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EVALUATION OF UPPER AIR AND SURFACE DATA TO DETERMINE DERECHO POTENTIAL ON JULY 8, 1993 USING JOHNS AND HIRT'S CHECKLIST

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1. Introduction.

A derecho with devastating winds swept across Nebraska the evening of July 8, 1993. It was one of the costliest storms in the state's history, demolishing buildings, snapping electric lines, and uprooting numerous trees along a swath over 250 miles long and almost 100 miles wide. Damage was estimated at nearly 100 million dollars. Fortunately, only 28 people were injured and no one was killed.

The purpose of this study is to determine if synoptic conditions favored the potential for derecho formation, using the checklist developed by Johns and Hirt (1987). They designed their decision tree for the operational forecaster to assess the potential for warm season derechos, which occur with stagnant weather patterns and weak synoptic scale features (Johns, 1993). The checklist is used after convection has developed in the area of interest.

Johns and Hirt list five initial criteria necessary for derecho development. If these conditions exist, the forecaster examines a second set of conditions. Results from the second group indicate if additional parameters need to be considered for derecho development. Forecasters can use radiosonde observations as a convenient source of data to compute the parameters used by the checklists.

2. Analysis.

Thunderstorms were forecast for the night of July 8-9, but there was no clear indication where or when storms would develop. The atmosphere was unstable over all of the Nebraska, but a cap of 0.4 to 1.5 degrees Celsius was suppressing convective activity. A frontal boundary was stationary from southwest to northeast Nebraska. No strong vorticity maximum or upper trough to trigger convection was evident in the upper air data.

Thunderstorms formed over northeast Colorado by 2225 UTC and quickly moved into southwest Nebraska. They moved through North Platte with maximum wind gusts of 56 knots at 703 PM CDT (0003 UTC) and reached Omaha four hours later at 1101 PM CDT (0401 UTC) with gusts measured to 63 knots (Table 1 lists the maximum wind gusts across the state. Figure 1 shows the gust recorder trace at the North Omaha NWS Forecast Office (OVN)).

Table 1. Maximum observed wind speeds, July 8, 1993.

STATION (OBSERVATION TYPE)	MAX GUST (KT)	TIME (UTC)
North Platte (WSO)	56	0003
McCook (SWOP)	58	0005
Lexington (AWOS)	54	0120
Kearney (AWOS)	63	0156
Grand Island (WSO)	63	0224
Lincoln (ASOS)	62	0315
Beatrice (AWOS)	36	0340
Fremont (AWOS)	60	0342
North Omaha (WSFO)	63	0401
Offutt AFB (AFB)	61	0401[1]
Millard (AWOS)	40	0420

Note 1. Maximum gust prior to losing power to equipment.
Note 2. Omaha Eppley (OMA) not included, site does not have a gust recorder.

The 0000 UTC July 9 upper air data and the soundings from North Platte and Omaha were analyzed using the derecho decision tree. Analysis and discussion of the data appear in bold print following each item in the checklist

A. If all of the following five conditions are present in the area of interest, proceed to Part B. Otherwise, derecho development is not likely.

		YES	NO
1.	500 mb flow direction 240 ^{0} or greater? **LBF: 255 ^{0}; OVN: 250 ^{0}.**	X	
2.	Quasi-stationary boundary nearly parallel to 500 mb flow? **The 2000 UTC surface analysis showed a nearly stationary front across Nebraska from North Platte to Norfolk; roughly parallelling the 500 mb flow (Figure 2).**	X	
3.	850 mb warm advection within 200 nm? **Temperatures were in the lower 20s across southern Nebraska, with +28 ^{0}C at Dodge City. The low level jet was advecting warm air northward and providing increased buoyancy.**	X	
4.	700 mb warm advection within 200 nm? **A short wave trough was across central South Dakota and Nebraska with light northwest wind and neutral to cool advection at North Platte. However, Omaha had +11 ^{0}C with +18 ^{0}C upstream at Dodge City (Figure 3).**	X	
5.	ELWS 25 knots or greater? Johns and Hirt defined ELWS as the estimated lower midtroposphere (LMT) wind speed. The LMT is the layer approximately 2.5 to 5.5 km, or 8,000 to 18,000 feet. They suggested a convenient method of calculating the winds by averaging the 700 and 500 mb winds. **LBF: 4 and 19 kt, respectively, averaging 12 kt; OVN: 30 and 48 kt, averaging 39 kt.**	X	

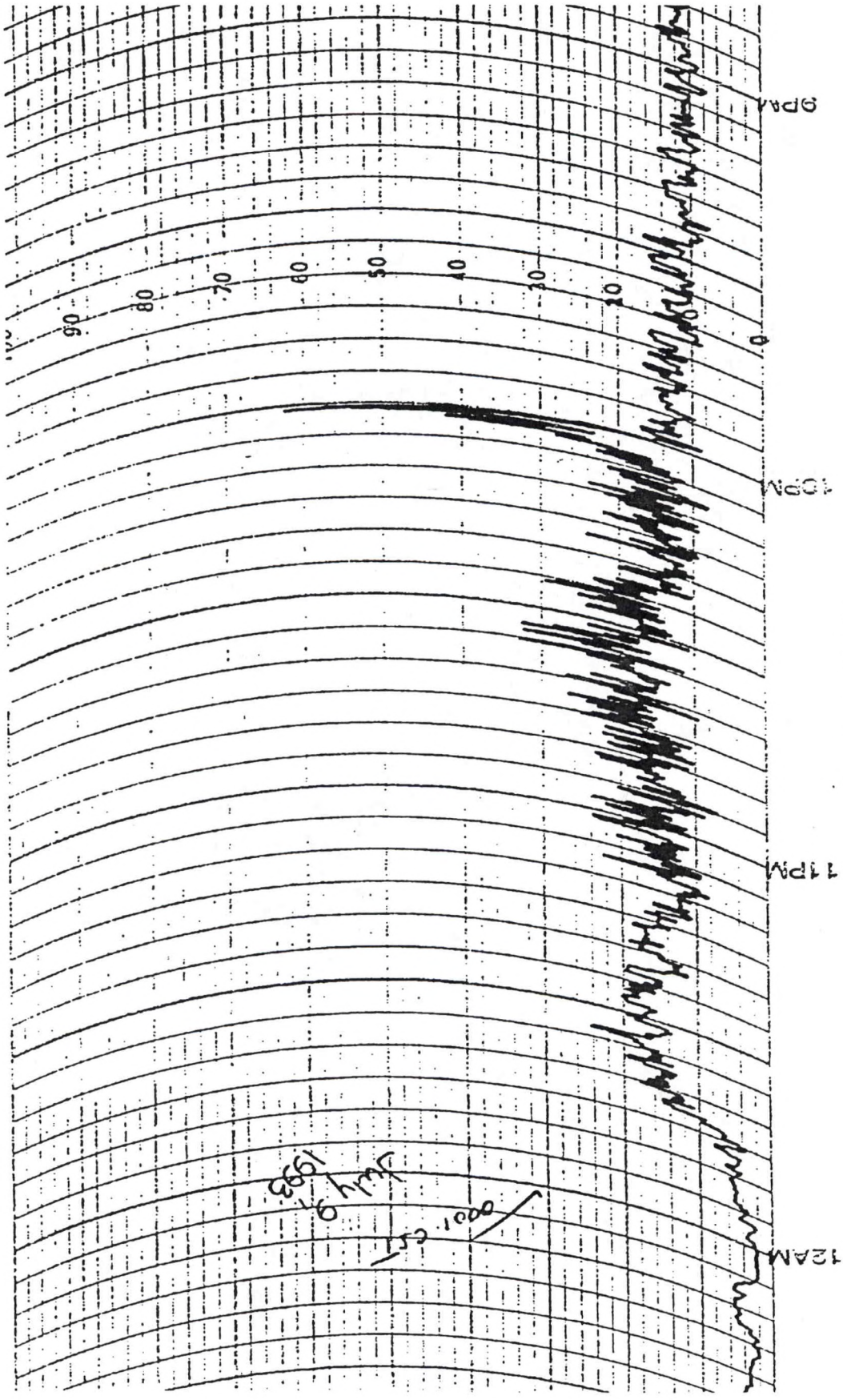

Figure 1. Gust recorder trace from WSFO Omaha (OVN), July 8, 1993. Peak gust of 63 knots at 1001 CST (0401 UTC).

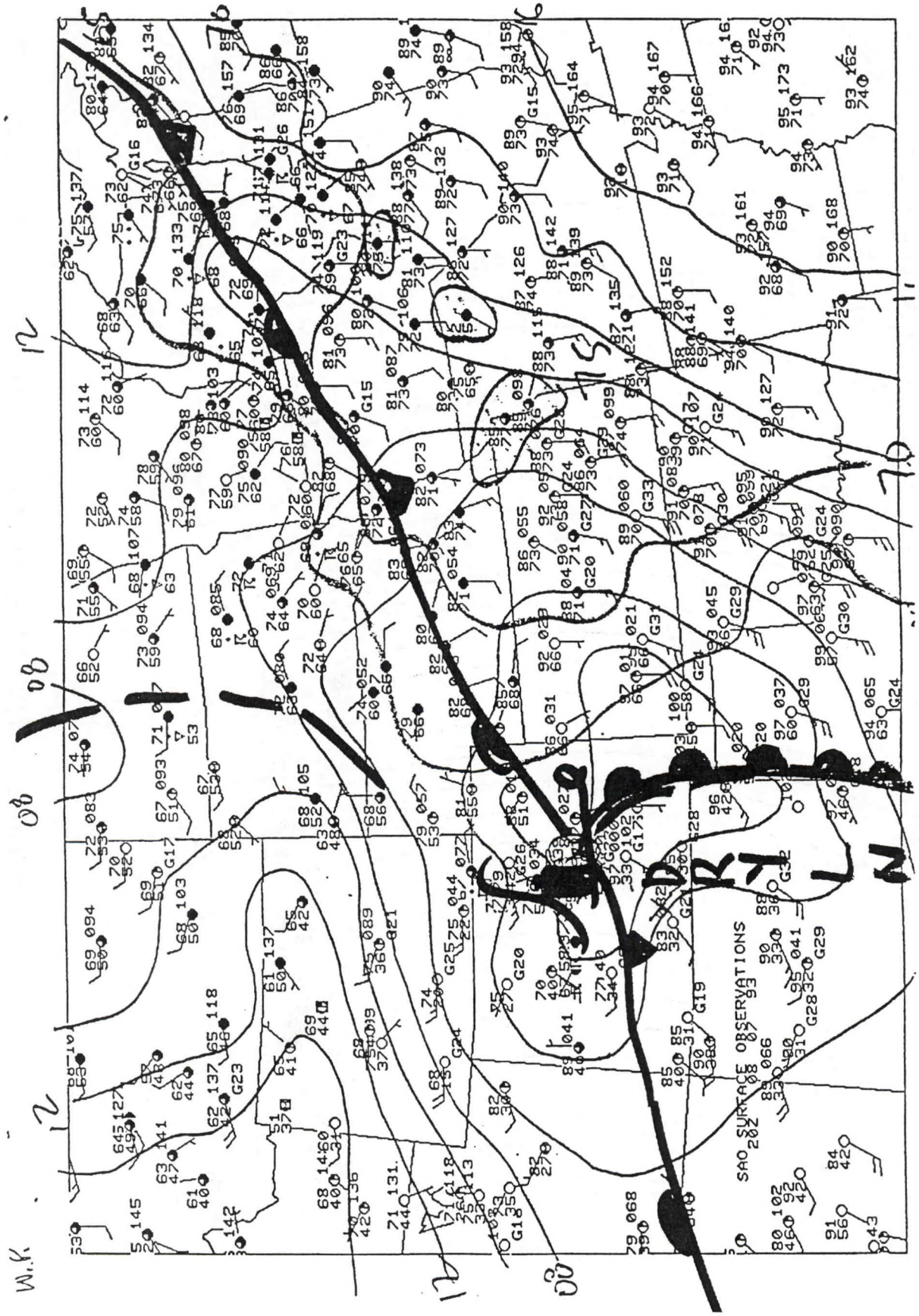

Figure 2. Surface analysis, 2000 UTC July 8, 1993. Stationary front across southwest to northeast Nebraska.

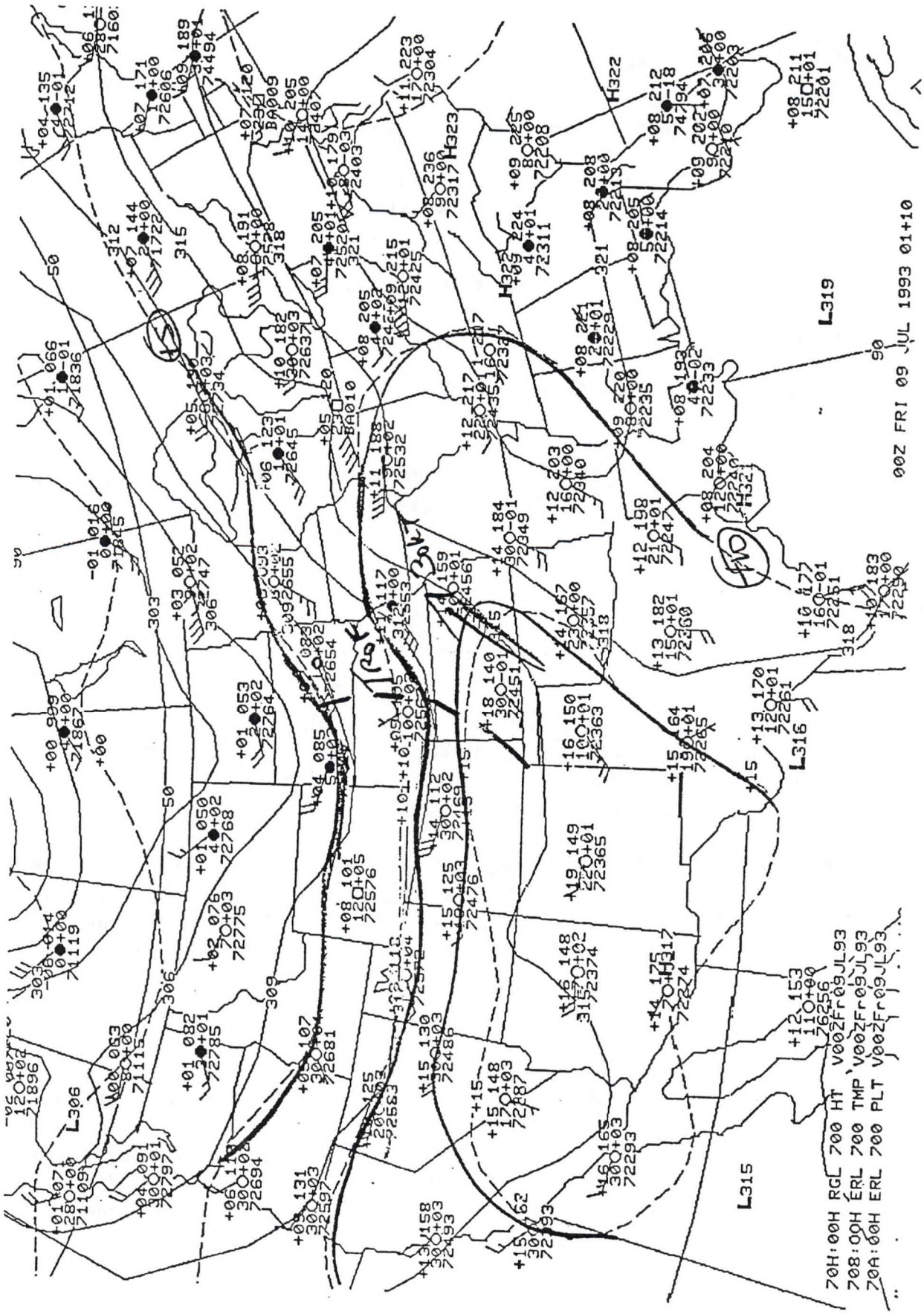

Figure 3. 700 mb analysis, 0000 UTC July 9, 1993. A short wave trough over central Nebraska brought cooler air into western Nebraska, but warm air advection continued over eastern Nebraska.

B. If all of the following three conditions are present in the area of interest, proceed to Part D. Otherwise, proceed to part C.

		YES	NO
1.	Maximum 500 mb, 12 hr height falls 60 m or greater? (50 m or greater at 00 UTC?) **500 mb heights rose 20 to 40 meters over Nebraska from 1200 UTC July 8 to 0000 UTC July 9. Height falls of 10 to 40 meters occurred from 0000 UTC to 1200 UTC July 9.**		X
2.	SELS lifted index (using the mean temperature and mixing ratio of the lowest 100 mb) -6 or lower? **LBF: -10; OVN: -6.**	X	
3.	ELRH (relative humidity in the LMT) < 80 percent? **LBF: 63%; OVN: 59%.**	X	

C. If both of the following conditions are present in the area of interest, proceed to Part D. Otherwise, derecho development is not likely.

		YES	NO
1.	SELS lifted index -8 or lower? **(see section B above).**	X	
2.	ELRH < 70% in initiation area? (<80% downstream?) **(see section B above).**	X	

D. Do the parameter values satisfying the criteria for the SELS lifted index and ELWS extend downwind along the quasi-stationary boundary for a distance of at least 250 nm from the convective system? If yes, be alert for derecho development. As discussed earlier, conditions for derechos were favorable downstream for at least 250 nm.

Johns and Hirt further caution forecasters to be suspicious of any squall line that moves 35 knots or greater in the direction of the mean flow. At 0030 UTC, Grand Island radar observed cells moving across southwest Nebraska from 250 degrees at 40 knots. This area of thunderstorms continued to move across the state at speeds between 40 and 50 knots, spawning the derecho.

3. Conclusion.

The warm season pattern derecho decision tree accurately indicated favorable potential for derecho formation across Nebraska on July 8. By using the checklist, forecasters can better define the area most conducive for severe thunderstorms. After the storms develop, a high rate of forward motion can alert forecasters and radar operators of a possible derecho. A quick evaluation of the derecho decision tree would confirm the possibility for the damaging wind storms. Subsequent statements and warnings could emphasize the severity of the storms, providing better notice to the public of their destructive nature and fast movement.

When using the derecho checklist, it is important to consider conditions over an area, rather than just a single point (such as an upper air sounding station). Johns and Hirt urge forecasters to examine soundings to determine if values derived from the observations are representative of the area. In this case, winds at North Platte were light and variable to about 12,000 feet MSL (or to the top of the inversion at 682 mb) (Figure 4), giving a ELWS well below the 25 knot threshold. A boundary was located south of the station and the lower part of the atmosphere may have been very different just a short distance away. The sounding may have been also affected by nearby convection. A forecaster using only North Plattes sounding data would have discounted the threat of derecho development.

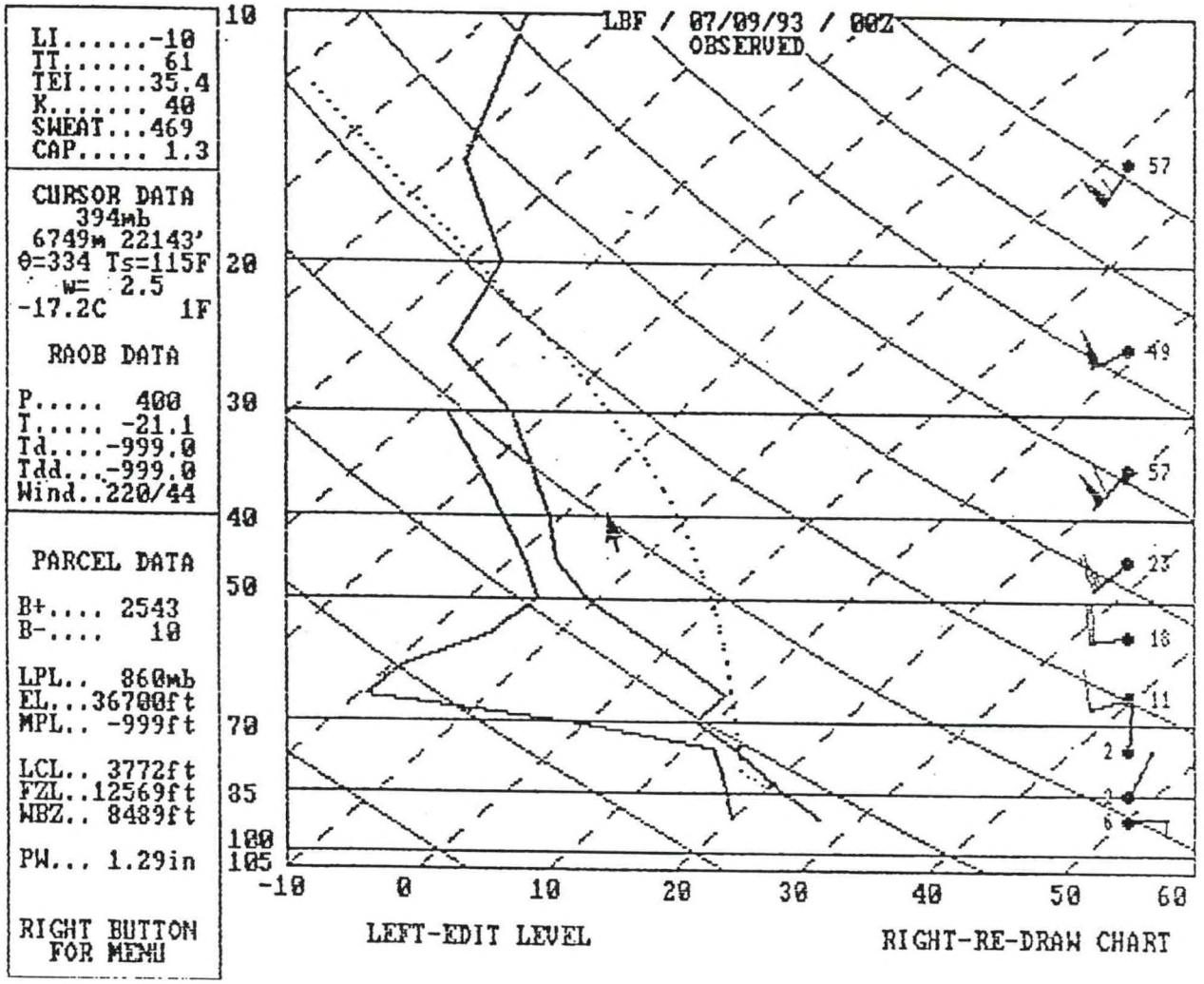

Figure 4. North Platte (LBF) radiosonde observation, 0000 UTC, July 9, 1993. Cooler air and light east to north winds from the surface to 700 mb affected calculations for the derecho decision tree.

The forecaster should examine other data sources to decide if the sounding was representative of the area or adjustments were necessary. Data from the wind profiler network should be used to augment the standard upper air network and monitor changing synoptic conditions which would increase storm potential.

4. Summary.

Forecasting severe weather is difficult in the absence of significant synoptic features such as cold fronts or upper level short wave troughs. The Johns and Hirt checklist for warm season pattern cases has proved useful in ascertaining derecho potential during such conditions. The checklist is quick and easy to use by operational forecasters; most of the parameters may be obtained from the SHARP workstation. However, forecasters must look at data across an area, not just at one point, to determine actual synoptic conditions.

5. References

Johns, Robert H. and W. D. Hirt, 1987: Derechos: Widespread Convectively Induced Windstorms. *Wea. Forecast.*, **2**, 32 - 49.

Johns, Robert H, 1993: Meteorological Conditions Associated with Bow Echo Development in Convective Storms. *Wea. Forecast.*, **8**, 294 - 299.

Hart, J. A. and W. D. Korotky, 1991: The SHARP Workstation: Skew-T Hodograph Analysis and Research Program [computer program users manual]. Bohemia, NY: NOAA, NWS Eastern Region, Systems Operations Division. (ERCP-13MC).