

# Tornado Learning Module



[Source](#)

**Tornadoes** are defined as rapidly rotating columns of air that extend from the base of a thunderstorm and make contact with the ground. Before reaching the surface, they are called **funnel clouds** <sup>1</sup>. Tornadoes are the most concentrated, powerful, and destructive forms of weather on the planet, and in this learning module, we will explore where tornadoes exist in the world, how they form, and how to stay safe if a tornado is close to you.

[Introduction to Tornadoes](#) (5:01)

## Tornado Intensity

Figure 1 divides tornado strength into three categories: weak, strong, and violent. The average tornado is weak and produces wind speeds that are generally less than 120 mph. While 85% of all tornadoes fall into this weak category, 70% of all tornado fatalities are from violent tornadoes (Figure 1). Luckily, as we can see from the chart, only 2% of all tornadoes reach the violent category. To get a feel for what these violent tornadoes look like, check out this video:

[Tornado Destruction](#) (1:23)

	Time	Wind Speed	% of Deaths	% of Tornadoes	Width
Weak	Few min.	<120 mph	5%	85%	100ft
Strong	Several min to an hour	120-200 mph	25%	13%	Up to ¼ mile
Violent	Several min to an hour+	>200 mph	70%	2%	Up to 1 mile

**Average Tornado:**  
Size: 150 ft to 0.5 mile in diameter (250 yds wide is typical)  
Time on Ground: 10 minutes (tracks 4 miles)  
Wind Speed: 110 mph  
EF-Scale Rank: EF - 0 to EF - 1  
Direction of Movement: SW to NE @ 20 - 40 mph

**Average Warning Time:**  
13 minutes (recent outbreaks = 30 min)  
Debris is the #1 killer

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Figure 1. Top - A chart that defines the characteristics of a tornado. Bottom - The definition of an average tornado.

[Source](#)

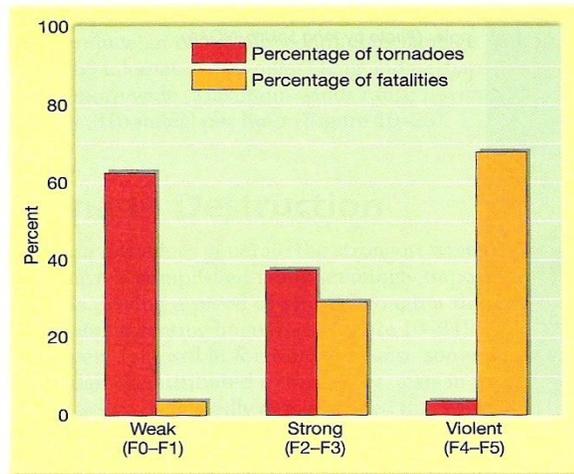


Figure 2. Tornado frequency and percentage of fatalities associated with each type.

## Tornadoes in the U.S.

On average, 57 people are killed each year in the U.S. by tornadoes. This makes tornadoes the second most deadly weather phenomenon in the U.S. in the last 30 years with flooding being the only weather type with more fatalities. Watch the following video to learn more about fatalities associated with tornadoes.

### [Tornado Fatalities in the U.S.](#) (7:48)

The top 5 states with the highest death rates (number of deaths per capita) are:

1. Mississippi
2. Arkansas
3. Alabama
4. Illinois
5. Indiana

Figure 3 shows where people are when they are killed by tornadoes. As we can see from this chart, nearly 44% of all tornado fatalities are in mobile homes, while 25% are in permanent homes.

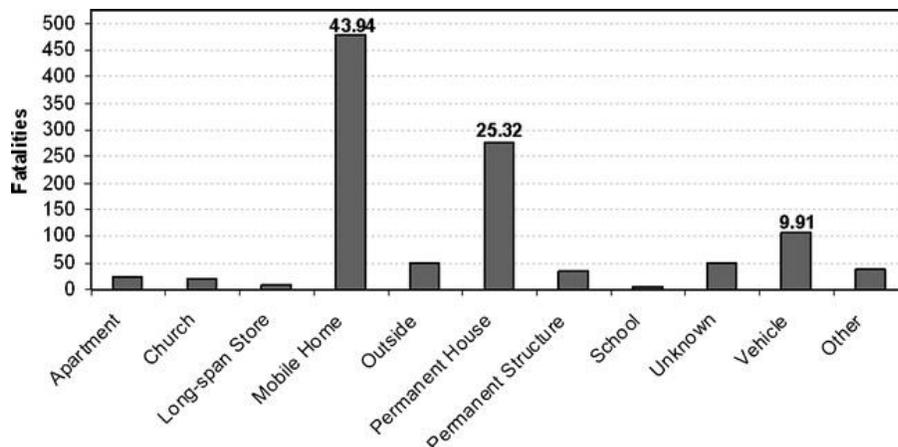


Figure 3. Tornado fatalities by location.

[Source](#)

Although tornadoes can happen any time of the year in the U.S., they are most common between March and August with May being the most active tornado month of the year. Every state in the U.S. has experienced tornadoes and 75% of the world's tornadoes occur in the U.S. (see bottom of Figure 4). Texas is the state that has experienced the most tornadoes over the last 50 years with nearly 8,000 tornadoes reported there since records began. Alaska has experienced the fewest tornadoes with only 3 observed in the last 62 years and none since 1981. Oklahoma has the highest tornado concentration and the capital Oklahoma City has been hit 125 times by tornadoes since 1890!

The top panel of Figure 4 shows the locations of all the tornadoes in 2011. 2011 was an extremely active year for tornadoes as there were 1690 reports across the U.S. On average the U.S. receives 1,200 reports of tornadoes each year, but in 2011, April alone had over 700 reports! In addition to this, 557 people died from tornadoes in 2011 making it one of the most deadly years on record. 2011 ranks as the 2<sup>nd</sup> most active year for tornadoes since 1952 (2008 ranks as 1<sup>st</sup>).

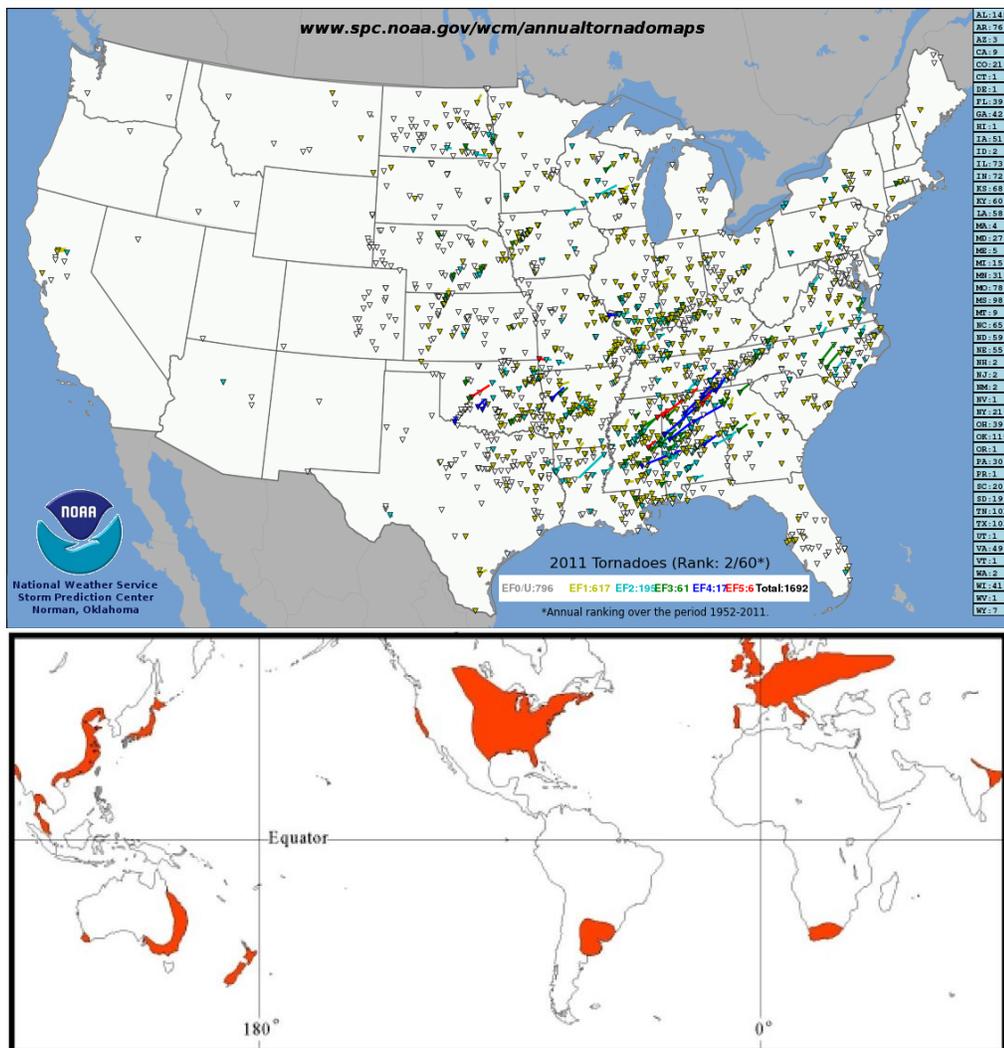


Figure 4. Top – 2011 Tornado Reports  
Bottom – Locations around the world where tornadoes often form.

[Source](#)

## The F-Scale and EF-Scale

In 1971, Dr. Theodore Fujita published the **Fujita Scale** (F-Scale), which is a scale that is used to rank the power and wind speed of a tornado based upon the damage it causes. Dr. Fujita studied 30,000 damage reports from over 70 years and created the F-Scale (Figure 5). The F-Scale is used by the National Weather Service to estimate the wind speeds within a tornado based upon the destruction it causes. Therefore, the F-Scale can only be used after a tornado damage survey has been completed. This means that you cannot use this scale to assess a tornado while the tornado is happening.

In 2007, the original F-Scale was upgraded to the **Enhanced Fujita Scale** (EF-Scale). This new scale added to Dr. Fujita's work by increasing the number of damage indicators used in the scale. One of the major differences between the two scales is that the new EF-Scale has a lower wind speed threshold for the 5<sup>th</sup> category (EF-5). On the F-Scale, a tornado must have 260+ mph winds to reach an F-5 while on the EF-Scale, a tornado need only 205 mph winds to be an EF-5. Since 1950, there have been 58 EF-5 tornadoes, making them the most rare of all tornadoes. An interesting statistic is that since 1999, there have been 9 EF-5 tornadoes, 6 of which occurred in 2011!

### EF-Scale

F Scale	Wind Speed	EF-Scale	Wind Speed
F0	45-78	EF0	65-85
F1	79-117	EF1	86-109
F2	118-161	EF2	110-137
F3	162-209	EF3	138-167
F4	210-261	EF4	168-199
F5	262-317	EF5	200-234

Wind speeds in mph, 3-second gust

Figure 5. Conversion of F-Scale to EF-Scale.

[Source](#)

## Tornado Formation

Although there are still some unknowns about tornado formation, we know that they need an unstable or imbalance in the atmosphere to form rotating columns of air. The most ideal location for initiation of tornadoes and the types of thunderstorms that they are associated with is called **Tornado Alley**. Watch this news report to learn more!

[Tornado Alley](#) (1:45)



Figure 6. Favorable conditions for tornado formation in Tornado Alley.

[Source](#)

### Video Lecture Notes 1

- Tornado Alley is defined as a region in the U.S. that has the highest number of tornadoes. This area includes Texas, Oklahoma, Kansas, Nebraska, Missouri, Iowa, Arkansas, Illinois, North and South Dakota.
- 75% of the world's tornadoes occur in the U.S.
- 5pm in the most active time of day for tornadoes, and near sunrise is the least active time of day.
- March – July is the typical time frame for tornado season.

Tornadoes form most often in supercell thunderstorms (see Figure 8). **Supercell thunderstorms** are the most powerful storms on the planet and their most defining characteristic is that they rotate as they form. When forming a supercell thunderstorm and eventually a tornado, wind shear is the most crucial ingredient. **Vertical wind shear** is the change in wind speed and direction with altitude in the atmosphere. To understand how wind shear plays a roll in tornado formation, check out this video!

### [Wind Shear and Tornado Formation](#) (1:23)

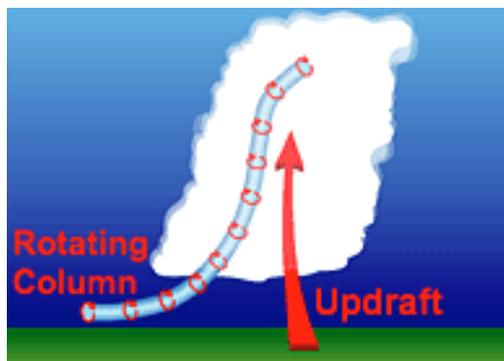


Figure 7. A rotating column formed by wind shear being tilted into the vertical direction by an updraft to form a rotating supercell thunderstorm.



Figure 8. Pictures of rotating supercell thunderstorms  
[Source](#)

Supercells are very efficient at making tornadoes because the large-scale storm motion (as you saw in the video) is already rotating. There are a few tornadogenesis theories meteorologists use to explain how tornadoes form, but they all follow the same principle called **conservation of angular momentum**. If you have ever spun around in a chair and tucked your arms in tight, you would have noticed that when you did this, you spun faster. This is because your body is trying to conserve momentum. When your arms are out wide, you spin slowly, but as you tuck them in you spin much faster. To see this process in action, watch this video of a figure skater!

[Figure Skater](#) (0:16)

In the same way, the rotation of a supercell thunderstorm must be concentrated into a small area to form a tornado. In Figure 9 on the next page, we can see the rotation of a supercell thunderstorm. The top arrow represents the rotating updraft, which meteorologists call the **mesocyclone**. The middle arrow is wrapping around what meteorologists call the “wall cloud.” From the rotation in the wall cloud, the tornado will emerge. Notice in this image that the smaller and more concentrated the area, the faster the rotation – just like the figure skater in the video above!

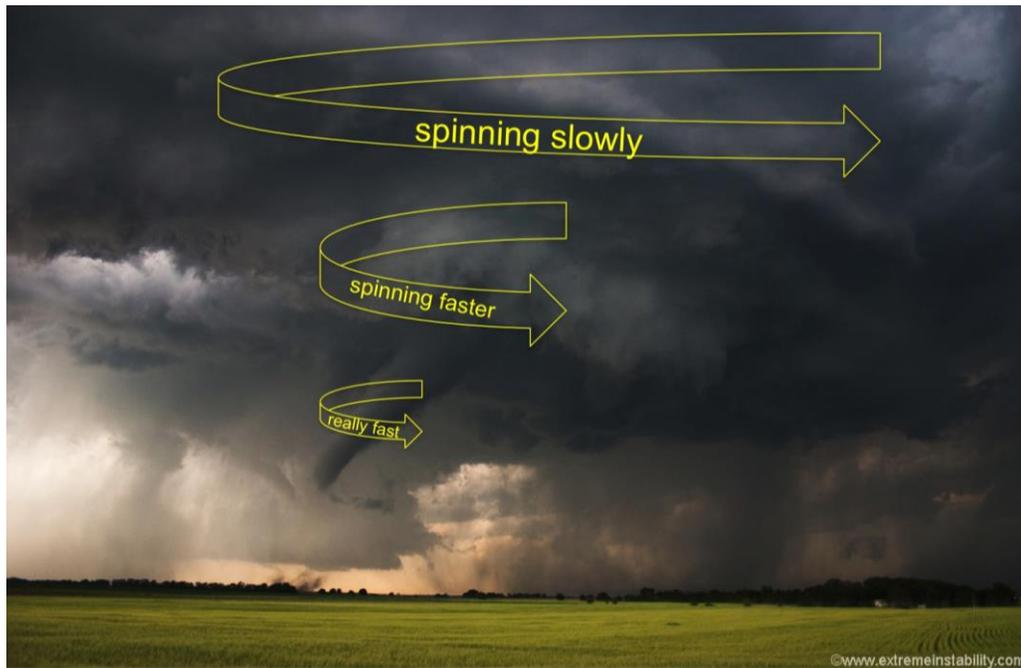


Figure 9. The rotating parts of the supercell thunderstorm.

[Source](#)

## Tornado Watches & Warnings

A **tornado watch** will be issued if a meteorologist forecasts that the ingredients for tornadic thunderstorm development are present in a given area. Weather forecasters from the National Weather Service (NWS) will issue a “watch box” like the one pictured in Figure 10 to inform the public of the areas that are likely to have severe weather. Many people are often confused about the differences between a tornado watch and tornado warning. Simply put, a tornado watch means, “conditions are favorable” for tornado development and a **tornado warning** means that a tornado has been detected with radar or has been seen by a trained storm spotter. If a tornado warning is issued, the NWS and Emergency Management will notify the public through radio and TV emergency broadcasts and the sounding of warning sirens. On the right side of Figure 10, you can see a typical tornado warning overlaid on a radar image.

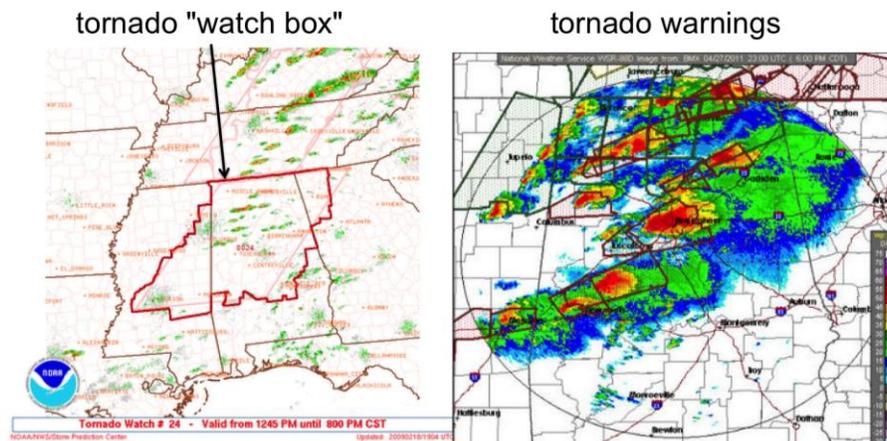


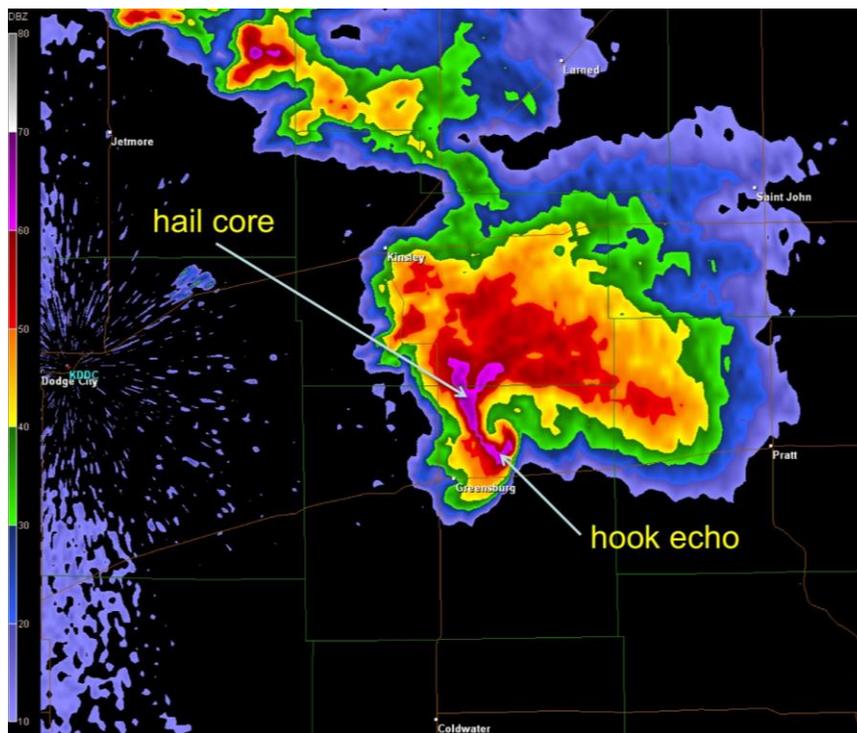
Figure 10. Left – A tornado watch box. Right – A series of tornado warnings overlaid on radar data.

## Doppler Radar

**Doppler radar** is the most important tool for detecting severe thunderstorms and tornadoes **2**. Let's take a few moments and learn how to use Doppler radar to identify a potential tornado. Figure 11 on the next page is a Doppler radar image from Kansas in 2007. The color-coding used in this image indicates the intensity of the precipitation. When the colors reach red, purple, pink or white, the radar is scanning through very heavy rain and hail, which are very dangerous parts of the storm.

The most identifiable feature on this radar image though is the **hook echo**. The small feature on the southwest side of this storm that looks like a fishhook indicates to a meteorologist that the storm is rotating and potentially producing a tornado. In this image, there was a tornado occurring and it was located in the center of the hook echo. As you can see in this image, the town of Greensburg KS is very close to the hook echo. In fact, about 20 minutes before this radar image was taken, the tornado had passed right over the town.

Figure 12 shows a before an after picture of this town when an EF-5 tornado passed through in May of 2007. Luckily, only 11 people died from this tornado even though 95% of the town was destroyed. The citizens of Greensburg can thank the NWS and Doppler radar for finding this tornado and warning them about 30 minutes in advance.



*Figure 11. A Doppler radar image of the May 2007 Greensburg, KS tornado. A hail core shown in pink (highest reflectivity on radar) and the hook echo represents a potential tornado signature where reflectivity curves like a hook.*

## Tornado Safety

So, what should you do if a tornado is coming toward you?

1. If you are outdoors and cannot take shelter, run at 90-degree angles from the tornado.
2. If you are in a car and on an open highway (no traffic and you can clearly see the tornado), drive away from the tornado. **DO NOT HIDE UNDER A BRIDGE.**
3. If you are in a car and you cannot drive away, **STAY IN YOUR CAR.** The Federal Emergency Management Agency (FEMA) has recently updated their safety advice and they now say to stay in your car if there is no other place of shelter.  
*Why? Modern cars are equipped with a lot of safety equipment like seat belts, airbags, and crumple zones, which are all designed to keep the occupants safe.*
4. If you are in your car and in a city, abandon your car for a nearby building or shelter.
5. If you are in a permanent home, get to the lowest level and to the interior of the building. Put as many walls and floors between you and the tornado as possible.
6. If you are in a mobile home, **ABANDON** it for alternative shelter.
7. No matter where you are, always protect your head. Flying debris such as tree branches are the number one reason people are injured or killed during a tornado.



Figure 12. View of Greensburg, KS before and after an EF-5 tornado struck.

[Source](#)

## **Pre-Class Activity 1, 2**

**Instructions:** Before teaching about tornadoes, have the students answer the questions below, followed by a scenario question for in-class discussion between you and your students. If time permits, try a live demonstration of tornado in a bottle as an example of how debris at the ground circulates around a tornado!

1. Which type of tornado is most frequent?
  - a. Weak
  - b. Strong
  - c. Violent
  
2. What is the name of the scale that characterizes tornado intensity?
  - a. Saffir-Simpson Scale
  - b. Rotation Scale
  - c. Destruction Scale
  - d. Barometer Scale
  - e. Enhanced Fujita Scale
  
3. Where is Tornado Alley located?
  - a. Coastal regions
  - b. The Great Plains
  - c. Texas
  - d. Southwest U.S.
  
4. What instrument is used to detect potential tornadoes?
  - a. Satellite
  - b. Barometer
  - c. Doppler radar
  - d. Anemometer
  - e. Thermometer
  
5. On average, approximately how many tornadoes are reported in the U.S. each year?
  - a. 50
  - b. 100
  - c. 250
  - d. 1,000
  - e. 2,500

**Discussion Question:** The National Weather Service has issued a tornado warning for your area. What are your next steps to ensure your safety?

## **Tornado in a Bottle Experiment Instructions**

## In-Class Activity

### Severe Weather Situation: Tornado

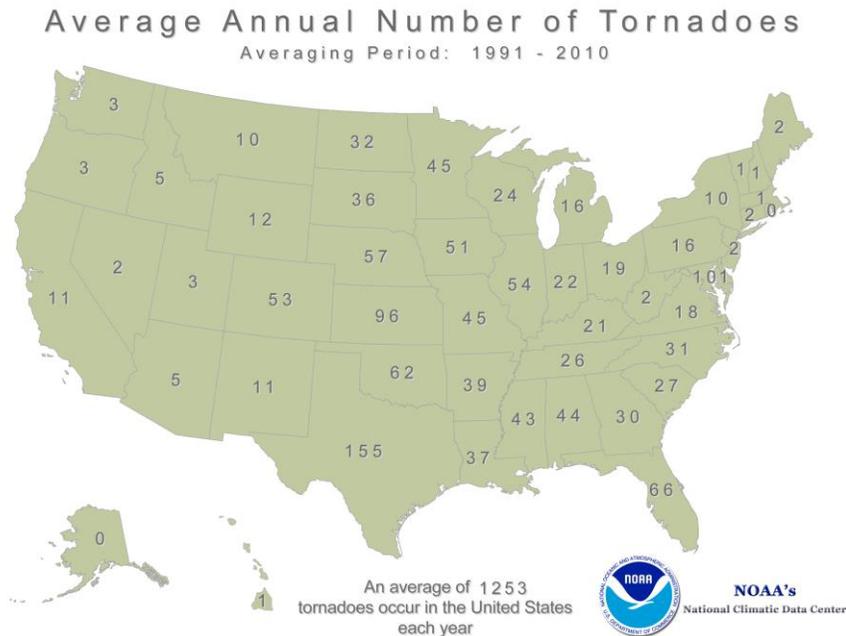
**Instructions:** In this project, your group will forecast and prepare for a tornado outbreak in the U.S. Each group member will choose one of the following roles and complete the tasks written at the end of each section.

1. Meteorologist
2. Homeowner
3. Mayor
4. School Superintendent

### Real World Application: Meteorologist 4, 5

#### Task #1

Below is a map of the average number of tornadoes per year for each state in the U.S. From this map, calculate the number of tornadoes per square mile for Illinois, Indiana, and Oklahoma. To do this, take the number given in each state and divide by the area of each state in square miles. You can find the area of the states by searching on Google.



#### **Annual Number of Tornadoes per Area:**

Illinois \_\_\_\_\_ Indiana \_\_\_\_\_ Oklahoma \_\_\_\_\_

## **Task #2**

Below is a list of statements that are the most commonly misunderstood things about tornadoes. Go through this list and decide which are myths or facts and then consult with your classmates about what they think. Finally, talk with your teacher about the right answers.

- |   |      |      |
|---|------|------|
| 1. Tornadoes have occurred in all 50 states.  | MYTH | FACT |
| 2. Tornadoes are attracted to mobile home communities.  | MYTH | FACT |
| 3. Tornadoes sometimes sound like a freight train.  | MYTH | FACT |
| 4. Tornadoes cannot hit downtown areas because the buildings deflect the airflow.   | MYTH | FACT |
| 5. Tornadoes can be invisible.  | MYTH | FACT |
| 6. Wind speeds within a tornado can exceed 300 mph.   | MYTH | FACT |
| 7. Tornadoes always rotate counterclockwise in the Northern Hemisphere.   | MYTH | FACT |
| 8. If a tornado watch has been issued, then this means a tornado has been sighted.  | MYTH | FACT |
| 9. If there is a tornado warning, you should open all the windows in your house or apartment.                             | MYTH | FACT |
| 10. When the tornado siren goes off, you should grab your video camera and go outside to catch it on film.                | MYTH | FACT |
| 11. Tornadoes can be made up of 2 or more smaller tornadoes called suction vortices.                                      | MYTH | FACT |
| 12. If you are driving in a car on the highway and see a tornado behind you, find the nearest overpass and hide under it. | MYTH | FACT |
| 13. When the tornado siren goes off, go to the innermost room on the lowest level of your house or building.              | MYTH | FACT |

### **Task #3**

As a meteorologist, it is important that you learn to properly convey weather information to the general public. Your task is to create a 5-minute weather broadcast like you might see on the Weather Channel about tornadoes. Remember that your classmates will not know much about what you have just learned so be sure to address the following topics in your broadcast:

1. Convey statistics about tornadoes in the U.S. (fatalities, numbers, etc.)
2. Discuss where tornadoes occur in the U.S. and when they are most common.
3. Explain the F-Scale and EF-Scale.
4. Explain how tornadoes form.
5. Discuss tornado watches and warnings.
6. Talk about tornado safety.

Build this weather broadcast using presentation software (like PowerPoint) and be sure to supplement everything you discuss with images and videos. Your teacher has access to several videos and pictures of tornadoes, so make sure to use your teacher as a resource as well as the Internet. Be sure both informative and entertaining!

### **Real World Application: Homeowner**

In 2011, a very powerful EF-4 tornado ripped through Tuscaloosa, Alabama. When the day was finally over, the tornado outbreak on April 27, 2011 had produced 292 tornadoes (a new record) and had killed 330 people. The situations laid out below are in regards to this event. To see this tornado, check out this video: [Tuscaloosa Tornado 2011](#)

You are an adult with a family living in Tuscaloosa. You are married, you have two kids, a pet, and your elderly mother lives next door. Your house has one floor and no basement. You have just heard that there's a really good chance that a tornado is going to hit your town in the next few days, and you need to get ready for it.

#### ***Before the Tornado:***

1. How would you protect your house from the stuff that will be flying around in the air during a tornado? (Would you get boards for your windows, etc.)
2. What kinds of things would you need to get together before the tornado to make sure you'll be okay afterward? (Would you want water? Food? Flashlights? What else?)
3. Would you want to get insurance beforehand to help you pay for damages to your house?
4. Would you want a generator in case your power goes out?

*You finish getting your house and family ready for the tornado just in time. The tornado comes to your part of town while you and your family are eating breakfast together.*

#### ***During the Tornado:***

1. Where would you go in your house to ride out the storm? (Hint: Avoid windows)
2. How would you help your elderly mother in a safe place?
3. How would you keep your pets calm? What about your kids?

*The tornado passes and everyone in your family (and extended family) makes it out okay.*

***After the Tornado:***

1. Would you check to make sure it's safe to go outside before leaving the house?
2. What possible dangers could be outside that you should look for? (Power lines? Unstable buildings?)
3. How would you make sure you have the supplies you need to repair your house if there's damage?
4. When would you contact your insurance agent to let them know about the damages to your house?
5. How would you help your mother & other neighbors get back on their feet?

**Task**

Build an evacuation plan for your home and share it with the students in your class. Be sure to include things such as:

1. How you will stay informed of the tornado while the storm is happening?
2. Where you will take shelter in your home?
  - Consider different style homes like ones with basements vs. those with crawl spaces, those on a concrete slab, those with multiple stories and even mobile homes
3. Who you would contact and how you would contact them if there was an emergency?
4. How you would protect your animals?
5. What you would do with your personal belongings?
6. How you might help your neighbors.

### **Real World Application: Mayor**

You are the mayor of Tuscaloosa. You are in charge of the public buildings (post offices, public transportation, etc.) and for the trailer park close to your town. You know that your town is in an area that has a good chance of getting hit by a tornado. Being the smart mayor that you are, you decide to prepare the town.

#### ***In Advance:***

1. How would you make sure the people in your town know about tornadoes and what to do in a tornado?
2. How would you make sure the buildings are safe?
3. How would you make sure hospitals and care facilities are prepared?
  - Do they need generators? What else do they need to protect the sick people inside?
4. Would you set up a tornado shelter in your town?

*One day, you hear that a tornado is headed directly for your town, and you need to make sure everyone can get through it.*

#### ***Right Before:***

1. Would you talk to FEMA about helping your town?
2. When would you evacuate the trailer park in your town? How would you get them to safety? (Hint: Use your public transportation resources)
3. When would you tell schools & public buildings to prepare for the tornado?
4. How would you warn people that a tornado is coming?

*The tornado hits, as promised.*

***During:***

1. Do you shut off the power or water so the lines don't get damaged or cause any destruction?

*The tornado passes, and you are okay – but you need to worry about the citizens of your town, too.*

***After:***

1. How would you help the citizens who don't have the means to help themselves?
2. Would you talk to FEMA about getting funding or help?
3. How soon would you assess the damage to public buildings and transportation?

**Task**

For this part of the project, put on a mock interview and either record it or perform it in front of the class. Designate an interviewer and have them ask the student who is playing the role of Mayor the questions laid out above.

### **Real World Application: School Superintendent**

You are the superintendent of the Tuscaloosa school district. You know that there is a good chance a tornado could hit, and you want the schools and the kids to be prepared.

#### ***In Advance:***

1. How would you make sure the kids know what to do in the event of a tornado?
2. How often should you have tornado drills?
3. How would you make sure your school is safe for a tornado?
4. How would you make sure you know when a tornado is coming in the first place?

*You hear one morning that a tornado is headed your way.*

#### ***Right Before:***

1. What would you do that morning to protect your school from damages?
2. How would you decide whether to send the kids home before the tornado hits?

*The tornado hits, as promised.*

#### ***During:***

1. How would you make sure all the kids & employees in the schools are safe?

*The tornado passes, and you are okay – but you have to make sure everyone in the schools in your district is okay too.*

#### ***After:***

1. How would you assess the damages to your schools?
2. How would you make sure all the kids & employees are okay?
3. What would you do if one of the kids in your school got hurt?

**Task**

Review your school tornado safety procedures and present this information to the class. Make sure you have included everything from student responsibilities to the teacher and principal's responsibilities. Discuss evacuation and shelter plans as well as the system that is in place to notify the students' parents. Use visual aids as a part of your presentation and make sure that everyone in your classroom knows exactly what to do in the event of a tornado warning.

## Take Home Assignment

### Part 1. Multiple Choice/True or False (Circle one) 1, 5

1. Which month typically experiences the most tornadoes?
  - a. March
  - b. May
  - c. June
  - d. August
  - e. December
  
2. What does the EF-Scale stand for?
  - a. Enhanced Fujita
  - b. Enhanced Force
  - c. Extreme Fujita
  - d. Extreme Force
  
3. Which two factors determine a tornado's intensity?
  - a. Wind speed and direction
  - b. Pressure and temperature
  - c. Number of houses destroyed
  - d. Wind speed and destruction
  
4. Which location is most ideal for tornado formation?
  - a. Northeast U.S.
  - b. Tornado Alley
  - c. Southwest U.S.
  - d. Florida
  - e. Rocky Mountains
  
5. What factor is most crucial for tornado formation?
  - a. Precipitation
  - b. Temperature
  - c. Wind speed
  - d. Wind shear
  - e. Hail
  
6. Before a tornado reaches the ground, it is called a funnel cloud.            T        F
  
7. Wind shear is a change in wind speed or direction with altitude.            T        F
  
8. Tornadoes form most often in supercell thunderstorms.            T        F
  
9. A tornado watch means a tornado has been spotted.            T        F
  
10. Watch boxes are issued when conditions are favorable for tornadoes.    T        F

**Part 2. El Reno and Moore Tornadoes (2013) 2, 3, 6, 7**

The infamous Moore and El Reno tornadoes occurred in Oklahoma less than 2 weeks apart in May 2013. Using information about these two devastating events, answer the following questions.

*The Moore tornado was estimated to be 1.1 miles wide at the ground and remained in contact with the ground for 14 miles (approximately 39 minutes).*

*The El Reno tornado was 2.6 miles wide and touched down for 16 miles (approximately 44 minutes). Maximum wind speeds exceeded 200 mph.*

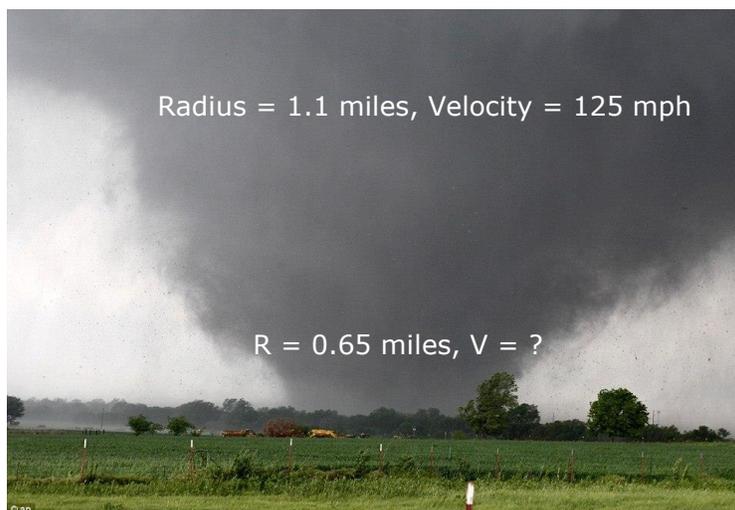
1. From the information given above, calculate the average speed of these two tornadoes in miles per hour.

**Moore** \_\_\_\_\_ **El Reno** \_\_\_\_\_

Recall, rotating objects and specifically tornadoes follow a principle called “conservation of momentum.” The conservation of momentum is defined as

$$(M \times R_1 \times V_1) = (M \times R_2 \times V_2)$$

where M is the angular momentum (conserved, or constant), V is the rotational speed, and R is the radius of the tornado.



2. Using the conservation of angular momentum equation, estimate the wind speed at the surface ( $V_1$ ) in the Moore tornado.

At the surface,  $R_1 = 0.65$  miles

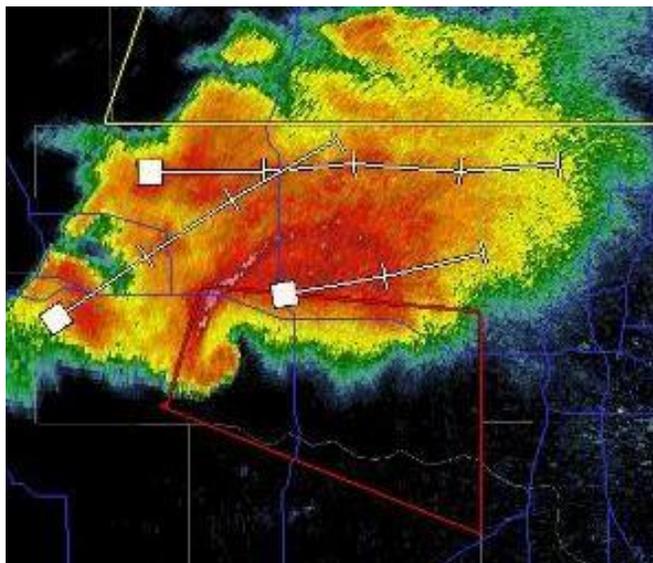
At some height above the surface,  $R_2 = 1.1$  miles and  $V_2 = 125$  mph

$V_1$  \_\_\_\_\_

3. Solely based on wind speed, which category (EF-Scale) would the Moore and El Reno tornadoes fall into?

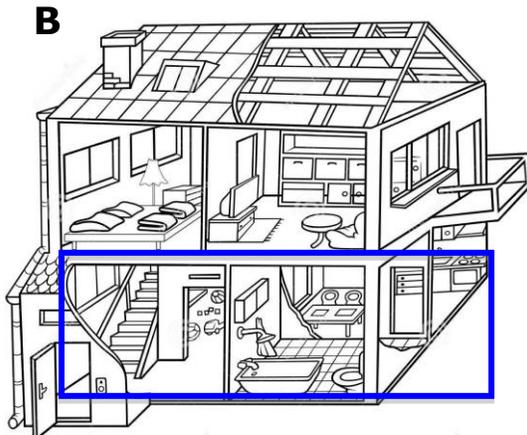
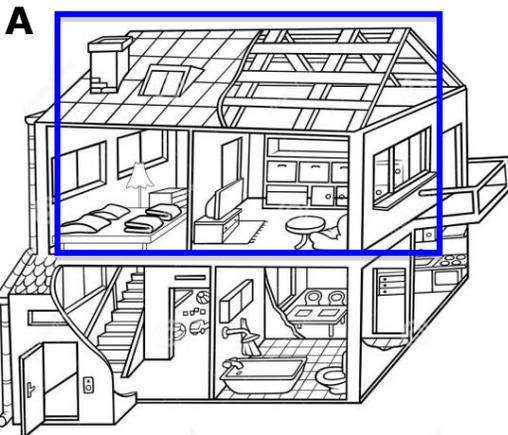
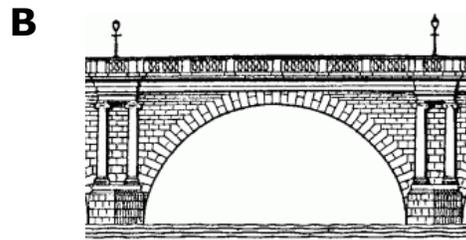
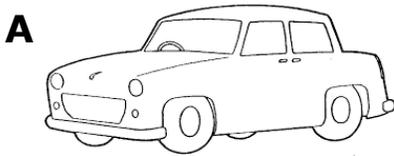
**Moore** \_\_\_\_\_ **El Reno** \_\_\_\_\_

4. What two features do you notice in the Doppler radar image below? Which of those two indicate a tornado?



### Part 3. Tornado Safety

**Instructions:** Choose the safest place to be during a tornado in the following scenarios.



## **Student Evaluation** 1, 2, 4, 5

**Instructions:** After completing the lesson on tornadoes, please have the students answer the following questions below.

1. Which type of tornado is most frequent?
  - a. Weak
  - b. Strong
  - c. Violent
  
2. What is the average warning time once a tornado has been spotted?
  - a. 1 minute
  - b. 5 minutes
  - c. 13 minutes
  - d. 30 minutes
  - e. 2 hours
  
3. What is the number one killer associated with tornadoes?
  - a. Fast winds
  - b. Hail
  - c. Flying debris
  - d. Insufficient warning time
  
4. What is the name of the scale that characterizes tornado intensity?
  - a. Saffir-Simpson Scale
  - b. Rotation Scale
  - c. Destruction Scale
  - d. Barometer Scale
  - e. Enhanced Fujita Scale
  
5. Where is Tornado Alley located?
  - a. Coastal regions
  - b. The Great Plains
  - c. Texas
  - d. Southwest U.S.
  
6. Wind shear is
  - a. a change in wind speed with altitude.
  - b. a change in wind direction with altitude.
  - c. the most crucial ingredient for tornado formation.
  - d. the most crucial ingredient for supercell thunderstorm formation.
  - e. all of the above

7. What instrument is used to detect potential tornadoes?
- Satellite
  - Barometer
  - Doppler radar
  - Anemometer
  - Thermometer
8. On average, approximately how many tornadoes are reported in the U.S. each year?
- 50
  - 100
  - 250
  - 1,000
  - 2,500
9. Tornadoes form most often in rotating supercell thunderstorms. Briefly explain how they begin rotating. Draw a picture to help describe the process.
10. A tornado that is 2.1 miles wide remains on the ground for 12 minutes. The path of destruction, such as the one in the picture below, lasted 4.8 miles. What is the area of destruction for this particular tornado?



- 2.1 sq. miles
- 2.3 sq. miles
- 4.8 sq. miles
- 10.1 sq. miles

## Common Core State Standards (CCSS) Initiative

To learn more, visit <http://www.corestandards.org>

## Next Generation Science Standards (NGSS)

To learn more, visit <http://www.nextgenscience.org>

The following standards are met in this learning module:

### 1. [CCSS.ELA-LITERACY.RST.6-8.4](#)

<b>Grade 6-8: Science and Technical Subjects</b>
Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific science or technical context relevant to grades 6-8 texts and topics.
Lecture: Introduction, The F-Scale and EF-Scale, Tornado Formation and Doppler Radar; Take Home Assignment: Part 1 & 2; Student Evaluation

### 2. [NGSS.MS-ESS3-2](#)

<b>MS-ESS3-2. Human Impacts</b>
Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.
Lecture: Doppler Radar; Take Home Activity: Part 2; Student Evaluation

### 3. [NGSS.MS-PS1-5](#)

<b>MS-PS1-5. Chemical Reactions</b> (Crosscutting Concept: Energy and Matter)
Matter is conserved because atoms are conserved in physical and chemical processes.
Lecture: Tornado Formation

### 4. [CCSS.MATH.CONTENT.7.G.B.6](#)

<b>Grade 7: Geometry</b>
Solve real-world and mathematical problems involving area, volume, and surface area of two- and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms.
In-Class Activity: Meteorologist; Student Evaluation

**5. CCSS.ELA-LITERACY.RST.6-8.8**

<b>Grade 8: Science and Technical Subjects</b>
Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.
In-Class Activity: Meteorologist; Take Home Assignment: Part 1; Student Evaluation

**6. CCSS.ELA-LITERACY.RST.6-8.3**

<b>Grade 6-8: Science and Technical Subjects</b>
Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
Take Home Activity: Part 2

**7. CCSS.MATH.CONTENT.7.RP.A.1**

<b>Grade 7: Ratios and Proportional Relationships</b>
Analyze proportional relationships and use them to solve real-world and mathematical problems.
Take Home Activity: Part 2

**8. CCSS.ELA-LITERACY.RST.6-8.7**

<b>Grade 6-8: Science and Technical Subjects</b>
Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
Video lectures