Measurements of Ocean Wave Spectra with Vertical Polarization X-Band Radar Image sequences

Limin Cui[1,2,3] and Yijun He[1,2*]

[1] Institute of Oceanology, Chinese Academy of Sciences, Qingdao, 266071, China

[2]Key laboratory of ocean circulation and waves, Chinese Academy of Sciences, Qingdao, 266071,China

[3] Graduate University of the Chinese Academy of Sciencs, Beijing, 100049, China

[*]E-mail:heyj@ms.qdio.sc.cn

Abstract:

Sea state parameters, which are the significant wave height, ocean wave period and ocean wave direction and can be derived from ocean wave spectrum, are the most important oceanic dynamic environment elements that affect maritime structures and ships [1]. The ocean wave spectrum can be obtained from marine X-Band radar image sequences that are the radar backscatter from the ocean surface, called sea clutters [2][3] . The experiments for horizontally (HH) and vertically (VV) polarized X-band marine radar were carried out in nearshore regions. The similar observations were reported by Dennis B.Trizna et al [4]. They studied the scattering mechanism of horizontally (HH) and vertically (VV) polarized X-band marine radar at low grazing angle, and proposed that horizontally (HH) polarized radar images are characterized by discrete sources of scatter, distributed scattering mechanism is responsible for these vertically (VV) polarized characteristics from these light to moderate wind speeds [4].

At grazing incidence, a difference between the image spectra from marine radar imagery and the corresponding spectra from in situ sensors can be observed. By using a MTF,this difference can be minimized [5].The estimation of modulation transfer function (MTF) for the HH polarization radar images was determined, $MTF \propto k^{\beta}$, presenting a mean value $\beta \approx 1.2$, by the numerical simulations and the experimental data analysis in the past years [5][6].

However, the modulation transfer function (MTF) for the vertically (VV) polarized radar has been unknown at high incidence angle. To determine the modulation transfer function (MTF) for vertically (VV) polarized radar, both the vertically (VV) polarized X-band marine radar and the buoy were used to observe the sea state simultaneously. The modulation transfer function (MTF) is obtained by existing inverse modeling technique.

The empirical modulation transfer function is given in [5], it is of the form

$$\left|M(k)\right|^2 = F_r(k)/F_{is}(k) \qquad (1)$$

Equation (1) $F_r(k)$ is the 1D radar wavenumber spectrum derived from the radar image spectrum:

$$F_r(k) = \int_{-\pi}^{\pi} \Psi_r\left[\bar{k}(k,\theta)\right] \cdot k d\theta \quad (2)$$

Where $F_{is}(k)$ is the corresponding spectrum derived from the ocean wave frequency spectrum

$S(\omega)$ measured by in-situ buoy.

$$F_{is}(k) = S[\omega(k)]\frac{d\omega}{dk} \qquad (3)$$

Equation (3) is valid for those cases where the Doppler shift effect in frequency due to a current is negligible [5].

In this paper, MTF for VV polarization radar is obtained empirically using the observation data and ocean wave spectrum is derived from vertically (VV) polarized X-band marine radar images. It is shown that the VV polarization radar image can observe low sea state parameters that HH polarization radar can not do.

Preference

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