Chapter

19 WEATHER ELEMENTS

Meteorologists, who are also called weather forecasters, define weather as "the condition of the atmosphere at any particular time and place." In simpler terms, the weather is the day-to-day changes in atmospheric conditions.

The weather is usually described by its elements. These include temperature, air pressure, humidity, clouds, precipitation, visibility and wind.

Everything the atmosphere does, plus the activity of the sun, affects the weather and can be considered weather elements. Thus, this chapter will first examine various weather elements within the larger categories of air masses and fronts, clouds and terrain factors. Then we will analyze wind shears and clear-air turbulence. Some of the unique weather patterns affecting the United States will end this chapter.

You are encouraged to develop a mental picture of the weather parts and to have a general understanding of how all the parts interact to cause weather—both good and bad.

Objectives

Define weather.
Describe the characteristics of air masses and fronts.
Classify the four types of fronts.
Describe the three general types of clouds.
Describe various cloud types and weather associated with them.
Define fracto and lenticular.
Classify five types of fog.
Explain how terrain affects weather.
Describe the impact of terrain and wind on aviation.
Describe the general characteristics of wind shear.
State the danger of wind shear to aviation.
Define temperature inversion and microburst.
Identify causes of clear-air turbulence.
Classify types of clear-air turbulence.
Define wake turbulence.

Air Masses and Fronts

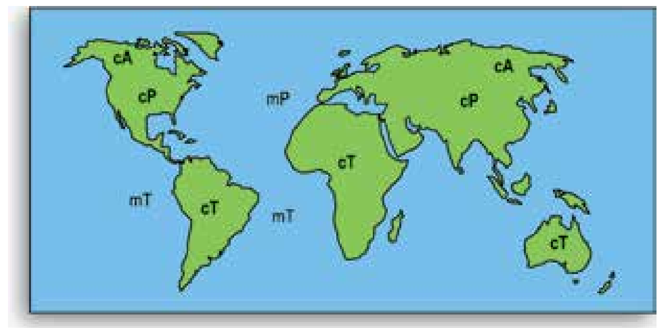
An air mass is a large body of air. It usually covers an area 1,000 or more miles across. It generally has the same temperature and moisture content within the entire mass. The temperature and moisture characteristics of the air mass are similar to those of the area in which the air mass originates.

Air Mass Type and Origination

A polar air mass (P) is cold and a tropical air mass (T) is hot. A maritime air mass (m) is humid and a continental air mass (c) is dry. Maritime air masses are formed over water and continental air masses are formed over land. Aviators and meteorologists in the United States are mainly concerned with two air masses — those that move southward from polar regions and those that move northward from tropical regions.

Here are the air mass classifications:

cA	=	**continental arctic**
cP	=	**continental polar**
cT	=	**continental tropical**
mT	=	**maritime tropical**
mP	=	**maritime polar**
mE	=	**maritime equatorial**



Characteristics of Air Masses

The characteristics of an air mass depend on four things: the surface over which it forms, the season, the surface over which it travels and the length of time it has been away from its source. The general movement of the atmosphere across the United States is toward the east. Air masses originating in the tropical and equatorial areas move toward the northeast. Those originating in the arctic and polar areas move toward the southeast. Cold air masses move more rapidly than warm air masses. The weather generally depends on the nature or origin of an air mass or the interaction of two or more air masses.

As an air mass moves away from its source, its original characteristics are changed by the earth's surface over which it passes. It may become warmer or colder, absorb or lose moisture, rise over mountains or settle into valleys. However, an air mass is not likely to lose all of its original characteristics.

Fronts

The boundaries between air masses of different characteristics are called frontal zones or fronts. A front moves along the earth's surface as one air mass displaces another. If a cold air mass replaces a warmer air mass, the boundary is called a cold front. If a warm air mass replaces a cold air mass, the boundary is called a warm front. When there is a big temperature and humidity difference between the two air masses, weather changes along the front will be severe.

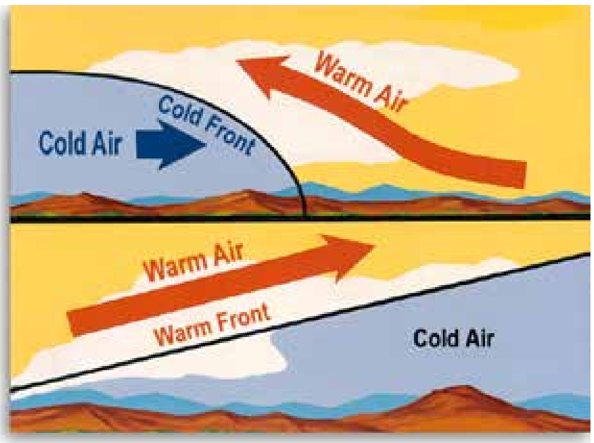
Cold Front. The cold front's general direction of travel across the United States is from the northwest to southeast. Cold fronts travel very far south, even in the summertime. The energy of a cold front depends on the amount of cold air that comprises the high-pressure cell behind it.

An Approaching Front *(NOAA Photo Library)*

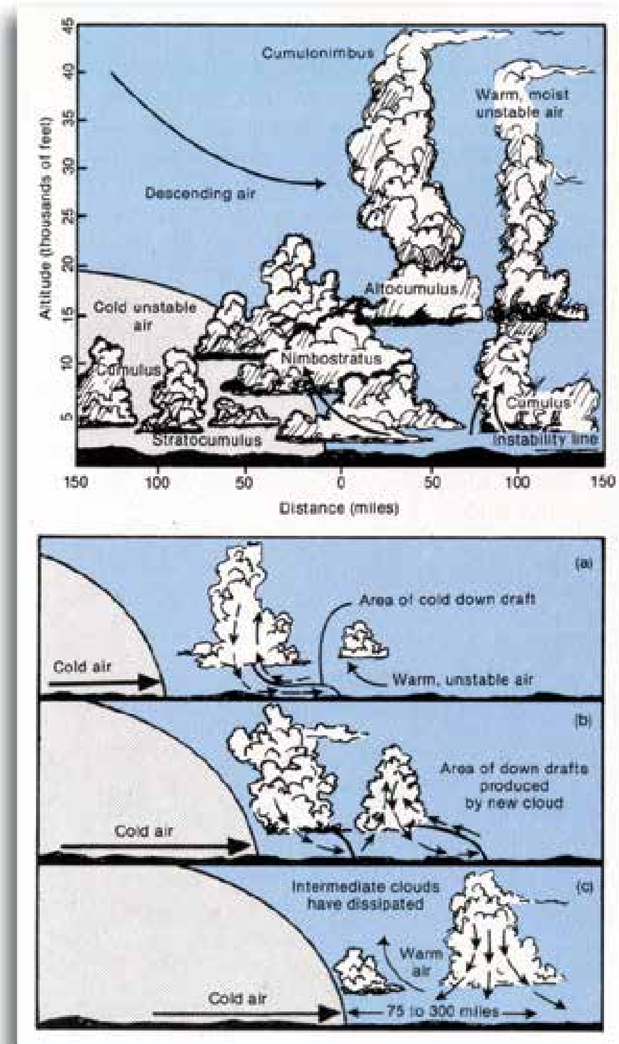
The front is the leading edge of the air mass and is formed at the junction of this high-pressure cold air with lower-pressure warm air. Since the cold air is denser, it pushes under the warm air forcing it upward. How much weather is associated with a cold front's movement depends on the condition of the warm air with which it is colliding. In the western states, the warm air is often dry. As a front moves through, the only noticeable change is a shift of wind, cooler temperature and possibly blowing dust.

As the "typical" cold front approaches the southern and eastern states, it encounters warmer vapor-laden air and problems for aviators begin. As the warm, humid air is forced upward, it cools and water vapor condenses into clouds creating thunderstorms. If the movement of the cold air mass is rapid, and if there is abundant water vapor ahead of it, very violent weather can occur. Lines of thunderstorms (squall lines) develop well ahead of the front—from 50 to 150 miles. These squall lines are in addition to the thunderstorms immediately ahead of the front.

Somewhere along the cold front there will be a low-pressure cell. In the area around this cell, the weather will be at its worst. Almost any type of cloud can be found here because this is where the amount of water vapor is high and the temperature and dew point temperature are very close. Therefore, as the air is lifted, only a slight drop in temperature causes condensation. If the season is summer, aviators can expect very poor visibility, exceptionally low clouds and a lot of rain. Winter makes the low-pressure area even more miserable for aviation because of freezing rain and snow.



A Diagram of a Cold Front and a Warm Front



The cold front (top) produces a squall line (bottom) resulting in very violent weather.

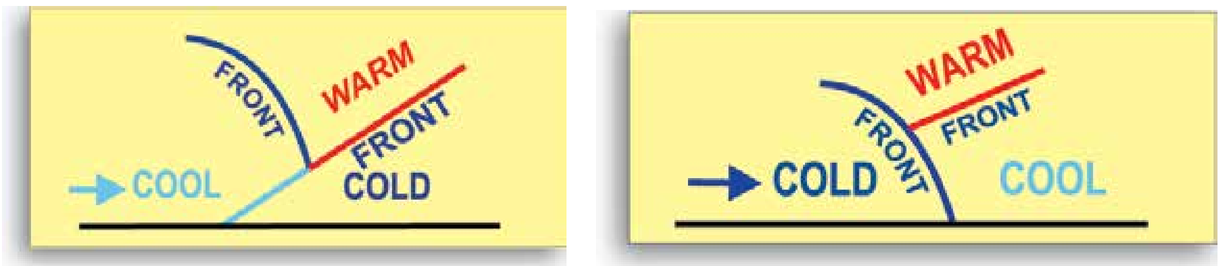
Warm Front. Although both cold fronts and warm fronts can exist without the associated low-pressure cell, the condition is not common. Therefore, the usual warm front is connected to a low-pressure cell, extends eastward from it and travels northeastward. Now, if the low-pressure cell did not move, the warm front would travel counterclockwise around the cell until it dissipated. However, the normal cold-front, low-pressure cell, warm-front complex involves movement of all three components; thus, the low-pressure cell tends to travel eastward/northeastward across the United States, taking the warm front with it.

Since warm air is less dense than cool or cold air, the leading edge of a warm front slips upward and over the cooler air forming a wedge shape. The warm air rises slowly and its rate of cooling is slow, which results in delayed condensation of the water vapor. The approaching warm front is announced by the appearance of cirrus (high, thin, wispy clouds). The cirrus may be as much as 1,000 miles in advance of the front. As the front approaches, other types of clouds are present and the sky gets darker and darker. Eventually, rain begins to fall.

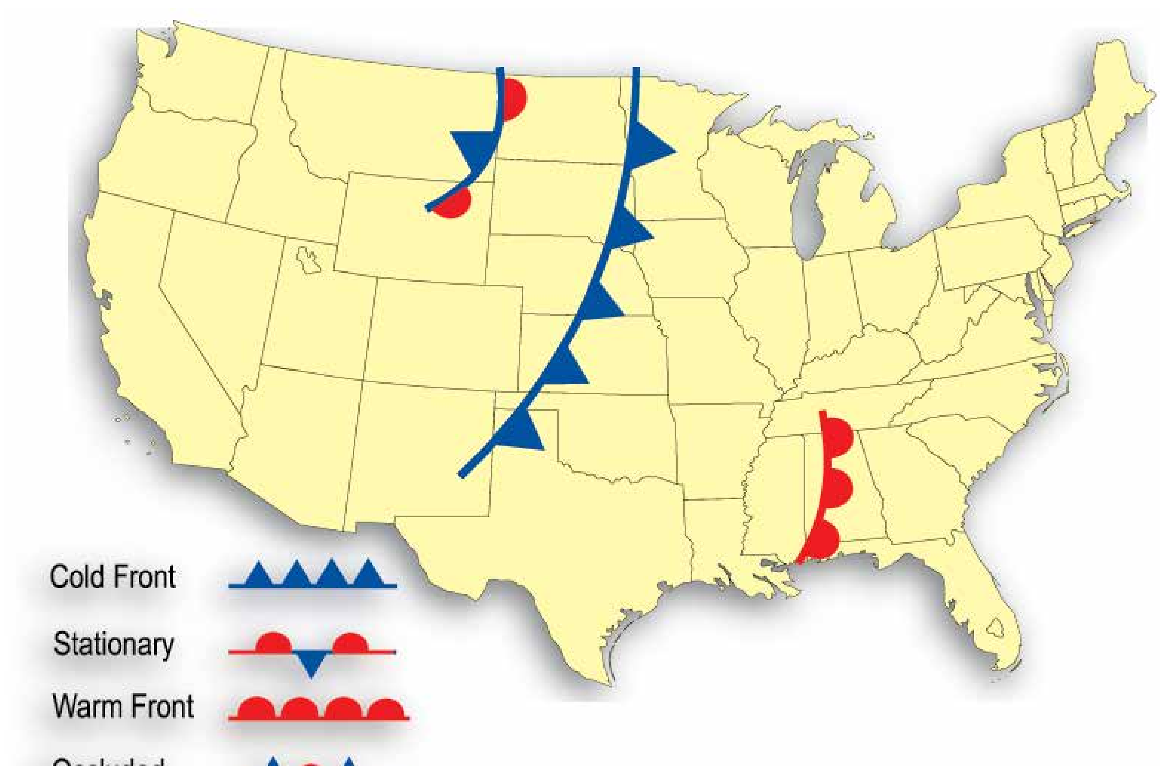
The above description of an approaching warm front is typical. However, fronts do not always act in this typical manner. For instance, a warm front may also cause violent thunderstorms, if the air in front of it is highly unstable. The atmospheric conditions ahead of and behind fronts are key in determining what kind of weather will occur.

Near the frontal boundary, clouds usually are low, there is gentle rain and visibility is poor. Often, the falling of warm rain into the cooler air near the surface causes fog. Fog is the archenemy of avia-

tion activities. After the front passes, there is a rise in temperature, general clearing and change in wind direction. In the winter months, the passage of a warm (relatively speaking) front usually causes icing conditions at very low altitudes, which may extend downward to the surface. In the more northern latitudes, snow may also be associated with the warm front.



Diagrams of Warm and Cold Occluded Fronts



This shows how fronts appear on weather maps.

Stationary Front. When air masses lose their "punch" and are not replacing one another, a stationary front develops. The weather along a stationary front can be very bad for aviation. In parts of the country where there is a large amount of moisture, just about every form of weather can be found along the stationary front. There may be very slow-moving thunderstorms at some locations. At other locations, there may be large areas of drizzle and fog.

Near the trailing edge of any front, there will be a stationary-front condition because a frontal zone cannot go on forever. Such "trailing-edge" stationary fronts are caused by the great distance between the pressure cell and the end of the front attached to it. When the distance becomes great enough, the identity between cold and warm air is lost. The front in that area no longer exists.

Occluded Front. Another type of frontal development is called an occlusion or occluded front. It is formed when a warm air mass, lying between two cold air masses, is lifted up by the cold air mass behind it. The rapidly lifted warm air cools and creates a low sometimes causing severe precipitation to occur. Such a front will also cause the usual cold-front and warm-front weather. As the occluded front passes, there is little change in the temperature of the ground air, because at that level, there is only a change of cold air masses.

Clouds

The previous chapter explained how condensation takes place. Condensation is also how clouds form. Clouds will form wherever the dew point temperature and water vapor happen to be collocated within the atmosphere.

Clouds form at different altitudes above the surface, varying from hundreds to thousands of feet. They take on characteristic shapes according to altitudes, temperatures and the movement of the atmosphere at their levels.

Cloud Types

The three general types of clouds are cumulus (piled up), stratus (layered), and cirrus (high, thin appearance). All other types come from these three, and we usually talk about them as low, middle and high clouds.

Low. Beginning at the lower altitudes, between 300 and 6,500 feet, the stratus, cumulus, stratocumulus, cumulonimbus and nimbostratus types of clouds are found. Stratus means to stretch out and/or cover as a layer. Cumulus means a piling up of

Cumulus

Stratus (Note Tower Fading in Cloud)

Cirrus

rounded masses; thus, the cumulus cloud looks bumpy. Nimbo is the combining term to indicate that a cloud is at the moment producing precipitation or is capable of producing precipitation. This precipitation is more closely associated with rain, but it also includes snow and sleet.

Middle. The middle clouds are first identified by the prefix "alto" (high, but not highest). At middle altitude, which is between 6,500 feet and 20,000 feet, the stratus and cumulus shapes are found, but are known as altostratus and altocumulus. Nimbostratus can be classified here too.

High. At 20,000 feet and up, cirrus types appear. Cirrus means wispy or fleecy. There are cirrus, cirrostratus and cirrocumulus. Cirrus are thin and lacy. Cirrostratus are slightly thicker and look more like a layer. Cirrocumulus are similar to cirrostratus, but have a slightly bumpy appearance.

Fracto and Lenticular. Another combining term associated with the various cloud types is "fracto," which means broken and/or ragged. Thus, we can combine fracto with stratus to describe a broken stratus layer—fractostratus.

There is a special type of cloud that frequently forms as strong winds sweep up and over the tops of high mountains. It is called a lenticular formation and its name is the result of its lens-like shape (double convex). A lenticular can, and does, form over other than mountainous areas, but the classic lenticulars are more frequent in the mountains.

What do these cloud types mean? Stated simply, they tell what can be expected with regard to turbulence, visibility and precipitation. Following will be a study of the cloud types and their general characteristics in more detail. First, however, the reader must understand that these characteristics are probabilities and averages. No one can point to a particular type of cloud and guarantee the exact conditions that will be found near it.

Stratus and Altostratus

Stratus has a smooth appearance. It indicates to pilots that no turbulence (bumpiness) is associated with the cloud. However, the stratus may be nothing more than fog that has developed at the surface and risen a hundred or so feet above the surface. The stratus may or may not produce some type of

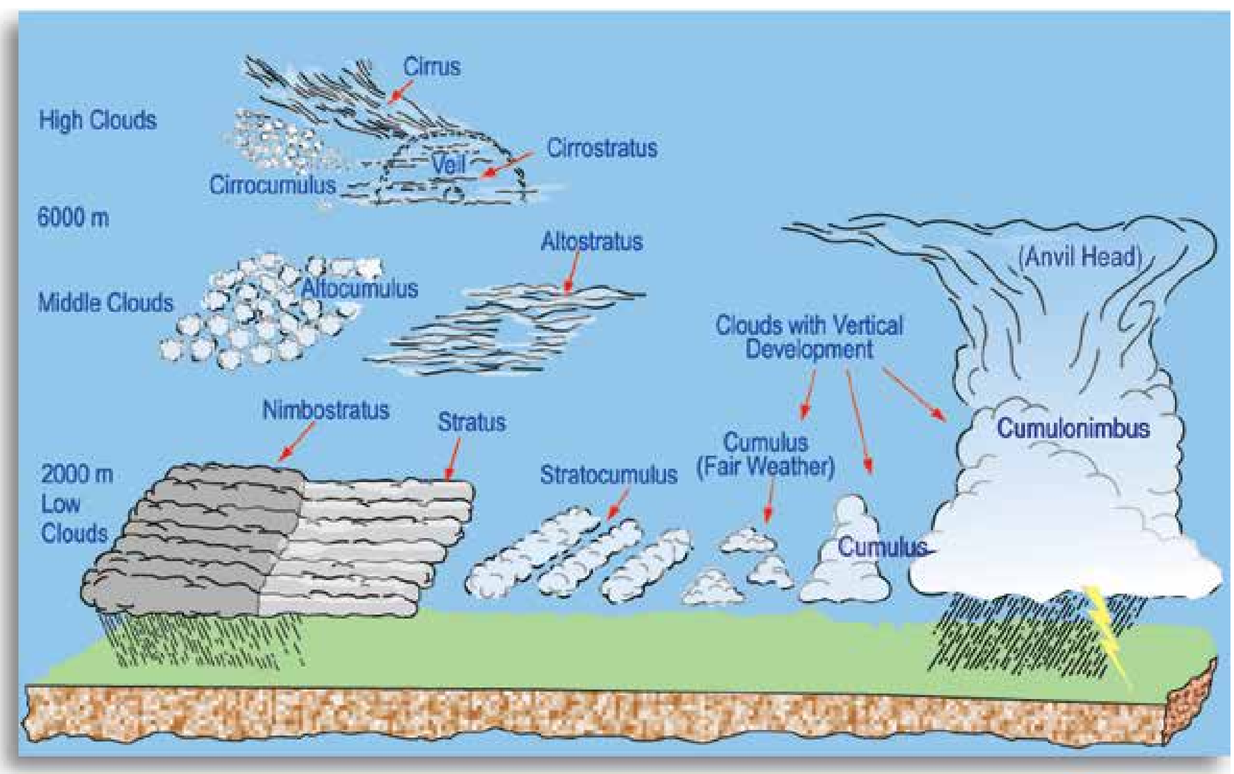
Altostratus

precipitation. If precipitation does occur, it will be light drizzle in the summer or light snow in the winter. The reason why simple stratus produces so little precipitation is that it is relatively thin. For a cloud to produce significant precipitation, a thickness of 4,000 feet or more is the norm.

To aviation, stratus can cause problems. Low stratus can create visibility problems for pilots. It can hide the fact that they are flying into or toward very unfavorable or dangerous weather. Thus, stratus can be a hazard to aviation because of reduced or obscured visibility.

The simple altostratus usually is relatively thin, perhaps more so than the lower-level stratus. It produces a gray or bluish veil through which the sun may be dimly seen. Due to its altitude—particularly in the winter months—it may contain ice crystals and supercooled water droplets. If the altostratus does produce precipitation, it will be very light.

The cirrostratus appears at high altitudes and is very, very thin. It is composed entirely of ice crystals. The light of the sun or moon refracted by these crystals can sometimes cause a halo effect around the sun or moon.



The 10 Basic Cloud Types

Stratocumulus

The similarity of stratocumulus to stratus lies in the layering characteristic only. This cloud has numerous bumps on the topside and usually is rather thick. Heavier rains and snow can be expected from this type of cloud. Turbulence of varying intensity can also be expected nearer the bottom of the layer.

Stratocumulus

To pilots, the appearance of stratocumulus is a warning that flying under these clouds most likely will bring low visibility and probably strong turbulence. Flying over these clouds is not wise either. The stratocumulus can mask higher and more severe cloud buildups.

Cumulus with Vertical Growth

Cumulus alone has a harmless, puffy, cotton-ball appearance with a horizontal dark base. It is known as fair-weather cumulus. It develops from thermals or updrafts of heated air containing a relatively small amount of water vapor. Upon reaching the dew point temperature at altitude, the vapor condenses and forms a small cloud; since no more vapor is available or the thermal dissipates, the cumulus does not grow.

Cumulus with Vertical Growth

Flight below fair-weather cumulus can be rather bumpy because the airplane flies into the updrafts beneath the clouds. However, no danger is involved—just the slight discomfort of a choppy flight. Therefore, aviators find it better to climb above such clouds and enjoy a smooth ride.

However, cumulus with vertical growth, or building cumulus, deserves attention. It will produce at least a strong rain shower with moderate to severe turbulence. Chances are it will develop into a thunderstorm.

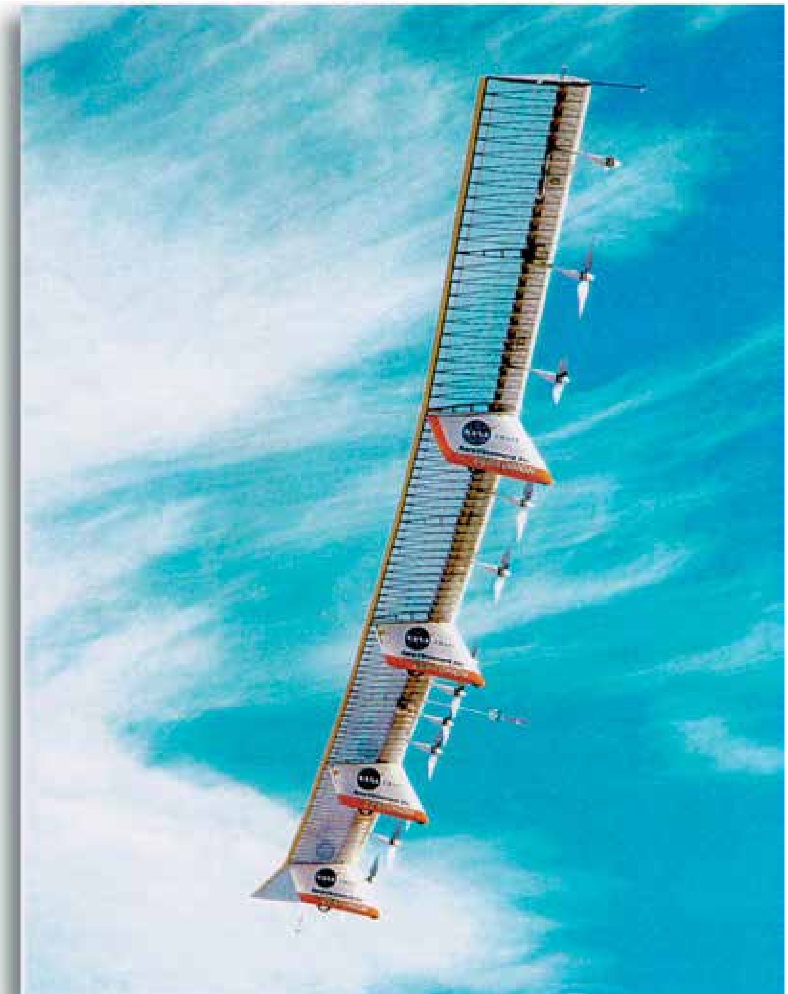
Vertical-growth cumulus can be expected if the relative humidity is high, the temperature is hot, and the air is unstable. Thus, the spring and summer months are the best times for this type of cloud buildup. Very strong updrafts are characteristic of these clouds as they build higher and larger. As conditions become more favorable, two or more clouds will merge and form an even larger cell from their combined energies. This type of growth continues until the cloud becomes a cumulonimbus. As a cumulonimbus, it has developed precipitation along with thunder and lightning. With further building and increase in intensity, the cumulonimbus is called a thunderstorm.

	CLOUDS		ASSOCIATED WEATHER	
Type	**Approximate height of bases (feet)**	**Description**	**Precipitation types**	**General**
Cumulus	1,500 10,000	Brilliant white in sun, dark blue or gray in shadows detached domes or towers, flat bases	If building rain or snow showers	Good surface visibility and fair weather, if not building. If building, high winds, turbulence
Altocumulus	6,500-16,500	White or gray layers. rolls or patches of wavy, solid clouds	Intermittent rain or snow, usually light	Turbulence likely: generally good surface visibility
Stratocumulus	A few feet above surface to 6,000	Gray or blue; individual rolls or globular masses	Light rain or snow showers	Strong gusty surface winds, particularly if ahead of a cold front turbulence
Cumulonimbus	1,500-10,000	Large, heavy, towering clouds; black bases; cauliflower-like or anvil-shaped tops	Heavy showers: possibility of hail	Associated with severe weather, turbulence, high surface winds; surface visibility usually fair to good outside of precipitation
Stratus	A few feet above surface to 3,000	Low, gray, uniform, sheet-like cloud	Light drizzle, light snow	Poor surface visibility, air smooth
Altostratus	6,500-16,500	Gray or blue veil or layer of clouds; appears fibrous; Sun may show as through frosted glass	Light continuous precipitation	Usually poor surface visibility; air smooth moderate surface winds
Nimbostratus	1,500-10,000	Dark gray, thick, shapeless cloud layer (really a low altostratus with precipitation)	Continuous precipitation	Visibility restricted by precipitation; air smooth; calm to light surface winds
Cirrus	16,500-45,000	White, thin, feathery clouds in patches or bands	None	If arranged in bands or associated with other clouds, usually a sign of approaching bad weather
Cirrostratus	16,500-45,000	White, thin cloud layers; looks like sheet or veil; halo around moon or sun	None	Often a sign of approaching bad weather; surface winds bring overcast skies
Cirrocumulus	16,500-45,000	Thin clouds in sheets; individual elements look like tufts of cotton	None	Indicate high-level instability

The chief danger with vertical growth or building cumulus clouds is extreme turbulence inside the cloud. Some pilots try to fly through the gaps or holes between developed thundershowers or thunderstorms. Unfortunately, cell merger can close the gaps faster than some planes can make it through. Then clouds, turbulence and rain suddenly surround the pilot.

The degree of turbulence in a building cumulus can be seen if you will take the time to watch one. The top continues to gain altitude and round protrusions build quickly, swirling upward, outward and downward from the rising column. Although the buildup looks graceful and appears to be at slow-motion speed, this is not the case. It is an illusion brought on by the distance between you and the cloud. Perhaps a better illustration of the latter point would be a modern, jet transport aircraft and its contrail, which seem to be creeping across the sky, while the actual speed involved may be 600 mph. The various cloud types, and the weather associated with them, are summarized in the table on page 425.

Altocumulus



Cirrus and Cirrostratus Clouds

Fog Types

Fog is a surface-based cloud because it develops within the atmosphere. It is considered separate of clouds because of how it is formed. It is a cloud in contact with the ground. There are five types of fog: radiation, high-inversion, advection, evaporation and upslope.

Radiation fog is so named because it forms at night when land surfaces radiate much of the heat absorbed from the sun back into space. The cool land surface in turn cools the air near it (by conduction) to below the dew point and fog is formed. High-inversion fog is actually a low cloud; it is formed by condensation of water vapor at or near the top of cool air that is covered by a warmer air layer. Advection fog is formed when wind blows moist air over a cold surface and the surface cools the air to its dew point temperature. Evaporation or steam may occur when cold air moves over warm water; the water's normal evaporation process saturates the cooler air with water vapor, and the dew point is reached. Upslope fog results when wind carries moist air up a mountain slope or sloping land until the air is cooled.

Fog Rolling In Under the Golden Gate Bridge

Terrain Factors

You learned earlier that terrain has a very significant influence on how much solar radiation is absorbed or reflected by the earth's surface. The presence of mountain ranges in the path of a weather front can change the characteristics of the front greatly. Gentle, rolling hills also contribute to the manufacture of weather.

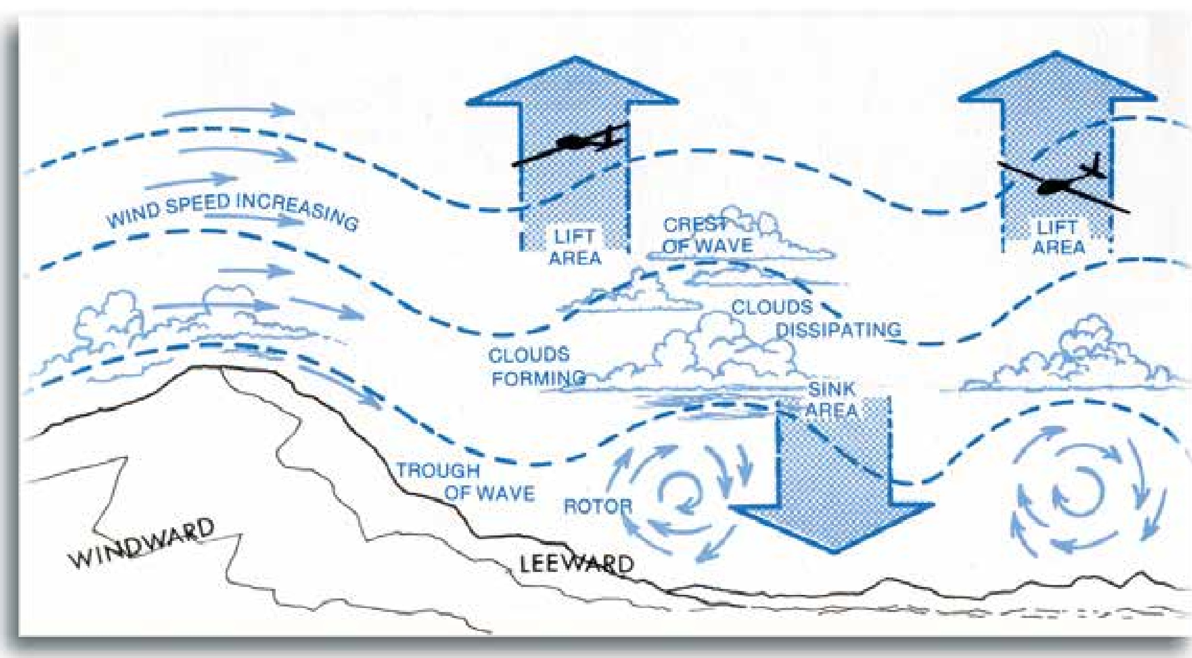
An excellent example of mountains as weather makers is the High Sierra in California. Maritime tropical air masses coming into Southern California are filled with moisture and heat. Directly in the usual path of these air masses is a popular ski area and just a few miles past it is one of the driest spots in the world-Death Valley. What happens to the moisture in an air mass from the time it leaves the Pacific Ocean until it passes over Death Valley?

As the air mass enters the United States, the mountains cause it to rise. As it rises, it cools and loses practically 100 percent of its moisture on the western slopes of the mountains in the form of snow. This accounts for the excellent ski conditions. As it descends the eastern slopes, this dry air is heated and absorbs the small amount of moisture in the vicinity of Death Valley. This process is repeated again and again all over the world in the Himalayas, the Alps, the Caucasus and other mountain ranges where windward (facing the wind) slopes are moistened with rain and snow, and where leeward slopes are dry.

Along many seacoasts, there is a breeze from the sea by day. This moist, relatively cool air rises and heats as it passes across land. Clouds form a short distance inland and may bring showers by afternoon. At night, the land cools more rapidly than the sea, the current is reversed and the breeze blows from land to sea.

Wind blowing toward, or with, land formations that slope gently upward carries moisture-laden air to the altitude where its dew point temperature is located and condensation can occur. The reverse can happen if the wind forces clouds, which have already formed, downward into warmer air. The clouds will again become water vapor.

At any time the flow of wind is interrupted, turbulence develops. The severity of the turbulence depends on wind speed and the complexity and height of the obstruction to the wind. Gentle rolling



The Results of Strong Winds Crossing a Mountain Range.

hills, for example, will produce a mild turbulence for hundreds of feet above them. In the areas of the country where there are mountains, turbulence can be severe.

Even if the atmosphere is stable, a strong wind striking a mountain or range of mountains may produce little turbulence on the windward side. However, the leeward side will be very dangerous to flying. Turbulent downdrafts will be created and they can force an airplane into the side of the mountain with little or no warning.

When the wind strikes mountains at 50 mph or more, the result is extreme turbulence. The effect of this turbulence can be seen by the types of clouds formed—if sufficient water vapor is present. At or slightly below the elevation of the mountain crest, there may be what is known as rotor clouds. These clouds show by their shape and motion that the air coming over the mountain is spinning on an axis that parallels the mountain's linear shape. Higher up, there probably will be the lenticular-type clouds that we mentioned earlier. These lenticulars form at the crests of atmospheric waves, which develop as the force generated by the wind striking the mountain is transmitted upward.

For aircraft, flight into the area where rotor clouds are located must be avoided because of the danger of structural damage. Flight at higher altitudes, where the wave formations are located, produces inaccurate readings on the aircraft altitude indicator. Readings may be off as much as 1,000 feet. This is caused by the differences of atmospheric pressure within the wave formations. However, mountain waves are good news to at least one segment of aviation. Sailplane enthusiasts find the mountain wave to be the ideal weather condition for sustained and very high flight. By flying the crests of such waves, the sailplane pilot can gain and maintain altitudes that would not otherwise be possible.

Wind Shear

Wind shear is an atmospheric condition in which changes in speed and direction of the wind occur. At one level, the wind is traveling in one direction, while at an adjacent level either the wind is traveling in a different direction or the air at that level is calm. Turbulence is located at the junction of the two atmospheric layers involved in the wind shear phenomenon.

Aviators may experience horizontal wind shear when there is a temperature inversion. That is, nighttime radiation cooling may produce a layer of cool, calm air at the surface extending to a hundred or so feet above the surface while air above this layer is warm and moving. This kind of atmospheric condition is dangerous to aircraft during takeoff and landing because of the possibility of very abrupt changes in airspeed. The amount of danger depends on how fast the warm upper layer of air is moving and the direction of the aircraft's flight.

Vertical currents of air (updrafts or downdrafts) are forms of wind shear too. The strong vertical current near the approach or departure end of a runway can change the airspeed and flight path of an airplane greatly. This sort of air current is often experienced in a mild form during the summertime. The small airplane can be bounced up and down as the pilot tries to maintain a smooth and correct descent toward the runway. No matter how much the pilot tries to manipulate the controls, these summertime vertical air currents can make the descent seem very erratic.

The downdraft shear, or microburst, associated with large thunderstorms, can be particularly dangerous. The force of such downdrafts has caused even large airliners to strike the ground before reaching the runway. Microbursts, perhaps more than any other type of wind shear, have been the cause of aviation tragedies across the world.

A microburst is caused when a column of air is quickly cooled (usually by rain) and rapidly falls towards the earth. The air speed in a microburst often exceeds hurricane force and the resulting damage closely resembles that of a tornado. Recently, commercial aircraft and airports have been equipped with special doppler and infrared radar that can detect microbursts and give pilots enough warning to avoid them.

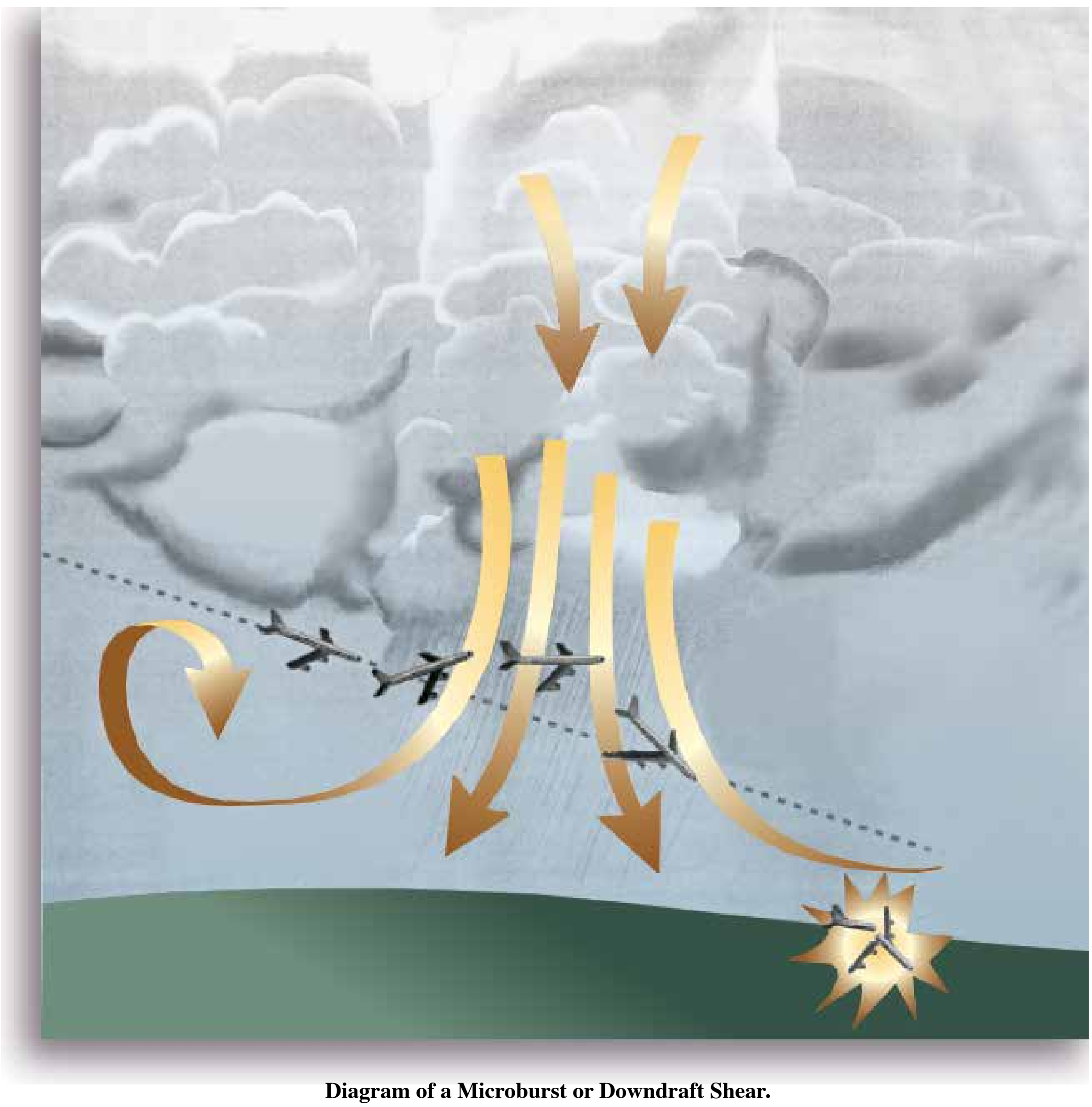


Diagram of a Microburst or Downdraft Shear.

Clear Air Turbulence

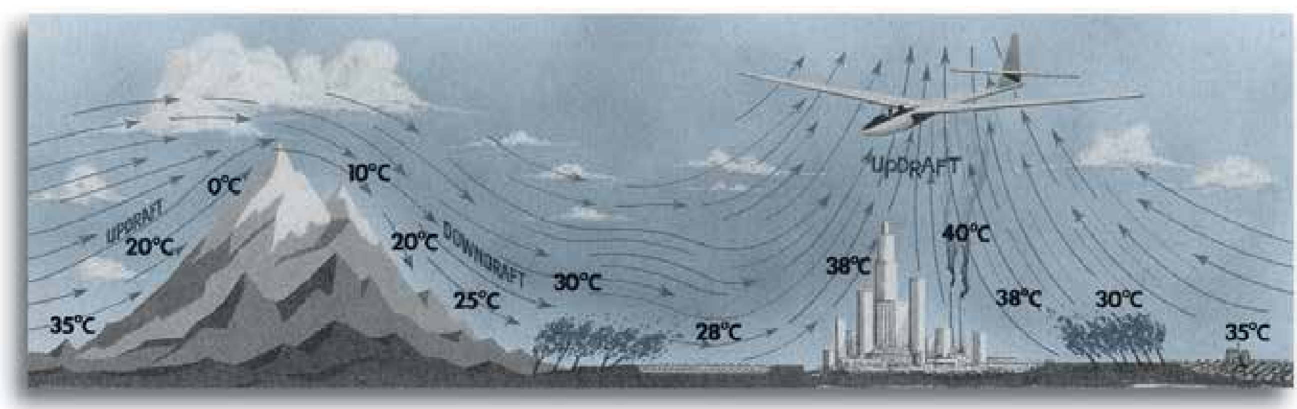
Turbulent air can be signaled by the presence of certain cloud types. However, clear air turbulence (CAT) may exist at different places and altitudes, but be completely invisible. The causes of such turbulent air may be one or a combination of the conditions discussed earlier: vertical growth if currents, wind shear and obstructions (such as mountains) to wind flow.

Since CAT cannot be seen, the first actual knowledge of the existence of a CAT area comes to the meteorologist, or weather service specialist, from pilots who fly into it. Pilots radio their location and the severity of the turbulence encountered to the weather service. This information is then made known to other pilots so those who will fly through the same area can be prepared.

The probability of CAT can be expected, even if it cannot be seen. Light CAT usually is found in hilly and mountainous areas even when winds are gentle. Light turbulence also occurs below 5,000 feet when the air is colder than the earth's surface (soon after the passage of a cold front), and at anytime the wind is blowing about 20 mph.

Turbulence can be further classified as light, moderate, severe and extreme. There are no ironclad criteria for designating these levels of turbulence, because how much turbulence exists depends on the person reporting it and the type of aircraft flying through it. It is generally agreed that the following sensations and reactions describe the various levels of turbulence: light—occupants of aircraft may be required to use seat belts, but objects in aircraft remain at rest; moderate—aircraft occupants must wear seat belts and unsecured objects move about; severe—aircraft may at times be out of control, occupants are thrown against seat belts and unsecured objects are tossed about; extreme—entire aircraft may be tossed about and is practically impossible to control. Structural damage to aircraft may result.

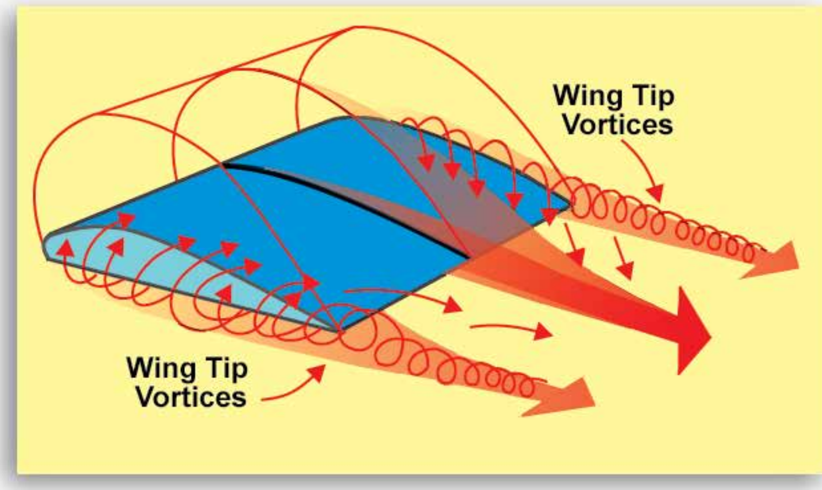
In addition to nature's CAT, there is one man-made type of CAT. This is called wake turbulence



Some Causes of Clear Air Turbulence

and is caused by large aircraft in flight. As the wings of these large aircraft slice through the atmosphere, air spilling over and around their wingtips forms a vortex—a twisting, horizontal column of air that possesses a tremendous amount of energy. These vortices can have the same effect on small aircraft as severe CAT.

Under landing and takeoff conditions, the small airplane that flies into a vortex may strike the ground before its pilot can regain control. Aviators, therefore, must be wary of natural and man-made atmospheric turbulence.



Formation of Wake Turbulence

Unique Weather Patterns

El Niño and La Niña. The cyclical warming of the east Pacific Ocean sea water temperatures off the western coast of South America directly influences the weather patterns all over the world. When the normal pattern is disturbed, there are significant changes in weather patterns in the United States and across the world. The El Nino occurs when warm waters move in and displace the colder waters for a longer than normal period of time. A La Nina is the opposite, i.e., ocean temperature off the coast of South America is colder than normal for a longer than normal period. This also impacts weather patterns across the world.

Key Terms and Concepts

- weather
- air masses: polar, tropical, maritime, continental
- fronts: cold, warm, stationary, occluded
- cloud types: cumulus, stratus, cirrus
- nimbo and alto
- fracto and lenticular
- five types of fog: radiation, high-inversion, advection, evaporation, upslope
- windward, leeward and rotor clouds
- wind shear
- microburst
- levels of turbulence: light, moderate, severe, extreme
- clear air turbulence (CAT)
- wake turbulence

? Test Your Knowledge ?

MATCHING

1. *Moist and warm air mass formed over subtropical waters.*
2. *Body of air with generally the same temperature and moisture content.*
3. *Boundary between two air masses.*
4. *Cold and dry air mass.*
5. *Moist air is blown over a cold surface.*
6. *Moist air is carried by wind up a mountain until the air is cooled.*
7. *Actually a cloud.*
8. *Forms at night when the land surface cools the air above it to below the dew point.*

a. Air mass
b. Front
c. Maritime tropical
d. Continental polar
e. Upslope fog
f. Advection fog
g. Radiation fog
h. High-inversion fog

FILL IN THE BLANKS

9. *Whatever the atmosphere is doing at any time is one way of defining _________.*
10. *_________, _________ and_________ are the general types of clouds.*
11. *All other types of clouds come from the above three and are classified according to _________.*
12. *Stratocumulus is likely to produce precipitation in the form of _________ or _________.*
13. *Altostratus produces moderate surface _________.*
14. *The _________ cloud is most often associated with violent weather.*
15. *_________, _________ and _________ have no types of precipitation associated with them.*
16. *_________ and _________ are closest to the surface of the earth.*

MULTIPLE CHOICE

17. *Wind shear involves changes in speed and direction of the wind*
    a. *horizontally.*
    b. *downwardly.*
    c. *upwardly.*
    d. *all of the above.*
18. *A microburst is a threat to aviation and is associated with*
    a. *temperature inversion.*
    b. *horizontal movement.*
    c. *thunderstorms.*
    d. *updrafts.*

19. *Which of the following means a piling up of rounded masses?*
    a. *cumulus.*
    b. *stratus.*
    c. *cirrus.*
    d. *nimbostratus.*

TRUE OR FALSE

20. *An occluded front occurs when a warm air mass is "sandwiched" between two cold air masses.*
21. *A stationary front has a lot of movement along its edge.*
22 *A cold front's general direction is from southeast to northwest.*
23. *Warm fronts are usually associated with low-pressure cells.*
24. *The term lenticular results from the concave-shaped cloud that forms over mountains.*
25. *Fracto is a term only associated with rain clouds.*
26. *Terrain factors may be one of the factors causing clear air turbulence (CAT).*
27. *The turbulence classifications of light, moderate, severe are the same for all pilots.*
28. *Wake turbulence is produced by large aircraft only on landing.*

SHORT ANSWER

29. *Is it generally safer for the pilot of a small aircraft to fly on the leeward side or the windward side of a mountain range? Give reasons for your answer.*
30. *If you are flying at 7,000 feet on the windward side of a 15,000-foot mountain range, what affect will its rotor clouds have on your flight?*