How good are 2D-morphodynamic models in reproducing bed morphology of meandering channels? Analyzing the strengths and limitations of three popular 2D models

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Abstract: The applicability of the three widely used 2D morphodynamic models: Telemac2D, Nays2DH and CCHE2D in replicating meander bed morphology are investigated. The models were applied to simulate an experimental case of a sine-generated meandering channels from the previous works available from the literatures. Simulation results showed that each model is capable of satisfactorily reproducing the meander bed morphology but there exist significant differences in capturing particular bed features like point bar, outer bank scour, etc. Further analysis under different flow and other hydraulic conditions might be necessary to get more detailed insights of the various aspects of the morphodynamic models.

Keywords: Morphodynamic models, meander morphology, Telemac2D, Nays2DH, CCHE2D.

Methods

- An experimental case is chosen from the available literatures from the past and three widely used 2D morphodynamic models are applied to simulate the bed morphological changes.
- The performance of each of the models in reproducing the experimental results are investigated.
- The three morphodynamic models used are Telemac2D, Nays2DH and CCHE2D.

- Telemac2D solves the shallow water equations (momentum and continuity) using the finite-element approach in an unstructured (triangular elements) computational mesh. The sediment transport model sisyphe and the hydrodynamic model Telemac2D are internally coupled.
- Nays2DH is a computational model within IRIC interface for simulating unsteady horizontal (2D) flow, sediment transport, and morphological changes of bed and banks in rivers. It is based on general curvilinear coordinates.
- CCHE2D is also a depth-integrated 2D model for simulating free-surface turbulent flows, sediment transport, and morphological change. This is a finite element-based model of the collocation method using quadrilateral mesh. The governing equations solving the flow are two-dimensional depth-integrated Reynolds equations in the cartesian coordinate system.
- Constant steady discharge of 9.8l/s (inflow boundary condition) with average flow depth 5cm (outflow boundary condition) was supplied to the inlet rectangular channel of width 80cm having fixed banks. Non-uniform sand having median diameter d_{50}=0.65mm was used as bed material in the channel of bed slope of 1:250 along the centerline.

Results

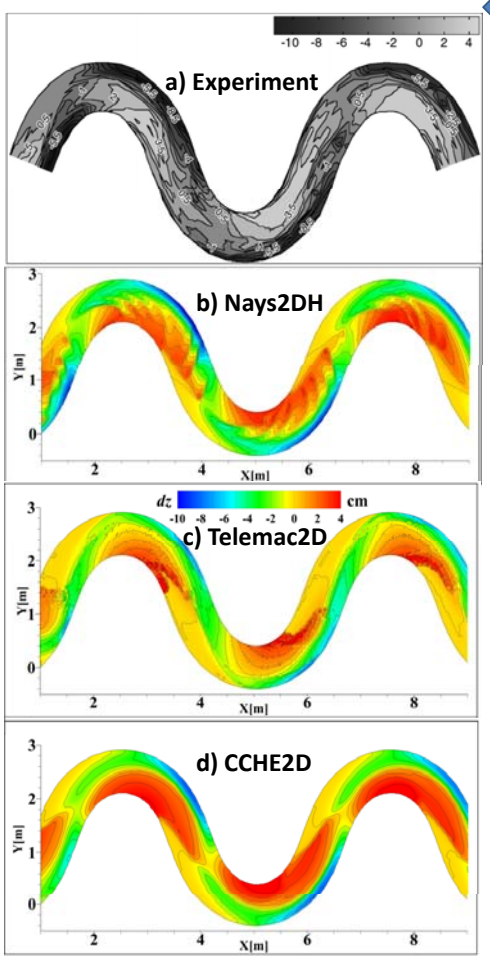

Figure 1: Change in bed morphology at the end of the 170minutes; a) Experiment, derived from Ferrera da Silva and El-Tahawy (2008) b) Nays2DH c) Telemac2D D) CCHE2D.

Conclusions

- In general, all the models satisfactorily reproduced the various bed morphological features obtained in the experiments like deep scour along the outer banks as well as the point bar along the inner bank.
- Comparatively, Nays2DH better captured the length including the depth of erosion along the concave banks.
- But the length and the size of the formation of point bar on the convex bend was better reproduced by CCHE2D.
- However, the location of the beginning of the point bar on the convex bend matched close to the experiment in Nays2DH and Telemac2D. The scour depth along the outer bank including the size of the point bar was slightly underestimated in case of Telemac2D.
- It can be concluded that each model, in general, is capable of satisfactorily reproducing the meander bed morphology but there exist differences in capturing particular bed features like point bar, outer bank scour, etc.
- However, further analysis under different flow conditions might be necessary to get more detailed insights of the various aspects of the morphodynamic models.

Bibliography

Ferrera da Silva AM and El-Tahawy T (2008). On the location in flow plan of erosion-deposition zones in sine-generated meandering streams. Journal of Hydraulic Research 46, 49–60.