Exploring the relationship between hydrograph characteristics and the time evolution of sand bed morphology

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The development of sand bed morphology in response to steady flow is adequately described in most bedform phase diagrams. This includes the prediction of bedform wavelength, height and shape, all important parameters in estimating flow resistance. However, during time-varying flow, such as that experienced during the passage of a flood wave, the implicit assumption that bedform adjustment tracks changes in flow depth and velocity does not hold true due to bedform hysteresis. Consequently, there is a need to understand which characteristics of unsteady flow drive the disequilibrium dynamics between bedform geometry and hydraulic conditions. This paper describes a series of experiments designed to identify the impacts of hydrograph characteristics on the morphodynamic evolution of alluvial dunes. Mobile sand bed (D_{50} of 450μm) experiments were undertaken in a 16m long, 1.6m wide flume. Sediment was water worked under steady unidirectional flow until equilibrium bed conditions were achieved, after which a hydrograph was applied. At the end of the hydrograph, a period of steady flow was once again run until equilibrium conditions were attained. Hydrograph one consisted of steeply rising (80 minutes) and falling (65 minutes) limbs with hydrograph two characterised by longer rising (170 minutes) and falling (230 minutes) limbs. During the hydrograph discharge was changed in discrete steps. Bed morphology profiles were measured continuously along a 5m by 0.6m, centreline transect using twelve ultrasonic sensors. Three-dimensional flow was measured with a stack of Acoustic Doppler Velocimeters downstream of the transect. Suspended sediment was quantified using a three-frequency set of Acoustic Backscatter Sensors. The impact of these differing hydrograph characteristics are discussed in terms of differences between equilibrium bed morphologies, evolving flow field characteristics and the dynamics of suspended sediment concentrations through the hydrographs.

Presented at: AGU Fall Meeting, 14 - 18 December 2015,
San Francisco, USA

bedforms in unsteady flows