Effects of depth and water surface slope on dune development

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1. Introduction

Changing flow conditions during river floods cause a non-linear response in bedform adjustment. The maximum bed shear stress precedes the maximum water level for a given flood because the water-surface slope increases during the arrival of a flood wave. In contrast, water surface slope and shear stress decline prior to absolute flow depth during falling stage. The relative magnitudes of water surface slope and depth vary during different flood waves, but also between rivers and spatially along sections of river channels. As a result, bedform morphology and the associated sedimentology may be expected to show greater variation than expected from the range of flow depths, and the nature of the bedform response to flood waves ought to vary between different locations.

2. Methods

To investigate the relative importance of water surface slope and depth, a series of laboratory experiments were executed in which flow stage and velocity were varied both independently and simultaneously. The experimental flume of 16m long and 2m wide contained a mobile bed with a D50 of 239µm (Figure 1). During the experiments flow depths varied from 0.15 to 0.25 m and water surface slopes varied from 0.002 to 0.0005. Bedform responses to changing flow conditions, in particular dunes, were measured over a 5 m test section at repeat intervals of 300 s throughout the 120 hrs of experiments. Water depth, water surface slope and depth-averaged velocities were measured at fixed locations along this test section.

3. Results and preliminary interpretation

The results confirm that the morphodynamic response of bedforms to changes in water surface slope and water depth are indeed different. In particular, changing water surface slope and water depth have different effects on bedform superimposition and trough scour, which affect the growth and decay of dunes. These findings imply that the morphodynamic adjustments of dunes varies between locations, not only because of grain-size effects and flood durations, but also due to unique water surface slope – depth characteristics for given locations. Such differences in morphodynamics may also be observable in the sedimentary signatures of different locations.

4. Conclusion

Although the separation of the effects of water surface slope and water-depth may be subtle in natural river systems, the distinction of their relative significance for bedform adjustment during flood waves yields valuable insight into dune morphodynamics and enables us to improve our predictive models.

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bedforms in unsteady flows