CASE STUDY OF A TORNADIC SUPERCELL IN FINLAND 28 AUGUST 2005

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I. INTRODUCTION

During the morning and before noon hours of 28 August 2005, a supercell thundestorm developed in a surface trough over Gulf of Finland and moved over the Helsinki metropolitan area. The supercell storm produced two successive tornadoes, classified as weak (F1). The second tornado hit a golf course where several people were injured.

The storm travelled trough Helsinki Testbed mesoscale observational network (Saltikoff et al. 2005) and the second tornado occurred near two weather radars (Fig. 1). The storm passed the Vaisala dual polarization Doppler radar at Helsinki University (Kumpula radar) within 5 km and Finnish Meteorological Institute`s (FMI) C-band Doppler radar (Vantaa radar) within few kilometers. Supercell and tornado indicators like hook echo, bounded weak echo region (BWER) and tornado vortex signature (TVS) were discovered in radar images. Hydrometeor types were classified by using differential reflectivity (ZDR).

A few tornadic supercell thunderstorms have been documented in Finland earlier (Teittinen et al. 2006) but they typically seem to occur in the afternoon or evening. Similarly the diurnal tornado peak in Finland is in the afternoon and early evening (Teittinen and Brooks 2006) with less than 10% of cases (mostly waterspouts) occurring before noon. The possibility of a supercell thunderstorm or a tornado was not anticipated by FMI forecasters, so a severe thunderstorm warning was not issued.

FIG. 1. The location of tornado damage is indicated by black dots with Fujita-scale ratings to each point were damage survey was done. Tornado occurrence times, approximated by the eyewitness observation and emergency reports and locations of two radars has also been denoted.

II. THE STORM ENVIRONMENT

During 28 August 2005, the eastern North Atlantic, Scandinavia and Finland were part of a vast low pressure area (Fig. 2). At night, a wave developed along with 500-hPa trough in southern Sweden and moved northeast toward the Gulf of Finland. The tornadic storm developed at the warm side of the warm front. A low level jet at 850 hPa stretched from the Baltic Sea to the Gulf of Finland and was strengthening and increasing the low-level wind shear during the tornadogenesis. According to Helsinki Testbed mesonet observations, the surface winds were southwesterly before and after the storm. The 300-hPa upper-level jet over southern Finland was weak with maximum wind speeds around 30 m/s.

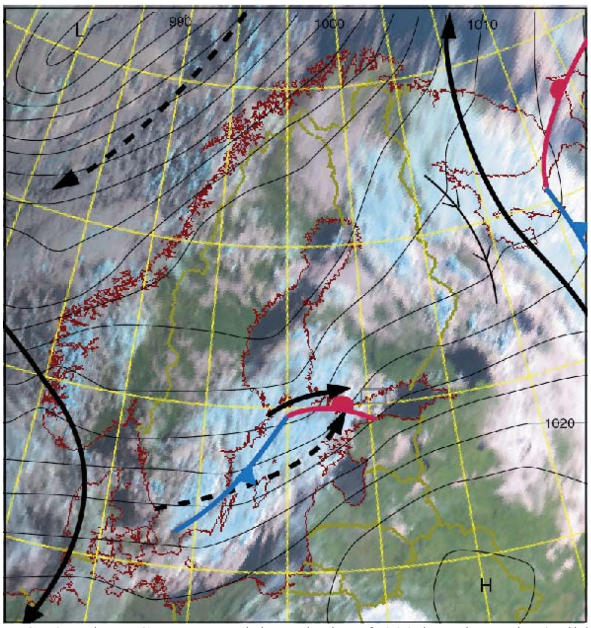

FIG. 2. The ECMWF model analysis of 300-hPa jet axis (solid arrows ≥30 m/s) and 850-hPa low level jet axis (dashed arrows ≥15 m/s) and surface isobars (black lines) overlaid on Meteosat satellite image with manual frontal analysis at 0600 UTC 28 August 2005. The location of Fig. 1 is indicated by grey box.

III. POLARIMETRIC RADAR OBSERVATIONS

The tornadic storm produced two successive tornadoes. The storm first developed over Gulf of Finland. Initially, the radar images showed at 0615 UTC several isolated convective cells, which collided at 0630 UTC when the storm reached the shoreline. The storm developed fast, and moved northeast at an average of 10 m/s. As a signature of a supercell, a hook echo was observed for the first time at 0650 UTC. The first tornado was observed 15 minutes later at 0705 UTC and it lasted for 10 minutes. Based on the damage reports, the tornado was situated at the tip of the hook. The hook echo was evident throughout the storm's whole tornadic phase, until 0810 UTC. At the time the first tornado developed, the storm diameter was 12 km with a height of 6 km, defined by 15 dBZ reflectivity. The maximum reflectivity throughout the storm volume was 57 dBZ at 2 km height. A bounded weak echo region (BWER) was not detected during the first tornado.

The first observation of the second tornado was 20 minutes after the first one, at about 0735 UTC. As the storm had just passed the end of the damage track, a BWER was clearly observed at 0750 UTC (Fig. 3). The BWER with 600 m diameter, was visible at 1 km height with 62 dBZ reflectivity maximum right above BWER at 2.5 km. After the second tornado, BWER was still detectable at 0800 UTC but disappeared after that. One wind damage report was received along the storm track later, at 0810 UTC, thus the storm might have produced third short lived tornado or downburst. The tornado debris cloud is visible in Vantaa radar images (Fig. 4) as reflectivity maximums in the tip of the hook echo. The reflectivity maximums are visible at 300 and 400 m at height with 0.9 and 1 km diameters. During that time the tornado was confirmed at ground and caused F1-damage.

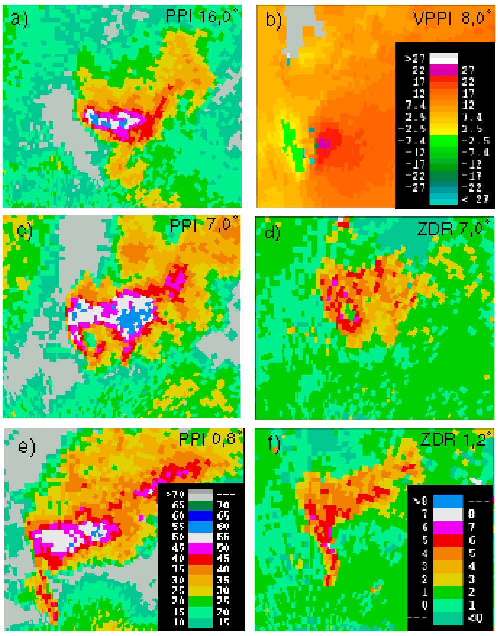

FIG. 3. Kumpula radar a) PPI at 16.0° elevation at 0753 UTC, b) VPPI at 8.0° elevation at 0749 UTC c) PPI and d) ZDR at 7.0° elevation at 0752 UTC, e) PPI at 0.8° elevation at 0750 UTC and f) ZDR at 1,2° elevation 0752 UTC.

The BWER can be also seen in differential reflectivity (ZDR) (Fig. 3d-3f). BWER is formed as a strong updraft carries hydrometeors to higher levels. In the strong updraft, the smallest particles follow the flow and advect back to the cloud. Biggest particles fall against strong updraft and organize around it following the circulation (Dowell et al. 2005). In Fig. 3d, high ZDR values in high reflectivity area around BWER and on the storm left flank suggest massive particles with flattened shapes. Similar ZDR observations have been done in Oklahoma tornadic supercell case (Ryzhkov et al. 2005). High ZDR values dominate throughout the most of the storm, and when coincident with high radar reflectivity, suggest that graupel or hail were not associated with this storm, instead heavy rain. Observations from hail was not received, which supports this assumption.

Mesocyclone signature is shown in Doppler velocity data in Fig. 3b. Highest tangential velocity in mesocyclone was ±15 m/s. Diameter of mesocyclone at 0749 UTC was about 1.5 km at 900 m height. The tornado vortex signature (TVS) had 300 m diameter at 300 m height, and differential velocity of 18 m/s and was situated right rear edge of the mesocyclone core.

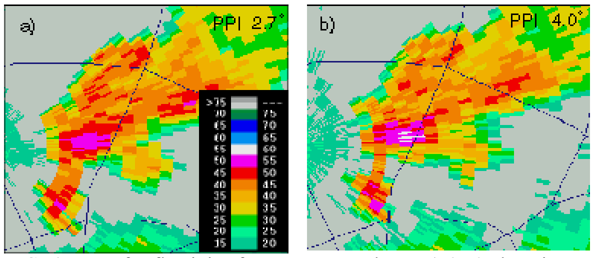

FIG. 4. PPI of reflectivity from Vantaa radar at a) 2,7° elevation at 0749 UTC and b) 4,0° elevation at 0747 UTC. The debris cloud range from the radar is 4 km.

IV. DISCUSSION

The Finnish Meteorological Institute did not issue warning for this tornadic supercell. The forecasters don't have in operational use tools like radar algorithms to help to detect potentially severe storms from general thunderstorms and the warning area covers the whole Finland. In operational radar pictures this small storm did not appear to be severe. Also the time of the event was unusual, since tornadoes in Finland typically occur in afternoon and early evening. This study has shown that the severe thunderstorm signs were detectable well before the tornadogenesis. If similar storms want to be warned for in the future, the operational radar tools have to be developed further.

V. ACKNOWLEDGEMENTS

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VI. REFERENCES

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