

Heating of Earth and Air Circulation

Causes of Air Circulation

- 1) Uneven solar energy inputs
- 2) Rotation of the Earth

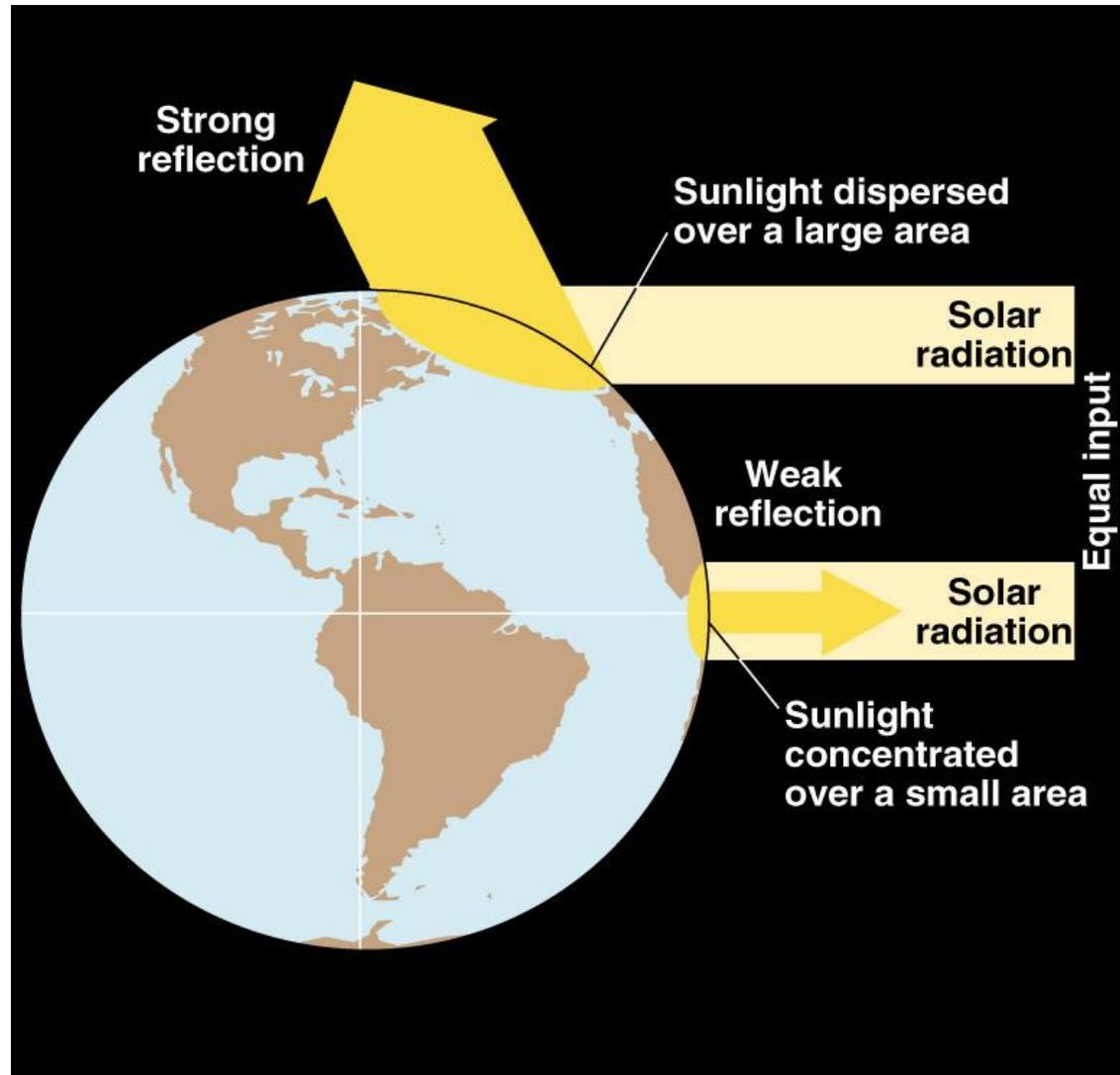
Global Circulation Patterns

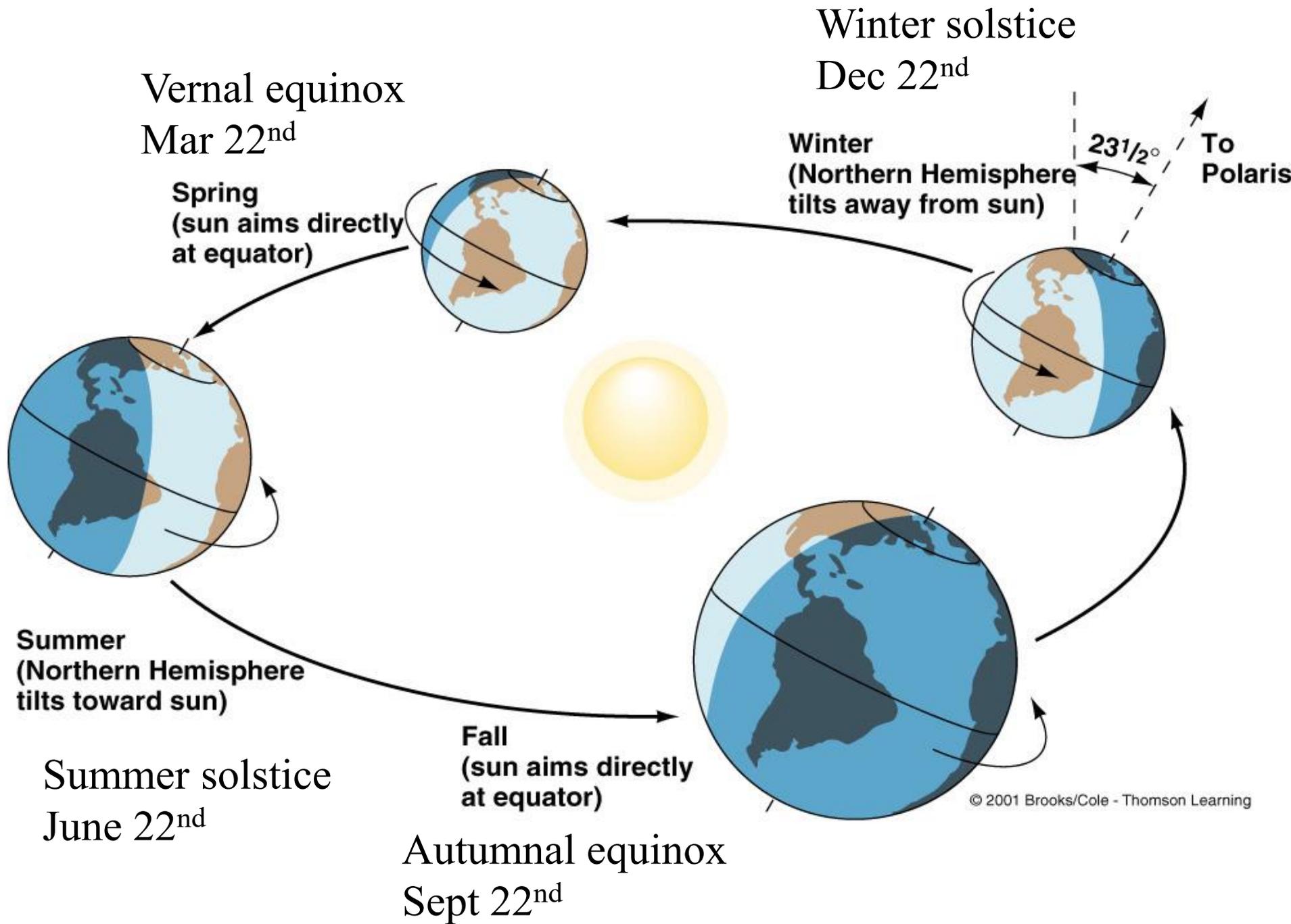
Local Events and Storms

Uneven Solar Energy Inputs: Earth is heated unevenly by the sun due to different angles of incidence between the horizon and Sun.

This angle of incidence is affected two factors:

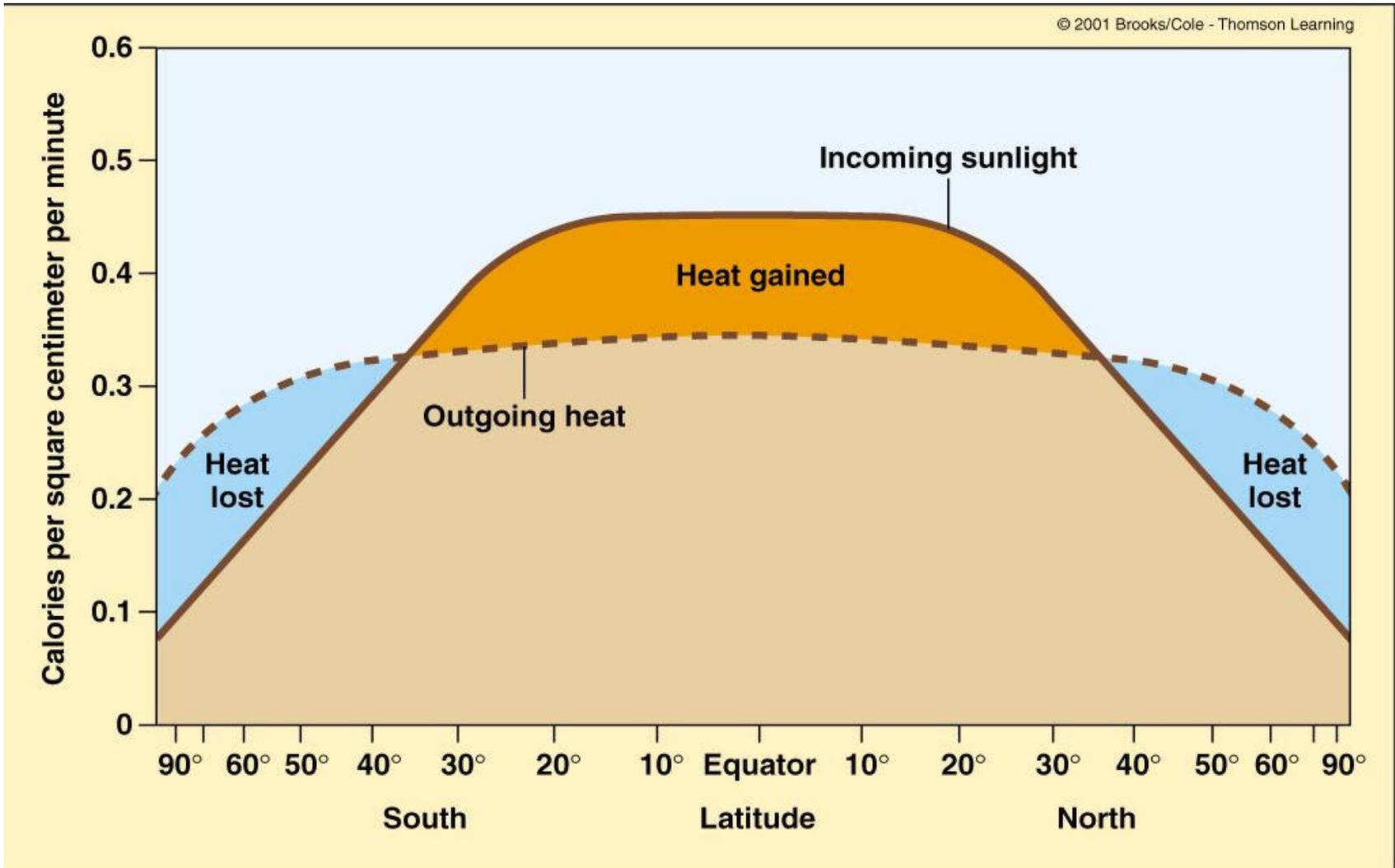
- 1) Latitude: solar inputs are most dense when the sun is overhead in the tropics; reflection is low. The reverse holds true in polar regions.
- 2) Season: Due to Earth's annual orbit around the Sun on an axis tilted by 23.5° .





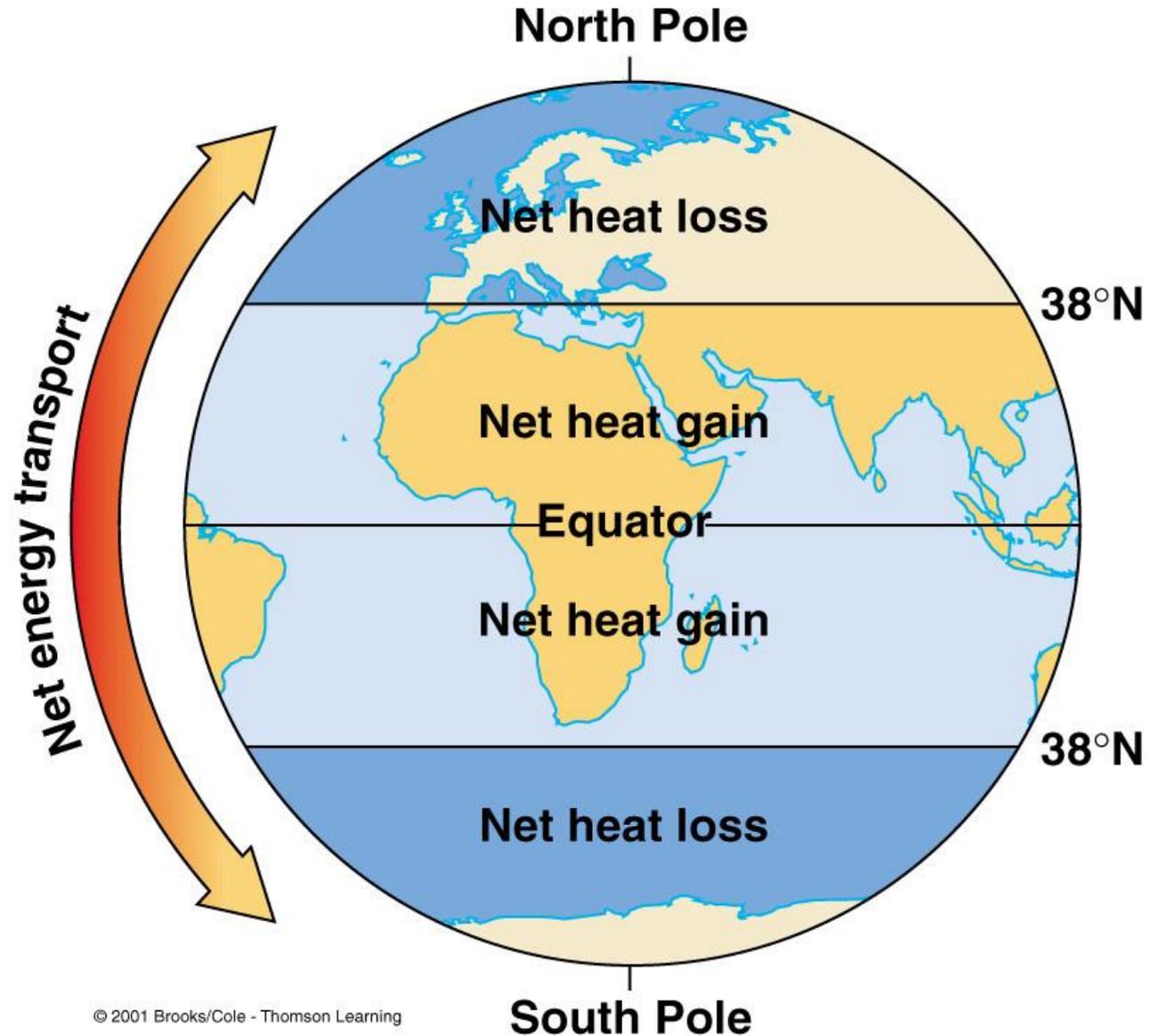
The Global Heat Budget with Latitude:

Losses by long-wave radiation is fairly constant at most latitudes, whereas inputs are variable and greatest in the tropics.

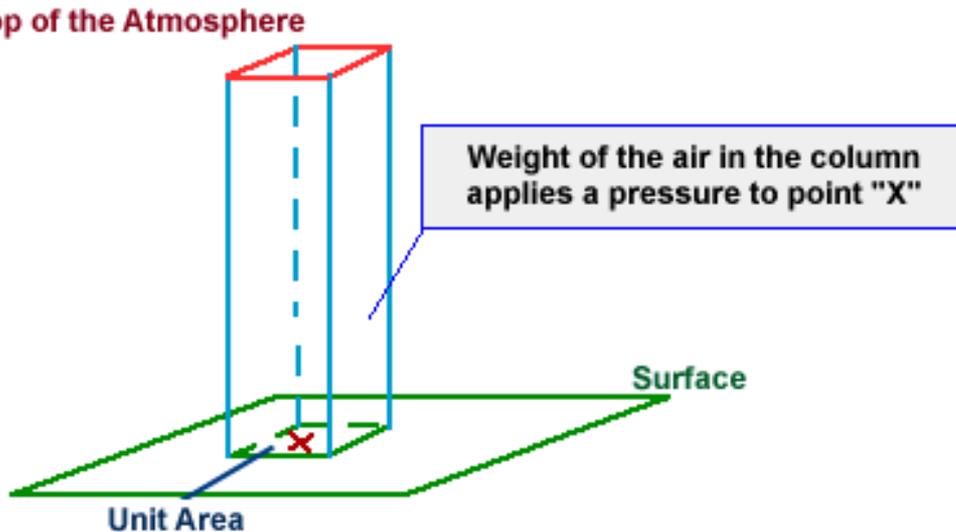


Heat inputs from the tropics are delivered to the poles via atmospheric and ocean circulation, each delivering about 50% of the tropical heat.

These circulation patterns are partly due to heat gradients, or more accurately pressure gradients.



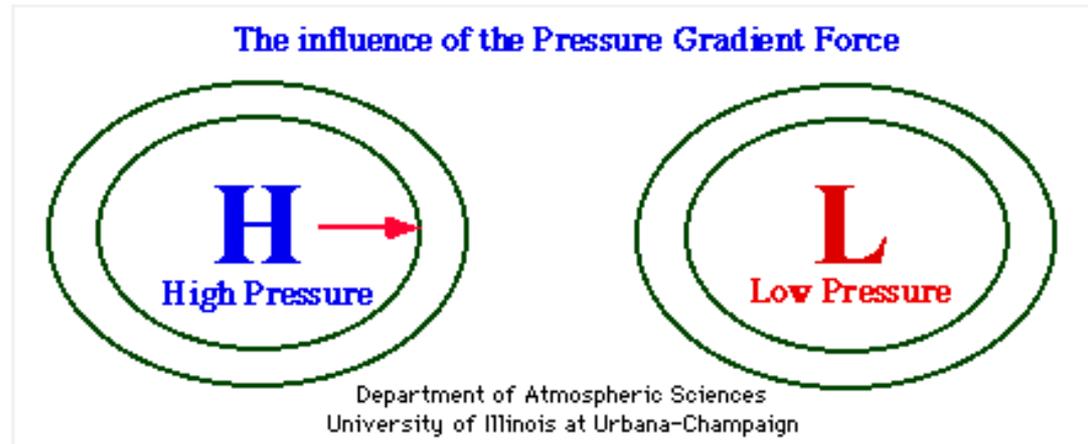
Atmospheric pressure gradients = winds



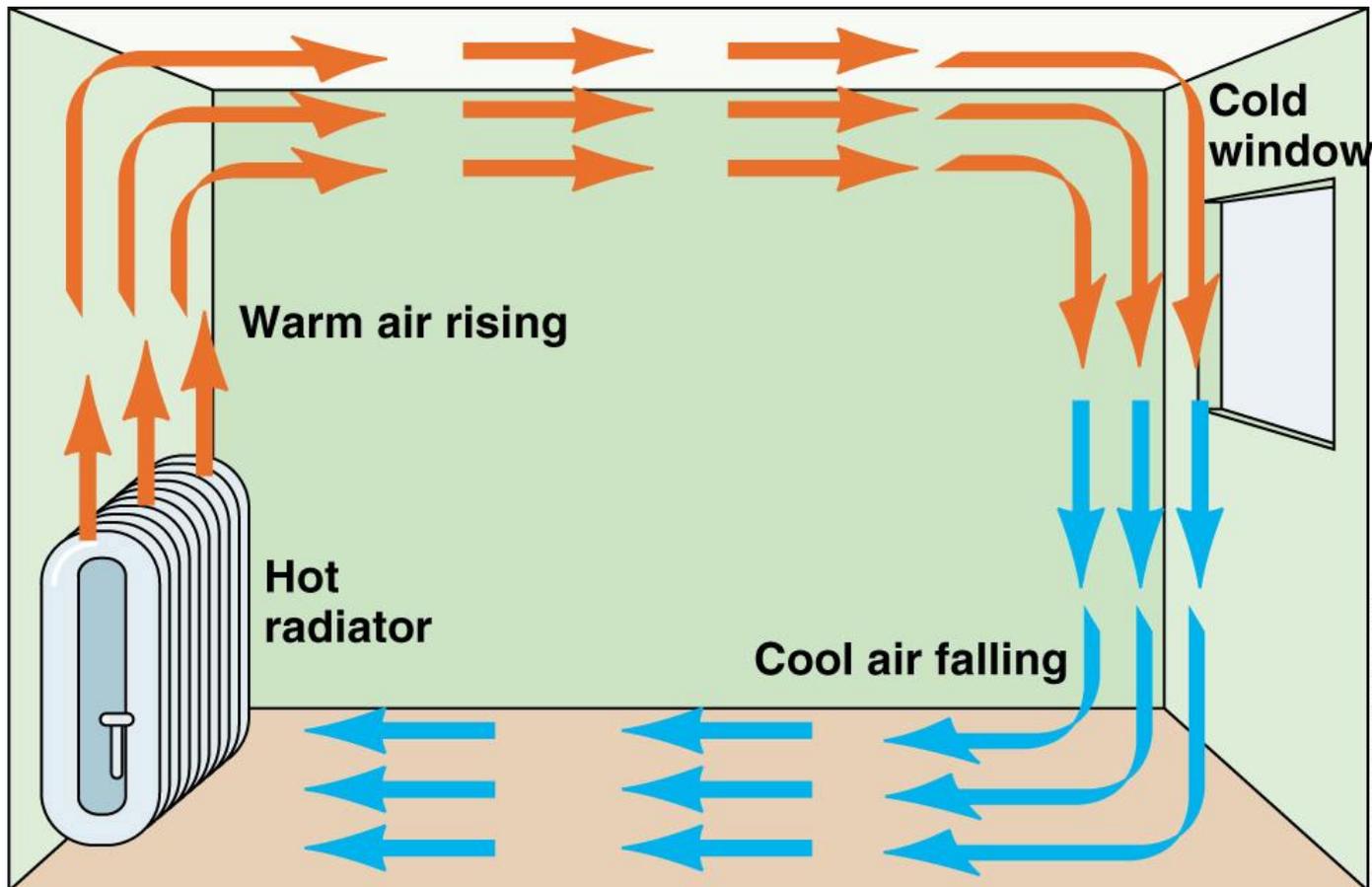
Net force from high to low pressure is called the pressure gradient force and initiates air movement, i.e. wind.

Low Pressure: warm, moist, low density air, is lighter and rises.

High Pressure: cool, dry, high density air is heavier and sinks



Convection cells establish themselves due to the pressure gradient with latitude and altitude. The flow of air due to pressure differences generates winds.

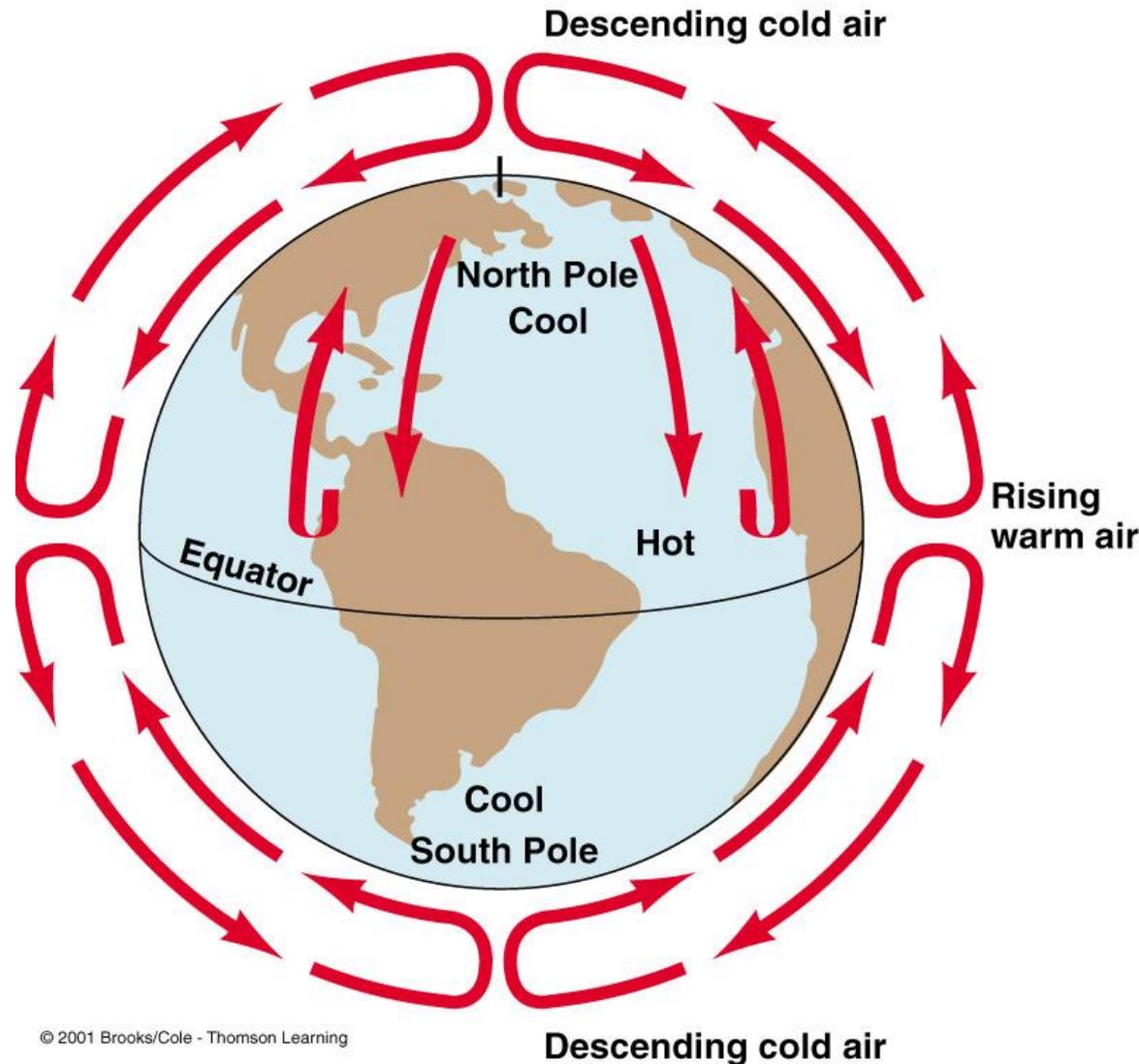


The intense heating of the tropics by solar radiation sets up a strong convection cell near the equator. As water evaporates from the ocean, the overlying air becomes less dense .

Air loses moisture and cools as it rises and moves poleward. It becomes more dense and sinks at poles

Winds would blow across the surface of Earth from the poles toward the tropics.

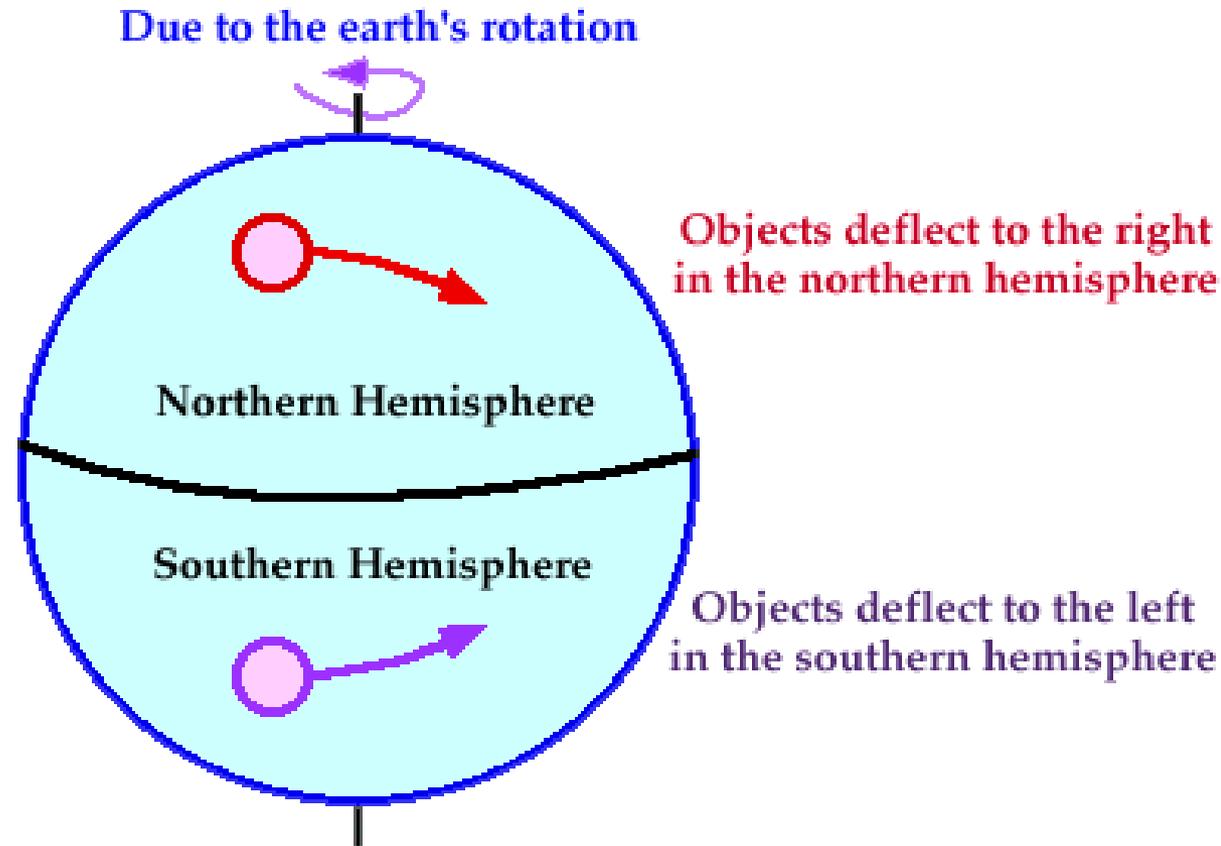
Idealized pattern without accounting for Earth's rotation.



Rotation of the Earth: Coriolis Effect

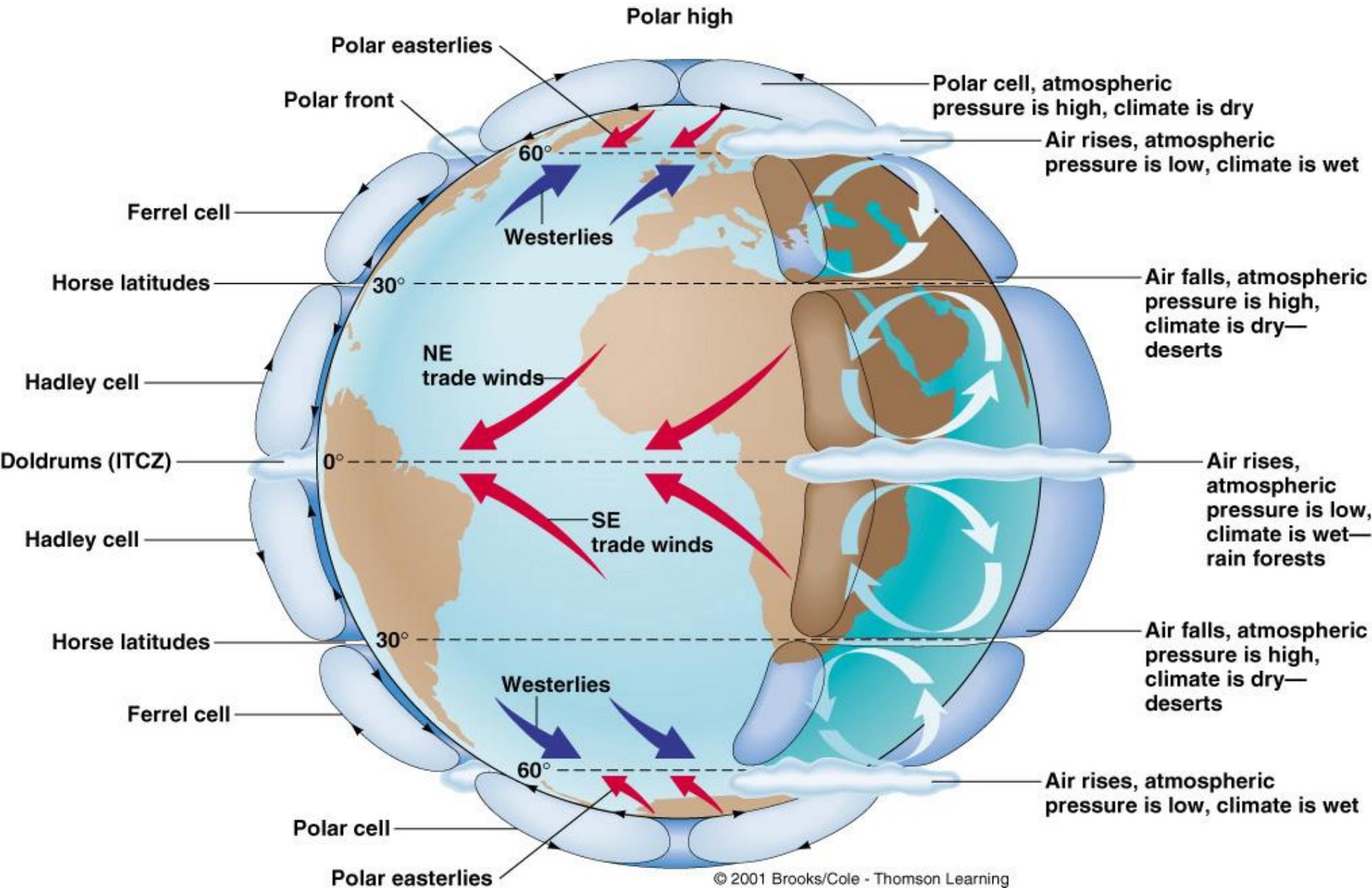
The idealized model of a single convection cells driving atmospheric circulation in each hemisphere is incorrect.

The eastward rotation of the Earth causes a deflection in wind flow (Coriolis Effect) that results in three smaller atmospheric convection cells in each hemisphere.



Perspective of earthbound observer.

Gaspard Gustave de Coriolis, 1835.



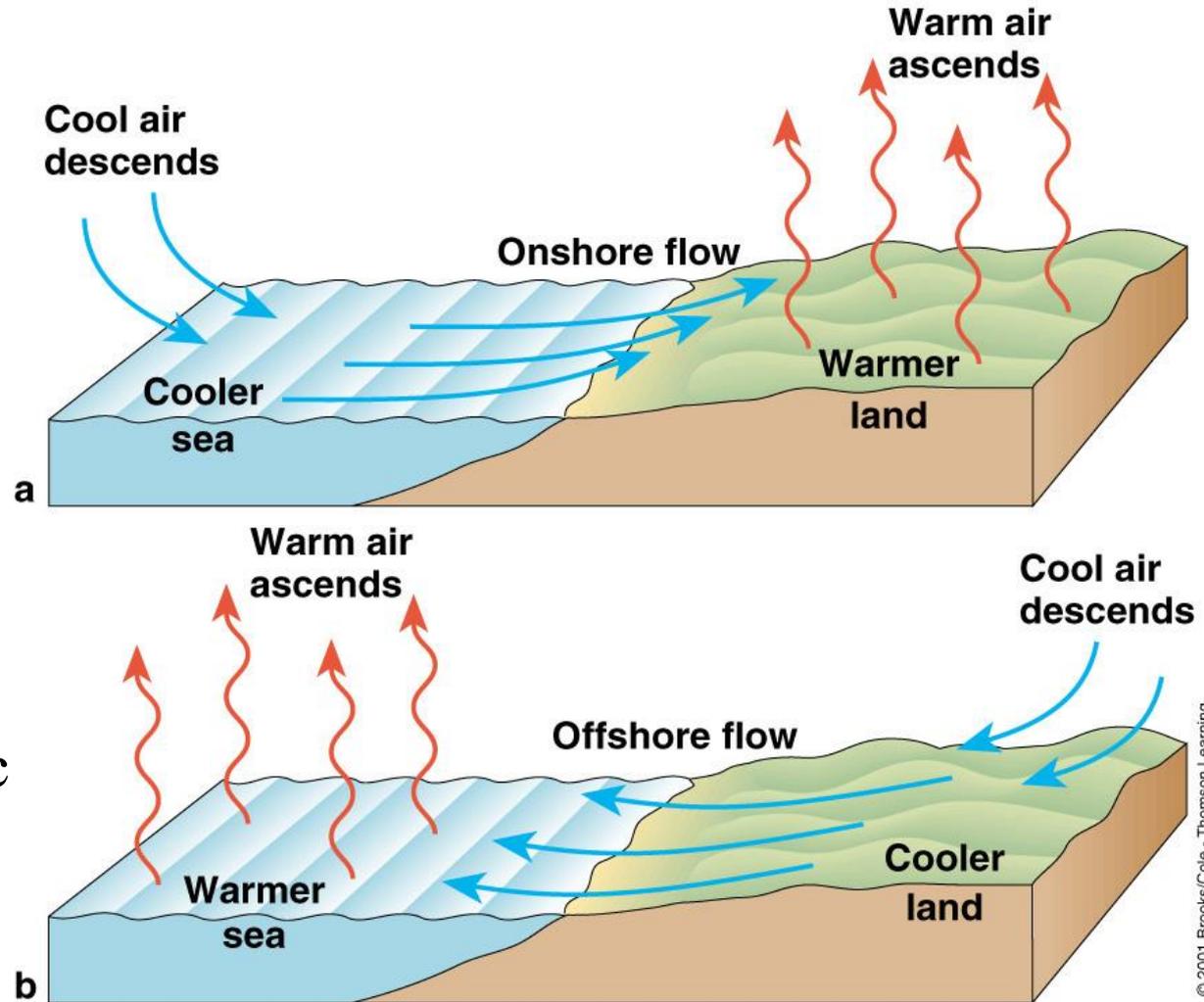
Global Circulation Patterns

- Again, there are three atmospheric convection cells per hemisphere (Hadley, Ferrel, and Polar).
- Low pressure belts are where air rises and climate is wet (Intertropical Convergence Zone (0°) and Polar Front (60°)).
- High pressure belts are where climate is dry (Horse Latitudes (30°) and Polar High (90°)).
- Surface winds converge at low pressure belts:
 - ITCZ: NE & SE Trade Winds (easterlies).
 - Polar Front: Westerlies and Polar Easterlies.
- There are latitudinal shifts in these patterns with season.

Sea Breezes and Land Breezes

There are localized patterns of air circulation superimposed or superseding those of global scale.

These too are the result of differential heating causing air pressure gradients, but their cause is due to difference in the specific heat of land versus sea, not solar intensity.



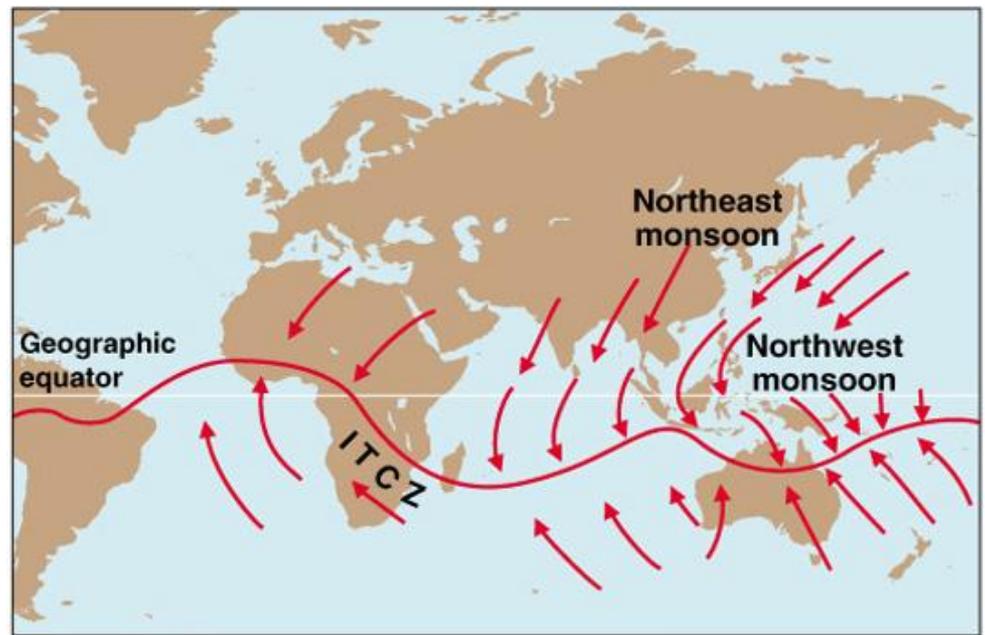
Monsoons:

Caused by:

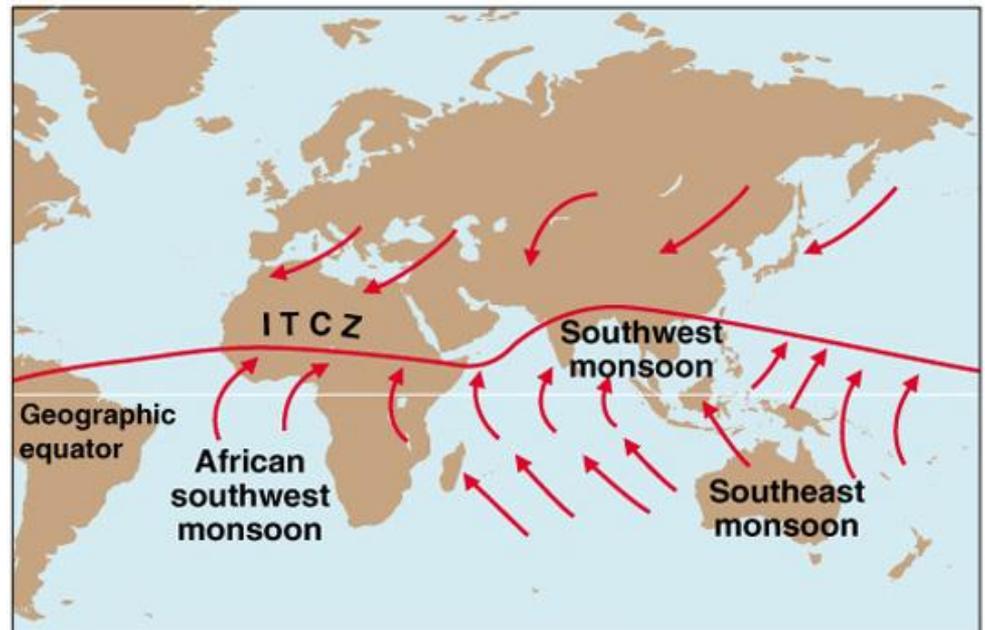
1) difference in specific heat of land and sea; and 2) seasonal shift in the ITCZ.

Winter: weaker NW and NE monsoons of SE Asia and N. Australia. Cool and dry.

Summer: strong SW and SE monsoon of India, SE Asia and parts of Africa. Intense heating of Asian continent and warm moist Indian Ocean air create extremely wet, warm and stormy conditions.



a January



b July