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Bed Composition: a Key Factor for the Channel-Flat Equilibrium?

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A Missing Piece in the Sediment Puzzle

Several hydrodynamic mechanisms are responsible for residual sediment transport in tidal basins. *Lag effects* and *tidal asymmetries* are the dominant ones. If waves are not considered, these two mechanisms always import sediments into the "shallow" region (a few meters below MSL). Thereby the intertidal area should continuously accrete with sediment coming from adjacent channels, whereas a balance is observed. Resuspension by small-amplitude waves is the main counter-mechanism acting on the tidal flats, but those waves cannot reach out to the bed in deeper areas. Furthermore, baroclinic circulation scarcely affects sediment transport in many inlet systems, such as the Wadden Sea. However, those systems have stayed close to dynamic equilibrium for the last decades. Since the hydrodynamics alone does not explain a balance in the channels, we hypothesize that the counter-mechanism has a *sedimentological* origin instead, arising from the progressive landward fining of the bed composition.

Methodology

In order to test our hypothesis, two steps are undertaken using the *Vlie* basin in the Wadden Sea as case study. (1) Sediment data analysis: a statistical model will assess the variability of the bed composition with respect to hydro-morphological properties of the basin. (2) Morphodynamic modelling: an exploratory model will simulate the channel-flat exchange as a 1D process, accounting for multiple sediment fractions and implementing a non-directional wave parametrization (Young & Verhagen, 1996) into the package *Delft3D.*

Preliminary Analysis

In Fig. 1, the dense (1-2 per km^2) samples of the *SedimentAtlas Waddenzee* (RWS, 1989-1997) are binned into discrete intervals ($\Delta x = 2.5$ km) of their distance from the inlet. The coarse-fraction content of the bed ($D \geq 250\ \mu m$) is largest near the inlet and decreases inside the basin. Fine sand is nearly equally present. Finer fractions ($D < 125\ \mu m$) are hardly present in the deeper channels, but they increase steadily shorewards. Morphodynamic simulations with a single grain size and without waves confirm that lag effects and tidal asymmetry lead to continuous sedimentation on the tidal flats at the expense of the shallow channels (Fig. 2), with the low-water line approximately marking the transition between accretion and degradation. The planned simulations will allow for the influence of waves and of spatial gradients in the bed composition. The anticipated outcome is that residual transport can vanish once those two factors are considered. If verified, future investigations in estuarine morphodynamics should consider the joint effects of tidal forcing, wave forcing and bed composition.

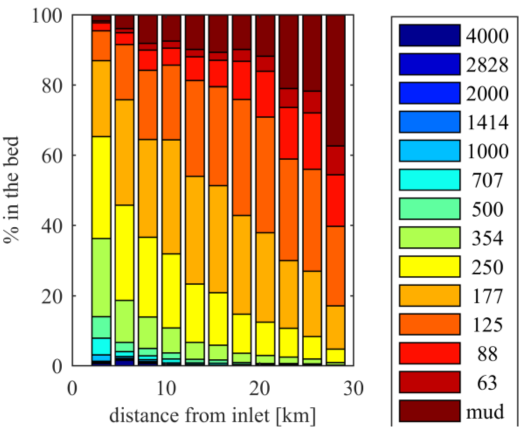

Fig.1: Variability of the Vlie basin's surficial bed composition with distance from the inlet.
The legend indicates the grain sizes in μm.

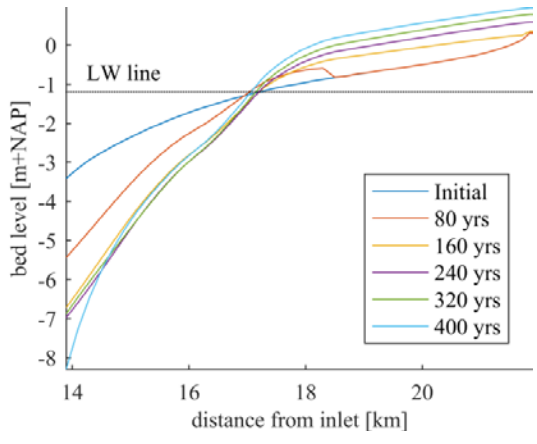

Fig.2: Bed-level evolution of a morphodynamic simulation with single-sediment fraction
(125 μm) and only tidal forcing.