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AN INTRODUCTORY LOOK AT THE SOUTH TEXAS DOWNBURST

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1. INTRODUCTION

Severe convective storms that produce the localized and damaging wind phenomenon known as downbursts have been observed in many areas of the continental United States. Being exclusively a by-product of the convective process, they occur with the highest frequency during the spring and summer months over the western and southern tier of states. It is here during these times of the year that convective instabilities are greatest. In fact, during the summer when major synoptic-scale systems are weak and wind and temperature fields are poorly-defined, downbursts appear to be the primary severe weather threat.

Downbursts apparently occur with great regularity in Texas. In North Texas alone, Read (1987) has documented some eleven cases of downburst occurrence during the summer of 1986. In addition, a particularly notable occurrence in Dallas-Fort Worth in August of 1985 spelled the demise of Delta Airlines Flight 191 in which 134 people lost their lives (Caracena 1986).

A search through the accounts in Storm Data would seem to support the claim that these damaging wind events are common in South Texas as well. The author has on file some twenty or so occurrences of downbursts during the past five years across the region. The South Texas events occurred predominantly during the spring and summer; but, unlike most other regions of the United States, have been known to occur in virtually every month.

Some of these downburst-producing storms cause considerable damage. Such was the case on 7 September 1987, when a particularly intense series of wet downbursts produced an estimated $4 million of damage in and around San Antonio. This study examines in some detail the precursory atmospheric conditions associated with this event. In turn, this wet event is compared to conditions surrounding a rare dry downburst that took place on 2 September 1982 in San Antonio. The hope is to discern critical differences between the two environments and provide a sound starting point for an extensive climatological study of South Texas downbursts.

2. SUMMER CONTROLS ON CONVECTIVE WEATHER IN SOUTH TEXAS

Convective activity that develops across the broad and diverse region of South Texas during the summer typically has afternoon surface heating as its triggering mechanism. The activity rarely becomes severe. Due to the proximity of the Gulf of Mexico, the air mass across the area during summer is usually quite moist in the lower levels; and, as a result, is highly convectively unstable. What day-to-day variability is exhibited in the convective activity manifests itself mainly in location rather than in intensity. In other words, the problem facing the forecaster is where it is going to rain, not how intense the rain will be.

One of the most favorable patterns for widespread convective activity across South Texas is established when a strong and quite persistent warm upper ridge shifts slightly north or weakens on its southern periphery. When this pattern occurs, deep easterly flow develops to high levels and opens the Gulf up for advection of abundant moisture into the area. Vertical mixing and the presence of only a weak capping inversion at best result in an extensive moist layer. While this pattern normally is not conducive to generating strong surface wind, the deep convection often produces some of the heaviest rainfall of the summer across the area.

When the upper ridge is positioned directly over South Texas, even under conditions of extreme instability, convection is unable to proceed much beyond the towering cumulus stage. Subsidence produced mainly by adiabatic descent of air underneath the ridge results in the development of a well-defined, mid-level capping inversion. At times the cap can become quite strong, especially when the intensely-heated air of the plateau region of northern Mexico is advected over the area. In addition, cooler marine air from the gulf often flows underneath the cap, resulting in a relative strengthening of the inversion. Lift produced from surface heating alone is usually insufficient to overcome this cap. But, when coupled with added lift from some surface discontinuity, vertical motion can possess the extra impetus needed to break the cap. When this extra lift occurs, release of the instability can be rapid, resulting in very deep convection.

A common discontinuity found over South Texas in summer is the sea-breeze front. This front and the mesoscale circulation under which it is driven can, and many times does, penetrate far inland. On days when intense inland heating occurs, especially over the elevated Mexican plateau, a very strong thermal gradient is established which may drive the circulation inland some 240 km. Penetration of this extent provides a unique opportunity for direct interaction with a number of other boundaries, thunderstorm outflows for example, across inland areas of South Texas.

As pointed out by Doswell (1982), the sea breeze, like surface heating, is in itself not strong enough to trigger severe convection. Its overall circulation is characteristically too shallow and involves wind speeds of only a few meters per second. As a result, the large-scale flow at times can completely mask the circulation's existence. Nevertheless, its interaction with surface heating or, more importantly, other lifting mechanisms can dramatically enhance pre-existing convection.

Thunderstorm outflow boundaries provide another very important source of lift during the summer. Oftentimes the outflows originate well to the north or west of South Texas and travel great distances into the area where they collide head-on with moist low-level southeast flow off the Gulf. The lift produced under these circumstances can be quite strong, and subsequent thunderstorm development often is rapid.

3. THE MICROBURST OF 7 SEPTEMBER 1987

3.1 Description of the Event

Around 2200 GMT, a rapidly developing line of strong thunderstorms entered the northern extremities of Bexar County. Within an hour, the line of storms became quite intense as it moved southward across the San Antonio metropolitan area. The storms produced heavy rain (maximum around three inches), frequent lightning, small hail, and a series of very damaging microbursts. During the event the peak wind recorded at the National Weather Service Forecast Office was 59 knots. However, damage surveys in the most directly affected area just to the east of the Weather Office suggest that winds may have briefly exceeded 90 knots within the strongest microburst.

When it was all over, the city had experienced an estimated $4 million of damage. Most notable among the damage reports was the downing of a 90 meter paging tower into a nearby apartment complex. Fortunately, no one lost their life, but five people did sustain injuries of varying degrees. Also, five single-engine aircraft were reported overturned by the microbursts at Stinson Field on the south side of San Antonio.

Several funnel clouds were reported, but the post-storm survey of the damage pattern strongly supported the occurrence of microbursts. The most serious damage was confined to a two-mile swath north-to-south across the city; and, in accordance with accepted nomenclature (Fujita 1985), correctly categorizes this event as micro in scale.

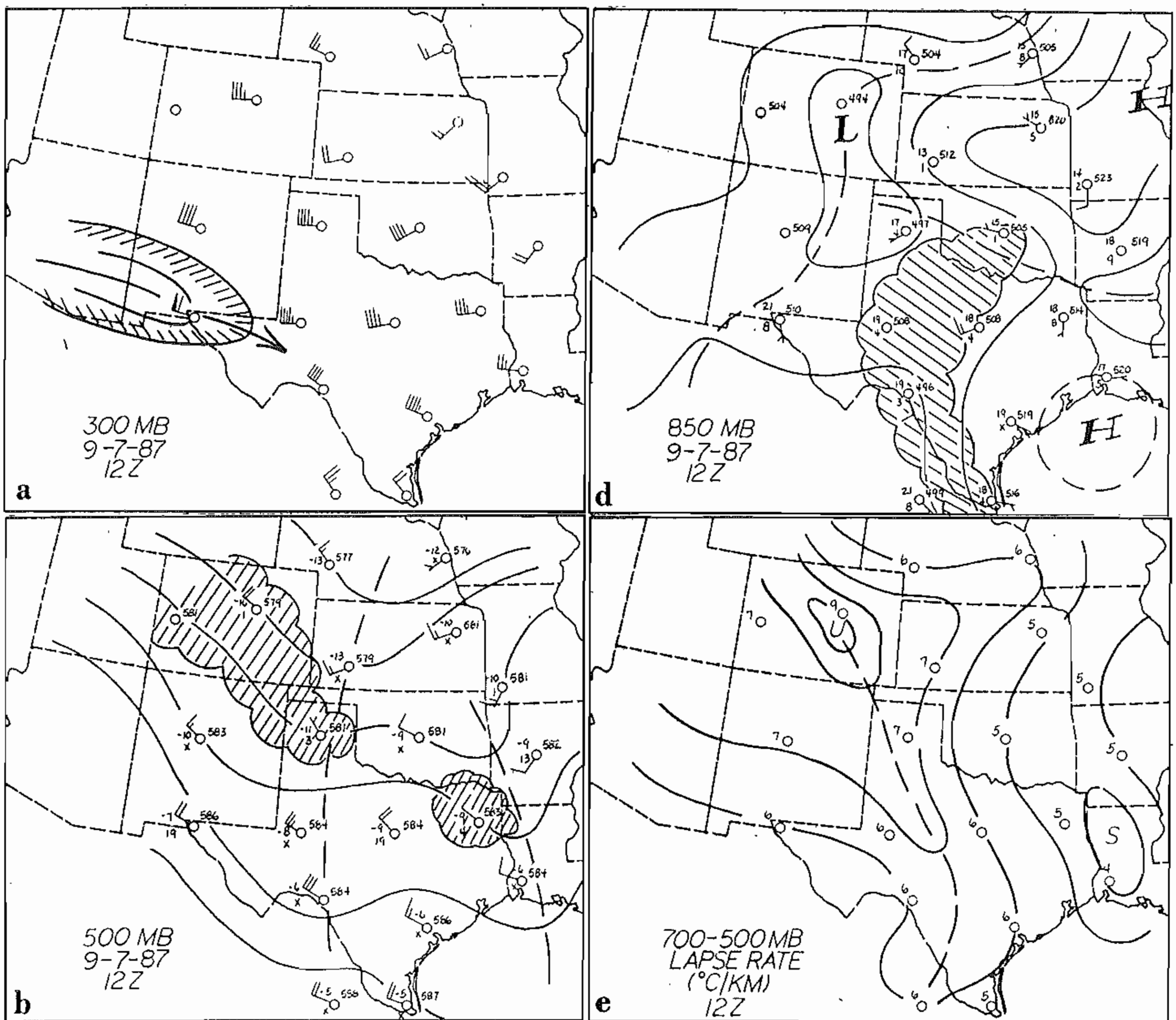
3.2 Upper-Air Analysis

The 1200 GMT upper-air analysis of 7 September 1987 is shown in Fig. 1 (a-e). Conditions at this time were some 10 hours in advance of the actual microburst-producing storm, and therefore provided the forecaster with a good representation of the pre-storm environment.

As seen in both the 500 and 300 mb analysis, South Texas was under northwest flow aloft. Wind speeds at 300 mb were approximately 20-25 knots above normal for early September. An upper jet streak with wind speeds of at least 60 knots was nosing across El Paso and into West Texas. The presence of this jet was not evident below the 300 mb level. Ahead of this jet, considerable diffluence in the flow field was noted over South Texas.

Across West Texas a weak north-south oriented trough was embedded in the upper flow. This trough was best defined at 700 mb. Additionally, an east-west oriented trough or boundary was evident at 850 mb over southern Oklahoma, associated with a surface stationary front positioned in the same general area.

Moisture across South Texas at 1200 GMT was confined to the lower levels of the western sections. The 850 mb analysis revealed a narrow axis of moisture extending along the Rio Grande River and across Del Rio, with a very sharp moisture gradient to the east across south central Texas to the middle Texas coast. A region of high dew points at 700 mb was aligned along the upper trough and the north-south extension of the surface stationary front.



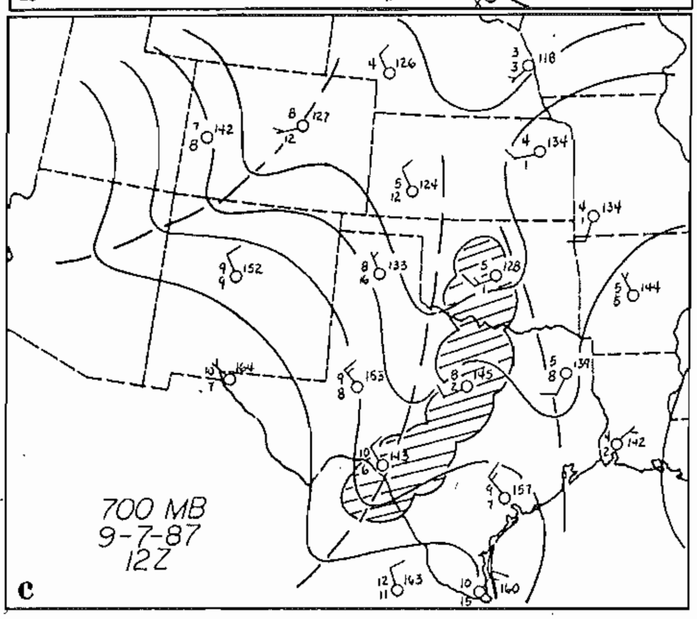


Fig. 1. The 1200 GMT upper-air analysis on 7 September 1987.
(a) 300 mb analysis. Hatched area indicates location of jet.
(b) 500 mb analysis. Shaded area represents moisture.
(c) same as (b) except for 700 mb.
(d) same as (b) except for 850 mb.
(e) 700-500 mb lapse rates(°C/km).

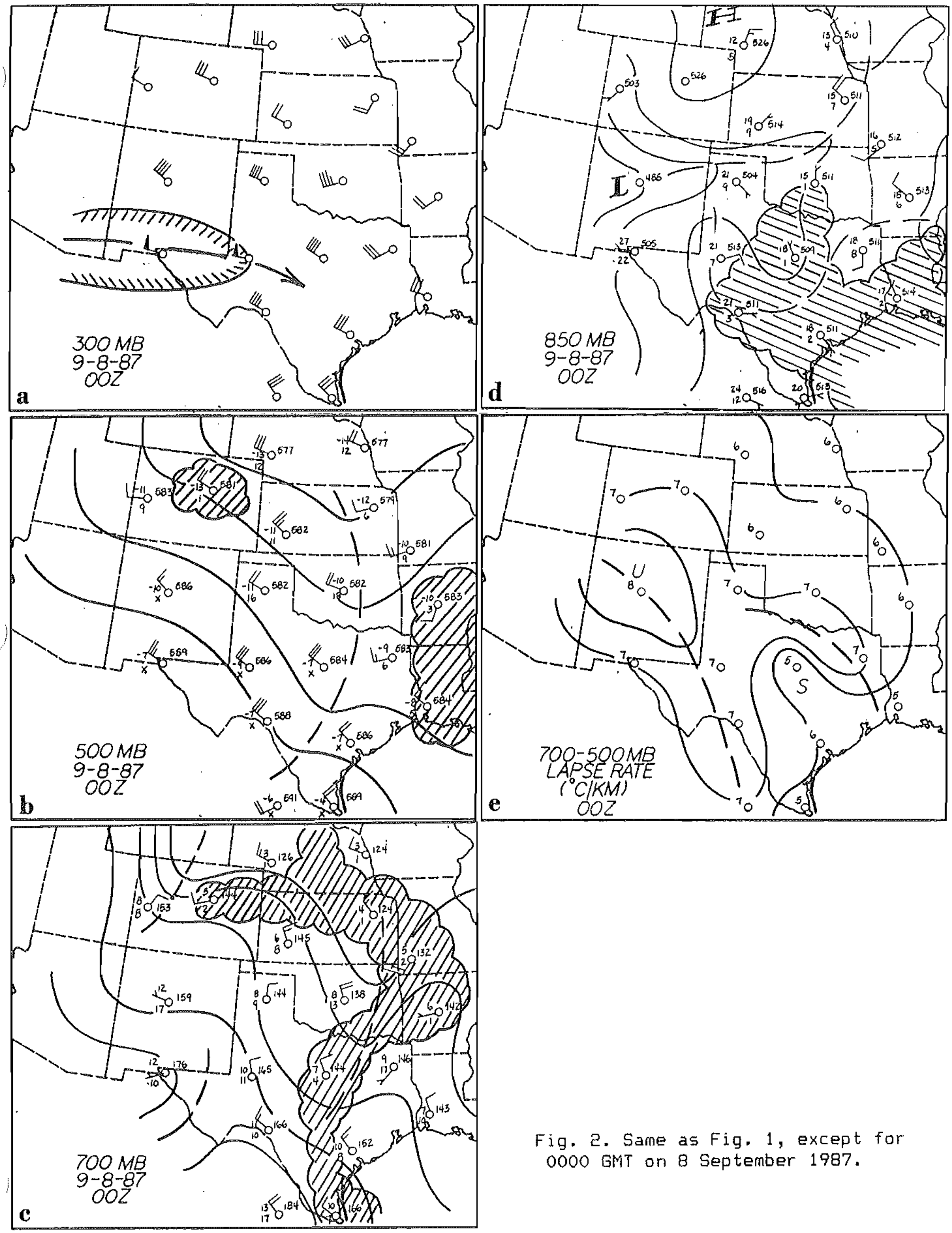


Fig. 2. Same as Fig. 1, except for 0000 GMT on 8 September 1987.

The presence of moisture at this level was presumably the result of vertical transport of lower-level moisture within an area of morning shower activity.

The temperatures of -6°C at 500 mb would normally be considered too warm to support convection. As a rule, forecasters look for temperatures of -8°C or colder during the summer months in South Texas. Of course, sufficient destabilization of the air mass can occur in the presence of the warm temperatures aloft, through the addition of heat in the lower levels. Along these lines, a developing thermal ridge and area of warm advection were becoming evident in the 850 mb analysis.

Figure 1e shows the extent of mid-level instability that existed across the area at 1200 GMT. Based on pioneering work done by Doswell et al. (1985), and further demonstrated in an in-depth study by Bedard (1986), it has been determined that there is a definite tendency for microbursts to occur in environments characterized by steep 700-500 mb lapse rates. It appears that this has some utility in South Texas as well. Clearly, an axis of relatively steep 700-500 mb lapse rates did extend into South Texas at 1200 GMT.

From the upper-air analysis, several important atmospheric changes could be expected to take place into the afternoon hours of 7 September that would support the development of strong, possibly microburst-producing, thunderstorms. First, the upper trough was associated with cooler temperatures (-8°C or colder) aloft and, embedded within northwest flow, likely would move across the area during the day. Further destabilization of the air mass could be expected, with the axis of mid-level instability persisting over the area. Some increase in the depth of the moist layer was likely as vertical mixing continued and the lower-level wind field responded to the approaching trough. Finally, increased lifting support at high levels could be expected as the 300 mb jet continued its approach.

A look at the 0000 GMT upper-air analysis for 8 September 1987 (Fig. 2 a-e) reveals that many of the expected changes did take place. The upper trough did move across the area advecting slightly cooler temperatures (-7°C) at 500 mb. Additionally, the axis of mid-level (700-500 mb) instability did persist, although little or no change in steepness was noted from 1200 GMT.

Moisture increased dramatically across the area in the lower levels. Conditions at Victoria(VCT), for example, progressed from extremely dry to very moist (dew point of 16°C) at 850 mb. In fact, the deepest moisture was now positioned across south central Texas.

The boundary that was positioned over southern Oklahoma at 850 mb at 1200 GMT apparently surged southward into south central Texas and no doubt helped to focus the development of convection. Confluence of the flow pattern and pooling of moisture near the boundary were quite evident.

3.3 Surface Analysis

At 1800 GMT, a stationary front extended north-to-south from a weak wave near Wichita Falls across Brownwood and Junction to just north of Del Rio. To the east of the front, a broad ridge covered much of East and South Texas. A developing trough along the Texas coast signaled the existence of the sea-breeze front and its associated circulation. Persistent morning cloud cover and cool temperatures over East Texas were effectively delaying inland penetration of the sea-breeze front, especially along the upper coast.

Showers and thunderstorms were becoming quite active along and to the east of the stationary front. A favored area for development was just west of Waco in the vicinity of a strengthening thermal gradient. Already, convective outflow was becoming evident in the wind field.

The surface analysis for 2100 GMT (Fig. 3a) identified some significant changes. Outflow from a large thunderstorm complex near Waco was very well-defined and spreading rapidly to the east and south. The southern end had pushed to just north of Austin and was triggering new convection west of the city.

Meanwhile, the sea-breeze front was penetrating slowly inland along the middle and lower coast. It was responsible for triggering weak convection along its leading edge northwest of Victoria. In addition, the front was interacting with a developing thunderstorm complex near Beaumont in Southeast Texas.

For this particular event, the 2100 GMT surface analysis appeared to be critical to the forecaster's awareness of developments to follow. Several clues pointed to south central Texas as the favored area for significant convective development. First, it appeared that the outflow boundary north of Austin and the sea-breeze front, or more specifically outflow from convection along the sea breeze, were on a collision course near San Antonio. Convergent flow into the San Antonio area had become significantly enhanced over what was apparent three hours previous. Further, a feature noted by Read (1987) in his study of North Texas downbursts was beginning to evolve. A well-defined maximum temperature ridge was developing in the region between the two approaching outflows. If downbursts were to develop, they would likely do so within this temperature ridge. Finally, the strongest pressure falls (-2.7 mb/3 hrs) were occurring near San Antonio.

An hour later at 2200 GMT (Fig. 3b), the convection along the sea-breeze front had blossomed, thus producing a strong outflow boundary that was spreading outward in all directions. Rapidly lowering pressure over San Antonio had manifested itself in the form of a mesolow. This low coupled with outflow from the sea breeze-induced convection was greatly increasing convergence into the rapidly organizing line of convection north of San Antonio. Also, it was quite likely that the convergence was being aided by the orographic effects of the Balcones Escarpment. This enhancement in the convergence is not uncommon for southward-moving systems over the Hill Country of central Texas.

The line of convection continued to exhibit explosive development as it moved into San Antonio approximately 30 minutes later. The damaging microbursts occurred during this time in the area of greatest convergence between the NWS Forecast Office (SAT) and Randolph AFB (RND). It is hypothesized, based on a post-storm damage survey, that the microbursts occurred in succession along and behind the more extensive gust front. Such a characteristic has been noted by Bedard et al. (1986).

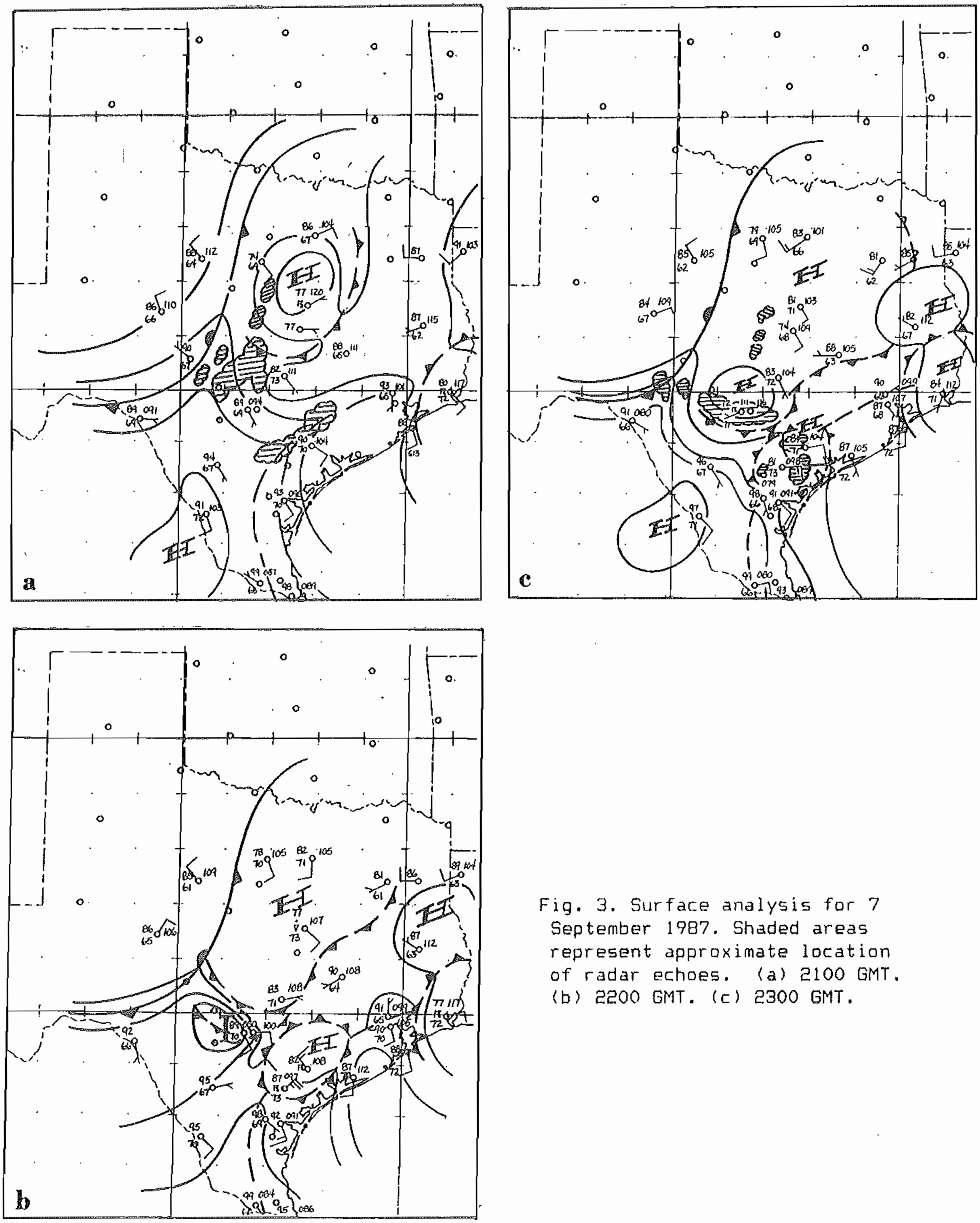


Fig. 3. Surface analysis for 7 September 1987. Shaded areas represent approximate location of radar echoes. (a) 2100 GMT. (b) 2200 GMT. (c) 2300 GMT.

By 2300 GMT(Fig. 3c), the gust front had moved south of San Antonio and the line of thunderstorms over the city was decaying rapidly. Convergence ahead of the gust front was weakening and outflow from the thunderstorm near Victoria was slowing its northward movement. Also, the inland penetration of the sea-breeze circulation had ceased.

3.4 Analysis of Sounding Data

Figure 4a shows the 1200 GMT rawinsonde data for 7 September 1987 at Del Rio (DRT), approximately 240 km west of San Antonio. The sounding is characterized by an extremely deep moist layer extending from the surface to 560 mb. Above this layer, the air is quite dry and potentially much cooler. The lapse rate in the subcloud layer, which extends upward from the surface to a Convective Condensation Level (CCL) of 4800 feet AGL, is very nearly moist adiabatic (-4°C/km). This sounding is believed to be characteristic of many wet downburst environments (Fujita 1983).

In assessing the potential for convective storm development, it must be noted that the positive energy area in the sounding is not particularly large. The Lifted Index is only -3. Subsequently, the potential for strong sustained updrafts would have to be considered rather low. Note, however, that there is considerable potential (convective) instability available by virtue of the rapid drying above the moist layer. Further, there is but only a weak capping inversion between 800 and 770 mb to prevent release of this instability.

If consideration is limited initially to the role of afternoon surface heating in triggering convection, then the critical temperature (Convective Temperature) required to initiate the process is 31°C (88°F). The maximum temperature reached that day in San Antonio was in fact 33°C (92°F). Using this temperature and assuming that thorough mixing of the subcloud layer occurs during the day, we can expect a deep dry adiabatic layer to develop with a slight increase in the positive energy (Lifted Index lowering to -4). However, even with this condition, complete erosion of the mid-level cap would not result. It is estimated that an additional 20-30 mb of lift would be needed, in addition to that supplied by surface heating alone, to completely break the cap and release the instability.

The 0000 GMT sounding on 8 September at DRT (Fig. 4b) shows that the deep, dry adiabatic layer did develop with the top of the mixed layer at 824 mb. In addition, some drying is evident in the mid levels, with the lowest 150 mbs becoming more moist. This change, of course, increased the potential instability in the air mass, which, when lifted by the outflow boundary, likely resulted in the development of severe storms.

4. THE MICROBURST OF 2 SEPTEMBER 1982

4.1 Description of the Event

A rapidly developing and dissipating isolated thunderstorm moved across the San Antonio International Airport at approximately 2200 GMT. This storm spawned a brief microburst that produced a peak wind gust of 53 knots. Being extremely localized, only minimal damage resulted. In fact, the overturning of one light aircraft was the only damage recorded.

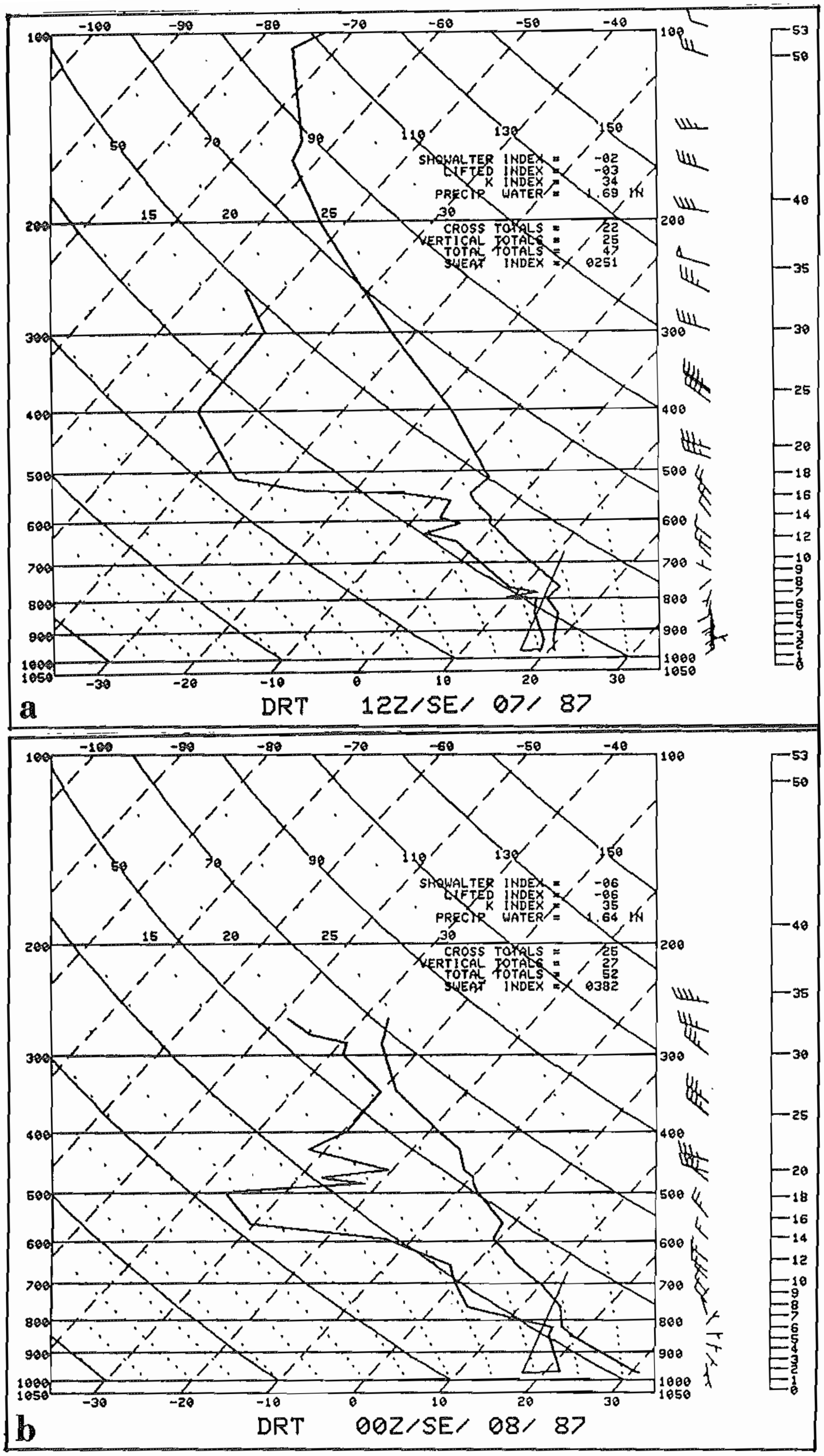


Fig. 4. Sounding data at Del Rio (DRT) for (a) 1200 GMT on 7 September 1987 and (b) 0000 GMT on 8 September 1987.

The entire life cycle of the storm was less than one hour. Except for reduced visibility from blowing dust produced by the microburst, no other weather of consequence accompanied the storm. It was classified as a dry downburst, since only a trace of rain was recorded at the surface. Further, it was classified as a microburst, since the Weather Service Office in San Antonio, less than one mile away, did not experience the wind gust.

4.2 Upper-Air Analysis

The 1200 GMT upper-air analysis for 2 September 1982 is shown in Figure 5 (a-e). Like that of the 7 September 1987 case, conditions at 1200 GMT should have provided the forecaster with a good representation of the pre-storm environment.

The upper levels (500 and 300 mb) over South Texas that morning were characterized by relatively weak flow. Wind speeds at 300 mb, for example, were about 10 knots below normal for the time of year. The only indication of upper jet flow was well to the north of the area over Nebraska, Iowa and Missouri.

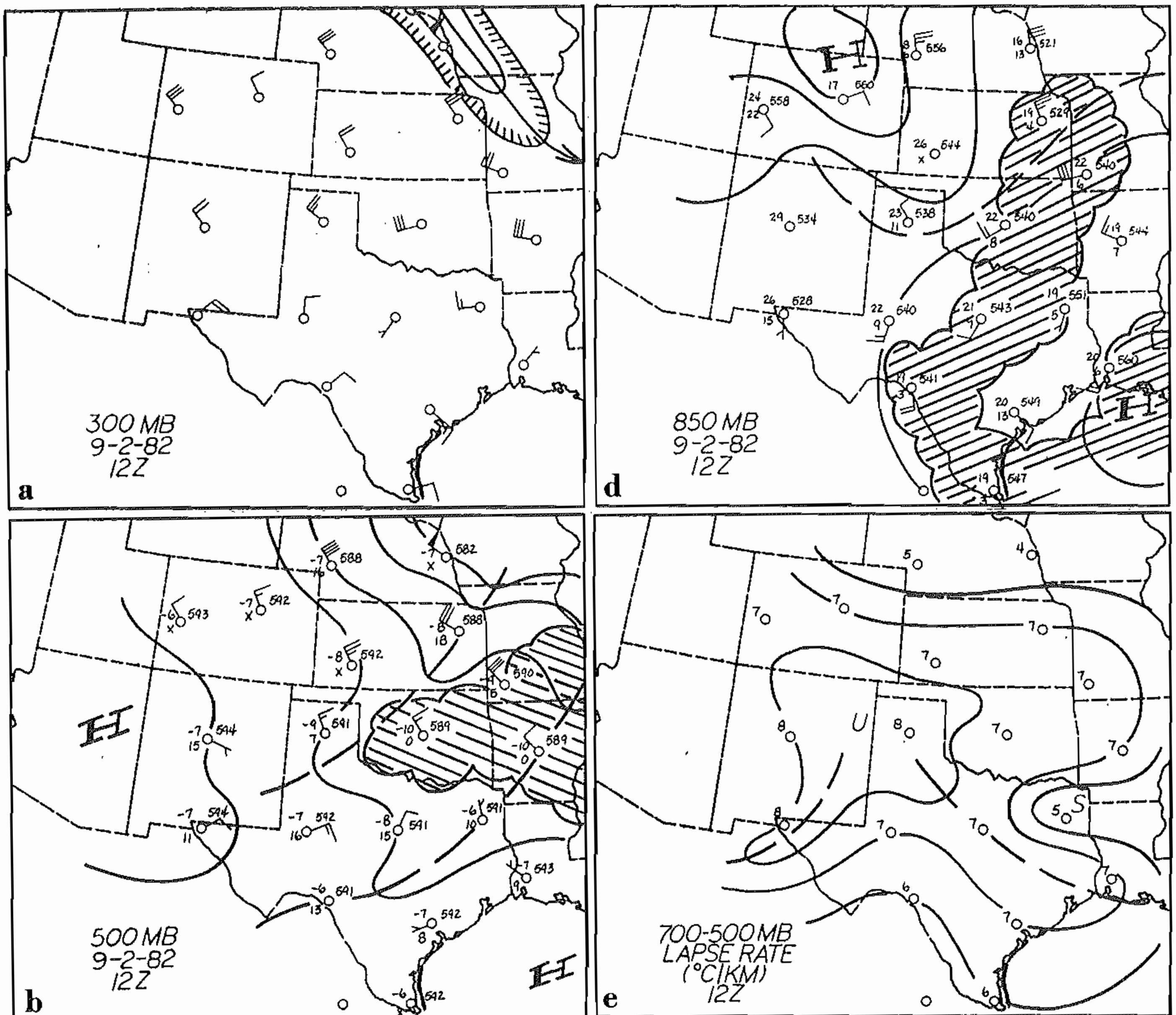
Troughing was evident in the upper wind and height fields over Texas. In fact, two short-wave troughs showed up on the 1200 GMT 500 mb analysis; one extending from northeast Texas into and across south central Texas, and the other lying across the Panhandle region. This second trough would have to be considered the more dominant one with a strong surge of northwest flow evident in its wake. The impulse across south central Texas represented nothing more than a weak cyclonic shear zone in the 500 and 700 mb analysis. The only trough of note at 850 mb was an apparent frontal trough also positioned across the Panhandle.

The only moisture of concern across South Texas at 1200 GMT again was confined to the lower levels in a narrow axis leading from the Gulf of Mexico northward along the Rio Grande Plains. Above 850 mb, significant moisture could be seen well to the north and west of South Texas.

The thermal state of the atmosphere appeared marginal for convective development. No warm advection was noted in the lower levels and temperatures at 500 mb were in the -6°C to -7°C range. Passage of the upper troughs, however, might be expected to result in slight cooling at this level, probably on the order of 1°C.

Figure 5e shows that some mid-level instability was evident across the area. An axis of steeper 700-500 mb lapse rates extended across north central and southeast Texas. Although south central Texas was south of the main axis, very unstable air did extend into the area. Thus, the downburst threat could be considered real if convective storms did develop.

By 0000 GMT, approximately two hours after the microburst occurrence, a few noticeable changes had taken place (Fig. 6 a-e). The frontal trough at 850 mb had pushed southward into central sections of the state; whereas above that level, the weak cyclonic shear zone had remained essentially stationary. An increase in moisture was noted in the low and mid levels across the area. At VCT, the 850 mb dew point temperature rose 8°C, with a similar but much less



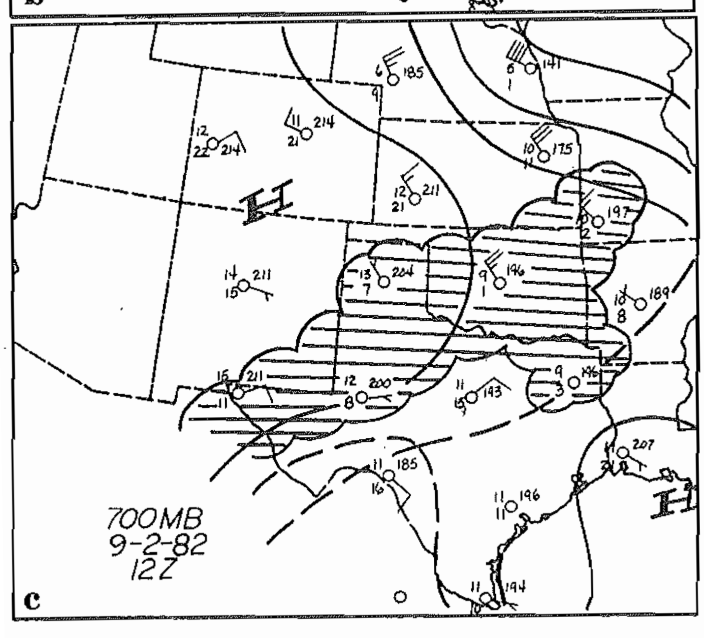
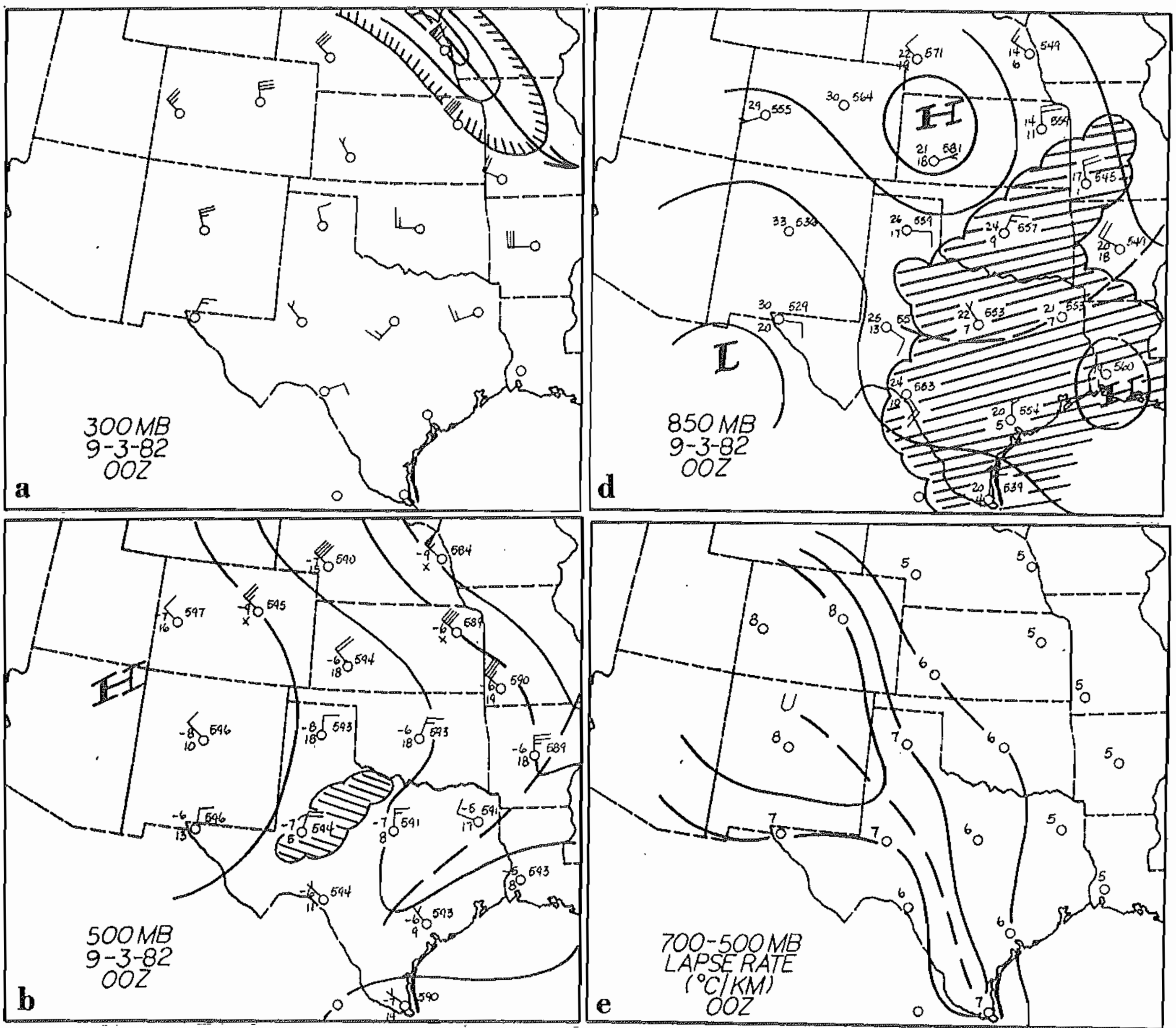


Fig. 5. The 1200 GMT upper-air analysis on 2 September 1989.
(a) 300 mb analysis. hatched area indicates location of jet.
(b) 500 mb analysis. shaded area represents moisture.
(c) same as (b) except for 700 mb.
(d) same as (b) except for 850 mb.
(e) 700-500 mb lapse rain(°C/km).



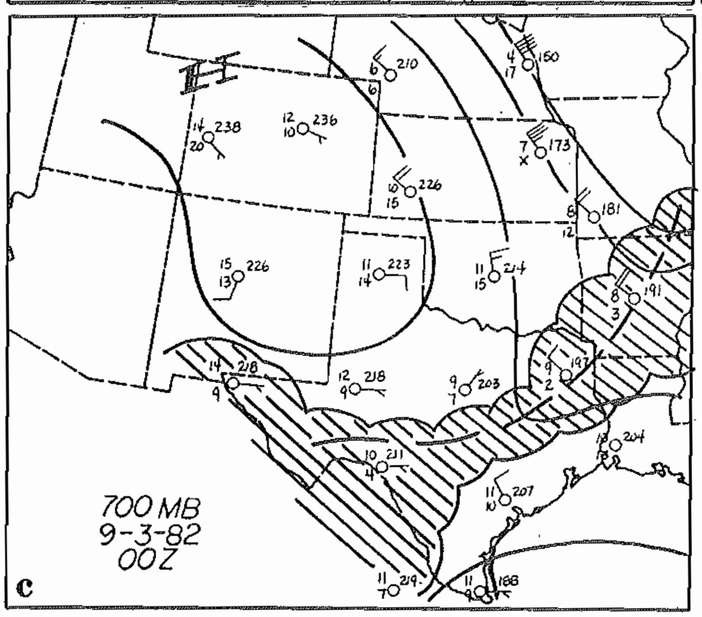


Fig. 6. Same as Fig. 5, except for 0000 GMT on 3 September 1982.

significant increase at 700 mb at both VCT and DRT. Temperatures aloft had not cooled as expected. In fact, if anything, they warmed 1°C. This may explain why convection remained fairly isolated across the area that afternoon. Finally, the axis of mid-level instability (Fig. 6e) did remain positioned over South Texas, but had shifted west into the vicinity of microburst occurrence.

4.3 Surface Analysis

During the afternoon of 2 September 1982, a slow-moving cold front extended east-to-west across North Texas into sections of West Texas. The front was responsible for triggering thunderstorm development in and around Abilene which subsequently produced a well-defined, rain-cooled boundary. The boundary spread rapidly to the east and south.

By 1800 GMT, the boundary had reached San Angelo on the southern end and Stephenville to the east. Meanwhile, evidence of a developing sea-breeze circulation was beginning to show over the coastal plains. Ahead of both the sea-breeze front and the outflow boundary, surface temperatures had reached well above 32°C (90°F), thus producing a very distinct thermal ridge.

Three hours later at 2100 GMT (Fig. 7), the outflow boundary had pushed to Junction in the Hill Country. In the vicinity of Junction, a weak low had developed along the boundary. The sea-breeze front had penetrated inland to the west of Victoria, approaching San Antonio. Temperatures in the region separating the sea breeze and thunderstorm outflow had climbed to near 38°C (100°F). Clearly, movement of the outflow and sea breeze favored intersection near San Antonio.

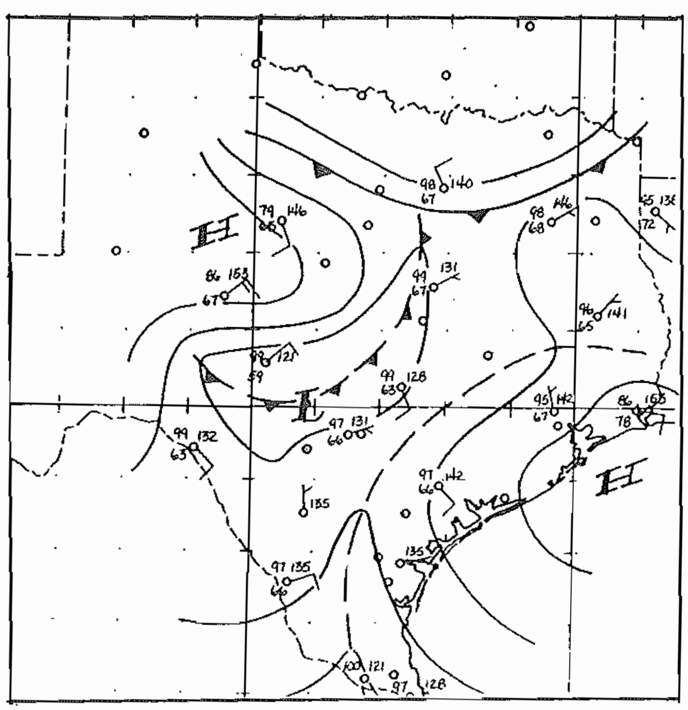


Fig. 7. Surface analysis for 2 September 1982 at 2100 GMT.

4.4 Analysis of Sounding Data

The 1200 GMT sounding on 2 September 1982 at DRT (Fig. 8a) shows considerable convective instability. A very moist layer extended from the surface to 724 mb, capped aloft by much drier and potentially cooler air. The Lifted Index of -6 along with the large positive energy area suggested the potential for strong and sustained updrafts.

The lapse rate in the subcloud layer from the surface to a CCL of 852 mb (3600 feet AGL) already tended toward dry adiabatic with a value of -8°C/km. A weak capping inversion was evident at 890 mb, but could be eliminated easily assuming that surface heating produced thorough mixing and a Convective Temperature of 31°C (88°F) could be reached.

The maximum temperature at San Antonio that afternoon was 37°C (98°F). As shown in the 0000 GMT sounding for 3 September (Fig. 8b), mixing did produce a very deep, dry adiabatic layer which completely destroyed the capping inversion. However, some decrease in the degree of potential instability was indicated with the drying in the subcloud layer and a slight increase in moisture in the layer above 700 mb.

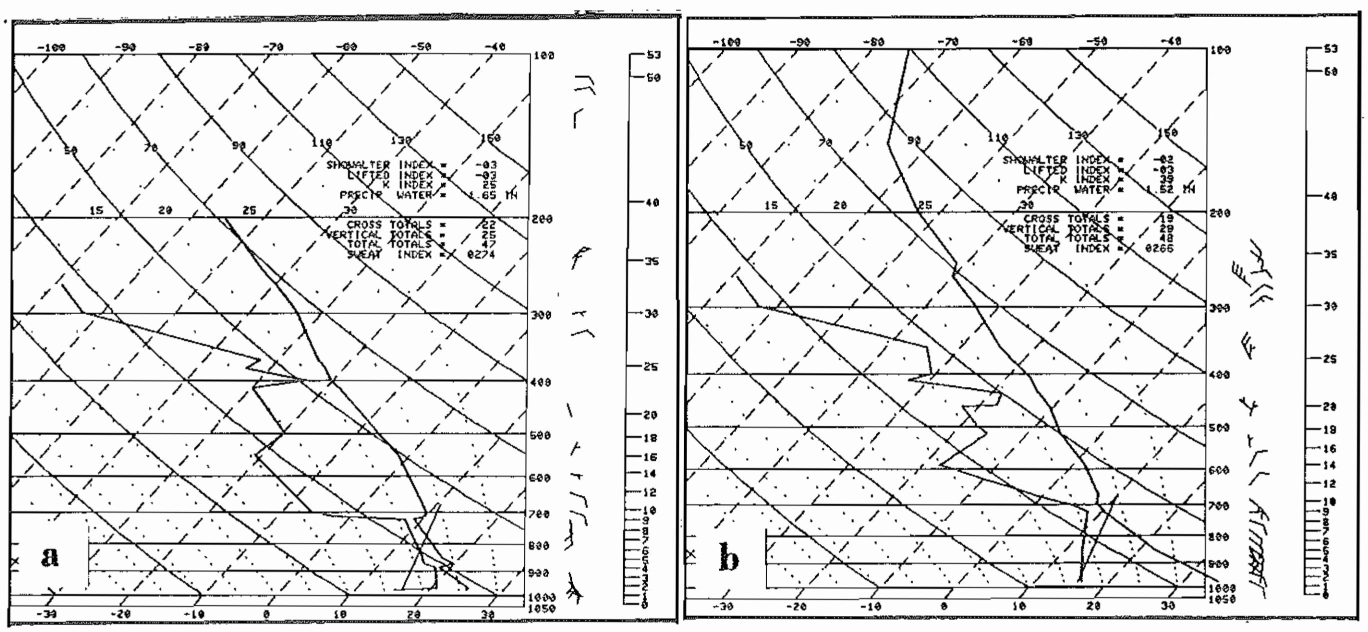


Fig. 8. Sounding plots at Del Rio (DRT) for (a) 1200 GMT on 2 September 1982 and (b) 0000 GMT on 3 September 1982.

5. DISCUSSION

In comparing the two downburst events of this study, the most significant differentiating factor concerns the large-scale synoptic environments in which each storm developed. The wet downburst event (7 September 1987) developed within a highly organized environment characterized by stronger than normal upper-level wind speeds, upper diffluence, considerable vertical shear, high potential instability, and deep low-level moisture. Under these conditions, convective storms often organize into lines with outbreaks of severe weather more widespread and persistent. Post-storm evidence of this event suggests that as the line of storms moved across San Antonio a series of microbursts occurred along and behind the major gust front.

On the other hand, the dry event of 2 September 1982 developed within an environment that seems to typify atmospheric conditions across South Texas in summer. In other words, the environment was characterized by generally light winds, weak vertical shear and high potential instability. Storms that develop in the absence of shear tend to be more isolated (less organized) with any surface severe weather more short-lived. The entire life cycle of the dry event was less than one hour.

Despite the large-scale differences, the processes that forced the events in the low levels were strikingly similar. The main forcing mechanism in each event was a southward-moving outflow boundary originating from earlier convection in another region of Texas. New convection spawned by this boundary interacted to varying degrees with a northwestward-moving sea-breeze front.

In the wet case, the interaction was rather indirect. The leading edge of the sea-breeze circulation triggered convective storm development, which in turn produced a definable outflow boundary. This boundary, on approaching the area around San Antonio, served to enhance moisture convergence into the storms approaching from the north. To some extent, the process was similar to that described in the Eastern Airlines Flight 66 accident in New York (Fujita et al. 1975).

Conversely, the surface analysis of the 2 September 1982 event suggests that the interaction was more direct. In this event, the sea breeze may have actually intersected the southward-moving outflow boundary, resulting in the development of a downburst-producing storm.

The sea breeze, as discussed earlier, is quite common across the coastal sections of South Texas during the warmer months of the year. As a result, it is hypothesized that its role in the triggering of potential downburst-producing thunderstorms in this area may be of paramount importance. An extensive climatological study of downbursts across South Texas is planned for 1989 with the hope of examining this role.

It appears that several processes, both kinematic and thermodynamic, may contribute to the actual generation of the downburst in South Texas. As reported by Caracena et al. (1987), an environment that is characterized by a dry and potentially cooler layer superimposed over a deep moist layer is conducive to the development of penetrative downdrafts and subsequent surface downbursts. Both the dry and wet events in this study exhibited just such an environment.

Secondly, the role of subcloud evaporative cooling from falling precipitation and its contribution to negative buoyancy would seem important, especially with regard to the dry event. Conditions favorable for this process would be a deep, dry adiabatic lapse rate below cloud base along with a high rain-water mixing ratio near cloud base and a small drop-size distribution (Srivastava 1985). In order to achieve the necessary drop-size distribution, a dry environment and weak updraft velocities (small positive area) are needed. The dry event did possess the larger positive area of the two, yet the subcloud dry adiabatic layer was extremely deep (approximately 9000 feet). As a result, it is felt that considerable evaporative cooling occurred, offset somewhat by adiabatic warming during downdraft descent.

Thirdly, the high precipitable water content and subcloud mixing ratio, along with heavy rain at the surface support the role of precipitation loading in the wet event. This process may be a significant generator of downbursts, since it is believed that most downburst storms in South Texas are wet with high precipitable water content.

Finally, we must examine the role of vertical momentum transport. Forbes et al. (1980) conducted an extensive study of this transport in the central and northern tier of states. They found that the most favorable scenario for generating downbursts from downward momentum flux was an upstream high-level jet streak that moved over a well-defined low-level jet. The low-level jet, in fact, was thought to be the primary source for downward-directed momentum. Obviously, winds in the South Texas dry event were too light to contribute much to momentum flux. This could have been a contributing factor in the wet case, although the source of momentum would have had to originate at higher levels, since no well-developed low-level jet was apparent. At present, the contribution is thought to be minimal, but deserves more study.

Examining only two cases of downburst occurrence makes it very difficult to formulate a useful scheme for forecasting downburst potential. However, a few generalizations can be offered. It appears that the precursory conditions for downburst occurrence in South Texas may include:

a. high potential (convective) instability,

b. relatively high 700-500 mb lapse rates,

c. a high precipitable water content,

d. a weak (at best) capping inversion, and

e. some low-level forcing mechanism (in addition to surface heating).

With these conditions satisfied, downbursts could be expected to develop within a region of maximum surface temperature (ahead of a boundary or between two approaching boundaries) and strong moisture convergence.

Similarly, a few generalizations regarding the differentiation of the types of downbursts (wet vs. dry) can be made. First, it is hypothesized that dry downbursts are likely to occur mainly under conditions of weak winds and vertical shear (i.e. in the absence of major synoptic-scale weather systems). Organized advective processes in the presence of sustained synoptic-scale vertical motion oftentimes would result in too deep of a moist layer. A significant differentiator, therefore, might be the depth of the moist layer. Certainly in this study, the moist layer was some 150 mb deeper in the wet case versus the dry case. Additionally, as reported by Caracena (1979) and various other researchers, the pre-downburst environments of wet events oftentimes featured a near moist adiabatic subcloud lapse rate as opposed to the dry adiabatic lapse rate in dry events.

6. CONCLUSION

The purpose of this pilot study was to identify potentially useful parameters that can be examined in more detail during a planned comprehensive climatological study of South Texas downbursts. Several promising parameters were identified. No doubt, the South Texas downburst occurs frequently, and apparently under a number of different weather regimes. As a result, developing a useful forecasting scheme may prove to be a formidable task.

Several new diagnostic tools have arrived on the scene in the Forecast Offices during the past year or two which may shed some new light on processes that may be occurring just prior to downburst generation. Foremost among these tools is the AFOS Data Analysis Programs (ADAP) which performs an hourly mesoscale analysis over the forecast area (Bothwell 1988). An operational evaluation of ADAP during a high downburst threat is planned for the summer of 1989.

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