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Interactions between bar dynamics and herbaceous vegetation in gravel bed rivers: numerical simulations using BASEMENT

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A new 2D morphodynamic model for gravel bed rivers have been used to investigate the interaction between alternate bar dynamics and herbaceous vegetation. In particular, bed topography evolution has been coupled with the growth of vegetation, included as a function of the access to ground water.
Numerical simulations were performed using the code BASEMENT (Vetsch et al., 2013), with the addition of a new submodel, dealing with the numerical description of the vegetation. The vegetation was allowed to grow during the dry season on exposed areas, and the vertical distribution of peak biomass was modeled as a function of the bed elevation, using a simple analytical formulation, following Marani et al. (2013). Flow resistance was divided into a component exerted by the bed and a component exerted by vegetation (Crosato and Saleh, 2010; Li and Millar, 2011); in this way we reproduced both the decrease in bed shear stress, reducing the sediment transport capacity of the flow within the plants, and the increase in hydraulic resistance, reducing flow velocity.
The model was applied to a hypothetical case study, with grain size, longitudinal slope, and hydrological regime similar to that of the Magra River (Italy). A straight river reach, 125 m wide and 20 km long was simulated. Starting from an initially flat configuration, the river developed its own bar morphology, under steady formative conditions. After reaching a dynamic equilibrium, we allowed the vegetation to grow and interact with the morphodynamic evolution, reproducing a sequence of floods and growing seasons at low flow. We assumed that vegetation can be uprooted only if the bed shear stress exceeds a fixed threshold.
Different scenarios were examined, varying the effect of vegetation in terms of increased resistance and threshold for uprooting (i.e. added sediment cohesion). Preliminary results confirmed that the herbaceous vegetation has a stabilizing effect on river morphology. As the density and strength of vegetation increases, the vegetated bars became stable, almost stopping their downstream migration. Emerged areas became wider and higher, because of sediment deposition induced by the vegetation, leading to positive feedback for vegetation growth and establishment. Interestingly, we found that the effect of the vegetation has a treshold behaviour, with the positive feedbacks inducing a rapid shift from bare soil towards a vegetated, more stable scenario.

Refrences

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