Lesson 304:

Air Pressure & Wind

304

A lesson about the motions and circulation of the atmosphere.

Fundamental Questions

Attempting to give thorough and reasonable answers to the following questions will help you gauge your level of understanding this lesson. Students that can confidently answer these questions have mastered the concepts of this lesson.

1. In what ways does wind affect life on Earth?
2. In what ways does wind affect climates on Earth?
3. Where on Earth would you expect to find the "best" weather?
4. Where on Earth would you expect to find the "worst" weather?
5. What would happen to wind if the entire world were covered by dust that completely blocked sunlight for an entire day?

Lesson Objectives

At the end of this lesson, students should have mastered the objectives listed below.

1. Students understand how air pressure and air density are related.
2. Students know the average air pressure at sea level.
3. Students understand that air pressure is exerted in all directions and that is why we do not feel the "weight" of the atmosphere.
4. Students can explain how altitude, temperature, and humidity are related to air pressure.
5. Students understand the differences between aneroid and mercury barometers.
6. Students recognize that the sun is the ultimate energy source for most winds.
7. Students understand how differences in air pressure create winds.
8. Students can accurately read and create isobar maps.
9. Students recognize that the spacing of isobars indicates the pressure gradient and strength of winds.
10. Students understand that the winds are named for the direction the winds comes from.
11. Students understand what the Coriolis Effect is and how it affects wind and other fluids.
12. Students understand how the equator, wind speed, and surface friction can enhance or weaken the Coriolis Effect.
13. Students understand the relationship between cyclones/anticyclones and the Coriolis Effect.
14. Students can describe the distribution, movements, and patterns of global winds and Hadley cells.
15. Students can make reasonable weather forecasts based on air pressures.
16. Students are familiar with the instruments and units used to measure the characteristics of air and wind.
17. Students can compare and contrast local winds such as sea breezes and land breezes.
18. Students understand the difference between continental and maritime air masses.

Important Terms

The following terms are some of the vocabulary that students should be familiar with in order to fully master this lesson.

1. air mass
2. air pressure
3. anemometer
4. aneroid barometer
5. anticyclone
6. average air pressure
7. barometer
8. continental air mass
9. convection
10. Coriolis Effect
11. cyclone
12. doldrums
13. friction
14. fronts
15. global winds
16. Hadley Cell
17. horse latitudes
18. humidity
19. interpolation
20. isobars
21. isotherm
22. jet stream
23. knots
24. land breeze
25. local winds
26. maritime air mass
27. mercury barometer
28. polar easterlies
29. polar front
30. pressure gradient
31. sea breeze
32. trade winds
33. westerlies
34. wind
35. wind vane

Assessment Questions

The following are examples of questions that students should be able to answer. These or similar questions are likely to appear on the exam.

1. What is air pressure?
2. What are the three causes of air pressure variations?
3. Draw a basic graph that shows what happens to air pressure if the temperature, humidity, or elevation of the air changes.

4. What is the standard air pressure at sea level in bars? In millibars? In pounds per square inch (psi)? In inches of mercury? In millimeters of mercury?
5. What kind of weather is generally associated with low air pressures?
6. Why does air pressure generally go unnoticed?
7. Draw a diagram that shows what a mercury barometer does and how it works.
8. What is the difference between a mercury barometer and an aneroid barometer?
9. What is wind?
10. What causes wind?
11. What are isobars?
12. In which direction is a westerly wind blowing?
13. Why does humid air weigh less (i.e. have a lower air pressure) than dry air that has the same temperature?
14. What is the Coriolis Effect?
15. Compared to slow-moving air, is the Coriolis Effect stronger or weaker for fast-moving air?
16. Compared to mountainous areas on the continents, does the surface of the ocean generally produces low or high friction for moving air masses?
17. Is the Coriolis Effect is stronger or weaker for air moving over a high-friction surface, such as a mountain range?
18. Is the Coriolis Effect is stronger or weaker near the equator?
19. Draw how winds will generally move in high and low air pressure systems of the northern hemisphere. Be sure to consider how the Coriolis Effect will influence the apparent paths of the winds.
20. Wind generally moves air away from a pressure high and toward a pressure low. Why?
21. In which direction does a cyclone in the northern hemisphere spin?
22. In which direction does a cyclone in the southern hemisphere spin?
23. In which direction does an anti-cyclone in the northern hemisphere spin?
24. Draw a weather map symbol for a weather station that has recorded the following data: southeasterly wind moving at 36 miles per hour, mostly cloudy (75%), air pressure of 1005 millibars, air temperature of 62°F.
25. What is an isobar? An isotherm? Interpolation?
26. Draw the three-celled circulation model for global winds.
27. What is the origin of the expression “stuck in the doldrums”?
28. What kind of air pressure is generally found over continents during the winter and what kind of air pressure is generally found over the oceans during summer?
29. Draw a diagram of sea-breeze circulation.
30. Draw a diagram of land-breeze circulation.
31. Explain why continental air masses (cT and cP) are generally drier than maritime air masses (mT and mP).
32. Describe the four main types of air mass fronts.

Related Web Sites

The following are some web sites that are related to this lesson. You are encouraged to check out these sites to obtain additional information.

1. http://stratus.ssec.wisc.edu/courses/gg101/coriolis/coriolis.html
2. http://education.nationalgeographic.com/education/encyclopedia/coriolis-effect/?ar_a=1
3. http://en.wikipedia.org/wiki/Coriolis_effect
4. http://geography.about.com/od/physicalgeography/a/coriolis.htm
5. http://en.wikipedia.org/wiki/Atmospheric_pressure
6. http://kids.earth.nasa.gov/archive/air_pressure/index.html
7. http://www.srh.noaa.gov/jetstream/atmos/pressure.htm
8. http://en.wikipedia.org/wiki/Global_winds
9. http://en.wikipedia.org/wiki/Global_wind_patterns
10. http://en.wikipedia.org/wiki/Wind
11. http://science.nationalgeographic.com/science/earth/earths-atmosphere/wind/
12. http://www.weatherwizkids.com/weather-wind.htm

Related Book Pages

The following are the pages from your book that correspond to this lesson.

Comprehensive E.S. Book	Intensive/Honors E.S. Book	Meteorology/GIS Book
pp. 532-555	pp. 278-284	NA

Massachusetts Standards

The following are the Massachusetts Framework Standards that correspond to this lesson.

Earth Science Learning Standard(s) NA

What’s Next?

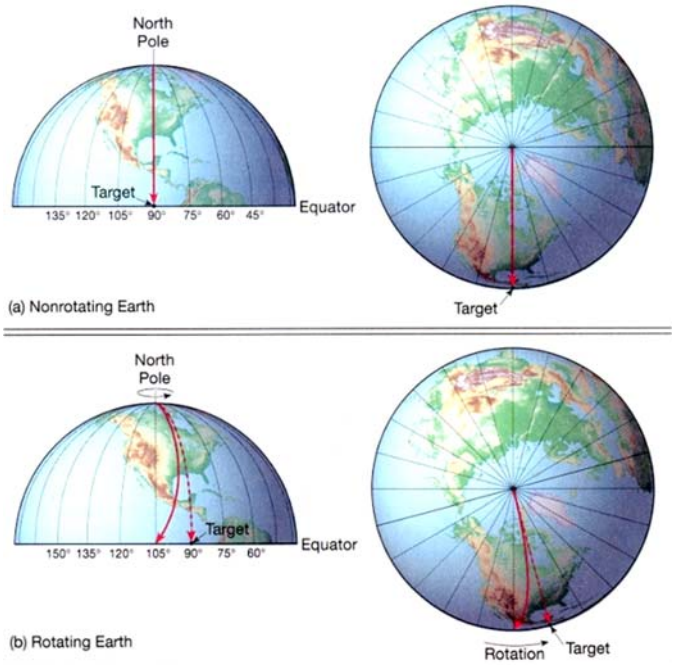
CCCIV. **Air Pressure and Winds**

A. Understanding Air Pressure

1. **Air Pressure** – the *force* that air exerts on the surface of Earth per unit of area
    a. Average air pressure at sea level – 1 bar, 1013 millibars (mb), 14.7 pounds per square inch (PSI), 760 millimeters of mercury (mmHg), 29.92 inches of mercury (inHg)
        i. At sea level, the weight of a column of air would be 14.7 pounds per square inch. Column of air over 1 square centimeter (1 cm x 1 cm) of your palm weighs about as much as 1-liter bottle of Coke.
        ii. The normal range of the Earth's air pressure is from 980 mb to 1050 mb.
        iii. The lowest pressure ever recorded was 888 mb
        iv. Lower air pressure generally means poorer weather
    b. Air is a gas so air pressure is exerted in all directions – up, down, and sideways. The air pressure pushing down on an object usually balances the air pressure pushing up on the object. Imbalances can occur and that is what we call *wind*.
    c. Air pressure varies due to:
        i. *Altitude* – pressure decreases with increasing elevation; density of gases decreases with increasing elevation
        ii. *Temperature* – warm air is less dense than cold air so warm air exerts less pressure
        iii. *Water vapor content* – H_2O weighs less than O_2 and N_2 so air that has high H_2O content exerts less pressure because it weighs less than dry air
2. **Barometers** – instruments used to measure air pressure ("bar" means pressure)
    a. **Mercury barometer** – shows changes in air pressure by air pushing liquid mercury up into a tube or mercury being released from the tube into a pool
    b. **Aneroid barometer** – size of canister shrinks/expands as pressure changes

B. Winds

1. What is wind?
    a. Winds are created by horizontal differences in air pressure due to unequal heating of air. The sun is the ultimate energy source for most wind.
    b. Wind is air moving from areas of high pressure to areas of low pressure in order to balance out the pressures
        i. Spacing of **isobars** on air pressure maps indicates how much the pressure changes over a given distance.
        ii. Closely spaced isobars indicate a steep **pressure gradient** and therefore more powerful winds.
        iii. Widely spaced isobars indicate a gentle pressure gradient and therefore lighter winds.
    c. Name of the wind tells you where the wind is coming *from* (e.g. easterly winds blow from the east)
2. **The Coriolis Effect**
    a. The path of objects moving in a straight line through a fluid (liquid or gas) appears to be deflected because of

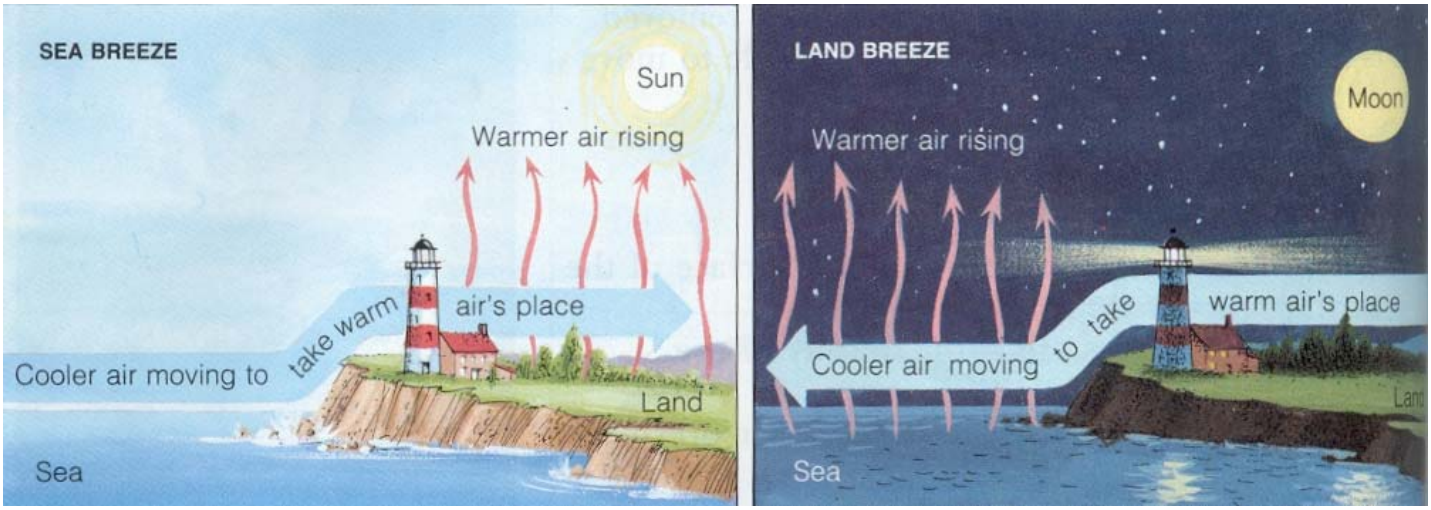


earth's spherical shape and rotation

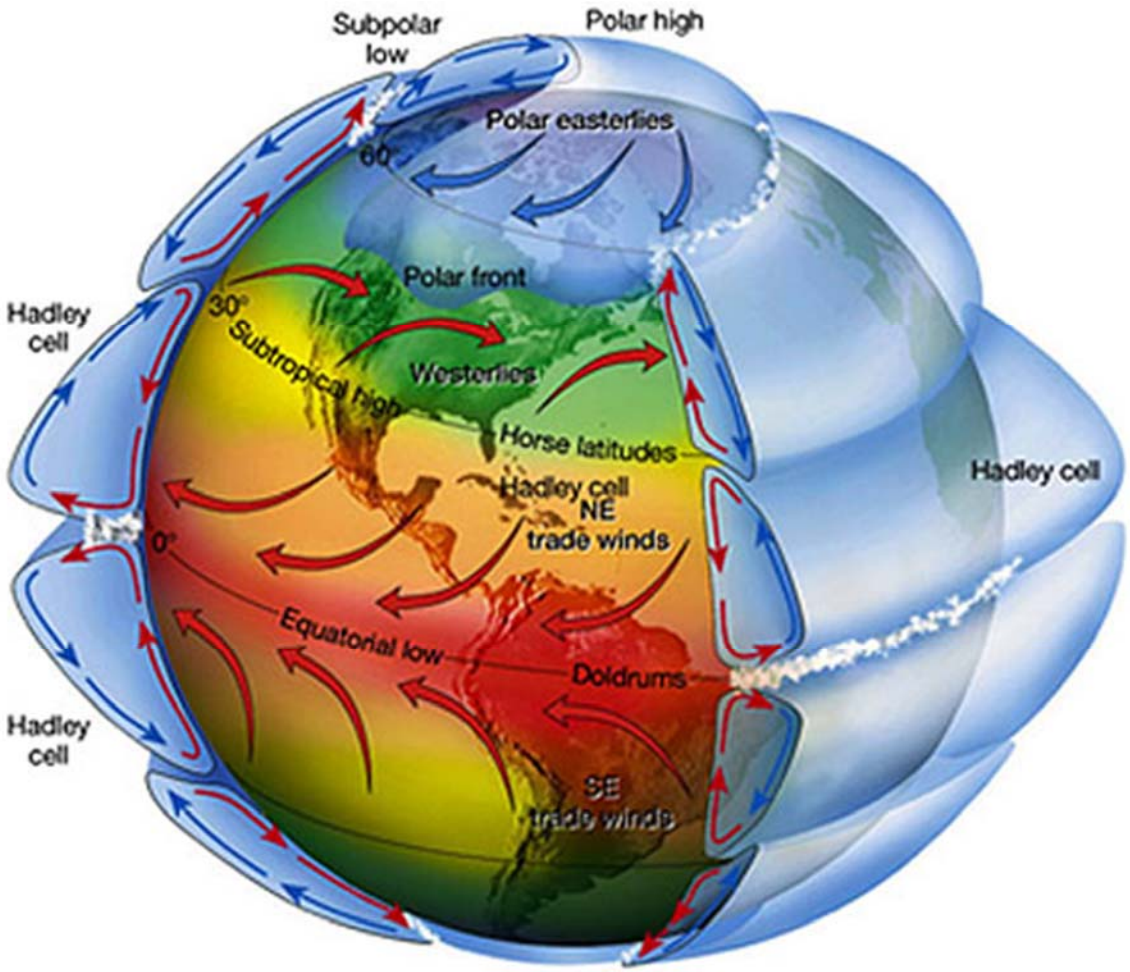
b. The motion is always deflected to the right in the northern hemisphere and to the left in the southern hemisphere.

c. The faster the air moves, the more it is deflected

3. **Friction**
   a. Friction is a force of resistance that is caused by the irregular surface of earth acting upon the movement of air
   b. When air movement is slowed by friction, the wind direction changes
4. **Local winds** – blow in any direction and cover small distances
   a. **Sea breeze** – flow of air from sea to land due to daytime heating of land which in turn heats air around it, creating low pressure area
   b. **Land breeze** – flow of air from land to sea due to nighttime cooling of air over land which creates a high pressure area on land



5. Global Winds
   a. Equator receives most sunlight so lowest pressure air is found there and highest pressure air is found at poles
   b. In general, warm equator air rises and moves toward poles and cold polar air sinks and moves toward equator
   c. **Coriolis Effect** – apparent shift in the path of any fluid or object (e.g. wind) moving above the surface of the Earth due to Earth's rotation
   d. **Doldrums** – very calm surface winds found near equator due to intense heating of air and formation of low pressure area where warm air is constantly rising
   e. **Horse latitudes** – very calm winds found at about 30° N and S latitudes; skies are clear and air is dry
   f. **Trade winds** – warm, steady easterly winds that circulate between the equator and 30°
   g. **Prevailing westerlies** – strong westerly winds found between 30° and 60°
   h. **Polar easterlies** – very cold, weak easterly winds flowing from poles toward equator
   i. **Jet streams** –high-altitude (near the tropopause), high-pressure belts of air that move quickly (125 mph) from west to east
6. Measuring Wind
   a. **Wind vane** – measures wind direction by pointing into the wind
   b. **Anemometer** – measures wind speed
   c. **Knots** – used to measure wind speed; one *knot* is equal to 1850 meters per hour


Subpolar low
Polar high
Polar easterlies
60°
Polar front
Hadley cell
30°
Subtropical high
Westerlies
Horse latitudes
Hadley cell
NE trade winds
Hadley cell
0°
Equatorial low
Doldrums
Hadley cell
SE trade winds

The Weather Channel

WEATHER EXPLAINERS

Arctic Blast Sets Record High Pressure

By Chris Dolce · January 10 2015 12:00 AM EDT · weather.com

The blast of Arctic air this week set some temperature records in parts of the South and East, but that wasn't the only type of record that was broken.

Typically Arctic air masses that invade the United States are accompanied by strong high pressure systems. In the case of the bone-chilling air that invaded the central and eastern states during the middle part of this week, the area of high pressure was exceptionally strong. In fact, some cities in the northern and central Plains set records for the highest atmospheric pressure ever recorded in any month of the year.

Atmospheric pressure is measured using a barometer. You may hear from meteorologists on The Weather Channel or elsewhere refer to this as barometric pressure.

Among the cities where all-time record high pressure was set on Wednesday include:

- Grand Island, Nebraska (1056.9 millibars)
- Lincoln, Nebraska (1055.9 millibars)
- Omaha, Nebraska (1055.3 millibars)
- Concordia, Kansas (1055.1 millibars)
- Topeka, Kansas (1054.3 millibars)
- Des Moines, Iowa (1052.15 millibars)
- North Little Rock, Arkansas (1045.07 millibars)

Map showing lines of equal pressure and the strong area of high pressure in the U.S. on January 7, 2015.

The highest measured barometric pressure in the U.S. is 1078.6 millibars which was recorded on January 31, 1989 in eastern Alaska at Northway which reached -62 degrees. That January was the coldest single month on record at Juneau with an average temperature of 6.8 degrees and Nome recorded its coldest temperature on record with -54 degrees on January 27 and 28.

In the contiguous U.S. the highest barometric reading is 1064 millibars which was measured at Miles City, Montana, on December 24, 1983. This strong area of high pressure brought one of the coldest Christmas holiday's for much of the country east of the Rockies. It was the coldest Christmas in northeast Ohio and northwest Pennsylvania and blizzard conditions occurred as well. That December was also the coldest December on record for Sioux Falls, South Dakota, and Sioux City, Iowa.

Agata, Russia, holds the world's highest measured barometric pressure reading of 1083.3 millibars on Dec. 31, 1968. Agata is located in the Central Siberian Plateau at an elevation of 855 feet.

Besides being accompanied by very cold temperatures, the extreme high pressure can also bring an increase in aches and pains, including headaches and migraines.