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CASE STUDY ON A TROPICAL CONTINENTAL SQUALL LINE OBSERVED AT DARWIN, AUSTRALIA USING BY FOUR DOPPLER RADARS

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1. Introduction

The Japan Australia Tropical Mesoscale Experiment (JATMEX; Iwanami *et al.*, 1999) was conducted from Dec. 1999 to Mar. 2000 at Darwin, Australia in order to improve knowledge of the mesoscale convective systems. We succeeded in observing the whole life cycle of a squall line on 21 Jan. 1999. In this case, the distinct convective line was formed rapidly after a merger with some isolated convective cells (see area NE in Fig. 1 (c)).

In this paper, we will focus on the process of a formation of convective line by using the data of 4 Doppler radars and surface weather station network.

2. Data

2.1. Observation facilities

Darwin is a town located at about 12 ° 27” S, 130 ° 50” E in the northwest part of Australia. It is one of the primary sites for TRMM ground validation studies and also attractive field for the studies of the tropical convective systems. Observation facilities in JATMEX were four Doppler radars, rain gauge network, mesoscale weather station network and radio soundings (Iwanami *et al.*, 1999).

2.2. Radar operation and analysis method

Two X-band radars were operated 18 or 15 tilt volume scan every 6 min, and two C-band radars routinely employed volume scan every 10 min. The observed data was interpolated to an orthogonal grid with 2km spacing in horizontal and 0.5km in vertical by using SPRINT. Wind fields over 200km × 200km in horizontal plane were synthesized from the interpolated data. Unfortunately, C-band polarimetric radar stopped the operation, because it malfunctioned at the time (1000UTC) of the passage of a gust front.

3. Results

3.1. Development of the squall line

Infrared image of GMS showed that the squall line generated in the southeast of Darwin

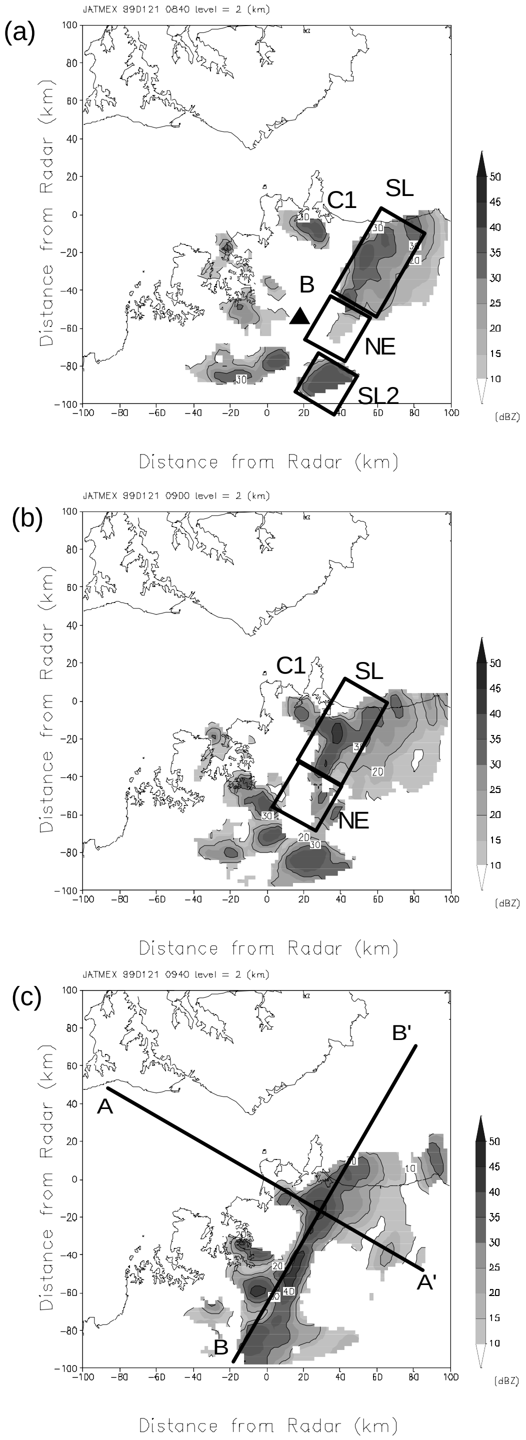

Fig. 1 Horizontal cross-section of Reflectivity, (a) at 0840UTC, (b) at 0900UTC and (c) at 0940UTC

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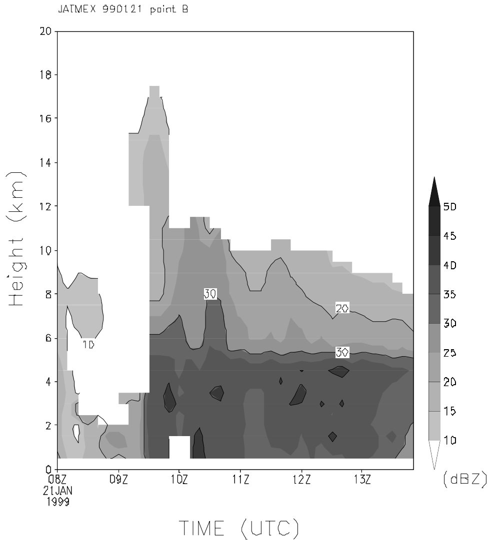

Fig. 2 Time height cross-section of radar reflectivity (dBZ) at point B in Fig. 1 (a).

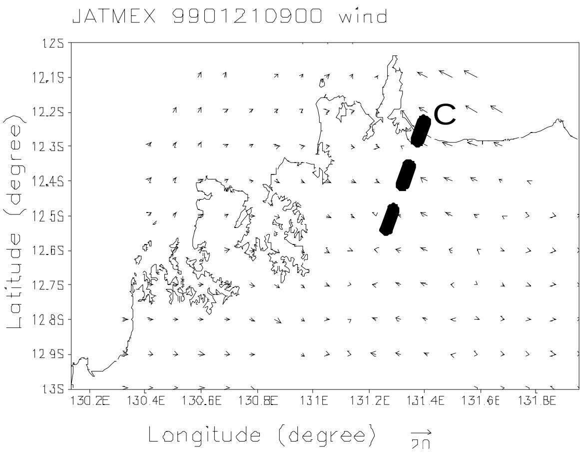

Fig. 3 Surface wind at 0900UTC. Line C indicates convergence line according to sea breeze and environmental wind.

at 0600UTC, and moved to northwest the speed of 7.5 m/s. The squall line reached the observation area at 0800UTC. Fig. 1 shows horizontal cross section of radar reflectivity at the height of 2km. As shown in Fig. 1(a), echoes were able to be classified to the distribution to 3groups, which were convection lines SL and SL2 that formed the large convective line of the squall line later and convective cells over coastline. There was no echo area NE between SL and SL2. At 0900UTC, short convective line SL and convective cell SL2 moved toward northwest, although the convective cells over coastline still stayed there (Fig. 1(b). At this time, SL merged with convective cell C1 and one convective cell inside SL developed rapidly, although other convective cell did not develop. After merger, high reflectivity area appeared over NE, and it formed large convective line with SL and SL2 (Fig. 1 (c)). In order to see a formulation process of convective line over NE, the time-height cross-section of reflectivity at point B where convective line was rapidly formed was shown in Fig. 2. The echo over 30dBZ appeared after the merger (0910UTC), although the weak echo under 20dBZ was seen occasionally before the merger. Moreover, it was interesting that the echo suddenly appeared at the height of 18 km of 0930UTC.

3.2. Analysis

Sounding data observed at 2300UTC 20 Jan. 1999, which observed the environment before the squall line onset, showed that it was unstable condition under 800 hPa (CAPE was 1800 J/kg) in Darwin Area. Melting level was at the height of 5km. Moreover, low to middle level southeasterly flow and upper northwesterly flow were observed, which indicated that it was break periods of monsoon in Darwin area (Holland 1986). The automated weather stations network at 0900UTC observed the southeast wind that was environmental wind. Moreover, it was observed the northwest wind was the sea breeze. The weak convergence area (10^{-4} order) by the sea breeze and environmental wind was occurred on line CL of Fig. 3.

Fig. 4 (a), (b) and (c) are vertical cross sections of A-A' of the reflectivity and system relative wind field at 0840UTC, 0850UTC and 0910UTC, respectively. As shown in Fig. 4(a), the contour of 30dBZ inside C1 leaned toward SL at 0840UTC. The inclination of the echo indicated that ice particles, which were generated in C1 and transported to above melting level, were transported to SL by upper wind toward SL. Over area SL, a strong echo core was not seen and updraft was weak. Moreover, echo top over 10dBZ was reaching only to the height of 10km.

At 0850UTC, the echo core of which reflectivity exceeded 40dBZ in the height of 3 km to 5 km was observed. Because the updraft inside SL was weak, the echo core was not occurred by the updraft from surface but was occurred by the ice particles transported from C1 (Fig. 4 (b)). As shown in Fig. 4(c), it should be noted that the updraft was intensified over the height of 8 km, although the updraft from surface to 5km was relatively weak.

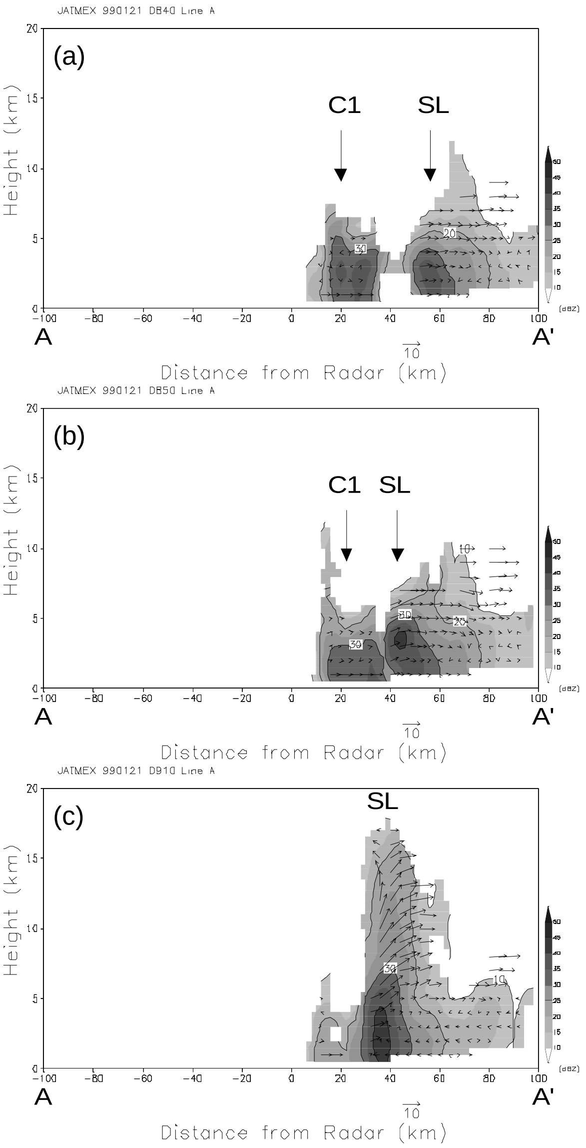

Fig. 4 Vertical cross-section of reflectivity and synthesized wind field along a line A-A' in Fig. 1(c), (a) 0840UTC, (b) 0850UTC and (c) 0910UTC

It was expected that the latent heat, which was generated by growth of ice particles transported from C1, caused the updraft strength in the upper level. Echo top over 10dBZ was reaching to the height of 18km by this upper strengthen updraft.

In order to consider the process of rapid formation of convective line over NE, vertical cross section of B-B', which were perpendicular to a direction of system movement, were shown in Fig. 5 (a), (b). Fig. 5 (a) indicated that echo did not appear in upper level of NE and synthesized wind field did not blow toward NE from SL or SL2. However, upper wind over SL blew toward area NE at 0930UTC. In lower to middle level, updraft was weak over NE. These results indicated that the ice crystals in upper SL transported toward area NE. Transported large ice particles, which were not able to be supported with weak updraft, fell and formed a strong echo under melting layer.

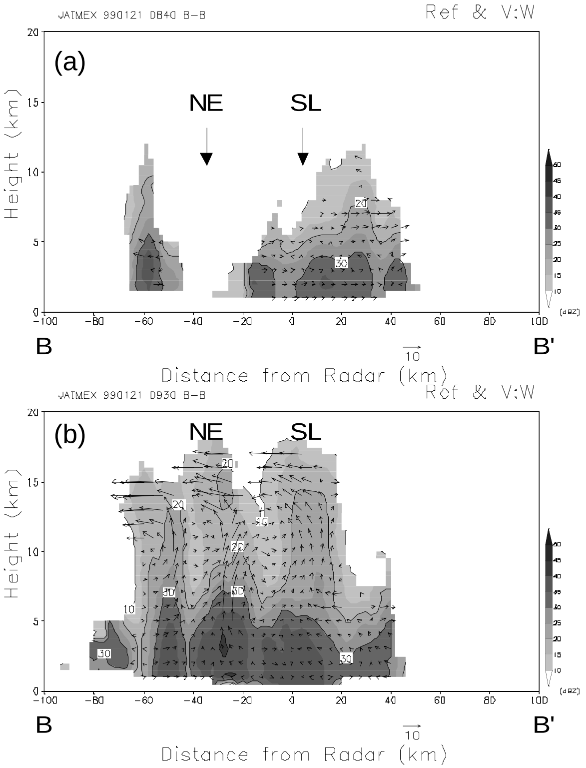

Fig. 5 Vertical cross-section of reflectivity and synthesized wind field along a line B-B' in Fig. 1(c), (a) at 0840UTC and (b) at 0930UTC

4. Summary

The squall line occurred in Darwin, Australia was observed 4 Doppler radars until 1000UTC and 3 Doppler radars after 1000UTC. In this case, it was succeeding to observe that strength process of a convective cell after the merger between short convective line (SL) and convective cell (C1), and the rapid formation process of convective line where was no echo region (NE). The results indicated that microphysical interaction according to the merger was important for the formation of the convective line.

5.Reference

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Holland, G. J. 1986: Interannual variability of the Australian summer monsoon at Darwin: 1952-82. Mon. Weather Rev., **114**, 594-604.