EGU22-11880
https://doi.org/10.5194/egusphere-egu22-11880
EGU General Assembly 2022

Responses of gravel-bed river networks to periodic environmental change

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Environmental conditions exert a primary influence on surface processes such as the production, transport and deposition of sediment. An implication of this behaviour is that sedimentary deposits may record information about past environmental change and its influence on landscape evolution. Extracting this information requires an understanding of the ways in which material is transported from upstream source regions to downstream sedimentary sinks. As such, many recent studies have explored responses of alluvial rivers, the principal agents of sediment transport, to variations in sediment and water supply. In general, these studies have focused on resulting variations in sediment delivery to downstream sinks. However, changing sediment and water supply also results in changes in slope along alluvial rivers, accommodated by aggradation and incision of the valley floor. Cycles of aggradation and incision appear to be recorded by fluvial landforms such as cut-and-fill terraces at many sites around the world. These records may therefore provide an important yet underutilised link between climatic change and resulting variation in sediment production upstream, and the stratigraphic record downstream.

Here, we investigate responses of alluvial rivers to environmental change, with particular focus on resulting variations in channel elevation that could be recorded as fluvial terraces. We employ a recently developed model describing the long-profile evolution of gravel-bed rivers that takes a non-linear diffusive form. This model is defined in terms of measurable properties of river valleys, so should be readily applicable to real settings. For the simple case in which properties such as water discharge and valley width do not vary downstream, we obtain approximate analytical solutions to the diffusive equation that describe resulting variations in the river long profile and bedload sediment discharge. When periodic variation in sediment or water supply is imposed, periodic aggradation and incision occurs that is damped and phase shifted with respect to the imposed variation. Depending on whether sediment or water supply is varied, variation bedload sediment discharge can be damped or amplified. The extent to which signals are modified depends on the distance down valley and the relationship between the forcing period and the valley's intrinsic response time. Using numerical models, we also explore more complex cases in which water discharge is supplied along the valley, and describe a method for estimating the response time of gravel-bed river networks. Finally, we compare our predictions with observations

from a selection of well-studied terrace sites. Our results highlight which kinds and timescales of past environmental change could be represented in fluvial terrace and stratigraphic records and will facilitate improved interpretation of those records.