NON-LINEAR DISPERSION EFFECTS IN NEARSHORE WAVES: PERSPECTIVES FOR DEPTH-INVERSION APPLICATIONS

Kévin Martins, UMR 5805 EPOC, University of Bordeaux, kevin.martins@u-bordeaux.fr
Philippe Bonneton, UMR 5805 EPOC, University of Bordeaux, philippe.bonneton@u-bordeaux.fr
Olivier de Viron, UMRi 7266 LIENSs, La Rochelle University, olivier.de_viron@univ-lr.fr
Ian Turner, Water Research Laboratory, UNSW Sydney, ian.turner@unsw.edu.au
Mitchell Harley, Water Research Laboratory, UNSW Sydney, m.harley@unsw.edu.au
Kristen Splinter, Water Research Laboratory, UNSW Sydney, k.splinter@unsw.edu.au

INTRODUCTION

Remote-sensing technology, combined with depth-inversion algorithms, presents a promising opportunity to quantify the morphological evolution of sandy beaches during storms. Current depth-inversion algorithms such as *cBathy* rely on the linear wave dispersion relation to invert depth from remotely-sensed dispersion properties. In the surf zone, however, non-linear amplitude dispersion effects become important and significant deviations from the linear dispersion are expected (Martins et al., 2021). Optical imagery also suffers from other technical limitations when dealing with breaking waves (*e.g.*, saturated pixels and phase shifts), which affects the stability and accuracy of remotely-sensed wave dispersive properties. These limitations explain the poor accuracy reached with common approaches in the surf zone (typically 100% error). This contribution paves the way to new depth-inversion algorithms suited to the surf zone, based on remotely-sensed free surface elevation data (*e.g.*, by lidar scanners). We here report on the first efforts to account for non-linear amplitude dispersion effects.

METHODS

We use surface elevation datasets collected at high resolution in three laboratory experiments: two experiments performed over plane beaches with varying slopes (1:100 during GLOBEX; 1:35 during van Noorloos' experiments), while the third one was performed over a barred profile. Wavenumber spectra κ_{obs} are extracted along the wave flume using cross-spectral analyses. Non-linear amplitude effects on the dominant wave dispersive properties are quantified with the Boussinesq theory of Herbers et al. (2002) as follows:

$$\kappa_{rms}(\omega) = \frac{\omega}{\sqrt{gh}}\sqrt{1 + \frac{h\omega^2}{3g} + \frac{h^2\omega^4}{36g^2} - \beta_{am}(\omega)} \qquad (1)$$

where ω is the angular frequency, g is the acceleration of gravity, h is the mean water depth and β_{am} are the amplitude dispersion effects:

$$\beta_{am}(\omega) = \frac{3}{2hE(\omega)}\int_{-\infty}^{\infty} B^{\mathrm{Re}}(\omega', \omega - \omega')d\omega' \qquad (2)$$

where E and B are the spectral and bispectral densities of the free surface elevation signal.

RESULTS

At the peak frequency (ω_p), the Boussinesq theory of Herbers et al. (2002) accurately predicts the 10-20% deviation from the linear dispersion that typically occurs prior to breaking and in the surf zone (Martins et al., 2021). At high harmonics, the improvements compared to the linear wave dispersion are much more significant (difference between c_{rms} and c_{obs} within 5% up to $3\omega_p$).

When the surface elevation signal is known, h becomes the only unknown of Eq. 1. The depth-inversion problem can then easily be turned into a non-linear optimisation problem based on the good match between κ_{rms} and κ_{obs}. In the presentation, we will present the benefits of this approach, which allows depth estimates with less than 5-10% errors in the surf zone. Current limitations for applications in the field will be addressed and perspectives for the future of depth-inversion in the surf zone will also be discussed.

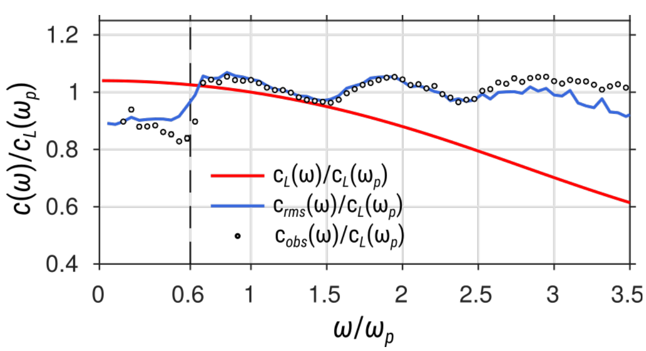

Figure 1 - Observed ($c_{obs} = \omega/\kappa_{obs}$) wave phase speed normalised spectra compared with linear and Boussinesq ($c_{rms} = \omega/\kappa_{rms}$) predictions at breaking during GLOBEX (irregular wave test A3).

REFERENCES

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