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# THE "OWL HORN" RADAR SIGNATURE IN DEVELOPING SUPERCELLS


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## 1. INTRODUCTION

Using a mobile, 3 cm-wavelength radar system built by a group at the University of Massachusetts at Amherst, we have been able to survey supercell thunderstorms with a much finer spatial and temporal resolution than using the WSR-88D radar, owing to the fact that WSR-88D radars are fixed, while we may consistently approach storms at ranges of 10 to 20 km. Consequently we are able to see features of supercell thunderstorms that might otherwise go unresolved by other observing systems. In the course of the 2001 severe storm season in the Central Plains, we observed a curious, recurring reflectivity signature on our radar display which we have called the "Owl Horn" signature (because the radar reflectivity signature resembles the horns of an owl). The feature was apparent from various viewing angles with respect to the storms exhibiting the signature, thus eliminating the possibility of the feature being an artifact of the radar. The U. Mass. radar operated with an antenna beamwidth of 1.25 degrees, transmitted 1 microsecond pulses, and had a range resolution of 150m.

We have undertaken a study of the "Owl Horn" signature using the Tracking Radar Echoes by Correlation technique (TREC). We have found nothing in the literature that discusses the "Owl Horn" signature. Although TREC has previously been applied to clear air and hurricane environments (Tuttle and Foote, 1990; Tuttle and Gall, 1999), also absent from the literature is an application of TREC to severe storms and supercell storms in the interest of studying supercell evolution, although Rinehart (1979) has previously studied internal storm motions by applying TREC to severe storms. Through the application of TREC to our radar reflectivity data (Doppler wind data were not available in 2001) during May and June, 2001, we find an estimate of the horizontal wind field around and in the "Owl Horn" signature. In this paper we summarize the characteristics of the signature and identify the conditions under which it occurs and speculate why.


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## 2. THE TREC TECHNIQUE

The TREC technique is a pattern recognition procedure applied to radar reflectivity data using a cross-correlational analysis. Radar-echo data are stored in arrays, and on each iteration an array is compared to all other arrays of the same size for the subsequent time step to determine which array exhibits the highest correlation with the previous array. The array size is an arbitrary input parameter in the program, but it is limited in range, since if it is too large, resolution is sacrificed and if it is too small a trustworthy correlation coefficient may not be found (Tuttle and Gall, 1999).

As illuminated by Tuttle and Foote (1990), a strong advantage to TREC is that only one radar is required, and the technique produces a wind field wherever there are reflectivity data. However, Rinehart (1979) found in a comparison of wind-field estimates in a convective storm from TREC with a dual-Doppler analysis of the wind field that there were significant differences, possibly owing to strong vertical motion, vertical shear, and rapid convective precipitation development as characterize thunderstorms.

Typically, the radar-echo data used in TREC are taken several minutes apart since ground-based WSR-88D radar data are obtained on roughly five minute scales. Since the mobile Doppler radar obtains data roughly every 20 seconds and our features of interest are on a much smaller time-scale than those of previous studies, we take advantage of our finer temporal spacing to refine the analysis in our study.

One hurdle to overcome in the TREC analysis was obtaining a storm-relative wind field. Since storm-motion data were lacking in our cases, we resolved the issue by a two-step TREC procedure. First we applied the TREC algorithm to the reflectivity data to obtain a ground-relative wind field. We then calculated the average $u$ and $v$ components of the wind field by averaging the $u$ and $v$ components of all of the individual calculated wind vectors and treated this averaged vector as the mean storm-motion vector. We then re-ran the TREC algorithm and used as an input parameter

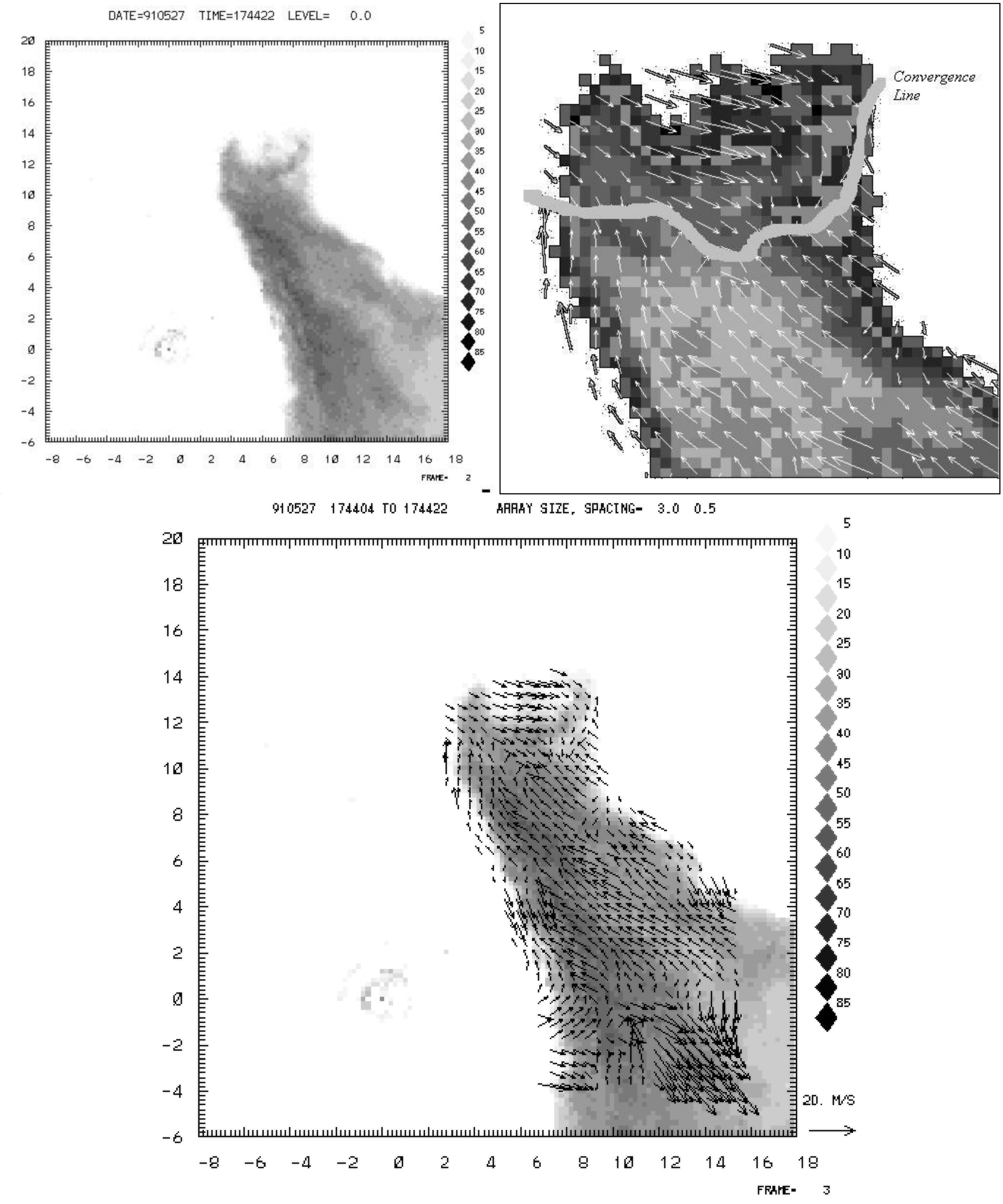


*Figure 1: TREC wind analyses from the May 27, 2001 case. The reflectivity signature alone (upper left), the full storm TREC analysis (bottom), and an enlarged view of the "Owl Horn" region (upper right) with the convergence line drawn. Distance in km, wind speeds in $ms^{-1}$, reflectivity in dBZ, gridpoint spacing is 500m.*

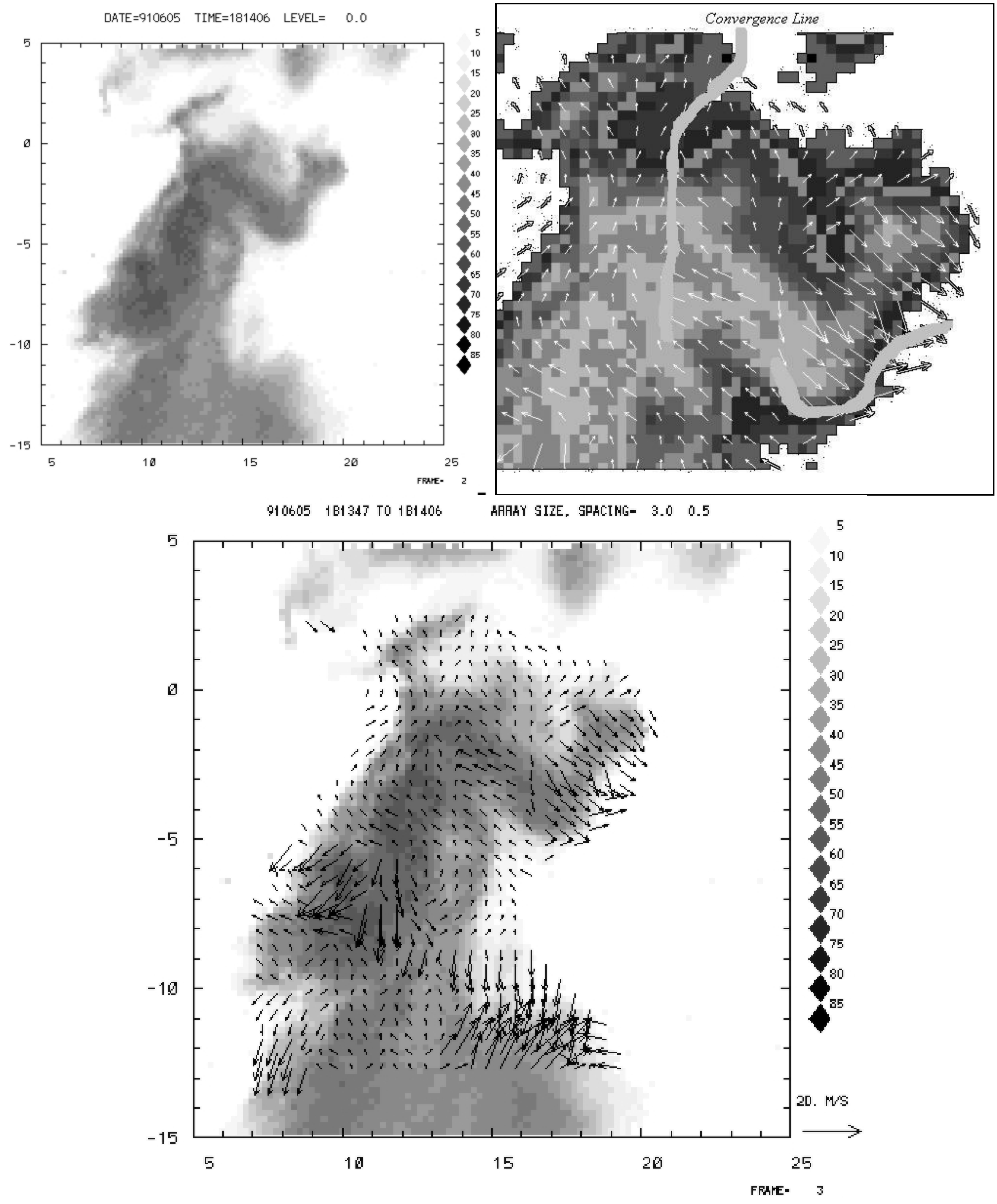


*Figure 2: TREC wind analyses from the June 5, 2001 case. The reflectivity signature alone (upper left), the full storm TREC analysis (bottom), and an enlarged view of the "Owl Horn" region (upper right) with the convergence line drawn. Distance in km, wind speeds in $ms^{-1}$, reflectivity in dBZ, gridpoint spacing is 500m.*

our computed average mean storm motion vector, subtracting the motion vector out from each of the re-computed wind vectors before producing the output display.

## 3. RESULTS AND DISCUSSION

The "Owl Horn" signature is characterized by two protrusions from the rear side (with respect to storm motion) of the storm reflectivity which seems first to appear when an isolated, relatively disorganized storm intensifies and becomes more organized. Temporally, the feature lasts no more than several minutes and disappears as the storm aquires more supercellular features. During the 2001 severe storms season in the Central Plains, we observed a well-defined "Owl Horn" signature on May 27 (west of Liberal, Kansas), May 28 (North of Raton Pass, New Mexico), May 29 (Turkey, Texas), and June 5 (near Woodward, Oklahoma). Indeed, the storms which exhibited the signature on May 28, May 29 and June 5 all developed into supercells which produced funnel clouds or tornadoes. We can not know the future of the May 27 storm if it had remained isolated, as it was overtaken by a very strong outflow boundary from an MCS to its north before it could develop further.

In analyses of both the May 27 (Fig. 1) and June 5 (Fig. 2) cases (gridpoint spacing of 500m), there is a temporally consistent boundary of convergent winds which lasts from five to ten minutes and seems to partition the storm. A temporally consistent downdraft is also apparent on the full storm analysis for each case.

One possible physical explanation for the "Owl Horn" is that the convergence line is an outflow boundary. This is reasonable, since the time-consistent downdraft is apparent in the large view of the wind fields from the divergent wind vectors. In the case of May 27, the boundary is moving with greater speed at its periphery than in the center where the analyzed winds opposing its motion rearward appear to be greatest. Thus the outer edges of the boundary could progress ahead of the central parts of the boundary and coincide with the appendages in the reflectivity. The June 5 case also supports the notion of the convergence line being an outflow boundary, as the divergent winds suggest the presence of a downdraft toward the rear of the storm.

## 4. SUMMARY

We have presented the characteristics of the "Owl Horn" signature and obtained a wind field by applying the TREC algorithm to our non-Doppler reflectivity data for several instances of the "Owl Horn." The analyzed wind field suggests the presence of a line of convergent winds at the back end of the storm, the periphery of which appears coincident with the "Owl Horn" signature. We speculate that the "Owl Horn" signature in an isolated High Plains storm may signify the transition of an ordinary cell into a supercell.

We are not aware of any numerical simulations of storms that have produced a feature like the "Owl Horn" signature, and expect that this may be due to two primary reasons: the unrealistic manner in which storms are initiated in simulations (thermal bubbles); and model resolution, which may be too coarse to resolve the feature. Since the University of Massachusetts X-band radar has been modified to include Doppler capabilities beginning in 2002, examinations of future instances of the "Owl Horn" signature may be in order with the extended data obtained with the new radar.


## 5. ACKNOWLEDGMENTS

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