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THE adaptation of dunes to changes in River flow

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ABSTRACT

The dunes that cover the beds of most alluvial channels change in size and shape over time and in space, which in turn affects the flow and sediment-transport dynamics of the river. However, both the precise mechanisms of such adaptation of dunes, and the hydraulic variables that control these processes, remain inadequately understood. This paper provides an overview of the processes involved in the maintenance and adaptation of dunes, provides new tools for the analysis of dune dynamics, and applies these to a series of bespoke experiments.

Dunes that grow compete for space, and dunes that decay need to shed excess sediment. Therefore, dune adaptation necessarily involves the redistribution of sediment over and among dunes. The details of sediment redistribution are not captured by mean geometric parameters such as dune height and wavelength. Therefore, new analyses of dune kinematics, bed-elevation distributions, and dune deformation are presented herein that aid the identification and analysis of dune dynamics.

Dune adaptation is often described as a morphological response to changes in water depth at a rate that depends on sediment mobility, which itself is a product of flow depth and velocity. However, depth and velocity are out-of-phase during the passage of flood waves, and they vary spatially across rivers from the thalweg to bar tops, and downstream along the river profile. In order to improve our understanding of the hydraulic controls on dune morphology and kinematics, a series of experiments was performed to investigate the response of dunes in fully-mobile sand (D_{50} = 240μm) to changes in flow depth and velocity.

The experimental results illustrate that water depth and flow velocity have separate effects on the processes that control dune adaptation, and that the crests and troughs of dunes do not respond simultaneously to changes in flow. Trough scour increases with flow velocity, but superelevation of the dune crests appear to show only a weak relation with flow depth. Flattening-out of dune crests is related to decreasing depth and increasing flow velocity. Bedform superimposition, a key feature of bedform kinematics, was associated with increased flow depth, but was also systematically