Flow structures over fixed 2D bedforms in transient states

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Flow processes measured in the laboratory over fixed, 2D or 3D bedforms have mostly been conducted at singular flow depths and with bedform dimensions set by scaling laws based upon equilibrium flow conditions. These results thus have limited applicability to many natural situations where bedforms and flow fields are co-evolving at different rates in response to transient conditions, such as changes in flow depth and flow discharge associated with a flood. The research presented herein investigates flow processes over 2D fixed bedforms under a range of non-equilibrium, transient, states in order to quantify the spatio-temporal changes in turbulence associated with steady conditions that are set at non-equilibrium depths and velocities.

Flow field information was obtained via Particle Imaging Velocimetry for a range of flow depths and mean flow velocities, mimicking conditions during the transient evolution of flow fields and bedforms during a flood wave. Changes in either flow depth or mean flow speed causes substantial migrations in the locations of maximum turbulence generation and dissipation. Flow speed does not have a significant impact on the height or length of the separation zone shear layer despite a large range in depth-averaged mean velocity whilst there is a weak relationship between decreasing flow depth and a reduction in flow separation zone length. The flow field downstream of reattachment changes substantially with changes in mean flow speed and flow depth. The turbulent wake zone after flow reattachment extends further downstream over the stoss slope and moves closer towards the bed with increasing mean flow speed. Wake stacking from upstream dunes over the flow separation zone was observed without a change in bedform geometry. These changes will likely drive morphological adjustment on the dune stoss side in response to flow variability and thus permits an exploration of the links between sediment transport, morphodynamics, and transient flow field dynamics of fluvial dunes.

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