On the Use of Surface PIV for the Characterization of Wake Area in Flows Through Emergent Vegetation

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ABSTRACT

New results from surface PIV measurements are presented. Surface PIV can potentially provide researchers with a cheap and versatile method for mapping 2D flow fields. This technique was evaluated in a laboratory flume with a random distribution of rigid plastic straws, as a representation of stems, to simulate flows through emergent vegetation. Velocities were computed via an open-source tool for conventional PIV, and a sensitivity analysis conducted, in which the factors, seeding particle size, particle image density, size of interrogation window, number of passes and contrast were evaluated. This analysis indicates that smaller seeding particles allow for a clearer visualization of flow structures, but larger particles offer higher local intensity contrasts, which in turn improve the results from PIV correlations. In general, surface PIV requires higher particle image densities to avoid transparency effects. Results of the sensitivity analysis show that, with the appropriate settings, 98.7% of data points were considered to be reliable. It was found that the best quality velocity maps were obtained with small seeding particles and intermediate window resolutions (16 x 16 pixels).

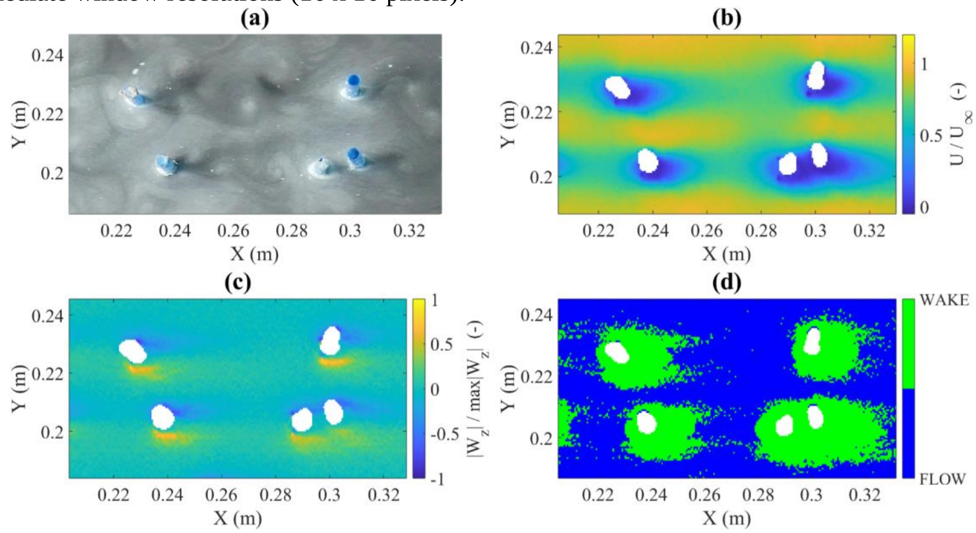

Fig. 1. Defined criteria to determine the wake area in flow through emergent vegetation. **(a)** Sample experimental section. **(b)** Time-averaged longitudinal velocity, as a fraction of the free stream velocity. **(c)** Time-averaged vorticity, as a fraction of the maximum absolute value of vorticity. **(d)** Wake area, shown in green for velocity fractions below 50% and vorticity fractions above 10%, respectively.

The practical use of this technique is illustrated by using the data to identify the portion of flow through vegetation occupied by wakes. For this, a straightforward, dual criterion, related to the generated vorticity and incident flow conditions is proposed. First, recirculation zones are characterized by vorticity values above a certain threshold, specified as a fraction of the measured absolute vorticity. Second, the influence of the wake further downstream is indicated by zones of longitudinal velocity defect, which are defined as non-dimensional velocity values below a certain threshold, expressed as a fraction of the mean incident velocity. Figure 1 shows a photograph of the experimental section with the optimum configuration of particle image density and seeding particle size (Fig. 1a), the time-averaged velocity and vorticity maps of the same section (Fig. 1b, 1c) and the delimitation of the wakes using the criteria just described (Fig. 1d).

Improvements in the quality of the velocity maps can be achieved by enhancing the local contrast of the seeding particles, either by having particles of different colours or different reflection indices. Further refinements of this research can lead to applications in several branches of fluid mechanics, such as *in situ* measurements of the flow field and analysis of scalar dispersion processes in ecohydralulics.