SILVER LINING TIMES NEWSLETTER

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IN THIS ISSUE

Storm Season 2006: The Year Without Juice

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Silver Lining Times is a newsletter dedicated to informing our clients and storm enthusiasts about our activities, as well as offering valuable and unique information. Scheduled publication is quarterly (in an ideal world): August 1, November 1, February1, May 1.

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Cover Picture: Beautiful supercell near Patricia, TX May 5, 2006. This storm produced an F-2 tornado around this time.

Master Class participants film the formation of a wall cloud beneath an impressive striated storm southwest of Colstrip, Montana June 8, 2006!

Welcome to another (albeit belated) edition of our newsletter. This storm season was a mixed blessing for Silver Lining Tours. On the positive side, we enjoyed the company of the largest number of participants in our history. On the other hand, this large group of avid storm chasers experienced one of the least active tornado seasons in recent memory. The good news is this means that there was little in the way of tornado-induced casualties or property loss over Tornado Alley this year. Within these pages we'll examine some of the causes of the 2006 tornado drought. We'll also discuss the reasons why the high plains are the storm chasers' refuge in a regime generally lacking rich low-level moisture (such as was the case this year).

Best Regards,

David Gold and Roger Hill
Partners, Silver Lining Tours

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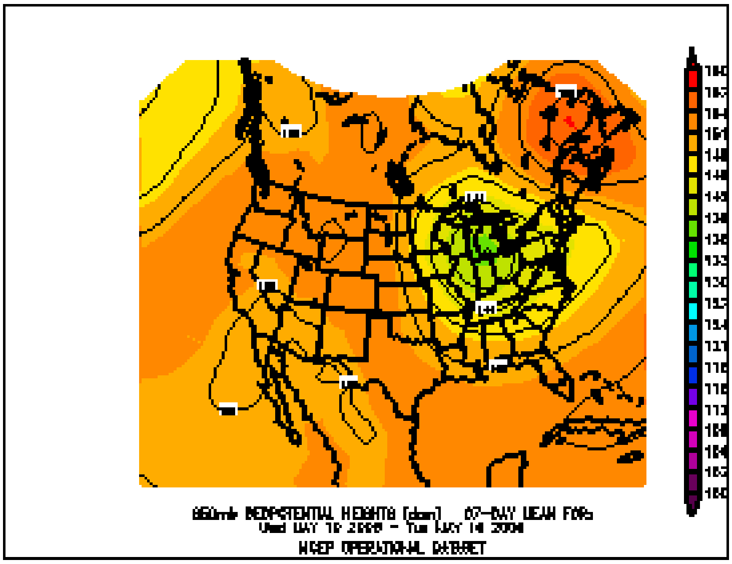
R.I.P. Tornado Season '06



Geopotential height field (850 mb), time-averaged over the period May 10-16. This was a storm-free period over the Great Plains.

It is easy to imagine that in relaxed settings, surrounded by their colleagues, many storm chasers will wax philosophical about the 2006 tornado season. I myself have tried to characterize the "Season That Never Was" with witty phrases — many inspired by the classic Clint Eastwood spaghetti westerns — such as "2006: For a Few Degrees More" (referring, of course, to degrees of surface dew point temperature) or "The Year The Mesos Died" (with a tip of the hat to Don McLean). Indeed, many young storm chasers have never experienced a year quite like 2006, one in which almost no photogenic tornadoes were produced during May and June. Some older chasers will point to 1988 as having been the last year as unproductive as this one. While a detailed examination of factors contributing to this year's tornado dearth is beyond the scope of this newsletter, it is nonetheless interesting to examine some of the proximate causes.

The big missing "ingredient" in 2006 was low-level moisture. After the May 9 southern Plains severe weather outbreak, a significant closed low took shape over the eastern U.S. and the lower tropospheric portion of this low (Figure 1) maintained strong northerly geostrophic winds across the Gulf Basin for over one week, sweeping the low-level moisture out of the Gulf and away from the U.S. Moreover, we never established persistent southerly low-level winds over the Plains, in part due to the fact that in the time-mean sense, we never really managed to lose the eastern trough and the associated northerly flow over the Gulf. This is depicted rather well in Figure 2, which shows the departure of the 500 mb flow pattern from its climato-

Weather Words

Helicity: A measure of the degree to which the low-level inflow (i.e., the air "feeding" a storm) is already spinning before ascending into the storm updraft. The measurement amounts to computing at various levels within the lowest portion of the atmosphere the degree to which the low-level winds mathematically "project" onto the horizontal vorticity vector at each of those levels.

Wet-bulb temperature: The temperature that a blob of air would be cooled to by evaporating water into it until saturation (without changing the pressure of the air). The higher the wet-bulb temperature, the moister the air.

Beaver tail: A very distinctive horizontal cloud feature resembling a beaver's tail. Such cloud features are commonly observed with significant supercells. This feature represents a primary inflow "channel" along which the air feeding a storm condenses as it mixes laterally with rain-cooled air produced within the storm's forward-flank precipitation core. In time-lapse movies of beaver tails, one can often see slow horizontal rotation about the edges of the tail as air flows inward toward the storm updraft!

FUNNEL FACT: The Fujita-scale method of rating tornado intensity is currently being replaced by the EF (Extended Fujita) method. The EF rating system attempts to refine intensity ratings based in part on damage to trees and other structures not incorporated in the original rating system.

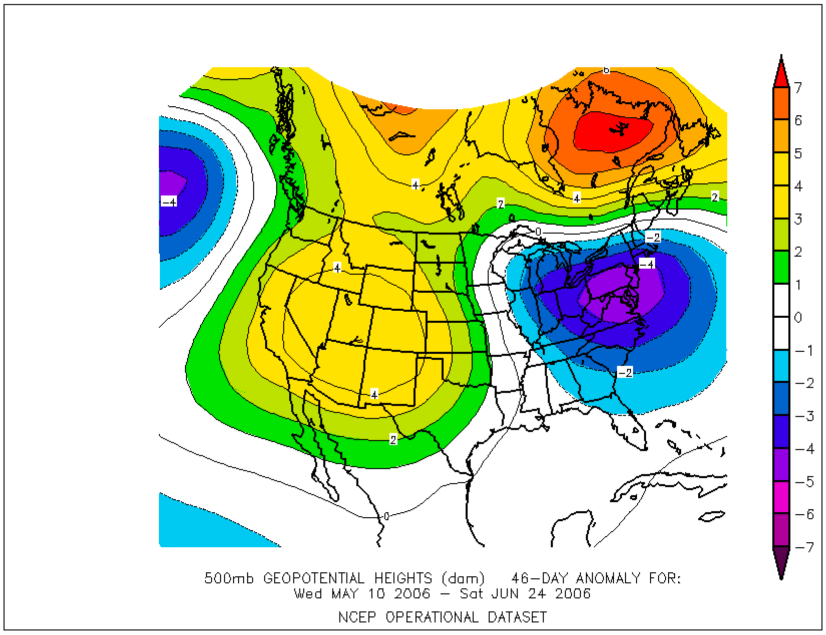


Figure 2: 500 mb geopotential height anomaly (relative to climatology) averaged May 10 to June 24, 2006. Note the very strong eastern trough/western ridge, keeping the Plains under northerly flow.

logical norm when averaged over the bulk of the 2006 tornado season (May 10 to June 24, 2006). The end result was that the deep, rich tropical moisture simply failed to return inland past the Gulf coastal plain after May 10. Consequently, storms that did develop were moisture starved, spewing forth tons of cold outflow air as rainwater evaporated and chilled in the very dry subcloud-layer atmosphere. Moreover, supercell storms formed almost exclusively on the higher terrain adjacent to the Rocky Mountains (see the following article) where convective temperatures were attainable given the meager moisture content of the lower troposphere. Few of these storms, however, had the juice to become tornadic.

Aside from the persistent hostile jet stream configuration shown above, long-term drought may have played some role in limiting low-level moisture. Large sectors of the southern U.S. began the spring with large rainfall deficits, a situation reflected in the Palmer Drought Severity Index (Figure 3). Dry soil tends to feed back on low-level atmospheric moisture availability by permitting hotter lower tropospheric temperatures, which in turn promotes more vigorous turbulent stirring — a process which tends to dry out the low-levels.

One mechanism that probably *cannot* be used to easily explain this year's low-level moisture anomaly: ENSO (or other modes of variability linked to air-sea interactions). Departures of sea-surface temperatures (SST's) from their climatological averages — the SST "anomalies" as they're referred to — have been near zero in most areas of the tropical and subtropical Pacific during the past few months. Very weak warm anomalies were detected across the tropical Atlantic over the three-month averaging window (April-June 2006) but that's about it. The causal linkage between air-sea interaction and mid-latitude drought condition (e.g., see the article by Schubert et al. 2004 – Science Magazine) is still tenuous, at best.

Causality aside, how does the 2006 tornado season stack up statistically? Well, on average 269 tornadoes are reported each May and 236 each June (10-year average, 1996-2005). This year's preliminary tornado count is 168 in May and 137 in June, or roughly 62% and 58% of the average, respectively. So, comparatively speaking, this year's tornado count was certainly well below the mean. However, it is worth pointing out that there is considerable year-to-year variability in these numbers (the standard deviation of tornado reports is125.6 for May and 86.1 for June). Also, it is hard to find periods of time in the tornado record where either May or June tornado totals remained significantly below

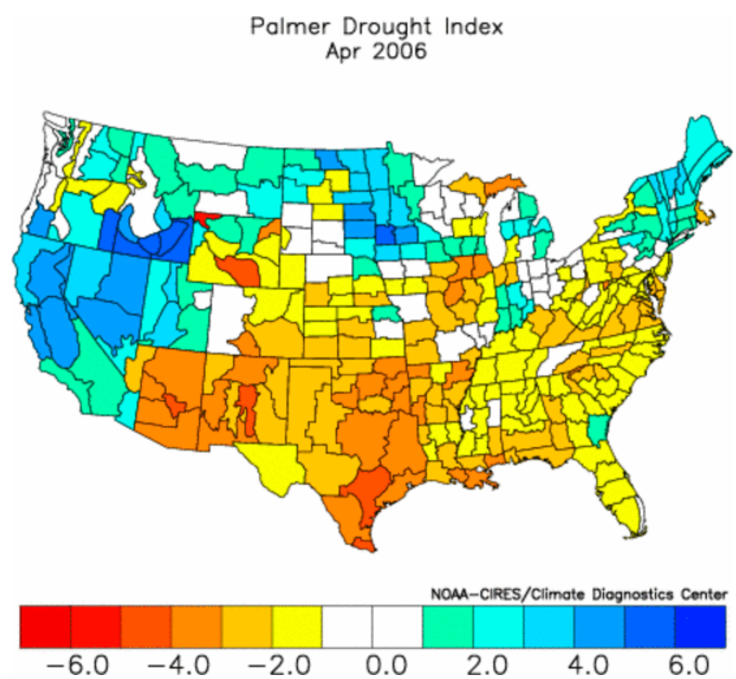


Figure 3: April 2006 Palmer Drought Severity Index. Note the severe drought over the southern Plains leading up to the 2006 tornado season.

average for more than two consecutive years. Does this mean that 2007 will be more active? There are too many factors (several of which are unknown or unknowable) to say, but in a crude statistical sense it is unlikely to be less active. One thing the record does show is that tornado counts can fluctuate wildly from one year to the next.

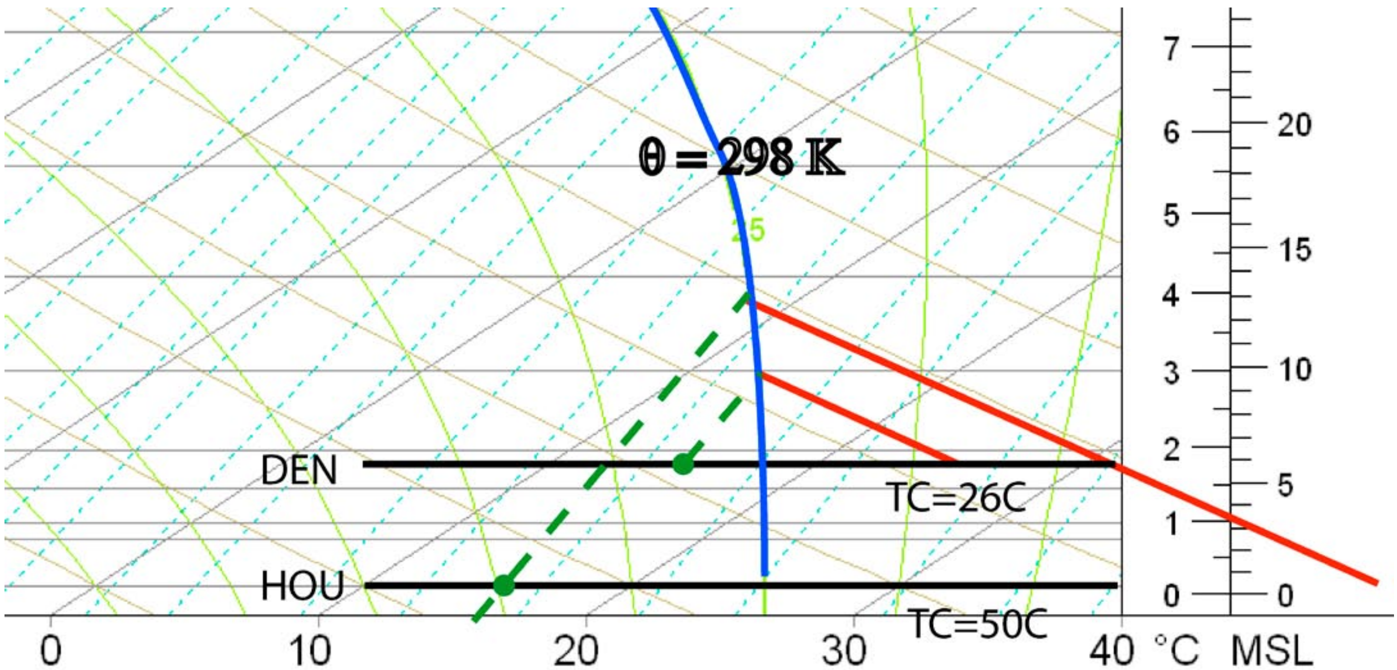


Figure 4: A sounding diagram with two parcels plotted, each one with a surface dew point temperature equal to 59F (15 C), but "starting" at different elevations: Houston (lower thick horizontal black line) and Denver (the top one). Dashed green lines depict how the dew point of each surface parcel would change so as to conserve mixing ratio during dry ascent. Solid red lines depict how the temperature of each parcel would change so as to conserve potential temperature during dry ascent. The surface temperatures are chosen in each case so as to achieve the same wet-bulb temperature at saturation given the dew point of 15C at the two different elevations. In other words, in each case the convective temperature (TC) is found and this represents the surface temperature required to achieve saturated ascent in each case.

In a year like 2006 when the central and eastern Plains are devoid of the rich tropical moisture necessary for significant tornadic storms in May and June, storm chasers run to the hills — the high plains. But exactly why is it that significant severe storms can develop over the high plains while the lower terrain to the east is storm-free? In general, there are two things going on in such a pattern. For starters, any time the elevated plateau (the Rockies and adjacent plains) is subject to strong heating, a thermally direct circulation develops and this is comprised of a low-level flow from the lower terrain to the east toward the elevated plateau, referred to in the meteorological venacular as "upslope" flow. The slope of the terrain (a few kilometers of rise per 1000 km of horizontal extent) mechanically lifts (and therefore adiabatically cools) the air as it approaches the mountains from the east. If this easterly air flow is sufficiently moisture-laden, the ascent inherent in the upslope flow can cool the air to saturation and clouds can form. If this upslope flow is not only moist but sufficiently buoyant, then thunderstorms, including severe storms, can also develop. How does one know whether an upslope flow regime is sufficiently buoyant to support severe storms? As usual, one must look at a series of soundings from around the region. However, my purpose here is more generic.

Rather than looking at specific examples, I want to use a blank sounding diagram to show how much of a difference the increase in elevation makes with regards to buoyancy. We can do that by first picking at random a curve on the diagram that represents the thermodynamic "path" an ascending parcel of air will take if it is lifted to saturation and, at the point of saturation (the LCL – the Lifted Condensation Level), is assumed to be warmer than its environment (i.e., assuming a case where the LCL equals the LFC [Level of Free Convection]). This curve (highlighted in dark blue) is depicted in Figure 4. It is no accident that I chose this particular curve; this is one that represents what a lifted parcel would "do" if lifted to its LFC on a sounding over the Great Plains in June when rich tropical low-level moisture is present. You should therefore consider this curve to represent a potentially very unstable lifted parcel (i.e., one possessing lots of CAPE). What I've omitted here is any attempt to overlay an actual sounding representing the "average" temperature trace of the real atmosphere, because this would only obfuscate the lesson, which now follows.

On Figure 4, two surface-based parcels, each arbitrarily assumed to have a surface dew point temperature of 59F (15 C), are plotted — one at Houston, TX (denoted "HOU") and the other at Denver, CO ("DEN"). The latter's ground elevation is about one mile above mean sea level (MSL) and the former near MSL (the ground at each station is denoted by a thick horizontal black line on the figure). In each case, I've computed the surface air temperature (denoted by "TC" on the diagram) required to achieve a wet-bulb potential temperature (marked on Figure 4 by the Greek symbol θ) of 298 K (or 25 C) *given* a surface dew point temperature of 15C (*my apologies to purists, who would correctly point out that I am confusing people by using θ, a symbol that is usually reserved for the potential temperature, rather than the wet-bulb potential temperature being discussed here*). Again, θ = 298K is a very warm value and one that might be achieved by a very unstable (i.e., CAPE-laden) parcel in a very moist June severe storm environment over the lower plains (e.g., eastern Nebraska or Iowa). Note that a much cooler surface temperature will yield θ=298K at Denver than at Houston. In fact, at Houston the temperature needed to get such a warm wet-bulb potential temperature value would be about 50C (122 F) – implying that there is no way such a high value of θ could ever be achieved at relatively low elevations with surface dew point values "only" in the upper 50's. On the other hand, a potentially very unstable value of θ is achievable at Denver with surface dew points in the 50's F. This, in a nutshell, is why you don't "need" as much moisture at higher elevations to get significant severe weather; a much cooler (i.e., realistically attainable) surface temperature at high elevations will achieve ample CAPE given dew points that just wouldn't cut it at lower elevations.