STATISTICS OF EXTREME WAVES IN COASTAL WATERS: LARGE SCALE EXPERIMENTS AND ADVANCED NUMERICAL SIMULATIONS

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INTRODUCTION

Freak (or rogue) waves have been a topic of interest in the scientific community for several decades. However, most of the attention has been devoted to the study of these waves in oceanic domains with deep water conditions (see Dysthe *et al.*, 2008). Few papers deal with rogue wave occurrences in coastal areas, in particular considering variable bathymetry. The present work aims at improving the knowledge on the statistics of extreme waves in irregular wave conditions propagating over a sloping bottom profile, through large scale experiments and advanced numerical models.

BRIEF OVERVIEW OF CURRENT KNOWLEDGE

Nikolkina & Didenkulova (2011) have collected data from mass media sources over the period 2006 - 2010. For the shallow water region and the nearshore areas, they have noticed more than 60 events leading to 38 fatalities. These authors noticed that those waves are quite rare, though this low statistics is maybe due to mild bottom slope of the particular coastal zone under consideration. In the west coast of India, Glejin *et al.* (2014) have recorded a maximum wave height of 6.9 m in a sea state with H_s = 3.2 m and relative water depth kh = 0.71 (with k the wave number). This low value confirms the existence of rogue waves in shallow water.

However, the mechanisms that lead to the occurrence of rogue waves in shallow water are not well explained by the theory of modulation instability. Indeed, this theory shows that when kh < 1.363, the wave train becomes stable. One explanation may come from the complex mechanisms in variable bathymetry, especially for cases of steep slopes or near the edge between a steep slope and a gentler slope, as the case of the continental shelf. Zeng & Trulsen (2012) and Viotti & Dias (2014) have performed numerical studies about the wave evolution over this kind of bathymetry and they also concluded that waves may exhibit complicated spatial structures.

Very few laboratory experiments are performed on the problem of rogue waves in shallow water and even fewer studies on the influence of the bathymetry on rogue wave occurrences. Trulsen *et al.* (2012) analysed experimental wave data recorded at MARIN (NL). Kashima *et al.* (2014) performed experiments in a 35 m long wave tank, to estimate freak wave occurrence in shallow water based on the computation of the kurtosis.

EXPERIMENTAL PROGRAM

A series of experiments with long-crested irregular waves are performed in the large scale wave flume at Tainan Hydraulic Lab. (THL) in Taiwan. The flume is 200 m long and is equipped with a piston-type wavemaker. A concrete bottom profile is constructed with a plane slope of 1:20. The offshore water depth, the peak period and the significant wave height (H_s) of the incident wave trains are varied, using a JONSWAP type spectrum (with two different values of the peak enhancement factor). This series of tests allow us to cover a range of values of the relative water depth (k_ph) and wave steepness ($k_pH_s/2$) both in the offshore part of the flume and over the shallow water area after the slope. Each test consists of over 6,000 individual waves, which allows to perform reliable statistical analyses, with particular attention for the tail of the distribution of free surface elevation and individual wave heights.

NUMERICAL MODELING AND COMPARISON

The experimental data sets are used to evaluate the applicability and accuracy of two numerical wave models: a high-order Boussinesq model based on Jamois *et al.* (2006) and the highly nonlinear and dispersive whispers-3D code based on the fully nonlinear potential flow theory (Yates & Benoit, 2015). The latter modeling approach has been validated with a series of challenging cases with high level of nonlinearity and variable bathymetry (Raoult *et al.*, 2016). The statistical distributions of wave heights obtained from the numerical simulations are compared with the experimental ones, with particular attention at locations where extreme waves occur more frequently.

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