Geophysical Research Abstracts
Vol. 19, EGU2017-4596, 2017
EGU General Assembly 2017
© Author(s) 2017. CC Attribution 3.0 License.

The importance of three dimensional dune morphology on the time dependent flow field

Richard Hardy (1), Dan Parsons (2), Arnold Reesink (), and Jim Best ()

(1) Durham University, Geography, Durham, United Kingdom (r.j.hardy@durham.ac.uk), (2) Geography, Environment and Earth Sciences, University of Hull, UK, (3) Geography and the Environment, University of Southampton, (4) Departments of Geology, Geography and Geographic Information Science, University of Illinois at Urbana-Champaign, USA

The flow field over dunes has been extensively studied and there is general understanding of the nature of the flow over dunes formed over two dimensional dunes under equilibrium flow conditions. This model is typically used to explain flow fields over all dunes fields. However, fluvial systems typically experience unsteady flow and therefore the sediment-water interface is constantly reorganizing to form complex three-dimensional morphologies (ripples, dunes and bar forms). Here we investigate how flow over natural three dimensional dunes differs from the accepted model of flow of two dimensional dunes.

A series of experiments were undertaken in a flume where fine sand was water worked under a range of unsteady hydraulic conditions to generate quasi-equilibrium three dimensional bed forms. On four occasions, the flume was drained and the bed topography measured with terrestrial LiDAR to create digital elevation models (DEM). Here to demonstrate the approach we choose the DEM with the greatest topographic variation and apply a new Large Eddy Simulation model with an wall-adapting local eddy-viscosity (WALE) turbulence model and a non-linear higher-order numerical differencing scheme. This provided a three dimensional time dependent prediction of the flow field over the static three-dimensional dune morphology at millimeter and hertz scale resolution.

The numerically predicted flows were analyzed by standard Reynolds decomposition approaches and Eulerian and Lagrangian coherent flow structure identification methods. The results show that the superimposed bed forms can cause changes in the nature of the classical separated flow regions, in particularly the number of locations where vortices are shed and the points of flow reattachment. Coalescence of vortices generated downstream and can be seen to move to the free surface and form kolk signatures. These structures also correlate in space and time showing a clear flow morphology feedback. The modified flow field determines the time dependent prediction of shear stress. This has significant implications for sediment entrainment and sediment transport dynamics and the results enable an improved process understanding of three-dimensional bed form adjustment.