Quantitative evaluation of ALOS/PALSAR data by radar polarimetry

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Abstract
The Japanese microwave remote sensing satellite ALOS/PALSAR was launched successfully in January 2006. PALSAR is a full-polarimetric SAR system, and we are interested in the use of the polarimetric information. Especially, we are working for quantitative interpretation of the SAR data by polarimetric approaches. We applied the polarization angle shift for estimation of azimuth angle of scattering targets. We applied this technique to two targets. The first example is the Sendai city area, and we could classify the urban area mountainous area quite easily. Then we applied it to developing area, where we have many private houses. We could estimate the azimuth orientation of the area from the polarization angle shift angle.

Keywords: Radar Polarimetry, Quantitative interpretation, orientation angle shift

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 observations.

The radar polarimetric function of PALSAR provides us much more information than conventional single polarization SAR such as JERS-1. The polarimetric SAR image contains complex amplitude of 4-components, and they can be used to understand the target much better. Now we are trying to use the polarimetric information. Until we obtain the PALSAR data, we have used the airborne Pi-SAR for the same purpose. Therefore, we can examine the Pi-SAR data and then we compare the Pi-SAR data with PALSAR data to evaluate its information.

The full-polarimetric data sets will provide much rich information compared to the conventional single-polarization SAR. The polarimetric information can overcome the limitation of the frequency-bandwidth, because the polarimetric information contains much information about the scattering objects. Therefore, even we cannot see the objects clearly in the SAR images, we can use the polarimetric information for understanding the scattering targets.

There are many techniques to use the polarimetric SAR information. I this report, we use the polarization angle shift to estimate the azimuth orientation of scattering targets.

The incident angle dependency of the SAR image in polarimetry in X-band is very clear in these SAR images. Polarization orientation angle shift which are closely related to the target configuration is well studied. Lee et al found out the relationship between the polarization orientation angle shift and the configuration of the ground surface patch. They showed that the polarization orientation angle shift is mainly induced by azimuth slope, and it is also a function of range slope and the radar look angle. Kimura et al applied this concept to urban area, and found the relationship between the polarization orientation angle shift and the azimuth angle of the vertical wall of buildings.

2. ESTIMATION OF TERRANIAN SLOPE AND AZIMUTH ANGLE OF TARGETS

2.1. Orientation Angle shift

Polarimetric SAR contains rich information compared to the conventional single-polarization SAR. We have used polarization angle shift to estimate the azimuth orientation of scattering targets, and could obtained good results.

In order to estimate polarization orientation angle θ from the polarimetric SAR data, an algorithm using the phase difference between RR and LL circular polarization given in (1) was used in this report.

$$\theta = [Arg(\langle S_{RR} S_{LL}^{*} \rangle) + \pi]/4 \quad (1)$$

When the argument $\langle S_{RR} S_{LL}^{*} \rangle$ is limited between –π and π, (1) has to be modified to account for negative polarization orientation angles by (2).

$$For\ \theta > \pi/4,\ replace\ \theta\ by\ (\theta - \pi/2) \quad (2)$$

Due to this rule, the ambiguously measurable range is also limited to -45 (deg) to 45(deg) because of the dividing factor 4 in (1), and the vertical axis and the horizontal axis of the polarization ellipse can be distinguished.

In order to evaluate the estimated polarization orientation angle from Polarimetric SAR data in urban area, we compared the L-band Pi-SAR data and ALOS/PALSAR data acquired in Sendai, Japan. We have used Pi-SAR data for observation of polarization angle shift, and have found that the orientation angel shift shows good agreement on the estimated azimuth angle of scattering targets for deterministic scattering objects such as buildings.

Since the resolution of ALOS/PLASR is not same as that of Pi-SAR, we created moving average images of the Pi-SAR data, and obtained images which have the similar size of the PLASAR image resolution.
Figure 1 shows the example of the polarization angle shift applied to the polarimetric SAR dada in the central urban area of Sendai city. In this area, Hirose river is flowing across the center of the city from North to South, and the east part of the river is urban area and western side of the river is mountainous area mostly covered by forest. We can see in Figure 1 (c) that, the orientation angle shift in the urban area is almost constant, which may be caused by the parallel structure of the roads and buildings in the urban area, and also due to the poor resolution of the image compared to the size of each buildings. On the contrary, outside the urban area, we can see various orientation angle shift distribution, which corresponds to the random azimuth orientation of the scattering targets.

Figure 2 shows the example of the polarization angle shift applied to the polarimetric SAR dada in the developing area of Sendai city, which is located in the Southwest are of Figure 1. We have aligned private houses in this area, and most of the houses are parallel to each other in separated regions, which is about 500m x 500m. We applied this technique by using Pi-SAR data, and found that the azimuth angle of the houses can be estimated very accurately in this area. Figure 2(c) and (d) show good agreements, and we think that PLASAR can be used for azimuth estimation, too.

3. CONCLUSIONS

The resolution of PLASAR polarimetric mode is about 20m, and is not small enough to observe the details of scattering objects on the ground surface. However, we think that the polarimetric information is still preserved in it.
We plan to apply the same technique to larger area. We have confirmed that the orientation of houses can be estimated from polarimetric shift angle, and we will observe the same phenomena in PALSAR, which has lower resolution.

Acknowledgement

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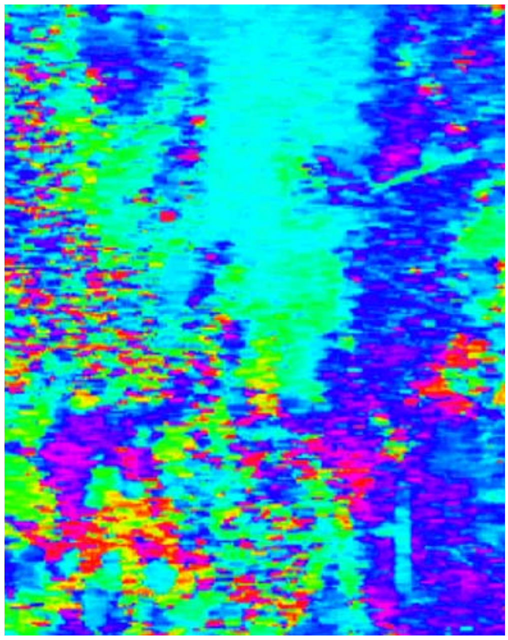
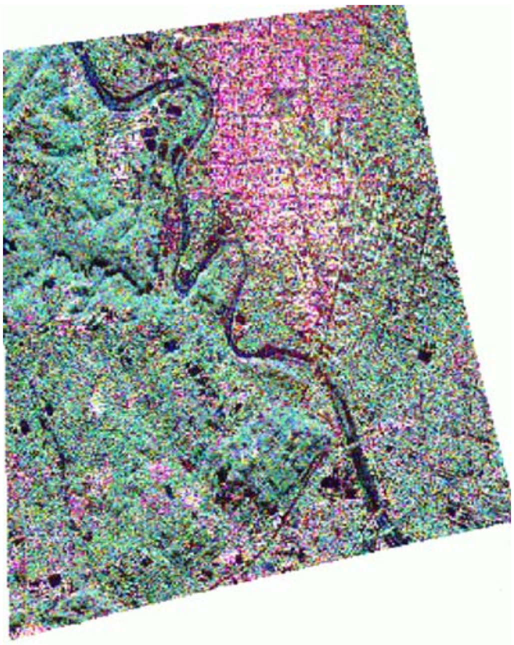
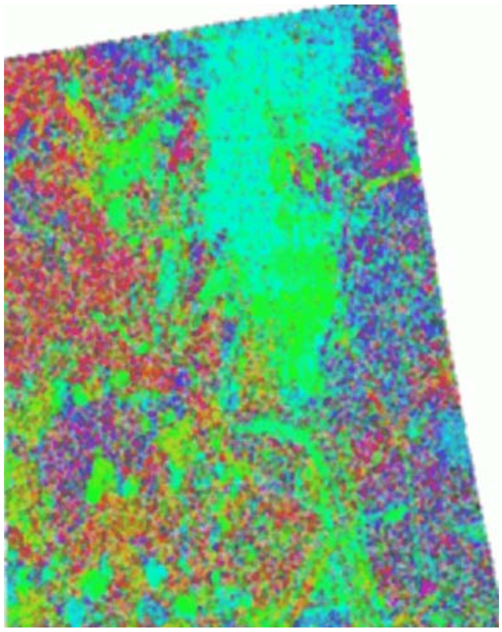
(a). Aerial photo



(c).PALSAR Orientation angle shift



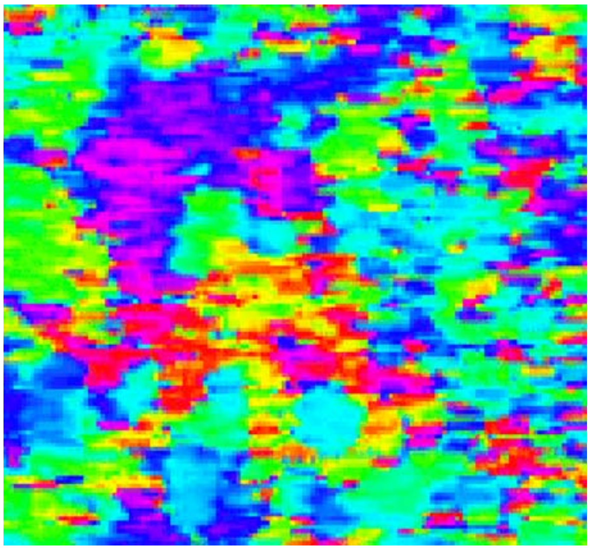
(b). Pi-SAR polarimetric image



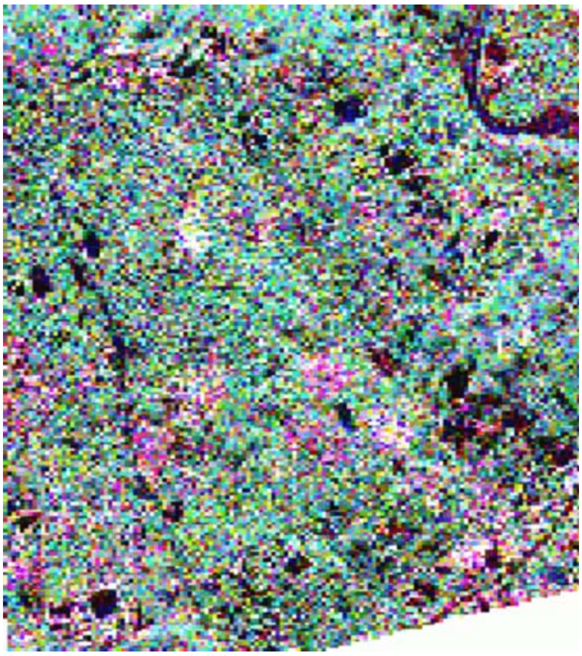
(d).Pi-SAR Orientation angle shift

Figure 1. Orientation angle shift in the central Sendai city area

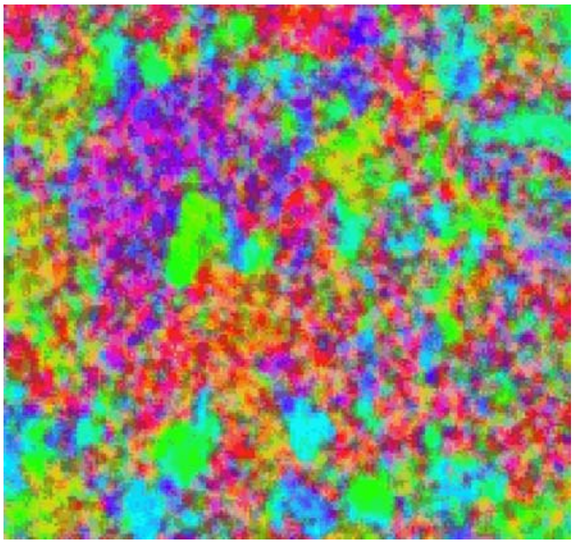
(a). Aerial photo



(c).PALSAR Orientation angle shift



(b). Pi-SAR polarimetric image



(d).Pi-SAR Orientation angle shift

Figure21. Orientation angle shift in the developing area in Sendai city