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Modeling flow and shear stress fields over unsteady three dimensional dunes

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The flow field over dunes has been extensively measured in laboratory conditions and there is general understanding on the nature of the flow over dunes formed under equilibrium flow conditions. This has allowed an understanding of bed shear stress to be derived and the development of morpho-dynamic models. However, fluvial systems typically experience unsteady flow and therefore the sediment-water interface is constantly responding and reorganizing to these unsteady flows and stresses, over a range of both spatial and temporal scales. This is primarily through the adjustment of bed forms (including ripples, dunes and bar forms) which then subsequently alter the flow field. This paper investigates, through the application of a numerical model, the influence of these roughness elements on the overall flow and bed shear stress.

A series of physical experiments were undertaken in a flume, 16m long and 2m wide, where a fine sand (D50 of 239μm) was water worked under a range of unsteady hydraulic conditions to generate a series of quasi-equilibrium three dimensional bed forms. During the experiments flow was measured with acoustic Doppler velocimeters, (aDv's). On four occasions the flume was drained and the bed topography measured with terrestrial LiDAR to create digital elevation models. This data provide the necessary boundary conditions and validation data for a numerical three dimensional flow model. The prediction of flow over the four static beds demonstrates the spatial distribution of shear stress and the potential sediment transport paths between the dune crests. These appear to be associated with coherent flow structures formed by localized shear flow. These flow predictions are currently being used to develop a fully three dimensional morphodynamic model to further understand dune dynamics under unsteady flow conditions.