Sea surface Simulation for SAR remote sensing based on the fractal model

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Abstract: The concept "fractal" is popularly was used in the world after the book "The fractal geometry nature" published in 1982. The fractal geometry is a simple tool of describing complicate world and mechanism and then many researchers paid attention to it.

Numerical simulation sea SAR surface is one of the foci of research now. Signification of applying "fractal" to the researching field lying to:

1. Researches such as multiple scattering and sea clutter et al., are in favor of improving performances of radar system and communication.

2. It can not only promote the development of characteristics of sea surface, the application of SAR measurement of environment but also convenient for the management of navigation et al.

3. It can be used to explain physical phenomenon of sea surface, for example, the hydrodynamic evolvement of ocean wave, the air-sea power exchanging and the analyzing the ocean current of sea et al,.

Recently, F.Berizzi et al. presented sea fractal surface models. We introduce 1-D and 2-D sea fractal model in the second part of this paper. We find: whether one dimensional or two dimensional sea. Fractal surface model, the surface becomes rough when one of ***b*** and ***S*** increases while another of them is invariable. So both ***b*** and ***S*** are effect on the roughness of the sea fractal surface.

In order to study the polarization effects on scattering coefficient and Radar Cross Section, exploiting Huygen's principle, Kirchhoff approximation and the model of sea fractal surface presented by F.Berizzi et al .,we derived the scattering fields, scattering coefficient, RCS and Poynting vector of 2-D sea fractal surface with finite conductivity illuminated by arbitrary polarization wave under the condition that the shadowing effect and multiple scattering are neglected. Our results coincide with those of other literatures. Meanwhile, receiving signals in different position are simulated. The result shows that depolarization effects in any position can be neglected though we derived out the expression of depolarization, while the cross polarization can not neglected.

Exploiting the scattering matrix which is worked out and calculated full polarimetric radar cross section (RCS) in the third part. The numerical results show: Normal backscattering RCS of sea fractal surface is degraded in exponential form with increasing of incident angles in HH polarization and VV polarization. When θ_3 is a certain invariable value, the maximum RCS appears at $\theta_2=\theta_1$ and RCS decreases when $|\theta_2-\theta_1|$ increases. We also find that values of the radar cross section calculated according to the formula which is presented by F.Berizzi et al. are greater than those of our results because it is assumed that the conductivity of the sea is infinite and then there is no loss when wave is reflected on the sea surface. In fact, however, the conductivity of sea surface is finite. Comparing theoretic result with numerical result, one can find that whether the relation between σ_{hh} and σ_{vv} or the relation between σ_{hv} and σ_{vh} is decided by the relative position between receiving antenna and transmit antenna. Critical angles(θ_{c1} and θ_{c2}) are derived in theory.

In the last part, numerically simulating the co-polarization signature with different sea fractal surface parameters in the experiments, we conclude: Sea fractal surface roughness has no effect on polarized parameters. The fundamental spatial wavelengths of the ocean wave have no effect on orient angle shift but have effect on ellipticity while other sea fractal Surface parameters are invariable. The radar incident angle only effects on the orient angle shift. The orient angle shift becomes zero when the radar incident angle is larger than a certain value. We find that the effects of sea fractal parameters on the ellipse parameters are virtually caused by mean slope of the sea surface.

Key Words: sea fractal surface, multi-polarization, scattering matrix, synthetic aperture radar, electromagnetic wave