C3.7 OBSERVATIONS OF FOGS WITH A MILLIMETER-WAVE DOPPLER RADAR

Akihisa Uematsu*[1], Hiroyuki Hashiguchi[1], Michihiro Teshiba[1], Koichi Hirashima[2], Taiichi Hayashi[3], Akira Yamamoto[4], and Shoichiro Fukao[1]

1. Radio Science Center for Space and Atmosphere, Kyoto University, Uji, Kyoto, Japan
2. Mitsubishi Electric Corporation, 3. Disaster Prevention Research Institute, Kyoto University
4. Meteorological Research Institute

1. INTRODUCTION

In the east Pacific coast of Hokkaido prefecture, Japan, fog frequently appears especially in summer seasons. It is important to know the feature and the transition of fog. We performed observations of fogs at Kushiro district, Hokkaido, Japan with a mobile 35 GHz scanning Doppler radar in the summer seasons of 1999-2002.

2. STRUCTURE OF ECHO PATTERN

In the observations of 1999 and 2000, we observed fog with drizzle in some cases. We will show a case of July 31, 2000. Figure 1(a) shows RHI displays of radar reflectivity factor directed southward (at the azimuth angle of 189.9 degrees) obtained at the intervals of 71 sec from 0503LT to 0505LT on July 31, 2000. Echo top was almost flat at the height of 500 m, and in the fog layer cellular structure of radar reflectivity factor more than –20 dBZ was observed. Structure of each cell was vertically standing above the height of 200 m, where there was a shear line as will mention below, and cell was leaning below that. Echo cells were periodically distributed, and period was about 1 km. This pattern moved northward, i.e., from the sea to the land at the all height of the echo. From this figure, velocity of moving echo pattern was almost 2.6 m/s.

Figure 1(b) shows RHI displays of Doppler velocity field. Because elevation of radar beam was low, Doppler velocity almost represents meridional component of horizontal wind. Positive value indicates southerly wind (from the sea to the land). There was a vertical shear of horizontal wind at the height of 200 m. Below the shear, meridional component of horizontal wind was almost zero or northerly wind, and above the shear southerly wind of 2-3 m/s was blowing. Therefore, moving velocity of echo pattern was not consistent to wind near the ground, but corresponded to wind velocity at the height above 200 m. We consider that there is a source of drizzle particles near the top of the fog layer and each drizzle particle is falling with blown by background wind which determine the movement of the echo pattern.

Figure 2 shows mechanism of moving echo pattern. We consider that there was southerly wind above 200 m and weak northerly wind below 200 m. (1) A drizzle particle ① appears at the height of 500 m. (2) Particle ① falls down with blown by southerly wind while new particle ② appears above. (3) Particles ① and ② fall down northward while ③ appears, (4) ①, ②, and ③ fall and ④ appears, and ① reaches the shear line. Particles ①～④ make up vertically standing echo pattern. (5) Particle ① fall with blown by northerly wind and moves slightly to the south, while ②～⑤ act in the same way as ①～④ of (4). Particles ① and ② construct leaning echo pattern. (6) ① falls southward and reaches the ground. At the same time, ②～⑥ act in the same way as ①～⑤ of (5). In this way leaning structure is formed at the height at 0-200 m. (7) ②～⑦ act in the same as ①～⑥ of (6). As a whole, echo pattern moved

* *Corresponding author address:* Akihisa Uematsu, Radio Science Center for Space and Atmosphere, Kyoto University, Gokasho, Uji, Kyoto 611-0011, Japan; e-mail: uematsu@kurasc.kyoto-u.ac.jp

northward with the same velocity as wind near the top of the fog layer.

In Figure 1(a), horizontal and vertical ratio of leaning cells below 200 m was 5:1. Differential of horizontal wind above and below the shear line was about 2.5 m/s, and if terminal falling velocity of drizzle particles is 0.5 m/s, we can explain mechanism above. Drizzle particles of diameter 160 μm correspond to the falling speed, and if liquid water content (LWC) is 0.01 g/m, radar reflectivity factor corresponds well with particle size. To confirm this mechanism, we need to compare LWC and drop size distribution with radar reflectivity factor.

3. EVOLUTION OF FOG AND STRATUS ECHOES

In July 20, 2002, developing fog and stratus was observed. Figure 3 shows time-range display of radar reflectivity factor at 1.1km south of radar site extracted from RHI data from 1858LT to 1936LT. At first, there were two layers, one was a fog layer at the height of 0-70 m, and another was a stratus at the height of about 450-700 m. Then the top of the fog layer ascended, and base of the stratus layer simultaneously descended until 1920LT. After that some cellular structure of about –30 dBZ appeared. At the same time Doppler sodar observation was performed, and horizontal wind was southerly wind and vertical wind was downdraft. It indicates that fog layer was developed under the stable sea breeze.

4. SUMMARY

We performed fog observations with a millimeter-wave Doppler radar at the pacific coast of Hokkaido, Japan in the summer seasons. Periodic cellular structure of fog with drizzle was observed, and velocity of moving echo pattern corresponded to wind velocity near the top of the fog layer. In another case, descending stratus and ascending fog layers were simultaneously observed under the stable sea breeze.

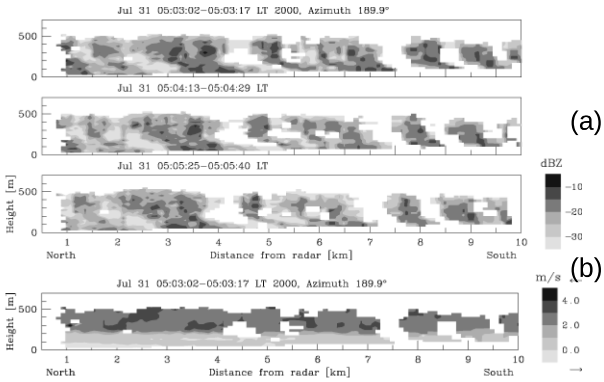

Fig. 1 RHI displays of (a) radar reflectivity factor at the azimuth angle of 189.9 degrees obtained at the intervals of 71 sec from 0503LT to 0505LT on July 31, 2000, (b) Doppler velocity field at 0505LT, positive shows northward (from sea to land).

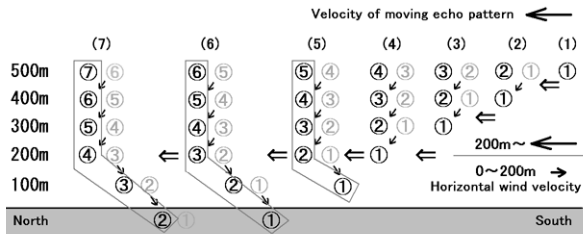

Fig. 2 Moving mechanism of echo patterns.

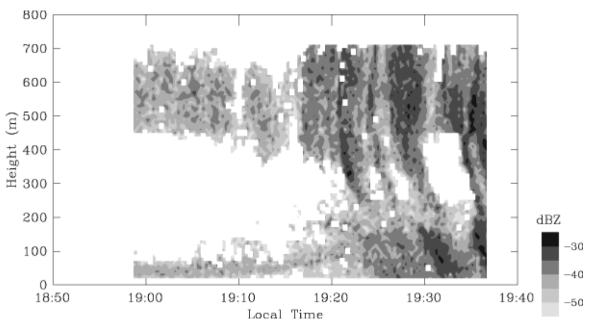

Fig. 3 Time-range display of radar reflectivity factor at 1.1 km south of the radar site extracted from RHI data of 18 sec resolution from 1858LT to 1936LT on July 20, 2002.