Deltares

Memo

To
Kennis Online

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Subject
Rijn Maas Monding
toegepast onderzoek

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1 Summary

The model of the Rijn Maas Monding (Rhine Meuse Estuary, RMM) is extended. A comparison with the hydrodynamic SOBEK reference model showed good agreement. A preliminary test with the morphological model has been performed but the morphological model needs improvement.

2 The extended Rijn Maas Monding model

The model is extended to include morphologically active branches and improve boundary conditions. For this, the rivers Noord and Spui are added, the river Oude Maas is extended towards the Hartelkanaal and the Haringvliet reaches the Haringvlietdam, see Figure 2.1 for an overview of the current model area.

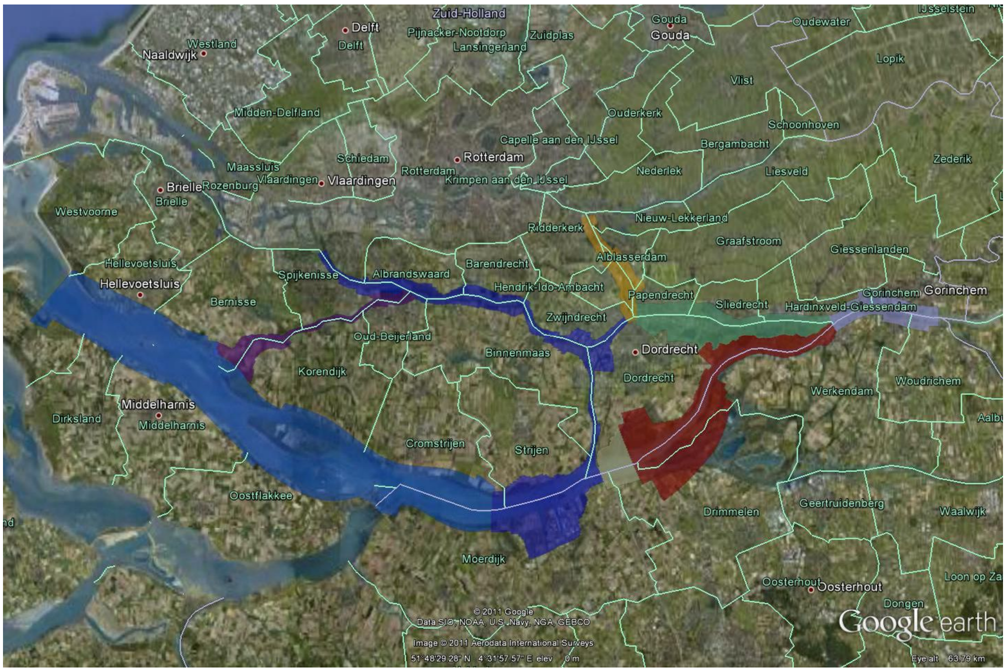

Figure 2.1 Location of the model area on a map. The RMM runs from the river Boven-Merwede to the river Noord in the North, the Haringvliet in the South and the Oude Maas at the Hartelkanaal in the North-West.

The area is modeled in six domains, the domain boundaries and the hydraulic boundary conditions are depicted Figure 2.3. The hydraulic boundary conditions are obtained from the ndb1_1_0 SOBEK model, see Figure 2.2. Figure 2.4 and Figure 2.5 gives an example of the conditions at the boundaries of the model.

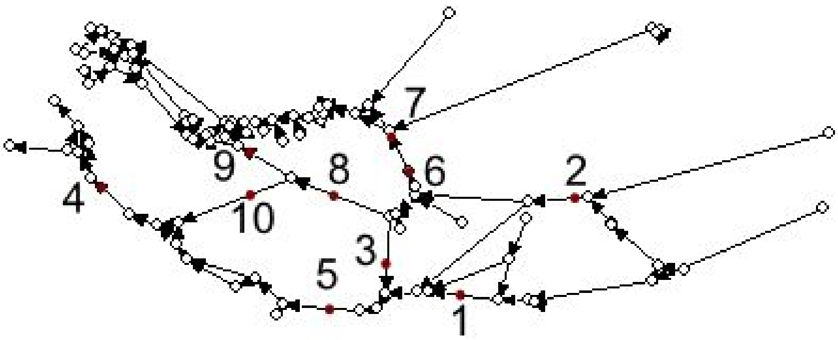

Figure 2.2 The SOBEK model used as a reference for the hydraulic computations. The observation points are given with red dots.

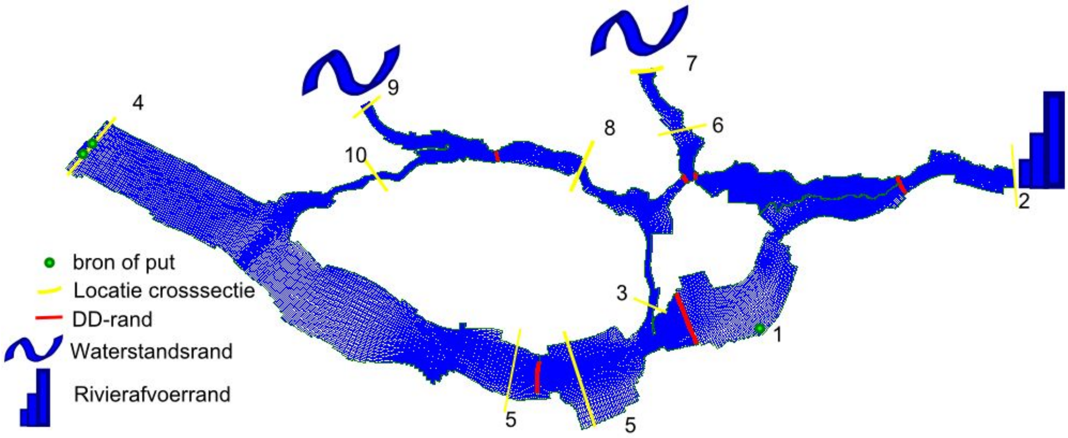

Figure 2.3 The model of the RMM is composed of six domains, the domain boundaries are depicted in red (DD-rand), The hydraulic boundary conditions are depicted with symbols, upstream at the Boven-Merwede a river discharge is given, downstream at the Noord and Oude Maas boundary are prescribed by water level time series. The hydraulic input of the Amer is modelled as a time series lateral discharge. At the Haringvlietdam, several time dependent discharges are used to model the functioning of the controlled dam.

Table 1 Locations in SOBEK model and their meaning in the Delft3D model

Location	#	
Amer	1	Lateral discharge
Boven Merwede (BoMe)	2	Q discharge
Dortsche Kil (Doki)	3	Observation point
Haringvliet (Hv)	4	Lateral discharge
Hollandsch Diep (Hodi)	5	Observation point
Noord (Nd)	6	Observation point
Noord boundary (Ndrand)	7	Water level
Oude Maas (Oma)	8	Observation
Oude Maas rand (OmaRand)	9	Water level
Spui (Spui)	10	Observation point

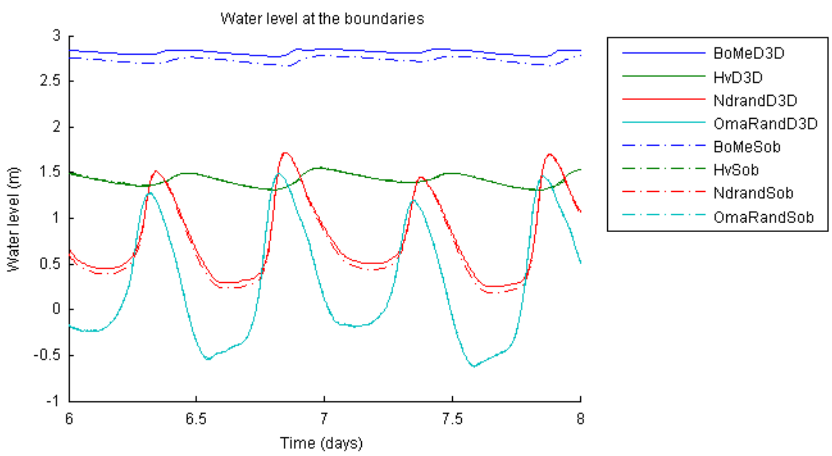

Figure 2.4 Water levels at the boundaries at high discharge. The boundaries at the river Noord (red) and the Oude Maas (light blue) are water level boundaries in the Delft3D model.

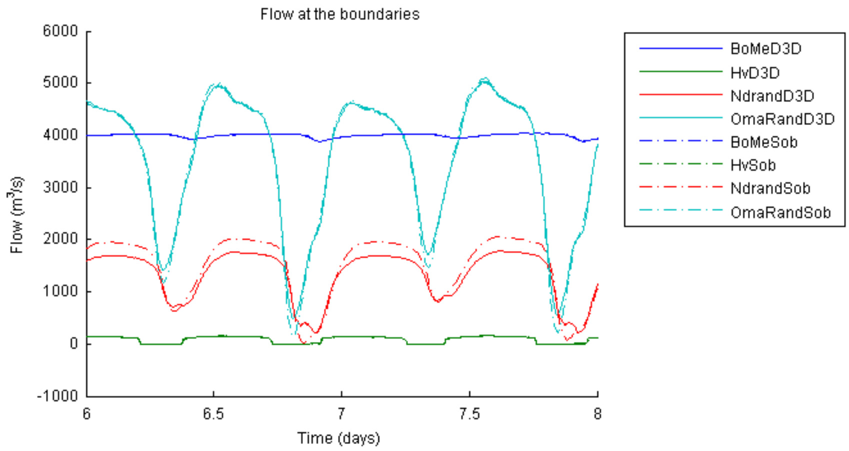

Figure 2.5 Discharges at the boundaries at high discharge. The boundary at the Boven Merwede (blue) has a prescribed total discharge boundary. At the Haringvliet Dam (green), several flow extractions are implemented in the model.

3 Hydraulic comparison

Three discharge levels are used, low, medium and high discharge at the Boven-Rijn. Table 2 gives an impression of the discharges in the SOBEK model at several locations.

Table 2 discharges RMM from SOBEK ndb1_1_0

Discharge (m^3/s)	Boven-Rijn	Tiel	Hagestein	Lith	Haringvlietdam
1	1000	804	25	88	0
2	2200	1504	390	264	-516
3	6000	3997	1158	1156	-3799

The Delft3D model was compared with the SOBEK hydraulic reference model. The comparison was performed on the numbered locations in Figure 2.2, Figure 2.3, and in Table 1. Special attention is given to the observation points in the center of the model (3, 5, 6, 8, and 10). The absolute depth averaged velocities are presented in Figure 3.1, Figure 3.2, and Figure 3.3, for low, middle and high discharge respectively, for a period of two days.
The velocities from the Delft3D model agree with the velocities from the reference.

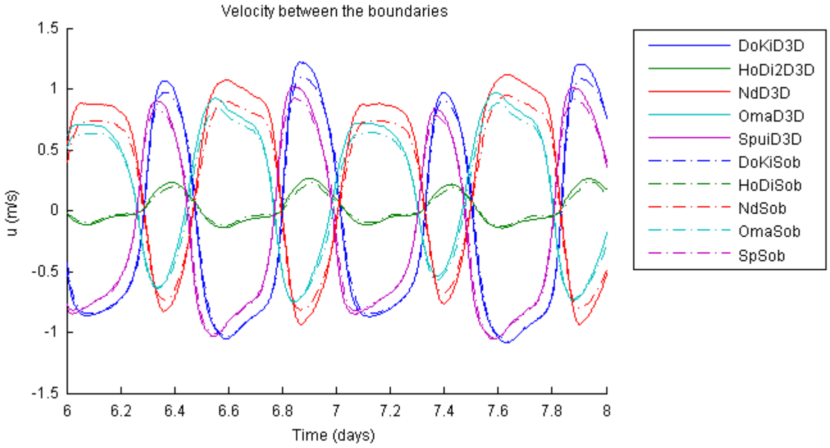

Figure 3.1 Low discharge. Absolute depth averaged velocities at non-boundary locations in the Delft3D model and the SOBEK Model.

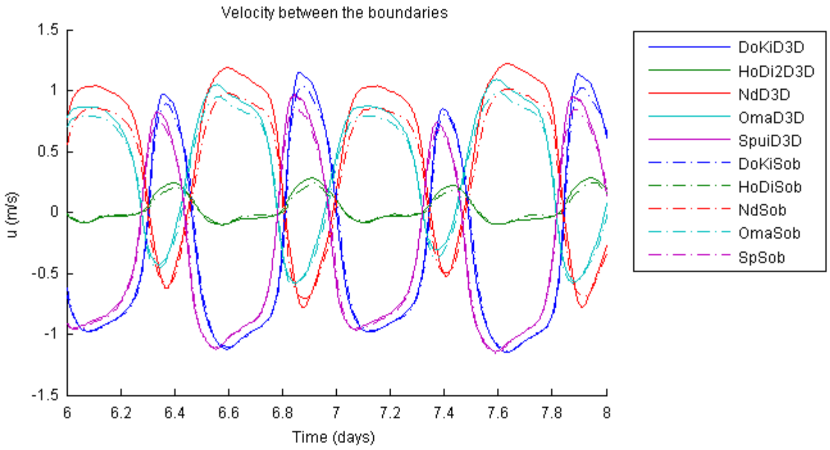

Figure 3.2 Middle discharge. Absolute depth averaged velocities at non-boundary locations in the Delft3D model and the SOBEK Model.

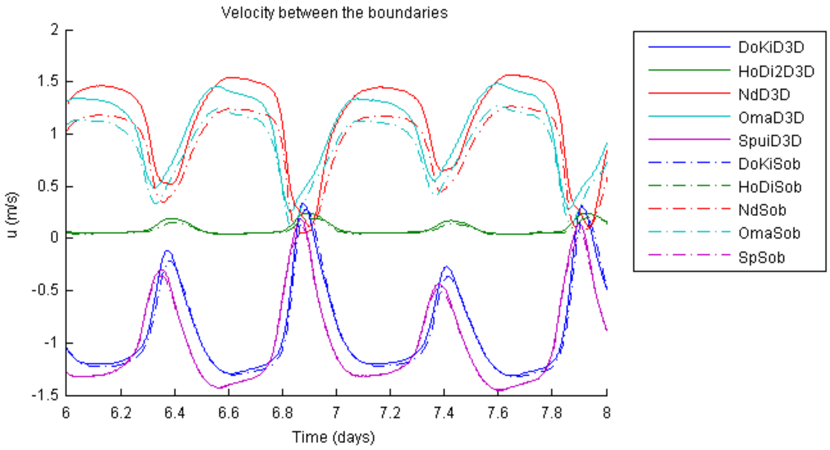

Figure 3.3 High discharge. Absolute depth averaged velocities at non-boundary locations in the Delft3D model and the SOBEK Model.

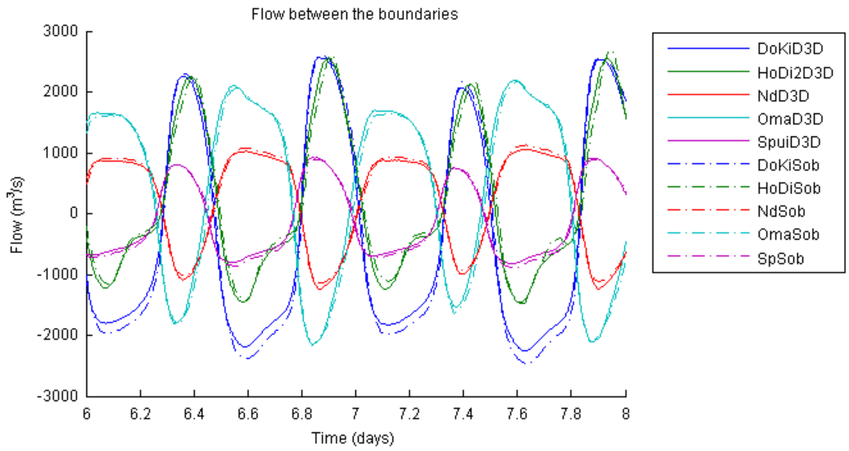

Figure 3.4 Low discharge. Total flow at non-boundary locations in the Delft3D model and the SOBEK Model.

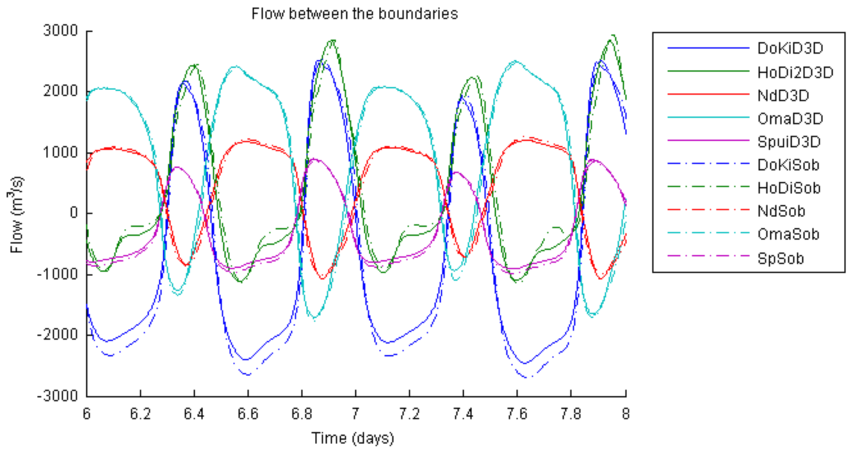

Figure 3.5 Medium discharge. Total flow at non-boundary locations in the Delft3D model and the SOBEK Model.

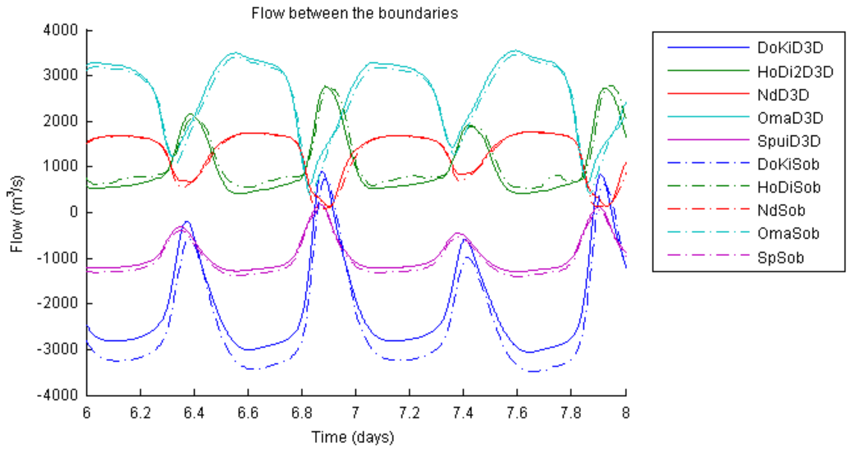

Figure 3.6 High discharge. Total flow at non-boundary locations in the Delft3D model and the SOBEK Model.

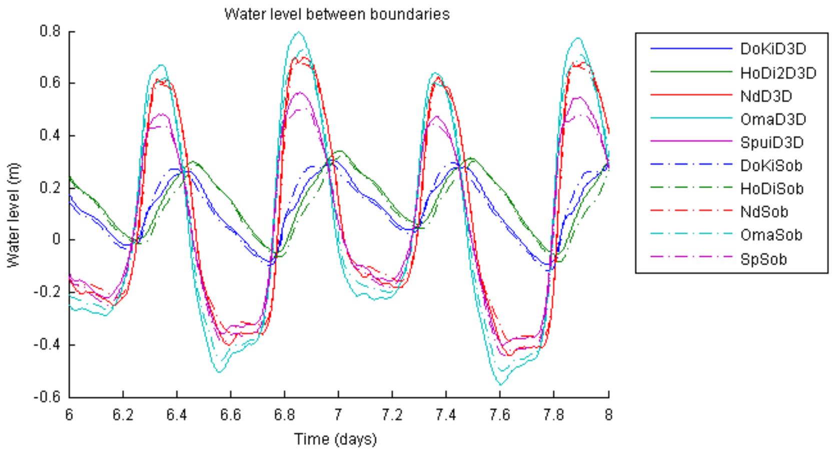

Figure 3.7 Low discharge. Water levels at non-boundary locations in the Delft3D model and the SOBEK Model.

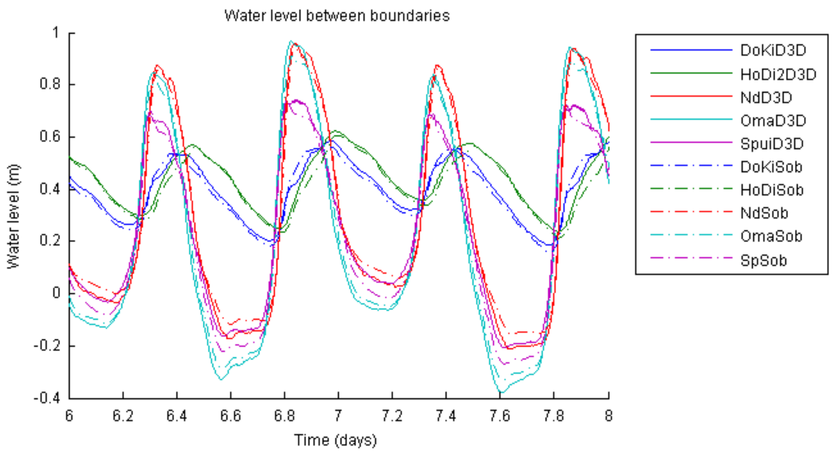

Figure 3.8 Medium discharge. Water levels at non-boundary locations in the Delft3D model and the SOBEK Model.

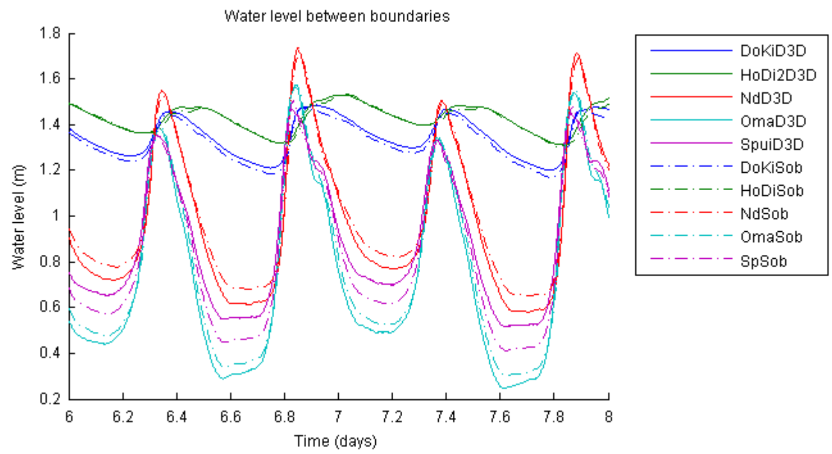

Figure 3.9 High discharge. Water levels at non-boundary locations in the Delft3D model and the SOBEK Model.

The time step of the previous model was 0.2 min. A test with a time step of 0.1 min was performed for all three discharges. Figure 3.10 shows the flow velocity within the model at low discharge levels. The simulation results of from different time steps overlap for flow velocity, water levels and discharge on all observation points. From these tests, it was concluded that the 0.2 min is sufficiently small for hydrological computations of the current RMM model.

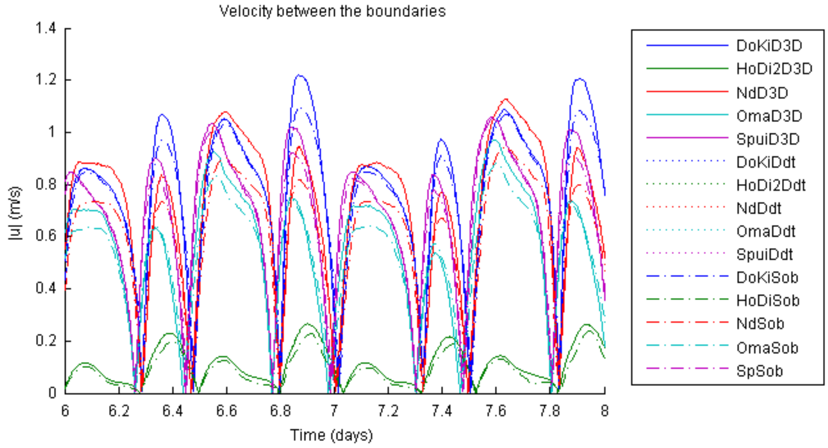

Figure 3.10 Low discharge. Simulation time step test, the dotted lines (with a time step of 0.1 min) and the full lines (with a time step of 0.2 min) overlap.

4 Implementation of morphology

Three fractions are considered, silt, sand, and clay. In the Dortsche Kil and parts of the Oude Maas, layer thickness is defined using the bed composition graphs. In the other parts of the model, a mixed layer approach is used. The mixed layer is not sufficient for morphological research in rivers like Noord, and Spui where packages of sand lay under thin layers of clay. For the Dortsche Kil, Oude Maas, Noord and Spui a survey of the ground composition is available and in future work sediment layer modeling has to be performed for Spui, Noord and Oude Maas. In the domains with the Noord, Haringvliet, Spui and the extended part of the Oude Maas the following distribution in the mixed layer was used:

Silt	Sand	Clay
34%	16%	50%

The hydrodynamical input for the model was obtained from the SOBEK reference model at low discharge. It ran during the full simulation period (12 days). In these simulations, the morphological factor was set at unity. In Figure 4.1, Figure 4.2, and Figure 4.3 the bed changes are presented for the Noord, Dortsche Kil, Spui, and Oude Maas.

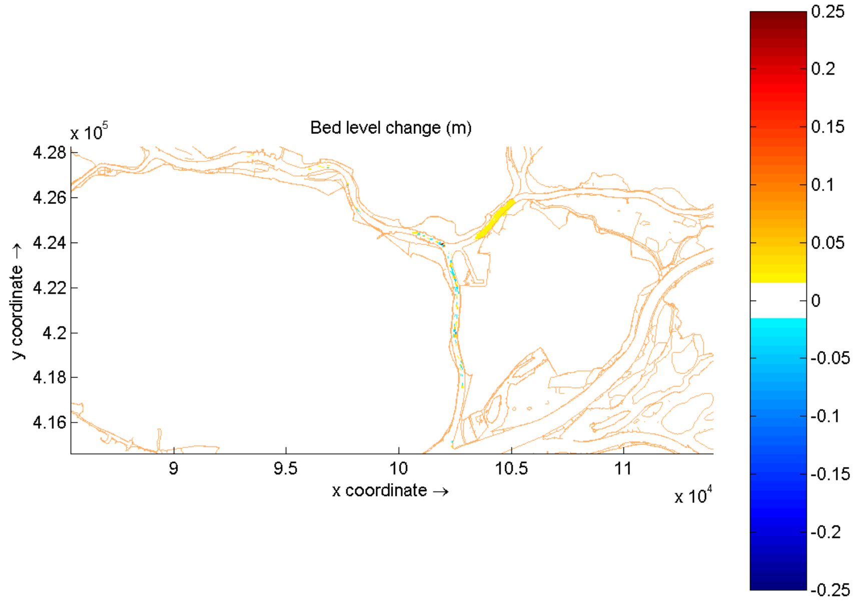

Figure 4.1 Bed level change after 12 days for the Dortsche Kil, and part of the Oude Maas.

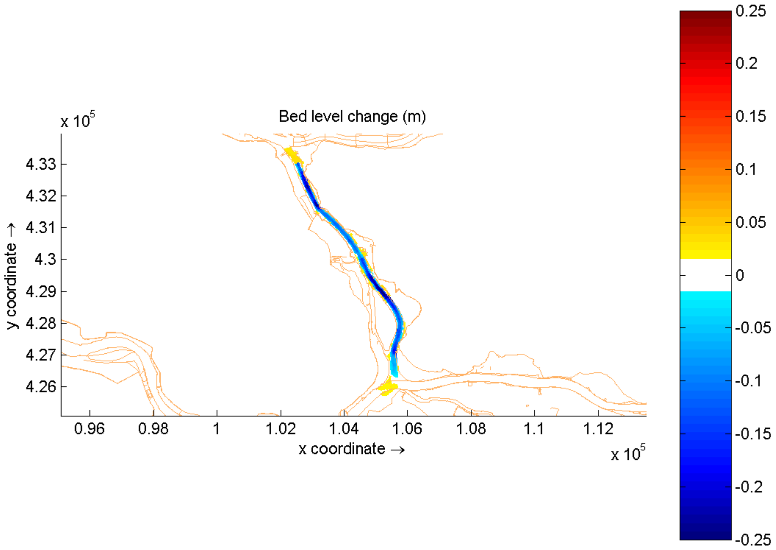

Figure 4.2 Bed level change after 12 days in the Noord, and a small part of the Oude Maas.

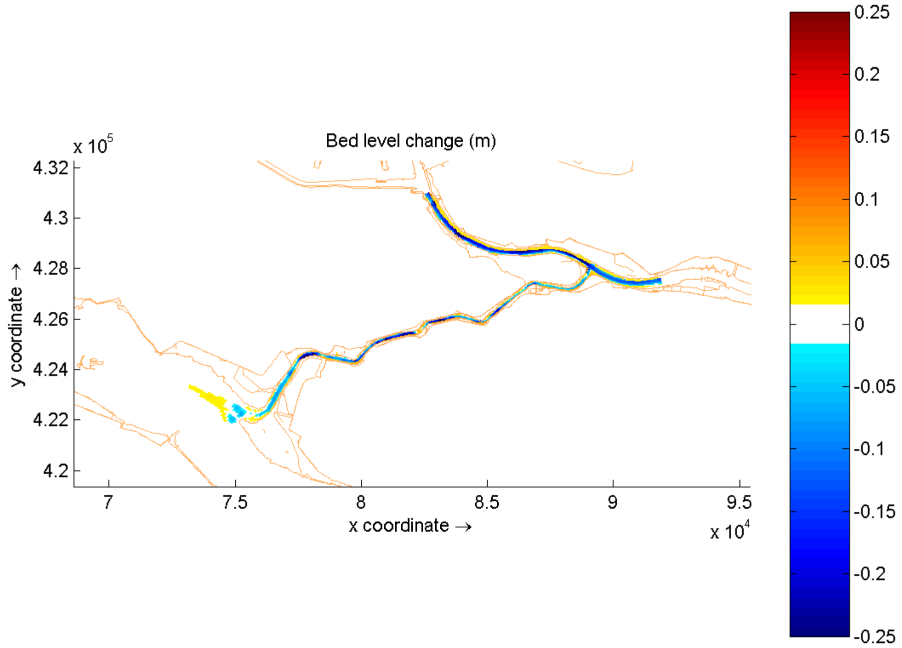

Figure 4.3 Bed level change after 12 days in Spui, and part of the Oude Maas.

5 Future work

Improvements of the model are summarized as:

- The sediment layers and their constituents (silt, sand, and clay fractions) have to be implemented based on the lithological profiles.
- Fixed layers are derived from multibeam data and have to be implemented in the model.
- Sediment input at the boundaries has to be investigated and implemented.
- Implementation of a controlled barrier at the Haringvlietdam.
- Improving the boundary at the Amer by extending the model.
- Extension of the Oude Maas into the harbour, and the modelling of the influence of salt.

6 Conclusion

Thy hydraulic calibration of the Rhine Meuse Estuary model seems to be satisfactory. Preliminary test with the morphological model has been carried out. The morphological model needs to be elaborated further especially with respect to layered sediment and fixed layers.

7 Appendix 1; Haringvlietdam

The opening of the sluices in the Haringvlietdam are controlled by the local water levels and the river discharge at Lobith (app. 2 days time lag). In the ndb1_1_0 SOBEK model, this control scheme is implemented. For the Delft3D model, such control mechanisms are under development. For future tests, in which the sluice opening protocol at the Haringvlietdam is studied with respect to its influence on the riverbed, such control mechanisms can be implemented in the Delft3D model. During the hydraulic comparison performed in this study the sluices where modeled as flow discharges. In this way, there was no control of the water levels but the results showed good agreement with the reference nevertheless.

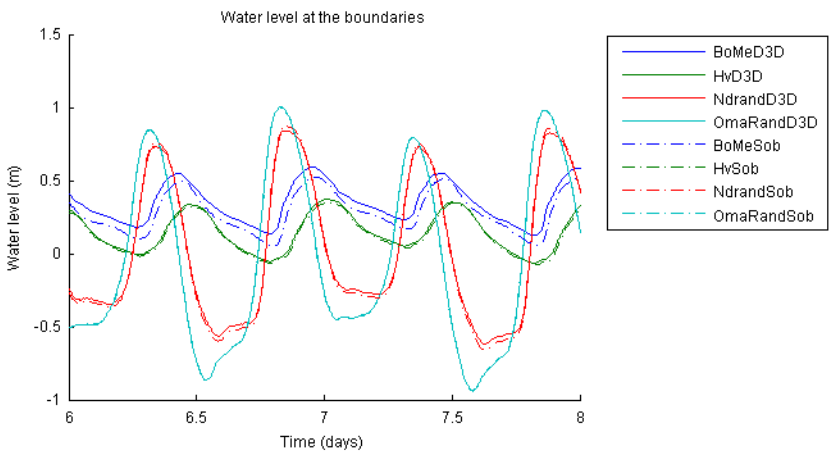

Figure 7.1 Water levels at the boundaries of the model at low river discharge. In green the water levels at the Haringvlietdam.

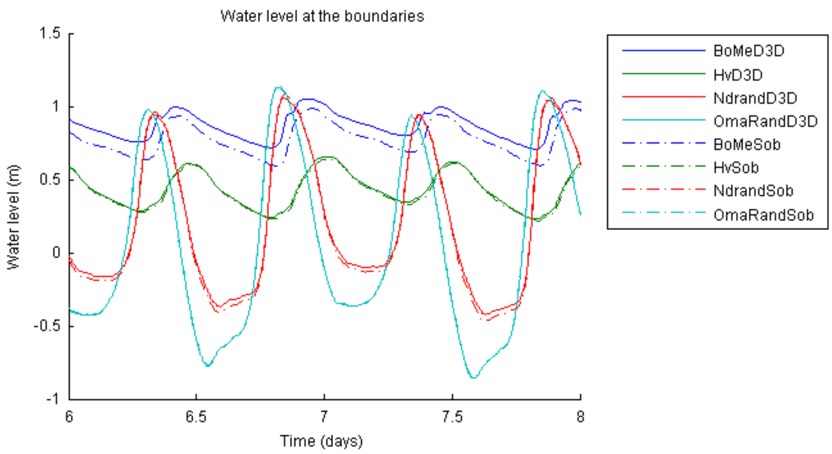

Figure 7.2 Water levels at the boundaries of the model at medium river discharge. In green the water levels at the Haringvlietdam.

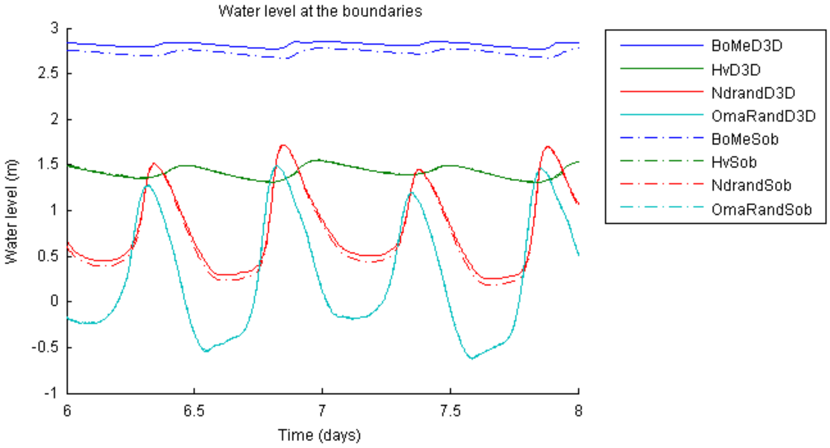

Figure 7.3 Water levels at the boundaries of the model at high river discharge. In green the water levels at the Haringvlietdam.

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