1. INTRODUCTION

Effected by high trough and surface weaker cold air, storm rainfall occurred during 31st Mar. ~1st Apr., 2004 in South China. The rainfall case was studied with a meso-scale dual-moment cloud resolving model, which was revised in Chinese Academy of Meteorological Sciences based on MM5v3. The cloud resolving model uses quasi-implicit calculating scheme, includes 11 prognostic microphysical variables, which are the mass content of water vapor, cloud droplets, raindrops, ice crystals, snow and graupels, the number concentration of raindrops, ice crystals, snow and graupels and the broadness of cloud droplets size distribution and 31 microphysical processes.

The central point was at (23°N, 113°E), two-way nested, horizontal resolution was 30 km and 10 km, respectively, the nest domain basically covered south China. 23 layers in vertical, the top pressure was 100 hPa. Grell convective scheme, Blackadar high boundary layer scheme, cloud-radiation scheme and the coupled cloud scheme were chosen. The model was initialed with NCEP re-analysis data at 00:00 UTC March 31, 2004, and run 36-h.

2. ANALYSIS OF CLOUDS AND RAINFALL

At 2100 UTC 31 March, 2004 there was southwest-northeast cloud band over north of Guangdong Province in GOES-9 infrared imagine. Cloud band gradually intensified during moving southward, at 0000 UTC 1 April, cloud developed to mature stage, which were about 200 km in width. Then, cloud continued to move southward, about 0300 UTC the front of cloud band was over South Sea, decayed away. The occurring time, location, shape and orientation of simulated cloud bands and their evolution were consistent with GOES-9 infrared imagine.

The distribution and amount of simulated surface rainfall during the main precipitating period were coincided with the observation. The mesoscale southwest-northeast rain band moved southeasterly with cold front moving. There were 4 strong precipitating centers in the rain band, whose lifetimes were beyond 3 hours, and moved mostly eastward, which agreed with the moving of radar echoes.

3. ANALYSIS OF SIMULATED AND OBSERVED RADAR ECHOES

Known from CAPPI Radar echo of 3 km height in HongKong, stronger radar echoes mainly moved eastward with time, however the main cloud bands moved gradually southeastward. Fig. 1a was CAPPI of 3 km height at 0100 UTC 1 April in Hongkong. In
the cloud bands there were some stronger radar echoes, which was about 50 km in horizontal scale and whose rainfall rate was about 20 mm/h.

Known from fig. 1b, the southwest-northeast band echoes mainly occurred at surface frontal line and post-frontal part. The maximum radar echoes reached 45 dBZ.

Seen from fig. 1c, the cold front clouds were not homogeneous, where lain convective cells. In the AA segment, the stronger echoes in lower layer linked up each other, which reached 200 km in horizontal scale, but in the upper layer could been resolved into 3 cells.

Seen from fig. 1d, the horizontal width of radar echoes is about 90 km. Near to the surface cold frontal line, the horizontal gradient of echoes is great, and the intensity changed sharply, which was characteristic of narrow cold front rainbands[1-3].

Seen from fig. 1e, there was another weak echo band in post-frontal cold air area, whose top was about 9 km high, horizontal width was about 40 km. There were 2 strong centre in the upper range and lower range of the cell. This belonged to wide cold front rainbands.

Seen from fig. 1f, the echoes in the warm areas was weaker, whose top was about 5 km. The distribution of these echoes was separated, which was different from those in fig. 1d.

In brief, the distribution of simulated radar echoes was agreement with radar observation. The southwest-northeast band echoes mainly occurred at surface frontal line and post-frontal part. The difference of individual echo in the different part of cold front was great.

4. ANALYSIS OF MICROPHYSICAL CONVERSION RATE

Conversion of hydrometers was the important microphysical process. So we should analyze the main precipitating process of cold front. We chose two points B1(24.33 °N,113.83 °E) and B2(24.85°N, 113.465°E) , which was located in different part of cold front (specified sites seen in fig.1b).

The maximum updraft of B1 reached 0.9 m/s, located during k=7~13. However, below k=12, there were downdrafts for B2, its maximum updraft was only 0.3 m/s, located in upper layer. Temperature profile of the two points was almost the same.

Seen from fig. 2a, for B1 the main growth process of raindrops was the collection of cloud droplets by raindrops in warm layer (Ccr). Warm rain process was clear. The melting of graupels (Mgr) was another main process for the growth of raindrops. But for B2, seen from fig.2b, the main process for the growth of raindrops was the melting of graupels (Mgr). And evaporation of raindrops (Svr) was a little big for there was no cloud water in lower layer. The main growth process of raindrops of the two points is different.

For B1 (fig. 2c), the main newborn processes of graupel are the collection of raindrops by ice (Ncri) and by snow (Ncrs). For there was little snow, the process of autoconversion of snow to graupel (Nasg) wasn't the main process for B1. The mechanism is different from that of narrow cold front rainband[4]. But for B2 (fig.2d), during k=12~16, Ncrs was the main process of newborn graupel, next was Nasg and Ncri. During k=17~20, only Nasg could produce newborn graupel.

Seen from fig.2e, the collection of cloud by graupel (Ccg) was the main process of graupel for B1, for there were full of supercooled cloud water. The mechanism is the same as the study of Rutledge and
Hobbs [4]. Snow was another source term for the growth of graupel. But for B2 (fig.2f), the collection of snow by graupel (Csg) was the main growth process of graupel.

In all, near the surface line, the updrafts was a little great, and the mass content of cloud water was great, then the processes of ice particles riming and collection of cloud droplets by raindrops were the main microphysical processes. However, in the wide rain band areas, updrafts only lay in upper layers, downdrafts were in lower layers, and there were mainly supercooled cloud water, graupels and snow crystals. Snow crystals was the main source term for graupel growing, precipitation was mainly formed by graupels melting, cold rain process was more important.

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REFERENCE


Fig. 1 Radar reflectivity of simulation and observation at 0100 UTC 1 April, (a) CAPPI of 3 km height at Hongkong (rainfall rate, mm/h, scan radius is 300 km); (b) simulated CAPPI of 3 km height (contour interval is 10 dBZ) and surface wind fields; simulated vertical cross section of radar reflectivity and wind fields along line LL(c), AA(d), BB(e), CC(f) in fig. 4b (contour interval is 5 dBZ), short dash line is 0℃, -10℃, -20℃ and -40℃ from bottom to up, respectively, thicker solid line is zero horizontal wind component parallel to the cross section.
Fig. 2 Instantaneous microphysical conversion rate of rain drops (a, b), graupel (e, f) mixing ratio ($10^{-3}$ g·kg$^{-1}$·s$^{-1}$) and number concentration of graupel (c, d, kg$^{-1}$·s$^{-1}$) at 0100 UTC 1 April, (a, c, e) B1, (b, d, f) B2, vertical coordinate is grid.