The response and hysteresis of alluvial dunes under transient flow conditions

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Bedforms perpetually adjust to spatially non-uniform and temporally unsteady flow conditions, with marked changes in flow causing hysteresis-effects in bed response. The rates and styles of adjustment are likely to differ depending on the relative magnitudes of changes in water surface slope, and thus bed shear stress, and flow depth. Slope and depth are likely to be temporally disconnected during the passage of flood waves, but also vary in spatially in their magnitude, for instance between the thalweg and shallower parts of the channel. This paper describes the first of a series of experiments set up to identify the relative roles of slope and flow depth for the morphodynamic adjustments of dunes under a range of transient flow conditions. Initial results suggest that the morphodynamics of dune growth and decay are controlled by four key factors:

i) the bedform stability range,
ii) spatial variability in bedform stability,
iii) bedform kinematics,
iv) the relative magnitudes of water surface slope and depth.

Bedform morphology was most sensitive to changes in water depth. In particular, the development of trains of superimposed bedforms on the stoss of larger dunes was observed following an increase in water depth and not in decreasing water depths. This association suggests that an abundance of superimposed bedforms is not unique to dune decay by cannibalisation, but related to a disequilibrium between dune geometry and the flow over the stoss slope. Fuller understanding of the causes for, and constraints on, dune adaptation to changing flows requires robust quantification of the flow field over out-of-equilibrium dunes.

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bedforms in unsteady flows