OBSERVATIONS OF A SUPERCELL STRUCTURE, ITS VISUAL APPEARANCE AND RELATIONSHIP WITH SEVERE WEATHER

Jenni Rauhala

Finnish Meteorological Institute, Helsinki, Finland, jenni.rauhala@fmi.fi

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I. INTRODUCTION

During the late afternoon and evening of 28 June 2009, a supercell thunderstorm moved over central eastern Finland. The storm moved from north to south causing vast damage during its over 5 hour life time (Fig. 1). The hail was up to 8 cm in diameter and downbursts caused F1 wind damage with two injuries.

The storm passed close to the Kuopio Doppler-radar, which allowed detailed analysis of storm development and its features both during and before severe weather. The radar analysis showed supercell features such as mesocyclone, bounded weak echo region and a persistent hook echo. Collapsing reflectivity cores were observed prior to the major downbursts. The storm went through a mesocyclone occlusion during its lifetime and its structure resembled a hybrid storm with characteristics of both supercellular and multicellular storms.

A unique observational material of the event was collected, including hail reports, wind damage reports as well as several photos of hail, wind damage and the storm itself. This study presents an analysis of storm development and a comparison of the reflectivity structures with both the visual appearance and the observed severe weather.

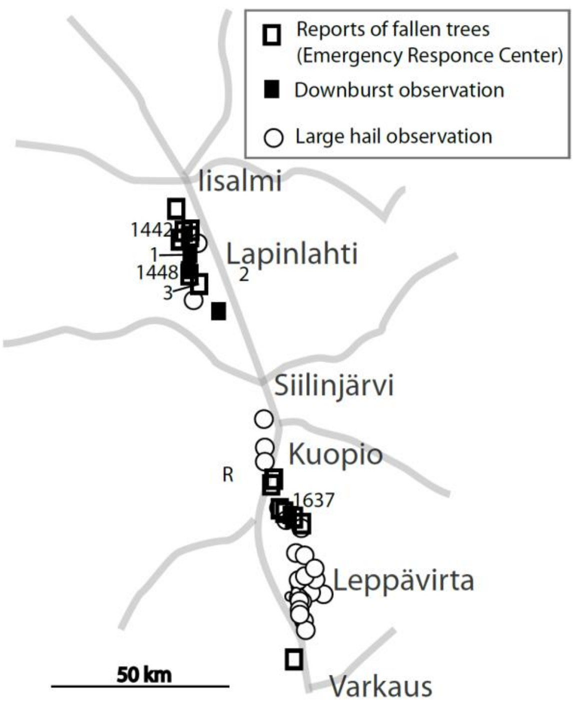

FIG. 1: General overview of the severe weather observations along the storm track on 28 June 2009. Numbers indicate locations that are discussed in the text. Radar location is indicated with R.

II. DATA

Finnish Meteorological Institute (FMI) received 33 hail reports along the storm track (Fig. 1). Most of the reports (29) were eyewitness reports received through observation report form for large hails placed on the FMI Web site (http://www.fmi.fi). Rest of the hail reports were received through e-mail after request for eyewitness reports sent to companies along the storm track.

The Emergency Response Center received 18 emergency reports caused by this storm; 4 reports caused by lightning damage, and 14 reports caused by damage of falling trees. Based on storm evolution on radar pictures, three of the emergency reports were received in less than 5 minutes from the occurrence of the damage. The times (UTC) of these emergency calls are indicated in Fig. 1. Although up to 8 cm diameter hail occurred in rural town Leppävirta, no emergency reports were received because of hail.

In addition to the 14 wind damage reports from the Emergency Response Center, FMI received 6 wind damage reports from the general public through observation report form placed on the FMI Web site. One of the reports included video footage and photos of starting downburst and gustnadoes over a lake.

Eyewitnesses provided several photos of both large hail and wind damage on the ground and aerial photographs of the wind damage in Lapinlahti taken from low-flying aircraft. Photographs of visual appearance of the thunderstorm at different stages of storm development were provided from 6 different locations by storm spotters and general public.

III. SEVERE WEATHER EVOLUTION

The storm caused downbursts and large hail along its path (Fig. 1). The first severe weather reports were received from Lapinlahti; there were downburst reports from several locations. Aerial pictures (Fig. 2, in location number 1 in Fig. 1) confirm that the F1-damage was caused by downbursts. The gustnadoes over water (Fig. 3, in location number 3 in Fig. 1) were followed by more F1-damage shortly after. Nearby large amounts of 1,5 cm hail caused damage to crops.

The next reports were further south along the storm track, in Siilinjärvi and Kuopio, where over 1,5 cm diameter hail was observed. This was followed by series of downbursts that caused F1-damage and two injuries. At the same time up to 3 cm hail was reported.

The large hail reports with increasing hail size continued further south, where first 4 cm hail was reported in rural town of Leppävirta. The largest hail, up to 8 cm was observed in the center of the town. After town centre, the hail size diminished to 3 cm in diameter. The large hail was followed by one more severe weather report, a wind damage report, before the storm decay.

FIG. 2: Downburst wind damage at location 1 in Fig. 1 (Photographs by Pasi Kannasmaa).

FIG. 3: a) Wall cloud seen from location 2 in Fig. 1 (Photograph by Pasi Kannasmaa,) and b) gustnado over a lake at location 3 in Fig. 1 (Photograph by Tapani Puurunen).

IV. STORM'S LIFE CYCLE

The storm started at 1230 UTC with weak southward moving reflectivity echoes. The storm quickly developed into a multicell storm. New cells developed on southern flank of the gust front as the storm moved southeast. At 1438 UTC the storm had developed into large intense cell with 60 dBZ reflectivity reaching height of 6 km. The radar measured 80 kts radial winds (Fig. 4) as the storm was causing F1-damage on the ground (Fig. 2). At this time the storm track turned right (more southward).

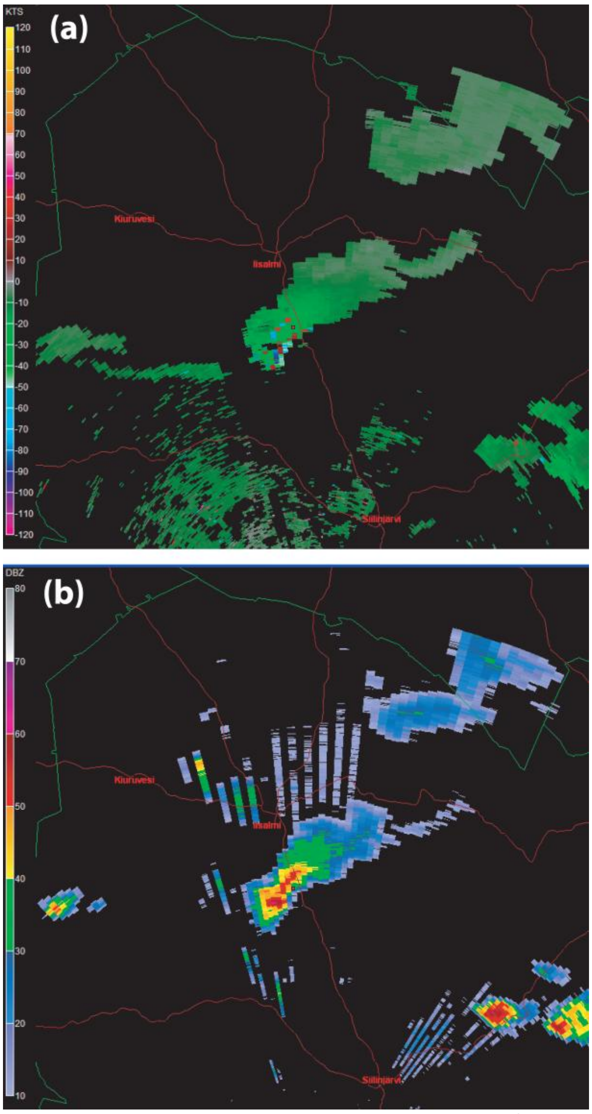

FIG. 4: a) Ground-relative radial velocity (kts) and b) reflectivity (dBZ) at 0,3˚ elevation angle during downburst at 1438 UTC.

During the following 15 minutes the radar showed supercell features including a persistent hook echo in the lowest elevation angles, a mesocyclone and a bounded weak echo region. At 1500 UTC the elevated reflectivity core collapsed and a weak echo notch developed behind the storm (Fig. 5a). The mesocyclone at storm midlevel was still strong (Fig. 5b). At 1500-1515 UTC the storm continued to cause wind damage in Lapinlahti (Fig. 1).

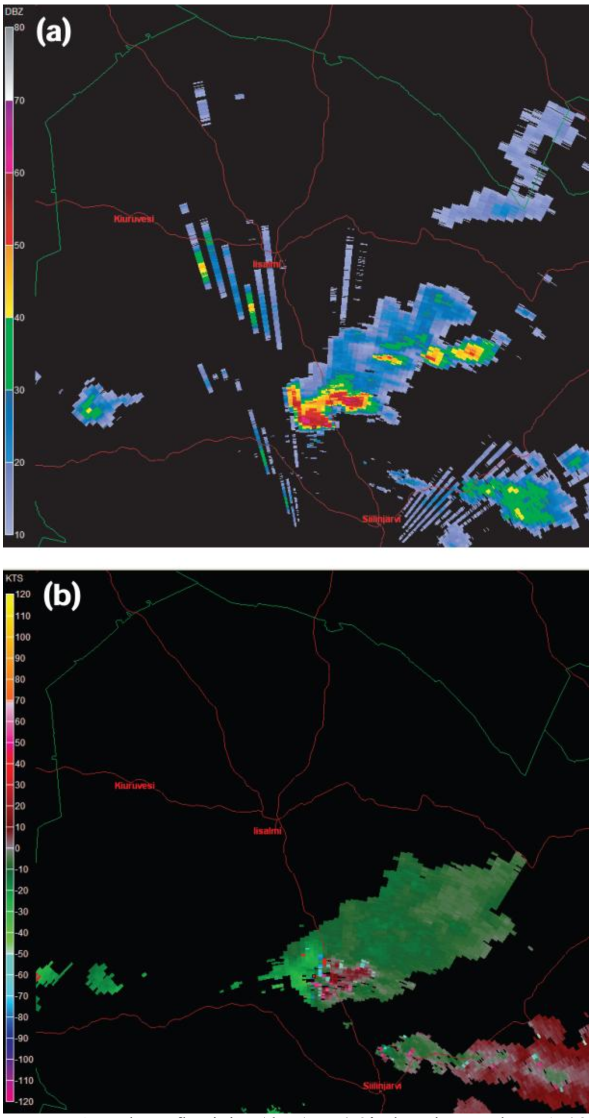

FIG. 5: a) Radar reflectivity (dBZ) at 0,3˚ elevation angle at 1508 UTC and b) radial velocity (kts) at 4,0˚ elevation angle at 1507 UTC.

Half an hour after the reflectivity core collapsed the storm began a mesocyclone occlusion (Fig. 6a). A new updraft core started to develop on the storms' forward flank and already at 1530 UTC (Fig. 6b) it was stronger than the old occluded core. At 1538 (Fig. 6c) the new updraft had developed a hook echo. The strengthening of the new rotating updraft and the weakening of the old mesocyclone was also observed in radial velocity figures (not shown). No severe weather reports were received during the mesocyclone occlusion phase.

The storm moved to south with a persistent hook echo. A pendant in the hook started to bend back and formed eventually similar weak echo notch behind the storm as was observed before the mesocyclone occlusion. After the reflectivity core collapsed at 1555 UTC, between 1610 and 1615 UTC the weak echo notch was the most distinct. At this time the storm caused wind damage in Kuopio (Fig. 1). The hook echo was apparent during this whole development.

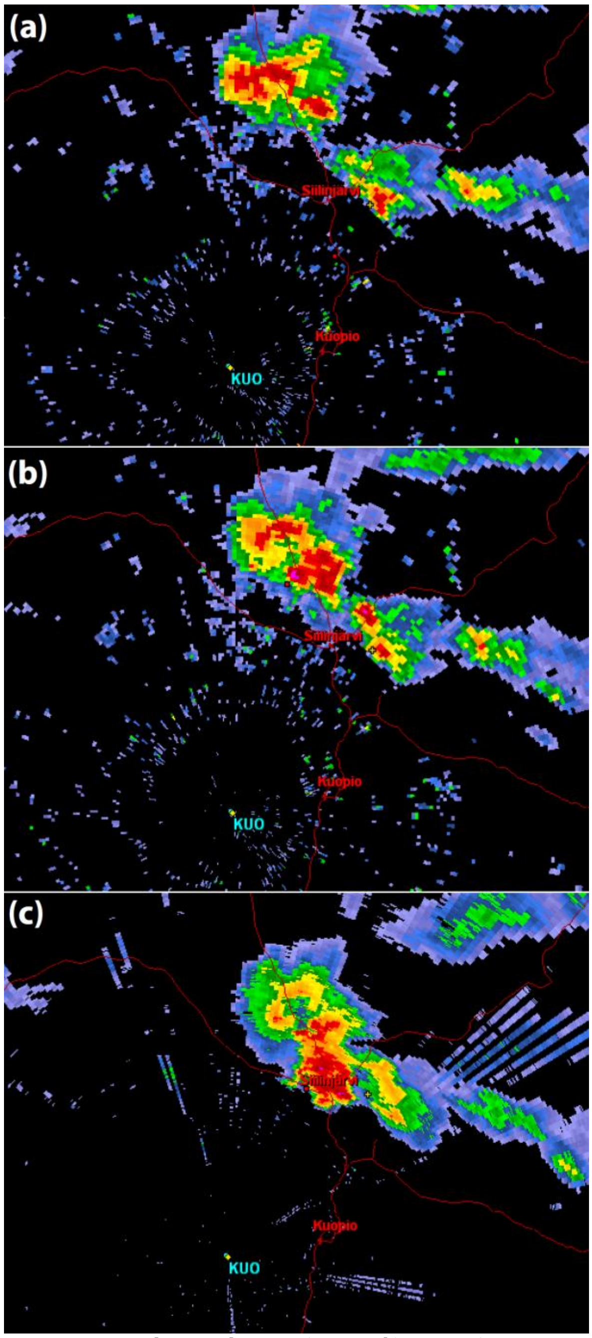

FIG. 6: Mesocyclone occlusion a) 1525 b) 1530 c) 1538 UTC with 0,3˚ radar reflectivity (dBZ). Coulour scale as in Fig.5.

The large hail observations in Leppävirta (Fig. 1) were preceded by ascending of the intense reflectivity core. It started at 1615 UTC and at 1710 UTC the 55 dBZ reflectivity core reached height of 7 km. This was followed by a reflectivity core collapse. Hail with more than 4 cm in diameter was observed on ground from 1655 to 1725 UTC, but the largest hail (8 cm) was observed on ground 10 minutes after the onset of the storm collapse. After this the storm continued moving south and weakened.