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Transformation of Short Wave Groups and Generation of Infragravity Waves on a Bar-type Beach

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ABSTRACT
This study investigates the coupling field of grouped wind waves and their associated infragravity waves on a bar type beach. First, an analytical model of the infragravity waves generated by time varying breaking point over a shore parallel bar is developed. Second, a numerical model to describe grouped wind waves and the resultant infragravity waves is investigated based on the Bousinesq equations. The time series of incident grouped waves are given by bichromatic waves. The generated infragravity waves by the time varying breaking point are detected using a low pass filter. Finally, comparisons between the numerical and analytical results are made and the advantages of each method are discussed.

Keywords: Wave groups; Bar type beach; Infragravity waves; Symonds model; Boussinesq model

INTRODUCTION

In a train of irregular wind waves, the high and low waves usually appear in groups. The existence of the wave groupings will induce secondary waves with a period corresponding to that of the groupings. The typical period of the long waves observed in a field is around 100s. The long waves, sometimes called “infragravity waves”, were first noticed in the nearshore area by Munk [1949] and Tucker [1950].

During a storm of one or two days, 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. Although the larger waves break further offshore making the surf zone wider, the wave heights in the inner surf zone remain the same as those during non-storm conditions because the wave heights after breaking 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. Katoh and Yanagishima [1990], based on their field measurements, reported that the infragravity waves induced by grouped wind waves play a significant role on the beach erosion.

So far, a number of analytical models have been developed to describe the generation mechanisms of infragravity waves. Longuet-Higgins and Stewart [1962] showed the presence of a set-down wave or “surf beat” forced by the radiation stress variations due to alternating high/low waves. Symonds et al. [1982] proposed a model to explain the long wave generation by a time-varying breakpoint mechanism. They considered such a situation that the wave grouping is destroyed by the breaking and afterward the wave height decays under the constraints of the local water depth. The breakpoint varies over the period of the grouped waves because higher waves in the group break further offshore than lower waves do. The time-varying breakpoint acts as a wave maker, inducing a slow variation of the set-up and generation of free long waves propagating both in offshore and onshore directions.

In this study, first, we take an analytical approach on infragravity wave generation and their development. The analytical solutions are comprised by Bessel functions for each calculating domains. The analytical model may provide the universal properties on the infragravity waves; however, such linear model is not able to present the solutions for the run-up region. And also, the short wave attenuation after wave breaking, which was simply modeled by the depth-limited wave height assumption, is not accurate enough.

A numerical model to describe grouped wind waves and the resultant infragravity waves is investigated based on the Bousinesq equations [Wei and Kirby, 1995]. The non-linear numerical model is considered to be able to represent the run-up motion beyond the still water shoreline as well as detailed wave attenuation mechanism after wave breaking.