The Melting Layer Observation using a Dual Ka-band Radar System

*Kenji Nakamura[1], Yuki Kaneko[2], Katsuhiro Nakagawa[3], Hiroshi Hanado[3], Masanori Nishikawa

1. Dokkyo University, 2. JAXA/EORC, Japan, 3. NICT, Japan

A method and results of a ground-based Ka-band radar observation of melting layers are described.

The core satellite of the Global Precipitation Measurement (GPM) carries two instruments for precipitation measurements, that is, a dual-wavelength radar (DPR) and a GPM microwave radiometer (GMI). The GPM covers the whole globe. In a high latitude region, snow frequently falls. Snow rate or equivalent rain rate measurements by radars are more difficult than rain observations, because snow particles have more complicated characteristics of radio scattering than rain drops. In very cold regions, snow is dry, but in slightly warm regions, wet snows more frequently fall. So, the wet snow observations are essential for measurements of global precipitation. The wet snow, which contains partly melted snow particles, has, however, much more complex characteristics in radiowave scattering than dry snow.

The DPR is a 13.6/35.5 GHz radar system. The 35.5 GHz (Ka-band) is a new one. For the full utilization of the 35 GHz radar, radiowave scattering characteristics of precipitation particles must be well understood. In the Ka-band, attenuation of the radiowave is strong, and conventional Ka-band radar measures only the combination of scattering and attenuation. It is important to separate the effects of scattering and attenuation for precise precipitation measurement using the Ka-band radar. In order to understand the effects of scattering and attenuation separately, a dual Ka-band radar system has been developed by JAXA. This system consists of two identically designed Ka-band radars. When a precipitation system comes between the two radars, the radars observe the precipitation system from opposite directions. The precipitation echoes in the Ka-band suffer from strong rain attenuation. The reduction due to rain attenuation appears symmetrically in both radar echoes. By differentiating averaged two radars' reflectivity with range, the specific attenuation can be estimated. After obtaining the attenuation (k), equivalent radar reflectivity (Ze) is estimated. In the melting layer, specific attenuation and the equivalent radar reflectivity significantly vary along the radio path, and the estimated specific attenuation is very sensitive to the setup configuration of the experiment. The accuracy of the estimated specific attenuation was found to depend on the curvature of the equivalent radar reflectivity, that is, the doubly differentiated value. The accuracy is also limited by natural fluctuation on the precipitation system. The observation has been performed along a mountain slope, and the radio path was near the surface. So, the precipitation system is likely affected by the topography and has a fine structure. In this case, even a small beam mis-matching of the two radars causes significant errors.

On 1 March 2015, a strong melting layer appeared. In this day, a melting layer suddenly appeared at 21:15 JST, and disappeared at about 21:40 JST. After that, the melting layer again appeared at about 21:30 JST. The sudden change of the melting layer was also observed by the micro rain radar. Doppler data also show rapid variation in radial velocity. The meteorological mechanism is not clear but it may be due to the slope wind in the mountain region. Figures (left) shows the Ze and k profiles relative to a reference height in the melting layer. The altitude of the peak of k is slightly higher than that of Ze. To show this fact more clearly, a k-Ze diagram is shown in Figure (right). The data show a loop-shape. This loop-shape appeared in other melting cases, and could be a general characteristic. The reasons of the loop-shape are found due to change of relative permittivity, and change of size of particles. The imaginary part of the permittivity first deceases (more attenuation) followed by increase of the absolute value of the

permittivity, which results in a loop-shape k-Ze relationship. The size of the particle decreases during melting. Combined effects of the changes of the permittivity and size cause the basic loop-shape. At the Ka-band, the Mie effect is significant, but in terms of the loop-shape, the Mie effect only slightly modifies the shape.

Figure:
Averaged k-Ze relationship for data on 1 and 2 March 2015. Left: The profiles of Ze and k relative to the reference height. Right: k-Ze diagram. Dark points are those near the center of the melting layer.

Keywords: DPR/GPM, melting layer