Investigation 1A

Surface Air Pressure Patterns and Winds

All Manual figures can be enlarged or printed by clicking on the figure to open it in a new browser tab or window.

Objectives

Weather is defined as the state of the atmosphere at a particular time and place. Our atmosphere is a mixture of gases with temperature, density, moisture, and movement. Many of our weather experiences involve air being in motion, whether as gentle breezes or hazardous gales. **Wind** is the motion of air relative to Earth's surface, changing temperature and humidity, producing clouds, and leading to precipitation. Across a horizontal surface, variations in air pressure 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 motions on a weather map allows us to predict future weather. The reported air pressure across the country identifies large-scale pressure centers of high and low pressure, associated with fair and stormy weather systems, respectively.

After completing this investigation, you should be able to:

- Locate highs and lows on a surface weather map.
- Draw lines of equal pressure (isobars) to identify patterns of surface air pressures.
- Describe the relationship between the patterns of high and low air pressure on a surface weather map and the surface wind directions.
- Apply the hand-twist model of wind direction to the circulation in highs and lows.

Air Pressure

Air pressure, at any point on Earth's surface or within the atmosphere, is determined by the weight of the atmosphere above that point pressing down on that point. Therefore air pressure decreases with increasing altitude, as there is less atmosphere to press down, and where the surface elevation is higher, the surface 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.

For this reason, air pressures routinely reported on surface weather maps are "corrected" to sea level, adjusted to what they would be if the reporting station was located at sea level. Adjusting air pressure readings to the same elevation eliminates 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, analyzing pressure measurements reveals horizontal patterns made by drawing lines where equal pressure is shown or would exist. 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.

The **Figure 1A-1** surface map 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).) 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.

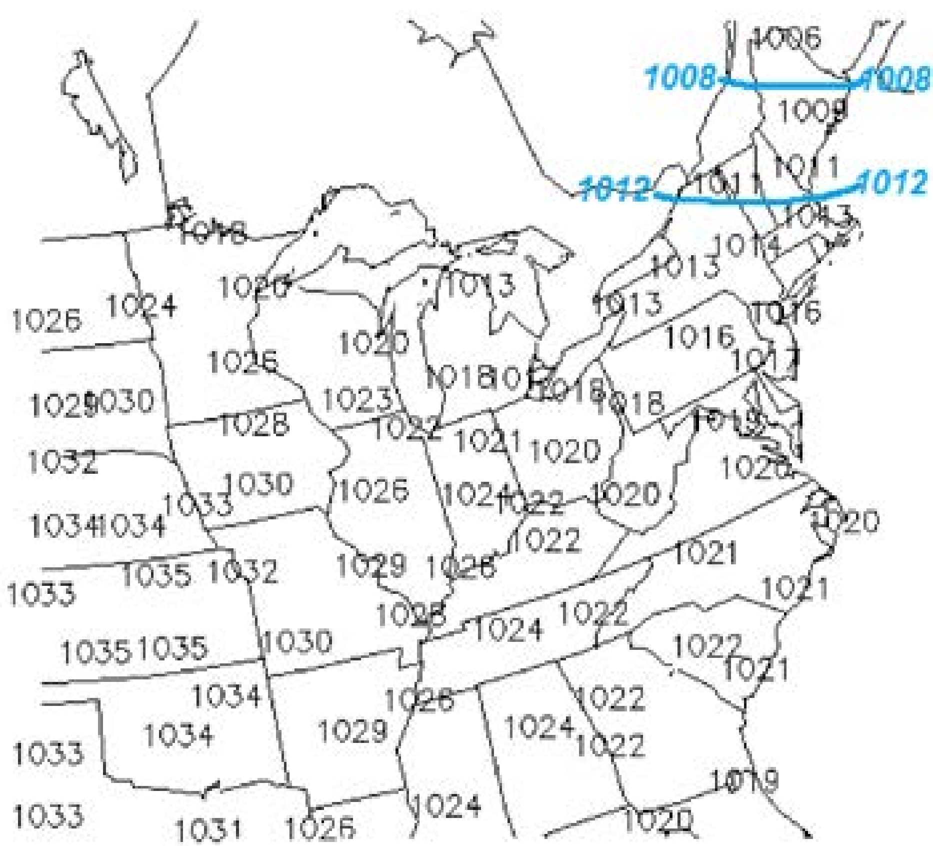

Figure 1A-1. Surface weather map with air pressure reported in whole millibar units. The 1008- and 1012-mb isobars have been drawn and labeled.

Print a copy of Figure 1A-1. Click on the image to open it in a new browser tab or window. *For online drawing tools, refer to Weather Studies Maps & Links (Link 1A-1), Extras, "Drawing Tools."*

If you are having trouble reading the colors on the maps in these studies, please access the free Visolve software at Link 1A-2.

1. On Figure 1A-1, the lowest plotted pressure is 1006 mb and the highest plotted value is ______ mb.

    a. 1030
    b. 1033
    c. 1035
    d. 1037

Complete the pressure analysis by drawing the 1016-mb, 1020-mb, 1024-mb, 1028-mb, and 1032-mb isobars. The isobars for 1008 and 1012 have already been drawn for you. Label each completed isobar by writing the pressure value at the ends of the lines (as shown in Figure 1A-1), or add a break for a closed circle.

Tips on 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 consistently 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 1000-mb isobar between the 996-mb and 1004-mb isobars even if no values between 996 mb and 1004 mb are plotted on the map.
g. Always label all isobars at both ends.

2. By U.S. convention, isobars on surface weather maps are drawn with the same interval as that described for the Figure 1A-1 map. This isobar interval is ______ mb. The isobar interval is selected to provide the most useful resolution of the field of data; too small an interval (for example, 1 mb) would clutter the map and too great an interval (for example, 10 mb) would not adequately define the pattern.

   a. 2
   b. 4
   c. 6

Also by U.S. convention, isobars drawn on surface weather maps are a series of values divisible by 4 (e.g., $1000 \div 4 = 250$). The progression of isobaric values can be found by adding 4 sequentially to 1000 and/or subtracting 4 sequentially from 1000 until the full range of pressures reported on the map can be evaluated.

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

   a. 1004
   b. 1006
   c. 1008
   d. 1011
   e. 1016
   f. Both b and d are correct

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 gradients.

4. From the isobar pattern you drew on Figure 1A-1, the horizontal pressure gradient is stronger across _____.
    a. Georgia to North Carolina
    b. Texas to Nebraska
    c. Iowa to Michigan

Optional: *Weather Studies Maps & Links* (Link 1A-1) routinely delivers unanalyzed ("Pressures") and analyzed ("Isobars & Pressures") surface pressure maps. Use the unanalyzed version to practice drawing isobars. If you would like to practice more on drawing isopleths (lines of a constant value) in groups of numbers, from simple to more complex patterns, go to Link 1A-3.

Air Pressure and Wind

Air pressure, which results from the weight of the overlying air, varies from place to place and over time. Horizontal differences in air pressure cause air to move, setting the stage for much of the weather we experience. Wind (air in motion) blows from where the air pressure is high to where the air pressure is low. Once in motion, air is influenced by the rotation of the Earth on its axis (the Coriolis Effect) and/or contact with Earth's surface (friction). The Coriolis Effect is important in large-scale weather systems (highs and lows, for example) and friction affects winds blowing within 1000 m (3281 ft.) of Earth's surface.

Print a copy of Figure 1A-2 and lightly draw a circle about 3 cm in diameter around the large L on the map. The L marks the location of lowest pressure in a low pressure area.

Figure 1A-2. Surface map with a low.

Use your non-writing hand to cover the circle with your palm as shown in **Figure 1A-3**. (The following analysis is more easily conducted if standing up.)

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

Rotate your hand counterclockwise, as seen from above, while gradually pulling in your thumb and fingertips as your hand turns until they touch the circle. Be sure the map does not move. Practice until you achieve a maximum twist with ease.

Place your hand back in the spread position on the map. Mark and label the positions of your thumb and fingertips 1, 2, 3, 4, and 5 as you perform the twist.

Slowly rotate your hand counterclockwise while pulling in your thumb and fingertips. Stop after quarter turns and mark and label (1 through 5) the positions of your thumb and fingertips. Continue the twist until your thumb and fingertips meet on the circle.

Connect the successive numbered positions for each finger and your thumb using smooth curved lines. Place arrowheads on the end of the lines to show the directions your fingertips and thumb moved. **The spirals represent the flow of surface air in a low-pressure system in the Northern Hemisphere.**

Print a copy of Figure 1A-4. Lightly draw a circle about 3 cm in diameter around the large H on the map. The H represents the location of highest pressure in a high pressure area.

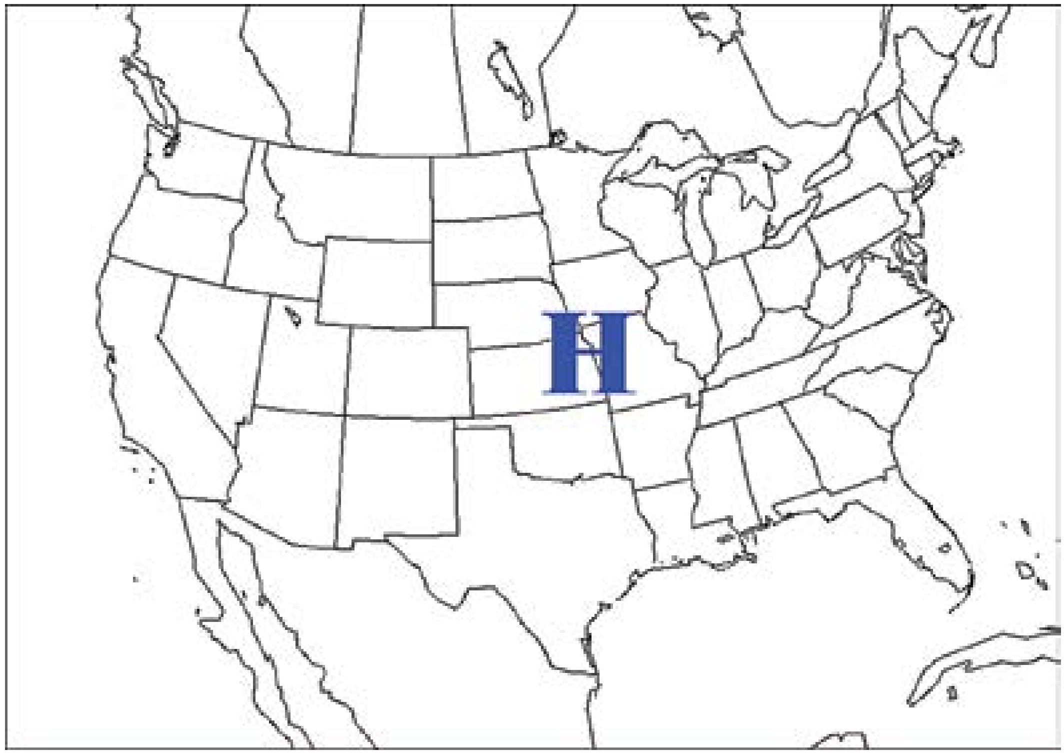

Figure 1A-4. Surface map with a high.

Place the map flat on your desk. Position your non-writing hand as shown in **Figure 1A-5** on your copy of Figure 1A-4, so your finger tips are on the circle you drew and your palm is centered above the H on the map

Figure 1A-5. Hand position for Figure 1A-4.

Rotate your hand slowly clockwise, as seen from above, and gradually spread out your thumb and fingertips as your hand turns. Be sure the map does not move. Practice this motion until you achieve as full a twist as you can comfortably. Place your thumb and fingertips back in the starting position on the circle. Mark and label the positions of your thumb and fingertips 1, 2, 3, 4, and 5 as you perform the twist.

Slowly rotate your hand clockwise while gradually spreading your thumb and fingertips. Go through about a quarter of your twisting motion. Stop, mark, and label (1 through 5) the positions of your thumb and fingertips on the map. Follow the same procedure in quarter steps until you complete a full twist.

Connect the successive positions for each finger and thumb using a smooth curved line. Place arrow heads on the ends of the lines to show the directions your thumb and fingertips moved. **The spirals represent the flow of surface winds in a high pressure system in the Northern Hemisphere.**

For more help and a visual reference, explore video on the hand-twist model at Link 1A-4.

5. Based on Figure 1A-2, which of the following best describes the surface wind circulation around the center of a low pressure system?

   a. Clockwise and inward spiral
   b. Clockwise and outward spiral
   c. Counterclockwise and inward spiral
   d. Counterclockwise and outward spiral

6. Based on Figure 1A-4, which of the following best describes the surface wind circulation around the center of a high pressure system?

   a. Clockwise and inward spiral
   b. Clockwise and outward spiral
   c. Counterclockwise and inward spiral
   d. Counterclockwise and outward spiral

7. On your surface maps, repeat the hand twists for the low and high pressure system models. Note the vertical motions of the palm of your hand. For the low, the palm of your hand ______ during the rotating motion. In the case of the high, the palm of your hand ______ during the rotating motion.

   a. falls ... rises
   b. rises ... falls

8. Imagine the motions of your palms during these rotations represent the directions of vertical air motions in highs and lows. Vertical air motion in a low is therefore ______ and in a high vertical air motion is ______.

   a. upward ... downward
   b. downward ... upward

9. Considering the complete air motions of the low pressure system, air flows ______.

   a. upward and outward in a clockwise spiral
   b. upward and inward in a counterclockwise spiral
   c. downward and outward in a clockwise spiral
   d. downward and inward in a counterclockwise spiral

10. In a high pressure system, air flows ______.

    a. upward and outward in a clockwise spiral
    b. upward and inward in a counterclockwise spiral

c. downward and outward in a clockwise spiral
d. downward and inward in a counterclockwise spiral

By analyzing the pressure values reported on weather maps to find pressure patterns, you can locate the centers of high and low pressures. We will see that these pressure centers often mark the midpoints of major weather systems, either regions of fair weather or stormy conditions.

Summary

From the experiences of everyday life, we all have a basic understanding of the workings of the atmosphere, weather, and climate. A surface weather map portrays graphically the state of the atmosphere over a broad geographical region at a specified time.

On a weather map, analyzing isobars reveals horizontal pressure patterns made by drawing lines where equal pressure is shown or would exist. An L symbolizes a low where local air pressure is relatively low compared to the surrounding area. Viewed from above in the Northern Hemisphere, surface winds blow counterclockwise and inward about the center of a low. On a weather map, H or high symbolizes a locale where air pressure is relatively high compared to the surrounding area. Viewed from above in the Northern Hemisphere, surface winds blow clockwise and outward about the center of a high.