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The importance of volumetric canopy morphology when modelling drag around riparian vegetation

Richard Boothroyd (1), Richard Hardy (1), Jeff Warburton (1), and Timothy Marjoribanks (2)

(1) Department of Geography, Durham University, UK, (2) School of Civil and Building Engineering, Loughborough University, UK.

Riparian vegetation has a significant impact on the hydraulic functioning of river systems. The bulk of past work concerned with modelling the influence of vegetation on flow has considered vegetation to be morphologically simple, and has generally neglected the complexity and porosity of natural plants, defined herein as the volumetric canopy morphology. However, the volumetric canopy morphology can influence the mean and turbulent properties of the flow, producing spatially heterogeneous downstream velocity fields.

By explicitly accounting for this in a computational fluid dynamics (CFD) model, and representing the plant as a porous blockage, complex flow structures and drag can be modelled. For a riparian species, Hebe odora, good agreement with flume measurements are found. Plant shear layer turbulence is shown to be dominated by Kelvin-Helmholtz and Görtler-type vortices, generated through shear instability. Porous representations of the plants, that allow for flow to pass through the plant canopy interior, are compared against fully impermeable plant representations. Penetration of fluid through the canopy in the porous case resembles ‘bleed-flow’, and this results in a plant wake region that significantly differs from the impermeable case, which is characteristic of wake flow around a traditional bluff body.

These results demonstrate the significant effect that the volumetric canopy morphology and porosity of natural plants has on the three-dimensional flow and in-stream drag, and enables a re-evaluation of vegetative flow resistance. The modelled results allow a species dependent Manning’s n to be calculated, and this presents an opportunity to move away from the conventional methods of representing vegetation in hydraulic models, in favour of a more physically determined approach. Given the importance of vegetation in river corridor management, and the increasing application of UAV imagery to map riparian vegetation, the numerical scheme developed here will have widespread application on understanding how natural vegetation partitions discharge between changes in velocity and depth, and how this impacts upon the conveyance.