Use of a Micro Rain Radar (MRR) for Measurements of Rain Drop Sizes and Quantitative Estimation Precipitation in Mountain Area

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Introduction and Contents

Observation of Drop Size Distribution (DSD) of precipitation included in clouds and that of reflectivity by precipitation altitude are very important in order to understand development of clouds and conduct Quantitative Precipitation Estimation (QPE). They are also considered as observation data that can help explain physical characteristics of precipitation observed on the ground and in the air. However, few studies have been conducted through the use of these observation data in Korea. In fact, DSD in relation to precipitation by altitude and reflectivity by altitude are considered as the most important information with regard to estimation of quantitative precipitation. It is due to the fact that it helps accurately figure out characteristics of precipitation within clouds and detect estimation errors in radar rain rate. In particular, as the QPE accuracy of precipitation is determined according to how accurately relationships between reflectivity (Z) and rain rate (R) that aim to estimate relationships between precipitation and reflectivity can be explained, it is necessary to take account of rain drop sizes and reflectivity by altitude, which leads to help explain variability of the DSD. In this regard, the study analyzed observation data from Micro Rain Radar (hereafter referred to as MRR), a remotely controlled rain observation device, in an effort to understand physical characteristics of clouds and precipitation, and the MRR data were used to estimate quantitative precipitation. Daegwalryeong (37°41'N, 128°45'E, 843 m ASL, mountain area) was selected to observe rain drop sizes and estimate quantitative precipitation in the mountain area.

The MRR in the Daegwallyeong Cloud Physics Observation Center is an MRR-2 model, which is FM-CW radar that modulates medium frequencies of 1.5-15 MHz into the radiofrequency of 24 GHz to continuously radiate a non-pulsed electromagnetic wave. The emitted signal is scattered back by the meteorologically meaningful targets, e.g., raindrop particles, and is received again by the antenna. Accordingly, diverse data, including the radar reflectivity of the raindrop particles and PSDs, can be obtained. Assuming Rayleigh scattering with particles smaller than the wavelength with the MRR-2, the area formed by the backscattering of the particles is directly proportional to the particle size to the 6th power. The spectrum power is calculated using the backscattering section area per volume and radar constant. Because the radar module of the MRR-2 is not in the pulse mode, the height of the target cannot be calculated using the difference between the pulse transmission time and the echo reception time. Therefore, the height of the target can be calculated by modulating the frequency of the electromagnetic wave transmitted from the MRR-2 into a linearly attenuated form and calculating its difference from the echo reflected from the target. The rain DSD by height is calculated from the terminal velocity of the particles and the backscattered section area.

The MRR is an FM-CW Doppler radar that uses a 24GHz electromagnetic wave. It calculates the DSD and the vertical profile of 30 layers such as the rain intensity and the water content derived from the DSD. The observation sensitivity is -10 dBZ/km, which corresponds to the rain intensity of 0.01 mm/h. The tipping-bucket rain gauge can detect a small amount of precipitation that is difficult to measure. The observer can select the observation time interval from 10 s to 3,600 s, and the observed height resolution can be selected from 10 to 200 m. The two-way parabolic antenna has a diameter of 0.6-0.7 m and an effective angle of 2°. Because the vertical speed of the particles can be measured using the MRR, the occurrence of the ascending current can also be identified.

(a) Purpose: Observation of the particle size in the precipitation cloud and of the falling speed and vertical distribution of the water content using the microwave radar reflectivity
(b) Measurement parameters: Particle falling speed, water content, and vertical particle size distribution
(c) Particle size: Raindrop (g) per 50 m^3
(d) Measurement wavelength threshold: 24 GHZ (K-band)
(e) Measurement interval and accuracy: 10 s average and 0.01 mm/h
(f) Height resolution: 10-200 m

Generally speaking, this study consists of two parts. First, it examined characteristics of the MRR data and verified the MRR data based on comparison between ground rain gauge data and S-band single-polarization radar data. Second, it estimated quantitative precipitation through the use of the MRR data. This study aimed to examine the efficiency of the MRR data and accurately estimate radar rain rate.

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