ATOC 1060-002
OUR CHANGING ENVIRONMENT

Class 10 (Chp 4)

Objectives of Today's Class:

1. **Global Energy Distribution**
2. **Introduce Global Circulatory Subsystems**
3. **Movement of Air**

http://atoc.colorado.edu/~whan/ATOC1060

Previous class: Climate modeling

How can we utilize our knowledge of Earth's current energy budget to predict what the Earth's surface temperature might have been in the past, or how it might vary in the future?

Climate system - complex - computer model.

In the model, all processes (clouds, greenhouse gases) are included. Global atmospheric general circulation model (AGCM):

⇒Atmospheric winds, moisture transport, energy balance, all weather phenomena.

Ocean general circulation model (OGCM):
⇒currents, heat transports, etc

Land surface model: land processes

Feedbacks: coupling among components

Global coupled climate model (3-dimensional)=>
predict climate variability; central role
in climate policy making today.

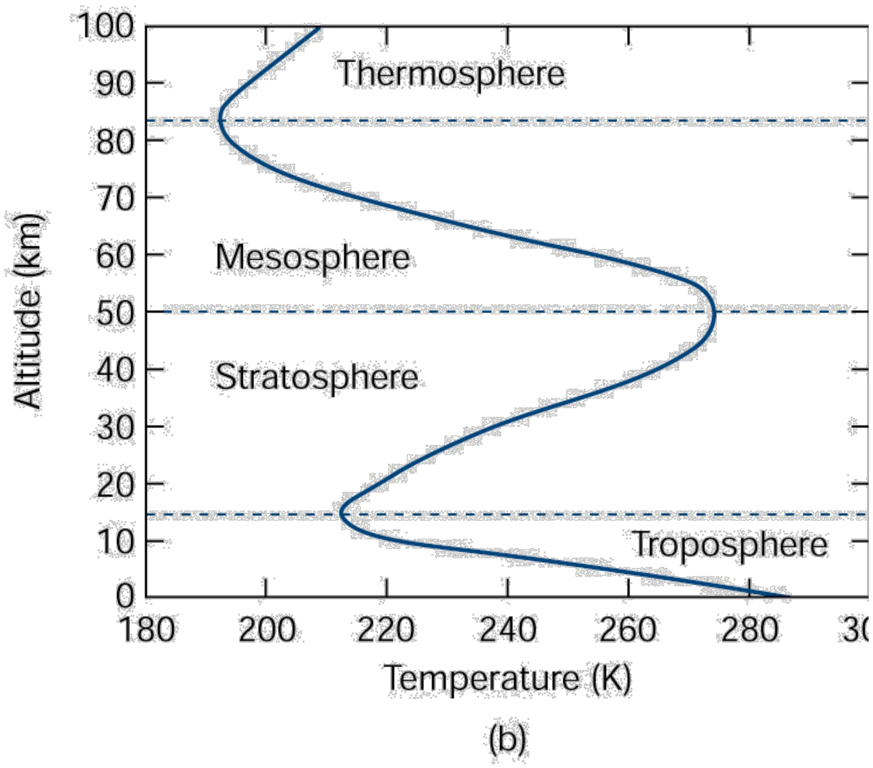
Simple, 1-dimensional (1-D) models

Radiative-convective model: average incoming solar & outgoing IR over entire Earth's surface; vertically, atmospheric structure is considered:

1-D: in altitude (vertical);

Each layer: energy absorption, emission, convection & latent heat in troposphere.

[a]Successfully predict: 33°C Temperature Change due to greenhouse effects!



Clicker's question 1

The 1-D climate models:

A. Consider the Radiative-convective effect;

B. Consider the vertical structure of the Earth's atmosphere;

C. Consider the horizontal structure of the Earth's atmosphere;

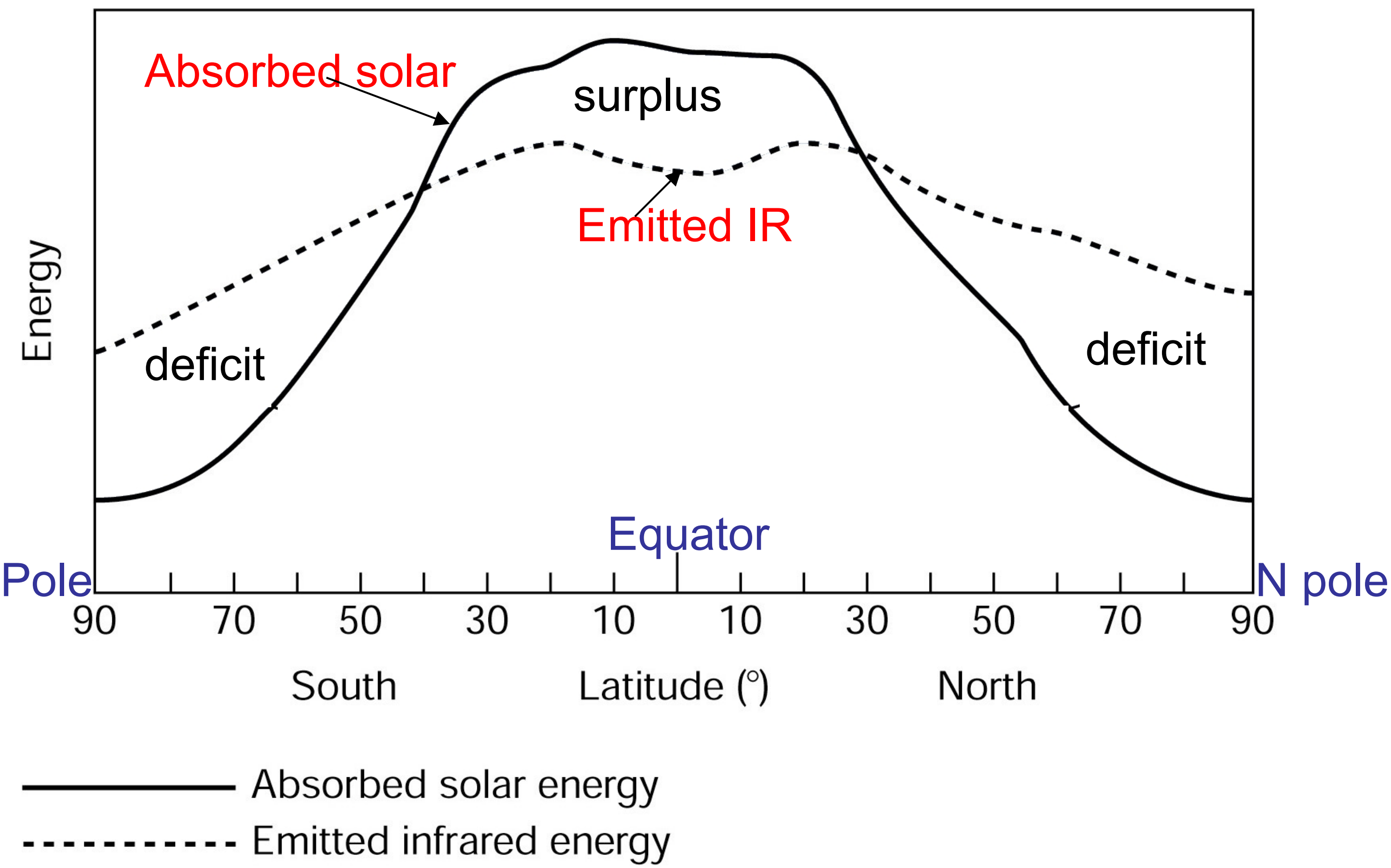
D. All of the above.

E. Both A and B.

1. Global energy distribution

- Incoming Solar radiation varies between pole & equator (how?); what about outgoing IR?
- Outgoing IR radiation varies with surface & air temperature
  - Hot equator radiates more than cold poles
- Is the entire surface of the globe in radiative equilibrium (Solar in = IR out)?

Incoming solar and Outgoing IR



Net Radiation

- Tropics: Solar radiation in > IR radiation out
- Poles: Solar in < IR out

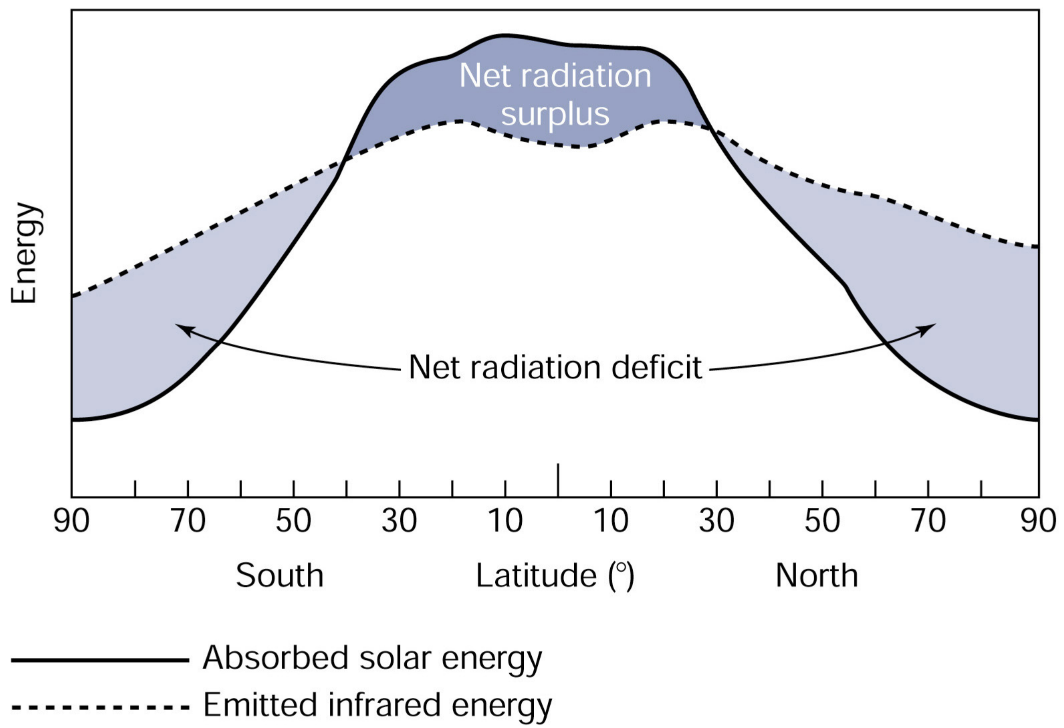


Fig. 4-2

Clicker Question 2:

Net Radiation flux on the Earth’s surface

a) Cools the poles and cools tropics

b) Cools the poles and warms the tropics

c) Warms the poles and cools the tropics

d) Warms the poles and warms the tropics

Questions

- Why doesn't equator keep heating up?
- Why don't poles keep cooling down?
  - Temperature differences drive circulation of atmosphere & ocean
  - Warm tropical air moves north, cold polar air moves south to balance temperature differences

2.Global Circulatory Subsystems:

- Response to uneven distribution of energy & matter
- Redistributes matter/energy to restore balance

Circulatory Subsystem	Circulation Mechanism	Timescale
Atmosphere	Winds	Weeks - Years
Ocean	Surface Currents	Years
	Deep Currents	1000's of years
Solid Earth	Plate Tectonics	Millions of Years

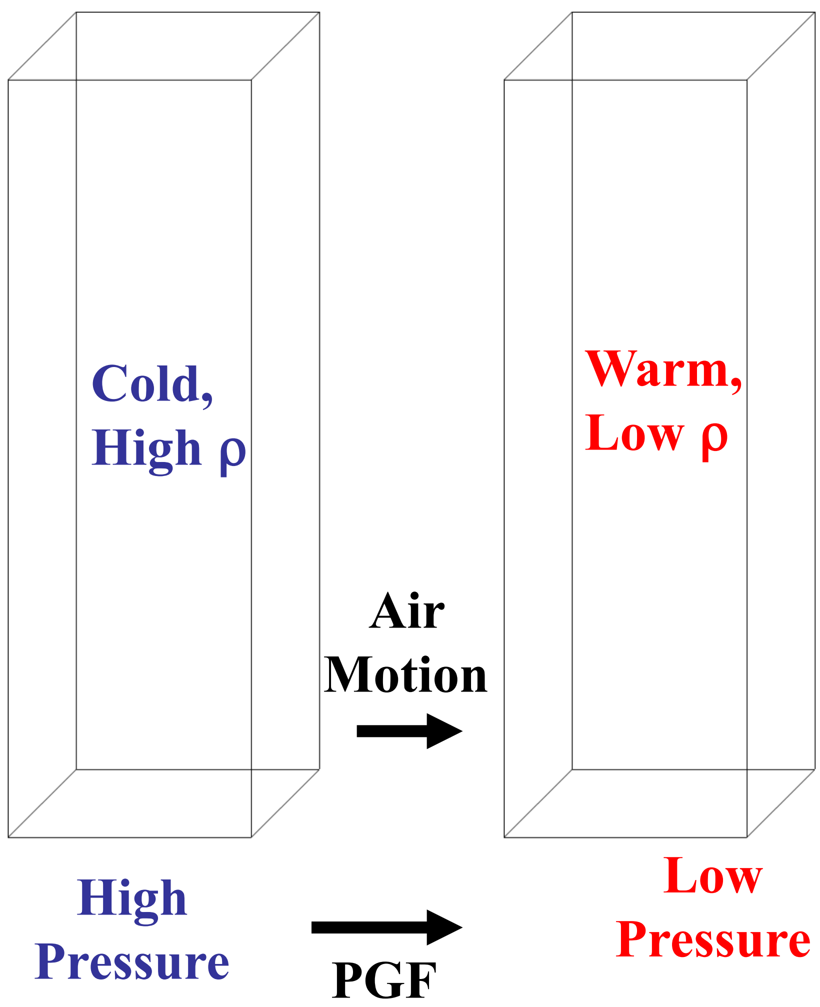
Atmospheric Circulation: movement of air

- Vertical movement: Buoyancy
  - 'Tendency of an object to float in fluid'
  - Controlled by density (ρ = mass/volume)
  - **Low density (light) fluid floats on high density (heavy) fluid**
- Density of air: increased temperature (T), decrease density (due to volume expansion). [example: hot air balloon]

Heated air => lighter => rises!

Cooled air => heavier => sinks!

•Horizontal Motion: pressure gradient force



- Two columns of air, with equal volume, different temperatures
- Pressure at surface depends on mass of air above => more pressure under cold air
- Air moves to balance mass
  - Pressure Gradient Force (PGF) moves air from high pressure to low

Summary: Movement of Air

- Heated air rises in atmosphere; cooled air sinks (subsidence)
  - Air moves vertically until it is neutrally buoyant (parcel density = surrounding air density)
- Air moves horizontally from regions of high pressure to regions of low pressure
  - Works to remove all pressure gradients

Clicker Question 3:

Choose the most complete, correct statement.

A. When an air parcel is heated from below, it rises in the atmosphere;

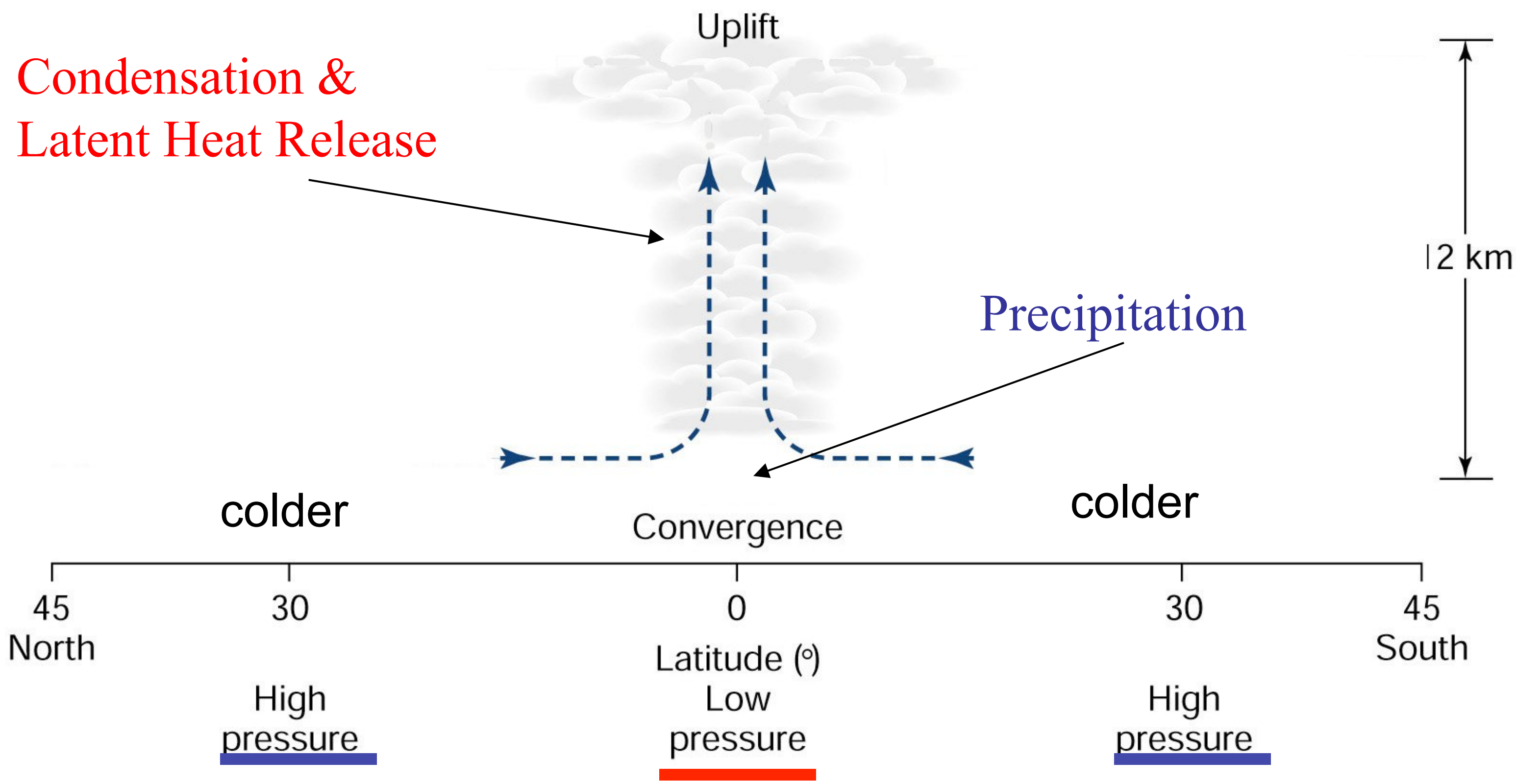
B. When an air parcel is heated, its volume expands and density decreases;

C. Air moves horizontally from regions of low pressure to regions of high pressure;

D. All of the above;

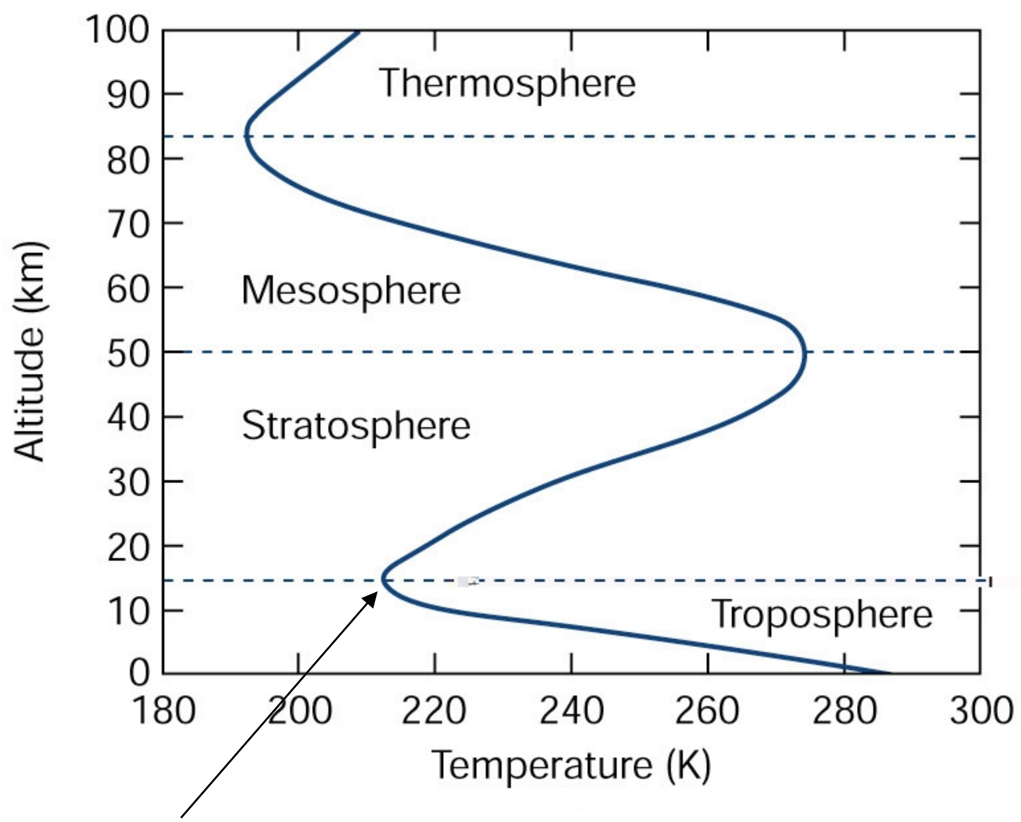
E. Both A and B.

Intertropical Convergence Zone (ITCZ)



- Equatorial area of surface convergence & rising air (strong convection)
- Cumulus towers & much latent heat release

- Recall structure of atmosphere:



Tropopause

Fig. 3-9b

- Temperatures increase in stratosphere (lower density)
- Air can't penetrate beyond troposphere
- Result: rising air *diverges* at tropopause

Hadley Circulation

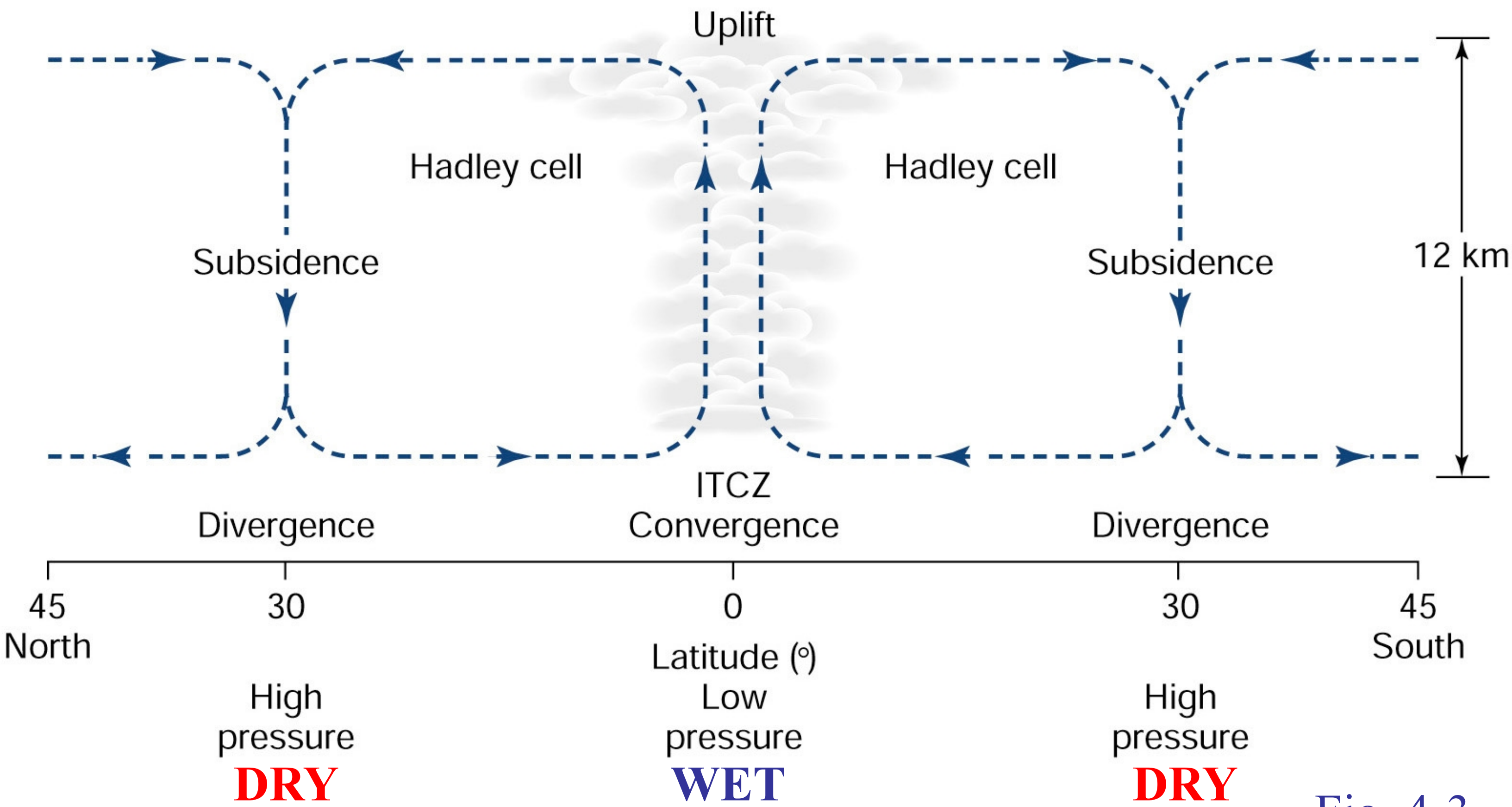


Fig. 4-3

- ITCZ & Hadley circulation is discontinuous, & most apparent over tropical oceans

Clicker Question 4:

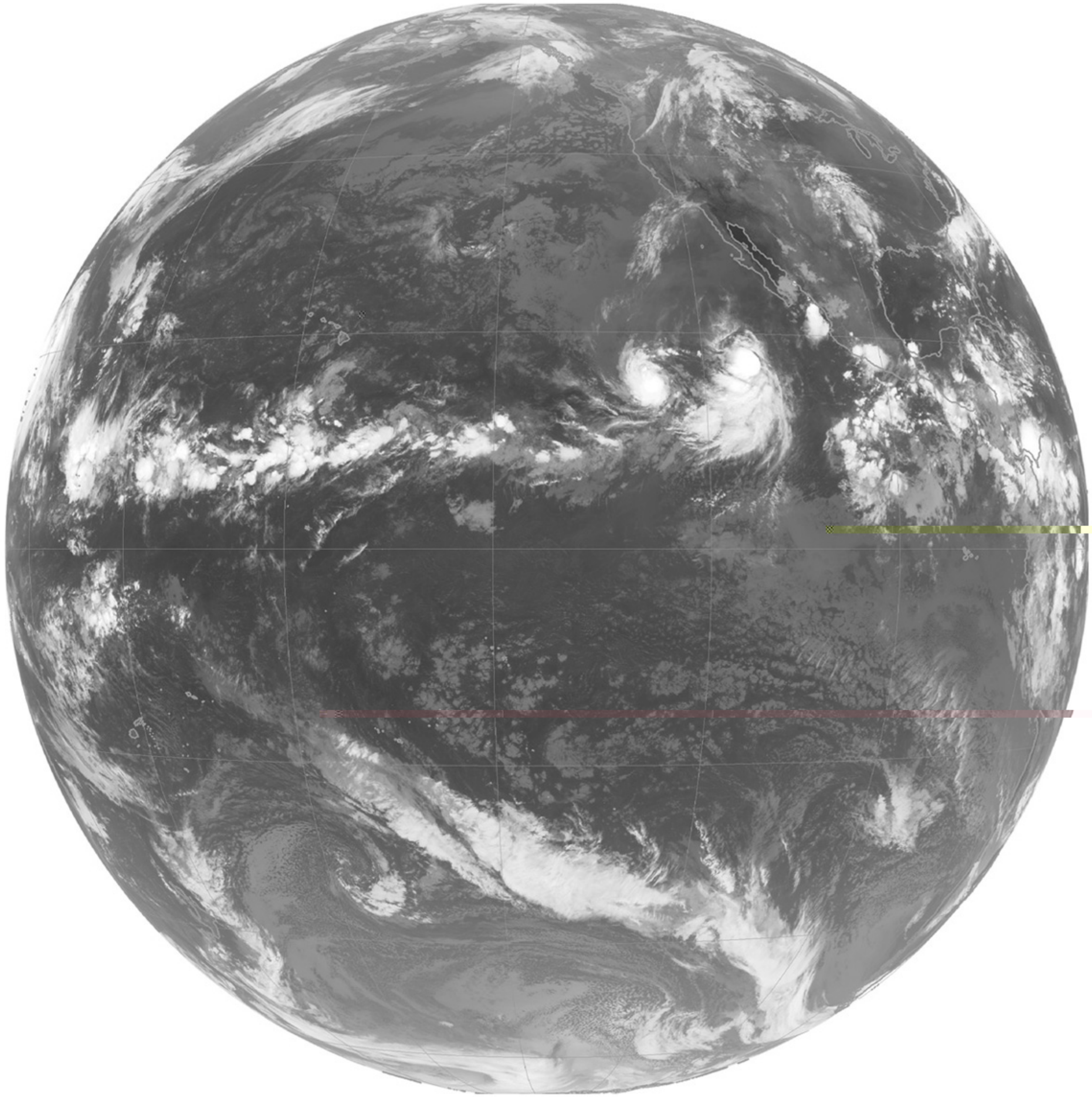
Choose the most complete, correct statements.

A. The ITCZ is associated with strong convection & precipitation;

B. The Hadley cell rises in the subtropics and sinks in the tropics;

C. The ITCZ is located in the subtropics and mid-latitudes;

D. Both A and B.



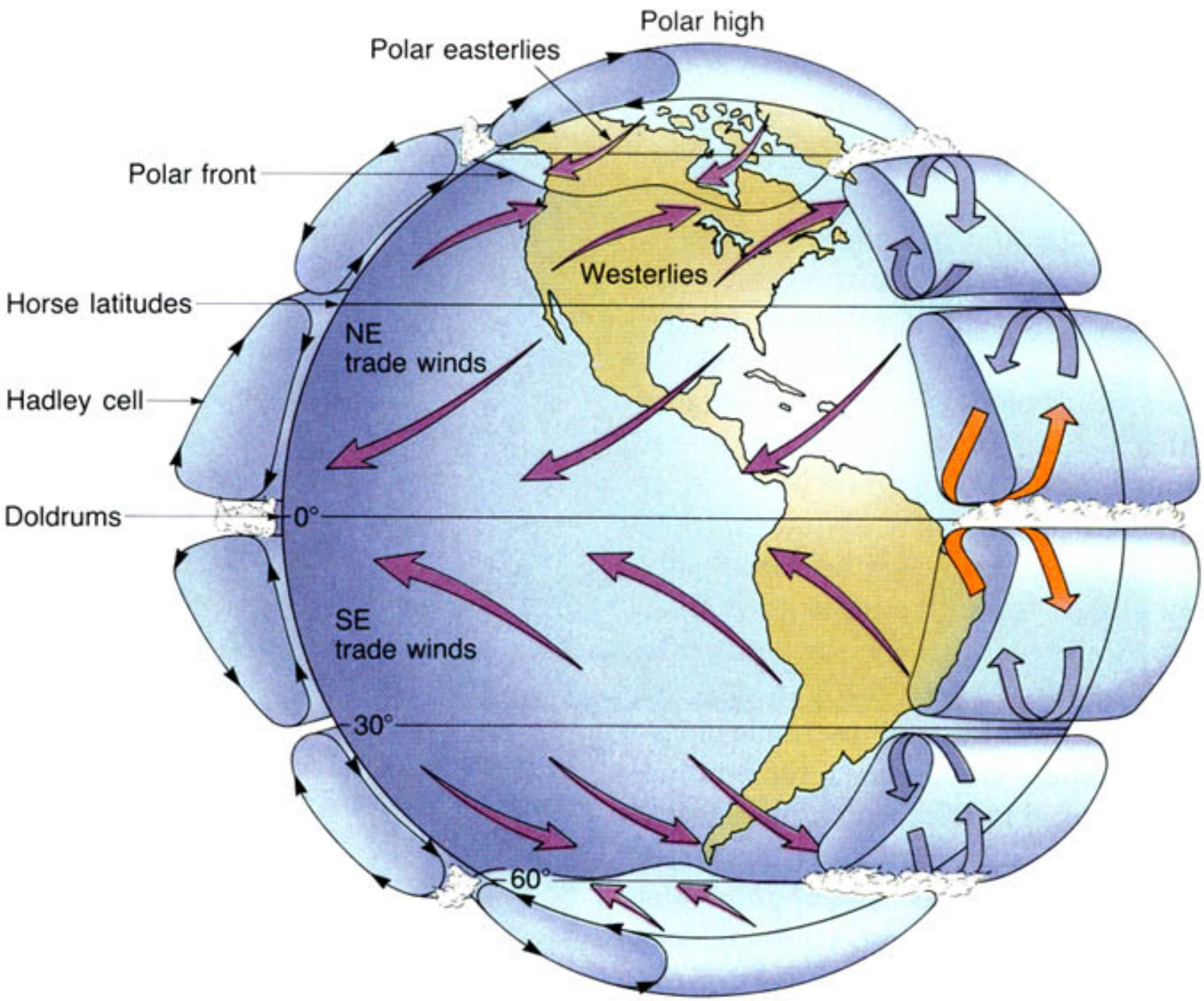


Figure 8•3 Idealized global circulation proposed for the three-cell circulation model.

Summary for: net radiation surplus in the tropics: