Sisyphe

Validation Manual

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Contents

1. Yen

1.1 Purpose

The purpose of this test is to assess the accuracy of SISYPHE at reproducing the bed evolution in an alluvial channel bend under unsteady-flow conditions. The mechanics of sediment transport in channel bends, frequently appearing in natural rivers, are much more complex than that in straight channels. The complexity is twofold. On the one hand, the sediment transport in a channel bend is subject not only to longitudinal transport but also to transverse transport and transverse sorting by the secondary flow inherently associated with bends. On the other hand, the unsteadiness of flow in natural rivers certainly has some effects on the structure of the flow field, thereby affecting the motion of sediment particles.

This test is the experimental setup (RUN 5) proposed by Yen and Lee (1995). In this case, the bed evolution of a 180° channel bed with an initial flat bottom is computed for a triangular-shaped 300 min. hydrograph. Numerical results are validated by measured contours of bed evolution after at the end of the experience and by measured bottom elevations at two different cross sections (90° and 180°). This validation case can be performed for uniform or graded sediment distribution.

1.2 Problem setup

The flume consists of a straight section of 11.5 m long, a 180° bend of 4.0 m radius and a downstream straight section of 11.5 m long, with a constant slope in flow direction equal to 0.002. The width of the flume channel is 1.0 m. A triangular-shaped inflow hydrograph with an initial discharge of $Q = 0.02$ m^3/s, a water depth at the outflow of $h = 0.0544$ m and a peak discharge of equal to 0.053 m^3/s (water depth $h = 0.103$m) at $T = 100$ min is used, see Figure 1.1. After $T = 100$ min, the inflow discharge is reduced linearly until it reached the initial values at the end of the experiment ($T = 300$ min).

The sediment is characterized by a median diameter of $D_{50} = 1$ mm. This value is used for the case uniform sediment. For the case graded sediment, five sediment classes with diameters $D = 0.31, 0.64, 1.03, 1.69$ and 3.36 mm are chosen to reproduce the sediment distribution of the experiment. For this case, an initial distribution of 20% for each class is adopted. The Engelund-Hansen formula is adopted to estimate the sediment transport capacity of the channel. The slope effect and the secondary currents correction are accounted for this test. The influence of the slope effect on the the direction of the bedload transport is accounted through the Talmon formula, with $\beta_2 = 0.85$. The influence of the slope effect on the the magnitude of the bedload transport is accounted through the Soulsby formula, with an friction angle of 35° The default value of $\alpha = 1$ is used for the secondary currents parameter, therefore the Engelund parameter $A = 7$. For the case graded sediment, two vertical sediment layers with a total thickness equal to 20 cm are assumed.

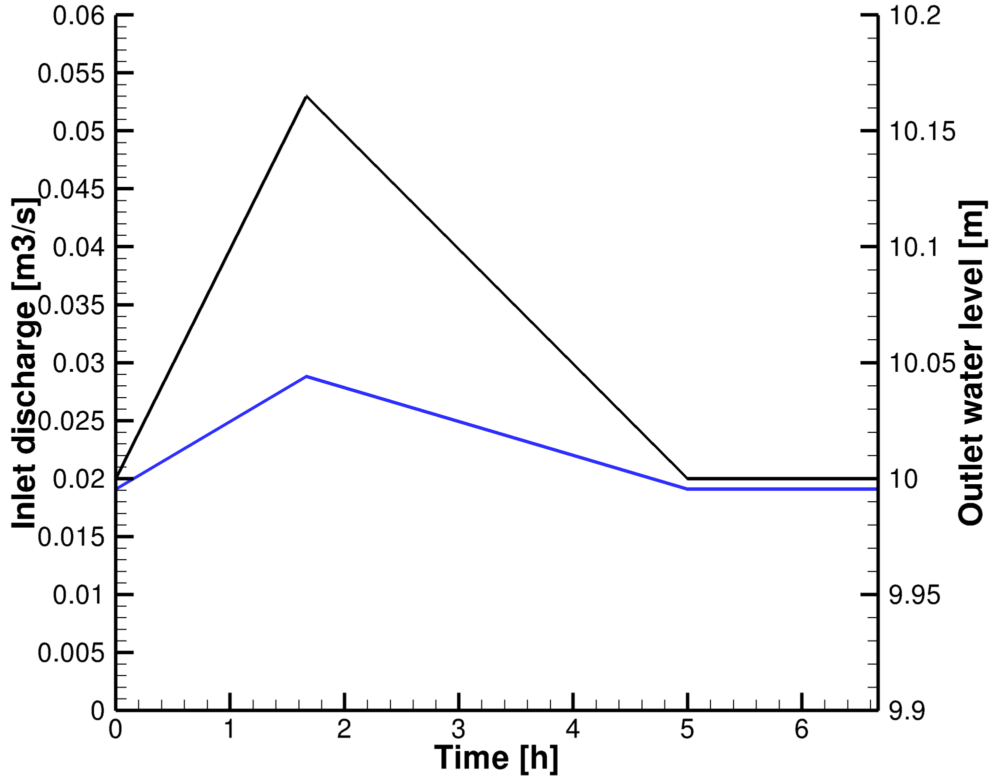

Figure 1.1: Triangular-shaped hydrograph.

A friction closure relationship, based on the Nikuradse roughness length is adopted to account for the bed resistance. For this case, $k_s = 3.5$ mm ($\approx 3 \times D_{50}$) and the Elder model is specified to parameterize the turbulent eddy viscosity. The critical Shields parameter is set at 0.047 and the bed porosity is 0.375.

1.2.1 Numerical setup

Numerical simulations were conducted on an unstructured, triangular finite element mesh with 3230 elements and 1799 nodes and a mean grid size of the order of 0.20 m (Figure 1.2). As initial condition, a fully developed (stationary) flow with a constant water-depth $h = 0.0544$m and discharge 0.02 m^3/s is imposed and the bottom has a constant slope in flow direction equal to 0.002.

The time step is set to 0.5 s. For a mean velocity in the range $[0.37 - 0.53]$ m/s and a mean grid size of the order of 0.2 m, the mean Courant number varies between 0.6 and 1.3.

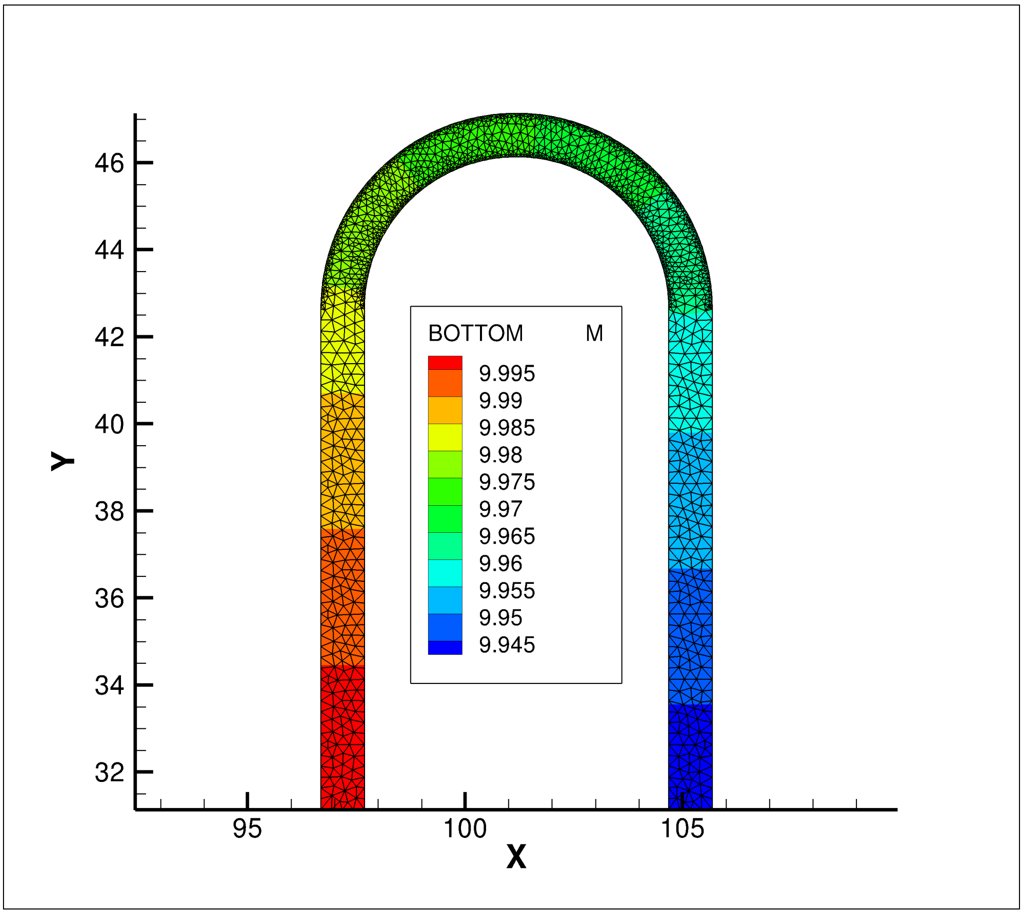

Figure 1.2: Finite element discretization of the bend.

1.3 Results

Numerical results of the normalized bed evolution are shown in Figure 1.5. Morphological changes exhibit the expected patterns of erosion and sedimentation at the channel bend, with the presence of a point bar along the inner-bank and a deeper channel along the outer-bank of the bend. The computed bed changes are in agreement with the measured data. Without accounting for the secondary flow effect, one cannot obtain such reasonable results. Numerical and observed bottom profiles at cross sections 90° and 180° are presented in Figure 1.6 for a total time equal to 5 hs.

1.4 References

Yen, C. and Lee, K.T. (1995) *Bed Topography and Sediment Sorting in Channel Bend with Unsteady Flow*. Journal of Hydraulic Engineering, Vol.121, No. 8.

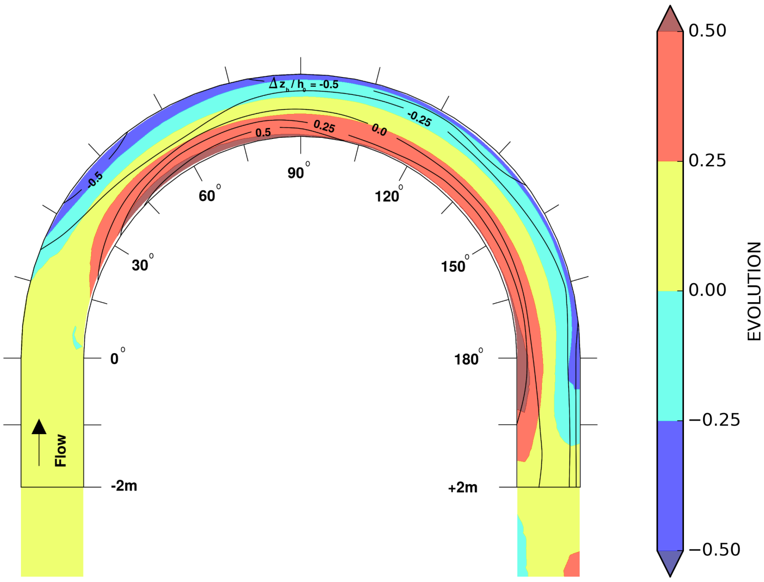

Figure 1.3: Comparison of simulated (coloured) and measured (black contour lines) normalized bed evolution.

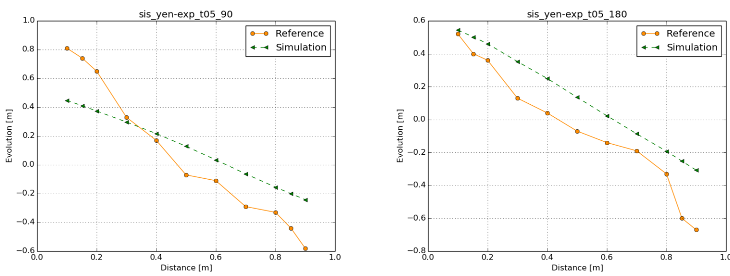

Figure 1.4: Comparison of simulated and measurement bottom elevation at cross section 90° (left) and 180° (right).

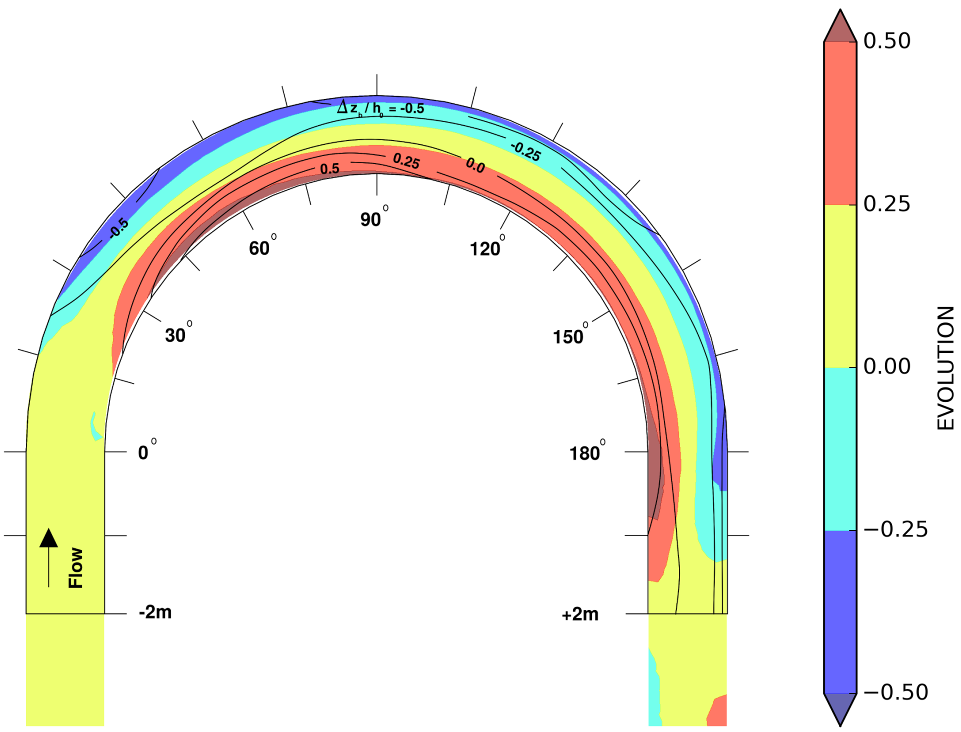

Figure 1.5: Comparison of simulated (coloured) and measured (black contour lines) normalized bed evolution.

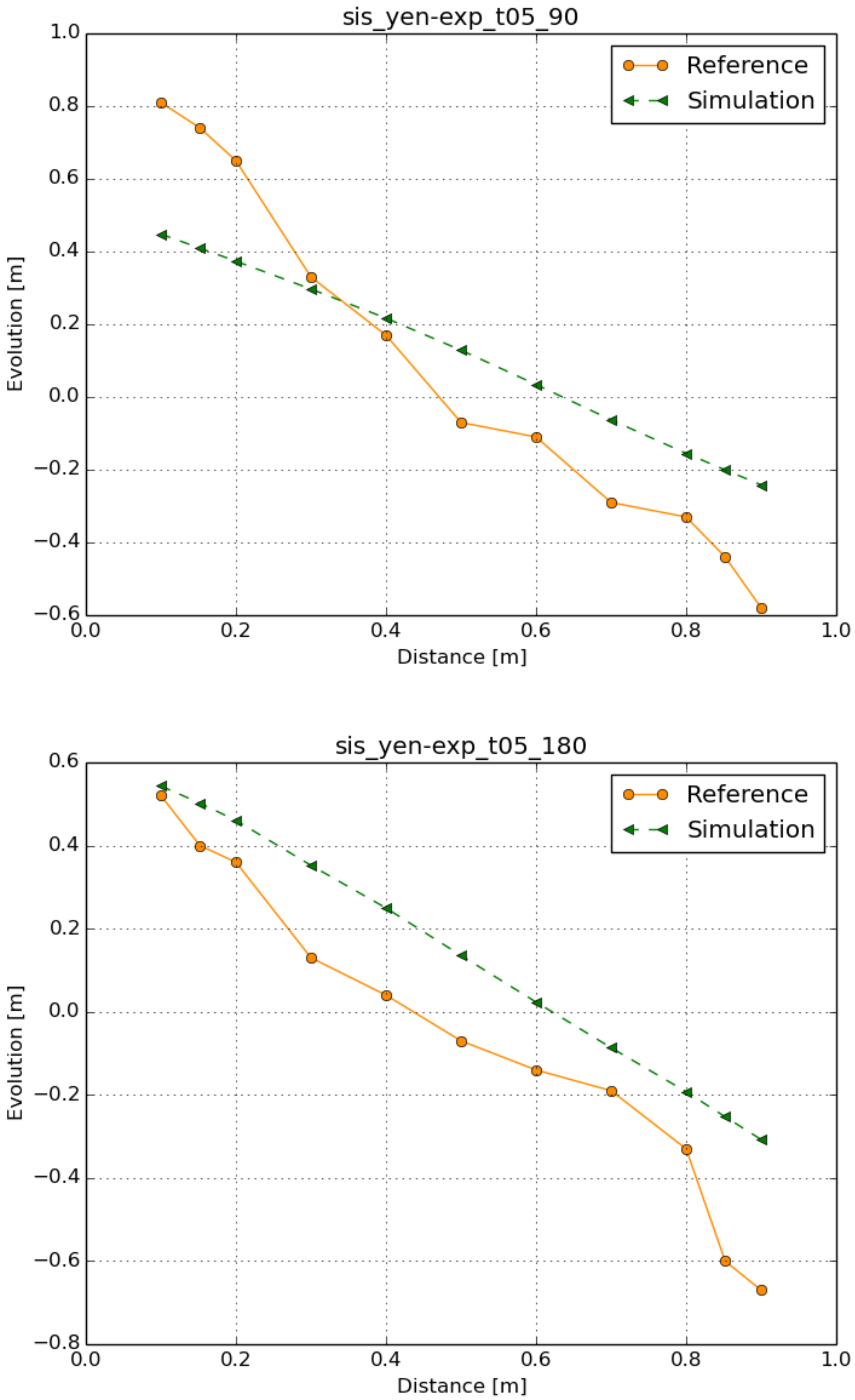

Figure 1.6: Comparison of simulated and measurement bottom elevation at cross section 90° and 180°.

2. Nestor example 1

2.1 Purpose

First test example for Nestor

2.2 Description of the problem

This example is for testing dredging and dumping of the previously dredged material.
100 m^3 material will be dredged in the polygon named `201_Abschnitt_1_2_1000m**2` defined in `_DigPolys.dat` over a time period of 100 s. The name must start with an integert number between 100 and 999. From position 4 is free text to help the user. Only the number is the identifyer of the polygon. This Dredging area is located between 100,5 and 300,5 m of the flume with an area of 200 x 5 = 1000 m^2. In this part only coarse material (dm=2mm) exists. The dredging starts 50 s after the simulation start (2000.01.01-00:00:50) and ended 100 s later (2000.01.01-00:02:30). This is defined in `_DigActions.dat`. The dredged material will create a final erosion of 0,1 m in the dredging area. The dredging rate (calculeted by Nestor) is the dredging volume devided by the dredging time and the dredging area $\frac{100m^3/s}{100s*1000m^2} = 0,001$ m/s
At the time when the dredging starts the dredged material will be dumped in the polygon named `field 202_Abschnitt_6_7_1000m**2`, which is located between 700,5 and 900,5 m of the flume with an area of 200 x 5 = 1000 m^2. The final sedimentation will be 0,1 m in the dumping field. In this part originally only fine material is located (dm=0,1mm). Due to a small dumping rate (preset to 0,0005 m/s), which is two times smaller than the dredging rate it takes 200 s to dump the material.
The sediment distribution will not be changed in the dredging area. In the dumping area the mean grain size will be increased during the dumping of coarse material. The final mean grain size is only 1,3 mm due to mixing processes of the Hirano layer model. Without mixing processes, the active layer would completely consists of the coarse material and would have a mean grain size of 2 mm as the sedimentation depth is as big as the active layer.

2.2.1 Physical parameters

The simulation has set up with three grain classes (d=0,1 / 0,2 / 2 mm), but only the fine and the coarse material are used. The bottom is discretised with three layers. A constant active layer (10 cm), an underlying stratum (10 cm) and a last layer up to the rigid bed (9.8m).

The Meyer-Peter Mueller transport formula is used but the MPM parameter is set to zero which avoids sediment transport. All bottom changes come from the dredging and dumping processes.

2.2.2 Geometry and Mesh

A 1000 m long flume with three widening parts has been chosen as test geometry (see figure 2.1). The width of the flume is 10 m and increases up to 30 m in the widening parts. Two of the widening parts are 100 m long and the third is 200 m long. The initial bottom has a continuous slope of 0,09 The node area for every node is 1 m^2 in order to calculate dredging and dumping volumes very easily.

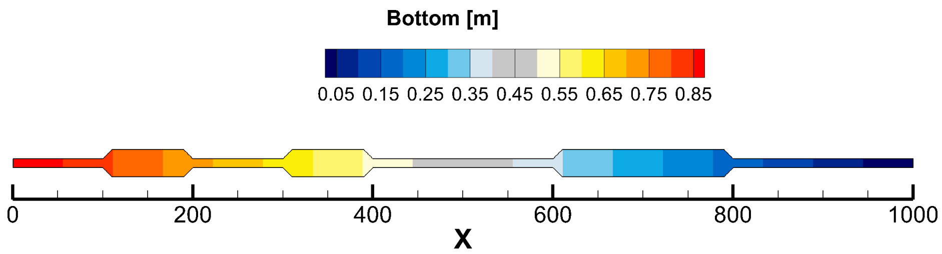

Figure 2.1: Geometry of the test flume with three widening parts

The mesh consists of 18411 nodes and 34800 elements.

2.2.3 Initial and Boundary Conditions

Steady state boundary conditions:

- Discharge at the inlet = 20 m^3/s
- Water depth at outlet = 1 m
- Sedimentological equilibrium at the inlet (zF is constant, QS will be calculated)

Fully developed flow from a previous simulation is used as initial conditions.
With a time step of 1 s a simulation period of 250 s are computed.

2.2.4 Numerical parameters

2.3 Results

Figure 2.2 shows the evolution after 50 s (start of dredging and dumping), after 100 s (end of dredging) and after 250 s (final simulation state and end of dumping process).

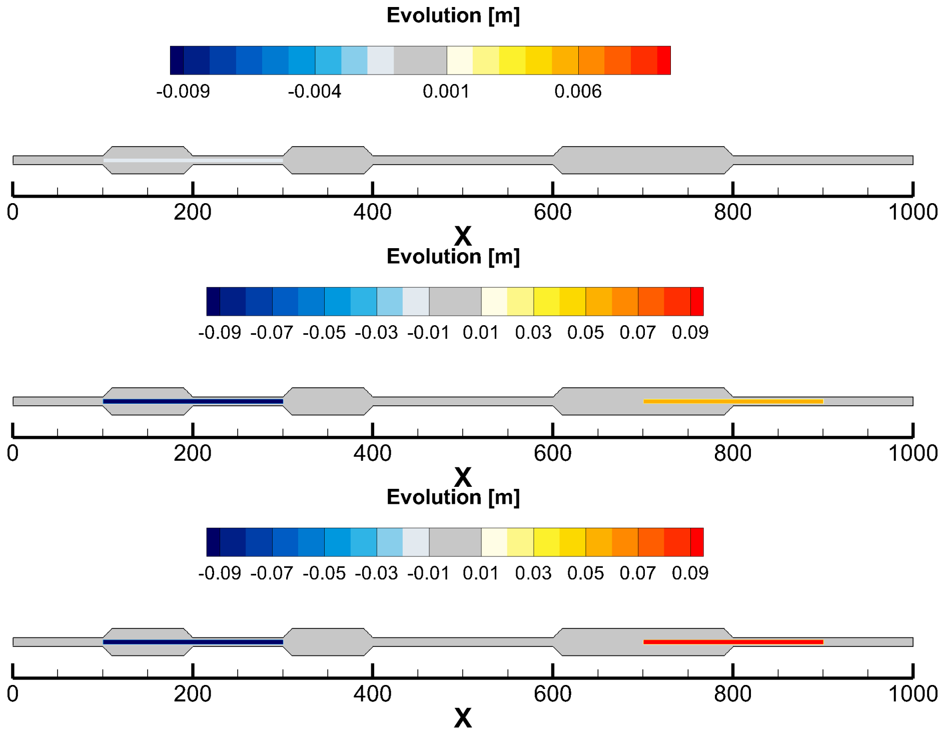

Figure 2.2: Simulated evolution after 50, 100 and 250 s.

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