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QUANTIFYING WAVE-INDUCED HYDRODYNAMICS NEAR A SALTMARSH CLIFF: AN EXPERIMENTAL PIV STUDY

J.R.M. MULLER[1], D. DERMENTZOGLOU[2], S. H. LAKERVELD[3], B. W. BORSJE[4], J.J. VAN DER WERF[5,6], S.J.M.H. HULSCHER[7], B. HOFLAND[8], A. ANTONINI[9]

1 University of Twente, The Netherlands, j.r.m.muller@utwente.nl;

2 Delft University of Technology, The Netherlands, d.dermentzoglou@tudelft.nl;

3 Delft University of Technology, The Netherlands, s.h.lakerveld@student.tudelft.nl;

4 University of Twente, The Netherlands, b.w.borsje@utwente.nl;

5 University of Twente, The Netherlands, j.j.vanderwerf@utwente.nl;

6 Deltares, The Netherlands, jebbe.vanderWerf@deltares.nl;

7 University of Twente, The Netherlands, s.j.m.h.hulscher@utwente.nl;

8 Delft University of Technology, The Netherlands, b.hofland@tudelft.nl;

9 Delft University of Technology, The Netherlands, a.antonini@tudelft.nl

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1 INTRODUCTION

Nature-based flood defences receive increasing interest as a viable option for improving flood safety worldwide. A contemporary case is using the ability of saltmarshes to attenuate waves during storm conditions for strengthening coastal flood defences. To ensure a long-term reinforcement of flood protection, it is important to understand the erosion mechanisms of saltmarshes during storms. One of the critical locations for erosion is at the transition between the saltmarsh and the bare mudflat, often characterized by a vertical step or cliff. These cliffs vary between 0.2 to 2.0 m in height, depending on soil characteristics and local hydrodynamics. However, wave-induced hydrodynamics that controls the (mass) erosion at the saltmarsh cliff are not fully understood. Also the role of saltmarsh vegetation on these near-cliff hydrodynamics are not clearly quantified. In this research, we present high-resolution measurements of wave-induced hydrodynamics at a saltmarsh cliff performed in a scaled wave flume experiment.

2 METHODS

In this research, a series of wave flume experiments are performed in a 39 m long, 0.8 m wide and 1.0 m deep wave flume at the Hydraulic Engineering Laboratory at Delft University of Technology (Figure 1a). Generated waves traverse over a saltmarsh transect, consisting of 5 m foreshore section with a slope of 1:45, a varying cliff height to a maximum of 0.12 m, 7 m saltmarsh section and dike section with a slope of 1:3.6. The experiments are designed according to Froude scale of 1:10. Vegetation is modelled by elastic cylinders, scaled according to Cauchy similitude. Offshore generated monochromatic waves range in height between 0.1 and 0.2 m at a water depth varying between 0.3 and 0.6 m, while nearshore (at the saltmarsh) waves are mainly depth limited. Water levels are measured by several wave gauges and laser scanners. Wave-induced pressures at the saltmarsh cliff are measured by pressure transducers mounted around the cliff.

Particle Image Velocimetry (PIV) is used to quantify near-cliff velocities and patterns over the full water depth and cliff length in a non-intrusive way. The PIV setup consisted of a FLIR ORYX camera with a 12.5 mm lens, recording an area of interest (AoI) of approximately 700 by 600 mm. As a light source, the inhouse developed, state-of-the-art LED line light was used (Bakker et al., 2021). In order to have a consistent illumination of the water column, the light was emitted from below the physical model upwards through a transparent bottom instead from above (Figure 1b). The water was seeded using 100 μm natural buoyant, polymide particles. The post-processing of the captured images consisted of internal and external image calibration, pair-wise cross correlation of the images and removing velocity outliers through a median filter by using the algorithms within the Matlab PIVlab Toolbox (Thielicke and Sonntag, 2021). The accuracy of the obtained velocities by PIV were validated on a case with a cliff of 0.12 m and without a cliff (both without vegetation). For these cases, Acoustic Doppler Velocimeter measurements were taken on several locations in the AoI, which were compared with the PIV derived timeseries for these locations.

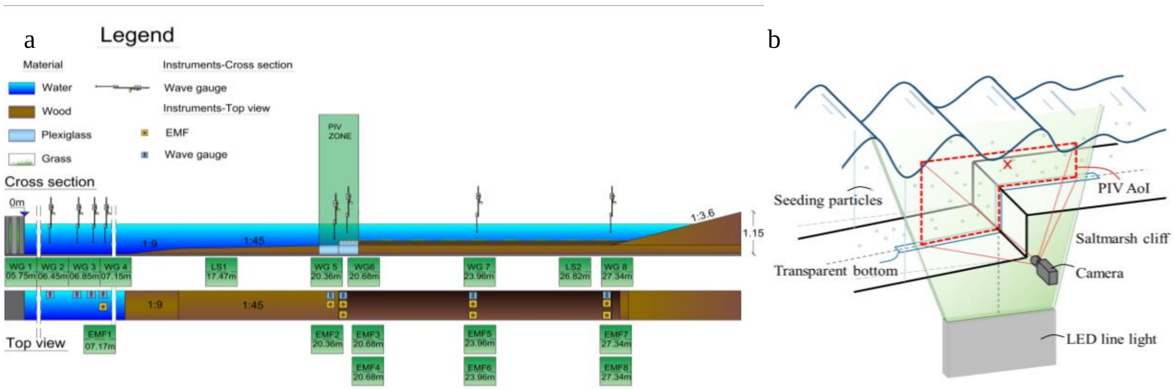

Figure 1. Schematic overview of wave flume setup (a), with detailed overview of the PIV setup at the saltmarsh cliff (b).

3 RESULTS

The validation of the velocity measurements obtained by PIV shows a good agreement with the ADV measurements for both with and without a cliff (Figure 2, left panel). These findings provide a solid base to further analyse the PIV data on overall near-cliff velocity patterns, near-bed velocities and the influence of vegetation on these velocity patterns. Similar to observations made by Suzuki and Klaassen (2011), the formation of eddies could be observed in front of the cliff in the trough of a wave (Figure 2, right panel). Further results of this data will be treated in more detail during the conference.

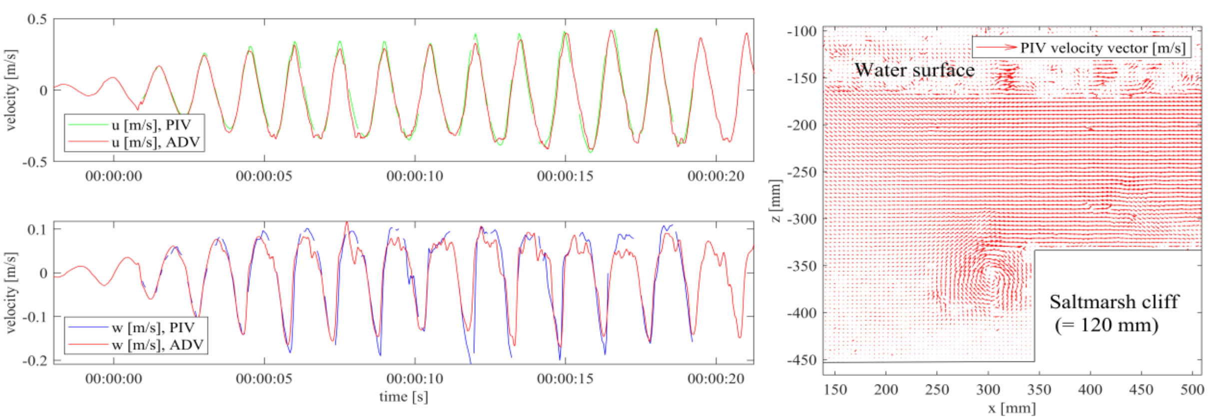

Figure 2. PIV and ADV retrieved time series at location X (see Figure 1b) during validation experiment, with wave height *H* = 0.10 m, wave period *T* = 1.5 s, offshore water depth *h* = 0.55 m, a cliff of 0.12 m and no vegetation (left panel) and a snapshot of the same experiment at t=5.4 s showing an eddy near the saltmarsh cliff (right panel).

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