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Comparison of unstructured finite-volume morphodynamic models in contracting channel flows

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Abstract

Unstructured finite volume methods are receiving increased attention mainly because of their ability to provide a flexible spatial discretization. Hence, some areas can be resolved in great detail while not over-resolving other areas. Development of these models is an ongoing process with significant longstanding issues with adaptive grids, efficiency, well-balanced flux-gradient and source-term approximations, and so forth. However, many of these problems have been solved with the current generation of models which have much promise for morphodynamic models in contracting channel flows. Our purpose is to compare a class of unstructured finite volume morphodynamic models in contracting channel flows. The proposed adaptive finite volume method has important advantages in the discretization of the gradient fluxes and source terms and can handle complex topography using unstructured grids and satisfies the conservation property. The adaptation criteria is based on monitoring the bedload in the computational domain during its transport process. The comparison is illustrated with a simple test case of contracting channel flow.

Keywords: Shallow water equations; Sediment transport; Morphodynamics; Finite volume method; Unstructured mesh

1. Introduction

In the present work we are concerned with the construction and application of a finite volume method for solving the morphodynamic models in contracting channel flows. The governing equations describe the hydrodynamics for the free-surface flow and morphodynamics for the sediment transport. Here, we consider the well-established shallow water equations to model the hydrodynamics and an Exner equation to model the morphodynamics. The coupled system forms an hyperbolic system of conservation laws with source terms. Computing the numerical solution of this system is not easy due to its nonlinearity form, coexistence of different space and time scales within the system, and the presence of the source terms. Hence, in many morphodynamics models, the sediment transport of the bed occurs on a transport time scale much longer than the water flow time scale, see [8,3,2] among others. It is therefore desirable to construct numerical schemes that preserve stability for all time scales. On the other hand, for many hydrodynamical models, it is well known that shallow water equations on irregular beds have steady-state solutions in which the flux

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