Coastal Engineering 115 (2016) 1–7

Contents lists available at ScienceDirect

Coastal Engineering

journal homepage: www.elsevier.com/locate/coastaleng

The second international workshop on swash-zone processes

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ARTICLE INFO

Article history:
Received 15 April 2015
Received in revised form 31 August 2015
Accepted 2 September 2015
Available online 9 October 2015

Keywords:
Beach face
Foreshore
Extreme events
Numerical modeling
Run-up

ABSTRACT

A workshop on swash-zone processes was convened in July of 2014 aimed to present the most recent research advances and to identify topics of future research. This paper presents the most critical topics discussed at the workshop with future perspectives. Recurring themes throughout the workshop (and this paper) are the ability to tie the research to problems of societal interest, focus efforts on understanding extreme conditions, and improve sediment transport and morphodynamic prediction from numerical models. Subsequent papers in the special issue highlight recent advances in swash-zone processes research.

1. Introduction

This paper follows the 2nd International Workshop on Swash-Zone Processes (hereafter 2nd workshop) attended by 27 researchers (Table 1) and held at the University of Delaware Newark, DE, USA (July 14–15, 2014). This work describes the ideas, concepts, and future directions that were identified/discussed during the workshop and in the process revisits some of the key issues addressed at the 1st International Workshop on Swash-Zone Processes (Puleo and Butt, 2006; hereafter 1st workshop). An effort was made to be more inclusive of graduate research assistants studying swash-zone or related processes due to their important role in the future of swash-zone research.

The main topics discussed at the second workshop were as follows:

a. Defining the swash zone in terms of hydrodynamics (e.g., as a larger region extending from the inner surf to back beach dunes during extreme conditions) or other natural geomorphological features.
b. The need to obtain new measurements and perform model simulations of storm and extreme events to identify the role that swash-zone processes have on the beach morphodynamics under such conditions.
c. Processes happening at the edge of the swash zone and in the initial stages of uprush and final stages of backwash may be the most important with regard to sediment transport but are the most difficult to measure/model.
d. Some strides have been made in understanding/measuring sediment transport, but these processes remain the most difficult to quantify fully and parameterize.
e. A variety of new models exist but there is a wide range in model capability and assumptions involved. Model suitability depends on the physical processes of interest.
f. Continued interaction between experimentalists and modelers of small-scale and large-scale processes is required to further advance knowledge. On one hand, the modelers should be aware of field and laboratory efforts in order to give feedback to experimentalists on the required information for model testing and calibration leading to model improvement. On the other hand, high-resolution modeling should be employed in order to improve current parameterizations.

Aspects of these topics are described more fully below with sections related to hydrodynamics, sediment transport and morphology, and numerical modeling. Many topics overlap but for this paper are placed into a particular category at the authors' discretion. Subsequent papers in the special issue highlight recent advances in small-scale swash-zone processes research (Chardon-Maldonado et al., 2016–in this issue), foreshore morphodynamics (Incelli et al., 2016–in this issue), provide an overview of recent advances in swash-zone numerical modeling via “benchmark” testing of several hydrodynamic models of swash-zone processes (Briganti et al., 2016–in this issue) and investigate run-up on

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http://dx.doi.org/10.1016/j.coastaleng.2015.09.007
0378-3839/

Table 1
Attendees at the second international workshop on swash-zone processes.

Researcher	Institution
Dylan Anderson[a]	Oregon State University
Roham Bakhtyar	University of North Carolina
Joe Calantoni	Naval Research Laboratory
Patricia Chardon-Maldonado[a]	University of Delaware
Nick Cohn[a]	Oregon State University
Daniel Conley	Plymouth University
James Heiss[a]	University of Delaware
Diane Horn	Birkbeck College
Tom Hsu	University of Delaware
Brad Johnson	United States Army Corps of Engineers
Nobu Kobayashi	University of Delaware
Holly Michael	University of Delaware
Ryan Mieras[a]	University of Delaware
Mary Munro[a]	Woods Hole Oceanographic Institution
Aline Pieterse[a]	University of Delaware
Jose Carlos Pintado Patino[a]	Universidad Nacional Autonoma de Mexico
Dubravka Pokrajac	University of Aberdeen
Matteo Postacchini	Universita Politecnica delle Marche
Jack Puleo	University of Delaware
Britt Raubenheimer	Woods Hole Oceanographic Institution
Peter Ruggiero	Oregon State University
Chris Russoniello[a]	University of Delaware
Stefan Schimmels	Forschungszentrum Küste
Hilary Stockdon	United States Geological Survey
Babak Tehranirad[a]	University of Delaware
Alec Torres-Freyermuth	Universidad Nacional Autonoma de Mexico
Fangfang Zhu	University of Nottingham

[a] Student research assistant.

storm, seasonal and interannual time scales, and under dune erosion scenarios (Palmsten and Splinter, 2016–in this issue; Park and Cox, 2016–in this issue; Ruggiero and Cohn, 2016–in this issue).

2. Hydrodynamics

The 1st workshop identified several key areas for future research related to hydrodynamics including a robust definition of the swash zone, investigating horizontal pressure gradients and turbulence, alongshore flows and velocity profiles over the swash depth. Several of these areas (e.g., turbulence and velocity profiles over depth) have been addressed in recent research and discussed further at the 2nd workshop. However, workshop attendees also discussed new areas for future hydrodynamics research (e.g., void fraction and boundary layer evolution) in addition to revisiting areas that have yet to receive adequate attention (e.g., alongshore flows and swash–swash interaction). This section focuses on the topics related to hydrodynamics that were identified within breakout groups during the 2nd workshop.

2.1. Turbulence

Swash-zone hydrodynamics and sediment transport are affected by high turbulence levels; specifically during uprush initiation. Bed-generated turbulence is also prevalent during uprush and in the latter stages of backwash. Much of our knowledge of turbulence in the swash zone arises from laboratory studies over fixed beds or from numerical modeling. Repeatability under laboratory studies is a major factor contributing to successful estimations (e.g., via ensemble averaging). Quantifying turbulence in the field or for mobile bed conditions under irregular waves continues to elude researchers. Sensors that can sample rapidly the velocity field are more readily available than in the past. Extracting turbulence information from the data is still problematic owing to separation of wave, mean, and turbulence quantities in a consistent way. Some strides have been made using multiple sensors with a short separation distance or velocity profile data for quantifying turbulent kinetic energy dissipation. However, these approaches may need to invoke some assumptions that could make inter-comparison with data/approaches from other sites difficult. In addition, turbulence length scales are not well known and will likely differ under different conditions. Swash-zone turbulence is a major unsolved problem from both a theoretical and measurement standpoint. Future work should be devoted to determine the most practical approaches to quantify turbulence under natural field conditions.

2.2. Void fraction

To our knowledge, void fraction measurements in the swash zone do not exist. It is clear the incoming bore is laden with bubbles and foam. The importance of the multi-phase nature of the flow on the flow field itself, pressure gradients, turbulence, momentum flux, and stress variability remain unknown. In addition, the void fraction adversely affects optical and acoustic sensors that are used to measure suspended sediment concentration and velocity.

2.3. Velocity profiles

New instrumentation such as the Nortek Vectrino II now permit the collection of velocity profiles in the field over a small range (0.02 to 0.03 m) at 1 mm vertical bin spacing. Data over more of the water column are needed to investigate the full velocity profile. Some approaches using multiple overlapping sensors in the vertical have been attempted with moderate success. However, required alongshore separation of sensors complicates concatenation of individually measured segments of the velocity profile. A single sensor spanning a larger range of the water column would provide a more robust measurement. Difficulties may arise from the required distance above the bed the sensor must be to increase the sensing range. Laboratory experiments allow for an extension of the measurement range through the use of imaging techniques such as the particle image velocimetry (PIV). However, PIV may still fail during bore arrival due to highly aerated flow. The measurement of the velocity profile into the highly concentrated near bed region (sheet flow) in field and laboratory settings is still in its infancy.

2.4. Wave boundary layer evolution

Laboratory observations and numerical models suggest that the boundary layer thickness in the swash zone increases quickly during the uprush, vanishes during flow reversal, and becomes depth limited during the backwash. The logarithmic model has been applied with moderate success in the swash zone of several laboratory studies over fixed beds and in the field under mobile bed conditions. The model can describe the general shape of the velocity profile and the bed shear stress during uprush. The model has more discrepancy predicting the velocity profile and bed shear stress in the backwash when compared to ground truth data over fixed beds. The model still requires more validation/testing over mobile beds. Other approaches to investigate the boundary layer velocity profile shape and evolution are necessary including in the presence of infragravity waves or during swash–swash interaction.

2.5. Pressure gradients

Past work has mainly focused on horizontal pressure gradients, showing that the sea surface slopes offshore for the majority of the swash cycle except near the run-up tip and at the surf/swash transition. Non-hydrostatic conditions, swash–swash interaction, and bed exfiltration/infiltration may require improved measurements of the dynamic pressure that could enhance sediment transport during these instances when the measurement of the surface slope alone may be insufficient. Vertical pressure gradients also deserve further investigation.