Weather Map Analysis

Introduction

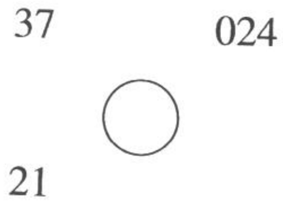
With a few exceptions (e.g., clouds), most atmospheric processes are invisible. How then do we "see" the weather in order to forecast its changes? The purpose of this lab is to learn how to construct and interpret weather maps. We will focus on the mid-latitudes, where identification of air masses, fronts, and mid-latitude cyclones can help meteorologists forecast changing weather patterns.

Surface Weather Maps

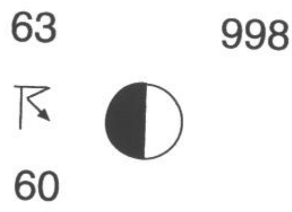
Every six hours atmospheric data are collected at approximately 10,000 surface weather stations around the world. These data are transmitted to one of three World Meteorological Centers, in Melbourne, Australia; Moscow, Russia; or Washington, DC. Weather data are disseminated to national meteorological centers where *synoptic-scale* maps are generated. *Synoptic* means coincident in time, and a synoptic map is a map of weather conditions for a specific time. By convention, the time printed on many weather maps is Greenwich Mean Time (GMT, also called Coordinated Universal Time), the time at the prime meridian. Meteorologists often call this *Zulu* or z time. Thus, a map labeled 1200z shows conditions at noon in London, which is 7:00 AM EST in New York.

In the United States an automated weather network collects hourly surface data. Since each station collects data for as many as 18 weather characteristics, a compact method of symbolization must be used to include all this information on a single weather map. The station model, developed by the World Meteorological Organization, is the standard format for symbolizing weather characteristics. Figure 10-1 illustrates the arrangement of data in the WMO model; Appendix C provides a complete list of symbols used in this lab.

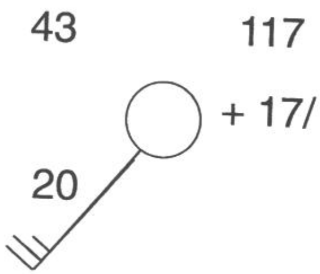
1. *Decode information from each of the following station models:*



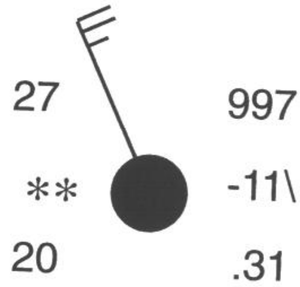
Barometric pressure __________
Temperature __________
Dew-point temperature __________



Barometric pressure __________
Temperature __________
Dew-point temperature __________
Sky coverage __________
Current weather __________



Barometric pressure __________
Temperature __________
Dew-point temperature __________
Sky coverage __________
Wind speed __________
Wind direction __________
Pressure change during last 3 hours __________
Pressure tendency __________



Barometric pressure __________
Temperature __________
Dew-point temperature __________
Sky coverage __________
Current weather __________
Wind speed __________
Wind direction __________
Pressure change during last 3 hours __________
Pressure tendency __________

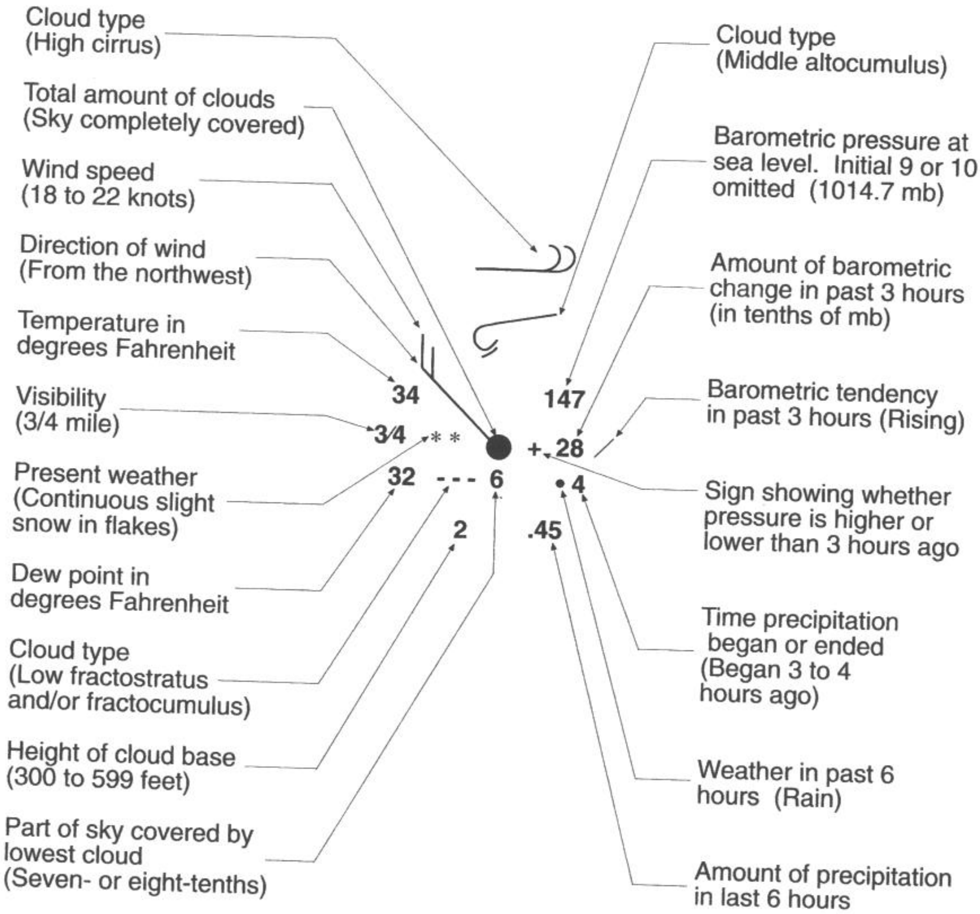


Figure 10-1. WMO station model.

Mapping Spatial Patterns of Meteorological Variables

Weather maps are most useful when their information is analyzed in some fashion. Highlighting the spatial patterns of specific variables—such as temperature, dew point, pressure, and winds—is a first step in weather analysis. We often use *isolines* (lines of constant value) for this purpose. Each type of isoline is named to reflect the variable being mapped: *isotherms* are lines of constant temperature; *isobars* are lines of constant barometric pressure; and *isodrosotherms* are lines of constant dew point.

Today meteorologists often use computer programs to draw isolines. Here we will construct some manually to better understand them. As a starting point, consider the isotherm drawn for 80° F in Figure 10-2.

2. *Complete the analysis in Figure 10-2 by constructing isotherms at 70° F and 75° F.*

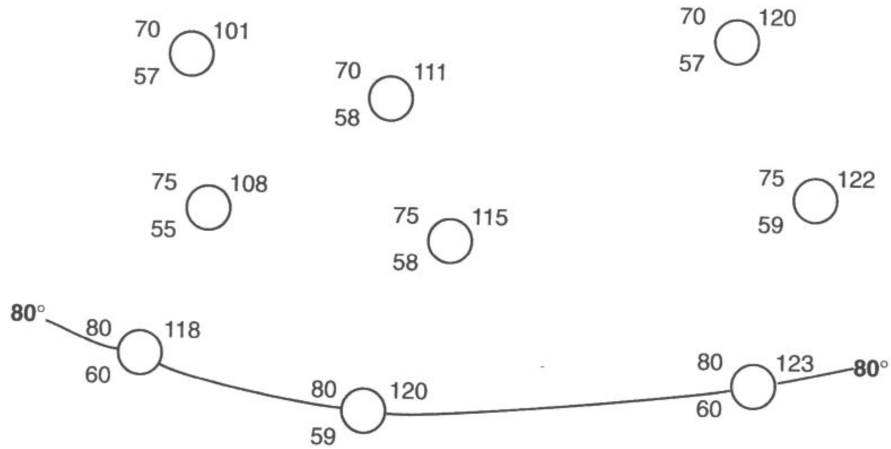
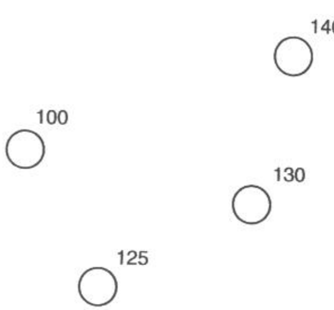
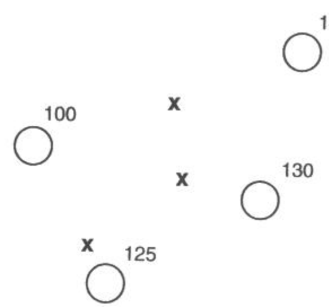


Figure 10-2

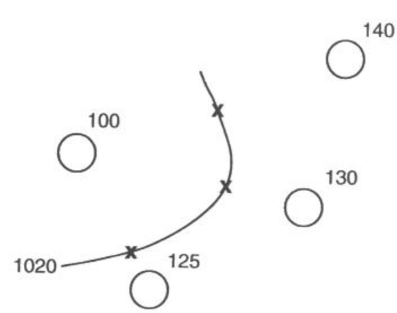
Drawing isolines in the previous example was straightforward, since the temperature at each station was exactly 80°, 75°, or 70° F. Because such patterns rarely occur in nature it is often necessary to *interpolate* between points. For example, we may want to draw a 1012-mb isobar (line of constant barometric pressure) using the following station data:



In a simple interpolation scheme we might decide that 1012 mb is exactly between 1010.0 and 1014.0 mb and would indicate this position with a small "x." A value of 1012 mb would also exist at two-thirds the distance between 1010.0 and 1013.0 mb, and at four-fifths the distance between 1010.0 and 1012.5 mb.



The "x's" that we draw represent new data points with a value of 1012 mb, through which we construct an isoline labeled "1012."



There are some conventions meteorologists use in constructing isolines. Study the isodrosotherms below.

- Because isolines are lines of constant value, they do not cross.
- Isolines should be relatively smooth. Sharp breaks are rare.
- They should be drawn at fixed intervals. Meteorologists traditionally use 4-mb intervals, centered on 1000 mb, for barometric pressure (e.g., 996 mb, 1000 mb, 1004 mb, etc.). For temperature and dew point, intervals of 5° F are commonly used.
- Isolines should be labeled near the edge of the map. When they form a closed figure, the label is inserted in a small break in the line.

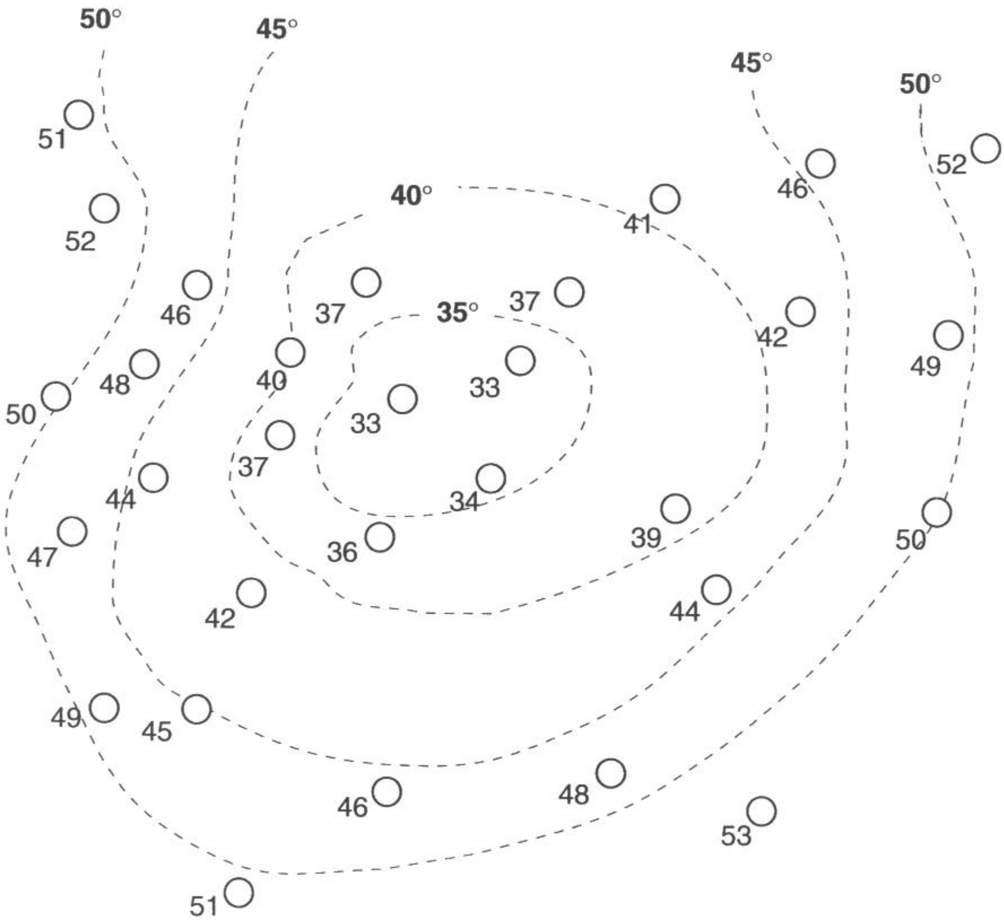


Figure 10-3. Isodrosotherms.

3. *Construct isotherms at 5° F intervals (e.g., 35° F, 40° F, 45° F) on the simplified weather map shown below. Use solid lines.*

4. *Using dotted lines, now construct isodrosotherms at 5° F intervals.*

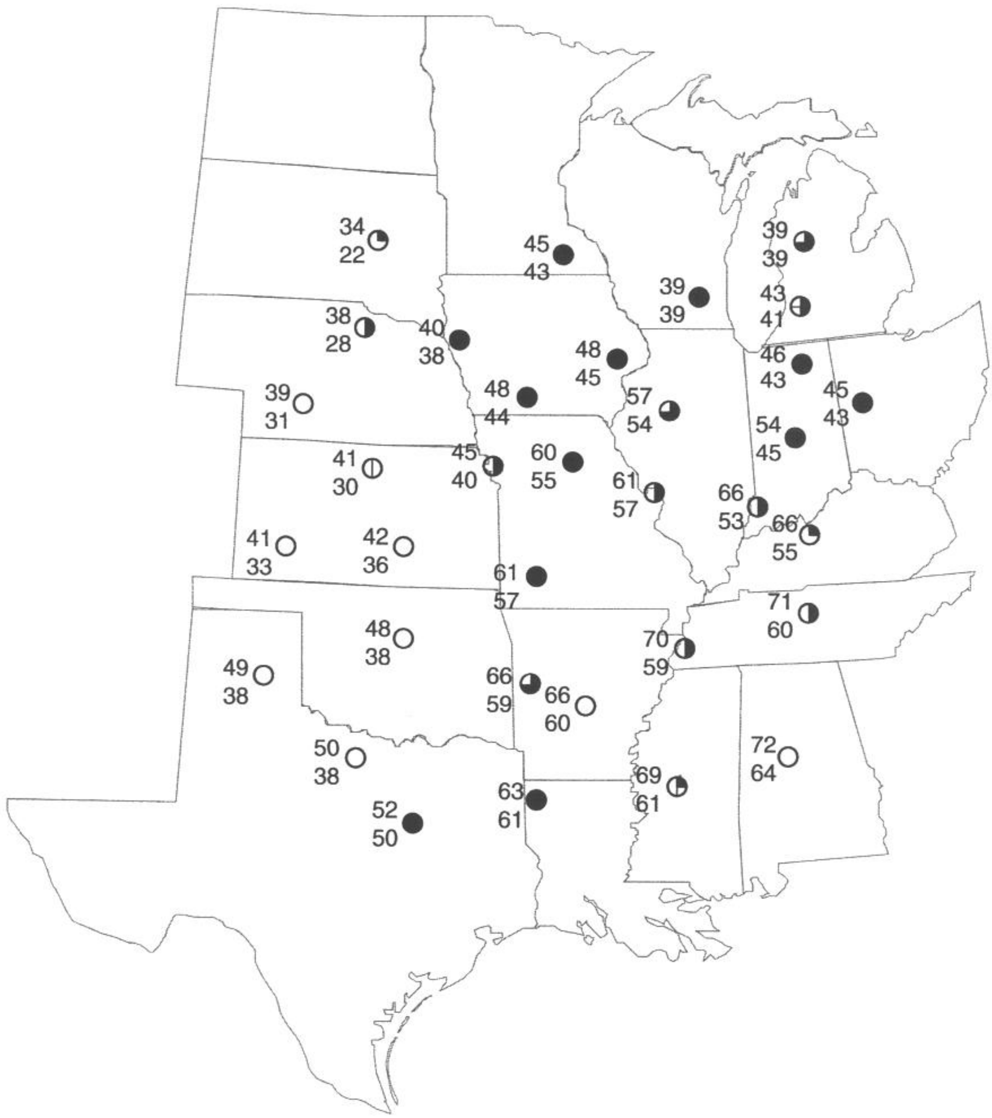


Figure 10-4

We can show wind flow patterns using *streamlines*, drawn parallel to the wind barbs used in the station model. Streamlines begin at an upwind location and are drawn as long lines ending with an arrow where the wind shifts abruptly (Figure 10-5).

5. *Complete the analysis below by drawing enough streamlines to illustrate the general wind flow.*

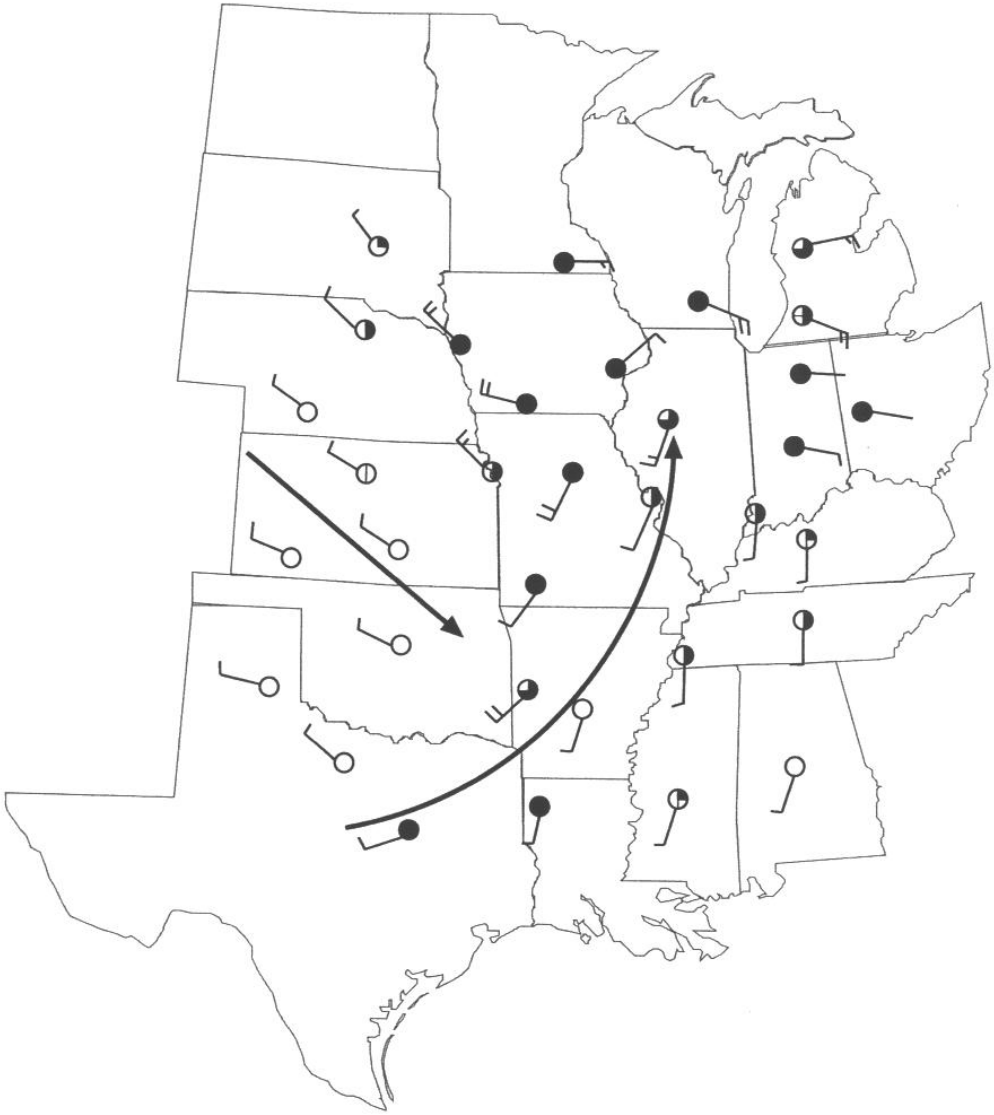


Figure 10-5

Air Masses and Fronts

An *air mass* is a large body of air with relatively uniform temperature and humidity characteristics. Air masses form over large land or water surfaces and take on the temperature and moisture characteristics of these surfaces, where they remain stationary for days or even weeks. Their moisture characteristics are classified as maritime or continental, and their temperature characteristics as equatorial, tropical, polar, or arctic. Maritime arctic and continental equatorial air masses are rarely found and therefore are not listed. Therefore the following types of air masses result:

— maritime equatorial (mE)
— maritime tropical (mT)
— maritime polar (mP)
— continental tropical (cT)
— continental polar (cP)
— continental arctic (cA)

Air masses often migrate from their source regions and affect mid-latitude weather. Examine the diagram below showing air masses affecting North America.

6. *Based on the source regions shown by the ovals, indicate each type of air mass influencing North America (mT, mP, cT, cP, and cA).*

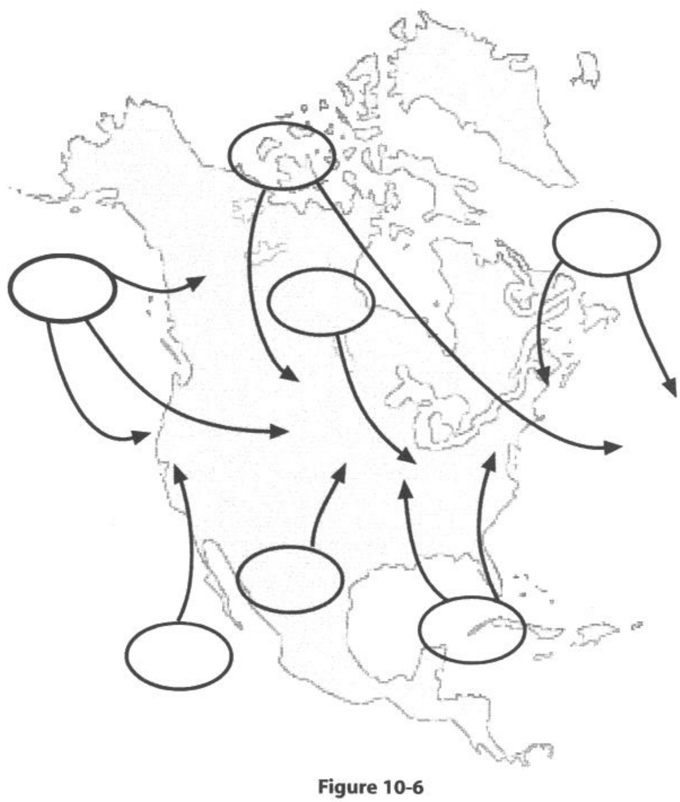


Figure 10-6

Fronts

A *front* marks the boundary between two unlike air masses. Fronts can be identified by any of the following characteristics: a sharp temperature gradient, a sharp moisture gradient, or a sharp change in wind direction. We categorize fronts according to their net movement. When air flows parallel to the boundary and neither air mass advances, the boundary is referred to as a *stationary front*.

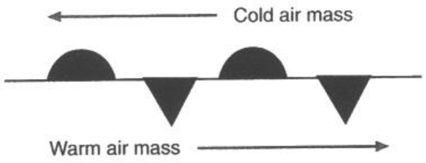


Figure 10-7. Stationary front—surface depiction.

When a warm air mass advances on a cooler air mass, the boundary between them is called a *warm front*. Because warm air is less dense, it will cool adiabatically and usually forms clouds ahead of the surface front.

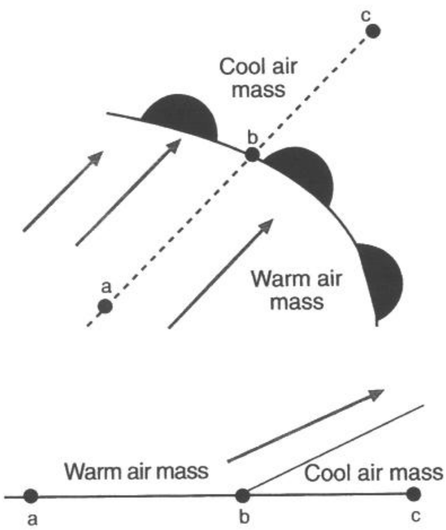


Figure 10-8. Warm front—surface depiction and cross section.

When a cold air mass advances on a warmer air mass, the boundary is called a *cold front*. In this case, cold air wedges itself beneath warm air because of its greater density. Surface friction creates a steep slope as the cold air advances. Since cold fronts generally move faster than warm fronts, warm air masses are lifted more rapidly along cold fronts and clouds grow to greater vertical extent than along most warm fronts.

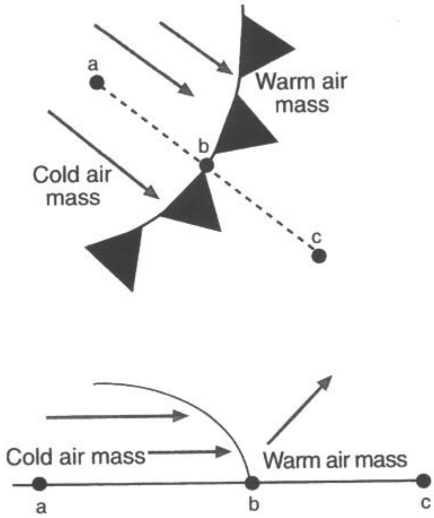


Figure 10-9. Cold front—surface depiction and cross section.

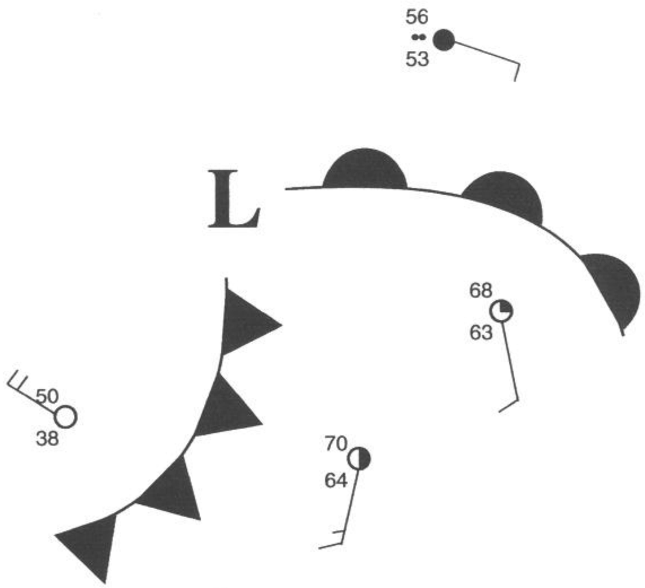


Figure 10-10

Usually, waves along a frontal boundary form a low pressure center. As air circulates around the low, warm and cold air masses advance, resulting in storm systems such as that illustrated in Figure 10-10. These fronts divide the contrasting air masses. Notice also how wind direction shifts across the frontal boundary.

As the wave amplifies, a cold front will often overtake a warm front. We define this new boundary as an *occluded front*.

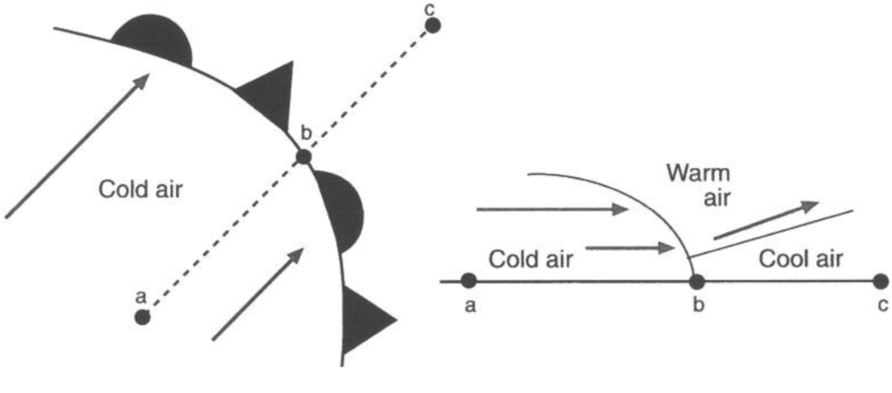


Figure 10-11. Occluded front—surface depiction and cross section.

7. *Using the map below:*
   a. Draw isobars at 4-mb intervals (e.g., 1004 mb, 1008 mb, 1012 mb).
   b. Label the low pressure center with an "L."
   c. Draw the warm and cold fronts.
   d. Label a maritime tropical (mT) and continental polar air mass (cP).
   e. Outline the area where cloud cover exceeds 75%.
   f. Shade the areas receiving precipitation.

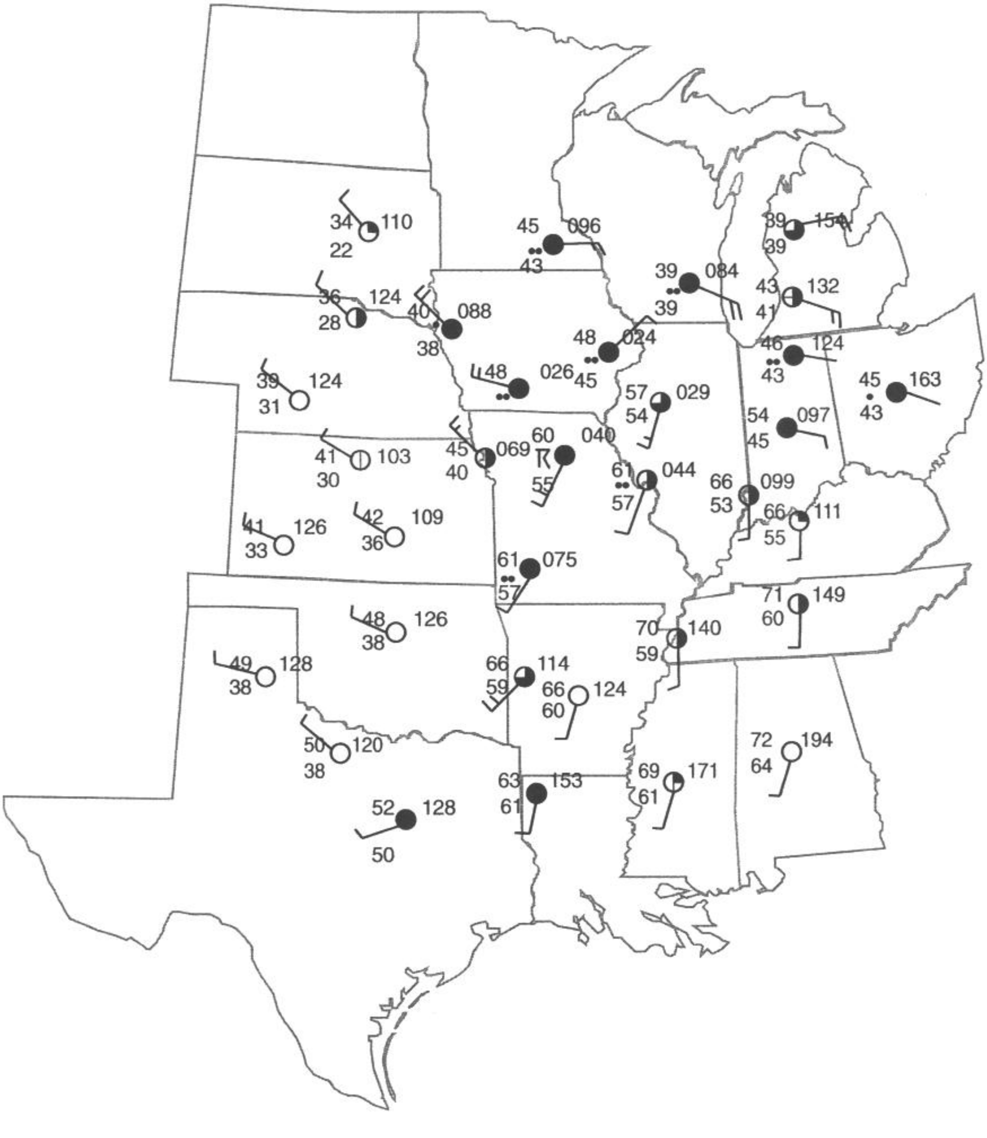


Figure 10-12