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Analysis on Mesoscale Characteristics of Severe Convective Weather in Guilin on April 19, 2025

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Abstract Using conventional observation data and Guilin Doppler weather radar data, the atmospheric circulation situation, environmental conditions and mesoscale characteristics of convective storms during the severe convective weather process in Guilin, Guangxi on April 19, 2025 were analyzed in detail. The results showed that the severe convective process was dominated by short-term heavy rainfall, accompanied by thunderstorm and gale. This was a strong convective weather process in the warm region. On the south side of warm shear line, with the south branch fluctuation moving eastward, strong convection occurred near the surface convergence line. With the establishment of low-level jet at night, organized development of convection system was obtained. The environmental conditions showed unstable stratification, inversion layer, small convective effective potential energy, large K value and strong wind shear, and the inverted V-shaped structure was at low level. The convective storm that produced short-term heavy rainfall presented as low centroid precipitation echo. The mixed convection in Xinlong, Baishou, Yongfu was caused by heavy rainfall supercell and presented as high centroid precipitation echo, with weak echo area, bounded weak echo area and medium-intensity mesocyclone.

Key words Severe convective weather; Short-term heavy rainfall; Convective storm

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Severe convective weather is one of the main types of major meteorological disasters in the world, with diverse disaster forms. Short-term heavy rainfall is easy to cause urban rainstorm, waterlogging and mountain torrent geological disasters; thunderstorm and strong wind can destroy power facilities and building structures; hail causes direct damage to crops and air transportation; although tornadoes occur at a low frequency, they are highly destructive. In recent years, meteorologists have done a lot of research on the environmental conditions[1], mesoscale characteristics[2-3] and formation mechanism[4] of severe convective weather. In spring, severe convective weather frequently occurs in Guilin, causing serious disaster losses. At 21:13 on March 21, 2019, a gale of 60.3 m/s (level 17) was observed at Lingui National Station in Guangxi, breaking the wind speed record since Guangxi had meteorological records[5], accompanied by short-term heavy rainfall with an hourly rainfall intensity of 47.9 mm and small hail. On the night of April 24, 2019, there was a heavy hail in Lingui, accompanied by a short-term heavy rainfall with an hourly rainfall intensity of 46.8 mm. The aircraft at the airport suffered serious losses from hail attacks[6]. The extreme short-term heavy rainfall in Guilin has obvious temporal and spatial distribution characteristics. The favorable large-scale circulation background provides abundant water vapor, unstable stratification and appropriate vertical wind shear environment. The mesoscale convergence line is the trigger mechanism. Before the occurrence of the short-term heavy rainfall, the atmospheric environment is dry at the top and wet at the bottom or the whole layer is wet. The warm cloud layer is thick, so it has a more appropriate CAPE.

The severe convective weather has the characteristics of strong locality and strong destructiveness. The severe convective weather occurred in Guilin at night on April 19, 2025. In this paper, the mesoscale characteristics of this process were analyzed, in order to provide an effective reference for improving the forecasting and early warning ability of severe convective weather.

1 Active situation of severe convective weather

From 20:00 on April 19 to 08:00 on 20th, 2025, heavy rain to rainstorm occurred in the middle of Guilin City, with local heavy rainstorm. The maximum rainfall was 177.4 mm in Baishi Township, Xing'an County, and the number of stations above rainstorm accounted for 23%. In the national weather stations, Lingchuan, Guilin, Guanyang and Lingui, rainstorm occurred, and the maximum rainfall in 24 h occurred in Lingchuan, which was 98 mm. From the hourly rainfall at Baishi Station in Xing'an, it can be seen that the short-term heavy rainfall was concentrated from 23:00 on the 19th to 01:00 on the 20th, and the precipitation in other periods was weak. The type of severe convection at night on the 19th was mainly short-term heavy rainfall. There were 65 stations with short-term heavy rainfall and 2 stations with extreme short-term heavy rainfall, which were respectively Mochuan of Xing'an (23:00 on the 19th) and Dongjiang of Qixing (00:00 on the 20th). The hourly rainfall intensity was 55.9 and 54.8 mm respectively. Thunderstorm and gale occurred at 4 stations, and the maximum wind speed occurred at Xinlong Station, Baishou, Yongfu,

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which was 26.5 m/s. Mixed severe convection occurred locally. The maximum wind speed at Yanshan National Station at 04:00 on the 20th was 23.6 m/s, and the hourly rainfall intensity was 25.2 mm. This severe convective weather process had the characteristics of large accumulated rainfall and concentrated rainfall periods. It was dominant by short-term heavy rainfall, and there was mixed severe convection.

2 Atmospheric circulation situation

At 20:00 on April 19, before the occurrence of strong convection, the trough of 500 hPa northeast cold vortex rapidly moved eastward to around 120° E. In the middle and high latitudes, controlled by the northwest airflow behind the trough, cold air kept moving southward. The ridge line of subtropical high was stably located in the south of 20° N, the west ridge point was located near 100° E, and Guangxi was located in the northwest side of subtropical high. The northwest air flow behind the north branch trough and the southwest air flow on the northwest side of subtropical high formed an east – west trough line in the middle and lower reaches of the Yangtze River, and produced a low vortex in northern Hunan. The south branch trough slowly moved eastward to 95° E, and small fluctuations move eastward on the south branch trough, providing certain dynamic conditions for this strong convection process. The 700 hPa low vortex moved from the northeast of northern Guizhou to northern Hunan, and the southwest low-level jet extended from the South China Sea to the north of southern China. Guilin was located on the south side of low vortex and the left side of jet stream axis. The 850 hPa warm shear was located at the junction of Hunan, Guizhou and Guangxi, Guilin was located in the front of southerly air flow on the south side of warm shear. The 925 hPa shear line was located in the middle of Guangxi, and Guilin was located between the boundary layer shear line and the low-level shear line. The center of surface warm low pressure was located in southwest Yunnan, the surface convergence line was located in northern Guangxi, and the surface convergence line in Guilin was located in the middle. It was a strong convective weather process in the warm region. On the south side of warm shear line, with the south branch fluctuation moving eastward, strong convection occurred near the surface convergence line. With the establishment of low-level jet at night, the organized development of convective system was obtained.

Seen from the mesoscale analysis (Fig. 1), the South Asian high was located in the South China Sea, and Guangxi was located on the right side of upper jet axis entrance area. Upper air divergence provided upward motion conditions for strong convection. There were two cold centers in northern Yunnan and northern Hunan at 500 hPa respectively. Guilin was located in front of the cold trough, and the 700 hPa warm center was located in southern Guangxi. The warm ridge extended from southern Guangxi to Guilin. The temperature dew point difference between northern Guangxi and eastern Guangxi was ≤ 4 ℃. Guilin was located in the wet area, and was on the left side of low-level jet stream axis. The 850 hPa warm shear line was located at the junction of Hunan, Guizhou and Guangxi. There was a significant southerly airflow in the south of shear line, which transported water vapor and heat from the South China Sea to Guilin. The warm center was located in the south of Yunnan, and the warm ridge extended to the north of Guangxi. The 925 hPa warm shear line was located in the middle of Guangxi, and there was a significant southerly airflow in the south. Guilin was located on the left side of low-level jet, between the low-level shear line and the boundary layer shear line, and in the upper dry and cold and lower warm and wet environment in front of the significantly southerly airflow.

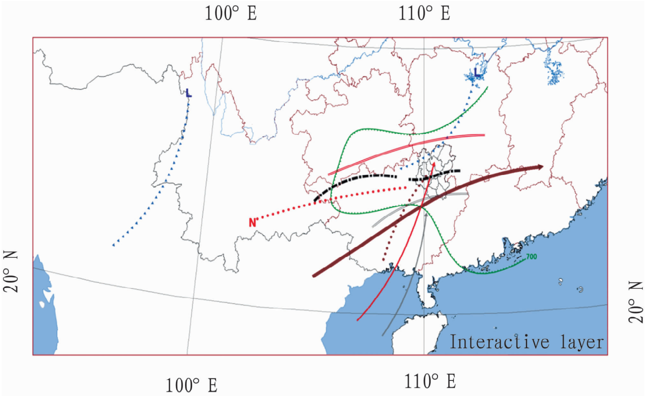

Fig. 1 Mesoanalysis chart at 20:00 on the 19th

3 Convective environmental conditions

From the sounding chart of Guilin at 20:00 on the 19th (Fig. 2), it can be seen that *T*85 reached 27.7 ℃, and the unstable stratification of upper dry and lower wet was conducive to the occurrence of strong convective weather. The convective effective potential energy *CAPE* was small, which was 143.9 J/kg. The *K* index was 42.7 ℃, which was conducive to the occurrence of short-term heavy rainfall. The vertical wind shear was 18 m/s, which belonged to the strong wind shear environment. The stratification curve of temperature and dew point in the low layer presented an inverted V-shaped structure, which was conducive to the occurrence of thunderstorm and gale. The height of 0 and –20 ℃ temperature layer was slightly higher than 600 and 400 hPa, which was not conducive to the occurrence of large hail. Due to ground

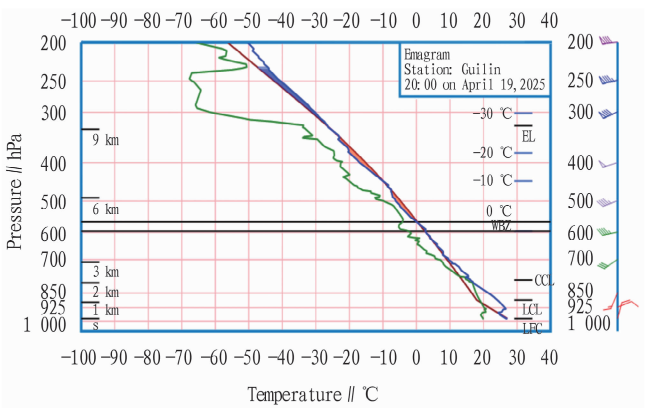

Fig. 2 *T* – ln*P* chart in Guilin at 20:00 on the 19th

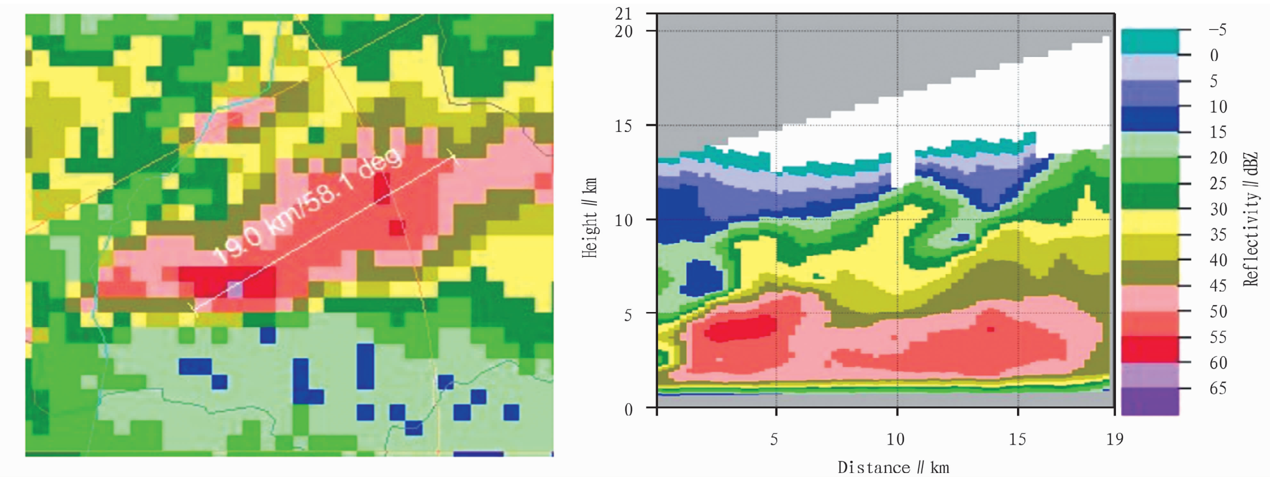

Fig. 3 Reflectivity factor (a) and profile (b) at 2.4° elevation at 22:08

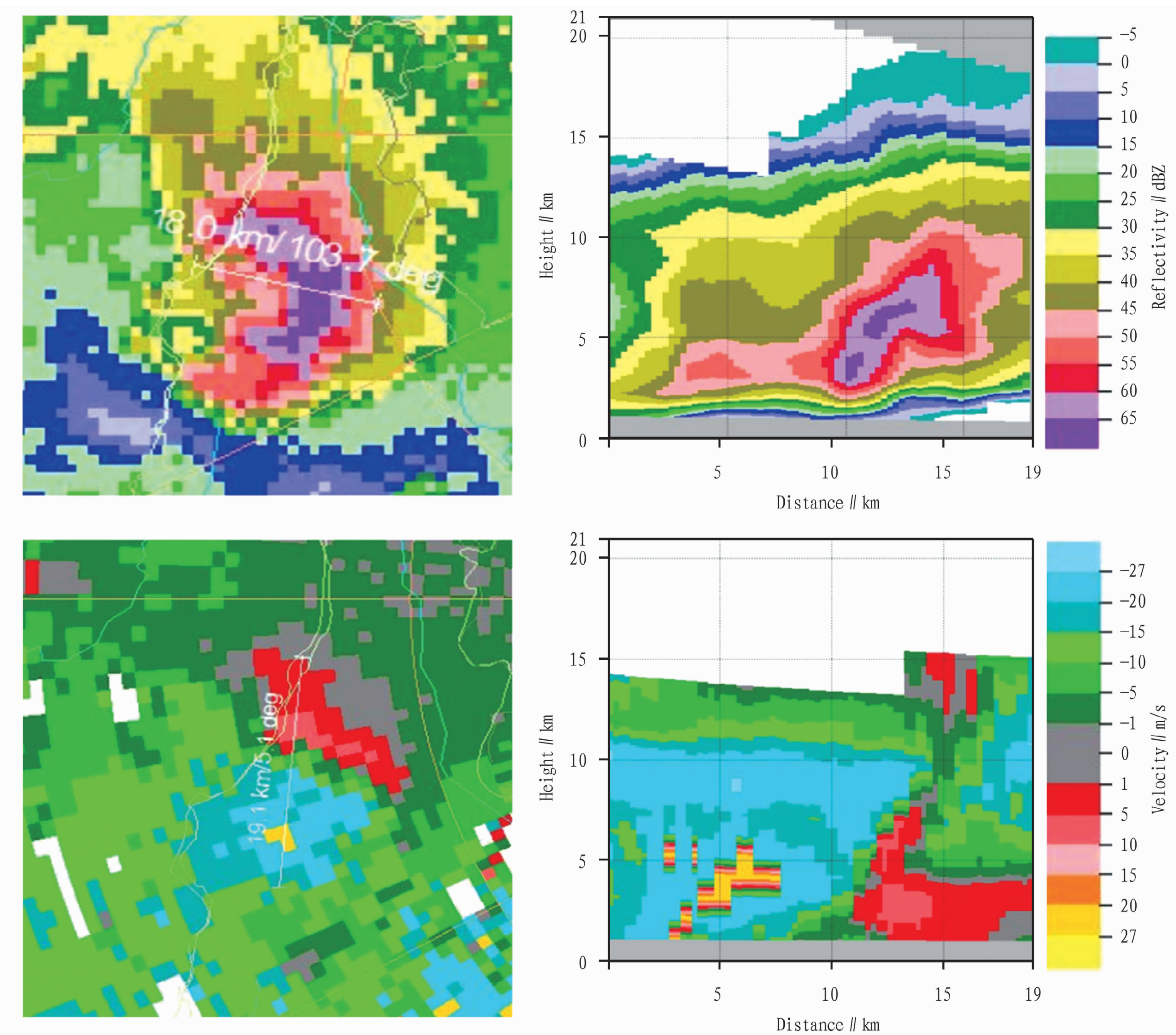

Fig. 4 Reflectivity factor (a) and its profile (b), radial velocity (c) and its profile (d) at 2.4° elevation at 23:54

warm low pressure control, the maximum temperature in central and southern Guilin reached 34.0 – 35.7 ℃ on the 19th. There was an inversion layer in the boundary layer, which hindered the vertical exchange of water vapor and energy, and a large amount of unstable energy accumulated in the boundary layer. The *K* index of this process reached 42.7 ℃, which was relatively rare and worthy of attention.

4 Mesoscale characteristics of convective storm

Seen from the reflectivity factor and profile near Mochuan, Xing'an at 22:08 (Fig.3), the strongest reflectivity factor of convective storm was 61 dBZ, and the precipitation echo above 45 dBZ was about 18 km long, which listed the effects to form short-term heavy rainfall. The extension height was lower, below 6 km, and it was a low centroid precipitation echo.

At 00:00 on April 20, an extreme wind speed of 26.5 m/s and a short-term heavy rainfall with an hourly rainfall intensity of 33.6 mm occurred in Xinlong, Baishou, Yongfu, which was caused by a heavy rainfall supercell. The maximum reflectivity factor of supercell (Fig.4) was 71.5 dBZ, and the moving speed was 62 km/h. The reflectivity factor profile showed a low-level weak echo area, a middle and high-level echo hanging and a bounded weak echo area. The precipitation echo above 60 dBZ extended to 8 km, which was a high centroid precipitation echo. The mesocyclone has a diameter of about 8 km, a rotation speed of 20 m/s, a duration of about 30 min, and a distance of 60 km from the radar station. It was a mesocyclone with medium intensity. Obvious radial convergence in the middle layer can be seen on the velocity profile.

At 04:00 on April 20, the extreme wind speed of 23.6 m/s and the short-term heavy rainfall with an hourly rainfall intensity of 25.2 mm occurred at Yanshan National Weather Station. The strongest reflectivity factor of convective storm reached 71 dBZ, and the moving speed reached 71 km/h. There was a low-level weak echo area, and the precipitation echo above 60 dBZ extended to 7.5 km. The moving direction of convective storm was perpendicular to the radar radial direction, but there was still a large wind speed area behind it.

5 Conclusions

(1) During the night of April 19, 2025, the types of severe convection in Guilin were complex, with only short-term heavy rainfall in some areas, accompanied by thunderstorm and gale in some areas. It had the characteristics of large accumulated rainfall, concentrated precipitation periods, mainly short-term heavy rainfall, and mixed severe convection.

(2) This was a strong convective weather process in the warm region. On the south side of warm shear line, with the south branch fluctuation moving eastward, strong convection occurred near the surface convergence line. With the establishment of low-level jet at night, the organized development of convective system was obtained.

(3) Before the convection, Guilin was located on the left side of the low-level jet, between the low-level shear line and the boundary layer shear line, and in the upper dry cold and lower warm wet environment in front of the significant southerly airflow. Unstable stratification and inversion layer were conducive to the occurrence of severe convective weather. Small convective effective potential energy and large *K* value were conducive to the occurrence of short-term heavy rainfall, and strong wind shear and low-level inverted V-shaped structure were conducive to the occurrence of thunderstorm and gale.

(4) The convective storm that only produced short-term heavy rainfall presented as low centroid precipitation echo, and listed the effects to form short-term heavy rainfall. The mixed convection in Xinlong, Baishou, Yongfu was caused by the heavy rainfall supercell, showing high centroid precipitation echo, with weak echo area and bounded weak echo area. The mesocyclone in the supercell was a mesocyclone with medium intensity.

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