Supercell storm motion prediction

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1. Introduction

Early definitions of supercell storms were based on non-Doppler radar data and they include features like a "vault" or "weak echo region", a "hook", "bow echo" etc. Beside that, supercell storm is characterized by a long life (up to several hours) with continuous and "steady-state" propagation and by deviation of movement direction from the mean wind.

Doppler radar observations define supercell storms as those which exhibit mid-level rotation (usually cyclonic), with the highest vorticity more or less coincident with the updraft core. This mid-level rotation is known as the **mesocyclone**, which can usually be seen by a Doppler radar.

2. Supercell storm motion

The analysis of supercell storm motion should reveal the reasons for direction deviation and enable to nowcast the storm motion in future operational use. In order to achieve that goal, it is necessary to highlight some mechanisms controlling supercell and thunderstorm motion.

The most important mechanisms related to supercell storm motion are **advection, propagation** and effects relating to presence of rotating vortex embedded inside the supercell storm, known as **mesocyclone.**

3. Supercell storm motion prediction

During a long period of observation, it was noticed that some clouds turn right when compared to the motion of all other clouds, and the aim of this paper is to prove that these clouds are cupercells. The second aim is to establish the size of the deviation in motion direction which can be used in operational work in hail suppression system and also in now casting of supercell motion. Velocities data for mean wind, supercell and non-supercell clouds are also analyzed and some conclusions are made.

For that purpose, we chosse 8 dates withh one or more supercells observed (15 in total) from the radar image archive. Original images are made by means of Gematronik radars in radar sites Samos and Fruska Gora (Serbia). These radars work in S band (10 cm wavelength) and the scanning schedule was set on every 4 minutes. The first indication about possibility of supercell existence is the hail damage reports for specific date. The final conclusions are made regarding to cloud shapes in reflectivity field images such as Max images (projection of maximum reflectivity) and vertical cuts of clouds. The duration of the clouds have been also taken into consideration.

Having in mind pieces of work about possibilities for supercell motion prediction by using mean wind, first of all, we have calculated the mean wind from soundings data. For that purpose, we choose the layer through 1, 5 to 9 km, which is approximately two third of average height of typical supercell cloud in this region. Mean wind data obtained in such way were compared to supercell and non supercell clouds motion.

Beside supercell trajectories, surrounding clouds trajectories are also drawn so the difference in motion direction can be seen. Whenever it was possible, we have choose clouds in different area referred to supercell cloud (in front of, beside, behind).

It must be emphasized that models for supercell motion prediction, which use mean wind, should be used only in cases when supercell genesis is not connected to nearby weather front existence. Furthermore, sounding measurement should take place most few hours before supercell genesis, at the distance less than 100 km.

After many years of radar observations, it can be concluded that, in Serbia, supercell development is mostly connected to the presence of weather fronts or instability lines which have a great influence on cloud motion. Therefore, there are a very few situations when using mean wind data could be useful for accurate prediction of supercell motion. For hail suppression and now casting purposes, more practical, simpler and more accurate method is to estimate mean wind in real time by using radar measurements and observations of non supercell clouds and then apply statistical rule about supercell direction deviation.

4. Conclusions

Analysis of cloud motion on chosen dates shows that supercell clouds have tendency of turning to the right regarding to prevailing direction of surrounding clouds or comparing to mean wind. The size of the deviation, compared to non supercell, surrounding clouds is rather uniform (19-30 degrees) in most of cases. The average angle between supercell clouds direction and non-supercell, surrounding clouds direction is 32 degree.

Compared to the mean wind in layer 1,5-9,0 km, the average supercell direction deviation has smaller value (27 degree), but the variability is much larger and goes from -4 to +50 degrees. Mean wind data are obtained from FNL model instead from real soundings for the particular point in specific time and it might be the reason for big variability and uncertain result. Great variability in data representing angle between mean wind direction and supercell clouds direction, point out to unreliability of cloud motion prediction by means of mean wind data. In lack of other option, this method can be used only for roughly estimation of supercell cloud motion.

Analysis of velocity shows that the most consistent data are those for difference between supercell and non supercell clouds velocity. According to them, it can be concluded that supercell clouds velocity is 10 percent larger then velocity of non supercell, surrounding clouds. Compared to the mean wind, supercell clouds velocity is only 4 percent smaller. Similar as for direction data, the differences between supercell velocities and mean wind are much more scattered than difference between supercell and non supercell clouds velocities. Therefore, more reliable and accurate method for supercell velocities prediction is to estimate velocity of the clouds in real time, using radar measurements and then apply statistical rule about supercell velocity difference.

If we use non supercell clouds motion data obtained by radar, the result can be written in form **32R110** or **32R+10**. This is usual denotation for supercell direction and velocity where 32 stands for angle of direction deviation in degrees, letter R means turning to the right, and 110 stands for percents of referred value (in this case referred value is velocity of non supercell, surrounding clouds). If we use mean wind data (in 1,5-9,0 km layer) the result can be written like **27R99** or **27R-1**.

This result came out from statistical analysis of 15 supercell clouds. For more reliable result more cases must be involved but the initial hypothesis about supercell diverging to the right compared to either mean wind or to the motion of non supercell, surrounding clouds is very well confirmed.

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