Impact Forecasting

United States April & May 2011 Severe Weather Outbreaks

June 22, 2011
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Executive Summary

An extremely active stretch of severe weather occurred across areas east of the Rocky Mountains during a period between early April and June 1. At least eight separate timeframes saw widespread severe weather activity – five of which were billion dollar (USD) outbreaks.

Of the eight timeframes examined in this report, the two most notable stretches occurred between April 22-28 and May 21-27:

The late-April stretch saw the largest tornado outbreak in world history occur (334 separate tornado touchdowns), which led to catastrophic damage throughout the Southeast and the Tennessee Valley. The city of Tuscaloosa, Alabama took a direct hit from a high-end EF-4 tornado that caused widespread devastation. At least four EF-5 tornadoes touched down during this outbreak.

The late-May stretch was highlighted by an outbreak that spawned a massive EF-5 tornado that destroyed a large section of Joplin, Missouri. The tornado led to 158 fatalities in the city, becoming the deadliest singular tornadic event since the National Weather Service officially began keeping records in 1950. A second EF-5 tornado during the period was recorded in central Oklahoma.

The table below shows a breakdown of the eight examined timeframes:

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<tr>
<th>Event Date</th>
<th>Event Location</th>
<th># of Deaths</th>
<th># of Structures/Claims</th>
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</tbody>
</table>

| Totals     | 589                   | 2.03 million | 25.15 billion          | 16.0 billion |

1 This total includes fatalities from tornadoes, large hail, straight-line winds and flooding.
2 This information has been compiled and obtained from various state and federal government offices and public media sources, including news websites, publications from insurance companies and financial institution press releases. Additional information was taken from the National Oceanic and Atmospheric Administration's (NOAA) Spring 2011 U.S. Climate Extremes report.

As of June 2011, with at least USD16.84 billion in severe weather insured losses recorded since January thus far, the year is already 330 percent above the 1990-2010 annual average (USD5.11 billion).

In addition to examining the outbreaks, this report further analyzes potential reasons for the high number of tornado fatalities. An overall breakdown also highlights some of the numerous records set during the early April to June 1 period.

The report also provides historical information regarding tornado statistics (including fatalities, number of touchdowns and cost) in the Appendix.
April 3-5, 2011

April 3

The storm system first organized early on Sunday (April 3), as an area of low pressure developed and strengthened after ejecting out of the northern Rockies. With warm and moist air out ahead of the advancing area of low pressure and frontal boundary, the atmosphere became very unstable across the eastern Plains, the Mid-Mississippi Valley and the Midwest during the late afternoon and evening hours. The Storm Prediction Center issued a Moderate Risk of severe weather for parts of Kansas and Missouri, while a broader Slight Risk area covered the Great Lakes. Squall lines eventually developed along the main frontal boundary, which spawned hundreds of reports of large hail (255) and damaging winds (75). A Tornado Watch was at one point issued for Iowa and Illinois (and later a Severe Thunderstorm Watch for northeastern Illinois and southeastern Wisconsin), though no tornadoes touched down. Widespread hail damage was reported to thousands of homes, businesses and vehicles with hail stones ranging from nickel to baseball-sized being recorded. Wind gusts as high as 80 mph (130 kph) were also recorded in conjunction with the clusters of thunderstorms. Eastern Kansas, western Missouri, Iowa and southern Wisconsin sustained the brunt of the damage between late Sunday and early Monday (April 4), with thousands of power outages also reported.

April 4

On Monday into early Tuesday (April 5), the main area of low pressure continued to race northeastward into southern Canada. Additional disturbances developed along the main frontal boundary as it continued to trek eastward. With an abundance of tropical moisture surging out of the Gulf of Mexico, an unusually large and powerful derecho (a widespread and long-lived windstorm that is associated with a fast-moving band of severe thunderstorms in the form of a squall line) raced through the Mississippi Valley, the Southeast, the Ohio Valley and the Mid-Atlantic States. This line of severe storms spawned at least 68 tornado reports (46 later confirmed by National Weather Service meteorologists), 90 large hail reports and 1,318 damaging wind reports. The SPC noted that the 1,476 storm reports from 7 AM Monday morning until 7 AM Tuesday morning set an unofficial one-day record dating to 2000 when records began being kept, surpassing the previous record which was set on April 2, 2006.
Tornadoes and straight-line winds (gusting to 90 mph (150 kph)) were responsible for much of the damage and uprooted trees, which was widespread throughout all of the affected regions. At least 20 states sustained various levels of damage from the squall line, and nearly one million residents lost electricity at the height of the event (including 500,000 in Georgia, 260,000 in the Carolinas and 134,000 in Tennessee). Among the hardest-hit areas came in Georgia, where at least seven of the storm’s nine blamed fatalities occurred. Emergency management officials responded to significant tornado and wind damage across dozens of counties in every section of the state. In Kentucky, multiple tornado touchdowns were recorded that damaged or destroyed dozens of homes and businesses. An EF-2 twister with 120 mph (195 kph) winds was confirmed near the town of Kevil that destroyed a farm and several nearby businesses. A second EF-2 tornado with 130 mph (210 kph) winds near Hopkinsville severely damaged multiple businesses (including the Toyoda Gosei Automotive Sealing manufacturing plant) and left dozens of people injured. Another notable tornado touched down in St. Landry Parish in Louisiana that caused major damage to dozens of homes. In nearby Tensas Parish in Mississippi, an EF-2 tornado damaged or destroyed at least 50 homes and also caused USD2 million in damage to the Tensas Water Distribution Association’s water treatment facility. In Tennessee, at least five tornadoes (three of which were EF-1) were reported that also led to widespread damage. High winds tore the roof off of an elementary school gymnasium in Ashland City and a high school located just west of Nashville.

April 5

By Tuesday afternoon, the squall line continued to shift eastward before exiting into the Atlantic Ocean. Parts of North Carolina, Virginia and Florida recorded wind gusts of nearly 70 mph (110 kph) which led to additional downed trees, power outages and damaged homes and other structures.

Economic Impact

After local National Weather Service meteorologists, insurance assessors and government officials were able to view the dozens of affected states, it was determined that total economic losses were approximately USD2 billion. Various insurers reported that more than 225,000 claims were filed by policyholders, with total insured losses in excess of USD1.4 billion.
April 8-11, 2011

April 8

The storm system organized during the day on Friday (April 8) as an area of low pressure developed along the remnants of a stationary frontal boundary draped across the Plains and the Tennessee Valley. Near the main area of low pressure in northern Oklahoma and southeastern Kansas, strong supercell thunderstorms developed during the early evening hours and spawned reports of golf ball and baseball-sized hail. Widespread damage occurred to tens of thousands homes, businesses and vehicles throughout the region. Also on Friday and early Saturday (April 9), additional damage was reported in Missouri, southern Illinois, Kentucky, Tennessee, North Carolina, West Virginia and Virginia as moisture riding along the stationary frontal boundary spawned large hail and damaging winds. Two tornado touchdowns (an EF-1 (110 mph (175 kph) winds) and an EF-2 (125 mph (205 kph) winds) were also recorded in Pulaski County, Virginia. At least 450 buildings were damaged and eight people were injured by the EF-2 twister.

April 9

As the day progressed on Saturday into early Sunday (April 10), the complex weather scenario continued with two separate areas sustaining major effects. In the Plains, a secondary area of low pressure developed during the early afternoon hours. The Storm Prediction Center declared a Moderate Risk of severe weather for areas surrounding the Minnesota and Iowa border. A Slight Risk was also defined for a broader region surrounding the Moderate Risk zone as well as a narrow line extending southward into Texas. As the day progressed, a tornado outbreak erupted in Iowa – where at least 14 confirmed touchdowns were recorded by the local NWS office. The most notable tornado event came in the town of Mapleton, where an estimated 60 percent of the town was affected and 20 percent was completely destroyed. The tornado, which was rated an EF-4 with at least 170 mph (275 kph) winds by NWS meteorologists, destroyed in excess of 100 structures and caused 14 injuries. Of the 13 other tornadoes that touched down across the state, seven were rated either EF-3 (3) or EF-2 (4). The most affected counties were Ida, Sac, Buena Vista and Pocahontas.
The second area on Saturday and early Sunday to be affected came in an area from southern Indiana through the Tennessee Valley into the Carolinas after a strong cluster of thunderstorms (also known as a mesoscale convective system (MCS)) crossed the region. The MCS (which formed along the stationary frontal boundary and was fueled by an abundance of warm, moist air surging northward out of the Gulf of Mexico) wrapped around the northern periphery of a ridge of high pressure settled over Florida. Hundreds of storm reports were recorded by the SPC in association with the cluster, with the vast majority of the reports noting large hail. The Carolinas were particularly affected, where golf ball to tennis ball-sized hail pummeled tens of thousands of homes, businesses and vehicles.

April 10

The active weather continued on Sunday into early Monday (April 11), where the focus shifted back into the Midwest and the Great Lakes with the development of yet another area of low pressure. The SPC declared another Moderate Risk area for most of Wisconsin and a Slight Risk area from the Upper Midwest southward into Texas. A rare PDS (Potentially Dangerous Situation) Tornado Watch was issued Sunday night for parts of Minnesota, Michigan, and Iowa, as well as most of Wisconsin. As forecast by the SPC, Wisconsin was significantly impacted by severe weather during the late afternoon and evening hours. At least 14 tornadoes touched down during the outbreak, which set an April one-day state record. The most notable tornado affected Lincoln County, where an EF-3 twister with 140 mph (220 kph) winds trekked across a 22-mile (35-kilometer) path and destroyed at least 51 homes and businesses. Additional tornado damage in the state included separate EF-2 twisters in Adams, Forest and Outagamie counties. The other ten tornadoes were EF-1 in strength and affected at least one dozen separate counties across the state.

As further daytime heating occurred, numerous thunderstorms also developed directly along and ahead of the main frontal boundary across the Mississippi Valley and the southern Plains. Tornado and severe thunderstorm watches were issued from southern Oklahoma northward to Sault Ste Marie, Michigan – and even as far north as central Ontario province in Canada. Among the hardest-hit areas came in North Texas, where torrential rains, large hail, straight-line winds and tornadoes were all reported. More than 90,000 power outages also occurred.
April 11

During the day on Monday, the storm system finally began to weaken while crossing the Deep South. However, widespread straight-line wind damage was prevalent throughout the region in association with the advancing squall line. In Bibb County, Alabama, a 110 mph (175 kph) wind gust was recorded that toppled several large trees.

Economic Impact

Based on storm damage assessments by NWS meteorologists and insurance assessors, it was determined that total economic losses were approximately USD2.25 billion. Various insurers reported having received at least 275,000 claims with total payouts anticipated to be in excess of USD1.5 billion. A large portion of these losses were hail-related and found in the Carolinas and Texas.
April 14-16, 2011

One of the largest single-system tornado outbreaks in United States history occurred from Thursday, April 14 to Saturday, April 16, 2011. In what was temporarily an all-time tornado outbreak record, a confirmed 162 tornadoes touched down across 14 separate states – leaving behind substantial damage and fatalities in its wake. A total of 48 people were killed due to incidents stemming from tornadoes, straight-line winds and flooding. At the time, the 38 fatalities recorded on April 16 became the largest number of fatalities in an outbreak in the U.S. since the February 2008 Super Tuesday tornado outbreak that left at least 57 people dead.

The below sections will chronicle the storm system day-by-day as it unfolded.

April 14

The storm system began early in the day on Thursday (April 14) as an area of low pressure developed in the Texas panhandle after initially ejecting out of the southern Rockies. The system quickly strengthened as warm temperatures, high dew points and plentiful atmospheric moisture surging out of the Gulf of Mexico fueled the system. The atmosphere destabilized throughout the areas of northern Texas, central and eastern Oklahoma, Kansas and Arkansas, which prompted the Storm Prediction Center to declare a Moderate Risk of severe weather for this large area. As the activity began, these regions were affected at first by leading individual supercell thunderstorms (which were initiated along the dry line) and later by the main squall line that developed along the main frontal boundary.

At least nine people were killed (seven in Arkansas and two in Oklahoma) in storm related incidents across the region on Thursday and early Friday (April 15) as 31 tornadoes touched down (including 23 in Oklahoma alone). Extensive damage was reported in the tornado-affected areas of the southern Plains and the Mid-Mississippi Valley, which destroyed homes, schools, businesses and vehicles. The hardest-hit tornado area came in the small town of Tushka, Oklahoma, where a large EF-3 tornado caused extensive property damage to dozens of homes, businesses, a school complex and a large trailer manufacturing plant. At least two fatalities, 43 injuries and more than 237 destroyed homes and businesses were recorded in Atoka County due to the tornado. Elsewhere in the state, large hail (up to softball-size) and straight-line winds (gusting to 80 mph (130 kph)) also led to widespread significant damage. Oklahoma’s governor later declared a state of emergency for at least 26 separate counties.

In Arkansas, five of the seven fatalities were blamed on straight-line winds knocking down trees and falling onto cars and homes in the middle of the night. The other two deaths were blamed on an EF-1 tornado in Pulaski County which was embedded within the advancing squall line.

Tornado damage in Tushka, Oklahoma (Source: Norman NWS)
April 15

As the day progressed on Friday, the frontal boundary continued to slowly push eastward as the main area of low pressure started to de-couple. With the large storm circulation swirling and meandering east-northeastward across the central Plains and the Mid-Mississippi Valley, several bands of severe thunderstorms were spawned from Illinois southward throughout the Deep South. In advance of the storm system, the SPC had declared a large part of the Deep South as a Moderate Risk area for destructive weather. By the end of the day, local National Service Meteorologists later confirmed that at least 72 confirmed tornadoes touched down – with the vast majority occurring in parts of Alabama and Mississippi.

Mississippi was the first area to sustain major effects on Friday afternoon, where it was later determined that 17 tornadoes touched down across the state. At least one confirmed fatality was reported. Among the hardest-hit areas came in the Jackson metropolitan area (particularly in city of Clinton, northern and western portions of the city of Jackson, portions of the city of Ridgeland and the Ross Barnett Reservoir). At least 10 people were injured by an EF-3 tornado with 140 mph (225 kph) winds. Numerous homes and businesses were damaged or destroyed, cars were flipped, thousands of trees were snapped and several power lines and poles were downed both by the tornado and from falling trees. In Greene County, an EF-3 tornado destroyed more than 100 homes and several other businesses were heavily damaged in the town of Leakesville. Significant tornado damage also occurred in parts of Attala County by an EF-2 tornado (120 mph (195 kph) winds) and Neshoba and Kemper counties by an EF-3 twister (140 mph (225 kph) winds). In addition to the tornadoes, large hail (up to softball-size) and straight-line winds were also responsible for major damage. Mississippi’s governor declared a state of emergency for 14 separate counties on Friday evening.

As the waves of severe thunderstorms pushed into Alabama during the late afternoon and evening hours, they continued to intensify as atmospheric conditions were extremely unstable in part due to the maximum daytime heating that was occurring. Central and southern sections of the state were particularly affected by the powerful thunderstorms, which led to the deaths of at least seven people. The NWS later confirmed that the 41 tornado touch downs were the second highest one-day total in state history. Storm reports indicated that hundreds of homes, businesses, churches and even the Hunt Oil Refinery had been severely damaged or destroyed by tornadoes that ripped through nearly 20 separate counties. The most notable tornado in the state was an EF-3 with 150 mph (240 kph) winds that tore across Autauga County while causing major damage and at least three fatalities. Another short-lived EF-3 twister traversed through central Tuscaloosa County, including southern sections of the city of Tuscaloosa – where a commercial area near McFarland Mall sustained major property damage. Two other EF-3 tornadoes with winds of 150 mph (240 kph) were confirmed in the state, which led to additional deaths and significant damage to the affected areas. In addition to the tornadoes, large hail (up to baseball-size) and straight-line winds led to even more destruction. Alabama’s governor declared a state-wide state of emergency.
Also during the day on Friday, additional storm damage was recorded across parts of Tennessee, Kentucky, Illinois and Missouri. A combined eight EF-0 and EF-1 tornadoes were confirmed, in addition to dozens of reports of damaging winds and large hail.

By late Friday into early Saturday (April 16), the storm system slightly weakened as the frontal boundary pushed into Georgia. Northwestern sections of the state sustained the brunt of the damage, primarily caused by large hail (up to baseball-size), straight-line winds (up to 80 mph (130 kph) and a weak tornado. According to Georgia Power officials, tens of thousands of power outages also occurred.

**April 16**

As the day progressed on Saturday, the main area of low pressure (which trailed behind the frontal boundary) traversed eastward through the Ohio Valley and into the Northeast, while bringing primarily heavy rains to the region. The cold front itself stretched southward through the Mid-Atlantic States into the Southeast. With an upper level trough, a strong mid-level jet stream and an abundance of moisture and daytime heating at the surface, atmospheric conditions in central and eastern North Carolina warranted the SPC declaring a rare High Risk probability for a severe weather outbreak in the region (the first such high risk probability rating of 2011).

**North Carolina**

As the SPC had forecast, North Carolina endured widespread severe weather as violent supercell thunderstorms developed in advance of a main squall line. A large PDS Tornado Watch was issued for central and eastern North Carolina and immediate adjacent areas in South Carolina and Virginia. The storms caused substantial damage throughout the state – including in the state capital of Raleigh, where three people were killed. At least 24 total fatalities were recorded in the state. According to local National Weather Service offices, tornado touchdowns were recorded in Bladen, Chatham, Cumberland, Duplin, Greene, Harnett, Johnston, Jones, Lee, Martin, Onslow, Person, Pitt, Robeson, Sampson, Wake, Wayne and Wilson counties with at least 6,440 homes being completely destroyed or severely damaged. The NWS noted that the hardest-hit areas were from Lee County up to Wake County and from Hoke County across Harnett County into Cumberland County.

The first areas in the state to see severe weather came on the east side of the Blue Ridge Mountains as a squall line descended and rapidly intensified along the Interstate 77 corridor. As the line tracked eastward, widespread tree and roof damage was reported in the towns of Salisbury and Lexington. The Salisbury storm, later rated an EF-1, became the first confirmed tornado from the outbreak in North Carolina. The Salisbury twister was quickly followed by tornadoes near the towns of Monroe (EF-0) and Burlington (EF-1). The Burlington area tornado was spawned by a supercell thunderstorm that would end up becoming the first of numerous multi-tornado/long-track supercells to cross the state.
As the main squall line continued to quickly move to the east, it entered an area that had seen maximum daytime heating under sunny skies. The line eventually began to break and fragmented into several powerful supercells by early afternoon. With very strong mid- and upper level wind shear present, the atmosphere became primed for tornadic development. By the late afternoon, a particularly dangerous supercell spawned a high end EF-3 tornado with 160 mph (260 kph) winds that touched down in the Sanford area. The twister destroyed a Lowe’s hardware store and an entire neighborhood consisting of more than 30 homes. The nearby towns of Dunn and Wilson also reported significant damage to dozens of homes and businesses. As the supercell (and tornado) continued to quickly race east-northeastward, it began to enter the Raleigh metropolitan area. The tornado first tracked through the city’s southwest side before crossing the southeast edge of the downtown area and later tracking through suburbs surrounding the city. Several homes and buildings homes were completely destroyed, and the campus of Shaw University was damaged so severely that classes were suspended for the rest of the school semester. The NWS later noted that the storm fluctuated between EF-0 and EF-2 strength while tracking through Raleigh, while crossing three interstate highways and narrowly missing a nuclear power plant. At least six fatalities were blamed on the tornado.

Elsewhere in the state, another notable EF-3 tornado with nearly 150 mph (240 kph) winds ripped through Bertie County, where the city of Askewville sustained substantial damage to hundreds of homes. Several homes were completely knocked off of their foundations. At least 12 deaths were blamed on the twister, making it one of the deadliest single tornadoes since 2008. Other supercells spawned additional powerful tornadoes in the towns of Fayetteville, Goldsboro, Jacksonville, and Wilson – all of which endured twisters of EF-2 or EF-3 strength. A combined six fatalities were recorded from those tornadoes.

After the event, North Carolina’s governor declared a state-wide state of emergency. The North Carolina Emergency Management later reported that the event spawned the most tornadoes that the state had seen since March 1984.

**Other affected states**

In South Carolina, at least six tornado touchdowns also caused widespread damage reports. Dillon, Georgetown and Berkeley counties were particularly affected. One tornado heavily damaged a church in the town of St. Stephen, just to the northwest of the city of Charleston. Local NWS officials reported that major damage had occurred after golf ball and softball-sized hail fell throughout the state. Nearly 250,000 Progress Energy customers also lost electricity at the height of the event throughout the Carolinas.
In Virginia, at least five fatalities were blamed on tornadic activity and flash flooding. The most notable event came in Surry, James City, York, Gloucester and Mathews counties, when an EF-3 tornado with nearly 165 mph (270 kph) winds left at least two people dead and 60 others injured in the town of Coke. NWS meteorologists determined that the powerful tornado crossed a 30-mile (50-kilometer) path, with the most destructive damage occurring in the Gloucester County communities of Ware Neck, Glen Roy Estates and Waverly Lane. Nearly 200 homes and businesses were damaged or destroyed by the twister. State officials noted that the tornado touched down in the switchyard of the Surry Nuclear Power Plant and caused a loss of power at the facility. Diesel backup power was quickly restored with the shutdown and cooling of the plant proceeding as designed with no physical damage to the reactors or release of radiation.

Nine other tornadoes touched down across Virginia during the event, including two EF-2 tornadoes. In Middlesex County, an EF-2 twister with winds estimated up to 135 mph (215 kph) caused heavy damage to at least 95 homes in Deltaville and also damaging a local middle school and several other buildings. The other EF-2 in the state, recorded in Isle of Wright County, damaged approximately 25 homes and farm equipment in the town of Smithfield.

It should be noted that additional confirmed tornado touchdowns occurred in parts of Maryland and Pennsylvania. By late Saturday evening, the frontal boundary fully exited into the Atlantic Ocean as clean-up efforts began across the region.

Outbreak summary

Over the three days of active weather, a total of 19 watches were issued by the Storm Prediction Center, including 17 tornado watches (two of which were PDS watches) and two severe thunderstorm watches.

At the time, this became the deadliest tornado outbreak event in the United States since February 2008, when at least 57 people died across the Tennessee Valley and the Southeast. As of this writing, 162 tornadoes (EF-0 (43), EF-1 (75), EF-2 (30) and EF-3 (14)) had been confirmed by National Weather Service meteorologists – in addition to hundreds of additional reports of damaging straight-line winds and large hail.

Economic Impact

Total economic losses throughout the affected regions were preliminarily listed at approximately USD2.5 billion, while various insurers received more than 160,000 claims with payouts in excess of USD1.7 billion.
April 19-21, 2011

The affecting storm system developed early in the day on Tuesday (April 19) across parts of the Plains after ejecting out of the Rockies. As the day progressed, the main area of low pressure quickly strengthened as an abundance of tropical air surged out of the Gulf of Mexico out ahead of the cold front. Early morning rain showers and thunderstorms throughout the region ahead of the leading warm front helped set the stage for the late afternoon and evening severe weather event, as daytime heating and plentiful sunshine caused the moisture to evaporate and create a highly unstable atmosphere. The system spawned fresh rounds of widespread severe weather across parts of the Plains, Mississippi Valley, Midwest, Ohio Valley and the Southeast before dissipating late in the day on Wednesday (April 20) into early on Thursday (April 21).

April 19

As previously noted, there were two episodes of severe weather during the day on Tuesday throughout the Plains and parts of the Midwest. The first areas to sustain effects came during the first half of the day as a line of thunderstorms spawned large hail across parts of central and eastern Missouri. The St. Louis NWS office recorded hail the size of baseballs in several locations during the morning hours.

The second episode was much more substantial, as straight-line winds and tornadic activity occurred in addition to the large hail. During the afternoon and evening hours, an area from central Illinois southwestward into northern Texas saw dozens of tornado touchdowns amongst hundreds of other large hail and damaging wind reports in association with a dangerous squall line. In total, the SPC officially recorded 51 tornado touchdowns, 572 reports of straight-line wind damage and 357 reports of large hail.

The most notable tornado damage occurred just outside the town of Girard, Illinois, where meteorologists determined that a strong EF-3 with 150 mph (240 kph) winds destroyed dozens of homes and barns. Elsewhere in central and southern Illinois, at least 13 other tornadoes touched down – including four with EF-2 strength in Montgomery, White and Wabash counties. The twisters damaged or destroyed dozens of homes and a large amount of farm equipment. Straight-line winds and suspected tornadoes also led to additional widespread damage in the state.
Shifting to Indiana, central and southern sections of the state recorded at least 24 separate tornado touchdowns (four of which were rated with EF-2 strength). According to NWS assessments, the tornadoes left widespread significant damage to dozens of homes and businesses. Other tornado damage included an EF-1 tornado in Bowling Green, Missouri in addition to other touchdowns in parts of Ohio and Kentucky. It should be noted that vast majority of the reported damage during late Tuesday and early Wednesday was blamed on large hail (including softball-size in parts of Oklahoma and Missouri) and straight-winds (in excess of 100 mph (160 kph) in some spots) along the advancing squall line.

April 20 and 21

During the day on Wednesday into early Thursday (April 21), fresh rounds of thunderstorms developed along the main cold front which stretched from the Northeast southward through the Mid-Atlantic States into the Southeast. At least 12 tornado touchdowns were confirmed reported into the SPC in addition to more than 200 reports of large hail and damaging winds. The hardest-hit areas included parts of Arkansas, Mississippi, Alabama, Georgia and Texas where large hail and straight-line winds were most prevalent. No injuries or fatalities were reported. In the days that followed, flash flood watches and warnings were issued throughout the Midwest and the Southeast as recent heavy rains caused several rivers to swell to flood stage.

Economic Impact

Total economic losses from the period were listed at nearly USD575 million, while various insurers received more than 100,000 claims with payouts in excess of USD350 million.
April 22-28, 2011

One of the most active seven-day severe weather periods in recorded history occurred throughout the eastern United States between Friday, April 22 and Thursday, April 28. Preliminary reports by National Weather Service meteorologists indicate that at least 355 tornadoes touched down across nearly two dozen states during the period.

The following sections will provide a breakdown of the seven-day period, with particular emphasis on the April 25 to April 28 timeframe which set an all-time record for tornadic activity:

April 22

During the day on Friday, the focus was on the Mississippi Valley, Plains and the Midwest as a mixture of very warm and humid air coupled with a developing storm system. As atmospheric conditions became highly unstable, it set the stage for severe weather from north Texas through Missouri and eastward into Kentucky with tornadoes, large hail (up to softball-size) and straight-line winds.

The most notable severe weather event came in the greater St. Louis, Missouri metropolitan area, where the strongest tornado since January 1967 pummeled the region. The twister caused extensive damage along a 21-mile (34-kilometer) path that started in St. Louis County, Missouri and ended in Madison County, Illinois. According to NWS meteorologists, the scenario was marked by two tornadic supercells which produced at least five tornado touchdowns. The most destructive tornado was an EF-4 with winds in excess of 165 mph (265 kph). The twister touched down at approximately 7:55 PM local time (0:55 UTC Saturday) near the northern edge of Creve Coeur Lake before quickly intensifying to EF-3 strength while entering the Maryland Heights community. Extensive damage was reported in Maryland Heights, with at least 1,170 homes being damaged or destroyed. The twister reached its peak EF-4 strength while passing through the Bridgeton area, where more than 900 homes were damaged and the Air National Guard building was also heavily impacted. After exiting the Bridgeton and St. Ann communities, the tornado took direct aim at the Lambert-St. Louis International Airport. At the airport’s main terminal building, many large windows were blown out or damaged by flying debris and a large section of roof was peeled from Concourse C. Four American Airlines aircraft and one Southwest Airlines airplane was damaged when the EF-2 twister (at that time) tore through the airport, which was forced to close for 24 hours due to the extensive damage. As the tornado exited the airport, it entered the Berkeley community where 450 homes were damaged. From there, the storm continued northeastward before crossing the Mississippi River and entering Madison County, Illinois. The twister damaged dozens of homes and other structures before finally lifting and ending its track. According to the Ameren utility company, at least 54,000 power outages in Missouri and Illinois were caused by the large tornado.

EF-4 tornado damage in Bridgeton, MO (Source: St. Louis NWS)
Elsewhere on Friday into early Saturday (April 23), parts of Oklahoma, northwest Arkansas, Illinois, Indiana, Ohio and Kentucky sustained damage primarily caused thunderstorms which developed along a frontal boundary in association with a squall line. The SPC recorded 229 large hail reports (some as large as baseballs and grapefruits) and 59 damaging wind reports. Both were the primary source of damage in these states.

April 23 and 24

On Saturday and Sunday, additional severe weather was spawned directly along the active cold front as it became stationary from central Texas east-northeastward into the Mid-Atlantic States. While multiple tornado touchdowns were recorded, the vast majority of the damage occurred due to hail and straight-line winds. Thousands of homes and vehicles were directly impacted as hail ranging from quarter to softball-size shattered windows and roofs. Winds up to 70 mph (110 kph) also led to roof and shingle effects. According to the SPC, a combined 107 damaging wind and 242 large hail reports were recorded during the 48-hour stretch.

April 25-28 Overview and Meteorological Synopsis

During the Monday, April 25 to Thursday, April 28 period, the Southern, Midwestern and Eastern United States endured one of the deadliest and most significant severe weather and tornado outbreaks in recorded history. Tornado touchdowns were recorded from Texas to New York during the timeframe, with catastrophic damage occurring in parts of Alabama, Arkansas, Georgia, Mississippi, North Carolina, Tennessee, and Virginia. Between the early afternoon hours on April 27 into the early morning hours on April 28, an estimated 190 tornadoes touched down – a prolific number that set a world record for most tornadoes in a 24-hour period. Throughout the entire April 25-28 timeframe, the National Oceanic and Atmospheric Administration (NOAA) noted that more than 430 tornadoes unofficially touched down (as of this writing, 335 have been confirmed by NWS and Environment Canada meteorologists). See the graphic on the right for a breakdown of the confirmed tornadoes, thus far, during the 96-hour period.

The outbreak also led to a significant number of storm-related and tornado-related fatalities. At least 344 fatalities were recorded during the outbreak from tornadoes, straight-line winds and flooding rains – including at least 317 on April 27 alone from 30 separate tornadoes. The 322 tornado fatalities make this the fifth deadliest outbreak in U.S. history. According to the NWS, April 27 represented the deadliest tornado day in the United States since the historic March 18, 1925 Tri-State Outbreak. That outbreak spawned the infamous Tri-State Tornado which left 695 people dead. The deadliest singular tornado on April 27 came in Hackleburg, Alabama, where at least 71 people died. This represented the deadliest singular tornado in the U.S. since May 25, 1955 when 80 people were killed in southern Kansas. See the graphic on the left for a breakdown of the confirmed fatalities during the 96-hour period.
Confirmed tornado touchdowns by state and day during the outbreak

<table>
<thead>
<tr>
<th>State/Province</th>
<th>Tornadoes confirmed by date/period</th>
<th>Tornadoes confirmed by rating</th>
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<tbody>
<tr>
<td></td>
<td>Early April 25</td>
<td>Late April 25</td>
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<tr>
<td>Alabama</td>
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</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1</strong></td>
<td><strong>39</strong></td>
</tr>
</tbody>
</table>

Early = from midnight to 12:00 pm CDT (0500 to 1700 UTC); Late = from 12:00 pm to midnight CDT (1700 to 0500 UTC). Tornadoes that crossed state or provincial boundaries were only counted once based upon where it initially touched down, regardless of whether it became stronger in another state.

Note that the above data is provided by the Storm Prediction Center and the National Weather Service.
Brief Meteorological Synopsis

The tornado outbreak was caused in part by a series of key atmospheric ingredients coming together all at the same time. On April 25, a vigorous upper level trough shifted into the southern Plains that interacted with a surface low attached to a frontal boundary over parts of northeast Oklahoma and western Missouri. Conditions were similar on April 26, as a combination of upper level, mid-level and surface conditions came together to create an extended threat of strong to violent long-track tornadoes during the afternoon and evening hours across parts of east Texas, Louisiana, Arkansas, and Mississippi. As the evening wore on, diurnal conditions allowed the development of a large cluster of severe storms (also known in the meteorological community as a Mesoscale Convective Complex (MCC)) that further crossed into parts of Tennessee, Alabama and Georgia into the early morning hours of the next day.

On April 27, the main area of low pressure moved eastward toward the Ohio, Mississippi and Tennessee Valleys. Behind the advancing upper level trough, an extremely active jet stream moved into the region that prompted very strong atmospheric wind shear (wind shear is key to tornadic development as wind directions veering with height prompt a horizontally spinning cylinder of air to straighten and drop to the surface as a vortex). With a secondary area of low pressure moving quickly northeastward along the frontal boundary, this added even more instability to areas across the Deep South and the Tennessee Valley. As maximum daytime heating occurred, and dew points continued to rise, this further aided atmospheric conditions becoming ripe for an extensive outbreak of severe weather.

The following sections will breakdown the progress of the severe weather and tornadic activity by day.
April 25

On Monday into early in the day on Tuesday (April 26), an area of low pressure developed in Texas along the tail end of the stationary frontal boundary before traversing through the southern Plains and the Mississippi Valley. With very warm surface temperatures, abundant moisture and an active jet stream, the atmosphere became extremely unstable and conducive to supercell thunderstorm development – in addition to the main squall line. In advance of the wave of severe weather, the SPC issued a Moderate Risk for parts of Texas, Oklahoma, Louisiana, Arkansas Mississippi and Tennessee within a broader Slight Risk area that stretched up into the Ohio Valley. During the afternoon hours, the SPC issued a PDS Tornado Watch for much of Arkansas, Missouri, Oklahoma, Texas and Louisiana. In the hours that followed, dozens of tornadoes touched down in addition to hundreds of other reports of large hail and damaging winds from Texas east-northeastward to Pennsylvania.

The hardest-hit area came across parts of Arkansas, where at least 10 people died in tornadoes and flash flooding. The most destructive tornado event tore through the small town of Vilonia, where an EF-2 twister destroyed upwards of 80 homes in the Quail Hollow subdivision, the local grocery store and other businesses, vehicles and infrastructure. Four deaths were blamed on the tornado. Another EF-2 tornado caused damage to a high school in Pulaski County and at Little Rock Air Force Base, where numerous buildings and vehicles were damaged. Heavy rainfall in northern sections of the state caused flash floods and river flooding, which led to at least six fatalities after vehicles were swept up by raging waters. In the town of Hardy, the city hall building and numerous homes were evacuated due to the Spring River exceeding flood stage. Floods also submerged numerous roads and agricultural land across the state. The damage led to the governor declaring a state-wide state of emergency.

Elsewhere, additional tornado, hail and straight-line wind damage was recorded throughout parts of Texas, Mississippi, Louisiana, Tennessee, Indiana, Kentucky, Ohio and Pennsylvania. Thousands of homes, vehicles, businesses and other structures sustained various levels of effects.

April 26

As the day progressed on Tuesday into early Wednesday (April 27), a new very large and complex weather pattern began to develop in the southern Plains, Mississippi Valley and the Southeast while also affecting areas into the Northeast and Midwest. Daytime heating, tropical moisture, an active jet stream and two separate shortwave troughs caused extreme atmospheric instability – prompting the SPC to declare a rare High Risk area for parts of Texas, Oklahoma, Arkansas, Louisiana, Mississippi and Tennessee. A large PDS Tornado Watch with very high tornado probabilities was issued that afternoon for that same area. As the SPC forecast, a dangerous outbreak of supercell thunderstorms occurred throughout the warned region. Nearly 100 confirmed tornadoes touched down, with parts of Texas, Arkansas (one fatality), Mississippi (four fatalities), Alabama (two fatalities) and Louisiana (two fatalities) sustaining the brunt of the damage.
The first reports of damage came in Texas, where numerous tornado touchdowns and hail as large as baseballs were recorded across northeastern sections of the state. In the small town of Edom, an EF-1 tornado destroyed at least 100 homes. Another EF-1 tornado severely damaged homes and buildings across Limestone County, particularly in the town of Groesbeck. As the supercells shifted eastward, they brought a second consecutive day of significant damage across Arkansas. According to the state emergency management agency, at least 10 separate counties reported destructive wind and flood damage. One person was killed in Sharp County after a tornado destroyed dozens of homes. More than 45,000 Entergy customers lost electricity at the height of the event. In Louisiana, the two fatalities occurred in separate flood-related incidents in the town of Monroe.

Severe damage was also evident throughout Mississippi, where the emergency management agency noted 23 counties with effects from tornadoes, large hail and straight-line winds. The three fatalities, which occurred in Kemper County, were blamed on tornadic activity that was also prevalent in Lafayette, Webster, Yazoo and Choctaw counties. Nearly 150,000 power outages were reported. In Alabama, at least two people were killed in St. Clair County as state emergency officials declared that heavy damage was extensive in six counties. Some of the more notable damage came in Marshall and Lauderdale counties, where multiple tornadoes left major effects. In the city of Birmingham, widespread damage to dozens of homes, businesses and schools was evident. At the Shuttlesworth International Airport, high winds also left damage to an on-site airplane hangar. More than 269,000 residents in the state lost electricity. Parts of south-central Tennessee were also directly impacted by the severe weather. A tornado near the town of Coldwater left a 10-mile (16-kilometer) path of damage to dozens of homes and businesses.

Outside of the Southeast and the Mississippi Valley, parts of the Northeast and the Midwest also endured rounds of severe weather. In Michigan, a weak EF-0 tornado was confirmed in Allegan County, a funnel was spotted in Kalamazoo County, and seven people were injured by a lightning strike in the town of Portage. Shifting eastward, severe thunderstorms brought wind damage and large hail across Pennsylvania and New York. Tennis ball-sized hail was reported in Lock Haven, Pennsylvania. An isolated supercell moved across Central New York during the afternoon hours which produced golf ball-sized hail in Syracuse and spawned a brief EF-1 tornado in Verona Mills.

It should be noted that the far-reaching storm system also brought severe weather damage to parts of Kentucky, Indiana, the Virginias and the Carolinas.
April 27

The severe weather outbreak on Wednesday and early Thursday (April 28) consisted of two waves. The first wave pushed through the Deep South early on Wednesday, particularly affecting parts of northeast Alabama and northwest Georgia. The town of Rome, Georgia was severely affected, where straight-line wind damage was reported to dozens of homes, schools and businesses. Notable damage locations included the Redmond Regional Medical Center, Berry College and Shorter University. Additional extensive wind damage was reported in Floyd, Gordon, Haralson and Dade counties. These storms knocked out power and telephone lines in several areas. While some power and telephone service was restored, some areas remained without power through the remainder of the day. Because of these outages, it caused some NOAA weather radio transmitter sites to stop functioning for the remainder of the outbreak.

The second wave developed as moisture surged out of the Gulf of Mexico, maximum daytime heating occurred, a cold front advanced eastward, wind shear veered at different levels of the atmosphere and a very active jet stream was enhanced by an upper level disturbance – all of which led to the atmosphere becoming extremely unstable and conducive for severe weather. The atmospheric conditions spawned numerous supercell thunderstorms and produced long-lived violent tornadoes, many of which devastated the northern two-thirds of central Alabama. In advance of the event, the SPC issued a rare High Risk warning area for the second consecutive day in parts of Mississippi, Alabama, Tennessee and Georgia.

As the SPC had forecast, an extremely serious widespread severe weather and tornado outbreak occurred. The National Weather Service released a statement saying that the event was an ‘outbreak of historic proportions.’
Alabama

The most destructive tornado from the outbreak came during the more explosive second wave of severe weather in the city of Tuscaloosa, Alabama, which sustained a near direct-hit. Tuscaloosa officials reported that the high end EF-4 tornado with at least 190 mph (305 kph) had up to a 1.5-mile-wide (2.5-kilometer) base and caused catastrophic damage throughout many sections of the city. Thousands of homes, businesses, schools and other structures were severely damaged or completely destroyed. At least 41 fatalities and more than 1,000 injuries were reported in Tuscaloosa. It should be noted that most buildings at the University of Alabama were largely spared from major damage. National Weather Service meteorologists reported that this tornado had an 80.3-mile (129-kilometer) path that devastated northern sections of the state. An additional 24 fatalities were blamed on this twister. Alabama’s Department of Insurance reported that total insured losses from this tornado alone was to exceed USD2 billion, which would rival state losses seen during hurricanes Katrina and Ivan. This also became, briefly, the costliest single tornado of all-time. The May 22, 2011 Joplin, Missouri tornado would later surpass this total – see page 30 for details.

The deadliest tornado in Alabama came in Marion, Franklin, Lawrence, Limestone and Madison counties, where a massive EF-5 twister with up to 210 mph (340 kph) winds struck and left at least 71 people dead. The tornado, which had a 0.75-mile-wide (1.2-kilometer) base and a 25.2-mile (40.6-kilometer) path, devastated the town of Hackleburg in Marion County, where some estimates suggested upwards of 75 percent of the town had been destroyed. Tremendous damage was reported to hundreds of homes, businesses, churches, schools and public infrastructure. Several subdivisions were completely wiped off of their foundations, while Hackleburg High School and the Wrangler Plant were also destroyed. This tornado became the first F-5 or EF-5 tornado in Alabama since the Birmingham tornado of April 8, 1998. A second confirmed EF-5 tornado in the state was later confirmed having ripped through Dekalb County with more than 200 mph (325 kph) winds. At least 26 fatalities were blamed on the twister.
Elsewhere in Alabama, deadly tornadoes left 23 people dead in Calhoun and St. Clair counties. Dozens more fatalities were recorded in the state. In the city of Huntsville, meteorologists at the National Weather Service were forced to evacuate to a reinforced steel room and turn over monitoring duties to the nearby Jackson NWS office as they saw multiple funnel clouds form over the main building. Another powerful tornado ripped through the town of Cullman and severely damaged the local medical center. Alabama Power reported that upwards of one million customers were without power during the height of the event. A spokesman from the company released a statement that indicated that the number of power outages had surpassed the number seen during hurricanes Dennis and Frederick, and nearly exceeded those seen during Ivan and Katrina. The tornadoes even forced the Tennessee Valley Authority to close three nuclear reactors at its Browns Ferry nuclear plant in north Alabama after 25 high-voltage power lines were knocked out. Plant operators noted that seven diesel, back-up generators worked properly. President Barack Obama declared a state of emergency in Alabama and ordered federal assistance to the hardest-hit areas. More than 2,000 National Guard troops were also deployed to assist in the rescue and recovery efforts.

Mississippi

Parts of Mississippi were also heavily impacted by the outbreak, with the Mississippi Emergency Management Agency indicating hundreds of injuries in addition to 35 fatalities. At least 50 counties sustained damage during the outbreak, where at least two confirmed EF-5 tornadoes tore across the state. The first EF-5 came in Chickasaw and Monroe counties before crossing into northwestern Alabama during the late afternoon hours. The town of Smithville took the brunt of the tornado when it was at its peak with winds in excess of 205 mph (335 kph) and had a 0.75-mile-wide (1.2-kilometer) base. The twister devastated the town as 202 homes, 21 businesses and 2 churches were damaged or completely destroyed. The majority of the destroyed homes were well-built and of recent construction. In total, the tornado covered a 35.1-mile (56.5-kilometer) path. The Smithville tornado officially became the first EF-5 tornado in the U.S. since May 2008’s Parkersburg, Iowa event.

The second EF-5 tornado of the day in Mississippi touched down in the afternoon across parts of Neshoba, Kemper, Winston and Noxubee counties. At least three people were killed in Kemper County after a mobile home was thrown at a distance of 300 yards (275 meters), two brick homes were flattened and vehicles were rolled hundreds of yards (meters). The local NWS also determined that parts of the ground had been dug up to a depth of around two feet (0.6 meters) over an area approximately 25 to 50 yards (23 to 46 meters) wide and hundreds of yards (meters) long. Meteorologists noted that the twister had winds in excess of 205 mph (335 kph), a maximum 0.5-mile (0.8-kilometer) width and a path of 29 miles (46.7 kilometers).
The two tornadoes became the first EF-5 or F5 tornadoes in Mississippi since 1966. This also marked the first time since March 13, 1990 (Hesston and Goessel, Kansas) that two or more EF-5 or F5 tornadoes had occurred on the same day.

**Tennessee**

In Tennessee, dozens of tornadoes crossed eastern sections of the state that left at least 34 people dead. One of the most notable tornadoes was an EF-4 with 190 mph (305 kph) winds that caused extensive damage in Hamilton, Bradley and Polk counties after initially touching down in extreme northeastern Georgia. At least 21 fatalities were blamed on this tornado (13 in Tennessee and 8 in Georgia) as it damaged or destroyed in excess of 200 homes and businesses during its 48-mile (77-kilometer) path. Also in the state, two additional EF-4 tornadoes were confirmed across parts of Blount, Sequatchie, Bledsoe and Rhea counties. Multiple fatalities were recorded in addition to widespread damage.

Besides the property damage in Tennessee, the severe weather wreaked havoc on the electrical infrastructure. Hundreds of thousands of Tennessee Valley Authority customers lost electricity at the height of the outbreak after 108 transmission lines and 353 towers and poles were snapped or destroyed. The TVA reported that total costs from April 27’s outbreak (USD200 million) were its costliest on record.

**Georgia**

As noted earlier, Georgia also endured multiple tornado touchdowns during the afternoon, evening and overnight hours. At least four twisters with EF-3 strength were recorded with major damage occurring to hundreds of homes, businesses, parks and a church. Of these four tornadoes, the most damaging came in Dade and Walker counties where at least two people were killed and more than 50 others were injured. Nearly two dozen homes were destroyed in addition to tens of thousands of trees being downed after the tornado with 150 mph (240 kph) winds entered the state after first touching down in Alabama.

**Other affected areas**

As the evening wore on and the storm system continued to shift northeastward, it brought even more severe weather along the Interstate 81 corridor from northern Virginia northward through Maryland, Pennsylvania and into northern New York into early on Thursday (April 28). Dozens of additional tornadoes were confirmed throughout this region, though most were smaller in scale and not nearly as damaging as the events from earlier in the day.

It should be noted that tornadic activity was also recorded in parts of southern Ontario and as far north as Ottawa in Canada. One tornado has been confirmed by Environment Canada and three others may also be classified. Damage was isolated across parts of Wellington, Waterloo, Oxford and Dufferin counties.
April 28

During the day on Thursday, the storm system continued to further push eastward through the Southeast and areas northward along the Atlantic seaboard into northern sections of New England. Additional reports of tornadoes, damaging winds and large hail were reported, though not nearly on the scale of what was seen during the previous days. Among the dozens of tornado touchdowns, at least five were rated at EF-2 strength in Virginia, Pennsylvania and New York. Hundreds of additional homes and other structures were damaged.

The storm system also brought fresh rounds of damage across parts of southern Ontario, Canada – where at least one person was killed. According to Environment Canada, as many as three additional tornadoes may have touched down though they have yet to be confirmed. Much of the damage was attributed to straight-line winds gusting to 80 mph (130 kph). The high winds led to a storm surge along the Great Lakes and caused damage to several boats. The Lewiston/Queenston Bridge between Canada and the United States, as well as several other elevated roads, was temporarily closed due to the high winds.

Economic Impact

Total economic losses during the seven-day period were listed at approximately USD10 billion. Insurers reported having received more than 650,000 claims from dozens of states and anticipated payouts to be in excess of USD5.5 billion.

The USD5.5 billion in insured losses makes this seven-day period one of the costliest stretches of severe weather in U.S. history.
May 9-13, 2011

May 9

During the day on Monday (May 9) atmospheric conditions became favorable for severe weather across parts of the northern Plains as moisture from a developing area of low pressure combined with additional moisture that was wrapping around the northern periphery of an upper level ridge of high pressure in the southern Plains. The Storm Prediction Center issued a Slight Risk of severe weather for an area including parts of Wyoming, Nebraska, South Dakota and North Dakota. As daytime heating occurred and a strong mid-level jet stream entered the region, several strong to severe thunderstorms developed in extreme eastern Wyoming, southwest South Dakota and northwest Nebraska.

South Dakota sustained some of the most notable impacts as two separate tornadoes (an EF-1 (100 mph (160 kph) winds) and an EF-2 (130 mph (210 kph) winds) touched down. The EF-2 twister damaged a shed north of the town of Philip and toppled a large electrical transmission tower. Outside of the tornado damage, large hail (ranging from golf ball to baseball-sized) was recorded across parts of Minnesota in association with the same cluster of thunderstorms as they shifted eastward.

May 10

The same weather pattern established on Tuesday (May 10) as the main area of low pressure traversed through the Upper Midwest and additional moisture continued to wrap around an upper level ridge of high pressure which had shifted into the Mississippi Valley. Beginning in Minnesota, an EF-1 tornado touched down in Wright County while causing isolated damage to outdoor structures. Most of the damage in the state was blamed on large hail and damaging straight-line winds which were prevalent in the greater Minneapolis metropolitan area.

However, the vast majority of Tuesday's activity occurred along a leading warm front which stretched from the Ohio Valley into the Southeast. With record high temperatures occurring, numerous strong showers and thunderstorms developed along the boundary. No tornadoes touched down, though the SPC recorded nearly 400 reports of large hail (up to baseball-sized) and damaging winds from northern Indiana southward into the Carolinas. Damage to homes, businesses and vehicles was widespread throughout the affected regions.
May 11-13

Between Wednesday (May 11) and Friday (May 13), the focus shifted back into the Plains, Midwest, the Mississippi Valley and the Southeast as an upper level area of low pressure strengthened while ejecting out of the Rockies. With an abundance of tropical moisture from the Gulf of Mexico combining with very warm temperatures, atmospheric conditions became favorable for severe weather. During the 72-hour stretch, the SPC separately declared large areas of the central and eastern sections of the country as a Slight Risk for severe weather. By the end of the period, the SPC had recorded at least 21 tornado touchdowns (15 later confirmed), 418 reports of large hail and 334 reports of damaging winds. Of the 15 tornado touchdowns across four states (Missouri, Nebraska, Iowa and Oklahoma), 11 were rated at EF-0 and four EF-1. However, damage from the tornadic activity was isolated and not widespread.

While tornado damage was minimal during the period, the large hail and damaging straight-line winds led to major damage to homes, businesses and vehicles from the Plains eastward into the Mid-Atlantic. The damage came from storms which were generally found direct along the cold front and ahead of the advancing warm front.

Economic Impact

Total economic losses were listed at USD300 million, while various insurers reported having received more than 50,000 claims with payouts listed in excess of USD200 million.
May 21-27, 2011

One of the most active and deadliest stretches of severe weather in U.S. history occurred during the seven-day period, which also saw the single deadliest tornado occur since the National Weather Service began keeping official records in 1950. Over the course of the seven-day stretch, an area from southern Texas to New England sustained major damage due to the severe weather. As of this writing, the Storm Prediction Center had recorded at least 325 unconfirmed (180 confirmed) tornado touchdowns, 2,187 reports of damaging winds and 1,839 reports of large hail. See the graphic on the right for a breakdown of the confirmed tornadoes, thus far, during the seven-day period.

As mentioned, in addition to the high number of severe weather and tornadic reports, a rather significant number of fatalities were also recorded during the stretch of time. At least 183 fatalities occurred, with the vast majority (158) of those coming from the massive EF-5 Joplin, Missouri tornado on May 22. The number of fatalities makes this the second deadliest outbreak since 1974 – second only to the late-April 2011 Super Outbreak.

The following sections will provide a day-by-day breakdown of the period:

May 21

The focus on Saturday (May 21) was in the Plains and the Midwest as two weather systems interacted with each other before a becoming a single area of low pressure during the afternoon and evening hours. By the end of the day, the SPC recorded nearly two-dozen tornado touchdowns and more than 250 other large hail and damaging wind reports.

The most notable effects came in eastern Kansas, where an EF-3 tornado with 165 mph (265 kph) winds ripped through the town of Reading at approximately 9:15 PM local time (2:15 UTC Sunday). At least one person was killed and five others were injured as the powerful tornado severely damaged or destroyed more than 200 homes and businesses. Total economic losses from the tornado were listed at USD2.3 million, with the amount almost evenly split between commercial and residential properties. Elsewhere in Kansas, hail larger than softballs (including an enormous hailstone measured at 5.25 inches (13.33 centimeters) was recorded just outside the city of Topeka. Baseball-sized hail was also recorded in other parts of the state.

Additional storm damage (primarily hail-induced) was recorded in parts of Texas, Oklahoma, Nebraska, Iowa, Minnesota and the Dakotas.
May 22

By early Sunday (May 22), the main area of low pressure continued to strengthen while slowly shifting north-northeastward through the Plains into the Upper Midwest. With an abundance of moisture surging out of the Gulf of Mexico combining with record warmth, high dew points, cold air sinking southward out of Canada behind the front and an active jet stream, atmospheric conditions became extremely unstable and conducive for tornadic activity in addition to large hail and damaging straight-line winds. In advance of the outbreak, the SPC issued a large Moderate Risk of severe weather for an area from eastern Oklahoma to Wisconsin. As predicted, numerous supercell thunderstorms developed ahead of the broken main squall line, which stretched from the Great Lakes down through the Mississippi Valley.

Minnesota and Wisconsin

The first tornadic supercell activity came in the greater Minneapolis, Minnesota metropolitan area. At least two people were killed and 43 others were injured after the NWS confirmed that no fewer than three tornadoes touched down in the region. The communities of North Minneapolis, St. Louis Park, Golden Valley, Fridley and Blaine were particularly affected, where a high-end EF-1 tornado with 110 mph (205 kph) winds damaged or destroyed more than 600 homes and businesses. An apartment building and a condominium complex were also severely affected. In addition to the 22,000 Xcel Energy customers losing electricity, several gas leaks were also reported throughout Hennepin County. City officials enacted a curfew over a four-square mile (10.4-square kilometer) section of Minneapolis on Sunday night into Monday morning (May 23) to help emergency personnel move around and to combat potential looting of damaged homes and businesses. Minnesota state officials reported that early damage costs were at least USD166 million to homes, buildings and infrastructure.

As the system pushed eastward, it also brought severe weather across parts of Wisconsin. Significant damage was reported in the town of La Crosse after an EF-2 tornado with 120 mph (195 kph) winds tore through southern sections of the city. More than 200 homes and businesses were severely damaged or destroyed in the first tornado to hit La Crosse in 50 years. The local mayor declared a state of emergency for the city. Total economic losses were estimated at more than USD10 million. At least an additional USD5 million in tornado losses occurred elsewhere in the state after more than 115 other homes and businesses were affected.
Joplin, Missouri
The most notable tornado event on Sunday came in Missouri, where the city of Joplin took a direct hit from a massive tornado which had at least a 0.75-mile (1.2-kilometer) width over a 22.1-mile (35.6-kilometer) path. NWS meteorologists confirmed that the tornado was an extremely powerful EF-5 with winds at one point up to 250 mph (405 kph). This marked the fourth EF-5 tornado of the year in the U.S. The twister was spawned by a dangerous supercell thunderstorm that had intensified rapidly in Cherokee County, Kansas before shifting into Missouri. The NWS reported that Joplin residents were given a 20-minute warning, though a torrential rainstorm obscured residents from realizing that a large, multivortex tornado was approaching. (Note: a ‘multivortex’ tornado contains two or more small and intense subvortices that orbit the center of a main tornado circulation.) According to local law enforcement officials, up to 25 percent of Joplin was completely destroyed by the tornado after it touched down at approximately 5:35 pm local time (22:35 UTC). City managers noted that as much as 75 percent of the city had suffered various degrees of damage. Assessments confirmed that catastrophic damage had occurred to more than 8,000 homes, 500 commercial properties, hundreds of additional businesses, schools, churches and other structures and at least 18,000 vehicles. At least 158 people died and more than 1,150 others were injured – making this the seventh-deadliest singular U.S. tornado dating to 1840. It also became the first Missouri F-5 or EF-5 to touch down in the state since 1957.

Among the notable damage locations included the St. John’s Regional Medical Center (which was forced to move all 100 patients other local hospitals due to the high level of damage), nursing homes, apartment complexes, Joplin High School, South Middle School, East Middle School, Cecil Floyd Elementary School, Irving Elementary School, Franklin Technological Center and Range Line Road – the city’s most densely built commercial area. Emergency management officials indicated that the damage zone stretched from 26th Street and Schifferdecker Avenue to 20th Street and Prosperity Avenue. Electricity and telecommunications throughout Joplin were largely cut off as police officers, firefighters and ambulances struggled to maneuver through debris-filled streets. According to Empire Electric District Company, which serves about 150,000 people in southwest Missouri, the tornado caused upwards of USD30 million in damages to its infrastructure alone and potentially wiped out as much as 15 percent of customer demand for electricity.
Missouri’s governor declared a state of emergency and activated the National Guard to work with state and local law enforcement agencies that were coordinating search and rescue and recovery operations. President Barack Obama later declared a federal disaster for the region which expedited federal resources to the region.

Damage assessments and official projections suggested that the total rebuilding cost of Joplin may approach USD3 billion. With tens of thousands of claims being filed by policyholders, total combined insured losses were listed in excess of USD2 billion – making the event one of the costliest singular tornadoes (if not the costliest) ever recorded.

Other affected areas
Additional tornado, large hail and straight-line wind damage was reported during the day and overnight hours along the advancing cold front. A broken, yet dangerous squall line developed along the main frontal boundary (and also ahead of a leading warm front) which led to various levels of damage throughout parts of Illinois, Iowa, Indiana, Michigan, Ohio, Oklahoma, Kentucky, Tennessee, Arkansas, North Carolina and the Virginias.

May 23
By Monday (May 23), additional severe weather was reported as the main area of low pressure shifted eastward. While the threat of tornadic activity was not as high as the day before due to a lack of necessary veering winds with height, the SPC again issued two separate Moderate Risk areas of severe weather for parts of Ohio, Michigan, Indiana, Illinois and also in Missouri, Oklahoma, Kansas and Texas. As daytime heating occurred, widespread showers and thunderstorms developed primarily along the cold front which stretched from New England back into the Plains.

The vast majority of the reported damage was due to large hail (up to tennis-ball size in some locations) and straight-line winds (including an 84 mph (140 kph) gust in central Illinois). However, at least 14 confirmed tornadoes touched down – including separate EF-2’s in Pennsylvania and Tennessee. Much of the Ohio Valley was impacted, where hundreds of thousands of power outages were reported in addition to commercial and residential property damage. Parts of Oklahoma and northern Texas also endured widespread hail damage.
May 24

During the day on Tuesday (May 24), yet another severe weather outbreak occurred across the central and southern Plains as a new area of low pressure developed after ejecting out of the Rockies. With the presence of a stationary frontal boundary, an abundance of tropical moisture, warm dew points, an upper level disturbance and an active jet stream, atmospheric conditions became extremely unstable and conducive for tornadic activity, large hail and damaging straight-line winds. The SPC issued another rare High Risk area for severe weather across parts central Kansas, central and eastern Oklahoma and extreme northern Texas – while giving a very high 45 percent chance for tornadic development. A Moderate Risk was issued for surrounding areas in those three states plus northwestern Arkansas and southwestern Missouri.

Oklahoma

Parts of Oklahoma sustained some of the worst tornado damage, including the greater Oklahoma City metropolitan region. At 12:50 PM local time (17:50 UTC), the SPC issued a PDS Tornado Watch for parts of central Oklahoma (including Oklahoma City) and northern Texas after tornadic activity had begun to occur in western sections of Oklahoma before trekking towards the east.

By the end of the day, NWS meteorologists determined that the largest tornado was an EF-5 (the sixth of 2011 in the U.S.) with winds in excess of 210 mph (340 kph) that tore through Canadian, Kingfisher and Logan counties along its 65-mile (100-kilometer) path. The twister caused substantial damage in the towns of Piedmont, El Reno, Guthrie, Cashion and Lookeba as dozens of homes and businesses were cleanly swept away from their foundations and trees were completely debarked. A nearby airport hangar and a trailer park were also destroyed. Oklahoma City itself was generally spared by the supercell thunderstorm accompanying the tornado, though hail and fierce winds led to some damage. In total, the tornado was responsible for at least nine fatalities and more than 100 injuries.
Elsewhere in the state, at least 16 other tornadoes (including two EF-4, two EF-3 and three EF-2) were recorded which impacted no fewer than 14 separate counties. In Grady, McClain and Cleveland counties, a confirmed high-end EF-4 with 190 mph (305 kph) winds left extensive damage in parts of the towns of Blanchard, Newcastle, Chickasha and southwestern sections of Oklahoma City. At least one person was killed and 15 others were injured. It should be noted that the large wedge twister took a path just south of the historic May 3, 1999 Moore tornado event that killed 41 people and caused catastrophic damage. The other recorded EF-4 tornado also affected Grady and McClain counties. The twister, with winds up to 190 mph (305 kph), tore through a 23-mile (37-kilometer) path and completely destroyed several homes. Debris from the tornado fell in the city of Norman. In the days following the preliminary assessments, the Norman NWS office reported that the two EF-4 tornado events may be upgraded at a later date.

One additional fatality in the state was reported in the Canton Lake EF-3 tornado that affected Dewey, Blaine and Major counties.

Due to the widespread destructive nature of the tornadic and severe weather activity, the state insurance commissioner declared an emergency.

**Texas and Kansas**

In Kansas, at least two people were killed near the Stafford County town of St. John after a tree was propelled into their van on U.S. Route 281 by a passing EF-2 tornado. Two other tornadoes (EF-1 strength) were recorded in the state. The majority of the damage in Kansas came from large hail and damaging straight-line winds (measured up to 100 mph (160 kph) in some locations). In Texas, no fewer than 10 confirmed tornadoes touched down across northern sections of the state. Dallas, Wagoner, Denton, Tarrant, Wise, Parker and Montague counties all reported tornadoes with varying levels of damage. The most notable tornado was an EF-2 that caused widespread damage to homes and businesses in the city of Denton. As the case in Kansas, most of the event damage in Texas came from large hail (up to softball-size in some instances) and damaging winds in excess of 90 mph (145 kph).

**Arkansas**

The state of Arkansas was also heavily affected, where at least two tornadoes touched down late on Tuesday into early Wednesday (May 25). The strongest was an EF-4 that tore through Johnson, Logan and Franklin counties, killing at least three people and injuring 15 others. The twister was on the ground for 46 miles (74 kilometers), with the town of Denning sustaining the brunt of the damage. Significant damage was reported to several neighborhoods and NWS meteorologists confirmed that the twister had at least a one-half mile-wide (0.8-kilometer) base. The second twister was an EF-3 that left one person dead and caused extensive damage in the greater Clarksville area in Johnson County.
Other affected areas
During the overnight hours on Tuesday into early Wednesday, a broken squall line and leading supercell thunderstorms continued to push eastward into parts of the Midwest (including Missouri, Iowa, Illinois and Indiana). It should be noted that additional severe weather in association with the presence of a stationary frontal boundary brought damaging storms to parts of Kentucky, Tennessee, North Carolina, Virginia and Maryland.

May 25
As the day progressed on Wednesday (May 25) and the main area of low pressure continued to slowly swirl eastward across the Plains into the Upper Mississippi Valley, the SPC again declared a High Risk for severe weather. The area stretched from near Memphis, Tennessee northward to Indianapolis, Indiana. A larger Moderate Risk area covered a region from Arkansas to the Ohio Valley. With a continuation of available moisture from the Gulf of Mexico, warm temperatures and dew points, an active mid-level jet stream and favorable upper level conditions, the atmosphere remained primed for violent, prolonged severe weather – including long-lived tornadoes. During the afternoon and evening hours, a large squall line developed along the advancing cold front with leading supercell thunderstorms out ahead of the line.

Despite the high number of tornado touchdowns (76 confirmed by NWS meteorologists), large hail (up to softball-sized) and damaging winds, the level of observed damage was much lower than seen in previous days. However, dozens of injuries and thousands of homes and other structures were damaged across parts of Indiana, Illinois, Missouri, Tennessee and other locations across the Mississippi, Ohio and Tennessee Valleys.

The most notable tornado event came in Sedalia, Missouri, where a confirmed EF-2 twister with 135 mph (215 kph) winds injured at least 25 people and destroyed several homes, businesses and a local high school. The strongest confirmed tornado was an EF-3 with 150 mph (240 kph) winds that caused extensive damage in the southeastern Missouri counties of Carter, Wayne and Madison. Along the twister’s 48-mile (77-kilometer) path, it destroyed four homes, two mobile homes, several trailers, and a school.
May 26 – 27

On Thursday (May 26) and Friday (May 27), the storm system began to slightly weaken while further shifting eastward. Fresh rounds of severe weather and torrential rains were reported along the main frontal boundary which stretched from the Northeast down into the Southeast.

At least 14 tornadoes touched down (including 10 in Pennsylvania), though the vast majority of the damage came from the nearly 950 reports of large hail and damaging winds that came into the SPC. In the greater Atlanta, Georgia metropolitan area, at least three people were killed as a result of straight-line winds.

In addition to the severe weather, heavy rains prompted additional flooding throughout parts of the Northeast.

Economic Impact

After thorough assessments from state and federal government officials, in addition to insurance assessors, it was determined that total economic losses from the event were approximately USD7 billion. Various insurers received at least 550,000 claims from the period with payouts totaling in excess of USD5 billion. Nearly half of these losses came from the Joplin, Missouri EF-5 tornado.

These losses represent one of the costliest stretches of severe weather in the U.S. in recorded history.
May 28 – June 1, 2011

Fresh rounds of severe weather impacted central and eastern sections of the United States during the end of May into June 1, leaving at least three people dead and more than 200 others injured.

May 28

The first reports of severe weather during the period came on Saturday (May 28) across parts of the Midwest and Great Lakes as a weak surface trough passed through the region. With daytime heating and an unstable atmosphere, numerous showers and thunderstorms developed ahead of the advancing trough. Large hail was prevalent in parts of Illinois (golf ball to softball-sized in some locations), Missouri, Iowa and Minnesota. Two minor tornadoes were reported in Minnesota, though damage was limited.

May 29

On Sunday (May 29), the remnants of a frontal boundary in the Southeast began to shift northward as a warm front through the Tennessee Valley, Midwest and New England. The warm front was attached to a developing area of low pressure in the Plains. As the day progressed, a strong cluster of thunderstorms organized in western Iowa and began to quickly traverse eastward through northern Illinois, northern Indiana, southern Michigan, northwest Ohio and eventually parts of Pennsylvania and New York.

Damaging straight-line winds (up to 80 mph (130 kph)) and large hail were most prevalent in association with the cluster of storms, though four EF-1 tornadoes also touched down (three in Michigan, one in Pennsylvania). In Battle Creek, Michigan alone, at least 900 structures were damaged. Additional tornado damage in Michigan was reported in the Coldwater and Perry areas, which saw dozens of homes lose their roofs. The vast majority of the damage throughout the Midwest, Ohio Valley and New England came from damaging straight-line winds in association with a bow echo that led the aforementioned cluster of thunderstorms.

May 30

By Monday (May 30), the focus shifted back into the central and northern Plains and the Upper Midwest as an area of low pressure developed after ejecting out of the Rockies and shifted north-northeastward. An elongated squall line developed along the cold front which spawned at least 23 unconfirmed tornado touchdowns in parts of Nebraska and South Dakota. Damage was minimal due to the tornadoes touching down in unpopulated areas. The Storm Prediction Center also recorded more than 200 additional reports of large hail (up to grapefruit-sized in some locations) and damaging straight-line winds throughout the region in association with the squall line.
May 31

On Tuesday (May 31), the frontal boundary continued to shift eastward through parts of the Midwest and Ohio Valley before entering the Northeast on Wednesday. Widely scattered damage was reported in sections of Indiana, Michigan and New York.

June 1

The focus on Wednesday (June 1) came across areas of New England as vast majority of the severe weather came during the afternoon and evening hours on Wednesday (June 1) across New England. With an area of low pressure entering Ontario and Quebec provinces in Canada, the attached frontal boundary trailed into the northeastern U.S. During the early morning hours, showers and thunderstorms occurred in Massachusetts, New Hampshire and Maine. The SPC noted that the morning precipitation (when combined with record high temperatures, abundant moisture and a strong upper level jet stream establishing over New England) helped enhance atmospheric conditions that were conducive for severe weather and tornadic activity during the afternoon and evening hours.

As the day progressed, severe thunderstorms began to develop along the frontal boundary in parts of New York, Vermont and New Hampshire. Widespread damage was reported in these states as large hail (up to baseball-size) and straight-line winds (in excess of 60 mph (95 kph) were regularly recorded in association with the thunderstorms. Four tornadoes also touched down in Maine, though damage was confined to unpopulated forest regions.

By late afternoon, the line of thunderstorms intensified while entering western and central Massachusetts. The local National Weather Service office began issuing tornado warnings for numerous communities as multiple tornadoes were spotted by Doppler Radar and trained weather spotters on the ground. By the end of the day, NWS meteorologists confirmed that at least three tornadoes (one EF-3 and two EF-1) touched down in the state – affecting the communities of Agawam, Auburn, Brimfield, Chicopee, Douglas, Millbury, Monson, Northampton, Oxford, Palmer, Springfield, Southbridge, Sturbridge, Uxbridge, West Springfield, Westfield, Wilbraham and Westover Air Force Base.
The most damaging tornado was the EF-3 with 160 mph (260 kph) winds that caused extensive damage along its 39-mile (63-kilometer) path in an area from Westfield to Charlton. Hundreds of homes, businesses and other structures were severely damaged or destroyed by the tornado. The electrical and transportation infrastructures were also impacted as more than 48,000 customers lost electricity and numerous roads were damaged. At least three people were killed and at least 200 others were injured – becoming the first killer tornado in Massachusetts since 1995. The tornado’s maximum width of 0.5 miles (0.8 kilometers) made it the second largest tornado in state history. The state typically averages two tornado touchdowns a year. The June 1 Massachusetts EF-3 tornado became only the ninth tornado ranked EF-3 or higher to touch down in the state since reliable records began in 1950.

Following the event, Massachusetts’s governor declared a state of emergency and activated 1,000 National Guardsmen to help in the recovery process.

Economic Impacts

Total economic losses from the timeframe were estimated at approximately USD500 million. In terms of insured losses, more than 30,000 claims were received by various insurers with total payouts estimated in excess of USD350 million.
Notable Severe Weather Facts: April 1 – June 1, 2011

- The May 22, EF-5 tornado in Joplin, MO set a record for the most fatalities (158) from a single tornado since the National Weather Service began keeping official records in 1950.

- The April 25-28 tornado outbreak (322 fatalities) was the deadliest in modern history, since the NWS began keeping official records in 1950. The total surpassed the previous record of 315 set during the historic Super Outbreak of April 3-4, 1974.

- April 27 marked the first time since March 13, 1990 (Hesston and Goessel, Kansas) that two or more EF-5 or F5 tornadoes had occurred on the same day.

- As of mid-June 2011, at least 540 tornado fatalities have occurred in the U.S. this year – which is 964% higher than the typical yearly average (1990-2010) of 56.

- As of mid-June 2011, at least 74 confirmed EF-3 or stronger tornadoes had touched down in the U.S. – which is 176% higher than the typical yearly average (1990-2010) of 42.

- With six confirmed EF-5 tornadoes in 2011 (thus far), this becomes the first year since 1998 that the U.S. has seen more than one EF-5 or F5 tornado touchdowns. 2011 has also tied 1974 for the most EF-5 or F5 tornadoes in a year with six.

- The 335 confirmed tornadoes during the April 25-28 outbreak set the record for largest tornado outbreak in world history. The previous record was 148 set during the April 3-4, 1974 outbreak.

- April 2011 set an all-time monthly record (preliminarily) with 875 tornadoes. The previous all-time monthly record was 542, set in May 2003. The previous April record was 267, set in April 1974. The 30-year (1981-2010) average number of tornadoes in April is 135.

- As of mid-June 2011, the NWS has preliminarily recorded approximately 1,482 tornadoes this year. The yearly record number of tornadoes was set in 2004 with 1,817. The 10-year average number of tornadoes is 1,274.

- April 4 set a one-day record (dating to 2000) for the most storm reports received by the SPC with 1,476. This breaks the previous record set on April 2, 2006 with 1,012.

- Alabama set a state record for costliest natural disaster event during the April 25-28 severe weather outbreak with insured losses in excess of USD2 billion. This surpasses the previous state record of USD2 billion set by 2004’s Hurricane Ivan.

- The state of Kansas set a single-month record in April with nearly USD503 million in insured storm losses. This surpasses the previous record of USD338 set in June 2008.

- Between April 1 and June 1, nearly five million customers lost electricity across the U.S. from severe weather events.
The tables below list the number of state-wide tornado records set for the month of April and also, thus far, for all of 2011. It should be noted that these totals are preliminary and subject to change until the National Weather Service and the Storm Prediction Center release their final assessments.

### April 2011 Tornado Records

<table>
<thead>
<tr>
<th>State</th>
<th>2011 Preliminary Tornado Reports</th>
<th>Old Record / Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alabama</td>
<td>140</td>
<td>35 / 2009</td>
</tr>
<tr>
<td>Arkansas</td>
<td>46</td>
<td>29 / 1979</td>
</tr>
<tr>
<td>Georgia</td>
<td>46</td>
<td>25 / 2009</td>
</tr>
<tr>
<td>Kentucky</td>
<td>41</td>
<td>29 / 1974</td>
</tr>
<tr>
<td>Louisiana</td>
<td>36</td>
<td>24 / 2000</td>
</tr>
<tr>
<td>Maryland</td>
<td>11</td>
<td>5 / 2002</td>
</tr>
<tr>
<td>Mississippi</td>
<td>121</td>
<td>26 / 2005</td>
</tr>
<tr>
<td>Missouri</td>
<td>30</td>
<td>26 / 1994</td>
</tr>
<tr>
<td>Nevada</td>
<td>3</td>
<td>1 / 1964, 2001, 2005</td>
</tr>
<tr>
<td>New York</td>
<td>8</td>
<td>4 / 1991</td>
</tr>
<tr>
<td>North Carolina</td>
<td>85</td>
<td>24 / 1996</td>
</tr>
<tr>
<td>Tennessee</td>
<td>50</td>
<td>42 / 1974</td>
</tr>
<tr>
<td>Texas</td>
<td>69 (tie)</td>
<td>69 / 1957</td>
</tr>
<tr>
<td>Virginia</td>
<td>35</td>
<td>18 / 2008</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>16</td>
<td>11 / 1984</td>
</tr>
<tr>
<td>Entire United States</td>
<td>875</td>
<td>263 / 1974</td>
</tr>
</tbody>
</table>

Source: Storm Prediction Center

### 2011 Annual Tornado Records

<table>
<thead>
<tr>
<th>State</th>
<th>*2011 Preliminary Tornado Reports</th>
<th>Old Record / Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alabama</td>
<td>160</td>
<td>94 / 2008</td>
</tr>
<tr>
<td>Kentucky</td>
<td>52</td>
<td>39 / 1997</td>
</tr>
<tr>
<td>Mississippi</td>
<td>136</td>
<td>109 / 2008</td>
</tr>
<tr>
<td>North Carolina</td>
<td>89</td>
<td>67 / 2004</td>
</tr>
<tr>
<td>Tennessee</td>
<td>75</td>
<td>46 / 2009</td>
</tr>
</tbody>
</table>

*As of June 20, 2011

Source: Storm Prediction Center
Additional Commentary: Why so many tornado deaths?

In the aftermath of the recent severe weather and tornado outbreaks, questions have been asked as to why there have been so many tornado fatalities. While there is not one exact reason for the spike in deaths, there are several possibilities as to why the numbers have been elevated in 2011. Below is a list of some of these reasons:

**U.S. Population**

Since 1950, the population in the United States has more than doubled. A trend over the last 60 years has been urban sprawl and expanding suburbs. More people are living in urban areas and there are now larger concentrations and densities of people around the country. Due to this fact, strong or violent tornadoes affecting cities now run an increased chance of causing fatalities.

**Tornado Strength**

The general rule is that the stronger wind speeds the tornado has, the greater chances for death and destruction. Tornadoes are rated based on a 0 (weakest) to 5 (strongest) ranking on the Enhanced Fujita Scale. This scale was updated in 2007 from the original Fujita Scale that was created in 1971 by University of Chicago professor Theodore Fujita. According to the National Weather Service, tornado strength EF-0 and EF-1 tornadoes (65 to 110 mph (100 to 175 kph)) are considered “weak,” EF-2 and EF-3 tornadoes (111 to 165 mph (176 to 270 kph)) are considered “strong,” and EF-4 and EF-5 tornadoes (166 to 200+ mph (271 to 325+ kph)) are considered “violent.” Below is a table from the NWS showing the percentage breakdown of number of tornadoes in the U.S. (1950-1994) by the EF-Scale and the percentages of fatalities:

<table>
<thead>
<tr>
<th>EF-Scale Rating</th>
<th>% of all Tornadoes</th>
<th>% of all Fatalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>EF-0 &amp; EF-1 (65 to 110 mph)</td>
<td>74%</td>
<td>4%</td>
</tr>
<tr>
<td>EF-2 &amp; EF-3 (111 to 165 mph)</td>
<td>25%</td>
<td>29%</td>
</tr>
<tr>
<td>EF-4 &amp; EF-5 (166 to 200+ mph)</td>
<td>1%</td>
<td>67%</td>
</tr>
</tbody>
</table>

It should be noted that violent tornadoes (EF-4 and EF-5) typically destroy or completely wipe away standard, stick-built residential homes and other structures that do not have a steel or concrete core. Structures that do not have extra anchoring devices that help enhance a building’s wind-resistant capabilities are also at risk. Because most residents do not have a safe storm shelter or a room able to withstand an EF-4 or EF-5 tornado, there becomes an increased chance of death.

**Time of Day/Day of the Week**

The time of day is a critical issue in terms of tornado fatalities. Since most people are asleep at night, they are unaware of any advancing tornadoes or a developing severe weather threat. This leaves people extremely vulnerable to being alerted to potential danger, especially if they do not own a NOAA Weather Radio.

The day of the week also plays a role. There are certain instances when people are active or unable to monitor weather situations at home on television or radio, which leaves them unaware of impending tornadic activity.
Building Type

The type of building plays a major role in the threat of fatalities. Southern states, which are prone to tornadic activity, tend to have a higher percentage of mobile homes and trailers which are not as safe as standard residential homes that are built with brick or are stick-built. In addition, southern states tend to have a higher percentage of homes and buildings without basements. While a basement does not guarantee safety due to the possibility of large pieces of debris falling into the basement area, it is safer than being above ground. Also, it should be noted that certain roof types are stronger than others. Some buildings are built round or octagonal, which tend to be more wind resistant. Large, big-box buildings and auditoriums are typically less safe because their large ceilings can easily collapse. The end result is an increased chance of death.

Structural Strength of a Building

The structural strength of a building can play a crucial role in determining the safety of an individual. The greater the amount of concrete or steel that surrounds a person, the safer they usually are. Buildings with a steel skeleton or an appreciable amount of concrete and brick can withstand greater wind speeds than standard stick-built homes. In addition, the more metal structural connectors installed in a home or building where wood meets wood, the stronger the winds that the structure can withstand. Most standard-built residential homes are unable to withstand tornadic winds. Also, some homes are not anchored to their foundation, which makes them vulnerable to sliding and being destroyed by the fierce winds. The end result is an increased chance of death.

Location in the U.S.

While tornadoes can occur in any section of the U.S., areas east of the Rocky Mountains see the vast majority of the tornadic activity. The most tornado-prone areas are found in the central and southern Plains, the Southeast, Mississippi Valley and the Midwest. This area is typically referred to as ‘Tornado Alley.’

The map below on the left shows tornado activity in the U.S. as a summary per 1,000 square miles; while the map on the right shows a summary of recorded F3, F4 and F5 tornadoes per 3,700 square miles.

Source: NOAA
Source: FEMA
Appendix A: Historical U.S. Tornado Statistics

Deadliest tornado outbreaks (* denotes unofficial totals prior to 1950):

<table>
<thead>
<tr>
<th>Rank</th>
<th>Date</th>
<th>Location(s)</th>
<th># of F2+ Tornadoes</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>March 18, 1925</td>
<td>MO, IL, IN, AL, TN, KY</td>
<td>*9</td>
<td>747</td>
</tr>
<tr>
<td>2</td>
<td>April 5-6, 1936</td>
<td>AR, TN, AL, MS, GA, SC</td>
<td>*12</td>
<td>454</td>
</tr>
<tr>
<td>3</td>
<td>March 21-22, 1932</td>
<td>AL, TN, KY, GA, SC</td>
<td>*12</td>
<td>330</td>
</tr>
<tr>
<td>4</td>
<td>April 23-24, 1908</td>
<td>AR, NE, TX, AL, LA, MS</td>
<td>*30</td>
<td>324</td>
</tr>
<tr>
<td>5</td>
<td>April 25-28, 2011</td>
<td>AL, MS, TN, GA, AR, VA, LA, KY</td>
<td>90</td>
<td>322</td>
</tr>
<tr>
<td>6</td>
<td>May 7, 1840</td>
<td>LA, MS</td>
<td>*1</td>
<td>317</td>
</tr>
<tr>
<td>7</td>
<td>April 3-4, 1974</td>
<td>12 states (and Canada)</td>
<td>95</td>
<td>315</td>
</tr>
<tr>
<td>8</td>
<td>May 27, 1896</td>
<td>MO, IL</td>
<td>*10</td>
<td>305</td>
</tr>
<tr>
<td>9</td>
<td>April 11, 1965</td>
<td>IA, WI, IL, IN, MI, OH</td>
<td>*38</td>
<td>256</td>
</tr>
<tr>
<td>10</td>
<td>June 8-9, 1953</td>
<td>MI, MA</td>
<td>*14</td>
<td>236</td>
</tr>
</tbody>
</table>

Source: Storm Prediction Center

Deadliest singular tornadoes (* denotes unofficial rating prior to 1950):

<table>
<thead>
<tr>
<th>Rank</th>
<th>Date</th>
<th>Location(s)</th>
<th>Fujita Rating</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>March 18, 1925</td>
<td>Tri-State (Missouri, Illinois, Indiana)</td>
<td>*F5</td>
<td>695</td>
</tr>
<tr>
<td>2</td>
<td>May 6, 1840</td>
<td>Natchez, MS</td>
<td>*F5</td>
<td>317</td>
</tr>
<tr>
<td>3</td>
<td>May 27, 1896</td>
<td>St. Louis, MO &amp; East St. Louis, IL</td>
<td>*F4</td>
<td>255</td>
</tr>
<tr>
<td>4</td>
<td>April 5, 1936</td>
<td>Tupelo, MS</td>
<td>*F4</td>
<td>203</td>
</tr>
<tr>
<td>5</td>
<td>April 6, 1936</td>
<td>Gainesville, GA</td>
<td>*F4</td>
<td>203</td>
</tr>
<tr>
<td>6</td>
<td>April 9, 1947</td>
<td>Woodward, OK</td>
<td>N/A</td>
<td>181</td>
</tr>
<tr>
<td>7</td>
<td>May 22, 2011</td>
<td>Joplin, MO</td>
<td>EF-5</td>
<td>158</td>
</tr>
<tr>
<td>8</td>
<td>April 24, 1908</td>
<td>Amite, LA &amp; Purvis, MS</td>
<td>*F4</td>
<td>143</td>
</tr>
<tr>
<td>9</td>
<td>June 12, 1899</td>
<td>New Richmond, WI</td>
<td>*F5</td>
<td>117</td>
</tr>
<tr>
<td>10</td>
<td>June 8, 1953</td>
<td>Flint, MI</td>
<td>F5</td>
<td>116</td>
</tr>
</tbody>
</table>

Source: Storm Prediction Center

Deadliest tornado seasons (* denotes season as of June 20, 2011):

<table>
<thead>
<tr>
<th>Rank</th>
<th>Year</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1925</td>
<td>794</td>
</tr>
<tr>
<td>2</td>
<td>1936</td>
<td>552</td>
</tr>
<tr>
<td>3</td>
<td>1917</td>
<td>551</td>
</tr>
<tr>
<td>4</td>
<td>2011</td>
<td>*544</td>
</tr>
<tr>
<td>5</td>
<td>1927</td>
<td>540</td>
</tr>
<tr>
<td>6</td>
<td>1896</td>
<td>537</td>
</tr>
<tr>
<td>7</td>
<td>1953</td>
<td>519</td>
</tr>
<tr>
<td>8</td>
<td>1920</td>
<td>499</td>
</tr>
<tr>
<td>9</td>
<td>1908</td>
<td>477</td>
</tr>
<tr>
<td>10</td>
<td>1909</td>
<td>404</td>
</tr>
</tbody>
</table>

Source: Storm Prediction Center
Appendix B: Costliest U.S. Tornadoes Since 1950

Costliest singular tornadoes (* denotes preliminary economic loss estimate):

<table>
<thead>
<tr>
<th>Rank</th>
<th>Date</th>
<th>Location</th>
<th>Actual Cost (USD)</th>
<th>Adj. Cost (2011 USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>May 22, 2011</td>
<td>Joplin, MO</td>
<td>*~$3 billion</td>
<td>*~$3 billion</td>
</tr>
<tr>
<td>2</td>
<td>April 27, 2011</td>
<td>Tuscaloosa, AL</td>
<td>*~$2 billion</td>
<td>*~$2 billion</td>
</tr>
<tr>
<td>3</td>
<td>June 8, 1966</td>
<td>Topeka, KS</td>
<td>$250 million</td>
<td>$1.66 billion</td>
</tr>
<tr>
<td>4</td>
<td>May 11, 1970</td>
<td>Lubbock, TX</td>
<td>$250 million</td>
<td>$1.39 billion</td>
</tr>
<tr>
<td>5</td>
<td>May 3, 1999</td>
<td>Oklahoma City area, OK</td>
<td>$1 billion</td>
<td>$1.30 billion</td>
</tr>
<tr>
<td>6</td>
<td>April 3, 1974</td>
<td>Xenia, OH</td>
<td>$250 million</td>
<td>$1.09 billion</td>
</tr>
<tr>
<td>7</td>
<td>May 6, 1975</td>
<td>Omaha, NE</td>
<td>$251 million</td>
<td>$1.01 billion</td>
</tr>
<tr>
<td>8</td>
<td>April 10, 1979</td>
<td>Wichita Falls, TX</td>
<td>$278 million</td>
<td>$824 million</td>
</tr>
<tr>
<td>9</td>
<td>June 3, 1980</td>
<td>Grand Island, NE</td>
<td>$285 million</td>
<td>$744 million</td>
</tr>
<tr>
<td>10</td>
<td>October 3, 1979</td>
<td>Windsor Locks, CT</td>
<td>$250 million</td>
<td>$741 million</td>
</tr>
<tr>
<td>11</td>
<td>May 8, 2003</td>
<td>Oklahoma City area, OK</td>
<td>$370 million</td>
<td>$437 million</td>
</tr>
<tr>
<td>12</td>
<td>June 9, 1953</td>
<td>Worcester, MA</td>
<td>$52 million</td>
<td>$419 million</td>
</tr>
</tbody>
</table>

Source: Storm Prediction Center
Appendix C: Enhanced Fujita Scale

The Enhanced Fujita Scale (EF-Scale) rates the strength of tornadoes in the United States based on the damage they cause. The Fujita Scale was first introduced in 1971 by Ted Fujita, before it was modified in 2007. The updated scale has the same basic design as the original Fujita scale: six categories from zero to five representing increasing degrees of damage. The revision occurred to better reflect examinations of tornado damage surveys by being able to align wind speeds more closely with associated storm damage.

To determine the tornado EF rating, the National Weather Service uses the scope of damage to estimate the three-second wind gust speed at the point of damage. It is important to note that the three-second gust is not the same wind as measured in standard surface observations. Standard measurements are taken by weather stations in open exposures, using a directly measured ‘one-minute-mile’ speed.

The original Fujita Scale relied heavily on engineering analysis of tornado damage. The listed wind speeds in the scale were all guesses and were never scientifically verified.

Enhanced Fujita Scale:

<table>
<thead>
<tr>
<th>EF Number</th>
<th>3-Second Wind Gust</th>
<th>Typical Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>65 to 85 mph</td>
<td>Light damage: Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over. Moderate damage: Roof's severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.</td>
</tr>
<tr>
<td>1</td>
<td>86 to 110 mph</td>
<td>Considerable damage: Roofs torn off well-constructed houses; foundations of frame homes shifted; mobile homes completely destroyed; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.</td>
</tr>
<tr>
<td>2</td>
<td>111 to 135 mph</td>
<td>Severe damage: Entire stories of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations blown away some distance.</td>
</tr>
<tr>
<td>3</td>
<td>136 to 165 mph</td>
<td>Devastating damage: Well-constructed houses and whole frame houses completely leveled; cars thrown and small missiles generated.</td>
</tr>
<tr>
<td>4</td>
<td>166 to 200 mph</td>
<td>Explosive damage: Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 300 feet; steel reinforced concrete structure badly damaged; high-rise buildings have significant structural deformation; incredible phenomena will occur.</td>
</tr>
<tr>
<td>5</td>
<td>Over 200 mph</td>
<td>Source: Storm Prediction Center</td>
</tr>
</tbody>
</table>

Original Fujita Scale:

<table>
<thead>
<tr>
<th>Scale</th>
<th>Wind Estimate</th>
<th>Typical Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>F0</td>
<td>&lt; 73 mph</td>
<td>Light damage: Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.</td>
</tr>
<tr>
<td>F1</td>
<td>73 to 112 mph</td>
<td>Moderate damage: Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos blown off roads.</td>
</tr>
<tr>
<td>F2</td>
<td>113 to 157 mph</td>
<td>Considerable damage: Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.</td>
</tr>
<tr>
<td>F3</td>
<td>158 to 206 mph</td>
<td>Severe damage: Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.</td>
</tr>
<tr>
<td>F4</td>
<td>207 to 260 mph</td>
<td>Devastating damage: Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown and large missiles generated.</td>
</tr>
<tr>
<td>F5</td>
<td>261 to 318 mph</td>
<td>Incredible damage: Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 meters (109 yards); trees debarked; incredible phenomena will occur.</td>
</tr>
</tbody>
</table>

Source: Storm Prediction Center
Appendix D: Severe Weather Terminology

**Atmospheric Stability** - An indication of how easily a parcel of air is lifted. If the air is very stable it is difficult to make the parcel rise. If the air is very unstable the parcel may rise on its own once started.

**Bow echo** - A radar echo which is linear but bent outward in a bow shape. Damaging straight-line winds often occur near the "crest" or center of a bow echo. Areas of circulation also can develop at either end of a bow echo, which sometimes can lead to tornado formation - especially in the left (usually northern) end, where the circulation exhibits cyclonic rotation.

**Cold Front** - A narrow transition zone separating advancing colder air from retreating warmer air. The air behind a cold front is cooler and typically drier than the air it is replacing.

**Convection** - The transfer of heat within a the air by its movement. The term is used specifically to describe vertical transport of heat and moisture, especially by updrafts and downdrafts in an unstable atmosphere.

**Derecho** - A widespread and usually fast-moving windstorm associated with convection. Derechoes include any family of downburst clusters produced by an extratropical MCS, and can produce damaging straight-line winds over areas hundreds of miles long and more than 100 miles across.

**Dew Point** - The temperature to which the air must be cooled for water vapor to condense and form fog or clouds.

**Downburst** - A strong downdraft resulting in an outward burst of damaging winds on or near the ground. Downburst winds can produce damage similar to a strong tornado.

**Downdraft** - A column of generally cool air that rapidly sinks to the ground, usually accompanied by precipitation as in a shower or thunderstorm.

**Dryline** - A boundary which separates warm, dry air from warm, moist air. The differences in the two air masses may be significant. The dry line is usually a boundary of instability along which thunderstorms form.

**Fujita Scale** - System developed by Dr. Theodore Fujita to classify tornadoes based on wind damage. Scale is from F0 for weakest to F5 for strongest tornadoes.

**Funnel Cloud** - A rotating, cone-shaped column of air extending downward from the base of a thunderstorm but not touching the ground. When it reaches the ground it is called a tornado.

**Gust Front** - The leading edge of the downdraft from a thunderstorm. A gust front may precede the thunderstorm by several minutes and have winds that can easily exceed 80 mph.

**Gustnado** - Gust front tornado. A small tornado, usually weak and short-lived, that occurs along the gust front of a thunderstorm. Often it is visible only as a debris cloud or dust whirl near the ground.
Hail - Precipitation in the form of balls or irregular lumps of ice produced by liquid precipitation, freezing and being coated by layers of ice as it is lifted and cooled in strong updrafts of thunderstorms.

High Risk (of severe thunderstorms) - Severe weather is expected to affect more than 10 percent of the area.

Hook Echo - A radar pattern sometimes observed in the southwest quadrant of a tornadic thunderstorm. Appearing like a fishhook turned in toward the east, the hook echo is precipitation aloft around the periphery of a rotating column of air 2-10 miles in diameter.

Instability - A state of the atmosphere in which convection takes place spontaneously, leading to cloud formation and precipitation.

Low - An area of low pressure, usually accompanied by cyclonic and inward wind flow.

Low-Level Jet - A region of relatively strong winds in the lower part of the atmosphere.

Macroburst - Large downburst with a 2.5 mile or greater outflow diameter and damaging winds lasting 5 to 20 minutes.

Mesoscale Convective Complex (MCC) - A large mesoscale convective system, generally round or oval-shaped, which normally reaches peak intensity at night. The formal definition includes specific minimum criteria for size, duration, and eccentricity (i.e., "roundness"), based on the cloud shield as seen on infrared satellite photographs.

Mesoscale Convective System (MCS) - A complex of thunderstorms which becomes organized on a scale larger than the individual thunderstorms, and normally persists for several hours or more. MCSs may be round or linear in shape, and include systems such as tropical cyclones, squall lines, and MCCs (among others). MCS often is used to describe a cluster of thunderstorms that does not satisfy the size, shape, or duration criteria of an MCC.

Microburst - A strong localized downdraft from a thunderstorm with peak gusts lasting 2 to 5 minutes.

Moderate Risk (of severe thunderstorms) - Severe thunderstorms are expected to affect between 5 and 10 percent of the area.

Multi-Vortex Tornado - A tornado in which two or more condensation funnels or debris clouds are present at the same time, often rotating about a common center or about each other. Multiple-vortex tornadoes can be especially damaging.

Outflow Boundary - A storm-scale or mesoscale boundary separating thunderstorm-cooled air (outflow) from the surrounding air; similar in effect to a cold front, with passage marked by a wind shift and usually a drop in temperature.

Relative Humidity - The amount of water vapor in the air, compared to the amount the air could hold if it was totally saturated. (Expressed as a percentage).

**Right Mover** - A thunderstorm that moves appreciably to the right relative to the main steering winds and to other nearby thunderstorms. Right movers typically are associated with a high potential for severe weather. (Supercells often are right movers.)

**Severe Thunderstorm** - A strong thunderstorm with wind gusts in excess of 58 mph (50 knots) and/or hail with a diameter of 3/4” or more. A thunderstorm with winds greater than 39 mph and/or hail greater than one-inch is defined as approaching severe.

**Shelf Cloud** - A low-level horizontal accessory cloud that appears to be wedge-shaped as it approaches. It is usually attached to the thunderstorm base and forms along the gust front. The leading edge of the shelf is often smooth and at times layered or terraced. It is most often seen along the leading edge of an approaching line of thunderstorms, accompanied by gusty straight winds as it passes overhead and followed by precipitation. The underside is concave upward, turbulent, boiling, or wind-torn. Tornadoes rarely occur with the shelf cloud.

**Shortwave (Shortwave Trough)** - A disturbance in the mid or upper part of the atmosphere which induces upward motion ahead of it. If other conditions are favorable, the upward motion can contribute to thunderstorm development ahead of a shortwave.

**Slight Risk (of severe thunderstorms)** - Severe thunderstorms are expected to affect between 2 and 5 percent of the area. A slight risk generally implies that severe weather events are expected to be isolated.

**Squall Line** - Any non-frontal line or narrow band of active thunderstorms. The term is usually used to describe solid or broken lines of strong or severe thunderstorms.

**Stability** - An indication of how easily a parcel of air is lifted. If the air is very stable it is difficult to make the parcel rise. If the air is very unstable the parcel may rise on its own once started.

**Stationary Front** - The boundary between cool and warm air masses in that are not moving.

**Straight Line Winds** - Thunderstorm winds most often found with the gust front. They originate from downdrafts and can cause damage which occurs in a “straight line”, as opposed to tornadic wind damage which has circular characteristics.

**Subtropical Jet** - The branch of the jet stream that is found in the lower latitudes.

**Supercell Thunderstorm** - A severe thunderstorm whose updrafts and downdrafts are in near balance allowing the storm to maintain itself for several hours. Supercells often produce large hail and tornadoes.

**Thunderstorm** - A storm with lightning and thunder, produced by a cumulonimbus cloud, usually producing gusty winds, heavy rain and sometimes hail.

**Tornado** - A violent rotating column of air, in contact with the ground, pendant from a cumulonimbus cloud. A tornado does not require the visible presence of a funnel cloud. It has a typical width of tens to hundreds of meters and a lifespan of minutes to hours.
**Tornado Alley** - The area of the United States in which tornadoes are most frequent. It encompasses the great lowland areas of the Mississippi, the Ohio, and lower Missouri River Valleys. Although no state is entirely free of tornadoes, they are most frequent in the Plains area between the Rocky Mountains and Appalachians.

**Tornado Warning** - Issued when there is likelihood of a tornado within the given area based on radar or actual sighting. It is usually accompanied by conditions indicated for Severe Thunderstorm Warning.

**Trough** - An elongated area of relatively low atmospheric pressure surface or aloft. Usually not associated with a closed circulation, and thus used to distinguish from a closed low. The opposite of ridge.

**Unstable Air** - Air that rises easily and can form clouds and rain.

**Upper Level System** - A general term for any large-scale or mesoscale disturbance capable of producing upward motion (lift) in the middle or upper parts of the atmosphere.

**Veering Wind** - Wind which changes in a clockwise direction with time at a given location (e.g., from southerly to westerly), or which change direction in a clockwise sense with height (e.g., southeasterly at the surface turning to southwesterly aloft). Veering winds with height are indicative of warm air advection (WAA).

**Vertical Shear** - The rate of change of wind speed or direction, with a given change in height.

**Wall Cloud** - A local and often abrupt lowering of a rain-free cumulonimbus base into a low-hanging accessory cloud, from 1 to 4 miles in diameter. The wall cloud is usually situated in the southwest portion of the storm below an intense updraft marked by the main cumulonimbus cloud and associated with a very strong or severe thunderstorm. When seen from several miles away, many wall clouds exhibit rapid upward motion and rotation in the same sense as a tornado, except with considerably lower speed. A rotating wall cloud usually develops before tornadoes or funnel clouds by a time which can range from a few minutes up to possibly an hour.

**Warm Front** - A narrow transitions zone separating advancing warmer air from retreating cooler air. The air behind a warm front is warmer and typically more humid than the air it is replacing.

**Water Vapor** - Water substance in a gaseous state that comprises one of the most important of all the constituents of the atmosphere.

**Waterspout** - A rapidly rotating column of air extending from a cumulonimbus cloud with a circulation that reaches the surface of the water, (i.e. a tornado over water).

**Wedge (or Wedge Tornado)** - A large tornado with a condensation funnel that is at least as wide (horizontally) at the ground as it is tall (vertically) from the ground to cloud base.

**Wind Shear** - Variation in wind speed and/or direction over a short distance. Shear usually refers to vertical wind shear, i.e., the change in wind with height, but the term also is used in Doppler radar to describe changes in radial velocity over short horizontal distances.
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