Investigation 1B

AIR PRESSURE AND WIND

Objectives

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) tends to blow from where the air pressure is relatively high to where the air pressure is relatively low. Air, once it is in motion, may be 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 of weather maps, for example) and friction affects winds blowing close to the Earth’s surface below an altitude of about 1000 m (3281 ft.).

After completing this investigation, you should be able to:

• Describe the relationship between the patterns of relatively high and low air pressure areas (Lows or Ls and Highs or Hs) on a surface weather map and the direction of surface winds.
• Apply the hand-twist model of wind direction to the circulation in actual highs and lows.

Introduction

Print Figures 1 and 3.

Figure 1. Low.
On your copy of Figure 1, lightly draw a circle about 3 cm or so in diameter around the large “L” shown on the map. The “L” marks the location of lowest pressure in a low-pressure area. Use your non-writing hand to cover the circle with your palm as shown in Figure 2. [Note: The following analysis is more easily conducted if standing up.]

![Figure 2. Hand position for Figure 1.](image)

Practice rotating 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, respectively, as you perform the twist.

Slowly rotate your hand counterclockwise while gradually drawing in your thumb and fingertips. Stopping after quarter turns, 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 individual finger and your thumb using smooth curved lines. Place arrowheads on the end of the lines to show the directions toward which your finger and thumb tips moved. The spirals represent the general flow of surface air that occurs in a typical low-pressure system in the Northern Hemisphere.
Now turn to your copy of Figure 3. Lightly draw a circle about 3 cm in diameter around the large “H” appearing on the map. The “H” represents the location of highest pressure in a high-pressure area.

Place the map flat on your desk. Position your non-writing hand as shown in Figure 4 on your copy of Figure 3, so your finger tips are on the circle you drew and your palm is centered above the “H” on the map.

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, respectively, 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 numbered positions for each finger and your thumb using a smooth curved line. Place arrowheads on the ends of the lines to show the directions your thumb and fingertips moved. The spirals represent the general flow of surface winds that occurs in a typical high-pressure system in the Northern Hemisphere.

1. Based on Figure 1, which of the following best describes the surface wind circulation around the center of a low-pressure system (as seen from above)? ______
   a. clockwise and inward spiral
   b. clockwise and outward spiral
   c. counterclockwise and inward spiral
   d. counterclockwise and outward spiral

2. Based on Figure 2, which of the following best describes the surface wind circulation around the center of a high-pressure system (as seen from above)? ______
   a. clockwise and inward spiral
   b. clockwise and outward spiral
   c. counterclockwise and inward spiral
   d. counterclockwise and outward spiral

3. On your surface with the 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.
   a. rises
   b. falls

4. In the case of the High, the palm of your hand ______ during the rotating motion.
   a. rises
   b. falls

5. Imagine that 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 ______.
   a. upward
   b. downward

6. In the case of the High, vertical air motion is ______.
   a. upward
   b. downward
7. 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

8. 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

Investigation 1B — Applications

Prevailing summer-season weather across much of the contiguous U.S. is occasionally interrupted by stormy episodes, including severe thunderstorms or perhaps even tropical systems. But there are usually few strong low-pressure systems and accompanying fronts that form in the middle latitudes during the warmest months of year. As a result, the relatively uniform summer warmth from long days of strong sunshine provides few temperature contrasts across the country, the fuel for such storm systems. These systems are typically found at higher latitudes in summertime (e.g., near the Canadian border), where the temperature contrasts likely exist. In mid-August 2017, one relatively broad low-pressure system formed in the central Plains States and moved northeastward into the Great Lakes region.
Figure 5. Un-analyzed surface weather map for 12Z 17 August 2017 with station model plots conveying surface weather observations of temperature, moisture, pressure, cloud cover, wind speed and direction. The centers of major features of High and Low pressure systems are depicted with “H” and “L” respectively.

Figure 5 is the “U.S. - Data” map from the RealTime Weather Portal for 12Z 17 AUG 2017. It depicts weather conditions at individual locations across the contiguous U.S. plotted using a coded format called the “surface station model.” This station model will be examined in more detail in Investigation 2A.

9. Selected weather-reporting stations are shown on the map as circles. The wind directions at those reporting stations are shown by the line (which can be thought of as an arrow shaft) depicting the air flow into each circle location that is reporting wind. In meteorology, wind at a station is identified by the direction from which the air is flowing, (i.e., air arriving at the station from the south is called a south wind).

Therefore, the wind direction at Chicago, in northeast Illinois, at map time was generally from the ________. [Keep in mind, because of the map projection used, the north direction may not be uniformly toward the top of the map. In the Chicago area, a north/south line would be nearly parallel to the Illinois-Indiana border segments.]

a. west-northwest  
b. north-northeast  
c. east-southeast  
d. south-southwest
10. Knowing the direction from which the wind at Chicago was blowing, it would be reported as a _______ wind.
   a. west-northwest
   b. north-northeast
   c. east-southeast
   d. south-southwest

One knot (1 nautical mile per hour) is about 1.2 land (statute) miles per hour. The wind speed is reported by a combination of long (10 knots) and short (5 knots) “feathers” attached to the direction shaft. At map time, Chicago had a 10-knot wind (one long feather). A double circle without a direction shaft, such as seen in NV, SD, and ND, signifies calm conditions. A shaft plotted without feathers would denote 1-2 knots.

11. A bold red “L” has already been marked on the map along the Minnesota-Wisconsin border to denote the general center of low pressure in that area. Compare the hand-twist model of a Low to the wind directions at stations in the several-state area surrounding the low-pressure center. Wind directions at these stations suggest that, as seen from above, the air was circulating generally _______ around this Northern Hemisphere low-pressure center.
   a. counterclockwise
   b. clockwise

12. The winds at stations around (several state area) the low-pressure center indicated that the air also was spiraling generally _______ the low-pressure center.
   a. outward from
   b. inward toward

13. This wind flow pattern about the Low is therefore _______ the hand-twist model of a Low.
   a. consistent with
   b. contrary to

14. A bold blue “H” has been marked on the map in central Colorado to denote the center of high pressure existing in that general area. Note the pattern of wind directions at stations in the several-state area surrounding the high-pressure center. Wind directions at these stations suggest that, as seen from above, the air flowed generally clockwise and spiraled _______ this Northern Hemisphere high-pressure center.
   a. outward from
   b. inward toward

In addition to the forcings of large-scale pressure patterns in this western portion of the country, air flows are also greatly influenced by the mountainous, high-elevation terrain that stretches from western Montana and Idaho southeastward to New Mexico and western Texas. As such, wind flow patterns around the high-pressure system may not fully display the anticipated rotational directions.
15. This wind flow pattern with respect to the High center is generally ________ the hand-twist model of a High.
   a. consistent with  
   b. contrary to

16. Review the Applications section of Investigation 1A. The surface weather maps from Investigation 1A were for the same time as this investigation’s Figure 5. The Investigation 1A, Figure 3, weather map shows the pressure analysis using isobars. The isobar pattern on the Investigation 1A, Figure 3, map ________ generally depict the positions of the L and the H marked on this activity’s Figure 5 map. (Also, if available, look at the isobar pattern you drew on Investigation 1A’s Figure 2 map; it should reveal those same pressure centers.)
   a. did  
   b. did not

When the current weather map available on the RealTime Weather Portal shows centers of Lows or Highs near your location, you might consider your local wind direction (as reported on weathercasts or shown by a nearby flag flapping in the wind, for example) with map circulations and the hand-twist model of weather systems. The typical designation of the L’s and H’s as centers of stormy and fair-weather systems, respectively, can be compared to satellite views showing clouds across the U.S. Check to see if the region around a Low center is generally cloudy or the broad area centered on a High as mostly clear.

A website that dynamically displays the forecast wind flow at the time shown in both direction and speed at locations across the U.S. can be found at Link 1B-1. Moving your cursor across the map will give the wind speeds at specific locations. You might compare the wind flow patterns seen at this site to those of the latest surface weather map’s positioning of Highs and Lows. Two other interactive maps showing winds across the globe are Link 1B-2 and Link 1B-3.

Further details for deciphering station data can be found in the “User’s Guide” (linked from the Extras section of the RealTime Weather Portal). The reporting surface weather stations plotted on course maps can be identified from the “Available Surface Stations” link on the Portal’s Surface data section and identities given in the User’s Guide. Also, a map of National Weather Service (NWS) offices can be found at Link 1B-4.

One tool for wind speed conversions between miles per hour and knots (as well as other quantities) and their formulas can be found at Link 1B-5.