CALIBRATION ACCURRACY ENHANCEMENT IN THE FIELD EXPERIMENT WITH A GROUND-BASED SCATTEROMETER

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1. INTRODUCTION

HPS (Hongik Polarimetric Scatterometer) was, at first, developed as an L-band scatterometer system for soil moisture estimation and backscattering coefficient measurement of many different kinds of distributed targets [1]. Now we are going to extend its capability for multi-band operations at L-, C-, and X-bands, because it is increasingly required to develop scattering and inversion models for the various satellite SAR systems at those frequency bands. Especially we focus on the X-band (9.65GHz) system in this study. In order to operate HPS system at X-band, we designed an additional active sub-circuit which consists of a frequency-conversion part, a polarization-switch part, an amplification part, and a power supply part. It's different from the L- and C-band HPS systems which do not have any additional active circuit. The X-band system needs more prudent calibration work [2-5] and precise evaluation. In this paper, we present the calibration work for field experiments and the evaluation method for their accuracy. The accuracy of the system calibration under outdoor field-condition is dependent on the precise measurement of a calibration target such as a metal sphere, a metal cylinder, and a corner reflector [6]. The calibration accuracy is also affected by various uncertainties over the field environment such as weather or spatial limitation. So, we show an automatic measurement technique with error reduction on target alignments of field measurements, using the so-called '2-D target scanning technique', and also using the user-friendly field-evaluation method. The whole procedure for calibration and evaluation is automated to minimize a user-dependent variation and adopted the Graphic User Interface (GUI) to reduce its complexity.

2. MEASUREMENTS

The ground-based HPS system at X-band consists of an automatic vector network analyzer, an X-band sub-circuit, an orthogonal mode transducer (OMT), a horn antenna, an 8-m boom structure, an antenna support, and two step-motors for controlling incidence angles in θ-, Φ- directions. The polarimetric data for system calibration can be obtained with the '2-D target scanning technique' using an incident angle control of the HPS system. The data can be used to make a good alignment between antenna and a calibration target even in bad field-condition. The field-calibration procedure is as follows: *1) After making an alignment between them by human eyes, 2) the operator sets up the scan range in θ-, and Φ- directions; e.g., if the scan range of ±3° is set, the total number of measurements is 7×7=49 points. 3) The automatic target scanning is started at the designated points on 2-D plane perpendicular to the bore-sight. 4) Then, the operator can select the data at bore-sight with a resolution and an error range of 1° and ±0.2°, respectively, for both θ-, Φ- directions.* Also, the measured polarimetric data can be visualized to 3D charts and easy to find the bore-sight data. This procedure for measuring a calibration target is automated, so that it minimizes the human-error. In order to verify this automatic '2-D target scanning technique', the polarimetric responses of various calibration targets are examined by using several different kinds of calibration techniques such as the STCT (single target calibration technique) [2] and the GCT (general calibration technique) [3]. We could obtain a precise target-alignment using this technique and also validate the technique by the comparison of the theoretical co-polarized phase difference (φ_{hh}- φ_{vv}).

3. EVALUATION OF CALIBRATION ACCURRACY

The calibration accuracy of most scatterometer systems is dependants on the precise field-measurement of a calibration target, which mainly depends on the human error of the scatterometer operator. For a precise measurement, we'd better use a specific technique, so-called '2-D target scanning technique', instead of using only operator's eyes. This automatic technique needs the 2-D polarimetric response of a calibration target. In other words, we use the plural polarimetric responses measured repetitively under the different conditions (especially different angles) to analyze the correlation of the distortion matrix for the HPS system. For this technique we mainly use the distortion matrix which has been denoted as [D] in [2] and [R], [T] in [3]. For example, the distortion matrix $[D_n]$ which is obtained by n-th measurement can be compared with the previously obtained distortion matrix $[D_{n-1}]$ with the analysis of the correlation between them. Then, the scatterometer operator can easily judge whether the correlation between $[D_n]$ and $[D_{n-1}]$ is converging into a specified condition (e.g., within 5%). After the automated data collection on the iterative measurements of a calibration target such as a metal sphere and the comparison of those distortion matrices, we can easily find a precise field-data for the calibration target. Even if the proposed measurement and evaluation procedures require more time to the operator for obtaining the multiple polarimetric data with the '2-D target scanning technique', it is necessary to use these procedure to reduce the calibration error. This enhanced calibration technique has been automated so that the operator can follow the procedure without difficulty. We obtained the precise backscattering coefficients of various distributed targets using the precisely determined distortion matrix with the enhanced field-calibration method.

4. CONCLUDING REMARKS

An enhanced field calibration measurement technique has been introduced in this paper. The '2-D target scanning technique' has been used to reduce the positioning-error in the alignment between an antenna and a calibration target. The automatic evaluation of the distortion matrices has also been introduced to give more efficient calibration procedure for a ground-based scatterometer system for field experiments. The automatic measurement and evaluation procedure will give a help to increase an accuracy of the calibration process in the field-measurements with a ground-based scatterometer, as well as the HPS system.

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