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Hydrodynamics of Infragravity Waves in Surf and Swash Zones

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1. 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 long waves with a period corresponding to that of the groupings. The typical period of the long waves is around 100s. The long waves, sometimes called infragravity waves.

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. In contrast, infragravity waves do not break in the surf zone and reach their maximum height at the shoreline. Thus, the infragravity waves are now considered to play a significant role on the beach erosion.

The present study investigates the coupling field of grouped wind waves and infragravity waves propagating over a plane slope beach and a bar-type beach. Based on the calculated wave fields, the contributions of the wind waves and infragravity waves to the sediment transport efficiency are discussed.

2. Results and Discussions

First, applicability of a generation model of infragravity waves proposed by Symonds et al. (1982) was investigated. The model considers the variation of the breaking points of grouped wind waves as a driving force to generate low frequency waves in both seaward and shoreward directions. The shoreward propagating waves will be totally reflected at the shoreline, which results in a standing wave pattern. After reflection at the shoreline, this wave will propagate seaward and superimpose itself on the directly seaward radiated wave depending on the relative phase.

Next, the incident wave groups propagation over a plane slope are analyzed based on time dependent mild slope equations including after-breaking dissipation term.

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The long wave generation is analyzed according to Symonds' model based on linearlized shallow water equations. To extend the prediction for landward swash motions, non-linear depth integrated shallow water equations are calculated.

Thirdly, an analytical derivation of long wave generation by a time varying break point over a linear shore parallel bar is presented. Our interests are focused on the effects of near-shore bar topography against the generation of low frequency waves. To keep the problem as simple as possible, the model is restricted as one dimensional cross shore motion, precluding edge wave solutions. Standing wave solution between the shoreline and the mean break point over the bar are obtained, and two possible resonance conditions are identified. By taking travel time into consideration, the Symonds' model has been modified. With using the concepts of the travel time and radiation stress, a Fourier series representation of the forcing terms is derived.

In order to evaluate sediment transport efficiency using the calculated grouped wind waves and infragravity waves, several kinds of newly proposed Shields parameters are proposed. The characteristics of the Shields parameter are investigated along the cross-shore direction.

3. Conclusions

The composite wave train of the grouped wind waves and infragravity waves generates much more sediment mobility than the sinusoidal wave train with the same average incident wave height. Effects of both the grouped wind waves and infragravity waves on sediment transport are evaluated through the proposed Shields parameters. The bimodal cross-shore distribution of the Shields parameter is found with maxima near the shoreline and the breaking zone. The grouped wind waves govern the sediment mobility in the surf zone, however, their contribution becomes negligible as they enter the swash zone where the infragravity waves dominate the sediment mobility. With increases of the incident wave height and the amplitude modulation rate, contributions of the infragravity waves to the sediment mobility are found to increase.