2A.4

Characteristics of descending reflectivity cores observed by Ku-band radar

Eiichi Sato, C. Fujiwara, K. Kusunoki and S. Saito
Meteorological Research Institute, Tsukuba, Ibaraki, Japan

1. Introduction

After some tragic heavy rains and flash floods in metropolitan areas in 2008, our project, Tokyo Metropolitan Area Convection Study (TOMACS) started in 2010 in order to clarify mechanisms of such disasters.

The authors installed a Ku-band radar, which was developed by Osaka Univ. (e.g., Mega et al. (2007), Yoshikawa et al. (2010)), in Musashino-shi, Tokyo (Fig. 1). Since it was designed to get a 3D volume scan per minute, it is expected to contribute to clarifications of mechanisms of severe and small scale phenomena in metropolitan area.

One of our targets is Descending Reflectivity Core (DRC) not only because DRC is a direct predictor of precipitations on the ground, but also because it can become a predictor of severe phenomena, such as tornadoes, microbursts, etc.

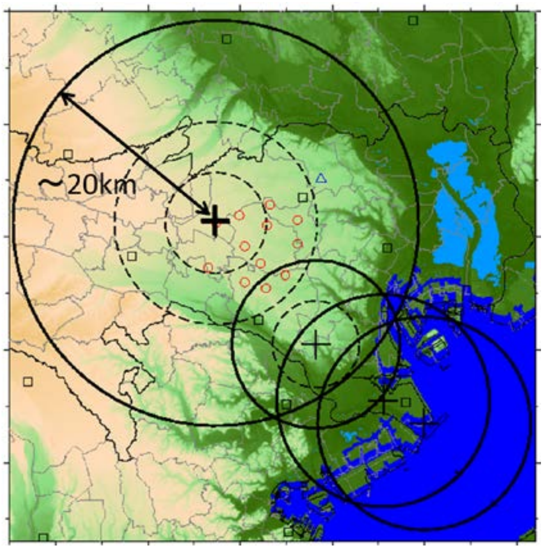

Figure 1: Observation area of Ku-band radar.（Bold **+** is the Ku-band radar. The others are LIDARs. ）

2. Specifications of the Ku-band radar

To realize fast scanning, the radar has two Luneburg lenses (Fig. 2). These antennas can easily change the elevation angle than a parabolic antenna. Moreover, the radar uses spiral scan, which change elevation angle seamlessly (Fig. 3). Table 1 shows other specifications of the radar.

Figure 2: Ku-band radar.
(Luneburg lens antennas)

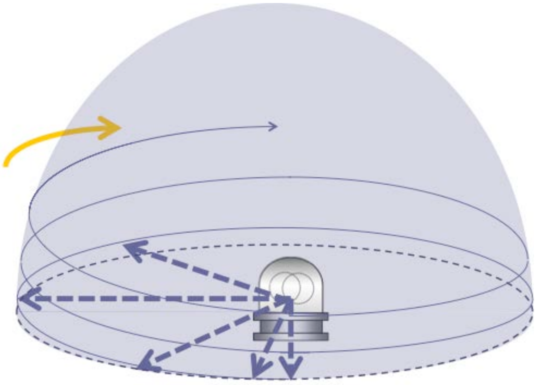

Figure 3: Spiral scan.

Table 1: Specifications of Ku-band radar.

band-width	80MHz（max）
chirp	FM-chirp(linear)
pulse-length	1～300μsec
PRF	5000Hz(max)
power	10W
antenna	Lunerburg lens x 2
resolution (range)	2.38m（variable）
resolution (azimuth)	3°
beam-width	3°
rotation speed	40rpm(max)

3. Definition of DRC

Originally, DRC was studied as a predictor of microburst. Roberts and Wilson (1989) proposed four predictors of downburst, and one of them was DRC. They also mentioned that decrease in *Az* (the area) in the precipitation core may be evidence of an accelerating downdraft.

On the other hand, DRC has also been focused as a predictor of tornado in supercell storms. Rasmussen *et al.* (2006) defined DRC as a reflectivity maximum pendant from the rear side of an echo overhang above a supercell weak-echo region, and they showed tornado formations were preceded by DRC in their cases.

In order to examine the thresholds between severe and moderate cases, the authors adopted broader definitions than the definitions before. We defined that a cell is an object whose reflectivity is ≥ 25dBZ, and a cell can contain several cores. A core is defined as a reflectivity peak and its surrounding area.

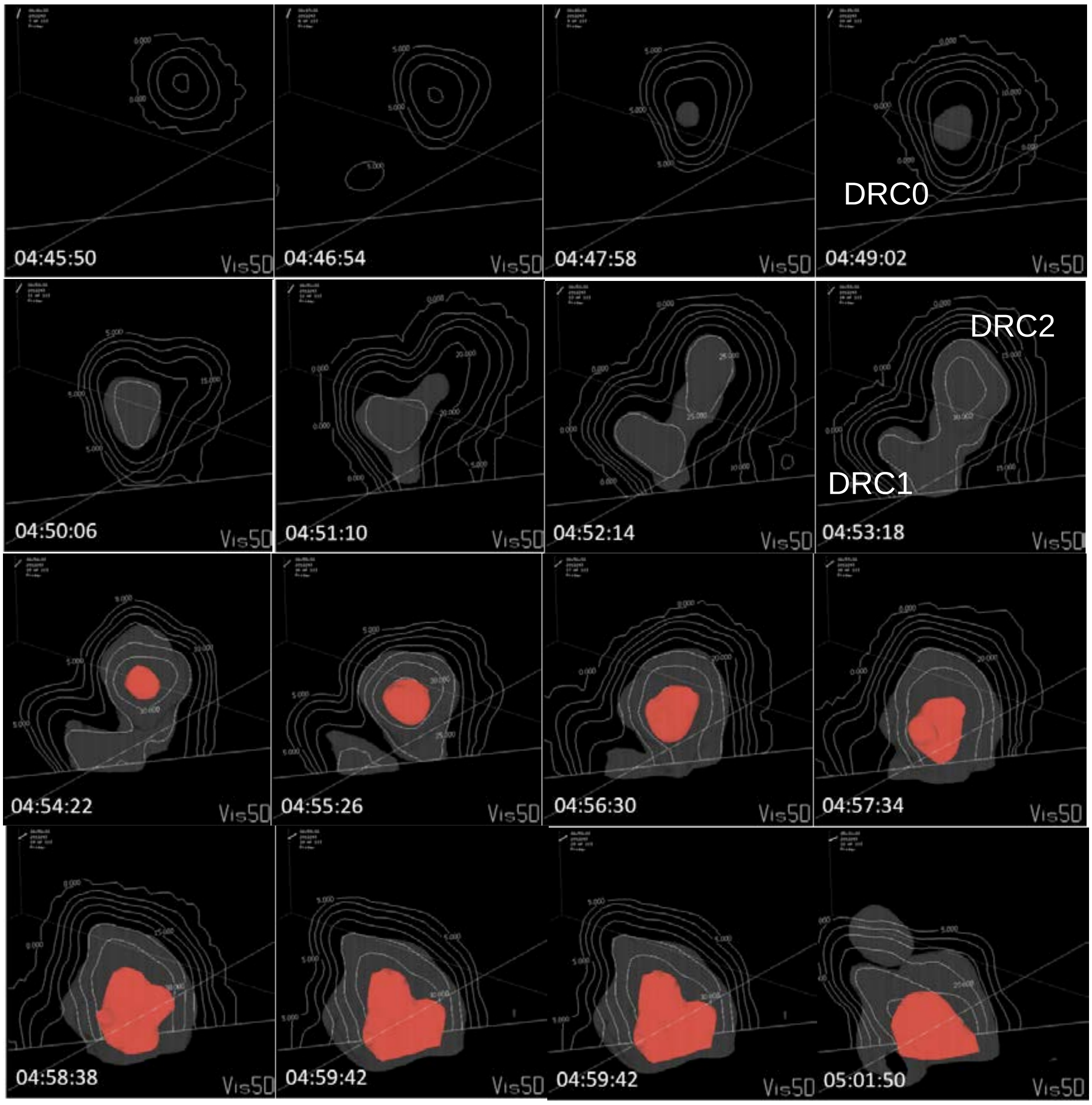

Figure 4: 3-D reflectivity image of a cell with DRCs. (gray:25dBZ,red:35dBZ)

4. Results

4.1 Sep. 1st, 2012: localized heavy rain

A localized heavy rain occurred in Tokyo on Sep. 1st, 2012. In this case, some cells looked like westplains storm (Foote and Frank, 1983) or multi-core cell (Kim et al., 2012). Figure 4 shows one of the cells, which contains three DRCs. Figure 5 shows heights of the DRCs and the area of the cell. In this case, the cores were generated at 3-4 km height, and their fall velocities were about 7-8m/s. The area of the cell became broader as the DRCs were descending.

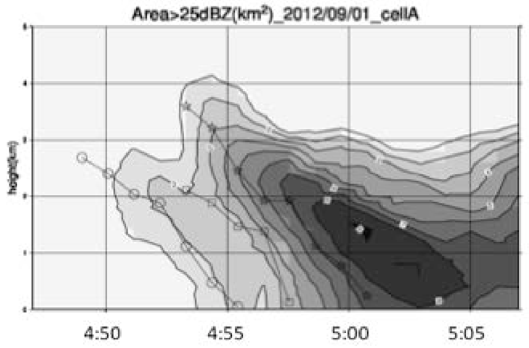

Figure 5: Heights of DRCs and the area (km^2) covered by echo ≥ 25dBZ.

4.2 July 23th, 2013: weak tornado

On July 23th, 2013, a weak tornado (< F0) occurred at about 16:00 JST in Chofu-shi, Tokyo, which is only about 7.5 km away from the radar.

The radar captured a hook echo and a low-level misocyclone (MC) from 15:56 JST (Fig. 6). The lifetime of the MC was about 5 minutes. Figure 7 shows 3-D structure of the storm at the moment the MC was generated.

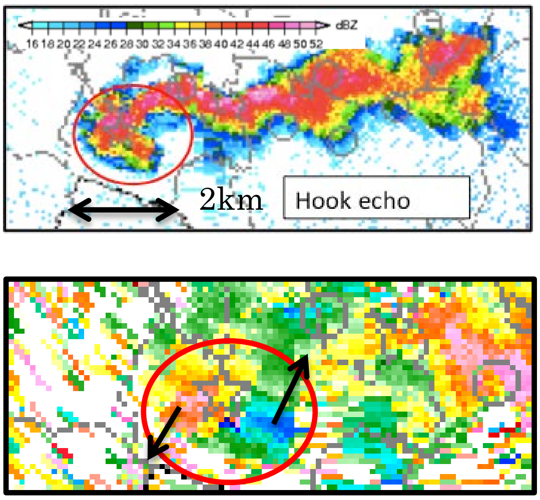

Figure 6: Reflectivity (upper) and Doppler velocity (lower) at 15:58 JST.

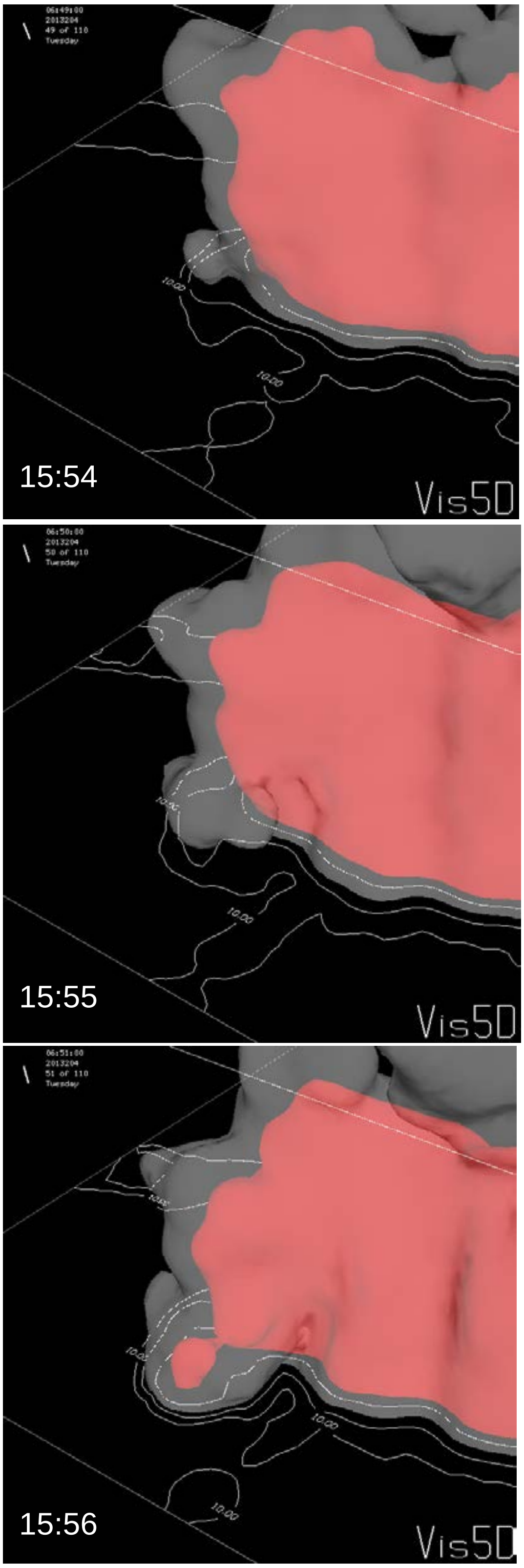

Figure 7: 3-D reflectivity (isosurface) and reflectivity near the ground (contour) at the moment the MC was generated (from south-east).

5. Discussion

Unlike the microburst cases in Roberts and Wilson (1989), the area of the cell became wider as the DRCs were descending. It may due to less amount of evaporation. We have to investigate more cases in order to determine the thresholds, which are needed to diagnose the severity of phenomena.

On July 23th, 2013, the authors successfully captured the moment the low-level MC was generated. It was revealed that the hook echo and the MC were generated only in 3 minutes. We are now analyzing the data from the point of view that 1) whether the parent storm was a "mini-supercell" and 2) DRC's role in tornadogenesis.

Acknowledgements

This research is supported by JST/MEXT. The authors would like to thank the observations department of Japan Meteorological Agency for giving operational observation data.

References

Byko, Z., P. Markowski, Y. Richardson, J. Wurman and E. Adlerman, 2009: Descending reflectivity cores in supercell thunderstorms observed by mobile radars and in a high-resolution numerical simulation. *Wea. Forecasting*, **24**, 155–186.

Foote, G. B. and H. W. Frank, 1983: Case study if a hailstorm in Colorado. Part III: Airflow from triple-Doppler measurements. *J. Atoms. Sci.*, **40**, 686-707

Kim, D.-S., M. Maki, S. Shimizu and D.-I. Lee, 2012: X-Band dual-polarization radar observations of precipitation core development and structure in a multi-cellular storm over Zoshigaya, Japan, on August 5, 2008. *J. Meteor. Soc. Japan*, **90**, 701-719

Mega, T., K. Monden, T. Ushio, K. Okamoto, Z. Kawasaki, and T. Morimoto, 2007: A low-power high-resolution broad-band radar using a pulse compression technique for meteorological application. I*EEE Geosci. Remote Sens. Lett.*, **4**, 392–396.

Roberts, R. D., and J. W. Wilson, 1989: A proposed microburst nowcasting procedure using single-Doppler radar. *J. App. Meteor.*, **28**, 285-303.

Rasmussen, E. N., J. M. Straka, M. S. Gilmore, and R. Davies- Jones, 2006: A preliminary survey of rear-flank descending reflectivity cores in supercell storms. *Wea. Forecasting*, **21**, 923–938.

Yoshikawa, E., T. Ushio, Z. Kawasaki, T. Mega, S. Yoshida, T. Morimoto, K. Imai, and S. Nagayama, 2010: Development and initial observation of high-resolution volume-scanning radar for meteorological application. *IEEE Trans. Geosci. Remote Sens.*, **48**, 3225–3235.