Application of adaptive beamforming to Dual Polarization Phased Array Weather Radar

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Abstract

The dual polarization phased array weather radar (Multi Parameter Phased Array Radar; MP-PAWR) at Saitama University has a strong point of the existing single polarization phased array weather radar (PAWR) and a dual polarization radar [1-2]. The PAWR has a rapid scanning rate and is capable of high-density observations in elevation; it produces approximately one hundred plan position indicator radar images with a 60 km range, at different elevation angles, in less than 30 seconds. The PAWR uses a fan-shaped beam with a narrow beamwidth (1.2 deg) in azimuth and a wider beamwidth (from 5.0 deg to 10 deg) in elevation. Dual polarization radar transmits horizontal and vertical pulse and provides measurement of the horizontal and vertical dimensions of target. Using two type of received signal, differential reflectivity (ZDR), Polarization correlation coefficient (ρ hv), and specific differential phase (KDP) are available. As a result it makes measurement of precipitation more accurately.

With digital beamforming (DBF), the elevation beamwidth can be reduced to 0.8 deg, using 112 antenna elements of the MP-PAWR. Although the fan-shaped beam is useful for rapid scanning, the received signals tend to be affected by ground clutter. The MP-PAWR is now adapted Fourier beamforming (FR), which is one of the most conventional beamforming method. However, the FR beamforming determines an antenna pattern uniformly and uniquely and increase sidelobe level due to the position of the antenna elements. If there were ground clutters in the low elevation angles, such as building or strong precipitations, it’ s difficult to observe precipitation correctly because of occurring incorrect echo around clutters or precipitation field. In order to solve this problem, an adaptive DBF method optimizing antenna pattern depending on shape of precipitation particle or whether there are clutters in observation area is considered. In this work, we applied the adaptive beamforming based on the minimum mean square error (MMSE) to the MP-PAWR to reduce the effect of ground clutters. The adaptive beamforming methods works well to reduce the ground clutter echoes using the numerical simulations [3].

The adaptive DBF method, which is referred as ‘MMSE method’, was used for the real measurement data of the MP-PAWR. However, MMSE method could not reduce the effect of the ground clutters for the real measurement data. The array output power estimated by the adaptive DBF method causes a large errors (over estimations) when the position and phase error of each antenna element are occurred [1]. To reduce the phase errors, we proposed the phase error correction method using the received signals from the ground clutters. When the antenna elements receive a plane wave from an arbitrary direction, the phase difference between adjacent channels should be a fixed value. Using these characteristics, the phase errors of the each element were corrected.

After the phase correction, we achieved to reduce the effect of the ground clutters. Comparison with FR method, the echo of the ground clutter is suppressed about 23 dB in the elevation angles from 5 deg to 10 deg. From the result of the correlation coefficient, which is one of the dual polarization parameters, the estimation result is significantly improved. Now we are working to discuss the effectiveness of the dual polarization parameters. In this presentation, we will present the advantage and disadvantages of the adaptive beamforming method for a dual polarization phased array radar.

References

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