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Diffusion wave modeling: Can we eliminate channel cross sections for flood routing purposes?

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Abstract

A typical problem in computational hydraulics is to transfer information (i.e., pressure and velocity field) from one river cross section to another. In hydraulic routing, the governing equations can be considered to be a combination of continuity and momentum equations for which its numerical solution requires a huge amount of data, e.g., river longitudinal and lateral cross sections. Unfortunately, these data are lacking in practical situations and their preparation calls for extensive human and financial resources. Furthermore, these valuable data are subjected to variation due to erosion and sedimentation processes. The basic question is to see if Saint-Venant equations can be simplified to a form which does not require river cross section. In the current literature, it is argued that diffusion wave has this characteristic. In light of this, it is further claimed that parameter(s) incorporated into Saint-Venant equations are of local and distributed nature while that of diffusion wave are of global and lumped characteristic. Thus, the purpose of the current paper is to explore the extent to which this claim is valid. Upon its validation, the diffusion wave routing can be effectively utilized to transfer the stage/discharge hydrographs to the required section.

Keywords: hydraulic routing, channel geometry, diffusion wave equation, Saint-Venant equations.

1. INTRODUCTION

A typical problem in computational hydraulics is to transfer information (i.e., pressure and velocity fields) from one river cross section to another in a meaningful and an efficient way. This information can be effectively utilized to design various hydraulic structures (e.g., dam spillway, bridge, levee height, flood mapping, etc.) as well as flood warning systems. This information transfer, invariably called flood routing, receives extensive attention in the last five decades or so due to importance of wise management of river related processes. As such, the literature is literally full of attempts to simulate the water flow in river corridor with new kernels essentially emerging from new technology.

In reference to the current state of the art on flood routing, water flow simulation can be achieved in three different ways, namely; hydraulic, hydrologic and data-driven approaches. In hydraulic routing invariably called physically-based routing or white box approach, conservation of mass and momentum in differential form will be utilized to simulate water flow in rivers. In hydrologic routing, the conservation of mass in lumped format coupled with empirical storage function will be implemented to transfer the required