Prediction of non-linear random wave characteristics in the surf zone

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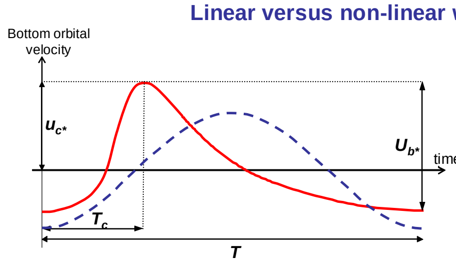
I. Motivation

<u>**GOAL:**</u> Development of an <u>accurate</u> and <u>computationally efficient</u> model to predict nearshore hydrodynamic characteristics for sediment transport calculations. Computational efficiency is a crucial requirement, due to the interdependency between bathymetry and hydrodynamics.

Tajima and Madsen (2002), hereafter referred to as TM, developed an efficient hydrodynamic model which describes the propagation of monochromatic or narrow-banded spectral waves into the surf zone. However, real waves in the near-shore region follow more complicated distributions than the simple one assumed by TM. The purpose of this work is to investigate how well non-linear characteristics of realistic wave distributions may be retrieved from TM's simple spectral model.

II. Procedure

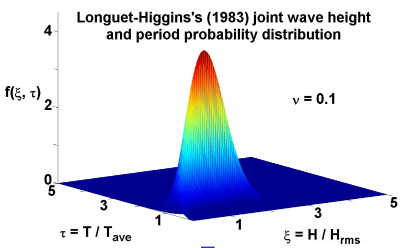
Linear versus non-linear wave



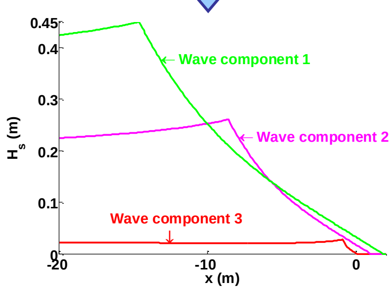
$$\text{Asymmetry} = 1 - \frac{2T_c}{T} \qquad \text{Skewness} = \frac{2u_{c*}}{U_{b*}} - 1$$

EC_g = E_f (linear wave) = E_f (nonlinear wave)

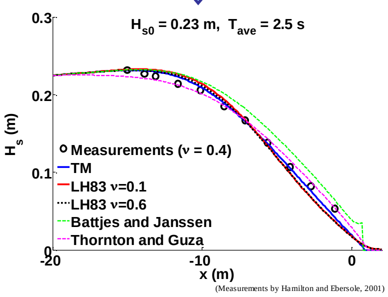
Random wave description and wave-by-wave approach



To model random waves more realistically, we represent the incident waves by the joint probability distribution of wave height and period suggested by Longuet-Higgins (1983). This allows us to examine the effects of spectral width, ν.



To study nearshore hydrodynamics associated with random incident waves, we use the so-called *wave-by-wave approach*. In this approach, a large number of individual wave components, each defined by *H* and *T*, are propagated using TM's monochromatic wave model. Nonlinear wave characteristics can be obtained for the individual waves by making use of the relationships between linear and non-linear wave characteristics developed by TM.



Mean wave characteristics are calculated at various positions in- and outside the surf zone by averaging the results for all individual wave components. In the figure (1:30 sloping beach), the results of the wave-by-wave approach are compared to the TM spectral model and to other existing wave models.

References

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III. Results

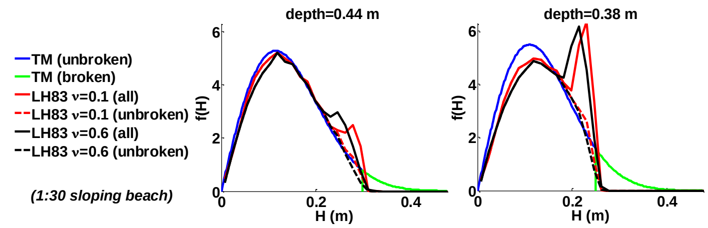
TM versus other wave models

In contrast to existing linear wave models, such as Battjes and Janssen's (1978) and Thornton and Guza's (1983), the TM spectral model presents two major advantages:

1. It can be applied to both monochromatic and spectral waves.

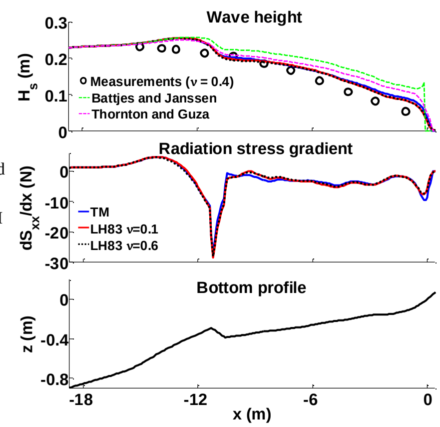
2. It provides estimates of non-linear wave characteristics.

Evolution of wave height distribution



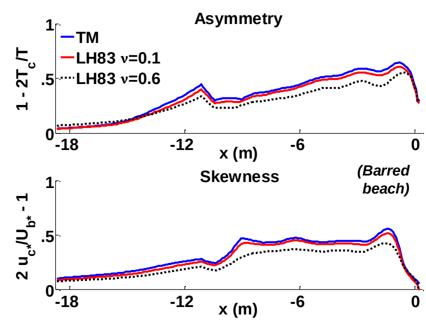
TM versus wave-by-wave approach

Since undertow, in addition to non-linear wave characteristics, contributes to cross-shore sediment transport, we compare radiation stress gradients predicted by the TM spectral model and by the wave-by-wave approach on a barred beach. We conclude that the TM spectral model yields predictions that are consistent with the more detailed wave-by-wave approach for a range of spectral widths.



Nonlinear wave characteristics

The wave-by-wave approach yields predictions of non-linear wave characteristics, obtained by probabilistically averaging the non-linear monochromatic results, but it is far more computationally demanding than the TM spectral model. However, accurate estimates of non-linear wave characteristics are obtained from the equivalent linear predictions afforded by the TM spectral model.



IV. Conclusions

1. The TM spectral wave model yields accurate results, is fully predictive, and provides estimates of non-linear wave characteristics.

2. The TM model's predictions, based on H_{rms} and T_{ave}, are in good agreement with the more detailed wave-by-wave approach for narrow banded spectra up to ν =0.6.

3. Nonlinear wave characteristics of importance to sediment transport computations in the surf zone can be estimated by applying TM's relationships between equivalent linear and nonlinear periodic waves to the predictions of the TM spectral model.

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