II Fronts and the Formation of Lows

Topic 6 What Is a Front?

OBJECTIVES

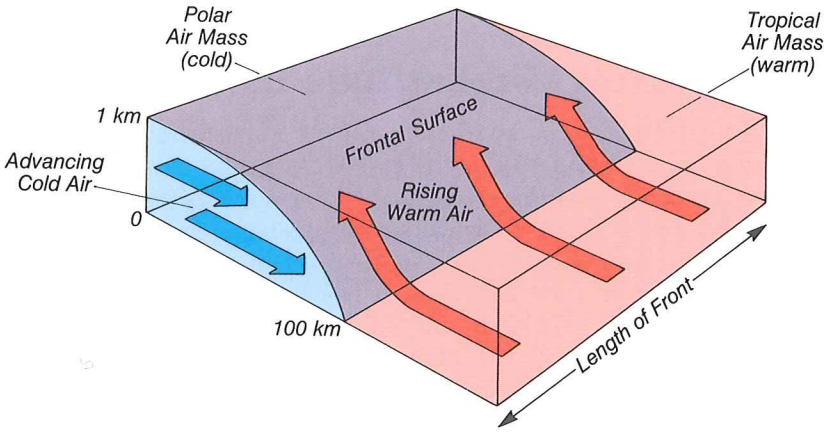
- **A** Define *front* and describe the shape of a front.
- **B** Discuss the four kinds of fronts and explain their origin and structure.
- **C** Trace the formation of a typical mid-latitude cyclone.

At any given moment several air masses may cover the United States. The boundary between any two air masses is called a **front**. Because the two air masses have different temperatures and humidities, the front is where the temperatures and humidities change. An approaching front means a change in the weather. The greater the differences between the air masses, the greater the change in the weather. On weather maps, fronts are drawn in regions of great change in temperature and wind direction and where isobars tend to bend.

Suppose the front is the boundary between a southward-moving, polar air mass and a slower-moving, tropical air mass. The polar air is colder and more dense than the tropical air. When they meet, the polar air slides under the warmer, lighter tropical air and forces the tropical air to rise. The shape that results is a wedge (Figure 29.5). The temperature and humidity changes across the front are not always sudden. The front can be a mixing zone ranging in thickness from as little as 200 meters to as much as 200 kilometers across.

Observations show that fronts have gentle slopes. The slope may range from 1 in 100 to 1 in 400. A slope of 1 in 100 means that the frontal surface rises 1 kilometer for every 100 kilometers of distance on the ground. Frontal surfaces may reach up to higher than 5 kilometers. As a result, fronts affect the weather in an area several hundred kilometers wide. Fronts may be several thousand kilometers in length.

Fronts almost always bring precipitation. At the frontal surface, warm air is rising high into the troposphere. Rising air means cooling, condensation, and then clouds and precipitation.



29.5 A front is a boundary between two air masses. At a front, the lighter (less dense) warm air is forced to rise over the heavier cold air. Note that the horizontal and vertical scales are very different. The slope of this front is 1 in 100.

29.6 A cold front passes through Colorado. Dust shows the cold air and the shape of the front. A very steep drop in temperature occurred after this front passed through. The frontal surface in the photo has a very steep slope, about 1 in 2.

Topic 7 Kinds of Fronts

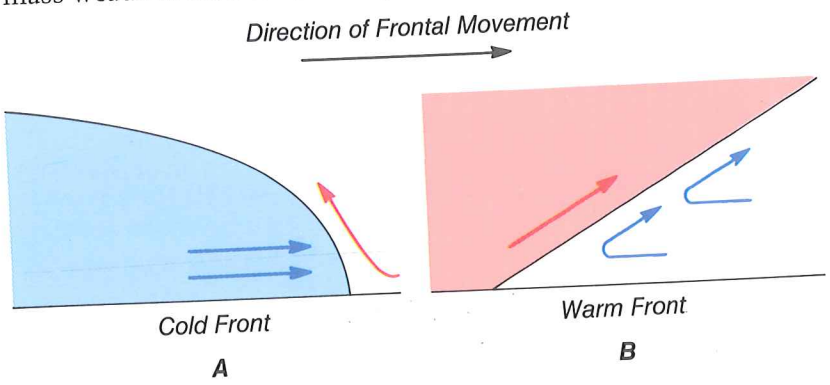
There are four kinds of fronts. In a **cold front**, the cold air is advancing and displacing warmer air. The front in Figure 29.6 is a cold front. In a **warm front**, warm air is pushing ahead and displacing colder air. If neither air mass is being displaced, the front does not move. It is called a **stationary front**.

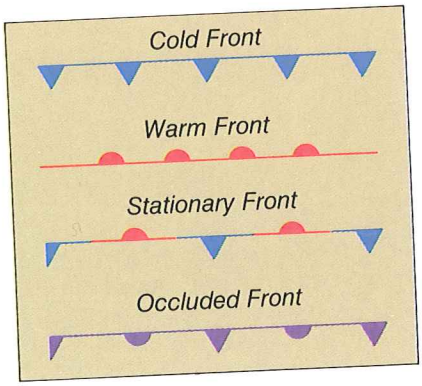
Cold fronts have steeper slopes than warm fronts, particularly in the lowest few kilometers. The slope is steepest near the ground. One of the most important reasons for this difference in slope is that the friction at the ground slows down the cold air, as shown in Figure 29.7. Warm fronts have more gentle slopes. Again, friction is important in keeping the slope shallow near the ground. The surface air, slowed down by friction, is left behind by the retreating cold air at higher levels. A warm frontal surface rises about 1 kilometer for every 400 kilometers.

Figure 29.8 shows the symbols used for fronts on weather maps. When a cold front overtakes a warm front, the result is called an **occluded front**. The solid triangles of the cold front and the solid half-circles of the warm front always point in the direction of the front's movement.

Fronts control the weather only at times when one air mass is displacing another. For a much longer time, the weather is air-mass weather. However, most precipitation comes with fronts.

29.7 Slopes of fronts near the ground. The cold front (a) has a much steeper frontal surface than the warm front (b). The blue and red arrows indicate the direction of movement of cold and warm air in each front.



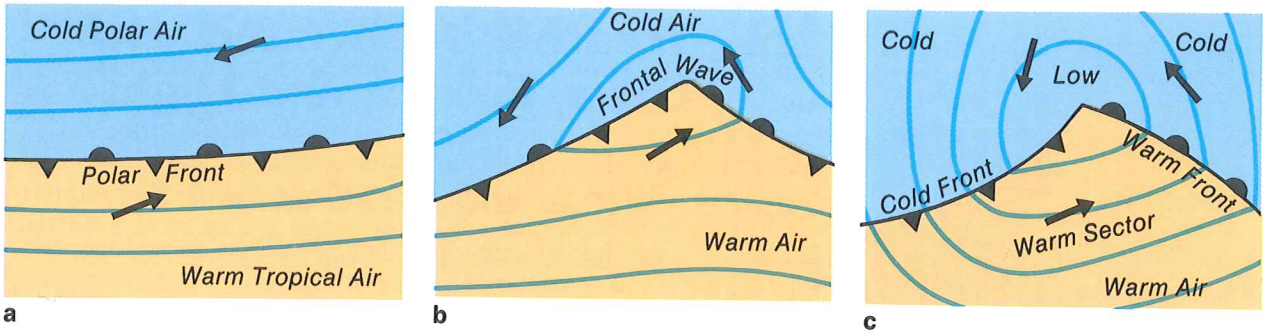


29.8 These are the international standard symbols for fronts.

Topic 8 How Mid-Latitude Lows Form

The polar front, described in Chapter 28, is the boundary between cool air masses in the polar easterlies and warm air masses in the prevailing westerlies. Polar air masses lie to the north of the polar front. Tropical air masses lie to the south of it.

According to a theory first put forward in the 1920's, a low starts as a kink or wave in the polar front. Such a wave could be caused by a wave or kink in the jet stream. Also, a kink would develop in the polar front if a cold air mass began moving southward, pushing part of the polar front ahead of it as shown in Figure 29.9(b).



29.9 These four diagrams of the atmosphere at Earth's surface trace the origin and growth of a Northern Hemisphere low. The blue lines are isobars. The arrows are pointed the way the wind is blowing.

The wave moves from west to east, like a wave passing through a stage curtain shaken at one end. The wave ripples the polar front. The front bulges southward on the west side of the wave, where polar air pushes tropical air southward. This southward-moving portion of the polar front is a southward-moving cold front. On the east side of the wave, the polar front bulges northward as a warm front. Here, tropical air pushes the polar air northward.

Between the cold and warm fronts is a large amount of warm tropical air. The warm air bulges into and over the heavier polar air to form a region of low pressure. The lowest air pressure is at the crest of the wave, where the warm and cold fronts meet. A low, or **cyclone**, has formed. The isobars around a low are roughly oval or circular, with a slight bend at the fronts. Winds whirl about the center of the low in a counterclockwise direction in the Northern Hemisphere.

The whole system moves eastward, but the cold front moves more rapidly than the warm front. The front that forms when the cold front overtakes the warm front, shown in Figure 29.9(d), is called an occluded front. The occluded front lengthens until the low weakens and the two cold air masses mix across the occluded front.

In summary, a low forms from a wave in a polar front. However, lows can also form along other cold or stationary fronts. It takes only 12 to 24 hours to form a fully developed mid-latitude low. Once the occluded front forms, the low can last an additional three days or more.

TOPIC QUESTIONS

Each topic question refers to the topic of the same number.

6. **(a)** What is a front? **(b)** Describe the relative positions of the air masses at a front and give the slope of a typical front. **(c)** Why do fronts bring precipitation?

7. **(a)** Describe the four types of fronts. **(b)** Compare the slopes of warm and cold fronts and explain why their slopes are different near the ground.

8. **(a)** Describe how a mid-latitude low forms on the polar front. **(b)** How is the polar front related to warm and cold fronts?