[entry]nyt/global/

1 Straight channels in 1D and 2D: including 90 degree bends

Quality Assurance

Date	Author	Initials	Review	Initials	Approval	Initials
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06 Feb 2019						

Version information

Date of study : 08 Dec 2017
Executable : Deltares, D-Flow FM Version 1.2.26.60016M, Jan 25 2019, 12:08:55
Location : $HeadURL:https://svn.oss.deltares.nl/repos/openearthmodels/trunk/riverlab/schematic/f28_mor1d_bakprof_hydraulics/c30_Channels_1D_zigzag_zero_bedslope/doc/chapters/case_text.tex$
SVN revision : $Rev : 2583$

Purpose

There is an important difference between SOBEK3 and D-Flow FM. In SOBEK3, the flow equations are solved in 1D: although the user can introduce geographical "bends" in a model, the equations are still solved as if the river is a straight line. Since D-Flow FM is set-up as a model-code for 1D-2D-3D, this is not the case for D-Flow FM. Also in 1D, the equations are solved in a vectorized way. This means that if there is a bend between computational nodes, the computed velocity can be very different from the velocity computed in SOBEK3. This test case is set-up to gain some insight in the effects of "bends" on water levels (backwater effects).

Linked claims

- "Bend effects" are treated differently in D-Flow FM and SOBEK3.
- For one single 90^o bend, the results are identical in 1D and 2D.

Approach

We start from an earlier test cases with straight channels in 1D and 2D: 'c10_straight_channel_1Dvs2D_zero_bedslope' (REF). In that test case we used a zero bed slope and bed level of 0 in the entire domain, which is convenient for modelling the channels with bends.

In this test case we add various channels containing "bend lay-outs", and compare the water levels with those computed for straight channels of the same length. We consider two bedlevtypes: 1 (faces) and 3 (zk). For one bend lay-out, we compare 1D and 2D results.

Model description

The figure below shows the computational domain, containing both the straight 1D and 2D channels (bottom two) and the channels with bends (top three).

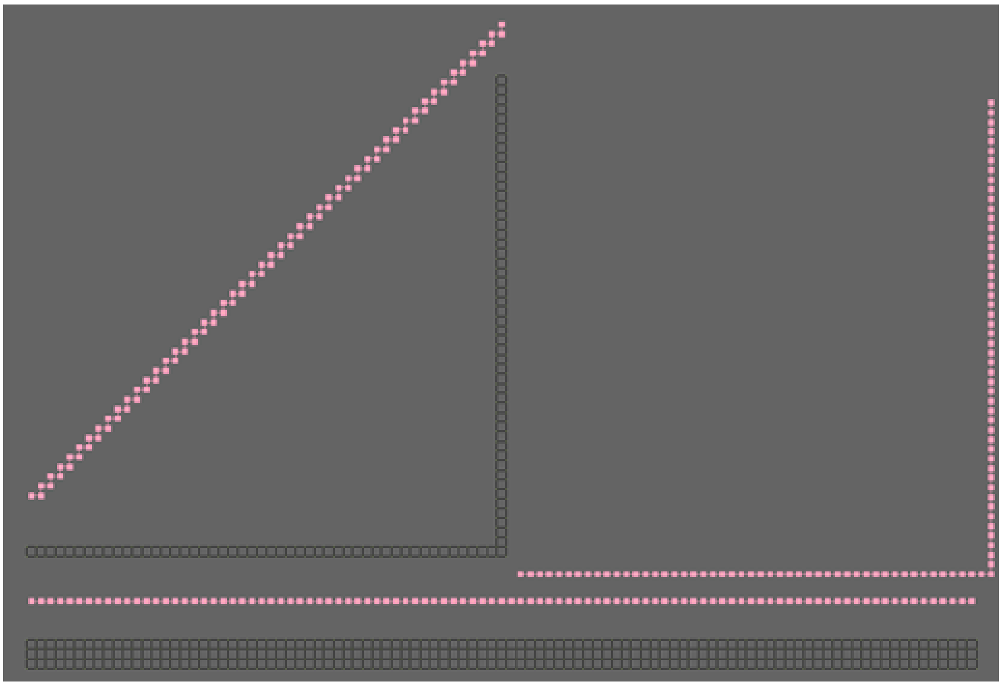

Figure 1: Figure of the layout of the model.

The 2D channel (3 cells wide, cell edges 0.1 m long, aspect ratio = 1) and 1D channel (0.3 m wide) are of equal length (30 m). Pressure points are at identical locations for the centerlines of the models. The bed level is 0 for the entire domain.

The model is forced with a constant discharge at the upstream boundary, and a constant water level at the downstream boundary. The discharge is 0.08 m^3/s for the 1D channel and 0.24 m^3/s for the 2D channel (since it is three cells wide). The water level at the downstream boundary (and because of the 0 bed level also the water depth) is 0.35 m.

For this test case we add the following grids to test the backwater effects due to bends:

- Two channels with a single 90^o bend, both in 1D and 2D (1 cell wide). The length of these channels is identical to the straight channels.
- One 1D channel with a 90^o bend between each node ("zigzag" per node, so each channel segment is 0.3 m long). Also for this case the total length of the channel is equal to the straight channel.

We use Bedlevtype = 1 and 3, which should be identical because of the uniform bed level in the computational domain. For the straight channel, the water levels are compared to a semi-analytical approximation of the surface profile.

Results

The results are shown in the figures below.

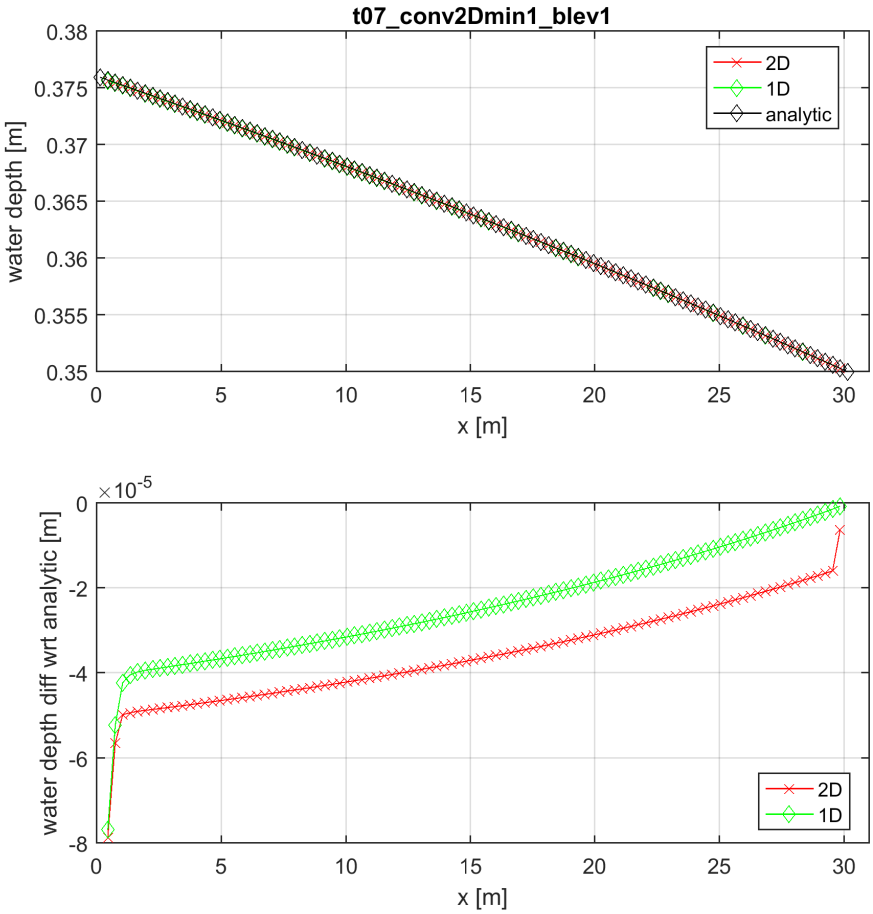

Figure 2: Comparison water levels in the straight channels for 1D and 2D with semi-analytical solution, bedlevtype=1.

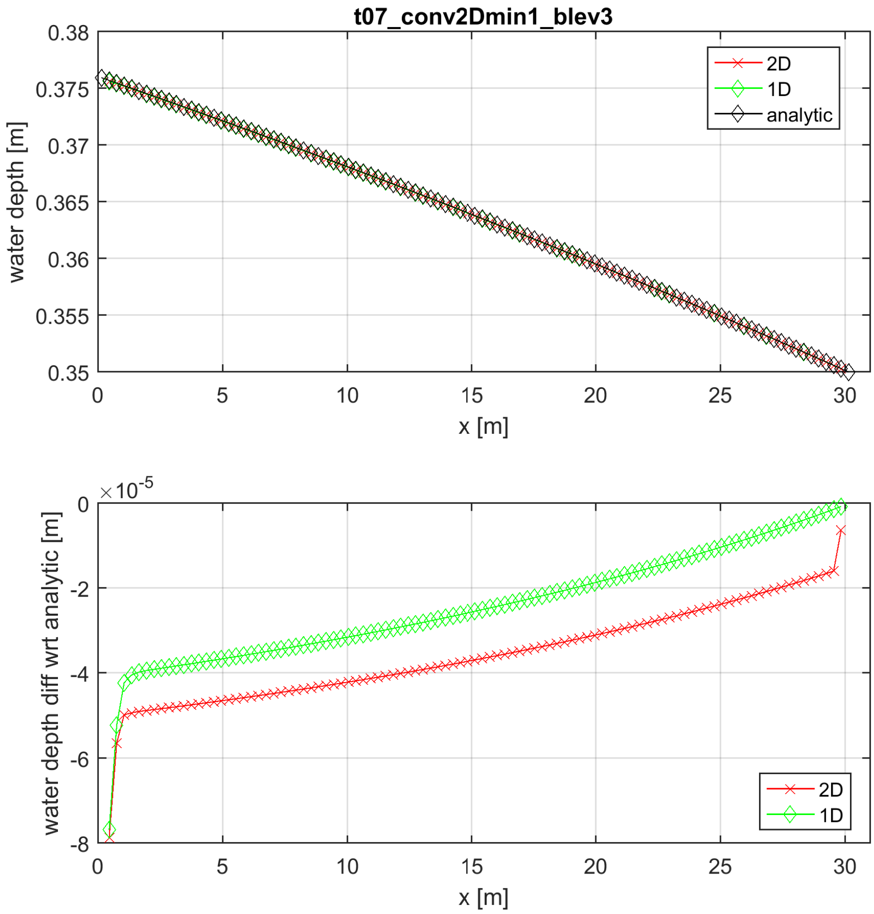

Figure 3: Comparison water levels in the straight channels for 1D and 2D with semi-analytical solution, bedlevtype=3.

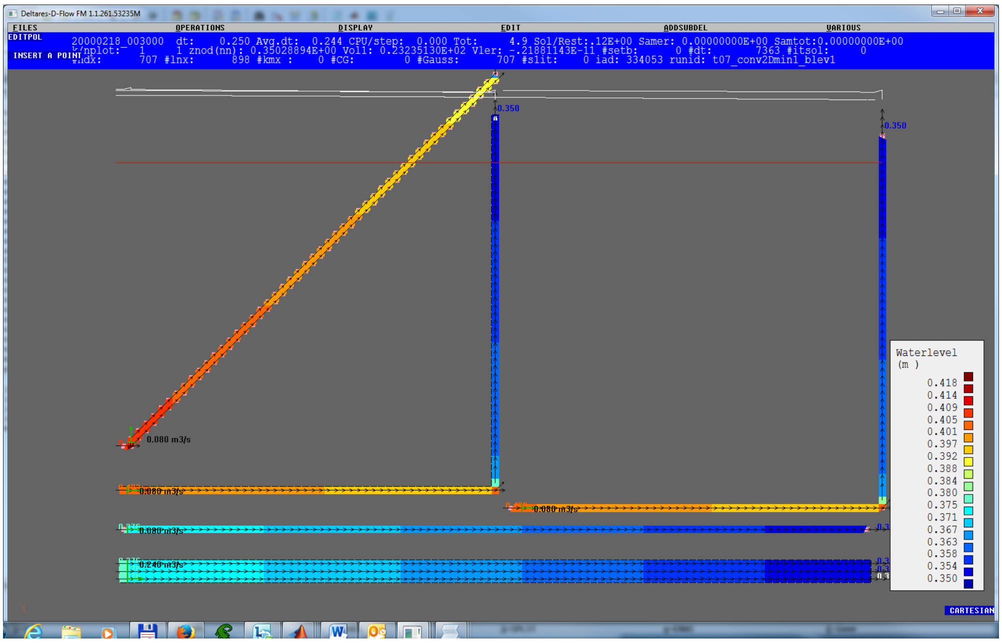

Figure 4: Impression of water levels including bends, bedlevtype=1.

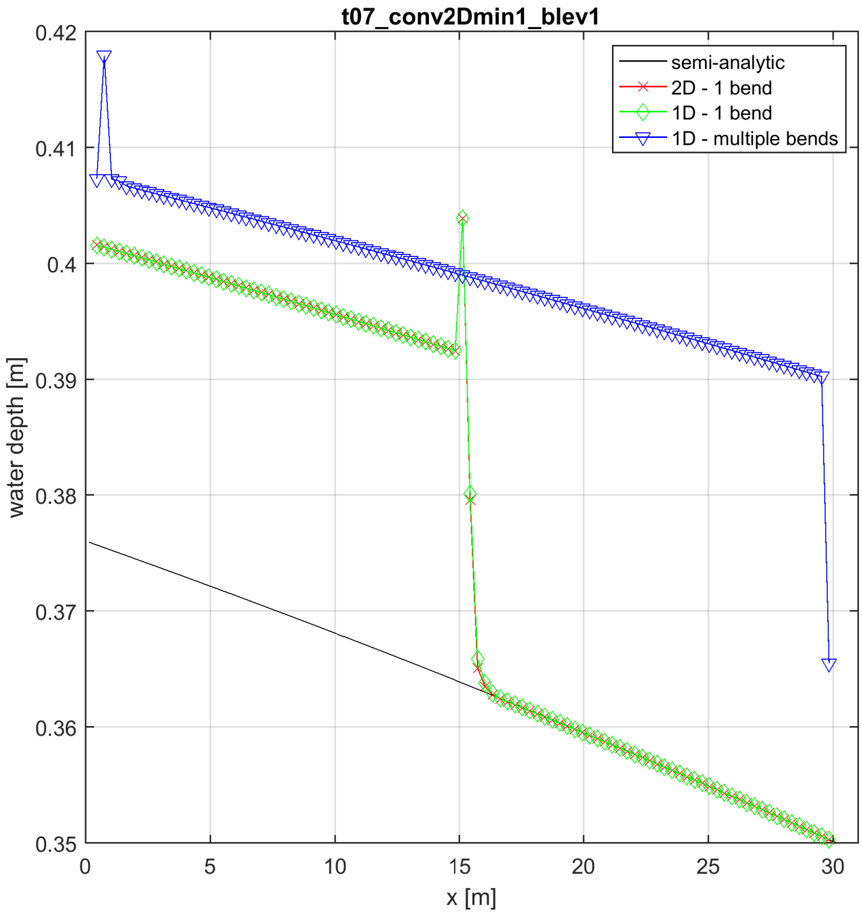

Figure 5: Comparison of water levels in channels with bends compared to semi-analytical solution of surface profile for straight channel, bedlevtype=1.

Analysis of results

From the figures above we can conclude:

- For straight channels: see previous test cases.
- Results independent of bedlevtype, so bend effects only analyzed for bedlevtype=1.
- Effect of one single 90^o bend is equal for 1D and 2D. For the considered geometry, the backwater effect is approximately 2.5 cm, which remains equal towards the upstream boundary of each model.
- For the case with multiple bends, the backwater effect originates at the downstream boundary. The effect is larger than considering one bend halfway a channel of equal length. In upstream direction, there appears to be no effect. Perhaps this is because we have schematized a 90^o bend at *each* node, making the channel virtually straight? At the upstream node, a backwater effect is visible due to the first downstream bend in the geometry.

Conclusion

"Bend-effects" are significant. It should be investigated how to treat this in D-Flow FM when considering 1D-models.
Another recommendation is to consider a “real world“ example for future test cases. Flow velocities in the channels with bends likely also deviate from those in the straight channel.