P4.9 Identification of Biological Scatterers and Radar Data Quality Control

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1. INTRODUCTION

Biological scatterers (BS), such as birds and insects, can cause serious biases and related data quality problem in the application of VAD (Velocity Azimuth Display) analysis, and precipitation estimates using radar observations. Discrimination of BS from meteorological scatterers is thus very important for radar data quality control, and it will also provide critical information for the safety of aviation. Radar observations have been used to detect and/or quantity bird movement in many studies (Eastwood 1967; Gauthreaux and Belser 1998). The recent study of Zrnic and Ryzhkov (1998) showed that insects and birds can be quite reliably detected from their polarimetric radar signatures as revealed by radar displays of polarimetric parameters such as differential phase, differential reflectivity, and correlation coefficient. Based on the previous studies, an automatic algorithm is being developed by the authors to detect BS for NEXRAD level II data quality control. The methodology and preliminary results are presented in this paper. The polarimetric signatures are used as the ground truth to verify our results.

2. METHODOLOGY

NEXRAD level II data includes 3 radar observed parameters: reflectivity, Doppler velocity, and spectrum width. Based on previous studies and the investigation of the radar data under different atmospheric conditions like clear air, cloud and precipitation, and with and without insects and birds, a parameter "score" is designed to discriminate the radar echoes. Biological echoes score higher than meteorological echoes. In the following case studies the echo with score higher than 5.0 is marked as a biological echo, if it is less than 5.0, it is a meteorological echo.

First, by computing the standard deviations (SD) of Doppler velocity, the texture of different radar echoes is inspected. The SD is obtained by subtracting the 7 points running mean of the raw Doppler velocity data from the original raw data along a beam. The results show that the SD of bird scatterers is higher than thunderstorm scatterers. Also considered, is the relative uniform and strong reflectivity (up to 30dBZ) of bird echoes (Fig.1). The above information is combined and weighted to calculate the score at each reflectivity point in radar coordinates. In the future, more information about bird and insect movement, such as flight speed, direction and height, etc. will be added to our algorithm.

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3. CASE STUDY

When birds migrate during the spring and fall season, disk-like or annular patterns are frequently observed by NEXRAD over north America. Here we have chosen two cases in the spring, one with possible bird echoes and the other with possible bird and thunderstorm echoes, observed by the KTLX radar to study this phenomenon and test our algorithm. At the same time, the observations of the Cimarron polarimetric weather radar, 51.6 km away from KTLX, are treated as ground truth to verify our classifications.

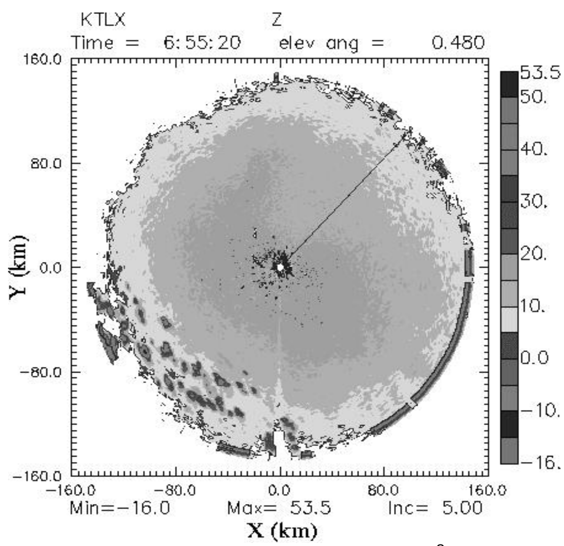

Fig.1 KTLX radar reflectivity field at 0.5^o elevation on 4 May 2001 (06:55UTC).

In the night of 3 May 2001, KTLX radar's reflectivity fields at different elevation angles show a disk-like pattern with maximum reflectivity around 15dBZ (Fig.1). On the southwest side of radar beyond 80km range, there are a few scattered storm echoes. VAD analysis indicates a strong south wind with mean velocity at about 25m/s below 3000m ASL.

OUN (Norman, Oklahoma) soundings at 00:00UTC and 12:00 UTC measured a similar shaped wind profile below 3000m, but with mean velocity at about 12m/s. The 13m/s difference between the 25m/s VAD and sounding results suggest that migrating birds contaminated the VAD estimated wind (Gauthreaux et al. 1998).

Ornithological studies found that south wind provides favorite tailwind for bird to migrate from south to north during the spring season, and most birds migrate after sunset and fly at typical speeds greater than 8-10m/s. One may argue that insect migration will show similar reflectivity pattern. But the 13m/s speed difference caused by biological scattereres can distinguish them since the flying speed of insects rarely exceeds 8m/s (Gauthreaux et al. 1998).

The simultaneous observations of Cimarron polarimetric radar also confirmed our inferences. The study on polarimetric radar observations of insects and birds have revealed that the differential reflectivity is usually higher (up to 10dB) for insect echoes than bird echoes (typically between –1 and 3dB), and differential phase is smaller (less than 40^0) for insect than bird (sometimes over 100^0). The differential reflectivity and differential phase observed for this case are about 3dBZ and 70 degree particularly. Correlation coefficient is about 0.75, much smaller than 0.95~1.00 of the meteorological scatterers. These results suggest that the scatterers are birds instead of insects or cloud (Zrnic and Ryzhkov 1998). Our algorithm successfully marks the whole disk-like pattern as biological scatterers.

On the following day (5 May 2001), a strong squall line swept across Oklahoma and Texas. After the squall line passed central Oklahoma, a disk-like pattern of reflectivity started building up around the KTLX radar (Fig.2). Thunderstorms were still observed at 80-150km ranges to the east of the radar. This observation provides a good case for testing our detection algorithm to correctly distinguish between storm and bird echoes.

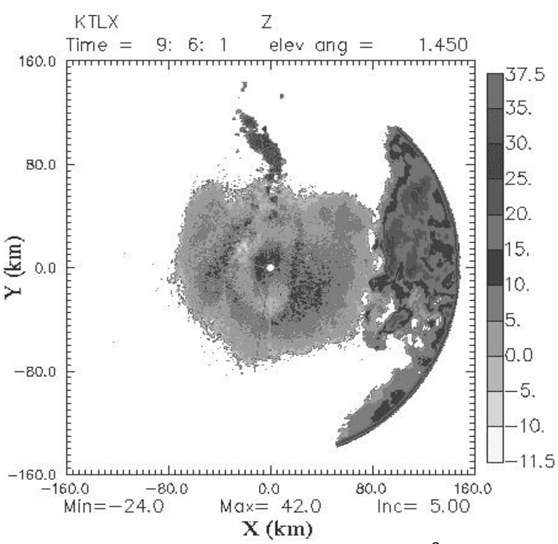

Fig.2 KTLX radar reflectivity field at 1.5° elevation on 5 May 2001 (09:06UTC).

The mean standard deviation of Doppler velocities shows an apparent difference between the disk-like region (~1.2m/s) and the thunderstorm region (~0.3m/s). Strong SSW wind in the disk-like region observed by KTLX radar also indicates birds were migrating from south to north. Fig.3 exhibits the classification results of our algorithm. Two different scatterer regions are clearly distinguished by a high score (>5) for birds and low score (<5) for thunderstorms. In addition, the polarimatric observations of Cimarron radar also support our results.

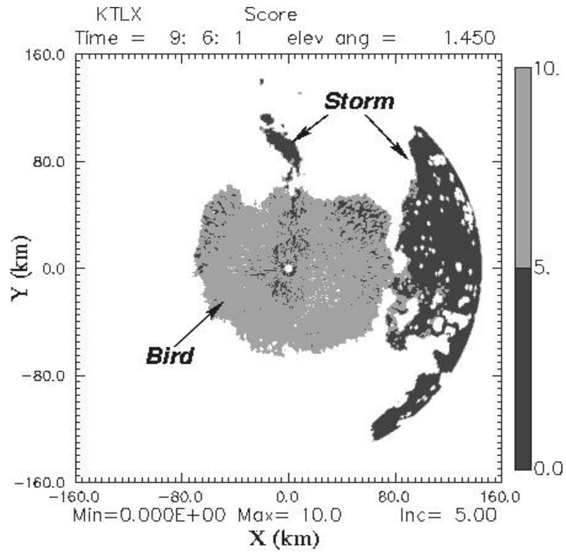

Fig. 3 Classification plot of score field for the observation as showed in Fig.3.

4. CONCLUSION

The preliminary case studies have demonstrated that the automatic discrimination of biological scatterers from meteorological scatterers is feasible. The texture information contained in the level II data is very useful for the classification of radar echoes and for data quality control. The similar algorithm is also applied on the discrimination of sea clutters from meteorological echoes. The results are quite convincible (Ryzhkov et al., 2002).

Acknowledgments:

The research work was supported by the FAA contract IA#DTFA03-01-X-9007 to NSSL, and by the NSF Grant ATM-9983077 and ONR Grants N000140210452 and N000140210453 to the University of Oklahoma.

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