I Thunderstorms and Tornadoes

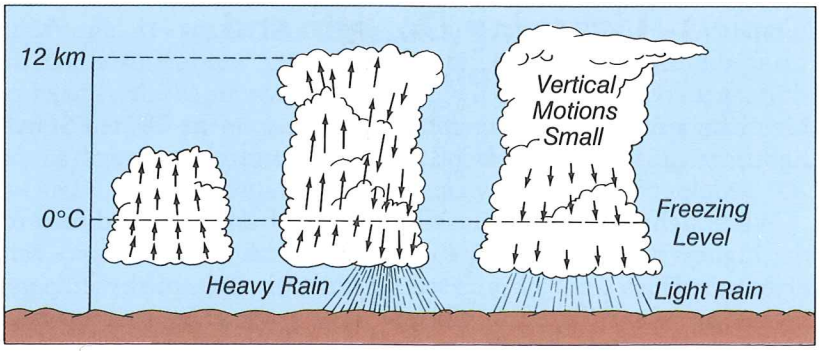
Topic 1 How Thunderstorms Form

Each day about 44 000 thunderstorms occur across Earth's surface. *Thunderstorms* are small-area storms formed by the strong upward movement of warm, unstable, moist air. They are formed of cumulonimbus clouds, are always accompanied by lightning and thunder, and usually produce rain. Strong thunderstorms produce high winds, hail, and even tornadoes. Single thunderstorms are 10–20 kilometers across and commonly are 10–15 kilometers deep.

Thunderstorms fall into two groups: local or **air-mass thunderstorms,** and organized or **frontal thunderstorms.**

Air-mass thunderstorms form within a warm, moist air mass. They start when the surface is strongly heated. Often single storms, they occur mostly in spring or summer and usually last less than an hour. Air-mass thunderstorms are widely scattered and form mostly over land. No one can yet predict exactly where an air-mass thunderstorm will form. Some form over mountains, perhaps started by the rising valley breeze, but others form almost anywhere over flat land or water.

Frontal thunderstorms usually form in warm, moist air on or ahead of cold fronts. Some thunderstorms, however, occur around warm fronts. Frontal thunderstorms often occur in lines along the frontal surface. They also occur in lines ahead of the front, called *squall lines*. The lines of thunderstorms can be hundreds of kilometers long. Slowly moving fronts or squall lines can produce heavy rains and flooding. Frontal thunderstorms occur most often in spring and summer. They are often stronger than air-mass thunderstorms and may last for several hours.



30.1 (left) An air-mass thunderstorm starts when heating of the ground causes vertical motions. (center) The weight of the falling rain and cooling by evaporation cause a downdraft to begin. (right) The downdraft spreads, choking off the vertical motions. The cloud dies.

OBJECTIVES

- **A** Compare the types of thunderstorms and show how and where they form.
- **B** Describe and explain lightning and thunder, and list places that are safe during lightning storms.
- **C** Describe tornadoes and severe thunderstorms and list the conditions that produce them.
- **D** Differentiate between watches and warnings issued for severe thunderstorms and tornadoes.

.2 Spectacular lightning displays
y be seen during a thunderstorm.

Topic 2 Electricity in a Thunderstorm

All thunderstorms produce lightning. Lightning is a discharge of electricity from a thundercloud to the ground, to another cloud, or from the ground to a cloud.

The temperature inside a channel of a lightning flash is believed to reach about 28 000°C. At this high temperature, the air expands explosively. This sudden expansion makes the tremendous sound wave called thunder. Light travels at 300 000 kilometers a second, so lightning is seen almost instantly. The sound waves from lightning, however, take 3 seconds to travel a kilometer, so you hear the sound of thunder after seeing a lightning flash.

Lightning strokes are often very long, so that some parts are close and some farther away. In this case, the sound is spread out in time, and the thunder rumbles. Rumbling also happens when thunder echoes from mountainsides. The greatest distance at which it is ordinarily possible for thunder to be heard is about 16 kilometers. Heat lightning is the glow of lightning so far away that its thunder cannot be heard.

Topic 3 Lightning Danger and Protection

Lightning can be very dangerous. Every year in the United States lightning causes thousands of forest fires and electrocutes about 200 people.

When lightning strikes, it is likely to go from the cloud base to the highest point projecting above the ground. It often strikes tall objects, such as trees, church steeples, and the tops of skyscrapers. Lightning rods are based on this fact. They project above the roofs of

Lightning Safety Tips

1. *Go indoors, if possible. If you are traveling, stay in your car.*
2. *Stay off bicycles, motorcycles, scooters, golf carts, or farm equipment.*
3. *If you are swimming, get out of the water. Get off small boats.*
4. *Avoid standing near or being the highest object in an area. Outdoors, the best protection is in a cave, ditch, or canyon. If you are out in the open with only isolated trees nearby, crouch in the open as far away from the trees as possible.*
5. *Indoors, stay away from open doors and windows and metal objects such as pipes, sinks, stoves, and radiators. Do not use the telephone or plug-in appliances.*
6. *If you feel lightning is about to strike — your hair stands on end or your skin tingles — drop to your knees and bend forward with your hands on your knees.*

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houses and are connected to the ground by a good conductor, such as a metal wire. When lightning strikes the rod, the electricity is conducted to the ground. Otherwise it might strike some part of the house and set the house on fire.

Where should one take shelter in a lightning storm? The best shelter is inside a building. Stay away from televisions, telephones, sinks, and bathrooms, since the electrical wiring and metal pipes of your house can conduct electricity. Cars are also very safe. Bathers and boaters should seek shelter as soon as a storm develops. A tree or small group of trees in an open field should be avoided. They attract lightning. If you are out in the open during a lightning storm, crouch on the ground.

30.3 A tornado at the bottom of a thunderstorm cloud

Topic 4 Tornadoes

Tornadoes are much more frequent in the United States than anywhere else in the world. Most tornadoes in the United States occur in the Mississippi River valley and the Great Plains. The conditions that produce strong thunderstorms often also produce tornadoes. Warm, moist air from the Gulf of Mexico moves northward into the Mississippi River valley and the Great Plains. This air extends from the surface up to 3 kilometers deep. Higher up, cool air moves eastward over the Rocky Mountains. So the air is moist at lower levels. It is also very unstable, with the temperature falling rapidly with height through a deep layer. A cold front approaches. This is ideal for producing thunderstorms. Strong wind increasing with height helps to make the thunderstorms stronger.

A **tornado** is a narrow, funnel-shaped column of spiral winds that extends downward from the cloud base and touches the ground. The strengths of tornadoes vary greatly. The strongest winds in a tornado are between 360 and 500 kilometers an hour. The funnel is usually less than 500 meters across at the ground. A tornado travels with its parent thunderstorm, at speeds ranging from 40 to 65 kilometers an hour. Tornado paths are somewhat irregular and usually less than 25 kilometers long. They pass in a few seconds with a thunderous roar. Tornadoes usually last no more than an hour and are accompanied by heavy rain, lightning, and hail.

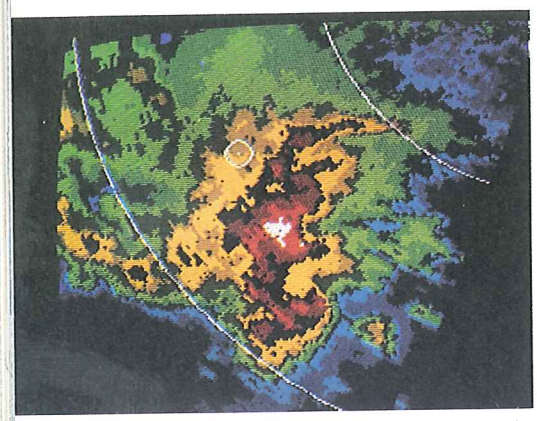
The tornado funnel is a mixture of cloud and dust. The pressure gets lower closer to the center of the tornado. As air flows toward the funnel, it expands from the lower pressure and cools. When the air cools to its dew point, tiny water drops form. Clouds form in exactly the same way when rising air reaches the condensation level. The low pressure in a tornado causes the condensation level to dip downward, forming the funnel of clouds. Sometimes the dust picked up by the tornado forms a separate funnel surrounding the condensation funnel.

Tornadoes over water are called **waterspouts.** Waterspouts are usually weaker than tornadoes. They occur with weak thunderstorms and even large cumulus clouds.

Tornado Safety Tips

1. *If you live in an area frequented by tornadoes, plan safety rules for your family. Choose the best tornado shelter area in your home and make sure everyone knows where it is. Keep a battery–powered radio that you can use in the event of an emergency. Watch any thunderstorm clouds for signs of a funnel, and know how to reach the local authorities if you spot one. Practice tornado drills.*
2. *In the event of a tornado, stay away from outside walls, windows, and doors. At home, go to the basement or an interior room on the lowest level. If possible, get under a heavy table or mattress.*
3. *In a public place, go to the designated shelter area or sit close to an interior wall on the lowest level.*
4. *Get away from mobile homes or vehicles if possible; find more substantial shelter.*
5. *If you are outdoors in an open area, look for a ravine or ditch. Lie flat and protect your head with your arms.*

30.4 Radar view of a severe thunderstorm. The inner colors indicate the largest or heaviest precipitation. The heavy precipitation is drawn into two hook shapes; these "hook echoes" indicate possible tornadoes. The existence of a tornado must be confirmed by spotter reports or winds from the Doppler radar. (The curved lines are 40 km apart.)



Topic 5 Severe Weather Watches and Warnings

When conditions favor the formation of severe thunderstorms or tornadoes, the National Severe Storms Forecast Center in Kansas City, Missouri, issues watches. A **severe thunderstorm** has wind gusts at least 80 kilometers per hour, hail about 2 centimeters in diameter or greater, or the presence of a funnel cloud or tornado.

Local weather stations issue severe thunderstorm or tornado warnings whenever necessary. Watches and warnings are broadcast over radio and television. Watches and warnings are also given for flash floods.

A *watch* covers an area of 100 kilometers by 200 kilometers or larger. It gives the time during which severe thunderstorms and tornadoes are possible.

A *warning* is issued when a tornado or severe thunderstorm has actually been sighted or detected on radar. It gives the location of the storm when detected, the area into which it is likely to move, and the period of time during which the storm could hit.

Tornadoes and severe thunderstorms are most frequent during spring and summer and are most likely to occur in the late afternoon. The worst tornado ever recorded was the Tri-State tornado which killed 689 people in Missouri, Illinois, and Indiana in 1925. From 1975–1979, tornadoes in the United States killed an average of 54 persons yearly. Fewer people have been killed by tornadoes in recent years because of improved warnings.

TOPIC QUESTIONS

Each topic question refers to the topic of the same number.

1. **(a)** What is a thunderstorm? **(b)** How are air-mass and frontal thunderstorms different?
2. **(a)** What is lightning? **(b)** What causes the rolling sound of thunder.
3. **(a)** Where does lightning tend to strike? **(b)** Explain how a lightning rod works. **(c)** List the safest places to be during a lightning storm.
4. **(a)** What conditions favor strong thunderstorms and tornadoes? **(b)** Describe a tornado, giving its shape, diameter, path length, speed of travel, and maximum winds. **(c)** What is the funnel made of? **(d)** Where do tornadoes most commonly occur?
5. **(a)** What is a severe thunderstorm? **(b)** What is a severe thunderstorm watch? **(c)** When are warnings given?