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ANTICYCLONIC TORNADOES IN 1980 AND 1981

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1. INTRODUCTION

Anticyclonic tornadoes have traditionally been regarded as weak and short-lived storms, with an occurrence frequency of one in several hundreds. But on 4 April 1981, an anticyclonic tornado of F4 intensity was spawned by a 28,000 ft thunderstorm in West Bend, Wisconsin. On 3 June 1980, three anticyclonic and four cyclonic tornadoes were spawned from a single, cyclonic mesocyclone in Grand Island, Nebraska. These two events not only reveal new information on the nature of anticyclonic tornadoes but also exemplify the relationship between the tornado and the mesocyclone.

2. THE WEST BEND STORM

A few minutes past midnight on 4 April 1981, the National Weather Service identified a storm as a bow echo (Fujita, 1981a) near West Bend, WI. The echo did not display any rotational characteristics and the echo tops were measured to 28,000 ft, however the storm spawned the strongest anticyclonic tornado ever confirmed (F4), and was the first clockwise twister to have caused fatalities (3 persons). Figures 1, 2, and 3 show mappings of the tornado track. Analysis of the area shown ir Figure 3 confirm that the tornado was rotating clockwise.

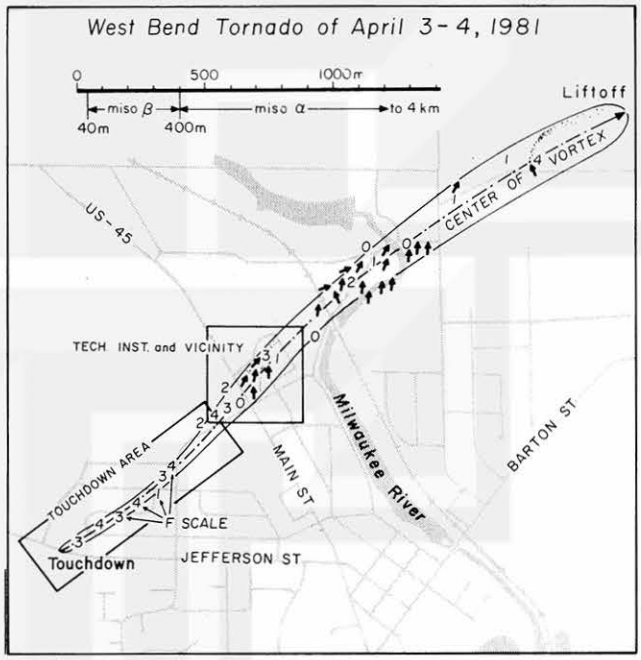

Figure 1. Overall mapping of the anticyclonic tornado at West Bend, Wisconsin on 4 April 1980. The boxed in areas are enlarged in Figures 2 and 3.

3. THE GRAND ISLAND STORM

On 3 June 1980, Grand Island, NE was struck by one of the most spectacular storms ever recorded. In 2 hours, a total of seven tornadoes were spawned by the parent mesocyclone. Three of these tornadoes were anticyclonic.

3.1 Satellite Imagery

Figure 4 depicts the Grand Island storm cloud at 0300 GMT on 4 June 1980. A V-shaped wake is seen near the west end of the cloud. A detailed analysis of the IR temperature pattern is shown in Figure 5. This wake has been observed in satellite imagery before and appears to be an indication

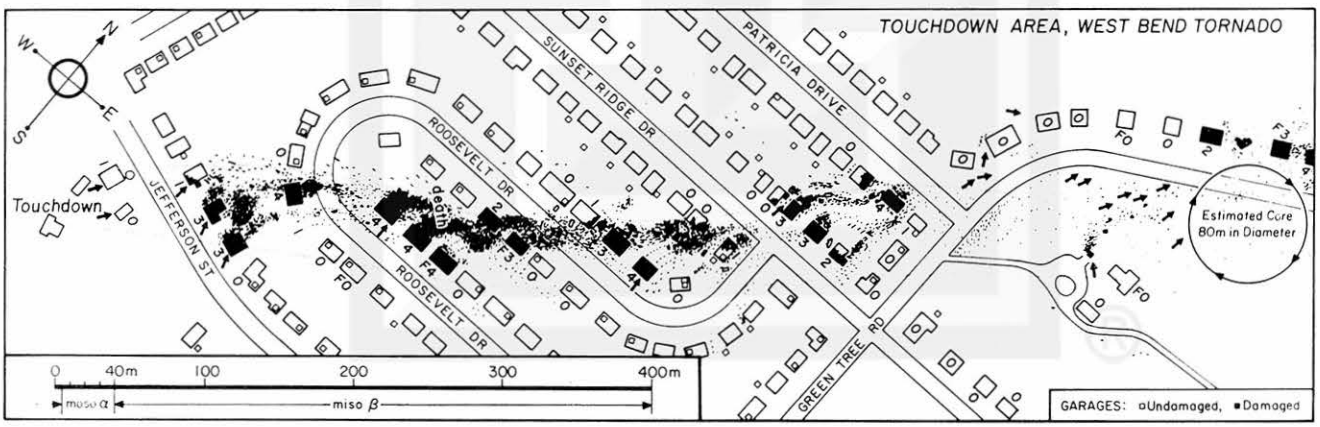

Figure 2. The beginning of the damage track of the West Bend tornado. The tornado caused F3 and F4 damage within seconds after touchdown.

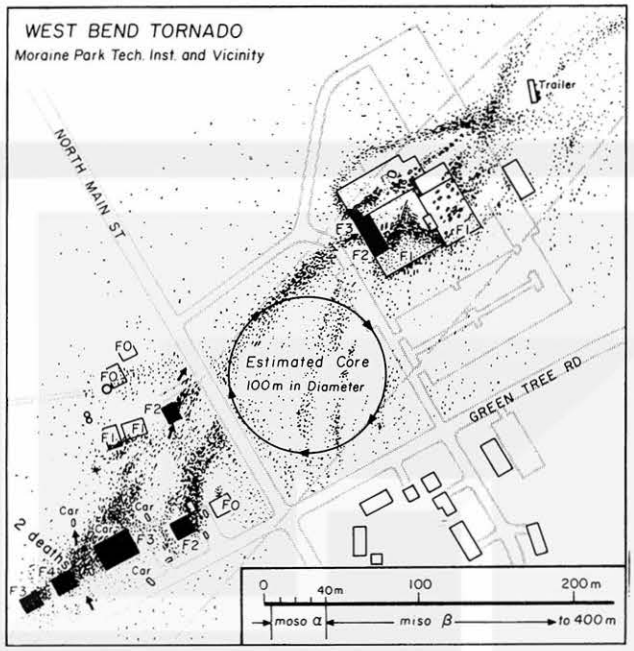

Figure 3. Damage mapping of the Moraine Park Technical Institute and vicinity. The tornado was traveling from the bottom to the top of the figure. Analysis of this area confirmed the authors initial suspicion that the tornado was anticyclonic.

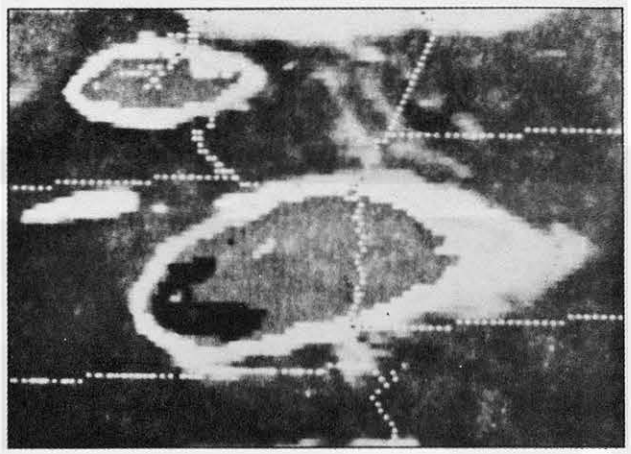

Figure 4. The Grand Island storm cloud at 0300 GMT on 4 June 1980 when Tornado No. 5 (F4) was on Locust Street. The image was enhanced by the Mb curve with the black area inside the anvil depicting temperatures colder than -60°C, and the gray area depicting temperatures colder than -54°C. A V-shaped wake is seen near the west end of the cloud.

that the storm is severe. For a thorough discussion, refer to Fujita (1982).

3.2 Damage Map

Aerial surveys were performed on 4-5 June 1980 to plot damage vectors and assess F-scale windspeeds in Grand Island. The results are presented in Figure 6. Tornadoes No. 2 (F1), No. 3 (F3), and No. 4 (F1) were confirmed to be anticyclonic.

3.3 Radar Analysis

During the storm, the NWS radar located at the Grand Island Airport recorded spectacular images of the evolving hook echo (the maximum range of the radar was set at 25 nautical miles).

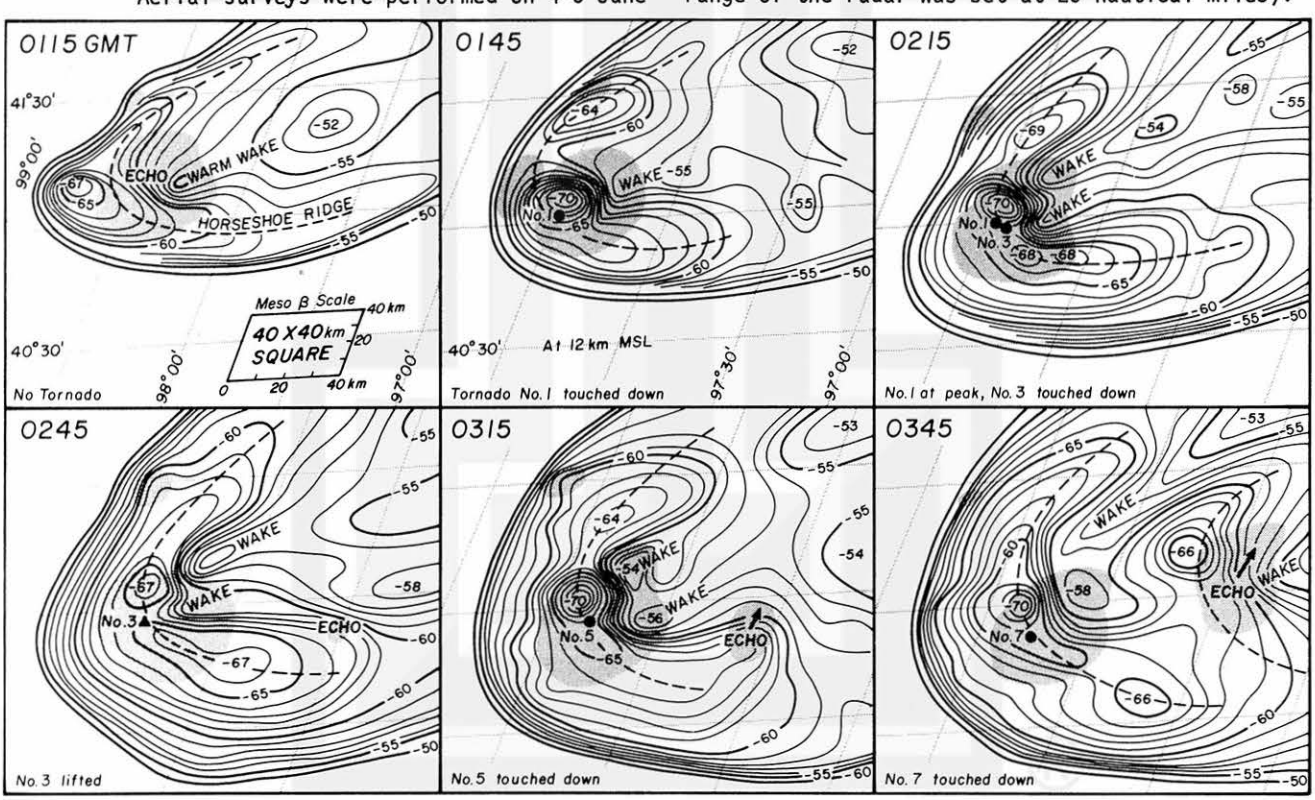

Figure 5. Pattern of IR temperature on the Grand Island tornado cloud drawn at 1°C intervals. Horseshoe ridges (cold temperatures) are shown with dashed arcs and depressions (warm temperatures) are shown by the areas labeled "wake". Grid lines are drawn at 12 km MSL. From Fujita (1981b).

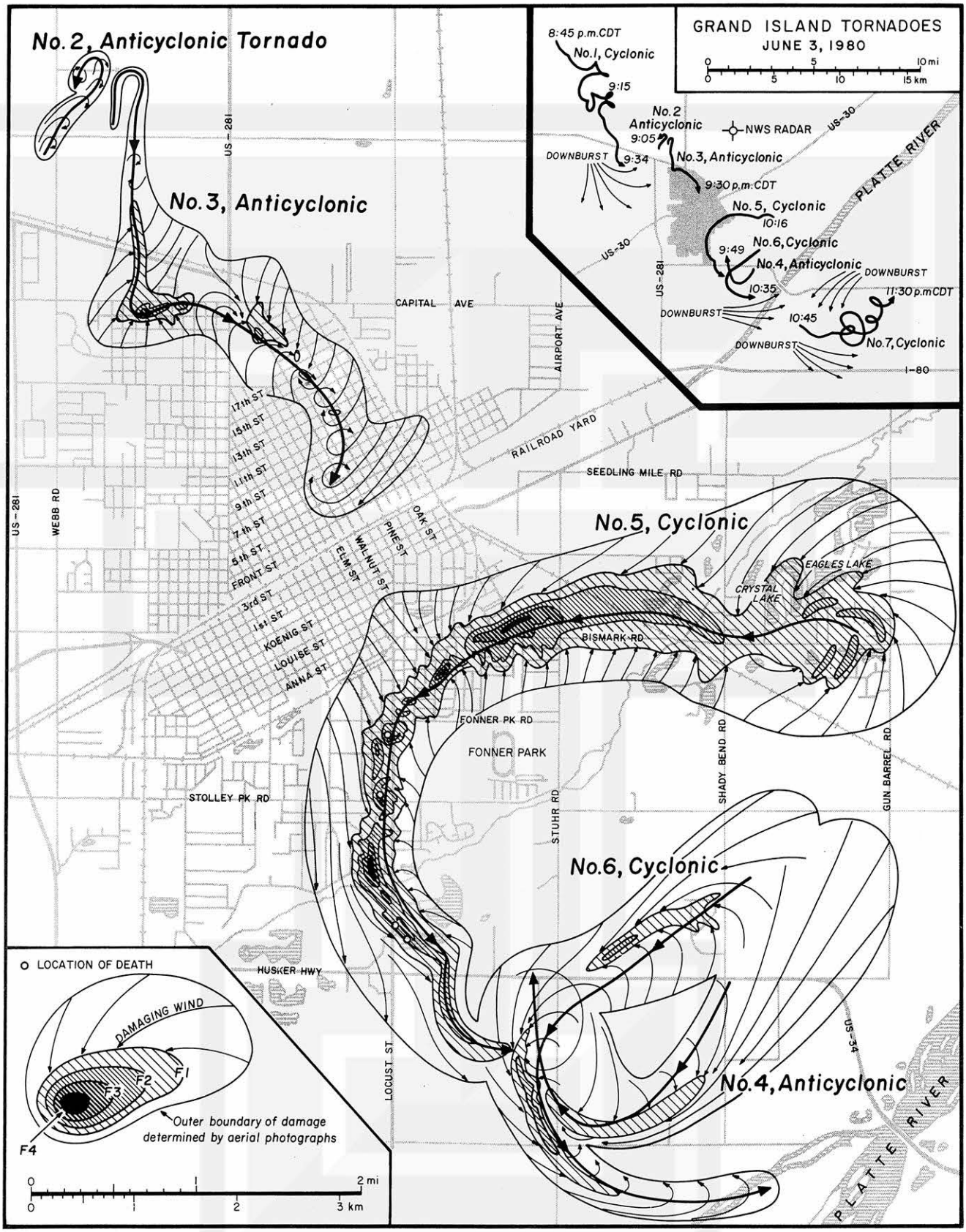

Figure 6. Overall view of the Grand Island, Nebraska storm of 3 June 1980, consisting of 4 cyclonic tornadoes, 3 anticyclonic tornadoes, and 4 twisting downbursts. Color copies of this map are available at the conference.

When the radar film was viewed in a time-lapse mode, the mesocyclone was rotating cyclonically.

During the occurrence of the four cyclonic tornadoes (Nos. 1, 5, 6, and 7) a weak-echo eye was centrally located within the hook echo (see Figures 7 and 8), analogous to the eye of a hurricane. Damage surveys revealed that the eye correlated exactly with the tornado location at the surface. This is believed to be the first time that a tornado was tracked by radar. This eye would appear as a Tornado Vortex Signature (TVS) with the use of Doppler radar (Brown, et al., 1978). Amazingly anticyclonic hooks formed during the occurrence of the anticyclonic tornadoes (Figure 9). In several instances both the anticyclonic hook and the weak-echo eye coexisted on the radar scope (Figure 8). Figure 10 depicts the evolving hook during the formation stage of Tornado No. 5.

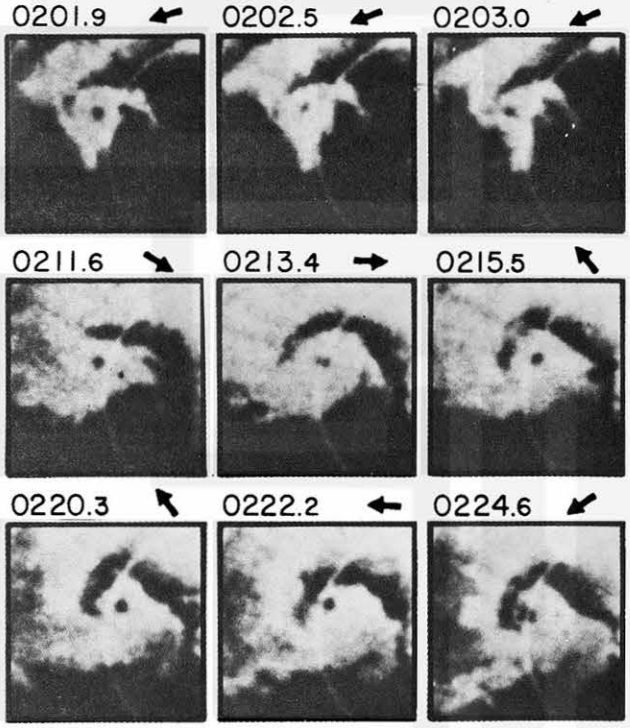

Figure 7. The weak-echo eye within the hook echo of the Grand Island Tornado No. 1 (cyclonic). The eye was 500-1000 m across. Arrows represent the motion of the eye within the mesocyclone. Ground surveys confirmed that the eye correlated exactly with the tornado location at the ground. Times are in GMT.

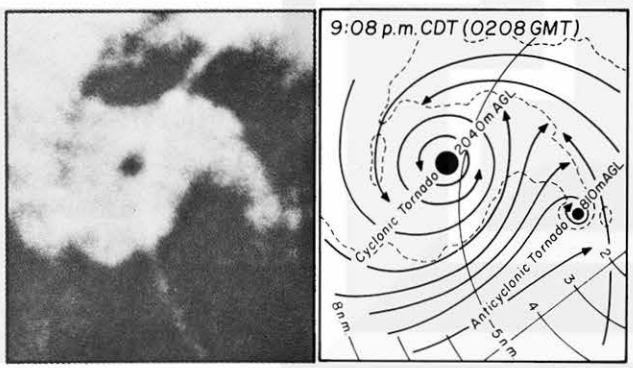

Figure 8. Relative positions of Tornado No. 1 (cyclonic) and Tornado No. 2 (anticyclonic). The eye of the mesocyclone marks the position of Tornado No. 1, and the anticyclonic hook protruding from the mesocyclone denotes the position of Tornado No. 2.

4. CONCLUSIONS

A detailed analysis of the severe storm events in West Bend, WI and Grand Island, NE permit us to reevaluate the nature of anticyclonic tornadoes. As a results of these studies, three conclusions are:

1. the anticyclonic tornado is not as rare as first thought;
2. the anticyclonic tornado can be as intense as a cyclonic tornado;
3. the anticyclonic tornado can form beneath a cyclonically rotating parent cloud.

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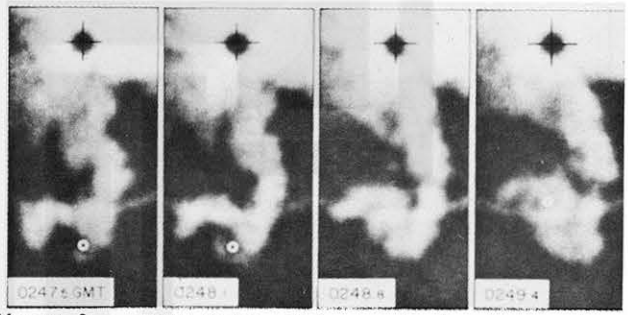

Figure 9. Four radar pictures showing the anticyclonic hook of Tornado No. 4. White circles denote the successive position of the tornado center.

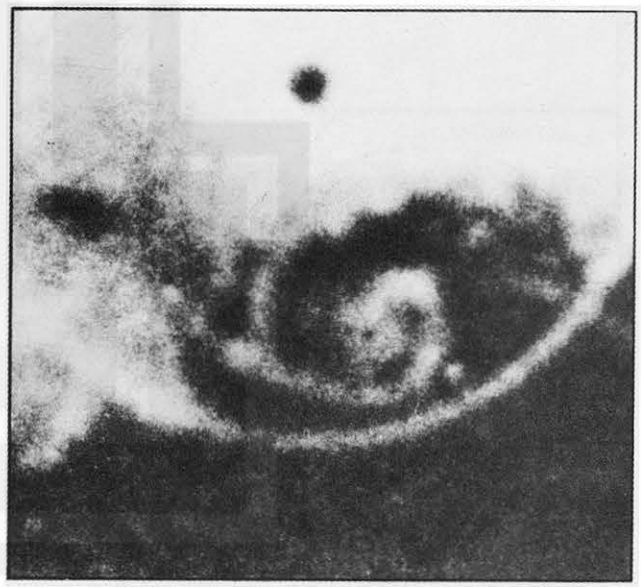

Figure 10. A spiral echo corresponding to the formation time of Tornado No. 5. The distance to the center is 6.6 km from the Grand Island radar.