The modelled distribution of suspended sediment in the Scheldt in typical winter conditions shows a maximum estuarine turbidity about 100 km from the mouth.

THE IFLOW MODEL:
A SIMPLIFIED MODEL FOR THE STUDY OF COMPLEX ESTUARINE SEDIMENT TRANSPORT

Many estuaries throughout the world are dredged in order to accommodate large vessels. In the Ems River estuary (Germany-Netherlands), this has probably led to a dramatic increase in the concentration of sediments suspended in the water, a phenomenon referred to as 'hyperturbidity'.

Maintenance dredging costs have risen and ecological quality has deteriorated. Due to the complexity of the processes involved in sediment transport, it is still unclear whether hyperturbidity is a possibility in other dredged estuaries, for example in the Scheldt (Belgium-Netherlands).

To improve our understanding of the effect of dredging on increased sediment concentrations in estuaries, Deltares is participating in a joint project with Delft University of Technology and Flanders Hydraulics, Antwerp. The iFlow model was developed as part of this project. This is an idealised, width-averaged, process-based model for water motion and sediment transport in estuaries. The main idea behind the model is not to describe the estuary as accurately as possible, but to include only the essential processes needed to describe large-scale trends and changes. This innovative approach provides a different perspective on sediment transport processes in estuaries. The basis of the model is a simple quasi-linear description of water motion and sediment transport. The model is structured so that this basis can be extended gradually with more layers of complexity.

The iFlow model simulations are completed in seconds to minutes, making it possible to conduct a vast number of simulations to study the effect of different values for uncertain parameters that represent complex natural processes and therefore to improve our understanding of these complex processes.

The model has now been applied to several estuaries and tidal rivers around the world, including the Delaware (USA), Yangtze (China), Ems and Scheldt rivers. In the Scheldt, the model has been used successfully to describe the sediment dynamics in various river discharge conditions. It has revealed that external and internal tidal asymmetry, spatial settling lag and river discharge are the most important sediment transport processes. It also shows how the magnitude of these processes changes when varying uncertain parameters that include bed roughness, erosion parameters and settling velocity and therefore helps us to understand under what model configurations low or high sediment concentrations are likely to be found.

We are currently extending the model to include the feedback between sediment concentration and hydraulic roughness. This will allow a first assessment of the possibility of a transition from low to high sediment concentrations as a result of dredging in the Scheldt. Insights from this study can be used to estimate the risk of a transition of this kind in the future, to determine priority parameters and locations for future field measurement campaigns and to select the scenarios for testing in more detailed three-dimensional models.

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Further reading

Dijkstra et al. (2017), A modular idealized process-based model for flow and transport in estuaries, Geoscientific Model Development