

# Tropical Storms Reduced Drought in Illinois in 2005

James R. Angel  
Center for Atmospheric Sciences  
Illinois State Water Survey

## ABSTRACT

The passage of four tropical systems alleviated drought impacts, particularly in southern and central Illinois during the 2005 growing season. The four systems were Tropical Storm Arlene, and Hurricanes Dennis, Katrina, and Rita. Several circumstances make this situation significant for Illinois. The historical tropical cyclone records indicate that while an occasional tropical system passes through Illinois (26 years since 1851), 2005 was the first time for four such systems in one season. Timing of 4 to 6 weeks between tropical systems benefited agriculture while minimizing flooding. Tropical Storm Arlene and Hurricane Dennis also occurred relatively early in the growing season when critical moisture was needed. Aggregating the rainfall from these four events shows that they provided significant drought relief in southern and central Illinois during the 2005 growing season. Without those four systems, southern and central Illinois could have been in drought almost as severe as that in northern Illinois with 7- to 10-inch rainfall deficits instead of the observed 1- to 6-inch rainfall deficits.

---

## INTRODUCTION

Beginning in March 2005, a severe drought developed in Illinois as significant rainfall deficits accumulated during the growing season. State-wide spring (March-May) rainfall was 5.42 inches below normal, and summer (June-August) rainfall was 2.87 inches below normal. The period of March-October was the fourth driest such period since state-wide records began in 1895 with only 19.69 inches of rain, 9.53 inches below normal. Precipitation deficits in northwestern Illinois, the area hardest hit by the drought, were on the order of 12 to 18 inches below normal at individual stations by the end of October. A more detailed account of the 2005 drought and its impacts can be found in Kunkel et al. (2006). One of the outstanding climatic aspects of the 2005 drought was the role of tropical storms in alleviating the drought across southern and central Illinois.

Tropical storms have been known to bring beneficial rains to drought-stricken areas, typically along the Gulf and East Coasts. Sugg (1968) documented nine such cases from 1928 to 1963, using the Palmer Drought Severity Index to identify areas in drought. The most significant example was the pair of hurricanes (Diane and Connie), only a week apart in 1955, which produced rains over 80,000 square miles that were considered to be in drought status along the East Coast. More recently, Hurricane Floyd produced heavy rainfall along the East Coast in September 1999, causing widespread flooding and

abruptly ending a drought emergency in New Jersey (Robinson, 2000). Larson et al. (2005) examined the climatology of land-falling tropical cyclones in the United States and Mexico, demonstrating that a significant portion of the mean annual precipitation along the Gulf and East Coasts comes from tropical cyclones. On average, a small contribution (less than 5 percent) extended as far north as extreme southern Illinois.

One of the outstanding features of the 2005 North Atlantic hurricane season was the record number of named storms (27) and three Saffir-Simpson category 5 storms (Shein 2006). This paper examines the four tropical storms (Arlene, Dennis, Katrina, and Rita) that passed through Illinois during the 2005 growing season. The precipitation pattern and other synoptic features of each storm are reviewed. The aggregated precipitation pattern and its impact on the 2005 drought are discussed.

## **DATA AND METHODOLOGY**

Three data sources were used in this study. Gridded precipitation data came from the Midwestern Climate Information System (MICIS) system (Kunkel et al., 1990) of the Midwestern Regional Climate Center, based on data from the US cooperative observer network. Daily weather map series were obtained from the National Weather Service (2005). Tropical cyclone tracks from the Atlantic and Northeast Pacific Tropical Cyclone HURDAT dataset from the National Hurricane Center (described in Neumann et al. 1999) for the period 1851-2004. This last dataset contains hurricanes (sustained wind speeds in excess of 74 mph), tropical storms (sustained winds between 40 and 74 mph) and tropical depressions (sustained winds between 23 and 39 mph).

For the 2005 season, dates when the tropical systems passed through Illinois were determined. Rainfall amounts from those days then were accumulated separately from the rest of the growing season. Finally, maps of total rainfall amounts from all sources, the total rainfall from tropical storms, and the total rainfall without tropical storms were determined for the growing season. Historical counts of tropical cyclones passing through Illinois were determined by identifying systems that passed north of 35°N latitude and between 85° and 93°W longitude. These latitude and longitude criteria were determined based on the tracks of the four storm systems in 2005.

Reconstructing the actual rainfall contribution of a storm system is challenging when using daily data. Because the data are a combination of morning, afternoon, and midnight observations from different stations, it was decided to include data not only from the dates when the tropical system passed through Illinois but also from the day after to include any morning observations after the event. In many cases, tropical systems moving through the Midwest can cover areas hundreds of miles wide and interact with existing synoptic features, such as a passing cold front. As a result, it is not always possible to identify rainfall exclusively from tropical systems.

## **RESULTS AND DISCUSSION**

There were four tropical systems of interest in 2005. Rainfall from those storms fell in Illinois on June 11-13 (Tropical Storm Arlene), on July 11-13 (Hurricane Dennis), on August 30-31 (Hurricane Katrina), and on September 25-26 (Hurricane Rita). Figure 1

shows their tracks. All four struck the Gulf Coast and then moved up the Mississippi and Ohio River valleys. Examination of previous records reveals that one or more tropical storms do occasionally pass through Illinois: two storms each in 8 years (1901, 1906, 1916, 1948, 1949, 1950, 1960, and 1985) and one storm each year in 18 years since 1851 (1879, 1891, 1893, 1898, 1909, 1912, 1923, 1933, 1940, 1942, 1947, 1953, 1955, 1970, 1986, 1988, 2001, and 2002). The 1940s, the most active decade, had seven storms passing through Illinois. Two decades, the 1950s and 1980s, had four storms in each decade. Only in 2005 were four storms per year reported, the maximum seen in the historical record, a rarity made even more impressive by a total of just three tropical systems passing through Illinois between 1956 and 1984.

There are several important features regarding the timing of the four 2005 events. The four events were spaced 4 to 6 weeks apart during the growing season, thus benefiting crop growth and minimizing the threat from flooding. Tropical Storm Arlene and Hurricane Dennis occurred relatively early in the tropical storm season and arrived at critical times in the growing season for Illinois. For example, Hurricane Dennis arrived in mid-July just as many cornfields were beginning the silking and tasseling stage when precipitation is particularly critical.

The first tropical system to pass through Illinois in the 2005 growing season was Tropical Storm Arlene in June 2005. Like the other three systems affecting Illinois that season, the storm moved up through the Gulf of Mexico, following first the Mississippi River valley and then the Ohio River valley. As Figure 2 shows, the rain in Illinois was confined largely to the southern part of the state along the Wabash River valley. Amounts of 1 to 2 inches were common in this area with a peak at Mount Carmel of 4.28 inches. The surface weather map for June 12, 2005, showed that a cold front located to the west in Missouri and Iowa did not appear to interact with the passing tropical system. Therefore, it can be concluded that the rainfall on June 11-13 was almost exclusively from Tropical Storm Arlene.

The second tropical system, a category 4 hurricane, was Hurricane Dennis in July 2005. After causing damage along the Gulf Coast, it moved inland and weakened to a tropical depression before reaching Illinois. The surface weather map for July 12, 2005, shows no pre-existing synoptic features in the Midwest to steer this storm. As a result, the storm meandered over Illinois for several days (July 11-13) before dissipating. Once again, timely rains greater than 1.5 inches were produced over southern Illinois (Figure 3), including a peak of 5.03 inches at Cairo. Even central Illinois received up to 2 inches of much needed rain. As with Tropical Storm Arlene, little or no rain fell in northern Illinois.

The third tropical system over Illinois was Hurricane Katrina in August 2005. While causing massive damage and more than 1800 deaths along the Gulf Coast, the system brought rain and no severe weather to Illinois. Of the four tropical systems, this one brought the least rain to Illinois and that rainfall was confined largely to southeastern Illinois. Amounts of about one inch were common in that area while southwestern Illinois and central Illinois received about 0.25 inches, while northern Illinois received none (Figure 4). The surface weather map for August 30, 2005, indicated no other rain-pro-

ducing features in the area so all rainfall on August 30-31 in Illinois was attributed to Hurricane Katrina.

The final tropical storm to affect Illinois was Hurricane Rita in September 2005. This storm produced widespread rains across the state (Figure 5) with typical amounts of 0.5 to 1.5 inches and up to 2.66 inches at Lebanon (east of St. Louis, Missouri) on September 25-26. Unlike prior storms, this one had benefits for northern Illinois. The surface weather map for September 25, 2005, indicated the presence of a rain-producing cold front that later moved through northern Illinois. Hurricane Rita may have interacted with this synoptic feature to enhance the rainfall across Illinois and is the only one of the four tropical systems from which some rainfall on chosen dates may have been from other synoptic-scale features.

During the 2005 growing season, Illinois experienced an intense drought that began in the spring with the most serious rainfall departures in north-central Illinois. Rainfall departures of 8 to 11 inches from the 1971-2000 mean for March-September occurred across much of northern and west-central Illinois (Figure 6). Rainfall departures in southern Illinois were less severe. In fact, extreme southern Illinois experienced near-normal rainfall during this time.

What was the total rainfall contribution of those four tropical systems? Figure 7 shows that the June-September aggregate rainfall ranged from 3 to 8 inches in southern Illinois, 1 to 3 inches in central Illinois, and less than an inch to 2 inches in northern Illinois. Clearly, the timely rains from these four storms reduced drought severity in the southern half of the state and in some areas even eliminated drought completely.

Figure 8 shows the March-September rainfall departures minus the rainfall of the four tropical systems. Rainfall departures would have been slightly more severe in northern Illinois, which already had the most impacts. The biggest impact could have been in central and southern Illinois, which experienced drought conditions almost as severe as those in northern Illinois with rainfall deficits since March 2005 of 7 to 10 inches. Such deficits would have had a significant impact on crop production, pastures, stream flow, water levels in small lake, and groundwater.

Kunkel et al. (2006) noted that the precipitation deficits observed in Illinois were consistent with weaker-than-normal low-level flow from the Gulf of Mexico and Atlantic Ocean moisture sources. In turn, this weaker-than-normal flow may have been the result of warmer-than-normal sea surface temperatures (SST) in the Atlantic and Gulf of Mexico. At the same time, the warmer SSTs are believed to be one of several factors contributing to a more active tropical storm season in 2005 (Shein 2006). The end result is that the warmer SSTs in 2005 may have had a hand in both causing and alleviating drought in Illinois in 2005.

There is considerable debate in the scientific community about the significance of the 2005 Atlantic hurricane season as it relates to climate change (e.g. Anthes et al. 2006 and Pielke et al. 2006). While storms were well-documented after they made landfall since the mid-1800s, their frequency and strength over oceans were improved by aircraft observations from the 1940s onward, and greatly improved by satellite observations from

the 1970s onward. This makes it very difficult to identify long-term trends in the database. In addition, there is substantial natural variability in the historical records, including an apparent 20-40 year “Atlantic Multi-decadal Oscillation,” that makes it harder to identify a global warming signal. The challenges and current state of science are accurately summarized in a recent statement by the World Meteorological Organization’s Tropical Meteorology Research Program Panel (McBride et al. 2006).

## **CONCLUSIONS**

Unprecedented passage of four tropical systems (Tropical Storm Arlene, and Hurricanes Dennis, Katrina, and Rita) alleviated drought impacts during the 2005 growing season, particularly in southern and central Illinois. Several circumstances make this situation significant from a climatological perspective. The historical tropical cyclone records indicates that while an occasional tropical system passes through Illinois (26 years since 1851), 2005 was the first time for four such systems in one season. Timing of 4 to 6 weeks between events benefited agriculture while minimizing flooding. Tropical Storm Arlene and Hurricane Dennis also occurred relatively early in the growing season when critical moisture was needed.

By aggregating the rainfall from these four events, it was shown that they provided significant drought relief to southern and central Illinois during the growing season. Aggregated rainfall amounts ranged from nearly 8 inches in far southern Illinois to less than an inch in northern Illinois. Without those four systems central and southern Illinois could have been in drought almost as severe as that in northern Illinois with 7- to 10-inch rainfall deficits instead of the observed 1- to 6-inch rainfall deficits.

## **ACKNOWLEDGMENTS**

The reviews of David Kristovich and Ken Kunkel are appreciated. This research was supported by the Illinois State Water Survey. Any opinions, findings, and conclusions are those of the author and do not necessarily reflect the views of the Illinois State Water Survey.

## **LITERATURE CITED**

- Anthes, R. A., R. W. Correll, G. Holland, J. W. Hurrell, M. C. McCracken, and K. E. Trenberth, 2006. Hurricanes and global warming – potential links and consequences. *Bulletin of the American Meteorological Society*, 87, 623-628.
- Kunkel, K., J. Angel, S. Changnon, M. Palecki, R. Scott, D. Winstanley, R. Claybrooke, S. Hilberg, and R. Larson, 2006. The 2005 Illinois drought. Illinois State Water Survey Informational/Educational Material 2006-3 (in press).
- Kunkel, K. E., S. A. Changnon, C. G. Lonquist and J. R. Angel. 1990: A Real-Time Climate Information System for the Midwestern United States. *Bulletin of the American Meteorological Society*, 71, 1601–1609.
- Larson, J., Y. Zhou, R. W. Higgins, 2005. Characteristics of landfalling tropical cyclones in the United States and Mexico: climatology and interannual variability. *Journal of Climate*, 18, 1247-1262.

- McBride, J. and Coauthors, 2006: Statement on tropical cyclones and climate change. WMO/CAS Tropical Meteorology Research Program, Steering Committee for Project TC-2: Scientific Assessment of Climate Change Effects on Tropical Cyclones. [Available online at [www.bom.gov.au/info/CAS-statement.pdf](http://www.bom.gov.au/info/CAS-statement.pdf).]
- National Weather Service, 2005. Daily Weather Maps [<http://www.hpc.ncep.noaa.gov/dailywxmap/index.html>], National Oceanic and Atmospheric Administration.
- Neumann, C. J., B. R. Jarvinen, C. J. McAdie, and G. R. Hammer, 1999. Tropical cyclones of the North Atlantic Ocean, 1871-1998. National Climatic Data Center, 256 pp. [Data resides at the NOAA National Hurricane Center at <http://www.nhc.noaa.gov/pastall.shtml>].
- Pielke, R., C. Landsea, M. Mayfield, J. Laver, and R. Pasch, 2006. Reply to "Hurricanes and global warming – potential linkages and consequences." *Bulletin of the American Meteorological Society*, 87, 628-631.
- Robinson, D., 2000. Hurricane Floyd rainfall in New Jersey. *Proceedings of the 12<sup>th</sup> Conference on Applied Climatology*, Asheville, NC, American Meteorological Society, 265-268.
- Shein, K. A., 2006. State of the climate of 2005. Special supplement to the *Bulletin of the American Meteorological Society*, Vol. 87, No. 6, s1-s102.
- Sugg, A. L., 1968. Beneficial aspects of the tropical cyclone. *Journal of Applied Meteorology*, 7, 39-45.

Figure 1. The storm tracks of all four tropical storms that passed through Illinois in 2005. They are, in chronological order: 1) Tropical Storm Arlene (X), 2) Hurricane Dennis (O), 3) Hurricane Katrina (\*), and 4) Hurricane Rita (+).

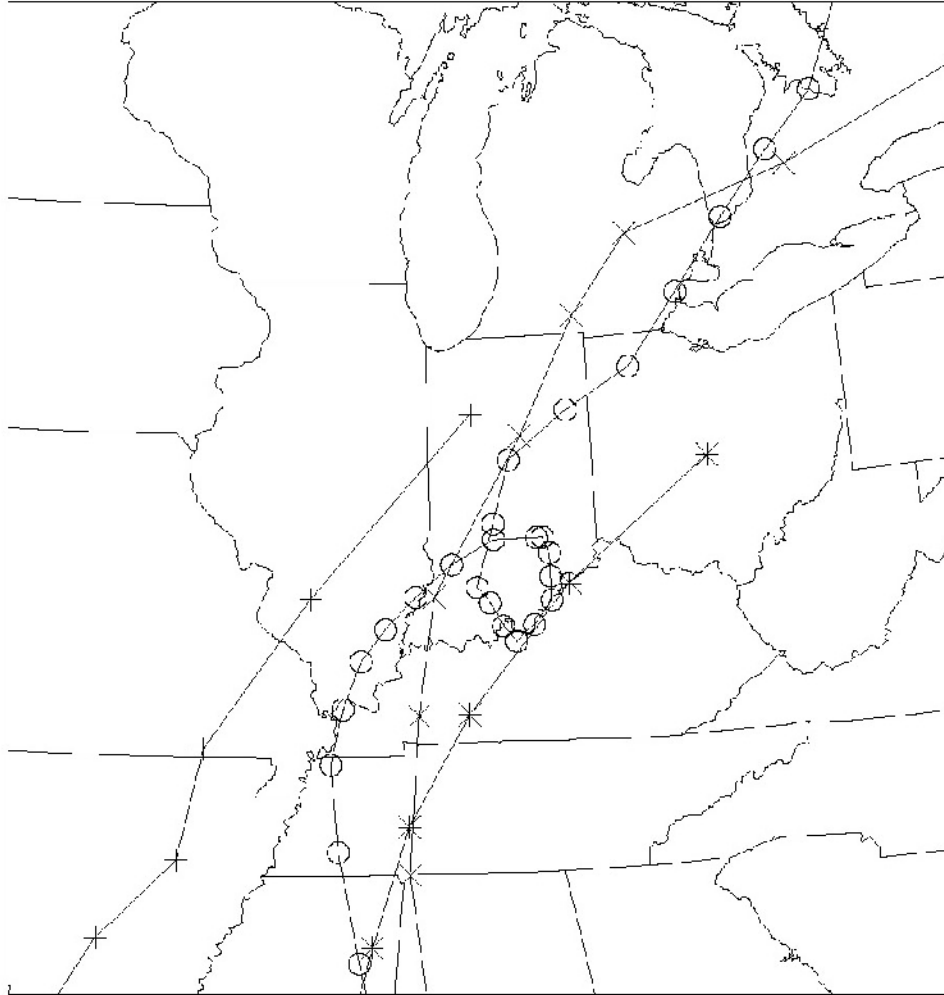


Figure 2. Rainfall (inches) from Tropical Storm Arlene.

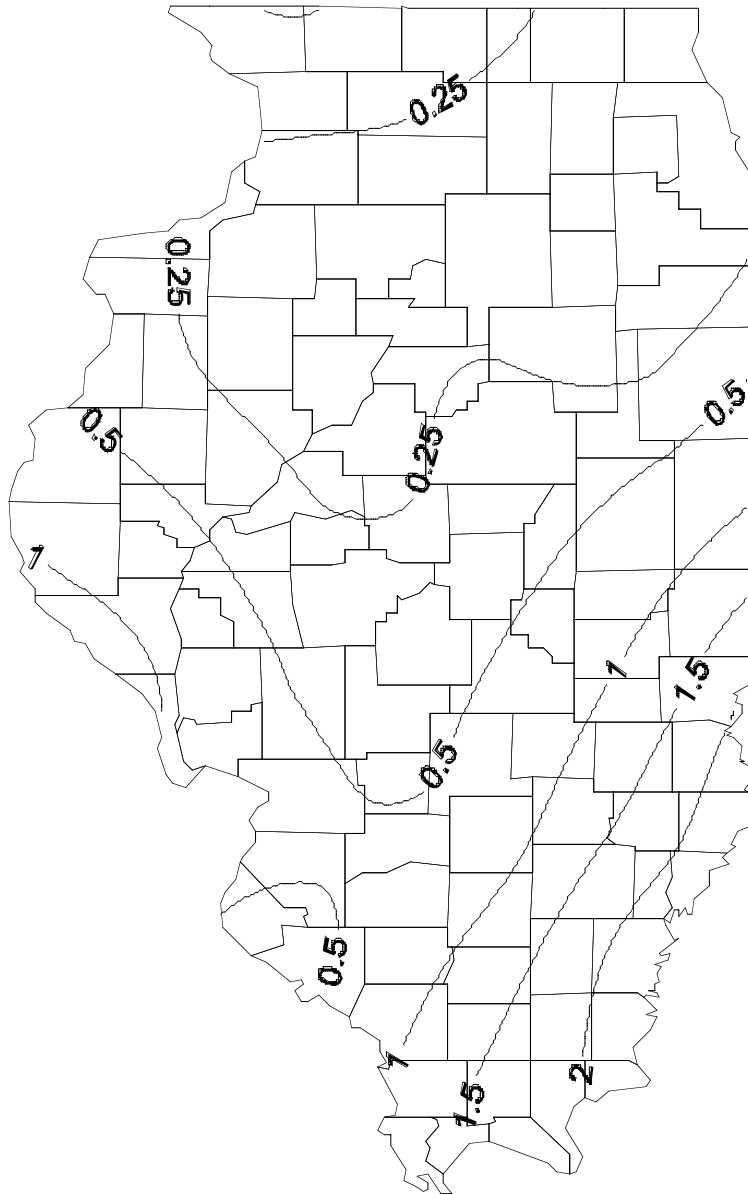




Figure 3. Rainfall (inches) from Hurricane Dennis.

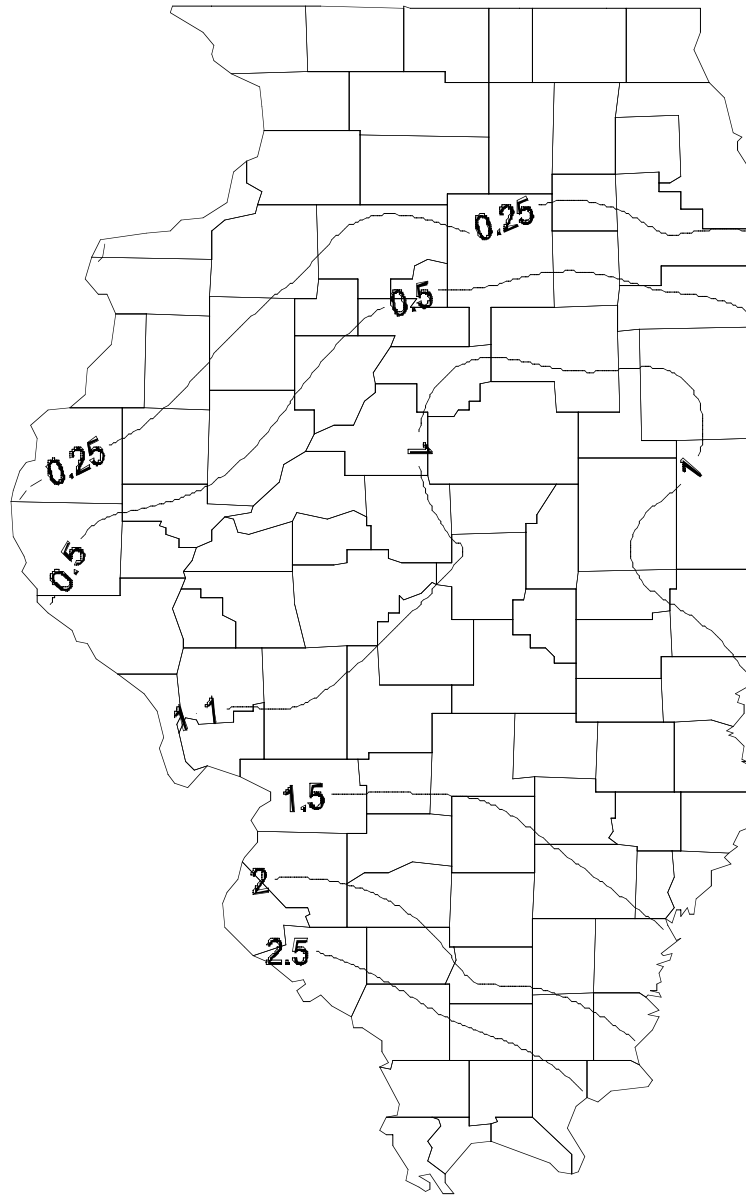


Figure 4. Rainfall (inches) from Hurricane Katrina.

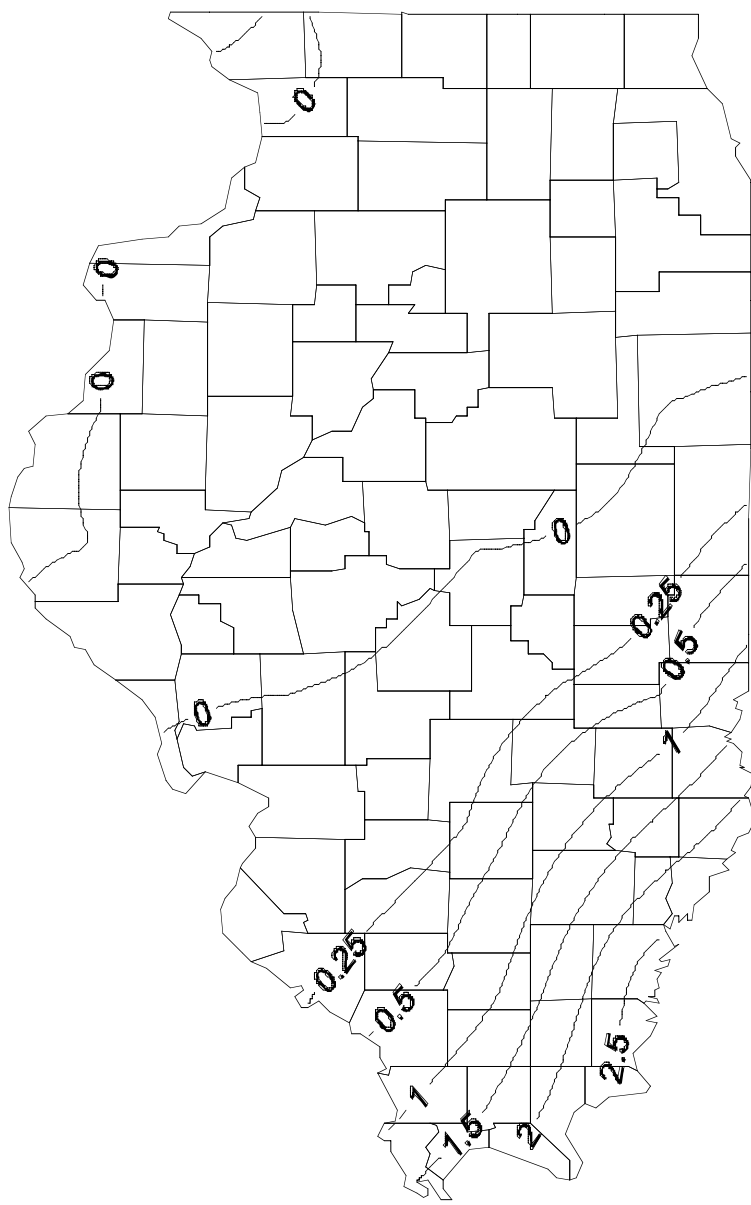


Figure 5. Rainfall (inches) from Hurricane Rita.

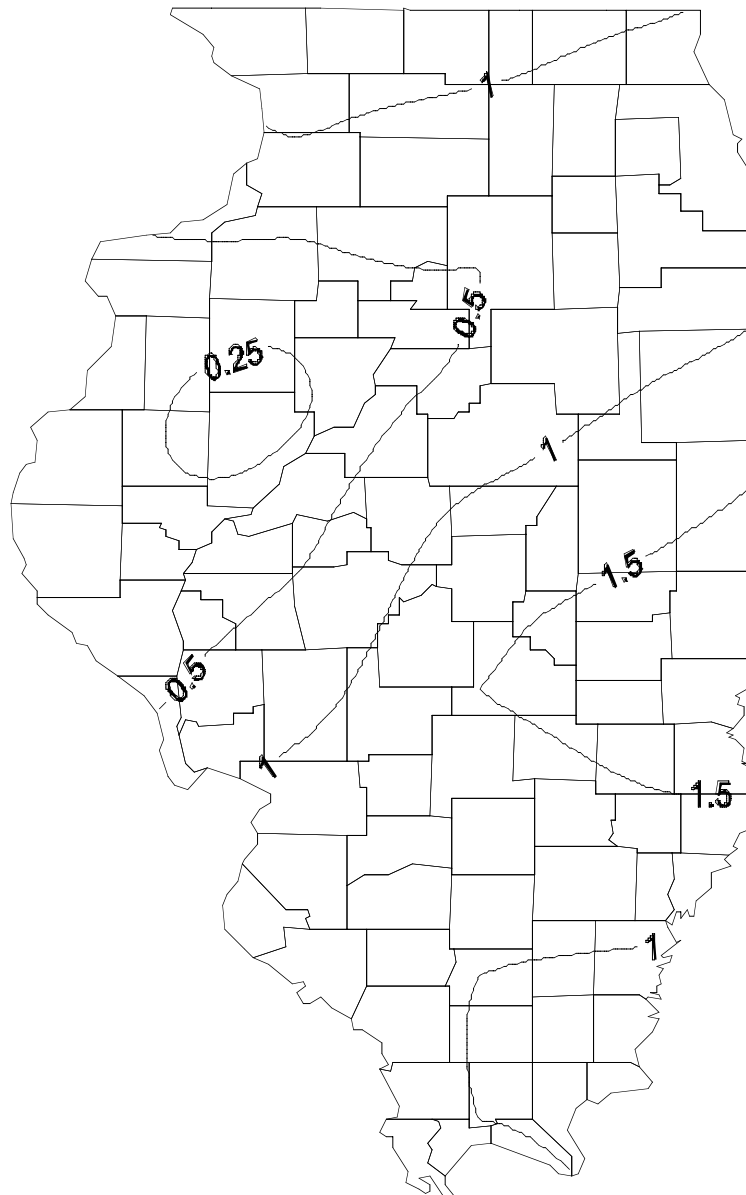


Figure 6. The March-September rainfall (inches), expressed as a departure from normal (1971-2000).

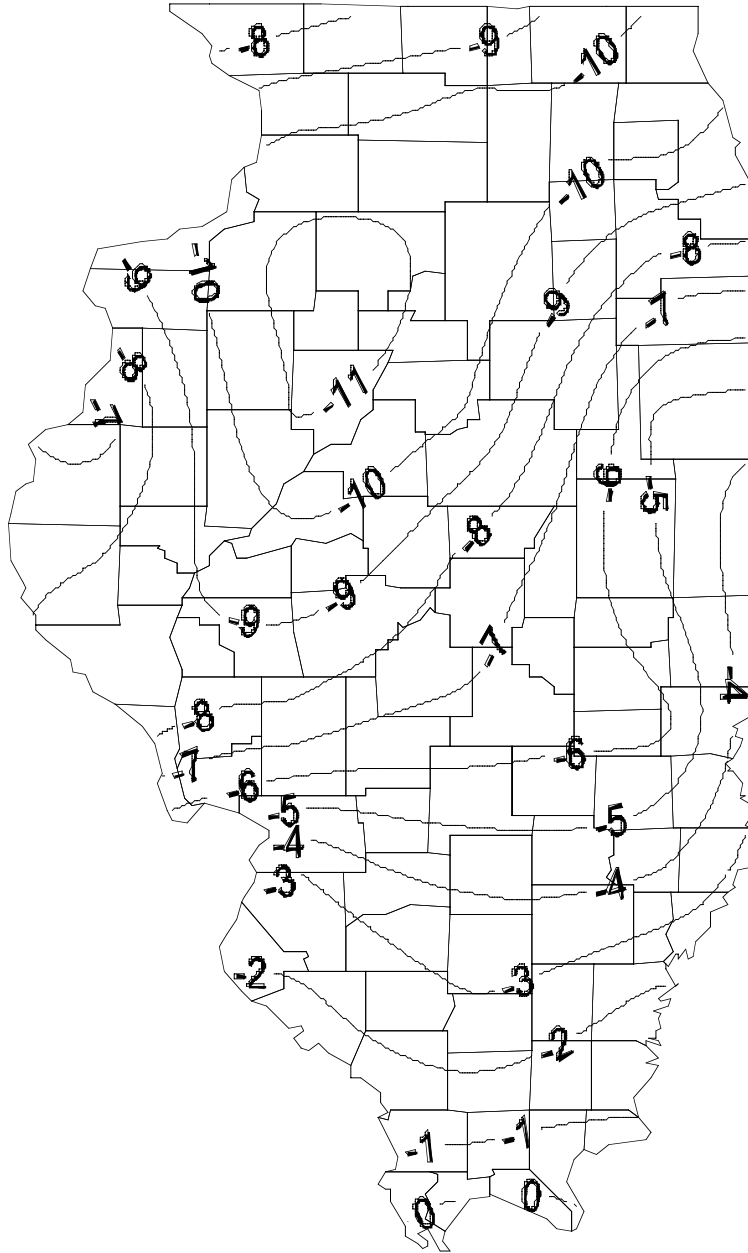


Figure 7. The accumulated contribution of total rainfall (inches) of the four tropical systems that passed through Illinois during the 2005 growing season.

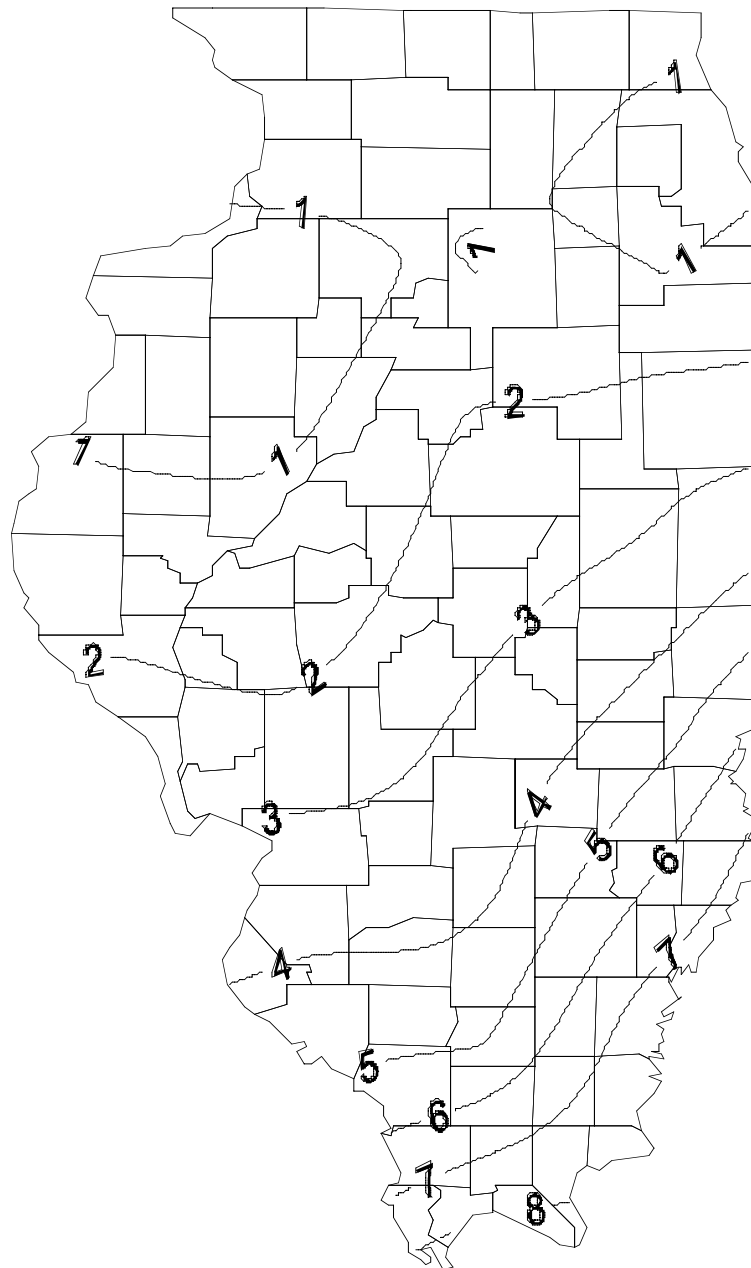


Figure 8. The March-September rainfall pattern, expressed as a departure from normal (1971-2000) in inches, with the rainfall of the four tropical systems that passed through Illinois during the 2005 growing season removed.

