Journal of Marine Systems 78 (2009) S37–S47

Contents lists available at ScienceDirect

Journal of Marine Systems

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

Wave run-up observations in microtidal, sediment-starved pocket beaches of the Eastern Mediterranean

M.I. Vousdoukas [a,*], A.F. Velegrakis [a], K. Dimou [a], V. Zervakis [a], D.C. Conley [b]

[a] Department of Marine Sciences, School of Environment, University of the Aegean, University Hill, 81100, Mytilene, Greece
[b] School Earth, Ocean & Environmental Sciences, Portland Square A504, University of Plymouth, Drake Circus, Plymouth PL48AA, UK

ARTICLE INFO

Article history:
Received 24 January 2008
Received in revised form 4 November 2008
Accepted 22 January 2009
Available online 10 March 2009

Keywords:
Wave run-up
Beach dynamics
Swash zone
Nearshore waves
Video imaging of waves
Image processing

ABSTRACT

A video-based method was used to acquire wave run-up information from 3 microtidal, sediment-starved 'pocket' beaches on the island of Lesbos (Greece, NE Mediterranean). The results showed that the investigated beaches exhibit particular characteristics with regard to the wave run-up, compared to the sandy oceanic beaches previously studied. Run-up heights appeared to be characterised by similar frequencies to those of the nearshore waves (studied through the acquisition of high frequency wave data in the nearshore zone). Low frequency motions are introduced via the swash, but their contribution to the total run-up energy appeared to be less significant than in previous studies. Previously-proposed parameterisations were mostly found not to describe adequately the present data, whereas predictions based on previously-proposed expressions were also not satisfactory, with the possible exception of the expression of Stockdon et al. [Stockdon, H.F., Holman, R.A., Howd, P.A., Sallenger, J.A.H., 2006. Empirical parameterization of setup, swash, and runup. Coast. Eng., 53(7), 573–588], which has been obtained on the basis of extensive datasets from diverse beaches.

1. Introduction

An improved understanding of the swash zone processes is essential for an enhanced diagnosis/prediction of beach morphodynamics (e.g. Komar, 1998; Van Rijn, 1998) and considerable research effort has been taking place over the past years towards this objective, on the basis of laboratory (e.g. Bowen et al., 1968; Gourlay, 1992; Dibajnia, 2002) and field (e.g. Holman, 1986; Holland et al., 1995; Ruggiero et al., 2004) observations, as well as modelling (e.g. Karambas and Koutitas, 2002; Li et al., 2002; Horn, 2006). A crucial parameter of swash zone dynamics is the wave run-up height R, the accurate prediction of which is vital for the effective design of coastal protection works (e.g. Briganti et al., 2005) and beach nourishment projects (e.g. Dean, 2001), the prediction of storm wave, surge and tsunami effects (e.g. Korycansky and Lynett, 2007) and the planning of efficient coastal management schemes (e.g. Munoz-Perez et al., 2001; Xue, 2001; Kroon et al., 2007). An early effort to parameterize the run-up height was by Hunt (1959), who suggested the following relationship:

$$R = H_o \xi \quad (1)$$

where H_o is the deep water significant wave height and ξ the Iribarren number (Iribarren and Nogales, 1949; Battjes, 1974), given by:

$$\xi = \frac{\beta}{(H_o/L_o)^{1/2}} \quad (2)$$

where β is the beach slope and L_o is the deep water wavelength.

Several studies followed, aiming to generate predictive run-up formulae and determine relationships (if any) between wave heights, beach slopes and the Iribarren number. Holman (1986) measured wave run-up through video imagery and suggested the following expression for the 2% exceedence of the peak run-up height ($R_{2\%}$):

$$R_{2\%} = (0.83\xi + 0.2)H_o \quad (3)$$

while Douglass (1992), using the same dataset, proposed an independent of the beach slope relationship for the maximum run-up height R_{max}:

$$\frac{R_{max}}{H_o} = \frac{0.12}{\sqrt{\frac{H_o}{L_o}}} \quad (4)$$

There have been other similar studies, which have related wave run-up to wave and beach slope parameters (e.g. Guza and Thornton, 1982; Raubenheimer et al., 1995; Raubenheimer and Guza, 1996). For example, Nielsen and Hanslow (1991) proposed the parameter $(\beta H_o L_o)^{1/2}$ as a

* Corresponding author. Faculdade de Ciências do Mar e do Ambiente. Universidade do Algarve, Campus de Gambelas, 8005 - 139, Faro, PORTUGAL. Tel.: +351 289 800900; fax: +351 289 706972.
E-mail addresses: mvousdoukas@ualg.pt (M.I. Vousdoukas), afv@aegean.gr (A.F. Velegrakis), kdemou@marine.aegean.gr (K. Dimou), zervakis@marine.aegean.gr (V. Zervakis), daniel.conley@plymouth.ac.uk (D.C. Conley).

0924-7963/$ – see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.jmarsys.2009.01.009

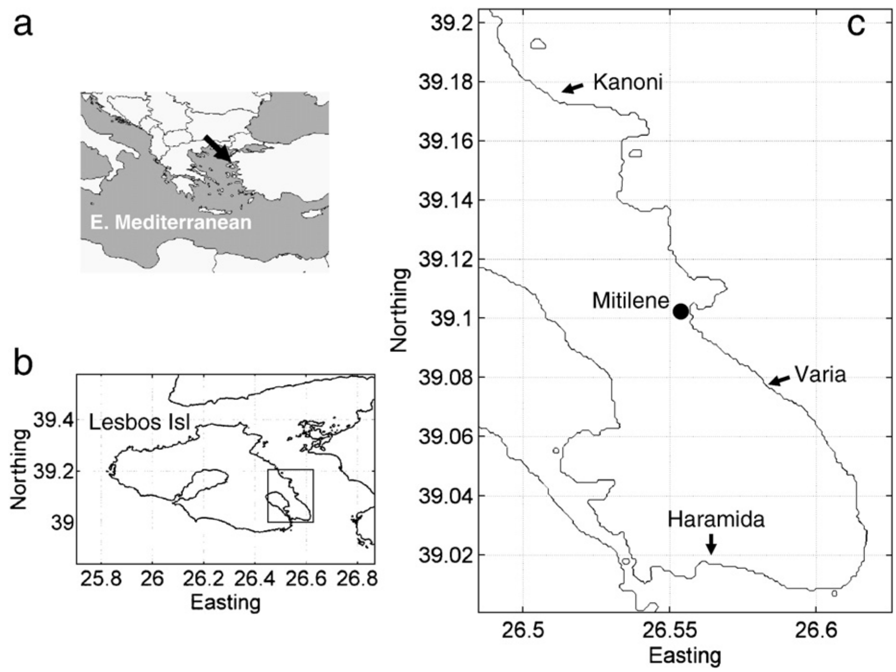

Fig. 1. Location of the experimental sites. Coordinates in degrees.

control, whereas Ruessink et al. (1998) and Ruggiero et al. (2004) suggested a linear relationship between the run-up height and ξ, after studying beaches under highly dissipative conditions. The most recent and extensive analysis (Stockdon et al., 2006) combined information from 10 different field sites and reached to the following relationships:

$$R_{2\%} = 1.1\left(0.35\beta(H_o/L_o)^{1/2} + \frac{\left[H_oL_o\left(0.563\beta^2 + 0.004\right)\right]^{1/2}}{2}\right) \quad \text{(all data)} \tag{5}$$

$$R_{2\%} = 0.043(H_oL_o)^{1/2} \quad \text{dissipative beaches } (\xi<0.3) \tag{6}$$

An interesting development regarding the acquisition of wave run-up information has been the use of video-based techniques, which over the recent years have been shown to be an effective tool in coastal research (e.g. Erikson et al., 2005; Holman and Stanley, 2007; Velegrakis et al., 2007), as they provide non-intrusive, low-cost measurements in the energetic nearshore zone. Thus, while earlier studies used mostly *in situ* sensors (e.g. electrical wires) for run-up observations (e.g. Hunt, 1959; Baldock et al., 1997; Baldock and Holmes, 1999), video-based techniques have recently become dominant in similar efforts (e.g. Ruggiero et al., 2004; Gorman and Coco, 2005; Stockdon et al., 2006). Most of these techniques use 'time-stack' images (e.g. Aagaard and Holm, 1989; Holland and Holman, 1993), which allow the acquisition of time-series of run-up excursion lengths, through the application of edge detection algorithms or manual digitization, which can be then translated into run-up heights, if the beach profile is known.

Previous run-up studies (upon which parameterisations have been based) have mostly taken place on sandy beaches exposed to oceanic wave and tidal conditions (e.g. Holman and Guza, 1984; Ruggiero et al., 2001; Erikson et al., 2005; Stockdon et al., 2006). However, there are many regions (e.g. the Mediterranean Sea), where the geological history, absence of oceanic swell, extreme storm waves and tides and particular climatic conditions have resulted in the formation of beaches with different characteristics, i.e. in the formation of narrow, sediment-starved 'pocket' beaches, fronted by seabeds with irregular morphology (e.g. see Velegrakis et al., 2005). Although most of these beaches are currently under erosion (e.g. EUROSION, 2004) and likely to be particularly vulnerable to extreme wave run-ups, no relevant studies have been carried out yet. Thus, the objective of this contribution is to present/discuss the results of a video-based, wave run-up study, carried out in the microtidal, sediment-starved beaches of the NE Mediterranean Sea (Greece), which are exposed mostly to locally-generated short waves.

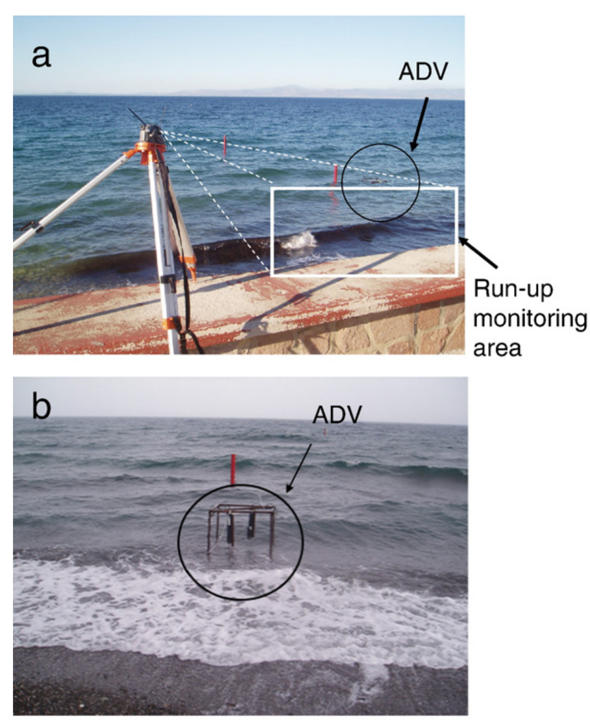

Fig. 2. Examples of the experimental layout in (a) Varia beach and (b) Haramida beach. Note that the camera was monitoring the wave run-up behind the instrument platform (the same cross-section).