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Comparative analysis of several sediment transport formulations applied to dam-break flows over erodible beds

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Transitory flows generated by dam failures have a great sediment transport capacity, which induces important morphological changes on the river topography. Several studies have been published regarding the coupling between the sediment transport and hydrodynamic equations in dam-break applications, in order to correctly model their mutual interaction. Most of these models solve the depth-averaged shallow water equations to compute the water depth and velocity. On the other hand, a wide variety of sediment transport formulations have been arbitrarily used to compute the topography evolution. These are based on semi-empirical equations which have been calibrated under stationary and uniform conditions very different from those achieved in dam-break flows. Soares-Frazao et al. (2012) proposed a Benchmark test consisting of a dam-break over a mobile bed, in which several teams of modellers participated using different numerical models, and concluded that the key issue which still needs to be investigated in morphological modelling of dam-break flows is the link between the solid transport and the hydrodynamic variables.

This paper presents a comparative analysis of different sediment transport formulations applied to dam-break flows over mobile beds. All the formulations analysed are commonly used in morphological studies in rivers, and include the formulas of Meyer-Peter & Müller (1948), Wong–Parker (2003), Einstein-Brown (1950), van Rijn (1984), Engelund-Hansen (1967), Ackers-White (1973), Yang (1973), and a Meyer-Peter & Müller type formula but with ad-hoc coefficients. The relevance of corrections on the sediment flux direction and magnitude due to the bed slope and the non-equilibrium hypothesis is also analysed.

All the formulations have been implemented in the numerical model Iber (Bladé et al. (2014)), which solves the depth-averaged shallow water equations coupled to the Exner equation to evaluate the bed evolution. Two different test cases have been studied. The first one is the benchmark case presented in Soares-Frazao et al. (2012), and consists in an instanteneous dam-break flow over a sand bed. The second one corresponds to the experimental studies performed at the Engineering Faculty of the UNAM (Fuentes-Mariles et al. (2010)) and consists in the erosion of a volcanic sand dike by an overtopping flow. In both cases experimental measurements of water depth and bed evolution are available to evaluate the performance of different sediment transport formulations. A sensitivity analysis to the physical properties of the bed material (grain density and size) is also presented for each formulation, in order to analyse to which degree the properties of the bed material need to be defined in the numerical model.

References

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