P112 Test of Attenuation-based QPE Methodology Using Polarimetric Upgraded WSR-88D Radars

Pengfei Zhang, Alexander Ryzhkov

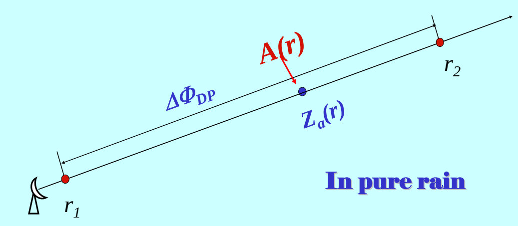
CIMMS, University of Oklahoma, Norman, Oklahoma

NOAA/National Severe Storms Laboratory, Norman, Oklahoma

Introduction

In spring 2013 all 122 NWS WSR-88D radars have been upgraded by adding dual-polarization capability. The improvement of quantitative precipitation estimation (QPE) with dual-polarization measurements is one of the primary goals of the upgrade. In addition to radar reflectivity, differential reflectivity, and specific differential phase, the specific attenuation A emerges as a promising variable for a more accurate QPE. The specific attenuation can be reliably estimated by a polarimetric radar from the combinations of the measurements of radar reflectivity and total differential phase. The advantages of the R(A) estimator of rain rate R include its low sensitivity to DSD variability and immunity to partial beam blockage, radar miscalibration, and impact of wet radome. Dual-polarimetric observations by several upgraded WSR-88D radars are utilized to examine the performance of R(A). The results of observations confirm all mentioned benefits of the R(A) technique. To validate the accuracy of R(A) estimate under different atmospheric conditions, the R(A) rainfall accumulations have been obtained for the events with different precipitation types and compared with rain gauge measurements. The results are promising, especially in the areas affected by partial blockage of the radar beam.

Methodology



In pure rain

Specific Attenuation:

$$A(r)=\frac{[Z_a(r)]^b f(\Delta\Phi_{DP})}{I(r_1,r_2)+f(\Delta\Phi_{DP})I(r,r_2)}$$

$$f(\Delta\Phi_{DP})=\exp(0.23\alpha b\Delta\Phi_{DP})-1$$

$$I(r_1,r_2)=0.46b\int_{r_1}^{r_2}[Z(s)]^b ds$$

$$I(r,r_2)=0.46b\int_{r}^{r_2}[Z(s)]^b ds$$

$b=0.72$

Rain Rate:

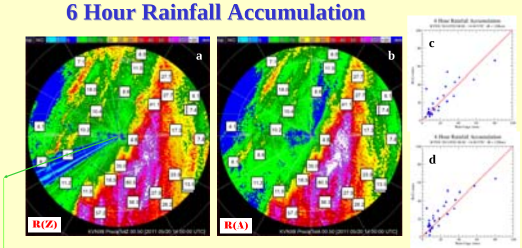
$$R(A)=4.12*10^3 A^{1.03}$$

T=20°C

$$R(Z)=1.69*10^{-2} Z^{0.717}$$

Radar QPE *vs.* Rain Gauges

6 Hour Rainfall Accumulation



00:80 – 14:00 UTC	*Correlation*	*Bias Ratio*	*FRMSE*	*MFRMSE*
R(A)	0.849	1.059	0.471	0.218
R(Z)	0.869	1.200	0.476	0.246

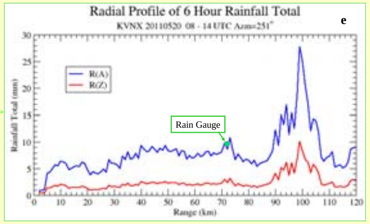
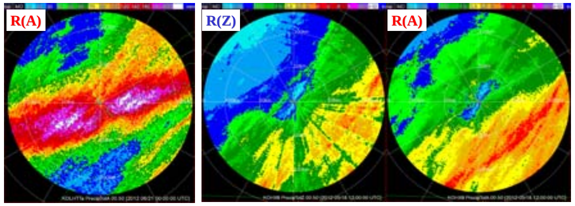


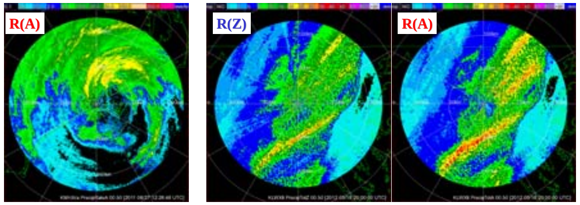
Fig.1 A 6-hour rainfall accumulation estimated based on the measurements of KVNX between 08:00 and 14:00 UTC on 20 May 2010 using R(Z) (Fig.1a) and R(A) (Fig.1b). Rain gauge measurements in this time period are overlapped (Fig.1a and b). The scatterplots of rain gauges *vs.* radar QPE are shown in Fig. 1c and d. The statistics of the comparison are listed below in the Table. The immunity of R(A) estimator to beam blockage is illustrated by the radial profile of 6 hour rainfall total in the azimuth of 251° where the radar beam is partially blocked (Fig.1e). The green dot at range of 72 km represents the rain gauge measurement coincident with the R(A) estimation (blue line), but rainfall total using R(Z) (red line) is lower due to partial beam blockage near the radar.

24 Hour Rainfall Total



KDLH: Duluth, MN KOHX: Nashville, TN

Rain Rate / 2 Hour Rainfall Total



KMHX: Morehead City, NC KLWX: Sterling, VA

Networking

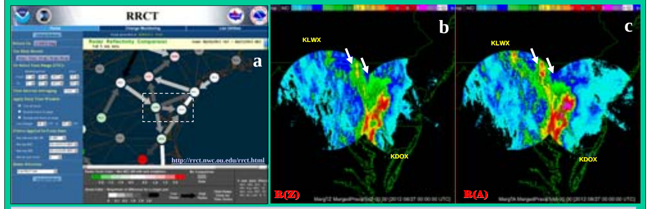


Fig. 2 Automatic cross-comparison of radar reflectivities measured by neighboring WSR-88D radars is provided by the NSSL Multi-Radar/Multi-Sensor QPE (MRMS) system. An example of such product for several WSR-88D radars is shown in Fig.2a. A 6-hour period comparison from 18:00 to 23:59 UTC on 26 August 2012 is made when a rain band moved through the domain. The data show that KLWX is "colder" by about 0.5 dB than KDOX (Fig.2a). This reflectivity calibration difference is clearly shown (marked with white arrows) in the 6 hour rainfall total estimation using convective R(Z) relation (Fig.2b). R(A) rainfall totals obtained from the two radars are much more consistent and there is no discontinuity along the equidistant line (Fig. 2c). This demonstrates obvious benefit of the R(A) methodology to provide seamless composite products because specific attenuation A is immune to radar miscalibration.

Conclusion

Although the R(*A*) method may fail in hail region and its accuracy may be affected by precipitation type or atmospheric temperature, compared with the existing dual polarimetric QPE estimators based on Z, Z_{DR}, and K_{DP}, the R(*A*) estimator has advantages being immune to radar miscalibration, partial beam blockage, attenuation, and wet radome as many case studies indicate. The method only requires the radial profile of measured reflectivity and total span of differential phase along a radar beam in pure rain environment. This method is also applicable for C and X band dual polarimetric radars.

Acknowledgment

The research was supported by NOAA/Office of Oceanic and Atmospheric Research under NOAA-University of Oklahoma Cooperative Agreement #NA11OAR4320072, U.S. Department of Commerce and by the U.S. National Weather Service, Federal Aviation Administration, and U.S. Department of Defense program for modernization of NEXRAD radars.