

ALONGSHORE SWASH FLOW VARIABILITY

Alexandra Muscalus, Woods Hole Oceanographic Institution, alexandra.muscalus@whoi.edu

Britt Raubenheimer, Woods Hole Oceanographic Institution, braubenheimer@whoi.edu

Steve Elgar, Woods Hole Oceanographic Institution, elgar@whoi.edu

INTRODUCTION

The swash zone, where broken waves run up and down the beach face, connects the nearshore ocean with the land. Swash zone waves and currents are important to beach morphological evolution (e.g., erosion and accretion), overtopping and flooding, and forcing on coastal infrastructure. However, the understanding of swash hydrodynamics is hindered in part by the challenges of obtaining measurements in the thin sediment-laden flows and bubbly bores that intermittently wet and dry the shoreline, and thus there are few spatially extensive observations of swash in the field.

Although field, laboratory, and modeling efforts have led to significant advances in the understanding of cross-shore swash flows, alongshore currents in the swash are not understood well. These flows may be sensitive to alongshore variations in the bathymetry, the surf zone waves, circulation patterns, and pressure gradients, and the wind. In the field, these environmental conditions may vary over a wide range of spatial scales, so investigating their relationships with currents in the swash requires observations both along and across the swash zone.

Here, cross- and alongshore currents in the swash zone along 100 m of the coast are estimated with remote sensing and particle image velocimetry (PIV) foam-tracking techniques for a wide range of incident wave conditions and nearshore bathymetry. Currents are compared with environmental conditions to analyze swash flow drivers.

FIELD OBSERVATIONS

Images and in-situ swash flow data were obtained for about 10 weeks during fall 2021 on the sandy Atlantic Ocean beach at the US Army Corps Field Research Facility (FRF) in Duck, NC, USA. Optical images (2 Hz) of the surf and swash zones were obtained from a camera mounted on a 40-m-high tower located just landward of the dune. The images were stabilized to correct for camera motion and rectified into real-world planar coordinates.

Three ADVs were deployed at alongshore coordinate $y = 615$ m (**Figure 1**) to measure swash flows at 8 Hz. The height of the sensors above the bed varied from about 0 to 0.4 m owing to erosion and accretion requiring frequent vertical adjustment to ensure sample volumes were within the swash water column. Data from intermittent periods when the sensors were above the thin swash flows (e.g., during the passage of wave troughs) were removed in post processing. In addition, inner surf and swash waves and water levels were obtained with 3 cross-shore transects of pressure gages (along the ADV transect and about 50 m alongshore to the north and south) enabling estimates of forces for alongshore flows. The swash zone

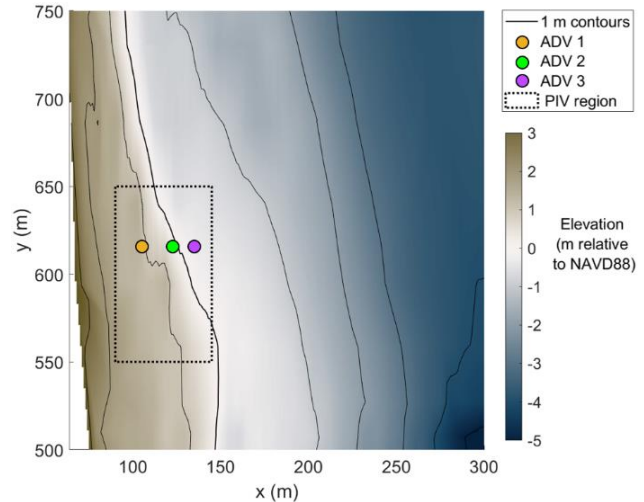


Figure 1 - Bathymetry (color scale at right and solid black curves at 1-m contours), ADV locations (colored circles, legend in the upper right), and the extent of PIV estimates (dotted black rectangle) on Sep 07, 2021.

bathymetry was measured hourly with lidars mounted on the dune. Offshore waves (8-, 17-, and 26-m water depth), winds, and water levels were measured continuously through the study.

SWASH PARTICLE IMAGE VELOCIMETRY (PIV)

PIV tracks the motion of particles between image pairs to estimate the corresponding velocities. Here, the open-source software *PIVlab* (Thielicke and Sonntag, 2021) was applied to the rectified images spanning 55 m in the cross-shore (**Figure 1**, the rectangle for $90 < x < 145$ m) and 100 m (**Figure 1**, the rectangle for $550 < y < 650$ m) in the alongshore to estimate 2 Hz swash velocities by tracking foam particles on the water surface. The direct Fourier transform correlation PIV algorithm was applied to 3.2×3.2 m initial interrogation windows with two sub-passes (each halving sub-window dimensions) to compute vector fields at 0.8 m spatial resolution.

DISCUSSION

Cross-shore velocities at 2 Hz estimated with remote sensing (black curves in **Figure 2**) are similar to those estimated with in situ current meters (colored curves in **Figure 2**). Ten-minute mean alongshore velocities estimated with remote sensing (black curves in **Figure 3**) are similar to those estimated with in situ sensors (colored curves in **Figure 3**). Power spectra of cross- and alongshore flows estimated by the two techniques also are similar to each other (not shown).

The cross- and alongshore variability of the swash flows (**Figure 4**) will be examined for a range of conditions. Flow magnitudes will be compared with estimates of forcing

terms, and circulation patterns (e.g., spatial scales of flow features) will be examined with respect to bathymetry, surf zone processes, and wind through methods such as regression and correlation.

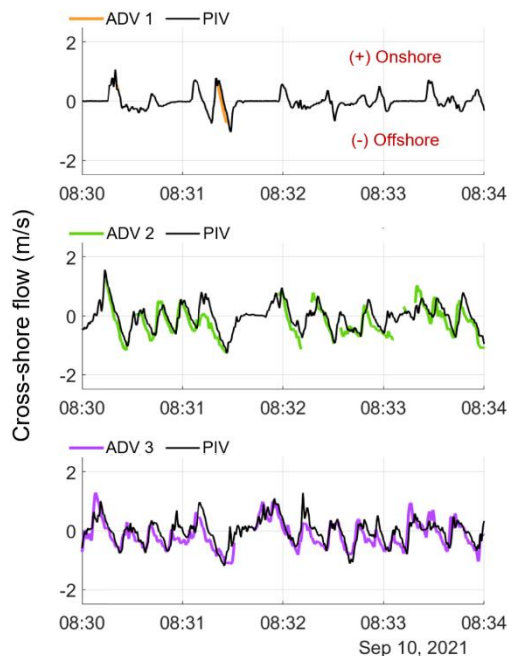


Figure 2 - Remote (black curves) and in situ (color curves) estimates of cross-shore velocity versus time at the three ADVs (colored curves correspond to the colored symbols in Figure 1). Positive flow is onshore. Missing in-situ data indicates low-quality measurements (i.e., the ADV was above the water surface).

REFERENCES

Thielicke, Sonntag (2021) Particle Image Velocimetry for MATLAB: Accuracy and enhanced algorithms in PIVlab. *J. Open Research Software* 9, DOI: <https://doi.org/10.5334/jors.334>

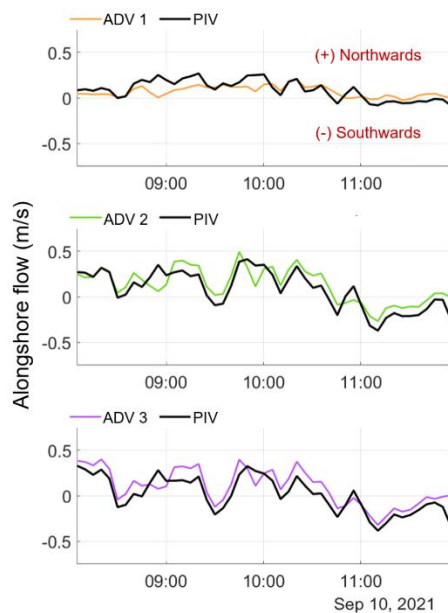


Figure 3 - Remote (black curves) and in situ (color curves) estimates of 10-min mean alongshore velocity versus time at the three ADVs (colored curves correspond to the colored symbols in Figure 1). Positive flow is to the north.

ACKNOWLEDGEMENTS

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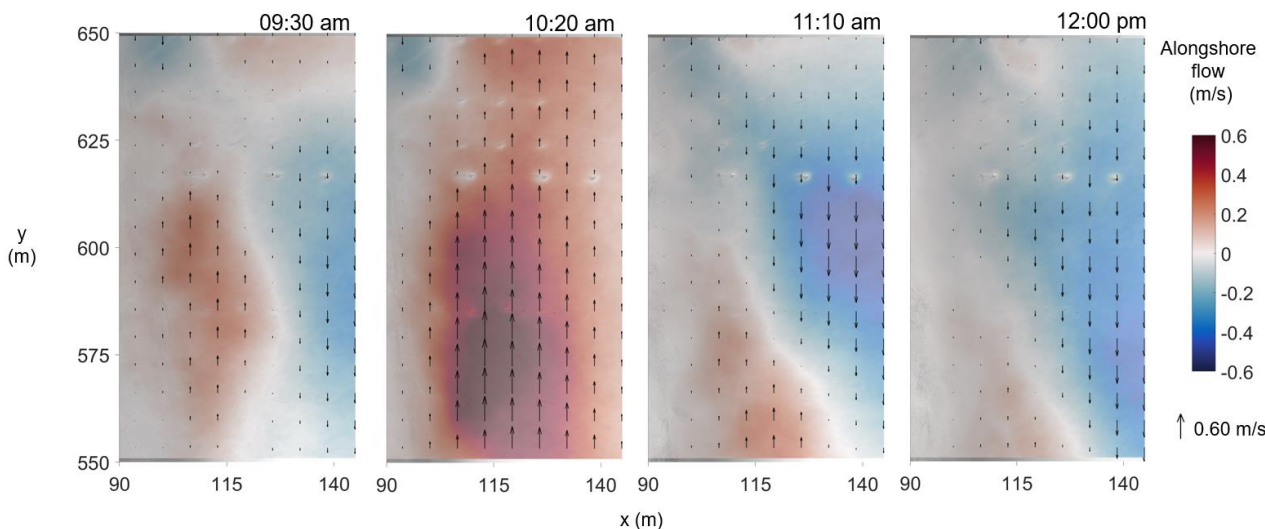


Figure 4 - 10-minute mean alongshore swash flows on Sep 10, 2021 shown at 50 minute time intervals. Both arrows and background color (red northwards, blue southwards) indicate alongshore flow direction.