P4A.3 MESOCYCLONE IN MINI SUPERCELL -- A CASE STUDY

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1.ABSTRACT

A mini supercell was observed in the northwestern Shandong province, China, on 27 September 2002. The storm was within 80-km of range from the Jinan radar. The structure and the development process of mesocyclone were detected. In the first hour of the case, the storm appeared as a multicell storm. In the second cell remarkable velocity shear was detected at 4-km level, but it did not reach the mesocyclone criterion. The third cell developed rapidly and soon became a mini supercell with V-notch and BWER. About 40 minutes later mesocyclone characteristics were detected. According to a series of 6-slice products SRM (56), the rotating velocity was initially observed at 1-km level and then developed upward. The mesocyclone existed almost 90 minutes with the average diameter of 5 km and its vertical range between 3.5 km to 6 km. The rotating velocity was about 17 $m \cdot s^{-1}$, and the momentum 170000 $m^2 \cdot s^{-2}$. At the end of the case the mesocyclone contracted by shrinking the top downward and the base upward. It disappeared at 4.1 km level. During the strongest period of the mesocyclone hails with maximal diameter of 13 mm were reported but no hazard winds occurred, perhaps because the mesocyclone was high above surface and did not touch down. Another cause was due to the low CAPE ($352 J \cdot kg^{-1}$) and the supercell was moderate relatively. The precipitation on the path of the storm was 3 mm to 10 mm.

2. METEOROLOGICAL CONDITION AND THE WEATHER

On 27 September 2002, near 0000 UTC, in the northeast of China there was a cold vortex at the high level. The cold air flows south at intervals. This is the typical weather situation that causes the hail occurrence in Shandong province [1]. On 27 morning (26 2200 UTC), there has been light rains by a weak cold air passing through Shandong province. Air soundings obtained at 0000 UTC 27 September in Jinan indicted convective available potential energy (CAPE) value of about $352 J \cdot kg^{-1}$, and 1-3km storm-relative helicity value about $134 m^2 s^{-2}$. These parameters didn't support that severe storm would occur that day. However, because Shandong was located in an area of surface low pressure, the surface temperature was warmed up rapidly by sunlight. The surface temperature at Chaocheng (54808) afternoon was 9ºC higher than it was in the morning. In addition to the cold air advection above, by 0500 UTC the first storm cell occurred in Linqing County. The storm moved southeast and developed into a supercell. It weakened and dissipated around 1000UTC in the evening (Fig. 1, A series of reflectivity (19) products of 1.5º elevation, omitted.). According to the surface record in Donge County, hails with maximal diameter of 13 mm occurred at 0715 and 0731 UTC. No hazard wind was observed along the path of storm. The precipitation was light, around 3-10mm, meanwhile.

3. STORM DEVELOPMENT AND MOVEMENT

At the beginning the storm appeared as a multicell storm. It developed into a supercell storm after an hour. The first cell was presented at 0511 UTC and dissipated at 0637 UTC. In the right front of the first convective cell the second cell occurred and developed at 0542 UTC. It dissipated by 0701 UTC. The 3rd cell developed at 0613 UTC in the right front of 2nd cell. It soon developed and became a supercell. The hail occurred about an hour later. Figure 1 (omitted) shows a series of reflectivity (19) product of 1.5º elevation.

According to a series of reflectivity products, the storm occurred initially at approximately 5 km high level. It appeared as a typical multicell storm. New cells occurred and developed on the right front of the old cells continuously. The old cells weakened and dissipated gradually.

In the mature phase of the storm, the maximal reflectivity remains in a high value, the average reached 59 dBZ (Fig. 2, The maximal reflectivity and VIL, omitted). The image from 0701 UTC 27, September (Fig. 1, omitted) shows that the echo had developed in a kidney-bean shape. At 0725 UTC on the right front of the echo, "V" notch appeared.

A series of vertical cross-section plots of reflectivity from Jinan radar, generated through

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the core of the storm at 0707, 0725, and 0802 UTC (Fig. 3, omitted) along the storm movement direction, show the feature of boundary weak echo region (BWER).

In the first hour, because of new cell arose on the right front of the storm, the movement direction lean to the right of the wind direction of 700 hPa, which was about 310°. When the storm became a supercell storm, the direction of the cell movement was nearly the direction of environmental flow.

The velocity of the storm movement increased gradually. It was about 22 km/hr at 0523 UTC and 40 km/hr at 0927 UTC. The increasing of the moving velocity is due to the storm developing in vertical height. Because the wind velocity is increasing with height, the higher the storm developed, the higher its mass core is, the faster it moved.

4. THE MESOCYCLONE

The Jinan radar WSR-98D identified mesocyclone from 0649 UTC to 0820 UTC with the default adaptable parameter (shown in table 1, omitted). Half an hour after the third cell arose, at the slices of 1.5° and 2.4° elevation, the pair of positive and negative velocity appeared. Afterward, the strength of the shear increased. The shear reached the maximum (-30, +5 m/s) at 0655 UTC. The WSR-98D radar identified mesocyclone first at 0649 UTC and the ID was 90.

The mesocyclone location was straightly above the V-notch. Its average diameter in horizontal is about 4.5 km with maximum of 6 km and minimum of 2.8 km. It existed between 3.5 km to 5.8 km in vertical direction with depth of 2.3 km. When it dissipated, it shrank at 4.1 km level with the top downward and the base upward. The maximal rotating velocity was about 17 m/s, and the momentum 170000 m^2/s.

In table 1 (omitted) the ID is the number of the mesocyclone from the WSR-98D. The AZ is the azimuth of mesocyclone movement relative to radar. The RAN is the range from the radar; The Top and Base are the top and base of the mesocyclone. The RAD and AZDIA are the diameters of mesocyclone in radius and azimuthal directions respectively.

Fig.4(SRM products in various elevation ,omitted) shows the SRM products in various elevations at the same time 0655 UTC. It shows the typical rotational structure of the mesocyclone. The air flows converged with cyclonic-wise at low level, rotated cyclonic-wise at mid low level, diverged with cyclone-wise at mid high level, and diverged at the top.

Why hazard wind didn't occur on the surface?

The integrated rotational strength (IRS) index[2] is calculated and shown in Fig. 5 (The integrated rotational strength (IRS) index ,omitted). The average diameter of the mesocyclone in this case is about 5 km. This is suitable to the nomogram in reference [2].

The mesocyclone diameter is approximately 6.4 km. In comparison with those of tornado or hazard wind on surface, the IRS is far smaller, and the vortex was at the middle level above the surface. It didn't touch down.

5.HAIL INDEX(HI) AND VERTICAL INTEGRATED LIQUID (VIL)

With the default adaptable parameters, WSR-98D system identified HI product as Probable, not Positive. The time is close to the actual hail-fall time. In this case VCP21 was taken with a large gap of elevation between 6.0° and 9.9°. It was probably one of the causes for the failure of the HI.

By default the HI algorithm doesn't take account of the heights of 0°C and -20°C level, or the variation of these levels in different seasons. In light of this consideration we changed the TH1 from 8 km to 7 km and replay the Archive2 data. The generated HI product became positive two times near the actual hail-fall time (table2, omitted)

Using the location function of PUP and the record of hail fall in Donge County, the location of the hail fall is association with the mesocyclone and a little bit left aside.

VIL was analyzed in this case. The default adaptable parameter is used. The VIL values by time are shown in Fig. 2 (omitted). Before the first mesocyclone was identified the VIL increased from 15 $kg{\cdot}m^{-2}$ to 35 $kg{\cdot}m^{-2}$. Afterward it reached to 45 $kg{\cdot}m^{-2}$ when the hail occurred.

It must be pointed out that because the VCP21 was obtained when there is a data gap between 6° and 9.9° elevation, the value of VIL was lower than its actual value.

6. SUMMARY

This storm occurred in an unfavorable environment. In spite of low CAPE and Helicity, the storm occurred due to the surface low pressure and the cold air flow above. But the mesocyclone occurred in the storm was not too strong and aloft at the middle level and didn't touch down, so no hazard wind occurred on the surface.

Hail fall occurred 27 min after the first mesocyclone was identified while the IRS index reached the maximum value. HI index reported Hail 15 min ahead of the hail fall. The VIL sharply increased 30 min ahead of the hail fall.

7.REFERENCES

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