What You Need to Complete this Merit Badge

**Required**

- Blue Card (from your Scoutmaster)

**Highly Recommended**

- Weather Pamphlet (from the troop library or the scout store)
- Weather Workbook (free just click on the link)
- Bonus Study Guide

Click on the link for instructions on how to fill it out.
The Merit Badge Pamphlet & Workbook

IMPORTANT NOTES!

1. This presentation does not replace the Merit Badge Pamphlet.
   Read the Merit Badge Pamphlet

2. The Merit Badge workbook can help you complete your requirements but you still need to
   Read the Merit Badge Pamphlet.

   The work space provided for each requirement in the workbook should be used to make notes for
discussing each item with your counselor, not for providing full and complete answers.

3. You must do each requirement to earn the Merit Badge.
Earth’s atmosphere can be thought of as an ocean. It is an ocean of air instead of water. The air is almost never at rest. Its restless movement is the source of everything people call weather. The study of the atmosphere and its weather is the science of meteorology.
The atmosphere is a mixture of gases, six of which are present in amounts large enough to be important in studying meteorology. Four of the six stay more or less in constant proportions, at least in the atmosphere’s lowest 8 miles or so. The most abundant of these is nitrogen, making up about 78 percent of the atmosphere. Oxygen is next, at about 21 percent, followed by argon at about 1 percent, and carbon dioxide at about 0.03 percent. Nitrogen, oxygen, and carbon dioxide are essential to life on Earth. If their proportions were to change significantly, all life would disappear. The atmosphere contains two other important gases. Go to the *Weather Merit Badge Pamphlet* and read about the other 2 gases starting on page 7.
A cross section of the atmosphere shows that it consists of four main layers. There is no “top” to Earth’s atmosphere. Instead, it gradually thins until it vanishes into the vacuum of space. The lowest layer of Earth’s atmosphere is called the **troposphere**. This layer varies in depth from about 10 miles at the equator to only 4 miles over the North and South poles. It is within this layer that most weather occurs.

The troposphere is constantly stirred by the motions that produce weather, so the mixture of gases is nearly constant. Earth’s surface, which is warmed by the sun, in turn warms the air of the lower troposphere. As a result, temperatures in this layer tend to decrease as altitude increases. On average, for every 1,000 feet gained, the air temperature will decrease by roughly 3.5 degrees Fahrenheit.

The layer above the troposphere is the **stratosphere**. This layer extends to a height of about 30 miles. In the stratosphere, the atmosphere is quite thin and the mixture of gases begins to change. The small amount of ozone in the stratosphere is vital to life on Earth because it absorbs the sun’s harmful ultraviolet radiation.

The boundary between the troposphere and stratosphere is called the **tropopause**, a lid on the weather-filled troposphere. Temperature begins to increase with height above the tropopause because an increasing number of ozone molecules absorb the sun’s ultraviolet radiation. Above the stratosphere is the **mesosphere**, which extends about 30 to 50 miles. Temperature decreases with height in this coldest layer of the atmosphere. The next layer is the **thermosphere**. Because of the sun’s rays, air temperatures in this layer can reach more than 1,800 degrees.

Go to the *Weather Merit Badge Pamphlet Chapter 1* and read more.
The Origin of Wind

In prehistoric times, humans became aware that the weather—cloudy or clear skies, warm or cold air—depended on wind direction and speed. During the 1600s, people learned that air has weight. Scientists discovered that air becomes lighter when it is warm and heavier when it is cold. Because the pressure that anything exerts on the surface of Earth depends on its weight, air temperature affects air pressure. Air temperature also is a factor in how winds arise. If air in one place is heated so that it is warmer than the air around it, that air tends to rise. As it does, air must flow in from around the heated region to replace the air that is rising.

Air has weight for the same reason you do. It is held to Earth by gravity. In fact, the air above a square inch of Earth’s surface exerts 14.7 pounds of pressure at sea level. Atmospheric pressure, or air pressure, is the amount of force the air exerts on a unit surface area (an area that has equal length and width). Why don’t you feel all that weight pressing down on you? One reason is that the air is not really pressing down but is pressing in all directions. Also, the air inside your body is pressing in all directions with equal pressure.
The Origin of Wind

If you live near a seacoast, you may see this process operate every day. During the day, the land heats more rapidly than the ocean. This heat warms the air over the land and makes it rise. Cooler air from the ocean flows in to replace it. In turn, the rising air over land flows out to sea at some level above the surface to replace the air flowing inland. This creates a sea breeze. At night, the opposite happens. The land cools more rapidly than the ocean. Air flows from land to sea at the surface, and the cycle is reversed. The circulation that results is a land breeze. Similar circulations can develop around mountains, creating mountain and valley breezes. The winds that create the weather all arise in this way, as a result of unequal heating. However, it is not always this easy to understand why winds behave the way they do.

The fact that sunlight does not evenly heat Earth’s surface means that temperatures vary from place to place and from time to time. This difference in air temperature (and therefore air pressure) creates a force that makes the air move from high- to low pressure regions, trying to equalize the pressure. When the motion of the moving air is vertical or nearly so, it is called a current. When the motion is more horizontal, it is called wind.

Go to the Weather Merit Badge Pamphlet Chapter 1 and read more.
Warm air near the equator, in the tropics, tends to rise and flow toward the poles (poleward). Along the way, the air cools and begins to sink. Because the equatorial regions are warm, they tend to form a belt of relatively low pressure. The regions of sinking air tend to be associated with relatively high pressure, in what are called the “horse latitudes,” or sub-tropics.

In a similar fashion, air over the poles tends to sink, being colder and heavier. This sinking sends the air flowing into the subpolar regions, where it warms and rises, forming a belt with relatively low pressure at the surface. (Remember, warm air brings about low pressure, and cold air brings about high pressure because it weighs more.)

The middle latitudes lie between the belt of subpolar lows and the sub-tropic highs. Most of the United States can be found in the Northern Hemisphere’s middle latitudes. The Southern Hemisphere also has middle latitudes. Air tends to flow poleward at the surface of Earth, and toward the equator (equatorward) aloft, completing the transition between the polar and equatorial circulations.
Notice on the diagram how the surface winds blowing toward the equator in both hemispheres tend to flow from east to west. Similarly, the surface winds blowing poleward tend to include a flow from west to east. Meteorologists refer to winds according to the direction from which they blow. Winds blowing from east to west are called *easterlies*, and winds blowing from west to east are called *westerlies*. If it were not for the development of easterly and westerly winds, the tendencies for winds to blow straight from high- to low-pressure regions would be very similar to the local breezes described at the beginning of this chapter.
The Relationship Between Wind and Pressure

To understand why global winds have both easterly and westerly movement, remember that Earth is rotating about its polar axis. It makes one complete turn in 24 hours, which causes day to alternate with night. The speed of rotation varies as you move north or south—it varies with latitude. You can see this on a globe. Spin the globe and watch while points near the equator move fast while the poles do not move at all. A point on Earth’s equator travels more than 1,000 miles per hour (about 25,000 miles in 24 hours), while the poles do not move. This difference in speed produces an interesting effect as seen by an observer watching things from Earth. Imagine firing a cannon due south. As the cannonball travels south, it passes over points that are moving more and more rapidly beneath it. Its path, as seen on Earth (the solid arrow), curves to the right. A mysterious force appears to make the path of the cannonball curve. An observer in space would see the path of the cannonball as a straight line (the dashed arrow in the diagram), but it appears curved to earthbound observers.

This apparent force—called the Coriolis force after French scientist Gustave-Gaspard Coriolis, who first described it—is very real to people living on the rotating Earth. It must be accounted for when firing long-range weapons. It also affects spacecraft such as the space shuttle. For the weather, it makes the moving air seem to curve to the right in the Northern Hemisphere and to the left in the Southern Hemisphere.

Much of the time, a low-pressure system is related to poor weather, and a high-pressure system is related to fair weather. The rising air of a low-pressure system invites the formation of clouds and precipitation. The sinking air of a high-pressure system makes cloud formation less likely.

Go to the Weather Merit Badge Pamphlet Chapter 1 and read more.
Moisture – The Water Cycle

The most important thing about the weather is the moisture it brings. The wind could blow night and day and the temperature could rise and fall, but if no rain fell, Earth would be in real trouble. Fortunately, in addition to a wonderful air-circulating system, Earth has a wonderful water-circulating system. The water vapor that forms clouds and precipitation comes mostly from evaporation from Earth’s oceans. A small part comes from lakes, streams, and transpiration, that is, the giving off of water by the leaves of green plants. Most of the rain that falls over land evaporates and is transported as water vapor by the winds, often many thousands of miles from its source.

Water vapor condenses (changes from a gas to a liquid) in clouds and falls back to Earth as rain, snow, and other forms of precipitation. Some precipitation forms runoff, the water that flows in rivulets and streams to the rivers. Part of the precipitation filters down into the ground to replenish the groundwater supply, which also feeds the rivers. Some groundwater is taken up by plants that restore it to the atmosphere through transpiration. Some precipitation falls as snow. Of this, most eventually melts and becomes runoff or groundwater. However, part of the snowfall remains frozen, locked into slow-moving rivers of ice called glaciers.

A considerable amount of Earth’s water supply is tied up in the form of ice over the polar regions of the globe, especially in Antarctica. The ice gradually moves in glaciers toward the ocean, but it may take hundreds or thousands of years for water that falls as snow over glaciers to reach the ocean.
All of the events described—evaporation, transpiration, water vapor transport, condensation, precipitation, runoff, and streamflow—are part of a cycle of events known as the water cycle, also called the hydrologic cycle. On the whole, the cycle is in balance, that is, the total amount of water on the planet remains constant.

A small amount of the groundwater becomes trapped in the ground, forming underground reservoirs called aquifers. In many parts of the world, including the United States, the water in aquifers is tapped for human use, especially for irrigation. Once the aquifers are drained, they may not fill again for thousands of years. Polar ice packs, glaciers, and underground aquifers tie up some of Earth’s water supply, but overall, water that evaporates from the oceans eventually finds its way back to the oceans.
Atmospheric humidity describes the amount of water vapor in the air. Air holding the maximum amount of water vapor possible is said to be saturated. The saturation point depends on the air’s temperature. Warm air can hold much more moisture than cold air can. Therefore, air can be pushed to saturation when it is cooled or when more water vapor is added (through evaporation or transpiration). On a clear night, the temperature of the air near the ground may fall until saturation is reached. If the air continues to cool to the point that it can no longer hold all the water vapor, some of the water will be forced to condense onto objects on the ground, forming dew.

The dew point is the air temperature at which saturation takes place when the air pressure stays constant. If the air already is saturated, the air temperature and the dew point are the same. Dew point often remains fairly constant during the day.

Some people refer to dew and frost as precipitation, but they are not forms of precipitation because they do not actually precipitate, or fall.

Go to the Weather Merit Badge Pamphlet Chapter 2 and read more about the Water Cycle.
Clouds and Precipitation

Clouds form when water vapor condenses to form ice crystals or water droplets in the air. Cloud formation generally is associated with rising air. Air cools as it ascends because pressure decreases with height. The drop in pressure causes the rising air to expand, eventually, the air to its dew point. Then condensation or freezing begins. The water vapor condenses around tiny particles in the air, such as dust or salt from the sea. The resulting droplets are about one-millionth the size of a medium raindrop. These condensed particles are so minuscule that turbulent air motion holds them aloft.

Learning Latin

The cloud names are derived from Latin words. If you learn the Latin meanings, you can more easily remember the cloud types. Here are the basic Latin-based words and their meanings.

- **Cirrus**: Curl or tendril of hair
- **Stratus**: A layer, like a blanket stretched out
- **Cumulus**: A heap or pile (Think of the word **accumulate**.)
- **Nimbus**: Rain
Cloud Formation and Types

Meteorologists use four main groupings for clouds: low clouds, middle clouds, high clouds, and clouds that develop vertically. Meteorologists also consider the shapes of clouds.

High Clouds
The highest clouds are generally above 20,000 feet and are called cirrus clouds. These high clouds are often wispy. Cirrus clouds are composed entirely of ice crystals because of their low temperatures and the heights where they form. Sometimes cirrus clouds are lumpy. Those are called cirrocumulus. Cirrocumulus clouds can be arranged in patches or aligned in rows.

Cirrus clouds forming in extensive flat layers are known as cirrostratus. Cirrostratus clouds can cover the whole sky or only part of it and can be quite thin and nearly transparent. When cirrus clouds give way to cirrostratus, precipitation may be on the way within the next 24 hours. The deep, towering thunderheads known as cumulonimbus clouds can be more than 50,000 feet tall and can occupy more than one height category. Their height certainly qualifies them to be high clouds, though meteorologists think of them as clouds of vertical development. Cumulonimbus clouds almost always flatten out near the tropopause. Their flat, anvil-shaped top is a help in identifying them. Cumulonimbus clouds will likely bring lightning, heavy rain, and possibly hail.
Cloud Formation and Types

Middle Clouds
The middle group of clouds, with heights roughly between 10,000 and 20,000 feet, has the prefix *alto-*.

This group includes *altocumulus* clouds, which often look like a fluffy blanket covering the sky. Altocumulus clouds also can appear in patches or in rows. They can be distinguished by the rounded contours of the clouds with small openings showing blue sky above, and by their height. Altocumulus clouds indicate that moisture is rising and that rain may be on the way.

*Altostratus* clouds appear flat and layered. Altostratus clouds occasionally can cover nearly the whole sky but can be thin enough to let the sun show through dimly. Altostratus clouds indicate an approaching warm front and a change of weather, such as rain or snow.
Cloud Formation and Types

Low Clouds

Low clouds appear from near Earth’s surface up to about 10,000 feet. *Stratus* clouds appear as a uniform cloud layer, with little or no texture. *Stratocumulus* clouds typically are flat and nearly uniform at their bases but puffy and clumped on top. They are likely to form heavy ridges that look like corrugated roofing. Stratocumulus clouds often indicate heavy precipitation, especially if they are at the head of a cold front. *Nimbostratus* clouds are dark, sheet like clouds and indicate that rain or snow is falling. *Cumulus* clouds form below 6,500 feet but can grow very tall, much taller than they are wide. Meteorologists consider them clouds of vertical development. When these fluffy “cloud ships” float in the bright blue sky, they are called fair-weather cumulus, and they usually mean good weather is ahead.

Watch the Video:  Cloud Types
Snow forms when cloud temperatures are well below freezing. Ice crystals become larger when they attract water from nearby super cooled water droplets. When the ice crystals are heavy enough to fall, they stick to other ice crystals and form snowflakes. Snow can form and fall even when temperatures at Earth’s surface are above freezing. If surface temperatures are warm enough, however, the falling snow will melt before reaching the ground and will fall as drizzle or rain. Melting snowflakes usually are small enough to become drizzle, but sometimes snowflakes clump together and form small white pellets called graupel (pronounce the “au” like “aw” in “crawl”).

Precipitation

A cloud is made of water vapor that has condensed into tiny water droplets or ice crystals. As more and more water vapor condenses, some of the particles collide with each other and merge to form droplets large enough to begin to fall. As they fall, they continue to grow by sweeping up smaller droplets along the way—a process called coalescence. When droplets become just large enough to fall to the surface, they are called drizzle. It may take a thousand or more cloud droplets to form a single drop of drizzle. As the droplets continue to grow, they reach a size large enough to be called rain.
Sometimes rain will fall and hit a layer of below-freezing air before it reaches the ground. The rain then forms ice pellets, or *sleet*.

If rain falls to the ground and hits a very cold surface, the result is *freezing rain*. Freezing rain can cause icy road conditions and can form heavy ice coverings on power lines and vegetation.

One of the most spectacular forms of precipitation is *hail*. Hail is the result of ice forming in the rising currents of air, or *updrafts*, of thunderstorms. When an updraft is strong enough, it holds the ice aloft. Many layers of super cooled water freeze to the ice pellets, adding to their size. They give the hailstone a structure like an onion.
Visibility

Visibility indicates the transparency of air. Air contains particles that reflect and scatter light, so that objects at a distance cannot be seen. Smoke from fires, dust picked up over land, and salt particles from evaporated ocean spray can be carried great distances by wind and can collect in still areas. Water droplets in the form of clouds or fog can also reduce visibility, as can raindrops and snowflakes if there are enough of them.

Supercooling

An interesting phenomenon called supercooling plays a role in the formation of snow. Water that is supercooled remains in its liquid state when the temperature is below freezing. The reason the water does not freeze is that, in order for a liquid to crystallize into a solid, there needs to be something for the crystals to form around, such as a particle of dust, salt, or plant matter. If a water droplet in a cloud contains no such particle, or nucleus, it will remain liquid. However, when a nucleus is present, an ice crystal will begin to form and grow around the nucleus.
The movement of a frontal system often is heralded by a procession of different cloud types, each signaling a greater likelihood of an approaching storm. You might first see a clear sky of high, feathery cirrus clouds, or “mare’s tails.” These clouds will thicken until the sun is hidden behind a thin cirrostratus veil. A gray curtain of altostratus clouds comes next, followed by a moist blanket of dark stratus clouds rolling close to Earth. Finally, nimbostratus clouds bring rain. Of course, not all clouds signal bad weather. Cirrus clouds detached from one another indicate that the weather will stay fair for a while. A scaly mackerel sky formed by cirrocumulus clouds usually promises fair weather, but it also might be a sign of inclement weather. Outdoor groups eager for dry trails welcome the sight of cumulus clouds. On hot days, however, travelers are wise to take cover if swelling cumulus clouds develop into dark cumulonimbus thunderheads, the breeders of violent storms.

Watch the Video: Precipitation
In radio and television weather reports, you often hear about fronts. A weather reporter might say something like, “A warm front is coming up the coast” or “A strong cold front is moving down from Canada.” These reports sound as though an invasion were on the way! In a sense, that’s right. The reports are describing the invasion of air masses. Air masses form when air remains in place over a particular region for several days. The air gradually takes on the characteristics of the surface beneath it. For example, air over tropical oceans becomes warm and moist, while air over snow-covered polar regions becomes dry and cold. When the air moves away from the place where it formed, known as its source region, it replaces air of a different type. The boundaries between air masses of different types are what meteorologists call fronts. Fronts are regions of transition and often are where important weather events take place. Air masses usually are associated with high-pressure regions (anticyclones) at the surface. Low-pressure regions (cyclones) dominate on the boundaries of air masses. By increasing the winds and pushing the air away from its source, the development of cyclones causes air masses to move away from their source regions.
When cold air replaces warmer air, the front is called a **cold front**. In the United States, cold air usually comes from the north or northwest of Canada and from the polar regions. Because cold air is denser than warm air, it tends to stay nearer the surface and wedges beneath the warm air. This tends to make the warm air rise, as seen in the diagram. The rising air cools by expansion, forming clouds and perhaps precipitation. Because the advancing cold air remains near the surface where friction is a factor, the movement of the cold air is slowed somewhat by the friction of objects and landforms on Earth's surface. This creates a steep slope along the leading edge of the front. The slope can mean that most of the rising motion along the front is confined to a narrow zone near the front.

When warm air replaces cold air, the front is called a **warm front**. Warm air masses form over the warm tropical oceans south and southeast of the United States and over land areas to the southwest. Those forming over oceans are moist. Those forming over land are dry. When warm air approaches a cold air mass, it tends to ride up over it rather than wedging beneath it. Unlike cold fronts, therefore, warm fronts tend to have gentle slopes. As the warm air rises and cools, clouds and precipitation may form. The shallow slope means that rain and clouds can precede the passage of a warm front by a day or more.

Go to the *Weather Merit Badge Pamphlet Chapter 3* and read more about Clouds and Precipitation.
Hazardous Weather

People readily adapt to routine weather changes that occur with the passage of air masses. Sometimes, however, the weather can become so violent that people need to take special precautions. Forecasters with the National Weather Service issue watches, warnings, and advisories to alert the public to potentially violent or hazardous weather. There is an important difference between a watch and a warning. A watch means that hazardous weather is possible or that conditions are favorable for it to develop. A warning is a more urgent notice that hazardous conditions already exist or are heading your way. Watches and warnings are issued for events such as winter storms, tornadoes, severe thunderstorms, high winds, and flash floods. The National Weather Service issues advisories when conditions are expected to cause serious inconveniences. A common type of advisory alerts motorists to hazards such as slippery roads caused by wintry weather.

Winter Storms
During the winter, some cyclones (low-pressure areas) develop into unusually intense storms that bring heavy snow, strong winds, and cold temperatures. When the wind is strong enough (above 35 miles per hour) and visibility is reduced to less than a quarter mile by snow or blowing snow, the event is termed a blizzard. Even if a snowstorm does not quite qualify as a blizzard, a combination of snow, wind, and cold can be deadly for people caught unprepared.

Always melt snow for drinking, rather than eating it to quench thirst. Using your own body heat to melt snow will lower your body temperature.
Thunderstorms
Thunderstorms are most common in the tropics and subtropics and during the warm season in the middle latitudes, but they
can occur in winter and at polar latitudes. They form when warm, moist air creates updrafts that form large precipitation
drops in clouds. As this precipitation develops, positive and negative electrical charges separate and build up in different
parts of the clouds and on the ground beneath the clouds. When charges have built up enough, they can “jump the gap”
between regions of opposite charge, discharging the areas. This discharge is what we see as **lightning**. Some lightning
flashes strike the ground, but most are from one part of a cloud to another. Lightning ground strikes, fairly common in the
United States, can be deadly. In the United States about 90 people die each year from being struck by lightning. **Thunder** is
caused by the great heat generated during the brief time (less than a second) that a lightning discharge occurs. The heat
causes the air to expand rapidly, as in an explosion. You hear thunder **after** you see lightning because of the difference
between the speed of sound and the speed of light. Sound travels at a speed of 1,100 feet per second, but light travels
at a speed of about 186,000 miles per second. Therefore, you will see a lightning flash almost instantly, but the sound of
thunder will take longer to reach you.

**Count the seconds it takes for the sound of the thunder to reach you after you see a lightning flash. Since a mile is 5,280 feet, it takes
thunder about 5 seconds to travel 1 mile.**
Floods
Floods are an unavoidable part of life along rivers. The torrential rains of thunderstorms or tropical cyclones can cause flooding. Some floods occur when winter or spring rains combine with melting snows to fill river basins with too much water too quickly. Such events usually take several days to develop. Other floods arise suddenly as the result of heavy localized rainfall. These flash floods can become raging torrents very fast, sometimes in less than an hour, and can sweep away everything in their path.

Tornadoes
On rare occasions, rapidly rotating columns of air form within a thunderstorm. When these rotating columns reach Earth’s surface, they become tornadoes. Tornadoes can produce the strongest winds on Earth, occasionally reaching 300 miles per hour or more. The tornado is an extreme form of cyclone, with very low pressure at its core. Most tornadoes produce paths of damage that are only a few hundred yards wide or less. Because tornadoes usually last only a few minutes, path lengths typically are a mile or less. A few tornadoes, however, are more than a mile wide and last for an hour or more, producing damage paths more than 100 miles long.

Hurricanes
Among the most dangerous storms that affect the United States are hurricanes. They originate in the southern part of the north Atlantic Ocean, the Caribbean Sea, the Gulf of Mexico, and the southeastern Pacific Ocean off the west coast of Mexico. Similar storms occur elsewhere in the world, notably in the oceans near India and Australia, where they are called cyclones, and in the western Pacific Ocean, where they are called typhoons. A general name for all such storms is tropical cyclone.

Go to the Weather Merit Badge Pamphlet Chapter 4 and read more about Hazardous Weather.
Measuring and Recording the Weather

Accurate information about the various factors that together define the weather is necessary in making reliable forecasts. For each of these factors, there is an instrument that measures intensity, velocity, or degree.

**Air Pressure**

Air pressure is measured using a barometer. An aneroid barometer is the type you are most likely to have at home or see in stores. It uses a small, thin-metal “box” sealed with average air pressure inside. The box contracts under high pressure and expands when the outside air pressure drops. An indicator needle is attached to the side of the box by levers and records the pressure on a dial. Scientific barometers used by laboratories and weather offices contain mercury, a metallic element that is liquid at room temperature. A simple mercury barometer consists of a slender glass tube filled with mercury and closed at one end. The open end of the tube rests in a bowl of mercury. The mercury in the tube falls to a level that is about 30 inches above the level of that in the bowl. A vacuum forms at the top of the tube. Air pressure acts on the surface of the mercury in the bowl, forcing the mercury up into the tube. The higher the air pressure, the higher the level of mercury in the tube.

Mercury is very poisonous. Just a small amount can pollute a large body of water such as a lake. The United States government has placed restrictions on mercury. If you have an old barometer that uses mercury, be careful never to open it up. Liquid mercury can be absorbed through your skin. Just a small amount can also poison the air, and disposing of it improperly will cause pollution.
Measuring and Recording the Weather

Barometers, either mercury or aneroid, are read in terms of the height in inches of a column of mercury. Average air pressure at sea level corresponds to a column of mercury about 30 inches tall. This is where the barometer reading comes from on weather reports—a pressure of 30.25 inches, for example. Air pressure at sea level varies by only a small amount. A reading of, say, 31 inches is unusually high, while a reading below 29 inches occurs only in the strongest cyclones, such as hurricanes. The exact height of the mercury column depends not only on air pressure, but also on the altitude where the reading is taken. To adjust for differences in elevation, it is common to correct the readings for altitude so that the measurements are comparable to those taken at sea level. On actual weather maps, pressures are converted to millibars, the scientific unit used to measure pressure. The numbers on the isobars on a weather map correspond to pressure adjusted to sea level in millibars.

The rate at which the air pressure is changing often is more important than the pressure reading itself. Air pressure rises typically with the approach of high pressure and its attendant fair weather. So if you hear a weather reporter say, “The barometric pressure is 29.65 inches and rising,” you can be pretty sure that good weather is on the way. Likewise, the approach of a low-pressure area causes the reading to fall.

Changes in pressure result in changes in width of an aneroid barometer’s sealed box. Levers and springs convert these changes into pressure readings.
Measuring and Recording the Weather

Wind Direction
You probably have seen wind vanes on houses and barns. Most are in the form of an arrow that pivots on special bearings so that it can turn freely in the wind. It is accurately balanced on the bearing. The size of the “feather” part of the arrow is larger so that wind vanes always swing into the wind and point in the direction from which the wind is coming.

Wind Speed
Wind speed is measured by an instrument called an anemometer. Although there are several types of anemometers, the most common type is a cup anemometer, in which three or four cups are mounted on horizontal rods. The unit is attached to a vertical rod so that it can rotate as the wind turns it. As wind speed increases, so does the speed at which the cups rotate. Wind speed is measured by the number of turns the cups make in a set period of time. Wind speeds can be measured in miles per hour, in knots, or in meters per second. A knot is one nautical mile per hour—a nautical mile is about 6,080 feet, roughly 15 percent longer than an ordinary mile of 5,280 feet. Miles per hour normally are used in the weather reports you hear on radio and television, while knots are used mostly in marine and aviation weather reports. Most scientific measurements are in meters per second.
Measuring and Recording the Weather

This scale was devised by Sir Francis Beaufort in 1805. Although used mainly to estimate winds at sea, the visible effects described here relate to observations on land.

<table>
<thead>
<tr>
<th>Beaufort Number</th>
<th>Description</th>
<th>Wind Speed (mph)</th>
<th>Observations (visible effects on land)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Calm</td>
<td>Less than 1</td>
<td>Smoke rises vertically.</td>
</tr>
<tr>
<td>1</td>
<td>Light air</td>
<td>1–3</td>
<td>Wind direction is shown by smoke drift, but not by wind vanes.</td>
</tr>
<tr>
<td>2</td>
<td>Light breeze</td>
<td>4–7</td>
<td>Wind is felt on the face; leaves rustle; ordinary vanes are moved by the wind.</td>
</tr>
<tr>
<td>3</td>
<td>Gentle breeze</td>
<td>8–12</td>
<td>Leaves and small twigs are in constant motion; wind extends a light flag.</td>
</tr>
<tr>
<td>4</td>
<td>Moderate breeze</td>
<td>13–18</td>
<td>Dust and loose paper are raised; small branches are moved.</td>
</tr>
<tr>
<td>5</td>
<td>Fresh breeze</td>
<td>19–24</td>
<td>Small trees in leaf begin to sway; crested waves form on inland water.</td>
</tr>
<tr>
<td>6</td>
<td>Strong breeze</td>
<td>25–31</td>
<td>Large branches are in motion; whistling is heard in telegraph wires; an umbrella is difficult to use.</td>
</tr>
<tr>
<td>7</td>
<td>Moderate gale</td>
<td>32–38</td>
<td>Whole trees are in motion; inconvenience is felt in walking against the wind.</td>
</tr>
<tr>
<td>8</td>
<td>Fresh gale</td>
<td>39–46</td>
<td>Twigs break off trees; progress generally is impeded.</td>
</tr>
<tr>
<td>9</td>
<td>Strong gale</td>
<td>47–54</td>
<td>Slight structural damage is reported; branches break.</td>
</tr>
<tr>
<td>10</td>
<td>Whole gale</td>
<td>55–63</td>
<td>Considerable structural damage is reported; trees are uprooted; seldom experienced inland.</td>
</tr>
<tr>
<td>11</td>
<td>Storm</td>
<td>64–72</td>
<td>Widespread damage is reported; very rarely experienced.</td>
</tr>
<tr>
<td>12</td>
<td>Hurricane</td>
<td>Above 72</td>
<td>Extreme damage is reported.</td>
</tr>
</tbody>
</table>
Measuring and Recording the Weather

How to Read a Weather Map

Weather maps you access may vary in detail from the maps shown. Simpler versions usually appear in newspaper and television weather reports, while maps analyzed by weather forecasters often are much more detailed. But general features (such as fronts) are shown similarly on most maps using standard symbols like those shown here.
Measuring and Recording the Weather

Visit a Weather Office
The National Weather Service has more than 120 offices in the United States and its territories. You should be able to arrange a visit to one while you are working on your Weather merit badge requirements. Alternatively, you might meet with a weather broadcaster at a local television station or an instructor from the meteorology or atmospheric science department at a nearby university or college. There also are many amateur weather observers who can show you the basic measurements, instruments, and weather charts.

The most obvious way to study the weather is to observe actual events and keep record of what you see. Daily observations of temperature, wind, pressure, clouds, and rainfall can help you understand how the atmosphere behaves. Keep a daily weather log, similar to the one shown, for at least a week. If possible, record observations for a month or more. Make entries at the same time each day. You can obtain readings from your own instruments, from local television or radio, and from Internet sites devoted to meteorology. Up-to-the-minute weather information is also available from the NOAA. NOAA Weather Radio, operating on high-band FM frequencies, transmits updates that can be received by special receivers and by AM/FM radios equipped with a weather-band feature. By comparing readings from day to day, you can see how the various weather elements change at your location in response to passing weather systems.

<table>
<thead>
<tr>
<th>Date</th>
<th>Observed Weather</th>
<th>Temperature</th>
<th>Relative Humidity</th>
<th>Wind (Direction/Speed)</th>
<th>Pressure</th>
<th>24-Hour Rainfall</th>
<th>Forecast for Tomorrow</th>
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<tr>
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</tbody>
</table>

Make your own weather chart, using this form as a guide. Keep a 30-day record based on local weather forecasts and your own observations. Make and record observations at the same time each day.

Go to the *Weather Merit Badge Pamphlet Chapter 5* and read more about Measuring and Recording Weather.
Weather and Climate Prediction

The whole of the atmosphere is involved in weather changes. To forecast the weather, a meteorologist must know conditions of temperature, pressure, humidity, and wind throughout the ocean of air, top to bottom and all over the planet. The meteorologist must know about Earth’s oceans as well. Because it is hard to obtain information where there are no people, such as over the oceans, there are many gaps in the knowledge used in weather forecasting.

Forecasting Tools and Instruments

Weather Balloons

Radar

Satellites

Go to the *Weather Merit Badge Pamphlet Chapter 5* and read more about Weather Balloons, Radar, and Satellites.
Weather and Climate Prediction

Climate
Recall that weather is the condition of the atmosphere over a particular area for a short time. Climate is the average of the weather over a region for a longer time, such as 30 years or more. The word climate comes from the Greek word klima, meaning “angle.” This name was used because the angle at which the sun strikes Earth largely determines the climate. At the equator, the sun is nearly straight overhead most of the year, so most of the equatorial region is hot. In the polar regions, the opposite is true. Poleward from the equator, the climate gradually shifts from hot to cold. In between are what we call the temperate zones, which include the United States.

We have seasons because Earth’s axis is tilted relative to the plane of its orbit around the sun. This tilt (about 23.5 degrees from the perpendicular) remains the same all year as seen from deep space (top) but changes relative to the sun (bottom). At the summer solstice (the first day of summer, bottom left), the North Pole tilts toward the sun, and the sun reaches its northernmost point in the sky. This is the longest day of the year in the Northern Hemisphere. The North Pole is in constant daylight, while the South Pole is in constant darkness. Everything is reversed at the winter solstice (the first day of winter, bottom, second from right). The South Pole tilts toward the sun, and the Southern Hemisphere has long days and warm weather as the sun appears at its southernmost point in the sky. In between, during the autumnal equinox and spring equinox, sunshine is evenly distributed across both hemispheres.
Human Impacts on Climate
An important thing to think about is the effect present human activities can have on future climatic conditions. In some areas of the world, human actions have had a clearly negative impact on the local climate.

Desertification
The work of archaeologists has shown that many areas that now are deserts once were fertile and productive. In such places, overgrazing, unsound farming methods, or mining have stripped the land of its protective plant cover and caused desertification of the land. Desertification has occurred in many countries near the Mediterranean Sea and the Arabian Desert. For example, the region north of Egypt and Egypt itself once had lush fields, orchards, and gardens, but over many years human activities resulted in the erosion of fertile topsoil and the loss of plant cover. A cycle began that produced parched soil, sand dunes, and scant rainfall. Similar events have occurred in the United States, such as during the “Dust Bowl” era of the 1930s, but changes in agricultural methods may have kept the effects from becoming permanent.

Acid Rain
Acid rain is another result of the effect human activities can have on weather and climate, some scientists believe. Rain becomes acidic when it is polluted by acidic substances emitted into the atmosphere by vehicles, power plants, and factories. Pollutants in the atmosphere contaminate the precipitation that later falls back to the ground. Scientists say acid rain can destroy life in lakes and rivers, which results in damage to the water cycle, crops, forests, outdoor statues, and buildings.

Other Threats to Climate
Recently, people worldwide have become aware of the possible threat of greenhouse gases. The most notable greenhouse gas is carbon dioxide, given off when fossil fuels such as coal, gas, and oil are burned. Another concern is the loss of the ozone layer. Ozone is a pale blue gas that plays an important role in the stratosphere, where it acts to shield all forms of life on Earth from the sun’s harmful ultraviolet radiation.
Careers in Meteorology

The meteorologists you probably are most familiar with are the weather newscasters on television. But there are many additional career opportunities for meteorologists.

Research and Teaching

Researchers work to further develop satellites, computer programs, mathematical formulas, and other instruments used in forecasting, analyzing, and collecting data related to climate and weather.

Forecasting

Weather forecasting is formally known as operational meteorology. Many forecasters work for the National Weather Service (a branch of the NOAA), which includes the National Center for Environmental Prediction as well as 124 field offices across the country. The National Weather Service is a government agency that gathers information from weather balloons, satellites, and observation stations around the world.

What knowledge and skills do you need to work in meteorology and its related fields? Some guidelines for what it takes to become a meteorologist are listed in the Weather Merit Badge Pamphlet on page 74.
Complete Requirement # 1

Read Chapter 1 in your merit badge pamphlet “Earth & Its Atmosphere”. Define meteorology. Explain what weather is and what climate is. Discuss how the weather affects farmers, sailors, aviators, and the outdoor construction industry. Tell why weather forecasts are important to each of these groups. *Weather Merit Badge Pamphlet page 71.*

Watch the Video: *Weather vs Climate*

Watch the Video: *What is Meteorology*

Once completed proceed to Requirement # 2.
Complete Requirement # 2

Read Chapter 4 in your merit badge pamphlet “Hazards of Weather”. Name five dangerous weather-related conditions. Give the safety rules for each when outdoors and explain the difference between a severe weather watch and a warning. Discuss the safety rules with your family.

Once completed proceed to Requirement # 3.
Re-read Chapter 1 in your merit badge pamphlet “Earth & Its Atmosphere”. Explain the difference between high and low pressure systems in the atmosphere. Tell which is related to good and to poor weather. Draw cross sections of a cold front and a warm front showing the location and movements of the cold and warm air, the frontal slope, the location and types of clouds associated with each type of front, and the location of precipitation.

Once completed arrange a meeting with your counselor
Complete Requirement # 4

Read Chapter 1 and 3 in your merit badge pamphlet “Clouds & Precipitation”. Tell what causes wind, why it rains, and how lightning and hail are formed.

Watch the Video:
What is Lightning made of?

Watch the Video:
How is Hail Formed

Watch the Video:
What Causes Wind

Watch the Video:
Why Does It Rain?

Once completed proceed to Requirement # 5.
Read Chapter 3 in your merit badge pamphlet “Clouds & Precipitation”. Identify and describe clouds in the low, middle, and upper levels of the atmosphere. Relate these to specific types of weather.

Watch the Video: Cloud Types

Once completed proceed to Requirement # 6.
Complete Requirement # 6

Read Chapter 2 in your merit badge pamphlet “Moisture – The Water Cycle”. Draw a diagram of the water cycle and label its major processes. *Explain the water cycle to your counselor.*

Not This  
or this  
or this

These are not the water cycle!

Once completed arrange a meeting with your counselor
Complete Requirement # 7

Read Chapter 6 in your merit badge pamphlet “Weather & Climate Prediction” and identify some human activities that can alter the environment, and describe how they affect the climate and people.

Once completed proceed to Requirement # 8.
Read Chapter 6 in your merit badge pamphlet “Weather & Climate Prediction”. Describe how the tilt of Earth's axis helps determine the climate of a region near the equator, near the poles, and across the area in between.

Once completed proceed to Requirement # 9.
Do **ONE** of the following:

a. Make one of the following instruments □ wind vane, □ anemometer, □ rain gauge, □ or hygrometer. Keep a daily weather log for 1 week using information from this instrument as well as from other sources such as local radio and television stations, NOAA Weather Radio All Hazards, and Internet sources (with your parent's permission). Record the following information at the same time every day: wind direction and speed, temperature, precipitation, and types of clouds. Be sure to make a note of any morning dew or frost. In the log, also list the weather forecasts from radio or television at the same time each day and show how the weather really turned out.

Here are links to make your own weather instruments:

Wind Vane, Anemometer, Rain Gage, Hygrometer

b. Visit a National Weather Service office or talk with a local radio or television weathercaster, private meteorologist, local agricultural extension service officer, or university meteorology instructor. Determine how severe weather and flood warnings reach the homes in your community.

Go to the *Weather Merit Badge Pamphlet Chapter 5*

Once completed arrange a meeting with your counselor. Be sure to bring your instrument if you have made one.
Do **ONE** of the following:

a. Give a talk of at least 5 minutes to a group (such as your unit or a Cub Scout pack) explaining the outdoor safety rules in the event of lightning, flash floods, and tornadoes. Before your talk, **share your outline with your counselor for approval**.

b. Read several articles about acid rain and give a prepared talk of more than 5 minutes about the articles to your unit. Before your talk, **show your outline to your counselor for approval**.
Complete Requirement # 11

Find out about a weather-related career opportunity that interests you. Discuss with and explain to your counselor what training and education are required for such a position, and the responsibilities required of such a position.

Once completed arrange a meeting with your counselor.
Congratulations Scout!

You have just earned your Weather Merit Badge.