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Modelling morphological changes over time scales of decades to centuries: a review

Michiel Knaapen¹

¹HR Wallingford, Howbery Park, Wallingford, OX10 9BA, United Kingdom
m.knaapen@hrwallingford.com

Abstract: Predicting morphological changes to coasts estuaries and rivers has always been one of the core aims of sediment transport modelling. Impact of human activity can last for decades to centuries. With computer power increasing exponentially, extrapolation of short term calculations or simplified models are now being replaced with long-term simulations of detailed area models. SISYPHE is shown to handle these simulations with varying success. From a number of theoretical and practical applications, issues arising from the long-term simulations are discussed:

- *Numerical instabilities.* Sub-mesh distribution of sediment leads to accretion in places where there is no sediment transport. Although this is now stopped for dry nodes, it can still lead to upslope transport creating ridges that are too high and channels too deep or accumulation onto a non-erodible edge. A downslope transport term can correct this, if it is not proportional to the calculated transport rate. Alternatively, an analysis of the sub mesh transport gradients might provide a better solution for the distribution of accreting material over the nodes.
- *Missing cross-shore processes.* Coastal modelling is known to be difficult. The interaction between waves, currents and sediments, leading to inherent 3D processes, with an onshore mass flux through asymmetric waves and wave rollers and an offshore undertow near the bed. This process is as difficult to solve in 3D as it is in 2D. In 3D, the spectral wave models give a poor approximation of the onshore mass flux and the distribution of the wave forces across the vertical are not understood well. In 2D, the onshore mass flux and offshore undertow can only be approximated with long known formulae. On top of that, there simply is a missing knowledge regarding the process that leads to the gradual built-up of beaches after a storm. Still, the results with SISYPHE models compares well with the results of 1-line modelling. Moreover, it brings the benefit of the additional insight in the small-scale effects.
- *Representative wave conditions.* For a long time, long-term morphological predictions relied on a representation of the wave conditions that are representative for the wave climate at the site of interest. However, when comparing results from models using time varying waves with models applying a representative wave condition; this does show up significant errors due to the wave breaking. The runs using a representative wave have the breaking waves in a single location, whereas the breaking zone for the time varying waves varies over time. Whereas the errors in the sediment transport rates are small, these small errors result in large difference in the erosion deposition pattern.
- *Morphological speed-up.* Several approaches have been proposed to speed up calculations by multiplying the bed changes. The maximum achievable speed-up with this approach depends on the complexity of the models, with about 20 possible for low energy situations, but approximately 10 the maximum for high energy situations such as a coastline.

Key words: Longterm morphology; sediment transport.