

# Postgraduate Conference Attendance Grant: Quantifying the Hydraulic Roughness of Vegetation Using Physical Modelling Experiments and Through-Water TLS, 2016 AGU Fall Meeting

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## Conference

The British Society for Geomorphology (BSG) supported my attendance to the American Geophysical Union (AGU) Fall meeting in San Francisco, December 2016. This was my first opportunity to attend such a large conference outside Europe and I was very keen to present my PhD research to an international and diverse audience and to discuss work undertaken by fellow researchers with cognate interests.



## Quantifying the Hydraulic Roughness of Vegetation Using Physical Modelling Experiments and Through-Water TLS

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### 1. Introduction

Plants function as large-scale, flexible obstacles that exert additional drag on surface water flows, therefore playing a significant role in controlling flood water and modulating geomorphic change. Vegetative drag varies depending on flow conditions and the associated vegetation structure and temporary reconfiguration of the plant (Figure 1). Whilst several approaches have been developed to describe this relationship, they have been limited due to the difficulty of accurately and precisely characterising the vegetation itself, especially when it is submerged in flow. In practice, vegetative drag is commonly expressed through bulk parameters that are typically derived from lookup tables.

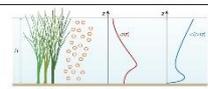


Figure 1: Emergent vegetation with vertical profile of frontal area per volume (a) and longitudinal velocity (b). The velocity profile varies with height, and plant geometry (from Kept, 2017).

### 2. Objective

In this study we combine through-water Terrestrial Laser Scanning (TLS) and flume experiments to investigate the relationships between emergent vegetation and drag. Specifically we:  
a. Develop a novel method of characterising vegetative structure as 3D porosity using TLS.  
b. Undertake a set of flume experiments to quantify if the reconfiguration of vegetation in different flow conditions and if the effect of different vegetation on flow dynamics, ultimately quantifying the hydraulic roughness.

### 4. Characterising vegetation structure using TLS

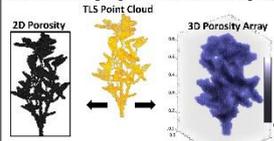


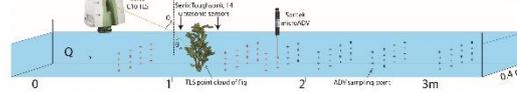
Figure 3: Using 3D point cloud data obtained with TLS technology (shown) the plant structure is characterised using a porosity approach. 2D porosity metrics (left) and 3D porosity arrays (right) are derived.

### 3. Flume Methods

Five different plants, each in four states of foliation were observed at three different flow velocities (total of 60 flume experiments). For each vegetation three different flow scenarios were used (see Table 1) and 3D ADV measurements were obtained at 12 cross-section locations (not all measurements shown on Fig. 2 for visualization purposes). Ultrasonic distance recorders measured water surface elevation continuously (1Hz) at 0.1m resolution upstream and downstream of the plant. TLS data were obtained using standard through-water methods (Smith et al., 2012).

Table 1: Flow conditions used in the experiments

Flow Scenario	Depth (m)	Velocity (m/s)	Reynolds	Froude	Strouhal
Deep	0.30	0.25	$2.2 \times 10^6$	0.15	0.15
Medium	0.25	0.30	$2.4 \times 10^6$	0.18	0.18
Shallow	0.20	0.38	$2.8 \times 10^6$	0.27	0.27



### 5. Characterising the flow field

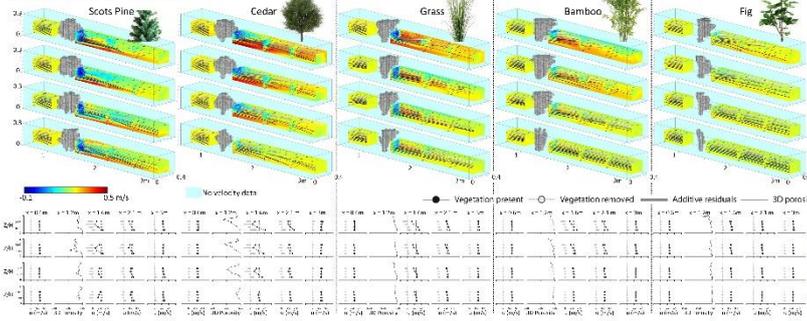


Figure 4: 3D interpolation of the ADV data highlights the velocity field adjustments downstream of the vegetation elements (top). From the obtained ADV data, cross-stream averages of the stream-wise velocity vector are calculated for selected cross-sections. Velocity profiles are compared with the data obtained in the absence of vegetation, and related to plant structure which is expressed using the variation of 3D porosity with the normalised distance from the flume bed (Z/H) (bottom). Plant foliage is reduced from top to bottom.

### 6. Quantifying plant deformation

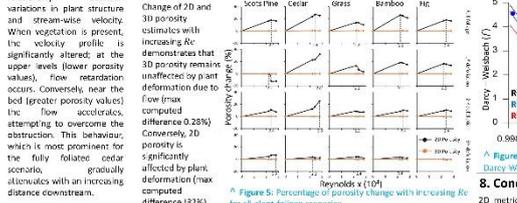


Figure 5: Percentage of porosity change with increasing Re for all plant-foliage scenarios.

### 7. Porosity VS hydraulic roughness

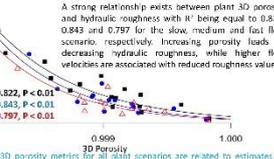


Figure 6: 3D porosity metrics for 3D plant scenarios are related to estimates of Dirichlet Weibach roughness for all flow scenarios.

### 8. Conclusion

2D metrics derived from the plant frontal area (e.g. 2D porosity) are useful, in combination with through-water TLS, to investigate plant deformation under active flow. However, they are insufficient for accurate estimation of hydraulic roughness because they are affected by plant deformation. Conversely, 3D porosity metrics are not affected by plant deformation, thus they offer an appropriate alternative for an accurate roughness quantification.

## Presentation

I presented a poster entitled 'Quantifying the Hydraulic Roughness of Vegetation Using Physical Modelling experiments and Through-Water TLS' (Figure 1) in the session 'Ecohydraulics: Integrating Research Findings from Laboratory and Field Experiments'. This was a great opportunity to present the final results of my PhD work for the first time. I discussed my research with leading experts in the field of Ecohydraulics whom I had not met before. They provided helpful feedback and new perspectives into my work.

## Attendance

I attended a great number of oral and poster sessions covering a range of geomorphology-related topics but also talks given by leading experts in other areas within geosciences. This was particularly useful as it provided a great insight in the work undertaken by scientists within my field but also those working in cognate areas. I also had a chance to attend a number of workshops and socials including a night out with the BSG postgraduate society.

Figure 1: My poster presentation at AGU Fall Meeting 2016

## Value

AGU Fall Meeting was a fantastic conference and I am grateful to the BSG for providing the necessary funds for my attendance. It was a great opportunity to present the culmination of my PhD and get essential feedback that helped me complete my write up and defend my thesis. It was also a unique opportunity to meet and interact with leading experts within the field of geosciences, at an international setting, and explore post-PhD career options.