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 causes 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 meters.

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:

Turn to Figure 1. Low. 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 to the right. [Note: The following analysis is more easily conducted if standing up.]

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.
Figure 1. Low

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.

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 finger and your thumb using a smooth curved line. Place arrowheads on the end of the lines to show the directions your fingertips and thumb moved. The spirals represent the general flow of surface air that occurs in a typical low-pressure system.

Now turn to Figure 2. High. 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.
Figure 2. High

Place the map flat on your desk. With your non-writing hand, bring the thumb and fingertips of your hand close together and place them on the circle you drew as shown to the below.

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.
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.

1. Which of the following best describes the surface wind circulation around the center of a low-pressure system (as seen from above)?
   - counterclockwise and outward spiral
   - counterclockwise and inward spiral
   - clockwise and outward spiral
   - clockwise and inward spiral

2. Which of the following best describes the surface wind circulation around the center of a high-pressure system (as seen from above)?
   - counterclockwise and outward spiral
   - counterclockwise and inward spiral
   - clockwise and outward spiral
   - clockwise and inward spiral

3. On your desk, 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 rises during the rotating motion.

4. In the case of the High, the palm of your hand falls during the rotating motion.

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 upward.

6. In the case of the High, vertical air motion is downward.

7. Considering the complete air motions of the low-pressure system, air flows
   - upward and outward in a clockwise spiral
   - upward and inward in a counterclockwise spiral
   - downward and outward in a clockwise spiral
   - downward and inward in a counterclockwise spiral

8. In a high-pressure system, air flows
   - upward and outward in a clockwise spiral
   - upward and inward in a counterclockwise spiral
   - downward and outward in a clockwise spiral
   - downward and inward in a counterclockwise spiral

As directed by your course instructor, complete this investigation by either:

1. Going to the Current Weather Studies link on the course website, or
2. Continuing the Applications section for this investigation that immediately follows.
Investigation 1B: Applications

Typical summer weather across the contiguous U.S. has warm balmy days over the southern half while storm systems and their accompanying precipitation track across the northern tier of states. After occupying the eastern half of the country for about a week, a dominant high pressure settled in the Southeast on August 27, 2013. Over the same time period, weak low-pressure centers moving generally eastward brought showers to the northern states along the Canadian border every few days. One such area of low pressure was traversing the Great Lakes on August 27th.

Figure 3 is the “U.S. - Data” map from the course website for 13Z 27 AUG 2013. It depicts weather conditions at individual locations across the contiguous U.S. plotted in a coded format called the “station model”. The station model will be explained in more detail in Investigation 2A.

Figure 3. “U.S. - Data” map for 13Z 27 AUG 2013.

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. 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 north is called a north wind. This helps to identify the atmospheric conditions of the arriving air. Therefore the wind direction at Kansas City, on the border of Missouri and Kansas, at map time was generally from the [(northwest)(northeast)(southeast)(southwest)]. (Much of the borders of western Missouri and Arkansas form a north-south longitude line.)
10. Given the direction the wind at Kansas City was from, it would be reported as a \((\text{northwest})(\text{northeast})(\text{southeast})(\text{southwest})\) wind.

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, Kansas City had a 10-knot wind (one long feather). [A double circle without a direction shaft signifies calm conditions, such as Charleston, SC, and Nashville, TN, whereas a shaft without feathers would denote 1-2 knots. One knot (1 nautical mile per hour) is about 1.2 land (statute) miles per hour.]

11. A bold red “L” has already been marked on the map along the Minnesota-South Dakota border to denote the general center of low pressure in that area. Compare the \textit{hand-twist} model of a Low to the wind directions at stations surrounding the low-pressure center marked by the L. Wind directions at these stations show that, as seen from above, the air spiraled generally \((\text{clockwise})(\text{counterclockwise})\) around this Northern Hemisphere low-pressure center. (Note: the wind direction shaft at Fargo, ND, is directly along the border line.)

12. The air also spiraled generally \((\text{inward toward})(\text{outward from})\) the low-pressure center.

13. This wind flow pattern about the Low is therefore \((\text{consistent with})(\text{contrary to})\) the \textit{hand-twist} model of a Low.

14. A bold blue “H” has been marked on the map in north-central Alabama to denote the general center of high pressure in that area. Compare the \textit{hand-twist} model of a High to the wind directions at stations surrounding the high-pressure center marked by the H. Wind directions at these stations show that, as seen from above, the air spiraled generally \((\text{clockwise})(\text{counterclockwise})\) around this Northern Hemisphere high-pressure center.

15. The air also spiraled generally \((\text{inward toward})(\text{outward from})\) the high-pressure center.

16. This wind flow pattern about the High is \((\text{consistent with})(\text{contrary to})\) the \textit{hand-twist} model of a High.

17. The Figure 3 surface weather map from Investigation 1A was for nearly the same time (the prior hour) as this Inv. 1B Figure 3. The Investigation 1A Figure 3 weather map shows the pressure analysis using isobars. The isobar pattern on the Inv. 1A Figure 3 map \((\text{did})(\text{did not})\) depict the positions of the L and the H found on the Inv. 1B Figure 3 map as the appropriately located pressure centers. (Also, if you look at the isobar pattern you drew on Investigation 1A Figure 2 map; it should reveal these same pressure centers.)

When the current weather map available on the course website 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 Ls and Hs 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 immediately around a Low is generally cloudy or the broad area centered on a High as mostly clear.

Further details for deciphering station data can be found in your \textit{User’s Guide} (linked from the course website). The reporting surface weather stations plotted on course maps can be identified from the “Available Surface Stations” link on the course website’s \textit{Surface} data section and identities given in the “User’s Guide”. Also a map of National Weather Service offices can be found at: \url{http://www.wrh.noaa.gov/wrh/forecastoffice_tab.php}.

One tool for wind speed conversions between miles per hour and knots (as well as other quantities) and their formulae can be found at: \url{http://www.srh.noaa.gov/epz/?n=wxcalc}. 