L-Band Polarimetric AIR/Pi-SAR Images around Niigata City

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Abstract - **Pacific Rim Campaign has been successfully carried out in 2000. The well known AIRSAR system by JPL flew over Niigata Area, Japan, on Oct. 2, 2000, which brought us the L-band fully polarimetric data set. On the other hand, Pi-SAR, developed by CRL and NASDA, Japan, simultaneously (2 hours in advance) flew the same path taking the same area data in the L-band. It became possible for us to carry out comparative analyses using the same area data. Since the resolution and incidence angle of each SAR are different, we examined the difference in the two POL-SAR images using correlation coefficient in the Right-Left Circular (RL) polarization basis, polarimetric entropy, and three component scattering power ratio.**

I. Introduction

Since the principle of radar polarimetry has somewhat matured, and the resultant polarimetric indices are to be used as routine procedure for polarimetric data analysis. The useful indices are polarimetric entropy and angle alpha [1], scattering power based on three-component scattering model [2], correlation coefficients in various polarization bases [3], and so on.

There are several airborne SAR platforms available such as AIRSAR, SIR-C/X-SAR, P-3, EMISAR, E-SAR, and Pi-SAR in the world. They provide us with various resolution, frequency, and incidence angle's data, depending on their platform's specifications.

However, we do not know the difference in polarimetric characteristic among each platforms in detail. The scattering characteristics in the same area should be identical if resolution and incidence angle are the same. But is the scattering matrix really identical for the same area with the same resolution acquired by both platforms? We do not know when they diverse. This point was examined here using AIRSAR and Pi-SAR system data sets. Fortunately, AIRSAR system flew over Niigata Area, Japan, on Oct. 2, 2000, which brought us the L-band fully polarimetric data set. And Pi-SAR, developed for the purpose of environmental observation by CRL and NASDA, Japan, simultaneously (2 hours in advance) flew the same path taking the same area data in the L-band. It became possible for us to carry out comparative analyses using the same area.

In the following, the difference of correlation coefficient in the RL polarization basis, polarimetric entropy, three component scattering power ratio in the two POL-SAR images are described.

II. Comparison Of Polarimetric Scattering Parameters Between The AIRSAR And Pi-SAR Data

The features of AIRSAR and Pi-SAR systems for the L-band polarimetric data sets are listed in Table I. Both systems use the same L-band frequency, however, incidence angle is slightly different. For the sake of comparison, we tried to pick up the same area with similar incidence angles. Fig. 1 shows high resolution color composite Pi-SAR image of western part of Niigata City. It contains water region (sea, river), pine trees, residential area, and paddy fields, which may have some characteristic polarimetric responses. Since our university was included in this image, it was convenient for us to get ground truth data. At first, we made polarimetric calibration [4] to Pi-SAR data, using four trihedral corner reflectors deployed along the seashore. Then we adjusted the resolution (3 m) of Pi-SAR to become that (10 m) of AIRSAR

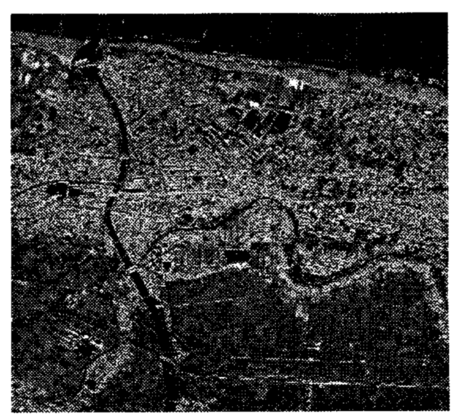

Fig. 1. L-band full resolution composite image of test site (HH: red; HV: green; VV: blue).

TABLE I L-band AIR/Pi-SAR Data Characteristics

	Pi-SAR data	AIRSAR data
Data-take	2 October, 2000	
Frequency [GHz]	1.27	1.238
Incidence Angle [deg.]	44.4-57.5	25.2-61.6
Pixel Spacing [m]	2.5 az. X 2.4 slt-rng.	4.6 az. X 3.3 slt-rng.
Resolution [m]	3.0 az. X 3.0 slt-rng.	10.8 az. X 5.5 slt-rng.

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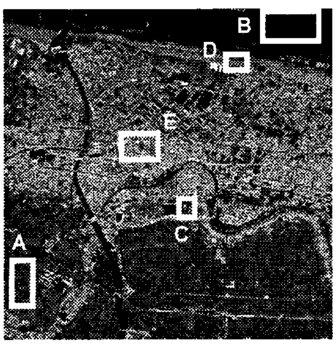
as shown in Fig. 2. It is seen in these images the appearance is almost the same. The boxes denoted in Fig. 2 indicatespecific targets as below and are also listed in Table II with incidence angles. Although they exhibit similar features in the image, the Pi-SAR had approximately 2 degrees larger incidence angles compared to AIRSAR case.

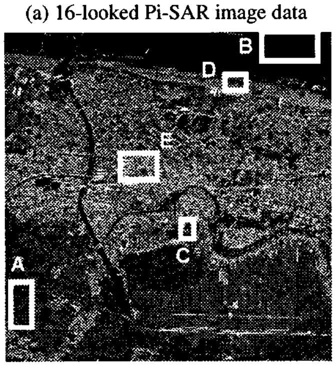
Area A Paddy field after harvest, with surface roughness, distributed and homogeneous
Area B Sea, calm, distributed and homogeneous
Area C Crop field, distributed and homogeneous
Area D Pine wood, vegetation, distributed and homogeneous
Area E Residential area, with a lot of houses, heterogeneous

Based on this situation, we carried out the comparison using correlation coefficient in the RL polarization basis, polarimetric entropy, three component scattering power ratio.

Correlation coefficient in both of the linear (HV) polarization



(a) 16-looked Pi-SAR image data



(b) AIRSAR image data with full resolution

Fig. 2. L-band composite images of test site (HH: red; HV: green; VV: blue) and extracted areas for analyses.

Table II. LIST OF INCIDENCE ANGLE

	Pi-SAR [deg.]	AIRSAR [deg.]
Area A (Paddy field)	46.8	43.8
Area B (Sea)	55.4	54.9
Area C (Crop field)	49.6	47.0
Area D (Vegetation)	54.1	53.2
Area E (Residential area)	51.5	49.6

basis and the RL basis were calculated. Since the RL basis provided a slightly better result, the correlation coefficients in the specific areas are depicted as a function of resolution in Fig. 3. The values of coefficient in areas A-C are almost the same. There is no difference by platform. However, the value for vegetation area D and for residential area E, AIRSAR data has larger value. This may be caused by the difference in resolution and incidence angles.

The averages of polarimetric entropy, and $\bar{\alpha}$ for area A-E are illustrated in Fig. 4, while three component scattering power ratio is shown in Fig. 5. For adjusting resolution and deriving these polarimetric parameters, average processing of covariance and coherency matrices is carried out in 2 by 2 pixel area for AIRSAR data, and in 8 by 8 pixel area for Pi-SAR data, respectively. These polarimetric indices in areas A-D are almost the same. Areas A-C indicate that surface scattering (Bragg scattering from sea and bare soil through canopies of crops) is dominant. In Area A and C, there exist relatively considerable volume scattering from canopies of the rice stem and crops. These areas have entropy ranging from 0.55 to 0.75 and $\bar{\alpha}$ with smaller than 40 degrees. In area D, there exist dominant volume scattering from canopy layer (consisting of twigs, and branches with uniform orientation distribution), considerable surface scattering from ground through canopy layer, and double bounce from ground-trunk structures. Polarimetric entropy H is higher than 0.85, and $\bar{\alpha}$ is around 45 degrees. In contrast, in area E, the difference of polarimetric indices is large. These parameters may be influenced by the difference in incidence angle and resolution, because the scattering mechanism and a scattering matrix in each cell change with variation of incidence angle and resolution. Area E has significant double bounce mechanism (scattering from wall-ground structures). For AIRSAR data, the surface scattering power ratio is nearly zero, polarimetric entropy H is 0.536, and $\bar{\alpha}$ is 50.7 degrees. For Pi-SAR data, the surface scattering power ratio is almost equivalent to the volume scattering one, H is 0.339 and $\bar{\alpha}$ is 54.1 degrees. This means the polarimetric scattering characteristics in urban region is sensitive to incidence angle and resolution.

III. CONCLUSION

In this paper, the comparison of polarimetric scattering characteristics for the same area, acquired by AIRSAR and Pi-SAR, is carried out using polarimetric indices derived from covariance and coherency matrices. For distributed and homogeneous targets such as water region and grass fields, the polarimetric indices are almost the same, in which the polarimetric scattering characteristics are independent of incidence angle and resolution. According to a homogeneous target with various scattering mechanisms such as forested

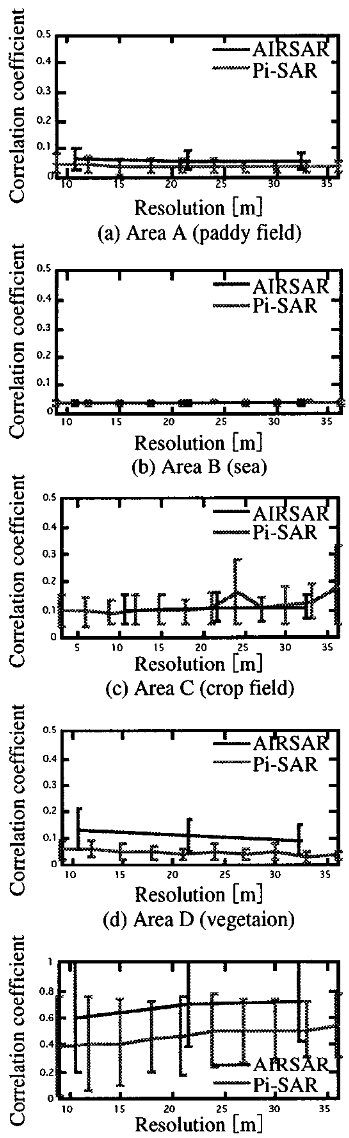


Fig. 3. Comparison of correlation coefficient between RR and LL channel for AIR/Pi-SAR data.

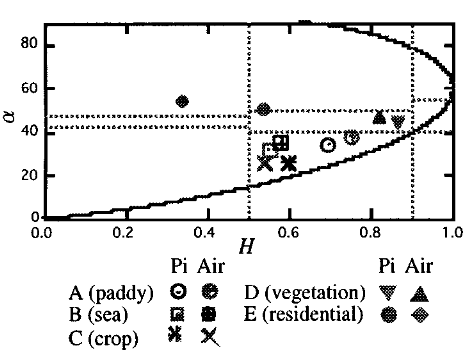


Fig. 4. Comparison of polarimetric entropy H , $\bar{\alpha}$ for AIR/Pi-SAR data.

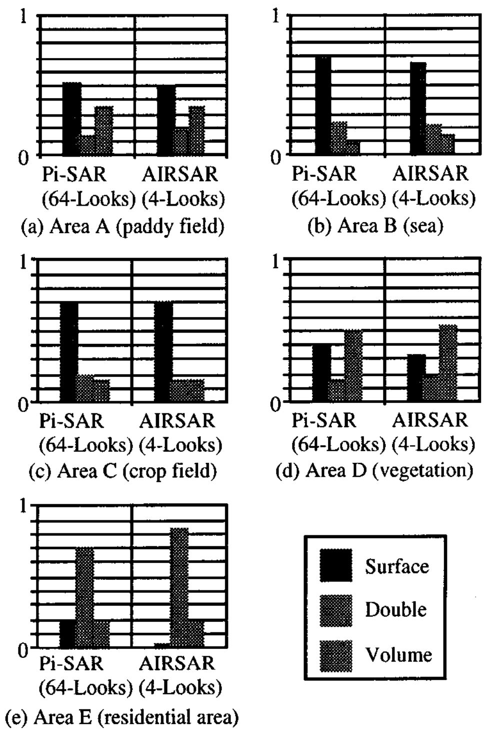


Fig. 5. Comparison of three component scattering power ratio for AIR/Pi-SAR data.

area, the difference of polarimetric indices is slight. For a heterogeneous target such as residential area, the difference is large, which means that the polarimetric scattering characteristics are sensitive to incidence angle.

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