



Cyclic steps on the Loess Plateau, China: Numerical modeling and field evidence

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Cyclic steps are upstream-migrating long-wave bedforms associated with Froude-transcritical shallow flow that can be sustained and orderly. They can develop in diverse environments, including water flowing over such varied bed materials as alluvium, bedrock and cohesive soil and the flow of turbidity currents in deep-sea settings. Cyclic steps are common features on the Loess Plateau, China, where the sediment is mostly highly erodible silty loess. In Qiaogou Gully on the Loess Plateau, we have observed 17 steps within a 500m reach. Despite the frequent study of cyclic steps, their formation and evolution over a bed composed of poorly consolidated silt is still not well understood. In this study, we present field data about cyclic steps on the Loess Plateau, including the longitudinal profile of Qiaogou Gully, the geometry of each step, and the sediment grain size distribution. We also implement a 1D morphodynamics model which can successfully reproduce the cyclic steps we observed in the field. Both purely erosional conditions and erosional-depositional conditions are considered in our simulations. We find that, (1) the initiation of cyclic steps is closely related to transcritical flow conditions, i.e. with Froude number that crosses unity; (2) a self-preserving headcut can coexist with cyclic steps under purely erosional conditions.