1 Straight channel with zero bed slope (hydraulics)

Quality Assurance

Date	Author	Initials	Review	Initials	Approval	Initials
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Purpose

The purpose of this test case is to test hydraulics for simple rectangular channel (so not-tabulated) with a zero bed slope. This is needed for correct interpretation of 1D-simulations including sediment transport and morphology. Computed water levels in 1D are compared with 2D (which is already validated) and a semi-analytical solution for the surface profile. By comparing flow velocities between 1D and 2D, we gain insight whether roughness and bed shear stress are modeled correctly in 1D.

Linked claims

- Water levels in 1D-model are identical to 2D-model for zero bed slope.
- Water levels are identical to semi-analytical solution of the surface profile.
- Flow velocity (and thus bed shear stress) in 1D-model are identical to Quasi2D-model for zero bed slope.

Approach

We start from an existing 2D test case which included sediment transport (switched off morphological changes). In D-Flow FM various options are available to specify the bed level, using so-called bedleveltypes. For morphology we use option 1, but for testing purposes also other zk-types are included. We test for three bedlevtypes: 1 (faces), 3 (zk) and 6 (faces via zk). For the 2D-grids we use the centerline values to compare with the 1D-results.

Model description

The figure below shows the computational domain, containing both the 1D and the 2D grid. 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 center lines of the models. The bed level is set 0 for the entire domain.

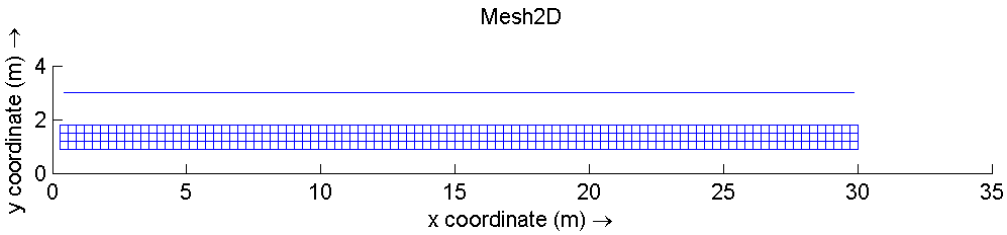

Figure 1: Figure of the layout of the model.

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 has a width of 3 cells). The water level at the downstream boundary (and because of the zero bed level also the water depth) is 0.35 m.

For the semi-analytical solution of the water surface profile with zero bed slope (and validation of it), see 'c99_belangerflat1d2d' (Bélanger-equation).

Results

Below are the results for water depth (Bedlevtypes: 1 (faces), 3 (zk) and 6 (faces via zk)) and flow velocity (only bedlevtypes: 1 (faces)).

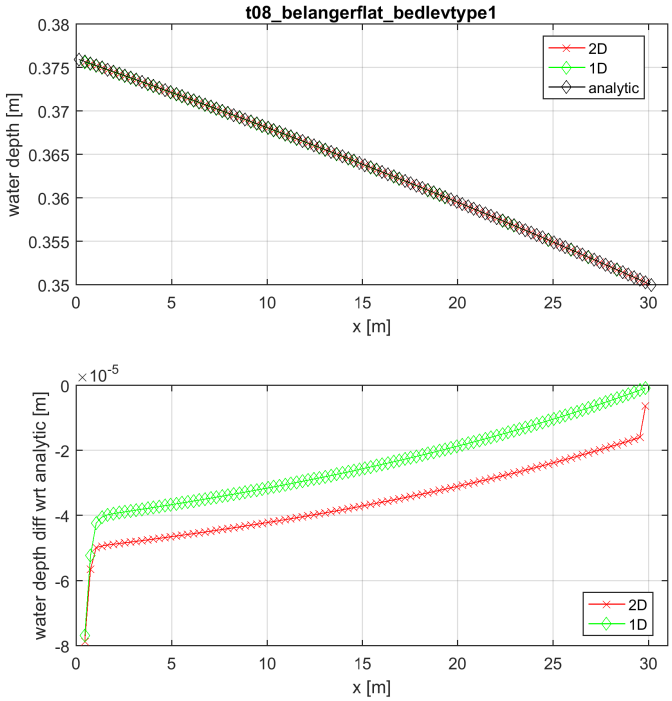

Figure 2: Water depth (top) and difference with semi-analytical solution (bottom) for bedlevtype=1.

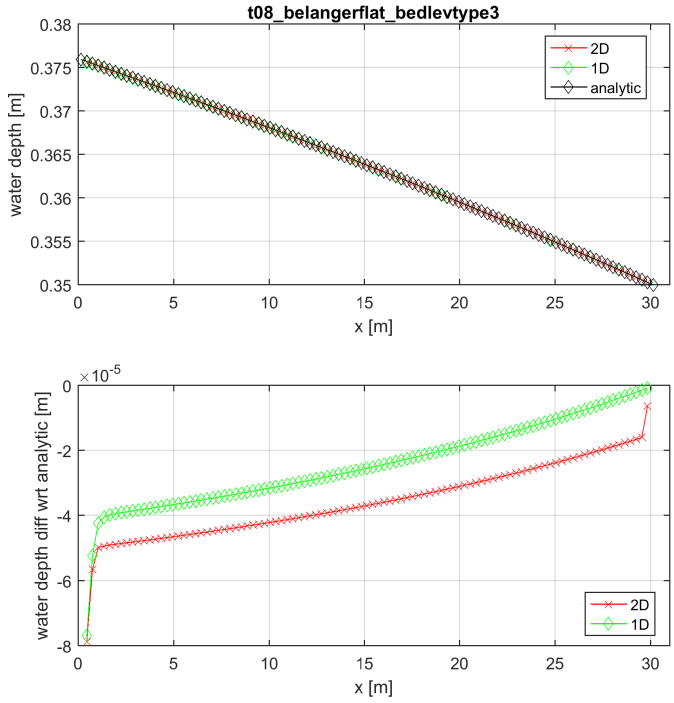

Figure 3: Water depth (top) and difference with semi-analytical solution (bottom) for bedlev-type=3.

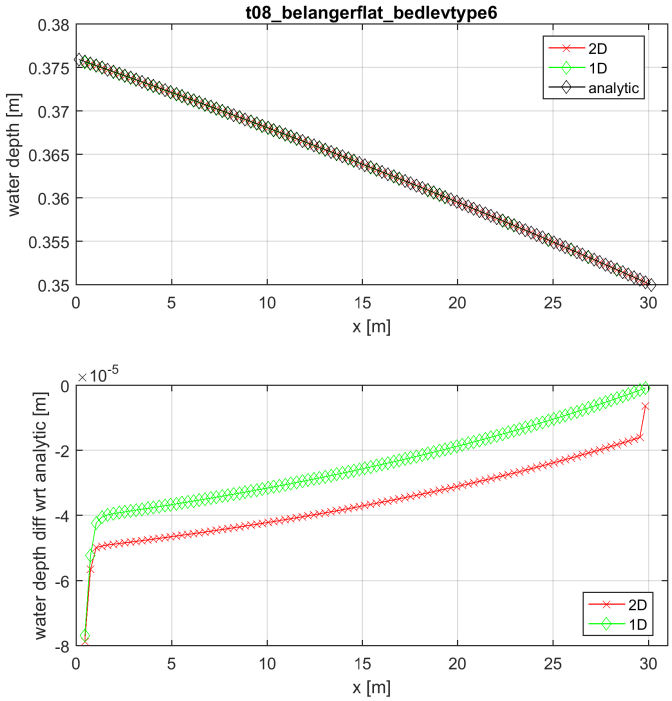

Figure 4: Water depth (top) and difference with semi-analytical solution (bottom) for bedlevtype=6.

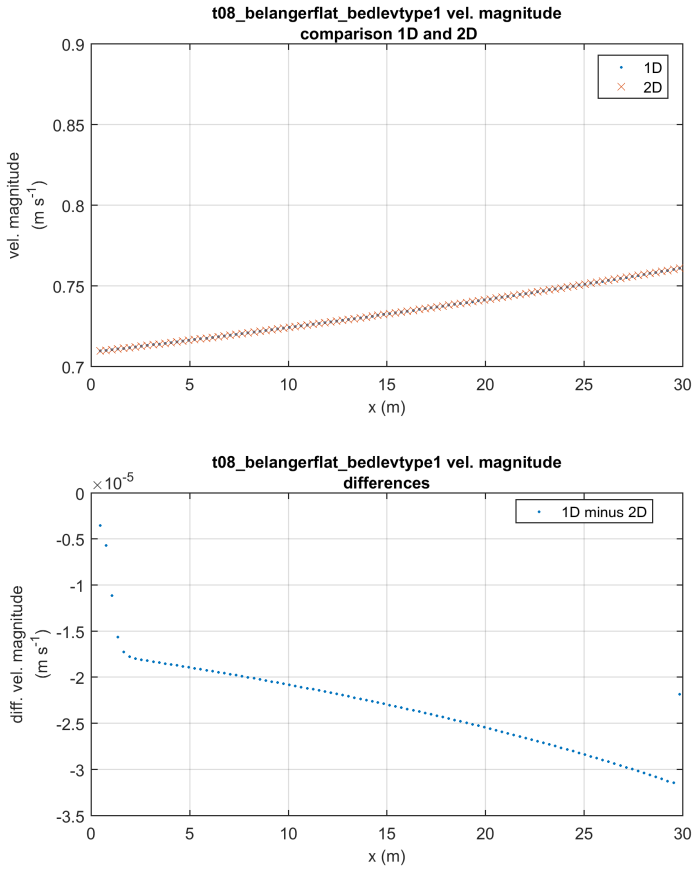

Figure 5: Flow velocity comparison in 1D and 2D for bedlevtype=1.

Analysis of results

- Water level: 1D is closer to analytical solution than 2D.
- Differences with analytical solution are small.
- Identical results for the considered bedlevtypes.
- Very small differences in flow velocity between 1D and 2D.

Conclusion

Differences in water level and flow velocities are small enough to use for test cases including morphology.
The water surface profile near the upstream boundary is different between 1D and 2D; this might need some attention in the future.