Coriolis Effect and Atmospheric Circulation

Background

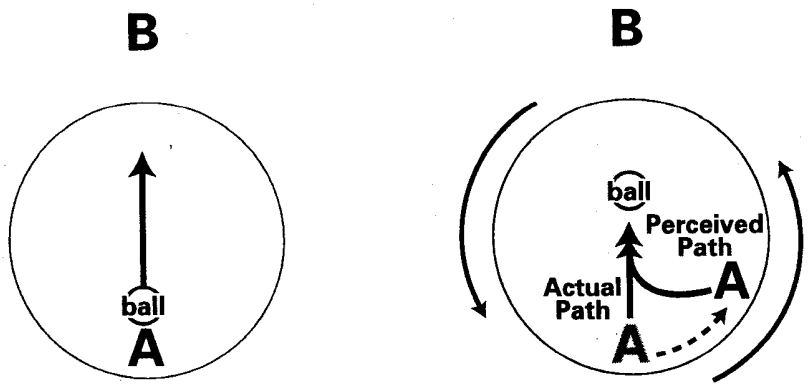
Global air circulation is a major influence on the world's climates. Air circulation is caused by four factors—uneven heating of the earth's surface, seasonal variation in temperature and precipitation, the rotation of the earth on its axis, and the physical properties of air, land, and water. The first two activities in this unit concentrate on how the rotation of the earth affects global air circulation. The last two activities look at how the uneven heating of the earth and the rotation of the planet affect wind patterns and the rotation of storms.

Due to the earth's rotation, large air masses tend to be deflected to the right or left depending on whether they are moving across the Northern or Southern Hemisphere. This phenomenon is referred to as the Coriolis effect, named after French mathematician Gaspard Coriolis (1792–1843), who analyzed it.

The Coriolis effect is used to explain why objects moving in a straight path on an object that is rotating at a constant speed appear to be deflected to one side. The effect is perceived only from the rotating object. If viewed from a stationary point, the object appears to move in a straight line. If you visualize a rotating disk, you can see that not all points on the disk are moving at the same speed. If you made a line along the radius of a record player turntable and marked two points on the line, one at the outer edge and one close to the center, and then spun the turntable, both points would of course stay on the line. The outer point, however, would travel a greater distance over the same amount of time than the inner point.

Now imagine person A on the outer edge of a merry-go-round. Person A has a ball and is going to roll it across the merry-go-round. If the merry-go-round is not rotating when person A rolls the ball, the ball will travel in a straight path when viewed from the merry-go-round and when viewed by person B standing nearby.

However, if the merry-go-round is rotating and person A rolls the ball again, the ball's apparent path will curve based on person A's frame of reference. However, to person B standing on the ground outside the merry-go-round frame of reference, the ball still appears to travel in a straight line. The ball is, in fact, traveling in a straight line, but because the outer edge of the merry-go-round is rotating faster than the center, as the ball moves towards the center, it appears to move to the left or right, depending on the direction of the merry-go-round's rotation.



The Coriolis effect on the movement of large air masses moving north or south is to deflect those in the Northern Hemisphere to the right and those in the Southern Hemisphere to the left. For example, an air mass moving from the North Pole toward the equator is deflected toward the west (to its right). One moving from the South Pole toward the equator is also deflected toward the west (but to its left).

The Coriolis effect is a critical component in the formation of large storm systems, such as hurricanes, cyclones, and typhoons. These storms begin with the heating of tropical waters. A heated air mass rises and moves toward the pole. The farther the mass moves from the equator, the greater its Coriolis deflection, setting in motion the storm's rotation. Interestingly, since there is no Coriolis effect at the equator, tropical cyclones tend to develop at least 500 km away from it, either to the north or south.

The Coriolis effect also influences ocean currents and the global wind belts. Around the tropics, air at the earth's surface heats and rises, then moves toward the poles. Because of their higher altitude, the masses begin to cool, and their poleward movement becomes deflected because of the Coriolis effect. As they cool, the masses sink again, move back toward the equator as surface winds, and are deflected in the opposite direction. The overall effect is to create steady bands of wind flow around the globe. The tropical winds are called the trade winds. Other global winds produced by the Coriolis effect and by rising and falling air masses are the subtropical westerlies and the polar easterlies.