Case Study 3: Dryline in TX and OK 3 May 1999

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ABSTRACT

A massive tornadic outbreak swept across Oklahoma and Texas on 3 May 1999. Nearly 70 individual tornadoes spun from 10 different supercells resulting in F4-F5 damage in some cities. This outbreak was partially due to dryline activity and partially due to the synoptic setup for the time period. The dry, well-mixed, unstably stratified air flowing east over the Rockies collided with moist, shallow, upslope air moving westward. The inversion over the moist air formed a cap that prevented convection until it was broken by the tropospheric jet and convergence along the dryline.

1. Introduction

During the late afternoon and evening hours of 3 May 1999, a violent tornado outbreak swept across portions of Oklahoma and Kansas. A total of over 70 tornadoes were documented from the ten tornadic supercells (Fig 1) which developed over the southern plains that afternoon and evening.

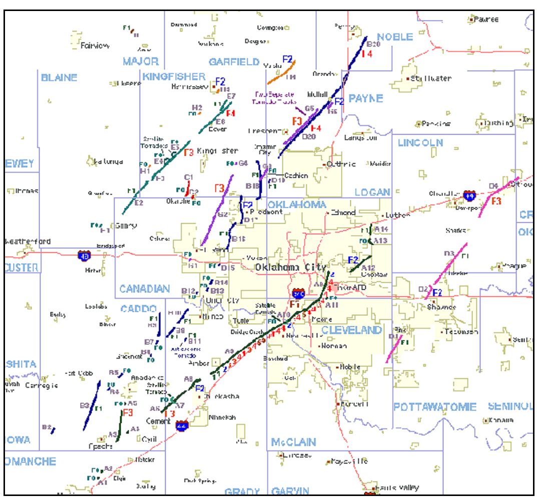

Fig 1 Storm tracks through the Texas region 3 May 1999.

Long-lived, violent (F4-F5 damage) tornadoes occurred in the Oklahoma City, Oklahoma and Wichita, Kansas metropolitan areas, as well as in the small towns of Mulhall and Dover to the north and northwest of Oklahoma City. This study proposes that the magnitude of this outbreak is partially due to the dryline and partially due to the fierce synoptic setup. Data sources are addressed in section 2. The evolution of the synoptic-scale environment is presented in section 3, with specific emphasis on the distributions of moisture, instability, and vertical wind shear. Mesoscale features are discussed in section 4. Section 5 summarizes the important aspects of this major regional tornado outbreak and directs attention to the critical points of this study.

2. Data

Data for this summary comes from a variety of sources. The National Oceanic Atmospheric Administration (NOAA) proved to be quite helpful. Figure 1 and statistical data from the tornado outbreak were obtained from the NOAA website. A number of figures were generated in garp and gempak. All of these utilize the eta model. This particular model was chosen because of its accepted accuracy. A majority of the information, including the cross sections and streamlines, comes from 0Z on 4 May 1999. This time falls in the midst of the outbreak.

3. Synoptic Overview

A large-scale trough was located over the western United States at 12 UTC 3 May (Fig 2), with a smaller short wave trough over Arizona. The large-scale trough amplified over the Rockies by 00 UTC 4 May, while the embedded short wave trough progressed from Arizona to western Oklahoma and Kansas.

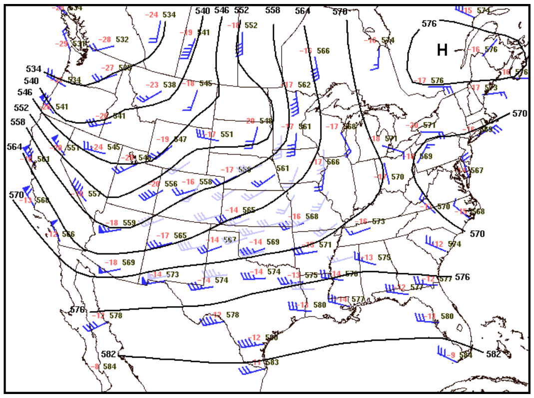

Fig 2 Height and Winds

In association with this deepening trough and southwesterly flow over the Rockies, a deepening surface low was located over the central high plains, with low-level southerly to southeasterly flow in the warm sector over Kansas, Oklahoma, and Texas. As destabilization continued over the southern plains, an upper-tropospheric jet streak moved east-northeast over Arizona and New Mexico, as shown in Fig 3.

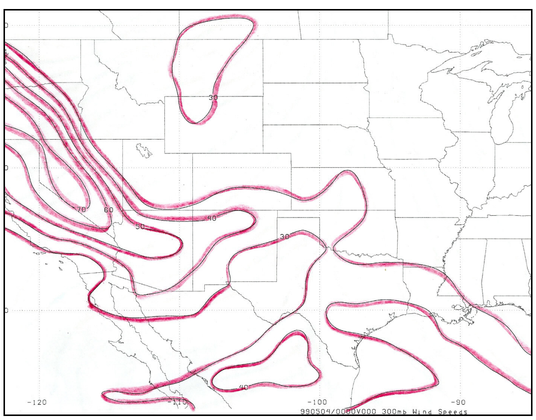

Fig 3 300mb Wind speeds from 3 May 1999

This region of diverging air helps to break the inversion and jump-start intense convection. Even though flow along the dryline is generally from the south, the observed winds show a definite convergence. This flow can be seen in Fig 4, which illustrates the streamlines of the 1000mb winds at the same time.

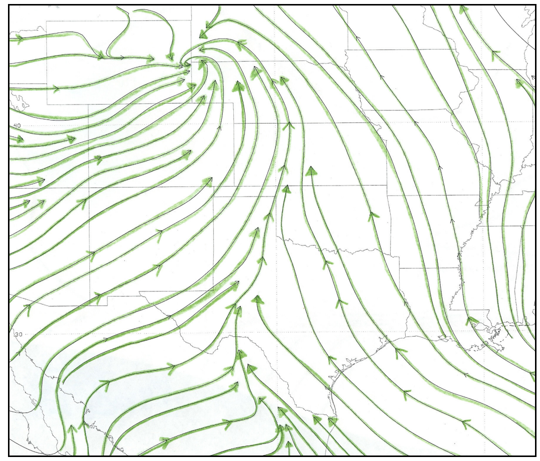

Fig 4 Streamlines 3 May 1999

4. Mesoscale Analysis

Fig 5 is a two-panel cross section taken across the dryline from Albuquerque, NM to Little Rock, AK at 0Z on 4 May 1999. Figure 5a plots theta-e and figure 5b is a plot of both theta and the mixing ratio (blue). The tight gradient of mixing ratio illustrates the dryline between Amarillo, TX and Norman, OK. By the mixing ratio values, it can be seen that the moist air is trapped under the area between 800mb and 700mb and that the values are relatively constant above that line.

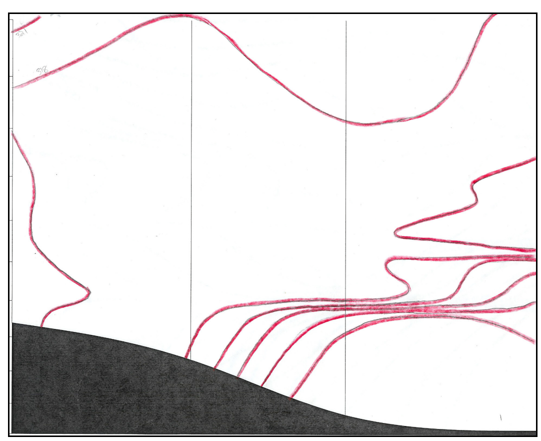

Fig 5a Vertical cross-section of theta contours

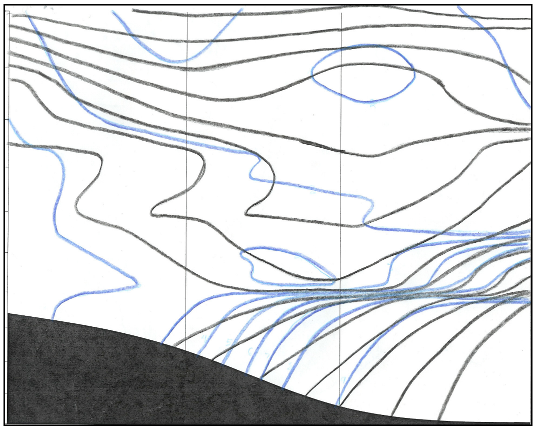

Fig 5b Vertical cross-section of theta-e (black) and mixing ratio (blue)

In figure 5a, this same barrier can be seen as a temperature inversion. To the west, a nearly adiabatic layer is observed immediately off the surface. In contrast, to the east, this well mixed layer is pushed up above the inversion into the mid-troposphere.

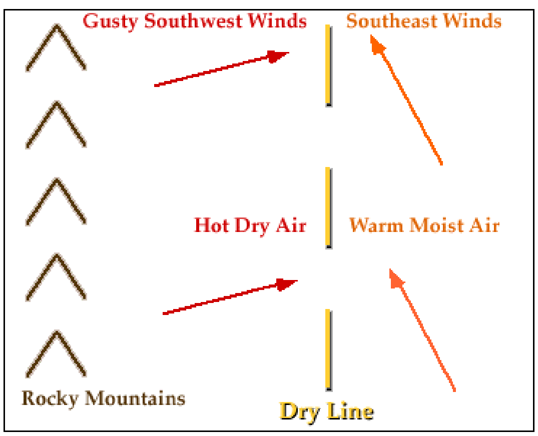

Fig 6 Conceptual model of a dryline

It is known that one of the major causes of drylines is the collision of moist upslope flow with drier downslope flow over the mountains. A conceptual model can be seen in Fig 6. It is also quite typical of drylines to have a layer of decreased stability above the low-level inversion. Both of these factors are consistent with this cross section.

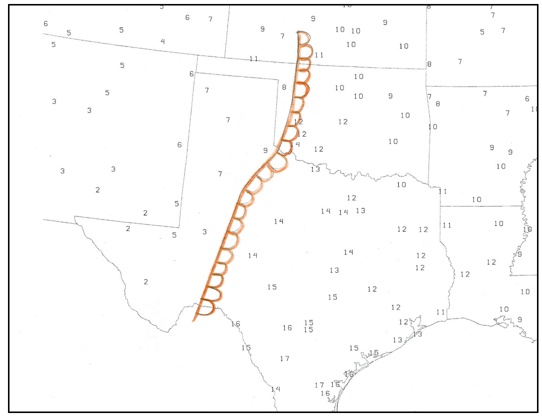

Fig 7a Dryline over Texas at 03Z

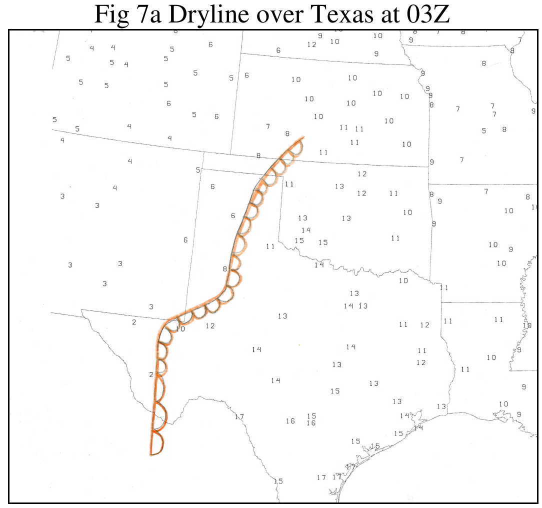

Fig 7b Dryline over Texas at 09Z

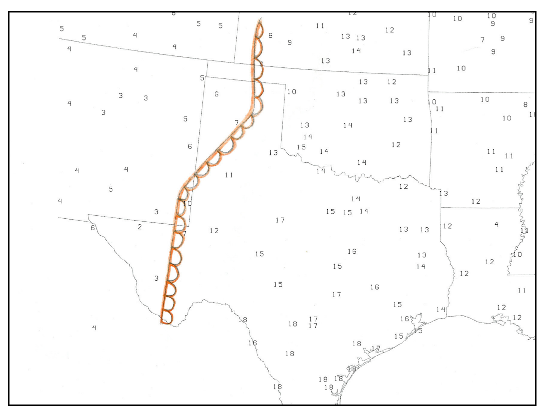

Fig 7c Dryline over Texas at 15Z

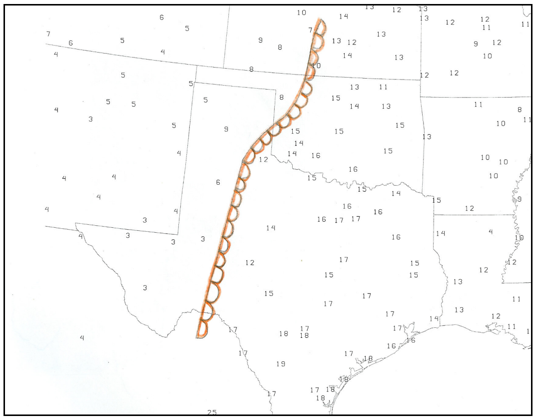

Fig 7d Dryline over Texas at 21Z

Fig 7a-7d illustrate the motion of the dryline from 03Z through 21Z on 3 May. Location of the dryline was determined by a change in the mixing ratio over a small area. It is seen that as the night progresses, (Fig 6a-6c) the dryline progresses to the west. During the day there is a visible jump of the dryline to the east. However, the entire dryline does not move at the same speed and at times not even in the same direction. This diurnal trend, with its variance, is consistent with dryline motion.

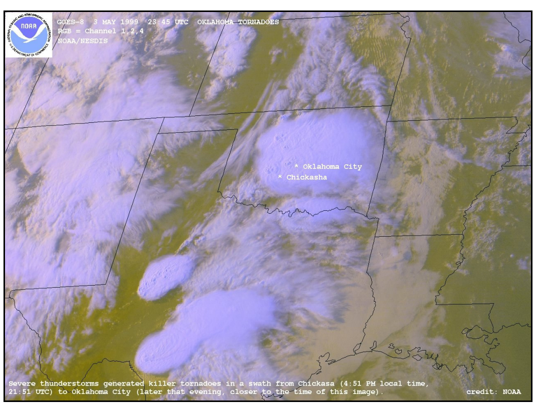

Fig 8 Satellite over Texas and Oklahoma 3 May

Fig 8 shows the GOES-8 satellite imagery. It highlights convective activity through central Texas up through western Oklahoma. This thin line of convective clouds sits directly over or perhaps slightly east of, the dryline at this time.

5. *Conclusion*

The 3 May 1999 tornadic outbreak was partially due to dryline activity and partially due to the synoptic setup for the time period. The dry, well-mixed, unstably stratified air flowing east over the Rockies collided with moist, shallow, upslope air moving westward. The inversion over the moist air formed a cap that prevented convection until it was broken by the tropospheric jet and convergence along the dryline. A combination of these factors made conditions right for one of the largest tornado outbreaks in Oklahoma's history.

References

www.NOAA.com
GARP and Gempak