Therefore, as the warm front of this late-spring cyclonic storm approaches Pittsburgh, the pressure will decrease. After the warm front passes through Pittsburgh where the temperature may have been 8°C (46°F) or more, the pressure will stop falling, and the temperature may rise up to 18°C–20°C (64°F–69°F) as mT air invades the area. At this point, Indianapolis has already experienced the passage of the warm front. After the cold front passes, the pressure will rise rapidly and the temperature will drop. In this late-spring storm, the cP air temperature behind the cold front might be 2°C–5°C (35°F–40°F). Detroit, which is to the north of the center of the cyclone, will miss the warm air sector entirely and therefore will experience a slight increase in pressure and a temperature change from cool to cold as the cyclone moves to the east.

Changes in wind direction are one signal of the approach and passing of a cyclonic storm. Because a cyclone is a center of low pressure, winds flow counterclockwise toward its center. Also, winds are caused by differences in pressure. Therefore, the winds associated with a cyclonic storm are stronger in winter when the pressure (and temperature) differences between air masses are greatest.

In our example, Pittsburgh is located to the south and east of the center of low pressure and ahead of the warm front, and it is experiencing winds from the southeast. As the entire cyclonic system moves east, the winds in Pittsburgh will shift to the south-southwest after the warm front passes. Indianapolis is currently in this position. After the cold front passes, the winds in Pittsburgh will be out of the north-northwest. St. Louis has already experienced the passage of the cold front and currently has winds from the northwest. The changing direction of wind, clockwise around the compass from east to southeast to south to southwest to west and northwest, is called a veering wind shift and indicates that your position is south of the center of a low. On the other hand, Detroit, which is also experiencing winds from the southeast, will undergo a completely different sequence of directional wind changes as the cyclonic storm moves eastward. Detroit’s winds will shift to the northeast as the center of the storm passes to the south. Chicago has just undergone this shift. Finally, after the storm has passed, the winds will blow from the northwest. Des Moines, to the west of the storm, currently has northwest winds. Such a change of wind direction, from east to northeast to north to northwest, is called a backing wind shift, as the wind “backs” counterclockwise around the compass. A backing wind shift indicates that you are north of the cyclone’s center.

The type and intensity of precipitation and cloud cover also vary as a cyclonic disturbance moves through a location. In Pittsburgh, the first sign of the approaching warm front will be high cirrus clouds. As the warm front continues to approach, the clouds will thicken and lower. When the warm front is within 150–300 kilometers (90–180 mi) of Pittsburgh, light rain and drizzle may begin, and stratus clouds will blanket the sky.

After the warm front has passed, precipitation will stop and the skies will clear. However, if the warm, moist mT air is unstable, convective showers may result, especially during the spring and summer months with their high afternoon sun angles.

As the cold front passes, warm air in its path will be forced to move aloft rapidly. This may mean that there will be a cold, hard rain, but the band of precipitation normally will not be very wide because of the steep angle of the surface of discontinuity along a cold front. In our example, the cold front and the band of precipitation have just passed St. Louis.

Thus, Pittsburgh can expect three zones of precipitation as the cyclonic system passes over its location: (1) a broad area of cold showers and drizzle in advance of the warm front; (2) a zone within the moist, subtropical air from the south where scattered convectional showers can occur; and (3) a narrow band of hard rainfall associated with the cold front (Fig. 7.8c). However, locations to the north of the center of the cyclonic storm, such as Detroit, will usually experience a single, broad band of light rains resulting from the lifting of warm air above cold air from the north (Fig. 7.8b). In winter, the precipitation is likely to be snow, especially in locations just to the northwest of the center of the storm, where the humid mT air overlies extremely cold dP air.

As you can see, different portions of a middle-latitude cyclone are accompanied by different weather. If we know where the cyclone will pass relative to our location, we can make a fairly accurate forecast of what our weather will be like as the storm moves east along its track (see Map Interpretation: Weather Maps).

**Cyclones and the Upper Air Flow** The upper air flow greatly influences our surface weather. We have already discussed the role of these upper air winds in the steering of surface storm systems. Another less obvious influence of the upper air flow is related to the undulating, wavelike flow so often exhibited by the upper air. As the air moves its way through these waves, it undergoes divergence or convergence because of the atmospheric dynamics associated with curved flow. This upper air convergence and divergence greatly influence the surface storms below.

The region between a ridge and the next downwind trough (A–B in Fig. 7.9) is an area of upper-level convergence. In our atmosphere, an action taken in one part of the atmosphere is compensated for by an opposite reaction somewhere else. In this case, the upper air convergence is compensated for by divergence at the surface. In this area, anticyclonic circulation is promoted as the air is pushed...
downward. This pattern will inhibit the formation of a middle-latitude storm or cause an existing storm to weaken or even dissipate. On the other hand, the region between a trough and the next downwind ridge (B–C in Fig. 7.9) is an area of upper-level divergence, which in turn is compensated for by surface convergence. This is an area where air is drawn upward and cyclonic circulation is encouraged. Convergence at the surface will certainly enhance the prospects of storm development or strengthen an already existing storm.

In addition to storm development or dissipation, upper air flow will have an impact on temperatures as well. If we assume that our “average” upper air flow is from west to east, then any deviation from that pattern will cause either colder air from the north or warmer air from the south to be advected into an area. Thus, after the atmosphere has been in a wavelike pattern for a few days, the areas in the vicinity of a trough (area B in Fig. 7.9) will be colder than normal as polar air from higher latitudes is brought into that area. Just the opposite occurs at locations near a ridge (area C in Fig. 7.9). In this case, warmer air from more southerly latitudes than would be the case with west-to-east flow is advected into the area near the ridge. Figure 7.10 shows that in reality, the jet stream curves with less regularity. Comparing Figures 7.9 and 7.10 you can see the difference between the theoretical and the real waves in the polar front jet stream.

Anticyclones Just as cyclones are centers of low pressure that are typified by the convergence and uplift of air, so anticyclones are cells of high pressure in which air descends and diverges. The subsidence of air in the center of an anticyclone encourages stability as the air is warmed adiabatically while sinking toward the surface. Consequently, the air can hold additional moisture as its capacity increases with increasing temperatures. The weather resulting from the influence of an anticyclone is often clear, with no rainfall. There are, however, certain conditions under which there can be some precipitation within a high pressure system. When such a system passes near or crosses a large body of water, the resulting evaporation can cause variations in humidity significant enough to result in some precipitation.

There are two sources for the relatively high pressures that are associated with anticyclones in the middle latitudes of North America. Some anticyclones move into the middle latitudes form northern Canada and the Arctic Ocean in what are called outbreaks of cold Arctic air. These outbreaks can be quite extensive, covering much of the midwestern and eastern United States. The temperatures in an anticyclone that has developed in a cold air mass can be markedly lower than those expected for any given time of year. They may be far below freezing in the winter. Other anticyclones are generated in zones of high pressure in the subtropics. When they move across the United States toward the north and northeast, they bring waves of hot, clear weather in summer and unseasonably warm days in the winter months.

Hurricanes

Though their overall diameter may be less than that of a middle latitude cyclone with its extended fronts, hurricanes are essentially the largest storms on Earth. Hurricanes are severe tropical cyclones that receive a great deal of attention from scientists and laypeople alike, primarily because of their tremendous destructive powers (Fig. 7.11).