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Long term 2D gravel-bed river morphodynamics simulations using morphological factor: are final configurations always reliable?

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In last decades, pushed by an increasing interest in environmental problems and supported by an exponential growth of computational capability, novel numerical methods and models have been developed. Despite the progress in parallel computing, computational time is still one of the main bottlenecks when dealing with long term environmental simulations. To overcome such time constraint in morphodynamic models, artificial acceleration of bed evolution has been implemented with different strategies (e.g. Roelvink 2006). The key idea is to accelerate the morphological evolution increasing the discrete bottom variations of a given "morphological factor" during numerical integration thus considerably speeding up computational time. On the other hand, an artificial alteration of the governing equations is put forward, for which related numerical and physical consequences are not completely known. The present work investigates the role of the morphological factor in numerical simulations of a well-defined, 2D reach-scale process in river morphodynamics, which can be taken as a benchmark for the established knowledge made available from theoretical and physical scale models developed in the past decades. The chosen process is the evolution of free migrating bars in a straight channel.

The numerical morphodynamic model used in this work is GIAMT2D (Siviglia et al. 2013), which solves the governing system of shallow water and Exner equations following a fully coupled approach with a finite volume method on unstructured triangular grids.

By processing numerical outcomes also through Continuous Wavelet Transform, the differences in free migrating bars properties (temporal evolution and equilibrium values of wavelength, amplitude, celerity) are investigated in simple test cases with different values of the morphological factor. Numerical results are compared with available analytical theories for free bars.

The outcomes highlight the consequences of using the morphological factor in the case of free bars and suggest the need for deeper investigations centred on other benchmark morphodynamic processes modelled with an accelerated bottom evolution. Moreover, the implications of morphological factor for different numerical strategies (ex. coupled, uncoupled) is still an open topic, as also revealed by the analysis of the governing system eigenvalues in a simple 1D case.

Roelvink, J. A. (2006). Coastal morphodynamic evolution techniques. Coastal Engineering. 53(2-3), pp 277–287.

Siviglia A., G. Stecca, D. Vanzo, G. Zolezzi, E.F. Toro, M. Tubino (2013). Numerical modelling of two-dimensional morphodynamics with applications to river bars and bifurcations. Adv.Wat. Res. 52, pp 243–260.