Rain Attenuation Correction of Reflectivity for X-Band Dual-Polarization Radar

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1. INTRODUCTION

Comparing with the conventional Doppler weather radar, dual-polarization radars can measure more valuable polarized information of precipitation system. Previous studies on the application of dual-polarization radars are mostly designed for S, C-band radars. The researches about X-band dual-polarization radars are limited, since X-band radars have severe attenuation comparing to S, C-band radars. However, due to low cost, small antennas, easy mobility and high temporal and spatial resolution, X-band dual-polarization radars have become an important detection equipment in the areas of cloud and precipitation physics, and weather modification. In order to improve the performance of X-band dual-polarization radars, the attenuation needs to be corrected before application.

2. METHODOLOGY

This paper proposes a high-resolution Slide Self-Consistency Correction (SSCC) method. This method is an improvement of Kim et al. (2010), which is based on the method of Bringi et al. (2001). Figure 1 shows the schematic diagram of the SSCC method.

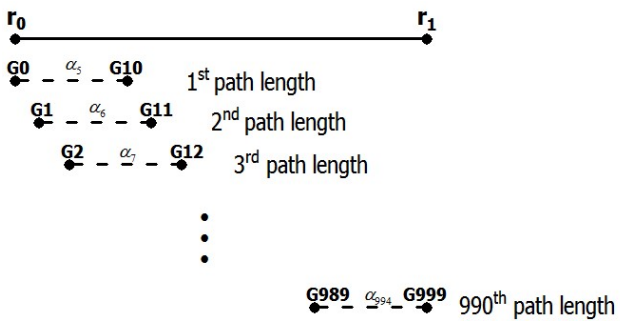

Figure 1. The schematic diagram of the SSCC method, assuming $\alpha_i = 0$ (i = 0~4; 995~999)

The SSCC method employs a slide window processing shown in Figure 1 by setting the distance between r_0 and r_1 as 1.5km (10 gates), thus α has a high-resolution of 0.15km, improving the resolution of α estimation. The corrected reflectivity using the SSCC method is compared with the intrinsic reflectivity at X-band. However, the intrinsic reflectivity at X-band is not equal to the reflectivity at S-band. Chandrasekar et al. (2006) proposed three different methodologies for obtaining the intrinsic reflectivity at X-band from the S-band radar reflectivity and the empirical conversion method is used in the paper. Figure 2 shows a plot of the intrinsic reflectivity at X and S bands for a monodispersed drop size distribution using the shape mode proposed by Beard and Chuang (1987). The relationship between the intrinsic reflectivity at X-band and the reflectivity at S-band is obtained by curve fitting, which is divided into three parts as shown where subscripts X and S indicate the simulated reflectivity at X-band and the measured reflectivity at S-band.

$$Z_{H,X} = \begin{cases} 0.9696Z_{H,S} - 0.0145 & Z_{H,S} \le 25dBZ \\ 1.1982Z_{H,S} - 5.7726 & 25dBZ < Z_{H,S} < 45dBZ \\ 0.8206Z_{H,S} + 11.7934 & Z_{H,S} \ge 45dBZ \end{cases}$$

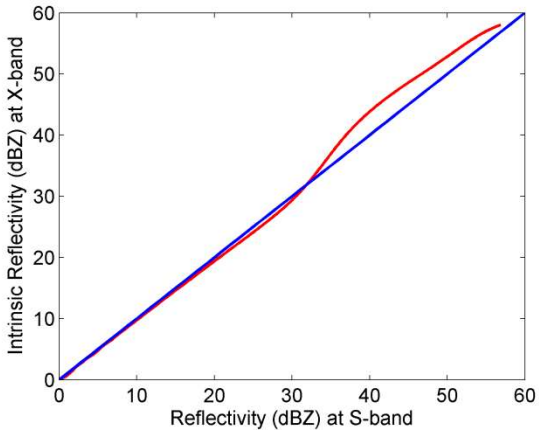

Figure 2. Scattering simulation of the intrinsic reflectivity at X and S bands. The blue line stands for the intrinsic reflectivity at X-band is equal to the reflectivity at S-band. The red curve is obtained by scattering simulation.

3. RESULTS

The new method is comprehensively evaluated with the reflectivity of convective cloud, stratiform cloud, and the stratiform cloud with embedded convection, which are all observed in June 2015 in Beijing.

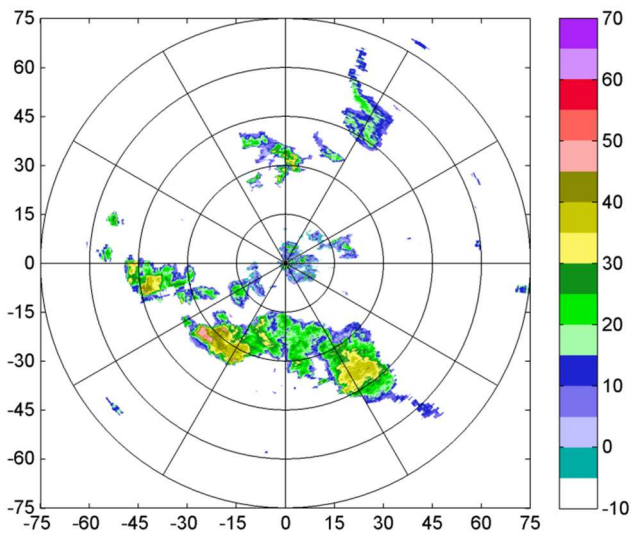

Figure 3. Original reflectivity at X-band for convective cloud on 19 June 2015. The color unit is dBZ, as the same in the following pictures.

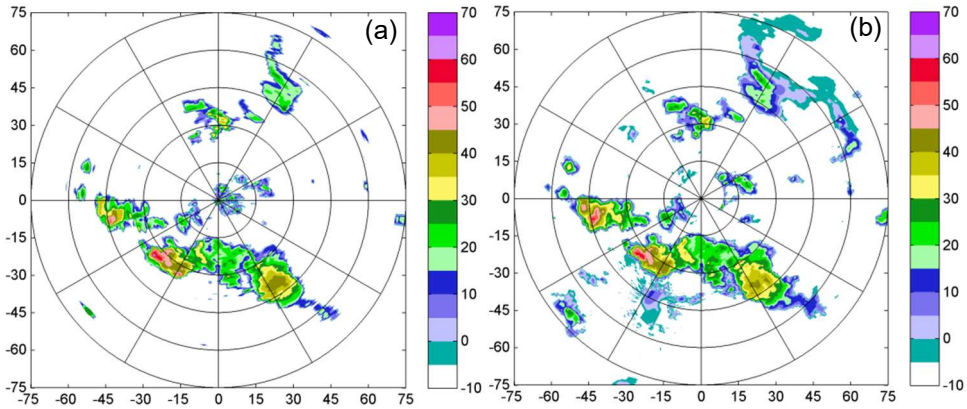

Figure 4. (**a**) Corrected reflectivity at X-band; (**b**) the intrinsic reflectivity at X-band.

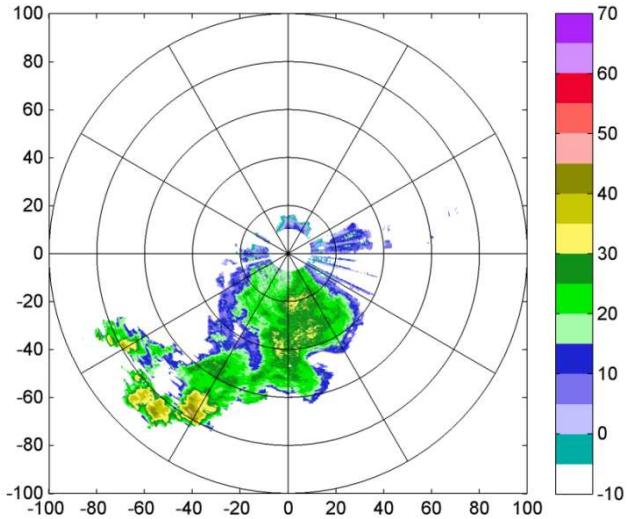

Figure 5. Original reflectivity at X-band for the stratiform cloud with embedded convection on 26 June 2015.

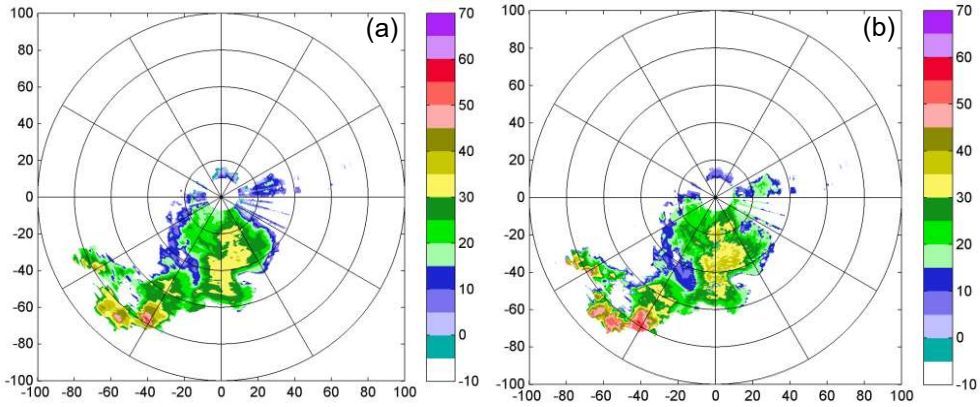

Figure 6. (**a**) Corrected reflectivity at X-band; (**b**) the intrinsic reflectivity at X-band.

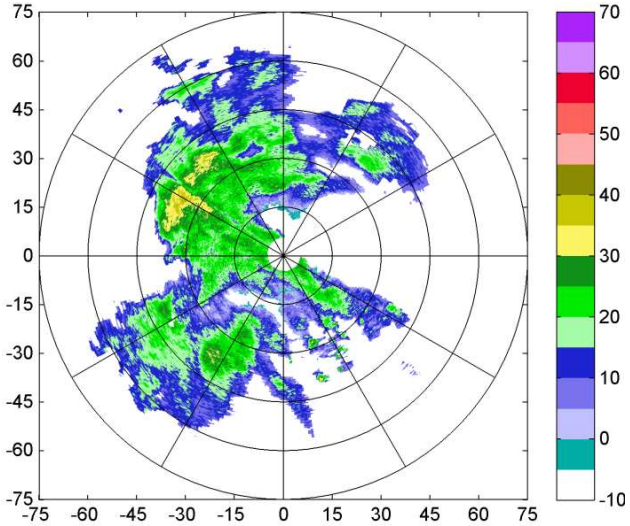

Figure 7. Original reflectivity at X-band for the stratiform cloud on 16 June 2015.

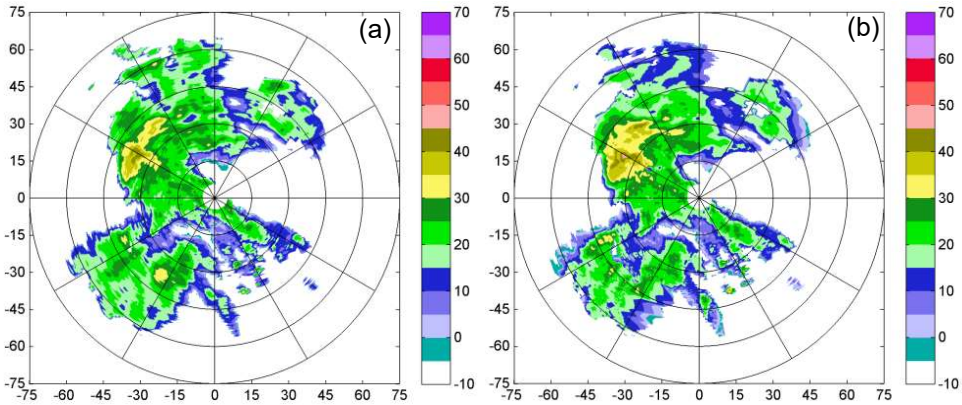

Figure 8. (**a**) Corrected reflectivity at X-band; (**b**) the intrinsic reflectivity at X-band.

Comparing with the intrinsic reflectivity at X-band, it is found that the new method can effectively correct the X-band dual-polarization radar reflectivity. To accurately retrieve meteorological products, a resolution of 1dB for the reflectivity is necessary. Figure 9b shows that there are more than 1dB differences between the Kim and SSCC from 35dBZ, illustrating that the SSCC method has a better performance than Kim et al.'s method at correcting convective cloud, especially with reflectivity greater than 35dBZ.

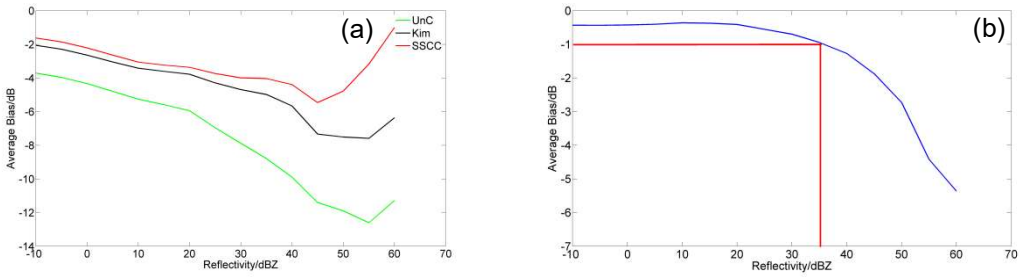

Figure 9. Average biases of the reflectivity for convective cloud. (**a**) The Average Bias (AB) of the uncorrected reflectivity (UnC), the reflectivity corrected by Kim et al.'s method (Kim) and the reflectivity corrected by the SSCC (SSCC); (**b**) the AB of the difference between the Kim and the SSCC.

4. CONCLUSIONS

Based on Bringi et al. (2001), the paper proposed a high-resolution Slide Self-Consistency Correction (SSCC) method for the X-band dual-polarization radar reflectivity. The SSCC method has two important advantages as follows:

1. Improving the correction resolution;
2. Having an excellent performance at correcting convective cloud.

In summary, the reflectivity of the X-band dual-polarization radar can be corrected effectively and accurately by the SSCC method.

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