# *Generation of Rain Drops at Cloud Bottom Observed with W-band Cloud Radar FALCON-I*

**Poster2-45** **Microphysical Studies with Radars**

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## 1. INTRODUCTION

Observation of clouds with radars in millimeter wave range is one of the most powerful remote sensing methods to derive information on interior of clouds because the Rayleigh scattering coefficients are proportional to $f^4$ (f = frequency). Therefore, sensitivities for small cloud water/ice particles are much better than those with centimeter wave ranges (Figure 1.). We have developed and are operating a cloud profiling FMCW (Frequency Modulated Continuous Wave) Doppler radar named FALCON-I (FALCON = FMCW Radar for Cloud Observations) at 95GHz.

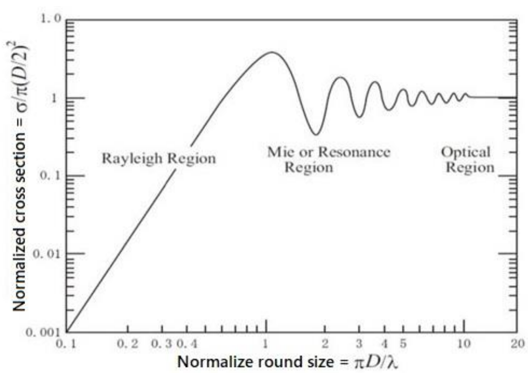


Figure 1. Normalized cross section relative to the normalized round sizes of spherical

## 2. PERFORMANCE OF FALCON-I

FALCON-I is a bistatic antenna system which is usually used for FMCW radar, and consists of two 1m-diameter antennas (Figure 2). We developed this facility by ourselves. It is a mobile on a truck in Japan and also on a vessel on oceans anywhere we need in the world. High spatial resolution of 0.18 degree FWHM and a high range resolution of 50m are realized with the FMCW type radar, which are about 10 times higher than those of normal pulse type radars. FALCON-I has enough sensitivities for faint clouds at high altitude and has high resolution in Doppler measurements.

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Figure 2. Cloud Profiling Doppler Radar FALCON-I. It consists of two 1-m diameter antennas.

## 3. OBSERVATION RESULTS AND DISCUSSION

### 3.1 Intensity map

August 15, 2017, clouds began to appear at an altitude of 6 km around 0:30 UT, and it began to rain on the melting layer around 0:35 UT, and the rain reached to the ground around 1:00 UT (Figure 3.).

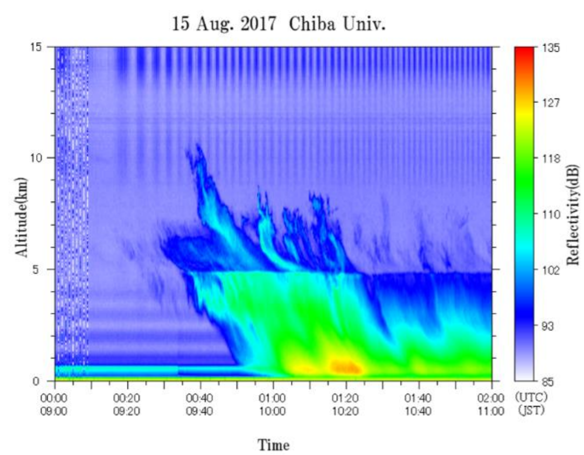


Figure 3. Intensity map of 15 Aug. 2017 obtained with FALCON-I

### 3.2 Doppler spectrul map

The Doppler spectrul map at 0:50:00 UT at the beginning of this rain is shown in Figure 4. There is a cloud in the altitude of 5 to 7 km whose Doppler velocity is -2 to 0 m/s, where, negative Doppler velocities indicate downward. A ridge structure shows a downward velocity increase from -1 m/s up to -6 m/s in only about 200 m from the cloud base altitude of 4.9 km, i.e. the melting layer (the ellipse part of Figure 4). This is a "raindrops generation, acceleration layer", and the diameter of the raindrop with a terminal velocity of -6 m/s at this altitude is estimated to be about 1.3 mm. We traced the time variation of the ridge structure (broken line in Figure 4.) where a collection of raindrops generated in this layer is falling. The altitude of the ridge structure decreases with time, and several similar ridge structures can be confirmed in altitude between 1 to 4 km. These facts show that raindrops were generated and dropped intermittently. [1] [2]

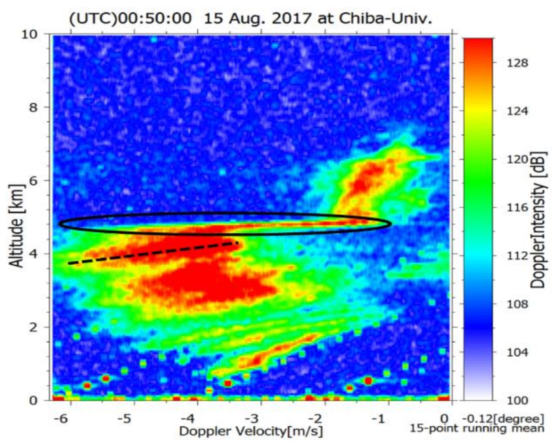


Figure 4. Doppler spectrul map of the beginning of the rain

### 3.3 Drop Size Distribution

We calculated the drop size distribution by converting the observed intensity to Z (radar reflectivity factor) and assuming the Doppler velocity to be the terminal velocity for corresponding drop size.

The Doppler spectrul map at 0:46:00 UT is shown in Figure 5. We picked up the data indicated by the black dots in Figure 5 and calculated the drop size distribution. Figure 6 shows the result that the number densities N increases as the particle size decreases.

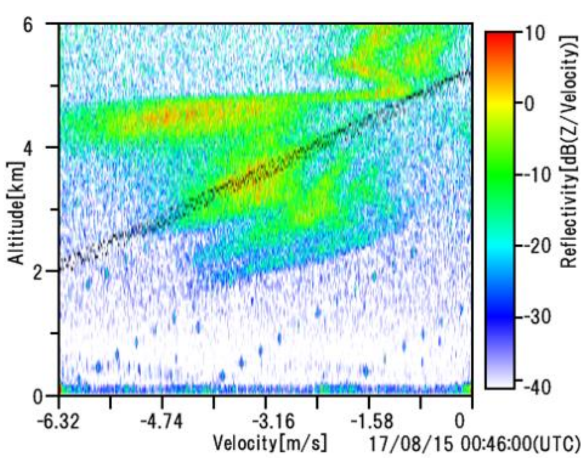


Figure 5. Doppler spectrul map at 0:46:00 UTC

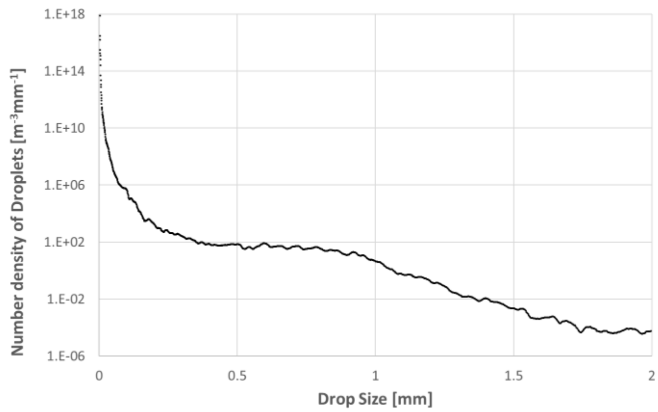


Figure 6. The drop size distribution calculated from Figure 5

We calculated the total amount of water in several drop size ranges by converting the drop size to volume by assuming the raindrops to be spherical and multiplying by the Number density. Figure 7 shows the time variation of the total amount of water from 00:46:00 UT to 00:48:00 UT. According to this, 0.6 to 1.2 mm rain drops decrease as it falls, but 0.4 to 0.6 mm rain drops increase from 00:46:30 to 00:47:15. These facts suggest that the drop size is reduced by splitting during the raindrops fall.

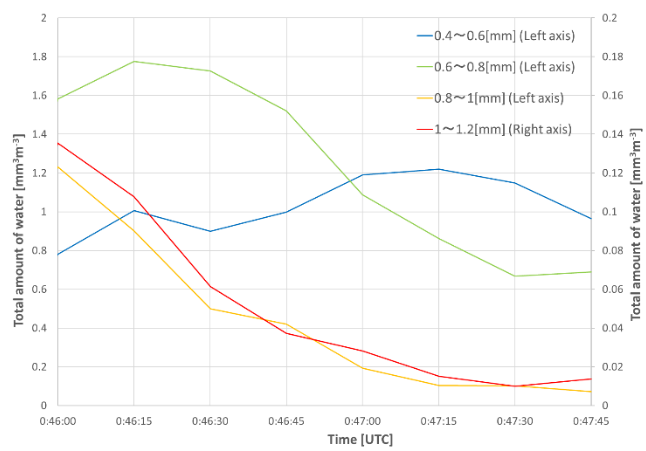


Figure 7. Time variation of the total amount of water from 00:46:00 UT to 00:48:00 UT

### 4 Reference

[1] Hyuga MORITA. Doppler analysis of ice particles and raindrops with the millimeter wave radar FALCON-I. Chiba University, 2019, Master theses.

[2] Ryo FUEDA. Analysis of Interaction between Clouds and Winds Observed with the Cloud Radar FALCON-I and a Wind Profiler Radar. Chiba University, 2019, Master theses.