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Analysing the intrinsic time scale of river bifurcations

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River bifurcations play a crucial role in the morphodynamics of multi-thread channel systems such as braided or anastomosed rivers, deltas and alluvial fans, as they guide the downstream distribution of water and sediment fluxes. Several experimental and theoretical studies have highlighted the unstable character of bifurcations, which tend to produce a differential erosion/deposition in the downstream channels, even in the case of symmetric planform configuration and boundary conditions. This leads to equilibrium states where the flow distribution can be highly unbalanced, depending on the channel width-to-depth ratio. The analyses performed so far have mainly focused on equilibrium configurations, while little information exists about the time evolution of the instability process. In particular, there is no systematic analysis of how the bifurcation timescale depends on the controlling parameters, such as the channel aspect ratio, and the length of the downstream channels. Evaluation of this “intrinsic” time scale is fundamental to study the response of river bifurcations to time variations of any “external” factor that influences the bifurcation dynamics, such as the water discharge, the downstream conditions, or the presence of migrating bedforms. In this work we consider a simple bifurcation, consisting of a straight channel with mobile bed but fixed banks, which splits in two bifurcates that diverge with the same angle. We employ a 1-D shallow-water model for the upstream channel and downstream bifurcates, which are connected by means of the nodal point relation proposed by Bolla Pittaluga et al. (2013). We then numerically analyse the development of the bifurcations instability, starting from an initially-small perturbation of the bed elevation. Finally, we extensively investigate the effect of the key controlling parameters, including the model calibration coefficients, also allowing them to vary in time. The evolution of water discharge asymmetry shows a first exponential growth stage, followed by an asymptotic behaviour that leads to the equilibrium configuration. Model results reveal the key role of the width-to-depth ratio in determining the speed of the bifurcation evolution. Specifically, the evolution is very slow when the system is close to marginal stability conditions, while it becomes increasingly fast when increasing the width-to-depth ratio. Moreover, the timescale of the bifurcation increases with the length of the downstream channel, unless their length-to-depth ratio is sufficiently high.