

SEVERE WEATHER HAZARD PROFILE AND RESOURCE GUIDE

This document serves as an educational reference for emergency managers and partners regarding severe weather. The goal within this document is to advance knowledge and understanding of severe weather threats by providing condensed summaries of relevant terminology, climatology, and Storm Prediction Center products.



SEVERE WEATHER OVERVIEW

Severe weather poses a threat to the public, as well as ongoing response and recovery operations; in fact, severe weather and heavy rainfall/flooding events have accounted for over 50% of federally declared Major Disaster (DR) declarations over the past two decades. The application of severe weather knowledge, awareness, and monitoring—across all areas within emergency management—can contribute to better decision making, resulting in more effective response, recovery, mitigation, and preparedness efforts that can ultimately decrease the impacts from these hazards.

Officially, severe weather consists of tornadoes, wind, and hail. Each of these hazards can occur on their own, or in association with other hazards such as hurricanes and flash flooding. Although severe weather can occur year-round, peak severe weather season is typically during the spring and summer months, ~March through July. During this timeframe, the frequency and intensity of severe weather events increases. On average, over 1,000 tornadoes occur annually ranging in intensity (EF0 – EF5), duration (minutes to an hour or more), and width (yards to a mile wide or greater). These tornadoes can occur anywhere, but they typically form east of the Rocky Mountains (Fig. 1) due to its supportive atmospheric conditions; with the Great Plains, the Southeast, and the Midwest being the most notable regions for tornado occurrence.

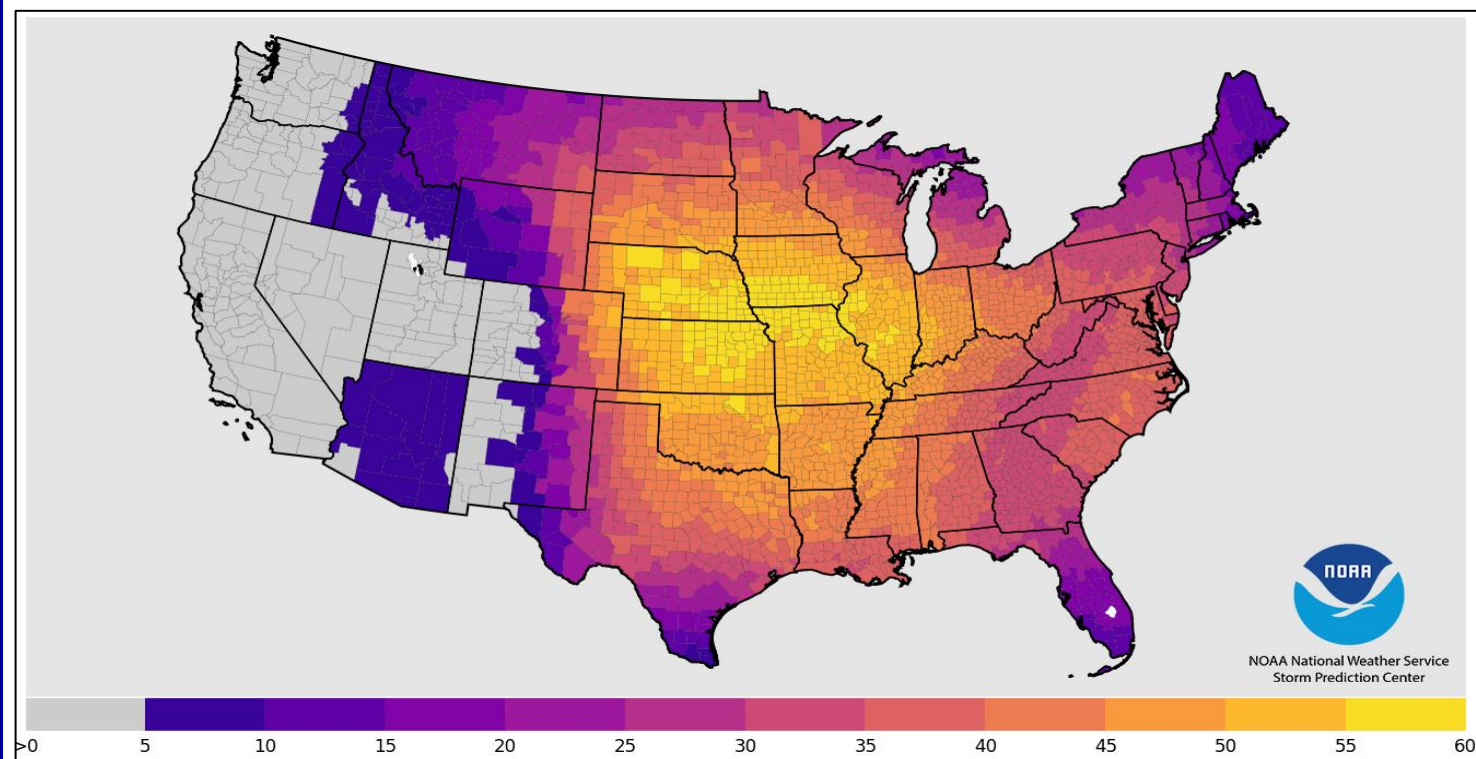


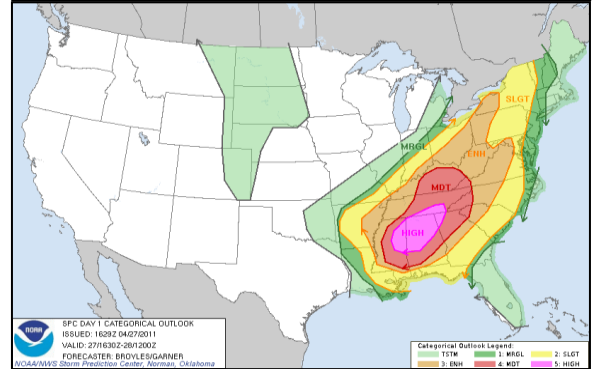
Figure 1: Severe weather risk frequency (www.spc.noaa.gov)

STORM PREDICTION CENTER SEVERE WEATHER PRODUCTS AND ISSUANCE TIMELINE

The Storm Prediction Center (SPC) is part of the National Weather Service (NWS) and resides within the National Weather Center located in Norman, OK. National products and services provided by SPC regarding severe thunderstorms and tornadoes are an essential source of information for the protection of life and property. The SPC relays forecasts of severe weather out to eight days, continually refining the forecast up until the event has concluded. SPC products are used by local NWS offices, emergency managers, private companies, and the media among others. SPC severe weather forecasts include four main products leading up to and continuing through an event. The four main products described below are issued according to the timeline outlined in Table 1.

SPC Severe Weather Products

- ✦ **Severe Weather Outlooks: *issued a day to eight days out***
 - ◆ Day 1, Day 2, Day 3, and Days 4-8
 - ◆ Based on coverage, intensity, and confidence
- ✦ **Severe Weather Watches: *issued several hours out***
 - ◆ Severe Thunderstorm and Tornado Watches
 - ◆ Particularly Dangerous Situation (PDS): Issued for higher confidence/intensity tornado or wind events
- ✦ **Mesoscale Discussions: *issued one to two hours out***
 - ◆ Outlook upgrades
 - ◆ Watch updates
 - ◆ Identify areas of concern
- ✦ **Storm Reports: *updated as event is ongoing/afterwards***
 - ◆ Visual/textual display of local NWS storm reports
 - ◆ Occasionally delayed due to operations/damage surveys



SPC SEVERE WEATHER PRODUCT	ISSUANCE/UPDATE TIME (EDT)
Day 1 Severe Weather Outlook www.spc.noaa.gov/products/outlook/day1otlk.html	2:00am; 9:00am; 12:30pm; 4:00pm; 9:00pm
Day 2 Severe Weather Outlook www.spc.noaa.gov/products/outlook/day2otlk.html	2:00am; 1:30pm
Day 3 Severe Weather Outlook www.spc.noaa.gov/products/outlook/day3otlk.html	3:30am
Days 4 – 8 Severe Weather Outlook www.spc.noaa.gov/products/exper/day4-8	5:00am
Severe Weather Watches www.spc.noaa.gov/products/watch	As Required
Mesoscale Discussions www.spc.noaa.gov/products/md	As Required
Severe Weather Storm Reports www.spc.noaa.gov/products/climo	As Required

Table 1: SPC severe weather product issuance timeline (www.spc.noaa.gov)

STORM PREDICTION CENTER SEVERE WEATHER RISK CATEGORIES

SPC utilizes five categories to describe and communicate a potential severe weather threat. The forecasted category is determined by the probability of occurrence for the three main severe weather hazards (hail, wind, and tornadoes). Forecasts utilize model data in conjunction with real-time observations of evolving conditions. Issuance of these categorical forecast are based on areal coverage, potential intensity, and forecaster confidence. Ranging from Marginal Risk (low end) to High Risk (upper end), the categories are described below in Figure 2.







THUNDERSTORMS (no label)	1 - MARGINAL (MRGL)	2 - SLIGHT (SLGT)	3 - ENHANCED (ENH)	4 - MODERATE (MDT)	5 - HIGH (HIGH)
No severe* thunderstorms expected	Isolated severe thunderstorms possible	Scattered severe storms possible	Numerous severe storms possible	Widespread severe storms likely	Widespread severe storms expected
Lightning/flooding threats exist with <u>all</u> thunderstorms	Limited in duration and/or coverage and/or intensity	Short-lived and/or not widespread, isolated intense storms possible	More persistent and/or widespread, a few intense	Long-lived, widespread and intense	Long-lived, very widespread and particularly intense
					

Figure 2: SPC severe weather risk categories defined (www.spc.noaa.gov)

SEVERE WEATHER TERMINOLOGY

- ⚡ **Severe Thunderstorm:** A thunderstorm producing hail of 1" or greater in diameter, and/or damaging winds of 58mph or greater, and/or capable of producing a tornado
- ⚡ **Significant Severe Weather:** Tornadoes of EF2+, and/or wind of 75mph+, and/or hail of 2"+
- ⚡ **Convection:** upward movement of air, results in thunderstorms
- ⚡ **Supercell:** intense, rotating thunderstorm associated with the threat for strong (EF-2+) tornadoes
- ⚡ **Squall Line/Quasi-Linear Convective System (QLCS):** Intense line of severe thunderstorms producing strong damaging winds and isolated weak, brief tornadoes
- ⚡ **Bow Echo:** Arched or bowing segment within the squall line/QLCS
- ⚡ **Derecho:** A squall line/QLCS that travels over 240 miles and produces widespread damaging winds \geq 58mph with gusts \geq 75mph
- ⚡ **Hook Echo:** Radar signature that indicates rotation
- ⚡ **Dryline:** Boundary between moist and dry air
- ⚡ **Funnel Cloud:** Rotating cloud not in contact with the ground
- ⚡ **Tornado:** Rotating column of air in contact with the ground
- ⚡ **Waterspout:** Tornado over water
- ⚡ **Tornado Watch:** Conditions are favorable for tornado development
- ⚡ **Tornado Warning:** A tornado is indicated via radar or observed
- ⚡ **Tornado Emergency:** Tornado warning indicating a stronger tornado is imminent for a populated area

ENHANCED FUJITA TORNADO RATING SCALE AND NWS DAMAGE SURVEY OVERVIEW

The Enhanced Fujita (EF) scale (Table 2) has been utilized as the tornado damage intensity rating metric by the NWS (the official agency tasked with assigning EF ratings) since 2007. Based on scientific advancements and research, the EF-scale was implemented as an upgrade to the original Fujita (F) scale developed in 1971 by Dr. T. Theodore Fujita. The scale utilizes damage indicators as a method for estimating wind speeds; however, rating accuracy will depend most significantly on what type of structures are impacted. It can be difficult to achieve an accurate rating when tornado occurrence primarily affects rural areas and/or encounters limited structures. Once significant damage has been reported, within approximately 24 hours (pending operational priorities or ongoing weather), the NWS conducts a damage survey to determine the rating. An initial rating is typically assigned within 24 to 48 hours after an event occurs. A final rating may be issued days to weeks after event occurrence, dependent upon analysis and any follow-up information collected. The designated EF rating is based on the highest damage estimate found along the track, as tornadoes often wax and wane in intensity as they move.


EF Rating	Wind Speeds	Expected Damage		
EF-0	65-85 mph	'Minor' damage: shingles blown off or parts of a roof peeled off, damage to gutters/siding, branches broken off trees, shallow rooted trees toppled.		
EF-1	86-110 mph	'Moderate' damage: more significant roof damage, windows broken, exterior doors damaged or lost, mobile homes overturned or badly damaged.		
EF-2	111-135 mph	'Considerable' damage: roofs torn off well constructed homes, homes shifted off their foundation, mobile homes completely destroyed, large trees snapped or uprooted, cars can be tossed.		
EF-3	136-165 mph	'Severe' damage: entire stories of well constructed homes destroyed, significant damage done to large buildings, homes with weak foundations can be blown away, trees begin to lose their bark.		
EF-4	166-200 mph	'Extreme' damage: Well constructed homes are leveled, cars are thrown significant distances, top story exterior walls of masonry buildings would likely collapse.		
EF-5	> 200 mph	'Massive/incredible' damage: Well constructed homes are swept away, steel-reinforced concrete structures are critically damaged, high-rise buildings sustain severe structural damage, trees are usually completely debarked, stripped of branches and snapped.		

Table 2: The Enhanced Fujita tornado damage intensity scale (www.weather.gov/jetstream)

The EF-scale ranges from weak or EF-0 (65-85mph) to strong or EF-5 (200+mph) with generally increasing damage the higher the rating. Damage descriptors range from 'minor' (EF-0) to 'massive/incredible' (EF-5). While most tornadoes fall on the low end (EF-0/EF-1) of the scale, there may be dozens to one hundred or more EF-2 or greater tornadoes (also known as 'significant' tornadoes) annually. EF-4 and EF-5 rated tornadoes, also known as 'violent' tornadoes, are the rarest to occur and varies greatly annually. For some years there are multiple violent tornadoes reported, while for other years there are none. Regardless, the threat for significant and violent tornadoes exists every year. As such, preparedness and planning efforts should incorporate the potential impacts of possible occurrence.

SEVERE WEATHER TIDBITS AND FACTS

In meteorological terms, severe weather is comprised of hail, wind, tornadoes, lightning, and heavy rainfall. A severe thunderstorm is defined as a thunderstorm producing hail that is at least 1 inch in diameter or larger, and/or wind gusts of 58 mph or greater, and/or a tornado. Although associated phenomena of lightning and flash flooding can also be deadly, the NWS doesn't use it to define a severe thunderstorm. The threat for severe weather exists for ~272 days on average. However, the number of days with tornado occurrence is lower. Generally speaking, the earlier a potential severe weather threat is identified within the SPC outlook products, the more likely a significant severe weather event or possible upgrade(s) will be. Higher end risk category (Moderate/High) issuance is a good indicator of an intense, more widespread threat typically. However, impactful, and strong tornadoes or damaging wind events do occur at lower risk levels as well. These events are just often times more isolated. While a good majority of tornadoes occur during the late afternoon and evening hours, they do occur at all hours of the day. In fact, nocturnal or nighttime tornadoes are the deadliest.

SEVERE WEATHER CHALLENGES AND LIMITATIONS

Tornadoes can cause significant destruction to property and infrastructure, as well as profound loss of life. However, when it comes to severe weather prediction, there are several caveats that pose a few challenges and limitations regarding severe weather forecasting and ultimately tornado formation. While scientific understanding and the ability to forecast tornadoes seasonally continues to be studied within the research community, advancements towards seasonal outlooks are limited and not widely available currently. Unlike hazards such as hurricanes, which can be monitored visually through satellite and radar imagery prior to landfall, severe storms and tornadoes typically cannot be seen until shortly before impact, which may only be a few miles or less. Due to the short fused, localized nature, and year-round occurrence of tornadoes, planning and preparing for destructive tornado impacts annually is imperative for an effective and efficient response, particularly in tornado prone areas.

Challenges:

- ☛ Tornadoes are short-fused events yet can be very destructive and require urgent response. Response efforts are either ahead or behind, there really is no in between.
- ☛ Multi-day severe weather events depend on evolution of conditions leading up to an event.
- ☛ Can't really see the storm as it evolves, so forecast predict how ingredients may come together.
- ☛ Many factors must align and requires a 'perfect storm' or near perfect set of ingredients.
- ☛ If conditions are off on time, location, etc., then the event may be more or less intense than expected with increased or decreased impacts.

Seasonal Limitations:

- ☛ Scientific knowledge and understanding
- ☛ Tornado seasonal prediction techniques are underway and show promise, but are in the early stages
- ☛ Difficult task due to a multitude of factors including short term and localized influences

Seasonal Planning:

- ☛ Timing, intensity, and duration vary across the U.S. with greater impacts in some locations due to population and/or infrastructure
- ☛ Damaging and rare events can still occur during 'below normal' seasons
- ☛ Focus attention on need to prepare as active severe weather periods approach

TORNADO PREPAREDNESS (www.weather.gov/safety/tornado)

- ☛ **Be Weather-Ready:** Check the forecast regularly to know when your area is at risk for tornadoes. Utilize news, NOAA Weather Radio, social media, or other channels to stay informed about watches and warnings.
- ☛ **Notifications:** Some communities have outdoor sirens; others depend on media and smart phones to alert residents of potential tornadoes. There are also various apps that can be utilized to alert you of a threat.
- ☛ **Response Plan:** Develop a plan that includes a designated emergency meeting place and communication information for your household (<https://www.ready.gov/make-a-plan>).
- ☛ **Practice the Plan:** Conduct a household drill regularly so everyone knows what to do and where to go when a tornado is approaching. Encourage all of your loved ones to prepare for the possibility of tornadoes.
- ☛ **Sheltering:** Identify a safe room in your home, such as a basement, storm cellar, or interior room with no windows on the lowest level (Figure 3). If you live in a mobile home or do not have a safe room, identify a nearby location. Plans for installation or reinforcement of a safe room can be found at www.ready.gov.



Figure 3: Tornado Safety (www.weather.gov/tornado)

TORNADO SAFETY (www.weather.gov/safety/tornado)

- ☛ **Home:** If you are in a tornado warning, go to your basement, safe room, or an interior room away from windows. Don't forget pets if time allows and bring any required medical supplies.
- ☛ **Workplace:** Follow the facility plan and proceed to your tornado shelter location quickly and calmly. Stay away from windows and do not go to large open rooms such as gymnasiums, auditoriums, or cafeterias.
- ☛ **Outside:** Seek shelter inside a sturdy building immediately if a tornado is approaching. Sheds and storage facilities are not safe, neither is a mobile home or tent. If you have time, get to a safe building.
- ☛ **Vehicle:** Being in a vehicle during a tornado is not safe. The best course of action is to drive to the closest shelter. If you are unable to make it to a safe shelter, either get down in your car and cover your head or abandon your car and seek shelter in a low-lying area such as a ditch or ravine.
- ☛ **School:** Know and discuss your child's facility plan and identified safe room locations. Follow accordingly.

TORNADO MYTHS (<https://stormaware.mo.gov/tornado-myths/>)

- ⚡ **MYTH:** Damage to homes during a tornado is caused by an explosion from changes in air pressure. Open windows in your house before a tornado to reduce damage by balancing the pressure.
 - 💧 **FACT:** Extremely strong winds in a tornado are the cause of damage, not pressure. Opening windows will only delay seeking shelter.
- ⚡ **MYTH:** Tornadoes cannot cross lakes, rivers, or other bodies of water.
 - 💧 **FACT:** Tornadoes can form on water (waterspouts) or land and cross bodies of water.
- ⚡ **MYTH:** Tornadoes never strike the same place twice.
 - 💧 **FACT:** Tornadoes can and do impact locations more than once within an event or separate events.
- ⚡ **MYTH:** A tornado is more likely to hit a mobile home park.
 - 💧 **FACT:** Tornadoes are not more likely to hit a mobile home park, but the chances of them doing more damage and destruction to mobile homes is greater than to other structures.
- ⚡ **MYTH:** A tornado cannot travel up and down hillsides.
 - 💧 **FACT:** Tornadoes can and do travel up and down hillsides.
- ⚡ **MYTH:** Tornadoes do not hit big cities.
 - 💧 **FACT:** Tornadoes can and have impacted large cities.
- ⚡ **MYTH:** If driving, I should abandon my vehicle immediately and take shelter under an overpass.
 - 💧 **FACT:** An overpass can actually accelerate winds, collect debris, and clog up roadways.
- ⚡ **MYTH:** Tornadoes can always be seen from far away and appears initially as a visible funnel cloud.
 - 💧 **FACT:** Tornadoes do not always have a visible funnel cloud, and they can be hidden by heavy rainfall during the day or by darkness at night.
- ⚡ **MYTH:** The safest place to take shelter from a tornado is in the southwest corner of a basement.
 - 💧 **FACT:** The safest place to take shelter during a tornado is in a safe room. Otherwise, seek an interior room on the lowest floor, as far as possible from exterior walls and windows.
- ⚡ **MYTH:** If a tornado is not coming directly towards me, I am out of harm's way.
 - 💧 **FACT:** Tornadoes do not follow a specific path or route and can change directions at any time.

SEVERE WEATHER RESOURCES AND LINKS

- ⚡ Storm Prediction Center: <http://www.spc.noaa.gov>
- ⚡ Storm Prediction Center FAQ: <http://www.spc.noaa.gov/faq>
- ⚡ National Weather Service: <http://www.weather.gov>
- ⚡ National Weather Service Safety: <http://www.weather.gov/safety>
- ⚡ Tornado Watches/Warnings: <https://twitter.com/NWStornado>
- ⚡ Severe Storm Watches/Warnings: <https://twitter.com/NWSsevere>
- ⚡ SPC Days 1-3 Outlooks for FEMA Regions: www.spc.noaa.gov/public/fema/images/
- ⚡ SPC Days 1-3 Outlooks for States: www.spc.noaa.gov/public/state/images/
- ⚡ SPC Outlooks Overview: <https://www.spc.noaa.gov/public/swodyoverview.html>

