

ALOS-PALSAR Quad-Pol Images and Their Applications

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Abstract: The four-component scattering power decomposition is applied to ALOS-PALSAR quad-pol data sets. PALSAR is Phased Array type L-band Synthetic Aperture Radar onboard ALOS (Advanced Land Observing Satellite) launched by JAXA, Japan, in 2006. It has acquired imagery for more than 190,000 fully polarimetric scenes although the polarimetric mode is designed as experimental. This paper presents some of scenes in Sichuan earthquake area to see how polarimetric data works and to show the effectiveness and usefulness of fully polarimetric information.

Key words: ALOS-PALSAR, polarimetry, scattering power decomposition

I. INTRODUCTION

More than three years have passed since the launch of ALOS satellite in 2006 January. ALOS is equipped with PALSAR and polarimetric data take function. Although the quad-pol mode is designed as experimental, PALSAR has acquired imagery for more than 190,000 scenes all over the world. The quad-pol data takes from space using a satellite was the first accomplished in the world by PALSAR. The details are listed in JAXA [1] and ERSDAC [2] web-sites. In this paper, some of Sichuan scenes in China are presented with the emphasis on the usefulness and effectiveness of fully polarimetric data for monitoring the disaster area.

The specific feature of polarimetric mode is as follows:

Incidence angle: 21.5 degree

Resolution on the ground: 20 m (azimuth) by 30 m (range)

Repeat cycle: 46 days

II. FOUR-COMPONENT SCATTERING POWER DECOMPOSITION

There are various imaging and analysis methods for quad-pol data sets. The software “PolSAR-Pro” [3] has been used as a popular toolbox for users. The representative and fundamental methods are based on ensemble averaging of several pixels bearing the second order statistics of polarimetric information. These processing schemes are shown in Fig. 1.

The HV basis imaging

The Pauli basis imaging

H-Alpha-Anisotropy imaging using eigenvalues of the coherency matrix

Power decomposition imaging

Since the H-Alpha-Anisotropy method of Cloude-Pottier [4] is well known and widely used [5,6], we focus on the scattering power decomposition method [7] developed at Niigata University. This power decomposition method is based on physical scattering models and was first developed by A. Freeman & S. Durden [8].

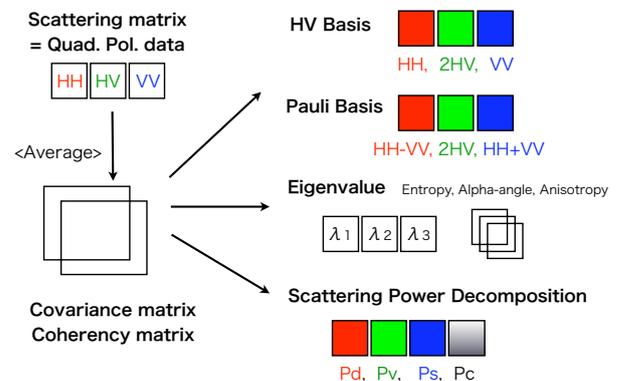


Fig. 1 Imaging methods of quad-pol data

The scattering power decomposition, consisting of the four terms Pd, Pv, Ps and Pc, displays the following advantages:

1. Easy implementation;
2. Computation time is quite small because simple calculations are required only;
3. The decomposed powers correspond to physical scattering mechanisms, i.e., surface scattering Ps, double bounce scattering Pd, volume scattering Pv, and helix scattering Pc;
4. Output color-coded images are directly recognized and easy to understand.

The four-component scattering power decomposition algorithm is provided in [6] and [7] using coherency matrix elements. If quad-pol data sets, i.e., scattering matrices, are provided, the calculation is quite simple and fast.

III. COLOR COMPOSITE IMAGE: STEP BY STEP PROCEDURE USING AN EXAMPLE (WUDU, CHINA)

One example is used to illustrate the imaging process. Provided with quad-pol data sets consisting of HH, HV, and VV component files, one can immediately obtain the following images shown below. The chosen area is Sichuan earthquake area (31.85N, 104.64E), Wudu, China, with imagery acquired by ALOS-PALSAR on June 23, 2008. Since HV=VH in the monostatic radar case assumed here, three scattering matrix elements are used to depict color-coded images with HH=Red, HV=Green, and VV=Blue.

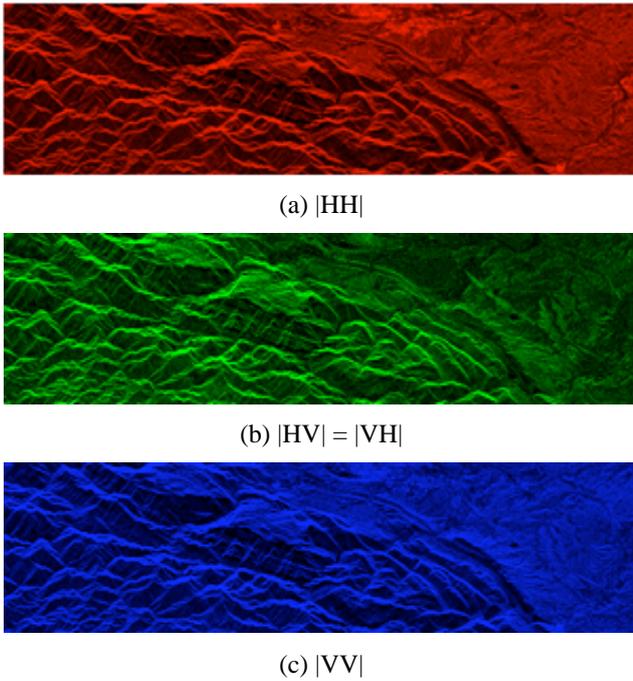


Fig. 2 Color coded polarimetric channel images ($|HH|$, $|HV|$, $|VV|$) © METI, JAXA

Using a three polarimetric channel data, it becomes possible to apply fully polarimetric data analysis and to make color-composite images. The first one is the color-composite of Fig. 2(a)-(c) in the H,V polarization basis as shown in Fig. 3 (a).

One can recognize the difference of polarization responses of radar scenes easily. Red areas are HH dominant areas and correspond to urban and bare soil region. However, it is impossible to distinguish in Fig. 3(a) between urban and bare fields.

If we change the polarization basis from H,V to Pauli, then the image becomes as shown in Fig. 3(b). The Pauli basis image is now widely used to illustrate specific scene scattering behavior since each color represents typical scattering mechanism briefly, i.e., $|HH-VV|$ for double bounce, $2|HV|$ for cross polarization, and $|HH+VV|$ for surface scattering. Bare soil areas are displayed as blue in this Pauli basis image.

The four-component scattering power decomposition yields surface scattering power Ps (Blue), double bounce scattering power Pd (red), volume scattering power Pv (green), and helix scattering power Pc (gray). The color-

coded composite image of Pd, Pv, and Ps becomes Fig. 3(c). The magnitude dimension is power. For the sake of comparison, the corresponding Google earth optical image is displayed in Fig. 4. It is seen that the image clearly shows the details of a specific scene with corresponding interpretation similar to Pauli basis images Fig. 3(b).

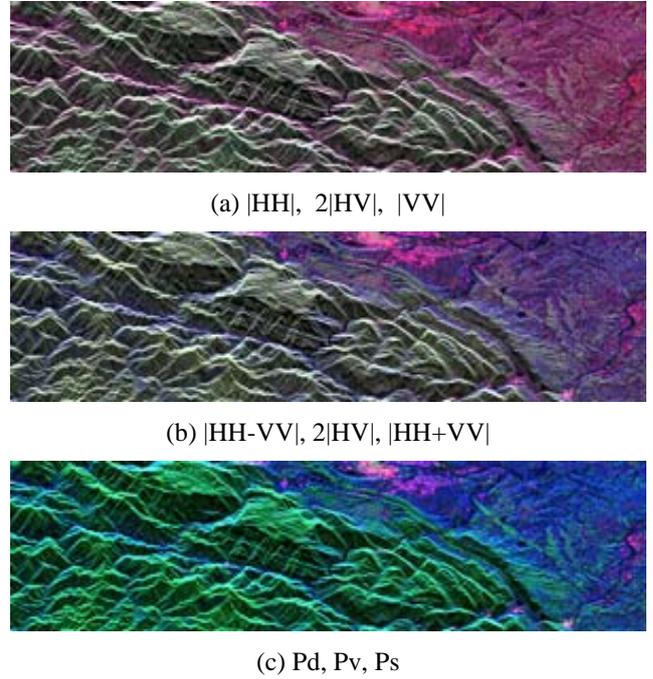


Fig. 3 Polarimetric color-composite images

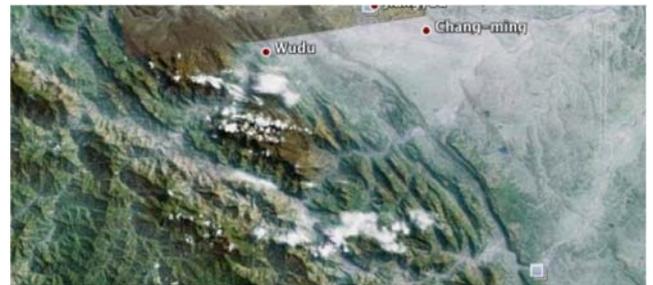


Fig. 4 Google earth optical image (for the same area) of unspecified date

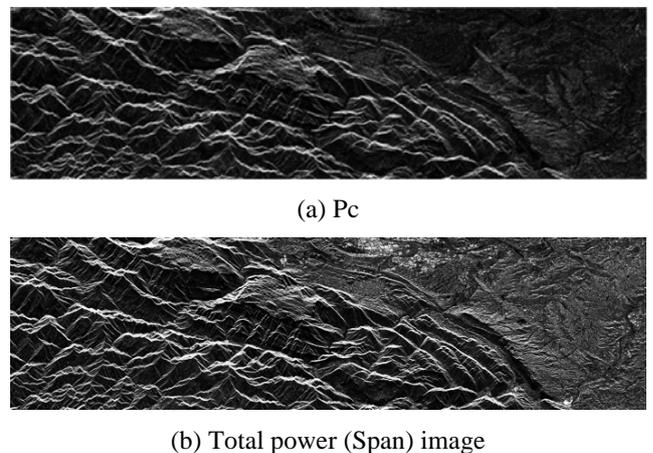


Fig. 5 The Pc image and the total power images for the same area.

The Pc image and the total power images are illustrated in Fig. 5 (a) and (b) using gray scale. Compared to the Span image, the Pc image seems to display ground topography suppressing bright scattering areas (urban areas of Chang-ming and man-made structure) in the L-band.

IV. APPLICATION OF ALOS QUAD. POL. IMAGE

If we close up the valley in the lower Fig.3 (c), the finer situation can be seen as in Fig. 6. Surface scattering (blue) lines in the mountain slope can be found and they might be corresponding to land slide areas caused by the great earthquake. Since bare soil causes surface scattering dominant in the L-band scattering, there is a possibility of detecting land-slide area by surface scattering Ps in mountainous area.

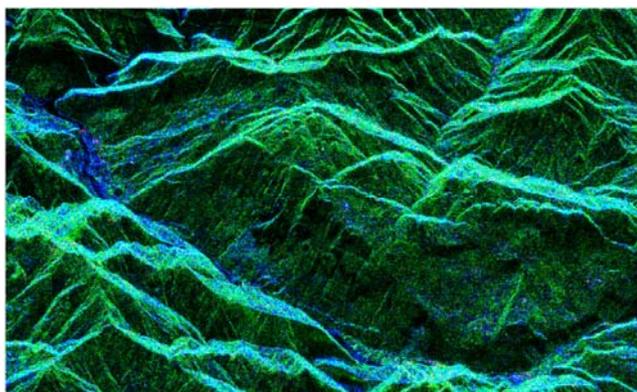


Fig. 6 Close-up image of the valley of lower Fig. 3 (c). Dark blue lines in the mountain slope may be land-slide.

Another application is detection of flood. Fig. 7 shows close-up Google earth image and Fig. 3 (c). Black area in the left of the decomposed image might be flooded because of scattering nature of radar wave.

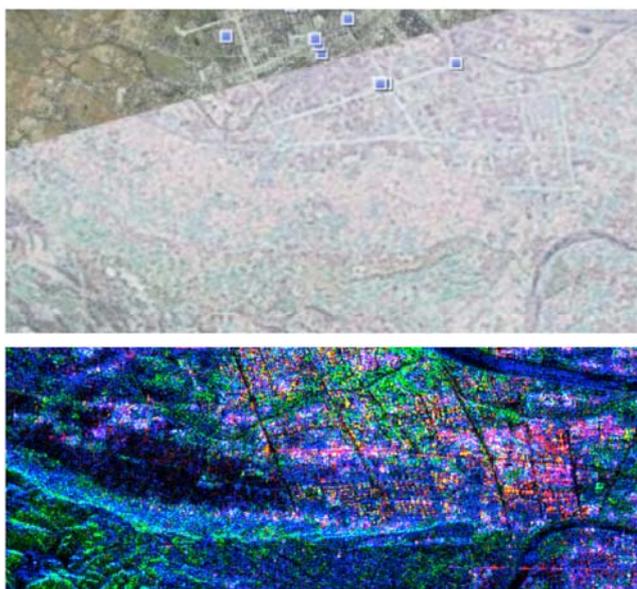


Fig. 7 Close-up image of Chang-ming on June 23, 2008. The dark area in the left might be flooded.

V. EXAMPLES OF OTHER ALOS QUAD. POL. IMAGE

Among various ALOS quad. pol. data sets, we show some images using the scattering power decomposition applied to Sichuan Earthquake areas on June 23, 2008. Google earth optical images are provided for comparison.

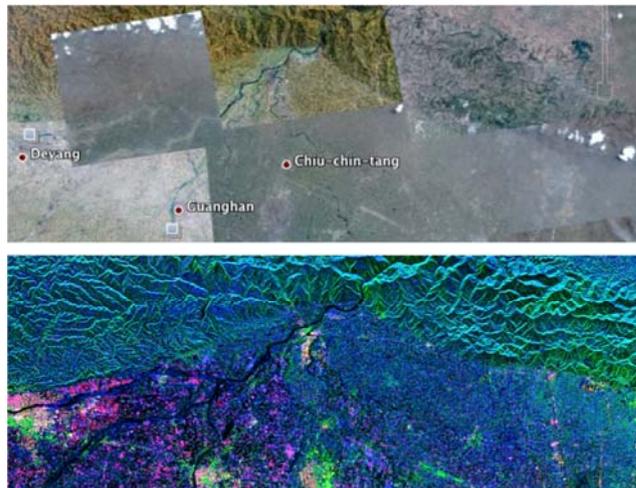


Fig. 8 Chu-chin-tang area (30.86N, 104.41E)

Cities are detected by double bounce scattering Pd (red) and volume scattering Ps (green). 3-D mountain shapes are clearly recognized compared to optical image. In addition, flat areas in optical image are well decomposed into Ps, Pv, and Pd area.

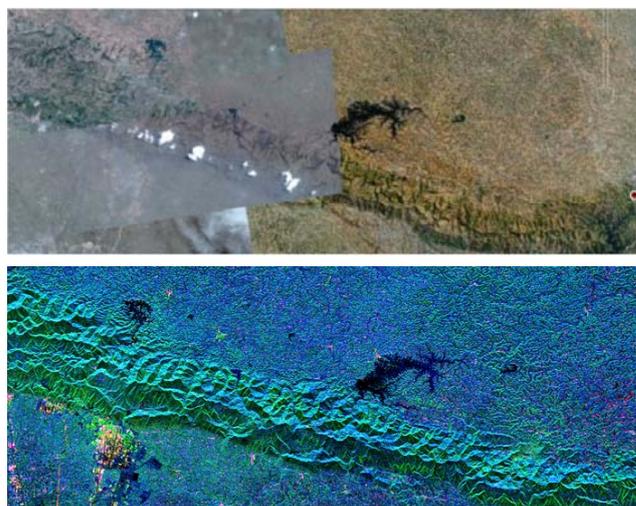


Fig. 9 30.36N, 104.29E area

The dark areas in Fig. 9 are caused by water surface (no reflection) in radar image, which agree with the optical image. Hence it is quite easy for POLSAR to detect flood area in the presence of cloud and at night. City in the left is detected clearly.

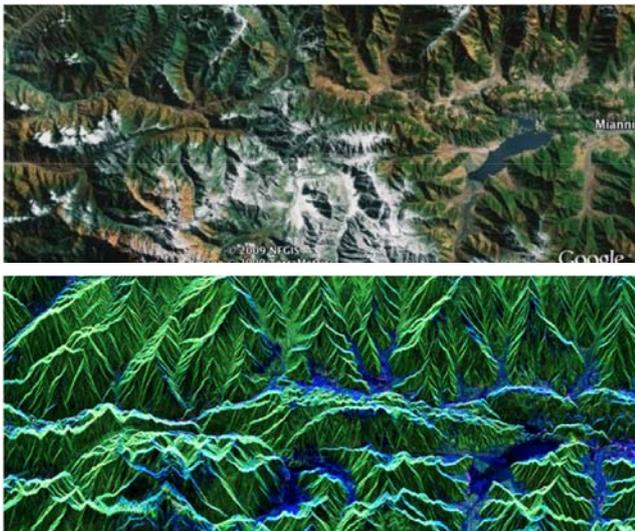


Fig. 10 Mianning area (28.86N, 102.34E)

Flood areas and lake can be indicated by dark area in the radar image. Some red points seem houses caused by double bounce scattering.

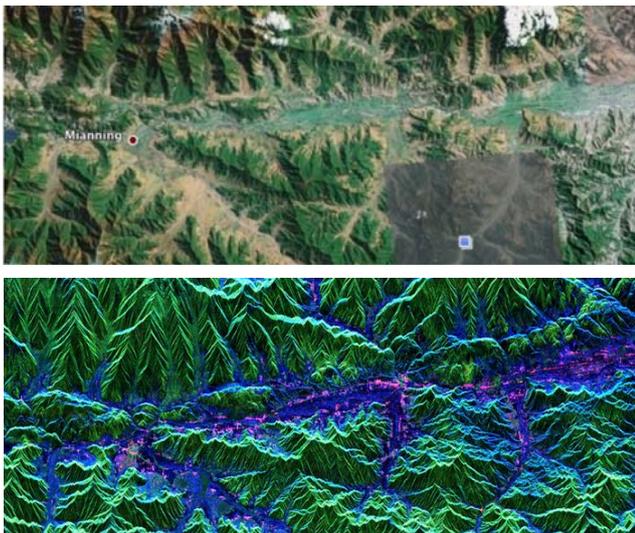


Fig. 11 Mianning area (28.36N, 102.22E)

It is possible to find houses along valleys in the decomposed image compared to optical image.

CONCLUSION

In further advancing algorithms for fully polarimetric quad-pol SAR implementation, the four-component scattering power decomposition method demonstrated in [7] and summarized here has taken us a step further towards reaching the limits of physical realizability in multimodal SAR remote sensing. Similar results are forthcoming for implementation of this new more powerful algorithm for the two other fully polarimetric space-borne SAR sensors [9] and [10] which when combined with that of ALOS-PALSAR [1, 2] will provide more complete all weather day/night imagery for a unforeseen applications in monitoring of the terrestrial covers.

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