Analysis And Application Of X-Band Dual-Polarization variables Of Ground Clutter

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Introduction

Ground clutter echoes can't be neglected since it's able to contaminate meteorological radar products. The understandings of ground clutter characteristics can be used for detection and suppression of ground clutter. The clutter map is a usual way to provide the position and spectrum parameters of ground clutter while the radar is scanning at specific elevation angle. Kessinger et al (2003) proposed a fuzzy logic algorithm with three spectrum moments to classify echoes. Berenguer et al (2006)distinguished precipitation from ground clutter or sea clutter with speed, echo top, reflectivity intensity gradients, texture and so on. Zrnic et al(2006) analyzed the zero-order autocorrelation coefficient characteristic of ground clutter. The dual-polarization variables of ground clutter are far different from weather echoes, which can be used to identify the clutter. The clutter and weather echoes under different wavelength have tiny difference of detailed characteristic. The paper mainly analyzes the X-band characteristic of clutter and weather echoes.

Statistical distribution

The majority ground clutter observed by XD radar occur in elevation between the 0.5o ~ 2.4o, therefore the statistical dual-polarized characteristics of clutter and weather is concentrated on low elevation. The radar is well-calibrated before experiments. The experiments are divided to two main modes of clear and precipitation. The experiments collect and restore the raw I/Q data which are used to computed dual-polarized parameters without valid data range restriction. That helps us to understand the clutter better.

The experiments last the whole year of 2010. The probability density distribution of dual-polarization variables of clutters and weather echoes are displayed in figure 1.

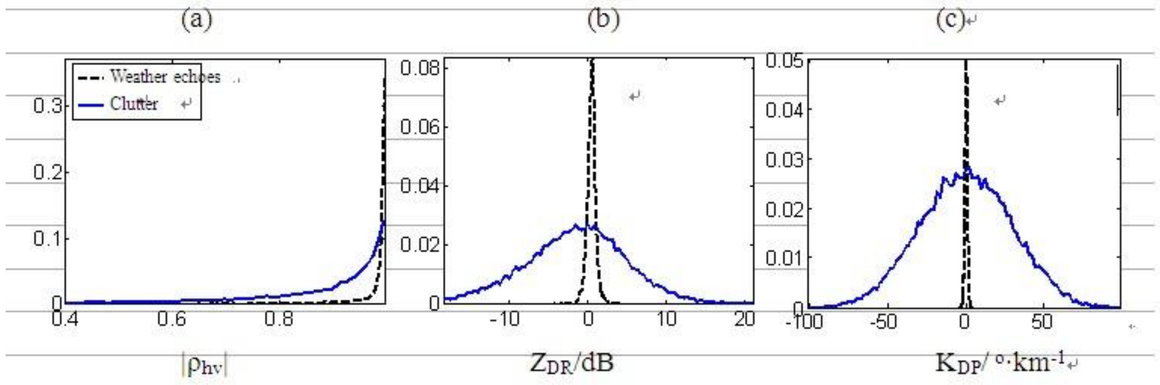

Fig.1 Normalized frequency distribution of polarized variables about clutter and weather echoes（a）correlation coefficient，（b）differential reflectivity，（c）specific differential phase

As can be seen from Table 1, The occurrence probability of weather echoes are more than 99.5% according to the specific data range, while the occurrence probability of ground clutter are much lower. The result will be opposite if the polarization variables are at the outside of the specific data range. The KDP is a better parameter to distinguish clutter and weather echoes.

Table 1 the occurrence possibility of ground clutter and precipitation echo under specific range

Data range	Precipitation (%)	Ground Clutter(%)
-3 dB≤Z_{DR}≤6 dB	99.5	43.2
$\|K_{DP}\|$≤6 °.km^{-1}	99.5	13.5
$\|\rho_{hv}\|$≥0.80	97.8	75.7

Ground clutter identification

Fuzzy logic method can be used to identify the echo type . The identification with fuzzy logic method has four step including fuzzification, rule inference, aggregation, and defuzzification. The four parameters of ZH, ZDR, KDP, and | ρhv | are inputs. The basic form of membership function(MSF) select asymmetric trapezoidal T-function, which determines the shape with the four parameters: left starting X1, the left end of the interval point value X2, the right starting point interval value X3, the right end of the interval point value X4.

$$T\left(x, X_1, X_2, X_3, X_4\right) = \begin{cases} 0 & x < X_1 \\ \dfrac{(x - X_1)}{(X_2 - X_1)} & X_1 \le x < X_2 \\ 1 & X_2 \le x < X_3 \\ \dfrac{(X_4 - x)}{(X_4 - X_3)} & X_3 \le x < X_4 \\ 0 & x \ge X_4 \end{cases}$$

Statistical polarization characteristics of weather echoes and clutter are used to construct their own MSF. Table 2 gives T-function parameters value of the weather echoes and ground clutter MSF.

Table 2 Membership function values of polarimetric variables for weather echo and ground clutter

		Weather echoes	Ground clutter
$T(Z_H)$	X1/dBz	10	30
	X2/dBz	15	40
	X3/dBz	45	55
	X4/dBz	70	70
$T(Z_{DR})$	X1/dB	-3	-20
	X2/dB	-2	-5
	X3/dB	5	5
	X4/dB	,6	20
$T(K_{DP})$	X1/(deg.km^{-1})	-6	-100
	X2/(deg.km^{-1})	-4	-30
	X3/(deg.km^{-1})	4	30
	X4/(deg.km^{-1})	6	80
$T(\lvert\rho_{hv}\rvert)$	X1	0.7	0.2
	X2	0.85	0.9
	X3	1	1
	X4	1	1

For clutter type, the weighting factor value of KDP, ZH, ZDR and |ρhv| are correspondingly 0.5,0.2,0.15 and 0.15. For precipitation type, the weighting factor value of KDP, ZH, ZDR and |ρhv| are all 0.25. Next “aggregation" process is inferred from two separate rules, selecting the maximum value as the sole final result. Finally it’s converted to the specific recognition results.

Fig 2 shows an application of identification.

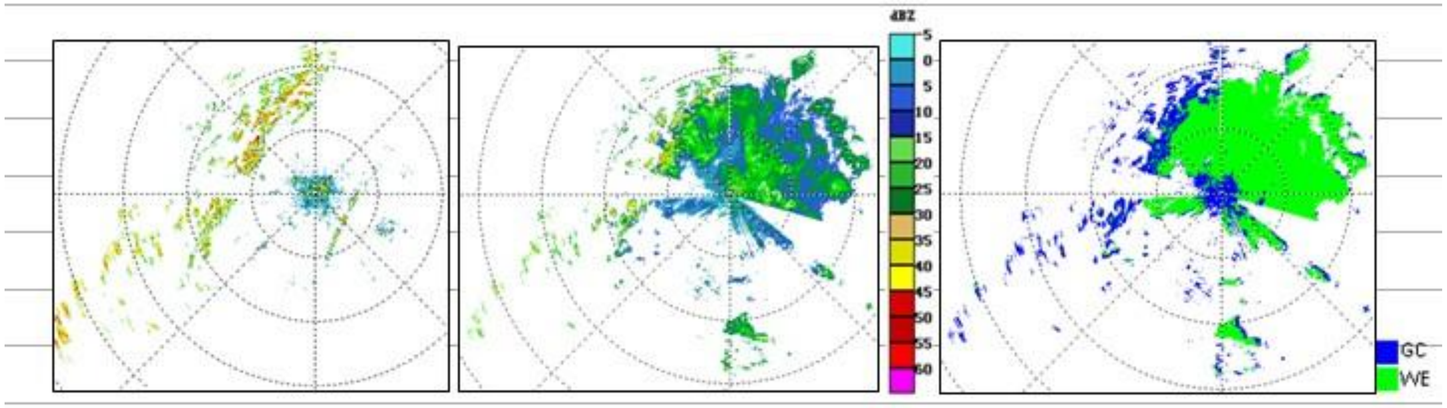

Fig.2 The PPIs of 0.5deg elevation are observed under clear and precipitation condition (a)ZH of ground clutter without precipitation (b) ZH of precipitation (c) Fuzzy logic identification result,GC represents ground clutter, WE represents weather echoes.

Conclusion

Polarimetric variables are not pre-restricted with specific threshold range, which are more useful for the recognition of of ground clutter characteristics. The majority of recognized ground clutters are similar to observation under clear-sky, however there are still a small part of precipitation echoes mistakenly identified as ground clutter. False recognition rate is subject to the rules of the fuzzy logic inference and aggregation, such as: unrealistic parameter value of T-function and unfair distribution of weighting factors. Since the polarization characteristics of clutter and precipitation have small overlapping, it can’t theoretically distinguish all clutter only by the polarization variables. Therefore it’s need to consider a compromise weight distribution and threshold adjustment.

Reference

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