

Three reasons why morphological models are only useful to extrapolate field data

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Some decades ago, the physics behind mathematical morphological models were very simple, only describing the basic processes. Nowadays these models are very complicated, with a lot of input parameters, and incorporating a lot of physical processes. This gives the impression that these models can correctly estimate morphological changes on beaches, navigation channels, sand banks,... The truth however is that they are even not able to predict correctly the direction of sediment transport if they are not extensively calibrated.

Results of recent detailed measuring campaigns in the Netherlands and the UK were compared with predictions of most of the mathematical models used in Europe (without calibration data). This comparison made clear that a model can be classified as 'good', if the error on sediment transport rate was less than a factor 10, the worst models under- or overestimate the sediment transport rate with a factor 100.

Three possible reasons can be distinguished:

1. Hydrodynamic reasons

The pattern of currents and waves near the beach is extremely complicated. Currents are induced due to the incoming waves: cross-shore undertow, long shore current due to oblique waves, currents due to breaking waves, streaming (near bottom current), rip currents,...

The summation of all these currents will result in a complex 3D flow pattern. If one of the components is modelled incorrectly, the predicted flow pattern might be completely different from the real flow pattern, resulting in a completely wrong sediment transport estimation. Field campaigns made clear that even the most complicated models are unable to correctly reproduce this flow pattern, where the undertow is the most difficult current to model.

Waves break at places which are difficult to predict, the asymmetry of the waves and bond long waves due to wave groupiness can become dominant for the sediment transport rate.

2. Morphological reason

The suspended sediment concentration profile is extremely sensitive to the presence and the dimension of bed forms (ripples). For increasing wave action and currents the ripples become higher and steeper till they become unstable. If the hydrodynamic action still increases the bed will become plain. The higher the ripples, the more sediment can come in suspension. When the ripples become flatter, the concentration will decrease (although hydrodynamic action becomes more intensive). However if the bed is completely flat, sheet flow occurs and the suspended sediment concentrations increase again.

The data used to predict ripple dimensions show a lot of scatter, making it difficult to predict the ripple dimensions. A small error on the ripple dimension will however cause a large error on the suspended sediment concentration profile.

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Small currents superimposed on waves or wave asymmetry might even reverse unexpectedly the direction of sediment transport.

3. Sedimentological reason

Computational Fluid Dynamics (CFD) models show that it is extremely important to describe the grain size distribution in detail. The suspended sediment concentration changes an order of magnitude if only (d_{50}), only (d_{16} , d_{50} and d_{86}) or (d_6 , d_{16} , d_{26} , d_{50} and d_{86}) are incorporated (d_i the grain size for which $i\%$ of the grains is finer). Since it is difficult to receive sedimentological data over the whole project field, field data can help to estimate the optimal grain size to be used in the model to estimate as good as possible the concentration profiles.

On the poster, own work with a CFD-model, and two measuring campaigns in the Delta wave flume and the wave tunnel of Delft Hydraulics will be presented, illustrating the three reasons why a field campaign is indispensable to calibrate morphological models.