Analysis of the characteristics in a strong convective weather process in China

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ABSTRACT

By using the numerical forecasting product, the convention, the automatic weather station and Doppler weather radar materials, it analyzed Hunan strong convective weather process on April 4, 2006. The result indicated: The preliminary weather returns to warmer continually, and accumulate massive unstable energies, the vertical wind shear, the power, the thermal energy and the water vapor condition are advantageous to the strong convection weather production; During this process, ground and the upper air temperature, the humidity, the kinetic energy perturbation quantity, the ground temperature perturbation is bigger than each level upper air of the temperature perturbation obviously, it explained that the ground thermal energy function is bigger than that of the high level; In the disturbance moisture field, transfers the weather to have the region each level humidity is smaller than the environment humidity perturbation, this possibly presents one of thunderstorm gale reasons, each level's humidity perturbation is quite big, therefore transfers is very exuberant; In the perturbation kinetic energy field, the region which the process happens of perturbation energy is bigger than that of before and after process obviously. In each level, 850hPa perturbation energy is the biggest, the ground comes second; The ground mesoscale spoke vanishing line and the strong convection's formation has the very good corresponding relationship. The intensity chart has the massive strong convection echo, the strong center is bigger than 55dBz, the echo top elevation is bigger than 12km, the Gust-Fronts characteristic is very obvious; On the speed chart, the mesoscale divergence line appear earlier than convection echo band approximately a half hour, what with strong echo band to correspond are the cyclone, against front echo characteristics and so on;

Introduction

From the mid-70s, through the double Doppler weather radar observation to understand thunderstorm system's internal structure, especially the system interior's three dimensional wind field (Ray et al.1975), discovered particularly the hail storms wind field has the cyclone type circulation characteristic, the ascendant current located at the weak echo region. Chisholm and Renick (1972) and Browning(1977) divides into the multi-monomer storm and the super monomer storm the storm through using the past storm research and the recognition of the storm power and the structure of Micro physics ; The storm has four stages: initial development period, the beginning of echo characteristic, mature stage, dissipation stage. Klemp(1987) reorganizes many year findings, showing that the Mesoscale cyclone in the fierce convection storm is the horizontal direction scroll which cuts by the environment vertical wind forms does after the convection development reverse creates. He simulates the super storm movement field structure, under the constant condition, the underlying level has a convergence area (the Gust-Fronts area), which is created by correlation of the warm wet underlying bed internal flow and the system precipitation outflow. Routunno et al. (1988) also using the analogue result pointed out that because the environment underlying level wind shear with the precipitation, the convection system after skirt the air current stimulates the new convective cell continually toward predestined affinity cold air, causes the mesoscale convection system development to be more lasting.

1 Process real state and disaster situation

On April 4,because of cold air heading toward south and the southwest pour slot joint influences, pour slot frontogenesis in middle of Hunan, presented the thunderstorm gale, the hail, the short-time rainstorm and so on strong convective weather, there were 23

county or city gale in the whole province , and 2 site hail in GuZhang, ShiMen, which the maximum diameter is 7mm. The maximum wind speed reaches 32m/s of the thunderstorm gale in Changsha area. The average precipitation is about 10.5mm in entire province. Southwest Hunan has the medium to heavy rain. There are 66.9mm rainstorm in Qianyang. The temperature falls all over the area 14~17℃ in the 24h. This strong convection process's main feature is the traveling speed is quick, by the thunderstorm gale weather, the precipitation is not obvious.

For gale influence, Changsha: In the city the advertisement, the lamphouse street sign as well as the city's appearance environmental sanitation also suffer the varying degree the destruction; Several hundred trees are folded on the Yuelu mountain; The numerous urban facilities also presented many place scars, the municipal transportation have had the jamming in many places, the residents were injured in varying degree in this storm. A hundred-year big tree are “broken off around the middle” by the gale, causing the road section to traffic jams for half an hour. About thousand populace have brought not the small puzzle, they reside temporarily the transition awning asbestos tiled roof is thrown off by the gale, homeless.

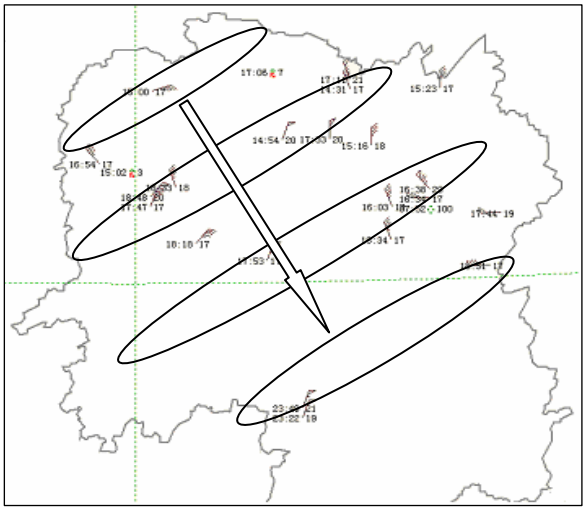

Fig. 1 Hunan thunderstorm gale distribution map on 4th

2 Weather situation analysis

Influenced by ground weak cold fronts on March 28, March 31, Hunan ground transfers behind the high pressure of southerly air flow controlling. The 500hPa upper air is the northwest air current. The temperature rises again continually. On April 1, Hunan upper air and the ground transfer the consistent southwest wind controlling, the southwest low altitude jet stream strengthen rapidly. At 08:00 on 4th, the southwest air current develops exuberantly, the 500hPa meridional circulation deepen. Changsha and Zhijiang’s 700hPa wind speed respectively is the 26 m/s, 20m/s,850hPa two stands is also 26 m/s, 20m/s. On the ground plot the entire province’s south wind was bigger than 4 levels, south Hunan also presents two stations Rafael to be bigger than 17m/s of southerly gale. As a result of the consistent southerly air current, the temperature rises again rapidly. The entire province high temperature reaches 30℃ above on 3~4th, the highest temperature surpasses 34℃ at the partial cities (county) in middle of Hunan, accumulated the massive energies for the strong convection weather's occurrence. Latter south low trough development moving towards east at 08:00 on 4th, although low level shear is at the north of Yangtze River, but the shear line north side's leaning north wind enlarges, ground cold air located at Yangtze River. Analyzes the automatic weather station materials, the ground cyclone wave starts to affect our province from 4th 12:00,the frontogenesis process is obvious, 16:00, the frontal zone located in middle of Hunan, the temperature difference reaches 10℃ above at the approximately 40 kilometers between survey stations. The upper air shear line located in middle of Hunan at 20:00, the both sides wind speed is big, the convergence is exuberant, the ground cyclone wave's low whorl center moves towards the boundaries of Jiangxi. The cyclone wave swept the area presented two station hail,

the most districts present the thunderstorm gale. Changsha station presented the 32m/s gale at 16:49. After 20:00, the cyclone wave continues to move to east, because our province has been in its rear part, the convection weather's intensity has weaken, movement reduces speed. on 5th in 08:00,the low level shear line moves to south Hunan, because the shear line stays south Hunan for a long time, the precipitation tends to be obvious, appeared one rainstorm.

According to the meteorological sounding material, aerological ascent material on 4th 08:00, three of Hunan meteorological sounding stations' wind direction turn clockwise along with the highly before strong convection weather occurs, with obvious warm advection and the medium strong wind vertical shear, meeting vertical wind shear condition which the strong convection weather forms. Showalter Index of three station is small in Table 1 showing atmospheric stratification is unstable. Changsha strong convection weather appears between 12~20:00, unstable energy transfers by the negative value from 08:00 to 20:00;The Huaihua station strong convection weather appears around 20:00, both two times are negative value; The Chenzhou station strong convection weather appears after 20:00, the unstable energy from transfers the negative value. Indicated it has very strong unstable energy when the strong convection weather occurs. The unstable energy of three stations change scope to be large, but Showalter Index to be small, therefore the former is more sensitive regarding the convection weather's occurrence. Whole province Showalter Index is small on 4th, with negative unstable energy, be advantageous to the convection weather production. Three stands transfers the stable stratification on 5th 08:00, and the strong convection weather ends.

Table 1 Hunan meteorological sounding station Showalter Index, unstable energy on 4th

		Changsha	Huaihua	Chenzhou
Showalter Index	08:00	0.1	0.1	0.3
	20:00	1.9	－0.5	-1.0
Unstable Energy	08:00	－33.6	－63.5	16
（J/kg）	20:00	33.0	－1547.3	-123.8

3 Perturbation physical quantity field analysis

Using the T213 material, in the enclosed area, neglecting the air quality along with the high reduction, calculated each perturbation kinetic energy, the perturbation temperature, the perturbation humidity. The perturbation physical quantity has removed the mean value, and could describe the small criterion characteristic better, being advantageous to the analysis synoptic process trigger mechanism.

3.1 Perturbation temperature

In Figure 2, the weather is clear in province at 08:00, and the gradient of temperature is small, strong convection weather soon appear in Xiangbei at 14:00, the North Hunan's temperature is bigger than the environment's obvious, presented an obvious temperature zone of action, forms a very great gradient of temperature, presents with the relative plot to echo band of the position consistently soon. The temperature perturbation positive value center has headed to south at 20:00, the corresponding relative plot the echo band position had headed to south also, but was still located in north Hunan, the temperature perturbation with echo band position to be more consistent.

Analysis of each level of the temperature perturbation (Figure 5), it mainly appears below 850hPa, and the biggest value is at the 1000hPa, difference 5℃ above with environment's temperature, but the high-level's is very small.

It shows that because of the low level been heated non-uniform, frontogenesis is one of this process main trigger mechanisms.

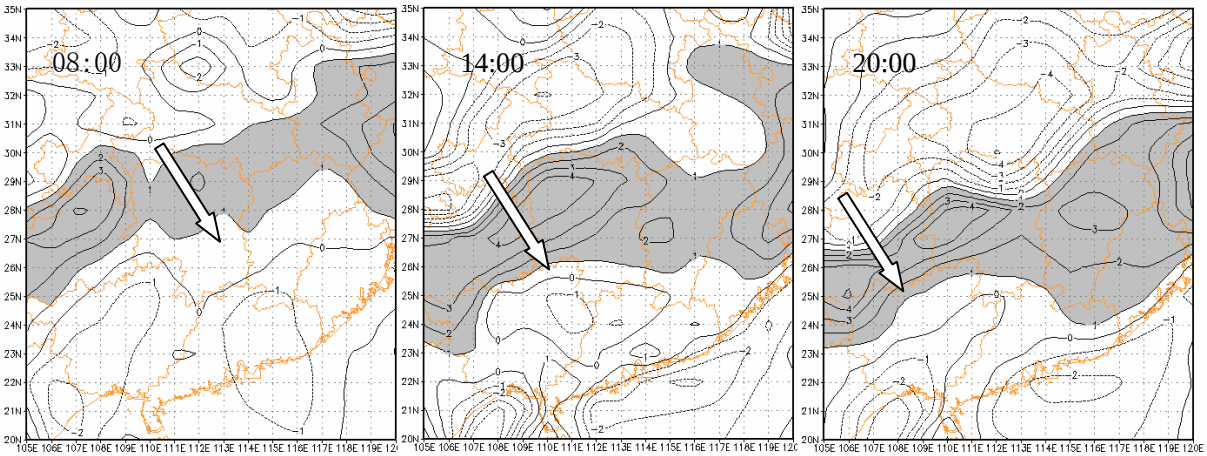

Fig. 2 1000hPa perturbation temperature field

3.2 Perturbation humidity

In each time moisture field on 4th, northwest and southeast of Hunan were relative high value zone of humidity, but north and middle of Hunan were low value zone, especially the west humidity is lower than other areas obviously. From vertical profile (chart 5b), north and middle of Hunan each level perturbation humidity were also low value areas, but it appeared the thunderstorm gale strong convection weather, which possibly because of the low environment humidity and few water vapor and small precipitation, therefore mainly by the thunderstorm gale weather, no other strong convection weather

On each level relative humidity perturbation chart, the humidity perturbation is very large in each level's perturbation, which is different from temperature perturbation obviously, even 200hPa has the obvious perturbation, therefore this process's convection is very exuberant, and the echo top elevation is bigger than 10km.

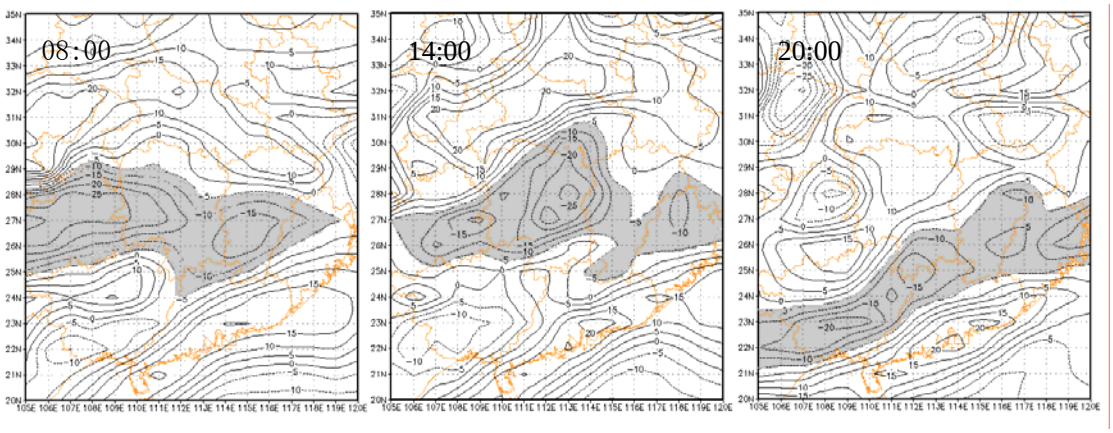

Fig. 3 1000hPa perturbation moisture field

3.3 perturbation kinetic energy

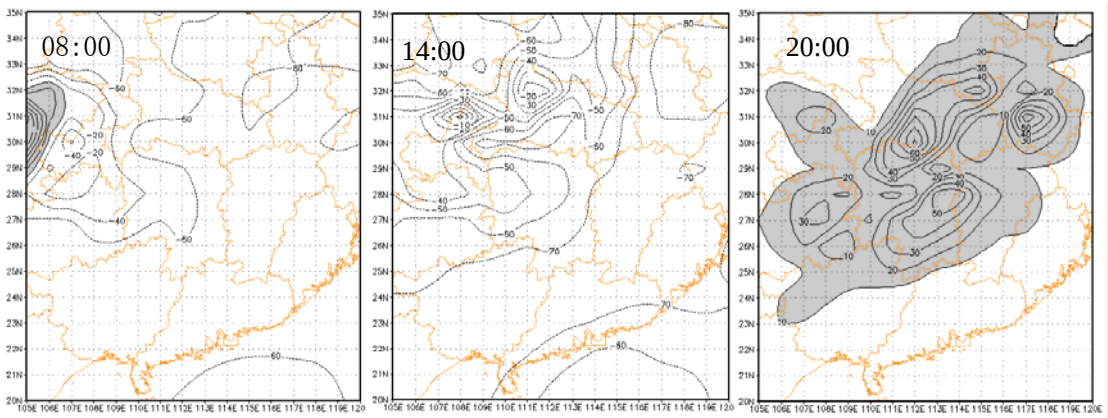

Fig. 4 850hPa perturbation kinetic energy field

The extreme value center of perturbation kinetic energy at 14:00, 20:00 on 4th is bigger than at 08:00on 4th and at 02:00 on 5th, the strong convection weather mainly appear during 14~20 times on 4th; The perturbation kinetic energy center moves to the south and east along with the time, similarly, the strong convection weather affects Hunan Province from north to south on the radar plot. Analysis of each level of the perturbation kinetic energy, the 850hPa is biggest, which is bigger than each level's. If it consider that air quality decreases along with height, the low level perturbation kinetic energy will be bigger, therefore if may determine that the perturbation kinetic energy of 850hPa also will be one of strong convection weather triggering mechanisms.

4 Radar echo analysis

This process selected Huaihua, Changde, Changsha of Hunan Province radar material to carry on the generalized analysis. The Changde radar has breakdown many times during the strong convection weather process, the Huaihua radar was seriously masked by terrain, and the echo charts of elevation angle of 2.4 still have many mask angles. Therefore this weather process analysis mainly regard by Changsha radar material primarily. The mainly analysis were index of reflection factor, the Doppler radial velocity and derive the product.

4.1 Index of reflection factorial analysis

Clearly on the PPI chart, a small convection echo developed in northwest of Hunan on April 4th,which move to northeast meanwhile, merges unceasingly strengthens, forms a Northeast - southwest striation echo band. It could clearly analyze the strong developing echo belt at the front of echo belt which was parallel with the Gust-Fronts and belt-shaped echo, therefore forms many echo bands. Echo band was composed of many convective cells; the forefront echo band intensity was strongest. The strong echo monomer's Intensity center is bigger than 60dBz, the echo top is higher than 12km. It analyzes each level of the PPI chart that the strong echo incline is not obvious along with the height. In vertical profile, it analyzes many convection echo monomers, not presenting the weak echo area or "the dome" the shape echo, the strong echo is located at below generally 8km, but it has the strong echo aerosol in 2 to 5 kilometers which is bigger than 55dBz. The most obvious characteristic is Gust-Fronts before the storm on PPI in this process, particularly approaches in middle of Hunan, when the convection echo just formed, its front part existence obvious Gust-Fronts. On the one hand it shows the cold air submersion current is very exuberant in storm, the ground forms the intense divergence, therefore this process mainly by gale weather primarily; On the other hand because Gust-Fronts and the storm apart far, shutting off the storm inward flow, therefore the storm has not formed the super monomer storm, mainly by strong storm, and the life history is short.

carrying on the generalized analysis with each hour ground automatic weather station material and correspondence time radar echo (Figure 5), it discovered that most strong echo band and the ground spoke vanishing line has the very good corresponding relationships, convective cell along guidance wind traverses, while echo band move to southeast along the ground convergence alignment. With the cold air heading south continually, the frontal zone slows down, the scope increases, the intensity has is weaken, therefore the precipitation increases, but the convection weather's intensity is weaken.

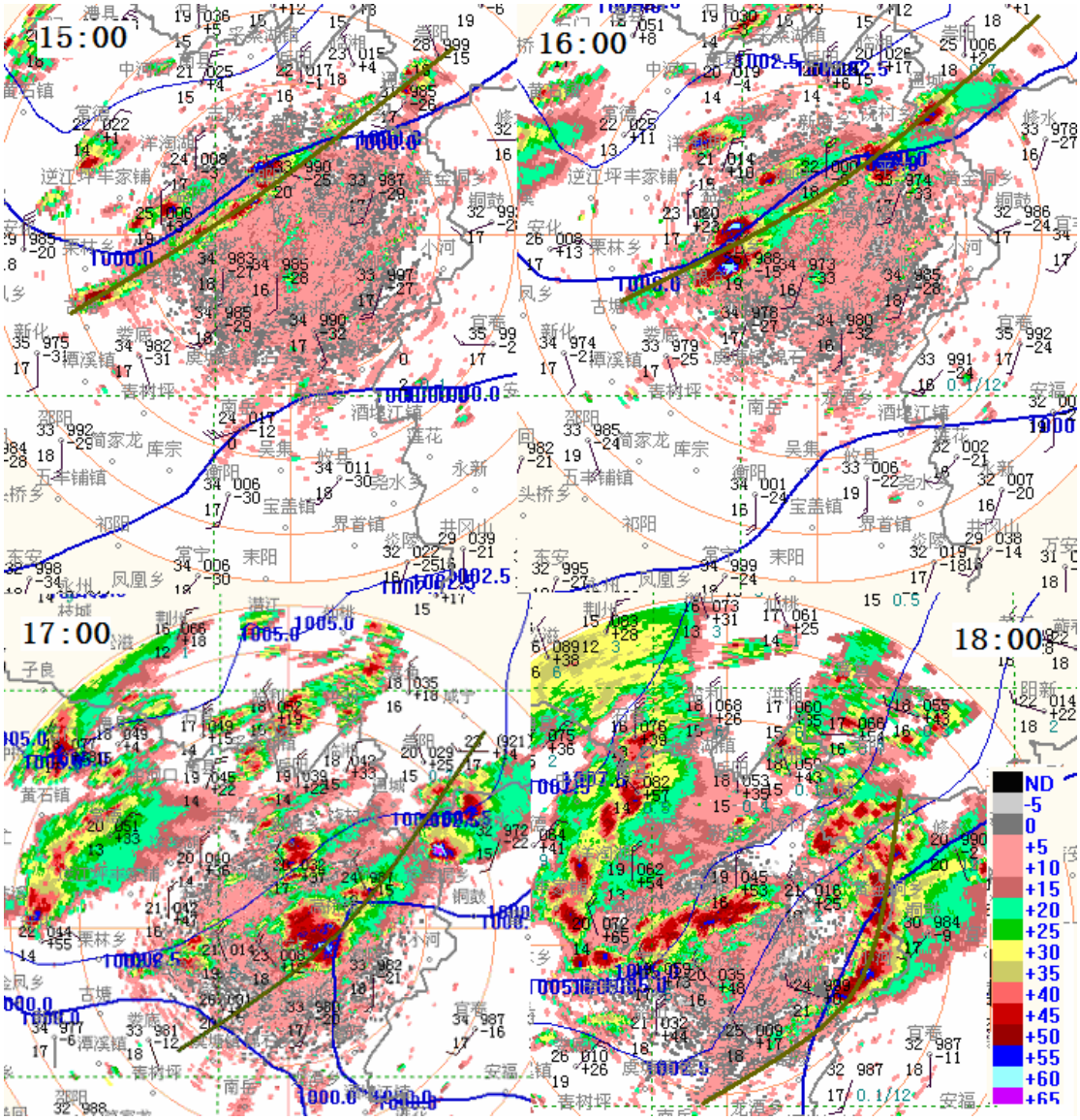

Fig. 5 Automatic weather stations and radar echo charts on 4th

4.2 Mesoscale system structure characteristic

On Doppler velocity chart corresponding with the strong convection echo, it has the mesoscale cyclone, the anticyclone generally in the low level. The convergence cyclone, the anticyclone, the against the wind area also frequently happen (e.g. Figure 6). There is non-precipitation echo on intensity chart at 13:34, but on 0.5 elevation angle's Doppler radial chart, it has a belt echo along Yueyang-Yangjiang-Taojiang(this actual altitude approximately 1300 to 1400km), approaches the radar for negative speed, clearly discernible, far away from radar one side for the speed, visible faintly, indicated that has the strong divergence. Both sides of divergence line of positive and negative speed were clearly discernible at 06:04, high-level (about 3.4,5km) has the cyclone, as well as more than 27m/s of gale nucleus to appear, meanwhile both sides of this line have the convection backflow belt formation. The divergence line appearance about early a half hour than echo band. Along with many echo bands formation, the northern section of divergence line is obviously on the speed chart, while the speed range in the south section which is far away from radar is small, evolving the cyclone and the anticyclone gradually. The negative speed is in left side of radial, while speed is in right. Meanwhile south section convective storm is much stronger than north section. The convective cell develops toward north, north section divergence line's negative speed area is surrounded by the speed area, forming the against wind area. When the storm moved to radar's south side, there is the spoke vanishing line in the wind south side, what corresponding with strong echo area was some very disorderly cyclone and the against wind area, 5 cyclones were observed during the process. When the echo head south furthermore, the clutter echo on speed plot becomes gradually orderly,

the low level transfers leaning north wind, high-level is the leaning south wind. In the intensity echo, the convective echo also gradually evolves the mixing echo, strong convective weather weaken, on the contrary the precipitation enlarges

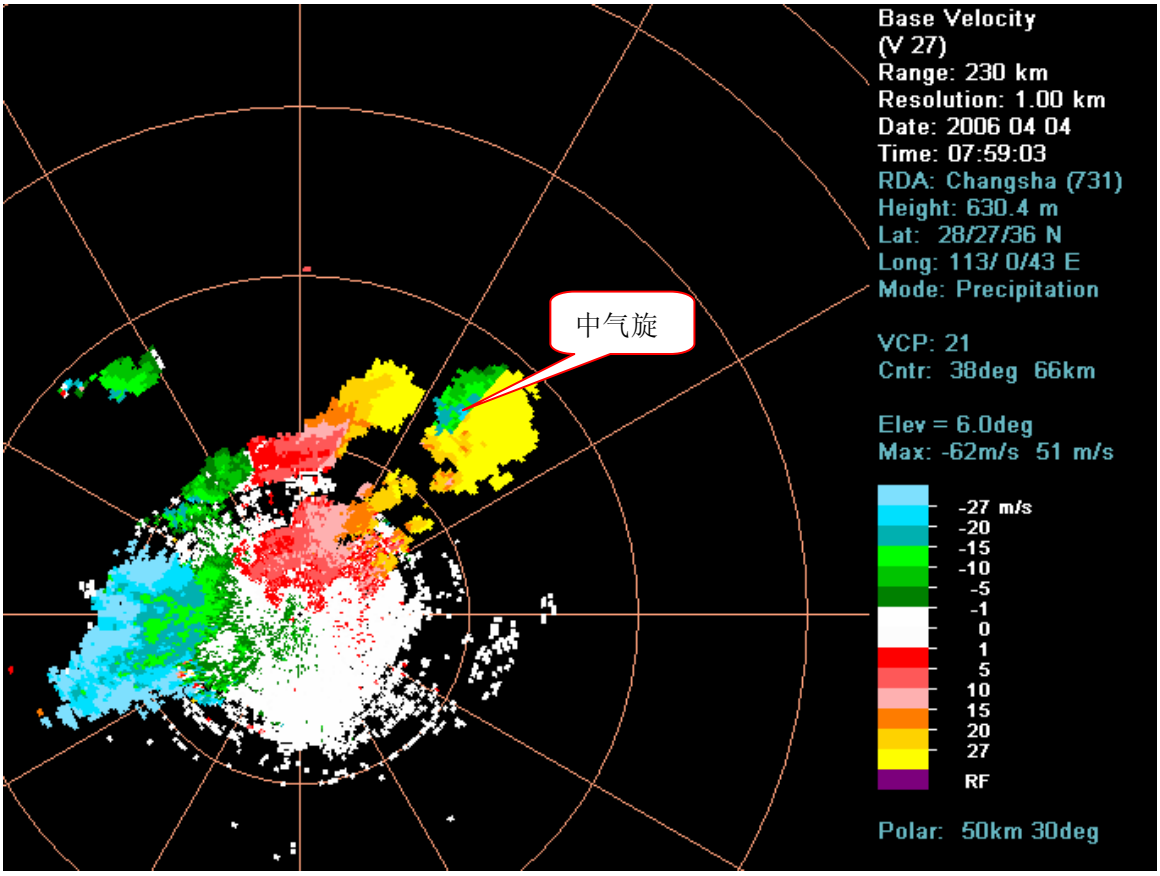

Fig.6 Radar Chart at 07:59,on April 4th,2006

5 Results

(1)The preliminary weather returns to warmer continually, the accumulation massive unstable energies, the vertical wind shear, the power, the thermal energy and the water vapor conditions are advantageous to the strong convective weather production.

(2) Analysis each level of temperature perturbation quantity in this process, before and during process influence, it has positive temperature perturbation, which is bigger than the environment temperature; after process influence, it has the negative temperature perturbation, which is smaller than the environment temperature. The ground temperature perturbation is bigger than each high level temperature perturbation obviously, showing that the ground the thermal energy function is bigger than the high level's thermal energy function.

(3) In the moisture field of perturbation, each level's humidity of where strong convective weather happened is smaller than environment's,forming convergence, while relative humidity is not large, it maybe one of the reasons of thunderstorm gale happening. Each level's humidity perturbation is quite large, therefore convection is very exuberant.

(4)In the kinetic energy field of perturbation, the perturbation energy of where process happened is larger than that of before and after process. In each level, the perturbation energy of 850hpa is the largest, and the ground's comes second.

(5) On intensity echo chart, there is typical strong convection echo in north Hunan, but the convective echo gradually evolves mixing echo in south Hunan. Gust-Fronts echo chrematistics is observed in north Hunan obviously.

(6）The divergence line happened earlier than echo band's appearance ahead of time about for a half hour.

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