Doppler Spectrum Estimation based on MMSE

*Naoya Takizawa[1], Hiroshi Kikuchi[1], Tomoaki Mega[1], Eiichi Yoshikawa[2], Tomoo Ushio[1]

1. Tokyo Metropolitan University, 2. Japan Aerospace Exploration Agency

The first Japanese Phased Array Weather Radar (PAWR) is installed at Osaka University, Suita campus in 2012. The PAWR is an X-band one-dimensional phased array radar which can perform a full volume scan of reflectivity and Doppler velocity at a range resolution of 100m in 30 seconds [1]. The PAWR observation is performed at urban area such as Osaka and Kobe. Therefore, the strong echoes from tall buildings are significant problem with the PAWR observation. Since the PAWR measurements at low elevations are heavily affected by ground clutter, many methods for filtering ground clutter have been proposed and utilized as a standard function of a weather radar [2], [3]. These filtering methods essentially filter around-zero velocity components, resulting in non-zero components corresponding to precipitation can be extracted. However, in a case of observing a low elevation which frequently includes strong ground clutter, the non-zero components of precipitation is not detectable due to clutter sidelobes.

We propose an Doppler spectrum estimation method via minimum mean square error (MMSE) to obtain the practically useful precipitation signals at a low elevation by suppressing clutter sidelobes. non-zero components of precipitation becomes detectable by reducing sidelobes due to around-zero components of ground clutter. A significant feature of this research is that the proposed method can be applied instead of the Fourier method which is the most conventional method to estimate Doppler spectrum. Therefore, any existing ground clutter filtering methods can be applied to a sidelobe-less Doppler spectrum calculated by the proposed method. In the sidelobe-less Doppler spectrum, ground clutter appears sharper than one by the Fourier method, and is easier to be eliminated by any existing filtering methods. To verify the effectiveness of the MMSE method, we applied it to the real measurement data with the PAWR. In comparison to Fast Fourier Transform (FFT) method, which is a conventional method, The MMSE method eliminated the ground clutter echoes existing at a low elevation angles more effectively.

[1]Juan J. Ruiz, Takemasa Miyoshi, Shinsuke Satoh, and Tomoo Ushio, A Quality Control Algorithm for the Osaka Phased Array Weather Radar. SOLA, vol 11, pp. 48-52, 2015

[2] R. J. Doviak and D. S. Zrnic, Doppler Radar and Weather Observations. San Diego, CA: Academic, 1993,

[3] A. D. Siggia, and R. E. Passarelli, Jr., Gaussian Model Adaptive Processing (GMAP) for Improved Ground Clutter Cancellation and Moment Calculation. ERAD 2004.

Keywords: Phased Array Weather Radar, ground clutter, Doppler Spectrum

