7B.4 Extracting Doppler Radar Wind Information in Weather Prediction

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1. Introduction

Doppler radars can measure the radial velocity of particles in a resolution volume. However, since these are derived from a phase measurement, the radial velocity is subject to folding. In order to derive the magnitude and direction of the wind from measurements of just one component, it is common to adapt a VAD model, such as described by Browning and Wexler (1968), in which the wind field across a region close to the radar is assumed to be uniform, and its vertical component assumed to be negligible. A sinusoid is then fitted to the data by Least-Squares. A description of operational application of VAD has been given, for example, by Andersson(1995).

In this work we propose a method to obtain information about the speed and direction of the wind field when the VAD assumption of a uniform wind field is inappropriate. Siemen and Holt (2000) showed that this method is potentially insensitive to folding and can give robust estimates of wind direction.

2. Different VAD signatures

Doppler Velocity data can show various VAD signatures for different kinds of wind fields, from the a curve to chaotic signatures. To develop a method to determine wind field information from VADs, it is necessary to know which signature represents which wind field feature and how to differentiate between the different signatures. Figure 1 shows six classes of VADs. With classification, it is possible to give forecasters and NWP modelers an estimate of which kind of wind field they have to handle. A method which seeks to determine the wind field from VAD data has to go through different stages to identify the different cases which may exist.

As can be seen from figure 1, Cases E and F represent wind fields that cannot easily be fit to simple wind field models, such as the linear homogenous case described by Browning and Wexler (1968). Case F is the simplest to check and should be done in the beginning to avoid unnecessary calculations. Case E is the result if all other methods of fitting have failed.

After it has been determined that enough data is available, the fitting of a sine curve can reveal if the data is as shown in case A. If a sine curve gives a good fit of the data, the wind field can be assumed to be linear and constant in height.

If a sine curve is not satisfactory, models of cases B and C can be estimated with a fitting at their zero crossings. Cases B and D need more investigation at all maxima and minima. For this, closer examinations of local linear fits were used. These local fits also make it possible to identify wind shear in the data (case D). An example for such local fits are shown in the next section and further ones can be found on the webpage. Cases A to D can occur together in various combinations.

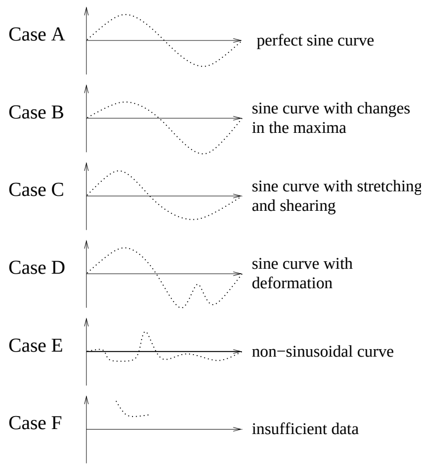

Fig. 1: Examples of how VADs can be classified.

An important feature of the signatures shown in figure 1 are the zero crossings. These zeros represent the locations where the wind direction is at right angle to the radar beam. This results from the fact that the radial component is zero and only the tangential component is describing the wind field. This makes the zero crossing an important indicator for describing the two dimensional wind field.

3. Example

We illustrate the wind retrieval method with a data set of a band of convective storms recorded on the 18th June 1997 by the SMR radar in Bologna. As can be seen from figure 2, a sine curve (shown dashed) is a bad fit for the given display. This is because a sine curve is fixed on two zero crossings 180^o apart which is not valid for this case.

Figure 2 shows linear fits over intervals of 15^o superimposed on the data. These local fits allow one to identify four zero crossings and the location and value of the minimum (-15.2 m/s at 10^o) and maximum (22.3 m/s at 140^o). This information can be used to identify the form of the wind field. Referring to figure 1, this VAD shows a mixture of cases B to

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D. The wind shear at 250^o can be determined through the positive gradient in the 16^{th} and 17^{th} interval in a row of many negative gradients (intervals 11 to 24).

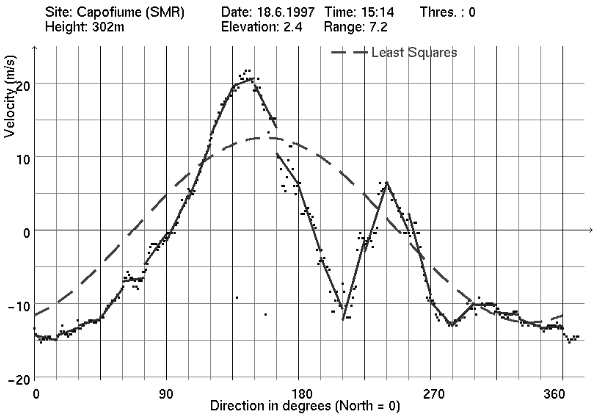

Fig. 2: VAD showing data from the 18th June 1997 recorded by the SMR Doppler radar. The dashed sine curve is the result of a Least Squares fit of a sine curve over the data. In this data '+' indicates away from the radar.

The procedure shown here is generally applicable. More examples, updates, and information about the method are given at *http://mo4.essex.ac.uk/vad*.

4. Visualisation of retrieved wind field information

PPI displays of Doppler velocity are not easily appreciated by a forecaster. To address this we are developing a display providing information obtained from the zero crossings, since they alone give guaranted information on the wind direction.

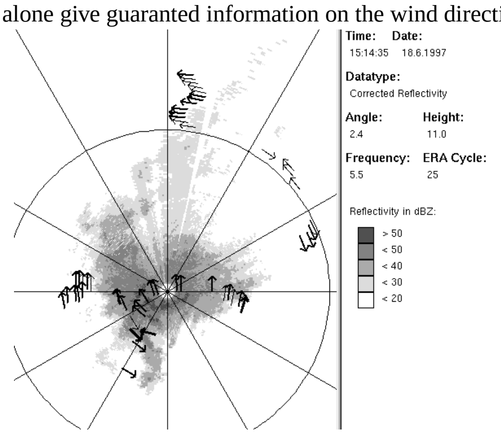

Fig. 3: Example of a Reflectivity PPI with arrows indicating where the zero crossings in the corresponding VAD were measured. The length of the arrows is proportional to the gradient at the crossing point (see figure 2). The data was recorded from SMR in Bologna on the 18th June 1997 (for a larger colour version of this figure see the webpage).

Figures 3 and 4 show the PPI of reflectivity and radial velocity for the scan considered in figure 2. The data is at a 25 km range around the radar. The arrows indicate the direction of the wind obtained from zero crossing at different ranges, the azimuth being given by the base of the arrow. The thickness of the arrow indicates an estimate of the wind velocity obtained from the gradient of the VAD plot at the zero crossing.

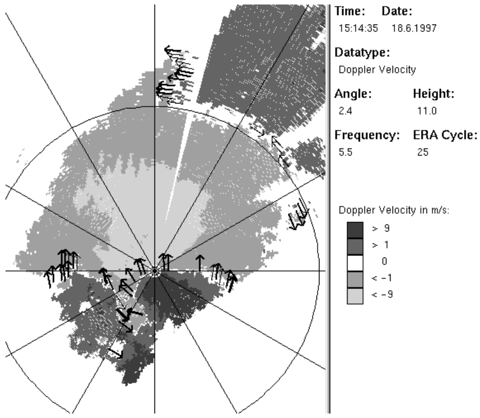

Fig. 4: As fig. 3, but a display of Doppler radial velocity.

5. Conclusion and further work

Methods based on sinusodial fits cannot give an accurate picture of the wind field. A more flexible method has to be used to cope with non regular features, such as wind shears and other non-linear flows. The method presented here makes it possible not only to identify homogenous wind fields, as other methods can do, but also to identify non regular features and describe them for usage by NWP and forecasters. Investigation is needed to show how data from different elevation can be analysed together and visualized. This can improve the accuaracy and produce a 3D picture of the situation.

5. Acknowledgements

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6. References

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