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Coupling 1D-2D Shallow Water models for Simulating Floods due to Overtopping and Breaching of Leeves

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ABSTRACT

Levees are one of the most commonly used structural mitigation measures to protect low laying areas against floods. Their overtopping or failure may have serious consequences in the areas developed under their protection. Current practice of preparing risk and vulnerability analysis studies based on running 1D river flow simulations and then simulating 2D flood propagation in the adjacent low-laying areas requires considerable effort and is time consuming. On the other hand, a full 2D representation of the river with its surrounding area would be too demanding from viewpoints of both data collection and computational effort. The present paper presents a technique for coupling two existing 1D and 2D numerical models (CCHE1D-FLOOD and CCHE2D-FLOOD) using a special version of immersed boundary method based on ghost-fluid technique.

Both of the codes are based on the conservative upwinding cell-centered Finite-Volume scheme presented in [1]. Fig. 1 schematically shows the coupling of 1D and 2D codes. The 1D river model is represented by a series of cross sections located at the intersection of the projection of thalweg line with the gridlines. If necessary, the cross sections at these intersection points are interpolated from surveyed cross-sections.

The 2D model employs a 2D regular structured grid which can be the DEM (Digital Elevation Model) describing the topography of the domain of interest. The typical cell sizes can be in the range of 10m-50m. When projected onto this 2D grid, the thalweg line of the river cuts through regular cells and defines an immersed internal boundary. The projected thalweg line is piecewise linear and each 2D cell can be cut only once by a straight line representing a river reach. At a given time step first the river flow is calculated with 1D model by taking into account lateral inflows and outflows computed at the previous time step. Different boundary conditions, such as a hydrograph, a stage discharge curve, etc, can be imposed at the upstream and downstream boundaries of 1D model. Then, for the same time step, the 2D model is calculated by treating the projected thalweg line of the river as an immersed internal boundary. This immersed internal boundary is handled using the Ghost-Fluid method proposed

in [2]. Along the immersed internal boundary the flows incoming from or outgoing into the 1D model computed in the previous time step are imposed as boundary conditions.

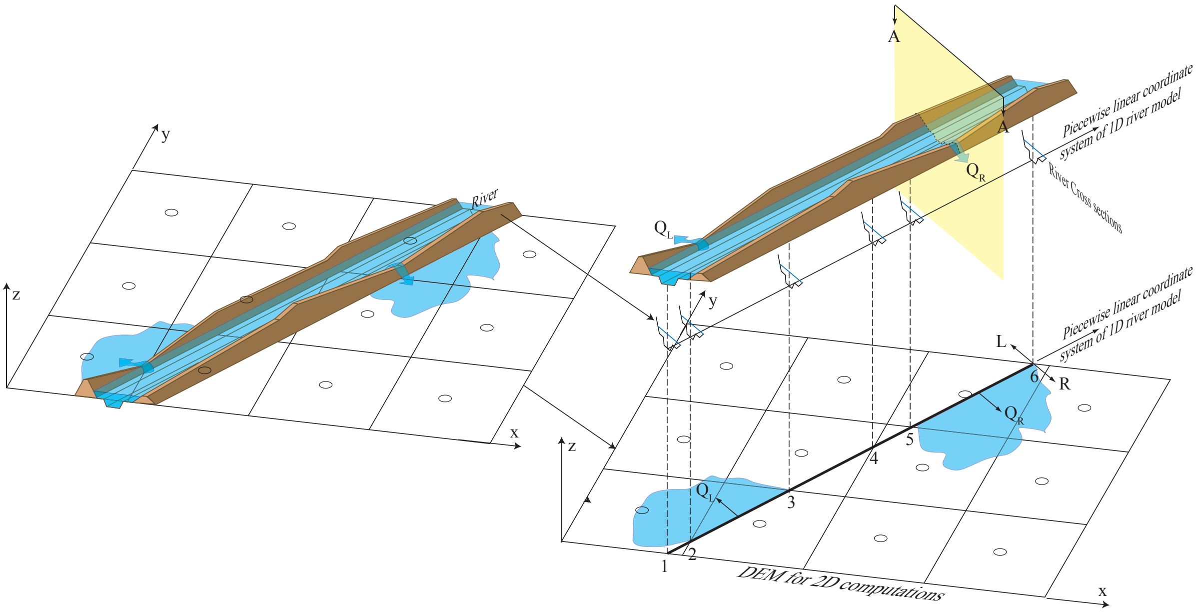

Figure 1: Regular DEM grid with a linear terrain feature: coupling scheme.

Once 1D and 2D model computations are completed, a new set of exchange flows, if any, are computed using weir equation under unsubmerged or submerged flow conditions depending on the water levels. 1D river model may exchange water with the 2D model of the surrounding area on both sides. A special data structure is, therefore, used to keep track of these flows exchanged between river reaches, represented by the line segments of the internal boundary, and the cells of the two dimensional model.

The effectiveness of the proposed algorithm has been verified on academic and on real world cases.

REFERENCES

[1] X. Ying and A.A. Khan and S.S.Y Wang. “Upwind Conservative Scheme for the Saint Venant Equations”. *J. Hydraul. Eng. - ASCE*, Vol.**130**, Issue No.**10**, 977–987, 2004.

[2] M. Altinakar, E. Fijołek, E. Miglio and W. Wu . “Ghost-Fluid Method for the inclusion of internal boundary in 2D Cartesian Grid Shallow Water Models”. *in preparation*, 2007.