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Equilibrium and non-equilibrium models applied to unsteady sediment transport

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SUMMARY

Sediment transport is ubiquitous in river and coastal morpho-dynamical systems and its influence on the global behaviour of these environmental systems can be decisive. Usually, sediment transport is divided into suspended and bed load, representing the different physical processes involved in the sediment movement. When only bed load is considered, the morpho-dynamical system can be mathematically modelled by the well-known shallow water equations for the hydrodynamic component coupled with a continuity equation for the solid mass, called Exner equation [1]. Exner equation is based on equilibrium hypothesis, which considers that the actual bed load rate is equal to the transport capacity of the flow, determined by one of the experimental closure relations reported in literature. This hypothesis is fairly admitted in steady and quasi-steady flow conditions, however for highly unsteady events, as floods or dyke failures, the actual bed load transport rate suffers a temporal and spatial lag respect to the flow capacity and the equilibrium formulation is no longer valid [2]. The non-equilibrium approaches have received increasing attention in the last years and have demonstrated to be suitable for modelling both highly erosive and scour phenomena.

In this work, the equilibrium and non-equilibrium formulations are applied to erosive problems involving unsteady flows and the presence of non-erodible layers. The system of equations is solved coupled by means of a Finite Volume Method (FVM) based on a Roe's approximated upwind scheme [3, 4]. The numerical model is robust and conservative. The equilibrium and non-equilibrium formulations are compared in terms of numerical prediction accuracy for these kind of complex erosive problems.

Keywords: Hyperbolic conservation laws systems, finite volume methods, non-equilibrium sediment transport, non-erodible layers.

AMS Classification: 35-Q35, 76-M12, 86-A05

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