Investigation 1B: AIR PRESSURE AND WIND

Objectives:

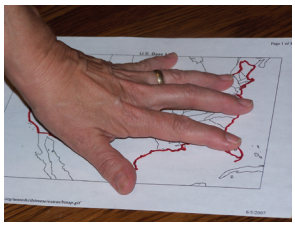
Air pressure, resulting from the weight of the overlying air, varies from place to place and over time. Air moves in response to horizontal differences in air pressure, setting the stage for much of the weather we experience. Wind (air in motion) tends to blow from where the air pressure is relatively high to where the air pressure is relatively low. Once air is in motion, its speed and direction 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 **L**s and Highs or **H**s) 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. Using your left hand (if you are right-handed) or your right hand (if you are left-handed), 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.

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 are 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.

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 in the sketch to the right.

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*)(*falls*)]** during the rotating motion.

4. In the case of the High, the palm of your hand **[(*rises*)(*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*)(*downward*)]**.

6. In the case of the High, vertical air motion is **[(*upward*)(*downward*)]**.

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

8. In a high-pressure system, air flows
[(*downward and outward in a clockwise spiral*)
(*downward and inward in a counterclockwise spiral*)
(*upward and outward in a clockwise spiral*)
(*upward 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 to the Applications section for this investigation that immediately follows in this Investigations Manual.***

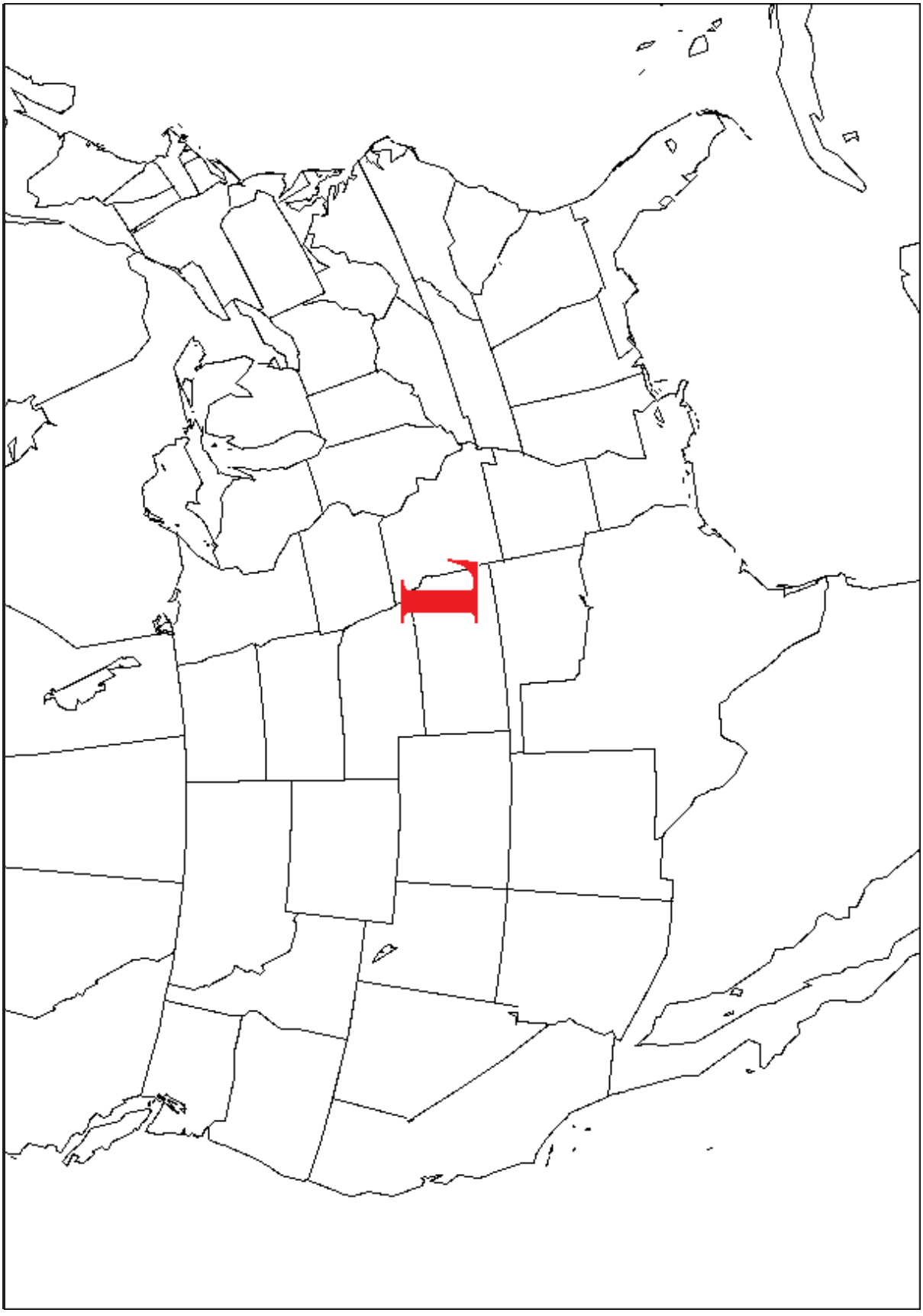


Figure 1. Low

Figure 2. High

Investigation 1B: Applications

AIR PRESSURE AND WIND

The **Figure 3** "U.S. - Data" map acquired from the course website is the depiction of weather conditions at stations across the contiguous U.S. at 12Z 30 AUG 2010, locally 8 AM EDT (7 AM CDT, 6 AM MDT and 5 AM PDT). The general weather conditions across the U.S. at map time consisted of scattered precipitation stretching from the northern Rockies and Great Plains to western Texas with additional showers generally across the Gulf of Mexico coastal areas while much of the north-central and northeastern portions of the country had fair weather.

9. Weather data at individual locations are summarized by being plotted in a coded format called the "station model." The wind directions at reporting stations on the map are shown by the line (which can be thought of as an arrow shaft) depicting the air flow into circles representing station locations. Wind at a station is named by the direction from which the air flows, *i.e.*, air arriving at the station from the north is a ***north*** wind. This helps to identify the atmospheric conditions of the arriving air. Therefore, the wind direction at Denver, in northeastern Colorado (highlighted in green), at map time was from the **[(*northeast*)(*northwest*)(*east-southeast*)(*south-southwest*)]**.

   (All reporting surface weather stations can be identified from the "Available Surface Stations" link on the website's **Surface** data section and identities given in the "User's Guide." Also a map of National Weather Service offices can be found at: *http://www.wrh.noaa.gov/wrh/forecastoffice_tab.php.*)

10. Given the direction the wind at Denver was from, it would be reported as a **[(*northeast*)(*northwest*)(*east-southeast*)(*south-southwest*)]** wind.

    The wind speed is given by a combination of long (10 knots) and short (5 knots) "feathers" on the direction shaft. [The station model will be explained in Investigation 2A. Further details for deciphering station data can be found in your *User's Guide* (linked from the course website).] At map time, Denver had a 15-knot wind (one long and one short feather). [A double circle without a direction shaft signifies calm conditions, such as Los Angeles, CA, and Tampa, FL and a shaft without feathers denotes 1-2 knots. One knot (nautical mile per hour) is about 1.2 land (statute) miles per hour.]

11. A bold blue "**H**" and a bold red "**L**" have already been marked on the map to denote the general centers of highest and lowest pressures, respectively. Wind directions at stations from northern Florida in an arc up to the Great Lakes and across Maine and Massachusetts show that, as seen from above, the air spiraled generally **[(*clockwise*)(*counterclockwise*)]** around the high-pressure center, denoted by the **H** along the Pennsylvania-West Virginia border. Winds near the center of the High were generally light or calm (double circles).

12. The air was also directed generally **[(*inward toward*)(*outward from*)]** the high-pressure center.

13. This flow **[(*is*)(*is not*)]** consistent with the *hand-twist* model of a High.

The local coverage of the sky by clouds at a station is denoted by the shading within the circle representing the station. An open circle means clear skies. Partial shading represents the fraction of sky covered by clouds. A dark circle means overcast conditions, *i.e.* completely cloudy sky.

14. From the station models surrounding the High on this map, it is evident a High produces generally **[(*clear*)(*cloudy*)]** skies.

15. The hand-twist model of a High includes vertical motions with air sinking. Therefore, areas of sinking air are likely to be locations of generally **[(*clear*)(*cloudy*)]** skies.

16. Next, compare the *hand-twist* model of a Low to the wind directions in the states about the low-pressure center appearing on the map. Wind directions at most of the stations across this area of the upper Great Plains show that, as seen from above, the air spiraled generally **[(*clockwise*)(*counterclockwise*)]** around this low-pressure center, denoted by the **L**.

17. The air also spiraled generally **[(*inward toward*)(*outward from*)]** the low-pressure center.

18. This wind flow pattern about the Low is **[(*consistent with*)(*contrary to*)]** the *hand-twist* model of a Low.

19. Note the local coverage of the sky as reported in the station circles within the circulation pattern of the Low. The skies, particularly to the north about the Low were generally **[(*clear*)(*cloudy or partly cloudy*)]**.

20. The hand-twist model of a Low includes vertical motions with air rising. Based on the Low shown on this map, areas of rising air are likely to be locations of **[(*clear*)(*cloudy or partly cloudy*)]** skies.

21. This pattern of cloud cover **[(*is*)(*is not*)]** consistent with low-pressure systems being characterized as "stormy", implying extensive cloudiness and possible precipitation. The weather at map time at Boise, ID, and Billings, MT was reported as light rain (two green dots).

22. Refer back to Investigation 1A. The Figure 3 surface weather map, "Isobars, Fronts, Radar & Data", of Investigation 1A **[(*was*)(*was not*)]** for the same day and time as this Investigation 1B, Figure 3, U.S. - Data map.

23. Note the precipitation areas as indicated by the radar shadings on the Investigation 1A, Figure 3 surface weather map. The precipitation areas across the northern Great Plains

states north of the frontal systems where winds flow toward the southwest and rising terrain **[(*do*)(*do not*)]** further support the indication of the Low as a "stormy" weather system.

When the current weather map available on the AMS Weather Studies website shows centers of stormy Lows or fair weather Highs near your location, you might consider comparing your local wind direction (as reported on weathercasts or shown by a flag, for example) with map circulations and the hand-twist model of weather systems. The 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 immediately around an **L** is generally cloudy or if the broad area centered on an **H** is mostly clear.

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

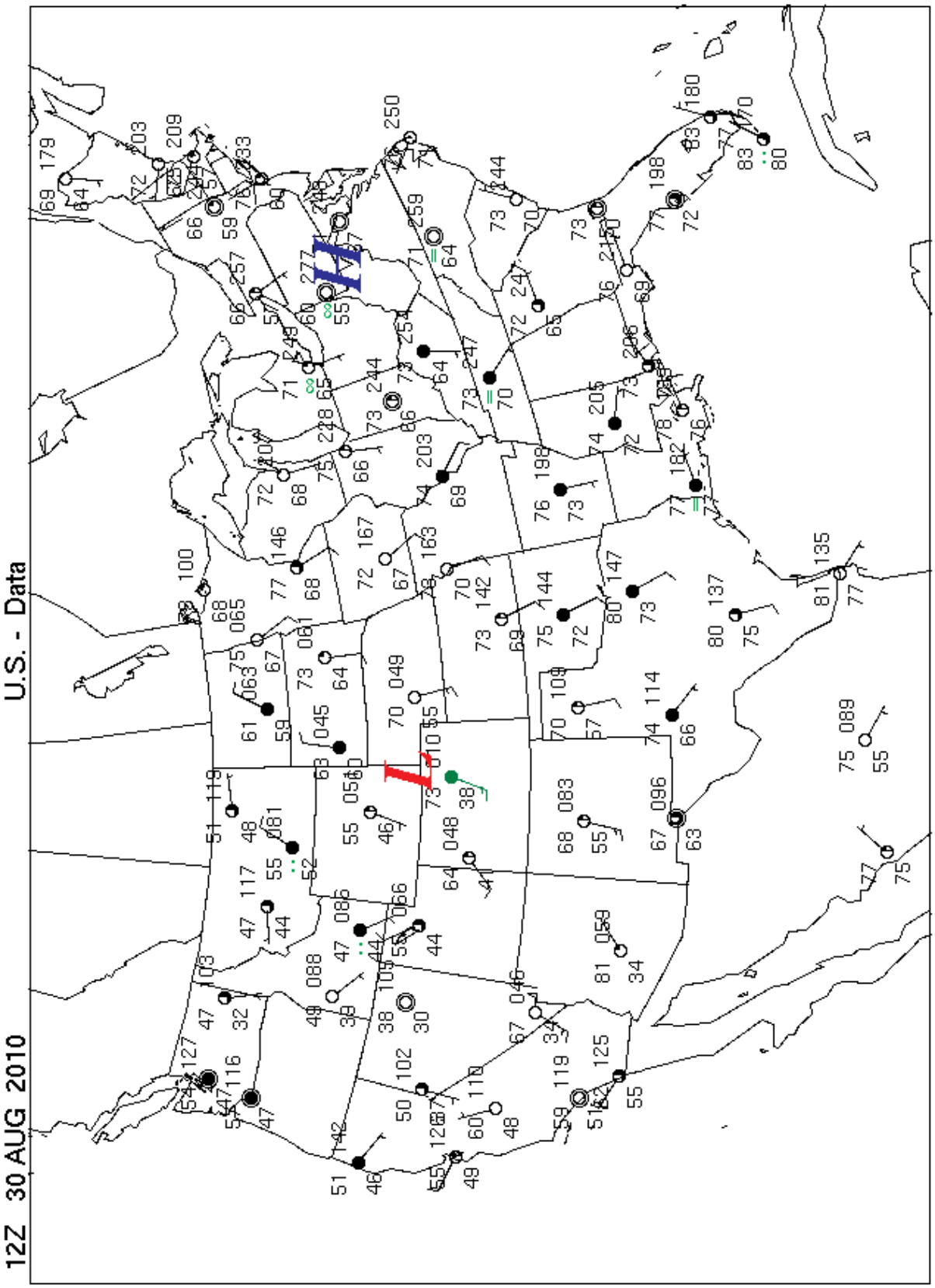


Figure 3. "U.S. - Data" map for 12Z 30 AUG 2010.