Appendix A: Equilibrium slope

Test cases

Test	Upstream boundary (IBedCond)	Downstream boundary (IBedCond)	MorFac
C1	0: bed level free	0: no bed level constraint	1.0
C2	1: bed level fixed	1: bed level fixed	1.0
C3	4: bedload transport rate prescribed (volume rate of bed material)	1: bed level fixed	1.0
C4	5: bedload transport rate prescribed (volume rate of stone)	1: bed level fixed	1.0
C5	4: bedload transport rate prescribed (volume rate of bed material)	0: no bed level constraint	1.0
C6	2: depth specified as function of time	0: no bed level constraint	1.0
C7	3: depth change specified as function of time	0: no bed level constraint	1.0
C8*	*4: bed load transport rate prescribed (volume rate of bed material)*	*0: no bed level constraint*	*10.0*

***In other test cases it appeared that there was something wrong when the morphological factor was larger than 2. Therefore the C8 case was not tested yet for the equilibrium slope.**

It has to be noted that the value for the downstream boundary is ignored in FM when there is no discharge coming in from that side. Therefore, test cases C3 and C5 should give identical results.

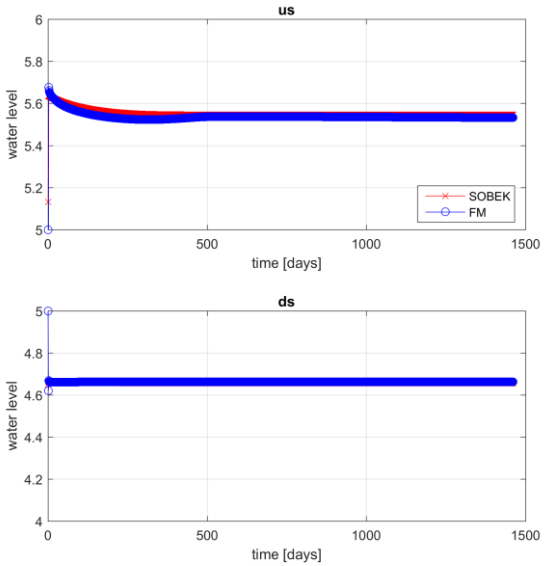
Results

The C1 and C2 test cases show similar results as SOBEK3. The results of D-HYDRO FM are (very) different from SOBEK when sediment is added at the upstream boundary. This is the case for the test cases C3 to C7.

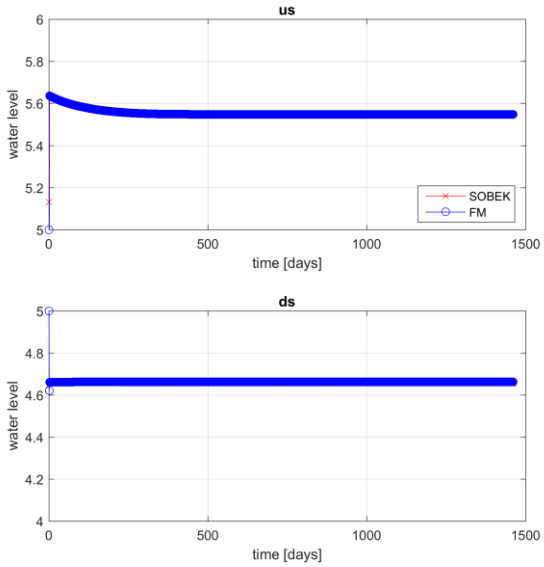
All simulations have been run for 4 years (1460 days).

a) hydraulics: water levels

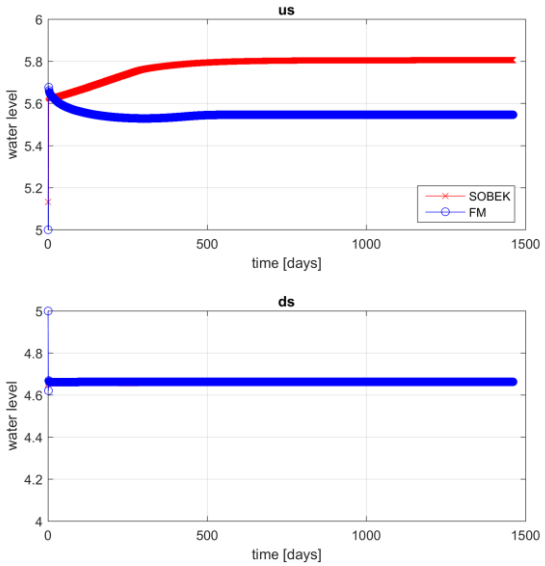
Figure 1 shows the water level over time for the different test cases. The water levels at the upstream boundary differ quite a lot for SOBEK and FM in the C3 to T6 test cases. The downstream water levels all show the same value, because the downstream boundary is fixed with a water level of 4.64 m.


us
water level
time [days]
SOBEK
FM
ds
water level
time [days]

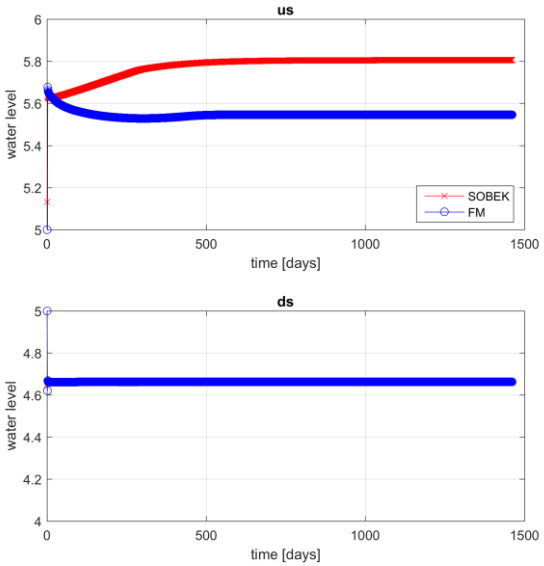
C1


us
water level
time [days]
SOBEK
FM
ds
water level
time [days]

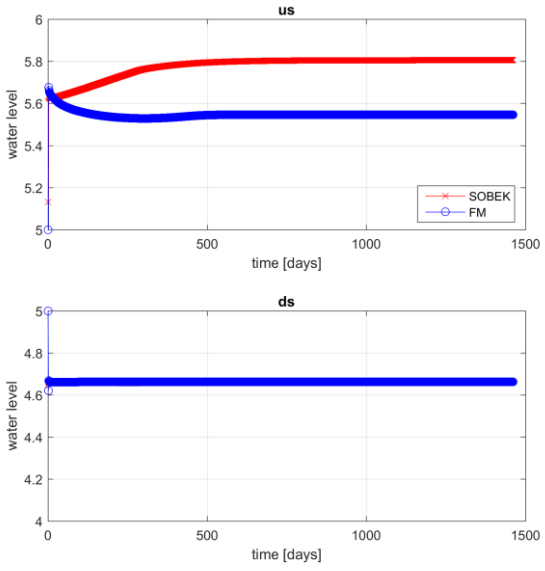
C2


us
water level
time [days]
SOBEK
FM
ds
water level
time [days]

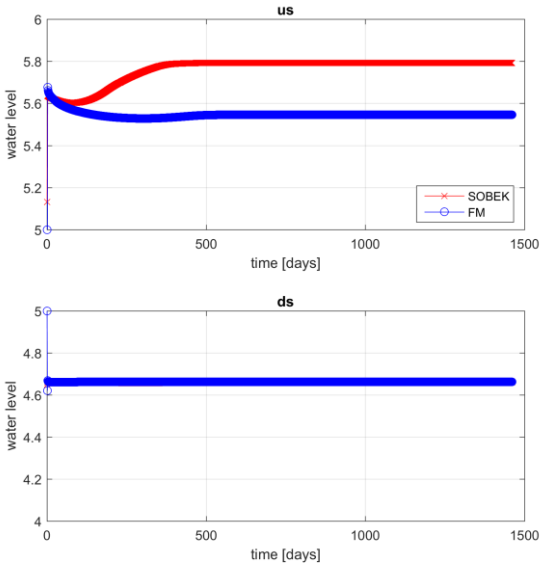
C3


us
water level
time [days]
SOBEK
FM
ds
water level
time [days]

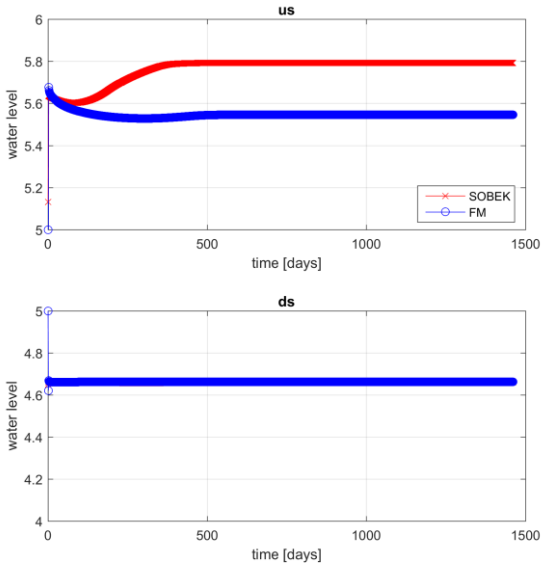
C4



C5



C6



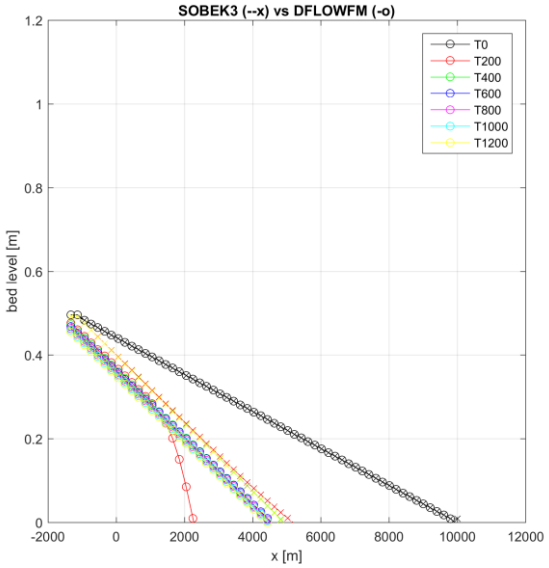
C7

Figure 1. Water levels for the different test cases. The upper figure (us) shows the water level at the upstream boundary, the lower figure (ds) shows the water level at the downstream boundary.

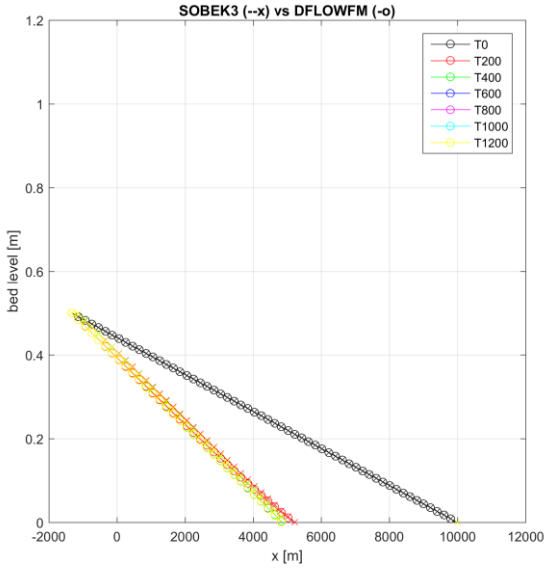
b) morphodynamics: bed level

The bed level change of C1 and C2 look very similar for FM and SOBEK (**Error! Reference source not found.**). The bed level updating in FM differs (a lot) from SOBEK for the test cases C3 to C7. The bed level updating goes wrong in FM when there is a sediment input from the upstream boundary (C3, C4, C5) or

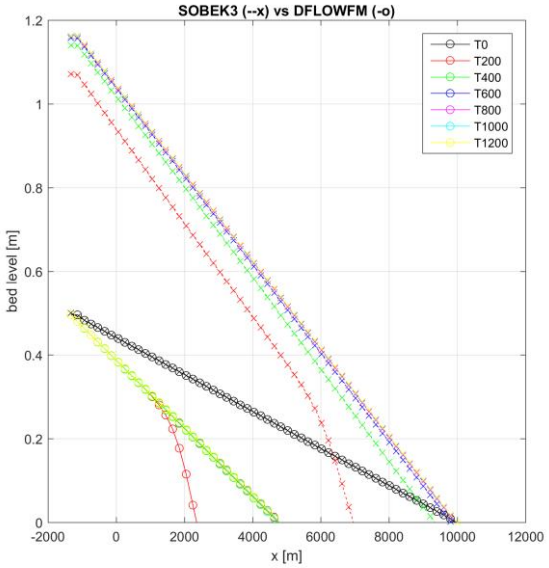
the depth is specified as function of time (C6, C7). SOBEK shows an increase in bed level height over time, whereas the bed level of FM only decreases over time.



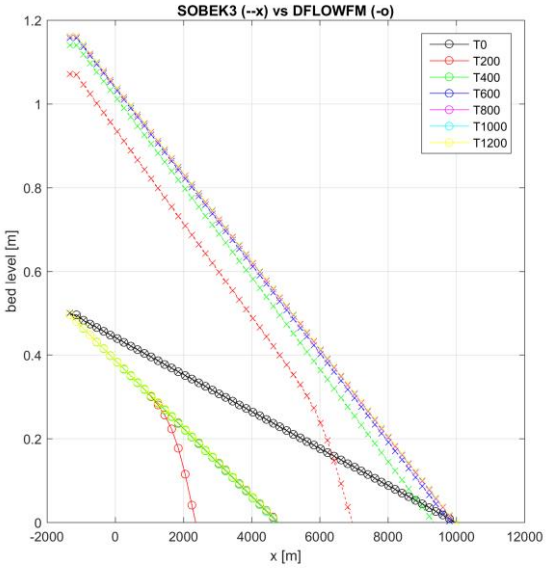
C1



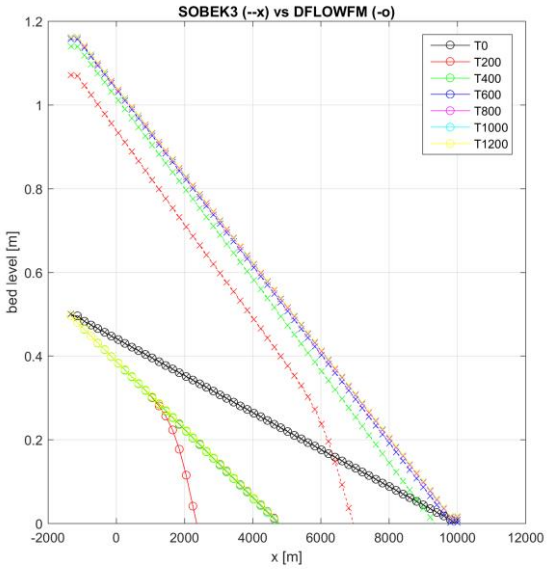
C2



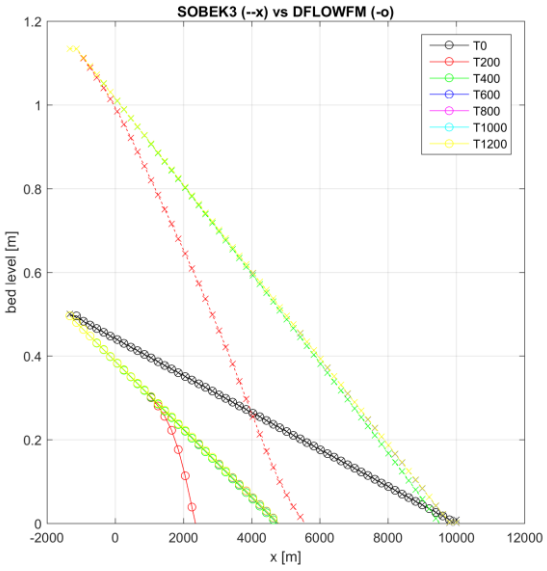
C3



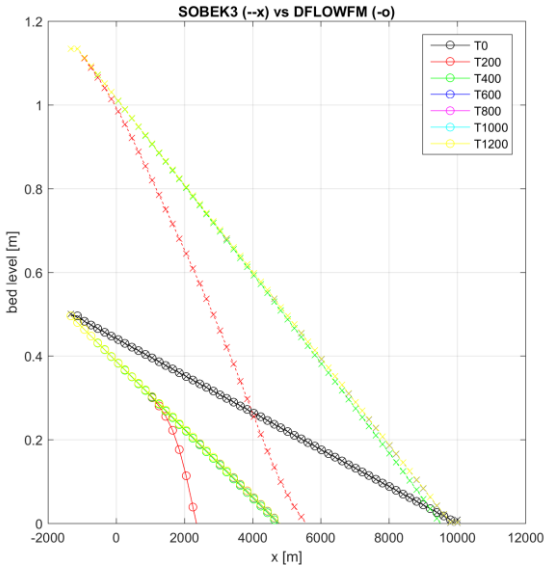
C4



C5



C6



C7

Figure 2. Bed level changes over time for the test cases over the length of the channel.

Discussion

The reason for the decrease in bed level height in FM when a bed level increase was expected was further researched. It appeared that in the so-called 'ghost-node' of FM at the upstream boundary, the sediment was already deposited (Figure 3). This can be found in the difference between the ghost-node L0 and L1 in Figure 3. Approximately 1/3 of the total bed load transport which is prescribed at the inflow

boundary is lost before it enters the domain. As a result, the outgoing bed load transport (L4, green) is larger than the incoming bed load transport (L1, red). Therefore, the bed level lowers. Whereas if the correct bed load transport of L0 (blue) would appear at the upstream boundary of the channel, the bed level height would increase. This can be found in the difference between the bed load transport coming in L0 (blue) and the bed load transport going out L4 (green) of the channel.

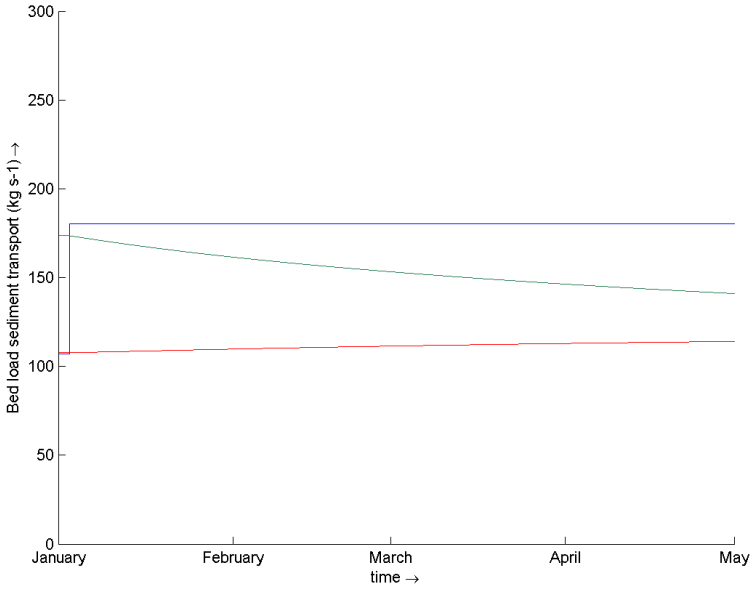


Figure 3 The bed load sediment transport (kg/s) in de 'ghost-node' L0 (blue), at the upstream part of the channel L1 (red) and at the downstream end of the channel L4 (green).

To make sure the hydrodynamics in SOBEK and FM are the same a test is done with morphological updating disabled (Figure 4). The flow velocity at the upstream and downstream boundary are almost the same for SOBEK and FM (<0.001 m/s difference).

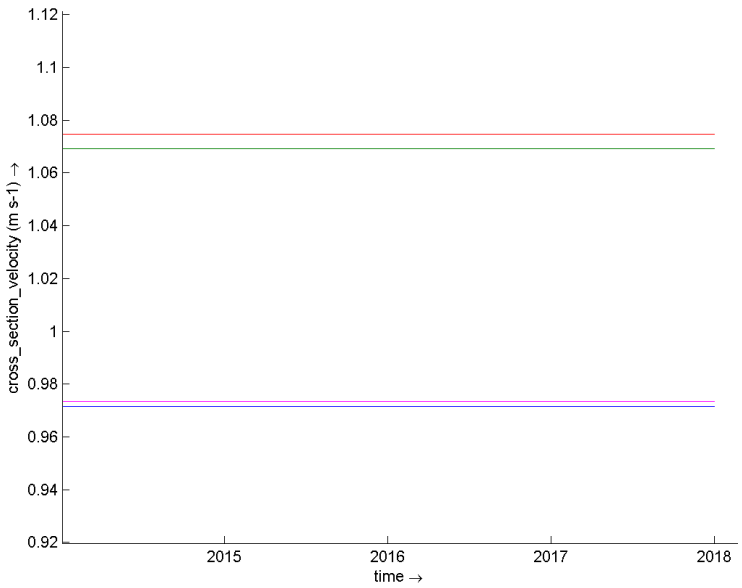


Figure 4. Flow velocity in SOBEK in upstream boundary (pink) and downstream boundary (red), flow velocity in FM in upstream boundary L0 (blue) and in downstream boundary L4 (green).

Several extra tests have been done to check if the bed level height can be increased in FM to show similar results to SOBEK. These included decreasing the time step, increasing the amount of sediment put in, setting the sediment input at 0 $m^3/s/m$ and increasing the number of cross-sections from 2 to 58. An overview of these tests is given in Table 1 (case C3) and Table 2 (case C5). In all test performed, it turned out that when there was a sediment input at the upstream boundary, SOBEK and FM showed very different results.

Therefore, another test was done which was a nearly identical schematization test case as C5 (C23_873_tststopshort) in FM (so schematization NOT obtained from SOBEK3). This test case was built in FM directly and included both a 2D FM-model (bottom schematization with grid cells) and the 1D FM-model (pink, top schematization) as used in the previous test cases.

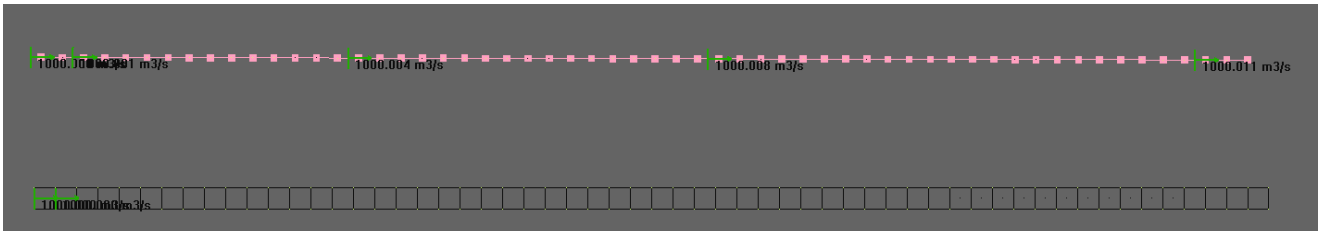


Figure 5. Schematisation of 1D FM (top channel) and of 2D FM (bottom channel).

The C5 test case that was used (c23_873_tststopshort) as a reference has a sediment input at the upstream boundary and an increase in bed level height was expected. As can be seen in Figure 6 the 1D FM channel is still not showing an increase in bed level height, whereas the 2D FM channel is showing the expected behaviour by increasing the bed level height.

Currently, it is under investigation why this behaviour is not correctly simulated in 1D.

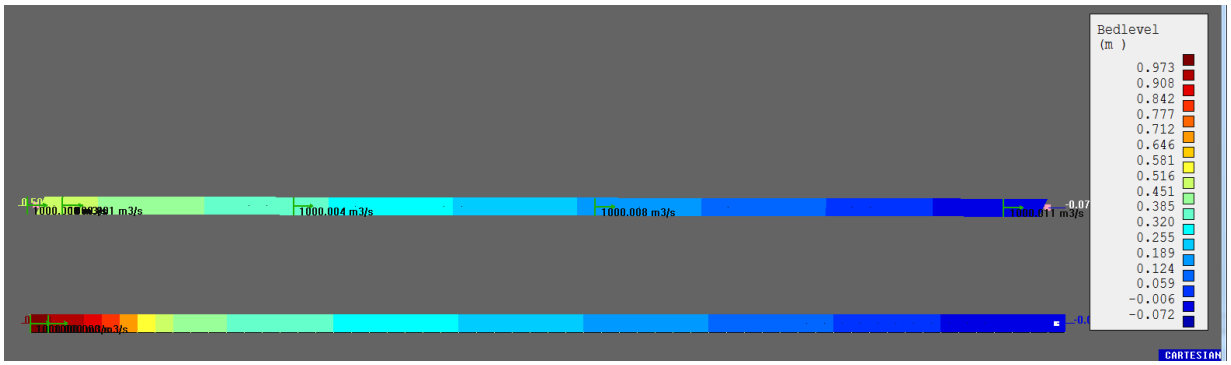


Figure 6. Bed level height in both the 1D FM (top channel) and of 2D FM (bottom channel) after 1 month.

When looking at the bed load transport in the two channels the same effect as for test case C5 can be found in the 1D channel, see the top two figures of Figure 7. The bed load transport decreases a lot from the ghost-node (L0) to the first cell (L1). In the 2D channel this effect is not seen. The first cell of the 2D channel also reaches a bed load transport of 180 kg/s. Therefore, the 2D channel works correctly and the 1D channel does not work correctly.

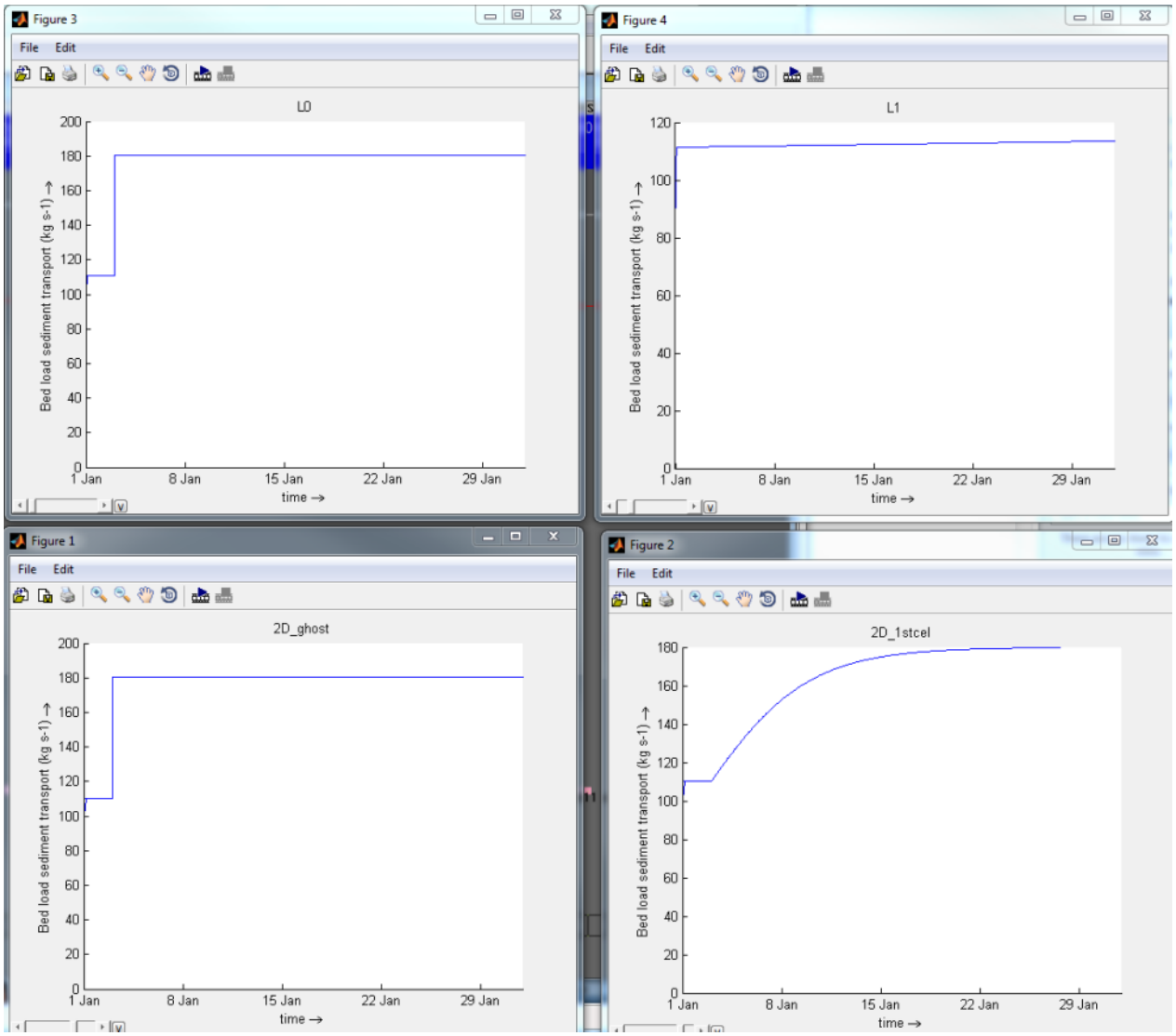


Figure 7. The bed load transport in the 1D channel in the 'ghost-node' L1 and in the first cell L2 (top two figures) and the bed load transport in the 2D channel in the 'ghost-node 2D_ghost and in the first cell 2D_1stcel (bottom two figures).

Conclusion

There appears to be something wrong in 1D-FM when there is a sediment input at the upstream boundary (both when reading the schematization from SOBEK3 and implementing it directly in DFLOWFM). Before the actual channel starts, the sediment is already deposited without increasing the bed level height. Therefore, a bed level increase in the FM 1D-channel can't be found.

Note that this is also linked to test case "c07_1D_boundary_condition_iBedcond4_icmpcond2" (paragraaf 3.2).

C3	upstream	downstream	input sediment (m3/s/m)	timestep (s)	duration	Morphological spin-up time (min)	D-Hydro FM exe version	Similar to SOBEK?
c21_es	4	1	5.63E-04	86400	4 years	720	dflowfm-x64-1.1.261.53704	No
c21_876	4	1	5.63E-04	86400	4 years	720	dflowfm-x64-1.1.261.53873	No
c21_873_longMorStt	4	1	5.63E-04	86400	4 years	2900	dflowfm-x64-1.1.261.53873	No
c21_873_shortMorStt	4	1	5.63E-04	86400	4 years	720	dflowfm-x64-1.1.261.53873	No
c21_873_moruit	4	1	5.63E-04	86400	4 years	-	dflowfm-x64-1.1.261.53873	No

Table 1: The tests done for test case C3.

C5	upstream	downstream	input sediment (m3/s/m)	timestep (s)	duration	Morphological spin-up time (min)	D-Hydro FM exe version	Similar to SOBEK?
c23_es	4	0	5.63E-04	86400	4 years	720	dflowfm-x64-1.1.261.53704	No
c23_873	4	0	5.63E-04	86400	4 years	720	dflowfm-x64-1.1.261.53873	No
c23_873_tststopshort	4	0	5.63E-04	120	4 months	2900	dflowfm-x64-1.1.261.53873	No
c23_873_tststopsh	4	0	5.63E+00	120	4 month	2900	dflowfm-x64-	No

ort_sedh					s		1.1.261.53873	
c23_873_tststopshort_sed0	4	0	0.00E+00	120	4 months	2900	dflowfm-x64-1.1.261.53873	Yes
c23_873_tststopshort_cross sections	4	0	5.63E-04	120	4 months	2900	dflowfm-x64-1.1.261.53873	No

Table 2: The tests done for test case C5.