BURSTING PHENOMENA DOWSNTREAM AQUATIC PLANTS GROWING IN NATURAL CONDITIONS

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Abstract The experiments in natural river were performed, where the velocity field was measured downstream single patches of submerged plants. Increased $\overline{u'w'}$ Reynolds stress outlined the spatial reach of wake area and signalized the presence of the coherent structures in the flow, which transported momentum and mass. The combined results from different measuring points showed that downstream the plant patch, the magnitude of bursting events depended on the distance and relative position to the vegetation height. The use of thresholding in the detection of coherent structures revealed that the passage of roller vortices was visible at the upper boundary of the plant's wake.

Keywords: turbulence, bursting events, coherent structures, quadrant analysis, aquatic vegetation.

Methods

Experiments took place in the unaltered, sandy bedded lowland river in central Poland, the Świder River. There were identified two flexible, submerged plants: *M. spicatum* L. and *P. crispus* L. They grew in patches of similar dimensions and downstream of them, 3D velocities were measured using acoustic Doppler velocimetry (Fig. 1). Velocity time series, after filtering, were subjected to modified quadrant analysis (based on Ferreira et al., 2009) to extract information about bursting events emphasizing sweeps and ejections. A threshold value of 1.8 was used to enhance visibility of the events with the highest $\overline{u'w'}$ Reynolds stresses. The events magnitude, their stress contribution and time characteristics were calculated.

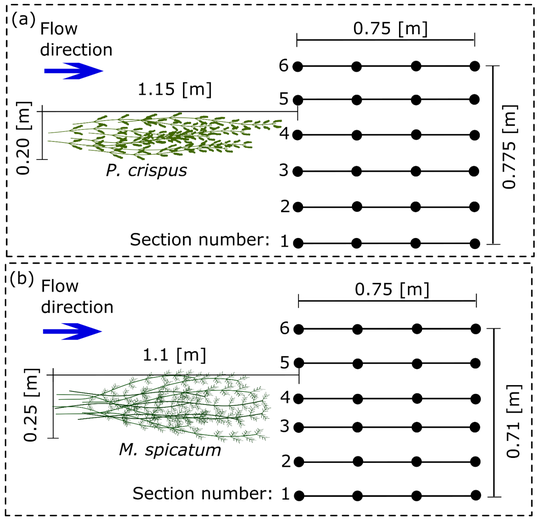

Figure 1: Sections where water velocities were measured downstream of plants.

Results

Analysis of the gathered data showed the following:

- Sweeps and ejections dominated both with and without using thresholds in all sections.
- In sections directly behind the plants, sweep events were strongest below vegetation height, while ejections carried most of the stresses above that level (Fig. 2).
- Points closest to the plants and around their maximal height were characterized by a highest frequency and stress contribution of the extreme events.
- Sequences of the extreme sweeps and ejections behind plants lasted on average longer than events from two other quadrants.

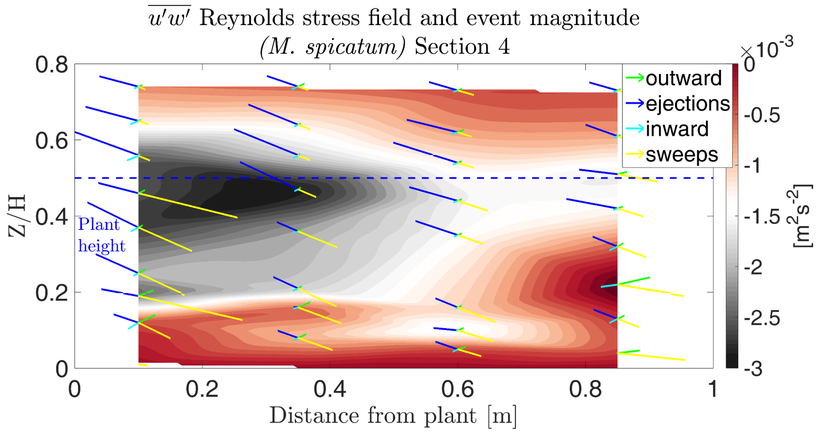

Figure 2: Magnitudes of extreme events (each color of the stripe represents different quadrant) and interpolated Reynolds stress field in section 4.

Conclusions

The implemented conditional quadrant analysis revealed that characteristics of coherent structures varied with relation to plant distance and height. Differences between event sequences lead to the conclusion that there were vortices originated from the plant – flow boundary. These created two patterns of bursting events:

- A strong sweeping motion of the eddies forming in the wake of a patch, pushing whirls into the low-velocity region directly behind a plant.
- A disturbance observed above the patch height in the mixing layer, where ejections carry vortices downstream towards the free surface but only up to distance of 0.6 m, i.e., approximately four times the height of the patch.

Results from the experiments confirm insights showed by Marjoribanks et al.(2017) in their simulations.

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