Global wind patterns

Unequal solar heating supplies the energy; density and pressure differences move air; Earth's rotation changes its direction. Together, these processes redistribute heat and moisture.

1. START WITH AN ENERGY IMBALANCE

Unequal heating

More direct sunlight in the tropics

→

Density differences

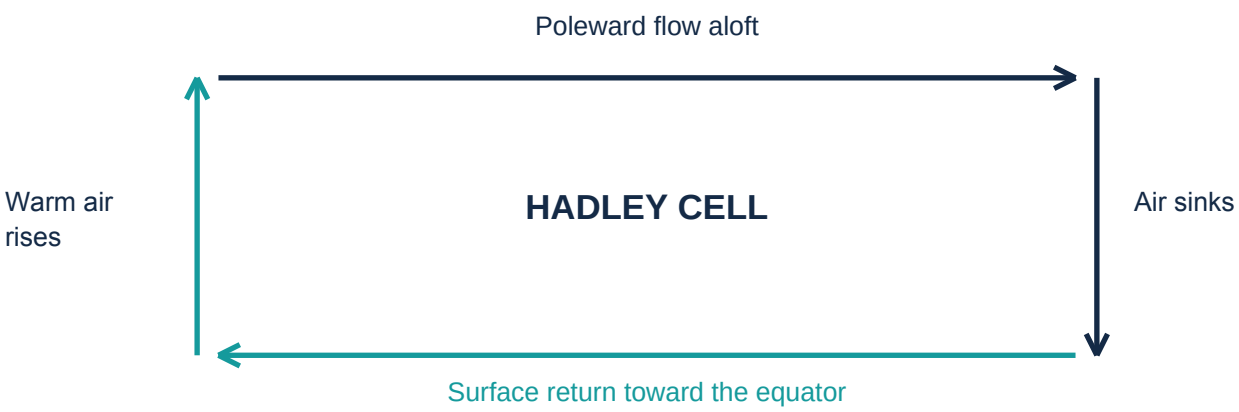
Warmer air is less dense at equal pressure

→

Air movement

Buoyancy and pressure gradients drive flow

2. FOLLOW ONE HADLEY CELL



0°: equator / low pressure

30° N: high pressure

3. THE SURFACE RETURN BECOMES A TRADE WIND

Surface pressure differences push air from the subtropical high toward the equatorial low. Coriolis deflection gives this return flow a westward component, producing the northeast trade winds north of the equator. A corresponding Hadley circulation occurs in the Southern Hemisphere.

Cross-section is schematic; east-west motion is not shown in the loop.

Unequal heating and three-cell model: Met Office, Global circulation patterns.
Hadley return flow and trade-wind directions: NOAA, Surface Ocean Currents.

Scope: College Board AP Environmental Science CED, Topic 4.5, p. 84.

Turn circulation into wind belts

Winds are named for where they come FROM. A westerly comes from the west and travels generally eastward. These belts describe prevailing surface winds, not every day's weather.

1. CORIOLIS: RIGHT NORTH, LEFT SOUTH

Earth's rotation makes moving air curve relative to the surface. Deflection is to the right of motion in the Northern Hemisphere and to the left in the Southern Hemisphere. Right and left depend on the direction of travel - they do not always mean east and west. Coriolis redirects moving air; it is not the original energy source for wind.

2. THE SIX SURFACE-WIND BELTS

LATITUDE / CELL	PREVAILING WIND	FROM → TOWARD	
60-90° N Polar cell	**Polar easterlies**	NE to SW	
30-60° N Ferrel cell	**Westerlies**	SW to NE	
0-30° N Hadley cell	**Northeast trades**	NE to SW	
0-30° S Hadley cell	**Southeast trades**	SE to NW	
30-60° S Ferrel cell	**Westerlies**	NW to SE	
60-90° S Polar cell	**Polar easterlies**	SE to NW	

Arrow key: north is up; east is right. Latitude boundaries are approximate.

Direction example: air moving south toward the equator in the Northern Hemisphere turns right, toward the west. It travels southwest, so the wind is named a northeast trade wind.

Rotation and hemisphere-dependent deflection: NOAA NESDIS, The Coriolis Effect.
Surface trade winds: NOAA NESDIS, What Are Trade Winds?

Scope: College Board AP Environmental Science CED, Topic 4.5, p. 84.

Connect winds to climate

Use the three-cell model as a broad pattern: Hadley cells span about 0-30°, Ferrel cells 30-60°, and Polar cells 60-90° in each hemisphere. The cells are not rigid compartments.

1. RISING AND SINKING AIR SHAPE RAINFALL

Near 0° Low / rising	Trade winds converge near the ITCZ; moist air rises and frequent rain is common.
Near 30° N/S High / sinking	Descending air warms, reducing relative humidity and suppressing cloud formation.
Near 60° N/S Low / rising	Polar and mid-latitude air meet; uplift supports cloud and storm formation.
Near 90° N/S High / sinking	Cold polar air descends. Polar regions receive little precipitation.

Ferrel circulation is an average pattern strongly maintained by mid-latitude weather systems, not simply a separate heat-driven convection loop.

2. WHY THE EQUATOR IS OFTEN WET

In the intertropical convergence zone (ITCZ), converging surface air rises. As it rises into lower pressure, it expands and cools. If it reaches saturation, water vapor condenses and clouds form; precipitation may follow. The ITCZ shifts seasonally with the zone of strongest heating.

3. APPLY THE MODEL WITHOUT OVERCLAIMING

Many subtropical deserts occur near descending Hadley air, but latitude alone cannot predict a place's climate. Land and ocean contrasts, mountains and seasonal shifts modify the pattern. Prevailing winds also transport airborne material and help drive surface ocean currents.

Keep the roles separate: heating supplies energy; pressure gradients drive flow; Coriolis deflects it; vertical motion helps explain rainfall.

Pressure belts, cell structure and climate: Met Office, Global circulation patterns.
Convergence, uplift and seasonal migration: Met Office, ITCZ.

Scope: College Board AP Environmental Science CED, Topic 4.5, p. 84.