Long-term modelling: why experimental evidence is hardly replicated numerically

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ABSTRACT

Aiming to model the very long-term (10^4-10^7 years) evolution of a river system, a 0-D two-reach two-grainsize model has been applied to several large rivers worldwide (Varrani 2017), showing its capability to reproduce two actual morphometric parameters, namely the longitudinal profile concavity and downstream sediment fining.

The main assumptions of such a schematic model (Figure 1) are quite strong: constant length and width of the highland and lowland reach, constant solid and liquid discharge feeding from upstream, fine and coarse representative grainsizes for all the system, no abrasion. To validate this simplified model, developed for the evolution of large basins over geological periods, it has been applied to an experimental setup with similar assumptions. Starting from the laboratory conditions reported in Paola et al. (1992), the comparison shows that the model can qualitatively reproduce the experimental trends for the two morphometric parameters.

Due to the experimental limitations (i.e., the duration of the experiment), it has not been possible to perform a thorough comparison, particularly regarding the downstream fining. Indeed, the experiment highlights equilibrium conditions strictly only for the longitudinal profile and not for the bed fining, owing to the bimodal mixture used and the temporal scale of analysis. Such results are confirmed in the numerical runs. which evidence the need for longer experiments to observe equilibrium conditions for the bed fining.

Indeed, for the application to the large rivers, a thorough comparison on the equilibrium states of the longitudinal profile and bed fining would not be possible, yet the trend of the results highlights how the present conditions alter the evolution of the river system as for the sediment transport is concerned. For highly anthropized rivers like the Mississippi and the Zambesi, on which large impoundments and dams have been built, the model results at the large temporal scale (≈10Ma) show an oscillatory behaviour not fostering any equilibrium condition. To corroborate such results additional data would be required, not only on the morphometric parameters output of the 0-D model, but also on the range of validity of the assumptions over such large time-scales, which has been tested at a preliminary stage (Franzoia, 2014; Franzoia & Nones, 2017).

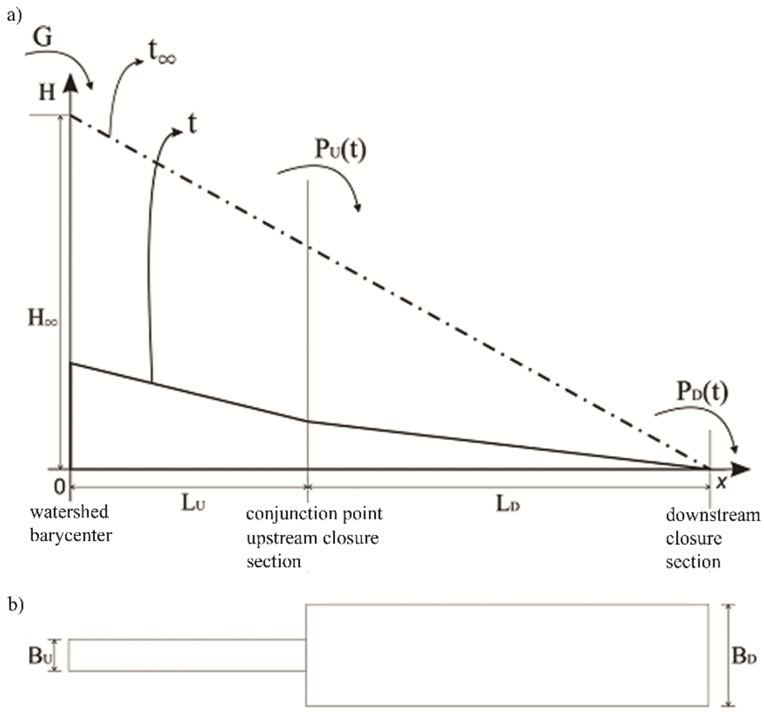

Fig. 1. Schematic representation of the main assumptions adopted in the numerical model: a) longitudinal and b) planimetric view. *G* is the constant sediment input from the production zone of the watershed, $P_{U,D}(t)$ are the sediment output from respectively the upper and the lower reach, H_∞ and is the relief elevation at indefinitely far-off (equilibrium) time t_∞ obtained by a continuous constant sediment feeding of the system, $B_{U,D}$ and $L_{U,D}$ are respectively the time-constant width available for the river to meander and the constant length of the upper and the lower reach.

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