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

*Keisuke HIKAWA[1], Taichi IURA[1], Hyuga MORITA[1], Ryo FUEDA[1], Yohei KAWAMURA[1], Toshiaki TAKANO[1], Atsushi HIGUCHI[2], Tamio TAKAMURA[2], Fumiaki KOBAYASHI[3], Kazuomi MOROTOMI[4], Shigeharu SHIMAMURA[4], Hisato IWASHITA[5]

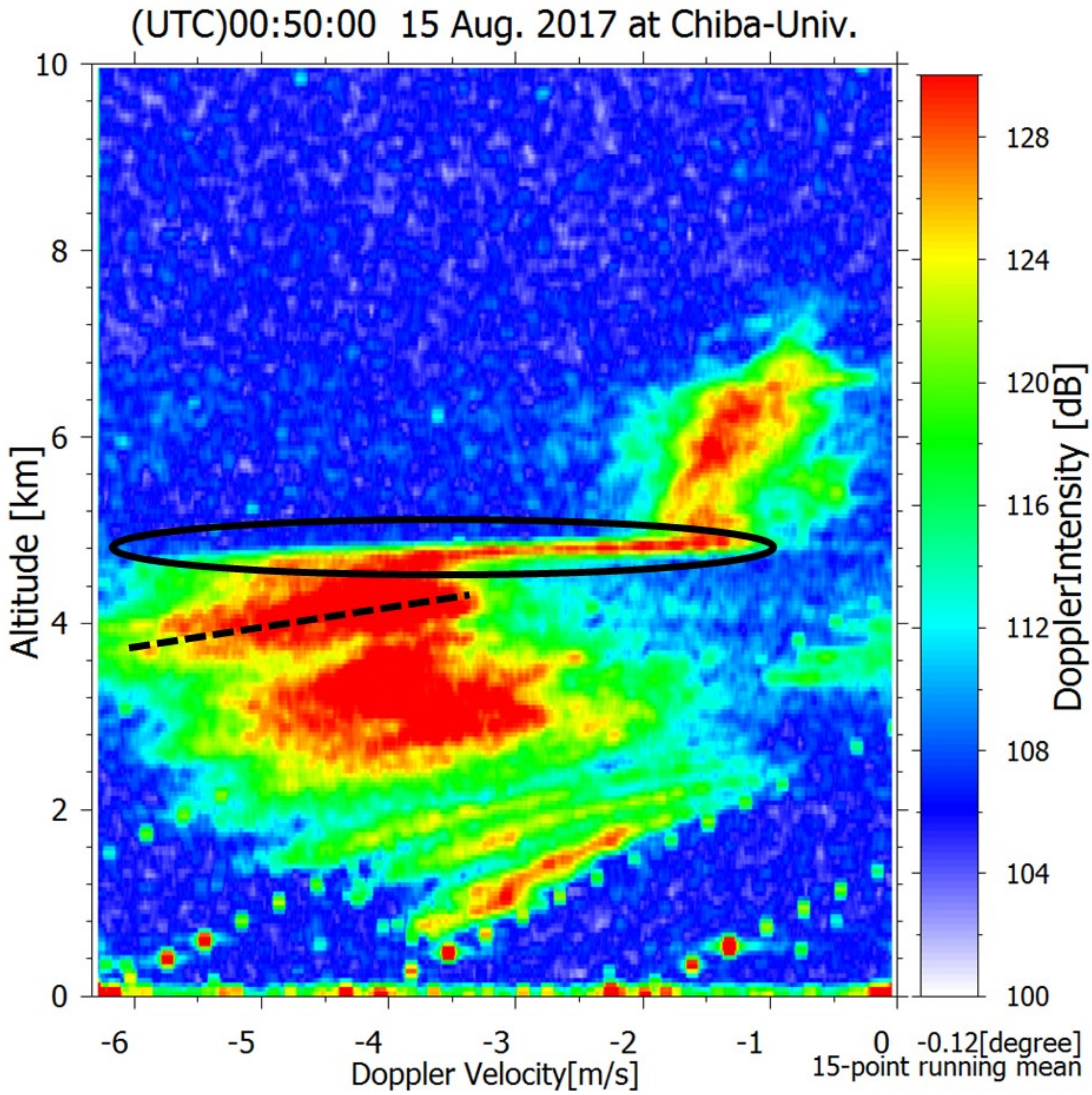
1. Graduate School of Engineering, Chiba University, 2. Center for Environmental Remote Sensing, Chiba University , 3. National Defense Academy of Japan, 4. Japan Radio Co., Ltd, 5. Meisei Electric co., Ltd

Recent years, abnormal meteorological phenomena increase around the world, for example, localized torrential rains, huge tornados, and typhoons and so on. We have to watch and investigate these phenomena. We have developed a cloud profiling FMCW (Frequency Modulated Continuous Wave) Doppler radar named FALCON-I in W-band at 95GHz at Chiba University to observe such phenomena. FALCON-I consists of two 1m-diameter antennas with high spatial resolution of 49 m is realized with the FMCW type radar. FALCON-I has enough sensitivities for faint clouds and fine rains and has high velocity resolution in Doppler measurements. In addition to the regular observation mode in which only the zenith direction is observed, it has a scanning observation mode in which observation is performed while mechanically scanning within ±5° from the zenith. In the regular observation mode, the time resolution is 10 seconds, and in the scanning observation mode, the time resolution is 15 seconds, and the height resolution is 49 m in both cases. In this study, we analyzed the generation of raindrops at the beginning of rainfall from clouds, which was observed in a campaign observations in August 2017.

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 the ground around 1:00 UT. The Doppler spectrum map at 0:50:00 UT at the beginning of this rain is shown in Fig.1. 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 -1.2 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 Fig.1). 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 about 1.3 mm. We traced the time variation of the ridge structure (broken line in Fig.1) where a collection of raindrops generated in this layer is falling. The altitude of the ridge structure decreases with the passage of 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. 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 certain drop size. As a result, it was found that number of raindrops with a diameter of about 0.9 to 1.1 mm increased with time, but the number of raindrops larger than 1.4 mm decreased. The result suggests that the size of raindrops decreased by evaporation and / or break up in this case during falling.

Fig.1 : Doppler spectrul map of the beginning of the rain

Keywords: Cloud Profiling Radar, W-band Radar, FMCW Radar, Generation of Raindrops, Melting Layer, Size Distribution



(UTC)00:50:00 15 Aug. 2017 at Chiba-Univ.
Altitude [km]
10
8
6
4
2
0
-6
-5
-4
-3
-2
-1
0
Doppler Velocity[m/s]
-0.12[degree]
15-point running mean
DopplerIntensity [dB]
128
124
120
116
112
108
104
100