ALOS PALSAR Fully Polarimetric Scattering Power Images over Taiwan

Yoshio Yamaguchi[1], Gulab Singh[1], Yi Cui[1], Tzu Yu Cheng[2], Bryan Chiyuan Chu[3]
[1]Department of Information Eng., Niigata University, 950-2181 JAPAN
[2] Graduate Institute of Space Science, National Central University, TAIWAN
[3] G-AVE Technology Corp., TAIWAN

***Abstract* – Advanced Land Observing Satellite (ALOS) Phased Array L-band Synthetic Aperture Radar (PALSAR) has acquired 23 fully polarimetric data sets over Taiwan during its operational period 20081115 – 20110420. This paper presents the scattering power decomposition images using the existing Y4R and GU4 algorithms. It is shown that land covers are precisely imaged with RGB color code indicating R: the double bounce scattering, G: the volume scattering, and B: the surface scattering, which can be useful to monitor the environment.**

***Index Terms* — SAR polarimetry, scattering power decomposition, ALOS-PALSAR, monitoring.**

I. INTRODUCTION

ALOS-PALSAR (2006.1-2011.4) was the first operational fully polarimetric radar satellite in the world [1]. Although the fully polarimetric mode was designed as being experimental, it had acquired imagery for more than 274,000 scenes during its period of operation, demonstrating the usefulness and effectiveness of fully polarimetric information. Since the polarimetric data has nine independent information in the second order statistics, we took advantages of these information to create full color image of acquired scene. The four-component scattering power decomposition scheme [2], [3] was employed to generate color images. The color image is composed of scattering power magnitude of three different scattering mechanisms, i.e., double bounce (Red), volume (Green), and odd bounce (Blue). This paper presents imaging results over Taiwan.

II. SCATTERING POWER DECOMPOSITION

Fig. 1 shows the concept of the four-component scattering power decomposition [2], [3], which is one of the model-based decompositions.

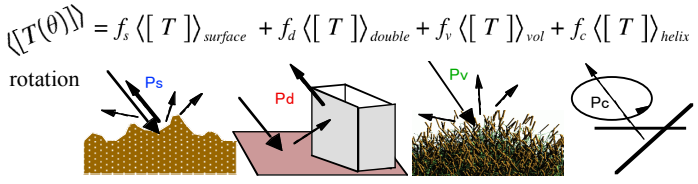

Fig. 1. Four-component scattering power decomposition

The acquired coherency matrix is rotated to minimize the cross-polarized component at the first stage, then, the rotated matrix is expanded into 4-sub matrices representing surface-, double-bounce-, volume-, and helix scattering mechanisms as shown in Fig. 1. After equating all matrix elements, we can determine each scattering power separately for which the details of the decomposition scheme are given in [2], [3].

III. ALOS-PALSAR POLARIMETRIC DATA SETS

All the polarimetric data sets acquired over Taiwan are listed in Table 1. There are 23 data sets in total during its operational period. The main features ALOS-PALSAR data sets are;

Frequency: L-band (1.27 GHz)

Resolution: 30 m in the range and 5 m in the azimuth direction for Single Look Complex data

Angle of incidence: 21.5 and 23.1 degrees.

TABLE I
ALOS PALSAR QUAD. POL. DATA SETS OVER TAIWAN

Date	Data no.	Incidence angle
20081115	ALPSRP149740430_P1.1_A ALPSRP149740440_P1.1_A ALPSRP149740450_P1.1_A ALPSRP149740460_P1.1_A ALPSRP149740470_P1.1_A	23.1
20090501	ALPSRP174100450_P1.1_A ALPSRP174100460_P1.1_A ALPSRP174100470_P1.1_A ALPSRP174100480_P1.1_A	23.1
20110322	ALPSRP274750440_P1.1_A ALPSRP274750450_P1.1_A ALPSRP274750460_P1.1_A ALPSRP274750470_P1.1_A ALPSRP274750480_P1.1_A	21.5
20110403	ALPSRP276500480_P1.1_A ALPSRP276500480_P1.1_A	21.5
20110408	ALPSRP277230440_P1.1_A ALPSRP277230450_P1.1_A ALPSRP277230460_P1.1_A	21.5
20110420	ALPSRP278980460_P1.1_A ALPSRP278980470_P1.1_A ALPSRP278980480_P1.1_A ALPSRP278980490_P1.1_A	21.5

In the scattering power decomposition, the window size for ensemble averaging was chosen as 3 in the range direction and 18 in the azimuth direction, which corresponds to 90 m by 90 m on ground. After the decomposition, a number of color-coded images are created to show full-color images with *Red: double bounce scattering, Green: volume scattering,* and *Blue: surface scattering*. In color-code rendering, we used the same measure that each power magnitude is proportional to the color brightness. After composing of a color-coded RGB image, the whole image brightness is changed to a certain level in order to be seen clearly, but keeping the same brightness level to other RGB images for comparison of time series data. The images shown in this paper are based on the same measure. Since each color directly corresponds to a scattering mechanism and power, it is easy to interpret the images by relating typical objects.

IV. IMAGING RESULTS

A. *Kaohsiung area*

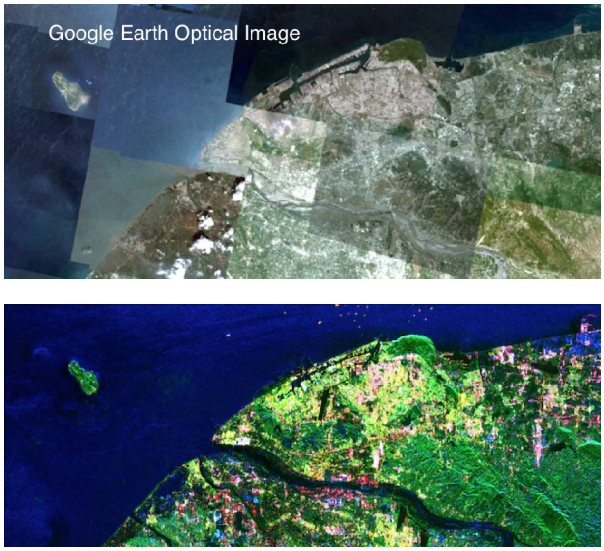

Fig. 2. Kaohsiung image

Heterogeneous objects in Kaohsiung area result in colorful images as shown in Fig. 2. Google earth optical image is provided for comparison.

B. *Orange Color Scattering*

Among various decomposition images, it is very rare to see "Orange color" in the final image. This orange color appeared in Tainan area as shown in Fi g. 3. According to the ground truth images, the scattering was caused by the mixture of the volume scattering in the upper leaves, and the double bounce scattering by tree trunks and ground.

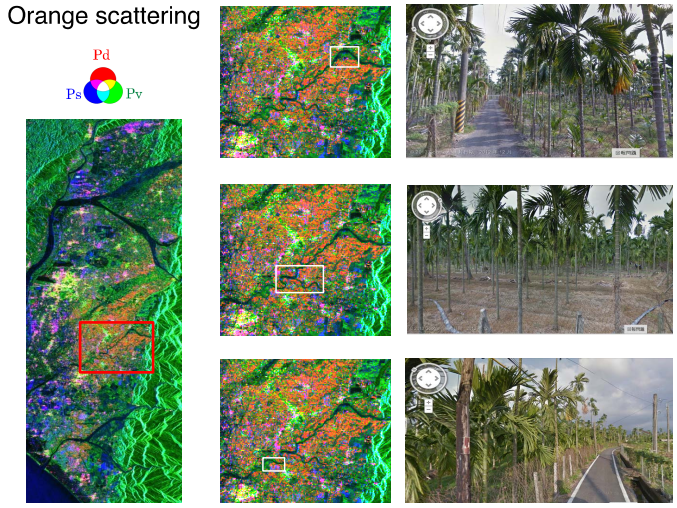

Fig. 3. Orange color scattering and its source in Tainan

V. CONCLUDING REMARKS

In this paper, some scattering power decomposition images of fully polarimetric SAR data are displayed to show the effectiveness and usefulness for monitoring. Color-coded images serve as a simple approach to identify areas of interest, since color represents the scattering mechanisms directly.

ACKNOWLEDGMENT

Authors would like to thank JAXA for providing precious ALOS-PALSAR data sets.

REFERENCES

[1] http://www.eorc.jaxa.jp/ALOS/index_j.htm
[2] Y. Yamaguchi, A. Sato, W. –M. Boerner, R. Sato, H. Yamada, "Four-component scattering power decomposition with rotation of coherency matrix," *IEEE Trans. Geosci. Remote Sens.*, vol. 49, no. 6, pp. 2251-2258, June 2011.
[3] G. Singh, Y. Yamaguchi, and S.-E. Park, "General four-component scattering power decomposition with unitary transformation of coherency matrix," *IEEE Trans. Geosci. Remote Sens.*, vol. 51, no. 5, pp. 3014-3022, 2013.
[4] T. Y. Cheng, Y. Yamaguchi, K. S. Chen, J. S. Lee, and Y. Cui, "Sandbank and Oyster farm monitoring with multi-temporal polarimetric SAR data using four-component scattering power decomposition," *IEICE Trans. Commun*. vol. E96-B, no.10, pp. 2573-2579, 2013.