113 EASTERN DRYLINE CLIMATOLOVE AND SYNOPTIC-SCALE ENVIRONMENT

R. S. Duell and M. S. Van Den Broeke
University of Nebraska-Lincoln, Lincoln, NE

1. INTRODUCTION

The dryline is an airmass boundary that typically sets up meridionally over the High Plains during spring. It marks a very strong moisture gradient between hot, dry air off the Mexican Plateau and warm, moist air originating over the Gulf of Mexico. It is also a zone of enhanced convergence, which makes it a focal point for convective initiation (Schultz et al. 2007), and the focus of much research. A number of dryline climatologies have been created; however, the published climatologies (Hoch and Markowski 2005; Rhea 1966) have focused on Great Plains drylines. This project is a study of drylines that move atypically far eastward. There are two objectives of this research project:

I) Create a five-year (2007–2011) climatology of dryline passages in the lower Mississippi River Valley region (see Figure 1 for domain); and

II) Construct composites of synoptic conditions associated with these eastern drylines.

2. METHODS

A computer algorithm was written that identified drylines according to three criteria. To be consistent with Hoch and Markowski (2007), a specific humidity gradient of at least a 3×10^{-8} m^{-1} (3 g kg^{-1} (100 km)$^{-1}$) was the first requirement of the identified drylines. Because this study specifically looks at eastern drylines, which are almost always synoptically active, a requirement for a virtual potential temperature gradient or a requirement for westward regression in the evening (typical indicators or a quiescent dryline) was not included. It became necessary to add additional criteria to separate drylines from frontal passages. The first criterion was modified such that the specific humidity gradient value was required to be higher to the east than to the west of the identified boundary.

* *Corresponding authors address:* Rebecca S. Duell/ Matthew S. Van Den Broeke, Department of Earth and Atmospheric Sciences • University of Nebraska • Lincoln, NE 68588-0340

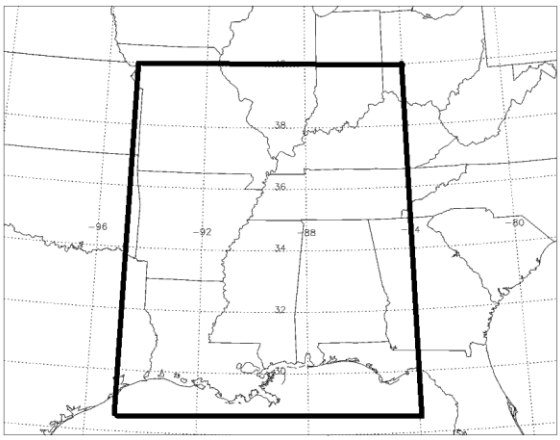

Figure 1: Domain of study

The second criterion used was a wind shift across the boundary, characteristic of a dryline. The winds to the west of the boundary were required to be from between 170˚ and 280˚. The winds to the east of the boundary were required to be from between 80˚ and 190˚. This wind shift from westerly or southwesterly to southerly or southeasterly is typical of the wind shift across the dryline, where the winds from the east originate over the Gulf of Mexico and the winds from the west originate from the Mexican Plateau. The final criterion used in this study was that the temperature gradient was required to be less than 0.02˚C km^{-1}. The wind shift criteria and the maximum temperature gradient criteria eliminated obvious cold fronts in which the winds had a significant northerly component, or there was a large temperature gradient across the boundary.

The computer algorithm used data from the National Centers for Environmental Protection (NCEP) North American Regional Reanalysis (NARR) dataset. This is a high-resolution (32 km grid spacing) three-hourly atmospheric and land surface hydrology dataset for the North American domain (Mesinger et al. 2006). This allowed for a very high spatial resolution of the data used. Each grid point in the domain was run through the algorithm and flagged if it met all three criteria. Flagged points were then run through an additional criterion that required three or more adjacent flagged points in order to rule out small scale boundaries or other discontinuities. Flagged points were then organized into a list of dryline hit days, which

were manually quality controlled to ensure any remaining fronts, sea-breeze boundaries, and outflow boundaries were excluded from the dryline dataset. Finally, air parcels on either side of the remaining flagged identified drylines were run through NOAA's Hybrid Single-Particle Langrangian Integrated Trajectory (HYSPLIT) model to visualize parcel trajectories and verify the origins of these air parcels. If parcels on the west side of the boundary were shown to originate from the Mexican Plateau and parcels on the east side of the boundary were shown to originate over the Gulf of Mexico, then the boundary met all this study's requirements for a dryline and was added to the dryline database and included in this study's climatology.

Once the climatology of eastern drylines was created, the synoptic features and anomalies for eastern dryline days were analyzed. Composite anomaly fields were created at the National Oceanic and Atmospheric Administration–Cooperative Institute for Research in Environmental Sciences (NOAA-CIRES) Climate Diagnostics Center Website (http://www.cdc.noaa.gov).

3. RESULTS

A total of seventeen dryline cases were identified in the lower Mississippi River Valley and Southeast regions from 2007 through 2011. Figure 2 shows the number of dryline passages that occurred in each state in the domain over the five years included in the climatology. Louisiana and Arkansas had the most passages, with seven dryline passages over the five years. Six drylines were analyzed in Mississippi, three in Missouri, and one in Alabama. The remaining states included in the study (Illinois, Indiana, Ohio, Kentucky, Tennessee, Georgia, and Florida) did not have any dryline passages analyzed from 2007 through 2011.

Table 1 shows the occurrence of dryline passages by month. Over the five years studied, three dryline passages occurred during the months of February, April, and May. Two dryline passages occurred in December, January and March, and one passage occurred in June. There were no dryline passages from July through November.

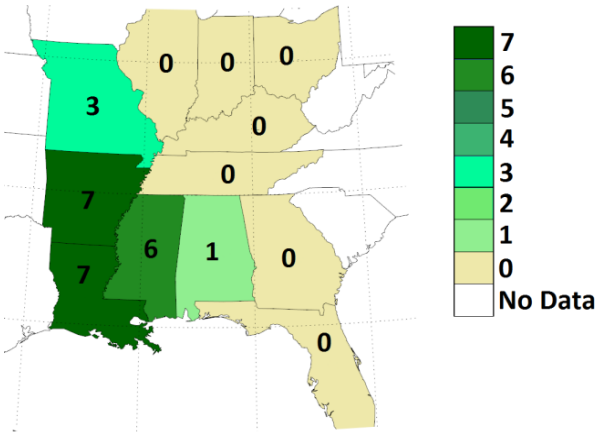

Figure 2: Number of dryline passages by state, 2007 – 2011

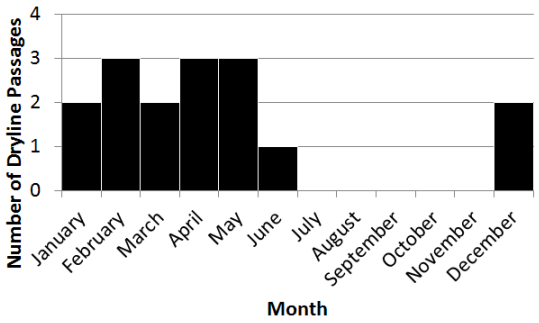

Table 1: Number of dryline passages through domain by month

Synoptic anomaly composites created for the 17 days in which drylines were present in the domain revealed some key synoptic features associated with eastern dryline passages. On eastern dryline days, an upper-level jet streak (Figure 3a) was present over eastern Texas and the mid Pacific coast. A positive 925-mb zonal wind anomaly was present over eastern Texas (Figure 3b), with a positive 925-mb meridional wind anomaly centered over the central /eastern Gulf of Mexico extending northward into Alabama (Figure 3c). A mid-level shortwave trough was present on almost all of the days over the central Great Plains (Figure 3d), and a strong surface cyclone was almost always present to the north of the dryline (Figure 3e).

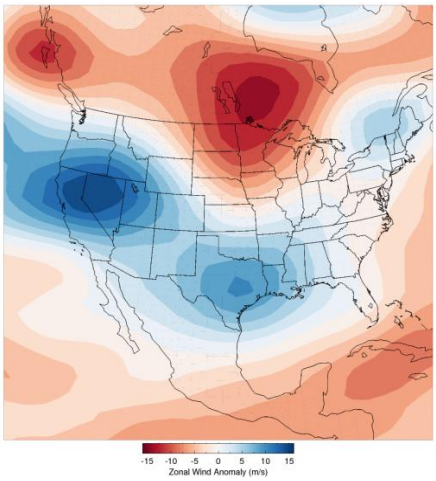

Figure 3a: 300-mb zonal wind anomaly (m/s)

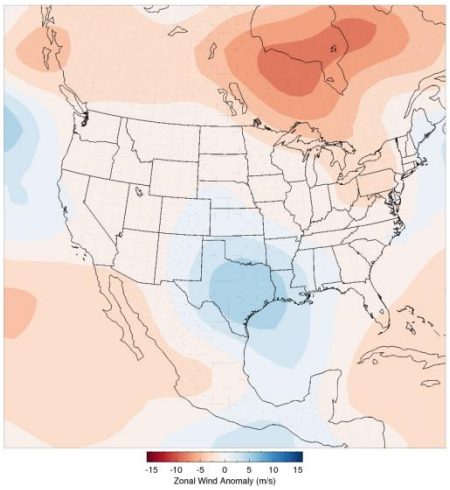

Figure 3b: 925-mb zonal wind anomaly (m/s)

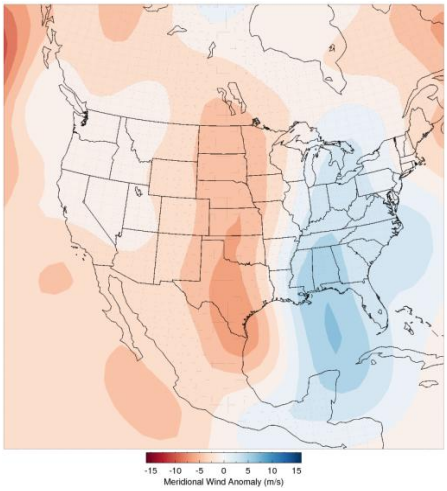

Figure 3c: 925-mb meridional wind anomaly (m/s)

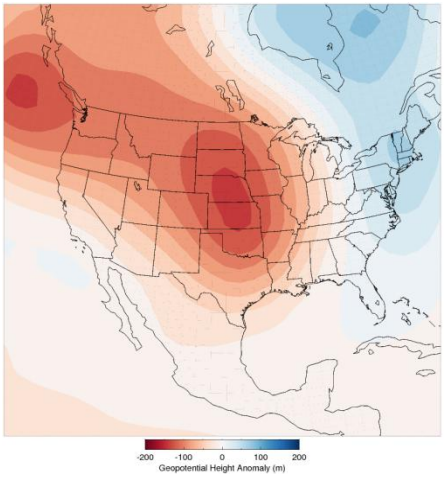

Figure 3d: 500-mb geopotential height anomaly (m)

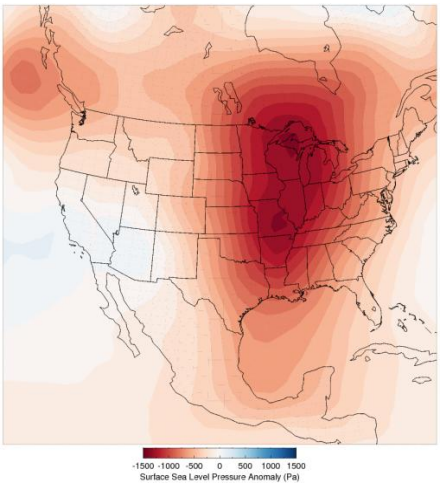

Figure 3e: Surface sea level pressure anomaly (hPa)

Reviews of the Hydrometeorological Prediction Center (HPC)'s archived surface analyses for the days on which drylines were present in this study's domain revealed that these drylines were often analyzed as secondary cold fronts. Overlaid severe weather reports from the Storm Prediction Center were presented for the 17 eastern dryline days and showed that severe weather outbreaks were common when drylines moved into the study's domain.

5. CONCLUSIONS

A computer program was written that identified drylines from five years of North American Regional Reanalysis data in the lower Mississippi River Valley region. A total of 17 dryline cases were identified in the domain from 2007 through 2011. The passages all occurred in winter and spring, with the southwestern portion of the domain experiencing the most dryline passages. These events were associated with very active synoptic setups in the south-central and Southeast U.S. with a strong jet streak aloft, a midlevel shortwave trough present, and a strong surface cyclone over the region. These drylines are often misanalyzed as secondary cold fronts. There are oftentimes severe weather outbreaks on days when drylines move atypically far eastward. In the future, a full 30-year eastern dryline climatology will be compiled using the computer algorithm. The domain will be expanded northward to 47°N and synoptic patterns will be further refined.

Acknowledgements. Special thanks to the University of Nebraska-Lincoln for providing funding for this project. We are also grateful for the help of the committee members for this project, Dr. Mark Anderson and Dr. Adam Houston.

REFERENCES

Hoch, J., and P. Markowski, 2005: A climatology of springtime dryline position in the U.S. Great Plains region. *J. Climate*, **18**, 2132-2137.

http://www.spc.noaa.gov/climo/reports/

http://www.hpc.ncep.noaa.gov/html/sfc_archive.shtml

http://ready.arl.noaa.gov/HYSPLIT.php

http://www.esrl.noaa.gov/psd/data/composites/hour/

Mesinger, et al. 2006: North American Regional Reanalysis. *Bull. Amer. Meteor. Soc.*, **87**, 343–360.

Rhea, J.O., 1966: A study of thunderstorm formation along dry lines. *J Appl. Meteor*., **5**, 58-63.

Schultz, D.M., C.C. Weiss, and Paul M Hoffman, 2007: The synoptic regulation of dryline intensity. *Mon. Wea. Rev*., **135**, 1699-1709.