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River Bifurcations

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Bifurcations are key elements shaping a variety of surface water streams such as river deltas, channel loops, anastomosing and braided rivers. Their geometry interacts in retroactive feedback loops with the upstream and downstream channels and other nodal elements (surrounding bifurcations and confluences).

The easiest way to analyse the dynamics of such bifurcations is by focusing on their planimetric geometry, i.e. the width of each anabranch, the deviation angle at the node along with the typical longitudinal and transverse extensions of a bifurcation unit. We are gathering imagery from laboratory experiments and, mostly, using remote sensing technique and are developing a procedure to measure the key features of bifurcation systems found in their diverse environments mentioned above.

This acquisition method does not yet respect the flow variation since the pictures represent only a single stage of the system evolution. Moreover, most of the data comes from low flow conditions, the formative discharge events being associated with bad weather and scarce optical quality. The dataset is being upgraded to a few time series of single short river reaches containing bifurcations.

Observing the already acquired data, we conclude that the majority of observed river bifurcations are asymmetrical, and they expose two characteristics: the first being the width of the upstream channel increases by a factor $\delta_W > 1$ to match with the sum of the widths of the downstream branches (i.e. “channel enlargement”, quantitatively verifiable by the measuring procedure). The second concerns the slope variation in the longitudinal axis and is for now only qualitatively verifiable from satellite data by observing the water reflection: the slope of the upstream channel increases by a factor $\delta_S > 1$ to meet the average of the downstream channel slopes.

The bifurcation system can be analysed in a pure mathematical way by applying the conservation of water and sediment masses and momentum over each channel, constituting the “BRT-model” [Bolla Pittaluga et al., 2003]. The BRT-model discriminates two cases in which the flux partition towards the downstream branches finds equilibrium, depending on whether the width-to-depth ratio (β_0) of the upstream channel crosses a threshold value β_{cr} : only one balanced equilibrium exists provided that $\beta_0 < \beta_{cr}$. In the other case, the bifurcation finds three equilibria: one unstable balanced and two reciprocal stable, highly unbalanced flux partitions. The BRT-model can be upgraded to account for the channel width and slope adapting to the flux partition along the bifurcates. Hereby, the “Miori-model” [Miori et al. 2006] is built and conserves the stable unbalanced configuration described by the BRT-model.

Such a model seems to reproduce qualitatively the features of the observed bifurcations, which are the unbalanced flux partition, the channel enlargement and averaged slope uplift.

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Miori, S., R. Repetto and M. Tubino (2006), A one-dimensional model of bifurcations in gravel bed channels with erodible banks, *Water Resour. Res., 42,* W11413, doi:10.1029/2006WR004863.