# On the Lack of Severe Weather in Texas and Oklahoma on 18 April 2000

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## ABSTRACT

There was dramatic potential for convective activity associated with a dryline through Texas and Okalahoma on 18 and 19 April, 2000. This case study analyzes the atmospheric conditions which smothered the convective potential forcing a null event. Through subsidence at mid levels on the eastern side of a dryline through western Texas and Oklahoma, the low level inversion, separating moist surface air and elevated mixed layer, was not broken but reinforced. The subsidence is attributed to convergence associated with a low level jet, as well as low level frontolosis associated with warming throughout the day on the 18th. It was found that the convergence was a greater forcing for subsidence than the frontolisis.

## 1. Introduction

With dominant westerly flow over the desert southwest, in combination with the lucky placement of the Rocky Mountains and the Gulf of Mexico, it is extremely common to see dramatic convection and thunderstorms over the Great Plains in the early spring. The Great Plains is known as tornado alley because low level moist air is advected northward out of the Gulf of Mexico and up against the Mountains. With desiccated, conditionally unstable air being blown off the mountain tops a loaded gun situation is developed as this warm, dry, unstable air is forced over the moist surface layer.

Although sever weather is common over this corner of the Earth, it is does not always form when conditions are right. The final piece of the puzzle is dynamic lifting over the loaded gun region or surface heating which forces the moist surface air through a capping inversion and into the dry mixed layer allowing for free convection. If there is no lifting or heating, there are no storms, and there is definitely no severe weather. Although it is a key ingredient, vertical motion can also be the hardest to forecast in the Southwest and Great Plains. With the Rocky Mountains disturbing the westerly flow off the desert, it is common to see vertically propagating gravity waves, although not very strong as the air is usually unstable during a convective event. Even so, the disturbed flow can add or take away from vertical forcing over the region.

Vertical flow is often forced by synoptic scale meteorology. Upper level troughs deepening over the western US will generate surface cyclones in the lee of the Rocky Mountains.

This synoptic situation leads to upper level westerly winds over the mountains, and low level southerly flow off the Gulf, east of the mountains associated with the surface cyclone. What is common in these situations, is vertical motions forced by the dynamics of the upper level wave. These vertical motions contribute greatly to breaking a low level inversion cap leading to the free convection described previous.

On April 18, 2000 a dramatic loaded gun set-up was evident over the western Great Plains: Nebraska, Kansas, Oklahoma, and Texas. One example of the convective potential is Norman Oklahoma at 0000z on the 19th, where CAPE exceeded 3000 while at the same time across the Panhandle of Texas into Oklahoma there was a ten degree drop in temperature with a 30 degree increase in dewpoint temperature. This type of surface and upper air set-up threatened to develop dramatic severe weather, however, nothing happened. Through the day on the 18th and into the 19th, there was no severe weather. Not only was there no severe weather, but there was hardly any sensible weather at all. After 0000z on the 19th, there were a few small scale thunderstorms in west central Texas, and some larger storms in southwest Nebraska, but the entire region characterized by the loaded gun vertical structure experienced nothing but clear skies.

This case study intends to show that the reason for the lack of any real convective activity was wide spread subsidence over almost the entire region of moist air at the surface. This subsidence is attributed to two atmospheric characteristics. The first is a mid level jet streak which pushed into the region setting up a large region of convergence associated with its left exit region. The second forcing was low level frontolosis associated with daytime warming and low level winds.

Although a nullevent is not the most interesting of cases to analyze, it is extremely important in the atmospheric sciences. This topic leads to better forecasting and analysis, particularly in regions such as the southwest and Great Plains. With a better understanding of the initial mechanisms that can either force or smother the development convective storms which may have the potential to form severe weather, more accurate forecasts can be made that may make the difference in life or death. The study of the internal dynamics of thunderstorms and super cells is a relatively new field. It attracts a lot of the attention away from the initial convective set up. Without taking anything away from the importance of these fields of research, it is important to realize that once a super cell is formed there may not be adequate time to alert people of the dangers ahead of it. It is the beginning stages showing the convective potential which matter most in terms of saving lives.

## 2. Data

Data on this event is primarily based on NAM (Eta) gridded model data. Because the interesting aspects of the event are almost completely associated with atmospheric dynamics, model data is exceedingly useful. The model data is analyzed using GEMPAK or General Meteorological Analysis Package Atmosphere radio sounds were taken from the University of Wyoming's Atmospheric Sciences Department archive. These data were used in making a hand drawn cross section as described in later sections. Other hand drawn figures were generated through analysis of gridded model data and intuitive conclusions there after. Most data was taken from 0000z April 19, 2000; however, earlier and later times are included as labeled in individual figure captions.

## 3. Synoptic Overview

Setting up a loaded gun atmospheric situation without any significant synoptic waves and cyclones or away from mountains and warm bodies of water is definitely not out of the question. However, there is not usually such a easy way to set up the situation so perfectly and so commonly. The main aid of the synoptic pattern is the associated dynamical vertical motion forcings. Many loaded gun situations go through time without any significant weather for these reasons. What is extremely interesting about the case of April 18, 2000, is that there was an upper level trough in the perfect place near the loaded gun situation. On first glance the case would look similar to many other cases responsible for producing destructive severe weather, but as described later, there was something slightly off.

Beginning at 1200z on the 18th, there was an upper level trough centered over northern California, with a rather impressive jet streak at 200 and 300 hPa in its southeast quadrant. At this time the maximum 200 hPa winds associated with the jet were 60 meters per second, close to 120 knots. Through the day on the 18th, the trough weakened significantly (Figure 1). With this weakening, the jet weakened as well, as the maximum 200 hPa winds barely reached 50 meters per second by 0600z on the 19th. The most dramatic change associated with the weakening of the trough is the transition from a curved, cyclonic flow to a much straighter, zonal flow. At 0000z on the 19th, the upper level flow is almost straight west southwest over the New Mexico Rocky Mountains.

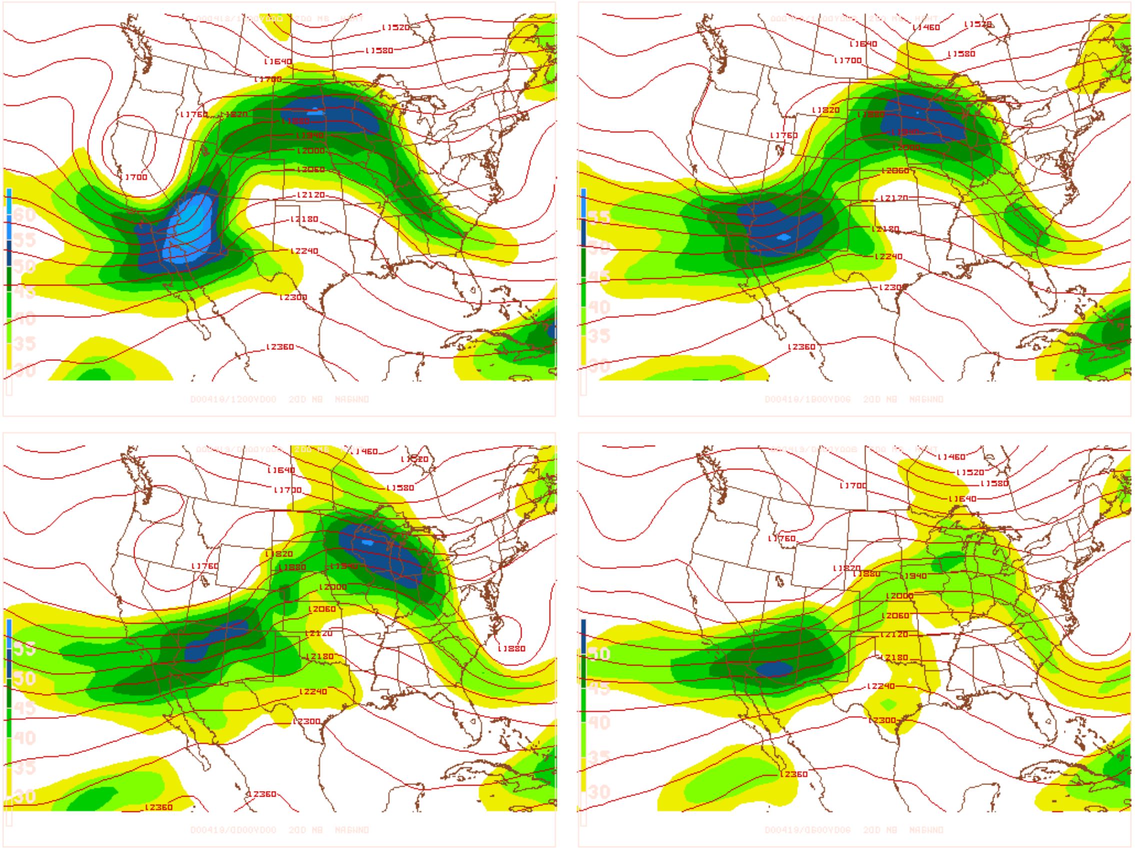

**Figure 1:** 200 hPa geopotential heights and isotacks showing the upper level trough and jet over the west coast and southwest and their gradual weakening through time.

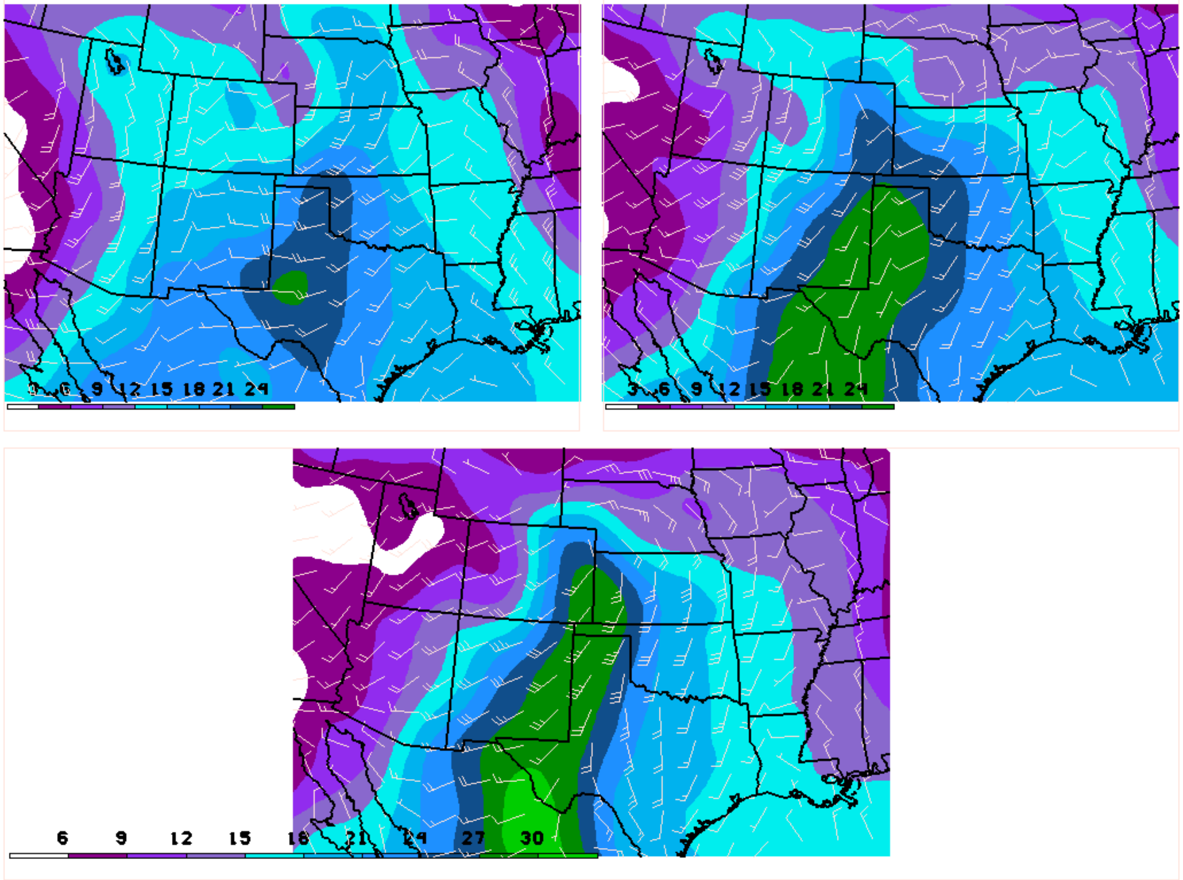

**Figure 2:** 850 hPa isotherms (degrees C) and observed wind barbs at 1200z and 1800z on the 18th and 0000z on the 19th. The dramatic warming throughout the day over western Texas, and the slight cooling over eastern Texas and Oklahoma is obvious.

At lower levels there is a fairly impressive jet associated with the upper level wave. At 500 hPa, the jet stretches eastward across the Panhandle of Texas, and into western Oklahoma. This low level jet is characterized by fairly dramatic speed changes across Oklahoma. This fact will be analyzed in detail in later sections. At 500 mb, there is also a bull's eye of absolute vorticity over central Colorado. This synoptic feature is extremely interesting as it applies to the storms in Nebraska, mentioned earlier, but it has no direct influence on the region focused on here.

At the 850 mb level, dramatic warming is evident in west central Texas throughout the day on the 18th (Figure 2). With dominant westerly and southerly flow it is not surprising that there is so much day time warming, however, the clear skies over the entire western Texas region must have also played a role. Western Texas is much more susceptible to surface heating being at higher elevation and taking on air from the Mexican Plateau to the south, as apposed to eastern Texas and Oklahoma as this region is characterized by low elevation and southerly flow right off the Gulf Mexico. Flow off the Gulf has a tendency to moderate the low level temperature and add substantial moisture. Figure 2 shows the warm tongue of air reaching northward to the southwestern tip of Nebraska by 0000z on the 19th. The figure also illustrates the contrast between the warm air to the west and the cooler air to the east and the development of a decent temperature gradient across Oklahoma and Texas.

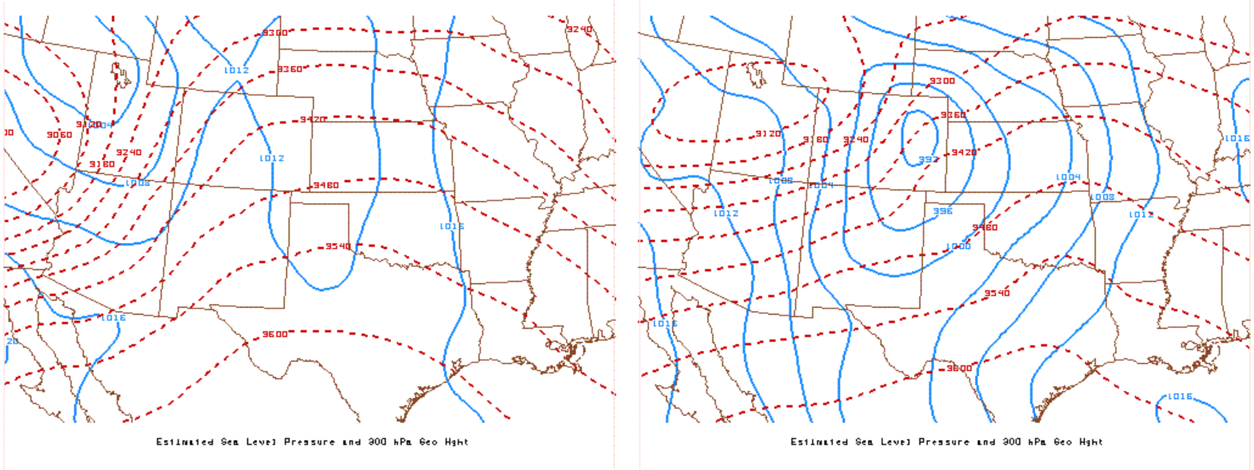

**Figure 3:** Estimated sea level pressure overlaid 300 hPa geopotential height at 1200z on the 18th and 0000z on the 19th. The Figure illustrates the significant surface cylcogenesis throughout the time period.

The 500 hPa ball of vorticity mentioned previous, although not directly significant to the region, is indirectly related to the convective potential. Positive vorticity advection by the thermal wind is a strong contributor to surface cyclogenesis (Martin, 2006). From 1200z on the 18th to 0000z on the 19th, it is obvious that there is respectable surface cyclogenesis over the Colorado Rockies through the southern Plains (Figure 3). Shown in Figure 3, model estimated sea level pressure contours illustrate the development of the surface cyclone associated with the upper level trough. At 1200z on the 18th, the surface low is centered over northwest Utah with a pressure minimum of 1004 hPa. By 0000z on the 19th, although there is weakening in the upper level wave, the surface cyclone deepens to 992 hPa. With this deepening came a transition to a more southerly flow on the cooler moist side of the region and westerly flow in the eastern side adding to the dramatic warm to cool, dry to moist contrast discussed here.

## 4. The Convective Set-Up

With the synoptic back ground described in the previous section it is easy to conceptualize the convective potential. Upper level westerly winds blowing over the southern Rocky Mountains and over moist cool air is the ideal synoptic condition for the development a dryline. A dryline forms when an elevated mixed layer generated by warm dry air being forced over mountains is advected over a surface moist layer in the lee of the mountains. The mixed layer pushes down on the surface moist layer trying to entrain it. This leads to erosion of the surface moist layer just to the lee of the mountains where it is shallow due to the high elevation relative to the deep elevated mixed layer. Through time the mixed layer eats away at the moist layer moving downhill generating a distinct horizontal contrast in moisture at the surface. In this case, the horizontal contrast in temperature and moisture is assisted, as described in the previous section, by warm, dry advection from the south at lower levels.

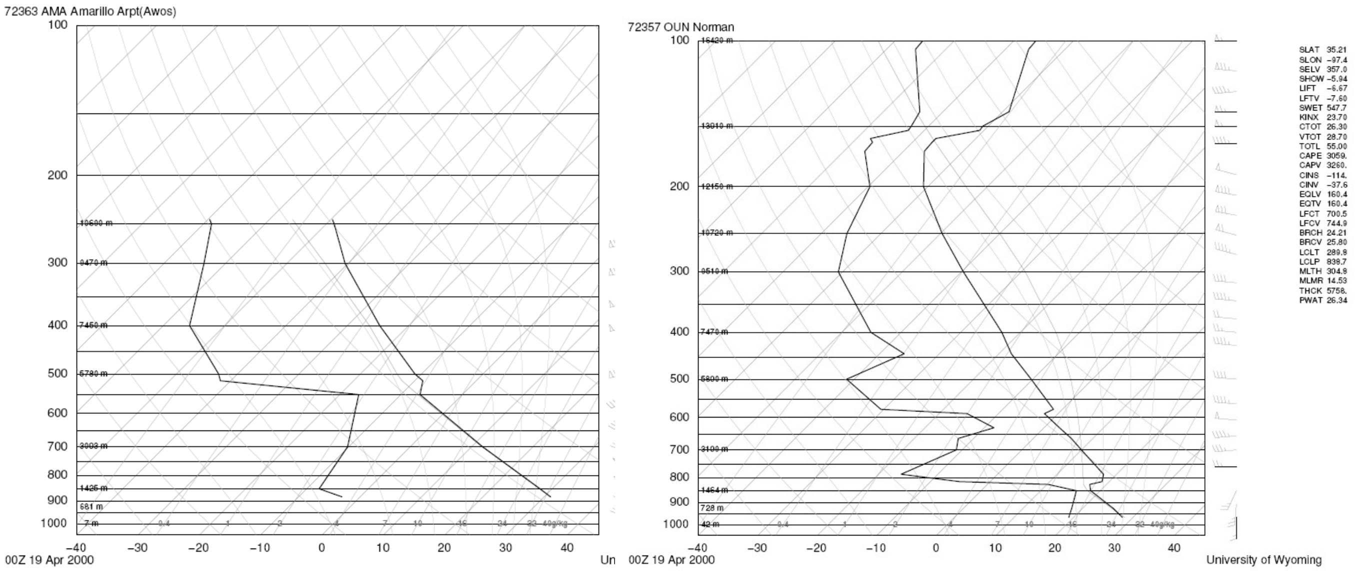

**Figure 4:** Soundings from Amarillo, TX and Norman, OK at 0000z on the 19th, showing among other things the dramatic temperature and moisture contrast across Texas and Oklahoma.

This is exactly what happens in this case as westerly flow aloft advects desiccated, hot, mixed air forced up the Rocky Mountains from the desert southwest. In this case cool moist air is advected out of the Gulf of Mexico and forced up against the elevated mixed layer which reaches the surface in the lee of the Mountains. At the same time the elevated mixed layer is forced over the top of the moist surface layer to the east as a capping inversion forms and prevents entrainment.

Figure 4 displays soundings from Amarillo, TX and Norman OK at 0000z on the 19th. The two soundings illustrate the horizontal contrast between the hot dry air at the surface to the west, Amarillo, and the loaded gun situation to the east, Norman. The Amarillo sounding shows the ridiculously hot surface air with temperatures reaching just above 30 C. The deep, dry surface mixed layer is easy to pick out with a dry adiabatic lapse rate in the temperature profile and a dewpoint temperature profile following the mixing ratio lines. A small stable layer exists at 550 hPa up to 510 hPa, showing a weak separation between the surface mixed layer and the elevated mixed layer. The incorporation of the elevated mixed layer downward is obvious as there is no LCL in the sounding profile.

The Norman sounding is completely different. The most obvious difference is the huge inversion at 825 hPa capping a much shallower, cooler, moist surface layer than that of Amarillo. Surface temperatures at Norman reach only 28 C with dew point temperatures of 20 C. Above the low level inversion there is a very dry conditionally unstable mixed layer. This layer continues upward to 600 hPa where it is capped again by a weaker inversion. Above this mid level inversion is another conditionally unstable mixed layer which continues upward to near 450 hPa. The Norman sounding represents the loaded gun atmospheric condition. The moist surface layer is capped by a strong inversion preventing any entrainment of the moist air into the conditionally unstable, dry, mixed layer above.

Generally a dryline is defined by at least a 10 degree contrast in dewpoint between two adjacent surface stations (Ray, 1986). In terms of defining a clear cut line representing the

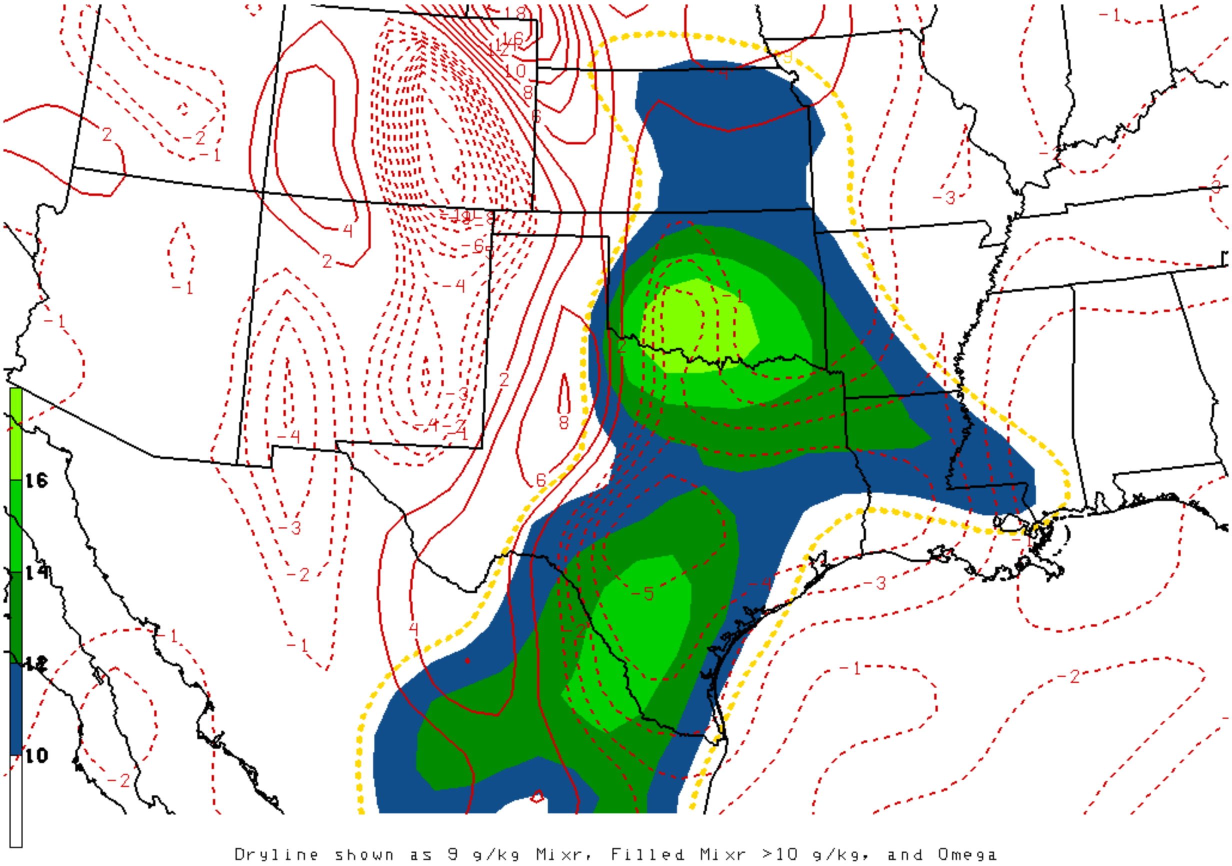

**Figure 5:** Plot of 900 hPa mixing ratio with the 9 g/kg isohume highlighted in yellow and filled contours of 10 g/kg and up. Red contours are of 700 hPa model calculated omega multiplied by -1 to give negative values downward and positive values upward. The Figure shows the subsidence dominating the moist surface layer. Data from 0000z on the 19th.

dryline, the 9 g/kg mixing ratio contour is a good approximation (Ray, 1986). This value is chosen as it represents a minimum value for the necessary moisture to form severe weather through convection. It has already been shown that there is a significant contrast in moisture, but is there enough moisture available for severe weather? Figure 5 shows the 9 g/kg isohume representing the dryline along with filled contours of mixing ratio from 10 g/kg up at 900 hPa at 0000z on the 19th. Based on this data there is more than enough moisture available over southern Oklahoma and Texas for severe weather. There is a maximum in moisture just to the east of the dryline with a value of 16 g/kg.

In terms of the development of severe weather, significant vertical shear is needed at mid to low levels to develop super cells capable of producing damaging hail, downdrafts forcing strong horizontal winds, and in the worst case, tornadoes. Vertical shear in the atmosphere allows for the slanted mechanical vertical motion associated with surface convergence which forces air upward to the level of free convection where an updraft is allowed to freely rise. Shear also contributes directly to the following drown draft which is necessary to reinforce super cell development. In this case there is more than enough vertical shear to support the development of super cells. From 900 to 700 hPa there is a 90 degree veer in the observed winds over Oklahoma and northern Texas, as the southerly flow associated with the surface cyclone is contrasted with the mid level westerlies associated with the trough (Figure 4).

## 5. The Null Event

At this point it is clear that there is substantial potential for convection and severe weather. Figure 6 is a Miller Diagram which summarizes all the characteristics of convection and severe weather described in the previous section. The dryline is shown with the warm tongue and moist tongue at lower levels. Vertical shear is illustrated as well, through low level, mid level, and upper level flow. With all of these variables in place there is only one last piece of the puzzle.

Up to this point vertical motion has not been discussed as it appears over the entire region of focus. It is already known that no significant convective activity develops over Oklahoma and central Texas. The mystery thus far has been why, and the key is in the vertical motion. Returning to Figure 5, the negative of model calculated omega is contoured at 700 hPa. What jumps out at first is that over almost the entire moist region there is only downward vertical motion. There is a well defined region of upward vertical motion barely overlapping the dryline to the west. This is relieving as at first glance it would explain the reason for no convection and storms over the moist region and the development of weak small thunderstorms over west central Texas.

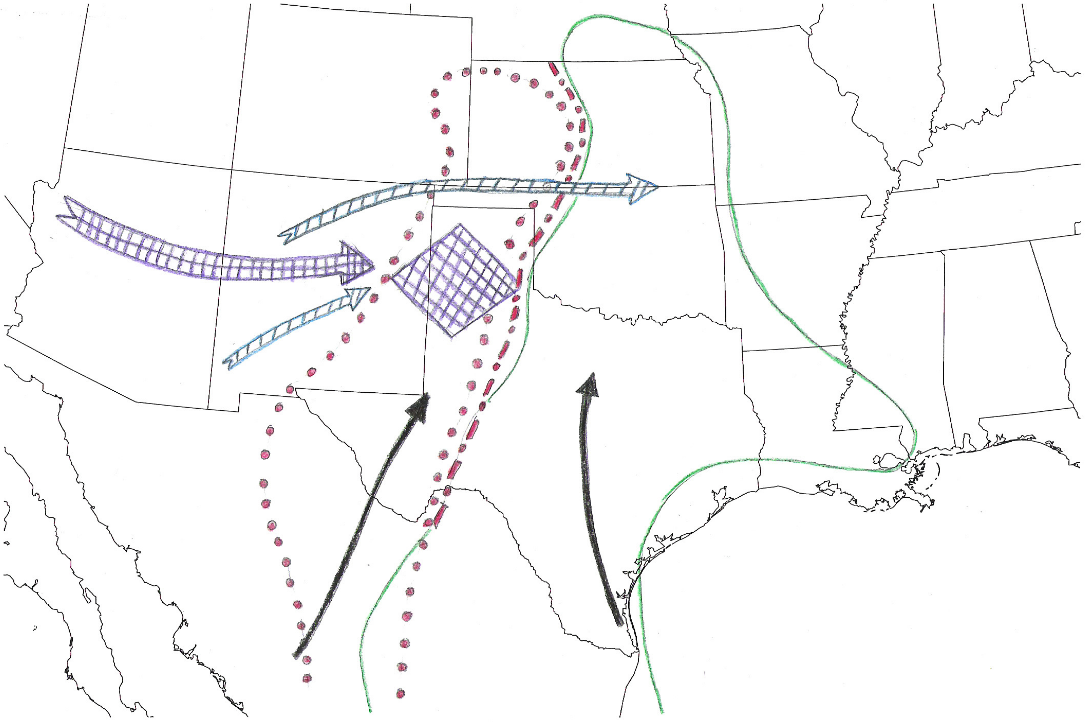

**Figure 6:** Miller Diagram summarizing the key features outlined in the convective set-up section showing 0000z on the 19th. 850 hPa moisture, warm tongue, and general flow, 500 hPa general flow, jet streak and jet maximum are shown. The dryline is also shown in between the warm tongue and moist region.

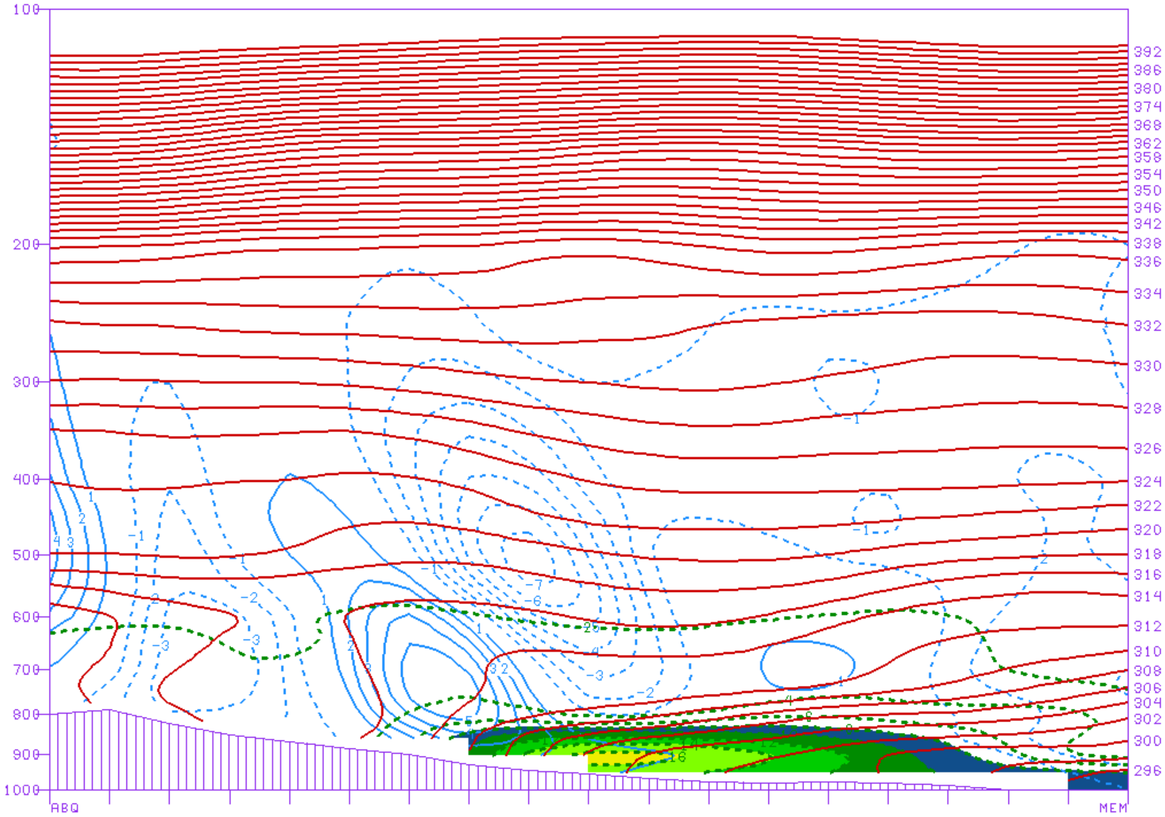

**Figure 7:** Cross section from Albuquerque, NM to Memphis, TN showing potential temperature in red contours, mixing ratio dashed green contours and color fills of 10 g/kg and above, and model omega in solid (upward) and dashed (downward) blue contours at 0000z on the 19th.

Taking a cross section from Amarillo, TX to Memphis, TN shows clearly the dryline, the surface moist layer, the elevated mixed layer, and the vertical motion (Figure 7). This cross section was taken because it cuts right through the dryline, perpendicular to any line of storms which could have theoretically developed along it. Contours of vertical motion in the cross section show the region of downward vertical motion maximizing at close to 500 hPa close to directly over the dryline. The upward vertical motion shown in Figure 5, right over the dryline, is also visible in the cross section; however, it is maximized at 700 hPa under the maximum in downward vertical motion. The downward vertical motion seen in Figure 5 is also reflected in the cross section right next to the upward vertical motion at 700 hPa.

Looking back to the Norman, OK sounding discussed in the previous section, the downward vertical motion is again illustrated. The mid level inversion discussed is actually a subsidence inversion forced by the downward vertical motion seen in Figure 5 and 7. The inversion is at about the 600 hPa level, while the maximum downward vertical motion is located at 500 hPa with substantial subsidence reaching downward to the 600 hPa level.

Now is the time when the question of why is posed. What effect is the downward vertical motion having on the development of convection, and what is causing it in the first place? The first question is a little more obvious then the second. It was explained previous that there needs to be some type of forcing to break the inversion cap separating the moist surface layer and the mixed layer above. This forcing can take the form of surface heating, bringing the surface layer close to the inversion temperature weakening the cap. The forcing can also take the form of some upward vertical motion that lifts the low level moist air into the dry mixed layer above. The motion must be strong enough to break the cap however. Without either of these two forcings over the moist layer of this case, there is no way to break the cap releasing the moist air into the mixed layer above.

In this case it is true that subsidence takes the place of vertical motion, and surface cooling takes the place of surface warming. In other words, the exact opposite of what forces free convection occurs over the loaded gun region. It is not out of the question to guess that the subsidence seen in Figures 5 and 7 actually strengthens the low level inversion, making it nearly impossible for the low level moist air to reach the elevated mixed layer.

### *5.1 Low Level Jet and Convergence*

All that is left at this point is to discuss what is causing the downward vertical motion over the moist region. The key to this lies in the low level jet described in the synoptic overview. A jet streak in the atmosphere forces a secondary circulation based on the theory of Sutcliff's expression for net ageostrophic divergence in a column (Martin, 2006). This circulation is caused by the changing speed of air moving through the jet. If one were to follow a parcel through a jet streak, one would see it positively accelerate in the direction of the flow going into the jet, and negatively accelerate as it moves out. This acceleration forces ageostrophic convergence and divergence in the four quadrants of the jet. Figure 8 is a conceptual model of this circulation. The left entrance region of a jet streak experiences convergence and subsidence, while the right entrance region experiences divergence and upward vertical motion. The left exit region of a jet experiences divergence and upward vertical motion, while the right exit region experiences convergence and subsidence.

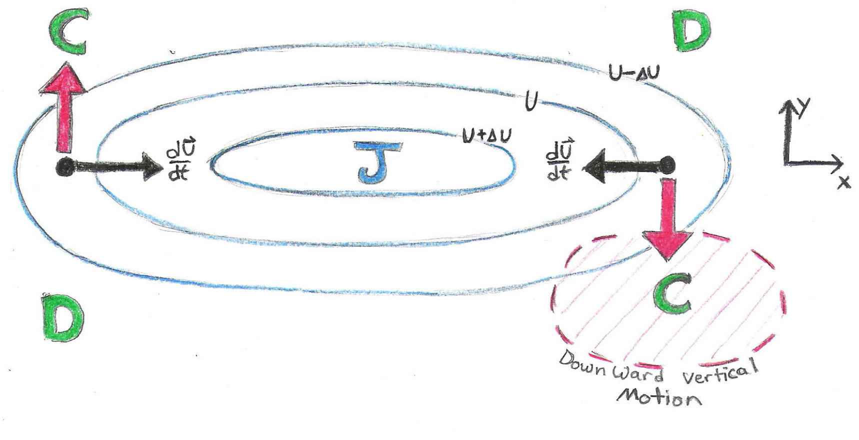

**Figure 8:** Conceptual model of a jet streak and the acceleration in observed flow giving rise to the ageostrophic (red) vectors. Areas of convergence are labeled with a C and areas of Divergence are labeled with a D. An example of the forced vertical motion is given for the right exit region.

A new cross section is needed to obtain a good image of the low level jet in this case. Figure 9 is a cross section perpendicular to the jet structure at 0000z on the 19th taken from Salt Lake City, UT to Corpus Christi, TX. What is first obvious in the cross section is the upper level jet and the characteristic potential temperature contour shape through it. What is less obvious is the 500 hPa potential temperature drop. Based on the thermal wind balance, this drop in the

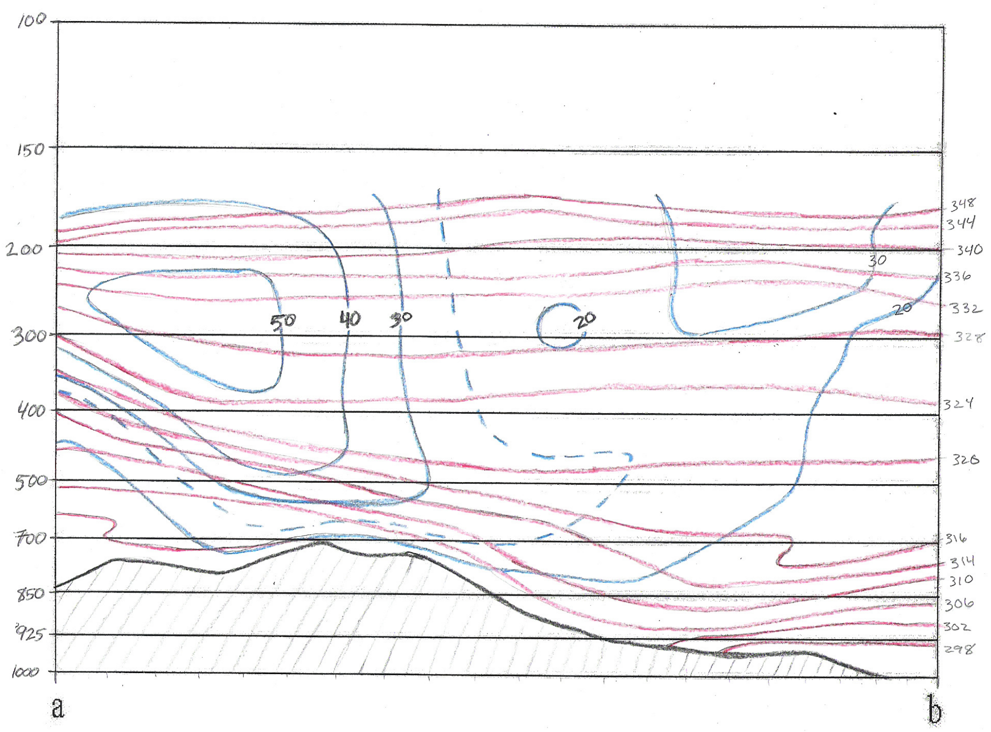

**Figure 9:** Hand drawn cross section between Salt Lake City, UT (a) and Corpus Christi, TX (b) at 0000z on the 19th. Theta contoured in red every 4 K, with isotacks contoured in blue every 10 m/s. The dashed blue contour (24 m/s) represents the low level jet tongue reaching out over Oklahoma and Texas at about 500 hPa.

theta contours must be accompanied by a change in wind speed. This is fulfilled in the image by a tongue of high wind speed reaching down across the region. This tongue of high velocity is the low level jet seen in the soundings discussed earlier.

Even though the low level jet is not nearly as strong as the upper level jet, it still has its own ageostrophic circulation. This circulation is illustrated in Figure 10 which displays observed wind barbs and ageostrophic wind vectors plotted on the left next to contours of downward vertical motion and filled contours of ageostrophic convergence at 0000z on the 19th. The dryline is included in the figure for reference. The top two images in the four paneled figure are showing 500 hPa convergence, and 600 hPa downward vertical motion. The bottom two panels show 600 hPa convergence and 700 hPa downward vertical motion. The vertical motion is plotted at lower levels because the convergence forces subsidence in the layer bellow it. It is clear that the subsidence aligns perfectly with ageostrophic convergence at both sets of levels.

The dryline allows for comparison between Figures 10 and 7 and 5. The subsidence seen in all three figures matches well with the convergence in Figure 10 and is just to the east of the dryline right over the region of strongest convective potential. The panels with wind barbs and vectors illustrate the circulation pattern with the jet streak to the left in both images and the converging ageostrophic wind vectors just to the right of the region of most intense observed

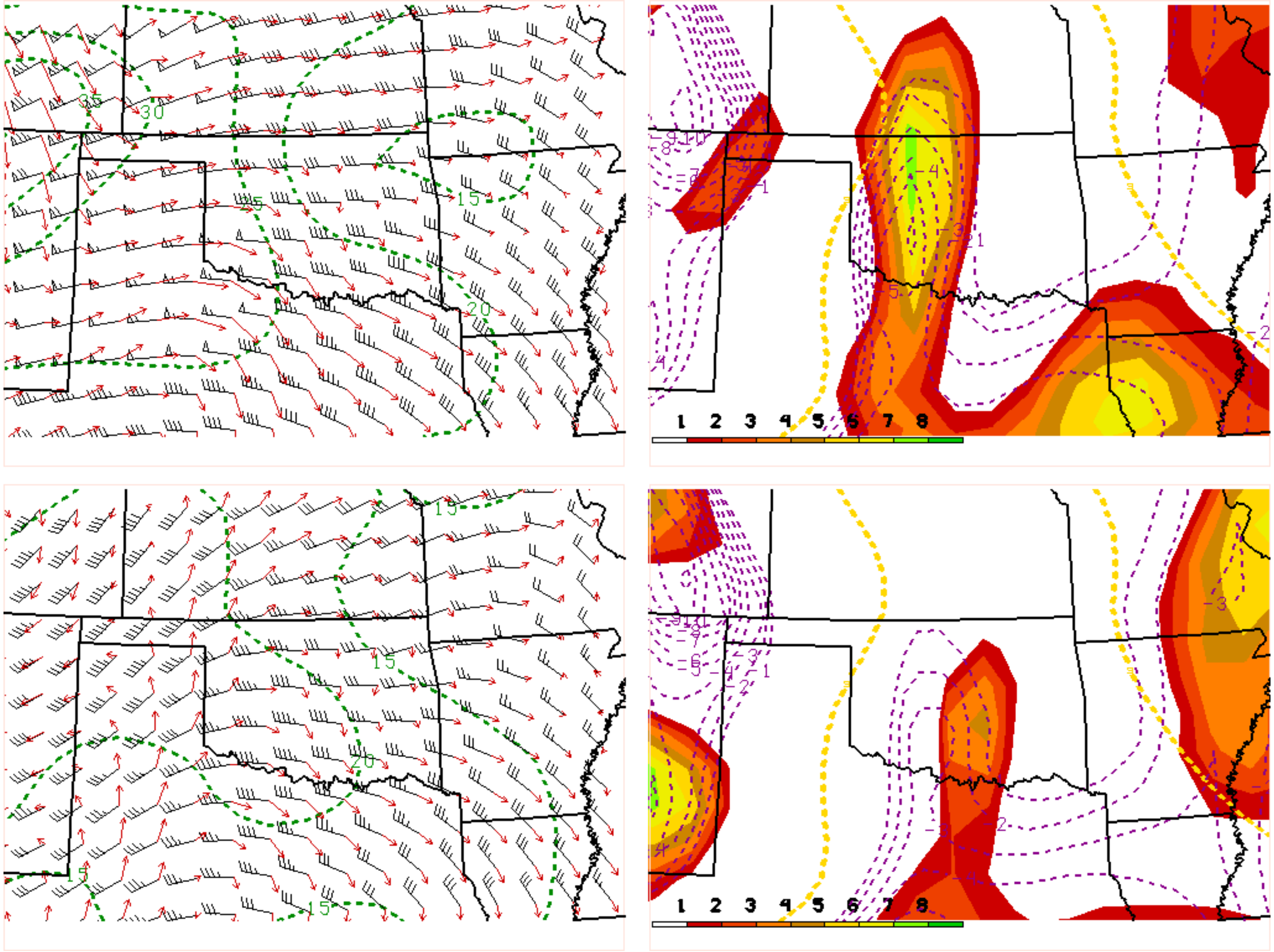

**Figure 10:** Left panels plot observed wind barbs and isotacks with red ageostrophic wind vectors at 500 and 600 hPa. Right panels plot ageostrophic convergence in filled contours and downward vertical motion in dashed contours at 500 and 600 hPa and 600 and 700 hPa respectfully. All images are from 0000z on the 19th.

velocity change. The downward vertical motion is more intense at 600 hPa than at 700 hPa, which would be expected based on Figure 7 as the vertical motion in this cross section is maximized at just bellow 500 hPa. Figure 10 shows the reason for this being more dramatic speed changes at 500 hPa then 600 hPa.

### *5.2 Frontogensis*

As mentioned in the introduction section, there was a small amount of sensible weather along the dryline in south central Texas by 0000z on the 19th. This convection is triggered by the low level upward vertical motion seen in Figures 5 and 7 which just over laps the dryline. Although this is insignificant compared to the potential for storms just to the east, it is interesting as the forcing for the upward vertical motion might contribute a component of downward vertical motion just to the east further expanding the analysis of the null event.

The horizontal pattern of vertical motion in Figure 5 matches well with contours of frontogensis shown in Figure 11. Frontogenesis is the dynamical shrinking of a horizontal thermal gradient. Mathematically, frontogenesis is defined as the full time derivative of the horizontal gradient in potential temperature. Often frontogenesis is forced by regions of

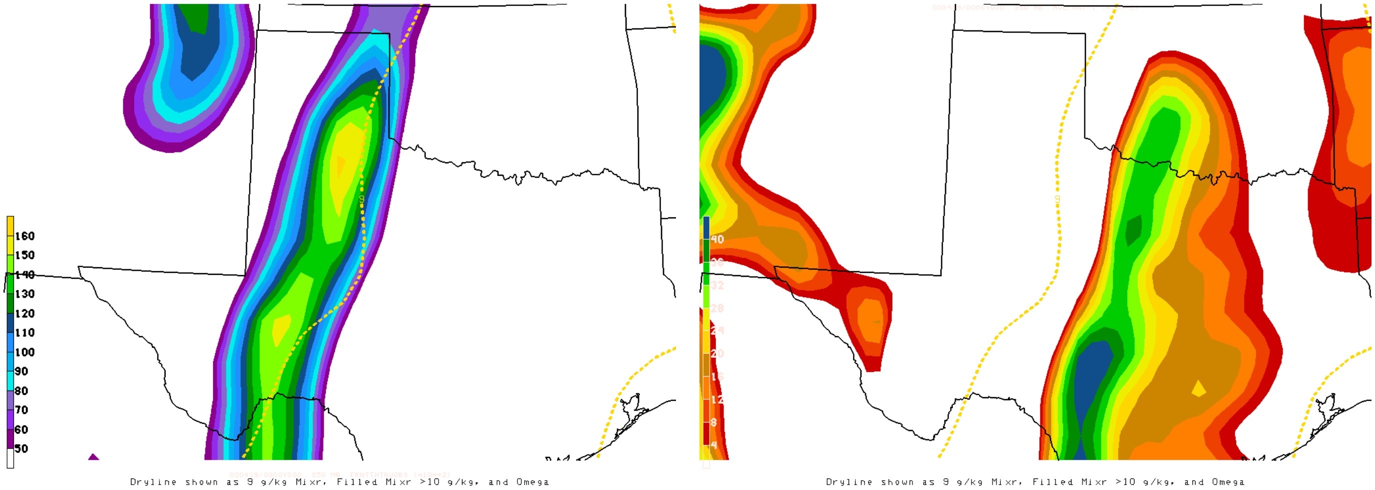

**Figure 11:** Figure of frontogenesis and frontolisis respectfully at 0000z on the 19th at 850 hPa. The dashed yellow line is the dryline (9 g/kg isohume) included for reference. The numbers on the scale are insignificant, however, the strength of the frontogenesis over the frontolosis is clear. Upward vertical motion in the column is expected in the region of frontogenesis and is confirmed by Figure 5.

confluence along pre-existing baroclinic zones. The confluent wind pattern physically squeezes the temperature contours together by varying thermal advection. Frontogenesis can also be forced by diabatic heating due to latent heat release in the atmosphere or by surface heating and vertical mixing (Martin, 2006). What is important about the concept of frontogenesis is the vertical motions associated with the dynamical process. Based on a semi-geostrophic approximation, a thermally direct circulation develops in association with positive frontogensis. This circulation is known as the Sawyer-Eliassen circulation based on the pioneering work done on the subject by these two scientists (Martin, 2006). The theory rests on the convergence and divergence of geostrophic Q vectors defined by the product of the horizontal derivative of the geostrophic wind and the potential temperature gradient. The Q vector side of this dynamical process reaches a little beyond the bounds of this case, mainly because frontogenesis is not the primary concern of the study.

Coming back to Figure 11, it is obvious that there is a significant region of positive frontogenesis on the warm, dry side of the dryline, and negative frontogenesis on the cool moist side. This leads to a conclusion that at this level, 850 hPa, there will be a thermally direct circulation around the dryline, or upward vertical motion on the warm, dry side of the dryline, and downward vertical motion on the cool moist side. This conclusion matches well with the already diagnosed vertical motion pattern visible in Figures 5 and 7.

It is important to discuss the fact that the contours shown in Figure 11 show the values of frontogenesis multiplied by 3 in order to define specific regions in a clear way. This helps for analysis from a qualitative stand point but does not give much for making conclusions from a quantitative stance. What little quantitative data can be gained from this analysis is that the upward vertical motion forcing is much stronger than the downward. The upward vertical motion shown in Figures 5 and 7 fits the pattern of positive frontogenesis almost exactly while the downward vertical motion is not as well defined. Looking back at the sounding data shown in Figure 4, it is unclear the magnitude of the low level subsidence. The frontolisis shown in Figure 11 is at 850, very close to the level of the low level inversion.

## 6. Summary and Conlcusions

Although severe storms in the Great Plains in the spring are extremely common, sometimes the atmospheric set-up does not allow them to form even if all but one variable is in the right place at the right time. April 18, 2000 is example of this type of event. Given the name null event, this type of case has every conceivable variable perfectly in place to produce free convection and possibly severe weather, but nothing actually happens. The April 18, 2000 case is a very interesting null event as there are regions where weak convective storms erupt, however, over the region of most dramatic potential, there is not a cloud in the sky. The goal of this study is to diagnose the missing piece of the puzzle which forces the lack of any sensible weather over Oklahoma and Texas. The hypothesis posed here is that mid level subsidence associated with a low level jet is responsible for not allowing anything to break the low level capping inversion separating the cool moist surface layer from the dry, conditionally unstable layer above it.

The convective set up ties together synoptics and mesoscale factors. The upper level trough pushing across the Rocky Mountians forced cyclogenesis in the lee of the mountains. The cylcogensis allowed for southwesterly flow off the mountains to the west and southerly flow off the Gulf of Mexico to the east. This allowed for, in addition to upper level westerly flow, a loaded gun vertical set-up over Oklahoma and east central Texas. A dryline was formed in the lee of the mountains along the Panhandle of Texas, Oklahoma border through central Texas representing a significant gradient in moisture through the region significant for convective potential. Soundings from central Oklahoma make the convective potential even more obvious with CAPE values exceeding 3000, and vertical profiles of the loaded gun situation.

With everything seemingly perfect, what really seems to put the fly in the ointment is the heating throughout the day. It was discussed that there was significant heating through the day on the 18th on the dry side of the dryline by both solar radiative heating and southerly warm advection off the Mexican Plateau. This warming caused the development of a significant temperature gradient through Texas. With a baroclinic zone comes a vertical change in winds based on the thermal wind relationship. In this case the low level jet is a result. The jet forced convergence and subsidence at mid levels over the east side of the dryline. This subsidence is in such a place that it does not allow anything through the inversion cap not only by taking the place of upward vertical motion, but also by intensifying the cap. Breaking the low level inversion cap is the key to forming any weather associated with a loaded gun situation. Breaking the cap allows moist surface air to flow into a deep, conditionally unstable, dry layer which causes free convection. Frontogensis at low levels is another effect of the daytime warming, however the effect seems to be only upward vertical motion in a shallow layer just to the west of the dryline. This motion is reflected in small scale storms which develop later in the day on the 18th and into the 19th.

The study of null events is an under rated area of mesoscale meteorology. Not only does the study of null events force a better understanding of convective storm events as a whole, it leads to better forecasts. Forecasting is the key when it comes to severe weather and convective potential. By increasing knowledge on the factors that lead to severe weather, whether they are purely atmospheric or they relate directly to the region of the world where the event takes place, it is possible to make more comprehensive forecasts. Better forecasting and awareness of the potential for severe weather can mean the difference in savings lives.

# REFERNCES

P. S. Ray 1986: Mesoscale Meteorology and Forecasting. American Meteorological Society. 549-572.

J. E. Martin 2006: Mid-Latitude Atmospheric Dynamics. Wiley. 150-154.