Backscattering Features of Oyster Sea Farming in AIRSAR Image and Laboratory Experiment

Seung-Kuk Lee, Sang-Hoon Hong, and Joong-Sun Won
Department of Earth System Sciences, Yonsei University
134 Shinchon-dong, Seodaemun-gu, Seoul, 120-749, Korea
e-mail: kuki@yonsei.ac.kr

Abstract: Oyster farming structures in tidal flats are well detected by SAR system. Each frame of these artificial structures is composed of two vertical and one horizontal wooden pole. We investigate characteristics of polarimetric features in the target structures. In this paper, the results of AIRSAR L-band POLSAR data and experiments in laboratory are discussed. The ratio of single bounce to double bounce scattering depends of vertical pole height, direction of horizontal pole to radar look direction, and incidence angle as well as sea surface condition. We have conducted laboratory experiments. According to target scale, Ku-band and targets downsized by scale of 10 are used. The results of the experiments are summarized as: i) total power of the backscattering is more affected by vertical poles than a horizontal pole; ii) and backscattering from a horizontal pole is sensitive to the relative radar look direction to target array. We conclude that water level can be effectively measured by using interferometric phase and backscattering intensity if vertical poles in the water are observed by L-band HH- or VV-polarization. Measurement of tide height can be further improved if double bounced components are separated from fully polarized SAR data.

Keywords: polarization, AIRSAR, tidal flat, Oyster framing structure.

1. Introduction

Recently, polarimetric SAR techniques of remote sensing have developed rapidly. The advantage of polarimetric SAR is to better understand scattering mechanism that renders polarimetric signatures seen in SAR image. A problem of analyzing these ploarimetry SAR data, such as airborne polarimetric SAR (AIRSAR) and Spaceborne Imaging Radar-C (SIR-C) systems is in understanding the scattering mechanisms that give rise to features in the different polarization parameters [1]. If scattering mechanism of some special targets or local areas can be understood using polarimetric SAR data, it is very helpful to another SAR applications and sensor design, etc.

Shrubs in flooded vegetation, natural or artificial scatterers such as mangrove, sea farm, and wind power generator in coastal regions generate radar double-bounce returns. Detailed backscattering mechanism and polarimetric characteristics in tidal flats and coastal region had not been well studied [2].

In this paper, the scattering mechanisms of the structure in tidal flat are investigated using AIRSAR data and results of experiment in laboratory.

2. Data and Method

On September 30, 2000, NASA/JPL's airborne SAR system, AIRSAR, was flown over an area around Gadukdo area in the south coast of the Korean Peninsula. The AIRSAR operation mode was XTI1 that produced C-band interferometry and L-, P-band full polarimetry data. We used L-band polarimetry data in order to estimate scattering mechanism in oyster farm. The oyster farms in this region are not registered, and consequently no official information is available. Oyster farm is detectable by 1m-high resolution optic system after an image enhancement. The test site is shown in Fig. 1. Each frame of these oyster farm structures is composed of two vertical and one horizontal wooden pole. A horizontal bar is supported with two vertical poles. Oyster farms normally consist of fifty to on hundred bars in array.

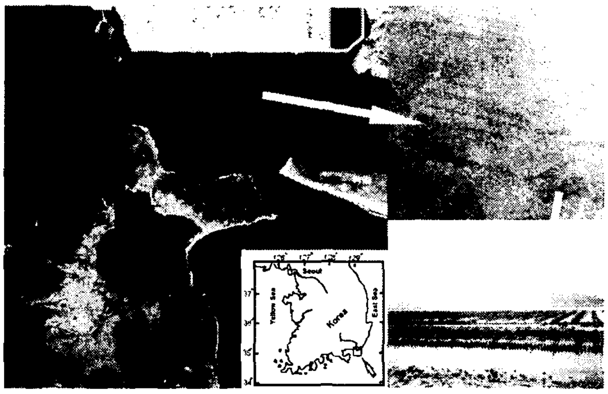

Fig. 1. Location map of study area and IKONOS image(Left), The oyster farms(Right bottom)

Table 1. Conditions of the experiment.

Antenna	Rectangular horn
Polarization	HH,HV,VV
Frequency points	201
Wavelength	2 cm
Center frequency	15 GHz
Sweep frequency	14 – 16 GHz
Scanning points	64
Scanning interval	1.0 cm
Antenna height	154 cm
Incidence angle	45 deg.

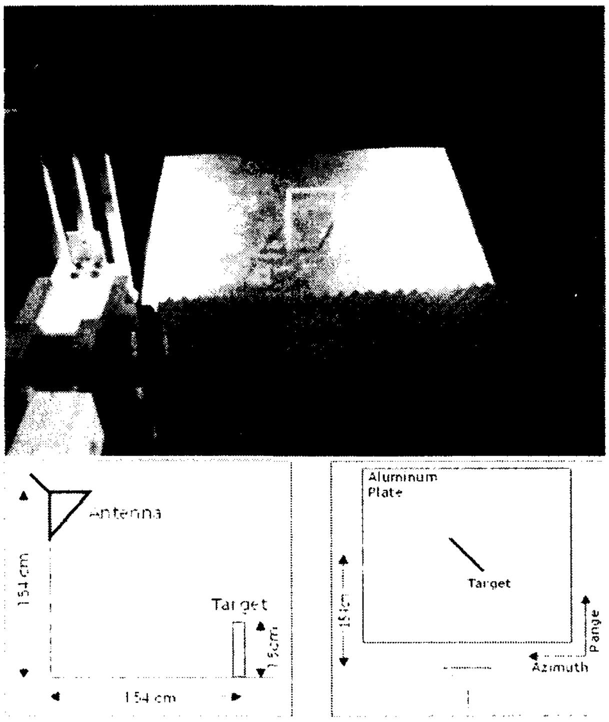

Fig. 2. Wave dark chamber(top), Antenna and target condition

We carried out an experiment simulating a target structure using a fully polarized Ku-band antenna in a laboratory. We made a simple target that was a down scaled oyster farm structure in tidal flats. This simulated experiment was conducted under various antenna-target geometries in a wave dark chamber. Table 1 and Fig. 2 show conditions of the experiment. Instead of water surface and wet wooden bar, we used aluminum plate and small target to cover by aluminum tape. Considering the actual size of frame and wavelength, we reduced the size of target and observation wavelength by a scale of about 1/10.

3. Results and Discussion

1) Simulated experiment in laboratory

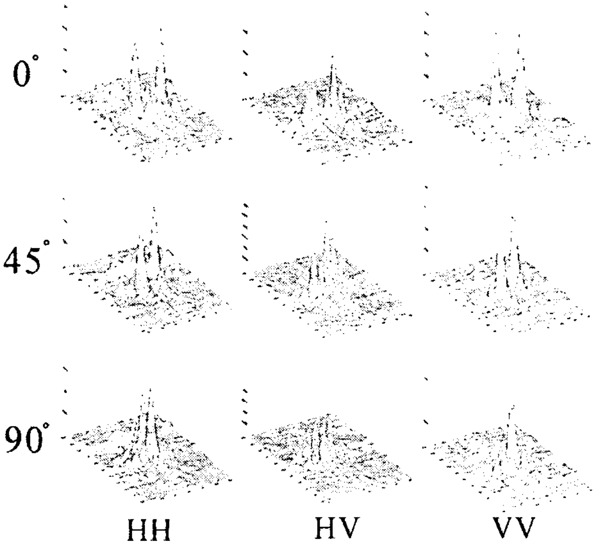

Fig. 3. Results of radar response. The rotation angles correspond to direction of the horizontal pole.

We measured in three directions of horizontal bar to azimuth: 0 degree, 45 degree, and 90 degree. The result is that backscattering is more affected by vertical poles and horizontal bar is sensitive to a relative radar look direction to the target (0°, 45°, 90°). Fig. 3. represents that HH-polarization is as strong as VV-polarization. The signal from vertical poles is dominant and it is stable. HH-polarization is dependence on directivity of horizontal bar. When the rotation angle increases, signal of the HH-polarization it decreases, but the signal of the VV- and the HV- are not changed.

The ratio of single bounce to double bounce scattering depends of sea surface condition and vertical pole height, direction of horizontal pole to antenna look direction. As shown in AIRSAR image, the amount of radar returns partially depends of the direction of horizontal pole. We measured in three cases: 0 degree, 45 degree, and 90 degree from azimuth. The total power was reduced as the rotational angle of horizontal pole increased. It can be found in Fig. 4.(a) that decrease width of the single bounce compared to double bounce is larger, as rotation angle increases. The single bounce changes as about 10dB from -50.7dB to -60.1dB. The other hand, double bounce decreases merely as 6dB at same condition. With

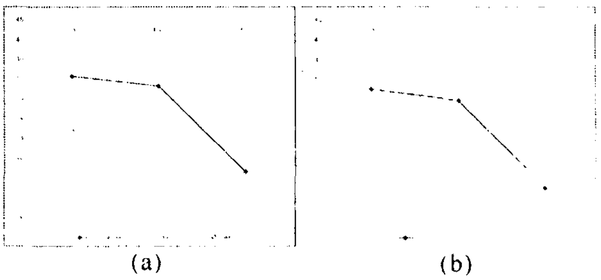
(a) (b)

Fig. 4. Ps stands for single-bounce, Pd for double-bounce, and Pv for volume scattering. Variation of each scattering as direction. (a), as target height.(b)

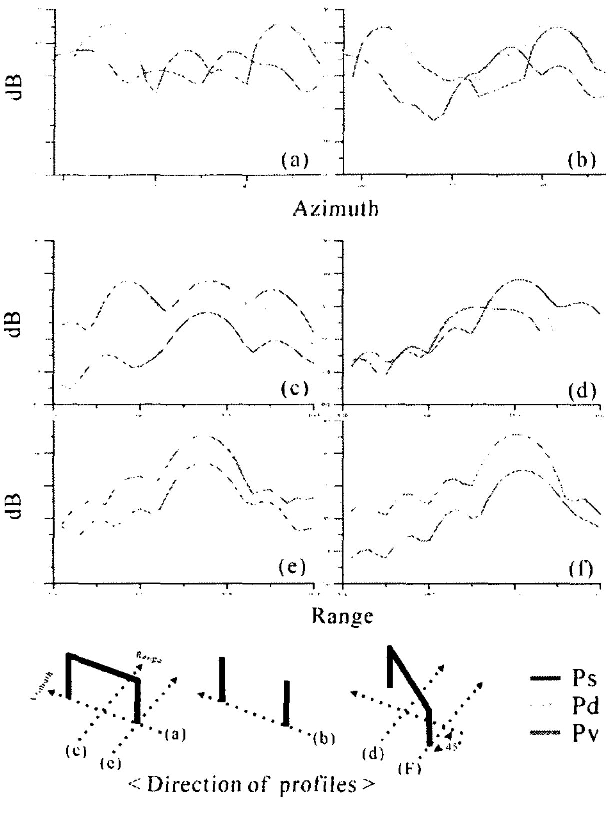

Fig. 5. Profiles along an azimuth and a range direction

this reason, double bounce grows remarkablely bigger than single bounce at 90 degree. This implies that single bounce is more sensitive to horizontal pole than double bounce.

In order to investigate the variation according to vertical pole height, we measured three vertical poles: 10 cm, 15 cm, and 20 cm. Double-bounced signals almost linearly increased as the height of vertical poles increased as in Fig.4. (b).

To investigate detail scattering mechanism in a target, we reviewed profiles. At the bottom of Fig. 5., it represents how to profile a target. Fig. 5(a), (b) show profiles along an azimuth direction. We draw profiles along a range of horizontal pole with 0 degree of rotation angle (Fig. 5.(c)) and horizontal pole with 45 degrees of rotation angle(Fig. 5.(d)).; vertical pole with 0 rotation angle (Fig. 5.(e)); vertical pole with 45 degree of rotation angle (Fig. 5.(f)). The results show that single bounce is as strong as double bounce from any pole. In an azimuth profile Fig. 5(a), returns from vertical poles are stronger than that from both horizontal pole and vertical poles. Single- and double-bounce from horizontal pole decrease as the rotation angle increases. In vertical pole only case Fig. 5(e) and (f), two profiles are similar to each other. We can understand that the signal from vertical poles is stable under various conditions.

2) AIRSAR data

As shown in Fig. 6, oyster farm is extremely well imaged by AIRSAR XTI1 mode. This AIRSAR image was

Fig. 6. Color composite of AIRSAR L-band POLSAR data: HH-pol.(Red), VV-pol. (Green), and HV-pol. (Blue).

acquired at low tide. In general, in area where bottom tidal flat was exposed to air as in the east parts of the image, HH-polarization is stronger than VV-polarization. VV-polarization produces relatively strong returns from oyster farming structures on the water surface in the west parts of the image. It is also important that the direction of the target structures relative to the antenna look direction.

We classified image by surface scattering and double bounce, volume scattering. Fig. 7 is the result of classification. The relative strength of each color in classified RGB images can be related to the relative strengths of the scattering mechanism [1]. To evaluate the detail scattering properties of artificial structures in tidal flat, 7sub

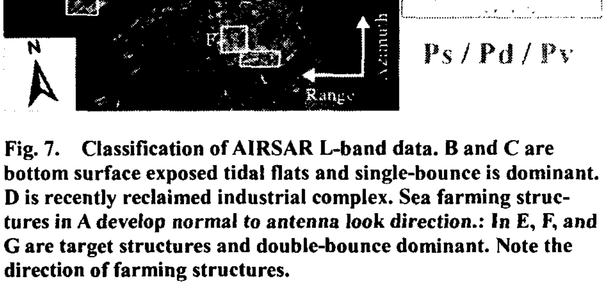

Fig. 7. Classification of AIRSAR L-band data. B and C are bottom surface exposed tidal flats and single-bounce is dominant. D is recently reclaimed industrial complex. Sea farming structures in A develop normal to antenna look direction.: In E, F, and G are target structures and double-bounce dominant. Note the direction of farming structures.

areas were selected as shown in Fig. 7. The selected sites can be grouped into 3 categories: Bottom surface was exposed to air as in A, B, C-areas; typical oyster farm structures develop above water surface as in E,F,G-area; and reclaimed industrial complex in D-area. Double bounce is dominant scattering mechanism over oyster farms. Single bounce is, however, not negligible over the targets. On the contrary, in the area where bottom tidal flats are exposed to air, a different scattering mechanism pattern is found. Double bounce drastically reduces and single bounce becomes dominant. Direction of horizontal pole is important to scattering mechanism. In A-area, horizontal pole runs parallel to azimuth direction (i.e. horizontal poles normal to the radar look direction). In this case, single bounce from horizontal bar becomes large. As the result of experiment in laboratory, it is found that single bounce is as important as double bounce to understand scattering features in oyster farm.

4. Conclusions

The results explain the scattering mechanism at oyster farming structure. We conclude the backscattering from vertical poles is generally the strongest. Double bounce is a significant mechanism in experiment and AIRSAR image. However, single bounce is not negligible. Single bounce is also sensitive to direction of horizontal bar. The returns from vertical poles are stable under various conditions, and increased in proportion to the height of vertical poles.

HH-polarization is as strong as VV-polarization. The signal of HH-polarization decreases as rotation angle increase, but HV- and VV-polarization do not change. As angle of horizontal pole to azimuth direction from 0° to 90°, double bounce decreases 6 dB and single bounce about 10dB. This means HH-polarization is sensitive to direction of horizontal bar.

From the result of experiment and image, it is found that the tidal flat included artificial structure is most estimated by vertical poles using HH- or VV- polarization.

Acknowledgement

Authors thank to Prof. Yoshio Yamaguchi and his graduate students who helped to design laboratory experiments and provided facility at Niigata University. We also thank to PACRIM 2000 team for AIRSAR data sets.

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