Geophysical Research Abstracts
Vol. 17, EGU2015-1466, 2015
EGU General Assembly 2015

Incorporating geometrically complex vegetation in a computational fluid dynamic framework

Richard Boothroyd, Richard Hardy, Jeff Warburton, and Nick Rosser
University of Durham, Geography, Durham, United Kingdom (r.j.boothroyd@durham.ac.uk)

Vegetation is known to have a significant influence on the hydraulic, geomorphological, and ecological functioning of river systems. Vegetation acts as a blockage to flow, thereby causing additional flow resistance and influencing flow dynamics, in particular flow conveyance. These processes need to be incorporated into flood models to improve predictions used in river management. However, the current practice in representing vegetation in hydraulic models is either through roughness parameterisation or process understanding derived experimentally from flow through highly simplified configurations of fixed, rigid cylinders. It is suggested that such simplifications inadequately describe the geometric complexity that characterises vegetation, and therefore the modelled flow dynamics may be oversimplified.

This paper addresses this issue by using an approach combining field and numerical modelling techniques. Terrestrial Laser Scanning (TLS) with waveform processing has been applied to collect a sub-mm, 3-dimensional representation of Prunus laurocerasus, an invasive species to the UK that has been increasingly recorded in riparian zones. Multiple scan perspectives produce a highly detailed point cloud (>5,000,000 individual data points) which is reduced in post processing using an octree-based voxelisation technique. The method retains the geometric complexity of the vegetation by subdividing the point cloud into 0.01 m3 cubic voxels. The voxelised representation is subsequently read into a computational fluid dynamic (CFD) model using a Mass Flux Scaling Algorithm, allowing the vegetation to be directly represented in the modelling framework.

Results demonstrate the development of a complex flow field around the vegetation. The downstream velocity profile is characterised by two distinct inflection points. A high velocity zone in the near-bed (plant-stem) region is apparent due to the lack of significant near-bed foliage. Above this, a zone of reduced velocity is found where the bulk of the vegetation blockage is more evenly distributed. Finally, flow rapidly recovers towards the free-stream region. Analysis of the pressure field demonstrates that drag force is non-linearly distributed over the vegetation. In the downstream direction, the drag force decreases through the vegetation. The experiment is extended to emulate vegetation reconfiguration in the flow, and is achieved through rotation of the vegetation about a fixed position (roots) on the bed. The experiment demonstrates a reduction in the total drag force and a shift in the contribution of different drag mechanisms as the degree of rotation increases. In the upright state, form drag dominates, but with additional rotation, the contribution of viscous drag increases. Consequently, the total drag force is found to decrease by approximately one third between the upright and fully rotated states of reconfiguration. Explicit representation of vegetation geometry therefore enables a re-evaluation of vegetative flow resistance. This presents an opportunity to move away from the conventional methods of representing vegetation in hydraulic models, i.e. roughness parameterisation, in favour of a more physically determined approach.