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Polarization-Selective Dihedrals and Its Application to Polarimetric Calibration Experiment of ALOS PALSAR

[#] Makoto Satake, Takeshi Matsuoka, Toshihiko Umehara, Akitsugu Nadai, and Seiho Uratsuka

National Institute of Information and Communications Technology
[#] Onna, Okinawa 904-0411, Japan
E-mail: satake@nict.go.jp

1. Introduction

Japan Aerospace Exploration Agency (JAXA) launched the Advanced Land Observing Satellite (ALOS), January 2006. The ALOS carries the Phased Array type L-band Synthetic Aperture Radar (PALSAR) that is the first spaceborne full polarimetric radar utilizing horizontally and vertically polarized microwaves both in transmission and reception, together with the Panchromatic Remote-sensing Instrument for Stereo Mapping (PRISM) and the Advanced Visible and Near Infrared Radiometer type 2 (AVNIR-2). While polarimetric radar is a powerful tool to extract detailed information of the target, compared with conventional single-parameter radar, one needs polarimetric calibration of the radar to exploit its capability. Although natural extended targets such as forest have been largely used for polarimetric calibration of synthetic aperture radars, it requires some assumptions in target's polarimetric scattering properties and there might be some uncertainty in them. On the other hand, if an appropriate combination of point targets of different polarizaion-selectiveness is available and they have accurate polarimetirc scattering properties and fairly large radar cross-sections, it is more straightforward to use them for polarimetric calibration.

Before its regular operation began in October 2006, JAXA conducted the calibration and validation activities of the ALOS sensors. We participated in the PALSAR calibration and validation, with polarization-selective dihedrals for polarimetric calibration. In this paper we describe the dihedrals and PALSAR calibration experiments with them.

2. Polarozation-Selective Dihedrals

We had developed polarization-selective dihedrals, including a horizontal-polarization dihedral (Shh=1, Svv=Shv=Svh=0) and a vertical one (Svv=1, Shh=Shv=Svh=0). They are made of an array of horizontally-placed or vertically-placed metal strips, to reflect radar transmission whose polarization is in the same direction as the strips. Also developed were a 45 degree rotated dihedral (Shv=Svh=1, Svv=Shh=0) and a 22.5 degree rotated dihedral (Shh=Shv=Svv=1, Svh=–1).

They are shown in Figure 1. The size of each plate of the dihedral was 1.6 m square, or 7 times of the PALSAR wavelength, for the all dihedrals. Radar cross-sections for the PALSAR and some properties of the dihedrals are shown in Table 1.

3. Polarimetric Calibration Experiments of PALSAR

In the August and October 2006, we deployed those dihedrals as well as a 1.1m trihedral (Shh=Svv=1, Shv=Svh=0) in open fields within Tomakomai forest area, Hokkaido, Japan. PALSAR observed them from an ascending and a descending orbit in the polarimetric mode. We set their azimuth and elevation angles carefully for the each PALSAR datatake. Coincident to the PALSAR observations, an airborne polarimetric SAR (L-band and X-band), Pi-SAR, observed those reflectors for the comparison.

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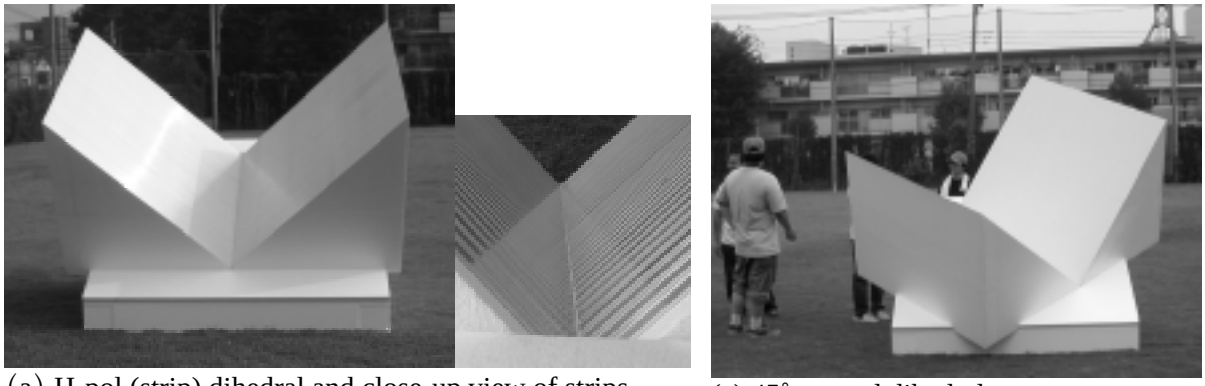
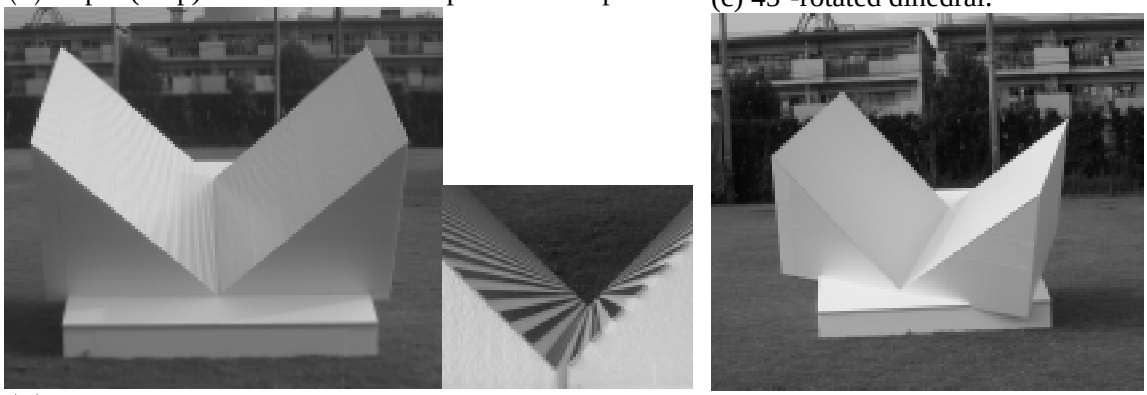


(a) H-pol (strip) dihedral and close-up view of strips.

(c) 45˚-rotated dihedral.



(b) V-pol (strip) dihedral and close-up view of strips.

(d) 22.5˚-rotated dihedral.

Figure 1: Polarization-selective dihedrals.

Table 1: Size and properties of dihedrals.

Type	Size	Radar Cross-section in dBsm	Sigma-0 over short vegitation in dB [*1,2]	Note
H-pol (strip) Dihedral	1.6 m square (~7 λ)	34.7 (HH)	+23 (HH)	VV/HH < –48dB
V-pol (strip) Dihedral	1.6 m square (~7 λ)	34.7 (VV)	+23 (VV)	HH/VV < –48dB
45˚-rotated Dihedral	1.6 m square (~7 λ)	34.7 (HV)	+31 (HV)	
22.5˚-rotated Dihedral	1.6 m square (~7 λ)	31.7 (All)	+20 (HH,VV) +28 (HV)	
Trihedral	1.1 m square	30.0 (HH,VV)	+18 (HH,VV)	

*1) Assumed pixel spacing as 12.5m x 12.5m (21.9 dBsm).
*2) Assumed Sigma-0 = –10dB (HH,VV), –18 dB (HV) in short vegetation.

4. Prelimenry Results

Pi-SAR L-band images of HH, VH, VV polarization channels are shown in Figure 2. ('VH' stands for vertical-polarization transmission and horizontal-polarization reception.) All the dihedrals showed polarimetirc properties as expected. For example, the 45-degree rotated dihedrals is seen only in VH images (as a bright spot), while the 22.5-degree rotated dihdrals is seen in all HH, VH, and VV images.

PALSAR polarimetric image data had been processed and supplied by JAXA. Some PALSAR images of the dihedrals are shown in Fugure 3 as an example. Quantitative analysis of the data is ongoing to estimate polarimetric calibration factors of PALSAR, with a combination of the reflectors. They will be evaluated with data of the other reflectors and compared to those estimated by JAXA.

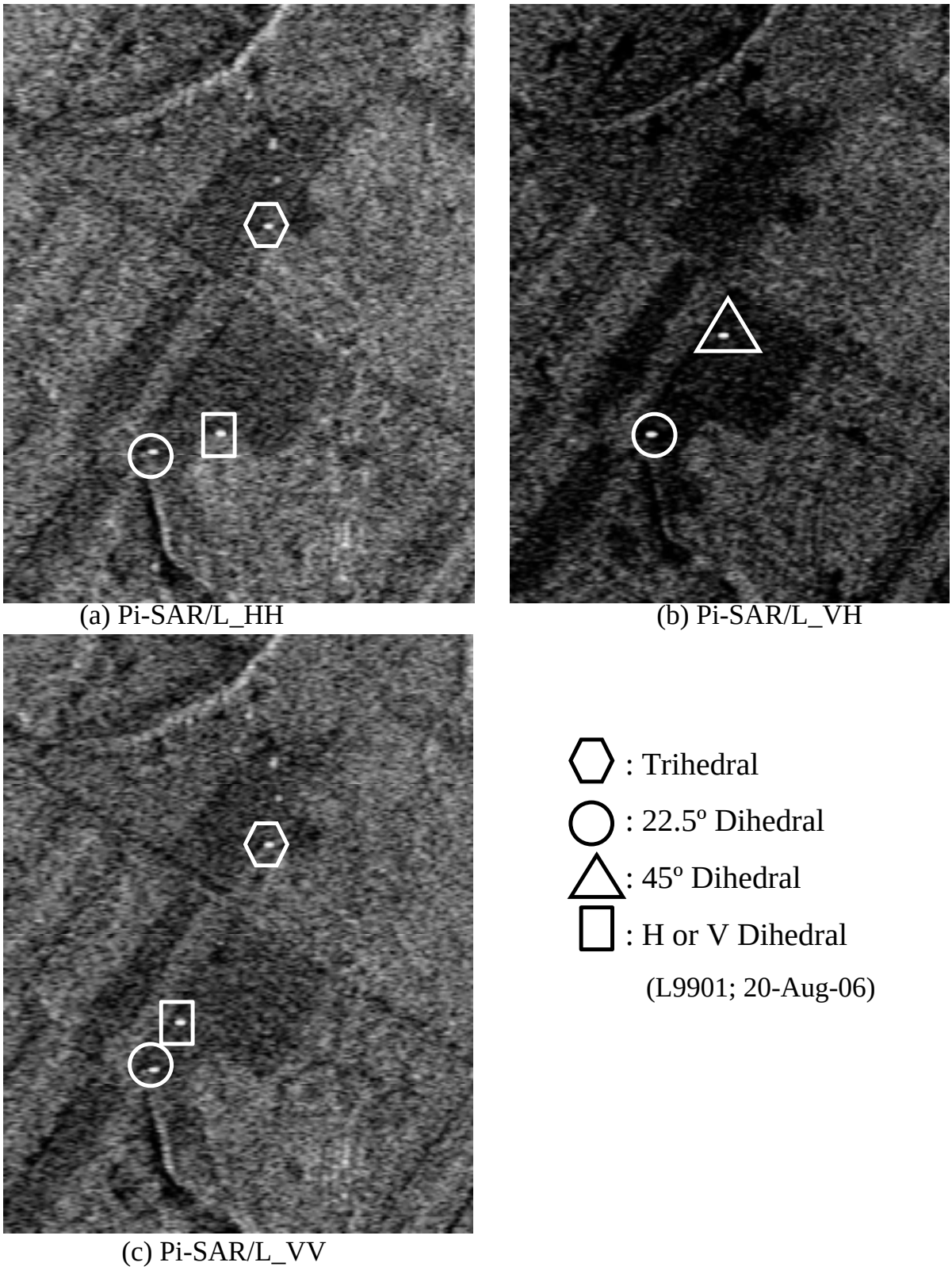


Figure 2: Pi-SAR/L-SAR images of dihedrals.

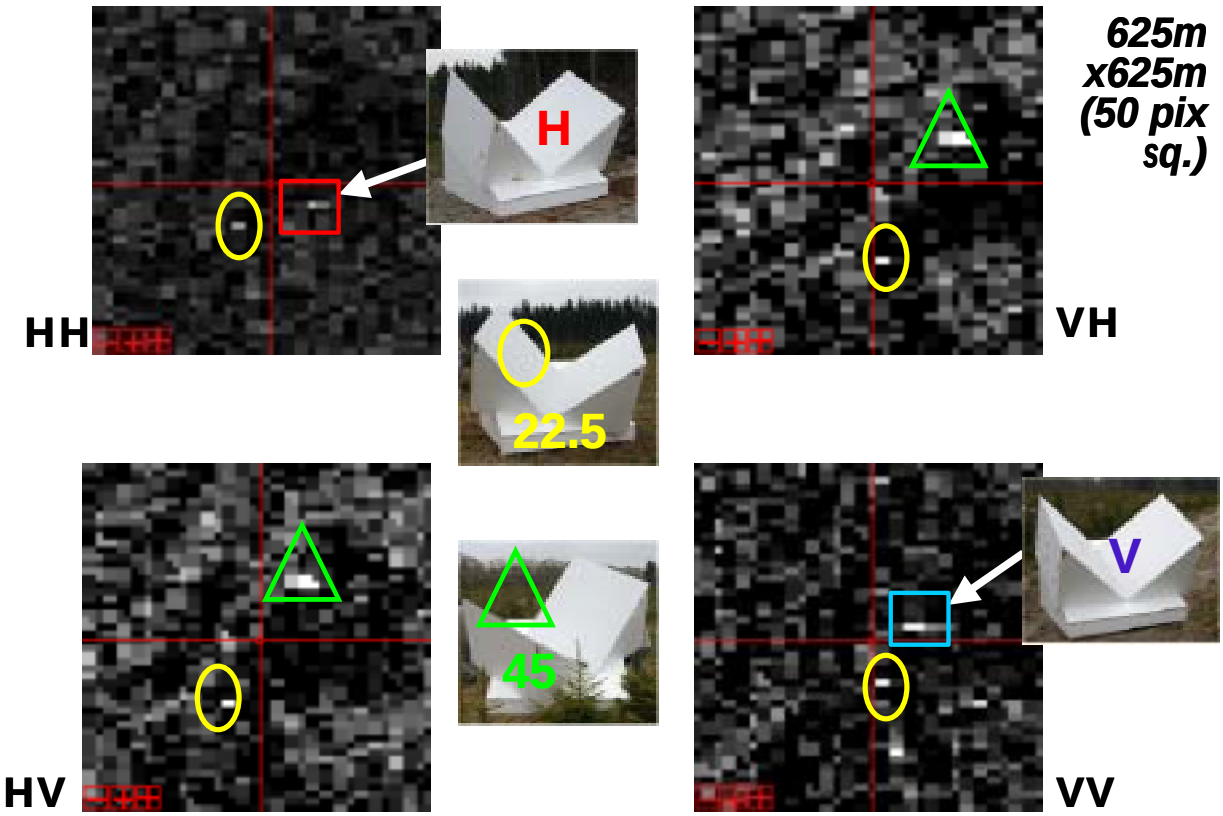


Figure 3: Example of PALSAR images of dihedrals.

Acknowledgments

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