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# Analyses on Grouped Wind Waves and Their Associated Long Waves Propagating over Composite Bottom Slopes

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## 1. Introduction

In a train of irregular wind waves, high and low waves alternately appear in groups. The existence of the wave groups will induce secondary waves with a period corresponding to that of the groups. The typical period of the long waves observed in a field is around 100s. The long waves are sometimes called "infragravity waves".

During a storm, beach erosion occurs rapidly with sand transport from the foreshore beach to the offshore. Formerly, wind waves were considered to be the main external forces of beach erosion. Even under stormy wind wave conditions, however, the after breaking wave heights in the inner surf zone are limited by the water depth. Therefore, it is difficult to attribute the abrupt beach erosion solely to the wind waves. In contrast, infragravity waves do not break in the surf zone and reach their maximum height at the shoreline. Several field studies have reported that the infragravity waves induced by grouped wind waves play a significant role on the beach erosion.

Symonds et al. [1982] proposed a model to explain the generation mechanisms of infragravity waves by temporal breakpoint variance. The breakpoint varies over the period of the grouped waves because higher waves in the group break further offshore than lower waves do. Thus, the time-varying breakpoint is considered to act as a wave maker of the infragravity waves.

This study aims to extend the Symonds' model to the more realistic beach morphology as the bar type beach, and investigates the coupling field of grouped wind waves and their associated infragravity waves, analytically and numerically. Comparisons between the numerical and analytical results are made and the advantage of each method is discussed.

## 2. Results and Discussion

An analytical model on infra-gravity waves over a shore parallel bar is developed. The analytical solutions comprised by Bessel functions are derived by dividing the calculating domain into several segments. A numerical model to describe grouped wind waves and the resultant infra-gravity waves is developed based on the fully nonlinear Boussinesq equations. The time series of incident grouped waves are herein given by bichromatic waves, where two sinusoidal waves of closely neighboring angular frequencies with the same amplitude are superimposed. The generated infra-gravity waves by the time varying breaking points are detected using a low pass filter.

The comparisons between analytical and numerical results for the infragravity waves are conducted by changing bottom geometries and grouped wave properties such as a modulation rate.

## 3. Conclusions

(1) Both analytical and numerical results on infra-gravity wave heights show node-loop structures in the on-offshore distributions. The numerical wave heights at the loop are found to be less than the analytical ones. The numerical results show slightly unclear nodes where their wave heights do not reduce to zero values. For the run-up height at the shoreline, the analytical results become more peaked compared to the numerical results.
(2) Both results show that amplifications of the infragravity wave heights occur under large modulation coefficient, which result in clear anti-node patterns at the bar crest.
(3) Concerning the wave groups, the numerical results show almost constant wave height distributions over the trough region, which agrees with the wave height distributions that the Symonds' model postulates.
(4) The numerical simulation can reproduce almost whole transformation processes; shoaling, breaking, after breaking and run-up on a foreshore slopes for wind waves and infra-gravity waves over the barred type beach. The analytical model only describes one way process of the infragravity wave generation from the modulated wind waves. Whereas, the numerical model is able to reproduce the mutual interaction process between wind waves and long waves. The influence of the long waves on short waves is found to be significant in after-breaking zone through the alteration of apparent eddy viscosity coefficient.

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