Mesocyclone

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1. Introduction

Mesocyclone is a rotating column of air inside a super cell cloud. Typical scale of a mesocyclone is from 2 to 15 kilometers in diameter and its place is usually on right flank of super cell cloud. Properly used, the term-mesocyclone is Doppler radar term; it is defined as a pattern of Doppler velocity field on a radial wind velocity display which satisfies specific conditions about intensity, height and duration.

Interaction between upwind flow and surrounding atmosphere with vertical wind shear determines the level of organization and intensity of convection. Resulting wind shear for super cell cloud should be over 20 m/s in layer from 2 to 6 km. On the wind hodograph it is usually shown as a curve in layer 0-3 km and straight line above that layer. Curved shape of hodograph for super cell storm indicates simultaneous shear of wind direction and velocity. Also, curved shape of hodograph indicates existence of maximum wind velocity on lower level which intensifies air inflow in cloud and creates favorably circumstances for further development of cupercell. It is well known that vertical wind shear cause development of dynamic processes in the cloud which affect the intensity, duration and movement of the storm. One of those dynamic processes is strong vorticity which is the essential prerequisite for formation and development of mesocyclone.

Strong air flows contain component of a rotational motion and although this motion initially take place around horizontal axes, vertical flows both in cloud and surrounding air, can force rotational flow to incline creating in that way a rotation around vertical axes. This vertical rotation can lead to formation of mesocyclone.

Beside shear, the intensity of mesocyclone depends on buoyancy as well. Diagnostic state equation order that upward rotation must be balanced with gradient pressure force which is pointed toward the center of rotation causing a fall of pressure on the middle height where the rotation is the strongest. This disturbance in pressure field leads to even stronger upward flow on mid level which has rotation and vertical wind intensification as a consequence.

Dynamic processes are more expressive if the layer with vertical wind shear is wider. The result of these processes is establishing permanent circulation with strong upward flow. Super cell cloud practically suck the air from surrounding atmosphere and continue development even long into the night regardless of absence of heating, weakening of instability and dissipation of other convective clouds. Dynamic processes also cause high pressure on the side of a storm where dominant flow is downward and low pressure on the side where dominant flow is upward creating in that way a decline of cloud axes and forcing the cloud to move to the right with reference to mean wind in the atmosphere. Scheme of flows in super cell cloud is given on Fig.1

2. Case study of mesocyclon on 31.08.2003. in Serbia

On 31.08.2003. cold front from west came across and typical super cell storm developed. This storm had all significant characteristics of supercell: typical appearance in reflectivity field (hook shape on the right side of the cloud and characteristic vertical cross section with explicit anvil and BWER), persistence of the cloud (it passed about 200 km and regenerated twice during the hours of observation), deviation in storm motion which was approximately 30 degrees and finally, rotational-convergent pattern in radial velocity field, indicating a presence of mesocyclone.

The presence of hook shape in reflectivity field and BWER (bounded weak echo region) inside the cloud is very well confirmed by means of radar images in reflectivity fields.

Important characteristic of super cell cloud with mesocyclone is diverging from prevailing wind to the right. Analysis of the cloud motion on 31.08.2003. shows that prevailing wind was west-southwest (252 degrees) and most of the clouds were moving in accordance with it, except super cell cloud which was moving from west (273 degrees). The reason for diverging to the right lays in activity of so called Magnus force which take place inside the cloud and in coordinate with other mechanisms can cause deviation of super cell cloud motion compared to the prevailing wind direction.

Mesocyclone can be defined as a pattern of rotational movement in a radial velocity field made by Doppler radar. In case of mesocyclone, pure cyclonic rotation should exist on middle levels while on low levels should be cyclonic convergence and on high levels cyclonic divergence. All these features are proved by means of radar images in velocity field.

3. Conclusions

Doppler radars with possibilities of measuring radial winds inside the clouds and possibility for archiving recorded digitalized data for later analysis are powerful tool for study of clouds from the genesis until dissipation. A great opportunity is given for insight of clouds and particles inside it to complete the knowledge about cloud dynamic and processes that take place in the cloud and around it. Raising the level of knowledge about all relevant processes should lead to improvement of hail suppression methodology and efficiency but also to lead to realization of its range and possibilities.

Wind speed data based on Doppler velocity field are confirmed by comparison with measured wind data from meteorological station Zrenjanin, where wind gusts over 20 m/s are recorded.

The storm gave heavy precipitation with showers and occasionally the hail along the path in north part of Serbia (Vojvodina). The total area with hail in Vojvodina was estimated to be about 25000 ha. Hail made a lot of damage both on agricultural crops and building objects, especially in town Zrenjanin where hail and violent wind crashed many windows, window blinds, roof tile etc. Hail reached the size of egg and on some places, connected grains reached the size of tennis ball.

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