Onshore-Offshore Swash Zone Properties

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Award Number: N0001401WX20753
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LONG-TERM GOALS

The goals of the project are to develop better understanding and predictive capability for non-linear time-dependent dynamics in the swash zone. Although sophisticated models for simulating swash hydrodynamic processes are available (a Navier-Stokes based swash model that implements the Volume of Fluid (VOF) method is being adapted under separate funding), detailed measurements within this dynamic region are needed to develop and validate models describing coupled fluid-sediment transport.

OBJECTIVES

This project is designed to collect and analyze both field and laboratory measurements of swash zone processes for comparison with the numerical VOF model results. Of particular interest is quantification of time-dependent flow velocities at high resolution over a large spatial area. Non-linear interactions may be extremely important in how shear stresses resulting from such flows mobilize and transport foreshore sediments. By observing the flow structure and resulting sediment response at high resolution under constrained forcing conditions, we seek to develop a shear stress formulation applicable to field conditions. The numerical model simulations will be used to expand our understanding at scales that can be predicted but not measured.

APPROACH

Swash zone measurements are being obtained by the Naval Research Laboratory at the Large-Scale Sediment Transport Facility (LSTF) at the Waterways Experiment Station in Vicksburg, MS. The LSTF is comprised of a 30-m by 50-m basin with waves generated using a series of four synchronized unidirectional spectral wave generators. In addition, longshore currents can be simulated using twenty independent vertical turbine pumps. A cross-shore array of wave gauges, acoustic Doppler velocimeters, arrays of fiber-optic backscatter sensors, and a rapidly-sampling beach profiler are mounted on a mobile, programmable instrumentation bridge that spans the basin. A series of twenty sediment traps are located in flow channels at the downstream end of the facility and the weight of sand that accumulates in each trap is recorded in real time. Supplemental instrumentation installed by NRL will allow measurement of water level elevation, alongshore currents and cross-shore currents along a series of cross-shore transects. We will also use video imaging techniques, such as particle image velocimetry, to record swash flow variation in the alongshore (see Holland et al., 1997; Holland et al., in press).

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
30 SEP 2001		**00-00-2001 to 00-00-2001**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Onshore-Offshore Swash Zone Properties	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Research Laboratory,,Code 7440.3,,Stennis space Center,,MS, 39529**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
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15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**4**	

WORK COMPLETED

Instrumentation was installed in the facility in May 2001 and two data sets have been obtained. The first set of conditions (sampled May 31 2001) comprised a simple wave case to verify instrument performance and the second set (sampled July 10 2001) was of 16 cm waves at 3 second period. The 6 m domain covered in detail by the in situ and video-based instrumentation is consistent with the domain being modeled by Dr. Slinn.

RESULTS

The main goal of the original test was to determine if the numerical VOF model gave sensible predictions under simplified laboratory conditions. The in-situ observations obtained by NRL (figure 1) show a consistent change in the onshore velocity component from offshore (bottom) to onshore (top). No strong vertical gradients were observed in this data collection, although we expect future data collections under different wave and profile conditions to allow for stronger gradients. In preliminary comparison with the numerical model (using an approximately 5 mm vertical grid spacing) we found good consistency between measured and predicted statistics such as maximum onshore and offshore velocity.

IMPACT/APPLICATIONS

This research is critical to the understanding of swash zone sediment transport processes and will greatly aid in the development of coupled models describing beach profile change and coastal erosion.

TRANSITIONS

These data are being made available to the investigators at the USACE LSTF for quantifying swash processes within their facility under various wave conditions.

RELATED PROJECTS

The most closely related project is the numerical simulation model for swash zone processes being developed by Dr. Donald Slinn at the University of Florida. NRL and UF are working collaboratively to develop and validate a high-resolution model describing swash zone processes.

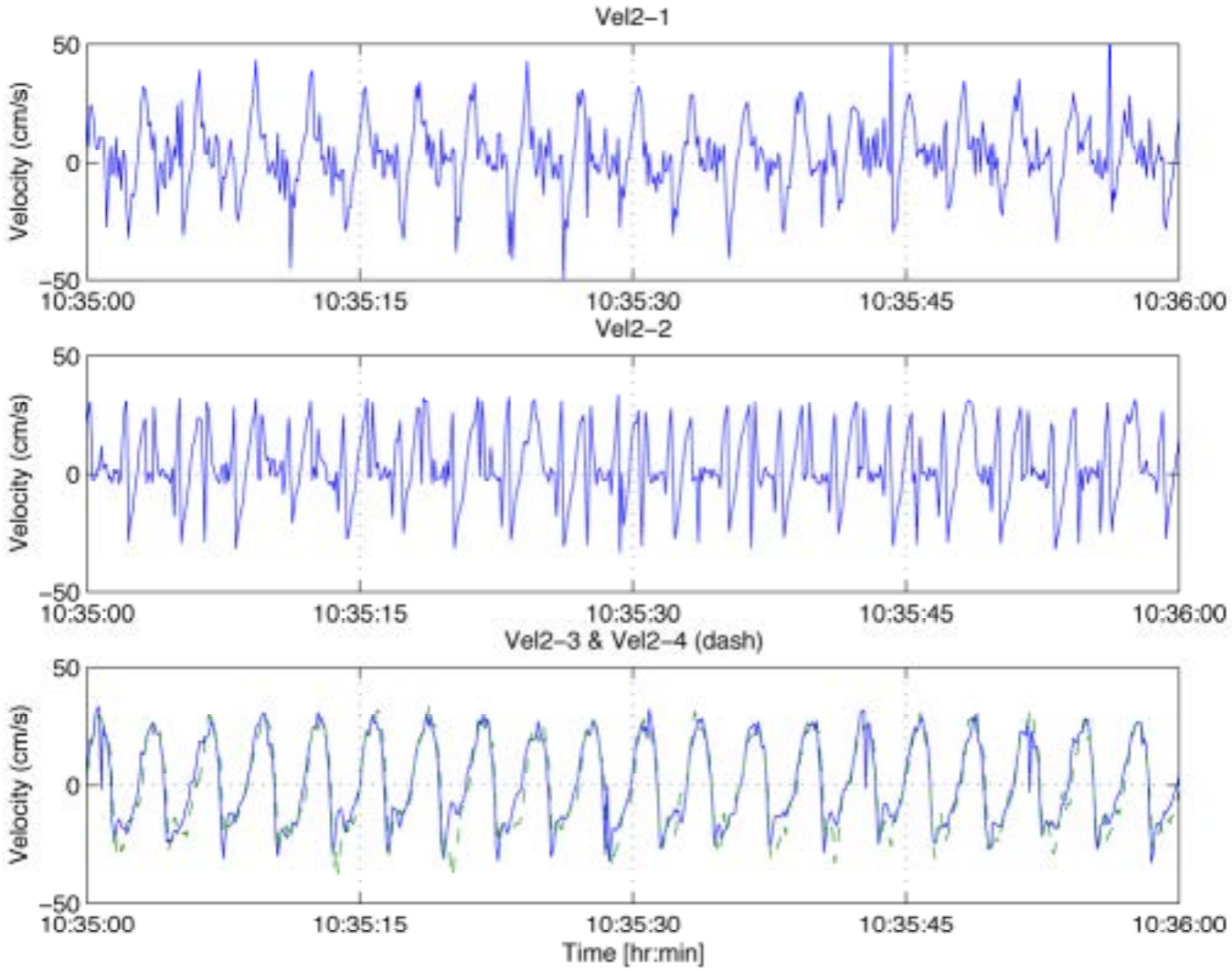

Figure 1 High-resolution swash flow measurements.
[Cross-shoredirected swash currents at 3 locations separated by 40 cm horizontally; onshore (top), mid-swash (middle) and offshore (bottom)]

REFERENCES

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