Air Pressure and Wind

Objectives

Many of our weather experiences involve air in motion, whether as gentle breezes or hazardous gales. **Wind** is the motion of air relative to Earth's surface. Wind often changes temperature and humidity, produces clouds, and leads to precipitation. Usually, when we talk about wind, we refer to its horizontal speed and direction, though it also has an important vertical component. For example, if we say an east wind is blowing at 10 m/s, we mean the wind is blowing horizontally from east to west. Variations in atmospheric air pressure cause winds to blow from areas of high pressure toward areas of low pressure. Determining these air pressure patterns, their differences, and the resulting horizontal and vertical air motion on a weather map allows us to understand weather and determine patterns. Air pressure reports across the country identify large-scale high- and low-pressure centers, which are associated with fair and stormy weather systems, respectively.

In this investigation, we will:

- Describe air pressure as the force exerted by the weight of the atmosphere and explain why it decreases with increasing altitude.
- Apply the hand-twist model to investigate horizontal and vertical airflow around a low- or high-pressure system.

Air Pressure

Air pressure, at any point on Earth's surface or within the atmosphere, is determined by the weight of the atmosphere pressing down on that point. Therefore, air pressure decreases with increasing altitude, as there is less atmosphere above the point, so where the elevation is higher, the air pressure is lower. Consequently, locating centers of high and low air pressure requires us to analyze air pressure values across the country at the *same* elevation.

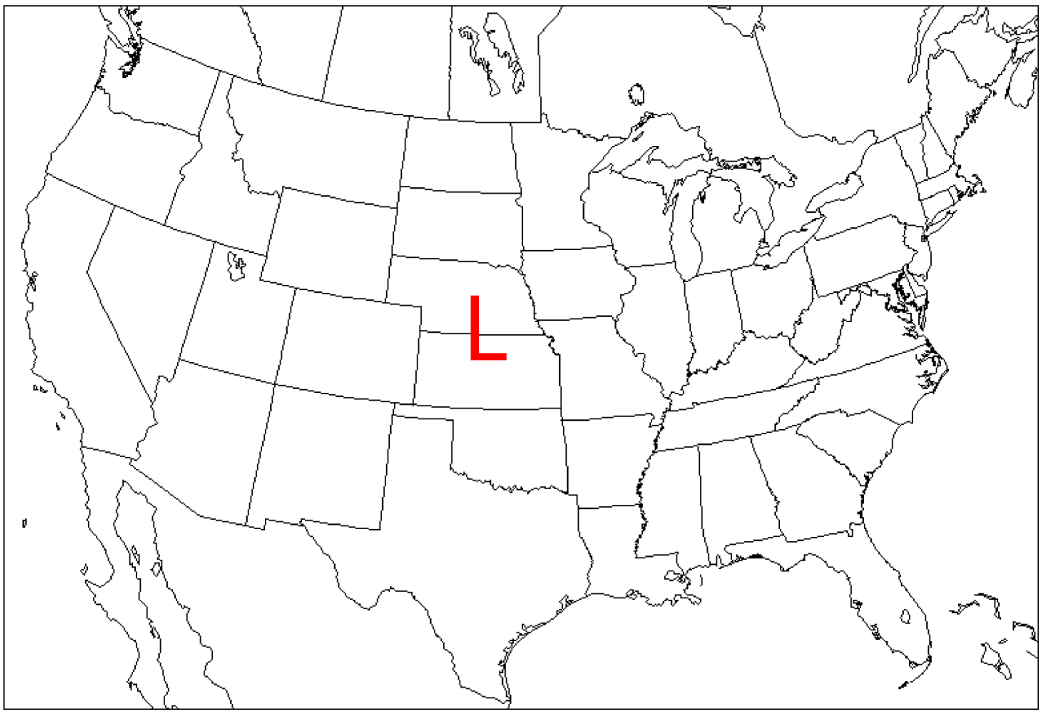
Air pressures reported on surface weather maps are "corrected" to sea level, adjusted to what they would be if the reporting station were located at sea level. By adjusting air pressure readings to the same elevation, we eliminate the variations of air pressure based on Earth's topography. These patterns reveal broad-scale areas of high and low pressure that create the weather we experience.

- Why does air pressure decrease as altitude increases? Explain your answer in terms of the atmosphere above a location.

Low-pressure Systems

The center of the lowest pressure in a region, called a *low* or *low-pressure system*, is marked with an L on a weather map. Some maps show a single dominant low, while others might display multiple connected lows. Air flows from higher to lower pressure toward a low, following the pressure gradient before additional forces influence it. By drawing wind directions around our own low, we can better understand the winds and weather patterns associated with a low-pressure system.

If you are not using this worksheet, you can just draw a large L on a blank piece of paper.



Place your palm flat on the low. The pressure will increase farther from the low, so your fingertips are at areas of higher pressure. Following the pressure gradient, move your fingertips inward while keeping your fingers straight until your fingers touch over the low. In completing this motion, your palm is raised off the paper.

Your fingertips are the air flowing down the pressure gradient, and, just as your palm moved up and your fingers came inward, the wind flowing toward a low lifts through the atmosphere. As the air in the low rises, it cools, and water vapor condenses, creating clouds that can bring rain or snow. We will investigate the mechanics of rising air and cloud formation later. For now, focus on the air flowing down the pressure gradient toward the low and then lifted in the center.

The pressure gradient is not the only force acting on moving air. A large-scale weather system is also influenced by the rotation of the Earth on its axis, which gives rise to the observed *Coriolis Effect* that deflects winds to the right in the Northern Hemisphere and to the left in the Southern Hemisphere.

Place your palm on the low again. For the U.S., which is in the Northern Hemisphere, the Coriolis Effect deflects winds to the right. Accordingly, as your fingertips move inward, the deflection to the right will cause them to rotate counterclockwise. Rotate your hand counterclockwise as you draw your fingers inward until they touch over the L.

Repeat the hand-twist model, and at 4 intervals, draw dots at the end of your fingers. Label each dot with the numbers 1–5, with 1 for your thumb and 5 for your pinky. Connect all the dots labeled 1 and put an arrow on the correct end to show the wind motion.

1. At the center of a low-pressure system, in either the Southern or Northern Hemisphere, the air flows _____ the center and the air in the center _____.

    a. inward toward ... rises
    b. inward toward... descends
    c. outward away from... rises
    d. outward away from ... descends

2. In the Northern Hemisphere, wind spirals _____ around a low-pressure system.

    a. clockwise
    b. counterclockwise

3. Bringing this together, in a low-pressure system in the Northern Hemisphere, air flows _____ in the center.

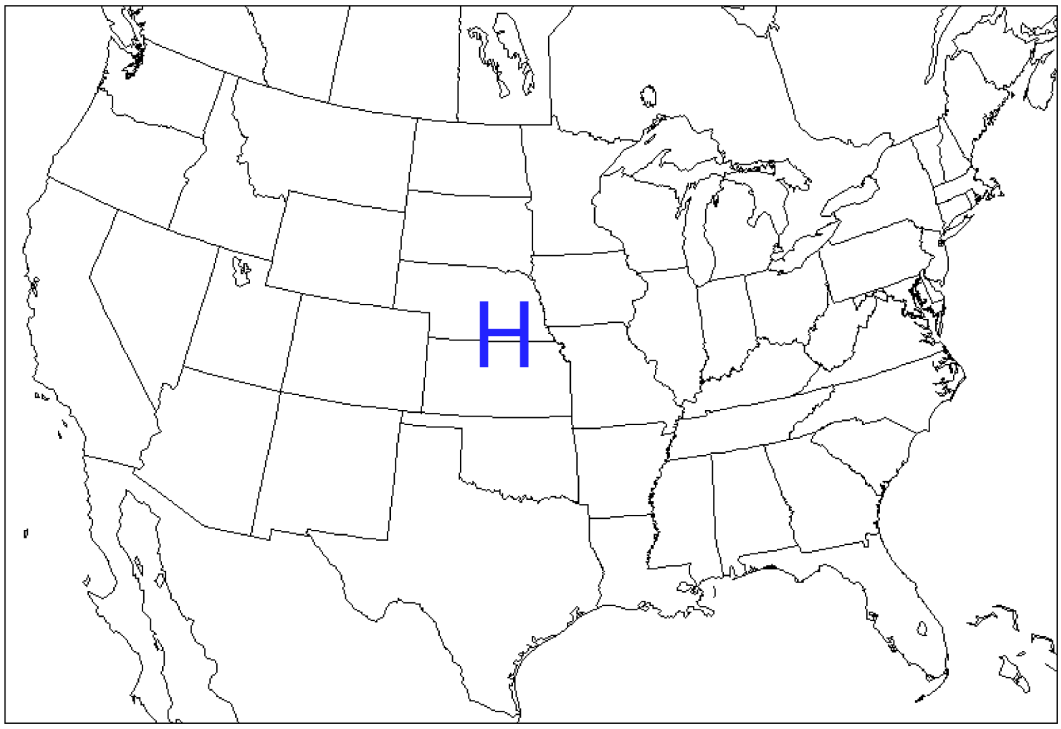
    a. outward in a clockwise spiral and rises
    b. inward in a counterclockwise spiral and rises
    c. outward in a clockwise spiral and descends
    d. inward in a counterclockwise spiral and descends

- Draw the vertical motion in and around a low-pressure system. What goes up must come down.

High-pressure Systems

Now that we understand the motion of a low-pressure system, we can investigate a high-pressure system. In many ways, a high and a low are opposites of each other. The highest pressure in an area is known as a *high* and is marked with an H on weather maps. Just as with a low-pressure system, there may be several nearby highs, but the center of the system will always have the highest pressure. Winds flow away from a high, toward lower pressure, following the pressure gradient.

If you are not using this worksheet, you can just draw a large H on a blank piece of paper.



Because the highest pressure is at the H, place your fingers close together on top of it. Following the pressure gradient, spread your fingertips apart while keeping your fingers straight until your fingertips have reached as far from the H as possible. In completing this motion, your palm will move until it is flat on the paper.

Once more, your fingertips have followed the pressure gradient, but with a high, as the air flows away from the center, it draws air downward. In a high-pressure system, air descends. As cooler upper air is drawn down, it compresses and warms. This warming increases the air's overall capacity for moisture, so there is little possibility for saturation or condensation. Therefore, the sky is often clear over a high. For now, focus on the air flowing down the pressure gradient, away from the high, and drawing air down in the center.

Place your palm on the high again. For the Northern Hemisphere, the Coriolis Effect deflects winds to the right, and so, for your fingertips moving outward, the deflection to the right will cause them to move clockwise. Rotate your hand clockwise as you extend your fingers outward from the H until your hand is flat on the paper.

Repeat the hand-twist model, and at 4 intervals, draw dots at the end of your fingers. Label each dot with the numbers 1–5, with 1 for your thumb and 5 for your pinky. Connect all the dots labeled 1 and put an arrow on the correct end to show the wind motion.

4. At the center of a high-pressure system, in either the Southern or Northern Hemisphere, the air flows _____ from the center and the air in the center _____.

    a. inward ... rises
    b. inward ... descends
    c. outward ... rises
    d. outward ... descends

5. In the Northern Hemisphere, wind spirals _____ around a high-pressure system.

    a. clockwise
    b. counterclockwise

6. For a high-pressure system in the Northern Hemisphere, air flows _____ in the center.

    a. outward in a clockwise spiral and rises
    b. inward in a counterclockwise spiral and rises
    c. outward in a clockwise spiral and descends
    d. inward in a counterclockwise spiral and descends

- Draw the vertical motion in and around a high-pressure system.

Summary

Weather maps help us visualize weather patterns, with isobars depicting the horizontal pressure gradient. These lines provide insight into how air flows across different regions. Pressure systems are represented with an L for a low, or low-pressure system, and an H for a high, or high-pressure system. Pressure gradients and the Coriolis Effect influence the flow of wind horizontally around these systems and vertically at their centers, influencing the weather we experience every day. Understanding the flow of air is the first step in understanding the atmosphere and how weather moves within it.

Expand

1. Using the hand-twist model, in which direction are storms to the south of a Low likely to move? What about on the north side?

2. Bonus: Is it more likely to be a storm near a high or a low? Why? (This has to do with the vertical motion of air.)

Answers

1. a. inward toward ... rises
2. b. counterclockwise
3. b. inward in a counterclockwise spiral and rises
4. d. outward ... descends
5. a. clockwise
6. c. outward in a clockwise spiral and descends