DRYLINE MAGIC by Tim Marshall

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Every spring, veteran storm chasers head to West Texas to catch a weather show they call "dryline magic". The dryline is a boundary that separates hot, dry air to the west from warm, moist air to the east. During the spring, it lurks on the western high plains. The dryline moves east during the day, acting like a rotary plow, churning up the warm, moist air ahead of it. If there is enough moisture and instability in the warm air, severe storms can form, storms that often produce high winds, large hail, and tornadoes. A dryline storm is more isolated, more visible, and more violent than any other type of storm. Storm chasers love them. Once they've seen one, most forget all about the fast-moving squall lines associated with cold fronts and the low-visibility storms along warm fronts.

I've driven through many drylines. One morning, while driving east of Lubbock, Texas, in hot, dry air, it seemed as if I suddenly hit a waterfall! The parched air in the car immediately became saturated and the windows all fogged up. Looking north and south along the dryline, I could see the cross sections of the two distinct air masses. To the west, the sky was sharp and clear, and distant cumulus clouds were crisp and white. In contrast, to the east, the air mass was hazy and cloudy, and I could make out only a few rows of yellow fuzzy cumulus before visibility faded into obscurity.

Later that day, on my return westward, I suddenly plowed through a wall of dust denoting the leading edge of the dryline. The muggy, oppressive air in my car was quickly evacuated, and it felt like I had driven into a blast furnace. My lips were chapped and my teeth gritty.

Dryline development

Topography plays an important role in dryline development and movement. The elevation from western Nebraska south through western Texas averages about 3,000 feet above sea level. Air descending the eastern slopes of the Rockies warms and dries out as it sinks, creating a hot, dry, cloud-free zone that gives birth to the dryline. As the parched air moves eastward toward lower elevations, it encounters more and more moisture and has more and more air to mix. This slows the dryline down and by mid-afternoon, the dryline usually stalls.

By early evening, the dryline is in full retreat back to the western high plains pushed westward by low-level southeast winds on the moist side of the boundary. Sometimes the dryline repeats this cycle for an entire week, producing the severe storms day after day. Dryline storms tend to be severe for several reasons. Upward forcing along the dryline tends to occur at specific points associated with waves or bulges along the boundary. Surface moisture convergence is enhanced at these points, and it is moisture that fuels storms. As a result, dryline storms tend to me more isolated and more severe than other storms, since they don't have to compete with neighboring storms for moisture.

Dryline forecasting

The dryline is identified on the weather map by a sharp gradient in dew point temperatures, usually around 50 degrees F. Sometimes, differences of 30-60 degrees F may occur between adjacent weather stations. In strong dryline situations, I have even seen negative dewpoints in the dry air with relative humidities in the single digits!!

In order to determine the probable movement of the dryline, I check the morning weather balloon soundings to see how deep the low-level moisture is east of the dryline. A moisture layer only a few thousand feet thick will tend to mix quickly, allowing the dryline to advance eastward rapidly. I have seen some drylines reach speeds of 50 mph when there is little low-level moisture in their paths. On the other hand, a moisture layer around 5,000 feet thick will tend to slow down the mixing process and could bring the dryline to a halt.

Forecasting dryline storm development is tricky and can leave storm chasers sunning themselves, rather than stalking a monster storm. The dryline will not produce a severe storm by itself. It usually has to wait for an upper-air disturbance to lift the warm, moist surface air to its east through a stable layer called the "cap" (temperature inversion) aloft. I study the morning soundings to determine the strength of this inversion. The thicker the inversion, the more difficult it is for a storm to form. Only the right combination of surface and upper-air conditions can lead to explosive storm development.

Once a storm does develop along the dryline, there is no guarantee it will become severe, since this will depend on other factors such as the amount of vertical wind shear present. The turning of the wind from southeast at the surface to westerly aloft (directional shear) is needed to cause storms to rotate. In addition, an increase in of wind velocity with height (speed shear) will knock over weak storms so only the strongest storms survive. Dryline storms eventually move off the boundary into deeper low-level moisture where they can feed and grow.

Key features

One of the key features I look for in forecasting the dryline is a *dryline bulge*. This forms when strong surface winds in the dry air accelerate a portion of the dryline eastward ahead of the rest of the boundary. Such winds can cause intense dust storms that obscure the sun. Sometimes, a surface low-pressure center forms along the dryline bulge, enhancing moisture convergence and increasing the chances for storm development.

A dryline-frontal intersection is also an area of enhanced moisture and surface wind convergence. The front can be cold or warm or an old thunderstorm outflow boundary. Storms that form at such intersections are literally located in a narrow canyon that channels moisture and wind into a storm. Stationary or slow moving cold fronts create a "point" for storm development at the intersection. In contrast, a rapidly moving cold front merging with a dryline frequently creates a "line" of storms or squall line.

Dryline storm chasing

When chasing dryline storms, I try to position myself in the moist air, about 20 to 40 miles ahead of the dryline. If I am behind the dryline, I may find myself battling blowing dust and strong gust winds that can slow me down. On the other hand, if the dryline is too far to the west, I have to plan for extra driving time to get through the intervening drizzle, low clouds, and fog.

As I drive, I monitor the weather conditions at selected cities by listening to radio stations that report dewpoint temperatures. I also carry a wet-bulb thermometer to measure the amount of moisture in the air. As the afternoon develops, I look for a boiling, foaming line of cumulus to the west of the moist air. This marks the mixing mechanism of the advancing dryline. I particularly look for clusters of cumulus towers that seem to grow and die repeatedly in the same area, possibly indicating the presence of a bulge, frontal intersection, or low-pressure center. Such agitated areas of convection are good severe storm generators. (Refer to Figure 1).

Once a storm does develop, I look around carefully to make sure there are no other storms nearby that could interfere with the development of my storm (Refer to Figure 2). I then judge the distance and movement of the storm and plan my chase route accordingly. Many times dryline storm chasing is a waiting game. If the temperature inversion aloft is too strong, storms will not develop, no matter how unstable the surface air is east of the dryline. On the other hand, I have learned never to turn my back on the dryline as long as there is daylight left; storms can explode and become tornadic in a mere 30 minutes -even on a retreating dryline. (Refer to Figure 3).

A dryline tornado outbreak

The following public weather statement was broadcast repeatedly on NOAA weather radio on April 26, 1991, the date of the deadliest tornado outbreak of the year.

"There is a HIGH RISK of severe thunderstorms over Oklahoma and Kansas today including the possibility of damaging tornadoes. A potentially dangerous weather situation is developing as a powerful storm system moves into the plain states. Moist and very unstable air is moving rapidly northward into Oklahoma and Kansas this morning and will remain in place this afternoon. The dryline, marking the western edge of the moist air, is located in the Texas panhandle. It will begin moving eastward by midday as strong upper-level winds over 100 mph swirl around the south side of the storm system and move into the central and southern plains. By early afternoon, thunderstorms are expected to develop rapidly along and ahead of the dryline. It is emphasized that this is a particularly dangerous weather situation for much of Oklahoma and Kansas. Extreme instability and strong winds aloft indicate the potential for a significant severe weather outbreak later today including the possibility of very destructive tornadoes. Residents are urged to take this situation seriously and keep in touch for the latest weather information throughout the day" --National Weather Service

As the message indicates, the morning weather maps on April 26, 1991 had tornado outbreak written all over them. Storm chasers studied the maps and all agreed that southern Kansas and northern Oklahoma looked most favorable for tornadic storms. Chase teams assembled and converged on the dryline by late afternoon. Over a half dozen storms developed along the dryline and, one-by-one, each storm became a tornado. While most of the tornadoes steered clear of populated areas, one struck a residential area in south Wichita and a mobile home park in Andover, KS killing 19 and injuring several hundred people (Refer to Figure 4).

DRYLINE PAPER FIGURES

Figure 1. An agitated area of convection is the first sign of a dryline thunderstorm.

Figure 2. A supercell storm forms along the dryline and no other storms are around.

Figure 3. Large tornado near Kellerville, TX on a dryline storm on June 8, 1995. Photo by Tim Marshall.

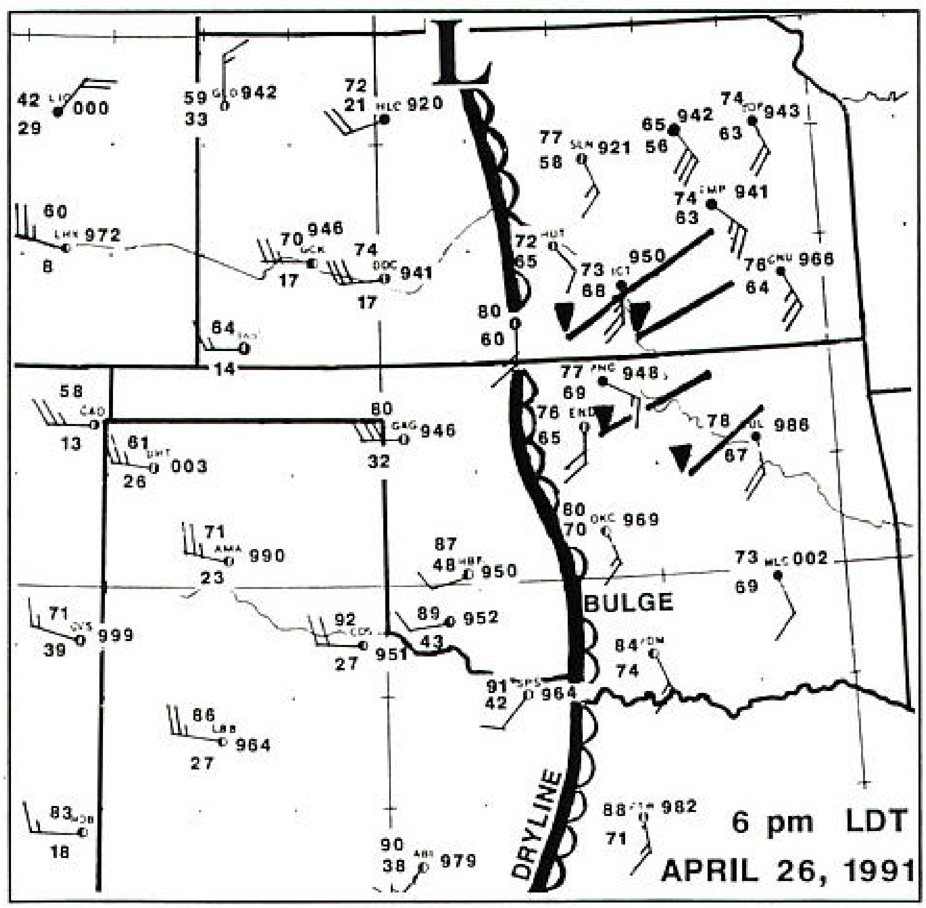

Figure 4. Surface weather map at 6 pm LDT on April 26, 1991 showing the dryline and the tracks of four tornadoes in southern Kansas and northern Oklahoma. The author was on the northernmost storm.