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Stability analysis of a bifurcation in a gravel-sand dominated river

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We extend a model introduced by Wang et al. (1995), which describes the stability of river bifurcations in large river systems, to conditions with mixed-size sediment. The one-dimensional model predicts the morphodynamic behavior at river bifurcations under a constant water discharge and constant sediment supply at the upstream branch , as well as a constant base level at the downstream end of each of the two channels downstream from the bifurcation. The model describes if (a) on the long-term each of the two channels evolve towards a stable state with a finite nonzero flow depth or (b) one of them slowly silts up. As the model is one-dimensional, it by definition cannot predict the partitioning of the sediment at the bifurcation over the branches. It therefore requires a nodal point relation that prescribes the ratio of the sediment supply to the downstream branches at the bifurcation point. As we specifically look into sediment mixtures consisting out of two fractions of sediment (here gravel and sand), we need two nodal point relations, one for the partitioning ratio of each grain size fraction over the downstream branches. The stability analysis reveals much more complex behavior for mixtures of two size fractions rather than one. Depending on the form of the nodal point relations we find 2 to 5 solutions for the combination of flow depths in the two branches. A global solution is one in which one of the branches silts up and closes, but the stability of that solution depends again on the form of the nodal point relation. Furthermore, the initial conditions appear to determine whether a stable state exists with only one open branch or one with two branches each having finite flow depth. The analysis also provides information on the time scales of reaching the stable equilibrium state. The form of the nodal point relation is essential to the analysis. It also is the most complicating factor in the validation of the model against measured data. We apply the model to a large bifurcation in the Rhine River in the Netherlands , where the bed consists out of mixed sediment.

References

Wang, Z.B., R.J. Fokking, De Vries, M. and A. Langerak (1995), Stability of river bifurcations in 1D morphodynamic models, J. Hydr. Res., 33 (6), doi:10.1080/00221689509498549