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The role of dunes on the morphodynamics of sandy braided rivers

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Sandy rivers are characterised by multiple scales of bed topography but dominated by alluvial dunes. Whilst the impact of topographic features such as dunes on flow structure and sediment transport processes is well researched, the extent to which such dune-scale effects control channel and bar-scale morphology and morphodynamics remains poorly constrained. Such bedform effects are typically neglected in two-dimensional (depth-averaged) morphodynamic models that are used to simulate river channel morphological evolution. To evaluate the significance of these issues, we report results from a combined numerical modelling and field monitoring study undertaken in the sandy braided South Saskatchewan River, Canada.

3D Numerical simulations were carried out using OpenFOAM, to quantify the mean three-dimensional flow structure within a 90 m x 400 m section of channel. To isolate the role of bedforms as a control on flow and sediment transport, two simulations were undertaken. The first used a high-resolution (∼3 cm) bedform-resolving DEM. The second used a filtered DEM in which dunes were removed and only large scale topographic features (e.g., bars, scour pools etc) were resolved. The results of these simulations show that the addition of dunes: 1) amplifies the amount of topographic deflection of flow at the bar scale when compared to flow deflection over dune-less topography; 2) forces flow away from bar tops and towards thalwegs by as much as 30%; and 3) re-distributes the magnitude of sediment transport rates by 20% from bar top to thalweg. Additionally, comparison of sediment transport direction shows little/no systematic effect of dune morphology on the deflection of sediment transport from near-bed flow directions. This is important as it demonstrates a lack of gravitational deflection that in turn indicates that the flow direction dominates sediment transport direction at the dune scale, and that the effects of dune morphology on the flow averages out over multiple bedforms. This work highlights the significant influence of dunes on river morphodynamics across a range of scales, and highlights important shortcomings in existing 2D model parameterisations of topographic steering.