Comparison of Vertical Velocities in Ice Clouds from Millimeter-Wavelength Radar Measurements

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Ice clouds are a major factor of the Earth’s radiation equilibrium that reflects and absorbs solar radiation. Especially, the estimation of microphysical parameter and dynamic analysis of ice clouds using ground-based cloud radar measurements have been performed (Delanoë et al. 2007; Kalesse and Kollias 2013). Protat and Williams (2011) proposed a technique for calculating the falling velocity and vertical air velocity by classifying ice clouds into four types. The purpose of this study is to analyze the characteristics of reflectivity and Doppler velocity according to the type of ice clouds and to derive the relationship between reflectivity and terminal fall velocity.

To analyze the characteristics of the ice clouds, we classified the type of ice clouds into a cirrus cloud, precipitation cloud, and anvil cloud (Feng et al. 2011; Protat and Williams 2011). The data of ice clouds include 19 cases (309 hours) of cirrus, 6 cases (90 hours) of precipitation cloud, and 9 cases (36.5 hours) of anvil cloud from June 2014 to October 2015. The observed Doppler velocity is the sum of the terminal fall velocity (Vt) of ice particles and the vertical air velocity (Vair). Since the Vair can be neglected when Doppler velocity is averaged over a certain time, the relationships of reflectivity and terminal fall velocity according to the type of ice clouds are directly derived from observed reflectivity and Doppler velocity.

The average time of radar moments was tested at 5, 10, 20, and 30 minutes. The coefficients (a) and the exponents (b) of the relationship derived from 20-minute average were compared for ice cloud types. The result of the relationship of cirrus cloud was a=0.65±0.43, b=0.03±0.19 and was similar to that of Kalesse et al. (2013). Comparing the averages of a and b between the precipitation cloud and the anvil cloud, the a of precipitation was 1.07, which was larger than the anvil (0.75). The b of precipitation was 0.12 and less than the anvil (0.16). The differences of the coefficients and exponents according to the type of ice clouds were due to the different microphysical mechanism with the ice crystal growth.

Acknowledgments
This research is supported by "Development and application of Cross governmental dual-pol. radar harmonization (WRC-2013-A-1)" project of the Weather Radar Center, Korea Meteorological Administration and supported by the principal project, "Research and Development for Meteorological Service (NIMS-2016-3100)" of the National Institute of Meteorological Sciences of the Korea Meteorological Administration.

Keywords: Vertical velocity, Ice cloud, Millimeter-wavelength radar