5.8 VERIFICATION OF WIND FIELD RETRIEVAL OF DOPPLER RADAR VELOCITY-AZIMUTH PROCESSING METHOD

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1 PRINCIPLE OF VAP METHOD

The VAP (Velocity-Azimuth Processing) method was put forward for retrieving the horizontal wind field from single Doppler radar data by Tao Zuyu (1992). Assume that the horizontal wind vectors are uniform in a very small azimuth interval (i. e., the local uniformity of wind field) and neglect the vertical fall speed of the particles of low elevation scan, the formula of horizontal wind retrieval based on the distribution of Doppler velocity profiles with azimuth are as follows (see Fig. 1):

Wind speed:

$$v = \left| \frac{v_{hr1} - v_{hr2}}{2 \sin\alpha \sin\Delta\theta} \right|,$$

Wind direction:

$$\tan\alpha = -\frac{v_{hr1} - v_{hr2}}{v_{hr1} + v_{hr2}} \cot\Delta\theta = an$$

$$\alpha = \arctan an, \qquad v_{hr1} - v_{hr2} > 0, v_{hr1} + v_{hr2} > 0$$

$$\alpha = \arctan an + \pi, \quad v_{hr1} - v_{hr2} > 0, v_{hr1} + v_{hr2} < 0$$

$$\alpha = \arctan an, \qquad v_{hr1} - v_{hr2} < 0, v_{hr1} + v_{hr2} > 0$$

$$\alpha = \arctan an - \pi, \quad v_{hr1} - v_{hr2} < 0, v_{hr1} + v_{hr2} < 0$$

where v is the wind speed, θ is the azimuth in the polar coordinate system, $\Delta\theta$ is the change in the azimuth, v_{hr1} and v_{hr2} are the radial velocities at the azimuth $\theta - \Delta\theta$ and $\theta + \Delta\theta$ measured by radar, α is the retrieved wind direction denoted by the angle between the wind direction and the radar beam.

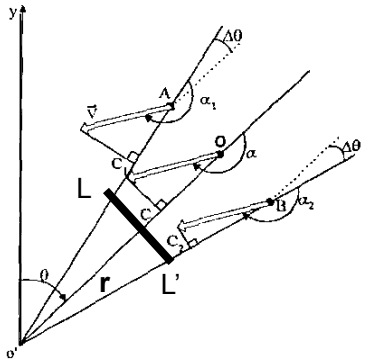

Figure 1 A schematic diagram of the relation between the wind vectors and the radial velocities on local uniform wind assumption.

Because spatial and temporal resolutions of the Doppler radar data are higher than all of other winds observations, it is difficult to obtain the detail information of wind field for objectively evaluating the results derived by VAP method. To prove the validity of the meso-β-scale characteristics on the retrieved wind fields by VAP method, Choi et. al. (1997) compared the wind fields obtained by the VAP method with the composed wind field from dual-Doppler radar data of TOGA-COARE IOP(December 1992). Their results shows both methods display the shear of wind direction associated with the gust front in convective systems, yet, a big advantage of the VAP method is that it can save a lot of time for data processing compared to the dual-Doppler and other methods.

In this present paper, the retrieved wind field by VAP method was compared and contrasted to the wind field derived from dual-Doppler radar (at Yichang and Jingzhou cities, see Fig. 2) in observational field experiment of 973 Project. Furthermore, the

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reconstructed image of the radial velocities from the retrieved wind field by the VAP method is contrasted with the original velocity image of Doppler radar at Yichang city in Hubei Province of China.

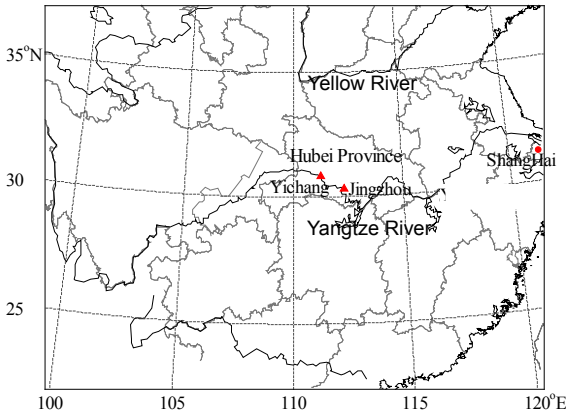


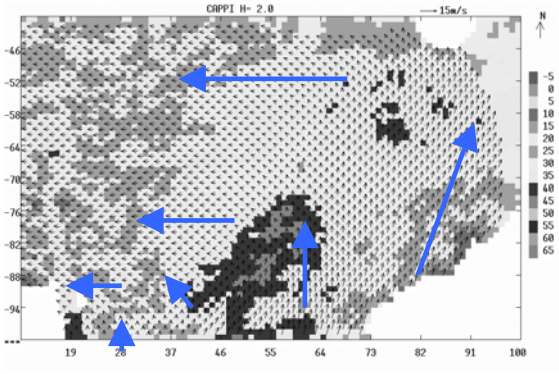
Figure 2 Locations of Yichang and Jingzhou in Hubei Province, P. R. China

2 DATA

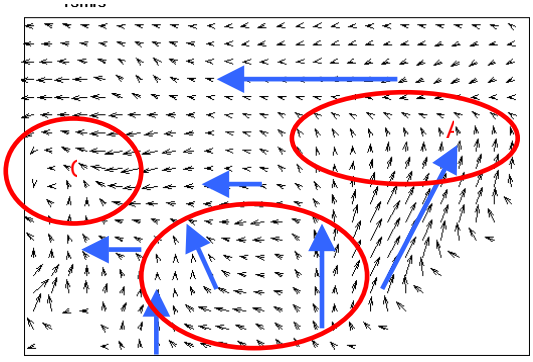
During the summers of 2001 and 2002, the observational field experiment on rainstorm supported by 973 Project of China was conducted in the middle and lower reaches of Yangtze River, and the combined observation of two Doppler radars was conducted to obtain the mesoscale wind field. However, the effective region is about one fourth of the radar scan area (Doviak et al., 1976). The radar data used in this paper was observed at Yichang and Jingzhou cites (see Figure 2) during a heavy rainfall case on July 22, 2002. The radar at Yichang is a WSR-980SA Doppler radar, and at Jingzhou is a C-band Doppler radar, which are made in China. The single Doppler radar wind field retrieval was made based on the measurements of the radar at Yichang city, and the composed wind field of dual-Doppler radar was based on the co-coverage of the radars at Yichang and Jingzhou.

3 COMPARSION BETWEEN WIND FIELDS RETRIEVED FROM SINGLE AND FROM DUAL-DOPPLER RADAR

Figure 3(a) is the retrieved wind field from dual-Doppler radar at Yichang and Jingzhou on 22th July 2002, and (b) is the single Doppler radar retrieval in the same area based on the Doppler radar measurements at Yichang by the VAP method. The dual-Doppler radar wind field was performed by Liu Liping of Chinese Academy of Meteorological Sciences. The comparison shows the retrieved wind field from single Doppler radar by VAP method is quite consistent with the one from dual-Doppler radar, and both of them can reveal that there exists an cyclonic stream field which turns the southerly to the easterly, however, the wind field from single Doppler radar covers the whole scan range of single radar.



(a) Retrieved wind field from dual-Doppler radar data（performed by Liu Liping, Chinese Academy of Meteorological Sciences）



(b) Retrieved wind field from single Doppler radar measurement by the VAP method

Figure 3 Retrieved wind field at 2 km height ASL at 3:25 (Local Time) on 22th July, 2002

The radial resolution of the retrieved wind field by the VAP method in the polar coordinate system is the

radial resolution of the Doppler radar, which is usually less than 1 km and can identify the mesoscale structure of the weather systems. Yet, what is the tangential resolution of the retrieved wind field by the VAP method? The tangential resolution L-L' (see Figure 1) is approximately equal to sin ($2\Delta\theta$) * r, where r is the radial distance. Table 1 gives the largest tangential resolution in the different radial distance, which shows that on the assumption of local uniform wind, the resolution is 3~10 km of the retrieved wind field by the VAP method in the distance range of 125 km. So, the VAP method can meet the demand of meso-α-scale and meso-β- scale analysis, but the meso-γ-scale features were eliminated in the retrieval.

Table 1 Tangential resolution of the retrieved wind field by the VAP method

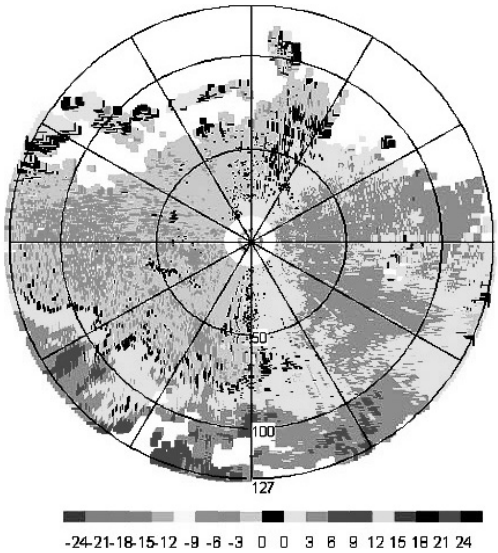
Distance (km)	<10	10~20	>20	125
$\Delta\theta$ (^{o})	7	6	6~2	2
L-L' (km)	2.4	4.1	6	8.7

4 COMPARSION BETWEEN RECONSTRUCTED IMAGE OF RADIAL VELOCITIES AND RADAR MEASUREMENTS

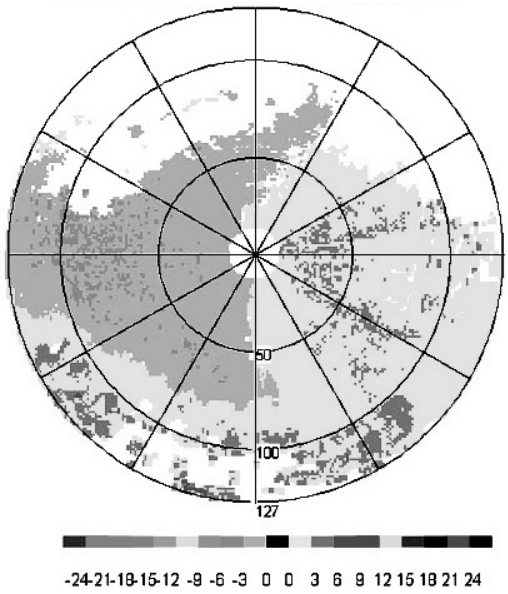
If the retrieved wind field by the VAP method can be re-converted to the original image of the Doppler velocity, it can prove the retrieval is reliable .

To furthermore verify the wind field obtained by the VAP method, the reconstructed image of the radial velocities was given in Figure 4 based on the radial components of the retrieved wind field by VAP method to contrast with the original image of the Doppler radar scan at Yichang city.

Because the VAP method has no any physical assumption, the two images of radial velocities are quite similar, which shows that the retrieved wind field is reliable. But, the value of reconstructed radial velocities from the retrieved winds are a little bit smaller than the observations. This is because the original data of radial velocity were smoothed to reduce error sensitivity in the VAP method processing. The smoothness cause the retrieved horizontal wind to be less 2~3 m/s than the actual wind.



(a) Radial velocities measured by Doppler radar



(b) Inverted radial velocities from the retrieval wind field by the VAP method

Figure 4 Radial velocities at 1.8 km height AGL at 3:25 on 22th July 2002 (Local Time)

5 CONCLUSIONS

In this study, the retrieved wind field from single Doppler radar by VAP method was compared and contrasted to the wind field conducted from dual-Doppler radar. In addition, the reconstructed radial velocities image from the retrieved wind field obtained by the VAP method was contrasted with the original image of Doppler velocity.

The results show that the retrieved wind fields by VAP method were reliable, which can be employed to retrieve the whole wind field in the radar scan range and to analyze the meso-*β*-scale features in the wind field.

Acknowledgement

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References

Choi, S.H, S.G.. Park, K.E. Kim, 1997, Estimations of horizontal wind fields by VAP method, *Journal of Korean Meteorlogy Society*, 33(3), 535~551

Doviak, R. J., Ray, P. S., Strauch, R. G. and Miller, L. J., 1976, Error estimation in wind fields derived from dual-Doppler measurement, *J. Appl. Meteor.*, 15: 868-878.

Tao Z. Y., 1992, The VAP method to retrieve the wind vector field based on single-Doppler velocity field (in Chinese), *Acta Meteor. Sin*., 50 (1)，81~90