MSc Earth Surface and Water
GEO4-4434 Wave-generated waves and coastal morphology

Final exam

Date: April 17, 2013
Location: Unnik - 211
Staff: Ruessink / Tissier

Please note the following:

- Before you start, carefully read the whole question.
- Put your name and student number on each piece of paper.
- You may use the books by Van Rijn and Holthuijsen, as well as the various journal papers discussed during the lectures. The use of hand-outs, power-points, lecture notes, and answers to (Matlab) exercises is not allowed.

Question 1: Surf-zone circulation

Coastal scientists deployed an extensive array of instruments to measure surf-zone circulation in the nearshore zone. The bathymetry on one particular day is shown in Fig. 1.1; it shows two well-developed rip channels (marked RIP A and RIP B). In this figure, X stands for cross-shore direction and Y for longshore direction. The contours indicate the bed elevation with respect to mean sea level (MSL), with negative meaning below MSL. The thick black line is the 0-m contour; the dashed line (-1 m MSL) is the location of the low-tide shoreline. Each black square is the location of an instrument that measured the mean cross-shore and longshore velocity.

a) During the 20-30 years, two contrasting theories have been proposed to explain the initial generation of rip channels. These two theories are based on "template" and "self-organization" processes, respectively. Describe how rip channels are formed in a template and in a self-organization model. Use your answer to highlight fundamental differences between both approaches.

Fig. 1.2 shows the mean velocity vectors during a high tide. The offshore significant wave height was about 1.5 m and the peak period was approximately 15 s. The waves were shore-normally incident. There was no wind.

b) Explain the surf-zone circulation seen in Fig. 1.2. Start your answer by making a motivated estimate of spatial variability in wave height.

c) Measurements were also taken at mid tide (0 m MSL). Motivate in what way the circulation would have differed from that at high tide. Assume that the offshore wave conditions were the same as at high tide.

A storm arrived several days after the measurements of Fig. 1.2 were collected. The storm caused the offshore significant wave height to increase to 2.5 m. The peak period dropped to 8 s. The storm waves arrived at an angle with 30 degrees with respect to the shore-normal.

d) Make a sketch of the variance-density spectra (in the offshore region) of the wave conditions during the former high tide and the present storm conditions. In words, highlight the differences between the two spectra. All offshore wave characteristics were sampled by a buoy with 2 Hz. The values on the y-axis of the spectra are of no concern.

e) Make a motivated guess of the evolution of the subtidal bathymetry during the storm.

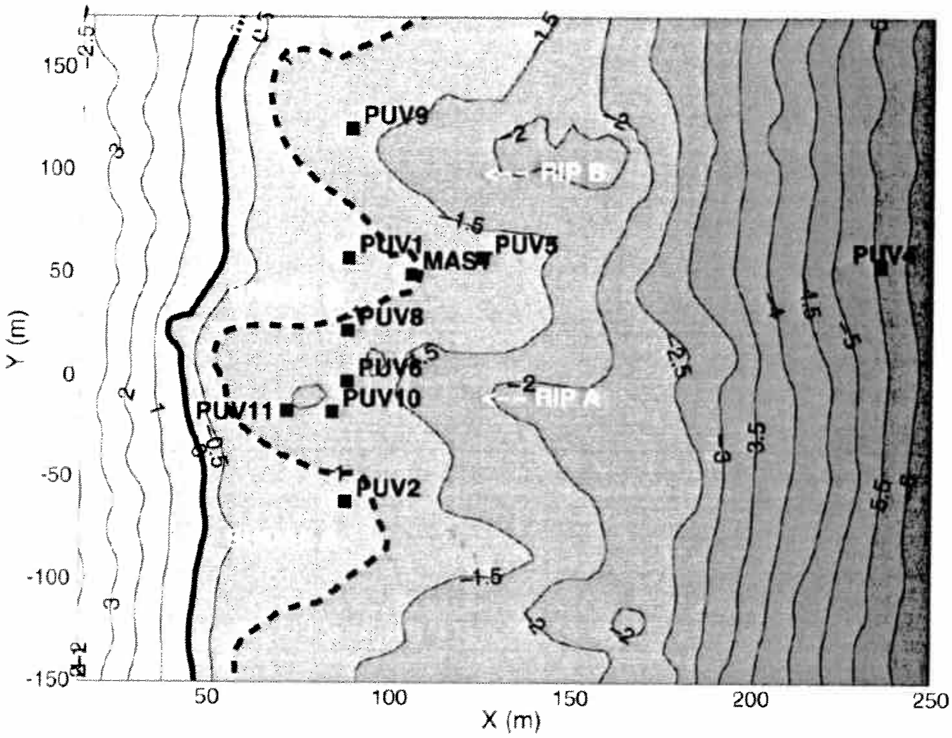

Fig. 1.1: Bathymetry (contours and colour shading) and instrument location (squares). X stands for cross-shore direction and Y for alongshore direction.

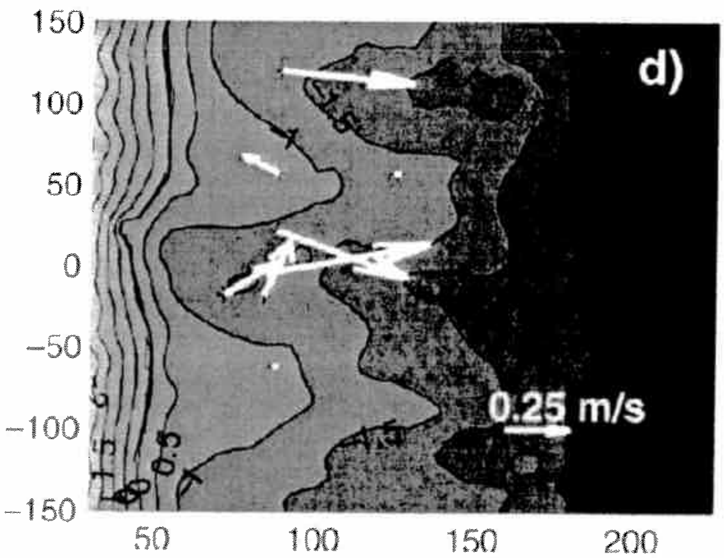

Fig. 1.2: Mean velocity vectors for a high tide during the measurement campaign. The arrows indicate both the magnitude and direction of the surf-zone circulation. The contours and colouring represent the bathymetry.

1,5 / 2   H / h = 0,5   1,5 / 0,5 = 3   1,5 / ...

Question 2: Nearshore hydrodynamics, sand transport and wave modelling

Fig. 2.1 shows results from a laboratory experiment with shore-normal waves. The top panels shows the set-down and set-up (black symbols) versus cross-shore distance. The bottom panel shows the maximum elevation of the wave crests and the minimum elevation in the wave troughs. The set-up and set-down are shown again in the bottom panel with the dashed line. Assume that the elevation difference between the wave crest and the wave trough equals the wave height.

a) Set-up and set-down can be predicted using the depth-averaged cross-shore momentum balance, which reads:

$$\frac{dS_{xx}}{dx} = -\rho g h \frac{d\bar{\eta}}{dx}$$

$\frac{dS_{xx}}{dx} \uparrow$ dan $\eta \downarrow$

Here, x is cross-shore distance (positive onshore), ρ is water density, g is gravitational acceleration, h is the water depth, $\bar{\eta}$ is the mean water level with respect to the still-water level, and S_{xx} is the radiation stress term given by

$$S_{xx} = \left(n - 0.5 + n\cos^2\theta\right)E + 2E_r\cos^2\theta$$

deep w: $n = 0.5$
shallow w: $n = 1$

Here, n is the ratio between the group velocity and the wave celerity, θ is the angle with respect to the shore normal, E is the wave energy and E_r is the roller energy.

Use these two equations to provide a detailed explanation of the set-down and set-up pattern as observed during the laboratory experiment.

b) Provide a motivated guess where on the cross-shore profile in Fig. 2.1 the waves were skewed, mixed skewed-asymmetric and asymmetric.

c) Explain why the wave-related sediment transport under skewed and under asymmetric waves is generally onshore directed when the bed material is a medium-sized sand (≈ 300 μm).

d) Explain why the total transport under asymmetric waves is generally offshore directed when the beach is alongshore uniform.

A scientist is looking for a way to numerically model the wave transformation and the wave-shape information provided in the bottom panel of Fig. 2.1. He has the option to use a wave-averaged and a wave-resolving model.

e) Explain what the terms "wave-averaged" and "wave-resolving" stand for. Provide examples of both types of models.

f) What would you advise the scientist when he is primarily interested in an accurate description of the wave shape? And what when he is ultimately interested in predicting sand transport and the morphological evolution of the beach? Briefly explain your answer.

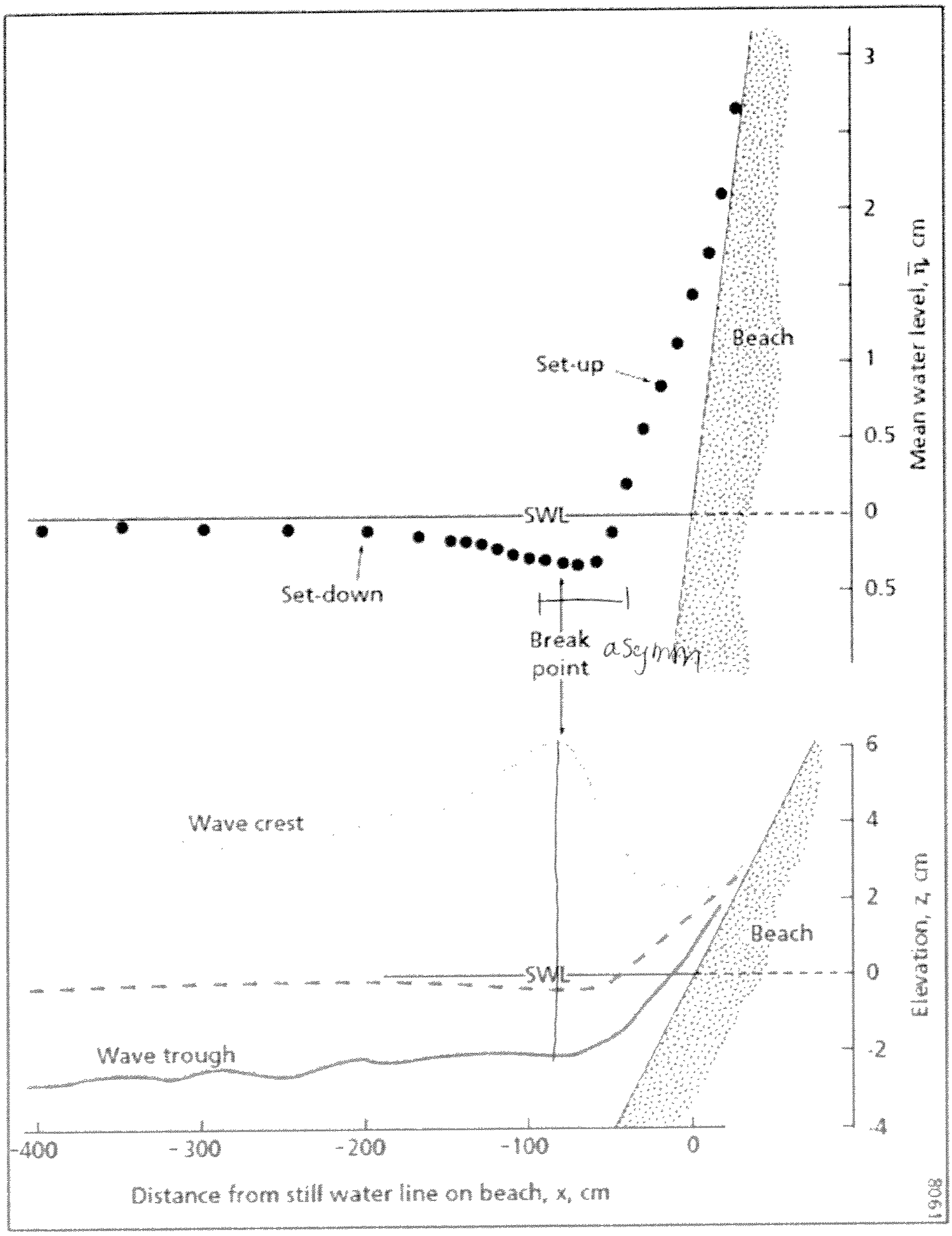

Figure 2.1 Results from a laboratory experiment