SEVERE CONVECTIVE STORMS WITH LITTLE OR NO THUNDER

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ABSTRACT

Three case studies of convective storms with little or no thunder are presented. Each storm produced severe wind gusts at the surface. It was found that none of the traditional upper-air indices consistently predicted the severe weather. The one thing that each of the cases did have in common was that there was strong wind aloft in the 3 km to 5 km layer above the ground. It has been shown that this is the layer in which the rain-cooled downdraft forms. The convective process brings down to the surface this high-momentum air which causes the severe wind gusts.

1. INTRODUCTION

Severe storm researchers have discovered many of the favorable environmental conditions for thunderstorms to produce severe weather. These were extensively reviewed by Miller (1972). However, there are some convective storms that produce severe weather without producing thunder. A well-known example is the waterspout in the tropics which forms from rainshowers that rarely extend more than 6 km into the atmosphere. Not so well-known are the strong wind gusts that sometimes accompany rainshowers, mostly in the winter and early spring, in the midwest United States. This paper will discuss three such storms, each of which occurred on a different day.

2. SYNOPTIC DATA

A. The 15 April 1976 Storm

On 15 April 1976 wind gusts to 28 m sec^{-1} (55 kts) were recorded at Topeka Municipal Airport between 6:45 a.m. and 7:05 a.m. CST. The wind gusts occurred during the passage of a rainshower that accompanied a dissipating thunderstorm. Only one flash of lightning was observed. Kansas City radar at 6:30 a.m. CST showed the storm in question with Video Integrator and Processor (VIP) level 3 intensity and a top of 10.5 km (34,000 ft). By 7:30 a.m. the VIP level decreased to two and the top decreased to 7.5 km (24,000 ft). Movement was from the southwest at 18 m sec^{-1} (35 kts).

Figure 1 shows the synoptic conditions at 6:00 a.m. CST with a squall line in eastern Kansas feeding on air with high moisture. Flow at 70 kPa (700 mb) was from the south-southwest with a jet maximum in southeast Nebraska. A minor 50 kPa (500 mb) trough (not shown) was located in central Kansas which helped create lifting in eastern Kansas.

The 1200 GMT Topeka sounding indicated a Lifted Index of -4.5 without taking into account any low-level heating. Figure 2 shows the hodograph of the winds aloft at 1200 GMT. The wind over Topeka veered in the lowest 2 km then backed

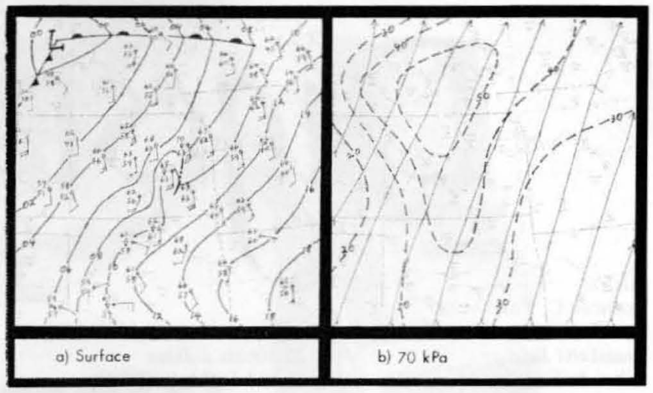

Figure 1. Synoptic maps on 1200 GMT 15 April 1976. (a) Surface and (b) 70 kPa, streamlines and isotachs.

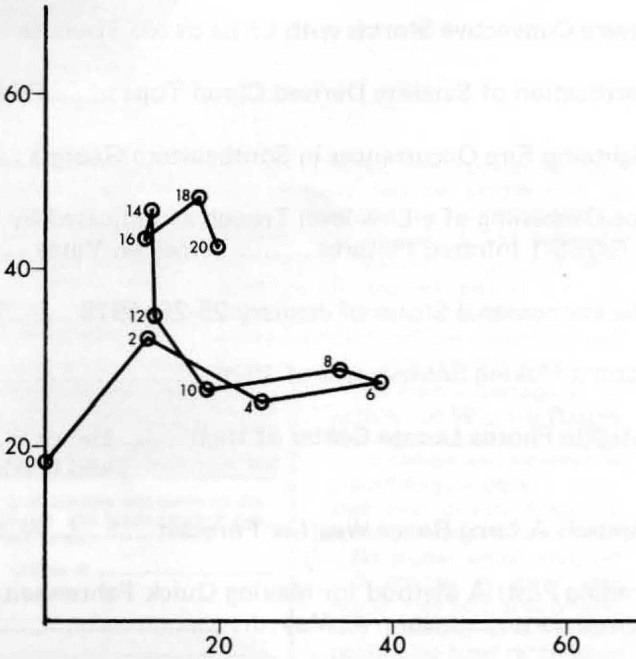

Figure 2. Hodograph for Topeka, KS on 1200 GMT 15 April 1976. Winds aloft in knots. Heights in thousands of feet.

between 2 km and 5 km. This means that the environment was becoming even more unstable.

Surface conditions changed rapidly in the Topeka area about the time of the strongest wind gusts. A mesolow formed with the storm as it was dissipating. Figure 3 shows a portion of the microbarograph for Topeka. The mesolow apparently had a short life because it could not be tracked either forward or backward in time with the surface data.

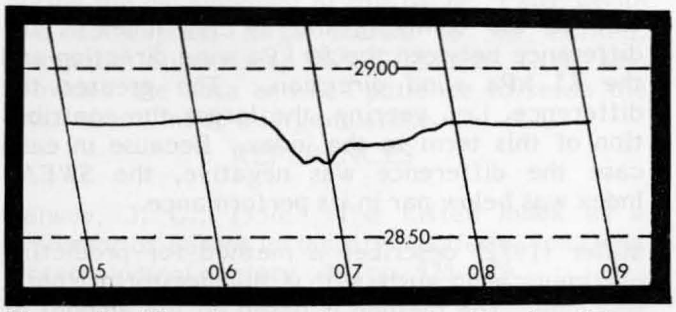

Figure 3. Microbarograph trace for Topeka, KS on 15 April 1976. Station pressure in inches of mercury. Time is CST.

B. The 16 April 1976 Storm

The next day between 4:00 a.m. and 5:00 a.m. CST damaging wind gusts caused power line and tree losses at Ottawa, Paola, and Lawrence KS (southeast of Topeka). No thunder or lightning was indicated by the persons reporting the severe wind gusts. Kansas City radar showed a band of storms with only VIP level 2 intensity level, tops around 6 km (20,000 ft), and a movement from the south at 33 m sec^{-1} (65 kts).

Figure 4 shows the synoptic conditions for this storm. The band of rainshowers was located along the surface front in eastern Kansas. The striking feature about this situation can be seen on the 70 kPa surface. Topeka had a 45 m sec^{-1} (88 kts) wind while at Omaha the wind was 44 m sec^{-1} (85 kts).

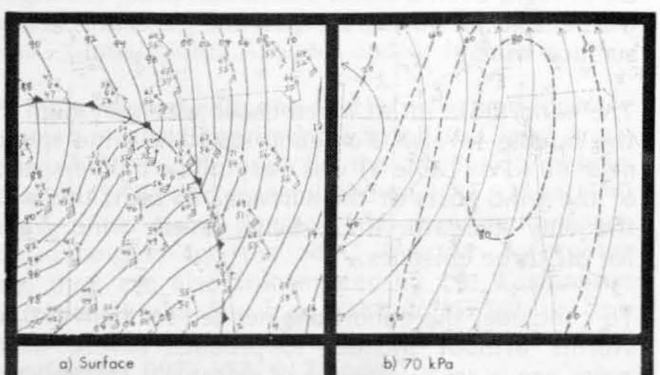

Figure 4. Synoptic maps on 16 April 1976. Depiction same as Figure 1. Surface is 1000 GMT. 70 kPa is 1200 GMT.

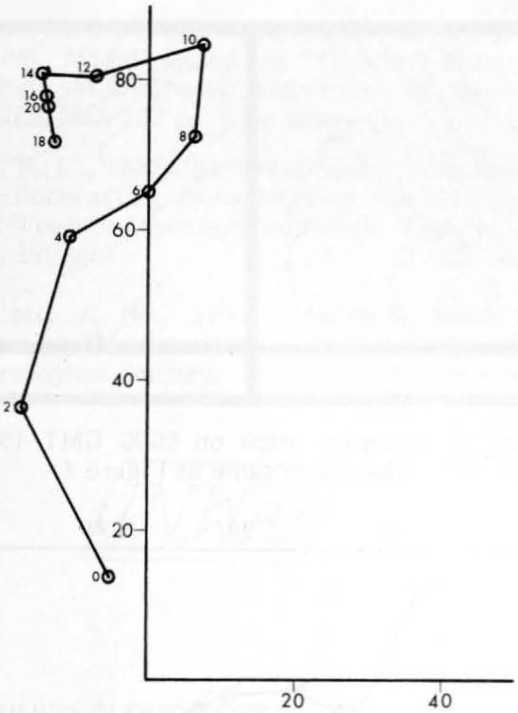

Figure 5. Hodograph for Omaha, NE on 1200 GMT 16 April 1976. Depiction same as Figure 2.

The Topeka sounding for this day was unrepresentative at 1200 GMT because the surface front had passed by release time. The Omaha sounding gave a Lifted Index of +2. The winds aloft in Figure 5 showed again that the stability was decreasing with veering up to 2 km then backing from 2 km to 5 km.

C. The 18 February Storm

Between 6:00 pm and 6:15 pm CST on 18 February 1977 severe wind gusts were associated with a rainshower near Olathe, a short distance southwest of Kansas City. Gusts over 26 m sec^{-1} (50 kts) were observed at Johnson County Executive Airport (OJC) to the east of Olathe and a power line was snapped in Olathe. Two flashes of lightning were observed during the episode. Kansas City radar indicated a cell of VIP level 2 with a top estimated near 6.5 km (22,000 ft). It was moving from the northwest at 26 m sec^{-1} (50 kts).

Figure 6 shows the synoptic conditions at 6:00 p.m. CST. The storm was near the center of a surface low that was moving rapidly southeast from Nebraska. The storm occurred just behind the cold front where the dew-point temperature was higher. Aloft at 70 kPa there was a jet maximum centered over western Nebraska but nosing into northeast Kansas.

The Topeka upper-air sounding at 0000 GMT showed very warm temperatures near the surface with very cold temperatures aloft. The Lifted Index was +2. The winds aloft in Figure 7 again

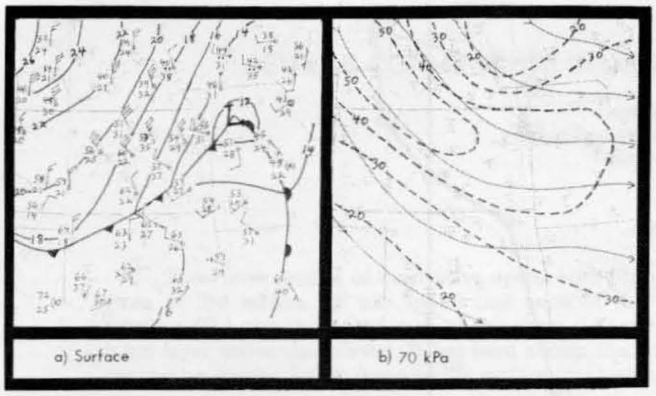

Figure 6. Synoptic maps on 0000 GMT 19 February 1977. Depiction same as Figure 1.

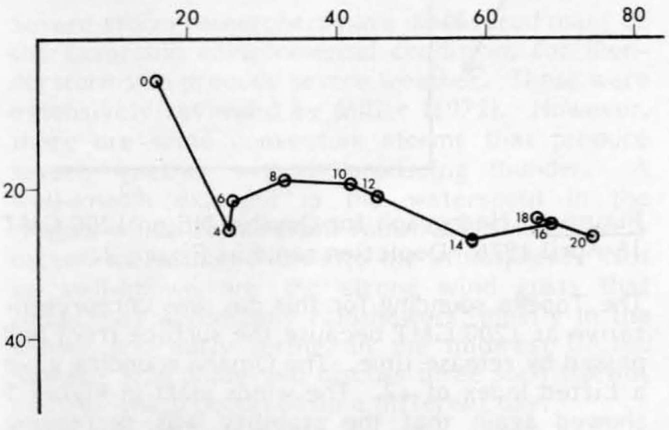

Figure 7. Hodograph for Topeka, KS on 0000 GMT 19 February 1977. Depiction same as Figure 2.

show that the atmosphere was destablizing as in the previous cases. The wind veered up to 1.5 km then backed from 1.5 km to 6 km.

3. ANALYSIS OF VARIOUS SEVERE WEATHER PREDICTORS

Various upper-air indices have been devised, each trying to quantify potential instability. Four of the most widely used were calculated for each sounding and are given in Table 1. They were the Lifted Index (LI) (Galway, 1956), the Showalter (1953) Index (SI), the Total Totals (TT), and the SWEAT Indices (Miller, 1972). A Lifted Index and Showalter Index less than zero indicate a good potential for severe weather. A Total Totals of 50 or greater is generally needed for severe weather. A SWEAT Index of 300 or greater is quite favorable.

Of the four, the Total Totals appeared to do the best to indicate the instability of the atmosphere. Only in the 16 April case did this index fall below 50. The Lifted Index and the Showalter Index were only favorable once, although it might be said that a Lifted Index of +2 in February shows low stability for that time of year. The SWEAT Index, which includes a contribution from the winds aloft, was below 300 in all three cases.

TABLE 1
Upper Air Sounding Statistics for Each Storm

	LI	SI	TT	SWEAT	Max Gust Forecast	Wind Speed near 60 kPa
15 April(TOP)	-4.5	0	51	269	37	48
16 April(OMA)	+2	+2.5	47	295	40	82
18 Feb(TOP)	+2	+2	53	193	53	64

Note: LI is Lifted Index, SI is Showalter Index, TT is Total Totals, SWEAT is SWEAT Index, Maximum gust is that derived from Miller(1972) in knots, and wind speed is that reported at 4.3 km(14,000 ft) in knots.

One of the terms in the SWEAT Index is the difference between the 50 kPa wind direction and the 85 kPa wind direction. The greater the difference, i.e., veering, the larger the contribution of this term to the index. Because in each case the difference was negative, the SWEAT Index was below par in its performance.

Miller (1972) describes a method for predicting maximum wind gusts with a thunderstorm from a sounding. The method is based on the amount of instability a moist parcel of middle-level air has with respect to the surface. A large temperature difference between rain-cooled middle-level air and the surface indicates a large acceleration of downdraft air and subsequent wind gustiness at the surface. The maximum wind gust for each sounding was calculated using the method. As indicated in Table 1, in only one case (18 February) did the method predict wind gusts over 26 m sec^{-1} (50 kts), the minimum for severe.

4. CONCLUSIONS

To explain why these small, weak storms produced severe wind gusts, an understanding of the structure of convective storms should be made. McCann (1975) noted that rain-cooled downdraft air at the surface originates from the 3 km to 5 km layer above the surface. This is near the 60 kPa level in eastern Kansas. In a steady-state storm the air at this level descends to the surface conserving the horizontal momentum it had when it was aloft. When the speed of the middle-level air is high, even a small storm can bring the high-momentum air to the surface and generate strong surface wind.

The wind aloft in all three cases was very high in the middle levels. For each case the wind speed near 60 kPa (Table 1) was very close to the speed of the wind gusts at the surface. In fact, this was the only indicator of possible severe wind gusts for all three episodes.

To conclude, the conditions needed for convective storms without thunder to produce severe wind gusts are a small amount of potential instability, synoptic scale lifting, and strong wind in the 3 km to 5 km layer above the surface. During the winter and early spring is the most likely time for the conditions to be met. The convective process, a result of the instability, produces the severe surface wind by bringing down high-speed air from middle levels. Severe storm warnings should be issued if small convective echoes form on radar when there is strong wind aloft.

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REFERENCES

Galway, J. G., 1956: The Lifted Index as a Predictor of Latent Instability. *Bulletin American Meteorological Society*, 37, pp. 528-529.

McCann, D. W., 1975: *A Kinematic Severe Thunderstorm Model Based on Tornado Proximity Soundings.* M.S. Thesis, University of Missouri, Columbia, MO, 102 pp. (Unpublished).

Miller, R. C., 1972: Notes on Analysis and Severe Storm Forecasting Procedures of the Air Force Global Weather Central. *Technical Report 200 (Rev.)*, 190 pp.

Showalter, A. K., 1953: Stability Index for Forecasting Thunderstorms. *Bulletin American Meteorological Society*, 34, pp. 250-252.