Investigation 1B

Air Patterns

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 are referring to the horizontal speed and direction, though wind does have an important vertical component as well. For example, if we say an east wind is blowing at 10 m/s, we mean that the wind is blowing horizontally from the east to the west. Variations in air pressure in the atmosphere result in winds blowing from where air pressure is high toward where it is low. 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 reported across the country identifies large-scale pressure centers of high and low pressure, which are associated with fair and stormy weather systems, respectively.

In this investigation, we will:

- Draw lines of equal pressure (isobars) to identify patterns in air pressures
- Describe the flow of air around lows and highs on surface weather maps
- Apply the hand-twist model to investigate the flow of air in 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.

On a weather map, we analyze pressure measurements by drawing lines where equal pressure is shown to reveal horizontal patterns. These lines are called **isobars** because every point on the line has the same air pressure (barometric). Each isobar separates areas of higher pressure from areas of lower pressure.

Figure 1B-1 shows air pressure in whole millibars (mb) at weather stations. A millibar is the traditional unit for atmospheric pressure. 1 mb = 100 Pascals (Pa) and 1 Pa = 1 Newton per square meter (N/m^2). For reference, the average mid-latitude, sea-level air pressure is 1013.25 mb. On the map, consider each pressure value to have been observed at the center of the plotted number.

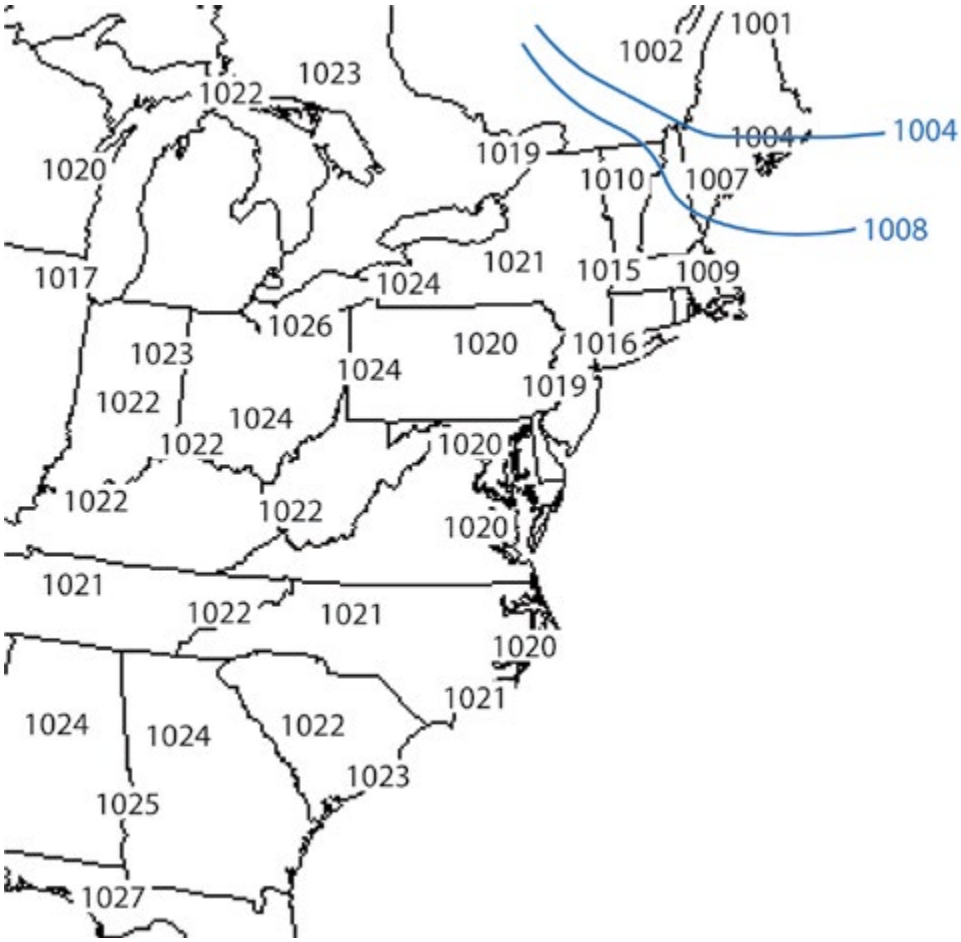


Figure 1B-1. Surface weather map with air pressure reported in whole millibar units. The 1004- and 1008-mb isobars have been drawn and labeled.

1. In Figure 1B-1, the lowest plotted pressure is 1001 mb and the highest plotted value is _____ mb.

    a. 1015
    b. 1020
    c. 1027
    d. 1032

Click on Figure 1B-1 to open it in a new tab. This allows you to either print it or draw on it with an online tool. For online drawing tools, refer to Weather Studies Maps & Links, section Extras, and click on "Drawing Tools."

The isobars for 1004 and 1008 have already been drawn for you. **Complete the pressure analysis by drawing the 1012-mb, 1016-mb, 1020-mb, and 1024-mb isobars.** Draw each isobar using the following directions.

Drawing Isobars

Keep the following rules about drawing isobars in mind when you analyze air pressure on a weather map.

a. Always draw an isobar so air pressure readings greater than the isobar's value are on one side

of the isobar and lower values are on the other side.

b. When positioning isobars, assume a uniform pressure change between neighboring stations. For example, a 1016-mb isobar would be drawn halfway between 1014 mb and 1018 mb.
c. Adjacent isobars tend to be shaped alike. The isobar you draw will align with the curves of its neighbors because horizontal changes in air pressure are usually gradual.
d. Continue drawing an isobar until it reaches the boundary of the plotted data or closes by connecting to its starting point.
e. Isobars never stop within a data field. They never fork, touch, or cross one another.
f. Isobars cannot be skipped if their values fall within the range of air pressures reported on the map. Isobars must always appear in sequence. For example, there must always be a 1016-mb isobar between the 1012-mb and 1020-mb isobars, even if no values between 1012 mb and 1020 mb are plotted on the map.
g. Label all isobars with the value or, for an enclosed value, create a break in the circle for the value.

2. By U.S. convention, isobars on surface weather maps are drawn with the same interval as in Figure 1B-1. This isobar interval is _____ mb, and all labeled isobars are divisible by this interval. This isobar interval was selected to provide the most useful resolution for data analysis: too small an interval, such as 1 mb, would clutter the map, while too large an interval, such as 10 mb, would not adequately define the pressure pattern.

   a. 2
   b. 4
   c. 6

3. Which of the following numbers would not fit the sequence of isobar values?

   a. 1004
   b. 1008
   c. 1010
   d. 1012

The change of pressure over distance is the **pressure gradient**. On surface weather maps, the directions of the horizontal pressure gradients are always oriented perpendicular to the isobars. The closer together the isobars appear on a map, the stronger the pressure gradient. Air pressure gradients cause wind to initially flow from where the air pressure is high to where the air pressure is low.

4. From the isobar pattern you drew on Figure 1B-1, the horizontal pressure gradient is stronger from _____.

   a. North Carolina to Georgia
   b. Florida to Tennessee
   c. Kentucky to Michigan
   d. Vermont toward New York

5. Considering the pressure gradient alone, wind in Connecticut will flow toward _____.

   a. Maine
   b. Michigan
   c. West Virginia

d. Maryland

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.

On a piece of paper, draw a large L. In **Figure 1B-2**, we provide an L on the center of a U.S. map, much as you would see on a weather map, but for this demonstration, you just need a space to work with.



Figure 1B-2. Map with a low.

Place your palm flat on the low, as seen in **Figure 1B-3**. 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.



Figure 1B-3. Hand position for Figure 1B-2.

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. We will discuss all the forces that influence wind in *Investigation 8A*.

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.

Watch a video of this hand-twist model.

Repeat the hand-twist model, watching how your fingers spiral. That is how wind flows around a low-pressure system in the Northern Hemisphere.

6. 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

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

    a. clockwise
    b. counterclockwise

8. 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

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.

Now, draw a large H on a piece of paper for a high-pressure system. We provide an H on the center of a U.S. map in **Figure 1B-4**, similar to a weather map.



Figure 1B-4. Map with a high.

Because the highest pressure is at the H, place your fingers close together atop it, as seen in **Figure 1B-5**. 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.



Figure 1B-5. Starting hand position for a high.

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.

Watch the video of this hand-twist model, beginning at 1:18 for the high.

Repeat the hand-twist model, watching how your fingers spiral. This is how wind flows around a high-pressure system in the Northern Hemisphere.

9. 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

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

    a. clockwise
    b. counterclockwise

11. 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

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.