Analele Universităţii din Oradea – Seria Geografie Tom **XX**, no. **2/2010** (**December**), pp **197-203**
ISSN **1221-1273**, E-ISSN **2065-3409** Article no. **202106-492**

SOME DOPPLER RADAR FEATURES OF SEVERE WEATHER IN SUPERCELLS CONVECTIVE STORMS

Cristian NICHITA
Regional Forecast Center Timişoara
15. Gh. Adam St., Timişoara, Romania, e-mail: cristi_nichita2004@yahoo.com

Abstract: Supercells convective storms have developed some specific radar charactersitics which provided clues to forecast meteorologists in monitoring severe weather. The supercells are often associated with severe weather such high damaging wind potential, large amount of precipitations, hail. Understanding the radar signature of supercell storm helps to forecast their evolution and to limit the damages.

Key words: supercells storms, wind shear, radar products

* * * * * *

INTRODUCTION

The meteorological radars established in Romania from 1967 provided only few meteorological product data. The meteorologists made precipitation forecasts based on the movement of radar echoes (Cristea, 2004). The Doppler radars installed in Romania by 2000 can detect the strength and position of weather echoes and measure the speed of the multiple targets in them towards or away from the radar (radial velocity).

Supercells convective storm are associated with strong vertical wind shear. Wind shear can be unidirectional or directional and represents the origin of the rotation.

Considering the amount of the precipitations, their location and distribution and where the mesocyclone is located, supercells are grouped into three different structural classes:

- high-precipitation (HP) supercells are known to produce flash flood events, and occasionally large hail, damaging winds;
- classic (CL) supercells are the most prolific producers of severe weather phenomena – severe wind, large hail (Rasmussen, 1997);
- low-precipitation (LP) supercells characterized by a relative absence of rain in and near a deep rotating updraft, and by the occurrence of light to moderate rain and/or large hail (Bluestein and Woodall 1990).

In western part of Romania most of the supercells convective storms are associated with cold fronts in warm season. These kinds of storms are often parts from Mesoscale Convective Ssystems organized in structure as bow echo or/and squall line.

RADAR PATTERNS ASSOCIATED WITH SUPERCELLS CONVECTIVE STORMS

A mesocyclone represents the most important signature that defines a storm as a supercell and it is a small-scale rotation associated with the updraft of a convective storm that meets established criteria for shear, vertical extent (shear extends at least 3 km in the vertical) and persistence – minimum of two volume scans (Convective Storm Structure and Evolution, Presented by the Warning Decision Training Branch, 2006).

The Mesocyclone Detection Algorithm of Doppler radar uses pattern recognition techniques to detect mesocyclones. This algorithm uses radial velocity and reflectivity data to detect storm-scale cyclonic vortex signatures. Interrogation of different elevation scans of Velocity products can aid in determining the height continuity of a mesocyclone.

For exemplification of this radar signature I used an example from July 08, 2009. The instability was a consequence of a cold front developed over Balcans and reached Romania at about 02.00 p.m. UTC.

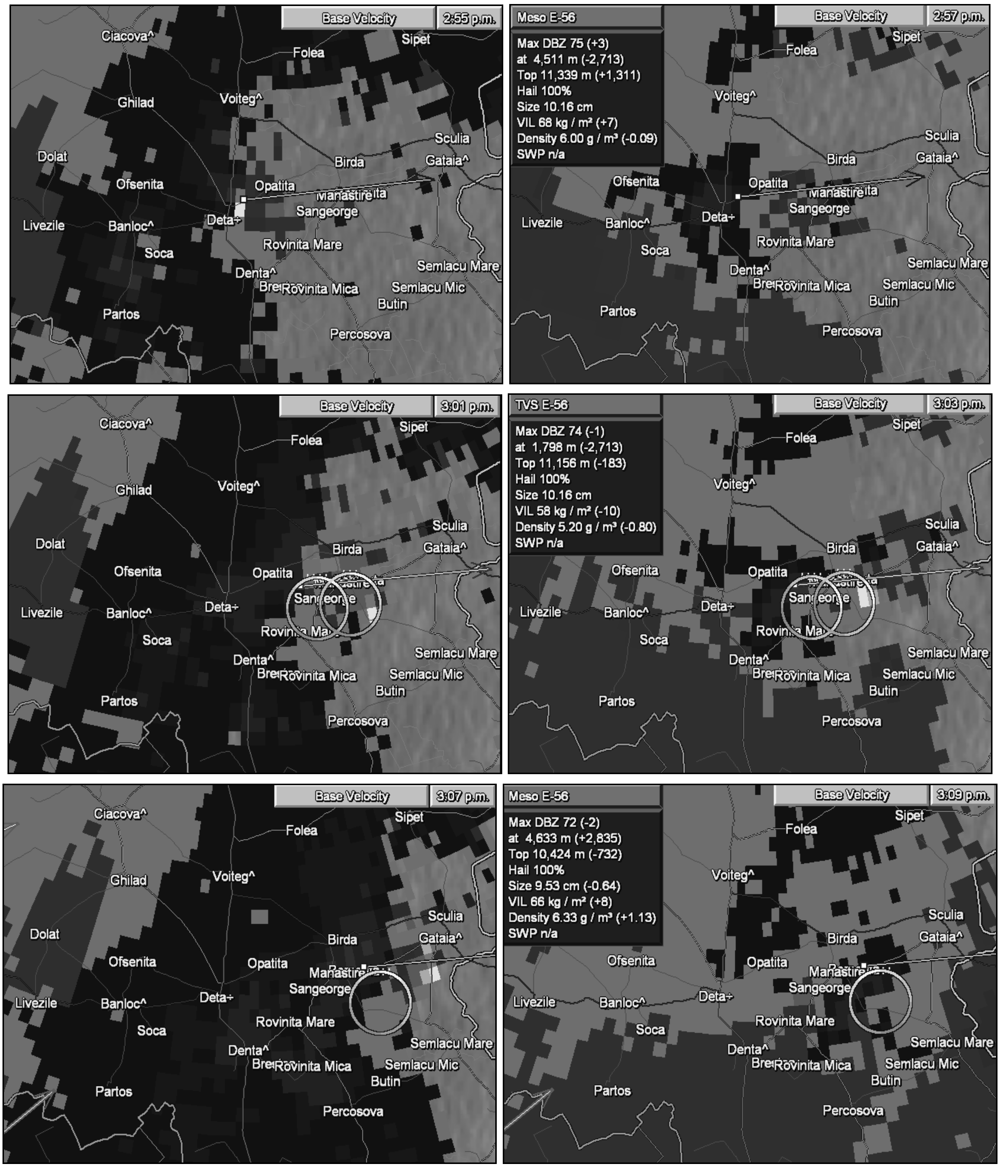

Figure 1. Mesocyclone Product Overlaid on Base Velocity Product

The radar Base Velocity images are from 02:55 to 03:07 p.m. UTC at 0.5 degrees (figure 1 – left) and from 02:57 to 03:09 p.m. UTC at 2.4 degrees (figure 1 – right). The images shows an intensification of the rotation at the second scan volume where radar detects another severe weather rotational phenomenon: the existence of tornadic circulations detected by Tornado Vortex Signature algorithm.

I kept radar storm characteristics labels for Echo Tops, Maximum Reflectivity, Hail size, Probability of Hail and Severe Hail, VIL (Vertically Integrated Liquid) and VIL density only at level three images (2.4 degrees). Analyzing the radar information it obvious that the storm structure is well developed by vertical, exceeded 11,300 m high.

High potential for hail with considerable size can be explained by very high values of reflectivity and VIL parameters.

In the figure 1 the mesocyclone respects the condition of shear, vertical extent and minimum persistence. The supercell produced severe wind (up to 20 m/s at Banloc), winch caused damages in Balnoc, Deta and Berzovia, and large amount of precipitations in very short times - 15 l/m^2 in 13 minutes (Banloc). There was no information about hail. Considering the radar information about the location of the mesocyclone and the storm effects at ground the storm structure can be associated with classic supercells CL.

The vertical profile of horizontal wind speed and its direction are estimated by Velocity Azimuth Display (VAD) Algorithm (figure 2).

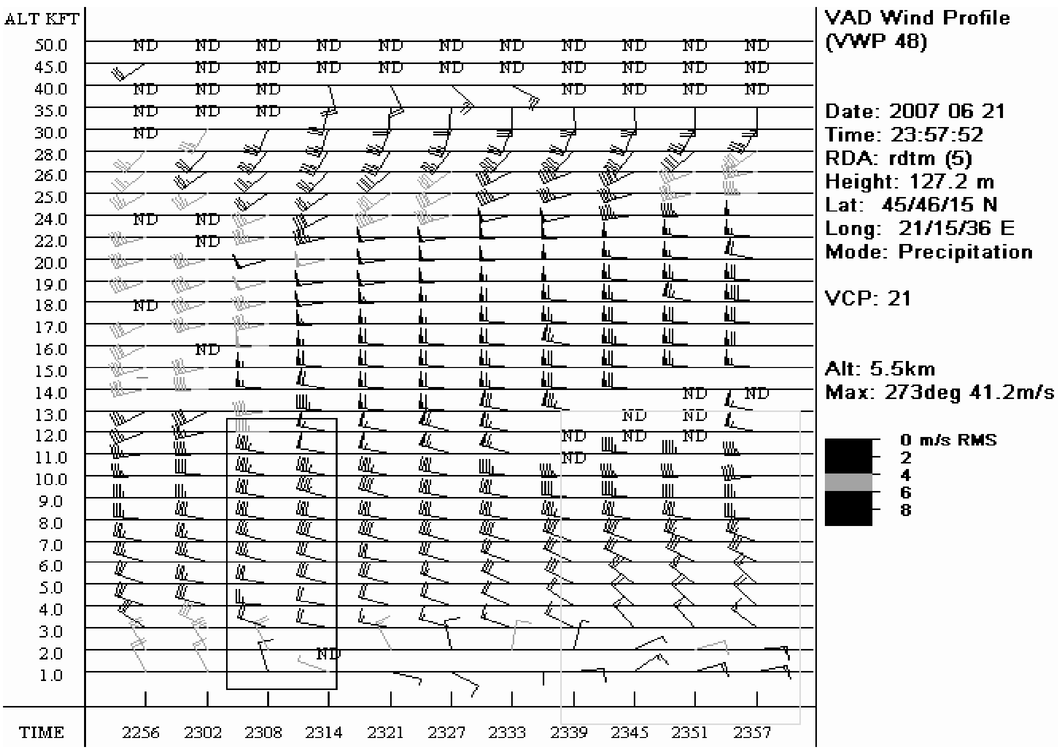

Figure 2. VAD Wind Profile Product used for shear detection-adapted

In this process also must be considered the change of wind direction with height (directional shear). Wind shear develops mid-level rotation and tilts the convective clouds. For example I used images from the June 2007 when the west part of Romania was under a cold front. In the Velocity Azimuth Display wind profile product can be seen both speed and directional vertical shear.

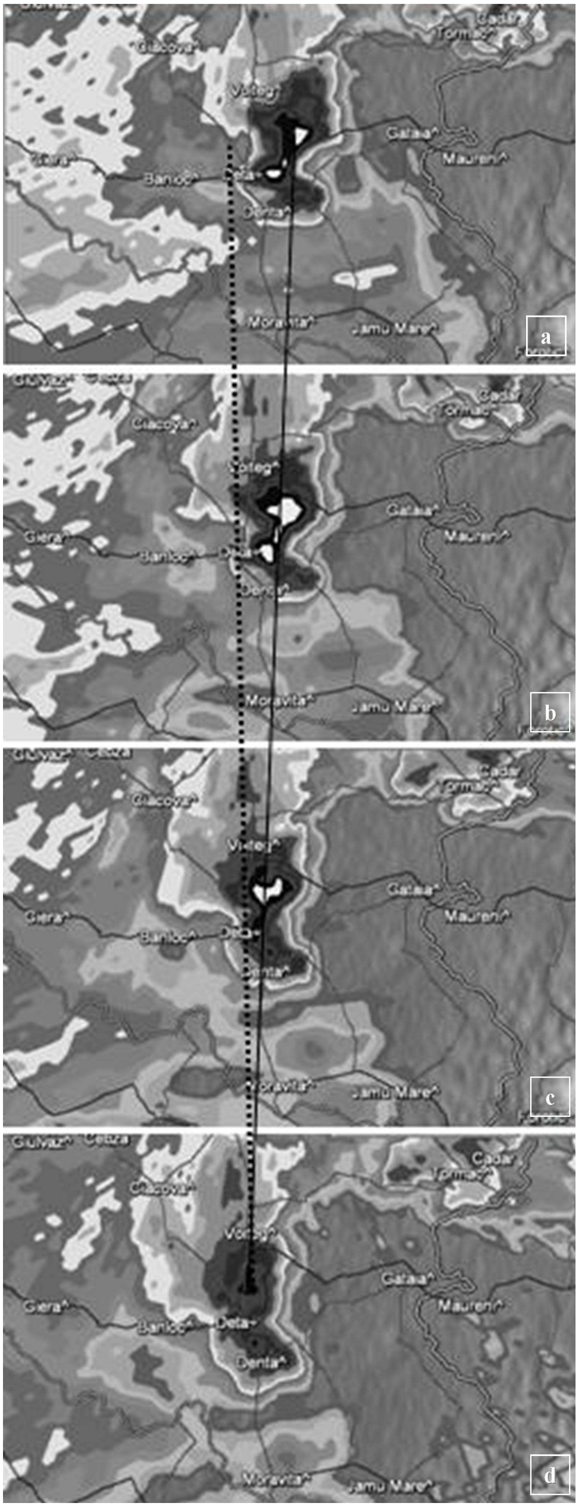

Figure 3. Multi-panel Reflectivity display of a Supercell Thunderstorm

As I said before, vertical wind shear produce convective clouds tilting and the resulted radar structure are named Weak Echo Regions (WER) or Bounded Weak Echo Regions (BWER). The presence of a WER or BWER is important indicator of an intense updraft and storm severity. These phenomena can be identified in many ways.

In figure 3 I evaluated the storm structure and clouds tilting in 4-panel Reflectivity product display. These Reflectivity products are slices with the following elevation angles: 0.5° (d), 1.5° (c), 2.4 (b) and 3.4° (a). This display is useful in determining the three-dimensional structure of a severe storm. At the upper level (a) the convective storm core is moved to the right from the reflectivity images at the same hour at first elevation (d) and echo overhang are obvious in the 4-panel product. This is a clue for wind speed increased on height.

The high reflectivity values at superior elevation angles – 75 dBZ at 3.4 degrees and "only" 68 dBZ at 0.5 degrees – indicate a strong updraft capable to support them.

As updraft intensity increases, the likelihood for intense downdrafts and large hail also increases. Low-level reflectivity gradient along the leading edge and front flank inflow notch shows the strong updraft and convergence. This structure increases the threat of damaging winds and show strong low-level convergence (Convective Storm Structure and Evolution, Presented by the Warning Decision Training Branch, 2006).

I represented the real vertical axe with thick line and with dotted line the normal vertical axe in order to show the storm structure tilting.

These base reflectivity display images must be used together with some other radar products to evaluate the weak echo region-base velocity, vertical cross section reflectivity (if available), echo tops, VAD wind profile etc.

The reflectivity images are from the same cold front case as in the part where I spoke about the mesocyclones (July 08, 2009 h. 03:02 p.m. UTC).

In vertically sheared environments Weak Echo Regions are common features of severe storms. These echoes are capped by high values of reflectivity. I illustrated this radar feature with another product: Cross Section Reflectivity which provides a vertical cross section of echoes. The image below is taken in August 2007 when the convection in the western part of Romania had structures as bow echoes (COMET, 1999).

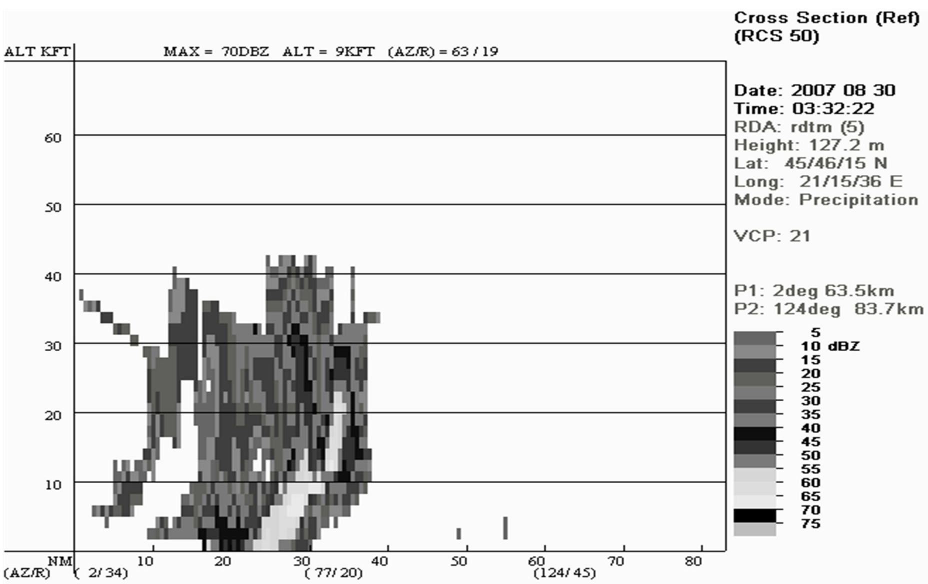

Figure 4. Display of a Weak Echo Regions structure (Vertical Cross Section) - adapted

In an environment with vertical wind shear, the updraft will tilt over. In figure 4 it is obvious the tilting of the convective clouds as a consequence of the vertical wind shear and also the Weak Echo Regions structure. The result of shear is a strong echo aloft with little or only weak echo beneath. The weak echo region, storm overhang, and highest storm top are typically on the leading edge of the storm.

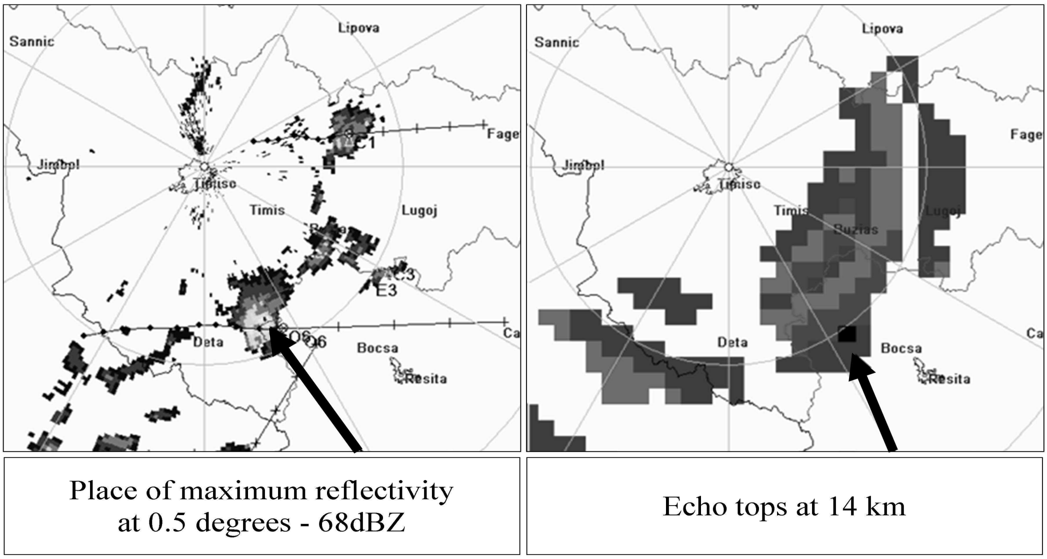

Figure 5. Multi-pannel display of Basic Reflectivity and Echo Tops – adapted

The discordance between the place of low-level reflectivity values and tops of the storms at the same time of the convective storm existence, as is showed in figure 5, also express the tilting of the convective storm structure and is a clue for the existence for the weak echo region. These images are from July 08, 2009, h 03.21 p.m. UTC.

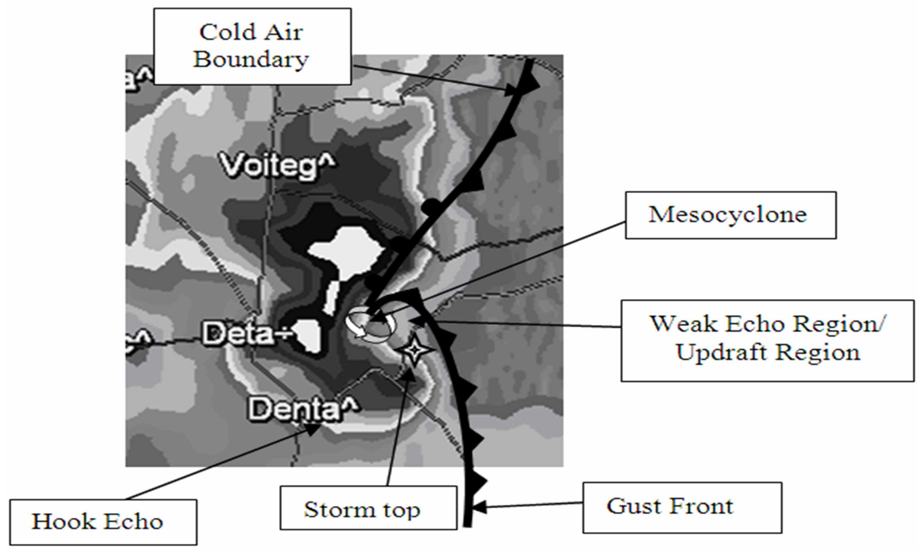

Figure 6. Schematic plan view of a supercell storm morphology

Meteorologists need to understand the likely morphology, behavior, and hazards associated with various types of supercells convective storms.

Conceptual models and modeling studies for origins, evolutions and organizations of convective storms and systems offered opportunities for storm evolution processes monitoring (Nichita et al. 2006).

In figure 6, I made a schematic plan view of the supercell thunderstorm from July 2009 and I showed its main dynamics components for understanding further behavior of the storm.

The schematic view of a storm as it's showed in figure 6 can be made only after analyzing all radars products. In addition it must be considered all the diagnosis and forecast parameters.

CONCLUSIONS

I discussed how to recognize radar supercell patterns based on shear profiles. Vertical wind shear is the most important factor for storm organization.

Recognition and interpretation of severe storm signature are forecast with many radar products. I kept radar images information unchanged for most examples I gave. I adapted only two images for best visualization of the atmospheric processes.

Mesocyclone and convergence signatures can be best monitorized with radar velocity products (Base Velocity and Mesocyclone Detection Algorithm); shear can be visualized with Velocity Azimuth Display (VAD) Algorithm.

The overhang of the storm and vertical extent of the weak echo regions can be also identified by comparing several elevation angles of Reflectivity in the multi-panel display and with Cross Section Reflectivity product, or analyzing the difference between the location of the maximum values of the reflectivity at low level and the storm top at the same moment.

Satellite images are also useful to detect some supercells storm features as overshooting.

Considering the radar information about the storm structure and analyzing more weather forecast models there were emitted some nowcasting warnings to central and local authorities. The storms caused traffic disruption, lots of houses were without electricity and many roofs were damaged.

For the situations I mentioned in this paper, there were issued many yellow code warning with small to moderate risk for damaging winds, rain, lightings and small hail and one orange code warning with moderate risk for damaging winds.

REFERENCES

Bluestein H.B., Woodall G.R., (1990), *Doppler-radar analysis of a low-precipitation severe storm. Mon. Wea. Rev.*, 118, 1640–1664.

Nichita C., Elza Hauer, Adina-Eliza Croitoru, (2006*), Situații de vreme severă cauzate de producerea prercipitațiilor abundente: Inundațiile din Banat, Aprilie 2005*, Riscuri şi Catastrofe, nr 3, an V, pag 105-114, Casa Cărții de Știință.

Cristea Maria, (2004), *Riscul climatic din Bazinul hidrografic al Crisurilor*, Edit. Abaddaba, Oradea.

Rasmussen E.N., (1997), *Variations in Supercell Morphology. Part I: Observations of the Role of Upper-Level Storm-Relative Flow*, Mon. Wea. Rev., 126, 2406-2421.

***, (1999), *Cooperative Program for Operational Meteorology, Education and Training (COMET), Mesoscale Convective Systems: Squall Lines and Bow Echoes*, Online training module, http://meted.ucar.edu/convectn/mcs/

***, (2006), *Convective Storm Structure and Evolution, Presented by the Warning Decision Training Branch*, Distance Learning Operations Course

Submitted:	Revised:	Accepted:	Published online:
May 7, 2010	September 14, 2010	October 14, 2010	November 11, 2010