Sate of art of Radar Polarimetry and its potential

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1 Introduction

The radar technology which uses the polarization of electromagnetic wave is radar polarimetry. Radar polarimetry requires more complicated radar hardware compared to the conventional single polarization radar system, however, it provide us much more rich information. Recently, new polarimetric radar sensors such as ALOS/PALSAR are available, and we are now working for applications of this new technology.

2 Polarimetric SAR

Japan has launched Earth observation satellite ALOS in 2006, which is equipped with Polarimetric Synthetic Aperture Radar PALSAR. PALSAR is a full-polarimetric SAR in L-band (23 cm wave length). In 2007, two full-polarimetric SAR sensors including TerraSAR (X-band, Germany) and RADARSAT-2 (C-band, Canada) started operation. C-band SAR ENVISAT has started its operation in 2002, which has limited polarization function.

SAR is not affected by weather condition, and SAR interferometry is available by using single-polarization SAR such as JERS-1 and ERS-1,2, therefore, its technology has been widely accepted since 1990s. SAR interferometry has great potential in applications such as disaster prevention and precise observation of ground surface displacement.

Until recently, any polarimetric sensors were not available, and its applications have not been widely understood. The new polarimetric SAR sensors will change the situation soon.

3 Radar Polarimetry

Radar polarimetry sensors measure not only the amplitude of the scattered wave, but it measures much more information of the targets. Electromagnetic wave is a vector field, and it contains information of the 3-dimentional objects, which scattered the wave. Scattering of wave can be described by a scattering matrix, which is a 4x4 complex matrix, and the radar cross section, which was used in conventional radar analysis, is only one real value of this matrix.

There are many ways to use radar polarimetric information. We discuss here about the frequency bandwidth and quantitative evaluation. Any practical radar system has limitation in its operation frequency bandwidth. The scattering is dependent on the frequency, therefore, we also have to select the operation frequency. Wave propagation material is normally suffered from strong attenuation, and the operation frequency must be low, which is the case in Ground Penetrating Radar. In these cases, the radar resolution is poor, due to the limitation of the frequency bandwidth. However, in radar polarimetry, we can get information about the scattering target without having the precise image of the targets. In addition, radar polarimetry can use new information, such as phase information included in the scattering matrix. We have used the difference of the right-hand and Left-hand circular polarization wave, which gives us the azimuth orientation angle information of the scattering objects. This is one of the examples of quantitative interpretation of SAR data, which could not be achieved by conventional single-polarization SAR.

4 Application of Radar Polarimetry

We are developing a ground-based SAR (GB-SAR) system, which can be used in fixed ground position. WE think GB-SAR can be used for calibration of airborne and space borne SAR sensors. In addition, GB-AR can be used for long-term observation of fixed targets. We are now applying this technology to ground surface moisture or tree evaluation. We believe these researches also develop further applications of polarimetric SAR.