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The equilibrium of alluvial rivers: How do rivers respond to the variability and stochasticity of water and sediment supply?

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Flow discharge and sediment supply are the two key factors that shape the morphology of alluvial rivers, in the way that rivers will adjust in the long term to reach an equilibrium state under which sediment supply can be transported by the flow through the channel. For natural rivers, both flow discharge and sediment supply can show very high variability and stochasticity, such as the mountain rivers where flash floods and episodic sediment supply are common. However, in flume experiments as well as numerical modeling (on geologic scales), flow discharge and sediment supply are often specified as a characteristic constant value or other simple forms for simplicity. How such simplifications affect the experimental / modeling results are still not well understood. In this study, we implement a one-dimensional morphodynamic model to explore the effects of the variability and stochasticity of water and sediment supply on the long-term river evolution. Various scenarios of hydrograph and sedimentograph are considered, including constant and varying rate of water and sediment supply. Our results show that rivers can approach different equilibrium states under different hydrograph scenarios, due to the fact that sediment transport relations are mostly nonlinear. The long-term equilibrium of rivers is not sensitive to the shape of sedimentograph, as long as the total volume of sediment input is fixed. When the stochasticity of water and sediment supply is considered, rivers show fluctuations on the short time scale, but a macroscopic equilibrium can still be reached when the averaging window is chosen properly. This finding would shed lights on how river equilibrium changes across time scales.