Dual-Radar Observation study of Squall lines in China

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A squall line is one of the linear mesoscale convective systems, which produces thunderstorm, gale, and heavy precipitation. This paper studied the three-dimensional (3D) dynamic structure of three squall line cases, using the dual-Doppler weather radar retrieval wind filed. The squall line in South China was on 31 March 2014 (hereafter referred to as SC), the case in Yangtze-Huaihe River was on 14 June 2009 (hereafter as YH), and the one in North China was on 16 September 2008 (hereafter as NC). The 3D conceptual models of the three squall lines were developed.

Many features among the three cases were similar. The results showed that the surface convergence line played an important role on the convective band formation. The mid-altitude radial convergence (MARC) was very clear at the mid-level of the squall front, which location was corresponding to the heavy reflectivity band. The mid-altitude radial convergence was important to the formation of the convective line. It indicated that the convective cells in the squall front produced the heavy rainfall.

Moreover, the contrastive analyse was applied to the similarities and differences of the three squall line. The synoptic condition and the thermodynamic condition of the atmospheric environment played important role on the structure differences of the squall lines. The spatial scale, duration, the storm-relative wind, the convective intensity, and the local heavy rainfall in the SC squall line were the strongest in the three cases.

First, the radar echo in the SC squall line was the strongest. The horizontal and the vertical scale of the SC case was the largest, too. The horizontal scale of the NC squall line and the YH squall line was about 100 km, and 200 km respectively in the mature period. The horizontal scale of the SC squall line was more than 400 km in its mature period. Some convective bands more than 50 dBZ were located in the SC squall line convective region. In the vertical scale, the SC case was the most intensive too. The echo of 30 dBZ was about 8.5 km height in the SC squall line. On the other hand, the echo of 30 dBZ in the other two cases was 6.5 km height only.

Second, the horizontal storm-relative wind speed in SC squall line was the strongest in the three cases. The convergence in the SC case was more intensive than the other two cases. In the SC case, the organizational characteristic of the horizontal font-to-rear flow was more remarkable than the others.

Third, the 3D wind field in SC squall line was the strongest in the three cases. The storm-relative wind speed in the convective region was up to the maximum of 20 m/s at 4 km height. The rear-to-front inflow entered the squall line at the height of 3km from the stratiform cloud region. The front-to-rear inflow entered the squall line below the altitude of 4km from the front. This inflow converted into two outward flows in the front of the convective cloud at 7km height. Part of the front-to-rear inflow moved forward, and the other part sloped into the stratiform cloud. In the YH case, the rear-to-front inflow entered the squall line from the stratiform cloud region at the altitude of 4 km. The front-to-rear inflow entered the squall line from the leading edge. In the convective cloud and the stratiform cloud region, the front-to-rear flow prevailed above 4 km height. On the other hand, the rear-to-front inflow entered the NC squall line below 2 km height. The front-to-rear inflow directed into the squall line from the surface to the

height of 5 km at the leading edge, and then converted into two outward flows. One flow was forward, and the other rearward. In the SC squall line, the updrafts in the convective region were the most intensive in the three cases, and its speed was about 13 m/s at the height of 6 km.

Keywords: Squall line, Dual-Doppler weather radar, Wind retrieve, the three-dimensional dynamic structure