MULTI FREQUENCY POLARISED TOPSAR FOR WAVE REFRAFCTION PATTERN

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ABSTRACT

This paper presents work done utilizing TOPSAR polarised data to investigate wave refraction pattern along the coastal water of Kuala Terengganu, Malaysia. For this purpose, 2-DFFT was applied with a selective window size of 100 x 100 pixels and lines to represent wave spectra refraction pattern. The quasi-linear model was used to map TOPSAR wave refraction spectra into the real ocean wave spectra. Wave spectra information such as wavelength and wave directions are used to predict refraction based on Huygen's principal. The wave spectra refraction pattern from TOPSAR polarised is compared with the results from wave refraction model and quasi-linear model. The statistical analysis of the quasi-linear model and wave refraction spectra model shows a good correlation.

It can be concluded that TOPSAR polarised data has potentials for monitoring wave spectra refraction pattern. The integration of quasi-linear model is more useful to identify the wave spectra refraction pattern.

INTRODUCTION

The refraction of waves is a phenomenon in which the energy is transferred laterally along the wave crest and it occurs when a chain of waves is interrupted by bottom topography. In case of the coastal process, the study of wave refraction is very important in understanding erosion-sedimentation process.

The one of methods employed to study the wave refraction pattern is a remotely sensed data Maged et al. [4]. The using of radar data in the study of wave refraction is under investigation. This is because the nonlinear relation between real wave patterns and waves imaging by radar. In order to use a radar data such as TOPSAR to detect the wave refraction pattern, the quasi-linear transform will be used to map the TOPSAR wave spectra pattern into real wave spectra as stated by Vachon et al. [5].

The main objective of this study is to employ TOPSAR polarised data to simulate wave refraction pattern along the coastal waters of Kuala Terengannu, Malaysia.

METHODOLOGY

Study Area

The study area is located in the South China Sea between 5° 21' N to 5° 27' N and 103° 10' E to 103° 15' E. This area is dominated by two-monsoon season. The southwest monsoon is from

May to August, the northeast monsoon is from December to March Wong [6] and Maged and Shattri [3].

TOPSAR Data

The composite image of polorised L-band and C-vv bands TOPSAR data is used. This data was acquired in 6 th December 1996.

Methods

The wave refraction pattern is extracted by using 2-DFFT, which applied with window size of 100 x 100 pixels and lines. This is because the actual size of image could not divided in 512 x 512. It is observed that the window size of 100 x 100 allowed to investigate more details on the spectra peaks convergence or divergence. As this details could not be observed by applying 512 x 512 on the limited size of the TOPSAR image.

Due to the nonlinear relation between ocean wave and radar wave spectra. We employed the quasi-linear in which quasi-linear is forward mapping the ground data spectrum into a TOPSAR image under the assumption of a quasi-linear MTF

$$Sq(K) = H(Kx;Kc)\ \{|\ Tlin(K)|2\ (\ (k)/2 + |Tlin(-k)|2\ ((-\ k)/2\} \qquad (1)$$

where Kx is the azimuth wavenumber component, and Tlin (k) is the linear MTF, which includes tilt modulation for HH polarization (Monaldo and Lyenga, [2] and Vachon et al. [5] The azimuth cut off function that depends on Kc which used to model the significant wave height by using a given formula,

$$Kc=R/V\quad F(\ (Hs)\ \ e \qquad (2)$$

where Hs is the significant wave height, R/V is approximately 32 s, and e is determined from the regression model between Kc and Hs.

The significant wave height modeled from azimuth cut-off used to model the wave refraction pattern. In doing so, the Huygen 's principle is employed to wave refraction pattern along the coastal water of Kuala Terengganu Malaysia. The amplitude of the spherical Huygens' wavelets from each element ds and received at a sequence area P (x,y)n (Fig.1).

The differential amplitude used to draw the refraction pattern can be given by

$$dE = A(x,y)\ ds_n\quad \cos(wt-kr) \qquad (3)$$

$$\frac{\qquad}{r}$$

where r the interval point from the source of wave propagation ds, P(x,y)n the receiving point with amplitude A and w is the wave frequency estimated from 2-DFFT.

RESULTS AND DISCUSSION

Fig.2 shows the polorised TOPSAR wave spectra. It is noticed that the wave spectra near to the Sultan Mohamed Airport tend to converge. The divergence zone is noticed along the

Terengganu River. Fig.3a shows a sharp peaks of wave energy spectra due to wave convergence. The flat peaks is shown in Fig.3a due to wave divergence. The wave spectra peak of wave convergence has lower frequency and higher energy compared to wave spectra peak of wave divergence. The wave spectra peak of wave divergence is shifted to the azimuth direction. The wave spectra peaks of wave convergence is shifted to range direction. This could be due to the effect of tilt modulation Fig.4 shows a comparison between orthogonal wave refraction drawn from ground wave data, TOPSAR data, and quasi-linear data .The orthogonal wavelength spectra coincided with each other. A comparison between Fig.2 and Fig.4 shows a similar finding. As the waves in December propagated from northeast direction. When the waves arrive to the onshore area, waves start to reduce their wavelengths and their directions. This is because of the effect of the bathymatery Lokman et al. [1]. A good correlation between wavelength modeled by significant wave height (quasi-linear) and ground data (Fig. 5). This is because that the quasi-linear model contains a tilt modulation function, which allowed the mapping of, ground wave into TOPSAR data. These results are agreed with Vachon et al.[5].

Figure 6 shows that there is a significant difference between wave length modeled from C-band ,L-band and ground data compared to Fig. 5b. As the maximum peak of L-HH band coincided with ground wave model compared to C-vv band. A comparison between Polarised TOPSAR wave refraction pattern and the previous study of Maged et al. [4], shows that the Polarised L-band TOPSAR data have more correlation compared to the C-band TOPSAR data. This indicates that composite data of the longer wavelength data (LHH and LVV) gives good imaging for wave refraction pattern compared to Cvv. This is because of the fact that the HH polarization data provides a larger tilt modulation than VV polarization for range traveling waves. These results are similar to Monaldo and Lyzenga, [2]

CONCLUSION

In conclusion, TOPSAR L-band is more useful to investigate wave refraction pattern. The integration between quasi-linear model and Huygen's principle is new method to identify the wave spectra refraction pattern.

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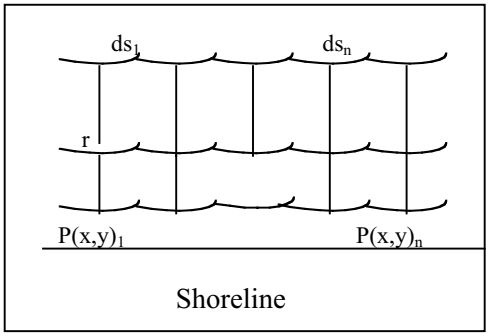

Fig.1 Sketch of Huygens' Wavelets

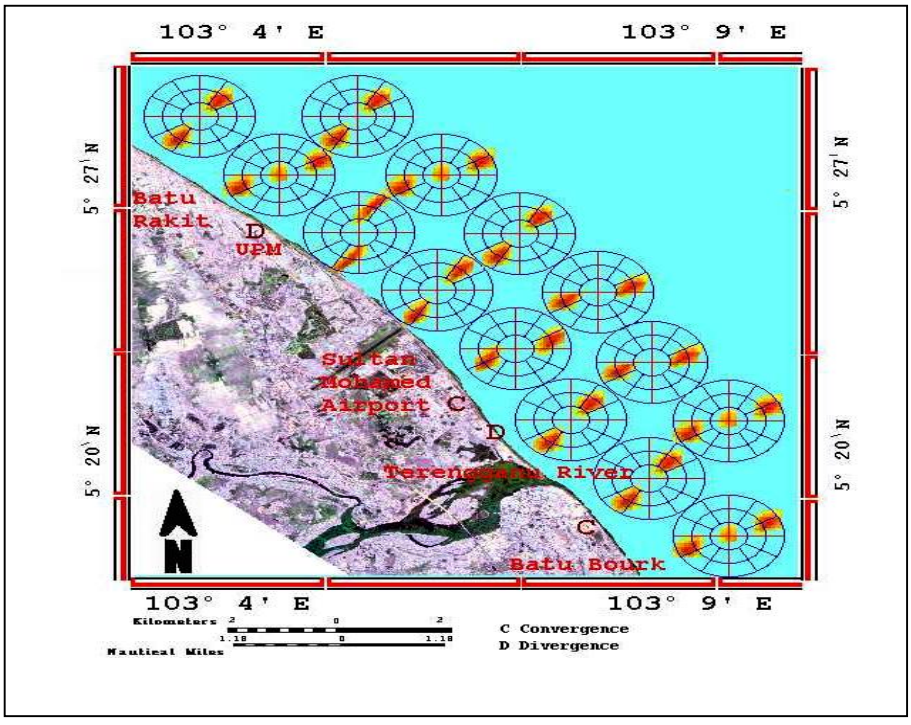

Fig.2 Wave spectra from TOPSAR

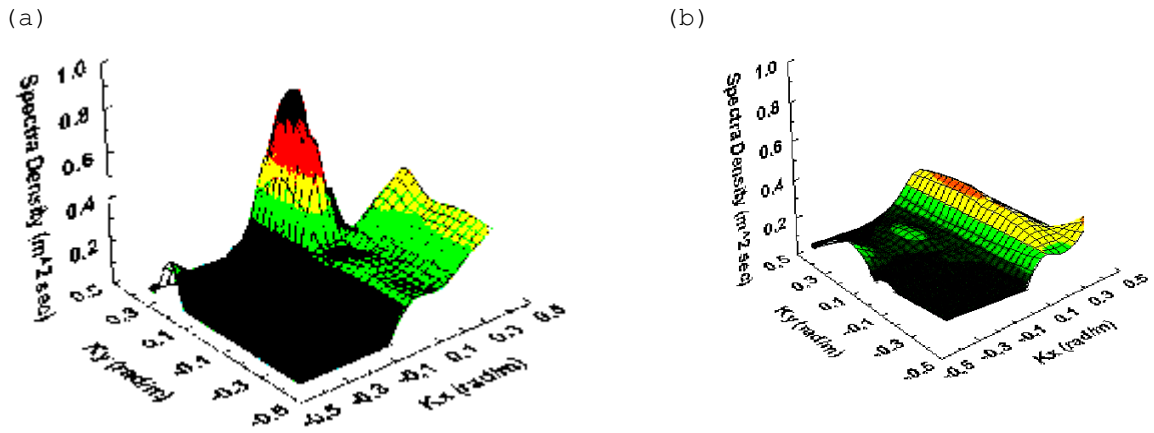

Fig 3 Wave Spectra Energy for (a) Wave Convergence and (b) Wave Divergence

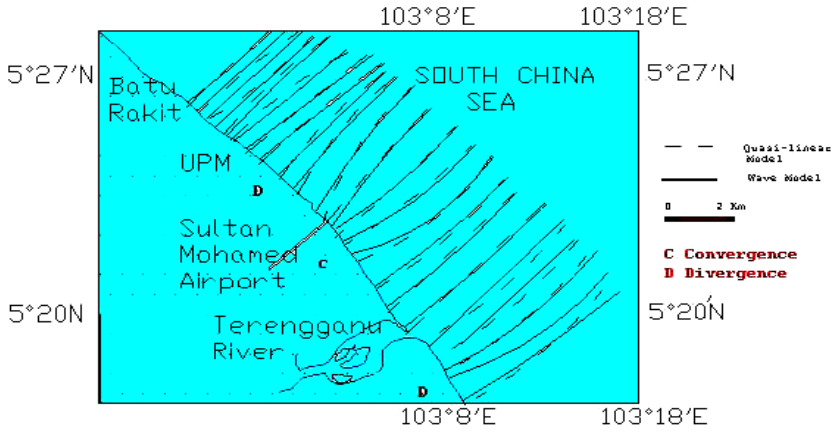

Fig.4 A comparison between wave refraction model and quasi-linear wave refraction

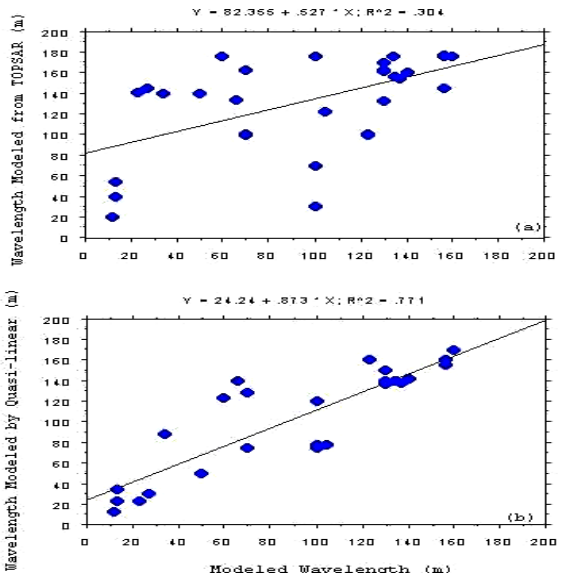

Fig.5 Regression between (a) ground wavelength and wavelength model from TOPSAR L-band (b) wavelength model from quasi-linear

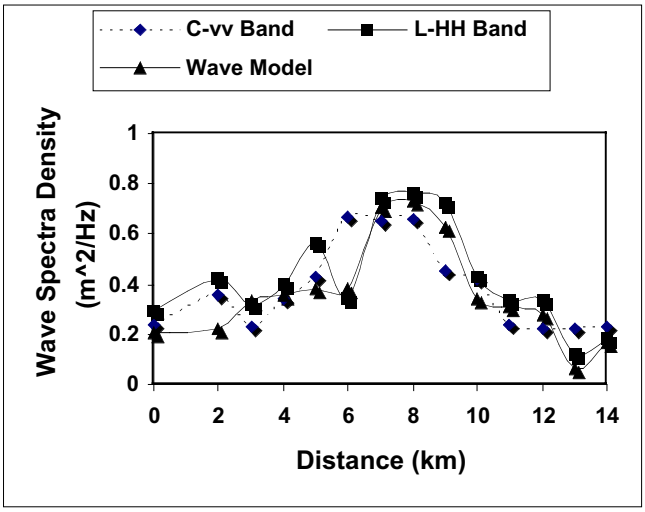

Fig.6 Wave Refraction Energy Spectra Spatial variation