Objectives

- **Compare** and **contrast** weather and climate.
- **Analyze** how imbalances in the heating of Earth's surface create weather.
- **Describe** how and where air masses form.

Vocabulary

- meteorology
- weather
- climate
- air mass
- air mass modification

Weather and Climate

- **Weather** is the current state of the atmosphere, including short-term variations that affect our lives.
- **Climate** describes the average weather over a long period of time and is usually averaged over the course of 30 years or more.
- Meteorology, weather, and climate are related.

A Question of Balance

- In meteorology, a crucial question is how solar radiation is distributed around the planet.
- The Sun feels hotter in the tropics because its rays strike Earth more directly, than it does in the polar regions where its rays strike Earth at a low angle.
- Because the Sun's rays are more spread out when they strike Earth at a low angle, the same amount of energy is spread over a larger area.

A Question of Balance

Balancing the Budget

- The tropics and other places maintain fairly constant average temperatures because heat energy is redistributed around the world.
- The continual motion of air and water reallocates heat energy among Earth's surface, oceans, and atmosphere and brings it into balance.
- Virtually everything that we consider to be weather is part of a constant redistribution of Earth's heat energy.

Air Masses

- An **air mass** is a large body of air that takes on the characteristics of the area over which it forms.
- Meteorologists call the region over which an air mass forms the source region.
- Air masses that form over land are generally drier than those that form over water.

Air Masses

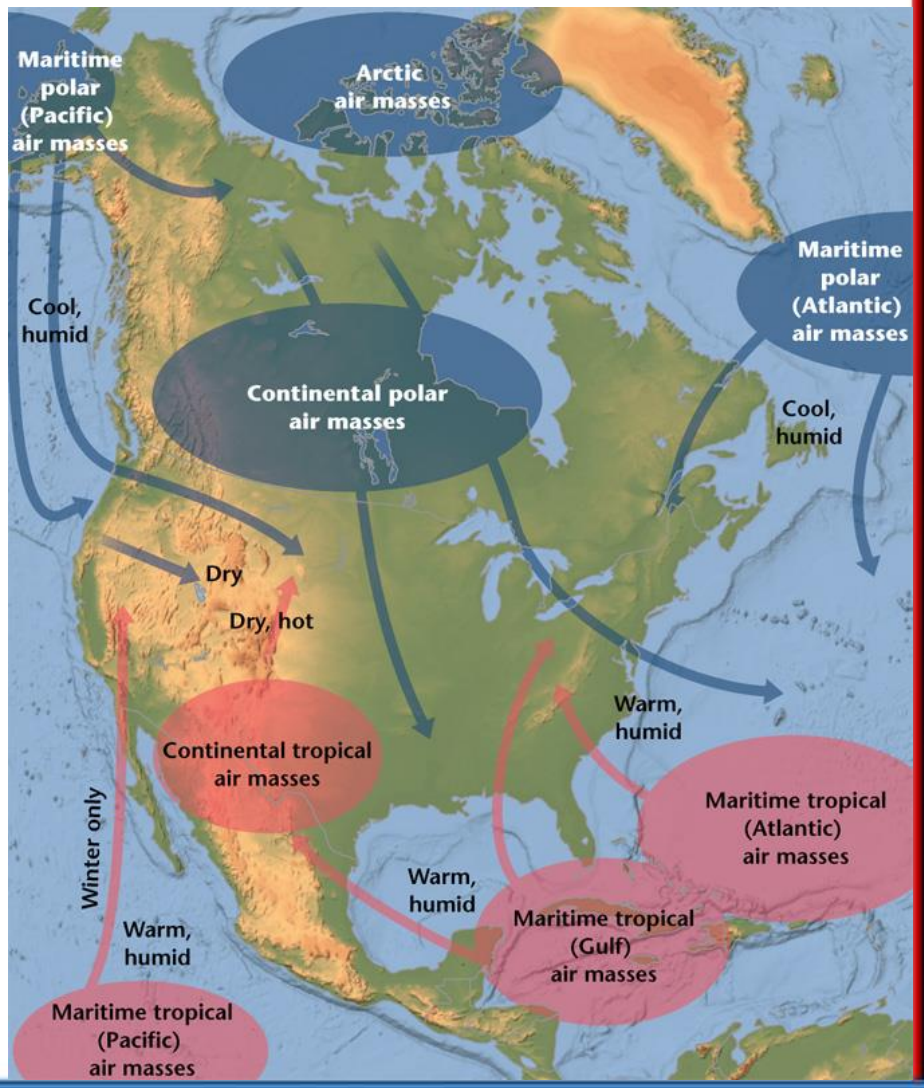
Classifying Air Masses

- Air masses are classified according to their source regions.
- The main types of air masses are:
  - warm and dry continental tropical (cT)
  - warm and humid maritime tropical (mT)
  - cold and dry continental polar (cP)
  - cold and humid maritime polar (mP)
  - arctic (A)

Air Masses

Classifying Air Masses

– Each of the major air masses that affects weather in the United States has a similar temperature and moisture content as the area over which it formed.



Air Masses

Source Regions

- All five main types of air masses can be found in North America because of the continent's proximity to the source regions associated with each air mass.
  - Maritime polar air forms over the cold waters of the North Atlantic and North Pacific.
  - Continental polar air forms over the interior of Canada and Alaska.
  - The origins of maritime tropical air are tropical and subtropical oceans, such as the Caribbean Sea and the Gulf of Mexico.

Air Masses

Source Regions

- All five main types of air masses can be found in North America because of the continent's proximity to the source regions associated with each air mass.
  - The desert Southwest and Mexico are the source regions of continental tropical air.
  - Arctic air develops over latitudes above 60°N in the ice- and snow-covered regions of Siberia and the Arctic Basin.
- The stability of air is an important factor in its ability to produce clouds and precipitation.

Air Masses

Air Mass Modification

- Eventually, air masses move, transferring heat from one area to another and thus establishing the heat balance.
- As an air mass moves, it starts to acquire some of the characteristics of the new surface beneath it.
- **Air mass modification** is the exchange of heat or moisture with the surface over which an air mass travels.
- Eventually, an air mass becomes modified to such a degree that its characteristics are almost the same as the new surface over which it is traveling.

Air Masses

Air Mass Modification

Table 12-1 Air Mass Characteristics

Air Mass Type	Source Region Stability		Characteristics	
	Winter	Summer	Winter	Summer
A	Stable		Bitter cold, dry	
cP	Stable	Stable	Very cold, dry	Cool, dry
cT	Unstable	Unstable	Warm, dry	Hot, dry
mP (Pacific)	Unstable	Unstable	Mild, humid	Mild, humid
mP (Atlantic)	Unstable	Stable	Cold, humid	Cool, humid
mT (Pacific)	Stable	Stable	Warm, humid	Warm, humid
mT (Atlantic)	Unstable	Unstable	Warm, humid	Warm, humid

Section Assessment

1. Match the following terms with their definitions.

B	meteorology
A	weather
C	climate
E	air mass
D	air mass modification

A. the current state of the atmosphere

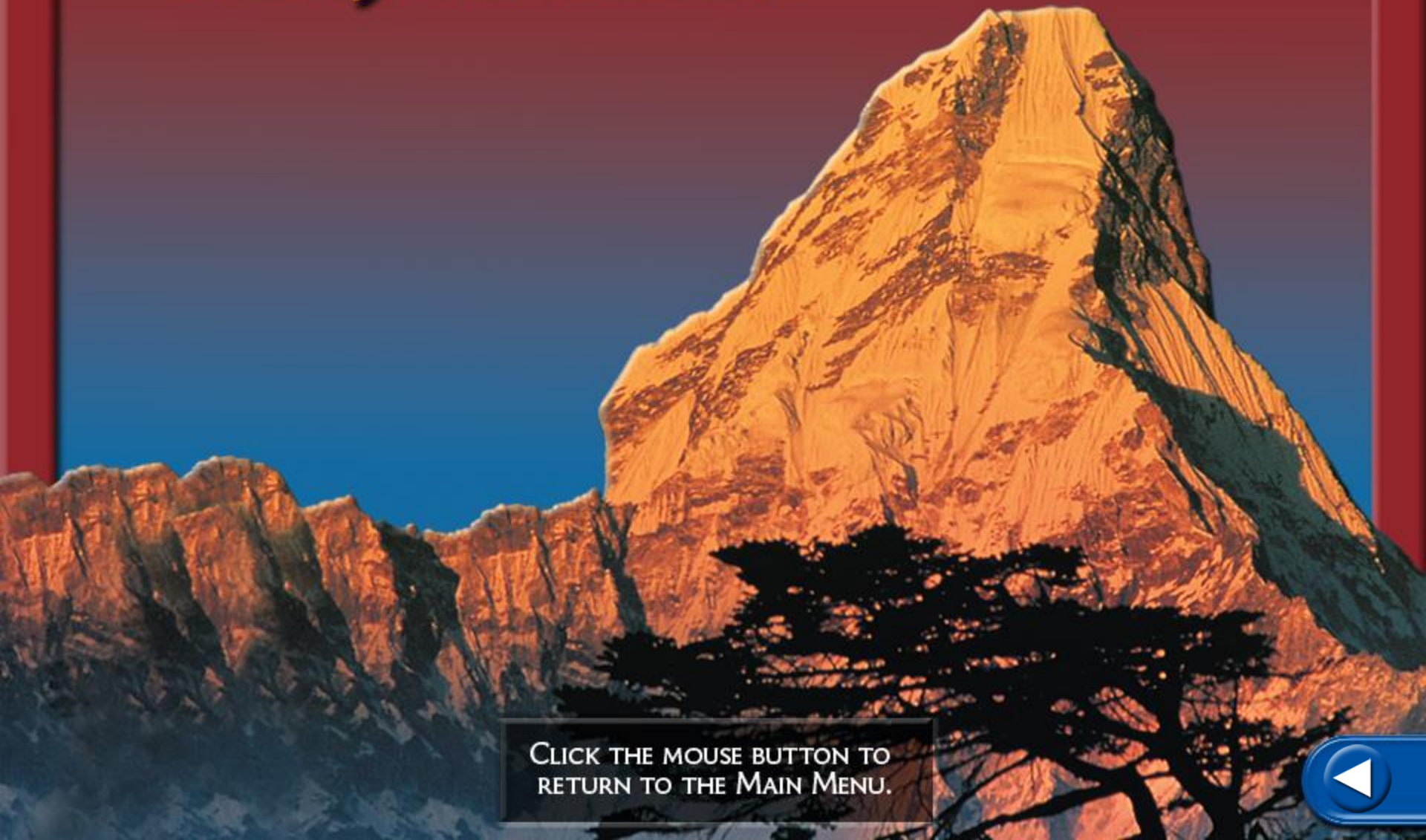
B. the study of atmospheric phenomena

C. the average weather over a long period of time

D. the exchange of heat or moisture with the surface over which an air mass travels

E. a large body of air that takes on the characteristics of an area over which it forms

End of the Section



Click the mouse button to return to the Main Menu.

Objectives

- **Describe** how the rotation of Earth affects the movement of air.
- **Compare** and **contrast** wind systems.
- **Identify** the various types of fronts.

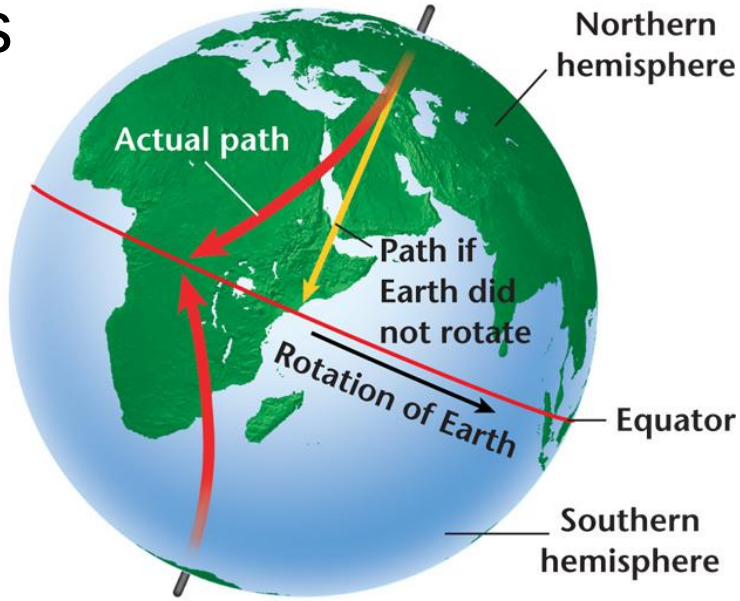
Vocabulary

- – Coriolis effect
- – trade winds
- – prevailing westerlies
- – polar easterlies
- – jet stream
- – front

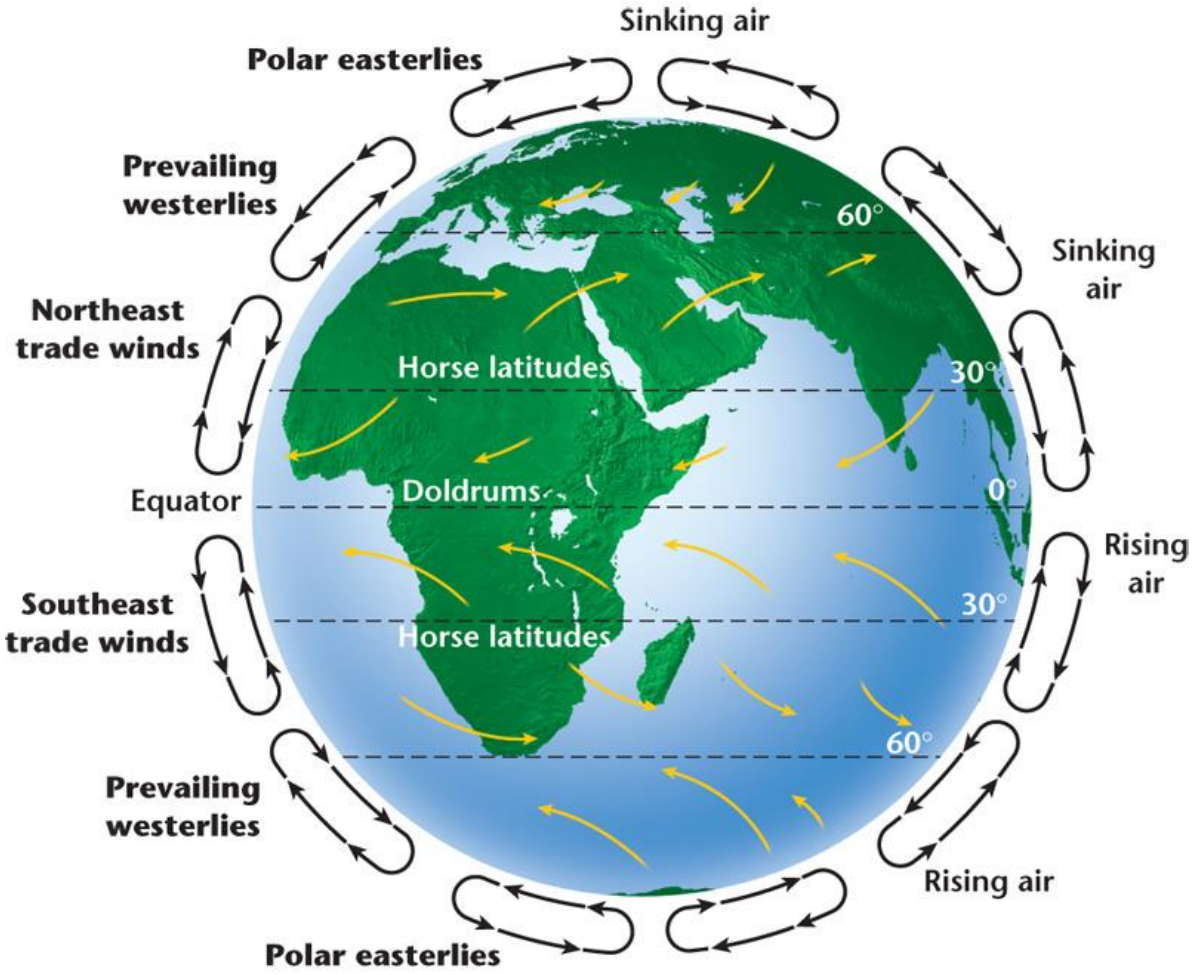
Weather Systems

- The **Coriolis effect**, which is a result of Earth's rotation, causes moving particles such as air to be deflected to the right in the northern hemisphere and to the left in the southern hemisphere.

- The Coriolis effect combines with the heat imbalance found on Earth to create distinct global wind systems that transport colder air to warmer areas and warmer air to colder areas.



Global Wind Systems



Global Wind Systems

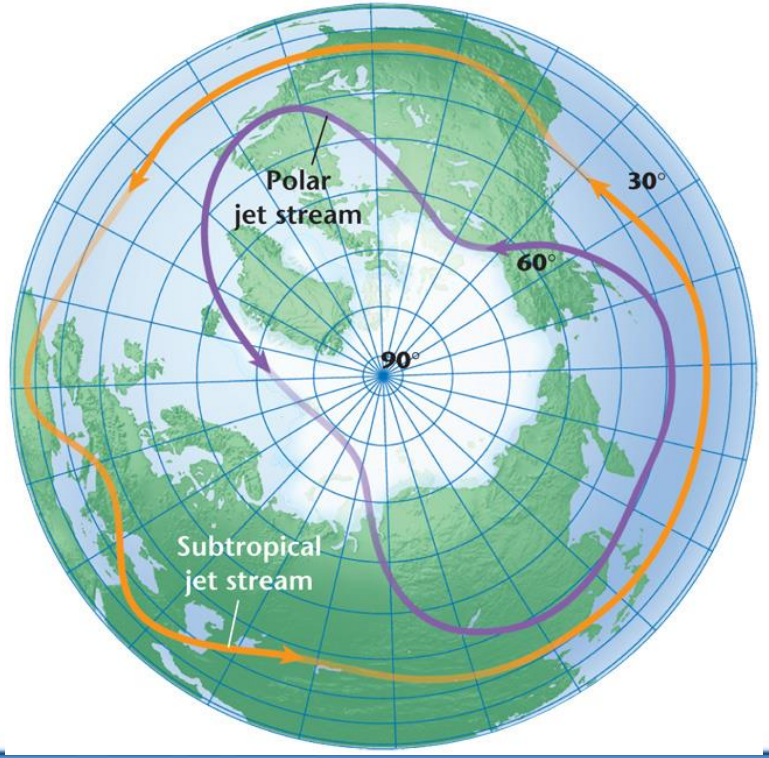
Other Wind Zones

- The **prevailing westerlies**, the second major wind zone, flows between 30° and 60° north and south latitude in a circulation pattern opposite that of the trade winds.
  - The prevailing westerlies are responsible for much of the movement of weather across the United States and Canada.
- The **polar easterlies**, the third major wind zone, lies between 60° latitude and the poles.
  - In both hemispheres, the polar easterlies are characterized by cold air.

Jet Streams

Jet streams are narrow bands of high-altitude, westerly winds that flow at speeds up to 185 km/h at elevations of 10.7 km to 12.2 km.

- The polar jet stream separates the polar easterlies from the prevailing westerlies.
- The subtropical jet stream is located where the trade winds meet the prevailing westerlies.



Jet Streams

Large-Scale Weather Systems

- The position of the jet stream varies, and it can split into different branches and later reform into a single stream.
- The jet stream represents the strongest core of westerly winds.
- Weather systems generally follow the path of the jet stream.
- The jet stream affects the intensity of weather systems by moving air of different temperatures from one region to another.

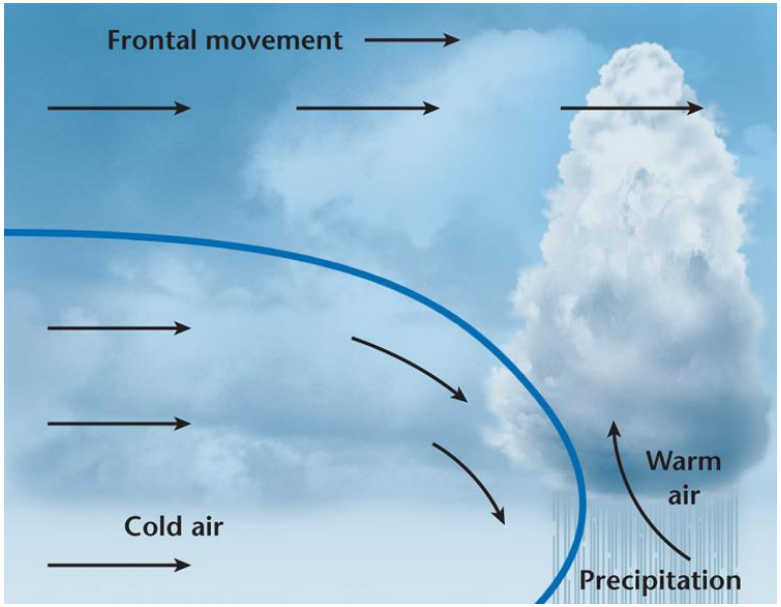
Fronts

- In the middle latitudes, air masses with different characteristics sometimes collide, forming a front.
- A **front** is the narrow region separating two air masses of different densities that are caused by differences in temperature, pressure, and humidity.
- The interaction between the colliding air masses can bring dramatic changes in weather.
- There are four main types of fronts: cold fronts, warm fronts, stationary fronts, and occluded fronts.

Fronts

Cold Fronts

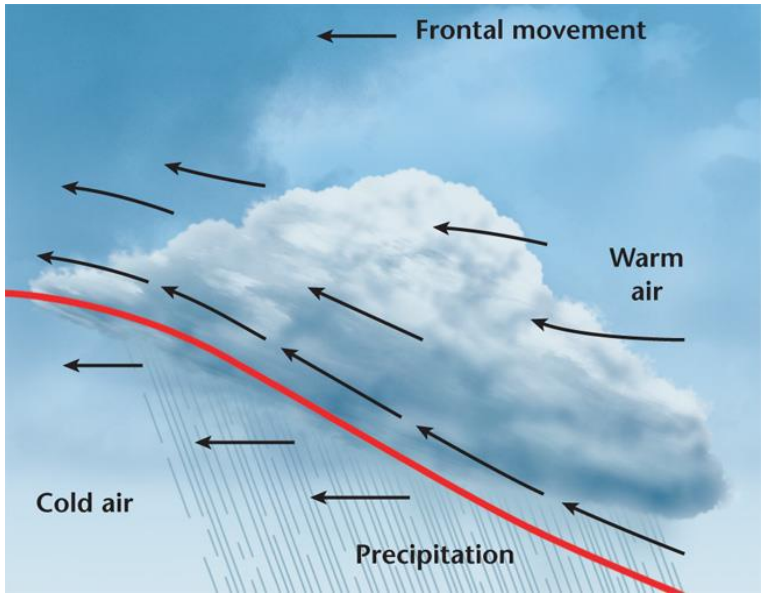
- In a cold front, cold, dense air displaces warm air and forces the warm air up along a steep front.
- Clouds, showers, and sometimes thunderstorms are associated with cold fronts.
- A cold front is represented on a weather map as a solid blue line with blue triangles that point in the direction of the front's motion.



Fronts

Warm Fronts

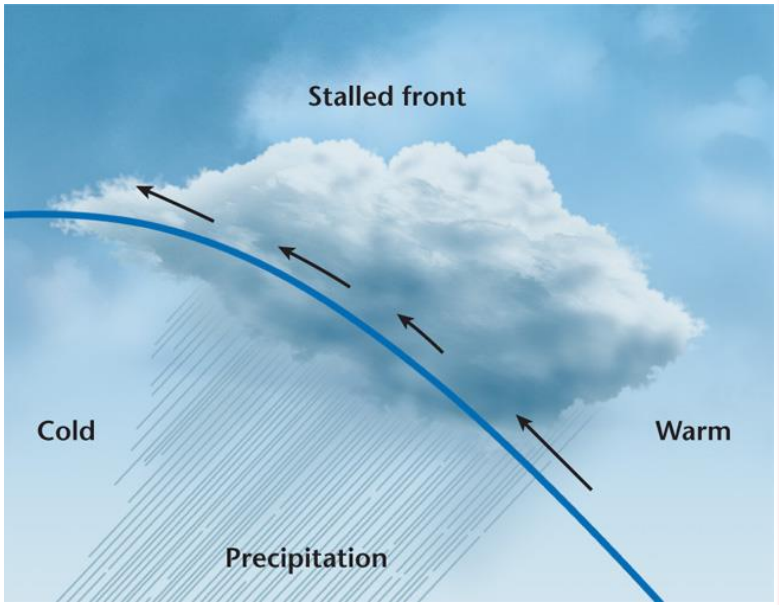
- In a warm front, advancing warm air displaces cold air.
- The warm air develops a gradual frontal slope rather than a steep boundary.
- A warm front is characterized by extensive cloudiness and precipitation.
- On a weather chart, a warm front appears as a solid red line with regularly spaced, solid red semicircles pointing in the direction of the front's motion.



Fronts

Stationary Fronts

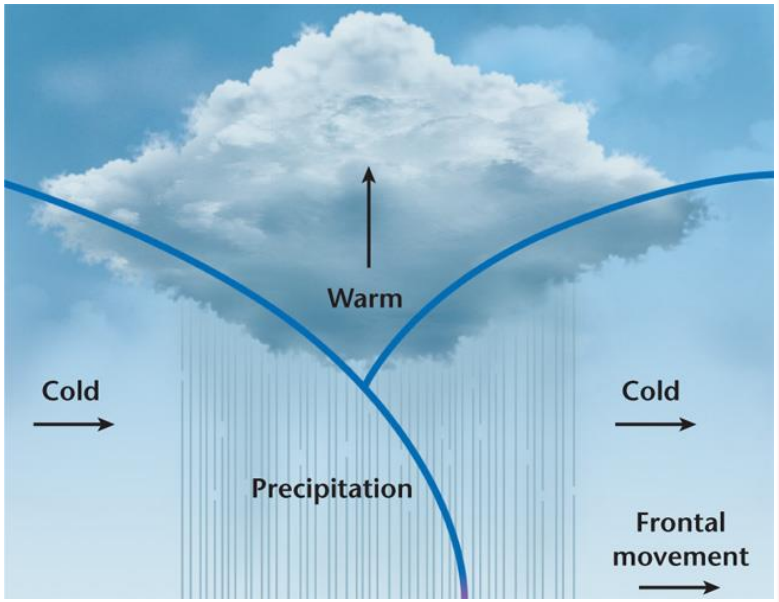
- A stationary front is the result of two air masses meeting and neither advancing into the other's territory, stalling the boundary between them.
- Stationary fronts seldom have extensive cloud and heavy precipitation patterns.
- A stationary front is represented on a weather map by a combination of short segments of cold- and warm-front symbols.



Fronts

Occluded Fronts

- An occluded front is the result of a cold air mass overtaking a warm front, wedging the warm air upward.
- Precipitation is common on both sides of an occluded front.
- An occluded front is represented on a weather map by a line with alternating purple triangles and semicircles that point toward the direction of motion.



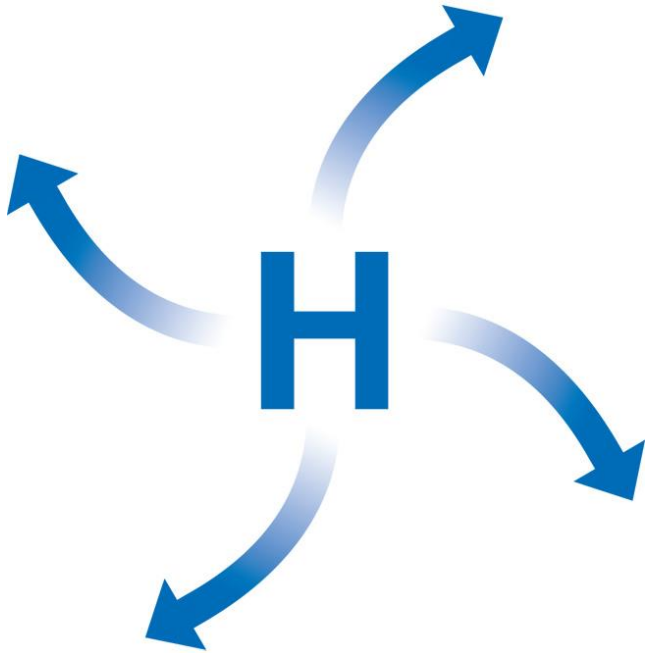
Pressure Systems

- At Earth's surface, rising air is associated with low pressure and sinking air is associated with high pressure.
- Rising or sinking air, combined with the Coriolis effect, results in the formation of rotating low- and high-pressure systems in the atmosphere.
- Air in these systems moves in a general circular motion around either a high- or low-pressure center.

Pressure Systems

High-Pressure Systems

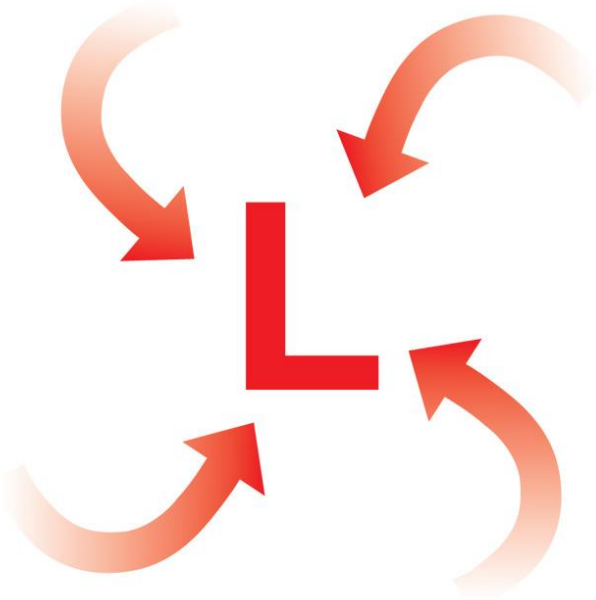
- In a high-pressure system, air sinks, so that when it reaches Earth's surface it spreads away from the center.
- The Coriolis effect causes the overall circulation around a high-pressure center to move in a clockwise direction in the northern hemisphere.
- High-pressure systems rotate in a counterclockwise direction in the southern hemisphere.



Pressure Systems

Low-Pressure Systems

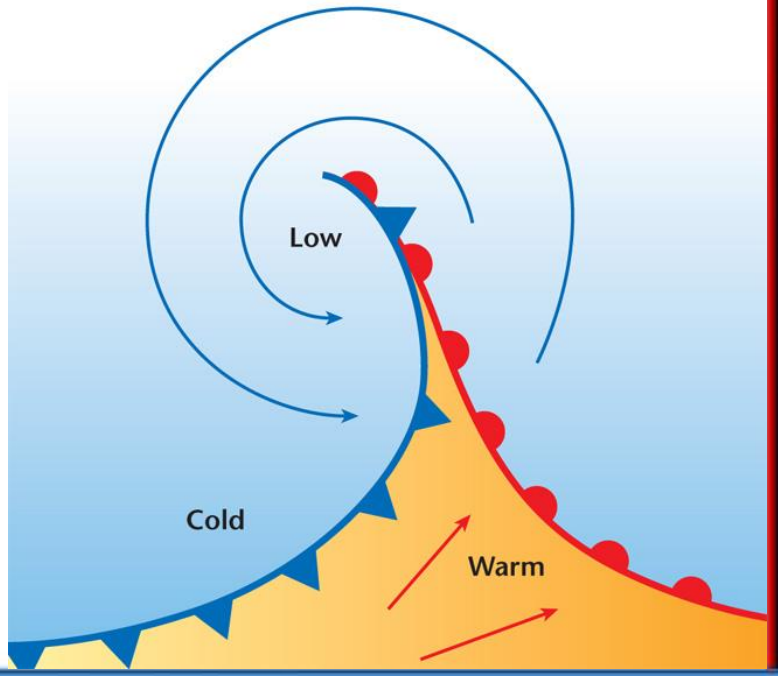
- In a low-pressure systems, air rises, causing an inward net flow toward the center and then upward.
- In contrast to air in a high-pressure system, air in a low-pressure system in the northern hemisphere moves in a counterclockwise direction.
- This movement is reversed in the southern hemisphere.



Pressure Systems

Low-Pressure Systems

- A wave cyclone, one of the main producers of inclement weather in the middle latitudes, usually begins along a stationary front.
- Part of the front moves south as a cold front and another part of the front moves north as a warm front.
- This sets up a counterclockwise or cyclonic circulation that can form into a fully developed low-pressure system.



Section Assessment

1. Match the following terms with their definitions.

D Coriolis effect

C trade winds

A jet streams

B front

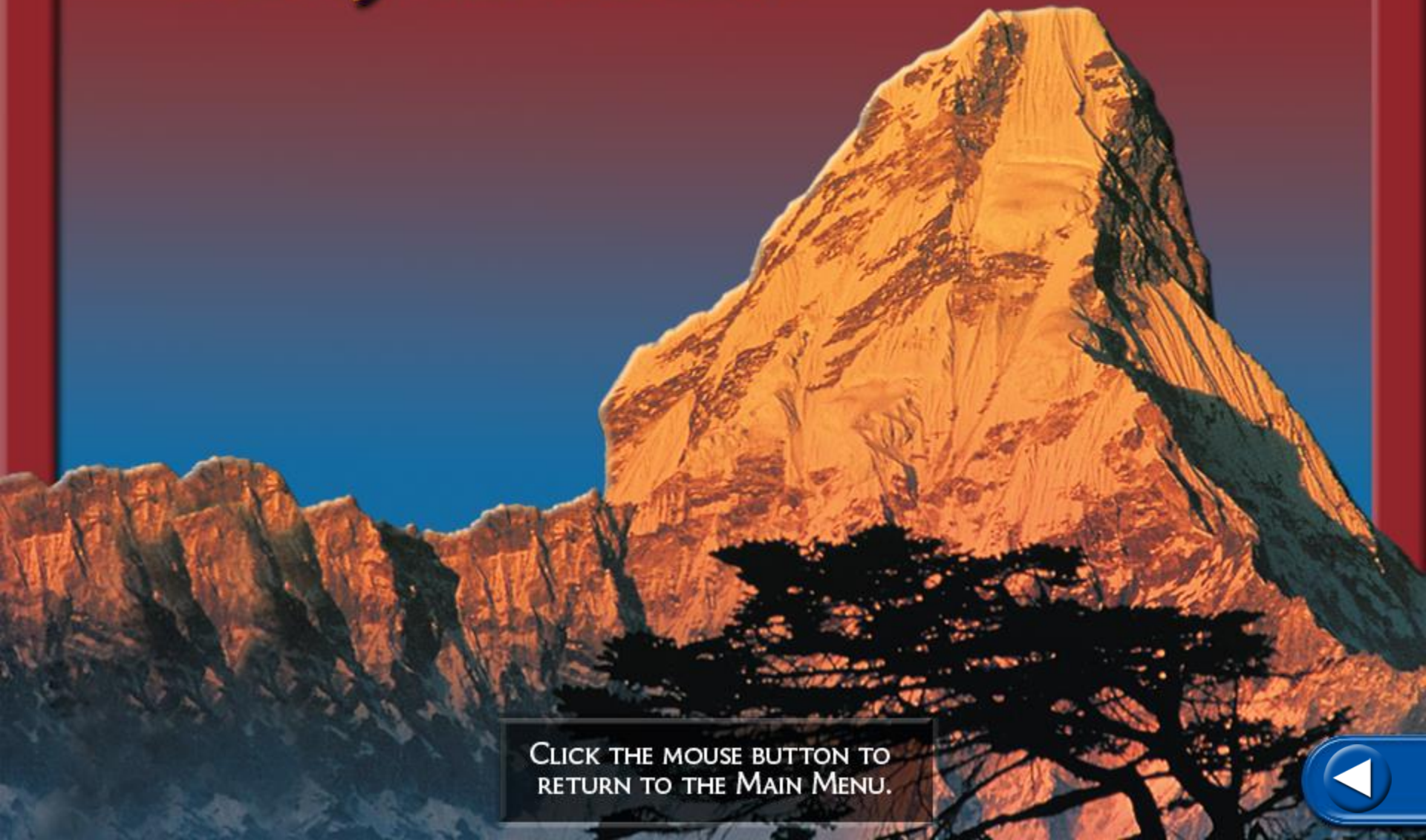
A. narrow bands of high-altitude, westerly winds that flow at high speeds

B. the narrow region separating two air masses of different densities

C. the major wind zones that occur at 30° north and south latitude

D. a result of Earth's rotation that causes moving particles such as air to be deflected to the right in the northern hemisphere and to the left in the southern hemisphere

End of the Section



Click the mouse button to return to the Main Menu.

Objectives

- **Recognize** the importance of accurate weather data.
- **Describe** the technology used to collect weather data.
- **Analyze** the strengths and weaknesses of weather observation systems.

Vocabulary

- thermometer
- barometer
- anemometer
- hygrometer
- ceilometer
- radiosonde
- Doppler effect

Gathering Weather Data

- Meteorologists measure the atmospheric variables of temperature, air pressure, wind, and relative humidity to make accurate weather forecasts.
- Two of the most important factors in weather forecasting are the accuracy and the density of the data, or the amount of data available.

Surface Data

- A **thermometer** is a device used to measure temperature.
- A **barometer** is a device used to measure air pressure.

Surface Data

Other Surface Instruments

- An **anemometer** is used to measure wind speed.
- A **hygrometer** measures relative humidity.
  - One type of hygrometer uses the temperature differences between wet- and dry-bulb thermometers in conjunction with a relative humidity chart to determine relative humidity.

Upper-Level Data

- To make accurate forecasts, meteorologists must gather atmospheric data at heights of up to 30 000 m.
- A **radiosonde**, a balloon-borne package of sensors, is presently the instrument of choice for gathering upper-level data.
- The sensors on a radiosonde measure temperature, air pressure, and humidity.
- The radiosonde is also tracked to determine wind speed and direction at various altitudes.

Weather Radar

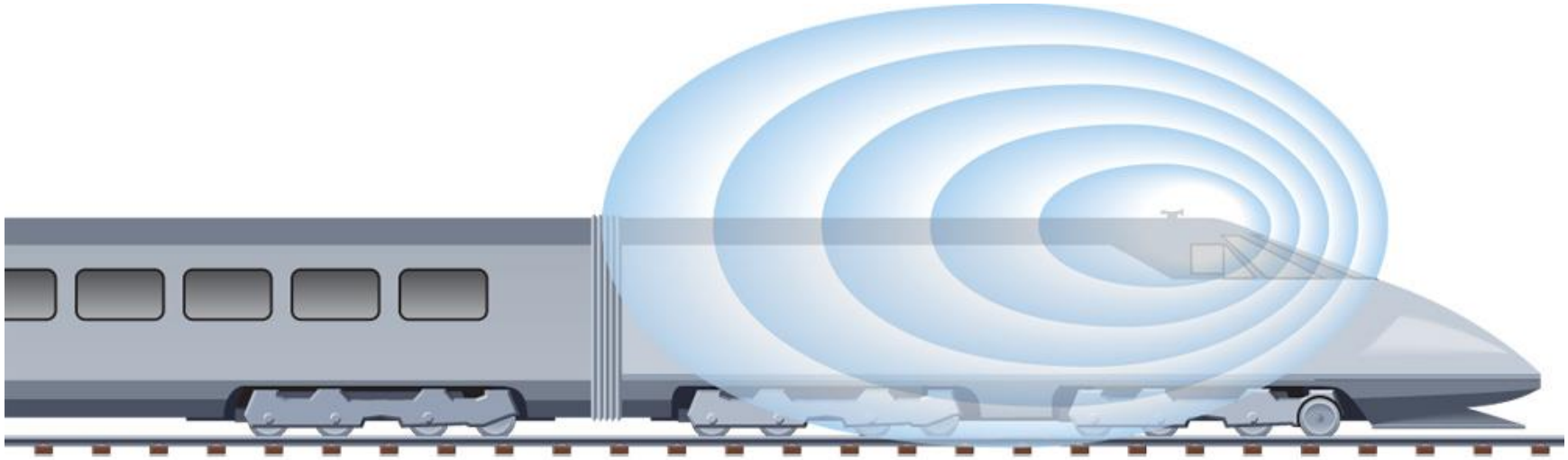
Doppler Radar

- The **Doppler effect** is the change in wave frequency that occurs in energy, such as sound or light, as that energy moves toward or away from an observer.
- Meteorologists use Doppler radar, which is based on the Doppler effect, to plot the speed at which raindrops move toward or away from a radar station.
- Because the motion of the moving raindrops is caused by wind, Doppler radar provides a good estimation of the wind speeds associated with precipitation areas, including those that are experiencing severe weather such as thunderstorms and tornados.

Weather Radar

Doppler Radar

As the train approaches, the sound waves ahead of it are compressed. These shorter waves have a high frequency, so the horn sounds high. Behind the train, the sound waves are stretched out. These longer waves have a lower frequency, so the horn sounds lower.



Weather Satellites

- In addition to communications, one of the main uses of satellites in orbit around Earth is to observe weather.
- Cameras mounted aboard a weather satellite take photos of Earth at regular intervals.
- Unlike weather radar, which tracks precipitation but not clouds, satellites track clouds but not necessarily precipitation.
- By combining data from the two types of technology, meteorologists can determine where both clouds and precipitation are occurring.

Section Assessment

1. Match the following terms with their definitions.

D thermometer

A barometer

C anemometer

E hygrometer

B ceilometer

A. an instrument that measures air pressure

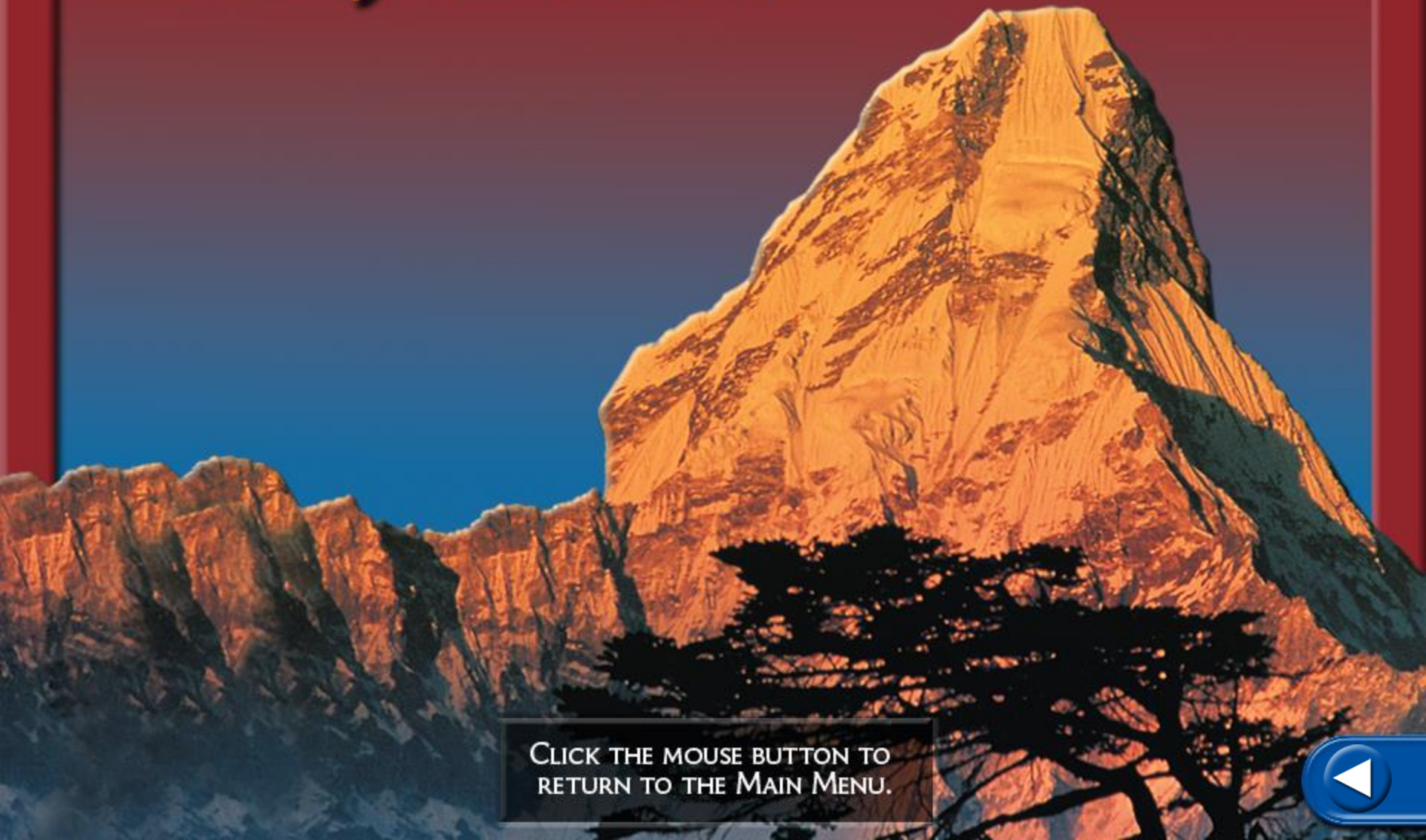
B. an instrument that measures the height of cloud layers and estimates the amount of sky covered by clouds

C. an instrument that measures wind speed

D. an instrument that measures temperature

E. an instrument that measures relative humidity

End of the Section



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Objectives

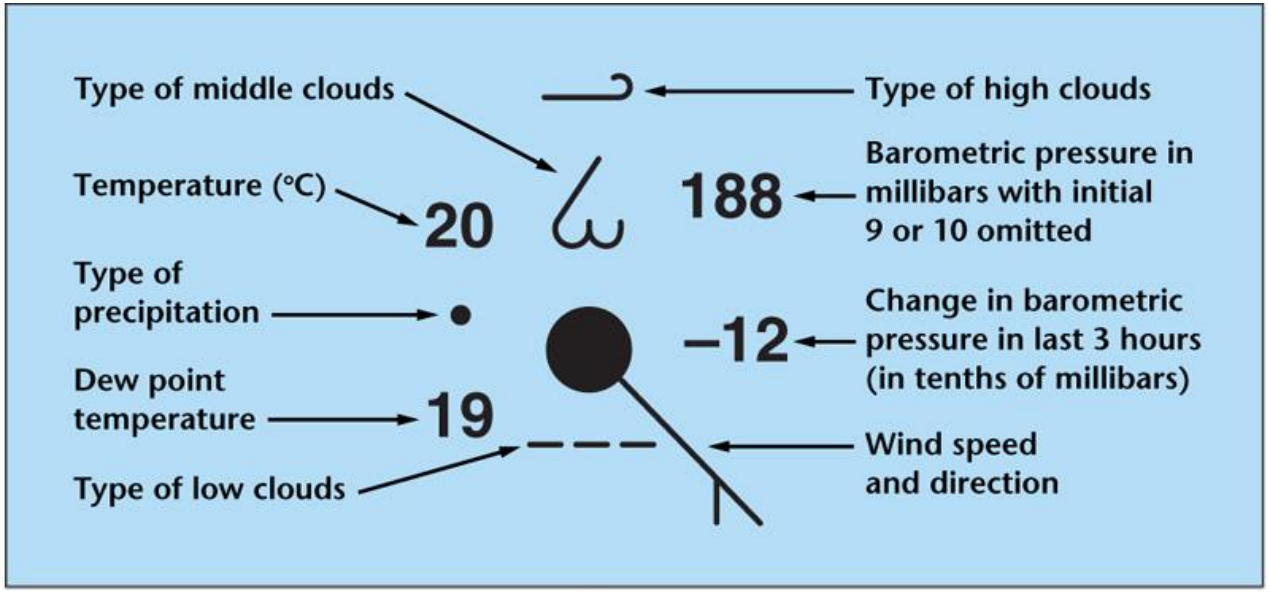
- **Analyze** a basic surface weather chart.
- **Distinguish** between analog and digital forecasting.
- **Describe** problems with long-term forecasts.

Vocabulary

- station model
- isopleth
- digital forecast
- analog forecast

Weather Analysis

- A **station model** is a record of weather data for a particular site at a particular time.
- Meteorological symbols are used to represent weather data in a station model.



Surface Analysis

- To plot data nationwide or globally, meteorologists use isopleths.

Isopleths are lines that connect points of equal or constant values, such as pressure or temperature.

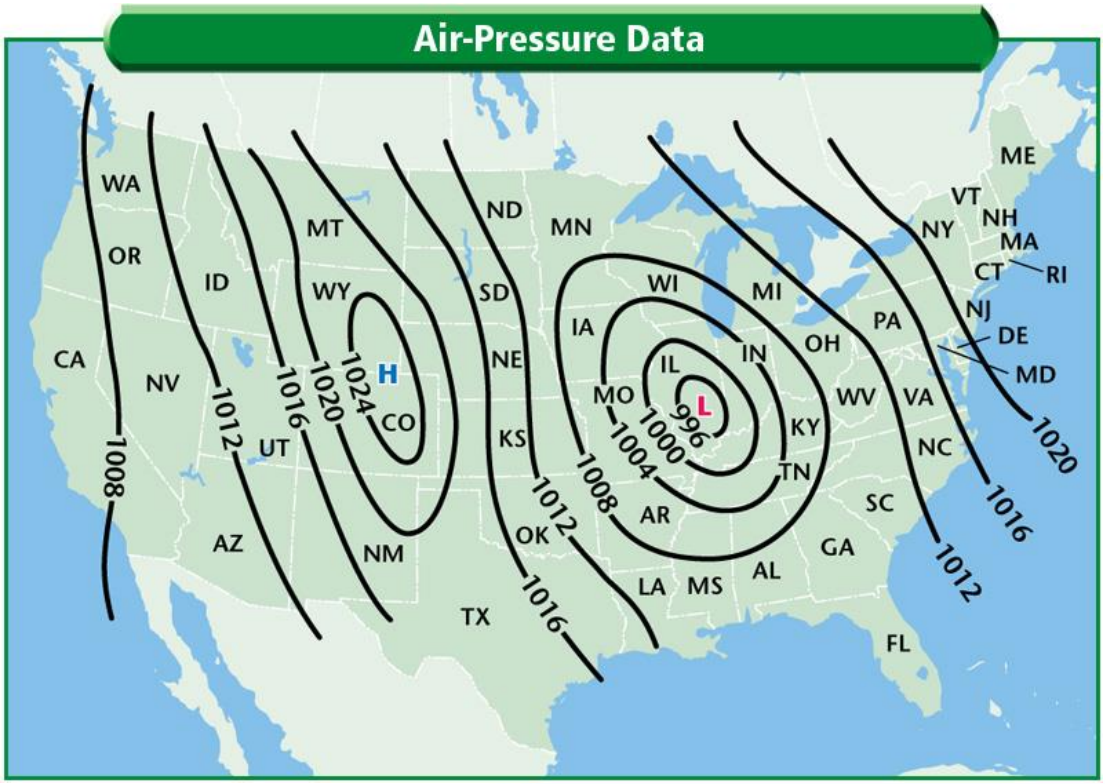
  - Lines of equal pressure are called isobars.
  - Lines of equal temperature are called isotherms.

Surface Analysis

- You can make inferences about weather by studying isobars or isotherms on a map.
- You can tell how fast wind is blowing in an area by noting how closely isobars are spaced.
  - Isobars that are close together indicate a large pressure difference over a small area and thus, strong winds.
  - Isobars that are spread far apart indicate a small difference in pressure which equates to light winds.

Surface Analysis

- Isobars also indicate the locations of high- and low-pressure systems.



Short-Term Forecasts

- Weather systems change directions, speed, and intensity with time in response to changes in the upper atmosphere.
- A reliable forecast must analyze data from different levels in the atmosphere.

Section Assessment

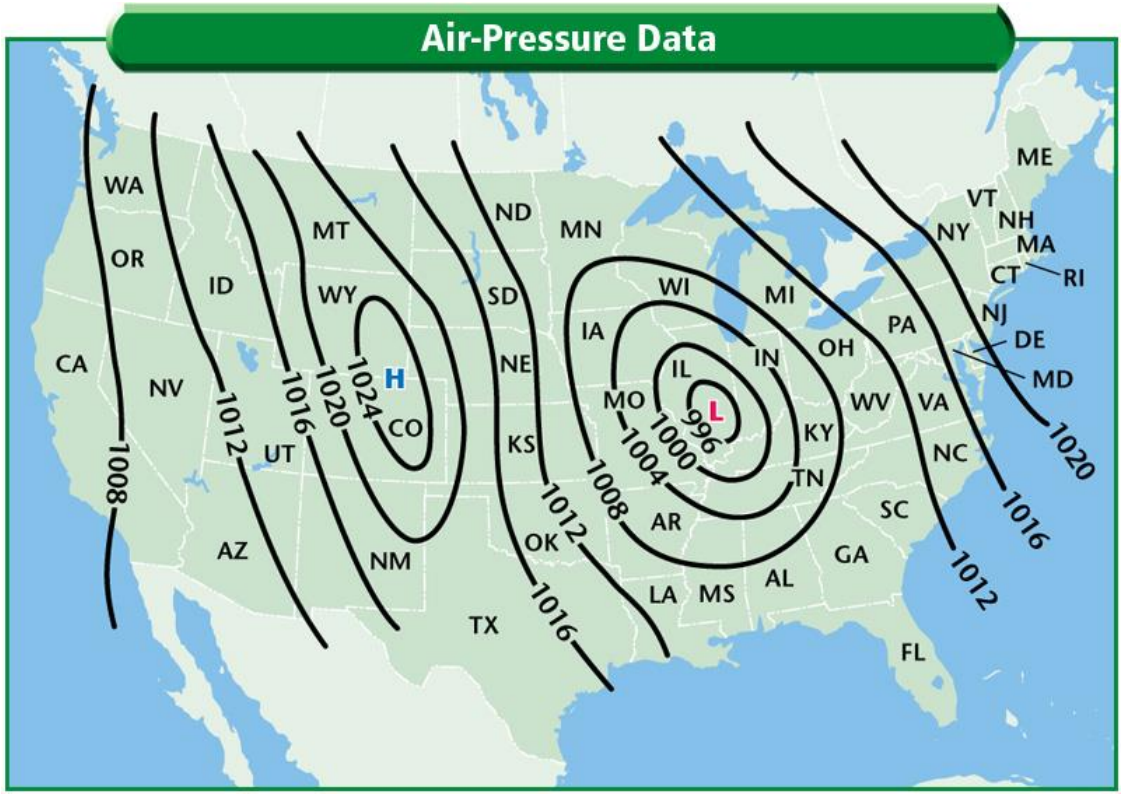
2. Based on the map below, where would the strongest winds most likely be located?

___ California

___ Texas

__X__ Missouri

___ South Carolina



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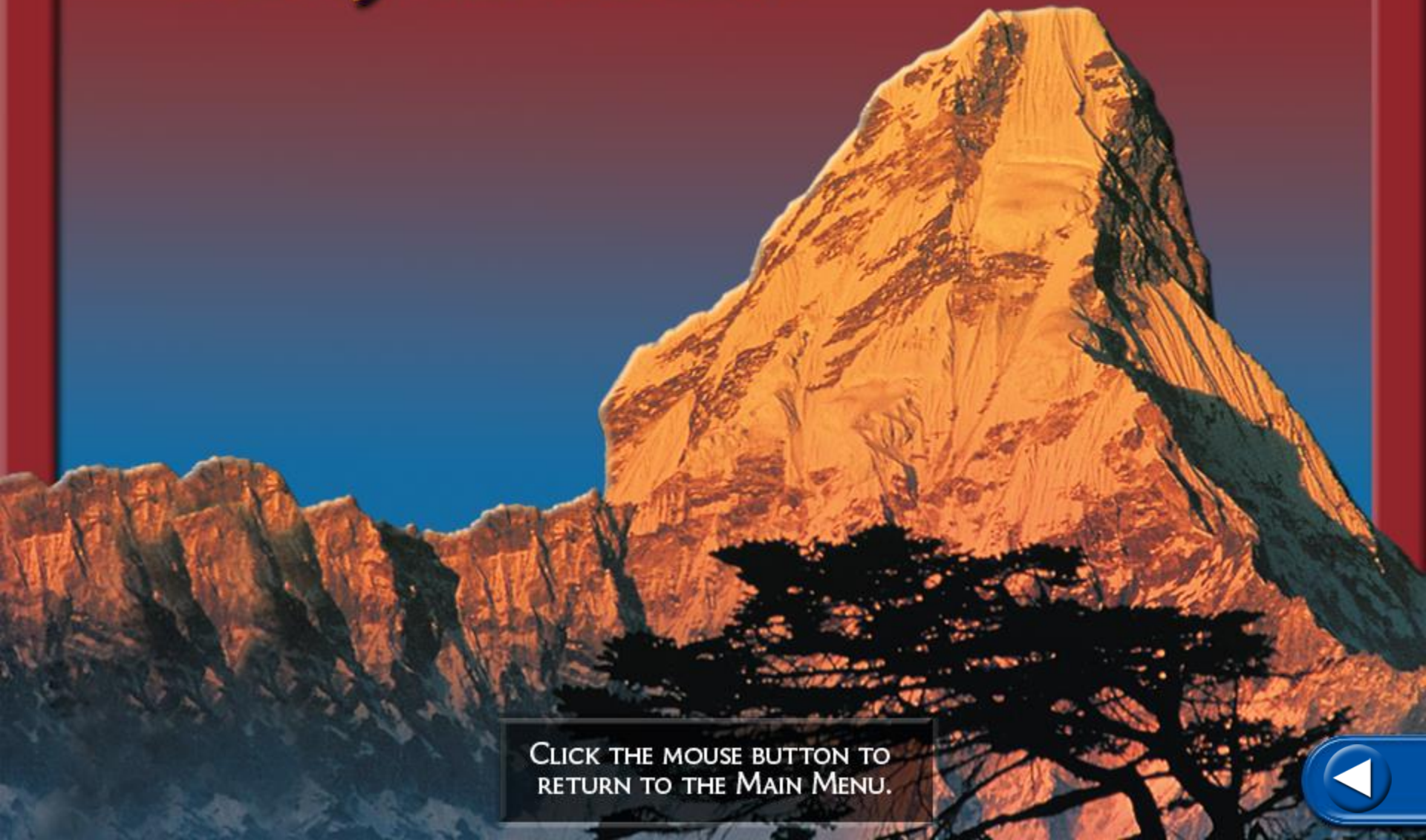

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Study Guide

Section 12.1 Main Ideas

- Meteorology is the study of the atmosphere. Weather is the current state of the atmosphere, and climate is the average weather over a long period of time.
- An air mass is a large body of air that takes on the characteristics of the area over which it forms.

Section 12.2 Main Ideas

- The Coriolis effect deflects air to the right in the northern hemisphere and to the left in the southern hemisphere. The Coriolis effect combines with the heat imbalance found on Earth to form the trade winds, prevailing westerlies, and polar easterlies.
- Weather in the middle latitudes is strongly influenced by fast-moving, high-altitude jet streams.
- A front is the boundary between two air masses of different densities. The four types of fronts are cold fronts, warm fronts, occluded fronts, and stationary fronts.

Section 12.3 Main Ideas

- Two of the most important factors in weather forecasting are the accuracy and the density of the data. Surface data are easier to gather than upper-level data.
- The most common instrument for collecting upper-level data is a balloon-borne radiosonde. Radiosondes measure temperature, pressure, humidity, wind speed, and wind direction.
- Weather radar pinpoints exactly where precipitation occurs. Weather satellites use both visible-light imagery and infrared imagery to observe weather conditions on Earth.

Section 12.4 Main Ideas

- A station model is a record of weather data for a particular site at a particular time. On a weather map, lines of equal pressure are called isobars and lines of equal temperature are called isotherms.
- Digital forecasting uses numerical data. Analog forecasting compares current weather patterns to patterns that took place in the past. All forecasts become less reliable when they attempt to predict long-term changes in the weather.

Multiple Choice

1. Which term best describes a bolt of lightning?

a. hydrometeor

b. lithometeor

c. electrometeor

d. meteor

Hydrometeor describes the forms of precipitation that contain water. *Lithometeor* describes smoke, haze, dust, and other condensation nuclei. *Meteor* meant “high in the air” to the ancient Greeks.

Multiple Choice

2. What would be the most likely classification of an air mass originating over Mexico and Arizona?

a. cT

b. cP

c. A

d. mP

Mexico and Arizona occupy a warm, continental regions; therefore, the air mass would be classified as a *continental tropical air mass (cT)*.

Multiple Choice

3. The horse latitudes represent a general area of _____ air.

a. rising

b. low-pressure

c. sinking

d. convergent

Rising, *low-pressure*, and *convergent* all describe areas where air rises from Earth's surface. At the *horse latitudes*, the northeast trade winds and the prevailing westerlies diverge, causing air to sink to the surface and then spread apart which creates an area of high-pressure.

Multiple Choice

4. What type of front is the result of a cold air mass moving rapidly and overtaking a warm front?

a. warm front

b. cold front

c. stationary front

d. occluded front

In an *occluded front*, the cold air squeezes the warm air upward between the two cold air masses.

Multiple Choice

5. Which of the following instruments is used to determine the height of cloud layers?

a. anemometer

b. ceilometer

c. hygrometer

d. barometer

An *anemometer* measures wind speed. A *hygrometer* measures relative humidity. A *barometer* measures air pressure. A *ceilometer* also estimates the amount of sky covered by clouds.

Short Answer

6. What are the main benefits that infrared imaging has over visible imaging?

Infrared imaging works by detecting heat. This is useful because it allows meteorologists to determine cloud heights as well as “see” clouds at night.

Short Answer

7. Why is density of data important when creating a digital forecast?

Digital forecasts use numeric data that is put into mathematical equations to determine how atmospheric variables will change over time. The more numeric data that is entered, the more accurate the forecast.

True or False

8. Identify whether the following statements are true or false.

true Weather refers mainly to short-term variations in the atmosphere.

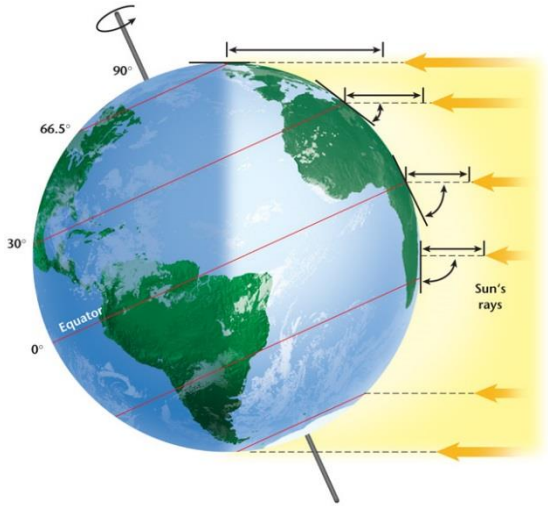
true The doldrums refers to the ITCZ.

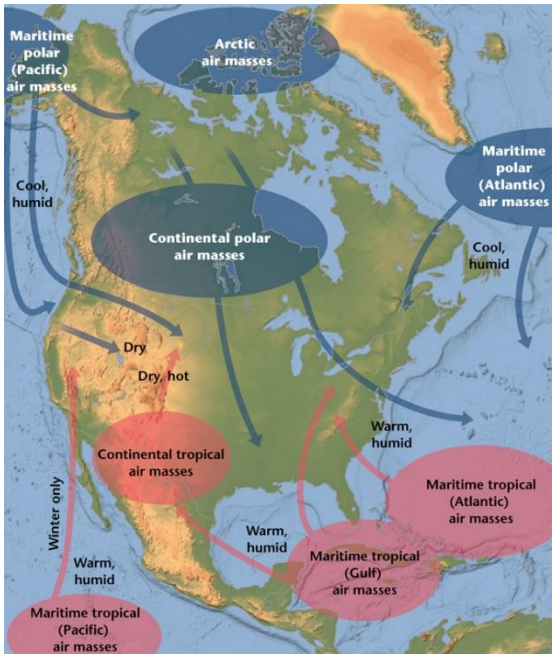
false A warm front is more likely to be accompanied by thunderstorms than a cold front.

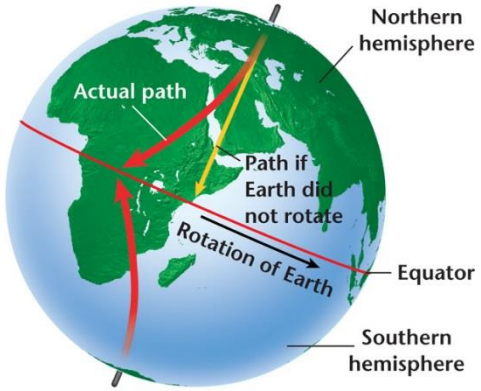
false Isobars that are close together may indicate an area of light wind.

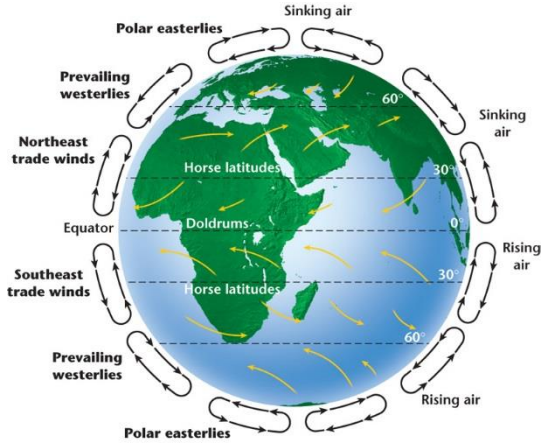
false The position of the polar jet stream does not shift more than a few kilometers.

Chapter 12 Images

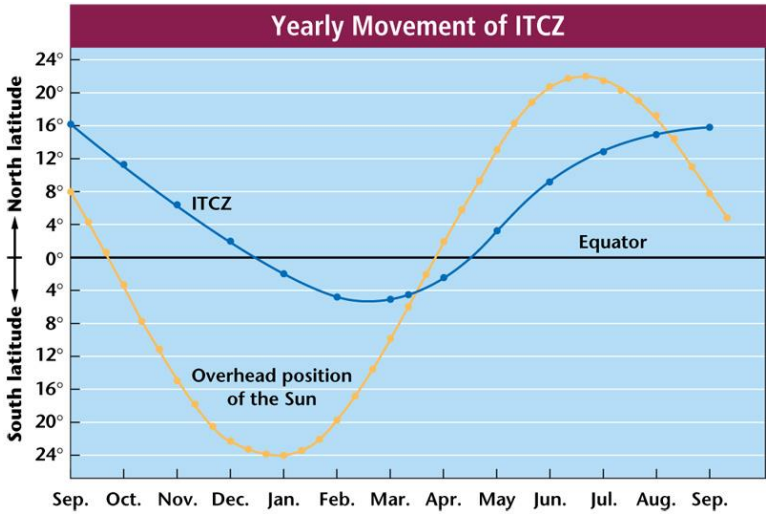


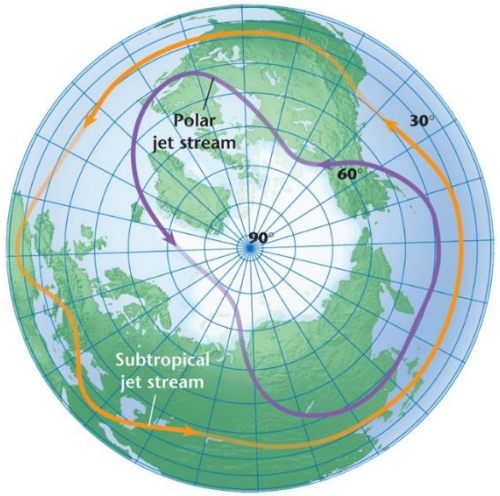


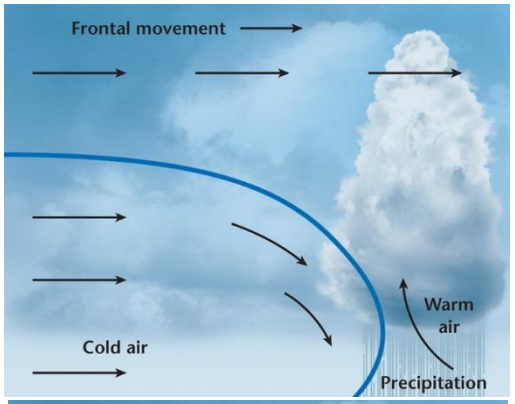


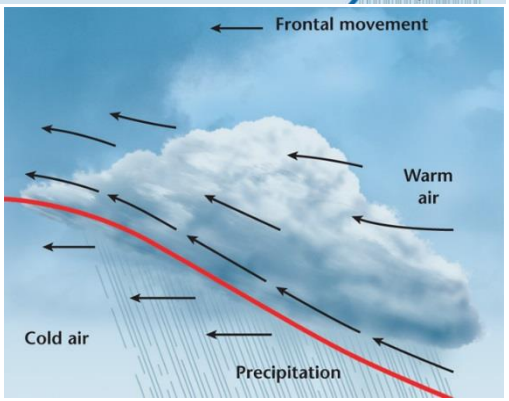


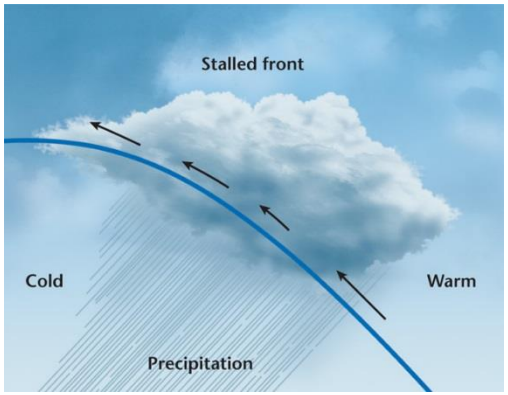
Chapter 12 Images

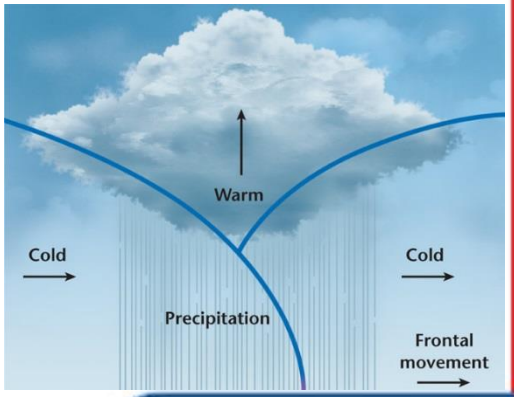




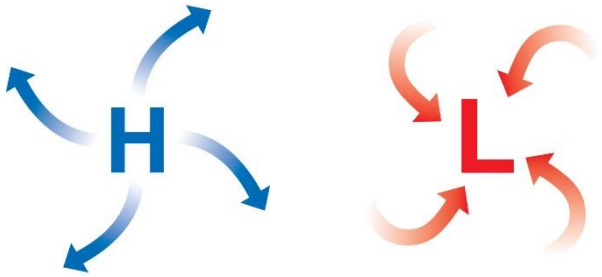


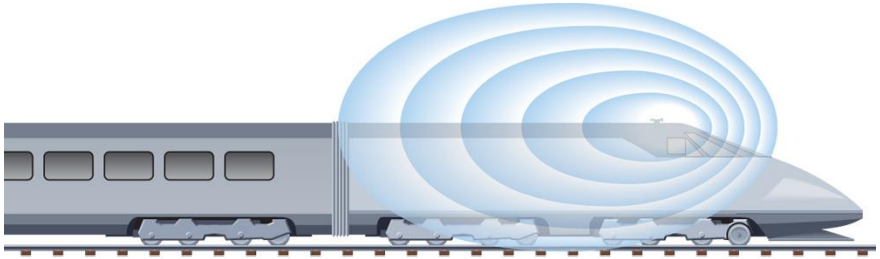


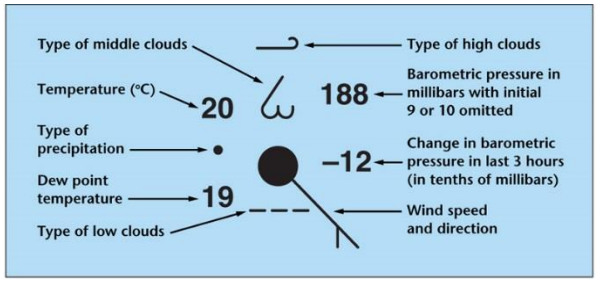


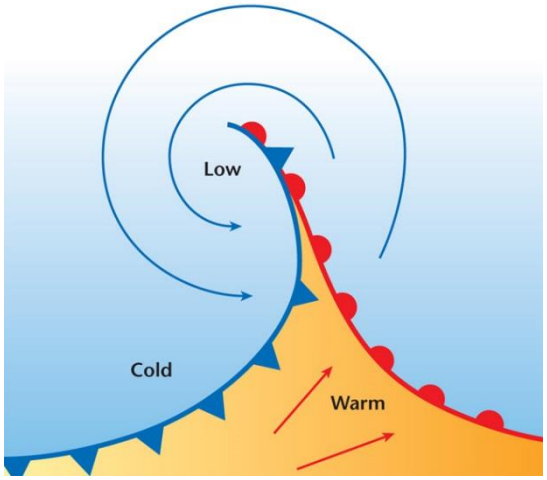


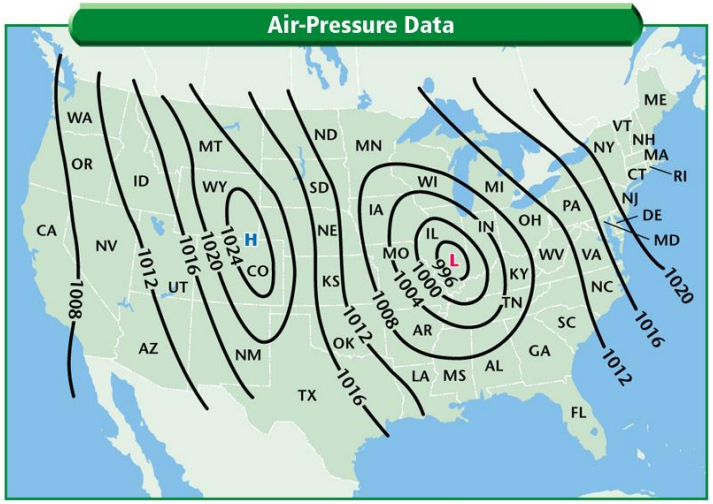
Chapter 12 Images











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