EXERCISE 15

Air Masses, the Middle-Latitude Cyclone, and Weather Maps

For many people living in the middle latitudes, weather patterns are the result of the movements of large bodies of air and the associated interactions among the weather elements. Of particular importance are the boundaries between contrasting bodies of air, which are often associated with precipitation followed by a change in weather.

Exercise 15 investigates those atmospheric phenomena that most often influence our day-to-day weather—air masses, fronts, and traveling middle-latitude cyclones. Using the standard techniques for plotting weather station data, the exercise concludes with the preparation and analysis of a typical December surface weather map.

Objectives

After you have completed this exercise, you should be able to:

1. Discuss the characteristics, movements, and source regions of North American air masses.
2. Define and draw a profile of a typical warm front.
3. Define and draw a profile of a typical cold front.
4. Diagram and label all parts of an idealized, mature, middle-latitude cyclone.
5. Interpret the data presented on a surface weather map.
6. Prepare a simple surface weather map using standard techniques.
7. Use a surface weather map to forecast the weather for a city.

Materials

colored pencils

Materials Supplied by Your Instructor

United States map or atlas

Terms

air mass
source region
front
warm front
cold front
occluded front
adiabatic cooling
polar front
instability
anticyclone
middle-latitude cyclone
wave cyclones

Air Masses

An **air mass** is a large body of air that has relatively uniform temperature and moisture characteristics. The area where an air mass acquires its traits is called a **source region**. For example, air with a source region over cool ocean water tends to become cool and moist, while air that stagnates over the American Southwest in summer becomes hot and dry.

Air masses are set into motion by passing high and low pressure cells. When the air mass moves out of its source region, its temperature and moisture conditions are carried with it.

1. Air masses are classified according to their source region: land versus water and latitude of origin. Explain the meaning of each of the following air mass classification letters.

   c: _____ P: _____

   m: _____ T: _____

Figure 15.1 shows the source regions and directions of movement of the air masses that play an important role in the weather of North America. Use the figure to answer questions 2–8.

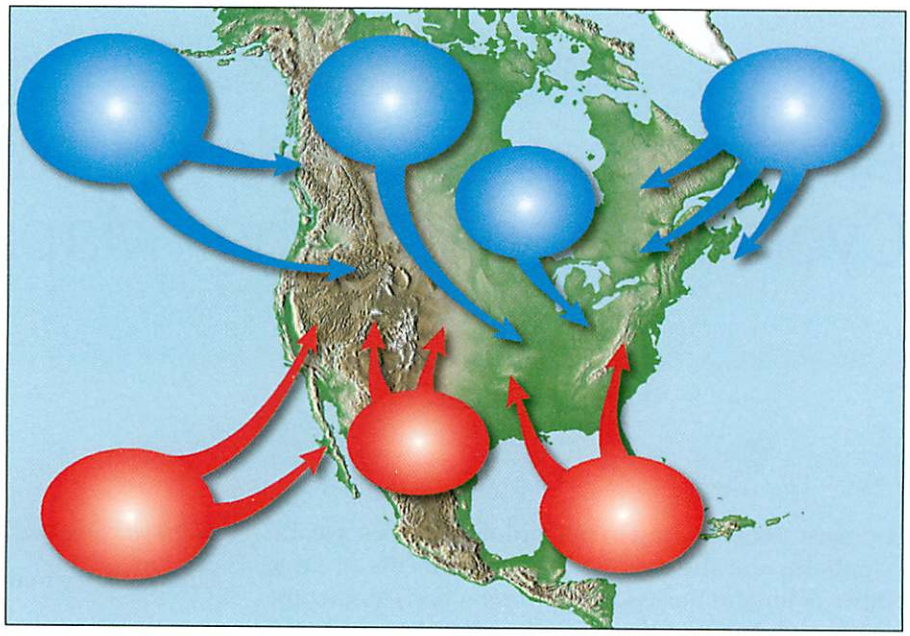


Figure 15.1 Source regions of North American air masses.

2. Label each of the following North American air masses on Figure 15.1. Then list the location of the source region of each in the following space.

	SOURCE REGION
cP:	_____
cT:	_____
mP:	_____
mT:	_____

3. What would be the typical winter temperature and moisture characteristics of each of the following air masses?

	TEMPERATURE	MOISTURE
cP:	_____	_____
mP:	_____	_____
mT:	_____	_____

Notice the paths of air masses indicated by the arrows on Figure 15.1.

4. The general movement of air masses across North America is (east to west, west to east). Circle your answer.
5. How does the movement of air masses across North America correspond to the global flow of wind over the continent?

_____

6. Which air masses would have the greatest influence on the weather east of the Rocky Mountains?

_____

7. A (cP, mT) air mass would supply the greatest amount of moisture east of the Rocky Mountains. Circle your answer.
8. A (cP, mP) air mass has the greatest influence on the weather along the northwest Pacific coast. Circle your answer.

Fronts

A **front** is a surface of contact between air masses of different densities. One air mass is often warmer, less dense, and higher in moisture content than the other. There is little mixing of air across a front, and each air mass retains its basic characteristics. A **warm front**, shown on a weather map by the symbol  , occurs where warm air occupies an area formerly covered by cooler air. A **cold front**, indicated on a map with the symbol  , forms when cold air actively advances into a region occupied by warmer air. An **occluded front**, shown on a weather map with the symbol  , develops when a cold front overtakes a warm front and warm air is wedged above cold surface air.

Fronts typically act as barriers or walls over which air must rise. When it rises, air will expand and experience **adiabatic cooling**. As a consequence, clouds and precipitation often occur along fronts.

9. On Figure 15.1, draw a line where air masses are likely to collide and fronts develop. Where does this boundary occur?

_____

10. In the central United States, east of the Rocky Mountains, a (cP, mT) air mass will most likely be

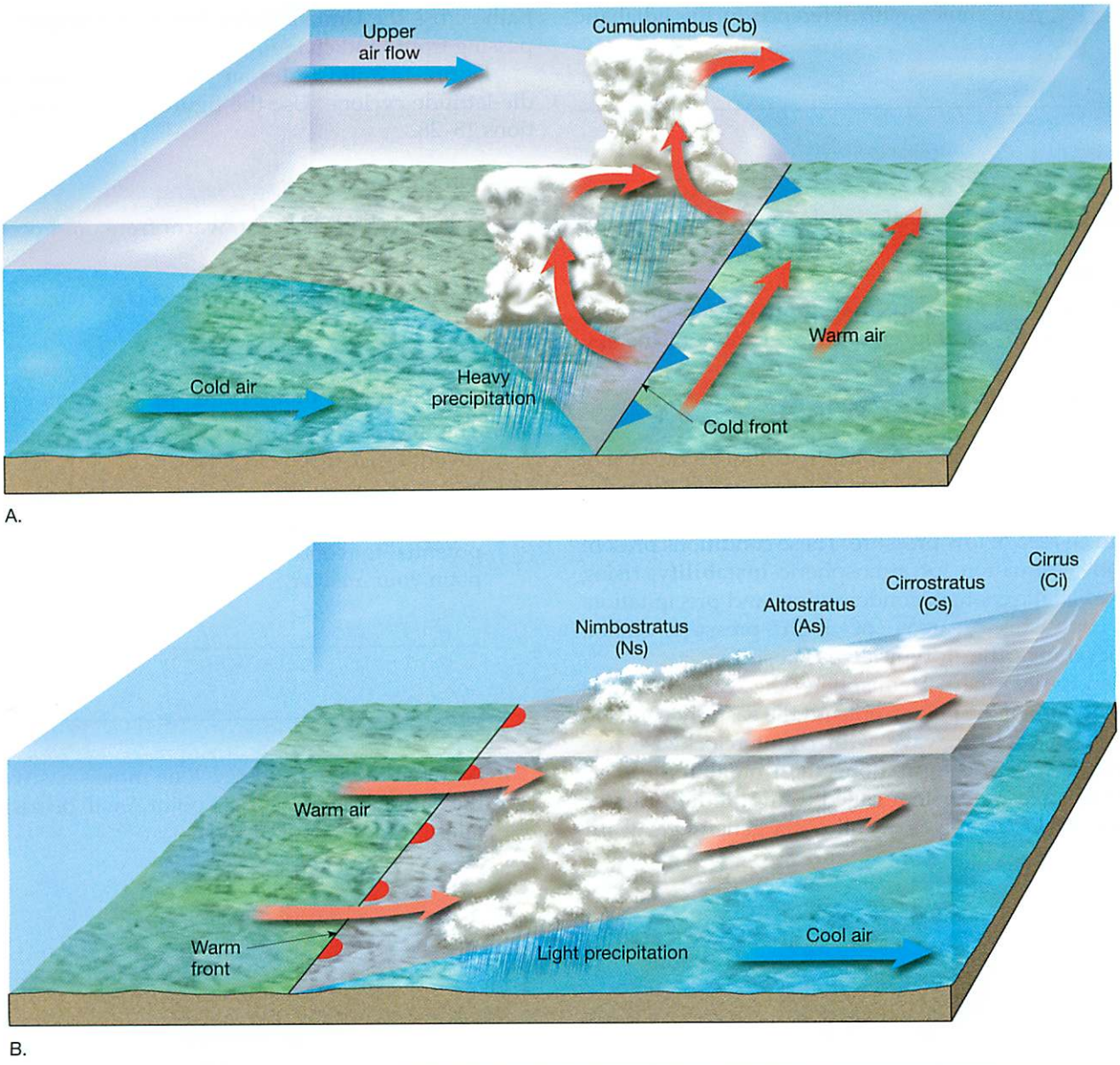


Figure 15.2 **A.** Typical cold front profile. **B.** Typical warm-front profile.

found north of a front, and a (cP, mT) mass to the south. Circle your answers.

Figure 15.2 illustrates profiles through typical cold and warm fronts. Observe the profiles closely and then answer questions 11–17.

11. Along the (cold, warm) front, the cold air is the aggressive or "pushing" air. Circle your answer.
12. Along the (cold, warm) front, the warm air rises at the steepest angle.
13. Along which front are extensive areas of stratus clouds and periods of prolonged precipitation most probable? Explain why you expect longer periods of precipitation to be associated with this type of front.

_____ front. Explanation:_____

_____

14. Assume that the fronts are moving from left to right in Figure 15.2. A drop in temperature is most likely to occur with the passing of a (cold, warm) front. Circle your answer.

The air following a cold front is frequently cold, dense, and subsiding.

15. (Clear, Cloudy) conditions are most likely to prevail after a cold front passes. Explain the reason

for your choice with reference to the adiabatic process.

16. Clouds of vertical development and perhaps thunderstorms are most likely to occur along a (cold, warm) front.
17. As a (cold, warm) front approaches, clouds become lower, thicker, and cover more of the sky.

Middle-Latitude Cyclone

Contrasting air masses frequently collide in the area of the *subpolar lows*. In this region, often called the **polar front**, warm, moist air comes in contact with cool, dry air in an area of low pressure. These conditions present an ideal situation for atmospheric **instability**, rising air, adiabatic cooling, condensation, and precipitation. In contrast, in areas of high pressure, called **anticyclones**, the air typically is subsiding.

In the Northern Hemisphere, the westerly winds to the south of the polar front and the easterly winds to the north cause a wave with counterclockwise (cyclonic) rotation to form along the frontal surface. As the low-pressure system called a **middle-latitude** (or **wave**) **cyclone** evolves, it follows a general eastward path across the United States, bringing a sequence of passing fronts and changing weather.

Figure 15.3 illustrates an idealized, mature, middle-latitude cyclone. Use the figure to complete questions 18–28.

18. On Figure 15.3:
    a. Label the cold front, warm front, and occluded front.
    b. Draw arrows showing the surface wind directions at points A, C, E, F, and G.
    c. Label the sectors most likely experiencing precipitation with the word "precipitation."
19. The surface winds in the cyclone are (converging, diverging). Circle your answer.
20. The air in the center of the cyclone will be (subsiding, rising). What effect will this have on the potential for condensation and precipitation? Explain your answer.

21. As the middle-latitude cyclone moves eastward, the barometric pressure at point A will be (rising, falling). Circle your answer.

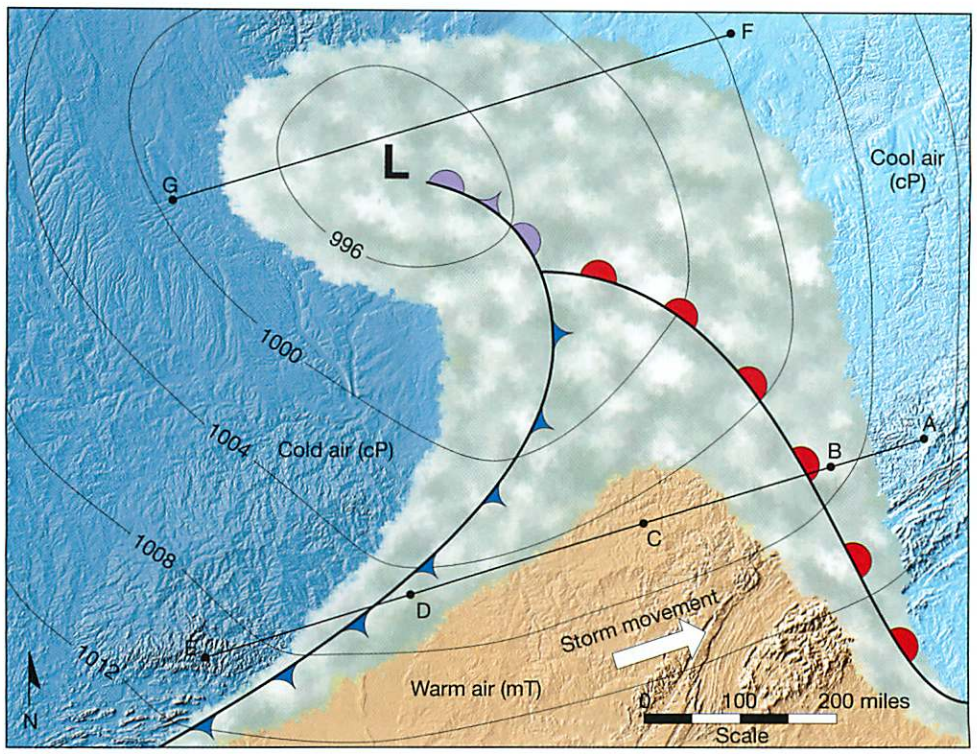


Figure 15.3 Mature, middle-latitude cyclone (idealized).

22. After the warm front passes, the wind at point B will be from the (south, north).

23. Describe the changes in wind direction and barometric pressure that will likely occur at point D after the cold front passes.

_____

_____

24. Considering the typical air mass types and their locations in a middle-latitude cyclone, the amount of water vapor in the air will most likely (increase, decrease) at A after the warm front passes.

25. The quantity of moisture in the air at point D will most likely (increase, decrease) after the cold front passes.

26. Use Figure 15.3 to describe the sequence of weather conditions—barometric changes, wind directions, humidity, precipitation, etc.—expected for a city as the cyclone moves and the city's relative position changes from location A to B, and then to C, D, and E.

_____

_____

_____

_____

27. Near the center of the low, a/an (warm, cold, occluded) front has formed where the cold front has overtaken the warm front. Circle your answer. Then answer questions 27a and 27b.

    a. What happens to the warm mT air in this type of front?

    _____

    b. With reference to the adiabatic process, why is there a good chance for precipitation with this type of front?

    _____

    _____

After the entire wave cyclone passes, pressure will rise.

28. Describe the general weather often associated with a high pressure cell, called an anticyclone.

_____

_____

As mentioned previously, middle-latitude cyclones form in the belt of subpolar lows. After you have reviewed the subpolar lows in Exercise 14, answer the following question by circling the correct responses.

29. During the (summer, winter) season the belt of subpolar lows and the polar front are farthest south in North America, and the central United States will experience a (greater, lesser) frequency of passing middle-latitude cyclones.

Weather Station Analysis and Forecasting

In order to understand, analyze, and predict the weather, observers at hundreds of weather stations throughout the United States collect and record weather data several times a day. This information is forwarded to offices of the National Weather Service where it and satellite data are computer processed and mapped. Weather maps, containing data from throughout the country, are then distributed to any interested individual or agency.

Weather Station Data

To manage the great quantity of information necessary for accurate maps, meteorologists have developed a system for coding weather data. Figure 15.4 illustrates the system and many of the symbols that are used to record data for a weather station. (*Note:* When plotting barometric pressure in millibars for a weather station, to conserve space, the initial number 9 or 10 is omitted and the last digit is tenths of a millibar. For example, on a map a barometric pressure of 216 for a station would be read as 1021.6 mb.)

Figure 15.5 is a coded weather station, shown as it would appear on a simplified surface weather map.

30. Using the specimen station model and explanations shown in Figure 15.4 as your guide, interpret the weather conditions reported at the station illustrated in Figure 15.5.

    Percent of sky cover: _____ %

    Wind direction: _____

    Wind speed: _____ mph

    Temperature: _____ °F

    Dew-point temperature: _____ °F

    Barometric pressure: _____ millibars

    Barometric change in past 3 hours: _____ mb

    Weather during the past 6 hours: _____

31. Encode and plot the weather conditions for the following weather station on the station symbol

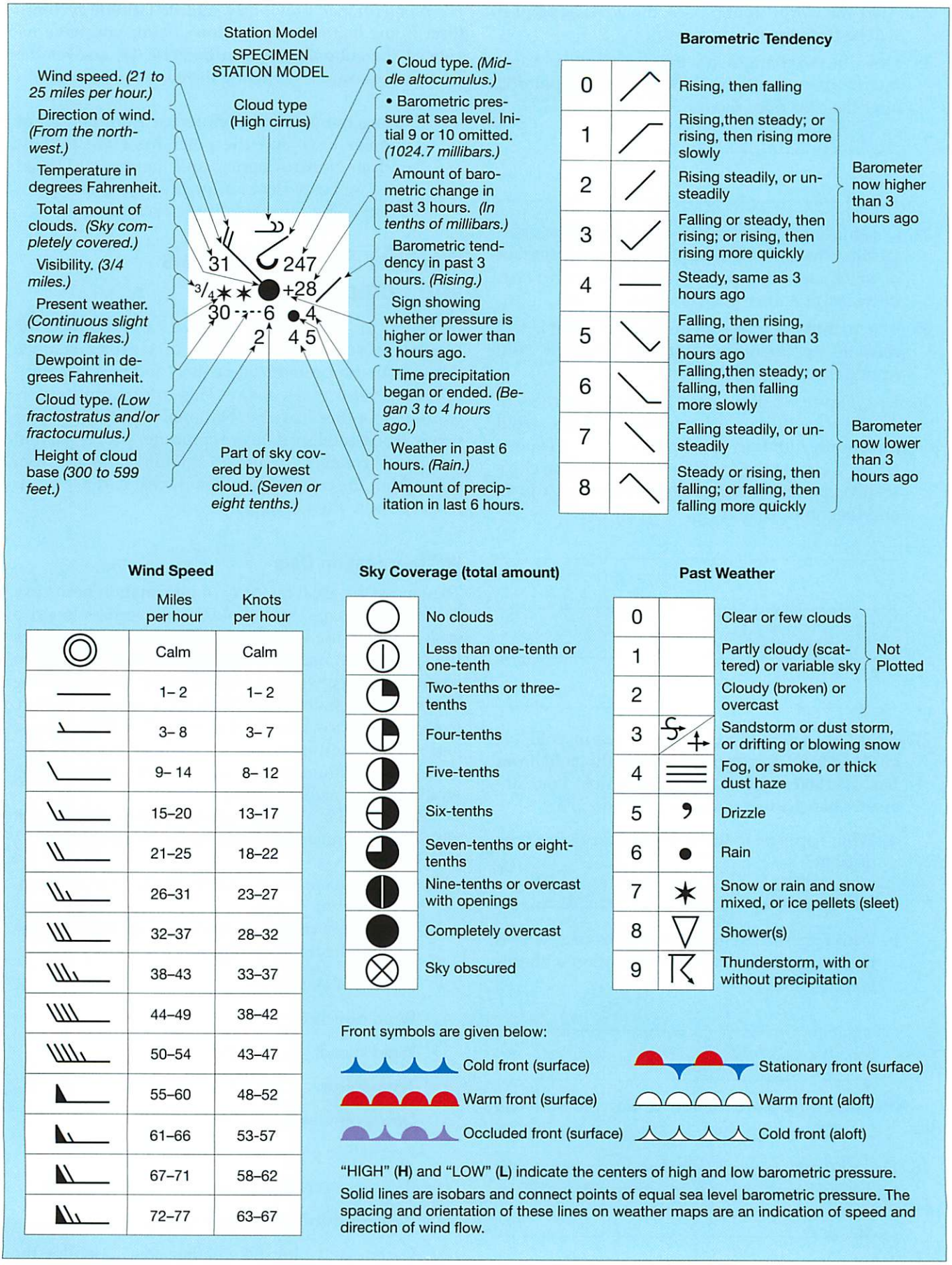


Figure 15.4 Specimen weather station model and standard symbols. (Source: Daily Weather Maps, U.S. Department of Commerce)

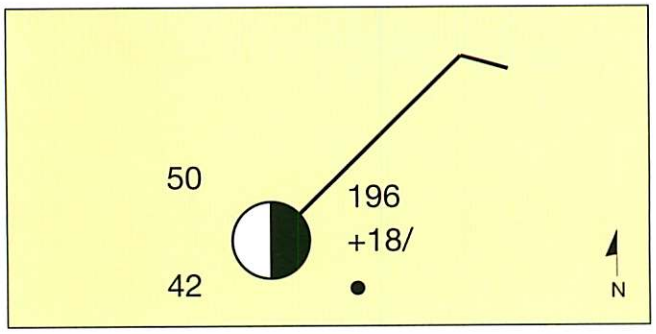


Figure 15.5 Coded weather station (abbreviated).

shown below. Use Figures 15.4 and 15.5 as your guides.

The sky is six-tenths covered by clouds. Air temperature is 82°F with a dew point of 50°F. Wind is from the south at 22 miles per hour. Barometric pressure is 1022.4 millibars and has fallen from 1023.0 millibars during the past three hours. There has been no precipitation during the past six hours.

Preparing a Weather Map and Forecast

Table 15.1 contains weather data for several cities in the central and eastern United States on a December day. Data for several of the cities have been plotted on the map, Figure 15.6. Use Table 15.1 and Figure 15.6 to complete questions 32 and 33.

32. Refer to stations where the data have already been plotted and the station model in Figure 15.4. Plot the data for the remaining stations on the map. Then complete the following steps.

Step 1: Beginning with 988 millibars, draw isobars as accurately as possible at four millibar intervals (992 mb, 996 mb, 1,000 mb, etc.). (*Note:* You will have to estimate pressures between cities to determine the location of isobars. Also, it may be a good idea to first sketch the isobars lightly in pencil.)

Step 2: By observing the data plotted on the map, determine the locations of the cold and warm fronts. Using the proper symbols, label the cold and warm fronts as accurately as possible on the map.

Step 3: Label the air mass types that are most likely to be located to the northwest and to the southeast of the cold front.

Step 4: Indicate areas of precipitation by lightly shading the map with a pencil.

33. Assume that the middle-latitude cyclone illustrated on the map was centered in Oklahoma the previous day and is moving northeastward. Indicate your forecast (temperature, wind direction, probability of precipitation, cloud cover, and barometric pressure) for the next 12–24 hours at the following locations.

Chattanooga, TN: _____

_____

_____

Little Rock, AR: _____

_____

_____

Washington, D.C.: _____

_____

_____

Raleigh, NC: _____

_____

_____

Weather Maps on the Internet

Apply the concepts from this exercise to an analysis of the current weather patterns in North America by completing the corresponding online activity on the *Applications & Investigations in Earth Science* website at http://prenhall.com/earthsciencelab

Table 15.1 December Surface Weather Data for Selected Cities in the Central and Eastern United States

STATION	% CLOUD COVER	WIND DIRECTION	WIND SPEED (MPH)	TEMP.	DEW PT. TEMP.	PRESSURE (MB)	PRESSURE 3 HOUR + OR −	PRECIP.
Atlanta, GA	20	SE	18	61	56	1000.7	−2.0	
Birmingham, AL	80	SW	15	70	64	998.1	−1.4	
Charleston, SC	10	SE	12	63	58	1008.0	−2.0	
Charlotte, NC	70	SW	14	54	49	1003.4	−4.4	Drizzle
Chattanooga, TN	60	SW	12	66	60	995.3	−2.5	Drizzle
Chicago, IL	100	NE	13	34	21	1003.2	−2.2	
Columbus, OH	100	E	10	34	28	996.8	−5.8	Snow
Evansville, IN	100	NW	7	45	43	987.2	−2.7	Snow
Fort Worth, TX	0	NW	5	46	43	1002.6	+1.4	
Indianapolis, IN	100	NE	30	34	32	993.2	−5.6	Snow
Jackson, MS	40	SW	10	72	67	1001.3	+1.2	Thunderstorm
Kansas City, MO	30	N	18	30	27	1005.5	+1.7	
Little Rock, AR	0	NW	10	46	43	1001.5	+2.7	
Louisville, KY	100	E	12	34	34	993.0	−4.2	Snow
Memphis, TN	80	NW	12	50	45	996.7	+5.8	
Mobile, AL	60	SW	10	72	68	1004.3	−0.3	
Nashville, TN	100	SW	18	56	55	991.5	−0.1	Rain
New Orleans, LA	20	SW	11	75	70	1003.9	−0.1	
New York, NY	100	NE	23	36	18	1016.9	−2.1	
North Platte, NB	30	N	9	9	1	1017.4	+3.2	
Oklahoma City, OK	10	NW	13	41	37	1005.9	+1.5	
Richmond, VA	100	E	10	45	45	1010.9	−2.4	Rain
Roanoke, VA	100	SE	10	39	39	1007.5	−3.6	Snow
Savannah, GA	30	SE	7	61	55	1007.6	−2.0	
Shreveport, LA	0	NW	8	46	43	1002.6	+1.4	
St. Louis, MO	100	NW	10	32	32	999.7	+1.7	Showers
Tampa, FL	50	SE	8	70	66	1011.0	−0.6	

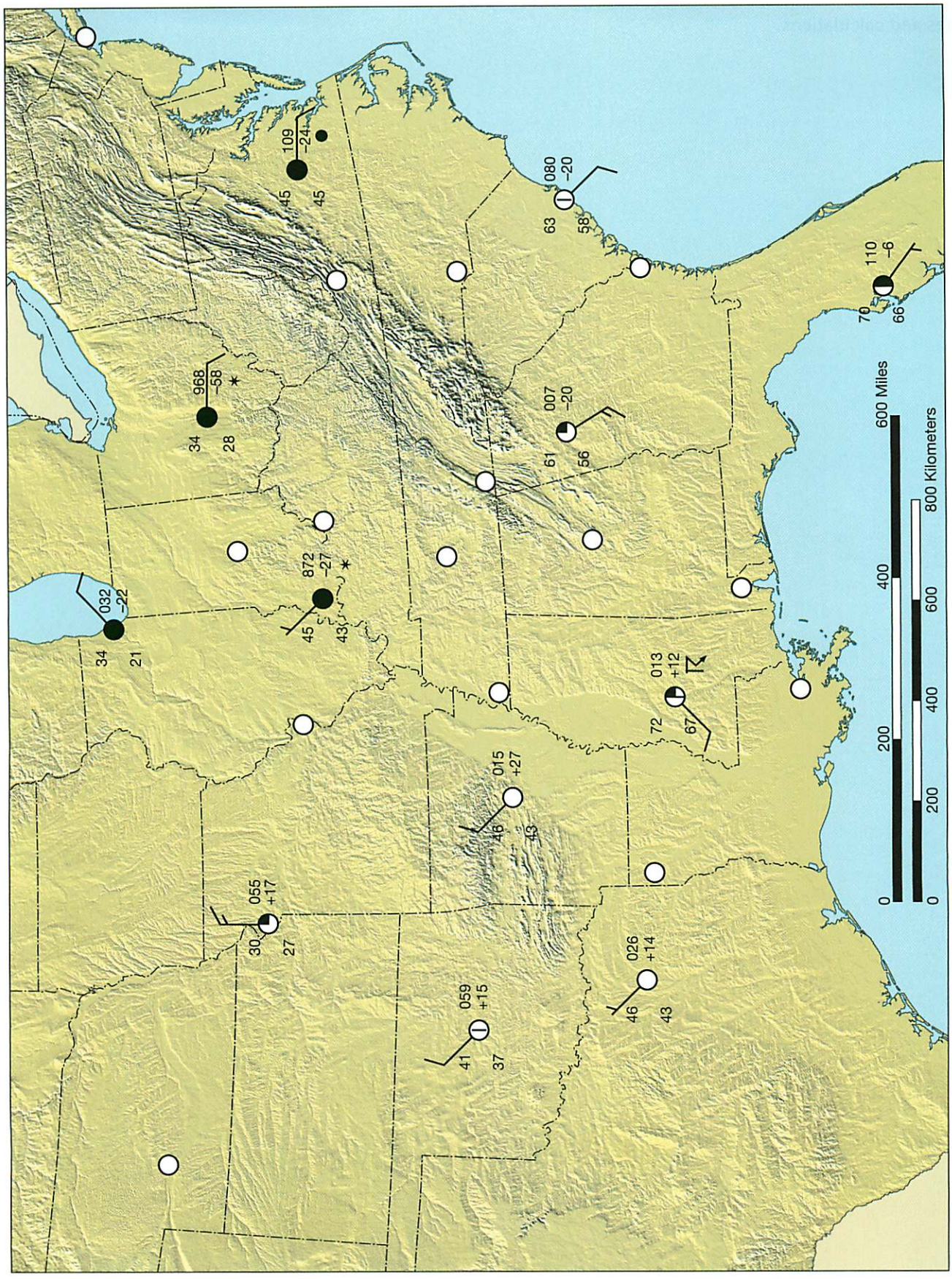


Figure 15.6 Map of December weather data for selected cities in the central and eastern United States.

Notes and calculations.

Air Masses, the Middle-Latitude Cyclone, and Weather Maps

Date Due: _____

Name: _____

Date: _____

Class: _____

After you have finished Exercise 15, complete the following questions. You may have to refer to the exercise for assistance or to locate specific answers. Be prepared to submit this summary/report to your instructor at the designated time.

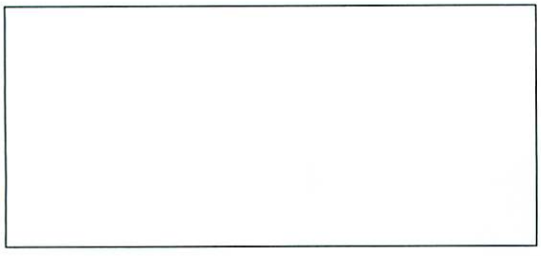
1. List the source region(s) and winter temperature/moisture characteristics of each of the following North American air masses.

   cP: _____

   mT: _____

   mP: _____

2. In the following space, diagram a profile (side view) of an idealized cold front. Label the cold air, warm air, and sketch the probable cloud type at the appropriate location. Draw an arrow on the diagram showing the direction of movement of the front.



Cold Front Profile

3. Indicate the type of front (cold, warm, or occluded) best described by each of the following statements.
   a. Steep wall of cold air: _____
   b. Warm air replaces cool air: _____
   c. Thunderstorms: _____
   d. Drop in temperature: _____
   e. After passing, wind comes from the south: _____
   f. Narrow belt of precipitation: _____
   g. Cold front overtakes warm front: _____
   h. Gradual rise of warm air over cool air: _____

4. Describe the sequence of weather events that a city would experience as an idealized, mature, middle-latitude cyclone that has not developed an occluded front passes over it. Assume that the center of the wave cyclone passes, west to east, 150 miles to the north of the city. Using a diagram may be helpful.

5. Refer to Figure 15.7. Draw a sketch of the December weather map that you prepared at the end of the exercise, question 32. Show isobars and wind direction arrows. Indicate and label the fronts.

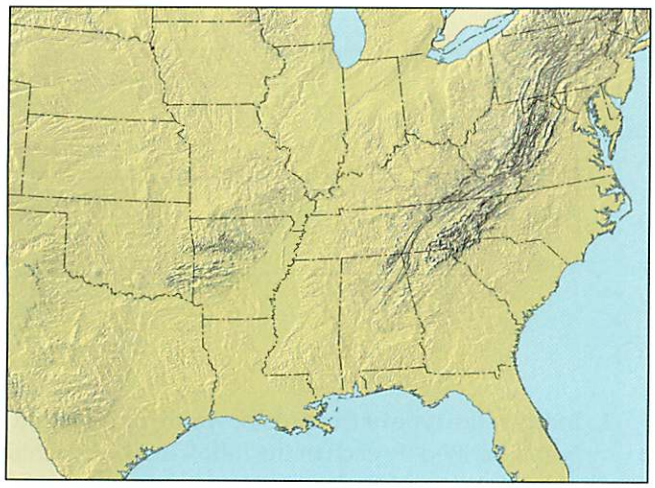


Figure 15.7 Sketch of the December weather map.

6. Based on the December weather map that you constructed at the end of the exercise, from question 33, what was your forecast for Little Rock, AR?

_____

_____

7. Write a brief analysis of the weather map in Figure 15.8.

_____

_____

_____

_____

Figure 15.8 Surface weather map for a March day with a satellite image showing the cloud patterns on that day. (Courtesy of NOAA/Seattle)