Velocity Distributions within Oklahoma Severe Storms

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ABSTRACT

Optimum design of a Doppler radar system for operation in a severe storm environment will depend on the maximum unambiguous velocity. Radial velocities of severe storms are examined from four Doppler radars over several hours on 20 May 1977. The probability of a radial velocity occurrence for a given pulse repetition frequency-wavelength combination is presented.

1. Introduction

Doppler radar's demonstrated utility in severe storms research is currently being transferred for use operationally by the National Weather Service and the Air Weather Service. If products (such as shear) or pattern recognition techniques are to be employed, ambiguities which would result in an unclear estimate of storm structure must be removed. Two principle ambiguities are the range in which all echoes appear to be located and the velocity interval within which all velocities are represented. Both the maximum unambiguous range (R_{max}) and velocity ($\pm V_{max}$) are related to the pulse repetition frequency (PRF), and hence to each other, as

$$R_{max}=\frac{\lambda c}{8V_{max}}, \qquad (1)$$

where λ is the radar wavelength and c the propagation speed of an electromagnetic wave. Algorithms such as described by Ray and Ziegler (1977) work well if most radial velocity estimates are contained within $\pm V_{max}$. Allowing modest aliasing (velocities outside the range $\pm V_{max}$) permits operation at a lower PRF and hence an extended unambiguous range. Through knowledge of the radial wind speed distribution, a suitable PRF or PRF scheme can be established. We have restricted this study to severe storms because they offer the greatest threat and challenge to interpretation. A radar system designed to accommodate these storms will be adequate for all others.

2. Results

During the afternoon/evening hours of 20 May and early morning hours of 21 May 1977, there were 16 tornadoes in Oklahoma. Network specifications and a summary of the data collected for these days are given in Ray *et al.* (1977).[1] We have examined radial velocities from four Doppler radars over a 3 h period on 20 May 1977 during which there were many severe storms. The data includes 30 separate volume scans with over 24 million observations. This work extends earlier computations by Doviak *et al.* (1978) for three volume scans through storms in previous years. Statistics of the Doppler data are summarized below.

The average percent occurrence of a radial velocity (all velocities are quantitized in 1 m s^{-1} intervals) is given in Fig. 1. Due to the quantization interval, the distribution of samples in each category presented in Fig. 2 is somewhat irregular. This irregularity is also reflected in the average percent occurrence. The proba-

[1] Ray, P. S., J. Weaver and NSSL Staff, 1977: 1977 spring program summary. NOAA Tech. Memo. ERL NSSL-84, 173 pp.

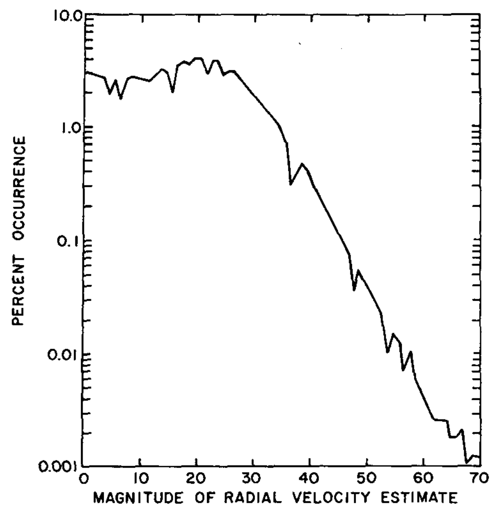

FIG. 1. Average percent occurrence of the radial velocity estimate magnitude. Speeds up to 120 m s^{-1} were allowed in the computations.

TABLE 1. Cumulative percent occurrence of radial velocity modulus estimate.

Velocity (m s^{-1})	Cumulative percent occurrence	Velocity (m s^{-1})	Cumulative percent occurrence
0–1	3.26	36–37	97.30
1–2	6.18	37–38	97.66
2–3	9.07	38–39	98.12
3–4	11.80	39–40	98.53
4–5	13.83	40–41	98.81
5–6	16.52	41–42	99.05
6–7	18.40	42–43	99.24
7–8	21.14	43–44	99.39
8–9	23.83	44–45	99.51
9–10	26.54	45–46	99.61
10–11	29.20	46–47	99.69
11–12	31.79	47–48	99.73
12–13	34.73	48–49	99.78
13–14	38.03	49–50	99.82
14–15	41.11	50–51	99.86
15–16	43.21	51–52	99.88
16–17	46.87	52–53	99.91
17–18	50.72	53–54	99.92
18–19	54.42	54–55	99.93
19–20	58.52	55–56	99.95
20–21	62.52	56–57	99.95
21–22	65.43	57–58	99.96
22–23	69.28	58–59	99.97
23–24	73.12	59–60	99.97
24–25	75.94	60–61	99.98
25–26	79.12	61–62	99.98
26–27	82.18	62–63	99.98
27–28	84.79	64–65	99.99
28–29	87.25	65–66	99.99
29–30	89.33	66–67	99.99
30–31	91.23	67–68	99.99
31–32	92.72	68–69	99.99
32–33	94.10	69–70	99.99
33–34	95.26		
34–35	96.24		
35–36	96.98		

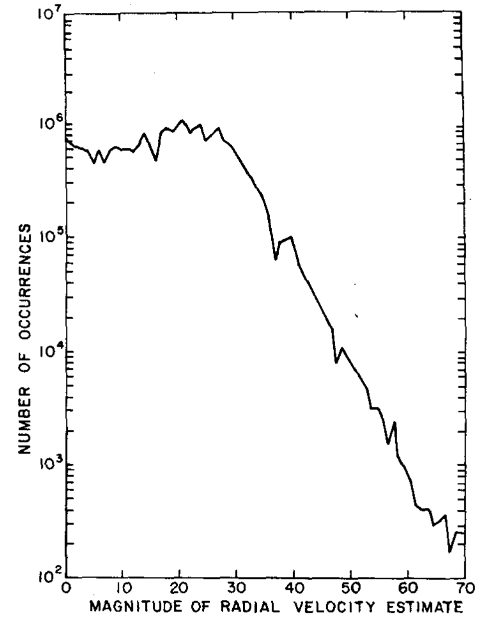

FIG. 2. Number of occurrences of the radial velocity estimate magnitude.

bility of a velocity not exceeding a given value is given in Table 1 and Fig. 3. From this, the likelihood that a radial velocity estimate will exceed a given value can be derived. Here, we see that for a PRF-wavelength combination yielding $V_{max}=\pm 15$ m s^{-1}, the probability is 60% that velocities will be aliased at least once and 0.5% that they will be aliased twice. If $V_{max}=\pm 25$ m s^{-1}, then only 25% of the velocities will be

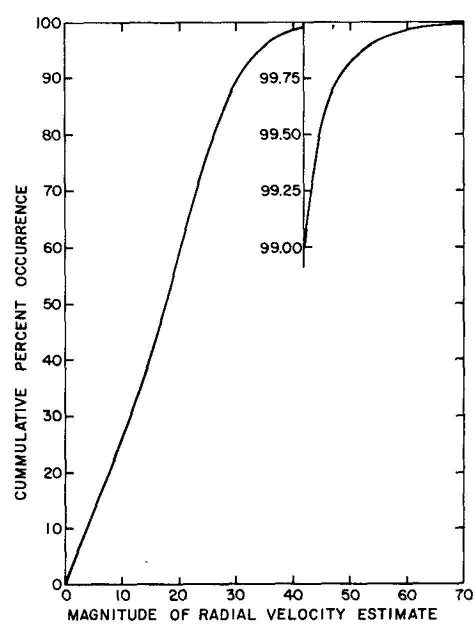

FIG. 3. Cumulative percent occurrence of the radial velocity estimate magnitude. Speeds up to 120 m s^{-1} were allowed in the computation.

aliased, and for $V_{max} \approx \pm 35$ m s^{-1} only 4% will be aliased.

The data base should be extended to provide a better estimate of the area storm climatology. Investigators with access to similar data in other regions of the country are encouraged to make similar calculations to assess the applicability of these results in other geographical areas.

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REFERENCES

Doviak, R. J., D. Sirmans, D. Zrnic and G. B. Walker, 1978: Considerations for pulse-Doppler observations of severe thunderstorms. *J. Appl. Meteor.*, 17, 189–205.

Ray, P. S., and C. L. Ziegler, 1977: Dealiasing first-moment Doppler estimates. *J. Appl. Meteor.*, 16, 563–564.