WIND SHEAR IDENTIFICATION WITH THE RETRIEVAL WIND OF DOPPLER WEARTH RADAR

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KEY WORDS: Wind shear, Doppler weather radar, Conventions, Wind field retrieval, Guangzhou

ABSTRACT:

A new method, which based on the wind field retrieval algorithm of Volume Velocity Process (VVP), has been used to identified the intensity of wind shear occurred in a severe convection process in Guangzhou. The intensity of wind shear's strength shown that new cells would be more likely to generate in areas where the magnitude generally larger than 3.0m/(s•km). Moreover, in the areas of potential areas of rainfall, the wind shear's strength would larger than 4.5m/(s•km). This wind shear identify method is very helpful to forecasting severe convections' moving and developments.

1. INTRODUCTION

The wind shear, which plays a key role in weather process' occurrence and maintenance, is a very important precursor of convections, such as heavy rainfall, squall line, mesoscale cyclones and typhoons etc. [1-2] Usually, for the wind shear's detection equipment, the mainly remote sensing tools are wind profile instrument, laser Doppler radar and Doppler weather radar. However, because of the degradation of signals by precipitation particles, not all of that equipment has ideal performance in weather processes, especially in precipitation processes [3].

In contrast, modern Doppler weather radar, which has outstanding advantage of remote sensing in rainfalls, can not only provide real time observations, but also obtain the evolution information of the atmospheric, such as wind shear and turbulence at the same time [4]. According to the theories of wind shear identify methods based, it can be sorted in two mainly categories. Ones is on the difference of radial velocity[5-7], and the other is on the variations of echoes[8].

Specifically, the wind shear is always consisted of vertical wind shear and horizontal wind shear, many wind shear identification methods are on the basis of the radial velocity, the radial velocity difference or both of them. However, the performance of existing methods always is affected by ground clutters and discontinuity of radar data. Therefore, misjudgement would be made of wind shear identification in the mentioned situations. For instance, the poor quality of radar data or the non-standard data pre-process, when radial velocity is small, will cause that the performance of these methods would not be very well.

Because the wind shear is a representation of wind field's unevenness. In this paper, a new wind shear identify method, which employed VVP (Volume Velocity Process) wind retrieval techniques, was developed to examine the unevenness in wind field.

2. A BRIEF INTRODUCTION OF VVP TECHNIQUE

Due to the analysis volume is a 3D region [9], , the wind field model of VVP method is suitable to use in high elevations or in the cases of analysis volumes with large width in vertical direction. Considering the radar as the center in the Cartesian coordinate frame, the center coordinate of the analysis volume is (x0, y0, z0), and the velocity of this point is V=(u0, v0, w0). Thus, the velocity onto each points of the analysis volume can be expressed as follows:

$$\begin{cases} u{=}u_0+u_x\left(x-x_0\right)+u_y\left(y-y_0\right)+u_z(z-z_0) \\ v{=}v_0+v_x\left(x-x_0\right)+v_y\left(y-y_0\right)+v_z(z-z_0) \\ w{=}w_0+w_x\left(x-x_0\right)+w_y\left(y-y_0\right)+w_z(z-z_0)+w_f \end{cases} \tag{1}$$

, where w_f is the terminal velocity of raindrop.

According to the projection between wind field and radar radial direction, the radial velocity measured by radar is:

$$V_r = u\cos\theta\cos\varphi + v\sin\theta\cos\varphi + w\cos\varphi \tag{2}$$

, where θ and φ are the azimuth and elevation angles, respectively. Obviously, the relationship between wind field and radial velocity can be written as:

$$V_r{=}\ V_h\times\cos\delta\theta\times\cos\varphi{+}w\sin\varphi \tag{3}$$

Where V_h is the horizontal wind velocity, $\delta\theta$ is the included angle between radar azimuth and horizontal wind, φ is the elevation and w is the falling speed of raindrop.

3. A TEST WITH REAL WIND FIELD

3.1 The wind shear identification algorithm and pre-process

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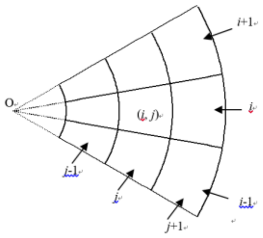

Figure1. The analysis volume point and its neighbour points

As shown in Fig. 1, the wind shear was calculated by making a comparison of the center point with 8 neighbour grids. The maximum gradient value of the velocity difference on unit length was selected to present wind shear magnitude. The value of wind shear is calculated on unit length as

$$S = \max\left(\frac{\sqrt{(du_{i,j})^2 + (dv_{i,j})^2}}{d_{i,j}}\right) \tag{4}$$

, where $\begin{cases} du_{i,j} = u_{i,j} - u_{i',j'} \\ dv_{i,j} = v_{i,j} - v_{i',j'} \\ d_{i,j} = \sqrt{(x_{i,j} - x_{i',j'})^2 + (y_{i,j} - y_{i',j'})^2} \\ i' = i \pm 1 \\ j' = j \pm 1 \end{cases}$

The wind shear’s unit is m/(s ·km).

4. A TEST IN THE PROCESS OF SEVER CONVECTION WEATHER HAPPED IN NANJING

For the sever convection happened in Nanjing, there has a strong echo regions (The delineated region as shown in Fig. 2 (a1-a3)). The maximum echo has exceeded 50 dBZ, and it is certain that severe convections existed in these regions and hail might occur. It also can be seen from Fig. 2 (b1-b3), positive and negative radial velocity regions existed in the delineated region. At the radius range of 80km in 310 degree, there was a region with strong wind, it infers that the convergence and convective developed rapidly here. Moreover, the echo area became bigger gradually.

On the contrary, the radial velocity increased at time of b2, it implies that the convections developed fast in this region. Based on the identification for wind shear in three independent times as shown in Fig. 2 (c1-c3), it can be found that the most intensive wind shear appeared in the strong echo regions. The strength of wind shear’s magnitude exceeded 4.5m/(s•km) and the location is corresponding to inflows in convection cells[10-11].

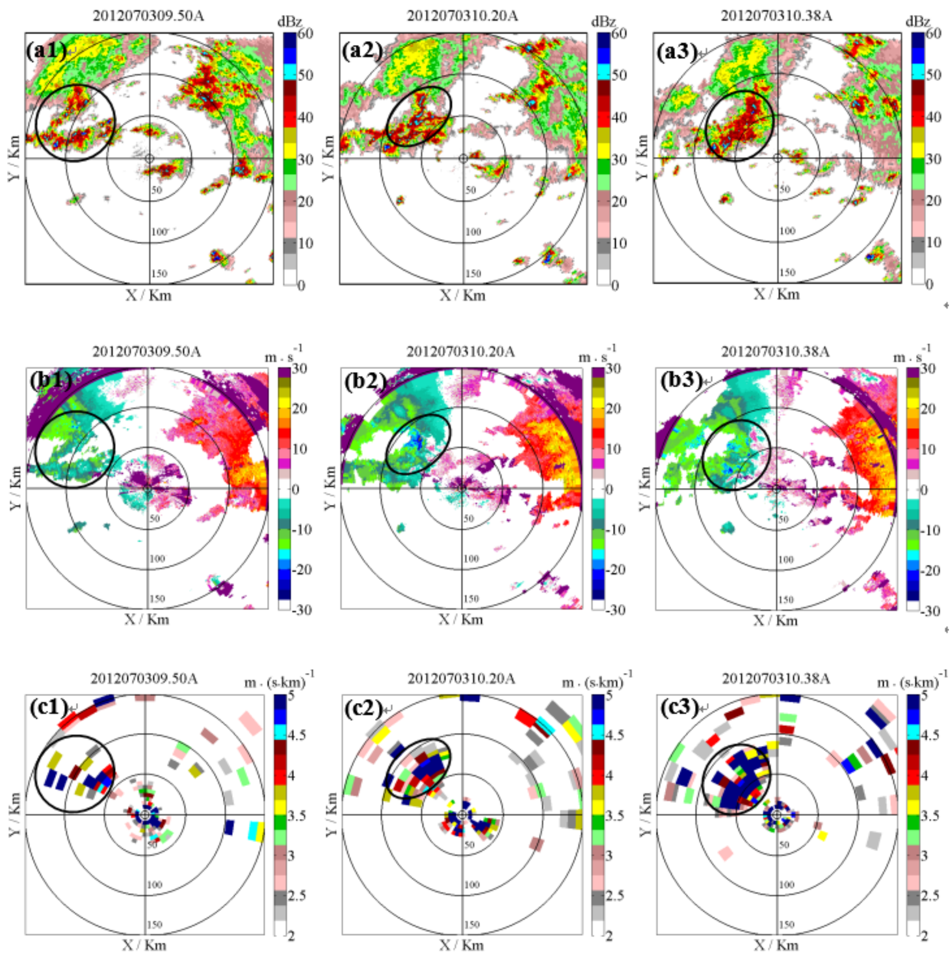

Fig2. The reflectivity factor (a1-a3), radial velocity (b1-b3) and the wind shear (c1–c3) at 17:50, 18:20 and 18:38, July 3, 2012, respectively. (Elevation: 1.5^{o})

According to the variation of echoes, it found that strong wind shear regions always appeared in the front of the main convection region. For an example, as shown in Fig. 2(c1-c3), the wind shear, where the strength has exceeded 4.0m/(s•km), always appeared at gust front. Consequently, intensive wind shear usually generated along with convection cells and appeared in the front. Since the region size of wind shear areas would increase and follow with severe weather processes, it can be used as a sign to indicate the movements and variation tendency for severe weather processes.

5. CONCLUSIONS

A new wind shear identification algorithm was proposed with the wind field retrieval techniques. According to the analysis and tests, we draw the following conclusions:

(1) Since wind shear is a presentation of wind field’s unevenness, a wind shear identification algorithm was proposed by calculating the retrieved wind velocity’s difference between neighboring analysis volumes. The larger the wind shear’s magnitude indicts the more unstable the wind field is.

(2) The results of one severe weather process happened in Nanjing shown that the strength of wind shear would exceed 4.5 m/(s•km) and move along with those processes consistently. Therefore, locations and moving direction of intensive wind shear could be used as a reference for severe convections forecasting.

ACKNOWLEDGEMENTS

Acknowledgements of support for the Key Scientific Research Projects in Colleges and Universities (17A170005); China Postdoctoral fund (2016M602232);Henan Provincial Postdoctoral Science Foundation; The National Natural Science Fund (41671425);Open Fund of Henan Key Laboratory of Integrated Air Pollution Control and Ecological Security (20170201).

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