Throughout the guide teaching tips are in red.

Activity Description and Estimated Class Time

In this 6-day activity, students forecast the following day's weather for football games to occur in Atlanta, GA, Denver, CO, Pittsburgh, PA, and Dallas, TX (NFL Teams Falcons, Broncos, Steelers, and Cowboys, respectively). To prepare, students learn about weather factors such as air masses, high and low pressure systems, and frontal boundaries. They also learn to interpret maps of surface air temperature and air pressure.

Suggested timeline:

Day	Minutes	Task
1	50	Part 1, air pressure and wind
2	50	Part 2, cloud and wind map
3	50	Part 3, interpreting surface weather maps
4	20	Part 4, predicting weather conditions
4	20	Part 5, pairs predict weather for game day
5	20	Part 5, large groups make consensus forecast
5	10	Part 5, pairs make quick forecasts for other 3 cities
6	30	Part 5, groups present gameday forecasts, class discusses accuracy
6	20	Weather wrap-up

Objectives

Students will develop an understanding of the following ideas and content:

- The influence of atmospheric conditions on local weather,
- How to interpret the symbols on surface weather maps and describe the weather conditions they indicate,
- How to identify fronts and their motions on a weather map and describe weather near the fronts,
- How to describe general relationships between wind patterns and centers of high and low pressure on weather maps,
- How to predict the next day's likely weather conditions at a few specific locations.

Students demonstrate understanding of these ideas by creating forecasts for a given location in the US where a hypothetical NFL football game will take place.

Correlations to NC Science Standards

7.E.1.3 Explain the relationship between the movement of air masses, high and low pressure systems, and frontal boundaries to storms (including thunderstorms, hurricanes, and tornadoes) and other weather conditions that may result.

7.E.1.4 Predict weather conditions and patterns based on information obtained from:

- Weather data collected from direct observations and measurement (wind speed and direction, air temperature, humidity and air pressure)
- Weather maps, satellites and radar
- Cloud shapes and types and associated elevation

Brief Science Background

Air masses are large bodies of air with consistent characteristics of temperature and moisture. Air masses take on these characteristics from the location where they form. They can be warm if formed near the Equator, cool if formed near the poles, humid if formed over water, or dry if formed over dry land. Air masses interact with each other to form weather systems, including high and low pressure areas and fronts. These interactions cause wind and precipitation. Tracking air masses allows meteorologists to predict local weather. The leading edge of an air mass is called a front. Warm humid air tends to lift, and when it does, it cools, causing the water vapor it contains to condense and form clouds. If the lifting is strong, the clouds can produce precipitation.

Part 1: Understanding Weather Maps: Air Pressure and Wind (50 minutes)

Materials

Materials for the whole class

- Ability to project from web sites

Materials for the whole class

- Colored pencils
- Handouts

Preparation

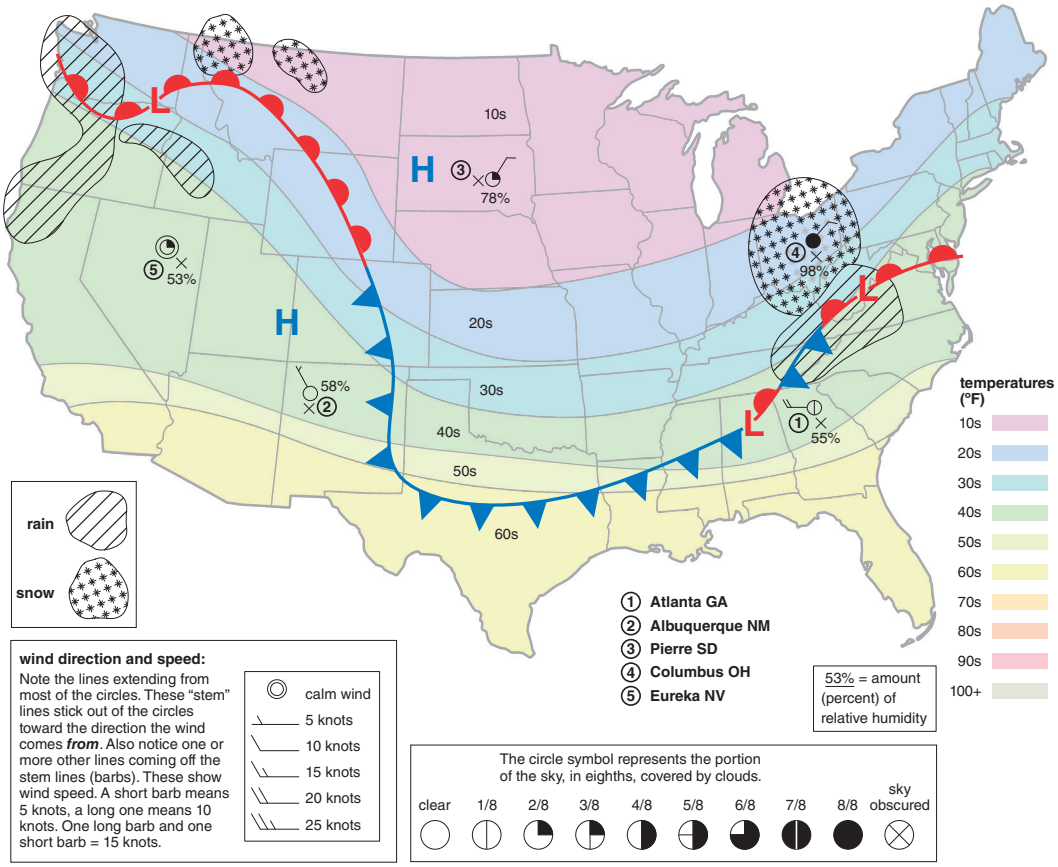
1. Photocopy SD-2, 1 for each student
2. Be ready to project Support Documents 1-5 and **http://hint.fm/wind/**

Exploration

Explorations are intended for students to engage with materials and concepts, ask questions, and share what they notice. Avoid teaching content in an exploration, even during discussions.

1. Tell the class that students will pretend to be weather forecasters predicting the following day's weather in cities where NFL football games will be played. The only tool available will be weather maps. The map will include all information needed to make the weather predictions. Project Supporting Document SD-1, a sample map. Make a class list of all of the observations and questions they can think of related to the map. Write down the list on chart paper or the whiteboard. **The list will be referred to in part 2 of this activity.**
2. Ask students what they imagine wind patterns look like over the whole country.

Support Document 1



Are they all in the same direction? Swirling around? Project the web site **http://hint.fm/wind/** and discuss what students notice about it. The moving white lines show ground-level wind over the whole US, updated hourly. Clicking on the map zooms in. Dragging moves the whole map. Call attention to the key at the left of the display that indicates wind speed. Students should see wind patterns. **The discussion sets the stage for understanding that large-scale forces are moving air around. Understanding how winds move allows meteorologists to make accurate weather forecasts. We need to understand the processes that cause weather to understand how weather can be predicted.**

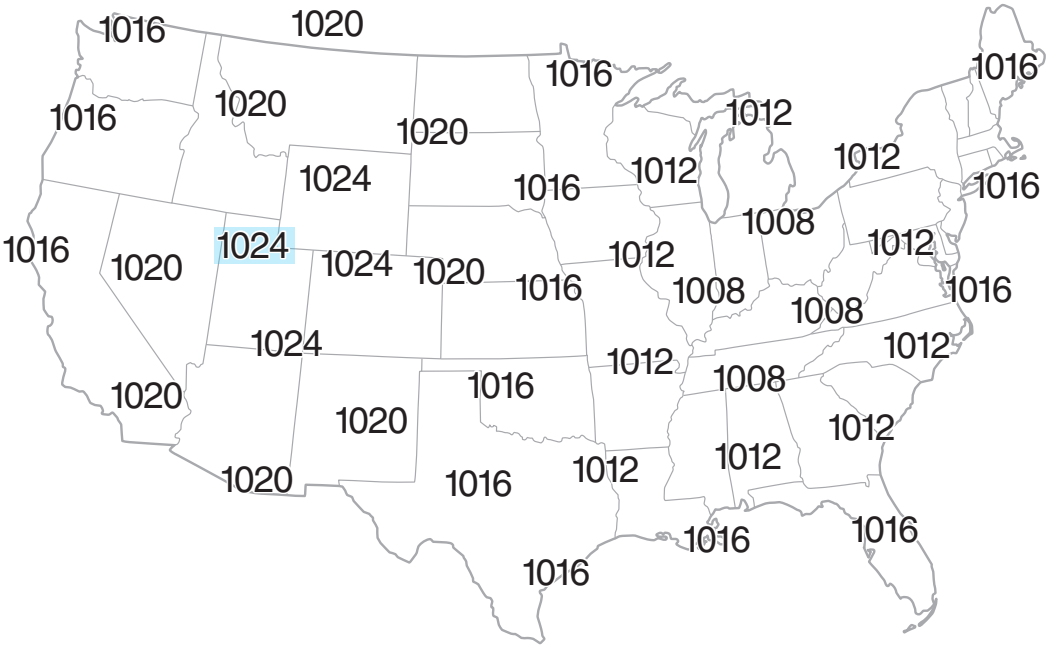
Part 1 – Understanding Pressure Maps

Procedure

1. While listing questions during the exploration, students might ask about symbols shown on the weather map. Explain that, to understand the symbols, we need to understand how the maps are created. We will begin with how air pressure maps are created. The teacher will explain how to fill out this map. Pass out SD-2, the surface pressure map. Explain that this map shows sea level air pressures for various locations over the continental US. The values are in whole millibars. Because these values are reported from measuring instruments on a regular basis, they are called "reports."
In case students ask, these pressures are called "sea level" because they are

adjusted to be the pressure at the place if it were at sea level. (Air pressure decreases with increasing altitude, so adjusting the air pressure readings to "sea level" removes the effect of elevation on the reading.) Millibars are meteorologists' measure of pressure. Higher numbers indicate higher pressure. To help make sense of the patterns of air pressures on the map, we draw lines connecting points of equal pressure. These lines are called isobars.

Support Document 2



2. Surface pressure map summary: Explain that to see the pattern of air pressures we connect points of equal pressure with lines, called isobars. Ask students to use a black colored pencil to lightly draw lines connecting identical values of sea level pressure. These lines, called isobars, do not cross each other. Isobars are usually drawn for every four millibars, using 1000 millibars as the starting point. Therefore, these lines have values of 1000, 1004, 1008, 1012, 1016, 1020, 1024, etc., or 996, 992, 988, 984, 980, etc.

   a. Surface pressure map procedure. Give the following directions: Before drawing, find all of the 1024 pressure readings. There are 4 of them in the western US. Begin drawing from the 1024 millibar station pressure over Salt Lake City, Utah, highlighted in blue. Draw a line to the next 1024 value located to the northeast (upper right). Without lifting your pencil draw a line to the next 1024 value located to the south and then to the one located southwest, finally returning to the Salt Lake City value. Remember, isobars are smooth lines with few, if any, kinks.

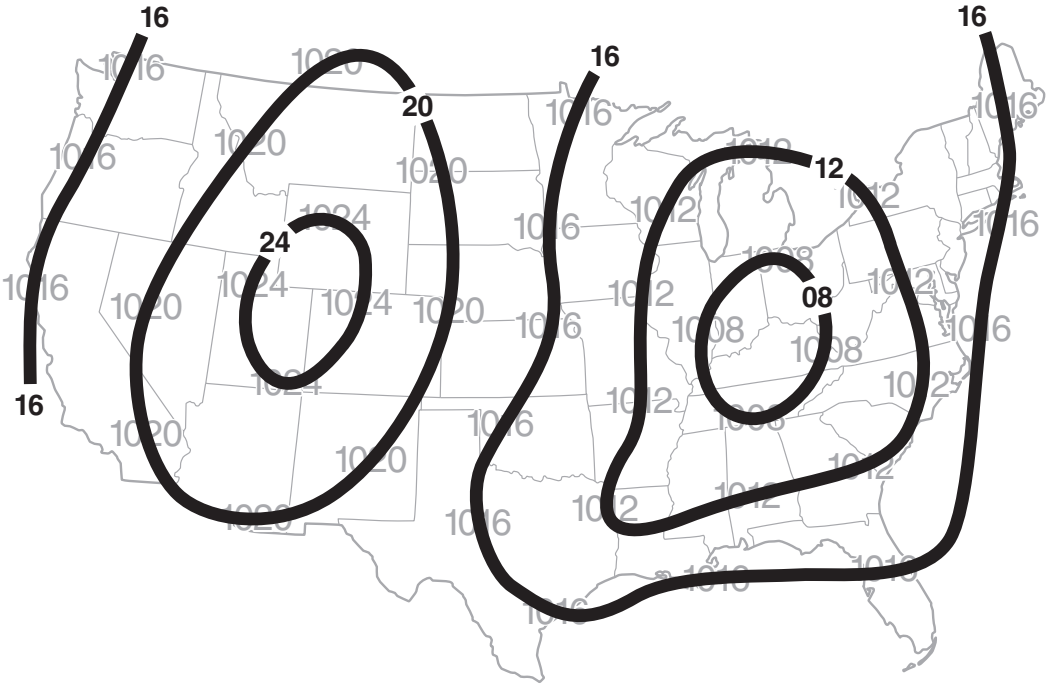
   b. The result is an elongated circle, centered approximately over Eastern Utah. This elongated circle is the 1024 millibar line. You can expect the pressure to be 1024 millibars everywhere along that line. Repeat the procedure with the next isobar value. Remember that the value between isobars is 4 millibars. Since there are no 1028 millibar values on the map, then your next line will follow the 1020 millibar reports. Then continue with the remaining values until you have connected all of the reports with isobar lines.

   c. Label each isobar line with the appropriate value. Traditionally, only the last

two digits are used for labels. For example, the label on the 1024 mb isobar would be 24. A 1008 mb isobar would be labeled 08. A 992 mb isobar will be labeled 92. These labels can be placed anywhere along the isobar but are typically placed around edges of the map at the end of each line. For closed isobars (lines that connect) a gap is placed in the isobar with the value inserted in the gap.

d. Project SD-3, showing how students' maps should look.

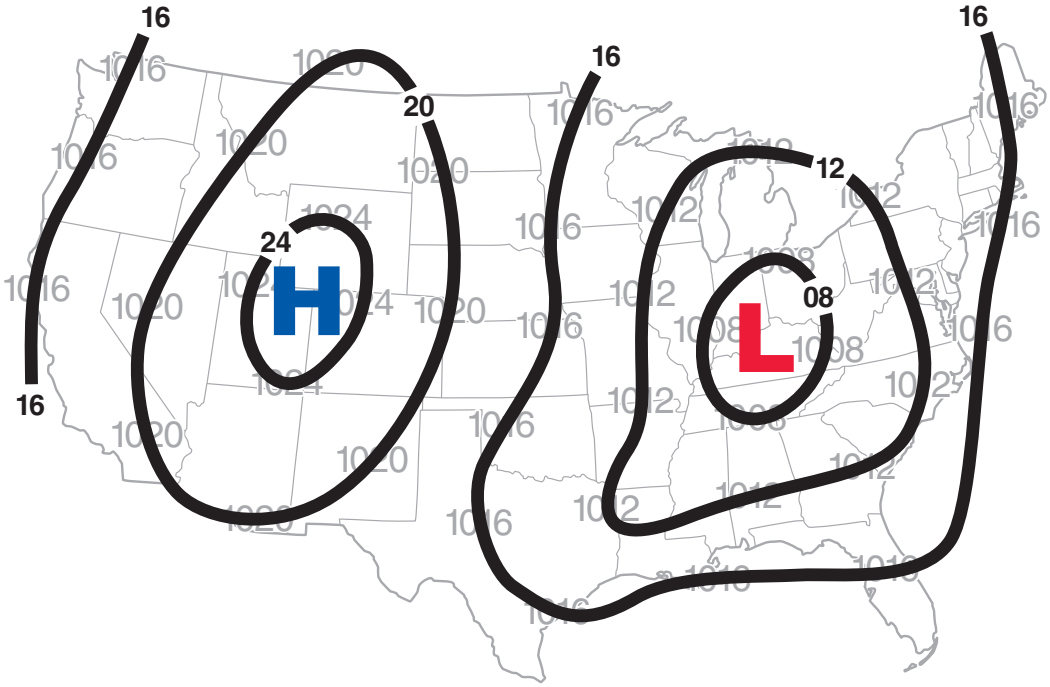
Support Document 3



3. Surface pressure map analysis: Explain that isobars can be used to identify areas of high and low pressure, or "Highs" and "Lows." Project SD-4 and explain that the pressure at the center of a high is greater than the surrounding air. The pressure at the center of a low is lower than the surrounding air. Students should label the center of the high pressure area with a large blue "H" and the center of the low pressure area with a large red "L". Their maps should look like SD-4.

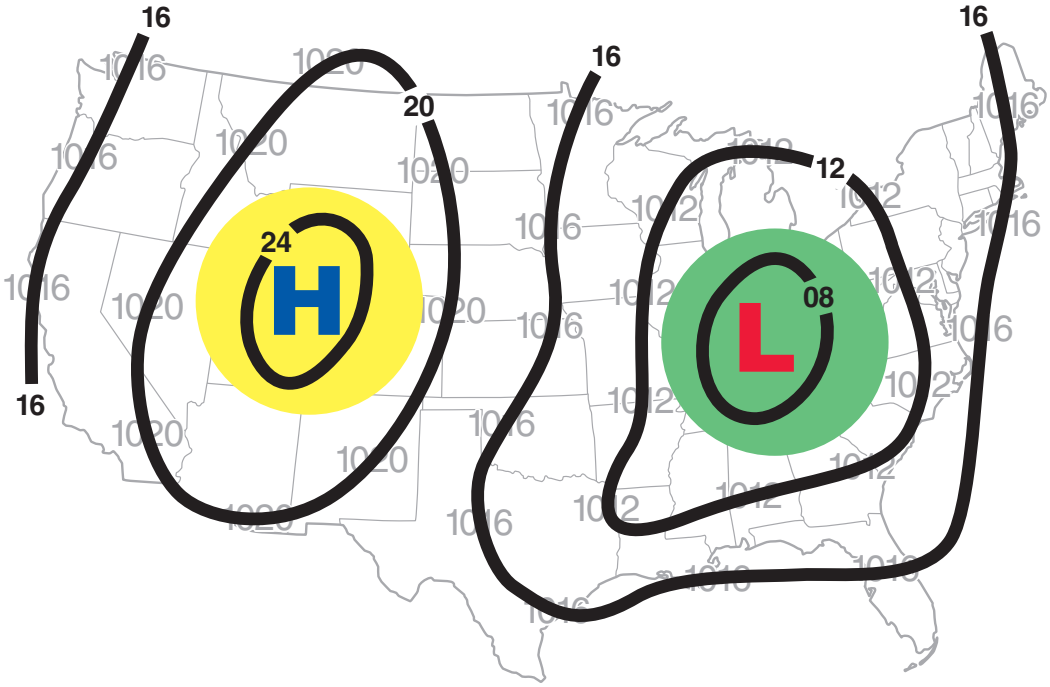
a. High pressure air is more dense than the air around it, and it tends to fall

Support Document 4



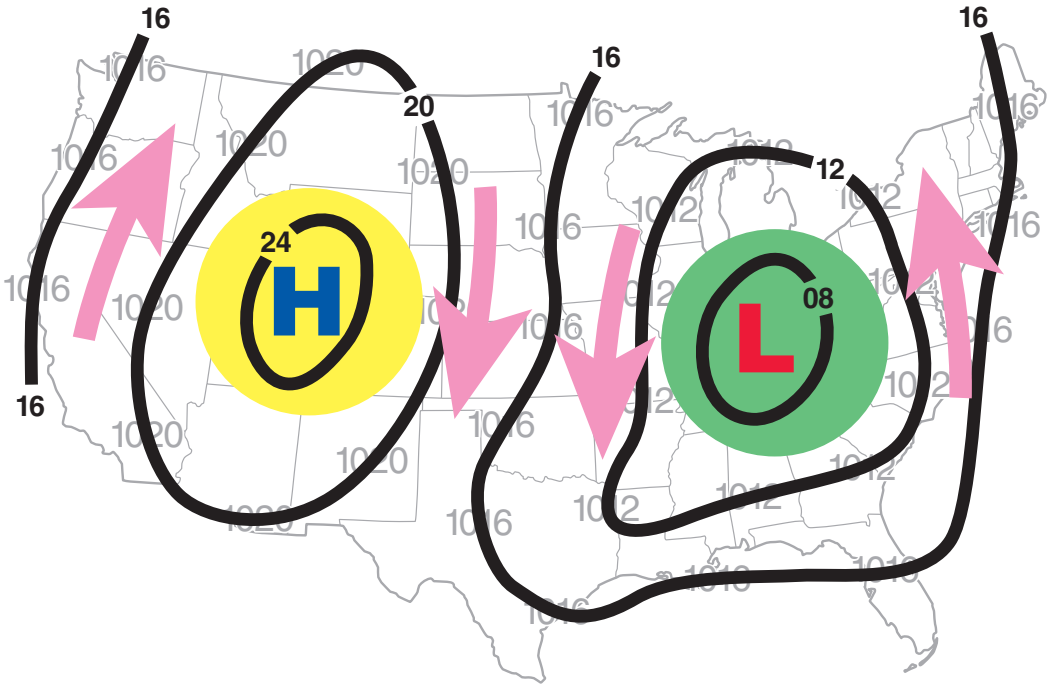
toward the earth. Because this air has lost much of its moisture, high pressure regions are usually associated with dry weather. Low pressure regions usually bring precipitation because low pressure air, being less dense, tends to rise. As it rises, it cools, and its water vapor condenses to become clouds or precipitation. With a colored pencil, shade areas you expect rain or snow green. Shade areas where you expect clear skies yellow. Project SD-5. Students' maps should look like SD-5.

Support Document 5



b. Explain that in the northern hemisphere, the wind blows clockwise around centers of high pressure. The wind blows counterclockwise around lows. Ask students to draw arrows around the "H" on their maps to indicate the wind direction and around the "L" on their maps to indicate the wind direction. Project SD-6. The final map should look like SD-6. **If necessary, review clockwise and counterclockwise with the class.**

Support Document 6



4. Show the current wind map at **http://hint.fm/wind/** and ask students to predict where they might find high and low pressure centers. Then compare the wind map to a surface weather map such as the one at **https//www.wunderground.com/maps/**. The wind patterns should circle counterclockwise around low pressure centers and clockwise around high pressure centers, though the wind patterns are often more organized around low pressure centers. High pressure centers are often difficult to identify solely from wind patterns; more information such as pressure isobars may be required to locate these.

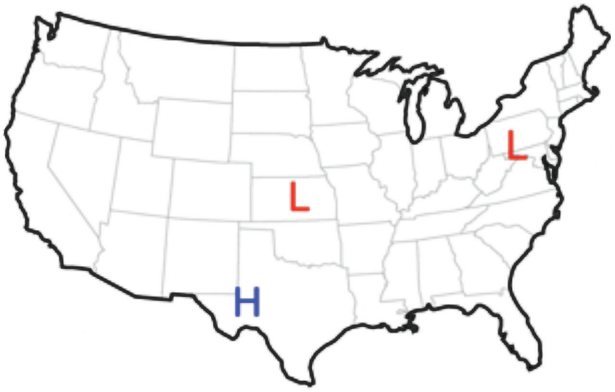
5. Project the wind map from October 30, 2012 found at **http://hint.fm/wind/gallery/oct-30.js.html**. **Don't tell students yet, but this map shows Hurricane Sandy.**

6. **Notebook prompt:** Ask students to identify where the low pressure center is located on the October 30, 2012 wind map. Have them provide evidence explaining why they selected that site.

7. Tell students that the October 30, 2012 wind map shows Hurricane Sandy. Point out the location of the low pressure center. **The low pressure center is located approximately over the state of Maryland. It can be easily identified from the counterclockwise wind swirl pattern.**

8. Challenge students to locate another low pressure center. They do not have to write this down in their notebooks. **The second low pressure center is located over Kansas.**

9. Challenge students to locate a high pressure center. Again, they do not need to write down the location. **The high pressure center is located in south Texas, midway between El Paso and San Antonio. It can be located by the clockwise wind swirl pattern.**



Part 2: Understanding Weather Maps: Cloud Cover and Wind (50 minutes)

Materials

Materials for the whole class

- Projector or document camera

Materials for students

- Colored pencils
- Index cards, 1 for each student
- Handouts SD-7, photocopied by teacher
- Handout "Weather Factor Reading – Air Masses and Fronts" (included in kit)

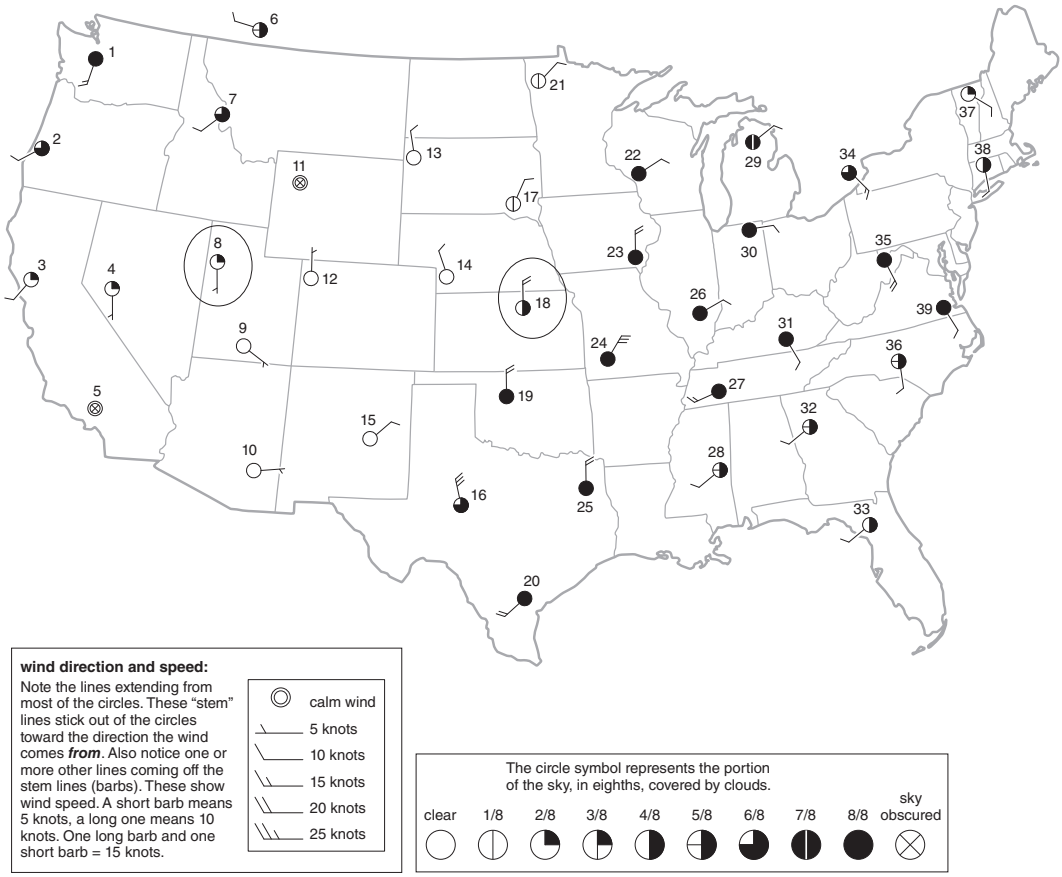
Preparation

1. Photocopy SD-7, 1 for each student.
2. Be ready to project Support Documents 7-9.

Procedure

1. Now we will consider other weather factors. Hand out the cloud and wind map SD-7 without telling students what information is displayed. Ask students what they notice about this map. **Accept any statements at this point. Misunderstandings will be corrected later.**

Support Document 7

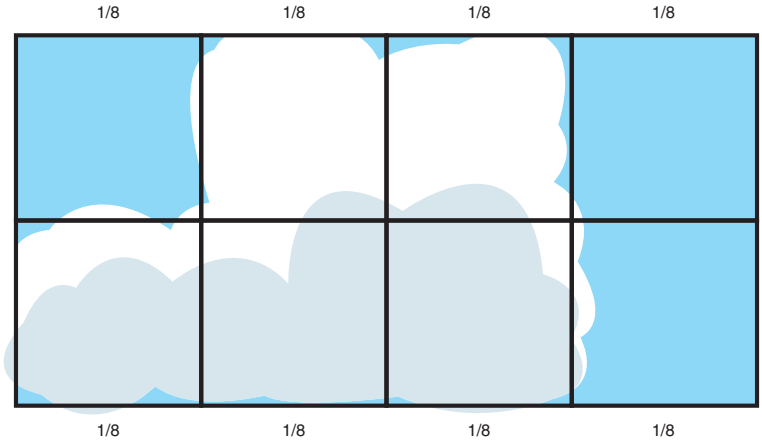


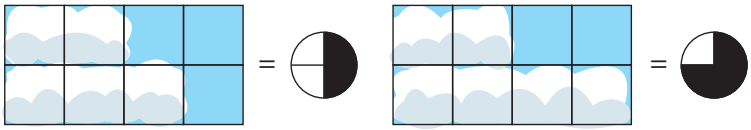
2. **Notebook Prompt** - Ask students to write down in their notebooks as much information as they can about location 8 in (SD-7). Hold a brief discussion about the information they gathered. Students will probably have questions about the wind speed, wind direction, and cloud cover symbols. Explain the wind and cloud cover indicators. **This map shows information about cloud cover, wind speed, and wind direction, and the map's key shows how to interpret these symbols. A knot is a measure of wind speed. One knot is about one mile per hour. The line extending from the cloud cover circle indicates the direction FROM which the wind is blowing – a line pointing straight up indicates wind blowing from the north. A flag on a flagpole in a north wind would be pointed south. Students will not know this, but the wind cloud data are drawn from atmospheric conditions at the same moment in time as the pressure map in part 1 on which students drew the isobars. We will reveal this to students later.**

3. Project SD-8 to discuss how cloud cover is measured. **The "sky obscured" image means that something is preventing an observer standing on the ground from seeing the sky – fog, sandstorm, etc.**

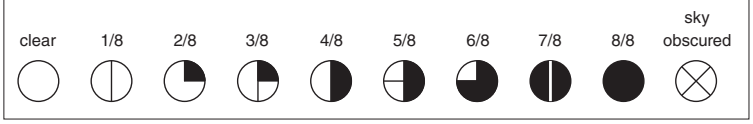
Support Document 8

Cloud cover is measured in one-eigths. Imagine squishing together all of the clouds you see in the whole sky, and counting how many one eighth panels they cover.





The circle symbol represents the portion of the sky, in eighths, covered by clouds.



4. Ask students again about location 8 in (SD-7). **Students can refer to the map legend to read the wind and cloud symbols – location 8 shows 2/8 cloud cover and wind coming FROM the south (towards the north) at a speed of 5 knots.**

5. Ask students to interpret location 18 in (SD-7). **Location 18 has 4/8 cloud cover and a wind blowing FROM the north (towards the south) at a speed of 20 knots.**

6. Hand out one index card to each student. Tell them to choose one location on the map and not tell anyone which location they chose. They should write their name, their location's cloud cover, wind speed, and wind direction on the index card. Collect the index cards, shuffle them, and hand one card to each student. The students will identify the location number indicated on their card and write that number down on the card. They will then check in with the person whose name is on the card to determine if they identified the correct location. **Note, some of the cloud cover, wind speed, and wind direction designations on the map are identical, for example numbers 19 and 25.**

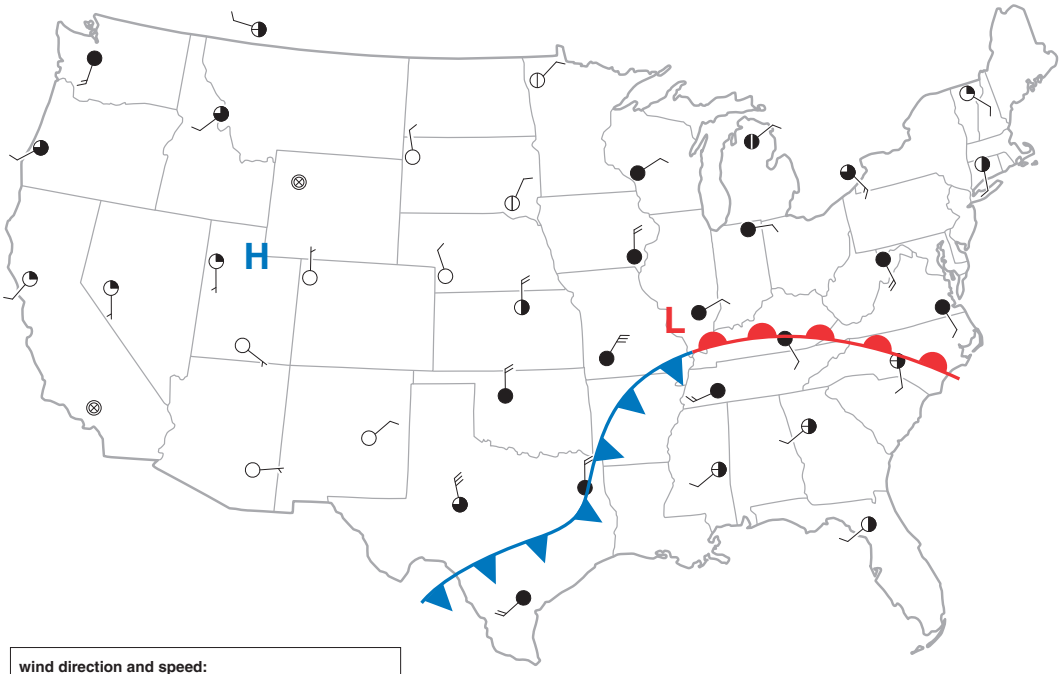
7. **Notebook prompt** – based on the direction that wind is blowing, have students place an H and an L on the wind flag map to indicate the likely location of high and low pressure centers. Have them provide evidence explaining why they placed the H and L where they did on the map.

8. Have the students compare and comment on the direction the wind blows around high and low pressure (based upon the arrows they drew) compared to the direction of the staffs on the surface map. **The wind direction markers show agreement between the surface air pressure map SD-2 (from part 1) and cloud-wind map. The high pressure area may be more difficult for students to locate.**

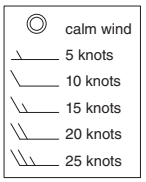
9. Have the students compare and comment on the cloud cover under the areas of high and low pressure. **The cloud cover is minimal under the areas of higher pressure and heavy under the areas of lower pressure. At this point, students can compare the pressure isobars map SD-2 (from part 1) with the cloud-wind map. Again, these maps show atmospheric conditions at the same moment in time. Tell students that wind speeds are highest where the isobars on a map are closest together – they will need to know this later on.**

10. Show SD-9 and have the students draw a cold front, in blue, and a warm front, in red, on their maps. **Remind them of the counterclockwise air currents around a low pressure area and that clouds or precipitation are often at a low pressure center. Explain that there is usually cloud cover or precipitation along and ahead of warm fronts and along and behind cold fronts.**

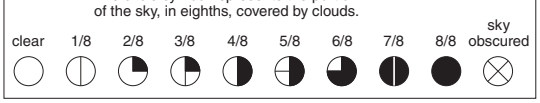
Support Document 9



wind direction and speed:
Note the lines extending from most of the circles. These "stem" lines stick out of the circles toward the direction the wind comes ***from***. Also notice one or more other lines coming off the stem lines (barbs). These show wind speed. A short barb means 5 knots, a long one means 10 knots. One long barb and one short barb = 15 knots.



The circle symbol represents the portion of the sky, in eighths, covered by clouds.



11. Remind students that they will use weather maps to predict weather for an upcoming NFL game. Hand out "Weather Factor Reading – Air Masses and Fronts." Give students 5 minutes to read it. **The fronts we marked on the cloud-wind map are where air masses meet. Boundaries between air masses are called fronts. Fast moving cold fronts indicate a rapid change in the weather. Warm fronts can also cause large changes, but somewhat more slowly than a cold front. On a weather map, fronts are drawn where there are large changes in temperature, wind direction, wind speed, and pressure. Fair weather is associated with "Highs" while stormy weather is associated with "Lows" and fronts that extend from them. Weather systems tend to move from west to east across the US and**

cover about 1/4 the distance across the country in one day. If a front remains intact for as long as 4 days, it will likely travel across the whole country.

12. Students should now understand how weather maps are constructed and how to interpret them. Revisit the class list of questions and observations about weather maps that were created at the beginning of part 1 and determine if any questions remain unanswered.
13. Collect handout "Weather Factor Reading – Air Masses and Fronts" for reuse.

Acknowledgement

The maps used during parts 1 and 2 of this lesson plan (surface pressure map and cloud cover/wind map) are part of the National Weather Service Weather Forecasting lesson found at **http://www.srh.noaa.gov/jetstream/synoptic/ll_analyze.html**.

Part 3: How to Use Surface Weather Maps to Predict Weather

During this section, students will learn how to interpret surface weather maps. They will see a surface weather map containing information about air temperature, humidity, precipitation, wind speed, wind direction, high and low pressure centers, and frontal boundaries. Afterwards, they will discuss each type of information on the map, and generate a list of weather conditions at 5 cities. Finally, students will get a similar map showing different weather conditions, and they will interpret weather conditions at the 5 cities.

Materials

Materials for the whole class

- Projector or document camera

Materials for students

- Handouts SD-11 and SD-13, photocopied by teacher
- Handouts SD-10 and SD-12, included in kit

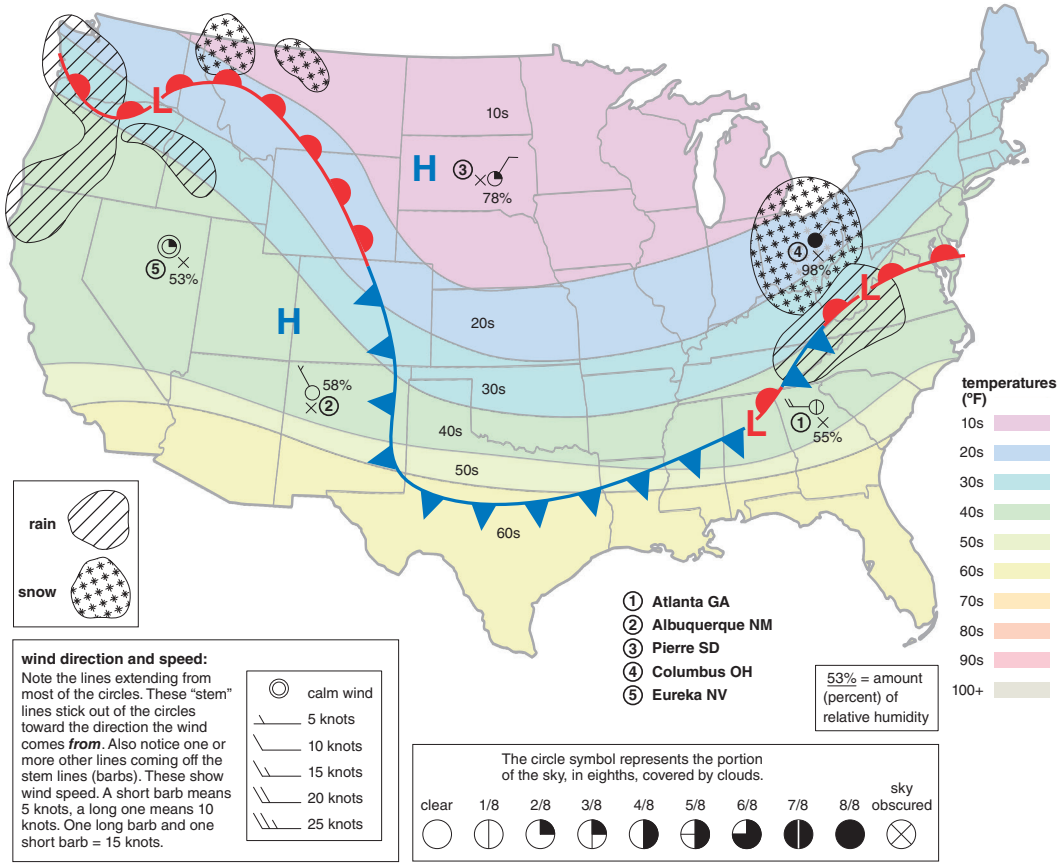
Preparation

1. Photocopy SD-11 and SD-13, 1 for each student.
2. Have handouts SD-10 and SD-12 ready to give out.

Procedure

1. Tell the class that they will work with weather maps like the ones they will use to predict weather at NFL games. Hand out and project SD-10, which shows weather conditions in February. Isotherms are drawn at 10˚F intervals, and shading between the isotherms indicates regions of similar air temperature. Humidity levels are indicated by the number next to each wind vane. **Relative humidity (RH) is a measure of how close the air is to being saturated with moisture. When RH is less than 40%, it feels dry outside, and when the RH is greater than 80%, it feels moist outside. Between 40 and 80%, RH is comfortable if the temperature is also comfortable. Precipitation can fall when the RH at ground level is less than 100%. For example it takes time and lots of evaporation to saturate air that has a RH of 50%.**

Support Document 10 **Weather conditions during February**



2. Pass out SD-11, the table handout. Explain that the table summarizes weather conditions in February for 5 cities shown on the map. The first line of the table is already filled out. Draw the table on the whiteboard and label the row headers. Show how each piece of data was obtained from the map for Eureka, NV. **The temperature of 44˚F is interpolated based on the distance between the two closest isotherms. Allow for a range of answers in the forties. The relative humidity is printed on the map adjacent to the cloud-wind indicator. The cloud cover is 2/8. There is no precipitation at Eureka. There is no line showing wind speed, so there is calm wind. Direction is not indicated for calm wind.**

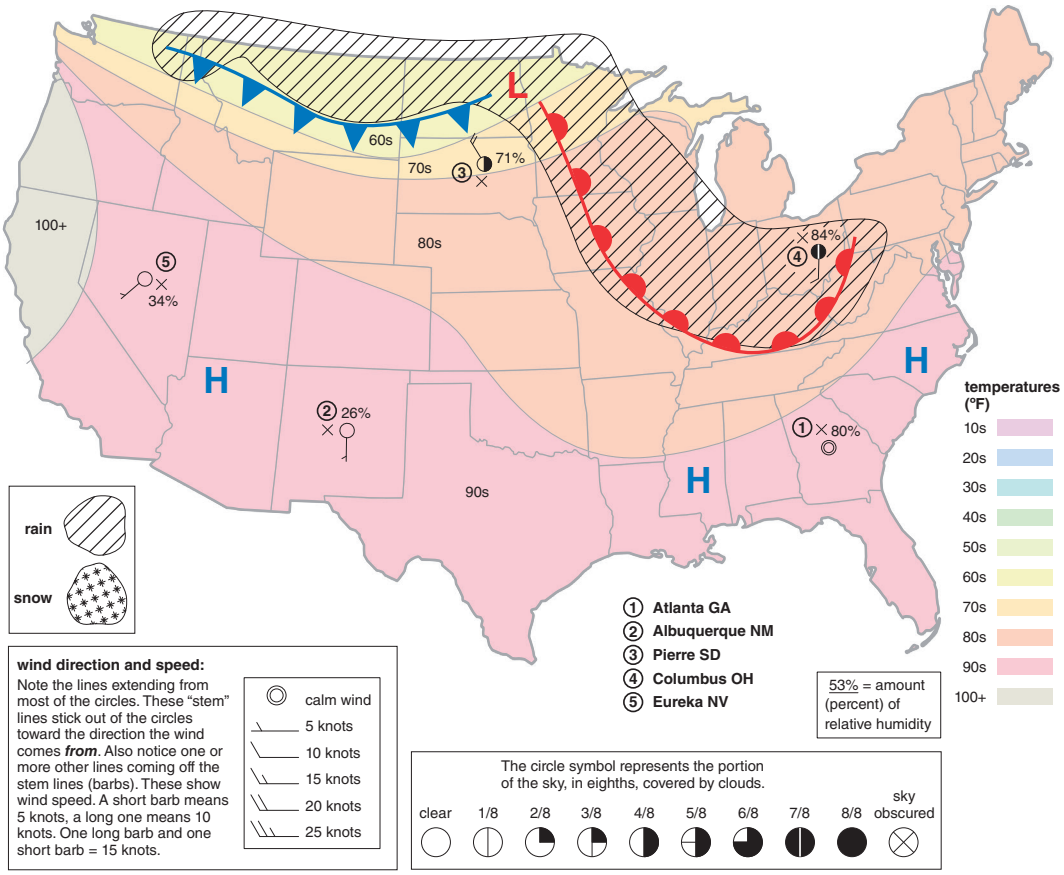
3. Lead a class discussion to fill out data for Albuquerque, NM. Let students complete the data for Pierre, SD, Atlanta, GA and Columbus, OH on their own, and guide class discussion to reveal the correct answers.

Support Document 11 Answers **Weather Conditions during February**

	Air temp ˚F	Humidity	Cloud cover	Precipitation	Wind speed	Wind direction
Eureka NV	44˚F	53%	2/8	None	Calm wind	n/a
Albuquerque NM	46˚F	58%	Clear sky	None	5 knots	Northwest
Pierre SD	7˚F	78%	2/8	None	10 knots	Northeast
Atlanta GA	48˚F	55%	1/8	None	20 knots	West
Columbus OH	27˚F	98%	8/8	Snow	10 knots	Northeast

4. To give students further practice reading weather maps, give out SD-12 and SD-13, the August weather map and its accompanying table, and have students work individually to interpret weather conditions for 5 cities and fill in the table. Hold a class discussion to reveal correct answers.

Support Document 12 **Weather Conditions during August**



Support Document 13 Answers **Weather Conditions during August**

	Air temp ˚F	Humidity	Cloud cover	Precipitation	Wind speed	Wind direction
Eureka NV	98˚F	34%	Clear sky	None	5 knots	Southwest
Albuquerque NM	95˚F	26%	Clear sky	None	5 knots	South
Pierre SD	80%	71%	4/8	None	15 knots	Northwest
Atlanta GA	93˚F	80%	Clear sky	None	Calm wind	n/a
Columbus OH	85˚F	84%	7/8	Rain	10 knots	South

5. Collect handouts SD-10 and SD-12 for reuse.

Part 4: Predicting Weather Conditions

In this section, students predict the location of various weather conditions using a surface weather map.

Materials

Materials for the whole class

- Projector or document camera

Materials for students

- Colored pencils
- Handouts SD-14

Preparation

1. Photocopy SD-14, 1 for each student.
2. Be ready to project SD-15.

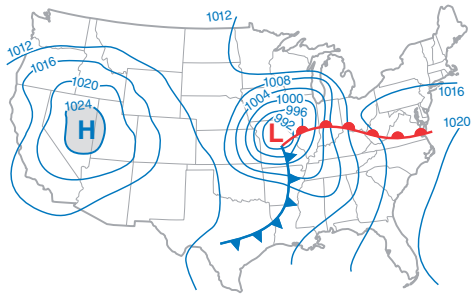
Procedure

1. Hand out SD-14. Tell students that they will shade the maps in the predicted column only where they think a particular weather condition will occur: highest and lowest pressures, precipitation, highest wind speeds, and clear skies. Ask them to discuss their answers in pairs and come to a consensus decision. Afterward, discuss one condition at a time with the whole class, asking students to explain their choices. After each discussion, reveal correct answers. Project SD-15 while discussing answers.
2. **Correct answers:**
   a. **Highest atmospheric pressure – the highest atmospheric pressure is found at the center of a high pressure system, labeled with a capital H on a weather map.**
   b. **Lowest atmospheric pressure – the lowest atmospheric pressure is found at the center of a low pressure system, labeled with a capital L on a weather map.**
   c. **Where precipitation is expected – precipitation typically occurs along and ahead of a warm front, along and behind a cold front, and around the center of a low pressure system.**
   d. **Highest observed wind speeds – the highest wind speeds are found where the isobars on a weather map are spaced closest together.**
   e. **Where clear skies are expected – under high pressure systems, air sinks towards the surface. As it sinks, air warms and dries out, typically resulting in clear skies in fair weather. Conversely, low pressure systems are generally associated with air rising. As air rises, it cools, and clouds form.**

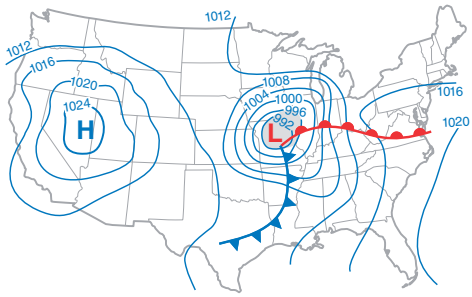
Support Document 15

actual answers

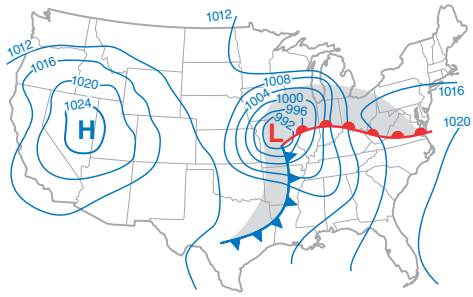
area of highest atmospheric pressure



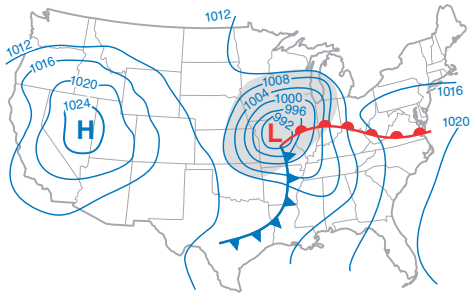
area of lowest atmospheric pressure



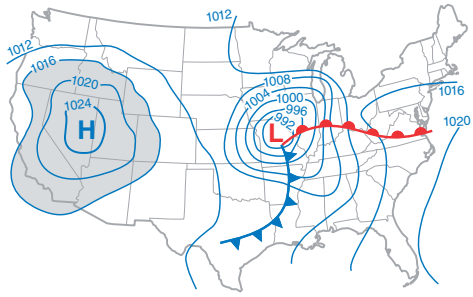
area where precipitation is expected



area of highest wind speeds



area where clear skies are expected



Part 5: NFL Weather Conditions

During this section, students will learn how to interpret surface weather maps. They will see a surface weather map containing information about air temperature, humidity, precipitation, wind speed, wind direction, high and low pressure centers, and frontal boundaries. Afterwards, they will discuss each type of information on the map, and generate a list of weather conditions at 5 cities. Finally, students will get a similar map showing different weather conditions, and they will interpret weather conditions at the 5 cities.

Materials

Materials for the whole class

- Projector or document camera

Materials for students

- Colored pencils
- Handout SD-16, included in kit
- Handout SD-17, photocopied by teacher

Preparation

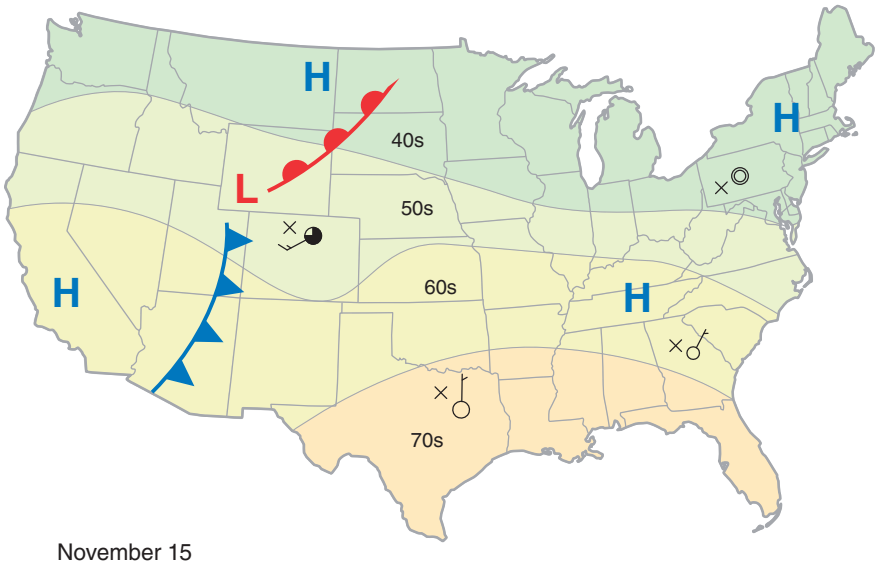
1. Photocopy SD-17, 1 for each student.
2. Be ready to project SD-18.

Procedure

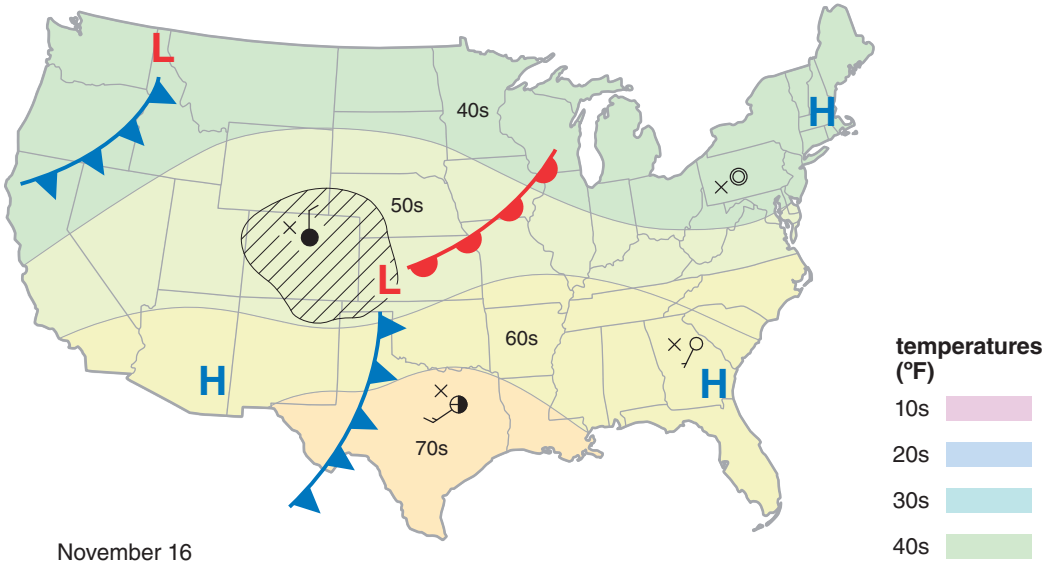
1. Set the scene for the class: NFL football games will be played tomorrow, November 17, in Denver, CO, Pittsburgh, PA, Dallas, TX, and Atlanta, GA. The home NFL Teams for those cities are the Broncos, Steelers, Cowboys, and Falcons, respectively. An average of 68,000 people are expected at each game, so your forecast is important!
2. Assign one city to each pair of students. Multiple pairs will work on each city. Give each team the 3 surface weather maps showing conditions on the 3 days before the game (November 14, 15, 16; SD-16) and SD-17, the blank map for November 17. Temperature data in these maps are for high temperatures. Give all teams 15-20 minutes to draw the surface weather map for November 17 on the top half of handout SD-17. They should forecast the expected high temperatures, chance of precipitation, wind speed, and wind direction for their city. They should record their forecasts and supporting evidence in their notebooks. **Students should work in pencil.**

Support Document 16

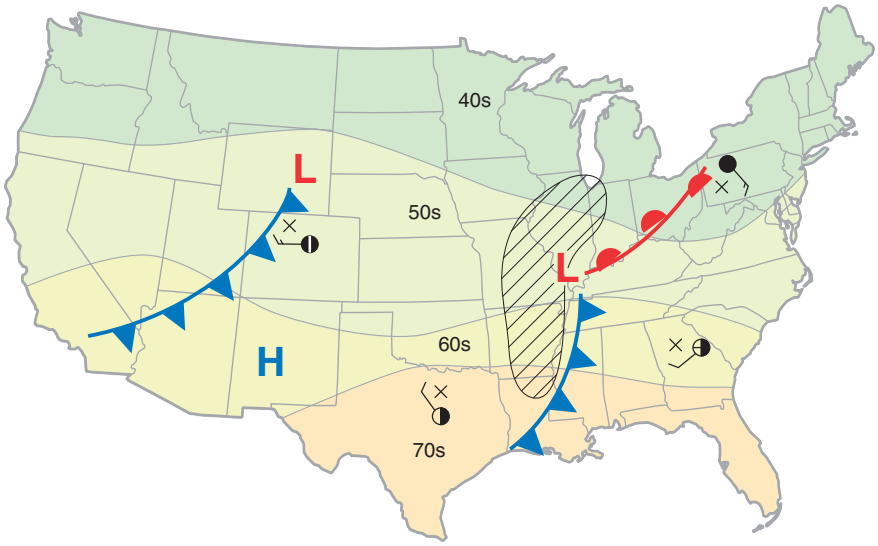
November 14



November 15



November 16



2. Assign one city to each pair of students. Multiple pairs will work on each city.
3. Ask pairs that worked on the same city to assemble into a larger group and try to come to a consensus forecast for their city. Let them know that a volunteer from the group will present their forecast during the next class period. (20 minutes)
4. Have students return to their pair groups. Give student pairs 10-15 minutes to make quick forecasts for each of the other 3 cities, using the surface weather map SD-17. Students should record their forecasts in their notebooks.
5. Ask a volunteer from each large group to present a forecast for their city to the class. All forecasts must include the expected high temperatures, chance of precipitation, wind speed, and wind direction. If possible, use a document camera to show each group's surface weather map as they present their forecast. Comparing with the forecasts they made working in pairs during step 4, the rest of the class will decide if they agree with the forecast or not.
6. Show the class SD-18, the surface weather map for November 17 and have students draw this map on the bottom panel of SD-17. Verbally share the expected forecast for each city. **Note: each of these is just one possible forecast. Other forecasts are valid as long as they are supported by evidence.**

   a. **General patterns –Weather systems tend to move from west to east across the US and cover about 1/4 distance across the country in one day. If a front remains intact for as long as 4 days, it will likely travel across the whole country. The strongest effect on these weather maps comes from two low pressure centers (L). The easternmost L has a warm front to its east and a cold front to its south, while the westernmost L has only a cold front to the south and west. The easternmost L also has rain falling to its west on November 15-17. As noted previously, wind tends to circulate clockwise around high pressure centers and counterclockwise around low pressure centers. The temperatures in these maps do not change much from day to day. The chance of rain in Pittsburgh and Atlanta could change if students predict a different location for the easternmost low pressure system.**

   b. **Denver, CO – high temperature 53˚F, no chance of rain, cloud cover 5/8, wind from the north at 20 knots. A low pressure center and cold front are near Denver, though there is no rain associated with this cold front. Cloud cover tends to be greater near low pressure centers.**

   c. **Dallas, TX – high temperature 73˚F, no chance of rain, no clouds, wind from the northwest at 5 knots. A high pressure center is close to Dallas, which tends to bring clear skies.**

   d. **Pittsburgh, PA – high temperature 48˚F, rain, cloud cover 8/8, wind from the southeast at 20 knots. The easternmost low pressure center is very close to Pittsburgh. Precipitation is falling ahead of the warm front and behind the cold front. Cloud cover is high and wind is from the southeast, as the wind is circulating counterclockwise around the low pressure center.**

   e. **Atlanta, GA – high temperature 65˚F, rain, 8/8 cloud cover, wind from the west at 15 knots. Atlanta is just to the west of the cold front associated with the easternmost low pressure center. Precipitation is falling behind the cold front. Cloud cover is high and wind is from the west, as the wind is circulating counterclockwise around the low pressure center.**

7. Collect handouts (SD-16) for reuse.

Support Document 18 **November 17**