Evaluation of Rainfall Rate Estimated by Specific Differential Phase of Ku-band Broadband Radar

*Keitaro Asai[1], Yoshitaka Nakamura[1], Eiichi Yoshikawa[2], Hiroshi Kikuchi[3], Tomoaki Mega[4], Tomoo Ushio[4], Takeshi Morimoto[5]

1. Kobe City College of Technology, 2. Japan Aerospace Exploration Agency, 3. The University of Electro-Communications, 4. Tokyo Metropolitan Univ., 5. Kindai Univ.

Severe weather caused by cumulonimbus clouds that develop locally both in time and space can cause a lot of damage on human lives. To reduce the damage, cumulonimbus clouds must be detected early by weather radars with high spatial resolution, and their warnings should be issued. A Ku-band broadband radar (Ku-BBR) was developed to achieve such high spatiotemporal resolution by applying pulse compression technique. The Ku-BBR observes with range resolution of several meters in a range of 20 km and scans whole sky with 30 elevation angles in 1 min [1][2]. A radar network consisting of three Ku-BBRs was later deployed to realize more frequent and more accurate observations [3].Furthermore, one of the Ku-BBRs had been updated to have dual polarization observation function (hereinafter, referred to as Dual-pol Ku-BBR) in order to verify effectiveness of polarization measurements at Ku-band and with the high-range resolution [4]. In contrast to many dual-polarization radars at X band existing, it is known that influence of rainfall rate is more likely appear in the polarization measurements at Ku band than those at X band.

In this study, the specific differential phase (Kdp) obtained by the Dual-pol Ku-BBR was evaluated by comparing to the disdrometer. At first, the measured PHIdp were screened by a quality control. From the relationship between the signal-to-noise ratio (SNR) and the standard deviation of PHIdp, the standard deviation of PHIdp tends to increase as the SNR decreases. Particularly, they sharply rise when the SNR decreasing from 15 dB. Therefore, range gates with SNRs which are less or equal to 15 dB were excluded from the analysis. Figure 1 shows the comparison with the disdrometer installed 6.4km displaced from the Dual-pol Ku-BBR. When a SNR was more than 15 dB, the rainfall rate estimated by the Dual-pol Ku-BBR were consistent with the disdrometer with a bias within 2.0 mm/h. In addition, a regression analysis results in its gradient of 0.98, bias of 1.64 mm/h, and correlation coefficient of 0.61.

In the presentation, we will provide the details of the observation experiments and the above comparison and verification, including the hardware and software of Dual-pol Ku-BBR.

[1] T. Mega, K. Monden, T. Ushio, K. Okamoto, Z. Kawasaki, and T. Morimoto, “A Low-Power High-Resolution Broad-Band Radar Using a Pulse Compression Technique for Meteorological Application”, IEEE Geoscience and Remote Sensing Letters, Vol.4, no. 3, pp. 392–396, 2007.

[2] E. Yoshikawa, T. Mega, S. Yoshida, T. Morimoto, T. Ushio, Z. Kawasaki, K. Imai and S. Nagayama, “Development and Initial observation of High-Resolution Volume Scanning Radar for Meteorological Application”, IEEE Transactions on Geoscience and Remote Sensing, vol. 48, no. 8, pp. 3225–3235, 2010.

[3] E. Yoshikawa, T. Ushio, Z. Kawasaki, and V. Chandrasekar, “Dual-Directional Radar Observation for

Preliminary Assessment of the Ku-Band Broadband Radar Network”, Journal of Atmospheric and Oceanic Technology, vol. 29, no. 12, pp. 1757–1768, 2012.

[4] E. Yoshikawa, T. Ushio, Y. Nakamura, and K. Asai, “Ku-band Small Weather Radar with Wide-band and Dual-Polarization Transmission,” International Workshop on Small Weather Radars, Colorado State University, Fort Collins, CO, 2018.

Keywords: Specific Differential Phase, Broadband Radar, Polarization Observation

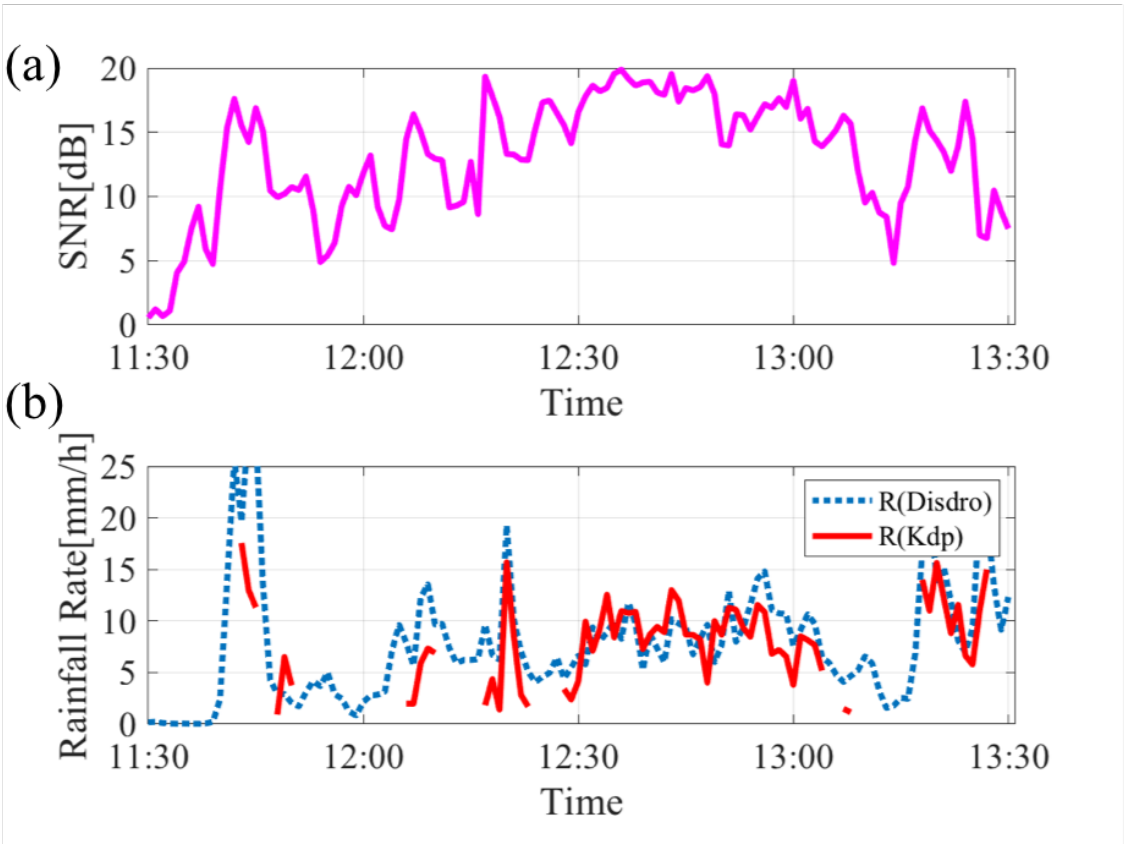

Fig.1 (a) SNR measurement directly above the disdrometer by the Dual pol Ku-BBR on May 13, 2018. (b) Rainfall rate measurements by Dual pol Ku-BBR and the disdrometer on May 13, 2018.