FIELD INVESTIGATION OF INFRAGRAVITY WAVE RESPONSE UNDER SINGLE-PEAKED AND DOUBLE-PEAKED SPECTRAL SEA STATES

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INTRODUCTION

Infragravity (hereafter IG) waves are surface gravity waves with typical frequency in the range of 0.005 - 0.04Hz, which are only a few centimeters high in the deep ocean, but amplify rapidly near the coast and can exceed 1 meter in stormy conditions, thus playing an important role in beach and dune erosion. Although the correlation between IG waves and incident short waves has been studied by many scholars before, yet the relationship between the frequency of IG waves and the spectral shape of incident short waves has not been fully understood. In addition, previous studies have often been discussed under single-peaked spectra incident wave conditions, and studies on the IG wave response under double-peaked spectra conditions are scarce. In fact, the probability of double-peaked spectra occurring in real sea states is not low (Soares, 1991). To further investigate the above issues, in this study, we analyzed a dataset collected from the nearshore waters of the North Indian Ocean during the Southwest Monsoon period (Fig.1). The study area was strongly influenced by high-energy swells from the North Indian Ocean during the observation period. while the double-peaked spectra formed by the superposition of the swell energy and the local sea wave energy occurred more often than the single-peaked spectra.

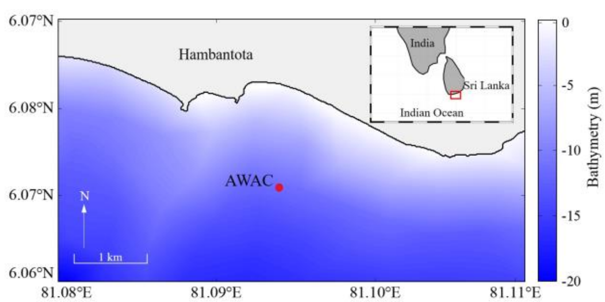

Figure 1 - Location of study area and observation point

METHOD

The instrument used for the measurements was a Nortek acoustic and current (AWAC) sensor placed at a water depth of 13 m at a distance of approximately 1.2 km from the shoreline. The sensor were set to collect 20 minutes of data per hour with a sampling frequency of 2 Hz. The measurements were taken from September 1 to 25, 2018, during the southwest monsoon. Spectral analysis of the surface elevation was performed using the Fast Fourier Transform (FFT). Statistically, the double-peaked spectra appeared a total of 654 times during the observation period, while the single-peaked spectra appeared 546 times.

The lower limit of the IG wave band was defined as 0.005 Hz to ensure the removal of any tidal signals. The upper limit of the IG wave band was set to 0.04 Hz to ensure that the IG energy level is not contaminated by occasional very high period swells. The frequency range of the short wave was defined as 0.04-0.4 Hz. Bound IG wave components are estimated from the frequency-direction spectra of short waves using the equilibrium theory derived by Hasselmann (1962). The shape of the incident short wave spectra is described using the peakedness factor Q_P. The numerical values of Q_P are normally more than 1.0, with larger values implying a narrower spectral shape.

RESULTS AND DISCUSSION

In order to investigate the effect of the incident short wave spectral shape on the IG waves, we compare the characteristics of the IG waves under single-peaked spectra and double-peaked spectra sea states. Fig.2 illustrates the boxplots of the characteristic parameters of short waves and IG waves for total, single-peaked spectra, and double-peaked spectra conditions. From the upper panel of Fig.2, it can be seen that there is no significant difference in short wave heights between single-peaked spectra and double-peaked spectra during the observation period (Fig.2a). Yet, the mean wave period T_{m02} and peakedness factor Q_P are significantly larger in the single-peaked spectra sea state than in the double-peaked spectra (Fig.2b and 2c), suggesting that the single-peaked spectra tend to have longer periods and narrower spectral shapes. In fact, longer period incident short waves tend to have narrower spectra than shorter period incident short waves, as evidenced by Fig.3 As can be seen from Fig.2d and 2e, both the total IG wave height and the bound IG wave height are larger in the single-peaked spectra sea state than in the double-peaked spectra, which implies stronger nonlinear coupling in the single-peaked spectra sea state. Surprisingly, there is no significant difference in the mean period of the IG waves between the two cases (Fig.2f).

In bound wave theory, stronger coupling occurs under narrow-banded conditions, implying higher levels of IG wave energy, which is consistent with the observations of this study. As shown in Fig.3, the IG wave height increases with Q_P, and this positive correlation is even stronger for the bound IG wave height. Meanwhile, the analytical solution of the bound wave mechanism suggests that the frequency of the generated IG waves should decrease under narrow-banded and long-period incident short waves, yet this is not well matched with the observations of this study (Fig.2f). This suggests that the relationship between the shape of the incident short wave spectra and the frequency of the IG wave is not simple.

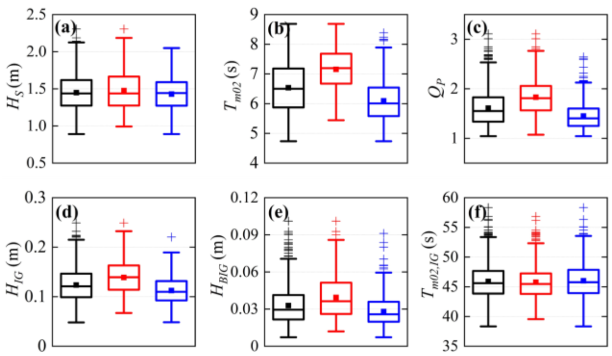

Figure 2 - Boxplots of short wave and IG wave parameters at total (black), single-peaked spectra (red), and double-peaked spectra (blue) sea states

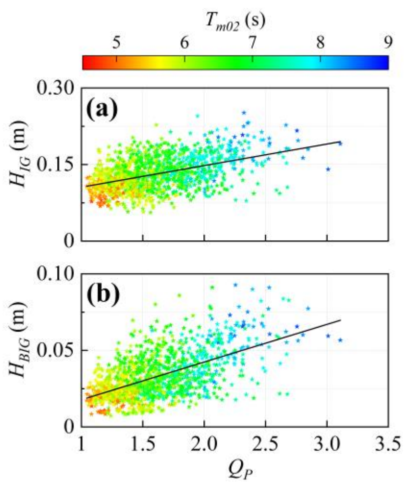

Figure 3 - Correlation between the IG wave height and the peakedness factor Q_P, with the color of the scatter representing the mean period of the incident short wave, where (a): total IG wave height and (b): bound IG wave height.

In the full paper, we will compare the spectral shapes of the IG wave band under single-peaked spectra sea states and double-peaked spectra sea states to further investigate the frequency characteristic of IG waves. Bispectral analysis will also be used to investigate the nonlinear energy transfer characteristic under these two sea states.

REFERENCES

Hasselmann, K. (1962):. On the non-linear energy transfer in a gravity-wave spectrum: Part 1. General theory, J. Fluid Mech, 12, 481-500.

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