A Concise Study Guide for the Weather Merit Badge

By Jay R. Stockton
Senior Forecaster
National Weather Service, Medford Oregon

This guide provides a concise step-by-step study guide for the Weather merit badge. It is patterned to track the badge requirements as listed in official publications of the Boy Scouts of America.

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Requirement 1: 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.

Let's start with the definition of meteorology. Meteorology is the study of the atmosphere and its weather. It is not limited to the atmosphere of the earth. Meteorologists study other planets and even atmospheric conditions around stars and in deep space.

The word meteorology is derived from two greek words. The first is "meteoron", which means "thing in the air". The second is "logos", which in this context means knowledge or discussion. So meteorology literally means "knowledge (or discussion) of things in the air".

There are many different kinds of "meteorons". A lithometeor is made of particles from the ground, such as flying dust and smoke. A hydrometeor is one composed of water, such as a raindrop or snowflake. Electrometeors include lightning and the aurora. Photometeors include rainbows, fogbows, halos, and mirages.

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Now let's talk about weather and climate. Weather consists of the short term (seconds to days) variations in the atmosphere with respect to heat or cold, wetness or dryness, calmness or storminess, clearness or cloudiness. Climate is defined as the average course or condition of the weather at a given location, usually over a period of years, as exhibited by temperature, wind velocity, and precipitation.

Another way to say this is that climate is what you expect, weather is what you get.

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Weather can affect people in many different ways. Farmers are greatly affected by the amount and type of precipitation their crops receive during the growing season. Crops can be damaged by too little or too much rain or by the timing of the rain. Hailstones from thunderstorms can damage fruit. Strong winds from any number of sources can break plants or affect the spraying of pesticides. Frosts and freezes can also damage or kill plants.

Sailors are especially vulnerable to weather as they usually cannot find shelter quickly. Winds are the most important factor as strong winds can generate rough seas, especially if they blow over a long expanse of water upstream from the boat. Sailors can get lost in fog, and freezing spray during cold conditions can damage and even capsize a boat.

Aviators are primarily concerned about three things: Icing, turbulence, and low ceilings and visibilities. Icing is caused by liquid water collecting and then freezing on the aircraft. This makes the airplane heavier, less aerodynamic, and harder to handle. Turbulence, primarily due to strong horizontal and vertical winds, can jostle the airplane, causing difficulty in handling as well as possibly damaging the plane. Low ceilings can obscure terrain and low visibilities make it difficult for the pilot to see where he is going.

The outdoor construction industry is mostly concerned about rain, because certain jobs can only be done in dry weather. Other concerns include strong winds, which can damage structures that are not completely built yet, and temperatures, which can affect the ability to do certain tasks. Of course severe weather, like tornadoes and hurricanes, can destroy all sorts of structures.

Requirement 2: 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.

There are many dangerous weather related conditions. In this discussion, we will cover the five listed in the Weather Merit Badge Series book. The scout may select other conditions not listed here.

Winter Storms: These can include snow/ice storms, blizzards, and extreme cold combined with strong winds.

Winter Storm Safety Rules: Stay dry, cover all exposed parts of your body, and avoid overexertion. Seek protection from the wind and build a fire if you can. If you are in a car, stay with the car, tie a brightly colored ribbon to the antenna, clear the exhaust pipe, and run the heater around 10 minutes an hour.

Thunderstorms: These are large cumulonimbus clouds with lightning and thunder. They may contain heavy rain, strong winds, and large hail.

Thunderstorm Safety Rules: Seek shelter such as a house or car. If that is not possible, become the smallest target that you can. Try crouching in a low area, but avoid gullies and stream beds. Stay away from open areas and tall objects such as trees or power poles. Stay away from water, metallic objects, and anything that uses electricity.

Flash Floods and Floods: These occur when creeks or rivers overflow their banks, or when urban drainage systems fail. Flash Floods generally occur due to intense rainfall over a small area or from a dam break, and the waters rise and fall rapidly. The flash flood occurs within six hours of the event that caused it. Floods generally occur on larger rivers and cover a wider area. Flood events can take days to rise, crest, and subside.

Flood Safety Rules: Get to higher ground. Do not camp in gullies or near stream beds. Do not drive into water.

Tornadoes: These are violently rotating columns of air, in contact with the ground, that descend from cumulonimbus clouds. They are often (but not always) visible as a funnel cloud. Winds near a tornado can be as high as 300 mph. Most tornadoes are less than a few hundred yards wide, last for a few minutes, and trace a path of a mile or less. However, there have been tornadoes that were a mile wide, last for an hour or more, and produce damage paths more than 100 miles long.

Tornado Safety Rules: The main danger from tornadoes is flying debris. Therefore the best option is to get to a place that provides as much protection as possible. If you have a basement, seek refuge there and get under a large object, such as a workbench. If you have no basement, the best place to go is a center room in the house, especially a bathroom, where the plumbing reinforces the walls. For the best possible protection, get into the bathtub with a mattress over your body. Stay away from windows. If caught in the open, find a low place that is not flooded, lie face down and cover your head.

Hurricanes: A hurricane is a large tropical cyclone with sustained winds exceeding 74 mph that occurs in the Atlantic or eastern Pacific oceans. They are known by a variety of terms in other parts of the world. The energy source for these storms is warm ocean water underneath the storm. Sustained winds can range up to 200 mph with higher gusts, and size can range from 60 to well over 600 miles in diameter. Hurricanes break up rapidly after they move over land.

Hurricane Safety Rules: Most hurricane damage is caused by the storm surge, which is high water that piles up ahead of the storm. Most hurricane deaths are caused by drowning. Therefore the safety rules are similar to that for floods. Leave the danger area. If that is not possible, get to the highest shelter you can find.

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Now let's talk about the difference between a severe weather watch and a warning.

Watch: Issued when the risk of a hazardous weather or warning event has increased significantly, but its occurrence, location, and/or timing is still uncertain.

Warning: Issued when a hazardous weather or flooding event is occurring, about to occur, or has a high probability of occurring.

Now it's up to you to discuss this with your family. It just might save your lives someday!

Requirement 3: 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 locations and types of clouds associated with each type of front, and the location of precipitation.

Atmospheric pressure is simply the weight of the atmosphere directly above any point on the ground or in the air. Therefore, one would expect the highest pressure values to be recorded at ground-based stations at or below sea level, while the lowest pressure values would be found on very high mountain peaks or in the air above those peaks.

When meteorologists speak of high and low pressure, however, they are talking about the horizontal variation of pressure, usually at sea level. These variations occur because the sun heats the earth unevenly. The equator receives a lot more heating than the poles do. Cold air is denser than warm air, so an air mass of cold air would weigh more than warm air. Thus, areas of high pressure tend to develop at the poles and low pressure at the equator.

Have you ever noticed how water in a swimming pool tends to flatten out after the swimmers leave and the wind dies down? If left undisturbed, the water in the pool will seek a state of equilibrium where all the water is at the same level. The atmosphere is always trying to attain a similar state of equilibrium, but it cannot actually reach that state since it is always being disturbed. So, the atmosphere is constantly trying to move areas of high pressure toward low pressure, just like water runs down a hill. In this process, the atmosphere creates what we know as weather.

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In general, areas of low pressure are associated with rising air. Rising air helps clouds and precipitation form, so those things tend to occur near lows. High pressure is associated with sinking air, which suppresses the formation of clouds, so high pressure is associated with clear skies.

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Frontal cross-sections follow on the next two pages. The first page depicts cold fronts, while the second page shows warm fronts. Together, they provide all the information needed to meet this part of the requirement.

Key for cloud abbreviations in the 3-D views:

Vertically developing clouds	Cb	Cumulonimbus
	Cu	Cumulus
Low Clouds (below 6500 feet)	St	Stratus
	Ns	Nimbostratus
	Sc	Stratocumulus
Middle Clouds (6500-18000 feet)	Ac	Altocumulus
	As	Altostratus
High Clouds (above 18000 feet)	Ci	Cirrus
	Cs	Cirrostratus
	Cc	Cirrocumulus

Source: http://apollo.lsc.vsc.edu (Copyright 2007 Thomson Higher Education)

Figure 1 Cold Front cross-section, planer view, and 3-D view

Source: http://apollo.lsc.vsc.edu (Copyright 2007 Thomson Higher Education)

Figure 2 Warm Front cross-section, planer view, and 3-D views.

Requirement 4: Tell what causes wind, why it rains, and how lightning and hail are formed.

As mentioned in Requirement 3, the atmosphere is constantly trying to make the air pressure equal everywhere, moving areas with higher pressure toward areas with lower pressure. Wind gets created in this process.

To see this on a smaller scale, let's look at sea breeze circulations.

Land heats and cools faster than water. Therefore, in the afternoon the land is usually a lot warmer than water next to it. The ground in turn heats the air above it, so the air over the ground becomes warmer than the air over the waters. The air over the ground rises (warm air is lighter than cold air). This creates an area of lower pressure over the land, and air moves in from the sea to replace it. This is what we call a sea breeze. The opposite occurs at night…the land cools faster than the sea. Then the air rises offshore, and air moves in from land to replace it. This is called a land breeze. Both processes are illustrated below.

Figure 3 Sea Breeze and Land Breeze cross-sections

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Now let's discuss how rain is formed. One needs two things to make rain: A source of water and rising air.

Water can come from a variety of sources, but before anything can happen, that water needs to evaporate into the air. When this happens, it becomes invisible water vapor. Air can hold only a certain amount of water vapor, and this amount increases as the temperature gets warmer. When air is holding all the water it can at a given temperature, we say that it is saturated.

Now if we take this air and raise it, we lower the air pressure pushing down on it. This in turn forces the temperature to drop. As the air cools, its ability to hold water decreases and eventually it becomes saturated. At this point in the process, clouds begin to form. If we keep lifting the air, it becomes even cooler and even more water condenses into the cloud. The water droplets hit each other and combine to form bigger and bigger water droplets. Eventually the droplets get so big that they can no longer be suspended in the air. At that point it falls out as rain.

The following figure may make the above clearer to you:

Source: Illinois State University College of Education
http://www.coe.ilstu.edu/scienceed/basolo/water/water.htm

Figure 4 Cloud and Rain Formation

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Lightning and hail are both created by thunderstorms.

As a thunderstorm develops, positive and negative charges collect on the ground and in various parts of the cumulonimbus cloud. Charges act a bit like pressure in that the atmosphere is always striving to have charges distributed evenly. Therefore, when the areas of positive and negative charge get large enough, a bolt of electricity jumps from one to the other to equalize the charge. We see this bolt of electricity as lightning. Lightning can be cloud-to-cloud, cloud-to-ground, or even cloud-to-air.

Hail is formed by a different process. Thunderstorms have updrafts (rising air) and downdrafts (descending air). Usually rain falls in a downdraft. Sometimes updrafts can develop below downdrafts. When this occurs, the rain is carried back up into the cloud. If it gets pushed above the freezing level, it will condense into ice. Eventually this ice will begin falling again in a downdraft. This updraft/downdraft process can be repeated many times and the developing hailstone will pick up a layer of ice with each cycle. At some point the ball of ice will be too large for the updraft to support it, and then it will fall as hail. Hail is usually marble-size or smaller and has cycled through the above process 2-3 times. However, hail as large as softballs have been recorded and these go through the cycle many times. The diagram below illustrates the process.

Source: http://gotoknow.org/

Figure 5 Hail Formation Process

Requirement 5: Identify clouds in the low, middle, and upper levels of the atmosphere. Relate these to specific types of weather.

Let's start by listing the clouds by type:

Cloud Type	Cloud Name
Vertically developing clouds (0-50000 feet)	Cumulonimbus, Cumulus
Low Clouds (below 6500 feet)	Stratus, Nimbostratus, Stratocumulus
Middle Clouds (6500-20000 feet)	Altocumulus, Altostratus
High Clouds (above 20000 feet)	Cirrus, Cirrostratus, Cirrocumulus

Cumulonimbus clouds are associated with showers and thunderstorms, while nimbostratus clouds are associated with steady precipitation, like snow and rain. The nimbus or nimbo designation indicates that the clouds are precipitating water or ice. The other clouds typically do not produce precipitation that reaches the ground, although they may produce precipitation that evaporates in the air before it reaches the ground. Meteorologists call this kind of precipitation "virga".

Figure 6 Cloud Types

Requirement 6: Draw a diagram of the water cycle and label its major processes. Explain the water cycle to your counselor.

The water cycle is best explained through a diagram. The main points to remember are that the total amount of water on earth is roughly the same at all times, and that this water is constantly being cycled from the ocean to the land and back again. There are some non-oceanic sources of water, such as springs, but many of these depend on water filtering in from the ground above.

Source: NOAA National Weather Service, Southern Region
http://www.srh.weather.gov/srh/jetstream/atmos/hydro_cycle.htm

Figure 7 The Hydrologic (Water) Cycle

Requirement 7: Define acid rain. Identify which human activities pollute the atmosphere and the effect such pollution can have on people.

Human activity releases pollutants into the atmosphere. Some of these pollutants contain sulfur particles, and these can mix with water in the atmosphere to form what we call acid rain. The biggest sources of atmospheric sulfur are power plants that burn coal with a high sulfur content. Acid rain tends to occur downwind from these plants, and so the worst areas for acid rain are the northeastern U.S. and southeastern Canada.

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Human activities pollute the atmosphere in many ways. Acid rain is just one result of these activities. Several more are discussed below.

Overgrazing, unsound farming practices, and mining can cause desertification of the land. In this process, fertile land becomes parched soil and sand dunes that can support minimal plant life.

Certain industrial chemicals known as chlorofluorocarbons have become widely distributed in the atmosphere, and these chemicals can break apart molecules of ozone in the ozone layer high in the atmosphere. This layer filters out ultraviolet light from the sun that are harmful to plants and animals, including humans. Its loss would lead to many more cases of sunburn and skin cancer, among other things.

Global warming is a topic that has been in the news a lot lately. The earth's atmosphere and oceans have definitely warmed over the past several decades. This has already begun to effect many people who live near sea level and near the north and south poles.

Natural processes put a lot of carbon dioxide in the atmosphere and human activities put in a lesser amount. Many scientists contend that the human contribution has created an excess of carbon dioxide that has led to global warming and that this warming will continue unless we cut back on our contributions. Others contend that the current warming cycle is primarily a natural event and the atmosphere will begin to cool several years from now. No one knows for sure what will happen.

Requirement 8: Do ONE of the following:

a. Make one of the following instruments: wind vane, anemometer, rain gauge, hygrometer. Keep a daily weather log for one week using information from this instrument as well as from other sources such as local radio and television stations, NOAA Weather Radio, 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.

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. Find out what type of weather is most dangerous or damaging to your community. Determine how severe weather and flood warnings reach the homes in your community.

Resources for Requirement 8a, including many useful web links, can be found at this site:

http://meritbadge.org/wiki/index.php/Weather

A form to record your observations can be found on the next page of this guide.

http://meritbadge.org/wiki/images/a/a0/Weather.pdf

If you need more weather observations to fill out your observation sheet, they can be found on your local National Weather Service (NWS) web site at:

http://weather.gov

When you arrive at this site, you will see a map of the United States. Click at your location on the map and your local NWS web site will come up with a more detailed map of your area. Click at your location once again and you will see a weather forecast for your area. On the right side of the page toward the bottom, you will see the latest weather observation taken at a site near your location.

Here are links to pages that tell you how to make your own weather instruments:

Wind vane:	http://www.ehow.com/how_2154709_make-wind-vane.html
Anemometer:	http://www.ehow.com/how_2225384_make-an-anemometer.html
Rain gage:	http://www.ehow.com/how_2086258_make-simple-rain-gauge.html
Hygrometer:	http://www.ehow.com/how_2079001_make-simple-hygrometer.html

		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Date								
Time								
Wind Direction (N, SE, etc)	Observed							
	Forecast							
Wind Speed (mph, kph, or kts)	Observed							
	Forecast							
Temperature (°F or °C)	Observed							
	Forecast							
Precipitation	Observed							
	Forecast							
Dew / Frost								
Cloud Types								

Table 1 Weather Observation Form for Requirement 8a

Cloud abbreviations for form entries:

Vertically developing clouds	Cb	Cumulonimbus
	Cu	Cumulus
Low Clouds (below 6500 feet)	St	Stratus
	Ns	Nimbostratus
	Sc	Stratocumulus
Middle Clouds (6500-18000 feet)	Ac	Altocumulus
	As	Altostratus
High Clouds (above 18000 feet)	Ci	Cirrus
	Cs	Cirrostratus
	Cc	Cirrocumulus

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Requirement 8b may require you to do some travelling, but you likely will not have to go too far. If you live in a rural area, the closest person on the list is most likely an agricultural extension service officer. If you live in a city, you are more likely to find a radio or television broadcaster or private meteorologist.

Talking to a National Weather Service meteorologist is your best bet for finding answers to how a warning reaches homes in your community. A list of National Weather Service offices may be found here:

http://www.weather.gov/organization.php

Click on one of the office links and you will see the home page for that office. Contact information can be found at the bottom of the office home page.

Finding a meteorology professor may be difficult. A list of universities that offer degrees in meteorology or atmospheric science can be found here:

http://www.nwas.org/links/universities.php

Requirement 9: Do ONE of the following:

> **a. Give a talk of at least five 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 at least five minutes to a group (such as your troop, patrol, or a Cub Scout pack) about the articles. Before your talk, share your outline with your counselor for approval.**

All the information needed to prepare the talk for Requirement 9a can be found elsewhere in this guide in the section covering Requirement 2. Once you have prepared the outline, share it with your counselor.

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As for requirement 9b, some of the required information was discussed under Requirement 7 elsewhere in this guide. For more information, there are many articles online that discuss acid rain. Try googling "acid rain".

Here are some of the resources found on the internet:

Wikipedia entry on acid rain: http://en.wikipedia.org/wiki/Acid_rain

US Environmental Protection Agency article on acid rain:
http://www.epa.gov/acidrain/what/index.html

US Geological Survey article on acid rain:
http://ga.water.usgs.gov/edu/acidrain.html

Once you have prepared the outline, share it with your counselor.

Requirement 10: 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.

There are a variety of weather-related career opportunities available for qualified individuals. The most familiar of these is the weathercaster on the television newscast.

Many meteorologists work as forecasters for the National Weather Service (NWS), which is a federal government agency with offices spread across the country. The military also employs meteorologists.

Others work for private forecasting companies such as Accuweather and The Weather Channel. Typically these companies provide weather forecasts to newspapers and radio stations, as well as specialized weather forecasts required by individual customers.

Many meteorologists work as researchers and teachers at universities across the country and the rest of the world. There are also several institutions dedicated to research, the largest of which is the National Center for Atmospheric Research (NCAR) in Boulder Colorado.

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Meteorology is essentially a specialized field of physics, so a strong foundation in math and science is required. Most job positions in meteorology require a college degree in Meteorology, Atmospheric Science, or a related field.

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Forecasters working for this agency issue weather warnings to the public that have and will save lives and property. Forecasters work nights, weekends, and holidays and often have to put in extra hours during severe weather events. One has to be dependable, capable, and responsible to perform this job well.

References:

Glossary of Meteorology, 2nd Edition (2000), published by the American Meteorological Society. ISBN: 1-878220-34-9

Weather, Boy Scouts of America Merit Badge Series (2006), published by the Boy Scouts Of America. ISBN: 978-0-8395-3274-3

Resources:

A handy site for rank advancement, award and merit badge requirements, including lots of useful web links, can be found here:

http://meritbadge.org/wiki/index.php?title=Main_Page

The page for merit badges in general can be found here:

http://meritbadge.org/wiki/index.php/Merit_Badges

The specific site for the Weather merit badge worksheet is:

http://meritbadge.org/wiki/index.php/Weather

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