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STRUCTURE OF MESO-β AND –γ-SCALE ON SOUTH CHINA HEAVY RAINFALL ON 12~13 JUNE 2005 USING DUAL-DOPPLER RADAR

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Abstract: The three-dimensional wind fields of the heavy rain on 12-13 June 2005 in Guangdong province are retrieved and studied with the volume scan data of the dual-Doppler radar located in the cities of Meizhou and Shantou. It is shown that the meso-β-scale and meso-γ-scale convergence lines located in the convective system at the low and middle layer play an important role in the heavy rainfall. The convergence line is the initiating and maintaining mechanism of the rain. A three dimensional kinematic structure model is also given.

Key words: South China heavy rain; 3-D wind; Dual-Doppler radar; wind retrieval; mesoscale structure

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1 INTRODUCTION

It is well known that there are frequent heavy rains in South China. Meteorologists have investigated various aspects of the heavy rain using mesoscale numerical simulation, satellite data and so on[1-6]. Due to the high spatial and temporal resolution of the radar data, Doppler radar has been one of the valuable tools for studying the structure and formation mechanism of the heavy rain. In recent years, Chinese meteorologists have made remarkable progress in single radar wind retrieval[7], assimilation[8-10] and heavy rain structure using the radar data[11-13]. Dual-Doppler radar wind retrieval technique can improve the retrieval accuracy obviously[14-19]. Some scholars make use of this retrieval technique to study the heavy rain structure in the Yangtze River valley [15-17]. This paper applies this technique to studying the South China heavy rain structure for the first time. In order to study the structure evolvement feature and the formation mechanism of the rain on 12 June 2005, 3D wind fields are retrieved, and relationship between the meso-β and –γ- scale kinematic structure and the heavy rain is analyzed. Furthermore, this work is also very helpful for developing the dual-Doppler retrieval method.

2 DUAL-DOPPLER RADAR WIND RETRIEVAL METHOD AND SYNOPTIC OVERVIEW

The 3D wind fields are retrieved by the synchronous volume scan data observed by Shantou and Meizhou radar in Guangdong province. The x axis is directed east, y axis is directed north and z axis points in the direction opposite to the gravity vector. The grid interval is 1 km in the horizontal and 0.5 km in the vertical. First of all, quality control is practised to the radar data and then 3D winds are retrieved with the MUSCAT technique[18]. Due to the southwest monsoon, upper-level trough and shearline, precipitation occurred on 12-13 June in the east part of Guangdong province. A heavy rain occurred in Puning and regions to its northeast from 15:00 to 21:00 June 12, up to 68mm in 24h in Puning area. There are some heavy precipitation centers in a SW-NE oriented rainband. The primary feature of this event is local, sudden and short-lived.

3 3D KINEMATIC STRUCTURE

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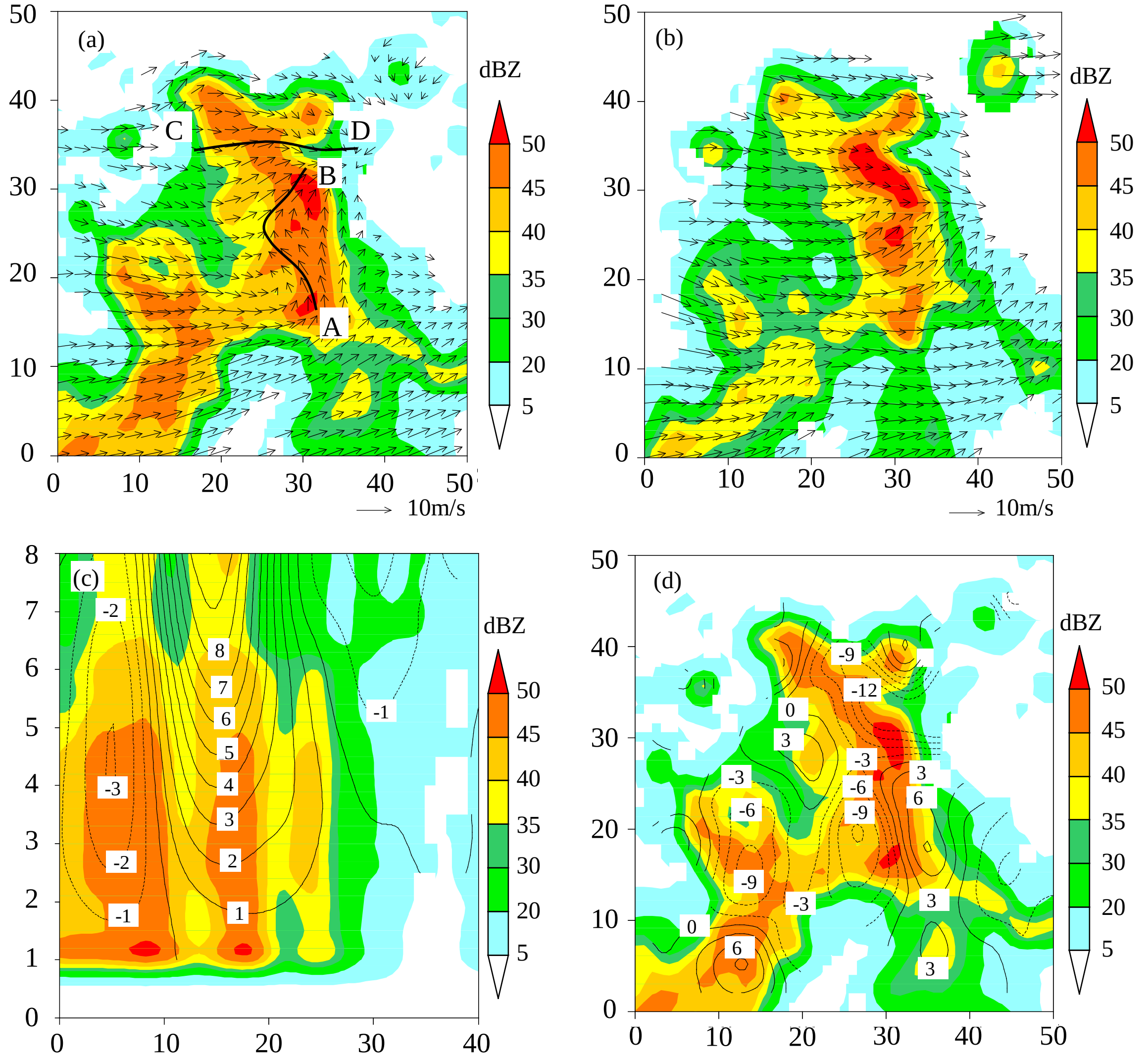

Fig.1 Reflectivity (color shaded), retrieval wind and divergence field at 16:10 June 12 2005, a. Horizontal wind at z=1.5km (thick solid line AB and CD present the convergence line); b: Horizontal wind at z=6km; c: Vertical cross section of w at x=13km (solid line stands for up velocity, dashed line denotes down velocity, unit: m/s); d: Divergence field at z=1.5km(unit: $10^{-4}s^{-1}$).

With the aim of studying the relationship between the 3D wind and the formation, evolution, sustaining and dissipation of the rainfall, 3D wind fields are retrieved in the heavy precipitation period.

3.1 *Wind field in the southwest rain region*

At 15:26 June 12, there were weak convergence lines below the 3km level in the convective cell that located in the western part of Shantou. The convergence line was composed of west and southwest wind. The levels above 4km was controlled by the west wind mainly. As presented in Fig.1a, the south part of the rainband at the altitude of 1.5km was controlled by the southwest wind, whereas convergence lines lay in the central and northern parts of the rainband and Puning located near the northern convergence line. The pattern of the strong echo band corresponded well to the convergence line. The horizontal wind field at the other low level was similar to that at 1.5km level. As shown in Fig.1b, the level at 6km was controlled by west wind. The vertical velocity in the vertical cross section along x=13 km is shown in Fig.1c. There was a strong updraft in the convective system along y=20 km whereas the downdraft lay on the south side of the updraft. As shown in Fig.1d, there were some strong convergence centers in the strong echo band and the strongest center lay in the northeast part of the rainband. This configuration can accumulate the water vapour and conduce to the development of the heavy rainfall. This wind field configuration lasted for a long time. After 17:15, the strong echo dissipated and the convergence line vanished too. At the same time, the convective cloud clusters in the northwest area of Shantou developed rapidly and a weak convergence line at the low layer began to develop too.

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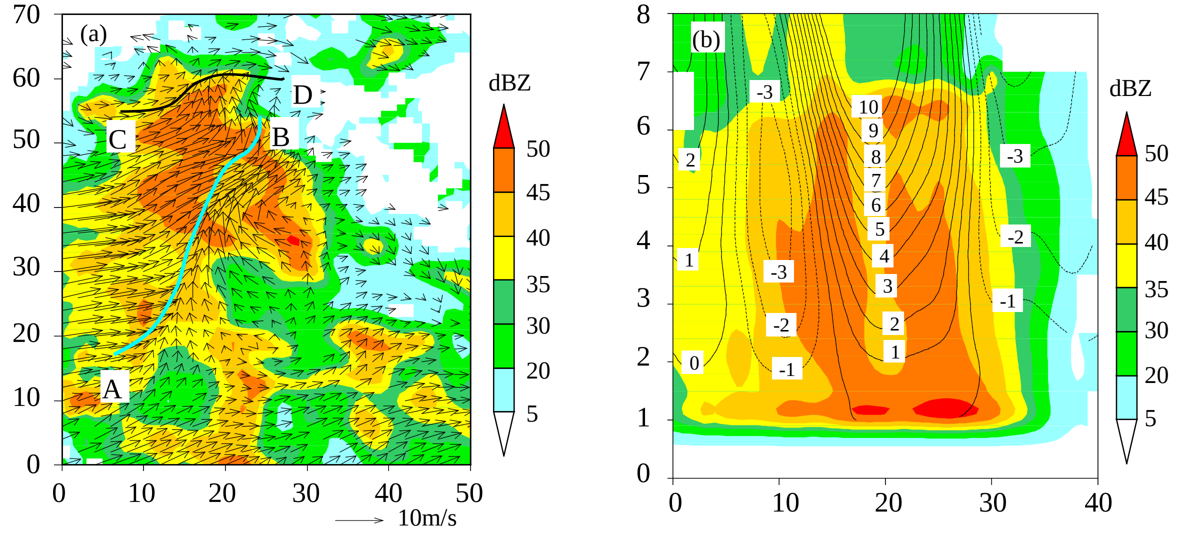

Fig.2 Reflectivity (color shaded) and retrieved wind at 19:33 June 12 2005, a. Horizontal wind at *z*=2km (thick solid line AB and CD denote the convergence lines); b. Vertical cross section of *w* at *y*=39km (solid line: up velocity, dashed line: down velocity, unit: m/s).

3.2 *Wind field in the northwest rain region*

As shown by the reflectivity and retrieved wind at 17:15, there was a SW-NE oriented meso-β-scale echo band at the 2km level in the northwest part of Shantou. A SW-NE convergence line was embedded in the central part of the echo band. The convergence line corresponded with the strong updraft whereas the downdraft region was distributed on the south and north sides of the convergence line. This configuration conduced to keep the heavy precipitation. The convergence line extended to 4.5km above the ground and tilted southward at the upper level. Some convergence centers and positive vorticity centers were distributed on the convergence band, and they have the similar distribution pattern. Hereafter, the wind field kept the similar structure for a long time.

3.3 *Wind field in the north rain region*

Fig. 2 gives the wind field in the north rain area at 19:33. From Fig.2a, we know that there are convergence lines at the 2km level. Fig.2b depicts the vertical velocity in the vertical cross section along y=39km. It shows that there is a strong updraft in the convective system but downdrafts in the west and east sides of the updraft. This dynamic structure conduced to the continuance of the heavy precipitation. Hereafter, the strong echo band and the convergence line

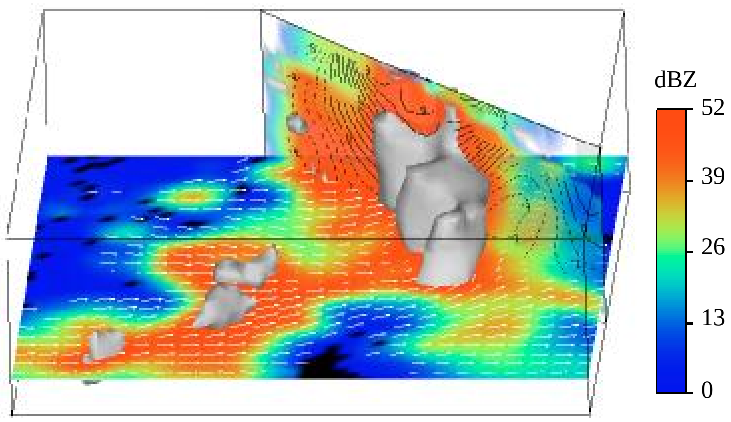

Fig. 3 Three dimensional kinematic structure of the heavy rainfall (the white arrow denotes the horizontal wind at the low level, the color shaded in the horizontal level presents the radar reflectivity, the contour line and the color shaded in the vertical cross section denote the *w* and the radar reflectivity respectively, the dashed line is downdraft and the solid line is updraft, the gray shaded donates the convective system which reflectivity is more than 45dBZ).

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embedded in it moved eastward as the rainband also moved eastward. At 19:51, the convergence line became weak while the strong echo band moved eastward and dissipated. The detailed structure of this heavy rain is analyzed in the Chinese version of this journal.

4 3D STRUCTURE MODEL

Fig.3 shows the 3D kinematic structure model of the heavy rainfall. The southwest wind transported the moisture to the heavy rain region. The NW-SE oriented meso-β-scale convergence band is formed at the low level of the rainband. Because the west wind in the north part was strong, the convergence line changed the orientation to east-west in the north region. The meso-γ-scale convective system in the north part was in the maturing phase with height at about 8km. The updraft was quite deep where the intensive precipitation occurred. There are downdrafts on each side of the updraft region. This configuration conduces to the continuance of the heavy rainfall.

For analyses of other aspects, refer to the Chinese edition of the journal.

5 CONCLUSIONS

In brief, the meso-β-scale and the meso-γ-scale convergence lines play an important role in the heavy rain. The convergence line is an important mechanism for the broken and maintain of the rainfall. The convergence at the low layer and divergence at the high layer result in the heavy precipitation too. This paper studies the structure with 3D wind only, we will study it comprehensively with other data and numerical simulation model in the further.

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