6. Wind and Surface Currents

Thus far in our study of ocean currents we have investigated gravity currents, thermohaline circulation, and the effects of the earth's rotation. Now we look at wind, how it forms in the atmosphere, and how it produces both surface waves and surface currents.

Winds are currents of air. Winds develop whenever two adjacent bodies of air have different densities. Denser air sinks, pushing less-dense air upward. This movement produces a convection current. See Fig. 6–1.

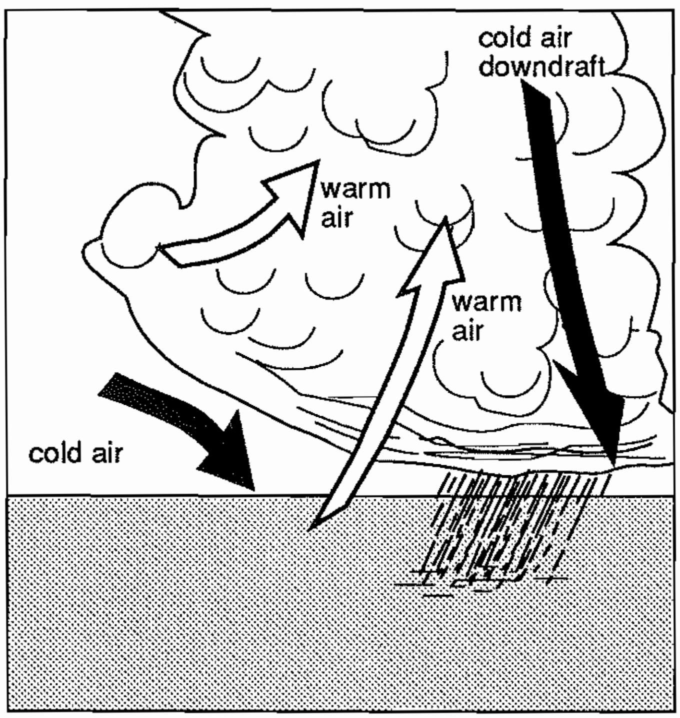

Fig. 6–1. A convection current forms when a dense, high-pressure air mass sinks and pushes up a less-dense, low-pressure air mass.

Two things affect the density and air pressure: temperature and water vapor. Warm air is less dense; cold air is more dense. Water vapor in an air mass decreases its density because vapor is only about half as dense as air. Rain, snow, and dew formation remove vapor from an air mass, leaving behind dryer, denser air.

Air is pulled toward the surface of the earth by gravity. The force of the air mass on the earth is called **air pressure**. Air pressure varies with the density of the air mass. At the same temperature, dry air exerts a greater force than moist air. Dry, dense air masses therefore produce high-pressure areas; moist, less-dense air masses produce low-pressure areas.

QUESTIONS

1. What is wind? How does wind develop?
2. How is a convection current produced in the air?
3. How can air become more dense? Less dense?
4. What kind of weather is associated with low pressure? With high pressure?
5. Look at a weather map in your local newspaper or on the evening TV news program. Where are the air masses more and less dense? What kind of weather would be associated with these air masses?

Global Winds

Sunlight is the earth's primary heat source. The energy from sunlight heats the oceans, atmosphere, lands, and forests, but the energy is not evenly distributed over the earth's surface. About 60 times more sunlight falls on equatorial areas than on polar areas. See Fig. 6–2. Consequently, hot equatorial air masses, which are often humid, are less dense than cold polar air masses, which are often dry.

At the poles, cold, dense air sinks, then flows toward the equator. Polar air becomes warmer as it moves away from the poles. Air masses at the equator move in the opposite manner. At the equator, hot, moist, and less-dense air rises and moves toward the poles. Equatorial air gradually cools as it moves away from the equator. The sinking of polar air and rising of equatorial air forms large-scale circulation patterns.

Earth's Rotation and Its Effect on Wind

When the earth rotates, it turns from west to east. However, because the earth is spherical, the surface at the equator moves much faster than at the poles. See Fig. 6–3. The atmosphere surrounding the earth also rotates at the same speed as the land and the ocean surface beneath it.

When we simulated the rotation of the earth in Topic 5, we saw that a fluid is deflected as it flows from the pole toward the equator. This deflection also occurs when an air mass moves toward the equator. See Fig. 6–3. In the northern hemisphere, as cold polar air travels southward, its rotational speed is slower than the rotational speed of the land and water beneath it. The cold air mass cannot keep up with the rotating earth. Therefore, air flowing from the north pole lags behind, producing cold, surface-level

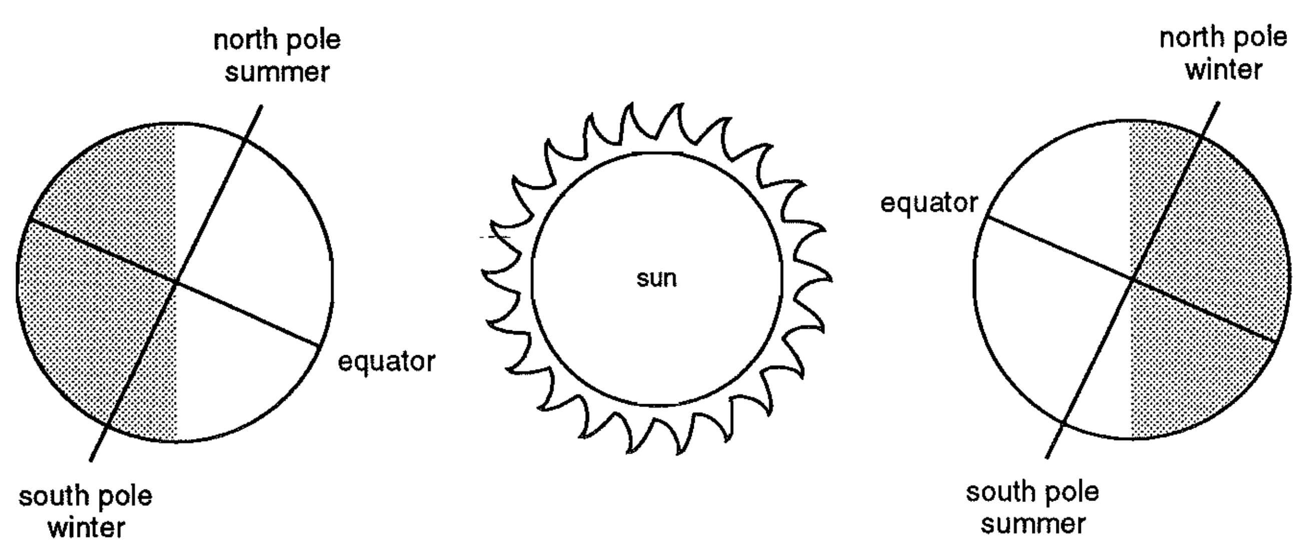

Fig. 6–2. Amount of sunlight at poles as affected by the tilting of the earth

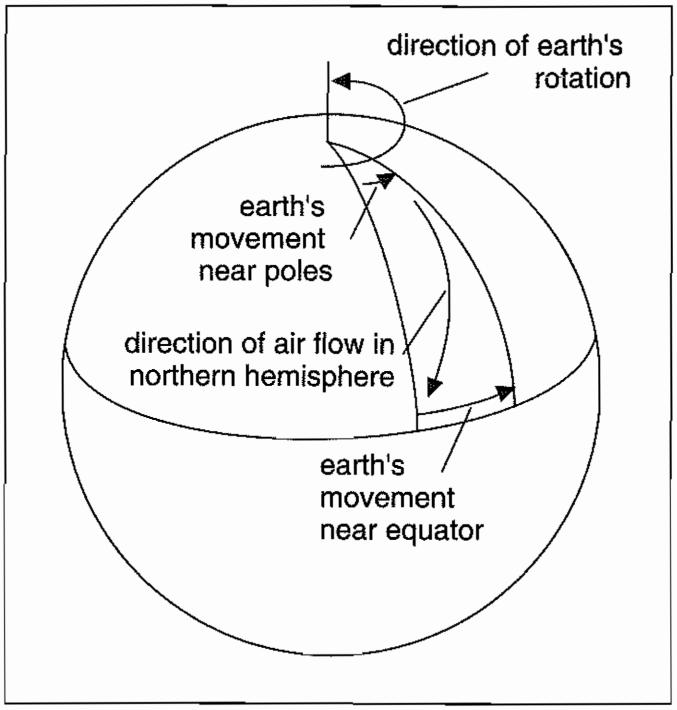

Fig. 6–3. An air mass flowing from the north pole toward the equator is deflected by the rotation of the earth.

winds that blow from the northeast. See Fig. 6–4. These winds are called the **polar easterlies.** Winds are named by the direction *from* which they blow.

As the polar easterlies move toward the equator, they become warmer and less dense. At about 60°N the air mass rises and moves northward at high altitude. This path of air circulation forms a closed loop called a **circulation cell**. See Fig. 6–4.

At the equator hot, humid air rises, cools, and loses moisture, producing rain. The cool dry air moves toward the north pole at a high altitude. The air gradually becomes cold, dry, and more dense. It begins to sink at about 30° N. The air then moves along the earth's surface back toward the equator, forming another circulation cell. See Fig. 6–4. These surface winds blowing from the northeast are called **tradewinds**. In the days when sailing ships carried goods from Europe to North America and from North America to the orient, they relied on these strong prevailing winds to make the journey as fast as possible.

A third circulation cell forms between 30° and 60° N. Here the surface winds blow from the southwest and are called the **prevailing westerlies**. The prevailing westerlies are the dominant winds blowing across most of the United States.

Similar circulation cells form in the southern hemisphere, producing characteristic surface wind patterns.

Two other areas were named because of the lack of steady prevailing winds. At the equator the air rises, producing a belt of weak, light, shifting winds called the **doldrums**. Because of the lack of winds, sailing vessels had a difficult time crossing the equator and were sometimes becalmed for

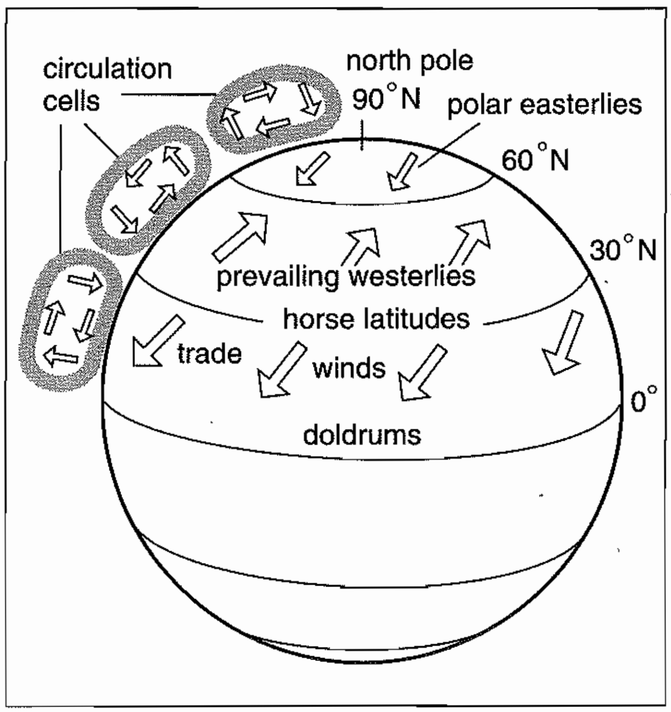

Fig. 6–4. Prevailing surface winds on a model of the earth, showing major circulation cells

long periods. Thus a long, monotonous period is sometimes called the doldrums.

At 30°N the air descends, also producing a region of light, variable winds. This region is called the **horse latitudes**. Supposedly, the horse latitudes got their name when sailing ships could not make headway and horses penned up in the hold died from lack of food and water and were thrown overboard.

QUESTIONS

6. Explain the reason that more sunlight falls on the equator than on the poles.

7. Show what the circulation cells look like in the southern hemisphere. Draw them on the edge of the globe as shown in Fig. 6–4. Show the vertical and horizontal direction of the wind in each cell.

8. Label either high or low pressure for the air masses
   a. at 30°N, 60°N, and 90°N.
   b. at 30°S, 60°S, and 90°S.

9. Using Fig. 6–4 as a model, draw arrows to show the circulation cells and direction of the surface winds as the air circulates in the southern hemisphere. Label the winds.

10. Compare the directions of the major currents of air in the northern and southern hemispheres. How are they similar and different?

11. Show where the doldrums and horse latitudes are located.

12. Winds at 40°S and 50°S are called the "roaring forties" and "furious fifties." In which direction do they blow? Why do they blow so strongly?

Winds and Surface Currents

Winds can produce currents if they blow from the same direction for long periods. When wind pushes constantly on the ocean's surface, water particles at the surface begin to move, but not in the direction of the wind. Largely because of the rotational effect of the earth, surface water flows at a 20°– 45° angle to the right of the wind in the northern hemisphere and 20°– 45° to the left of the wind in the southern hemisphere.

Because water molecules tend to stick to each other, surface water movement sets deeper layers of water into motion. The speed of each successive layer decreases, and the angle of deflection increases with depth. Eventually some water particles flow in the direction opposite to the surface current. This current pattern is called the **Ekman spiral**. See Fig. 6–5.

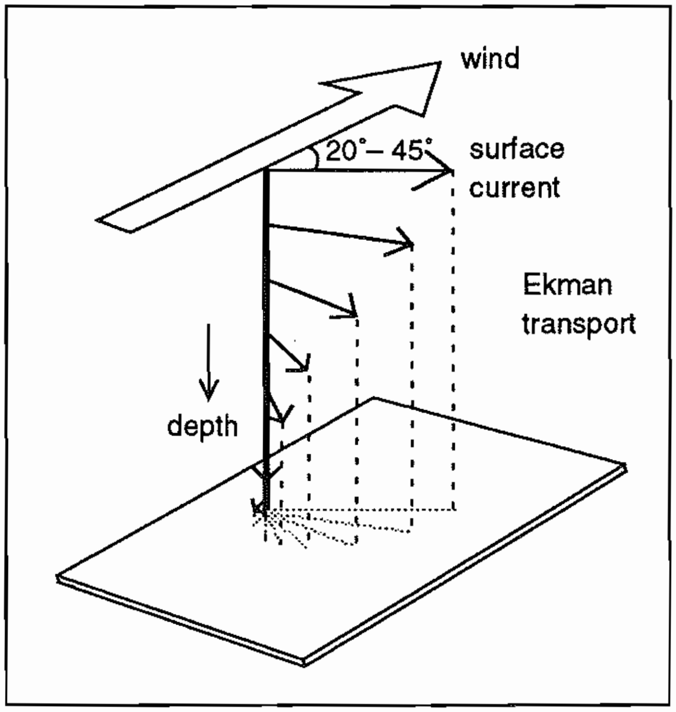

Fig. 6–5. The Ekman spiral