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THE LEMOORE NAVAL AIR STATION CLASSIC SUPERCELL TORNADO OF 22 NOVEMBER 1996

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During the afternoon of 22 November 1996, an F1 tornado touched down within the boundaries of Lemoore Naval Air Station (NAS) located in Lemoore, CA. The storm, which produced this short-lived tornado, exhibited several radar and satellite signatures common to supercells such as a hook echo, v-notch, weak echo region, and a flanking line. This supercell tornado was rare for the state of California.

Introduction

At 1505 PST (2305 UTC) 22 November 1996, a weak tornado (F1) touched down within the confines of Lemoore NAS, located 15 miles west of the Hanford (KHNX) Radar Data Acquisition sight and 25 miles southwest of the city of Fresno. The main damage path was approximately 1/4 mile wide by 1 mile in length. Tornadic duration was estimated at 10 to 15 minutes. This was the second of two tornadoes spawned by this storm. The first tornado touched down approximately 1/2 hour prior to the second tornado and was classified as F0 with no damage. The F1 tornado touched down 3/4 mile northwest of the main gate of Lemoore NAS and proceeded southeast across the main artery of the base (Enterprise Avenue) and dissipated to the east of the main gate at Highway 198. Structural damage to several buildings and static aircraft as well as downed utility poles and trees were evidence of the 73-112 mph winds. Windows in vehicles and structures were damaged, along with minor injuries suffered from associated 21/2" hail stones. No major injuries or deaths occurred.

Synoptic Pattern

The synoptic pattern on the morning of 22 November 1996 was one that closely resembled many previous severe weather events in central California including 21 March 1987 documented by Braun et al. (1991). A trough of low pressure was centered along the Pacific Northwest coast with short-waves rotating around it. The trough axis at 1200 UTC 22 November (Fig. 1) extended from the Pacific Northwest and southward to the eastern Pacific just off the northern Baja Peninsula. At the surface, a cold front had moved through the region in the early morning. At 850mb, a pool of relatively cool air (+5C) was situated just off the coast from near Eureka southward to near Vandenberg AFB. At 500mb, temperatures cooled to near -20C. At 300mb (r 3), a 90kt jet-streak was approaching the base of the trough. The

1200 UTC sounding from Oakland depicted an already unstable atmosphere with a Lifted Index of -4, a K Index of 31 and an impressive wind profile with ample speed and directional shear.

The morning forecasted high temperature of 63F was entered into the SHARP workstation modifying the 1200 UTC Oakland sounding (Fig. 3). The LI was -4 and the K Index was 31. The Total Totals Index read 53, the Bulk Richardson Number 25 (not depicted), and the CAPE 1098 J/Kg. The tropopause was at 29.2k feet (not depicted) and the equilibrium level at 29.9k feet. The hodograph depicted a clockwise curl with a 0-3Km Storm Relative Helicity of 177 (Fig. 4).

Radar Observations

Around 2100 UTC, thunderstorms fired up along a north-south line from Merced County south through western Kings County and drifted eastward. The line appeared to be associated with the passage of the last of the stronger short-waves within the long-wave trough. Wind at the surface was southerly and veered northwesterly behind the line. Thunderstorms along the line generally pulsed with the exception of one storm in southwest Fresno County. Radar reflectivities with the pulsating thunderstorms peaked at 50 dBZ. Echo tops were approximately 25k feet with VILS between 30 and 40.

At 2131 UTC, the southwest Fresno County storm had intensified to 69 dBZ. The storm's radar appearance was still a little diffuse, but was starting to show somewhat of a v-notch signifying its intensification (Fig. 5). The storm was moving southeast and by 2200 UTC a well-defined v-notch was depicted by the 0.5 degree base reflectivity scan (Fig. 6). A hook became evident as well with 60 to 65 dBZ reflectivity values wrapping around the updraft.

During the next several scans, the storm lost its v-notch and the hook appendage became hard to find. But by 2234 UTC, the 0.5 degree base reflectivity image showed improved storm definition (Fig. 7). Resuming a classic tornadic supercell appearance as the hook reappeared on the right rear flank. Two high dBZ cores emerged. One of them, in the front flank, measured 65 dBZ. The second was a 71 dBZ area which wrapped around the hook appendage itself. This reintensification could also be seen in the 2234 UTC VIL product where a mesocyclone was identified, and the 2240 UTC Echo Tops product which indicated a storm top to 31,000 feet (Fig. 8).

By 2258 UTC, the 0.5 degree reflectivity scan depicted an impressive Weak Echo Region (WER) in the southwest flank of the storm resulting from the strong rotating updraft (Fig. 9). This matched extremely well with the cyclonic rotation indicated on the Storm Relative Velocity product (Fig. 10) where inbound and outbound velocities reached 40kts. The VR/SHEAR value of .038/s was calculated at the 0.5 degree scan with a rotational diameter of 0.6nm and a rotational velocity of 40kts at a range of 14nm. The rotational velocity (Vin + Vout / 2) of 40kts verified the 40kt inbound and outbound velocities of the SRM product. According to Don Burgess of the Operational Support Facility, a shear value of .005/s represents a minimal mesocyclone while values approaching .020/s may signify a strong mesocyclone.

Post-Analysis of Storm Environment

The environment in which the Lemoore NAS supercell developed was one which depicted favorable shear within an unstable environment. As pointed out by Weisman and Klemp (1982) rotational potential depends upon these factors. Using the same 1200 UTC Oakland data, an estimated storm sounding was developed on SHARP (Fig. 11). Temperature and dew-point temperature were modified to represent the environment at the time of the storm. A surface temperature of 66F was used along with a dew-point temperature of 60F. The resulting sounding depicted increased amounts of instability. Calculations showed a LI at -8, a BRN at 51 (not depicted), a CAPE of 2223 J/Kg, and a 31.2k foot equilibrium level .

Helicity values were also modified taking real-time surface data and the jet-max into consideration. The hodograph (Fig. 12), with surface winds from 089 degrees/05 knots veering to 228 degrees/37 knots at 3 km calculated storm-relative values of 271 m2/s2. Davies-Jones et al. (1990) found that 0-3km storm-relative helicity values approaching 300 m2/s2 supported weak to moderate tornadoes while Weisman and Klemp (1982) compared clockwise curved hodographs with the maximum production of horizontal vorticity.

Conclusions

Central Valley supercells can be comparable to the more common destructive and deadly supercells of the Midwest, where well-organized rotating storms, produce surface damage 95 percent of the time and tornadoes 62 percent of the time (Burgess 1976). Once mature databases are established, one should not be surprised from comparable figures of the California Central Valley. Event after event have proven that with the defined synoptic and subsynoptic pattern, supercells large or small can develop over the California interior just as they do in the Plains.

References

Braun, S.A., and J.P. Monteverdi, 1991: An analysis of a mesocyclone-induced tornado occurrence in Northern California. *Wea. Forecasting*, **6**, 13-31.

Weisman, M.L. and J.B. Klemp, 1982: The dependence of numerically simulated convective storms on vertical shear and buoyancy. *Mon. Wea. Rev.*, **110**, 504-520

Davies-Jones, R.D., Burgess and M. Foster, 1990: Test of helicity as a tornado forecast parameter. *16th AMS Conference on Severe Local Storms,* Kananaskis Park, Alberta. 588-592

Burgess, D.W., 1976: Single-Doppler radar vortex recognition: Part I - Mesocyclone signatures. 17th Conference on Radar Meteorology (Seattle) AMS Preprint. 97-103

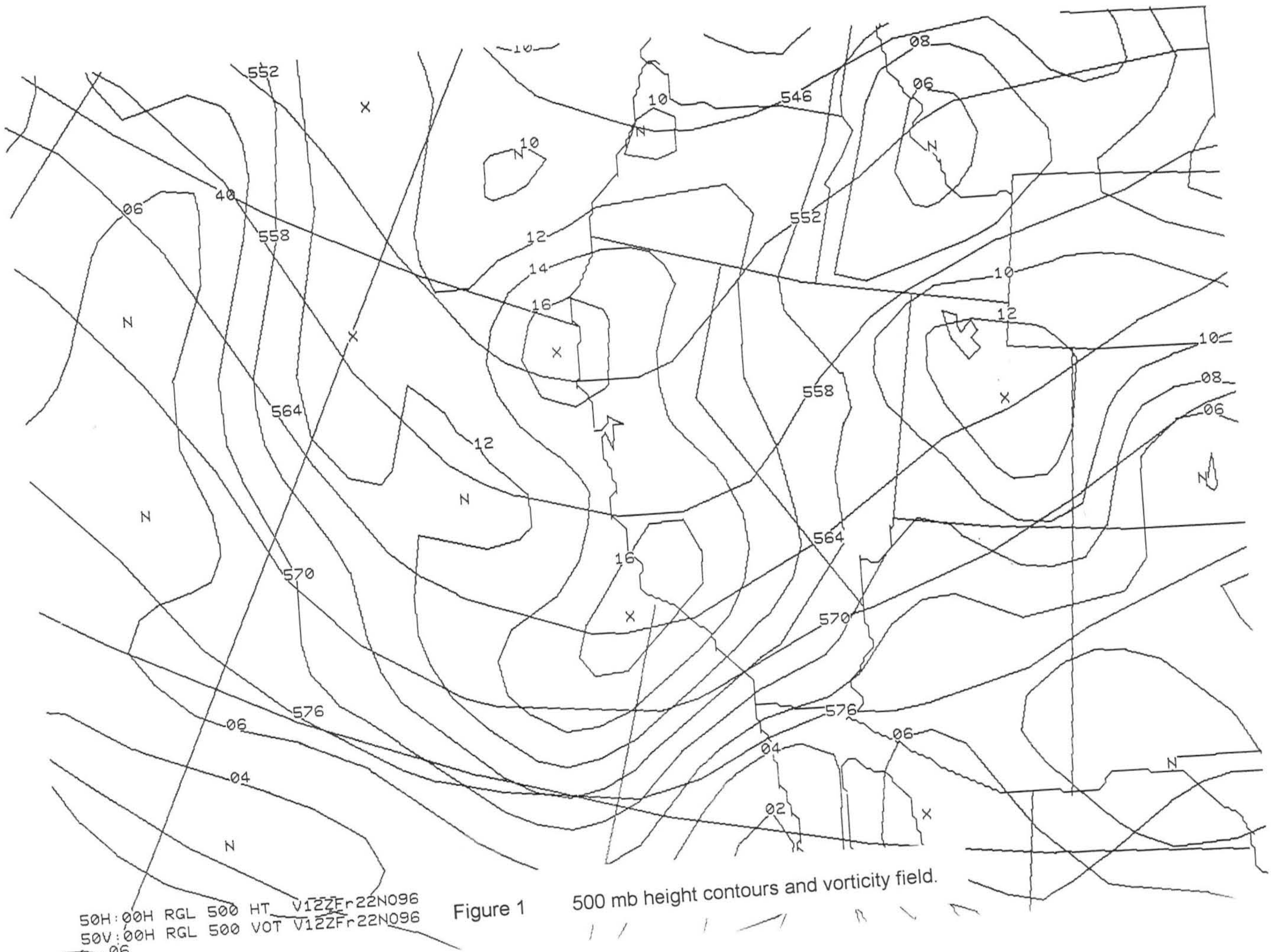

Figure 1 500 mb height contours and vorticity field.

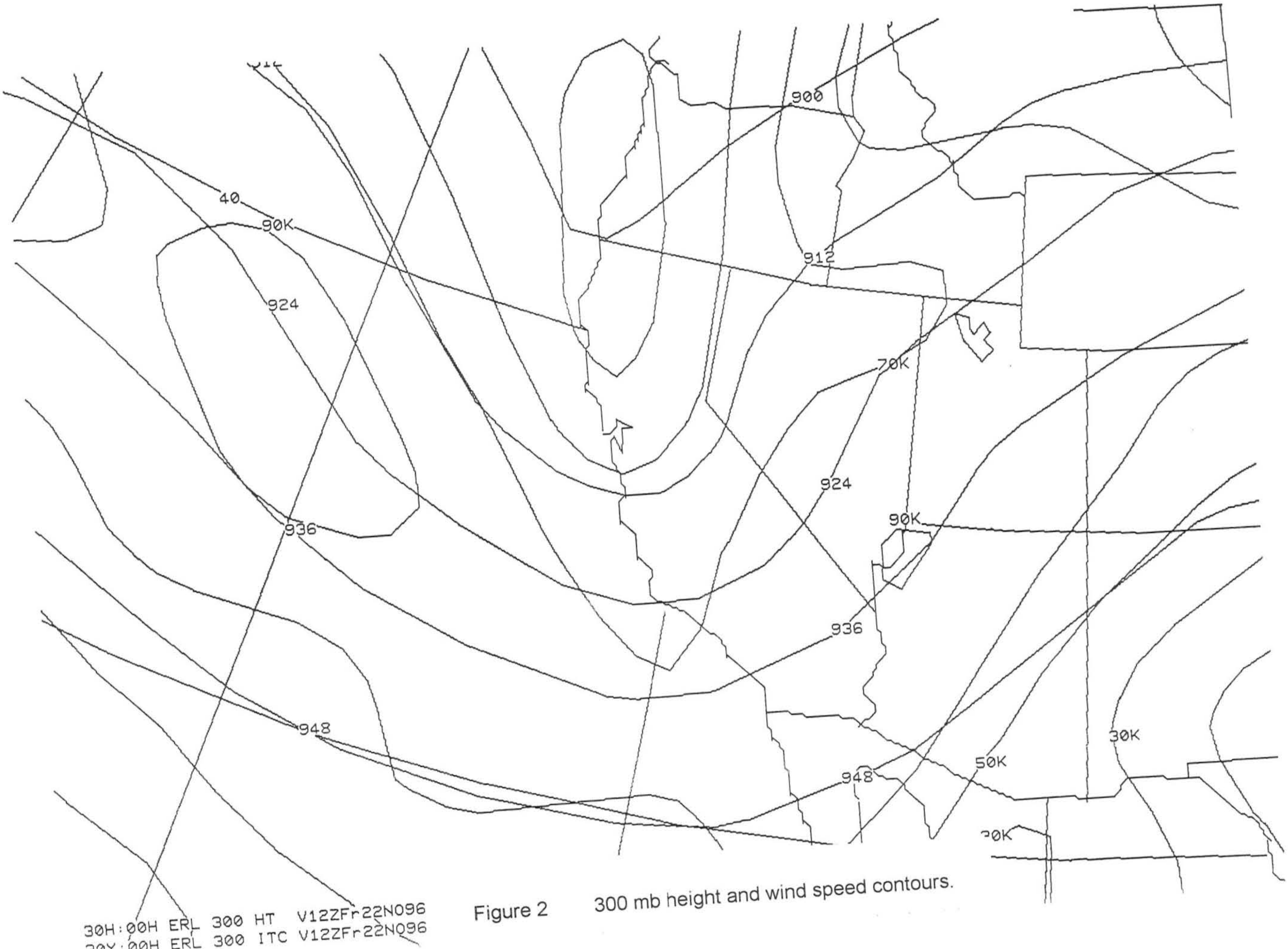

Figure 2 300 mb height and wind speed contours.

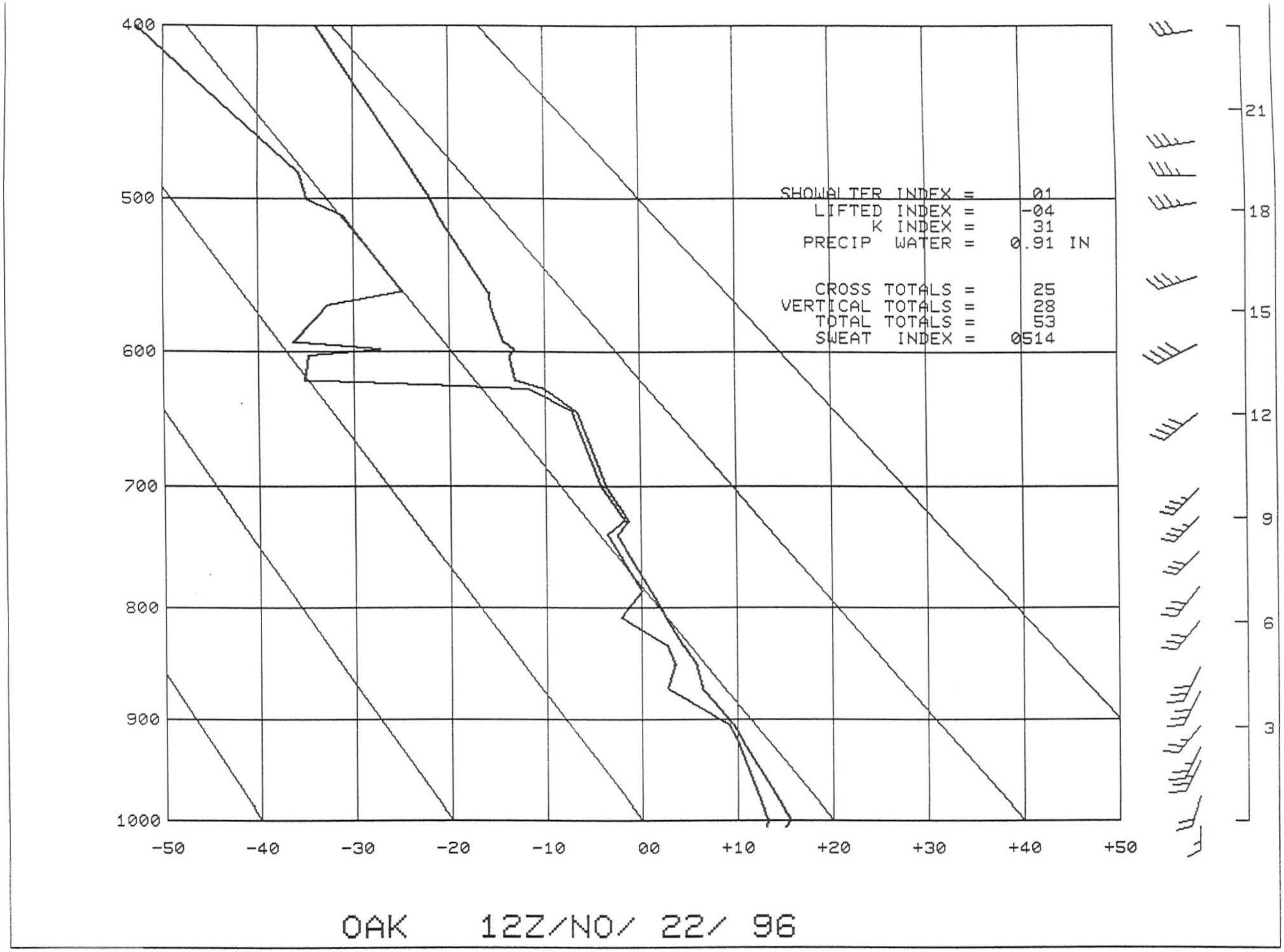

Figure 3 Oakland sounding for 1200 UTC 22 November 1996

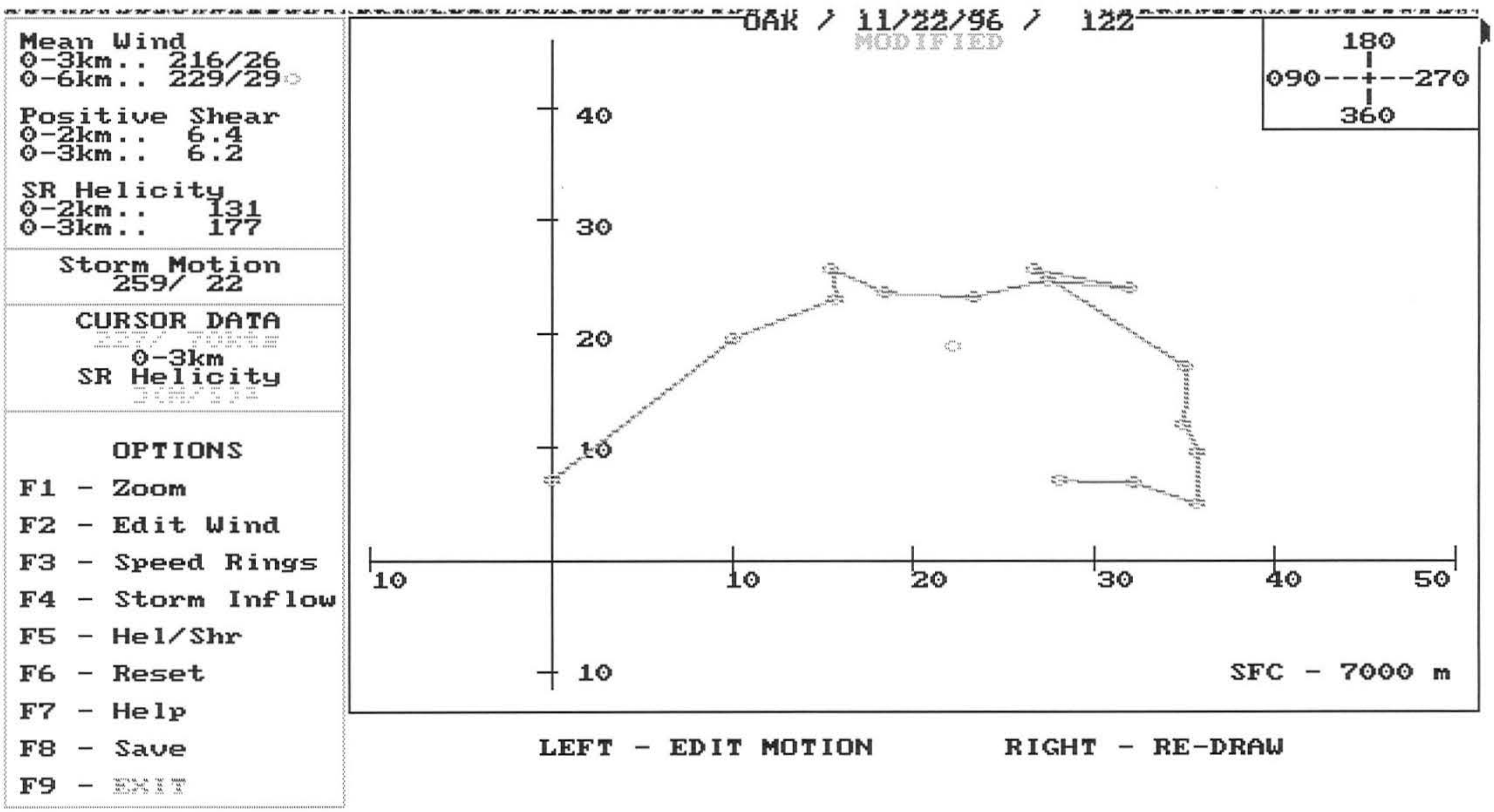

Figure 4 Oakland hodograph for 1200 UTC 22 November 1996

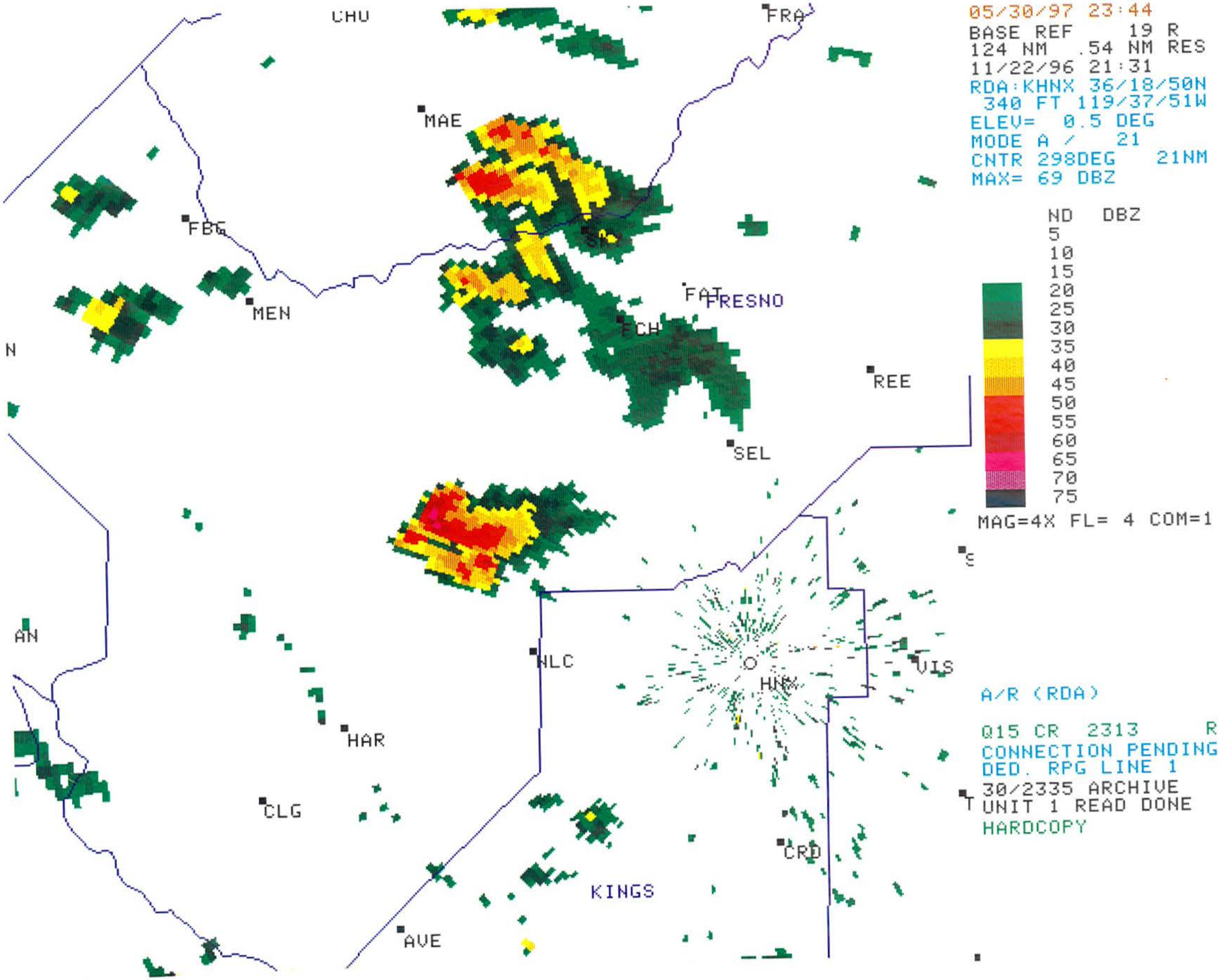

Figure 5 WSR-88D 0.5 degree scan at 2131 UTC 22 November 1996

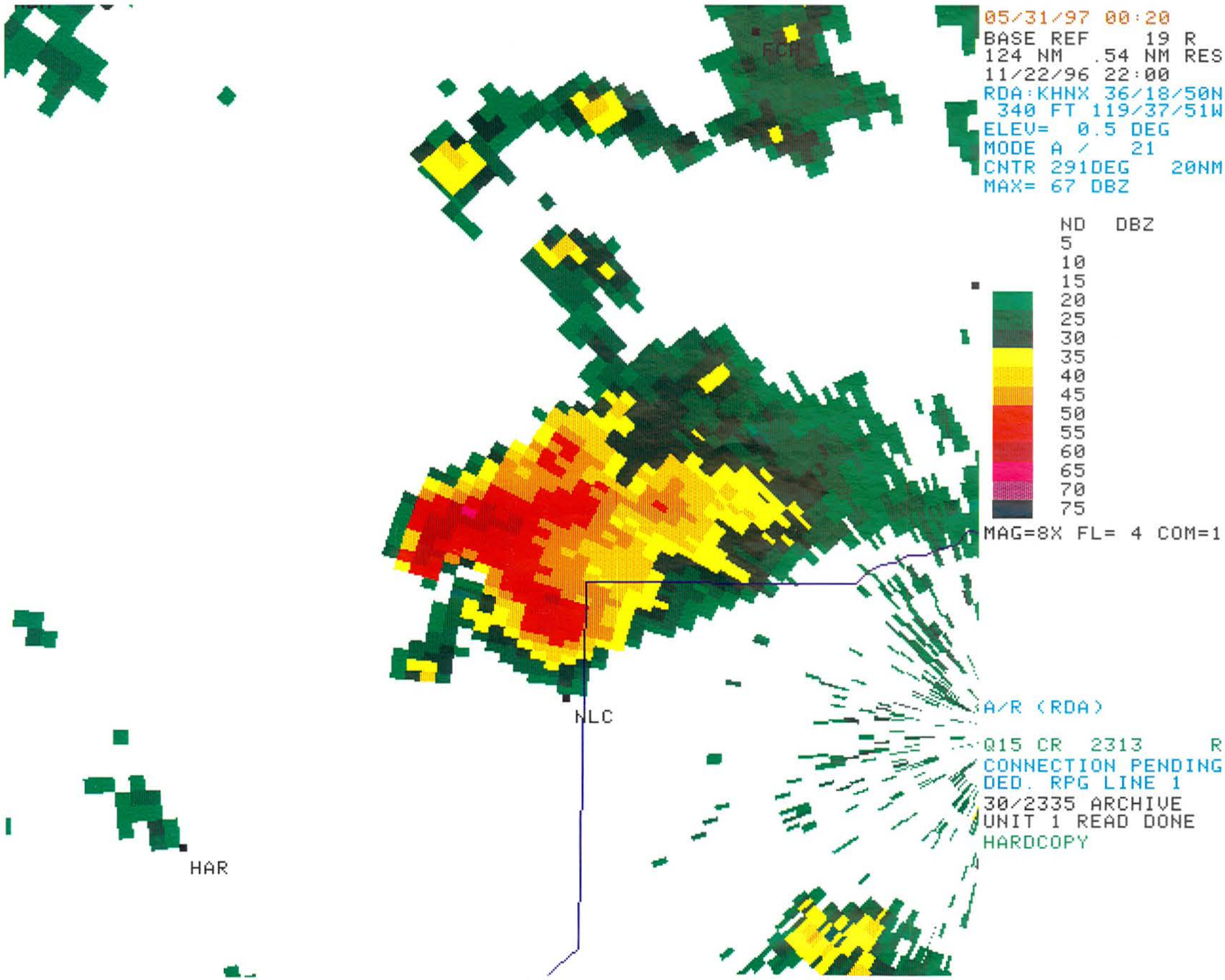

Figure 6 WSR-88D 0.5 degree scan at 2200 UTC 22 November 1996

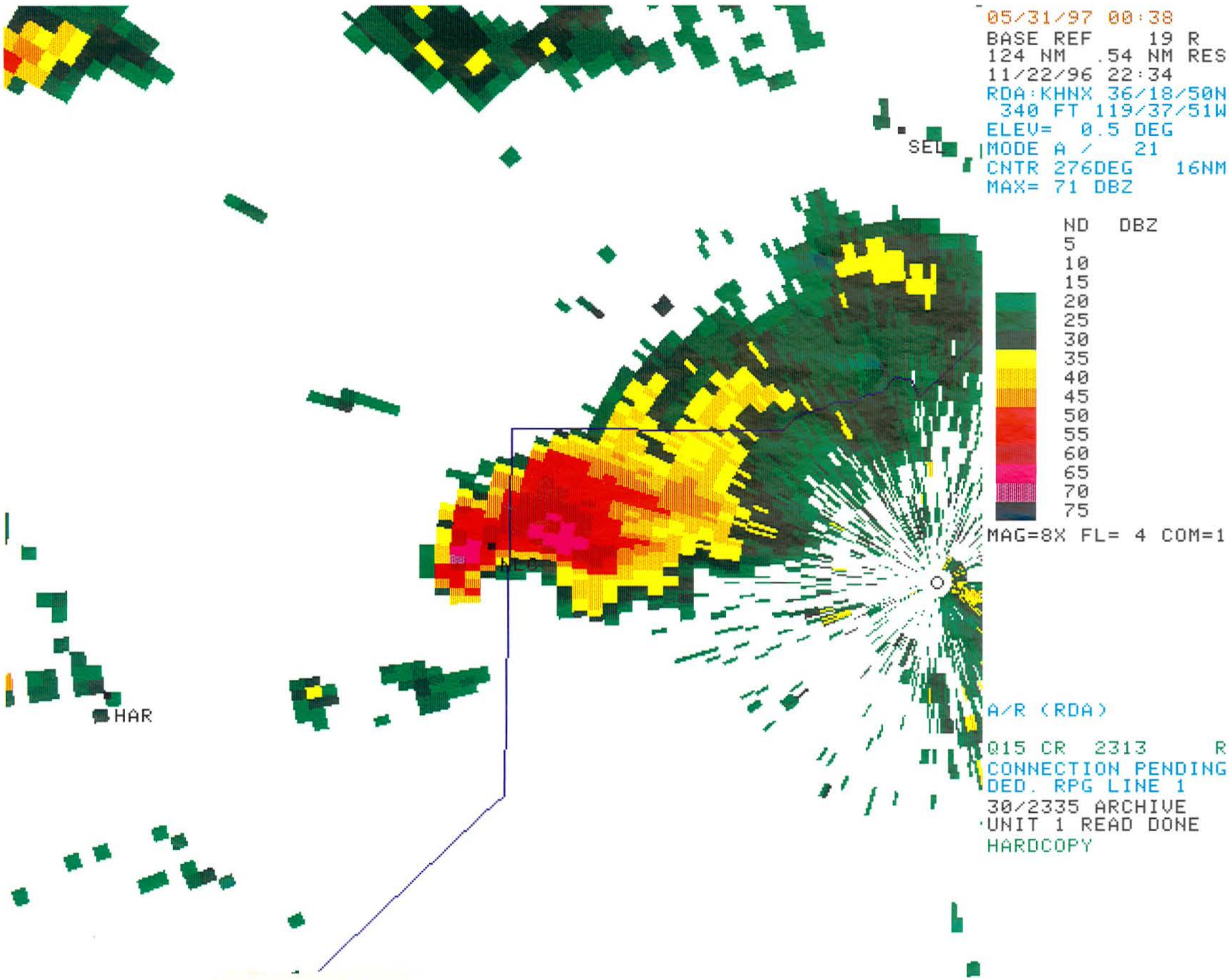

Figure 7 WSR-88D 0.5 degree scan at 2234 UTC 22 November 1996

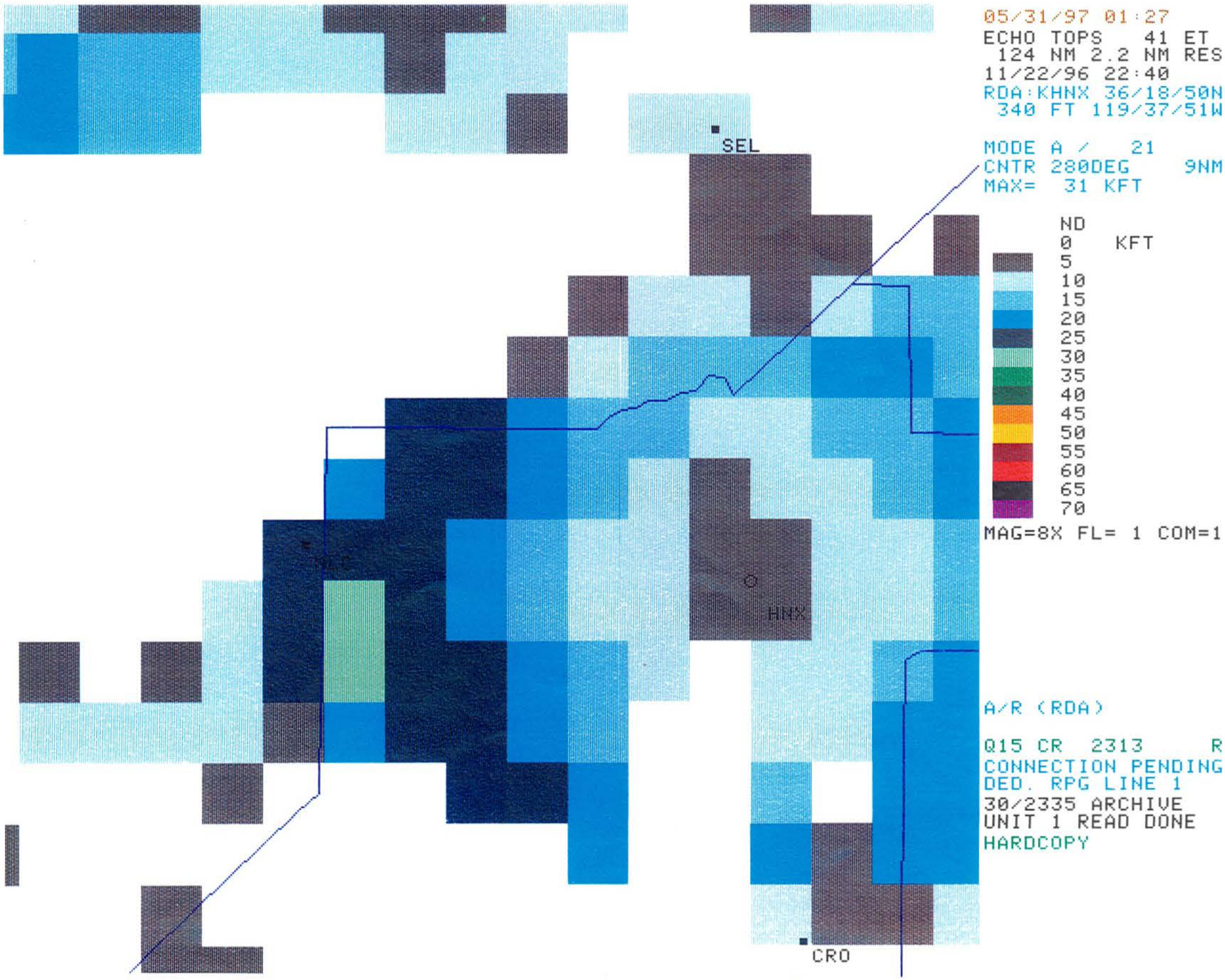

Figure 8 WSR-88D Echo Tops product at 2240 UTC 22 November 1996

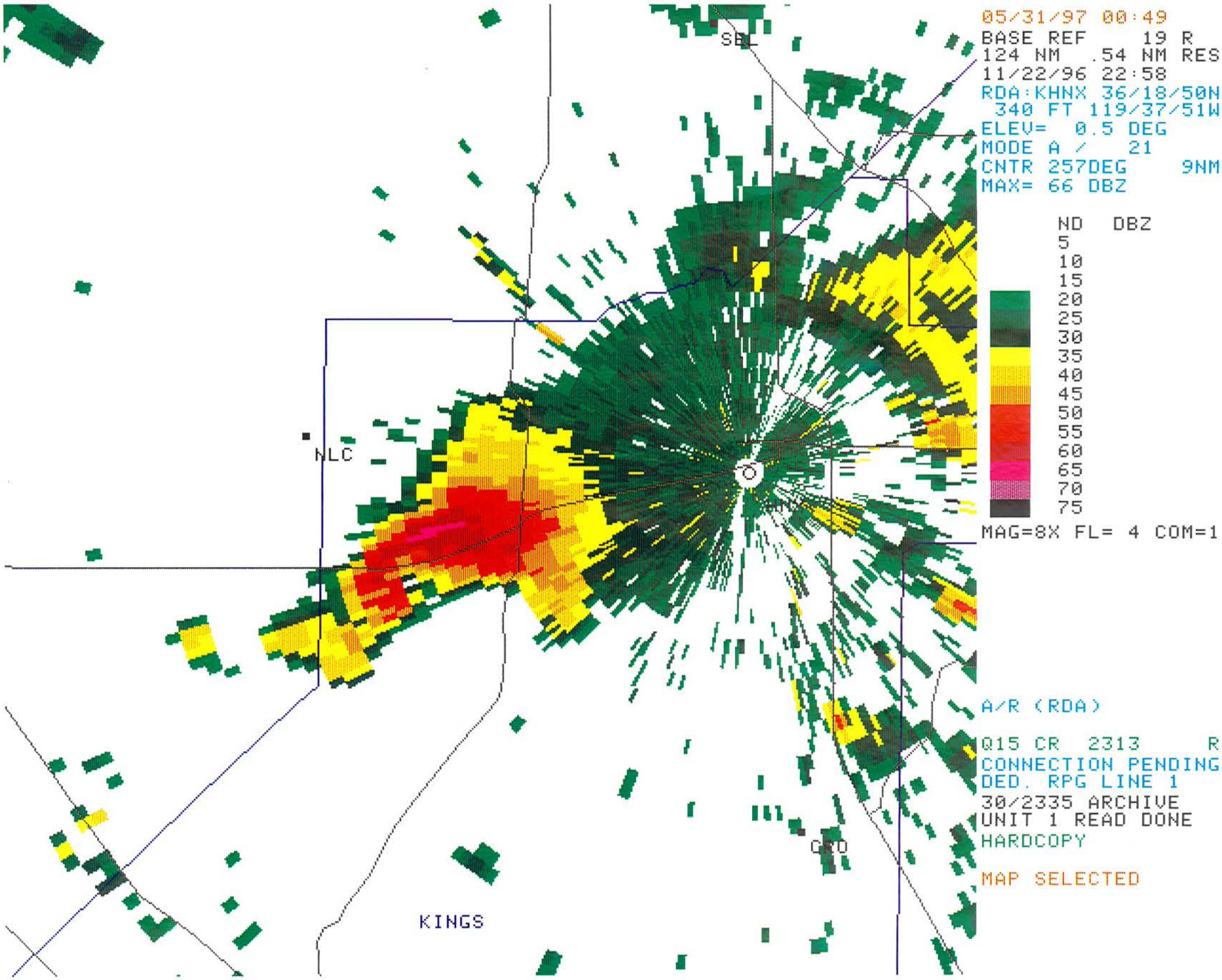

Figure 9 WSR-88D 0.5 degree scan at 2258 UTC 22 November 1996

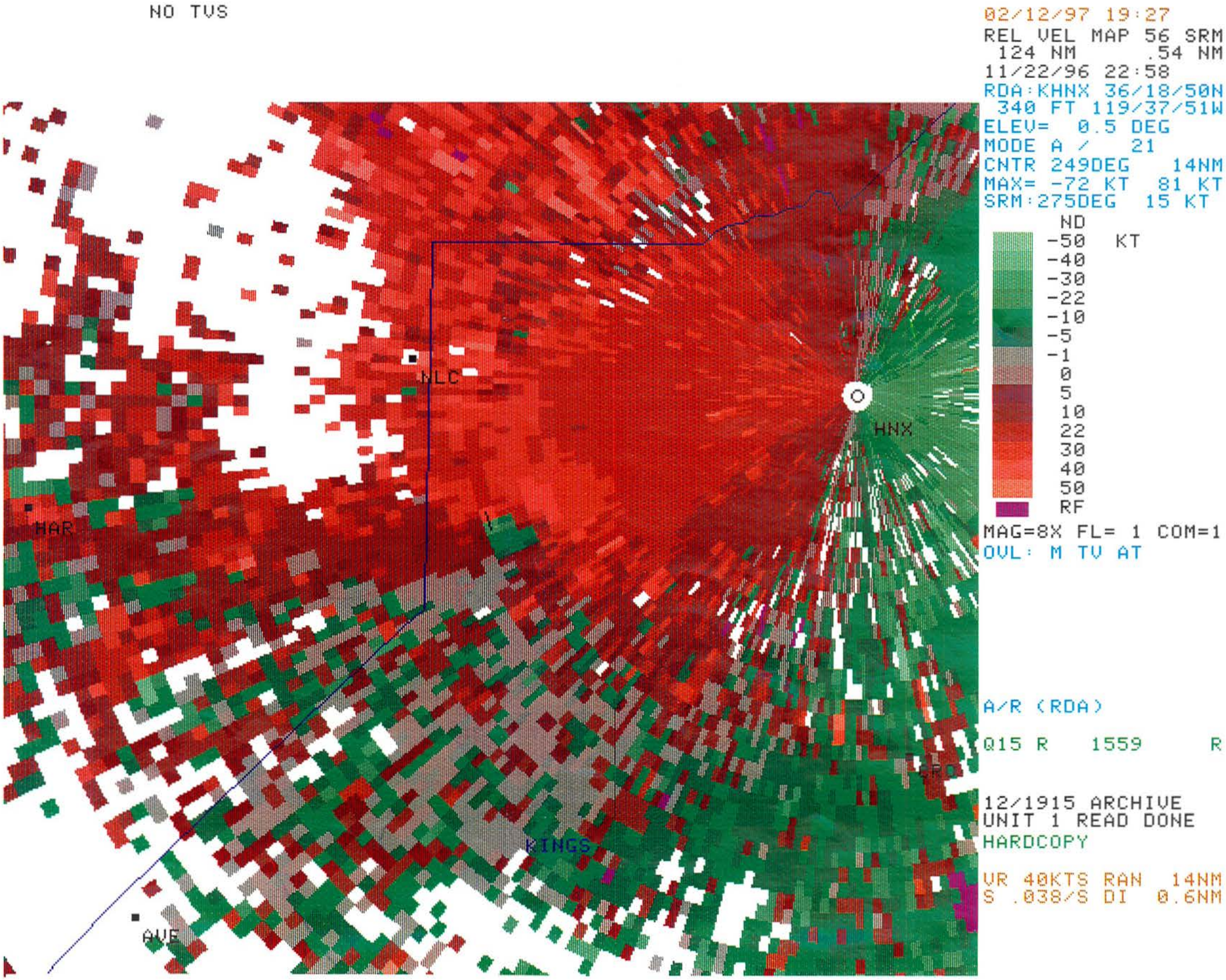

Figure 10 WSR-88D 0.5 degree SRM product at 2258 UTC 22 November 1996

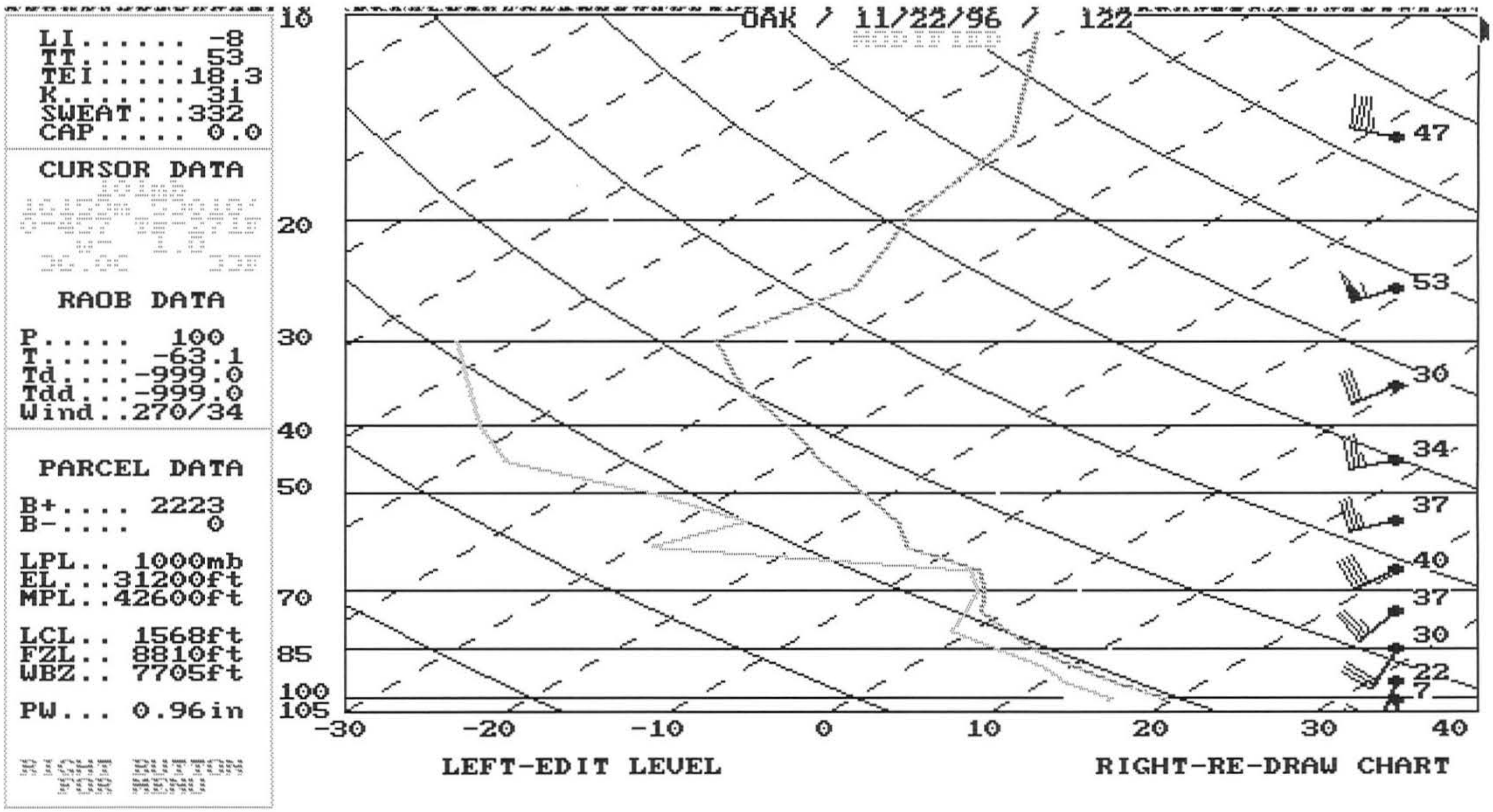

Figure 11 Modified Oakland sounding for 1200 UTC 22 November

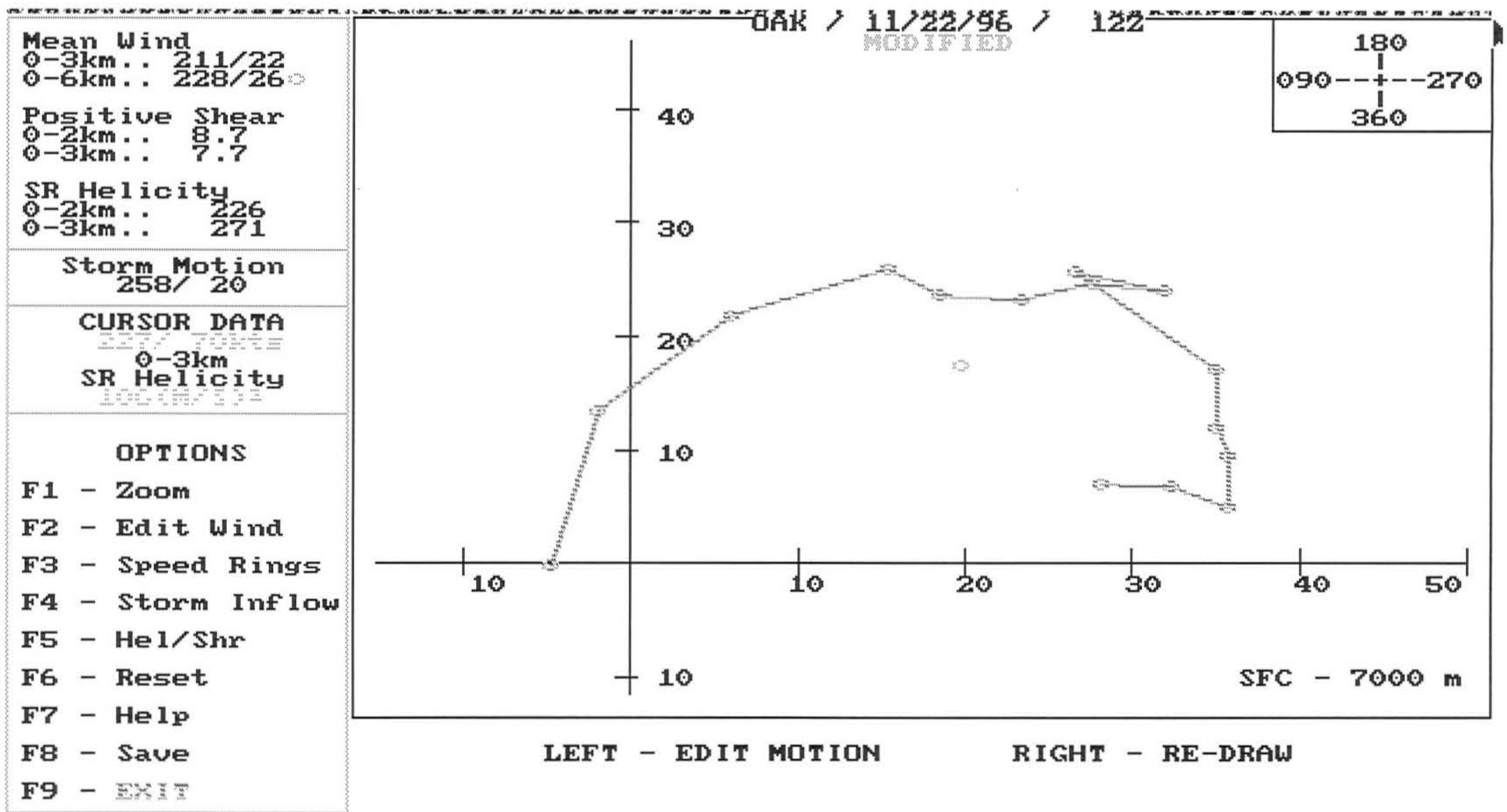

Figure 12 Modified Oakland hodograph for 1200 UTC 22 November