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Seeing through the fluid dynamics of flexible vegetation and canopy turbulence

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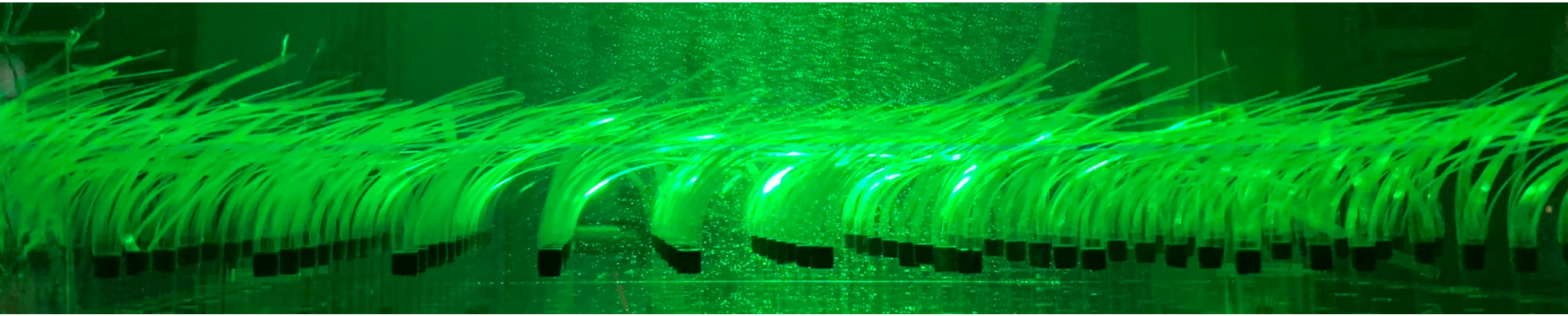

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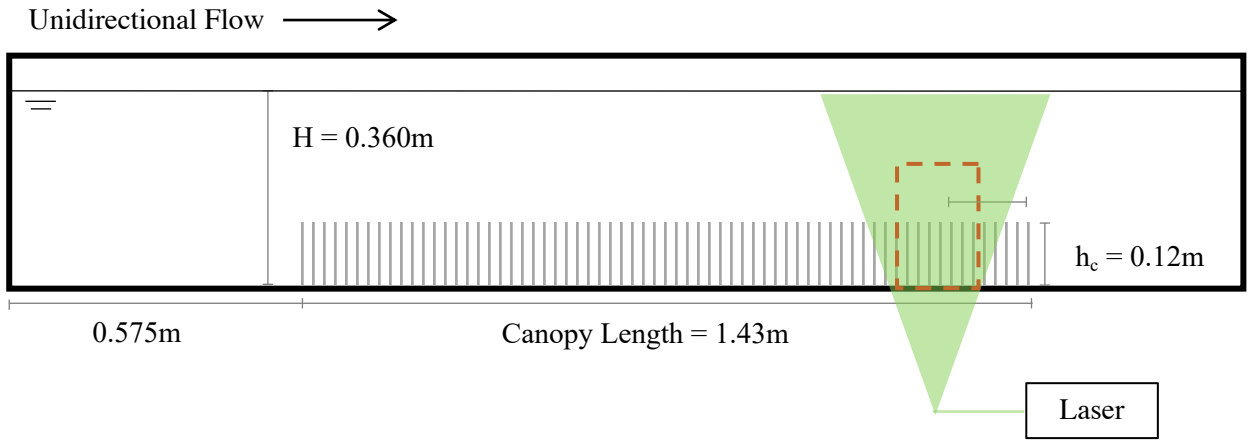

Figure 1: Experimental Flume Schematic, red dashed box indicates field of view (FOV)

Experimental Approach

Refractive Index Matching (RIM) Flume

2D Particle Image Velocimetry (PIV) @ 100Hz

5 Flow Conditions: $Re_H = 3.4 \times 10^4$ to 1.0×10^5

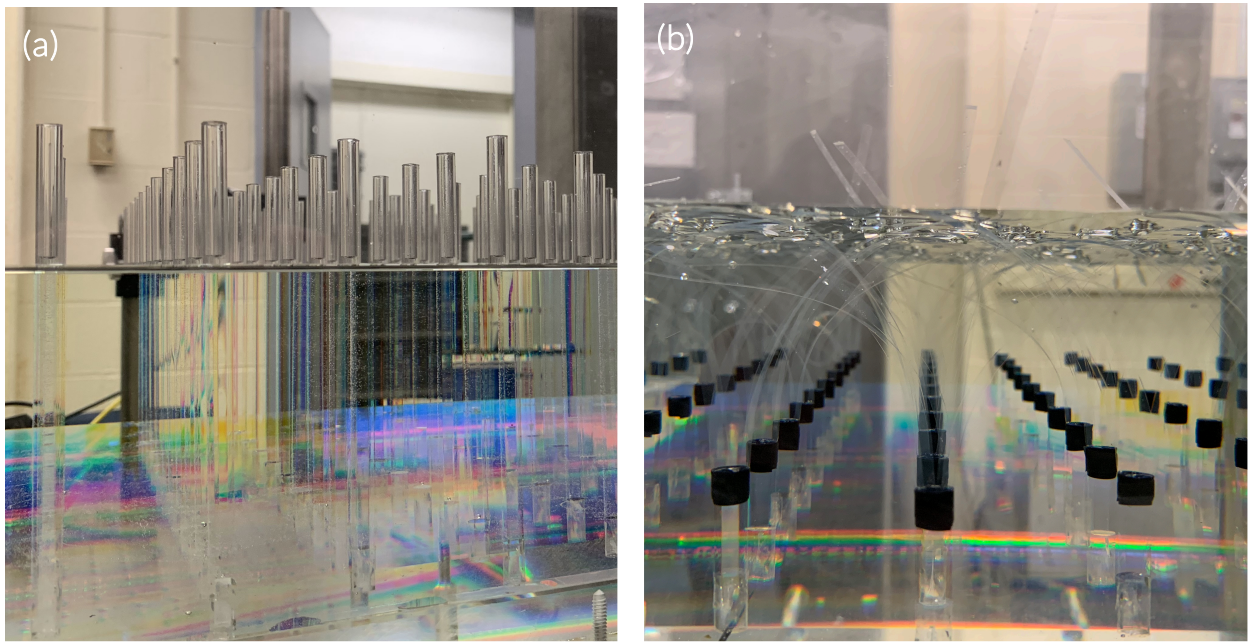

Figure 2: (a) rigid and (b) flexible canopies partially submerged to illustrate RIM

Flexible Canopy

Geometrically and dynamically scaled to match *Zostera marina* (a common seagrass species)

Rigid Canopy

Comparable geometry to flexible canopy, with submergence ratio of 0.3

Research Scope

Investigate the spatiotemporal flow dynamics above and within rigid and dynamically scaled flexible vegetation canopies, using RIM and 2D PIV.

1. Quantify space-time averaged flow processes
2. Evaluate spatial variability in time-averaged flow fields
3. Interpret instantaneous flow structure evolution, periodicity, and magnitude

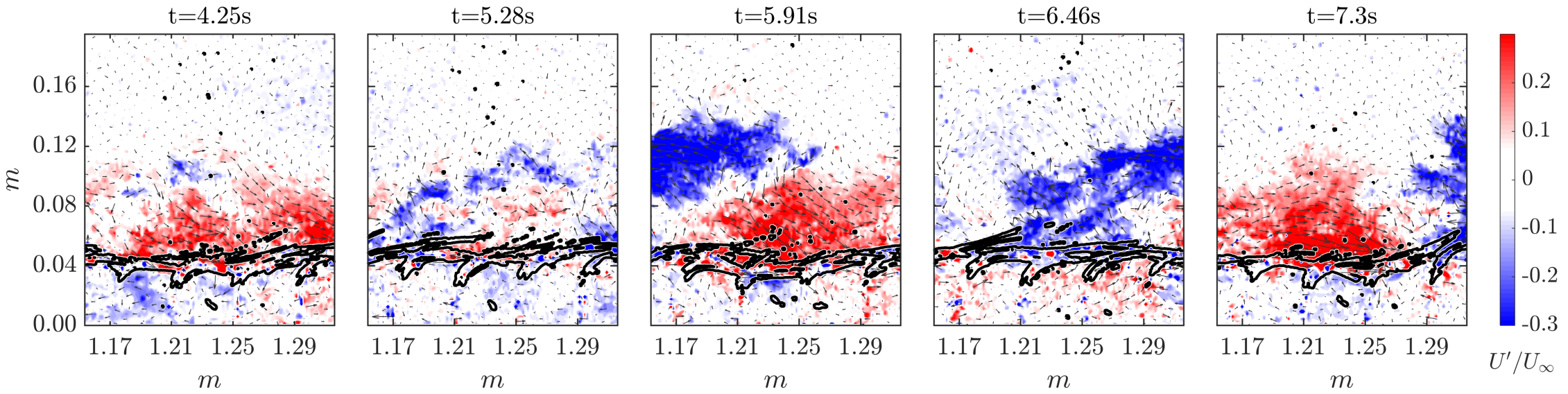

Figure 3: Time series of instantaneous field of view snapshots of flexible canopy. Canopy blades are marked by black outline, normalised u' colour contours, overlaid with u'v' vectors.

Evolution of instantaneous turbulence flow fields for flexible vegetation canopy

- Sweep-ejection events correspond to canopy depression and waving motion, but magnitude of events are variable
- Alternating primary flow direction observed above and within the canopy respectively
- Proceeding timesteps did not express same periodicity in events, revealing intermittent periodicity

Overview of Results

Flow field analysis revealed intermittent periodic coherent vortices at the canopy top, coupled with differing spatiotemporal flow dynamics due to canopy flexibility and morphology.

- Flexible canopy oscillations increased canopy top turbulence magnitude yet promoted in-canopy mean flow reduction

- Flexible canopy motion expressed an irregular period, and associated flow structures were of lower frequency than rigid canopy