EVOLUTION OF UNSTABLE WAVE PACKETS OVER VARIABLE BATHYMETRY

Olivier Kimmoun, École Centrale Marseille & IRPHÉ, Marseille (France), olivier.kimmoun@centrale-marseille.fr
Hung-Chu Hsu, Dept. of Marine Environment and Engineering, NSYSU, Kaohsiung (Taiwan) hchsu@mail.nsysu.edu.tw
Amin Chabchoub, The University of Sydney, Sydney (Australia) amin.chabchoub@sydney.edu.au

INTRODUCTION

Several field observations have reported the formation of rogue waves in coastal zones, see Chien et al. (2002) for an example in Taiwanese sea.
The mechanisms that lead to the occurrence of rogue waves in finite water depth to shallow water are not well understood yet under the conjecture of modulation instability. Indeed, this theory for uni-directional waves shows that when *kh* is lower than a threshold of 1.363 in homogeneous water depth conditions, the wave train becomes stable to side-band perturbations. Then if the wave train is stable, the appearance of rogue waves is not possible within this linear stability framework. One explanation may come from the complex wave transformation mechanisms in variable bathymetry, especially, for cases of steep slopes or near the edge between a steep slope and a gentle slope as it is the case of the continental shelf. Very few laboratory experiments have been so far addressing the influence of the bathymetry on extreme wave occurrence (Baldock and Swan (1996), Kashima et al. (2012), Ma et al. (2015))

EXPERIMENTAL SETUP

Experiments were performed in the mid-size visualization tank of the Tainan Hydraulic Laboratory (THL) in Tainan, Taiwan. This facility is 200 m long and 2 m large. At one end, a piston type wavemaker is installed. Three campaigns were performed corresponding to three different bathymetries. Their descriptions are given in figure 1.

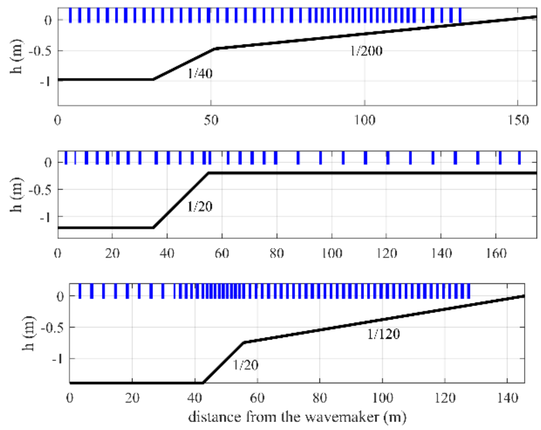

Figure 1 - Bathymetry of the three different campaigns. (Upper) 49 wave probes, (middle) 30 wave probes, (bottom) 60 wave probes.

The last bathymetry corresponds to a simplification of a cross section of the bathymetry of the North-West coast of Taiwan. To measure the surface elevation, capacitive wave probes were used. Their locations are also displayed in Figure 1 while the total probe numbers are given in the caption. For each setup, the unstable modulated waves are generated corresponding to Peregrine or Akhmediev breathers for different periods and steepness of the wave carrier and for different unstable envelope modulation periods.

RESULTS

Different numerical models have been used to validate our experimental results. A first family of models derived from the NLS equation in variable bathymetry. The first is a NLS model to 3rd order in nonlinearity (NLS3), obtained by Sergeeva et al. (2014) and the second which is 5th order in nonlinearity (NLS5) is obtained by Slunyaev (2005). The last model is different as it corresponds to a high order Boussinesq model (HOB) obtained by Bingham et al. (2009). An example of unstable wave evolution in the wave flume and following the three prediction models is given in Figure 2. It corresponds to the bottom bathymetry configuration of Figure 1. The parameters correspond to an unstable Akhmediev wave packet with a focusing distance of 26 m from the wave maker, a steepness of 0.13, a wave period of 0.9 s and an Akhmediev parameter, which determines the modulation period, of 0.47. For each experiment and models, the time-space evolution of the envelope amplitude is shown.

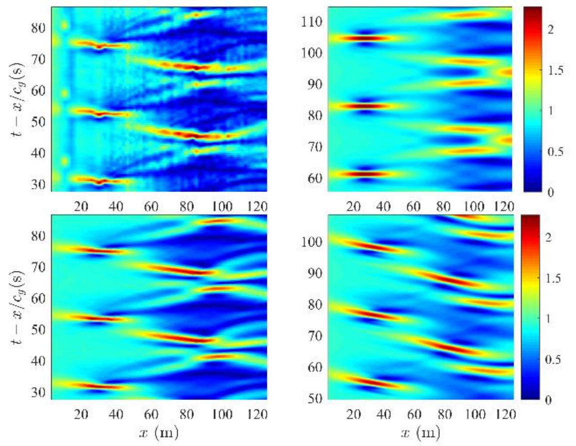

Figure 2 : (Left-top) Experiments, (Right-Top) NLS3, (Right - Bottom) NLS5, (Left-Bottom) HOB.

REFERENCES

Bingham, H. B., Madsen, P. A., & Fuhrman, D. R. (2009). Velocity potential formulations of highly accurate Boussinesq-type models. Coastal Engineering, 56(4), 467-478.
Chien, H., Kao, C. C., & Chuang, L. Z. (2002). On the characteristics of observed coastal freak waves. Coastal Engineering Journal, 44(04), 301-319.
T. E. Baldock & C. Swan, 1996, Extreme waves in shallow and intermediate water depths, Coastal Engineering, 27, 21-46.
Kashima, H., K. Hirayama & N. Mori, 2012. Shallow water effects on freak wave occurrence. Proceedings of 22nd International Offshore and Polar Engineering Conference, Rhodes, Greece, 3: 778-783.
Ma, Y.-X., Ma, X.-Z., Dong, G.H. (2015). Variations of statistics for random waves propagating over a bar. Journal of Marine Science and Technology, 23, 864-869.
Sergeeva, A., Slunyaev, A., Pelinovsky, E., Talipova, T., & Doong, D. J. (2014). Numerical modeling of rogue waves in coastal waters. Natural Hazards and Earth System Sciences, 14(4), 861-870.
Slunyaev, A.V. (2005). A high-order nonlinear envelope equation for gravity waves in finite-depth water. Journal of Experimental and Theoretical Physics, 101(5), 926-941.