NOAA Technical Memorandum NWS SR-121

OBSERVED MICROBURSTS IN THE NWS SOUTHERN REGION DURING 1986

- Four Case Studies -

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UNITED STATES
DEPARTMENT OF COMMERCE
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EDITOR'S NOTE: This Technical Memo represents current documentation and study of observed downburst events by operational forecasters at several Southern Region Forecast Offices during 1986.

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West Texas Dry Microbursts of 21 May 1986

by

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During the afternoon and evening of May 21, 1986, several microburst events occurred over the Panhandle and South Plains of West Texas. In addition to visual observations by several National Weather Service personnel, the presence of nearby microbursts were also detected by wind instruments at Lubbock, Reese and Amarillo.

The May 21st 12z raob soundings for both Midland and Amarillo (Figures 1a and 1b) indicated a potential for the development of dry microbursts. According to Doswell (Seminar - May 1986), Caracena (1986) and Fujita (1985), such a sounding is often characterized by very dry air in the lower layers of the atmosphere; above the dry air is found a moist layer. On the 12z Amarillo and Midland soundings for May 21st (Figures 1a and 1b), dew point depressions at 500 mb were 5°C or less; the lowest 10 thousand feet of the soundings were quite dry with depressions of almost 30 degrees within 2 or 3 thousand feet of the ground.

The morning data also showed strong mid-level instabilities as indicated by the difference between the 700 and 500 mb (T700-T500) temperatures (Figure 2). (Values of 24 to 26 are very high and indicate a nearly dry-adiabatic lapse rate between the two levels).

The mid-morning (15z) satellite photo (Figure 3) indicated an east-to-west oriented band of mid-level clouds extending across the Lubbock area indicating at least some moisture and upward vertical motion over the area.

The evening soundings (00z May 22) continued to show warm, dry air at low levels. Above that, a moist layer was evident between 500 and 600 mb at Midland (Figure 4a) and between 400 and 500 mb at Amarillo (Figure 4b). While the Midland sounding continued to show a potential for dry microbursts, there was a noticeable lack of mid-level clouds during the day in the Midland area (Figure 5). However, note that both the 12z and 00z Midland soundings indicated an inversion above the moist layer; the Amarillo sounding had no similar feature.

Afternoon high temperatures in the mid 90s to 100 degrees in the area (Figure 6) resulted in a super adiabatic lapse rate in the lowest few hundred feet with a nearly dry adiabatic lapse rate above that to almost 500 mb. The low-level humidities were around

8 to 10 percent. Even though clouds persisted over the South Plains area during the day, temperatures were still able to climb to near 100 degrees (possibly aided by clear skies just to the south or upwind).

Although Lubbock radar often indicated little or no precipitation, telephone communications with the observer at WSFO Lubbock revealed the presence of virga visible in several directions from the station. Surface observations and satellite photographs indicated numerous high-based convective cloud elements in the vicinity with bases around 10 to 12 thousand feet. Additional communications with the forecaster at Lubbock (Bill Alexander) later in the evening revealed several microbursts were visible from the WSFO. Alexander noted virga falling to within an estimated 7 to 8 thousand feet above the ground. Near the ground he observed an upward curling of the dust (often occurs as the microbursts strike the ground and spread out (Fujita, 1985)). Subsequent disucssions with other off-duty NWS personnel in the area revealed several other strong microbursts near Lubbock (Alan Moller) and near Amarillo (Mike Foster).

Surface observations from Lubbock, Resse and Amarillo showed the effects of microbursts in the area. While the "unperturbed" wind flow was from the south or southwest at 5 to 15 knots, wind gusts of 33 to 47 knots along with rapidly changing wind directions reflected occurrences of several microbursts (Figure 7). In some of the surface observations, the observer also noted blowing dust and virga.

Aviation concerns in the area also were affected by the microbursts. Several pilot reports noted moderate to severe air turbulence from 1 to 7 thousand feet AGL (Figure 8).

While radar and satellite indicated more significant thunderstorm activity in the northern Panhandle (and strong thunderstorm outlflows were also observed), Fujita and others have shown that strong downbursts can also occur from seemingly innocuous high-based cloud build-ups and virga. This was evident in the Lubbock area.

As suggested by Doswell, Caracena and others, the raob sounding is a good starting point for evaluating the likelihood of microburst formation. In addition to identifying a dry-microburst type sounding (which can occur frequently in the warm season), the forecaster may also want to look for other signs that would enhance (or diminish) the chance of microburst formation. Some signs may include:

1.) Areas exhibiting strong mid-level potential instabilities (T700-T500).

2.) An inversion above the mid-level moist area that could suppress convection and subsequent downbursts.

3.) Mid-level clouds suggesting upward vertical motion (and potential downburst formation). However, a cloud deck too extensive would reduce strong surface heating and in turn perhaps weaken the strength of the microburst.

4.) Sources of mid-level vertical motion and/or destabilization for later in the day (i.e. weak pva, cold advection above warm air, etc.).

5.) Nowcasting signs of microburst development might include: an Observer's reports of blowing dust (especially when the ambient wind field is not excessively strong), and ACCAS or virga (important parts of an observation that are lost when a human observer is replaced by a machine!); pilot reports of moderate to severe turbulence in low to mid levels within areas containing convective cloud elements.

6.) Radar indications of showers (even very small ones) or thunderstorms (no matter how weak).

Currently, there is no provision for specifically identifying dry microbursts in the Terminal Forecasts (FT's). However, there are ways one can indicate such occurrences. In this particular case I tried:

...chc rw- g45...

but have since seen perhaps a more eloquent way used by a forecaster in Arizona:

...ocnl 2bd g45 chc trw-...

with the visibility reduction being best suited for west Texas.

The detrimental effects that dry microbursts can have on aircraft, especially during the critical stages of takeoff or landing, have been documented by several authors (Fujita, etc.). This event was selected for study not only because it occurred within our aviation forecast responsibility area, but also because the event was observed by both man and machine "sensors". The study suggests some hints for forecasting and nowcasting microburst events, although additional studies are necessary to build a larger data sample.

REFERENCES

Caracena, F.C., and J.A. Flueck, 1986: The classification and production of small scale windshear events in a dry environment. Preprints, 33rd Annual meeting, American Aeronautical Society., AAS, San Diego, CA

Fujita, T.T., 1985: The downburst: Microburst and Macroburst., SMRP Reserach Paper No. 210, Dept of Geophysical Sciences, Univ. of Chicago, Chicago, IL

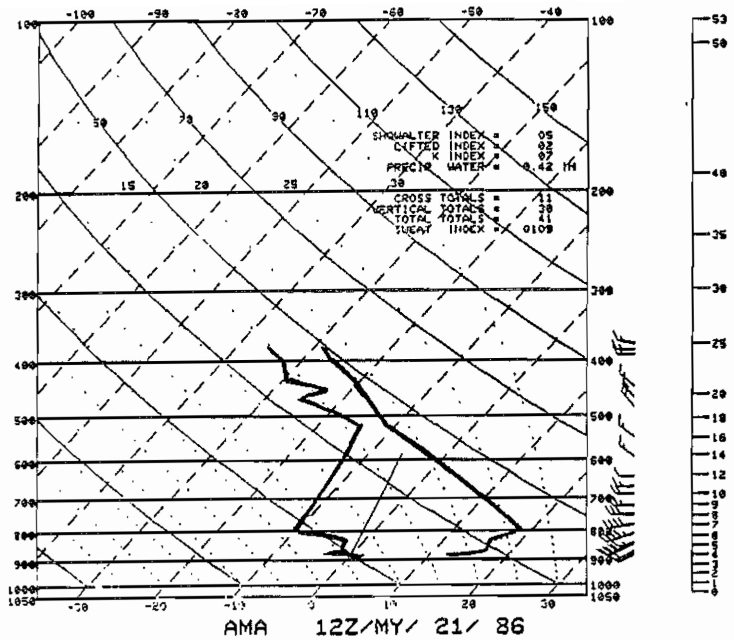


Figure 1a

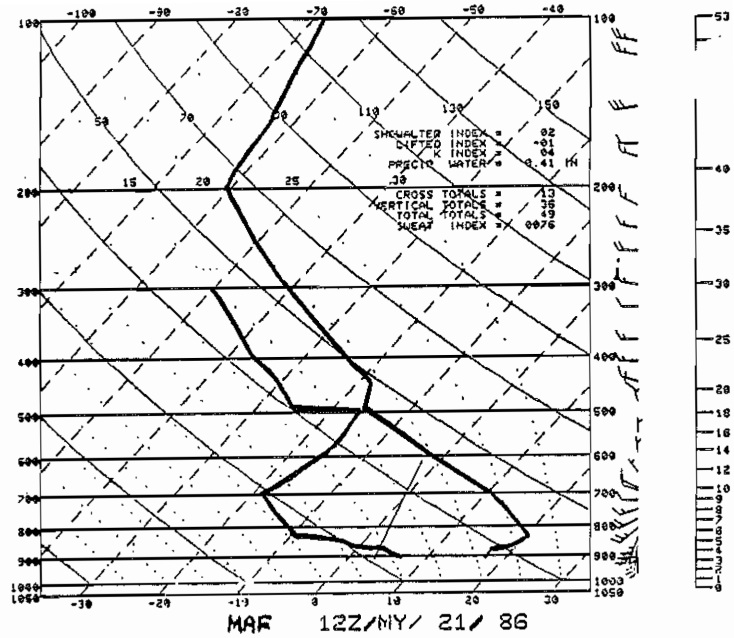
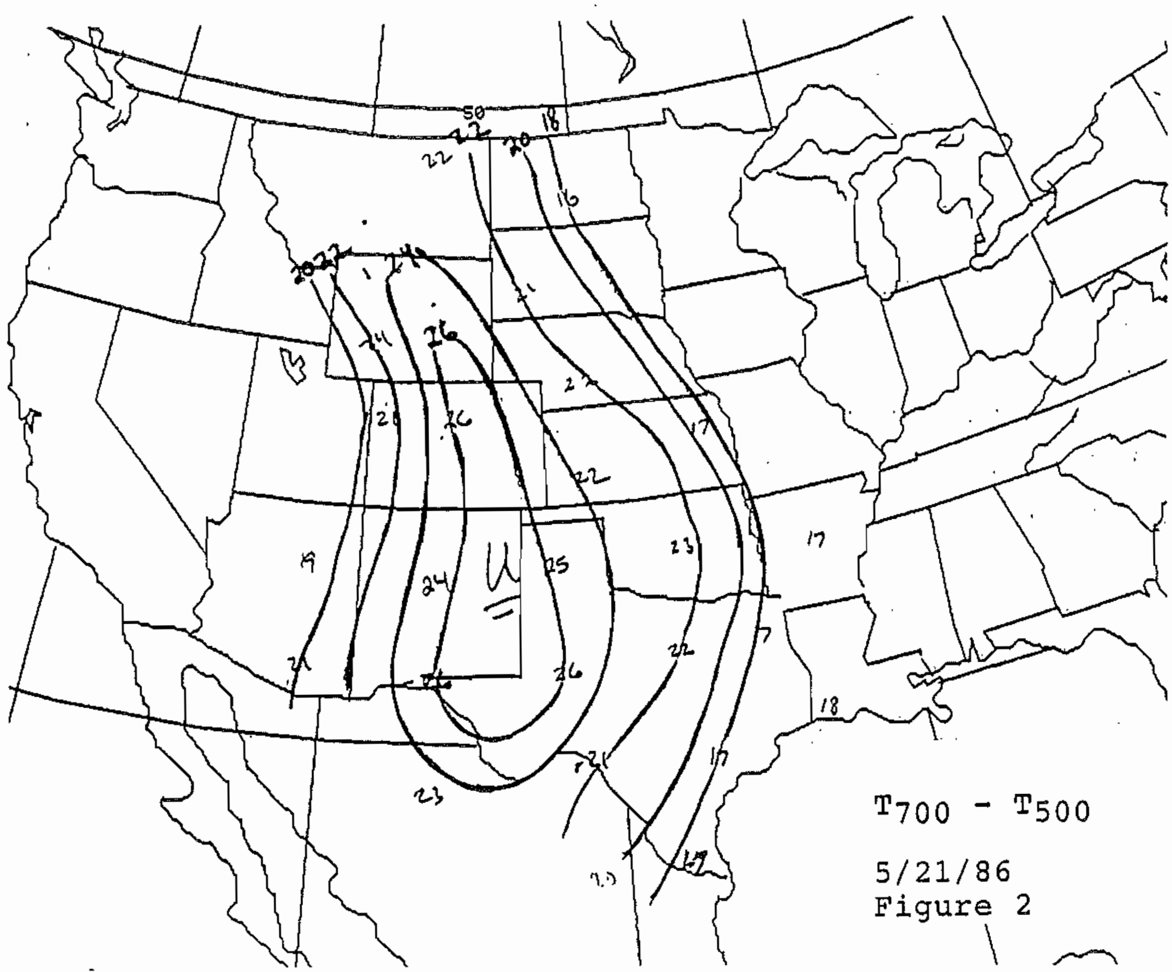


Figure 1b



$T_{700} - T_{500}$

5/21/86

Figure 2

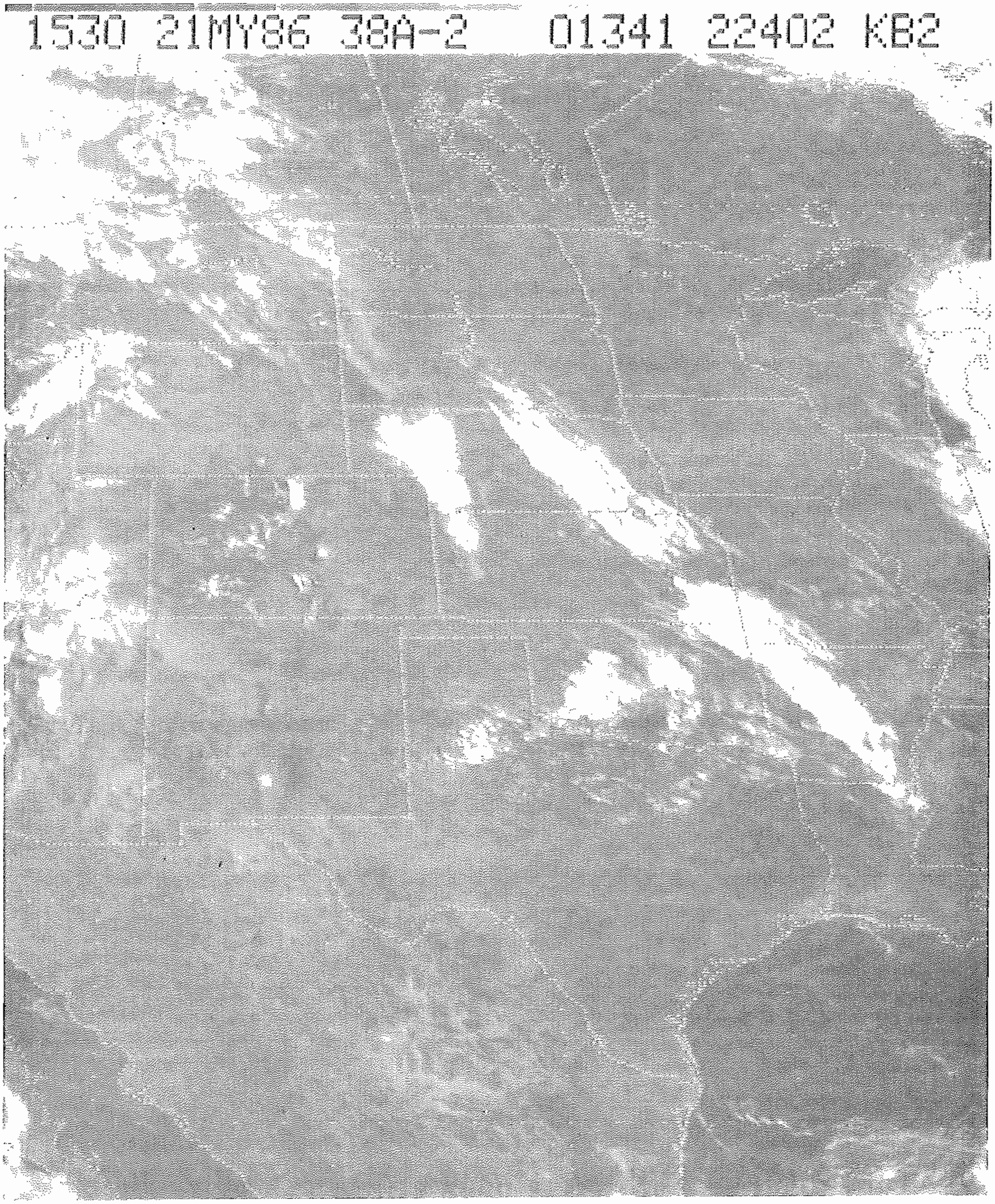


Figure 3

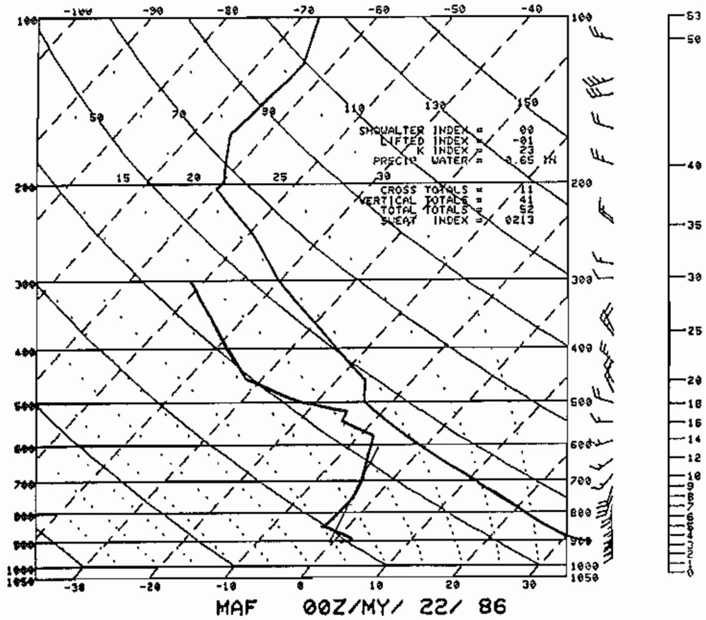


Figure 4a

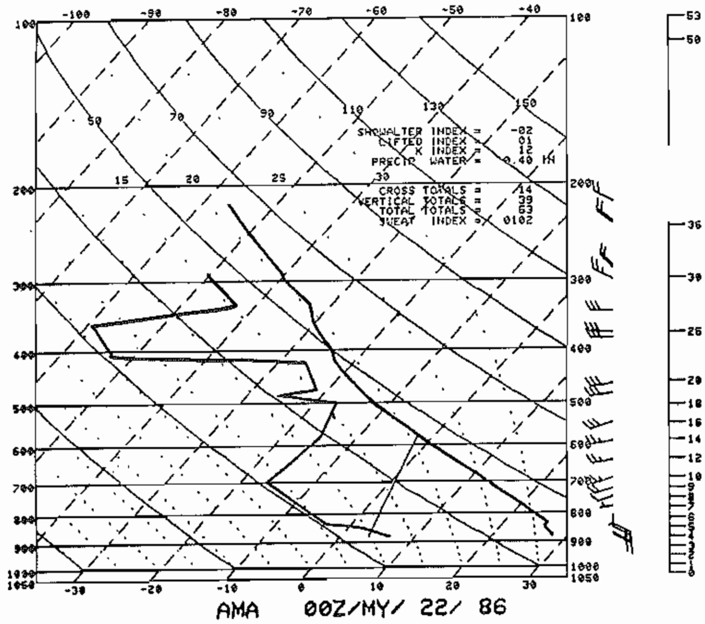


Figure 4b

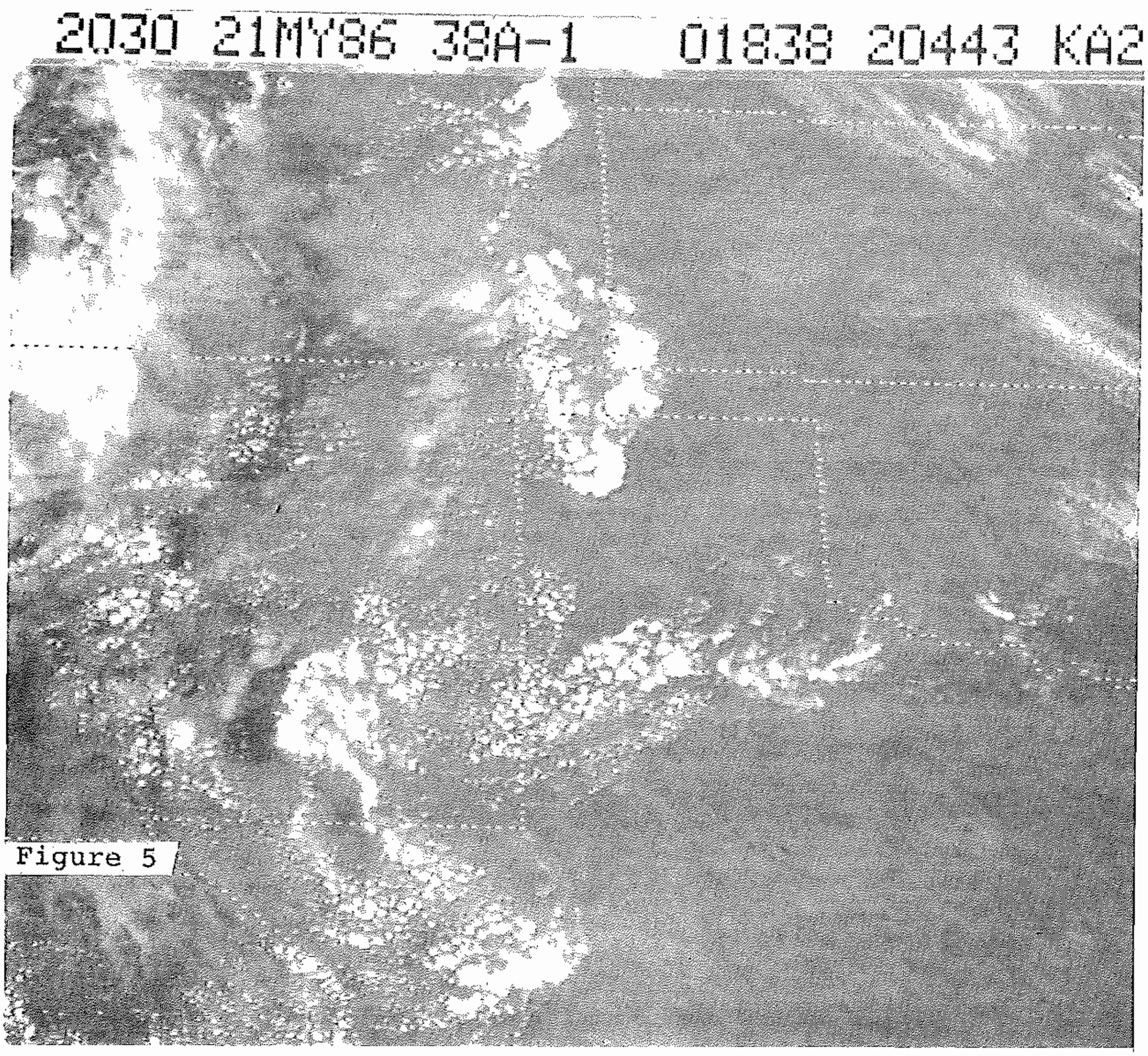


Figure 5

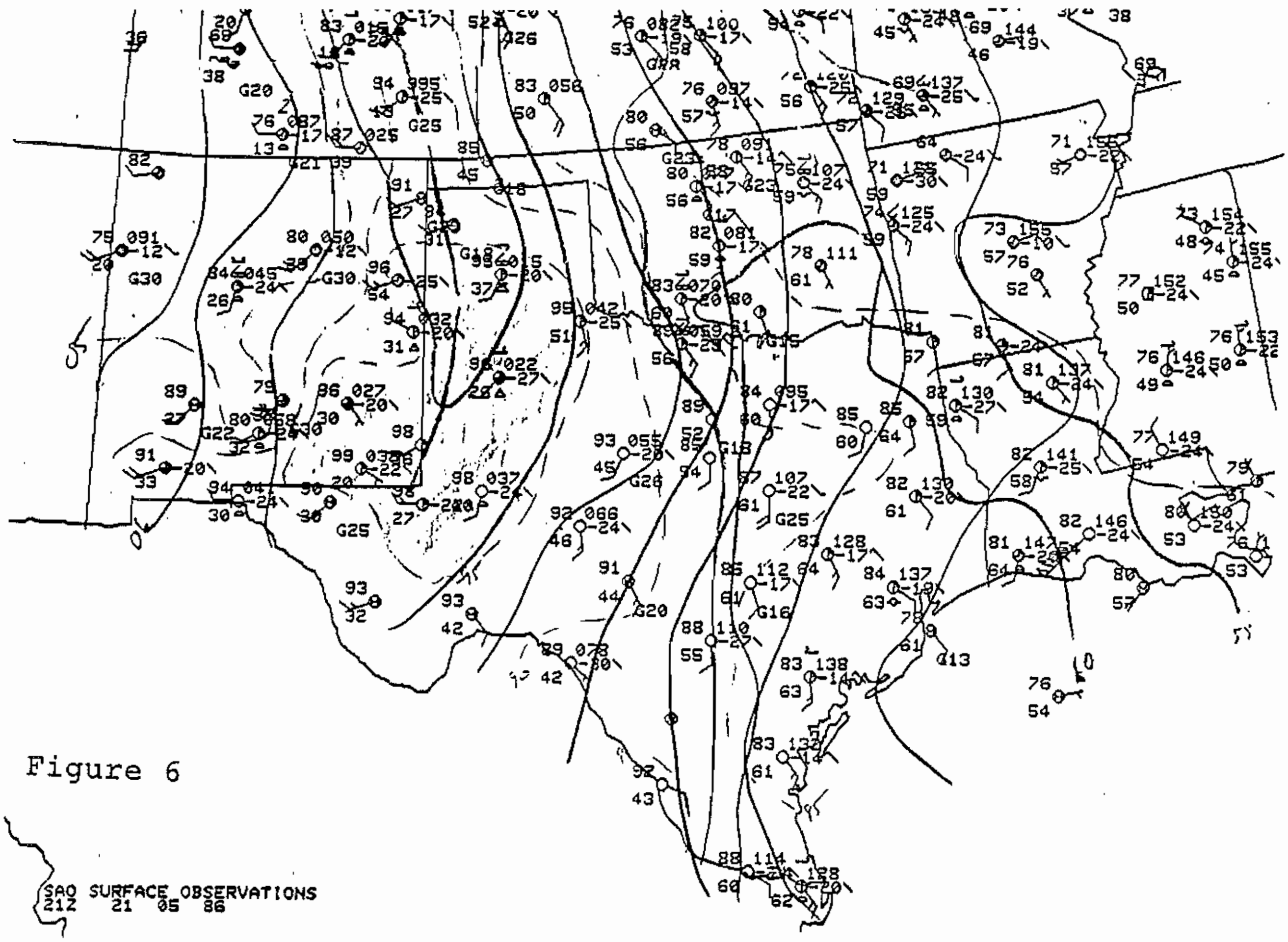


Figure 6

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TTAA00 KAMA 220250
AMA SA 0248 250 -SCT 20 003/75/52/1316/970/ 003 1106
AMA SA 0149 50 SCT 250 -SCT 20 008/79/48/1216/971
AMA SA 0047 70 SCT 250 SCT 30 005/85/48/1219/970/CB DSNT NE-SE
MOVG E/ RADAT 35144
AMA SA 2347 E70 BKN 250 BKN 30 005/86/48/1220G26/969/PK WND
2647/2257 CB E/ 719 1906 96 RADAT DLAD
AMA SA 2245 E70 BKN 250 BKN 30 005/92/27/2606/970/CB DSNT NE
VIRGA ALQDS
AMA SA 2147 70 SCT 250 SCT 25 009/92/36/2313/972/CB DSNT N
AMA SA 2050 70 SCT 100 SCT 250 SCT 30 015/95/37/2010/975/LN TCU AND CB
DSNT NW - N MOVG E/ 720 1973
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TTAA00 KLBB 220256
LBB SA 0254 50 SCT E100 BKN 250 BKN 15 013/89/28/1810/974/ 307 1178
LBB SA 0153 E50 BKN 250 BKN 15 010/91/28/1810/973/ VIRGA SW-N
LBB SA 0049 50 SCT E250 BKN 15 006/91/29/1612/972/ VIRGA ALQDS
LBB SA 2350 E50 BKN 250 BKN 15 006/93/29/1810G19/972/ VIRGA S-W-N/
719 1208 99
LBB SA 2250 E50 BKN 250 BKN 15 014/94/27/2106/974/ VIRGA SW-W
LBB SA 2151 E50 BKN 250 BKN 15 015/95/26/2724G33/975/ BD W-NW
LBB SA 2051 E50 BKN 250 BKN 15 022/96/26/2209/977/50 BKN V SCT/ 727
1208
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LBB SA 1850 80 SCT 250 -SCT 15 037/95/35/2412G19/982
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SAUS90 KLBB 220200
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 REE SA 2355 E40 BKN 10 007/95/34/1712G24/970/WND 04V27
 PK WND 2344/43/ 717 1200=
 REE SA 2255 E40 BKN 10 013/95/35/2008/972/PK WND 2226/18=
 REE SA COR 2255 E40 BKN 10 013/95/35/2008/972/PK WND 2226/18
 VIRGA W=
 REE SA 2155 E40 BKN 10 004/100/35/2110G24/973/WND 13V25 PK WND
 3628/10=
 REE SA 2056 E40 BKN 10 023/99/35/2406/976/WND LGT AND VRBL/ 724 1200=
 REE SA RTD 1957 E50 BKN 250 BKN 10 030/96/36/2114G22/978/WND 16V26=
 REE SA 1957 E50 BKN 250 BKN 10 030/96/36/2114G22/978/WND 16V26=
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Figure 7

```
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UBUS1 KWBC 220224

TX 220224
AMA UA /OV AMA/TM 0200/FL UNKN/TP BE90/TB LGT 50-140 MDT 90 & 130/RM
    SMTH ABV 140
NMCPRCTX
UBUS1 KWBC 220144

TX 220144
AMA UA /OV 8 S AMA/TM 0136/FL 70/TP B727/TB LGT-MDT
AMA UUA /OV AMA 8SW/TM 0131/FL50/TP C210/TB MDT-SVR
NMCPRCTX
UBUS1 KWBC 220124

TX 220124
AMA UA /OV 30SE AMA/TM 0035/FL 110/TP B737/TB MDT
AMA UUA /OV 20SE AMA/TM 0038/FL 90/TP B737/TB MDT-SVR
AMA UA /OV 10SE AMA/TM 0042/FL 60/TP B737/TB LGT-MDT
NMCPRCTX
UBUS1 KWBC 220024

TX 220024
LBB UA /OV LBB090010 /TM 2332 /FLUNK /TP T38 /TB LGT-MDT 060
NMCPRCTX
UBUS1 KWBC 212324

TX 212324
AMA UA /OV AMA/TM 2238/TL UNKN/TP BE20/RM -10 KTS SPEED FA RY22
    WIND SHEER
NMCPRCTX
 UBUS1 KWBC 212224

TX 212224
LBB UUA /OV LBB360006 /TM 2144 /FL 045 /TP BE90 /TB SVR /RM DURGD
LBB UA /OV LBB 300030-BGS /TM 2202 /FL 115 /TP PA28 /TB MDT
LFK UA /OV LFK 090037/TM 1935/FLUNKN/TP UNKN/SK 040 SCT 050
NMCPRCTX
 UBUS1 KWBC 212144
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Figure 8

FORECASTING POTENTIAL SEVERE DOWNBURST DAYS IN NORTH TEXAS

WILLIAM L. READ

WSFO FORT WORTH

INTRODUCTION

Severe thunderstorms (by definition, one that produces either a tornado, hail 3/4 inch or greater or winds of 50 knots or greater) are primarily a springtime phenomena for north Texas. For the most part, the summer season in Texas is characterized by dry and stable conditions with the dynamics of the westerlies well to the north. Climatological summaries suggest that summer season convection in north Texas is mostly the "air mass" type. A casual perusal of Storm Data over the past several years revealed that, although less common than in spring, severe thunderstorms occur with regularity during the summer months in north Texas. Storm Data further revealed that most of the reports involved damaging winds that were highly localized. This suggest that downbursts, most likely microbursts, are the primary severe weather producers during the summer in north Texas.

Review of literature available locally revealed little research on summer severe weather over north Texas. Johns, 1984, describes severe weather outbreaks in the southern plains with northwest flow aloft, a common summer season upper air pattern. Read, 1985, suggests the main threat from deep convection during the summer is excessive rainfall. From that study, north Texas experiences about two excessive (5 or more inches) rainfall events a summer.

Storm Data summaries show that severe occurrences are far more common than excessive rain events. Storm Data for the summer of 1985 listed 17 days with severe thunderstorms, all with damaging wind. The WSFO began archiving locally satellite imagary and various analyses and model forecasts in 1985. Using satellite imagery, the number of days in which deep convection occurred somewhere in north Texas was determined. Summer 1985 produced 59 thunderstorm days in north Texas. Examination of available analyses revealed only two thunderstorm days in which significant upper level dynamics were present.

The 1985 summer data sparked an interest in doing a more detailed study for 1986. The goal was to try to determine if one could forecast what we will term potential downburst days given the apparent lack of upper level dynamics. For days when severe thunderstorms were verifiable, detailed data sets were prepared.

Analysis of the data concentrated on conditions prior to onset. Most of the time, this meant 1200 GMT rawinsonde data and corresponding standard level charts. Various surface analyses and satellite imagery were used depending on the nature of the event and availability of the data. Summer 1986 produced 8 verifiable severe weather days. The next two sections of this paper will present a summary of the individual events followed by comparisons and a discussion of forecastibility of the events.

In the next section, each event is briefly discussed following the same format. First, the downburst occurrences are described. Then the 500mb, surface and sounding analyses are discussed. As much as possible, these analyses are for prior to the downburst event. Last, results of wind estimate techniques are given. The techniques used are: 1. a simple freezing level and ambient temperature technique by Wallington, 1961 (referred to hereafter as W), 2. a downdraft temperature versus ambient temperature technique by Miller and Fawbush, 1954 (referred to hereafter as M-F) and 3. a modification of M-F developed by Foster, 1958 (referred to hereafter as F).

DESCRIPTION OF THE EVENTS

(see following pages)

June 23, 1986

DOWNBURST EVENTS

Thunderstorms in Grayson and Fannin counties around 4 pm CDT (2100 GMT) produced damaging downburst winds. Grayson county airport, F39, reported gusts to 55 kts. Large trees were downed near Honey Grove in Fannin county. Another thunderstorm produced wind gusts estimated in excess of 50 kts in Dallas county around 530 pm CDT.

500 MB ANALYSIS

Several key RAOB sites were missing at 1200 GMT thus the 0000 GMT 500 mb analysis was used for this case (fig 1a). North Texas was located under the western end of a rather flat subtropical ridge. There was a hint of a weak north-south trough over eastern Texas. The wind field was very weak with speeds less than 10 kts. The thermal pattern was rather nondescript with temperatures around -7 degrees C being slightly cooler than normal for late June. With features this subtle, the NMC numerical models did not indicate any upper level convective trigger mechanism.

SURFACE ANALYSIS

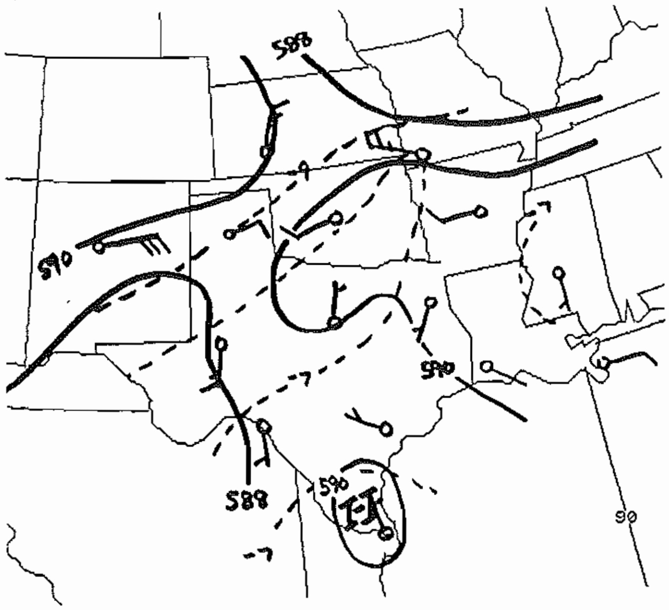
Thunderstorms had been active across northern Oklahoma and northern Arkansas since early morning. By 2100 GMT (fig 1b) this activity had produced outflow boundaries that were moving slowly south along the Red River. A fairly strong thermal gradient had developed across the boundaries with maximum temperatures just south of the boundary around 95 degrees F and minimum temperatures on the cool side near 75 degrees F. An axis of dewpoint temperature greater than 70 degrees F extended southeast from the boundary near ADM through LCH. The thunderstorms that produced the damaging winds formed in the warm sector just to the south of the outflow boundaries where the maximum temperature axis and maximum dewpoint axis overlapped.

SOUNDING

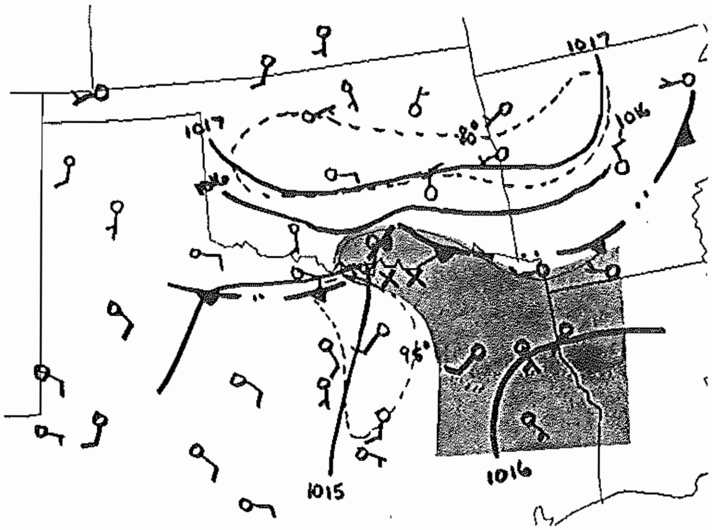
Figure 1c shows the 1200 GMT sounding for SEP. The most notable feature was the absence of a strong capping inversion. Plugging in a maximum temperature of 95 degrees F and a dewpoint of 68 degrees F to this sounding resulted in a surface based Lifted Index of -6 and a CCL of around 6000 feet AGL. The sounding would consist of three distinctly different layers: a dry adiabatic layer from the surface to 6000 feet, a moist layer from 6000 to around 12000 feet and a deep dry layer above 12000 feet.

WIND ESTIMATES

W..70 kts, F..58 kts and M-F..77kts.

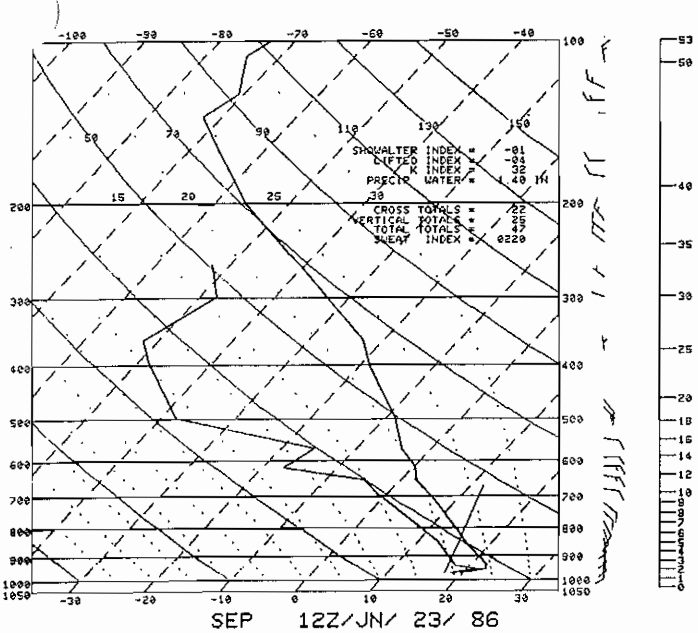


a. 500 mb analysis, 0000 GMT June 24.



b. Surface analysis, 2100 GMT. (X-Location of Downbursts; Dashed Lines-Isotherms; Solid Lines - MSL Pressure; Shaded Area - Dewpoints ≥ 70°C

c. Stephenville sounding, 1200 GMT.



d. Visual satellite imagery, 2130 GMT.

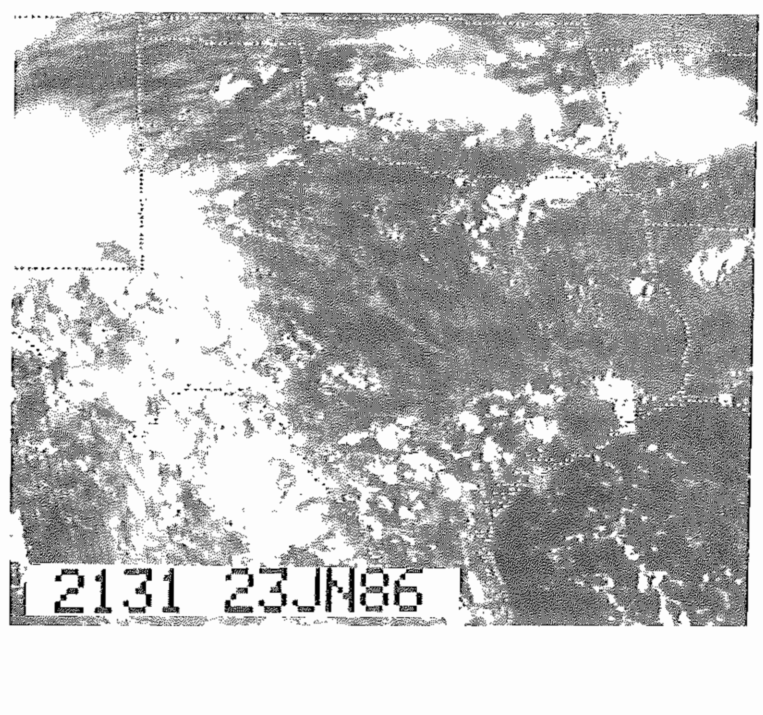


Figure 1. June 23, 1986

June 24, 1986

DOWNBURST EVENT

A thunderstorm developed over Fort Worth around 530 pm CDT (2230 GMT). This thunderstorm produced a microburst over the field at Carswell AFB (FWH) at 607 pm CDT. A wind gust of 55 kts was recorded. Damage reports from Tarrant and Parker counties indicated other microbursts occurred, but no estimates of wind speeds were received.

500 MB ANALYSIS

North Texas was located within a subtropical high pressure cell, centered in northern Oklahoma (fig 2a). No short wave features were detectable from the 1200 GMT data. Temperature and wind fields were weak. The temperature of -6 at 500 mb was about normal for late June in north Texas.

SURFACE ANALYSIS

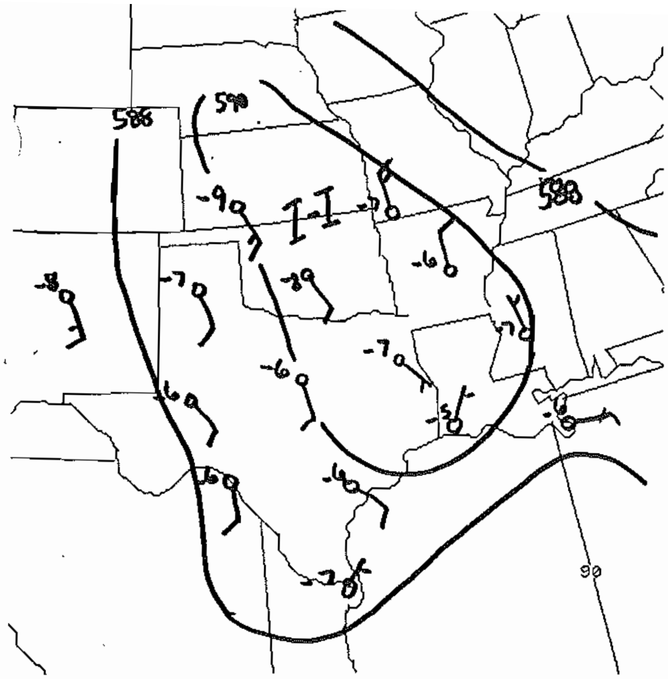
Early morning thunderstorm activity over southern Oklahoma and Arkansas had produced a weak outflow boundary across north Texas by mid afternoon (fig 2b). The boundary was best defined by the temperature contrast across the boundary..mid 90s in the warm sector and lower 80s in the cool sector. A pool of 70+ dewpoints coincided with the cool pocket along the Red River. The thunderstorm that produced the microburst developed in the warm sector, just south of the boundary.

SOUNDING

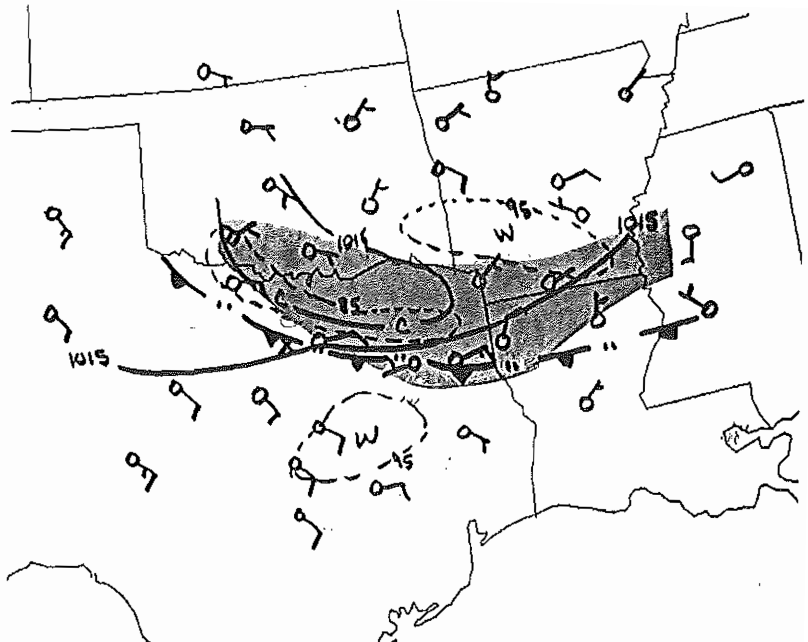
Figure 2c shows the 1200 GMT sounding from SEP. The sounding was characterized by a deep, rather moist lower troposphere with no important capping inversion. Modifying the sounding with the temperature and dewpoint..91,71..at FWH just prior to thunderstorm onset gave a surface based LI of -6. The CCL was around 6000 feet AGL. Three distinct layers were present: dry adiabatic layer from the surface to 6000 feet, moist layer from 6000 feet to 14000 feet and somewhat drier air above 14000 feet.

WIND ESTIMATES

W..59 kts F..59 kts M-F..63 kts

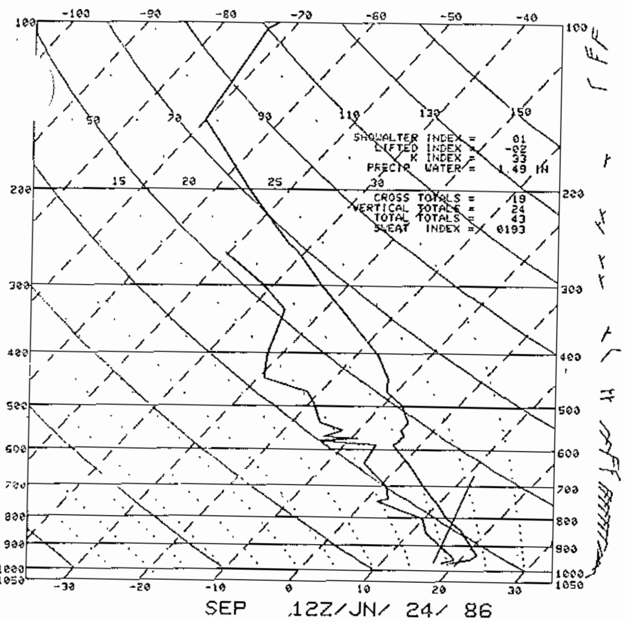


a. 500 mb analysis, 1200 GMT.



b. Surface analysis, 2200 GMT. Shaded Area - Dewpoints ≥ 70°C

c. Stephenville sounding, 1200 GMT.



d. Visual satellite imagery, 2231 GMT.

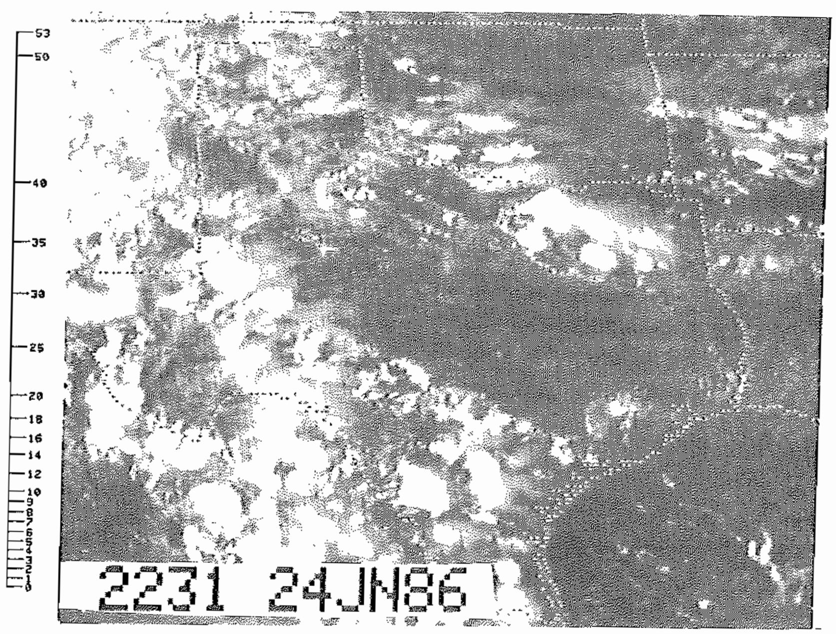


Figure 2. June 24, 1986.

June 28, 1986

DOWNBURST EVENTS

Thunderstorms in Lamar and Titus counties of northeast Texas produced damaging winds between 3 pm and 5 pm CDT (2000 and 2200 GMT). A microburst was observed by spotters in Paris with wind gust estimated near 60 kts. A downburst in Mount Pleasant downed numerous large trees, but no wind estimates were reported.

500 MB ANALYSIS

With a long wave ridge over the Rockies and downstream trough over the eastern United States, north Texas was under northwest flow at 500 mb (fig 3a). A minor short wave was embedded in the flow over southern Oklahoma at 1200 GMT. Temperatures within the short wave trough were actually a little warmer than on either side and were about normal for late June..-6 degrees C. This system was sufficiently large in scale for the NMC nested grid model to detect. The 12h prog valid at 0000 GMT June 29 placed the trough axis near an ABI to SHV line.

SURFACE ANALYSIS

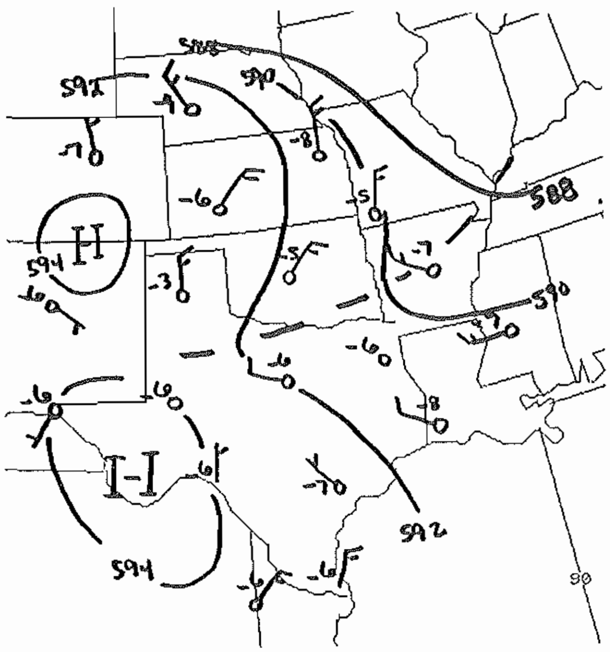
Nocturnal thunderstorm activity over Arkansas had produced a significant outflow boundary that was located over southeast Oklahoma and southern Arkansas early in the morning. Thunderstorms continued to fire along the boundary all morning, and by 4 pm CDT the boundary had progressed southwestward into northeast Texas. Figure 3b shows surface features at 4 pm CDT. The outflow boundary was oriented NNW to SSE across northeast Texas. A strong temperature gradient existed across the boundary with mid to upper 90s in the warm sector and upper 70s in the rain cooled air. Dewpoint temperatures were pooled in the mid 70s along the boundary. The thunderstorms that produced the downburst winds developed in the warm sector just west of the pre-existing boundary, were the maximum temperature axis overlapped the pooled dewpoint field.

SOUNDING

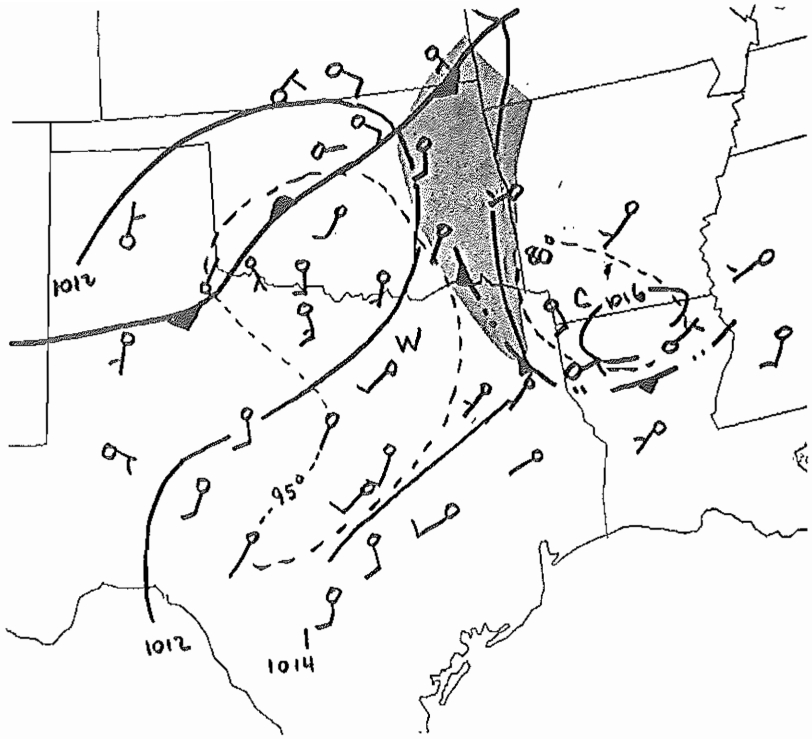
The 1200 GMT sounding for GGG indicated potentially unstable conditions for northeast Texas (fig 3c). A moist, weakly capped lower troposphere was overlayed with increasingly dry air through the mid and upper troposphere. Using a pre-thunderstorm temperature and dewpoint estimate of 96 and 70 degrees, the surface based LI was -6. The CCL was around 5500 feet AGL.

WIND ESTIMATES

W..80 kts, F..56 kts, M-F..65 kts.

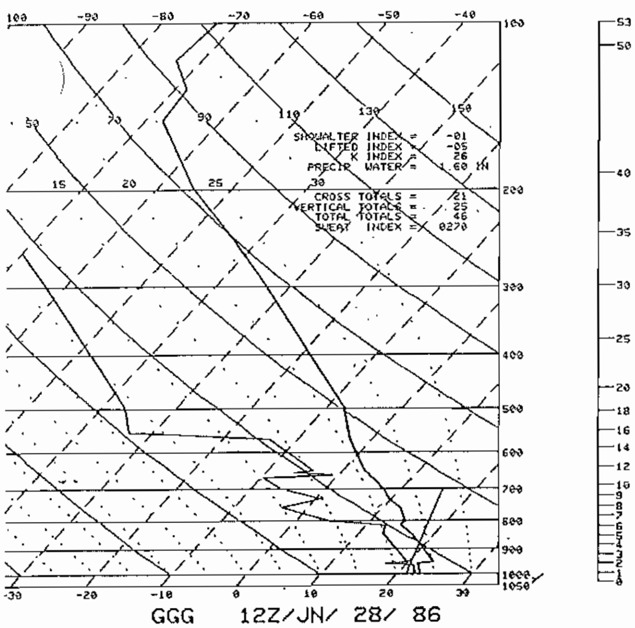


a. 500 mb analysis, 1200 GMT.



b. Surface analysis, 2100 GMT. Shaded Area - Dewpoints ≥ 75°C

c. Longview sounding, 1200 GMT.



d. Visual satellite imagery, 2230 GMT.

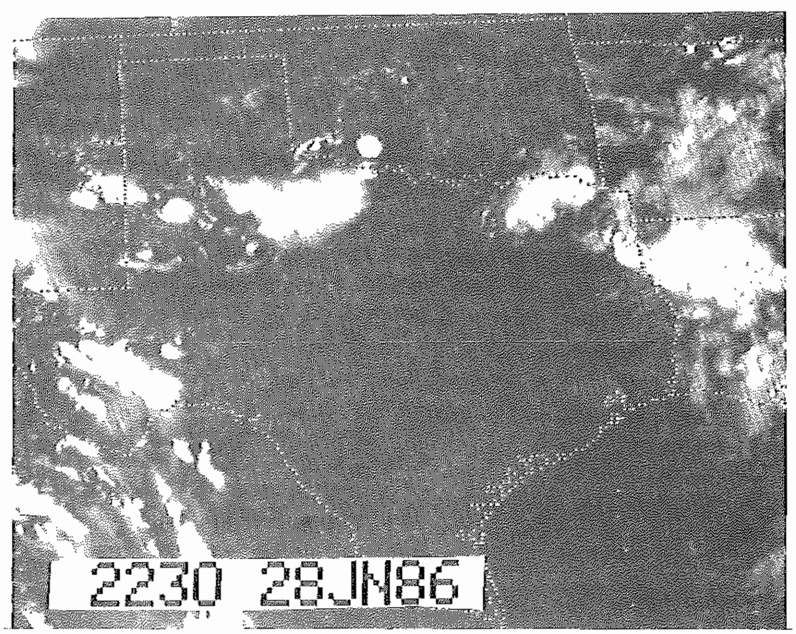


Figure 3. June 28, 1986

JULY 21, 1986

DOWNBURST EVENTS

Thunderstorms were scattered over most of north Texas during the afternoon and evening. Between 530 and 630 pm CDT several downbursts were observed. A spotter in Dallas county estimated wind speeds of 60 mph. Another thunderstorm in Parker county produced winds estimated between 60 and 70 mph. Further west, in Eastland county, considerable wind damage was reported. At 1030 pm CDT, a thunderstorm produced wind damage in Dallas and Tarrant counties.

500 MB ANALYSIS

A subtropical ridge was oriented east to west from southern Arkansas into central New Mexico (fig 4a). North Texas was in the weak easterly flow south of the ridge. Two very weak impulses were somewhat detectable in the easterlies. One was oriented east-west along the Red River and westward into southeast New Mexico. The other was apparent in extreme southern Texas. Perhaps the most notable feature at 500mb was the relatively cool temperatures..-8 degrees C. NMC models did not show any 500 mb convective trigger mechanism.

SURFACE ANALYSIS

At 1200 GMT, a weak frontal boundary was oriented east-west along the Red River. Scattered thunderstorms developed all along the front by 1800 GMT. Clusters of thunderstorms both in west Texas and northeast Texas layed down important outflow boundaries south of the front. A large area of thunderstorms in southern Louisiana pushed a north-south boundary into east Texas. Figure 4b shows surface conditions at 2200 GMT. A pocket of 100 degree air was situated between the above mentioned boundaries in central Texas. An axis of 70+ dewpoints extended northwestward from east Texas to near SPS. The late afternoon downburst producing thunderstorms in Dallas and Parker counties developed in the warm air along the outflow boundaries, where the thermal and moist axis overlapped. The Eastland county event occurred at an intersection of two boundaries, also in the hot air. The nocturnal event was a puzzle. One possibility was that the storm developed as the large north-south boundary intersected a weak boundary over Dallas and Tarrant counties.

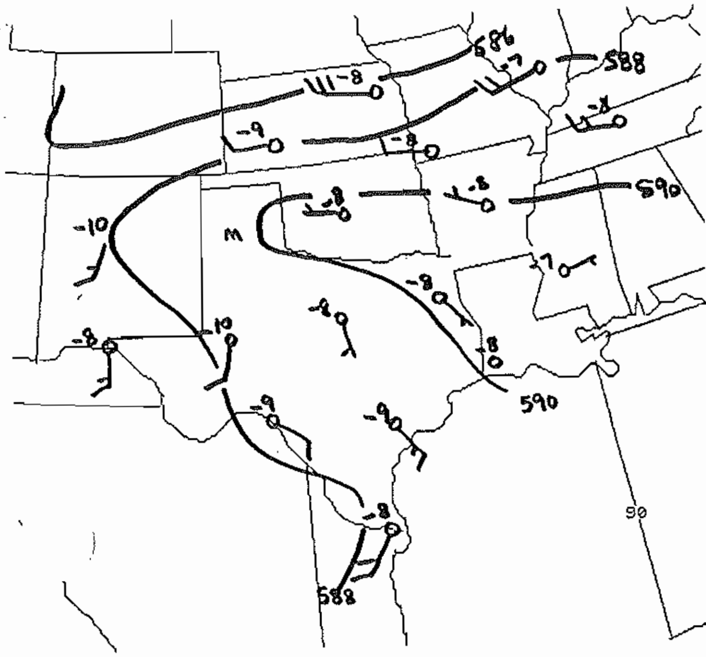
SOUNDING

Figure 4c shows the 1200 GMT sounding for SEP. Important features in the sounding are the lack of a capping inversion and the relatively deep dry adiabatic layer in the lower troposphere. Plugging in a temperature of 98 degrees and dewpoint of 67 degrees results in a surface based LI of -9 and a CCL of 7000 feet AGL. The expected afternoon sounding consists of a deep surface based dry adiabatic layer, a somewhat moist mid layer (720-500 mb) and a deep dry layer aloft.

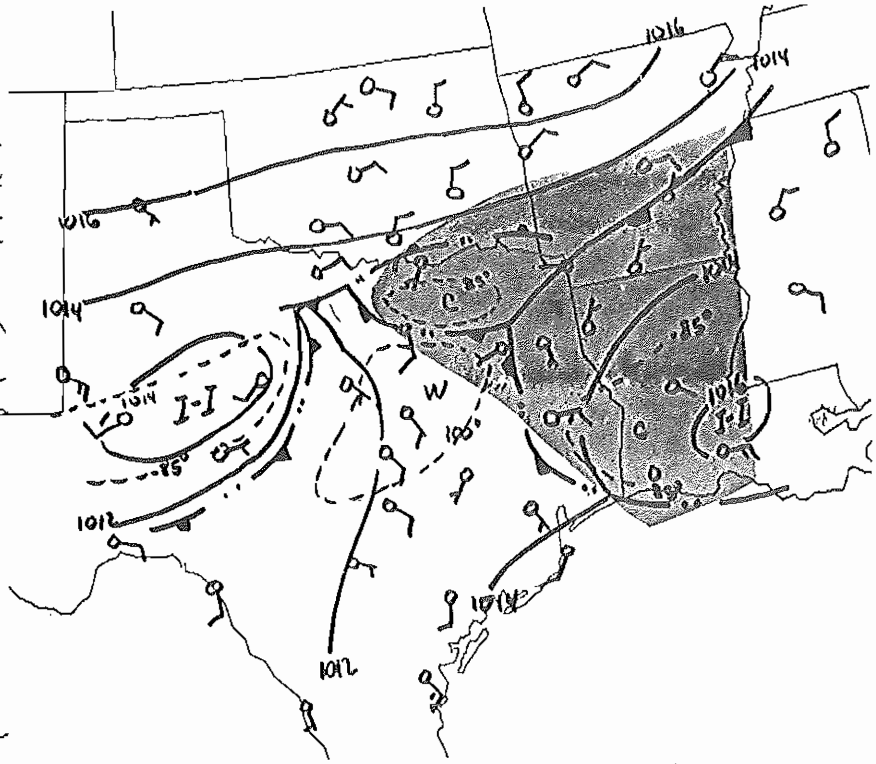
WIND ESTIMATES

W..86 kts, F..60 kts, M-F..73 kts.

Figure 4. July 21, 1986

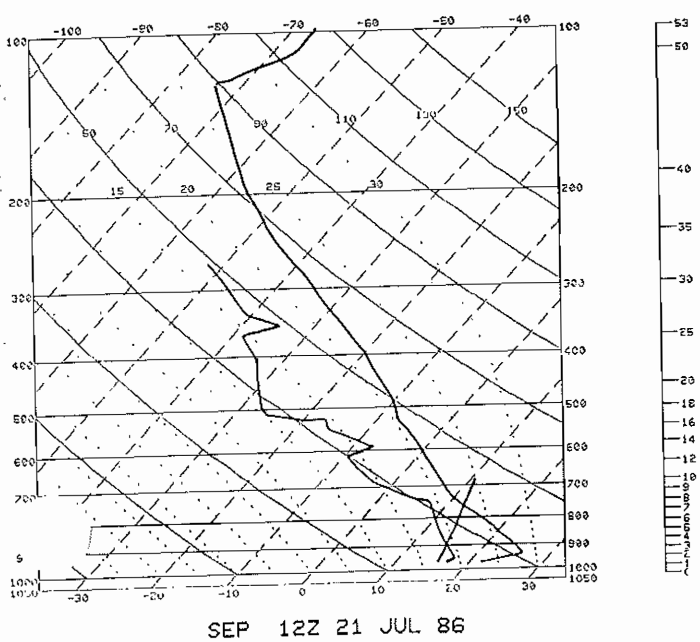


a. 500 mb analysis, 1200 GMT.

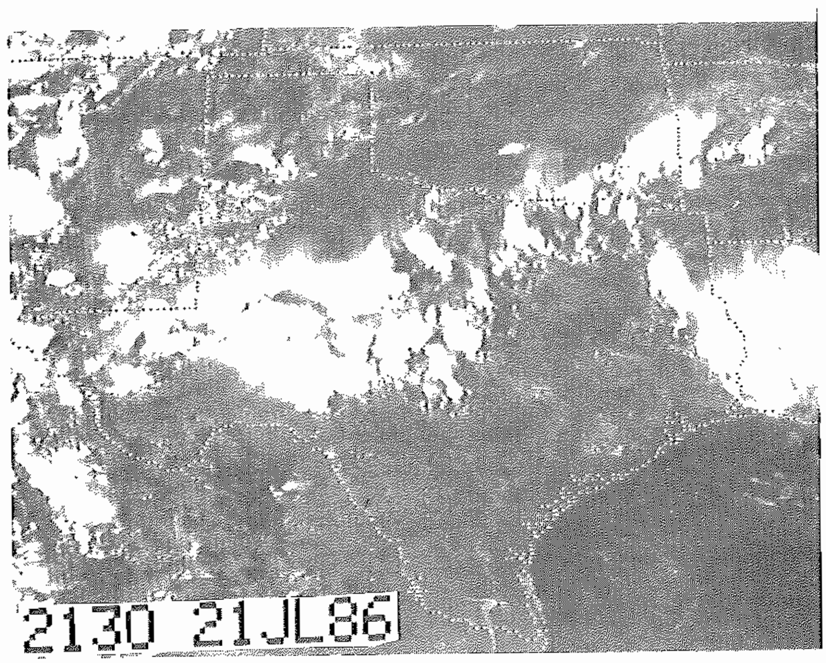


b. Surface analysis, 2200 GMT. Shaded Area - Dewpoints ≥ 70°C

c. Stephenville sounding, 1200 GMT.



d. Visual satellite imagery, 2130 GMT.



AUGUST 2, 1986

DOWNBURST EVENTS

The thunderstorms that produced downburst winds developed rapidly around 2 pm CDT between SPS-ABI-DFW. MWL observed a gust of 65 knots at 230 pm CDT. Several reports of 50 to 60 mph winds were recieved from Parker, Hood and western Tarrant counties between 3 and 4 pm CDT. The Parker county storm resembled a spearhead echo as described by Fujita, 1985.

500 MB ANALYSIS

Figure 5a shows selected portions of the 1200 GMT 500 mb analysis. In spite of many missing RAOBs, a rather significant, for early August, short wave could be seen in the northwest flow upstream from north Texas. PVA and cooler temperatures aloft associated with this system would be expected to serve as a convective trigger mechanism over north Texas during the day. The NMC Nested Grid model 12h 500 mb prog valid at 0000 GMT August 3 showed a weak vorticity maximum just north of ABI.

SURFACE ANALYSIS

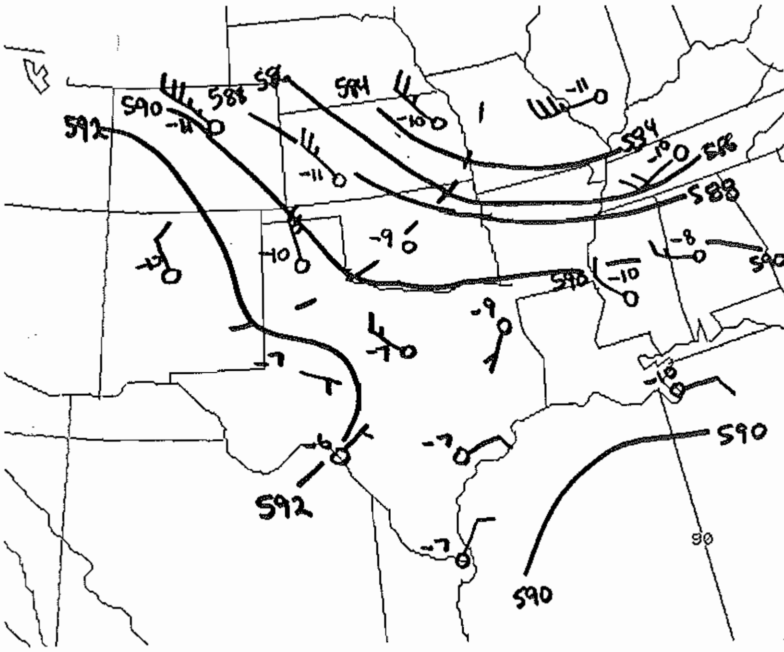
Typical of summer season northwest flow, the upper level short wave was overtaking the surface front during the day. By 1800 GMT (fig 5b) the upper level trough and surface front were coincident. An old outflow boundary from nocturnal activity was oriented northwest to southeast from the front north of ABI through DFW and LCH. A strong temperature gradient had developed across the boundary with above 100 degree readings south of the boundary to lower 80s on the cool side. An axis of 70+ dewpoints coincided with the old outflow boundary. Dewpoints in the 100 degree air were in the mid 60s, and had been increasing during the past three hours. Although thunderstorms developed all along the front and outflow boundary (fig 5d), the downburst producers were confined to the warm sector just south of the old outflow boundary.

SOUNDING

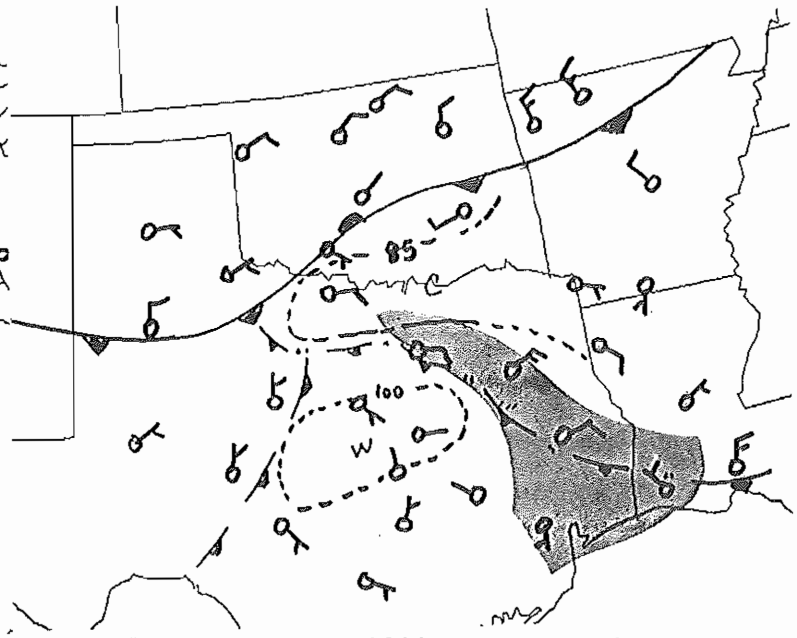
Figure 5c shows the 1200 GMT sounding for SEP. A forecaster looking at this sounding by itself would see the extensive dry air in the lower and middle troposphere and be hard pressed to forecast any thunderstorms. Apparantly moisture increased during the day. One can only speculate what the environmental sounding looked like at 1900 GMT. The increasing dewpoint in spite of very deep mixing suggests that rather dramatic moisture increase was taking place. Surface temperature of 99 degrees with a dewpoint of 65 degrees resulted in a LI of -9 and a CCL of 8000 AGL.

WIND ESTIMATES

W..89 kts, F..66 kts, M-F..80 kts.



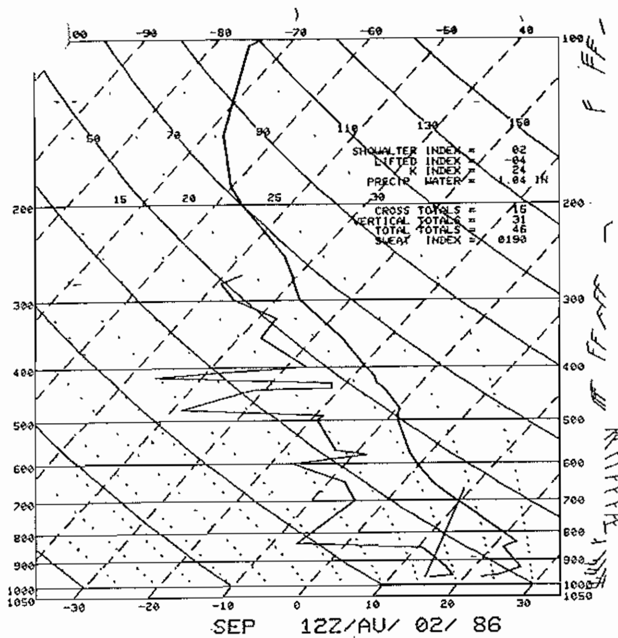
a. 500 mb analysis, 1200 GMT.



b. Surface analysis, 1800 GMT. Shaded Area - Dewpoints ≥ 70°C

d. Visual satellite imagery, 2030 GMT.

c. Stephenville sounding, 1200 GMT.



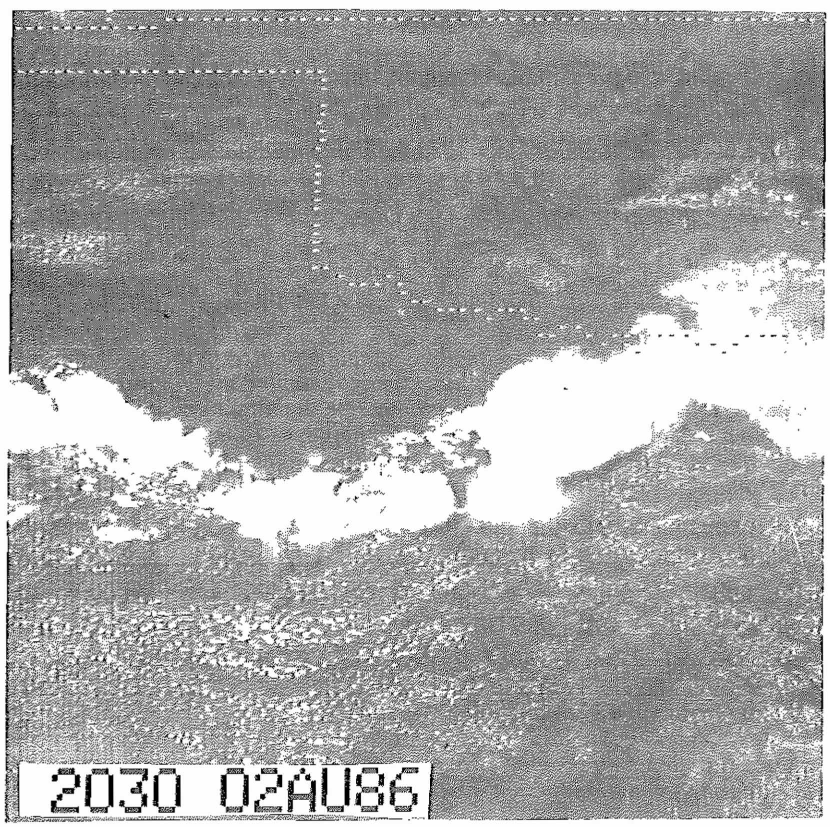


Figure 5. August 2, 1986

August 3, 1986

DOWNBURST EVENTS

Thunderstorms began to develop by 11am CDT over west and central portions of north Texas. Downburst winds were reported between 2pm and 5pm CDT. Reports of 60 mph or greater winds occured along roughly an ABI to TXK line. At 230 pm, a downburst occured over south Fort Worth. A storm spotter with an anemometer and computerized recording rain gauge happened to bear the brunt of the storm. He recorded gusts to 60 knots immediately followed by 5 minutes of torrential rains..at the rate of 9 inches per hour! This was the most active day during the summer with 9 confirmed downbursts.

500 MB ANALYSIS

North Texas was under northwest flow at 500mb on this day. A short wave was apparant upstream over northwest Texas and Oklahoma at 1200 GMT (fig 6a). Note the unusually cool..minus 10 degrees C..air over north Texas. The short wave and cool temperatures aloft would seem to be a potent upper level convective trigger mechanism. The NMC nested grid model 12h prog valid 0000 GMT placed a weak short wave just to the west of north Texas.

SURFACE ANALYSIS

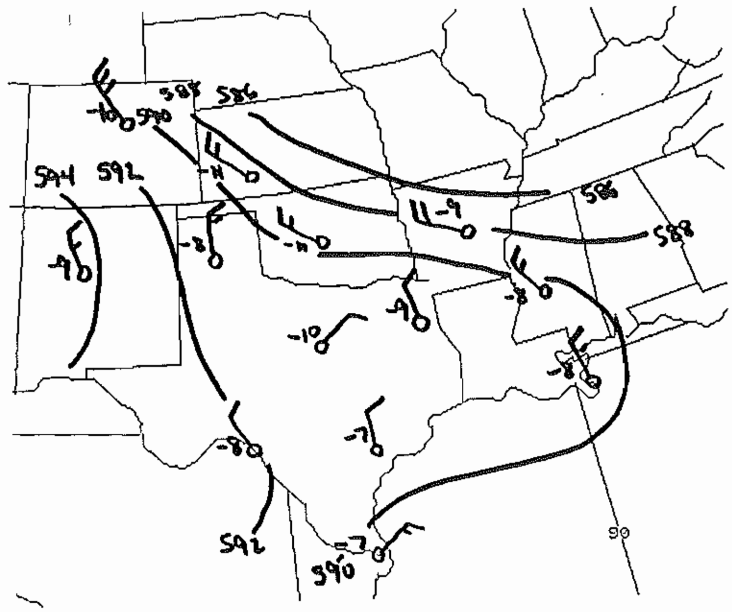
Figure 6b shows the surface analysis for 1800 GMT. A myriad of outflow boundaries were active across north Texas. Detecting long lived features this day was rather difficult, however, an area of relatively warm air persisted along the Red River. The north-south boundary located from near Wichita Falls to Stephenville at 1800 GMT moved eastward and intersected the east-west boundary located from near Fort Worth to Shreveport during the afternoon. The most intense thunderstorms formed along this intersection.

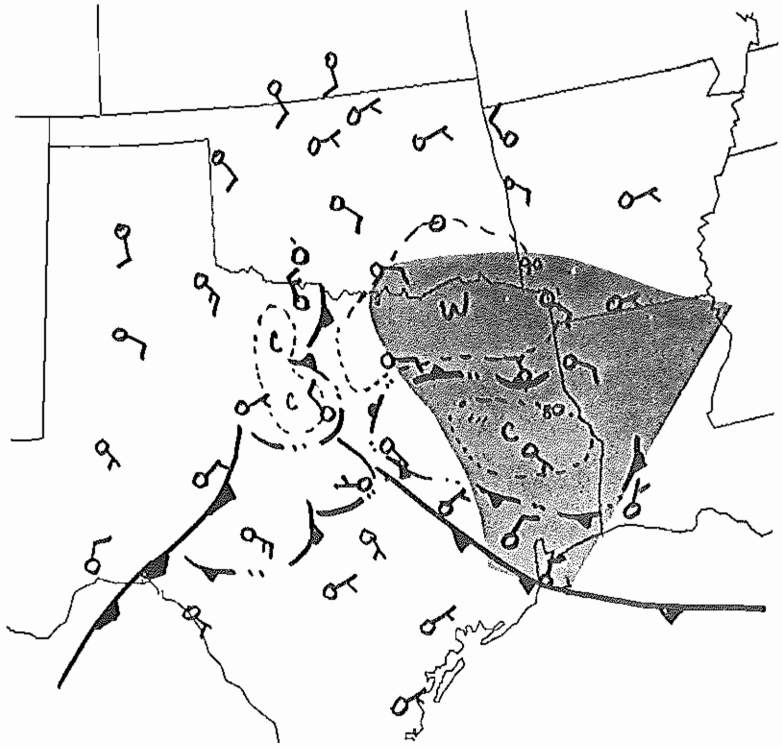
SOUNDING

Figure 6c shows the sounding for SEP at 1200 GMT. This sounding was very unstable with negligible low level capping. Using pre-thunderstorm temperature of 91 and dewpoint of 69 resulted in a surface based LI of -9 and a CCL of 5000 feet. The positive area achieved through lifting was quite large. The structure of the sounding with these surface conditions consisted of a dry adiabatic lower troposphere to 5000 feet, a moist layer from 5000 through 12000 feet and increasingly drier air above 12000 feet.

WIND ESTIMATES

W..66 kts, F..48 kts, M-F..65 kts.

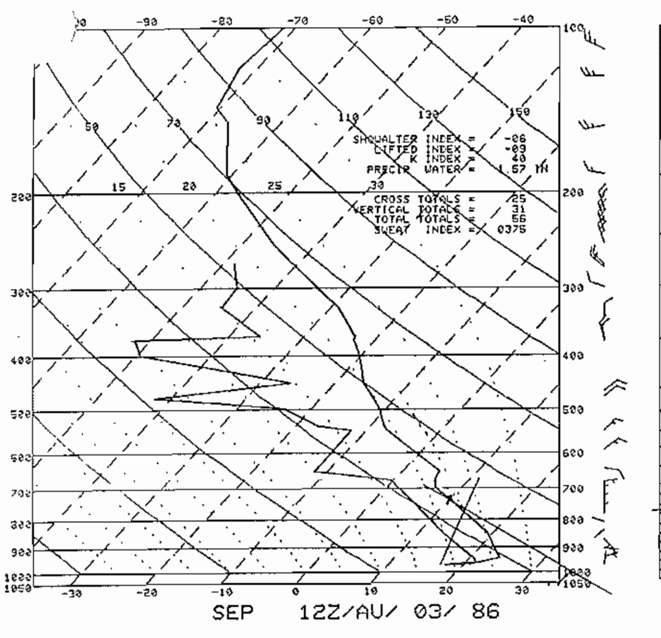




a. 500 mb analysis, 1200 GMT.

b. Surface analysis, 1800 GMT. Shaded Area - Dewpoints ≥ 70°C

c. Stephenville sounding, 1200 GMT.



d. Visual satellite imagery, 1930 GMT.

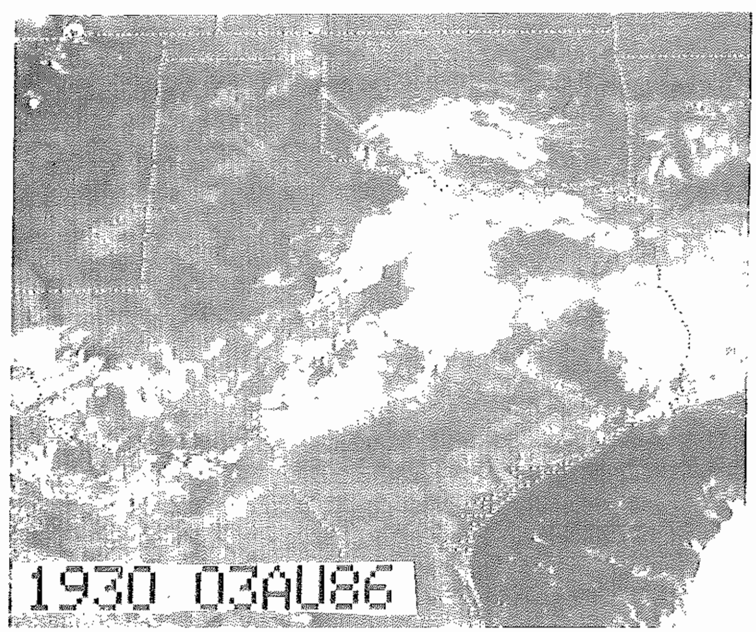


Figure 6, August 3, 1986.

AUGUST 11, 1986

DOWNBURST EVENT

Scattered thunderstorms occurred over eastern Texas during most of the afternoon without producing any reports of significant wind. By sunset, all thunderstorm activity had diminished except for one storm, located just east of Dallas. Strong winds were observed across all of Dallas and Tarrant counties between 830pm and 1000pm CDT. Redbird airport, RBD, located in south Dallas, recorded a wind gust of 50 knots at 904pm. By 930 pm the thunderstorm had dissipated, but strong outflow winds continued across Tarrant county until around 10 pm. Gusts of 30 to 40 mph were recorded at various locations in both Tarrant and Dallas counties. The extent of the strong winds suggest that this event was a macroburst, possibly with embedded microbursts.

500 MB ANALYSIS

At 0000 GMT August 12, 1986, north Texas was under northerly flow at 500 mb. The GGG sounding went through a thunderstorm and the data may not be representative of the pre-storm environment. A minor short wave trough was evident across southern Texas. Temperature data suggest weak cool advection was occurring across north Texas. With the weakness of the pattern, NMC numerical models showed no significant upper level trigger mechanism over north Texas.

SURFACE ANALYSIS

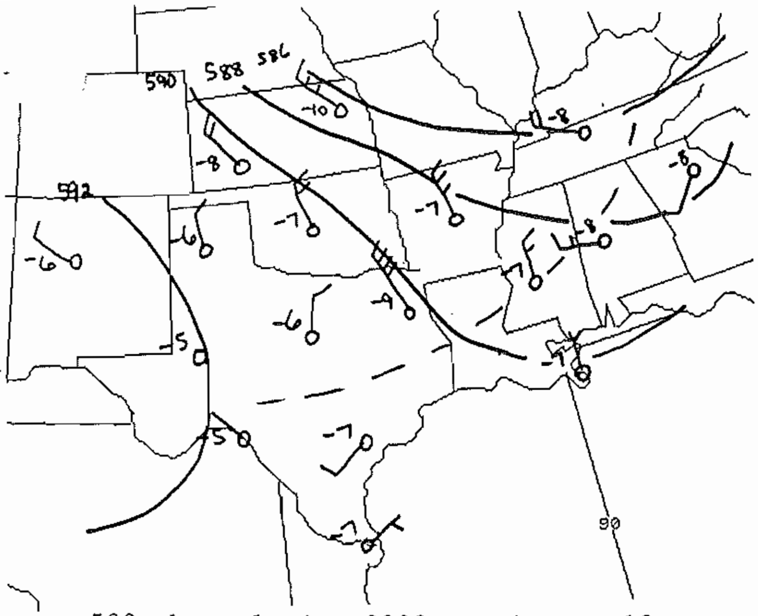
A very weak surface pattern existed over north Texas and surrounding areas early on the 11th. The only feature evident was a weak east-west trough across north Texas. However, temperature and dewpoint varied little across the trough. During the day scattered thunderstorms developed in somewhat more unstable air across southeast and east Texas. These became organized enough to produce an area of rain cooled outflow. By 0000 GMT August 12, the boundary had intersected the weak trough over north and northeast Texas (fig 7b). By this time a fairly strong temperature gradient had developed between the raincooled air to the south and warm air to the north. An axis of 70+ dewpoints had developed centered on the north-south portion of the outflow boundary. The downburst producing thunderstorm formed at the intersection of the trough and outflow boundary.

SOUNDING

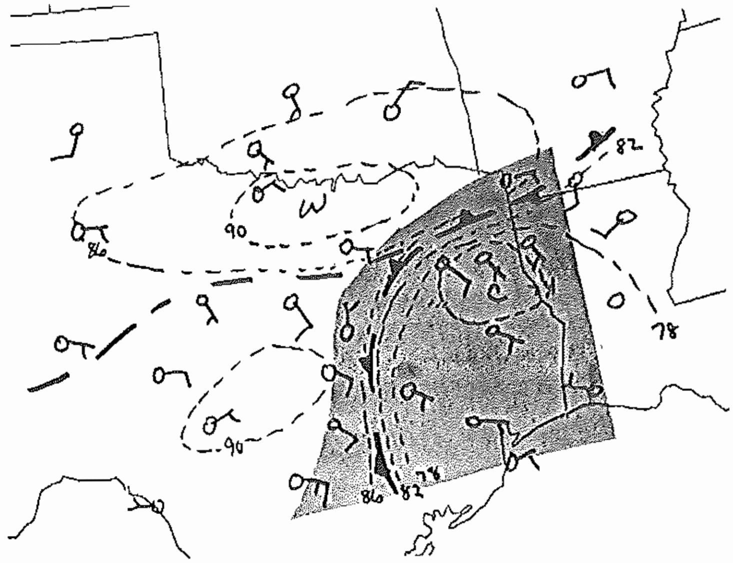
Figure 7c shows the 0000 GMT August 12 sounding for SEP. The surface air at SEP was somewhat drier than near the developing thunderstorm. Using pre-storm temperature and dewpoint of 88 and 71, the sounding yields a surface based LI of -5 and a CCL of 3500 AGL. The sounding consisted of only a moderate dry adiabatic sub cloud layer, a somewhat moist middle layer and dry air in the upper levels.

WIND ESTIMATES

W..55 kts, F..43 kts, M-F..60 kts.

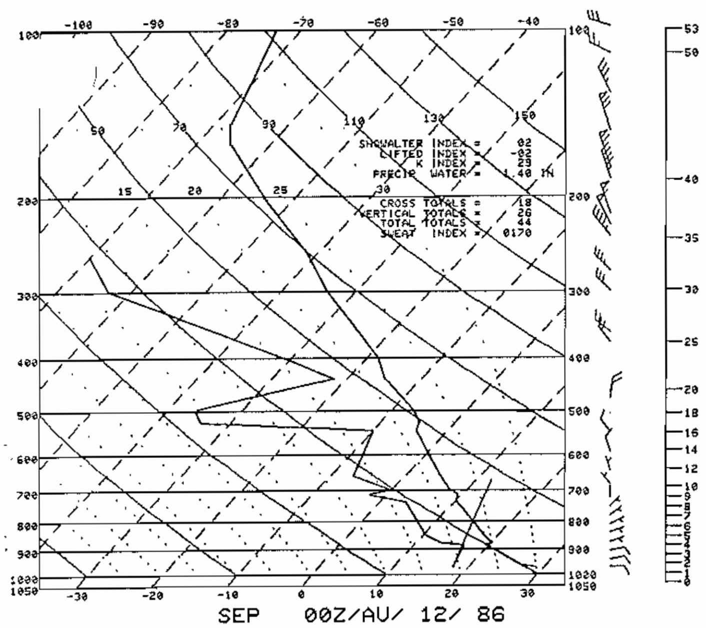


a. 500 mb analysis, 0000 GMT August 12.



b. Surface analysis, 0000 GMT August 12.
Shaded Area - Dewpoints ≥ 70°C

c. Stephenville sounding, 0000 GMT
August 12.



d. Infarared satellite imagery, 0130 GMT
August 12.

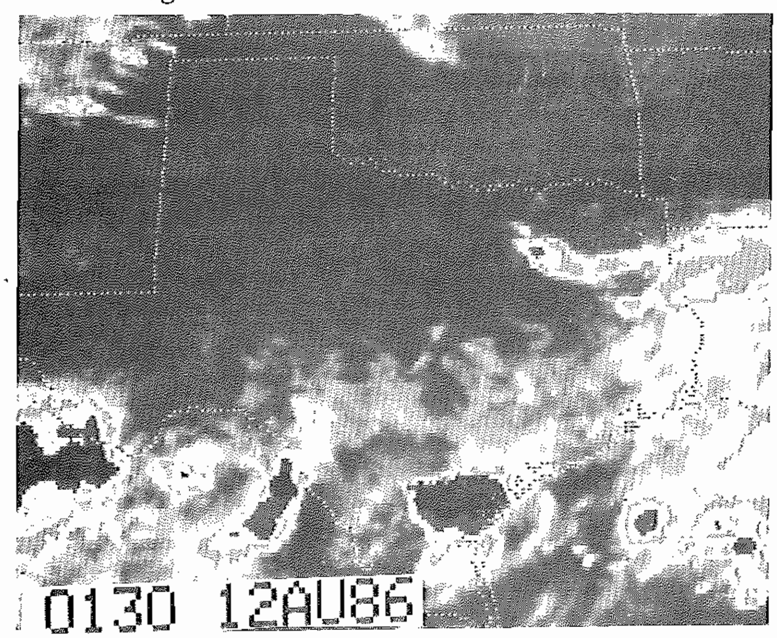


Figure 7. August 11, 1986.

AUGUST 18, 1986

DOWNBURST EVENTS

Thunderstorms developed after 1pm CDT along a weak surface trough from near ACT southeastward to southwest Louisiana. Between 2pm and 6pm CDT several downbursts were reported. The first occurred in Lufkin, with gusts estimated at 50 knots. Between 5 and 6 pm CDT, strong thunderstorms occurred near Chilton in Falls county, just south of ACT, and in the Bryan-College Station area, which is just south of north Texas. Winds were estimated to be at least 60 knots in both storms.

500 MB ANALYSIS

Figure 8a shows selected 500 mb features at 1200 GMT on August 18. North Texas was under northeasterly flow aloft with a strong high pressure cell centered over the central Rockies and a rather deep trough of low pressure over the eastern United States. No short wave features were evident in the flow. The -7 degree temperatures at 500mb were slightly cooler than normal. As expected, NMC numerical progs showed no upper level convective trigger mechanisms.

SURFACE ANALYSIS

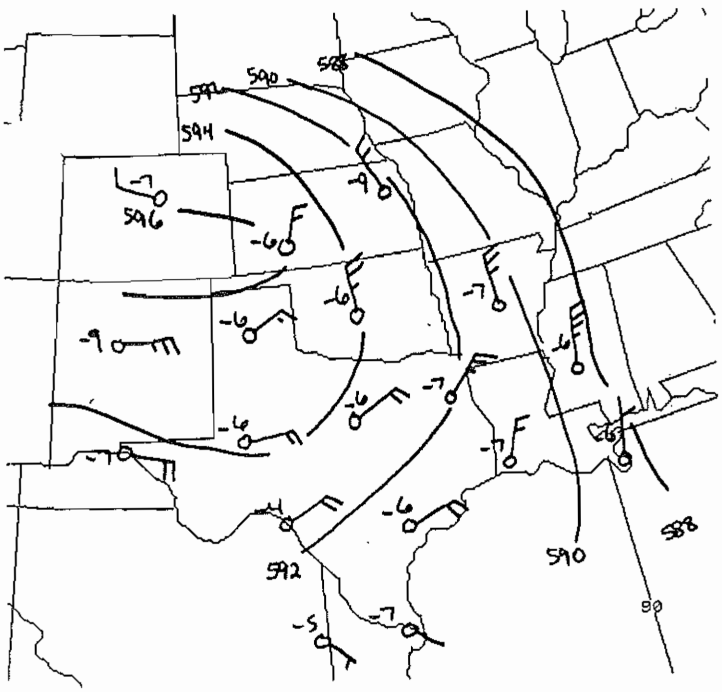
Figure 8b shows selected surface data and analysis at 2000 GMT. A weak trough, detectable both in the wind and pressure field, extended from central Oklahoma south-southeastward to near the Texas-Louisiana border. Dewpoints were somewhat higher along the trough line, with mid 70 readings extending inland to near Waco. Temperatures ranged from the lower 90s over northeast Texas to the low 100s just west of the trough. The temperature gradient was rather weak for this case. The downburst thunderstorms formed along the trough where the moist axis and hottest temperatures coincided.

SOUNDING

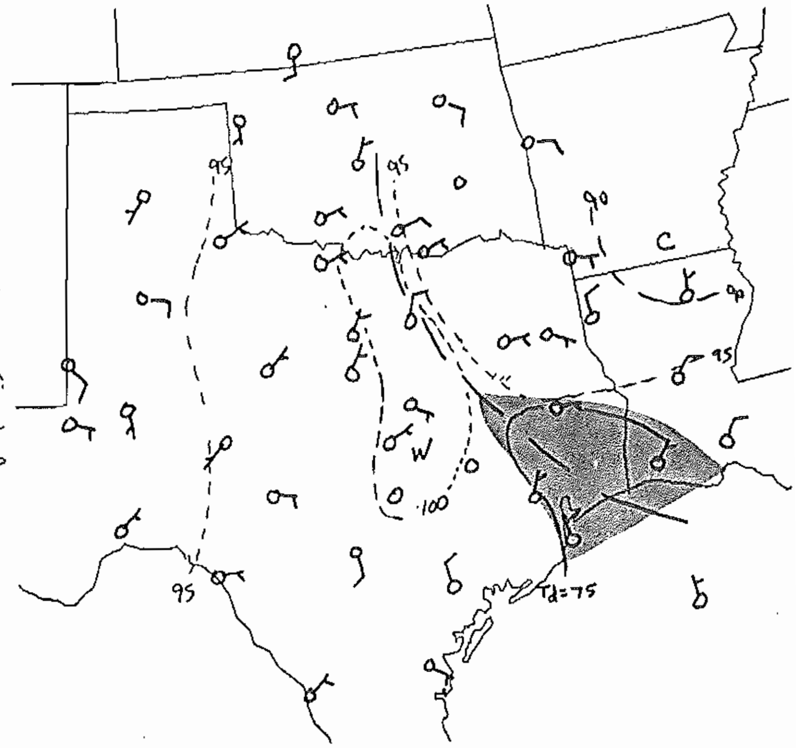
Figure 8c shows the 1200 GMT sounding for GGG. The most notable features are the high potential instability and the lack of low level capping. Plugging pre-storm temperature and dewpoint of 99 and 70 degrees into this sounding resulted in surface based LI of -8 at 500 mb and an incredible -15 at 300 mb. The CCL was 6000 feet AGL. The sounding consisted of a rather deep sub-cloud dry adiabatic layer, a shallow moist mid layer and dry air aloft.

WIND ESTIMATES

W..74 kts, F..56 kts, M-F..82 kts.

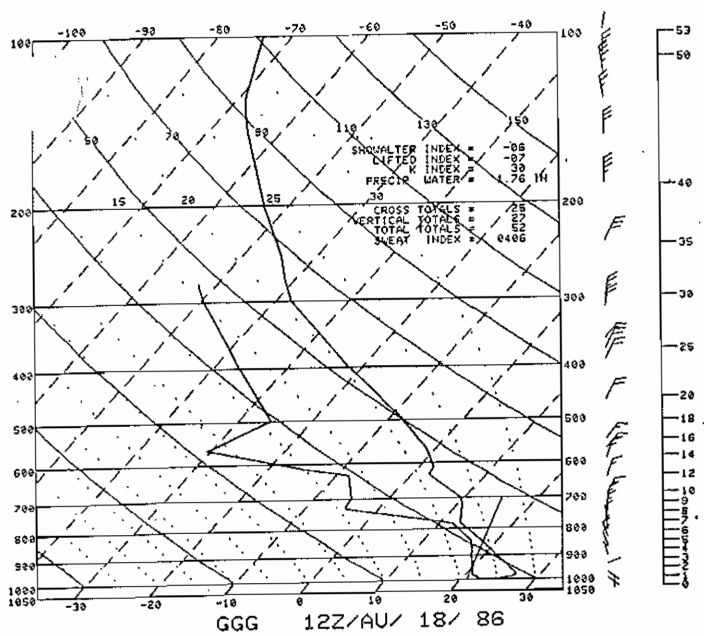


a. 500 mb analysis, 1200 GMT.



b. Surface analysis, 2000 GMT. Shaded Area - Dewpoints ≥ 75°C

c. Longview sounding, 1200 GMT.



d. Infrared satellite imagery, 2200 GMT.

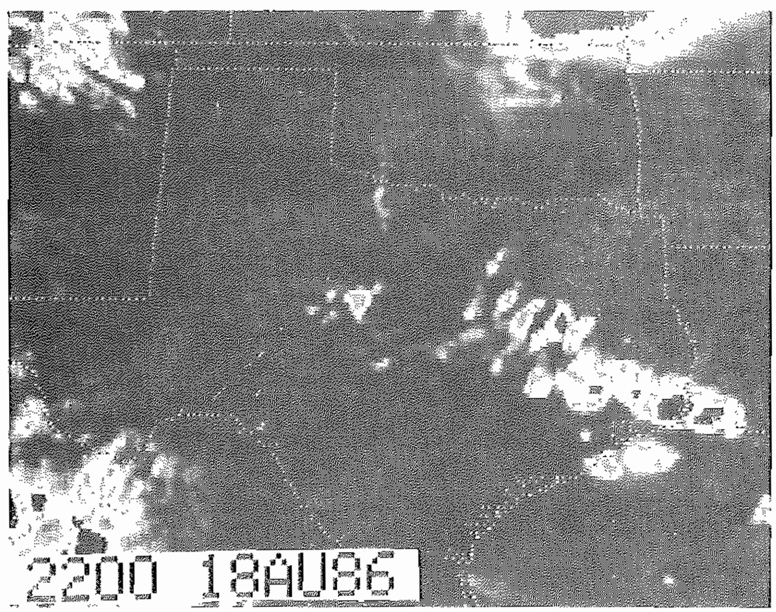


Figure 8. August 18, 1986.

DISCUSSION

1. COMPARISON OF EVENTS

Table 1 compares various features for the 8 downburst events. With the exception of two thunderstorms, the summer downbursts occurred during the mid to late afternoon, or around time of maximum heating. This should come as no surprise. The two evening events were unique in that damage and/or wind reports indicate that these were macroburst in scale, whereas all the others were very localized, or microburst in scale. The reported maximum wind speeds were all between 50 and 65 knots. Given the scale of the events, some underestimation is likely.

The downburst days occurred under a variety of 500 mb patterns. Three of the events occurred within a subtropical ridge, usually considered a stable, non-convective pattern. Two events occurred under north to northwest flow aloft with no detectable short wave features. The other three events occurred in association with short waves in northwest flow. The variability of patterns under which downbursts occurred suggests that 500 mb is not the level to search for forecast clues to these events.

Perhaps the most interesting feature in this comparison of events is the existence of a significant surface boundary. In all cases, the downburst producing thunderstorms formed just on the warm side of the boundary. Five of the events formed near the intersection of two boundaries. The boundaries developed in two different ways. Some were the result of decaying nocturnal convection over Oklahoma. The others evolved from early, non-severe convection. In each case, moisture increased along the boundary resulting in a pool of higher dewpoints located adjacent to an axis of higher temperatures. This combination along with convergence along the boundary likely served to enhance intense convective development.

On days where no such boundary evolves, no pool of moisture or sharp temperature gradient develop. The lack of a boundary also precludes large scale surface convergence. Thunderstorms that develop on these days would tend to be less intense, all else being equal.

A preconception concerning summer downbursts in north Texas was that the maximum temperature had to exceed normal. The normal high temperature from late June through August is generally in the mid to upper 90s. On five of the downburst days the maximum temperature was actually below normal. The other three cases occurred with near normal temperatures.

The soundings for these events explain why excessive high temperatures were not required for intense convection. For 7 of the events virtually no mid level capping was present, thus convection initiated at a lower temperature. The sounding for the August 2nd

FEATURE	EVENT							
	6/23	6/24	6/28	7/21	8/2	8/3	8/11	8/18
LOCAL TIME	4-6PM	5-6PM	3-5PM	5-7 PM &10PM	3-4PM	2-5PM	8-10PM	2-6PM
MICRO/ MACRO	MICRO	MICRO	MICRO	MICRO/ MACRO	MICRO	MICRO	MACRO	MICRO
WIND MAX (KTS)	55	55	60	60	65	60	50	60
500 MB PATTERN	WITHIN RIDGE	WITHIN RIDGE	S/W NWF	WITHIN RIDGE	S/W NWF	S/W NWF	NWF NO S/W	NLY FLO NO S/W
WARM SIDE SFC THERMAL BDRY.	YES	YES	YES	YES	YES	YES	YES	YES
INTERSECTING SFC BOUNDARIES	YES	NO	NO	YES	YES	YES	YES	NO
MAX TEMP	95	91	96	98	99	91	88	99
SFC BASED 500 MB LI	−6	−6	−6	−9	−9	−9	−5	−8
DEPTH OF SUBCLOUD DRY ADIABATIC LAPSE RATE (FT)	6000	6000	5500	7000	8000	5000	3500	6000
POTENTIALLY COOLER AIR ABOVE MOIST LAYER	YES	YES	YES	YES	NO	YES	YES	YES

TABLE 1

case probably underwent considerable change between 1200 GMT and onset of convection.

Modifying the 1200 GMT soundings by inputting the surface temperature and dewpoint at onset of convection showed that all cases were quite unstable. Surface based afternoon LI ranged from -5 to -9. For each case, the modified sounding indicated a rather deep subcloud dry adiabatic layer, ranging from 5000 to 8000 feet for the daytime events. This feature may play an important role in downburst generation.

2. DOWNBURST GENERATION

The soundings for north Texas downburst events do not fit neatly into either the dry or wet microburst models as presented by Caracena (1986). Soundings for most events appear to exhibit characteristics of both. Figure 9 is a conceptual model (not a composite) of soundings for north Texas downbursts at the time of onset. Although there may be considerable variability in the finer points from one event to another, the main features are most likely similar. The surface to about 6000 foot dry adiabatic layer resembles that of the dry microburst (fig. 10). The 6000 to 14000 foot relative moist layer with an elevated dry, potentially cool layer aloft resembles the model for a wet microburst (fig. 11). Of course, all the north Texas events were wet microbursts in that considerable precipitation reached the ground.

The effects of having features of both conceptual models in the north Texas soundings could very well be additive. The combination of penetrative downdrafts from aloft with the negative buoyancy generated from evaporation in the subcloud layer helps explain the consistently strong winds observed with these type of microbursts. A third effect, water loading, may also play a role in downburst generation for the north Texas events. This effect is generally downplayed as minor in other studies, for good reason. The high plains dry microburst occurs with soundings showing rather low water content and only moderate at best instability. The wet microburst events also occur under moderate instability, thus updrafts in these storms are not likely to be sufficient to hold large quantities of water aloft.

The north Texas events occur under quite different circumstances. The soundings at onset exhibit considerable instability and moisture. The positive area on the soundings indicate the potential for very intense updrafts, capable of holding considerable water aloft. The downrush of water when this updraft collapses may contribute significantly to downburst wind generation. The observed 9 inch per hour rainfall rate from the August 3rd storm attests to the incredible amount of water coming down in these events. Radar gives further evidence that water loading may be a factor for these events. For several events the radar operators noticed considerably larger VIP aloft prior to the observed downburst. One should remember, however, that many heavy rainfall producing thunderstorms produce little or no downburst winds.

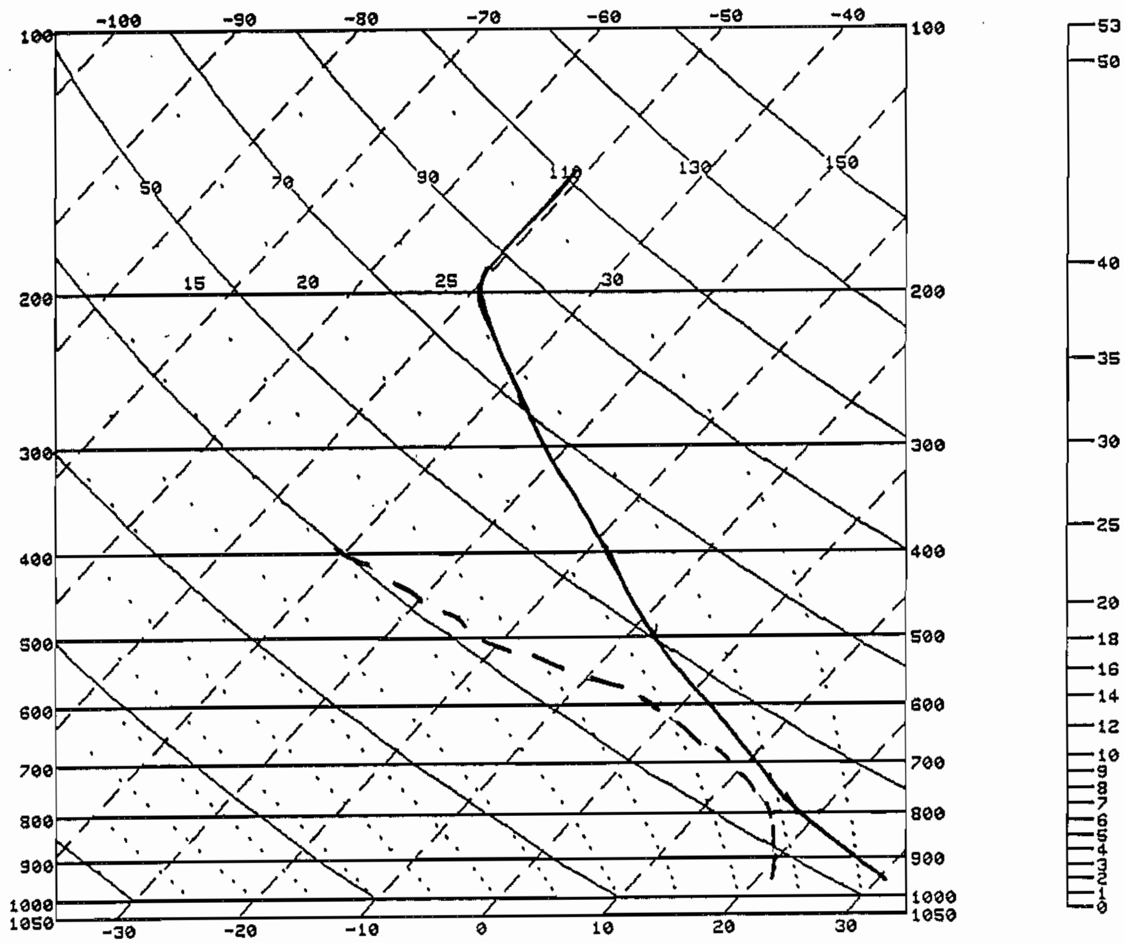


Figure 9. Conceptual sounding for north Texas potential downburst days at time of onset.

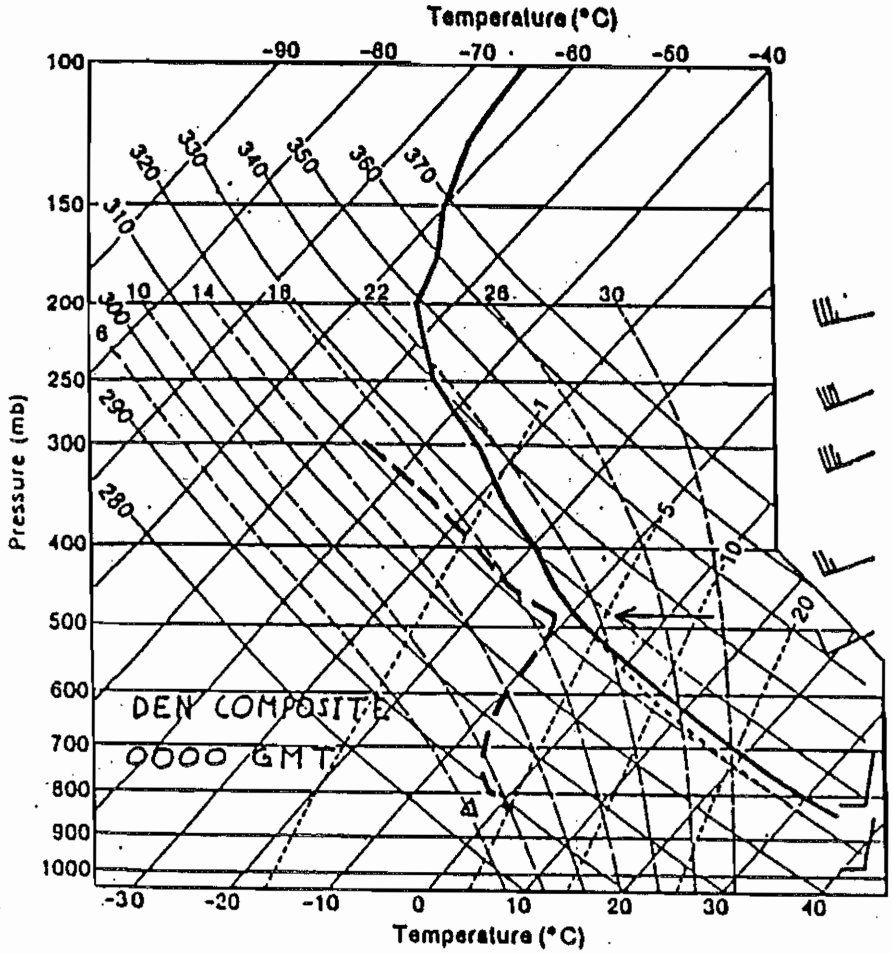


Figure 10. Example of a dry microburst sounding (from Caracena 1986)

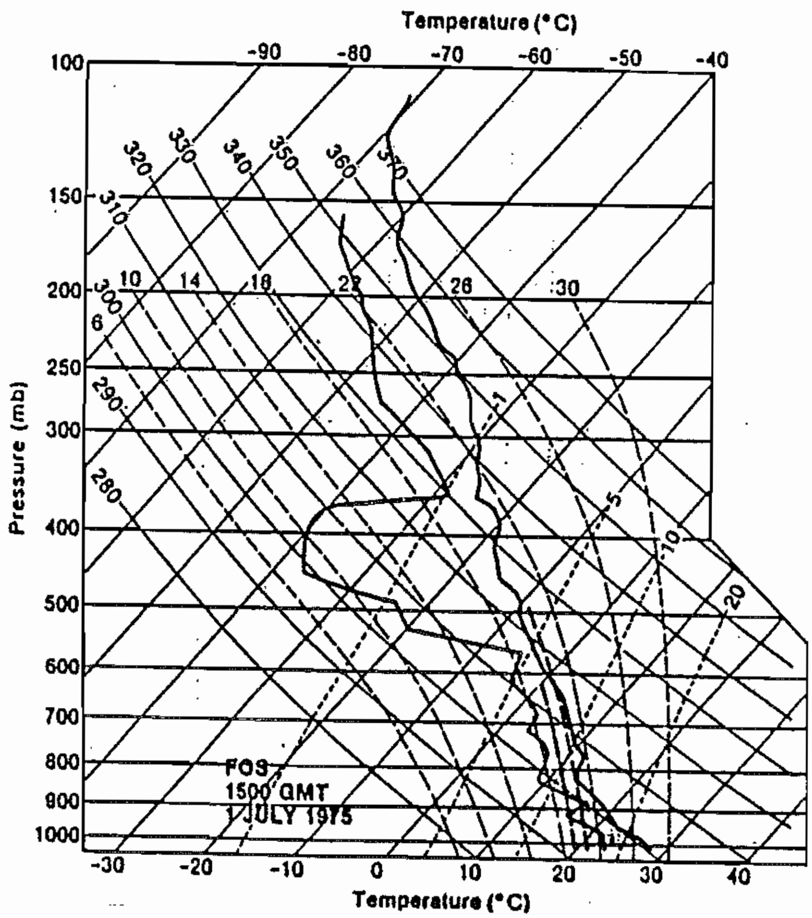


Figure 11. Example of a wet microburst sounding (from Carecena 1986)

3. FORECAST IMPLICATIONS

Several features observed during the 1986 study suggest possible short range forecast skill for potential downburst days. First, 1200 GMT soundings need to be modified by inputting expected afternoon surface temperatures and dewpoints. Using the modified sounding, keys for potential downbursts are:

1..large positive area.
2..little or no capping inversion.
3..dry adiabatic layer below CCL at least 5000 feet deep.
4..moist mid layer, between 5000 and 15000 feet.
5..elevated dry layer above 15000 feet.

The second factor the forecaster should consider is the existance or forecast development of a significant thermal boundary. Hourly mesoanalysis should be done on days when the soundings are favorable. Once the boundary develops, forecasts should be updated to include the possibility of strong thunderstorm winds. For example, a zone could read ..."scattered thunderstorms...locally damaging wind possible...."or an FT could read ..."FTW FT 031818 60 SCT CHC C10 X 1/2T+RW+G55...
While warning for these events may be very short fused, the above forecasts should heighten the users awareness to the potential.

FUTURE STUDY

This study has concentrated on forecasting days favorable for downburst development. More work needs to be done now on warning aspects of these downbursts. The radar observations for two events show some promise in this area. The presence of high VIP aloft prior to onset and the persistence of the cells that later produce the downburst may, if this happens for most events, lead to a technique for advance warning. This aspect will be studied further for the 1987 season.

The soundings for these events showed a need for further refinements to the conceptual models on downbursts. An effort will be made to work with the ERL community on this aspect.

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Report on the Mustang Downburst of 26 July 1986

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WSFO Oklahoma City

1. Meteorological Conditions

The synoptic-scale setting on the morning of 26 July was a far cry from the type usually associated with severe weather in Oklahoma. At 500 mb (FIG. 1a), a ridge was oriented WSW-ENE across northern Texas, with weak westerly flow aloft over Oklahoma. The temperature field indicates slightly cooler air aloft advecting into Oklahoma, a condition sometimes known to increase mid-level instability and thereby enhance the prospects for thunderstorm development. However the 500 mb analysis valid 12 hours later (7 pm CDT, or about 3 hours after the Mustang storm) shows that temperatures warmed by about 2 C over Oklahoma during the period (Fig. 1b). The ridge evolved into a closed high centered over north central Texas, while winds aloft dropped to less than 10 mph over central Oklahoma. The pattern shown is more indicative of one that would normally suppress thunderstorm development in the vicinity of the high center.

Conditions at the surface were more favorable for thunderstorm development. Earlier thunderstorms in Kansas left a well-defined outflow boundary lying east-west across central Oklahoma. By mid-afternoon (Fig. 2a) this boundary was approaching the Oklahoma City and Mustang areas slowly from the north. Surface temperatures ahead of the boundary were 100 or more, with dewpoint temperatures in the upper 50s and lower 60s. But behind the boundary, the combination of cool thunderstorm outflow air and cloud cover left temperatures in the upper 80s and 90s across northern Oklahoma. Moisture was more plentiful in the cooler air, with dewpoints near 70 degrees north of the boundary. Conditions on both sides of the boundary were sufficiently unstable to support thunderstorm development. However, the contrasting air masses and converging surface winds along the boundary identified the zone along the boundary as the most likely area for new development. The Mustang storm developed in this zone shortly after 3 pm (Fig. 2b).

During the two-hour period preceding the Mustang storm, the dewpoint at Oklahoma City dropped six degrees, yielding a dewpoint depression (temperature minus dewpoint) of 40 degrees. A high dewpoint depression is often observed prior to the occurrence of thunderstorms with damaging (downburst-type) winds.

The overall meteorological setting included a) weak flow aloft, with a 500 mb ridge nearly overhead; b) hot surface temperatures (above 100 degrees); c) dewpoint temperatures around 60 degrees, resulting in a large dewpoint depression; d) the close proximity of a front or outflow boundary, and e) the presence of cooler but more moist air behind the boundary, resulting in a pronounced air mass discontinuity along the boundary.

2. Chronology

The following is a time sequence of events that occurred during a one-hour period surrounding the time of the Mustang storm. All times are CDT. (Abbreviations: OKC - Will Rogers World Airport. WSFO - Weather Service Forecast Office, located at the airport. VIP - Video Integrator and Processor; refers to radar intensity contours from 1 (light) to 6 (very heavy).)

320 PM - Small isolated thunderstorm cell first detected by WSFO radar. Cell located 12 miles WNW of OKC, top 35 thousand feet, maximum VIP level 3.

329 PM - Cell is visible to WNW of WSFO. Heavy rain shaft has sharp, well-defined south edge, with evidence of "curling" motion near ground. This pattern often seen in connection with downbursts.

330 PM - WSFO advises OKC Approach Control that cell 8-10 miles WNW of OKC shows visual indication of microburst winds; recommends air traffic be kept at a safe distance from cell.

331 PM - Thunder begins at WSFO.

335 PM - Cell still shows visual evidence of microburst winds. WSFO issues Local Airport Weather Advisory (LAWA) for OKC area valid until 430 PM. Advisory indicates isolated thunderstorm cell 7 WNW OKC moving SE at 15 mph. Hail to 1/2 inch and wind gusts to 55 knots (63 mph) possible. Microburst winds also possible.

336 PM - WSFO notifies OKC Approach Control of LAWA. Approach Control advises that observer at Wiley Post Airport (9 NNW OKC) can see blowing dust from strong outflow near cell.

338 PM - WSFO informs FAA duty officer of LAWA.

340 PM - WSFO transmits LAWA via RCA computer to McAlester FSS, Wiley Post Airport, Tinker AFB, and OKC tower.

342 PM (approx.) - NWS Tulsa advises WSFO that their radar indicates cell W of OKC with top to 56 thousand feet. Maximum VIP level 4.

346 PM - Cell due W of OKC, moving SE. SW wind increases to 20 knots with gusts to 27 at WSFO.

350-415 PM - Cell moving toward S end of OKC runway 17R-35L, although heaviest precipitation core remains WSW of airport. Frequent cloud-to-ground lightning observed overhead and SW at WSFO. At least two commercial jets observed taking off on runway 17R during this time.

400 PM - NWS radar in Tulsa indicates cell top down to 48 thousand feet. Maximum VIP level 2, but radar beam being partially blocked by new cell developing NE of OKC.

401 PM - NWS employee advises WSFO of WNW winds in excess of 60 knots (69 mph) at his home in Mustang (7 W OKC). Gust to 91 mph recorded at Mustang City hall at same time.

403 PM (approx.) - Above report (60 kts.) relayed by WSFO to OKC Approach Control.

405 PM (approx.) - WSFO radar indicates cell decreasing in intensity. Decision is made not to issue severe thunderstorm warning, since storm has likely dropped below severe levels.

412 PM - Peak gust of 28 knots from SW recorded at WSFO.

420 PM - Report of 91 mph gust at Mustang City Hall reaches WSFO via CD radio.

422 PM (approx.) - WSFO updates OKC Approach Control: cell SW of OKC has top to 45 thousand, other cell NE of OKC has top to 48 thousand. Both cells moving SE and decreasing in intensity. LAWA will not be extended past 430 pm.

3. Damage Survey

A ground survey of storm damage was conducted on the evening of 26 July, roughly 3 hours after the storm. Participating were Arlon Hadlock, Fire Chief and Civil Defense Director for the City of Mustang; Gary Shidell, Assistant Civil Defense Director; and myself. The survey, while by no means exhaustive, included tours of the more heavily-damaged residential areas in west Mustang, as well as discussions with several residents who experienced damage to their property.

Detailed information regarding storm damage follows. Refer to the reference maps (Figs. 3 and 4) for locations. As can be seen in Fig. 4, damage was concentrated in an area 6 to 8 miles due west of Will Rogers World Airport.

Location A. Day Care center on Mustang Road: Roughly one-fifth of roof covering ripped off NW corner by high winds and deposited on ground around car canopy on front (E) side of building. Damage to roof allowed heavy rains to enter building, resulting in considerable water damage to interior rooms. First Baptist Church (across the street): Facade on front (W) side collapsed by high winds. In both cases, damaging winds came from WNW.

Location B. Residence of NWS employee is reported winds over 60 knots shortly after 400 pm (see previous section). Minor damage in area. Damaging winds came from WNW, but winds shifted to E at 30 to 40 knots shortly afterward.

Location C. Mustang City Hall: Wind equipment on roof recorded gust to 91 mph at 401 pm. Loose objects in fire station blown out through doors opened by high winds; otherwise only minor damage in area. Winds came from WNW.

Location D. Whippoorwill subdivision: Widespread damage to shingles and wooden fences. One home lost front porch roof and a portion of adjacent garage roof. Damage to some trees and chimneys, but charred marks on trees indicate that some of this damage was the result of lightning strikes. Debris trails indicate damaging winds came from about 240 degrees in north end of area, and from about 270 degrees (due W) in south end. Some fence components traveled several hundred feet.

Location E. Just south of Whippoorwill subdivision: Semi trailer, oriented N-S, blown on its side. Nearby 22-foot camper overturned rolled about 40 feet and destroyed by winds estimated from 280 degrees.

Location F. Lakehoma subdivision: Large tree limbs (diameter 1 foot) snapped off and blown onto house, resulting in minor roof damage. Damage appeared to be wind related, although other nearby trees with similar damage showed char marks indicative of lightning. Winds came from N.

Location G. Lakehoma subdivision, several homes NE of location F: Metal outbuilding blown from foundation, turned around 180 degrees, and destroyed. Several large branches (diameter about 9 inches) snapped from large tree nearby. Damage resulted from a NE wind.

Location H. Johnson Way: Several outbuildings heavily damaged or destroyed. Considerable damage to several sheds, with metal roof and siding components torn off and blown about 100 feet. Rear porch ripped from one home and blown up over the home; parts landed in front yard and driveway, resulting in heavy damage to windshield and dashboard of one vehicle. Damaging winds came from E.

The survey indicated that damage was entirely due to straight-line winds; in no case was there evidence of rotation indicative of a tornado. However the damage clearly reveals a divergent or "starburst" wind pattern radiating from a point just northwest of the intersection of State Highway 92 and 152 in west Mustang (point X in Fig. 3). This pattern strongly indicates that a small scale downburst, or microburst, descended to the ground at this point. (Point X lies in an open field, where only an areal survey would be able to provide more detail.)

There is also evidence that a larger downburst came to the ground earlier in the storm's life cycle, probably somewhere N or NW of Mustang, and also contributed to wind damage in the Mustang area. This conclusion is based on several factors. To begin with, recall from the previous section that visual evidence of downburst-type winds was observed from OKC as early as 329 pm, or one half hour before the damaging winds struck Mustang. Secondly, there were reports of wind damage near the intersection of Highway 92 and SW 29th Street, or about 3 miles north of point X in Fig. 3. Time constraints precluded a survey of this damage. However the parent thunderstorm was close to this area when the first visual evidence of a downburst structure was noted. Finally, damaging winds in downtown Mustang (E of point X) were predominantly from the WNW. This pattern suggests that the strong winds at points A through C in Fig. 3 were not entirely created by the microburst, but may have arisen in part from a larger downburst that developed earlier.

A downburst is defined as a strong downdraft which induces a outburst of damaging wind on or near the ground. The term microburst is used to describe a downburst of small horizontal dimensions (2.5 miles or less). The survey results indicate that the damage to the Whippoorwill and Lakehoma subdivisions was caused by what is known as an outflow microburst. A simplified diagram of this phenomenon is shown in Fig. 5. Note the radial wind flow at the surface away from the point of ground contact, and the similarity of the pattern to the damage pattern shown in Fig. 3.

The extent and severity of the damage indicate that the Mustang storm rated a strong F1 on the F scale of damaging winds. This classification indicates that wind speeds were between 73 and 113 mph in the damaged areas, so the 91 mph gust recorded at the City Hall is quite reliable. Furthermore, the worst and most concentrated wind damage occurred in connection with the microburst near point X, or about 2 miles west of the city hall. It is reasonable to conclude that wind speeds were even higher in this area, with gusts of 100 to 110 mph having likely occurred near point X.

For further information on downbursts, refer to The Downburst: Macroburst and Microburst by Dr. Ted Fujita, University of Chicago.

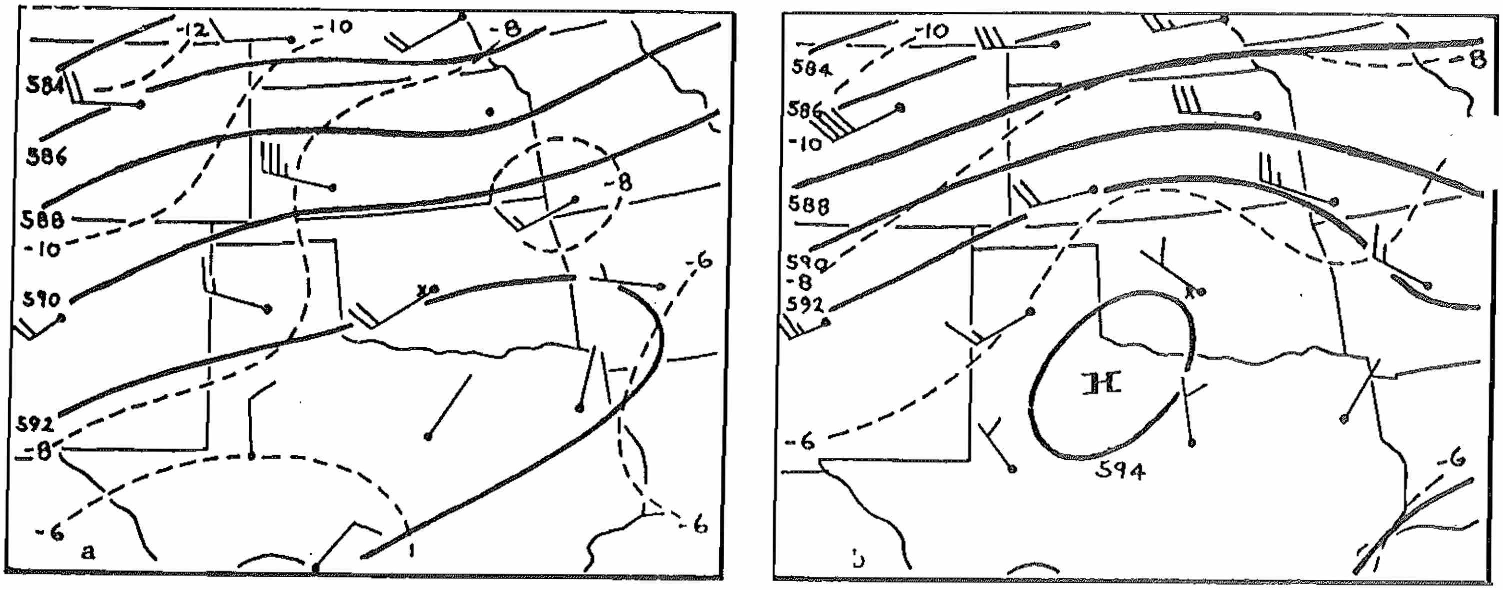

Fig. 1. 500 mb analyses valid at 700 AM CDT (1200 GMT) 26 July 1986 (a), and at 700 PM CDT (0000 GMT 27 July) (b). Solid: height contours every 2 decameters. Dashed: temperature every 2°C. Winds are plotted conventionally; full barb equals 10 knots. X indicates location of Mustang.

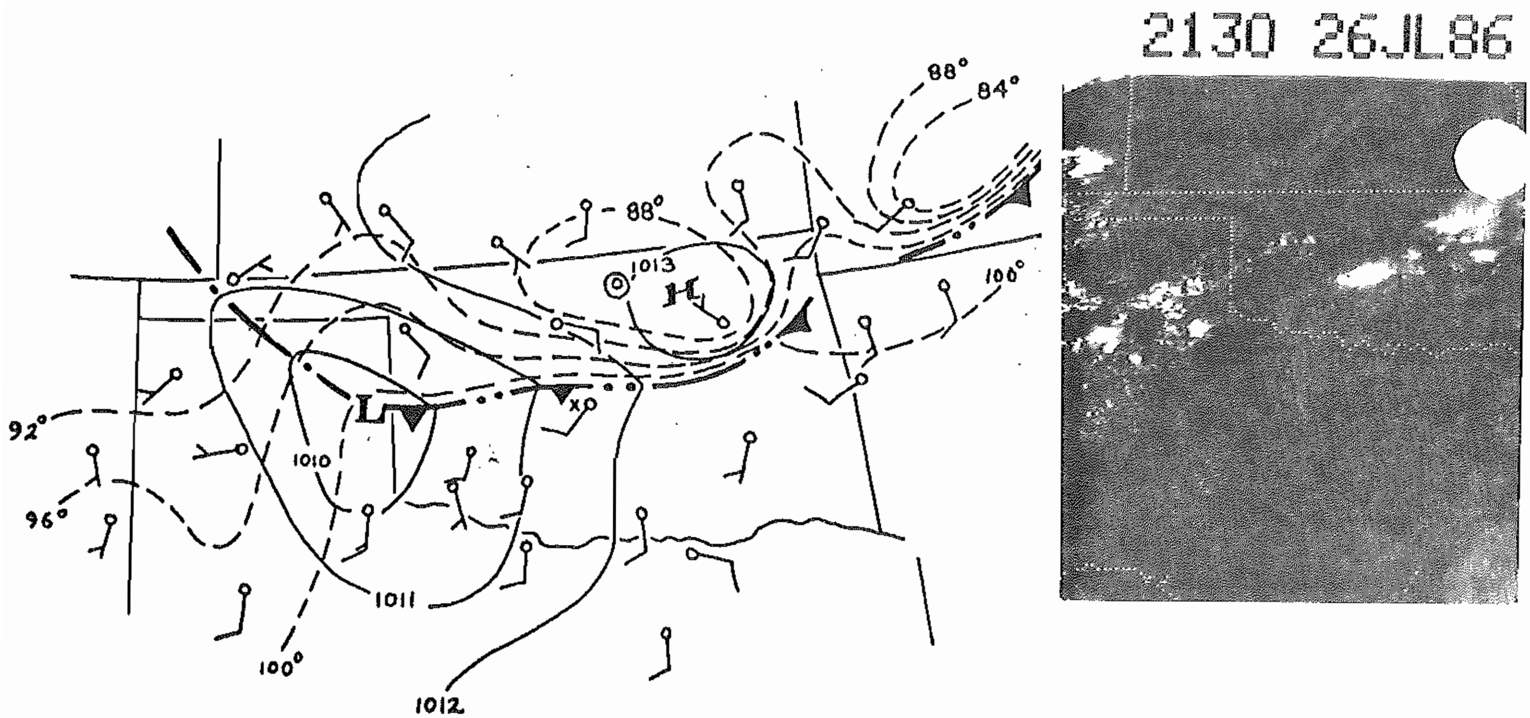

Figure 2. a) Surface analysis valid at 300 PM CDT (2000 GMT) 26 July. Solid: msl pressure every mb. Dashed: temperature every 4° F. Winds are plotted conventionally. X indicates location of Mustang. b) Satellite Image

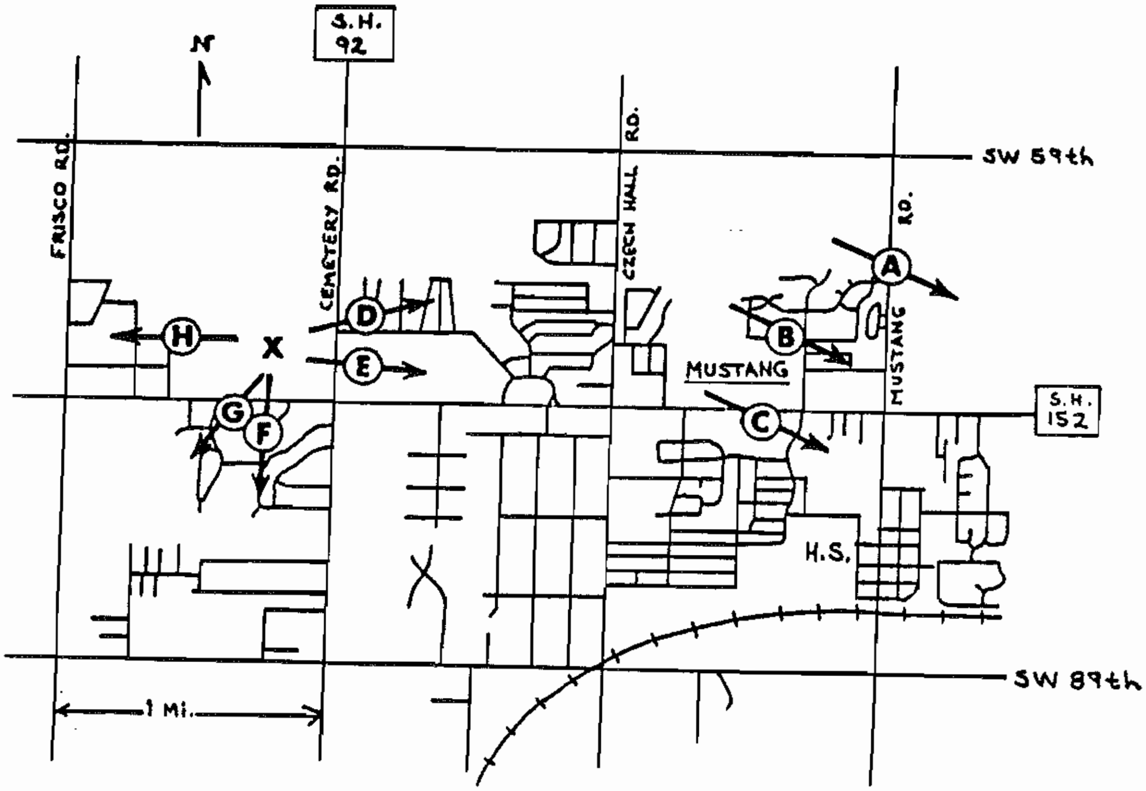

Fig. 3. Street map of Mustang, showing locations of key damage points. Arrows indicate wind directions based on damage survey. See text, section 3, for details.

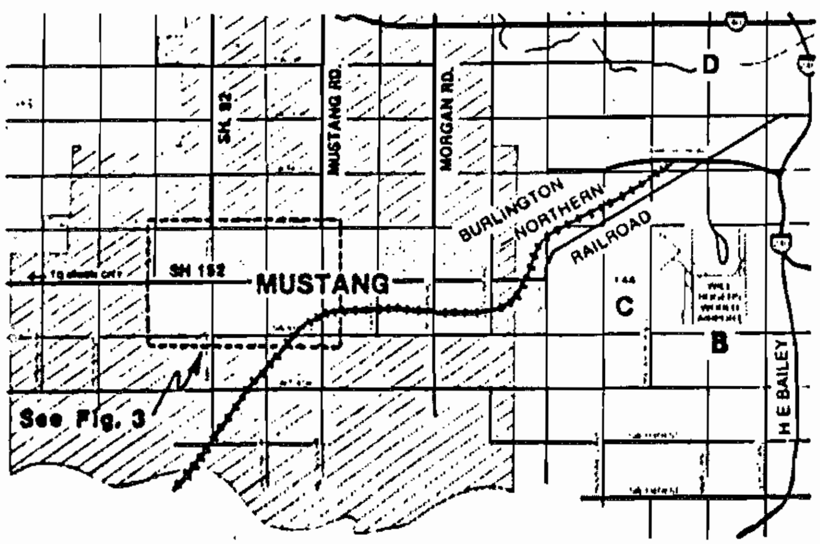

Fig. 4. Map showing location of Mustang relative to Will Rogers World Airport (B).

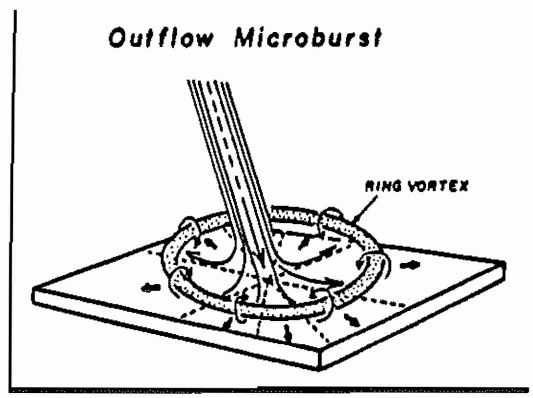

Fig. 5. Simplified model of an outflow microburst, showing radial or "starburst" surface wind pattern.

MEMPHIS MICROBURST of 18, July 1986

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This case study of a microburst which occurred over southern Memphis on July 18, 1986 will describe the factors that produced this intense storm. Attempts will also be made to determine if such an event can be forecast, and if so, how much lead time can be given.

On July 18, 1986 around 5:30 pm CDT a thunderstorm produced a downburst just to the southwest of the Memphis International Airport, Tennessee. The maximum wind gust observed at the airport by the Memphis Flight Service Station was only 34 knots. However, based on extensive tree damage, and minor damage to roofs and signs, wind speeds near 60 knots are likely to have occurred just southwest of the airport. The areal extent of damage was approximately 4 km in size. Based on the Fujita Planetary Scale, (The Downburst, 1985 chapter 2, p.9), this event can be classified as a microburst. Heavy rain was also associated with this microburst which correlates with other cases.

The satellite interpretation message issued midday on July 18th by Kansas City identified a tropical wave from Baton Rouge, Louisiana to Oxford, Mississippi moving west at 15 knots. This wave was moving along the southern periphery of a large high pressure system centered over central Tennessee and which covered the middle Mississippi River Valley (Fig. 1a). Southwest Tennessee was on the northern fringes of the tropical wave. However, including the tropical wave, ingredients were available for isolated to widely scattered thunderstorms. Ingredients available for thunderstorm development were as follows:

(1) Adequate moisture- the 12Z NGM analysis (Fig. 1b) showed mean relative humidity greater than 50% extending from the Gulf of Mexico northward to West Tennessee in association with the tropical wave.

(2) The 12z upstream sounding at Nashville found a Lifted Index of -3.3 and K-Index of 27.8.

(3) Full sunshine with intense heating (maximum temperature reached 100 degrees at the Memphis International Airport.)

All of these factors were identified by forecasters at Memphis before the event. Morning forecasts for Tennessee Zone 15 (which includes the Memphis Metropolitan Area) indicated a 20% chance of thundershowers during the day. In retrospect, 20% was probably too high.

By mid afternoon, scattered thundershowers developed over northern Mississippi and moved west at 10 knots. Around 5:30 pm, one thunderstorm moved along the southern edge of Memphis just to the southwest of the Memphis International Airport and produced a microburst. The temperature at the Memphis International Airport fell from 100 degrees to 82 degrees as the downburst occurred. Based on Fawbush and Miller (Bullentin of the American Meteorological Society,volume 35, Number 1, January, 1954) the difference between these two temperatures will support a peak gust near 55 knots at the airport. A greater temperature difference likely occurred to the southwest of the airport near the center of the microburst thereby supporting a higher peak gust.

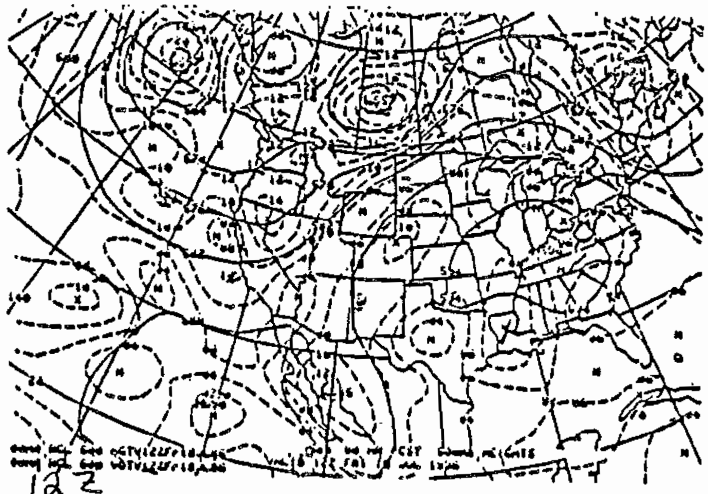
Figure 2 shows the satellite image from 2230Z. An accurate cloud precipitation top was not obtained for this storm due to the ground clutter surrounding the Memphis radar; however, cloud tops in thunderstorms over northern Mississippi averaged between 40,000 and 45,000 feet. The afternoon equilibrium level, based on the morning soundings, at Nashville and Little Rock were 42,000 and 40,000 feet respectively. Based on this information it is possible that the thunderstorm which hit Memphis surpassed the equilibrium level. This in turn, may have aided development of the microburst. Other factors in favor of microburst occurrence were observed on the 18th:

(1) The 12Z Nashville sounding (Fig. 3) showed a dry area around 500mb. This area advected westward during the day. The sounding also showed adequate low level moisture. This type of sounding is not unusual in the southeastern United States during the summer months.

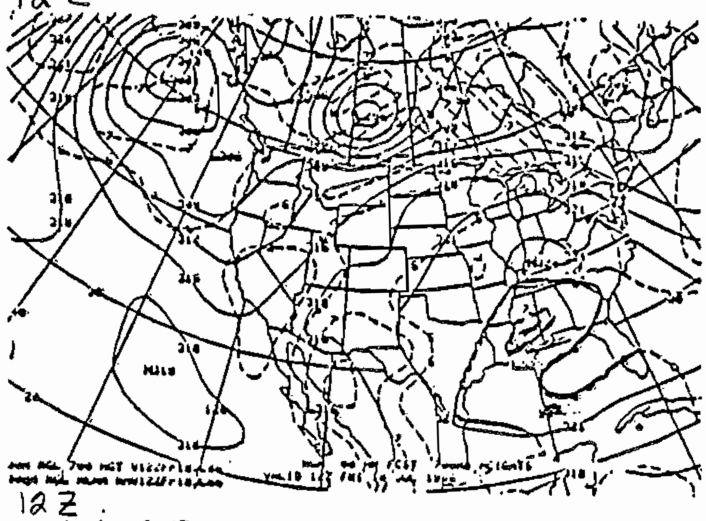
(2) The rapid decrease in surface temperature (18 degrees) was indicative of significant evaporative cooling aloft, which is associated with southeastern United States microbursts.

Based on the information provided in this case study, accurate forecasting of a microburst event is still beyond our capability due to the lack of a true micro network both at the surface and aloft. However, public awareness of microbursts can be increased by issuing timely weather statements which inform the public of the potential danger when thunderstorms begin to develop. Great care must be taken not to overwarn the public as these microbursts are a low probability event. A high false alarm rate, in our judgment, would create a serious lack of trust between the public and the National Weather Service.

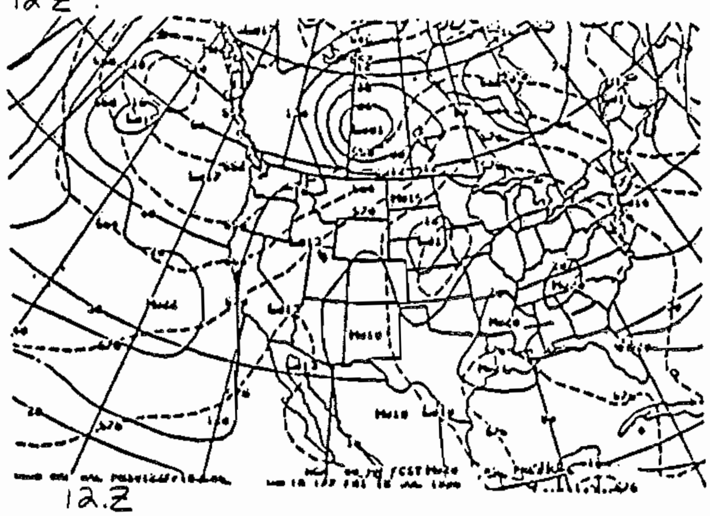
Figure 1a
(500 mb inverted trof from northern Louisiania to eastern Arkansas moved westward during the day)



1b
(Mean relative humidity was greater than 50 percent over southwest tennessee)



1c
(Surface chart indicated a weak trof over west Tennessee and another trof over central Mississippi)



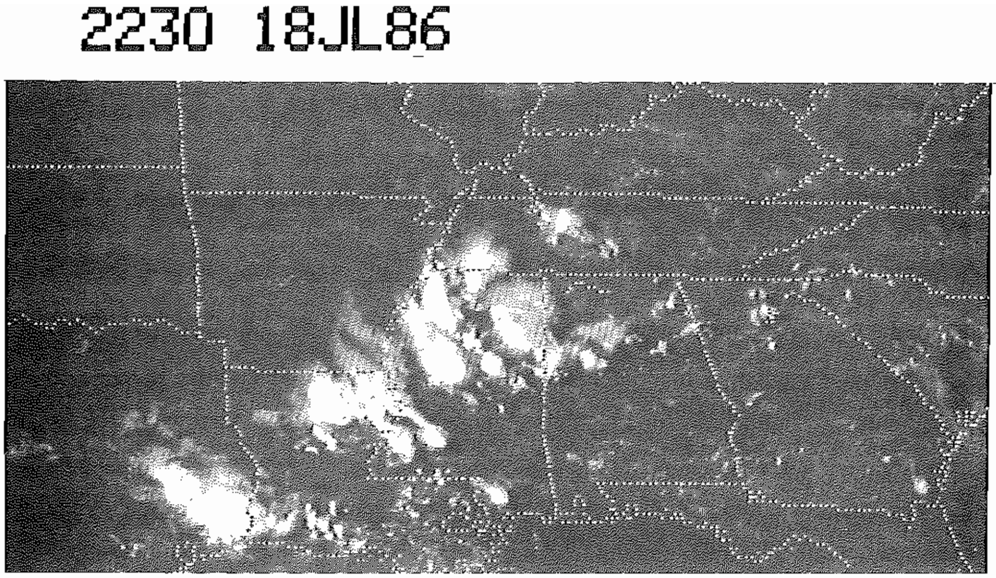


Figure 2

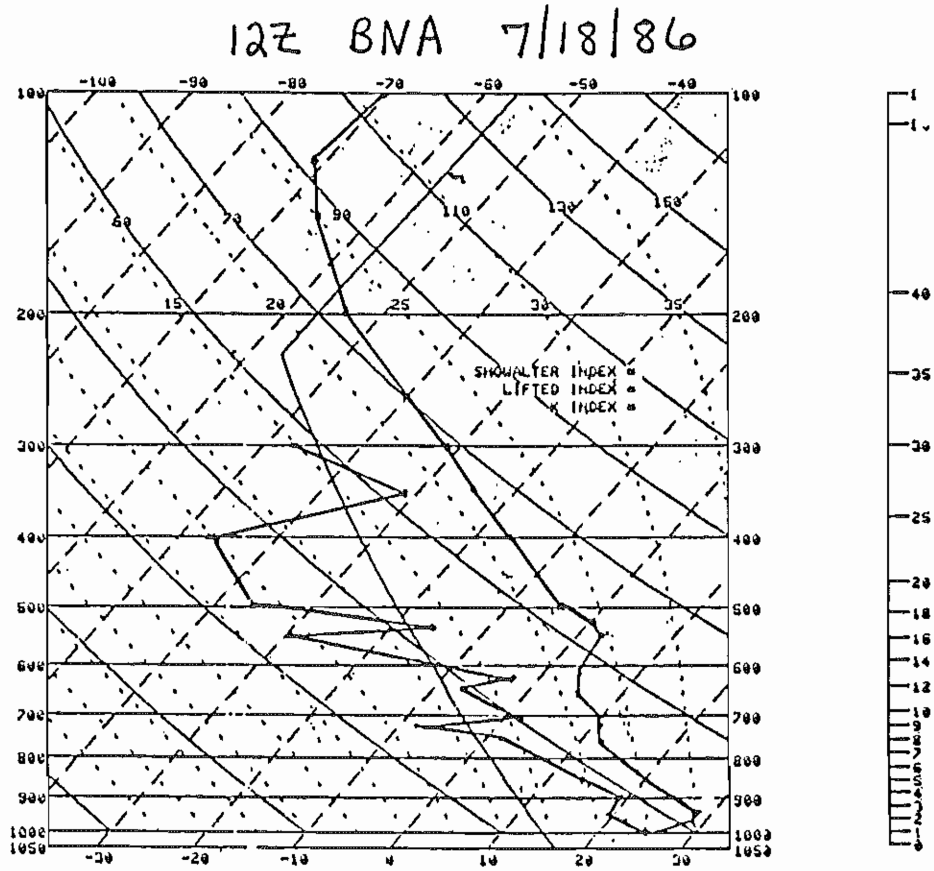


Figure 3

12Z sounding at Nashville indicated ample low level moisture and very dry air aloft at the 500 mb level which is indicitive of a microburst sounding. this sounding was associated with the westward moving tropical wave which affected southwest Tennessee later in the day.