SCIPP
A NOAA RISA TEAM

Tennessee Event Summary
June 5-10, 2014
Flash Flooding, High Winds, & Tornadoes (DR-4189)

Overview

From June 5th through 10th, 2014, several rounds of severe weather impacted Tennessee. A total of 23 counties, mostly in western TN, were declared as federal disaster areas due to damages from flash flooding, high winds, and tornadoes (Figure 1). Page 2 of this document offers an overview of the atmospheric conditions during the time of the event while pages 3-5 describe the event as it unfolded in addition to summarizing the damages and fatalities incurred during this event. This event ranked third among four other analyzed events within the past decade (2004-2014) in terms of max recurrence intervals. The highest return period recorded during June 5-10, 2014 was a 200 year event in west central TN.

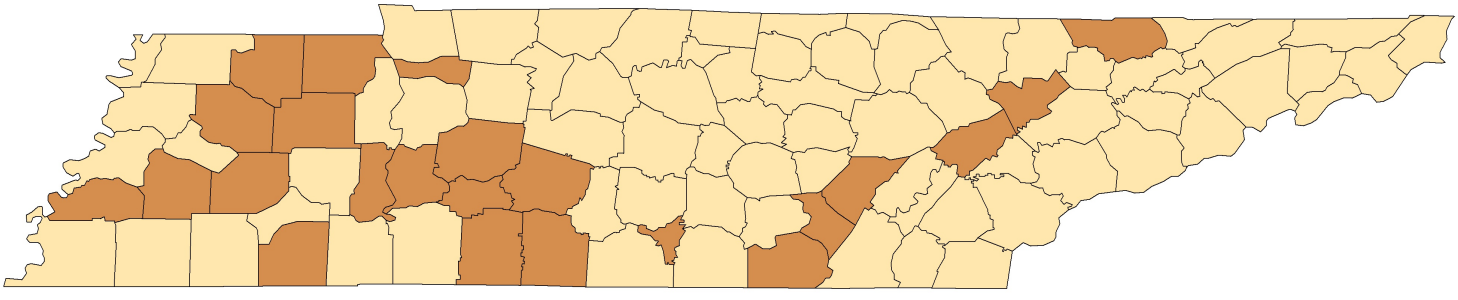

Figure 1: FEMA declared disaster counties within Tennessee

Atmospheric Conditions

The severe weather that occurred in Tennessee (TN) from June 5th through 10th was due to a combination of atmospheric factors that resulted in heavy rain, strong winds, and tornadoes. Leading up to the event, a large high pressure system was centered over Texas, resulting in warm temperatures across the Southern Plains (Figure 2). A weak cold front associated with a low pressure system in the northeast began to move into northern TN on the 5th. However, the front stalled over central TN and became stationary resulting in an unstable boundary over TN. Mesoscale Convective Systems (MCS) began to develop on the outer edge of the high pressure system resulting in what forecasters refer to as the "Ring of Fire" where just enough instability from warm temperatures exists along the edge of the high pressure system to allow storms to develop and move east/southeastward around the high pressure system. From the 5th-6th, both a mesoscale convective system and squall line developed along the outer edge of the high pressure system, moved across the Great Plains, and entered western TN, interacting with the stalled boundary to produce torrential downpours. Precipitable water values across western TN from the 5th through 6th were between the 80th and 99th percentile. Furthermore, CAPE (Convective Available Potential Energy) values across TN during the afternoon hours on the 5th and 6th were between 1000-2000 J/kg, significant enough to support strong, long-lived storms. Moisture and instability, coupled with the stalled front, resulted in thunderstorms moving over the same locations (called "training"). However, on the 7th, the stationary boundary over TN was pushed southward as a shortwave trough over the Southern Plains moved northeastward into the Ohio River Valley throughout the day. This shortwave trough allowed sufficient lift for thunderstorms to develop across western TN with one supercell producing an EF1 tornado. However, although there was sufficient instability, there was insufficient shear (change of wind speed or direction with height) for stronger tornadoes. From the 7th through 8th, the high pressure system over Texas began to move eastward out into the Gulf of Mexico while a low pressure system in the western United States began to form and dig southeastward towards the Southern Plains. A weak cold front out ahead of the low pressure system slowly began to move into western TN the morning of the 8th. However, due to less moisture and instability present, thunderstorm development was limited throughout TN. By the morning of the 10th, the low pressure system began to lift northeastward towards the Ohio River Valley. Rising motion on the east side of the low pressure system brought additional thunderstorms to western TN from the 10th through 11th. Convective storms in Mississippi and Alabama were steered northward by the low pressure system up into central TN on the 10th, strengthening into a squall line as they entered eastern TN due to daytime heating, abundance of moisture, and CAPE values close to 2000 J/kg. As the squall line moved through eastern TN, an EF0 tornado formed on the leading edge. However, as the low pressure system moved out of the Ohio River Valley, the forcing mechanisms needed for continued thunderstorm development came to an end.

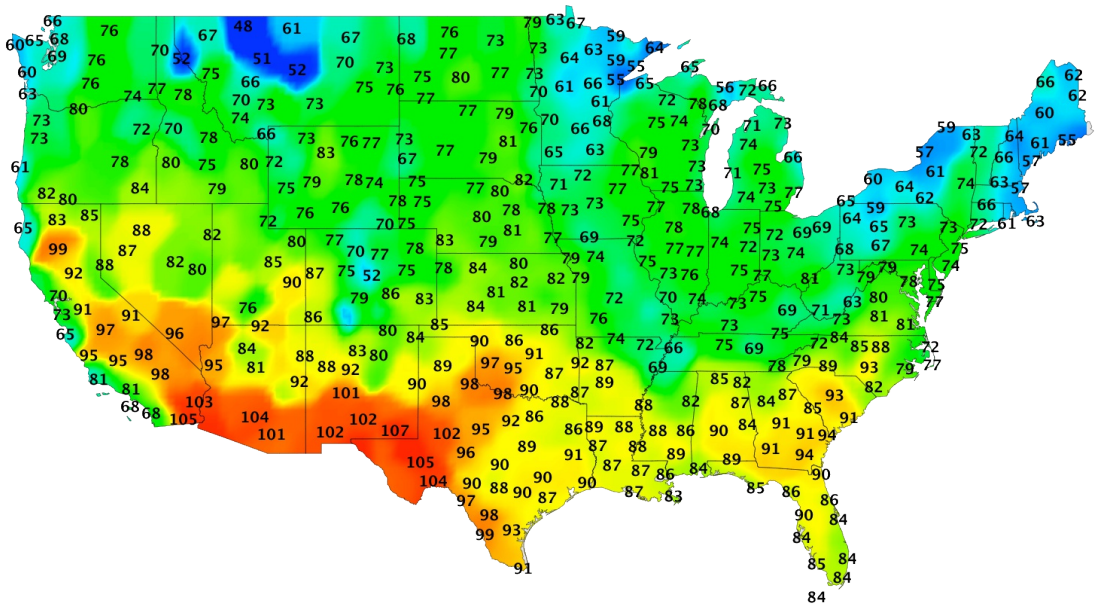

Figure 2: Temperatures across the United States at 4 PM on June 5th, 2014.

June 5th

During the evening hours on the 4th, developing scattered convective storms over southern Illinois, Missouri, and western Kentucky began to propagate southward, becoming more organized into a line of severe storms as they entered northwestern and northern Tennessee around 10 PM CDT (all times in CDT unless otherwise noted). The line of severe thunderstorms prompted a tornado warning for Dickson and Montgomery counties in north central TN and flash flood warnings for western and southwestern TN throughout the early morning hours on the 5th. As the severe storms moved southward into TN during the early morning hours, there were reports of numerous trees uprooted and damaged power poles and house roofs in central and western TN. As storms repeatedly moved over western TN, flash flooding occurred stranding people in their cars, washing out roads, and flooding several houses and businesses. By 8 AM, the National Weather Service (NWS) reported that 4 to 6 inches of rain had fallen over northwestern TN (Figure 3). Due to flash flooding, several water rescues were conducted that morning. Two people lost their lives due to the flooding, both of which were vehicle-related. Numerous water rescues and road closures were also reported in south central TN. By 10 AM, the NWS stated that grounds in western and south central TN were already saturated due to the ongoing rainfall. Convective storms continued to develop and train over western and central TN throughout the morning and afternoon on the 5th. A MCS that formed in the lee of the Rockies quickly moved across the Great Plains throughout the morning of the 5th and entered western TN as a squall line around 1 PM, bringing additional heavy rains. Numerous flash flood warnings for western and southwest TN were issued throughout the afternoon as convective storms trained over the same area producing heavy rainfall. Strong straight-line winds were also associated with these severe thunderstorms that knocked down numerous trees and power lines. In central TN, several flood advisories were issued for rapidly rising rivers. By 6 PM, the line of convective storms had moved out of TN. Aside from a few scattered storms in western TN, the early morning hours of the 6th remained relatively calm.

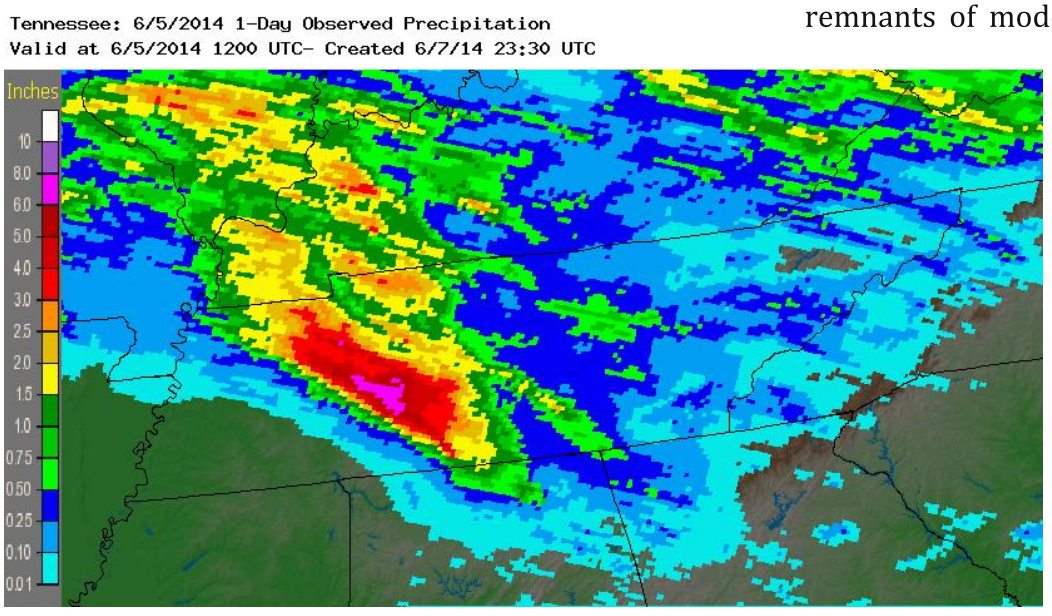

Figure 3: National Weather Service observed precipitation map for the 24-hour period ending at 6 AM, June 5th, 2014.

June 6th

By 8 AM, a line of scattered convective storms had developed over west central TN and moved southeastward out of TN by 1 PM. However, by late afternoon, an additional squall line entered far western TN, prompting flash flood warnings for counties in western TN and flash flood watches for south central TN. Flash flooding caused streets to be inundated with floodwaters in southwestern TN. The squall line began to dissipate as it approached central TN around 7 PM. Some remnants of moderately heavy rainfall remained behind the squall line, giving rise to flash flood warnings for parts of western and southern TN. A localized thunderstorm formed over north central TN causing flash flooding in Davidson County around 8 PM where 3 vehicles were stranded in floodwaters. Around 11 PM, convective storms rapidly developed once again over west central TN, traveled southeastward, and began to fall apart during the early morning hours on the 7th.

June 7th

There was a brief respite in heavy rainfall from the early morning to afternoon hours on the 7th. However, by 2 PM, a line of convective cells began to rapidly intensify, stretching from southwest to northwest TN. A severe thunderstorm located at the corner of Missouri and Kentucky moved into the far northwestern portion of TN around 3 PM. A tornado associated with this severe thunderstorm had already touched down in the far southeastern corner of Missouri before entering Lake County in northwestern TN. At 2:53 PM the NWS issued a tornado warning for Lake and Obion counties in far northwestern TN. At approximately 3:15 PM, the tornado crossed over the Mississippi River from Missouri into TN and moved through Lake and Obion Counties (Figure 4) In Lake County, a majority of the damage was to trees as many were clear cut or snapped due to the tornado. The tornado began to weaken as it entered Obion County yet still severely damaged trees in its path in addition to causing roof damage to numerous homes. Subsequent survey results from the NWS assessed this tornado as an EF1 with peak winds between 80-90 mph. At approximately 3:45 PM, the tornado dissipated in Obion County. Although the tornado had dissipated, numerous scattered convective storms present over western and southwestern TN prompted several tornado warnings, although no other confirmed tornadoes were reported. As additional severe storms in northeastern Arkansas moved into TN, a disorganized squall line formed over western TN around 6 PM and moved southeastward throughout the evening. The strong winds associated with this squall line damaged trees, power lines, and numerous structures. By 11 PM, most of the severe storms had moved out of TN, leaving behind only light rain over eastern TN.

Figure 4: Approximate path of the tornado that affected Lake & Obion counties on June 7th, 2014 (Image courtesy of Heartland StormTeam).

June 8th

There was a lull in rainfall during the morning and afternoon hours on the 8th. Despite the pause in rainfall, flood advisories and warnings were still in place for rivers across western TN as runoff from the previous days' rainfall continued to fill the rivers. Remnants from convective storms in eastern Arkansas entered western TN around 9 PM as a swath of light rain.

June 9th

During the morning hours on the 9th, light rain spread across western and central TN. While this rain was not heavy compared to the previous days' convective storms, the soil across western and central TN was already saturated. Therefore, any additional rainfall made this region particularly susceptible to flooding. Around 4 PM, a disorganized squall line stretching from eastern Arkansas to western Louisiana moved into western TN. Flash flooding was reported in parts of southwest TN as counties were not only affected by the disorganized squall line, but by convective cells out ahead of the squall line. The convective cells formed a more organized squall line as they moved across western TN. As the squall line strengthened, there were numerous reports of tree and power line damage in south central TN as the squall line moved through. Numerous flood warnings were also issued for rivers in western TN. Strong straight-line winds associated with this squall line produced gusts up to 50-60 mph in parts of south central TN. The squall line continued to move through central and eastern TN, then began to dissipate as it exited eastern TN early on the 10th.

June 10th

Although there was a brief halt in rainfall during the early morning hours on the 10th, scattered storms from northern Mississippi and Alabama entered western TN by 9 AM and strengthened as they moved through central TN by mid-afternoon. Due to the strong winds associated with these storms, there were reports of damage to trees and power lines resulting in power outages in parts of north central TN. The scattered convective storms quickly formed into a squall line and moved across eastern TN during the late afternoon and evening hours. As the squall line moved across Roane County in eastern TN, an EF0 tornado formed at 5:06 PM EDT just east of downtown Kingston and moved to the northeast along a hillside producing a distinct path 0.5 miles long and 100 yards wide. Hundreds of trees were destroyed in the path of the tornado. As the squall line continued to move through eastern TN, numerous trees and power lines were damaged. However, by 10 PM, storms across TN had ceased. Scattered light rain over TN was present during the early morning hours on the 11th, yet the torrential downpours from the previous days' convective storms had come to an end.

Figure 5: Damage from severe storms on June 10th in Anderson County (Image courtesy of *Oak Ridge Today*).

Damages & Fatalities

On August 13th, the U.S. Department of Homeland Security's Federal Emergency Management Agency announced that federal disaster aid was available for the state of Tennessee. A total of 23 counties, most in western TN, were declared as federal disaster areas due to the severe weather during June 5-10, 2014. According to the TN Emergency Management Agency, electrical utilities, state, and local governments spent close to $10 million due to damages from high winds, tornadoes, and flash flooding. Furthermore, more than 28,000 people were without power. The severe weather caused damage to trees, power lines, and numerous structures. Flash flooding also inflicted damage to several businesses and homes. Flash flooding resulted in three fatalities in west central TN.

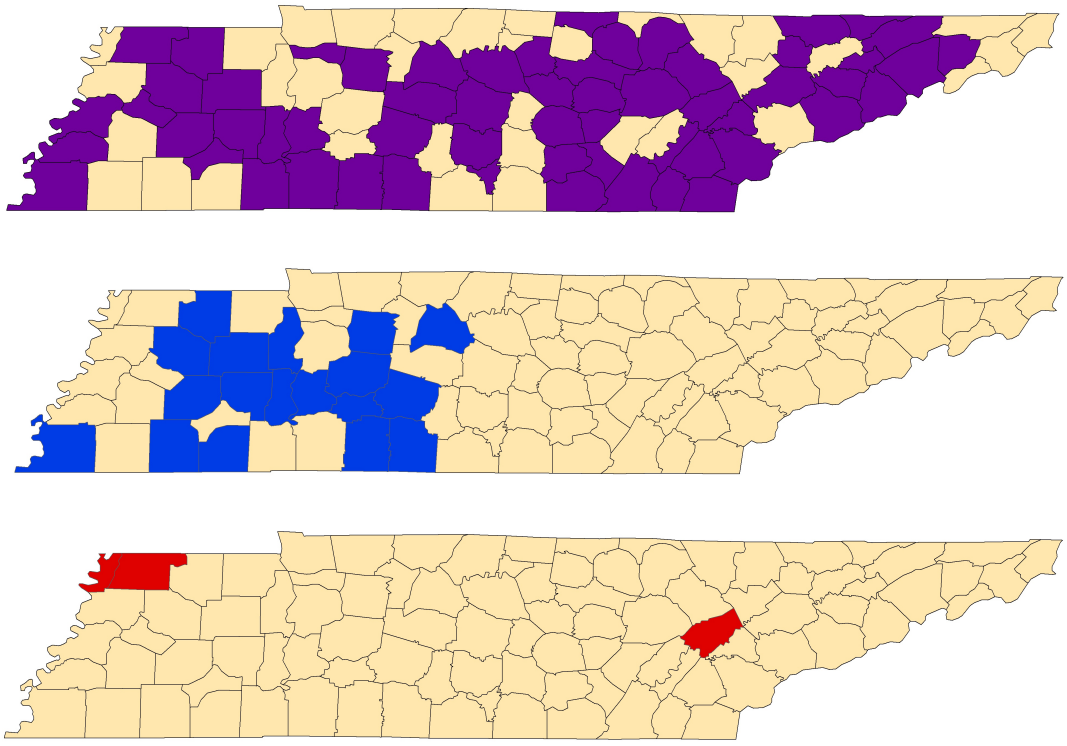

Figure 6: From top to bottom: NCDC Storm Reports from 1) TN counties that experienced high winds, 2) TN counties that experienced flash flooding, and 3) TN counties that experienced tornadoes.

Climatological Comparison

Rainfall events are often quantified in terms of their recurrence interval (return period), meaning, how often a type of rainfall event occurs on a year-to-year basis. These recurrence intervals have corresponding percentages that quantify the probability of how often certain types of rainfall events might occur. For example, a 50 year event has a 2% chance of occurring in any given year; a 100 year event has a 1% chance of occurring in any given year; a 200 year event has a 0.5% chance of occurring in any given year; and a 1,000 year event has a 0.1% chance of occurring in any given year. Regarding the June 5-10, 2014 event, the 10 highest rainfall amounts and their corresponding recurrence intervals can be seen in Figure 9. The highest return period recorded during this event was a 200 year event in Lewis county in west central TN. Within the past decade (2004-2014), three other significant rainfall events similar to the June 5-10, 2014 event in terms of magnitude were analyzed and their max recurrence interval recorded (Figure 7). Among the three other significant rainfall events within the past decade, the June 5-10, 2014 event was ranked 2nd to last in terms of recorded max recurrence intervals. Although the June 5-10, 2014 event did not experience as significant max recurrence intervals compared to other events, such as the 2010 Tennessee floods, rainfall amounts during this event contributed considerably to the total rainfall for June 2014. For example, western TN, which received the most rainfall during this event, averaged between 200% to 400% of normal precipitation for the month of June (Figure 8).

Event Date Range	Max Recurrence Interval
April 30-June 18, 2010	1000 Year Event
August 17-21, 2010	300 Year Event
June 5-10, 2014	200 Year Event
April 25-28, 2011	100 Year Event

Figure 7: Past events similar in magnitude to the June 5-10, 2014 event within the past decade (2004-2014). Events are ranked in order from greatest max recurrence interval to least max recurrence interval.

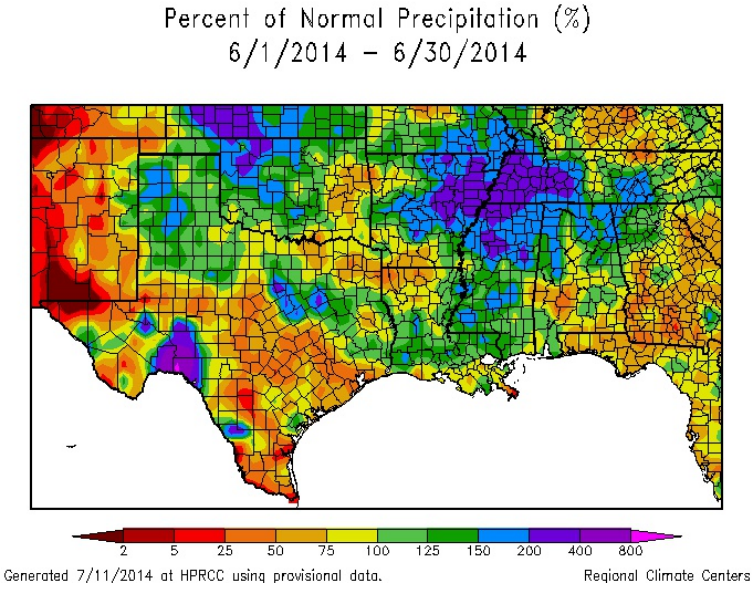

Figure 8: Percent of 1981-2010 normal precipitation for June 2014.

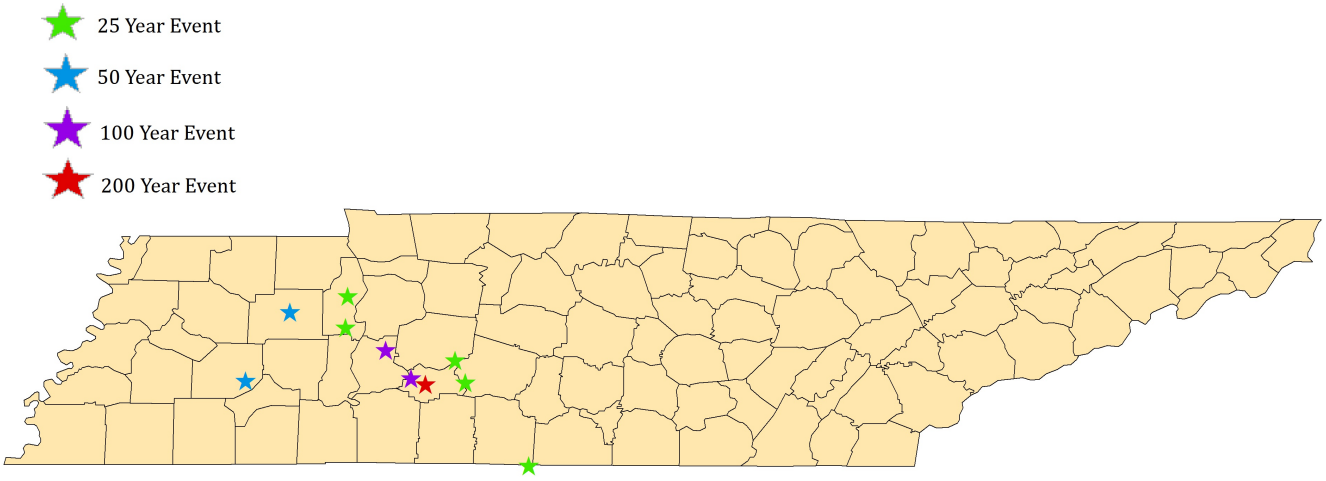

Figure 9: The 10 highest rainfall amount locations and their respective recurrence interval in years for June 5-10, 2014.

This report is part of a series of event summaries produced by the Southern Climate Impacts Planning Program. For questions regarding this report, please contact us at scipp@southernclimate.org. Last updated October 28, 2014 by Katarina Christian.