POLARIMETRIC SAR OBESRVATION OF ENVIRONMNT IN MONGOLIA BY ALOS/PALSAR

[1]Motoyuki SATO, [1]Koichi IRIBE, [2]D. ANARSAIKHAN
[1]Center for Northeast Asian Studies
Tohoku University, Japan
E-mail: sato@cneas.tohoku.ac.jp
[2]Institute of Informatics and RS, Mongolian Academy of Sciences
av.Enkhtaivan-54B, Ulaanbaatar-51, Mongolia
E-mail: amar64@arvis.ac.mn

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ABSTRACT: The Japanese remote sensing satellite ALOS/PALSAR was launched successfully in January 2006. We are carrying out polarimetric calibration of the PALSAR sensor, which has the full-polarimetric function of L-band SAR. We set corner reflectors in Ulaanbaatar in May and August 2006, and the acquired data was used to confirm the polarimetric calibration coefficients, which will be used for the data sets to be delivered from October 2006. In addition, the acquired polarimetric SAR data will provide new possibility in remote sensing. Since this is the world first satellite borne full-polarimetric SAR system, we cannot show many example in this moment, but from airborne SAR data, which we have studied, we show some examples of polarimetric SAR, which include tree type classification, and estimation of the orientation angle of scattering targets.

1. INTRODUCTION

JAXA(Japan Aerospace Exploration Agency) launched the earth observation satellite ALOS "Daichi", which is equipped with three independent sensors in January 2006. One of the sensors is "PALSAR" which is a full polarimetric SAR, which is the world first full polarimetric SAR system operated regularly on a space craft for a long term. PALSAR operates in L-band (1.27GHz) and is capable to observe the ground surface condition accurately compared to other SAR operating at higher frequency band, namely C-band or X-band. Therefore, we have a hope that ALSO/PALSAR will be used for various environmental observation.

ALOS data will be delivered from fall 2006, after sensor calibration operation. We have jointed polarimetric calibration validation missions for ALOS/PALSAR and have deployed corner reflectors. We selected Ulaan Baatar as one of the calibration sites, because we think ALOS data will be quite usefully used for environment studies in Mongolia. In this paper, we describe the calibration operation of the ALOS/PALSAR and show some first polarimetric SAR images in Mongolia acquired by ALOS/PALSAR.

2. POLARIMETRIC CALIBRATION IN ULAAN BAATAR

2.1 Test site

The first data acquisition for polarimetric calibration was conducted on 25 May, 2006. We set corner reflectors in a flat area inside the Chingis Khaan International airport, which is located west of Ulaan Baatar city (N47.836,E106.770). We selected this test site, because the topography is flat. The site is selected along the run way of the airport as shown in Fig.1. The ground surface was covered by grass, having about 30cm height. At the same time, we conducted Ground Penetrating Radar (GPR) measurement around the test site, in order to measure the ground moisture condition.

The second ALOS/PALSAR data acquisition was carried out in August 2006. We are now analyzing the data sets, but in this paper, we discuss only on the data acquired in the first trial in May 2006.

2.2 Corner Reflectors

We set 4 corner reflectors (CR) in this test site. The specifications of CRs are summarized in Table 1. Four reflectors were aligned along a straight line parallel to the run way, and each CR was separated 100m away from the other.

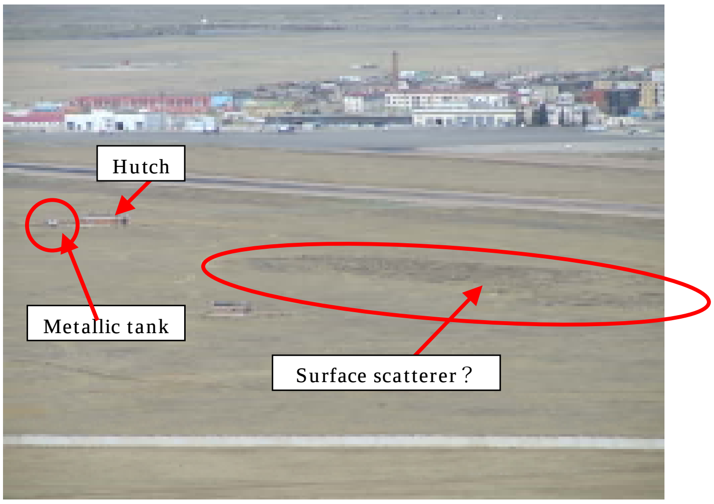
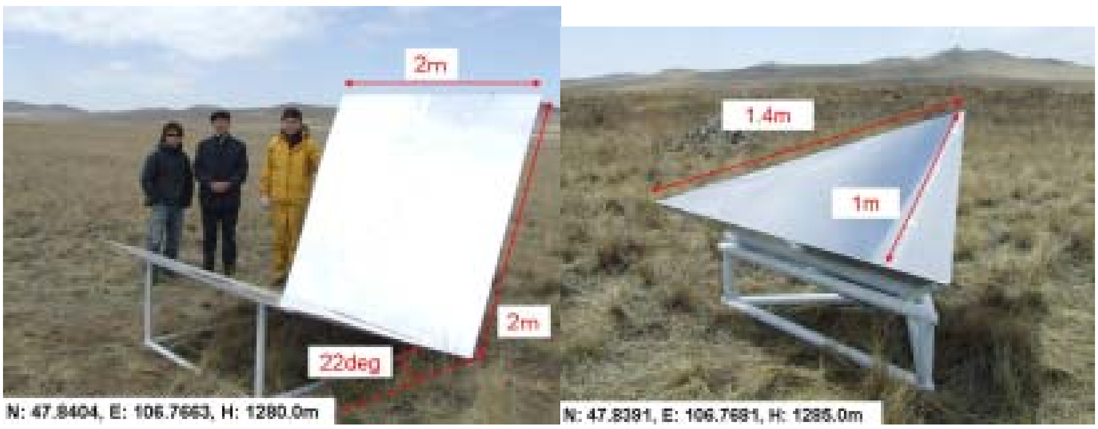


Fig.2　山腹から撮影した CR 設置場所風景

Figure 1　Test site for the corner reflectors in Chingis Khaan International Airport., Ulaan Baatar

Table 1 Corner Reflector Specifications

	Type	Size (m)	RCS (dBm^2)	Number
(1)	Dihedral	2	38.66	1
(2)	Small Trihedral	1.4	18,83	2
(3)	Large Trihedral	2	24.85	1



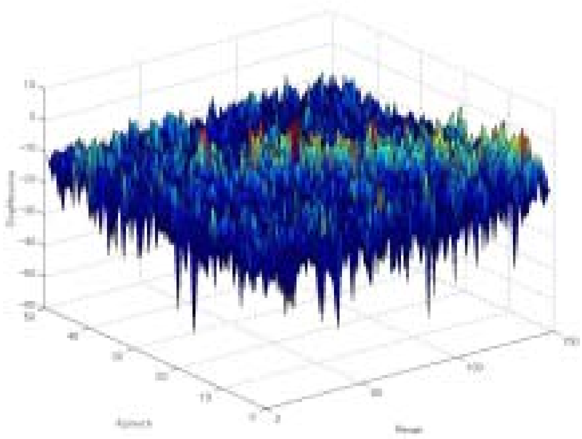
(a) Dihedral Corner Reflector　　(b) Trihedral Corner Reflector

Figure 2 Corner Reflectors

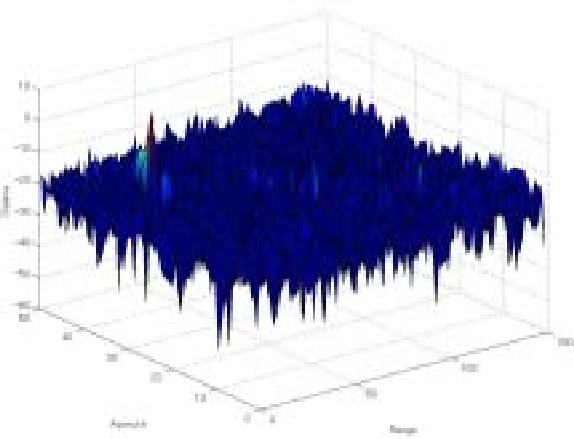
3. POLARIMETRIC ANALYSIS

3.1 Polarimetric SAR Informatioon

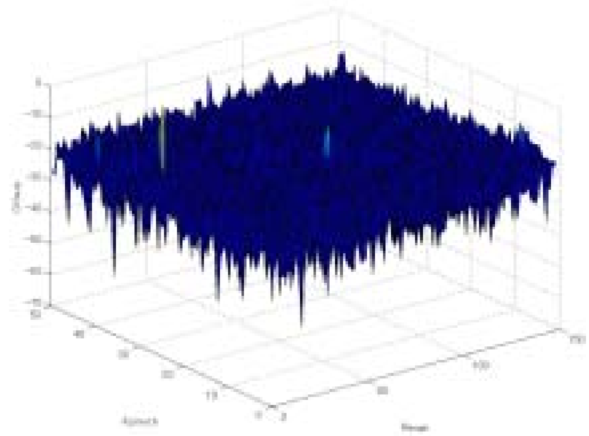
Fig.3 show the polarimetric SAR images, which are represented using the Pauli decomposition. The single bounce, the double bounce and the volume scattering components are shown in Figs. (a), (b) and (c) respectively. We can find the location of 3 dihedral corner reflectors in Fig.3(a), which is the single bounce component of the polarimetric SAR image. The dihedral corner reflector can be seen in Fig.3(b), which is the double-bounce component of the polarimetric SAR image. The background scattering is stronger than we have expected, and we thin it is due to the shallow off-nadir angle 21.5° which was used in this data acquisition.



(a) HH+VV (Single bounce)



(b) HH-VV (Double bounce)



(c) HV (Volume scattering)

Figure 3 Pauli decomposed polarimetric SAR image at the test site

3.2 Evaluation of Polarimetric Scattering from CRs

We could determine the location of the corner reflectors from the polarimetric SAR images. Then we picked up the polarimetric scattering coefficients from the SAR images in order to confirm the polarimetric characteristics of the SAR images. The polarimetric SAR images we have obtained fromj JAXA were already calibrated using the polarimetric compensation matrix, and the coefficients shown in the flowing sections are the original data we received from JAXA.

The theoretical scattering matrix of a trihedral and dihedral corner reflectors are give as:

$$\mathbf{S}_T = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \quad \text{(Trihedral corner reflector)} \qquad (1)$$

$$\mathbf{S}_D = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} \quad \text{(Dihedral Corner reflector)} \qquad (2)$$

The corresponding polarimetric signature of the trihedral and dihedral corner reflectors are shown in Fig.4.

The measured scattering matrix of the corner reflectors are:

$$\mathbf{S} = \begin{bmatrix} 1 & -0.3385 - 0.0161i \\ -0.2437 + 0.0175i & -1.0358 + 0.0598i \end{bmatrix} \text{(Dihedral corner reflector)}$$

$$\mathbf{S} = \begin{bmatrix} 1 & -0.0054 - 0.0742i \\ -0.0544 + 0.1092i & 1.0315 + 0.0314i \end{bmatrix} \text{(Small trihedral corner reflector)}$$

$$\mathbf{S} = \begin{bmatrix} 1 & 0.0703 - 0.0198i \\ -0.0602 + 0.0963i & 1.2227 + 0.0235i \end{bmatrix} \text{(Small trihedral corner reflector)}$$

$$\mathbf{S} = \begin{bmatrix} 1 & 0.1222 + 0.0482i \\ -0.1156 - 0.0530i & 1.1496 - 0.0159i \end{bmatrix} \text{(Large trihedral corner reflector)}$$

The corresponding polarimetric signature of the trihedral and dihedral corner reflectors are shown in Fig.5. We could confirm that in all the corner reflectors, the measured scattering matrix correspond well to the theoretical ones. Therefore, we think that the polarimetric calibration procedure by JAX is almost satisfactory.

We obtained the Multi-Look(4 Look) image fro the single look images and the scattering matrix of the corner reflectors were determined as follows:

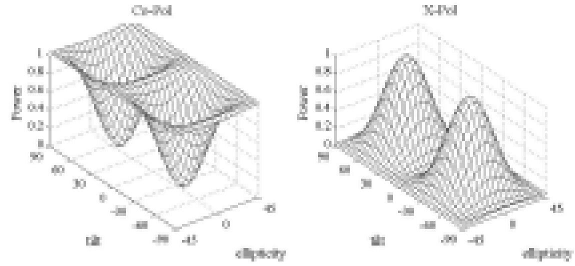
$$\mathbf{S} = \begin{bmatrix} 1 & -0.3174 + 0.0054i \\ -0.2421 - 0.0308i & -0.9966 - 0.0645i \end{bmatrix} \text{(Dihedral corner reflector)}$$

$$\mathbf{S} = \begin{bmatrix} 1 & 0.0549 - 0.1282i \\ -0.0521 + 0.0714i & 1.1376 + 0.2428i \end{bmatrix} \text{(Small trihedral corner reflector)}$$

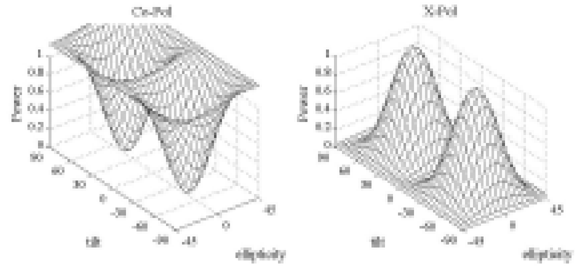
$$\mathbf{S} = \begin{bmatrix} 1 & -0.0599 + 0.0018i \\ -0.1652 + 0.1558i & 1.0440 - 0.5829i \end{bmatrix} \text{(Small trihedral corner reflector)}$$

$$\mathbf{S} = \begin{bmatrix} 1 & 0.0807 - 0.0164i \\ -0.0828 + 0.0233i & 1.2915 - 0.1245i \end{bmatrix} \text{(Large trihedral corner reflector)}$$

We do not find significant changes, but it seems that the data quality is slightly worse compared to the single look data sets. It may be due to the limitation of the resolution of the images. The nominal resolution of the ALOS/PALSAR in full polarimetric mode is 20x30m, and it is larger than the physical size of the corner reflectors. Therefore, in the multi-look data, the polarimetric characteristics pf the corner reflectors were lost.

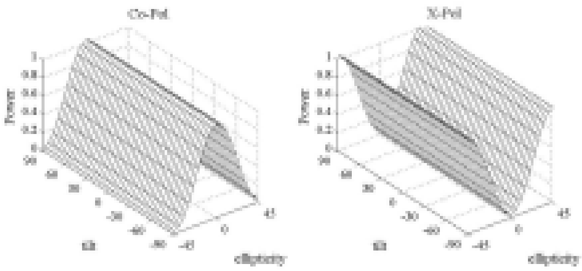


(a) Theoretical

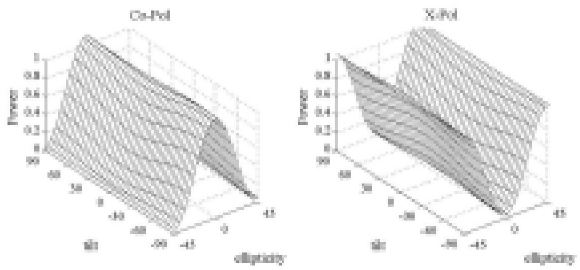


(b) Measured

Figure 4 The polarimetric signature of a dihedral corner reflector



(a) Theoretical



(b) Measured

Figure 5 The polarimetric signature of a dihedral corner reflector

4. APPLICATION IN ENVIRONMENTAL STUDIES

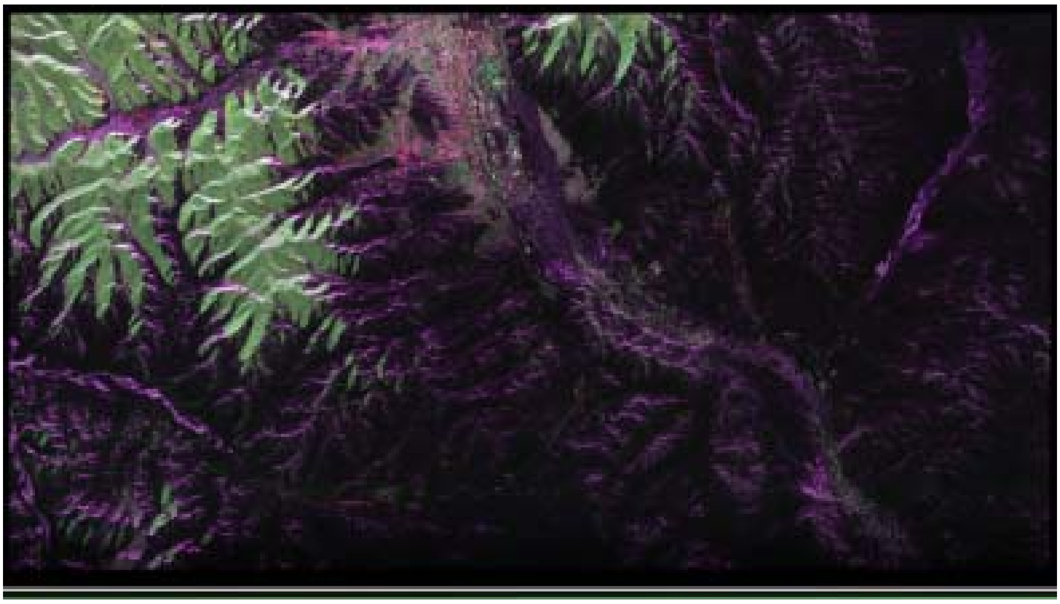


Figure 6 Polarimetric SAR image of Ulaan Baatar
(HH:Red, VV:Blue HV:Green)

Fig. 6 shows the Polarimetric SAR image of Ulaan Baatar area acquired in May 2006. The city is dominated by the HH and VV components, while the mountain area .is dominated by HV. We can observe the very fine structure of the ground surface topography in this image. By comparing the SAR image in different seasons and different years, we can observe the temporal change of the condition of vegetation, and also the development of the city. At the same time, with the combination of GPR, we are planning to sue this data for ground moisture content estimation.

5. CONCLUSION

In this paper, we demonstrated the first full polarimetric SAR image acquired in Ulaan Baatar are by ALSO/PALSAR. We observed the polarimetric chrematistics of the image, and by analyzing the polarimetric scattering from the trihedral and the dihedral corner reflectors, we could confirm the validity of the polarimetric calibration processed in this datasets.

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