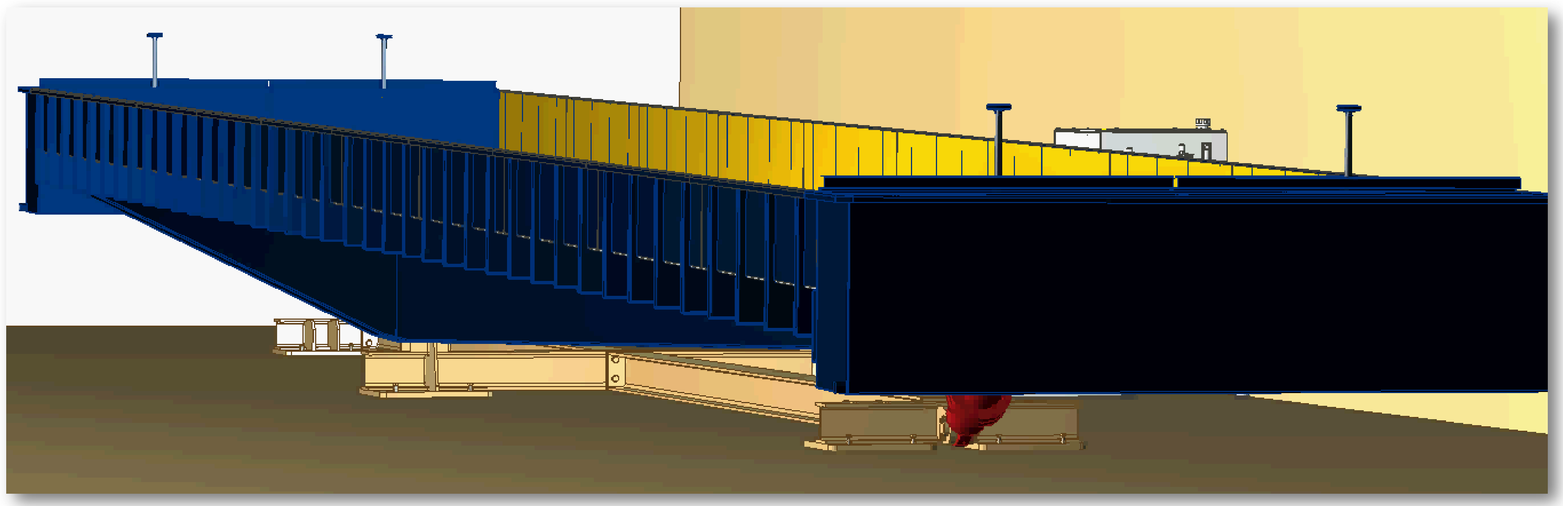

## Flagship: a novel experimental setup that creates dynamic tidal systems

**A periodically tilting flume causes bidirectional tidal currents and self-formed tidal systems. Pilots showed that this creates dynamic, short tidal basins and estuaries with tidal bars and mutually evasive ebb and flood channels.**

New facility, commissioned in 2014:

- Dimensions: 20x3x0.4 m, which fits one tidal wavelength for typical water depth and tidal period.
- Control: hydraulic pistons will tilt the flume from a gradient of -0.02 to +0.02 in seconds to minutes.
- Boundaries: header tanks at both ends to control water level and capture sediment
- Measurement: a fast automated gantry with stereo system

Enabling new technology



### Funding

Vici grant (2014), 5 year funding from the Netherlands Organisation of Scientific Research (NWO, STW), Innovational Research Incentives Scheme, www.nwo.nl/vi

### 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

youtube **movie** of Experiment

www.geo.uu.nl/fg/mkleinhans