Topic # 13
Atmospheric Circulation

How the Energy Balance Drives It and How It Results in Global Climate Patterns

p 77-83 in Class Notes

but first . . . Some review!

The Earth
[as viewed from space]
. . . has the organized, self-contained look of a live creature, full of information, marvelously skilled in handling the sun.

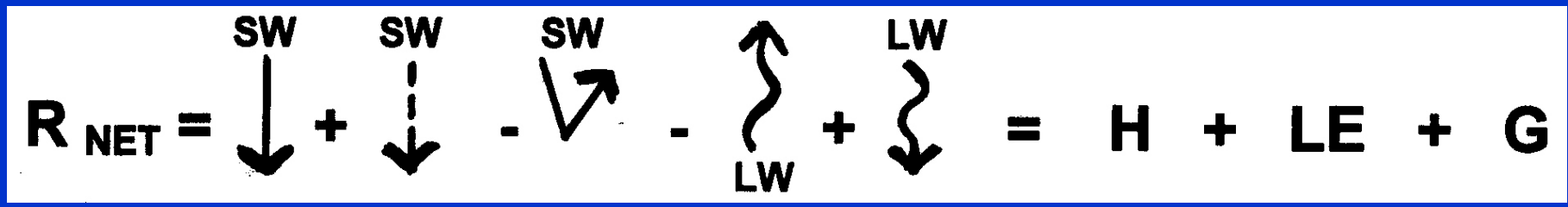
~ Lewis Thomas

OBJECTIVES:

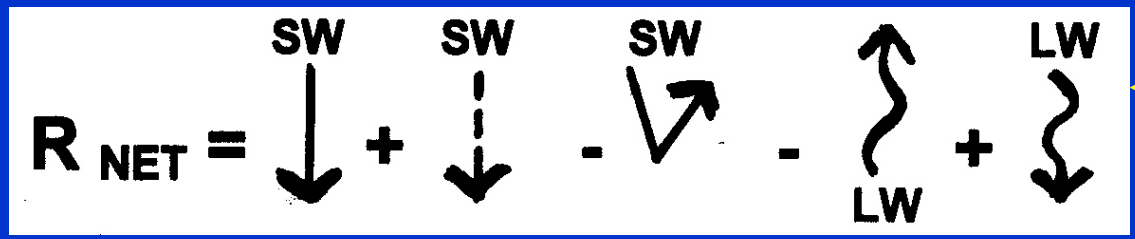
To understand how the Radiation/Energy Balance helps to drive global weather & climate

And learn a bit about how and why climates vary in different parts of the world.

RADIATION / ENERGY BALANCE



"Radiation Balance" part



All components are referring to electromagnetic radiation

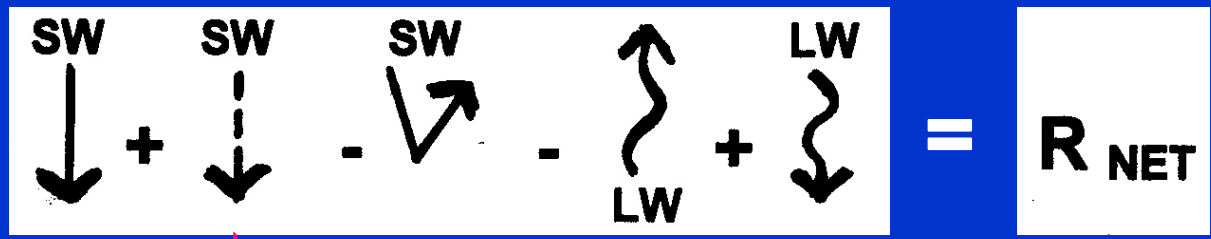
All components are referring to modes of heat energy transfer or heat energy storage <u>involving matter</u>

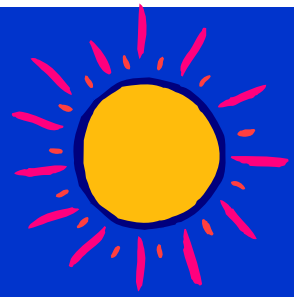
"Energy Balance" part

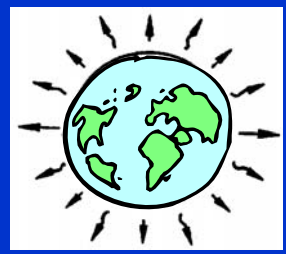
$$R_{NET} = H + LE + G$$

Start out here, with energy from the SUN radiated to Earth and so forth . . .

"Radiation Balance" part







The R_{NET} is then able to be used in thermal energy "heat transfer" processes which manifest themselves as weather & climate!

"Energy Balance" part

$$R_{NET} = H + LE + G$$

Thermal Energy Review

Heat **(def) = the thermal energy that is *transferred* from one body to another because of a temperature difference.**

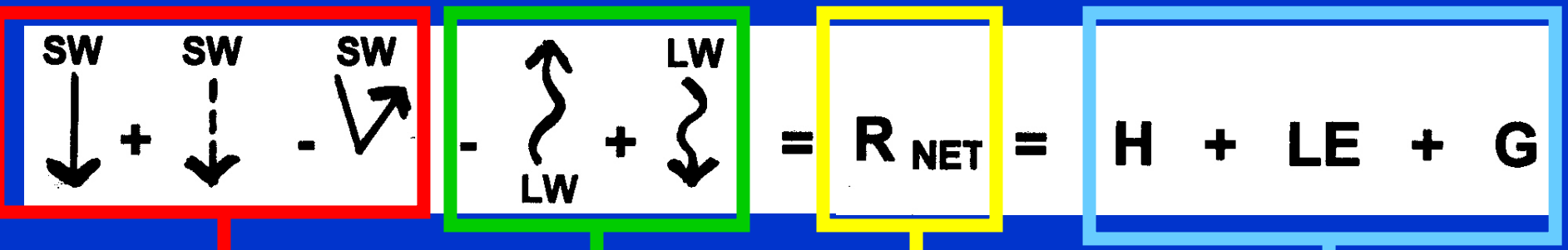
- **Sensible Heat transfer (H)**
- **Latent Heat transfer (LE)**

plus (after transfer) thermal energy can be STORED (G)

H + LE + G

Review

ENERGY IN THE EARTH-ATMOSPHERE SYSTEM



Ultimate source of energy is the SUN (SW)

After absorption of SW, LW energy is radiated in & out by EARTH & Atmosphere

Any NET (leftover) energy

Goes into the HEAT TRANSFER processes that drive climate

LINKING THE ENERGY BALANCE TO ATMOSPHERIC CIRCULATION . . .

We'll start with the SUN (SOLAR INSOLATION)

IN – SOL- ATION =

Amount of incoming solar energy received by a point on Earth's surface

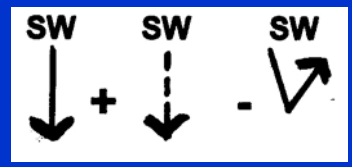
Take Notes on p 76

Recall quote on p 77 . . .

How <u>does</u> the Earth

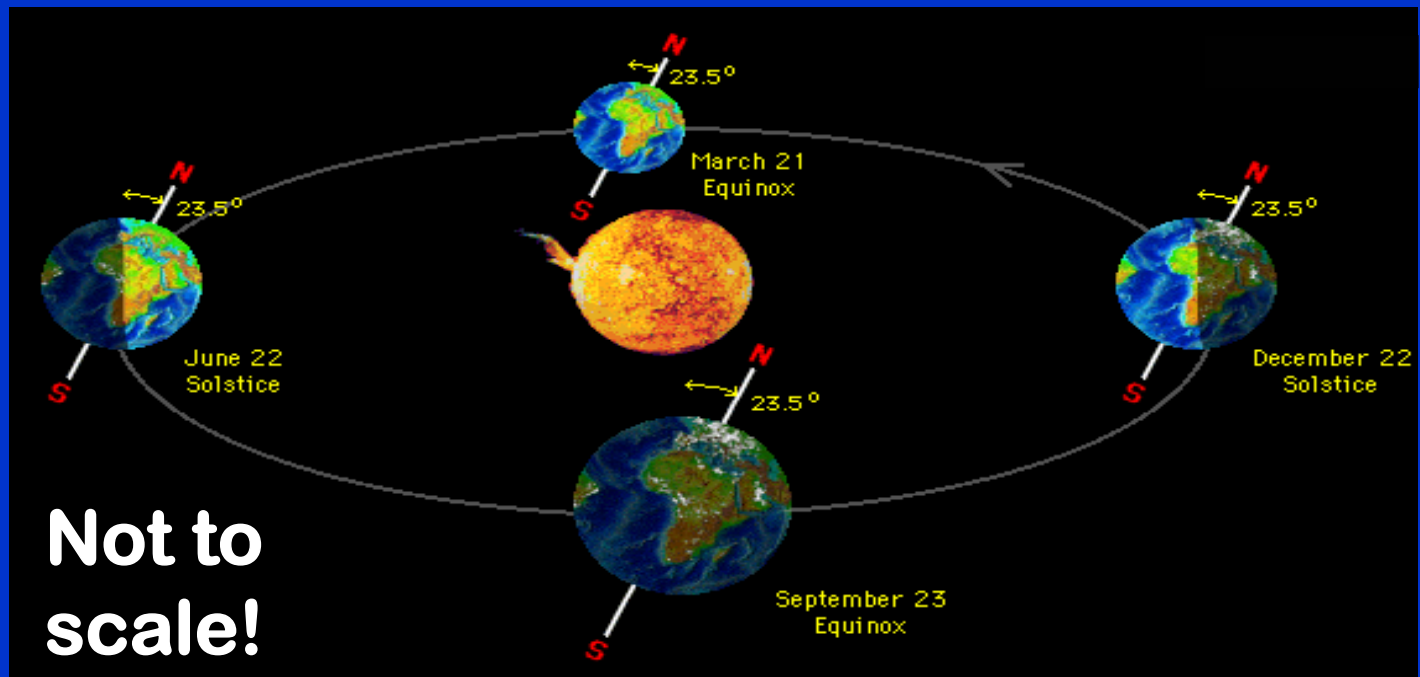
"HANDLE" THE SUN ????

To drive the circulation, the initial source of energy is from the Sun:



Seasonal & latitudinal variations of solar insolation: 3 Principles →

http://mesoscale.agron.iastate.edu/agron206/animations/01_EarthSun.html



Seasonal & latitudinal variations of solar insolation:

3 Principles of EARTH-SUN RELATIONSHIPS

(They define the SEASONS in different latitudes!)

#1 OBLIQUITY OF EARTH'S AXIS

#2 ECCENTRICITY OF EARTH'S ORBIT

 # 3 Timing of Seasons in Relation to Orbit:

Take Notes on p 76

Seasonal & latitudinal variations of solar insolation:

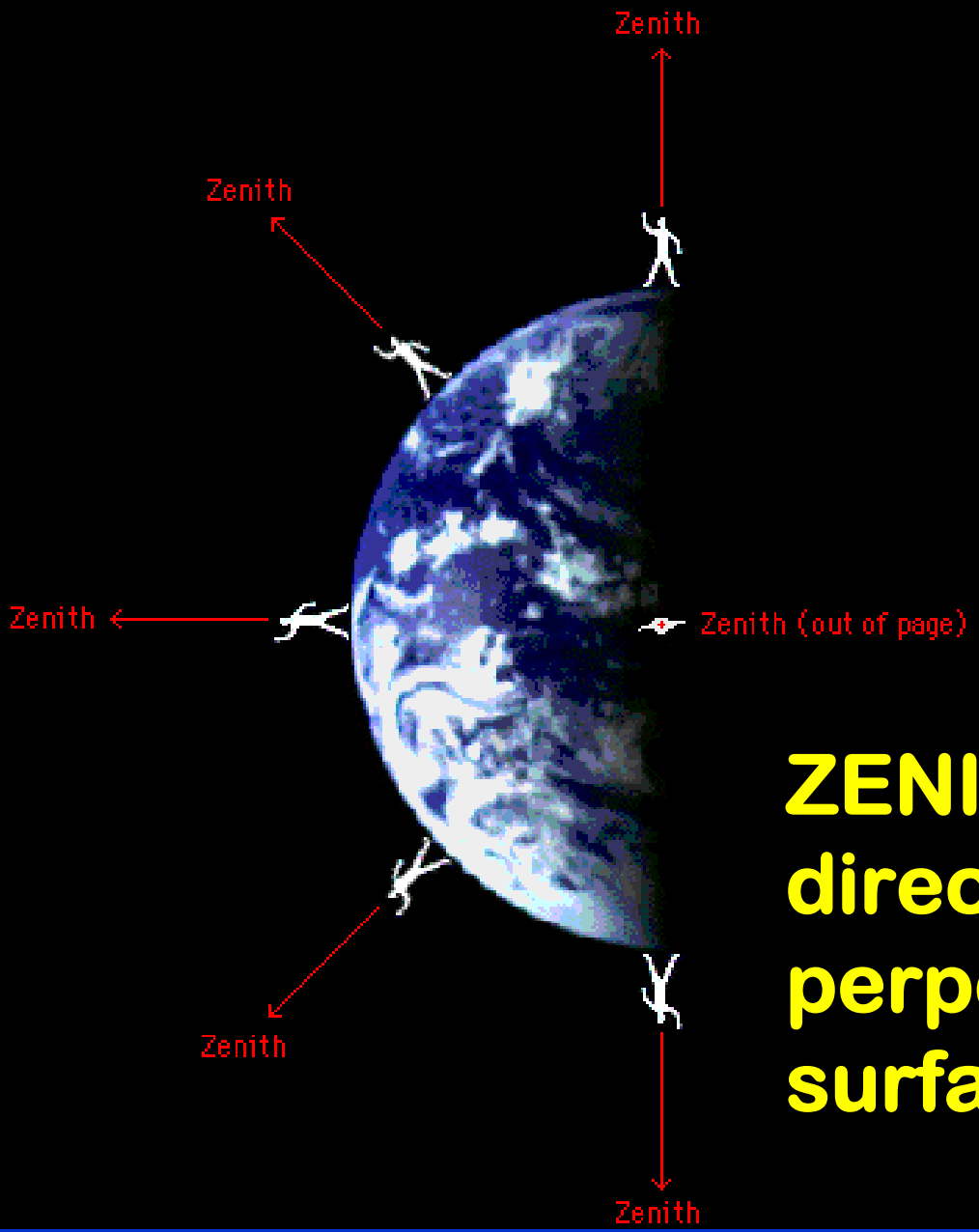
PLUS -- 2 factors that determine the AMOUNT OF SOLAR INSOLATION *as seasons progress:*

(1) **INTENSITY** of sun's rays

(perpendicular = more intense)

(2) **DURATION** of daily insolation

(longer day length = more insolation)

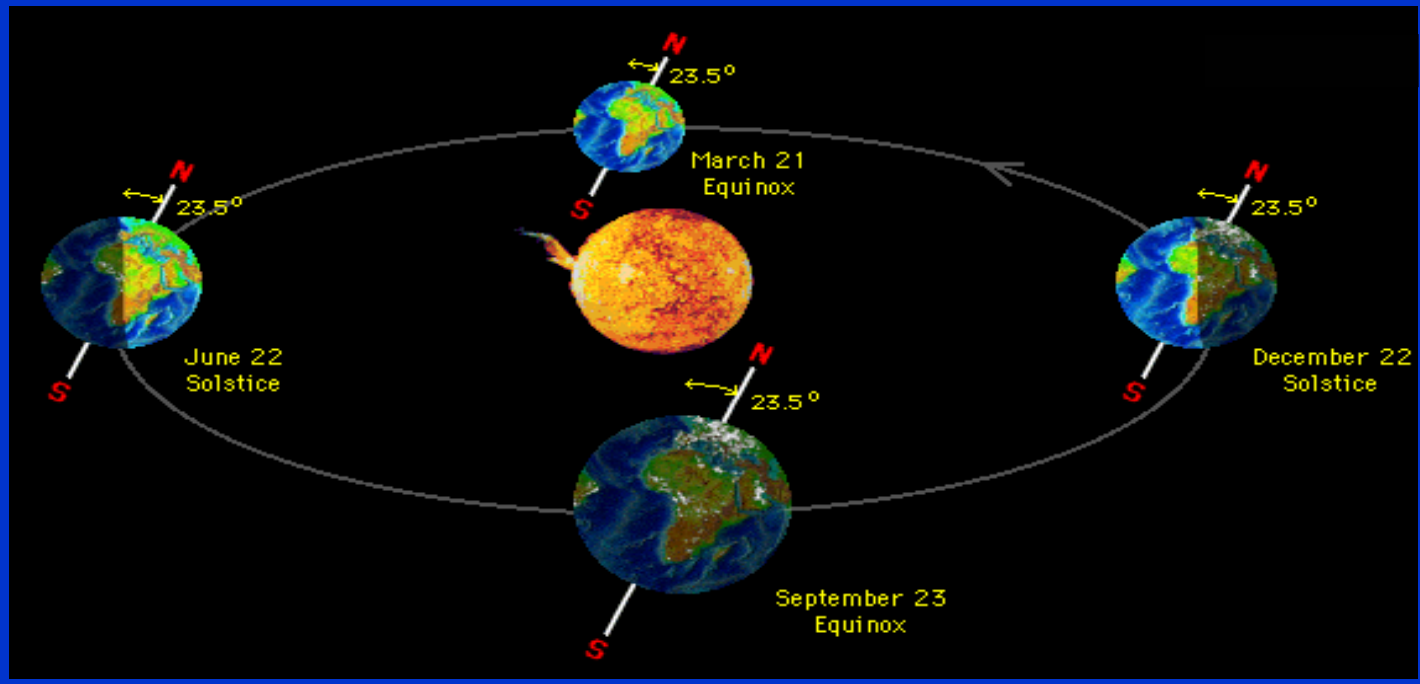


Since the zenith at any place on the earth is the point directly overhead (90° from all horizons), at each place on the earth it points in a different direction into space.

ZENITH – the point directly overhead & perpendicular to the surface

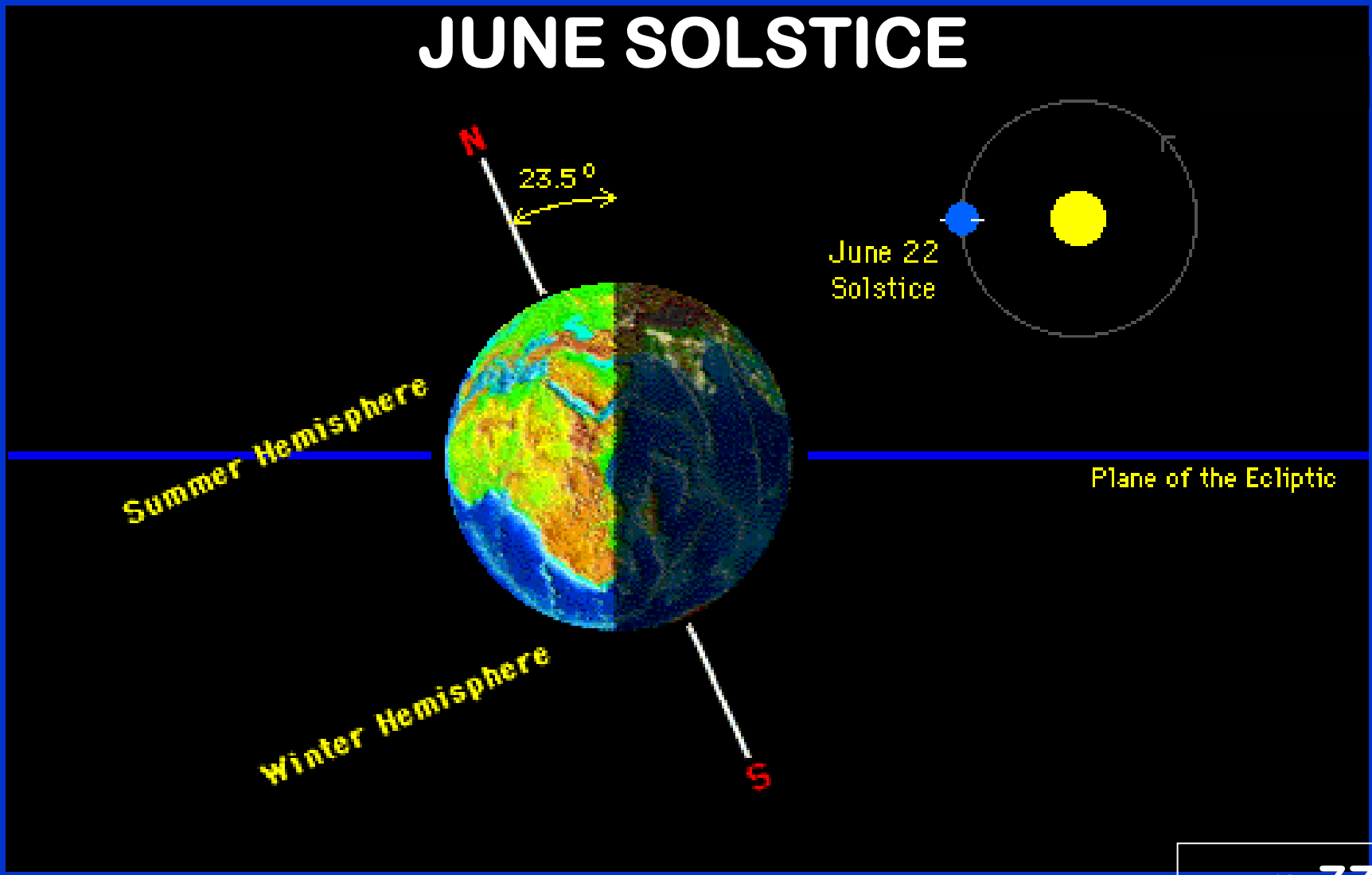
EARTH-SUN RELATIONSHIPS & The SEASONS:

http://mesoscale.agron.iastate.edu/agron206/animations/01_EarthSun.html



#1 OBLIQUITY OF EARTH'S AXIS

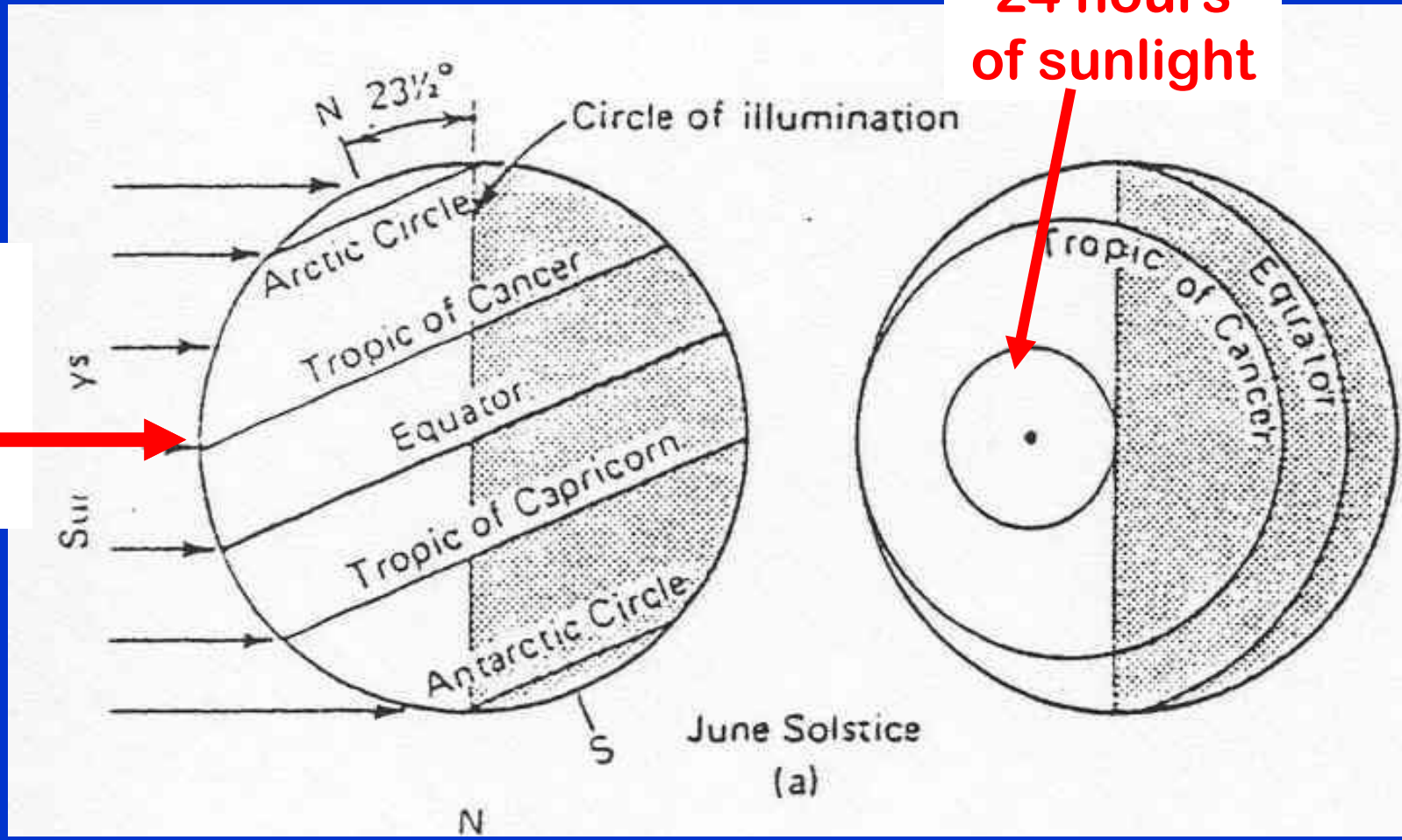
(axis "tilts" 23.5 degrees from plane of ecliptic)



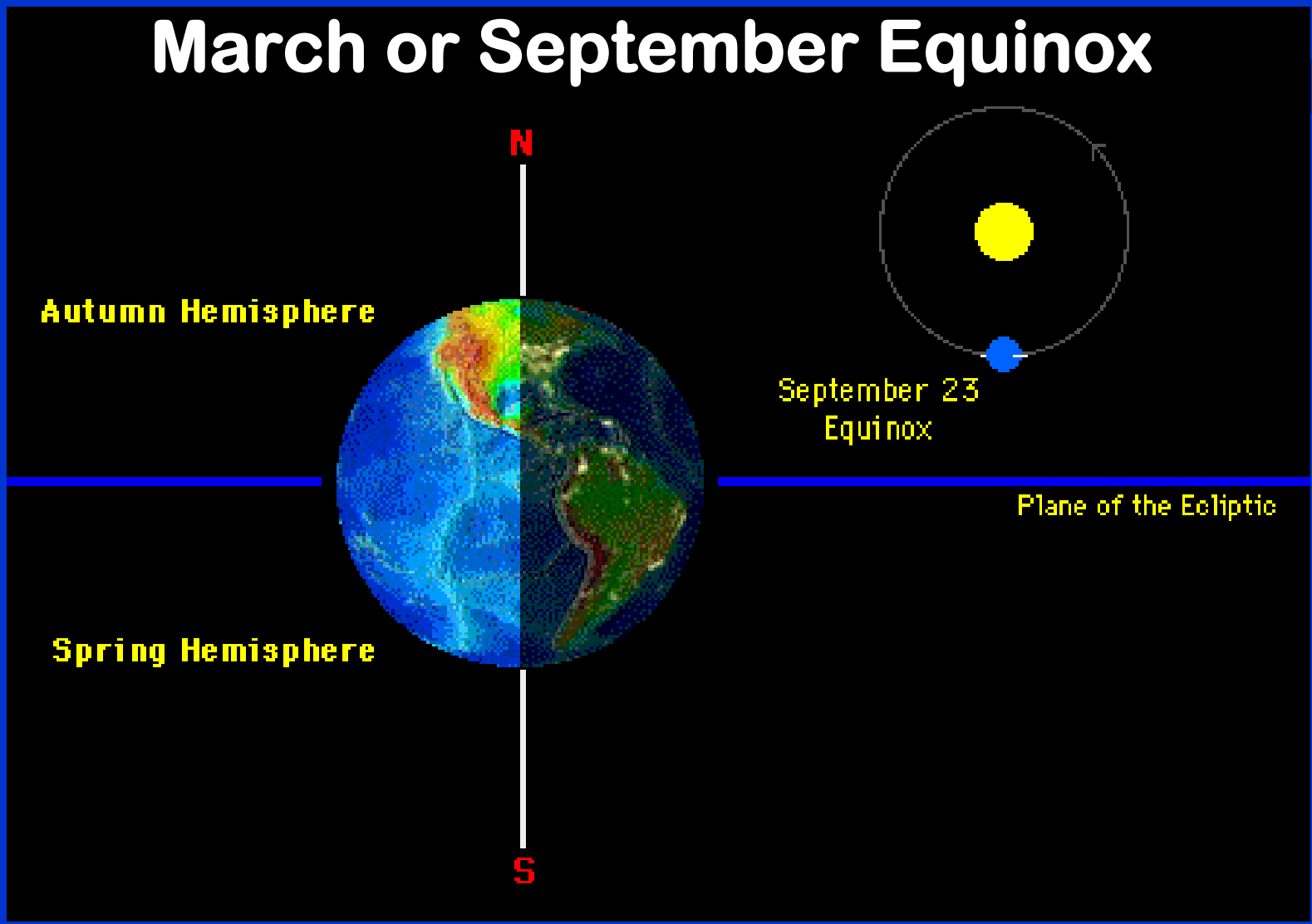
JUNE SOLSTICE

24 hours of sunlight

Most intense solar radiation



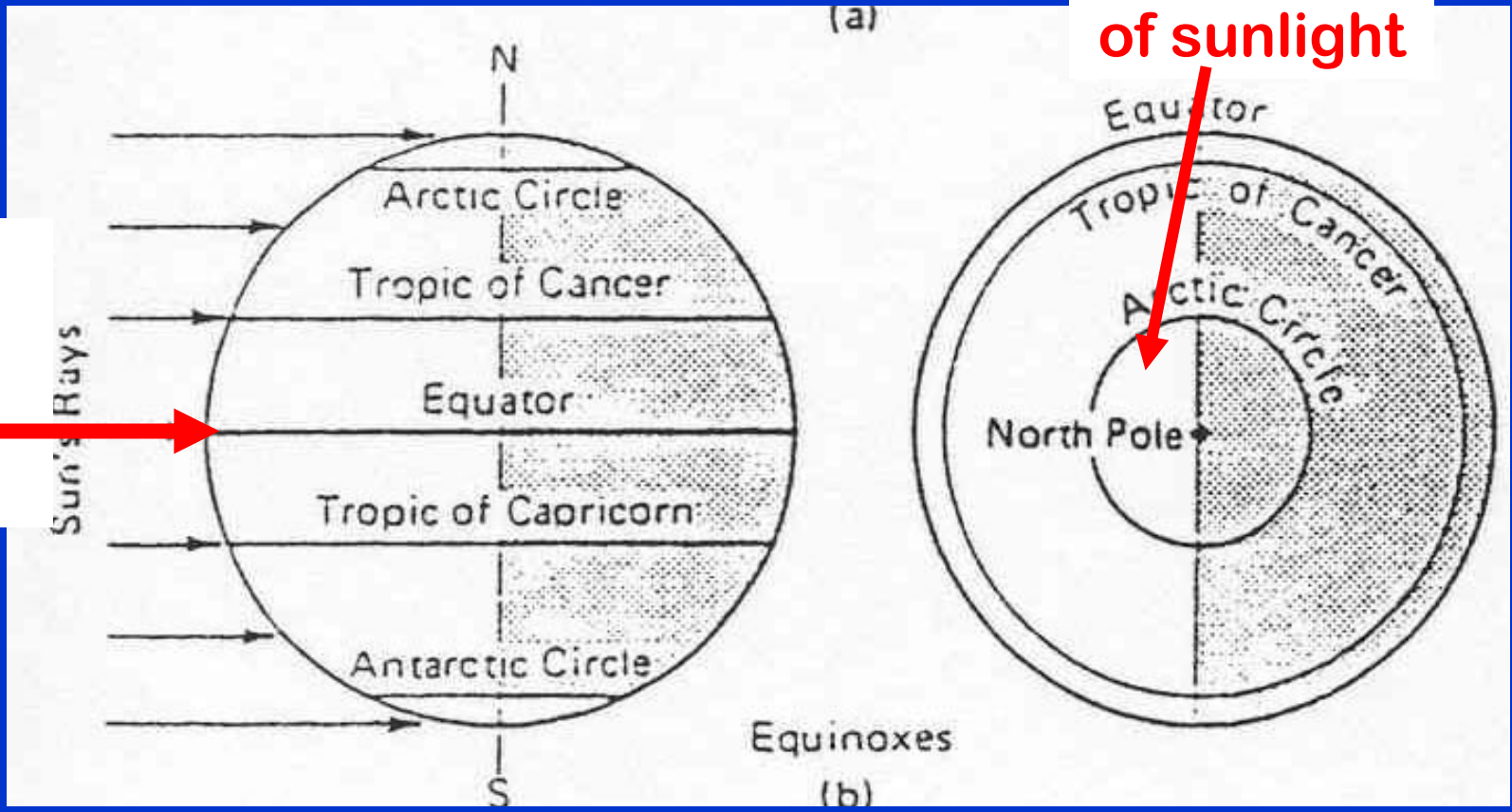
March or September Equinox



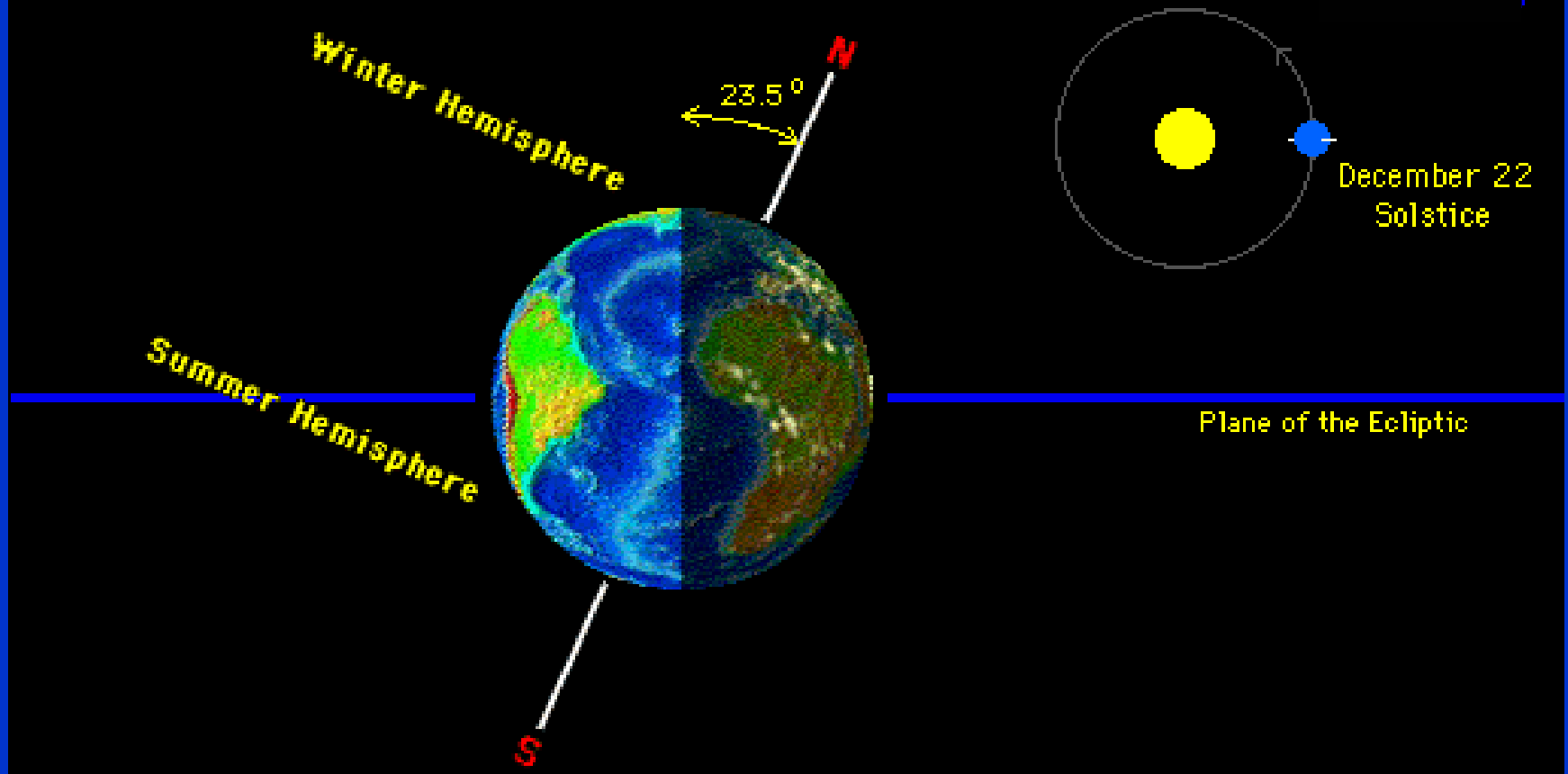
MARCH & SEPTEMEBER EQUINOXES

12 hours of sunlight

Most intense solar radiation



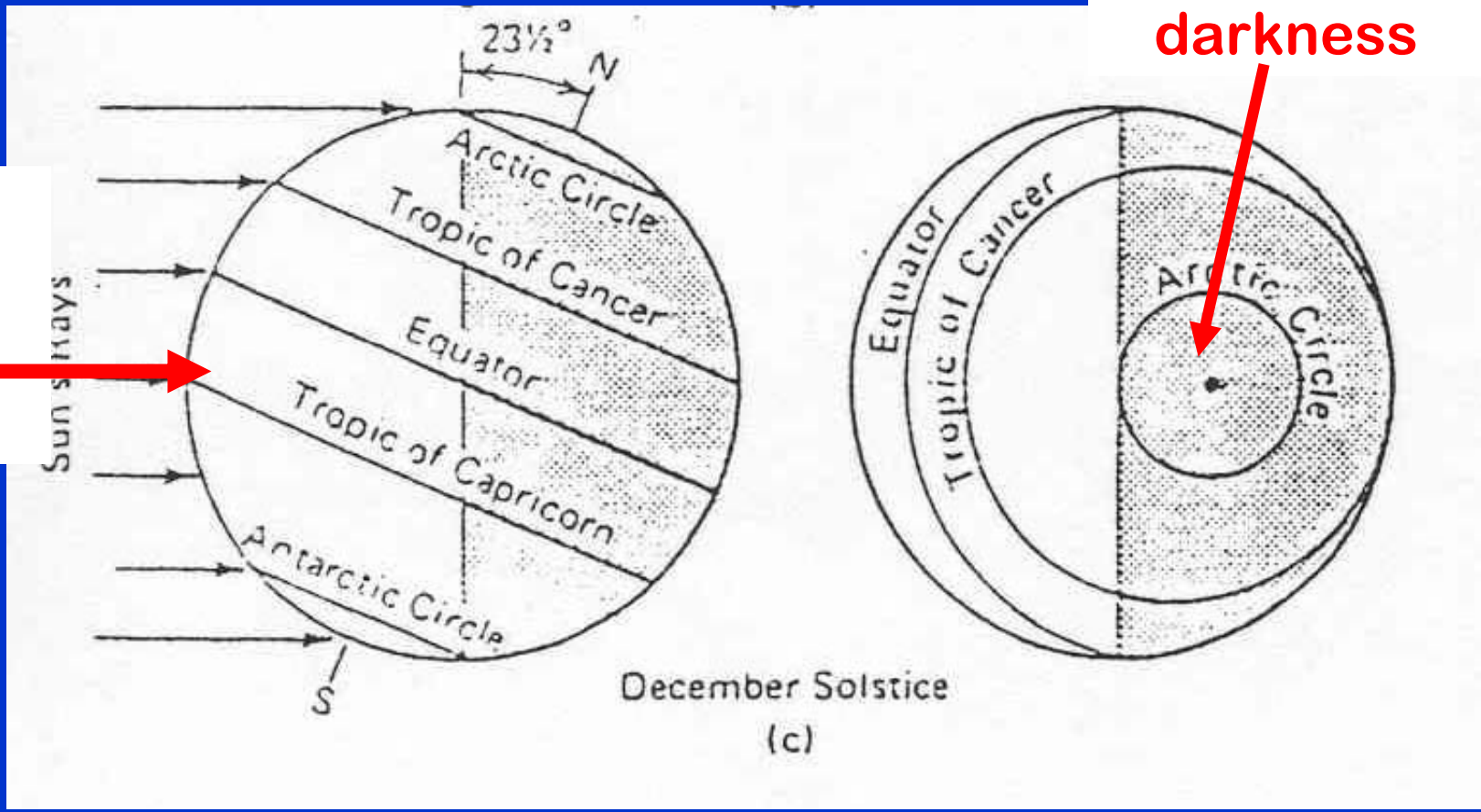
DECEMBER SOLSTICE



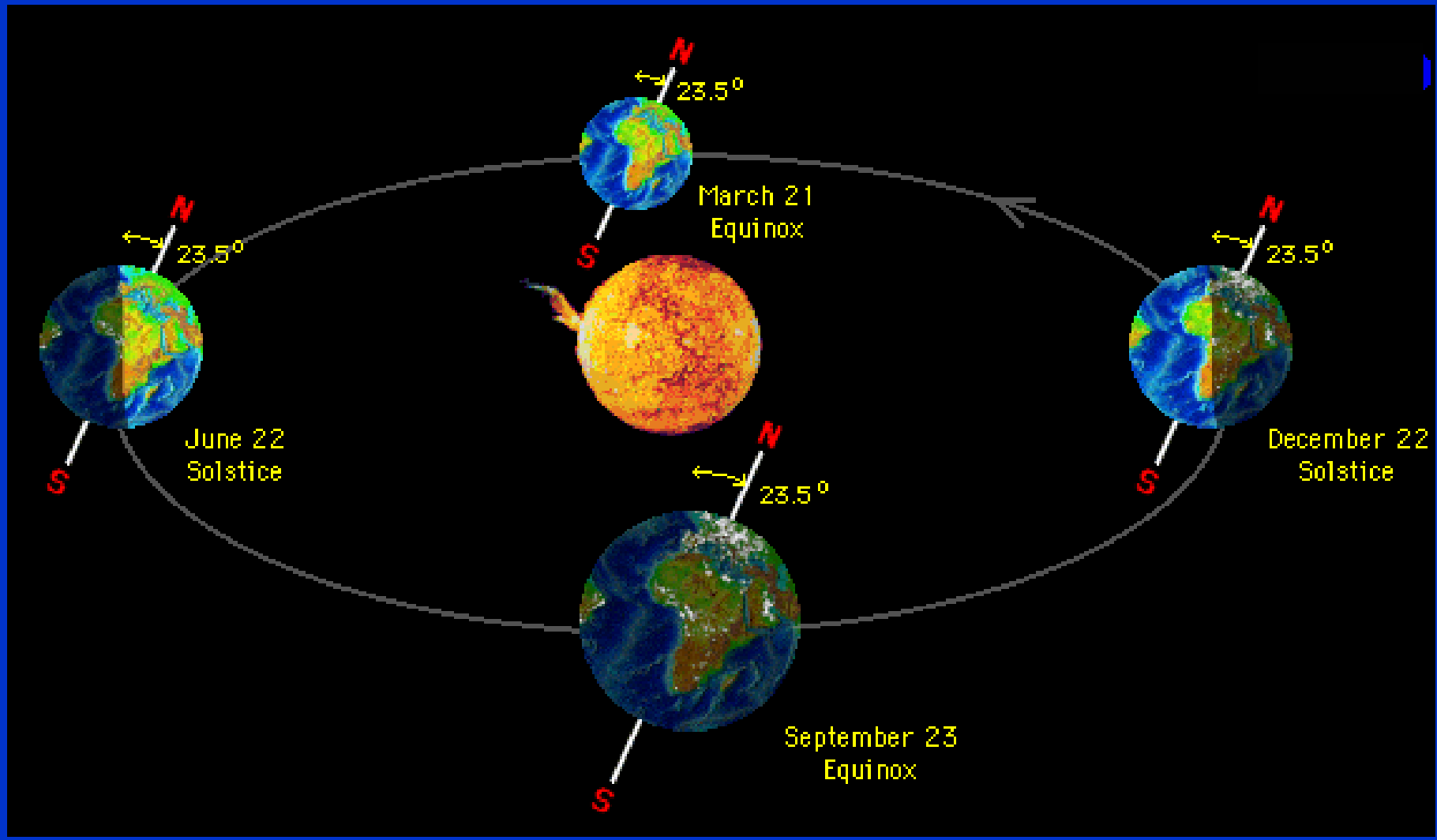
DECEMBER SOLSTICE

24 hours of darkness

Most intense solar radiation



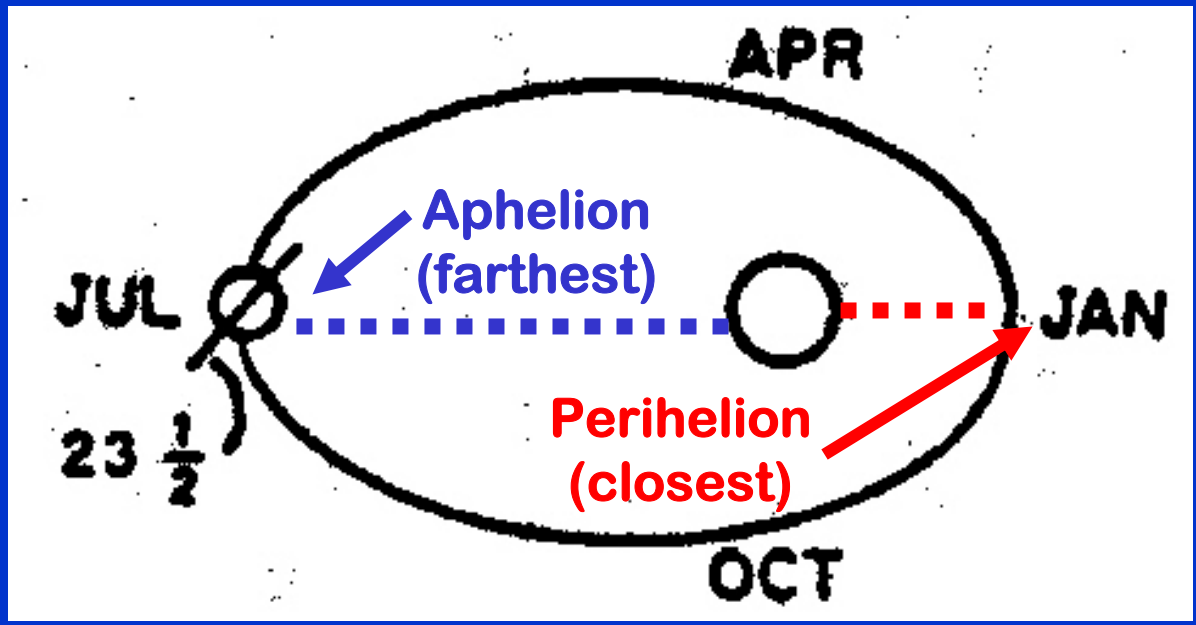
http://mesoscale.agron.iastate.edu/agron206/animations/01_EarthSun.html



Recap

#2 ECCENTRICITY OF ORBIT

Earth's orbit around sun is not symmetrical: "ellipse"



3 Timing of Seasons in Relation to Orbit: PRECESSION OF THE EQUINOXES

(Earth currently is closest to the Sun in January
– just after the Dec Solstice; but this has changed in the past)

Take Notes on p 76

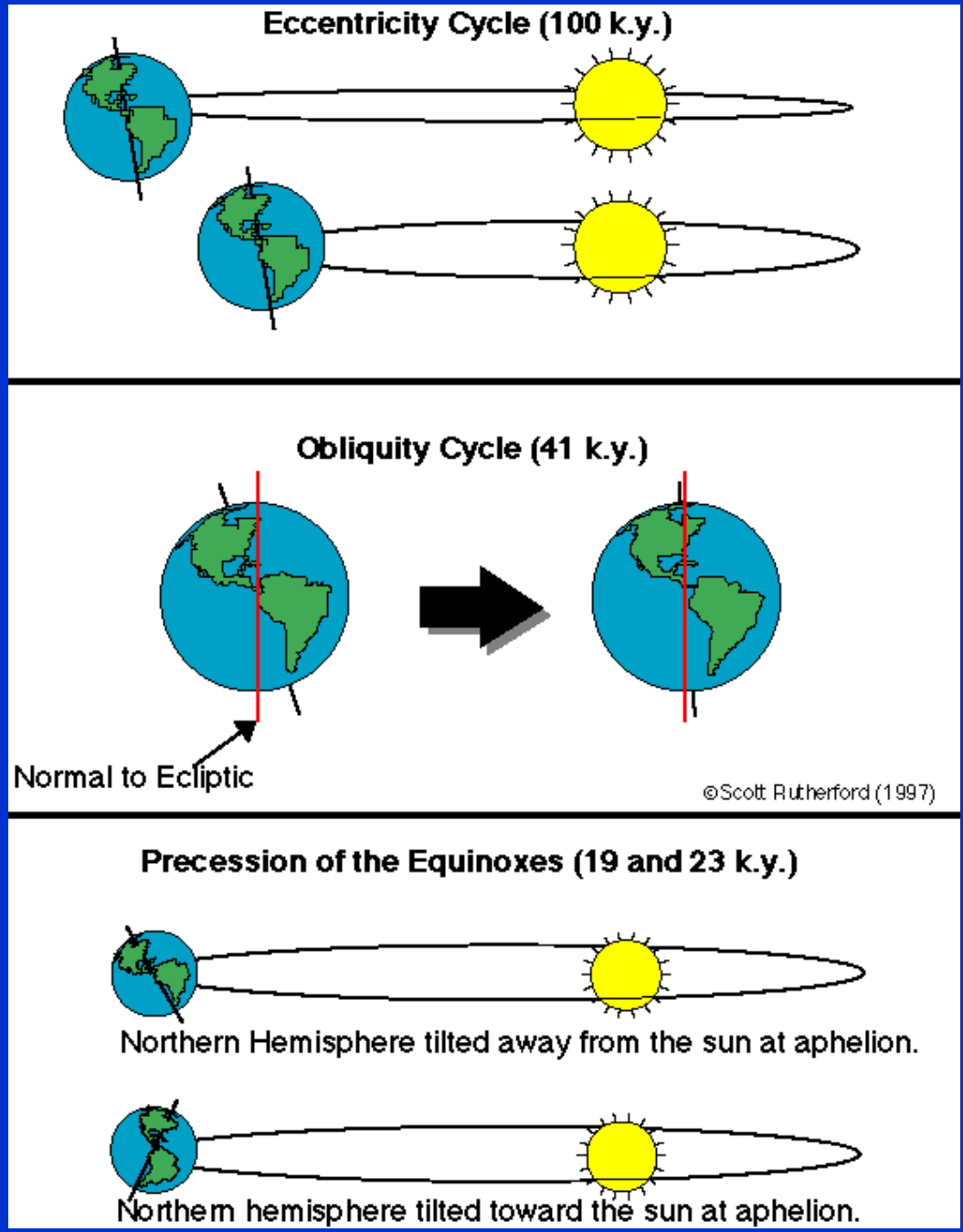
Obliquity

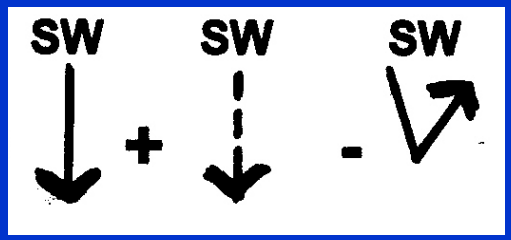
Eccentricity

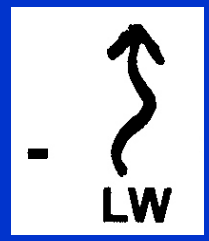
Precession

. . have all CHANGED over the past 100,000 years!!

IGC CD MODULE SELECT
➔"Weather in Motion" – Ch 16 Orbital Variations



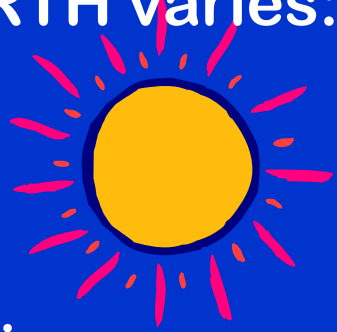




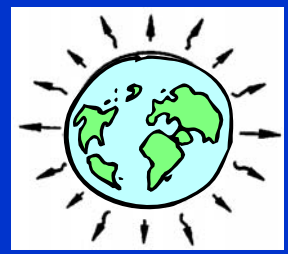
KEY CONCEPT:

The amount of SW absorbed by EARTH varies:

- by LATITUDE
- by SEASON

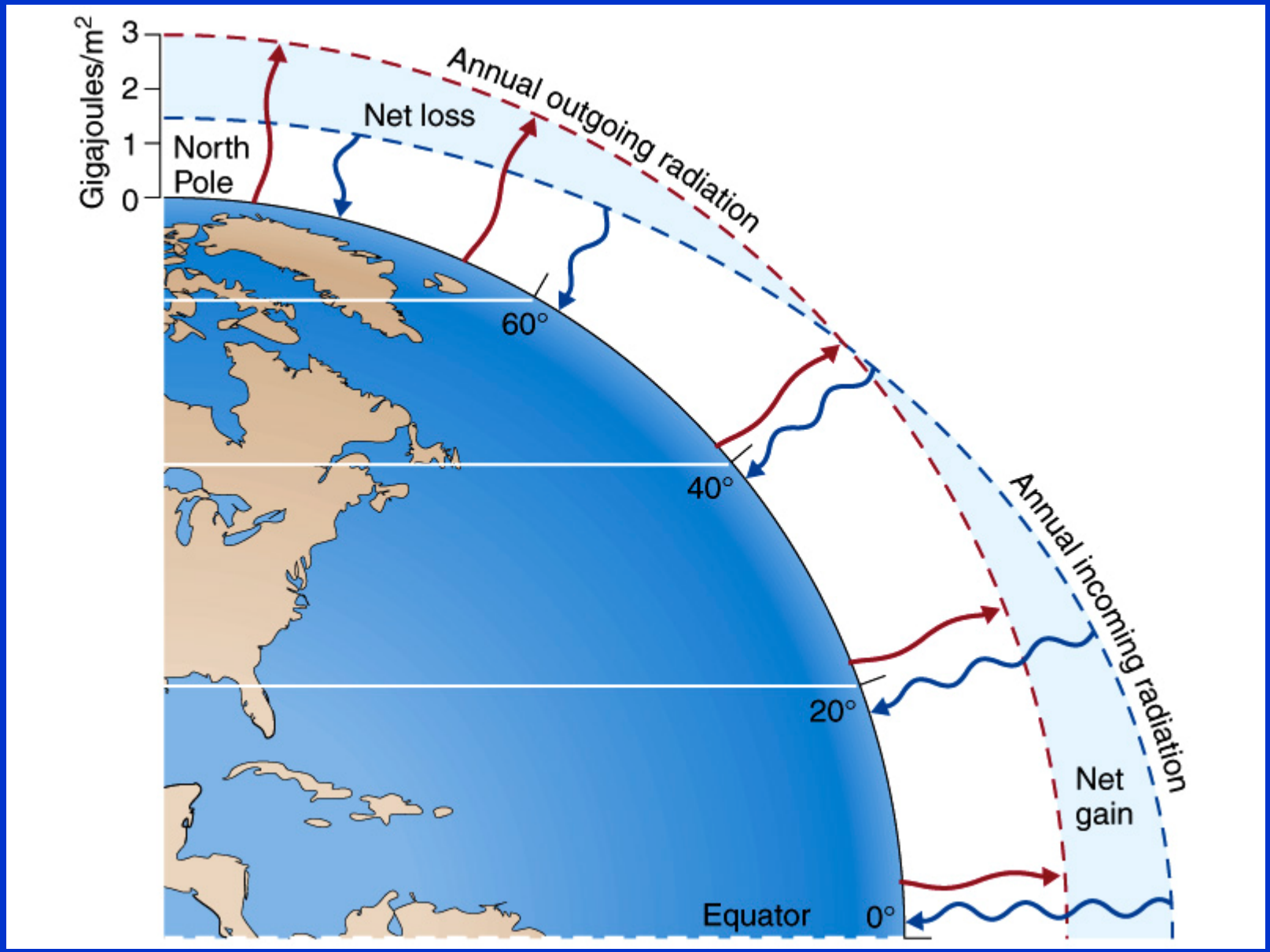


Annually, MORE is absorbed in the LOW LATITUDES (near Equator) than in the HIGH LATITUDES (near Poles)

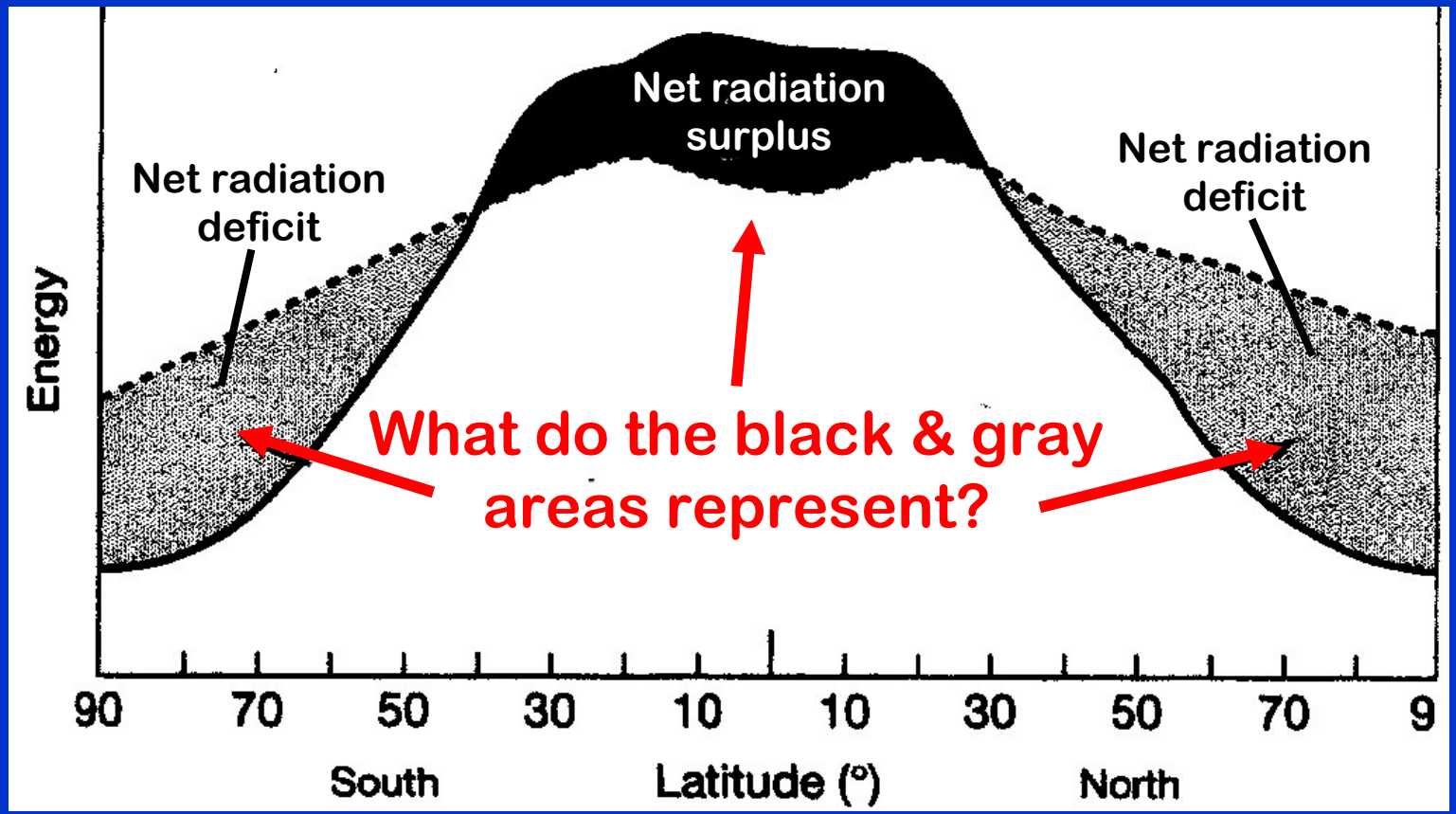


The EARTH radiates out LW fairly evenly from latitude to latitude, but MORE LW energy is radiated out in warm Equatorial latitudes & LESS in cold Polar latitudes

Remember? $E = \sigma T^4$



This Figure is on p 80



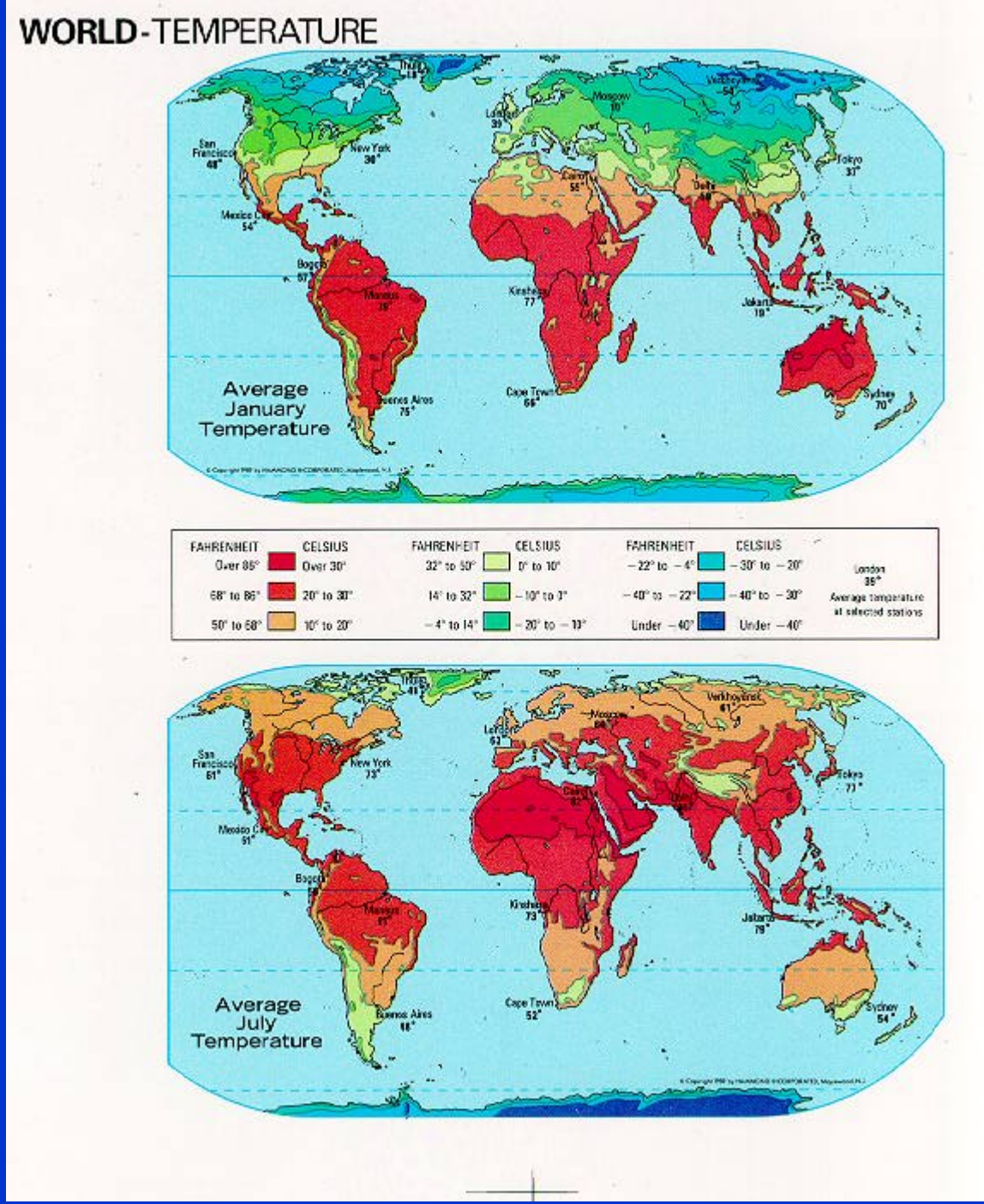
Absorbed solar energy

SW + SW - SW

Emitted infrared energy

(at top of atmosphere)

- LW

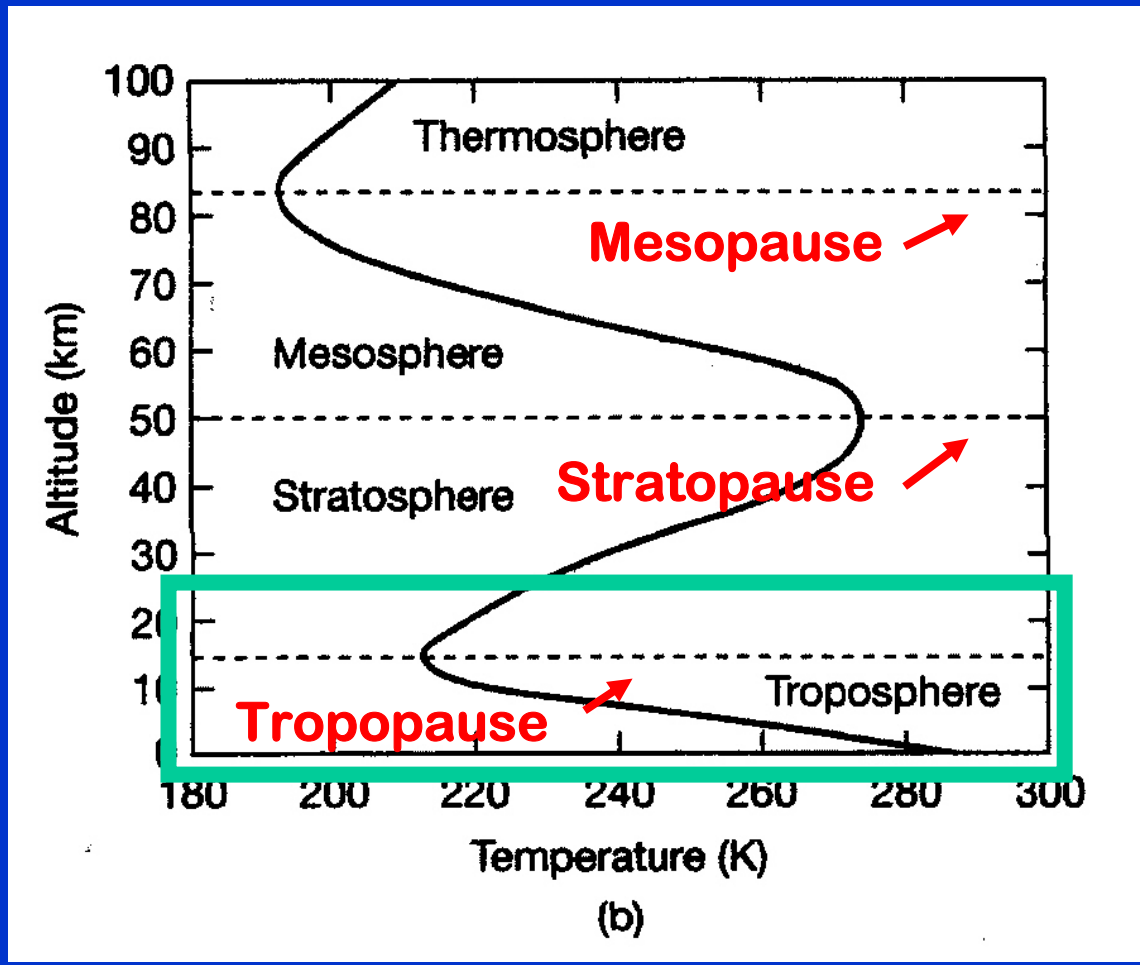


IGC CD MODULE SELECT
➔"Weather in Motion" – Ch 2 January & July 1999 Global Movie of Land & Sea Surface Temperatures & Clouds

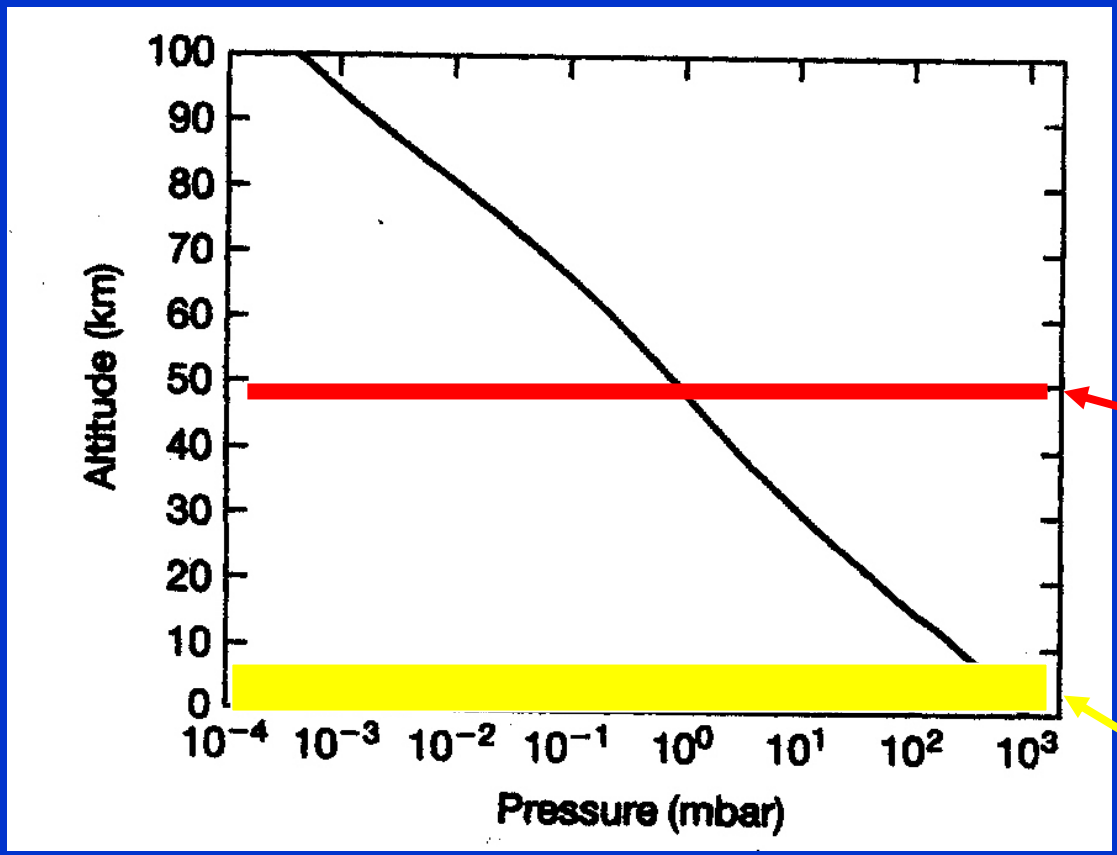
Recall: Vertical Structure of the Atmosphere

defined by ***CHANGES*** *in* ***TEMPERATURE*** *with height.*

MOST WEATHER & CLIMATE PROCESSES take place in the TROPOSPHERE (& some in Stratosphere)



ATMOSPHERIC PRESSURE



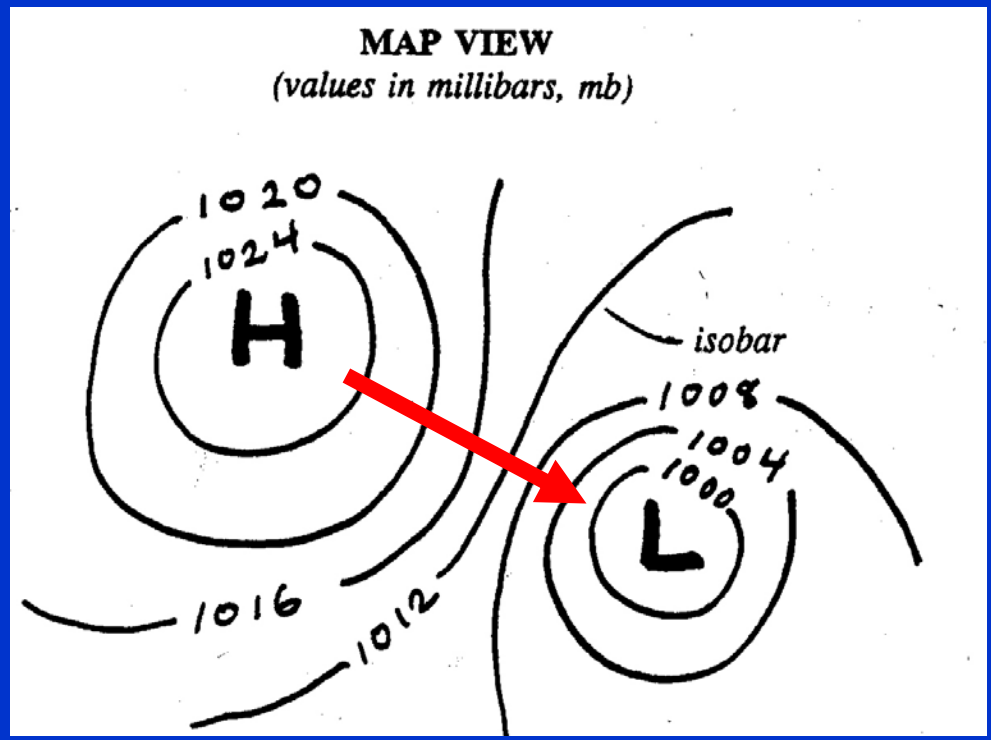
Def: the weight of the air above a given point or level.

Atmospheric Pressure & Mass Vary with Height

99% of mass lies below ~ 50 km (top of Stratosphere)

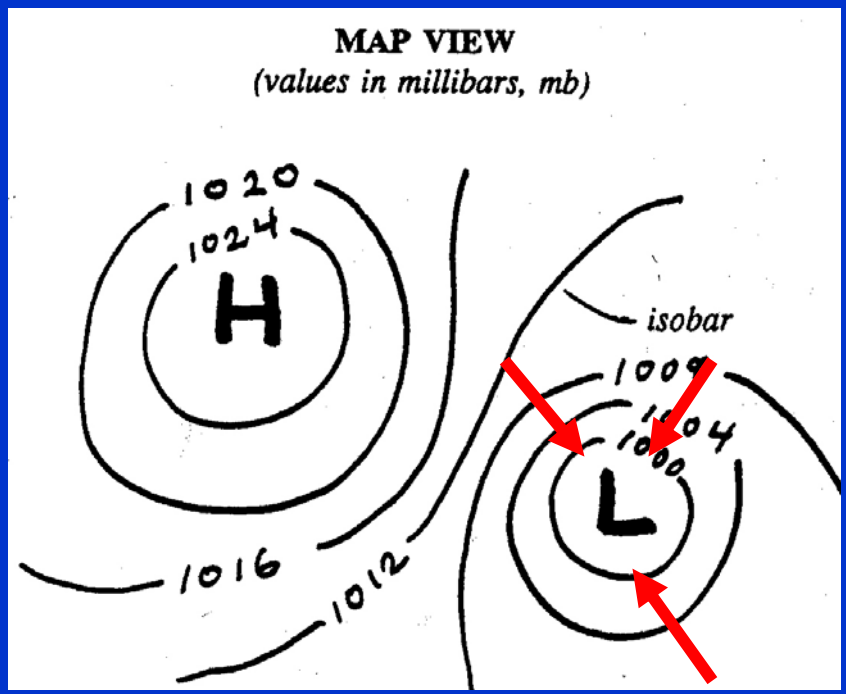
50% of mass lies below ~ 6 km (middle Troposphere)

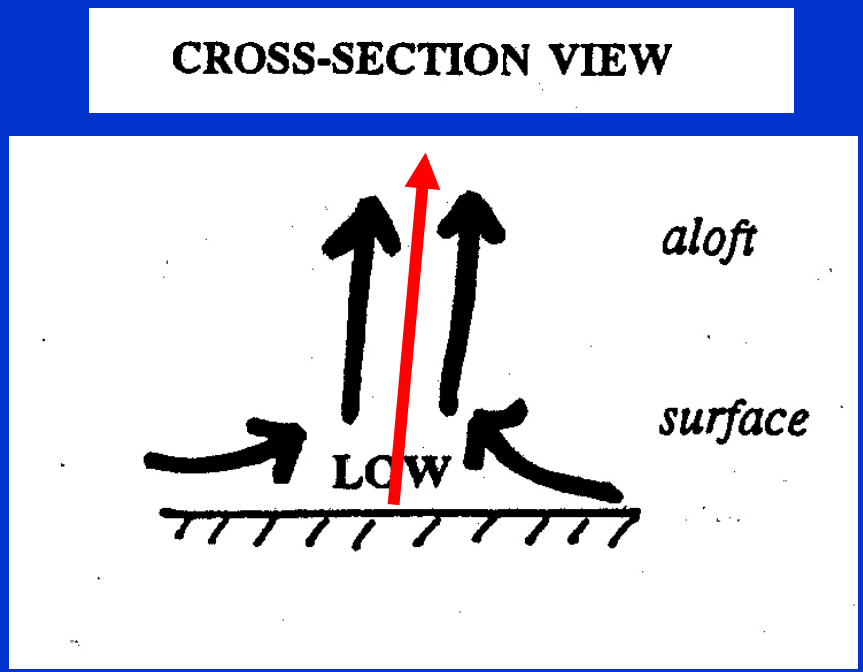
In general: Winds tend to flow from HIGH ➔ LOW Pressure areas



Areas or centers of high and low pressure at the Earth's surface have the following characteristics:

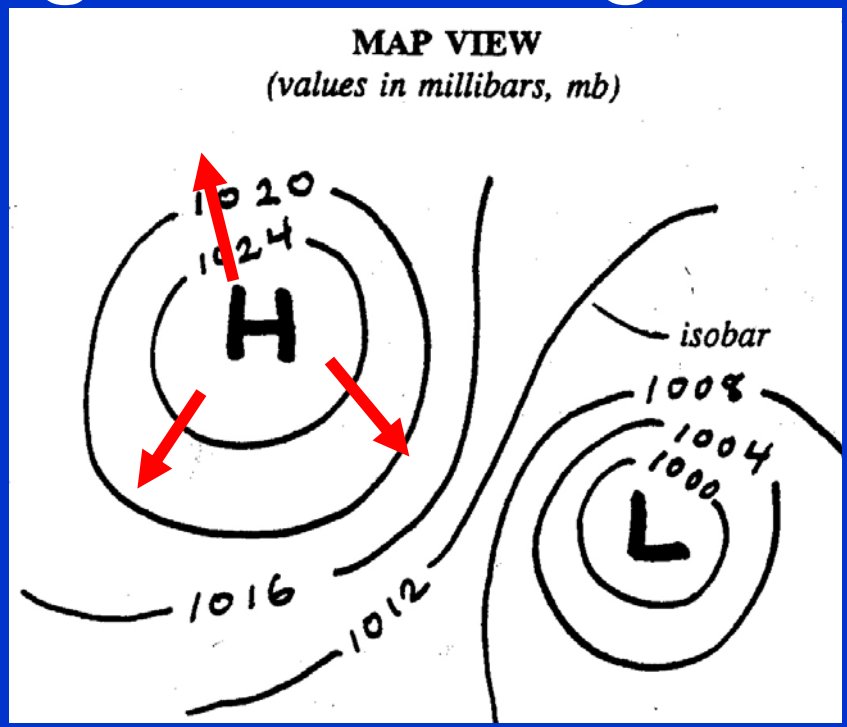
LOWS - air converges into lows and rises in the center of lows

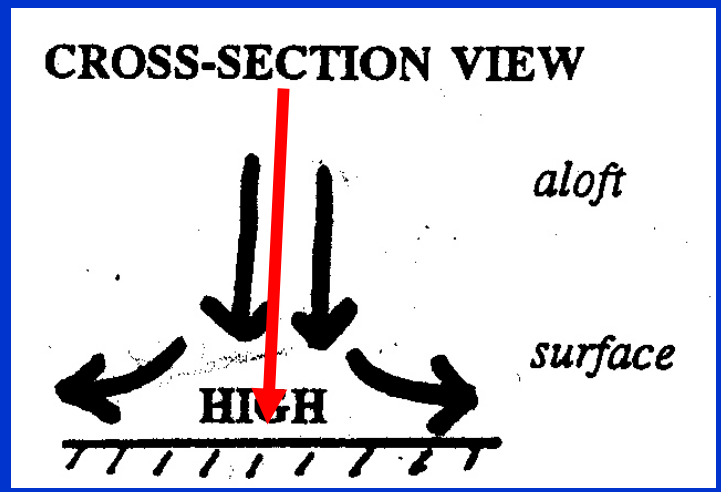




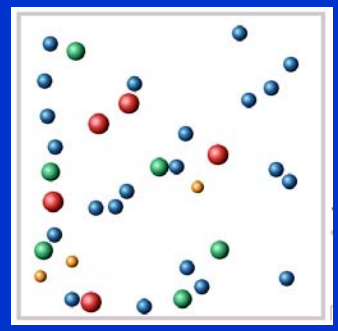
Areas or centers of high and low pressure at the Earth's surface have the following characteristics:

HIGHS - air subsides in the center of highs and diverges out of highs

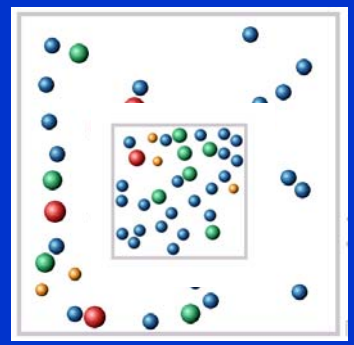


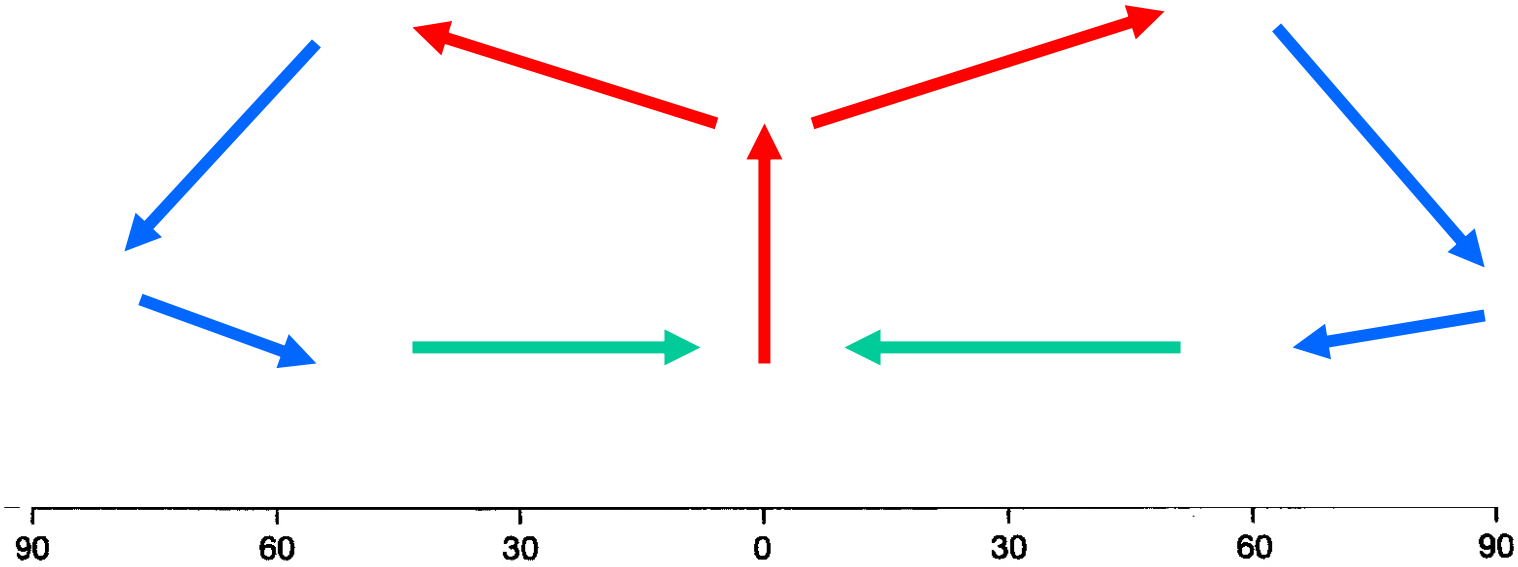


LOWS: (rising leads to **expansion and cooling** of air, and condensation of water vapor ==> clouds and possibly precipitation)



HIGHS: (sinking leads to **contraction and warming of air**, and increased water vapor holding capacity ==> clear skies, dry air)





Northern Hemisphere

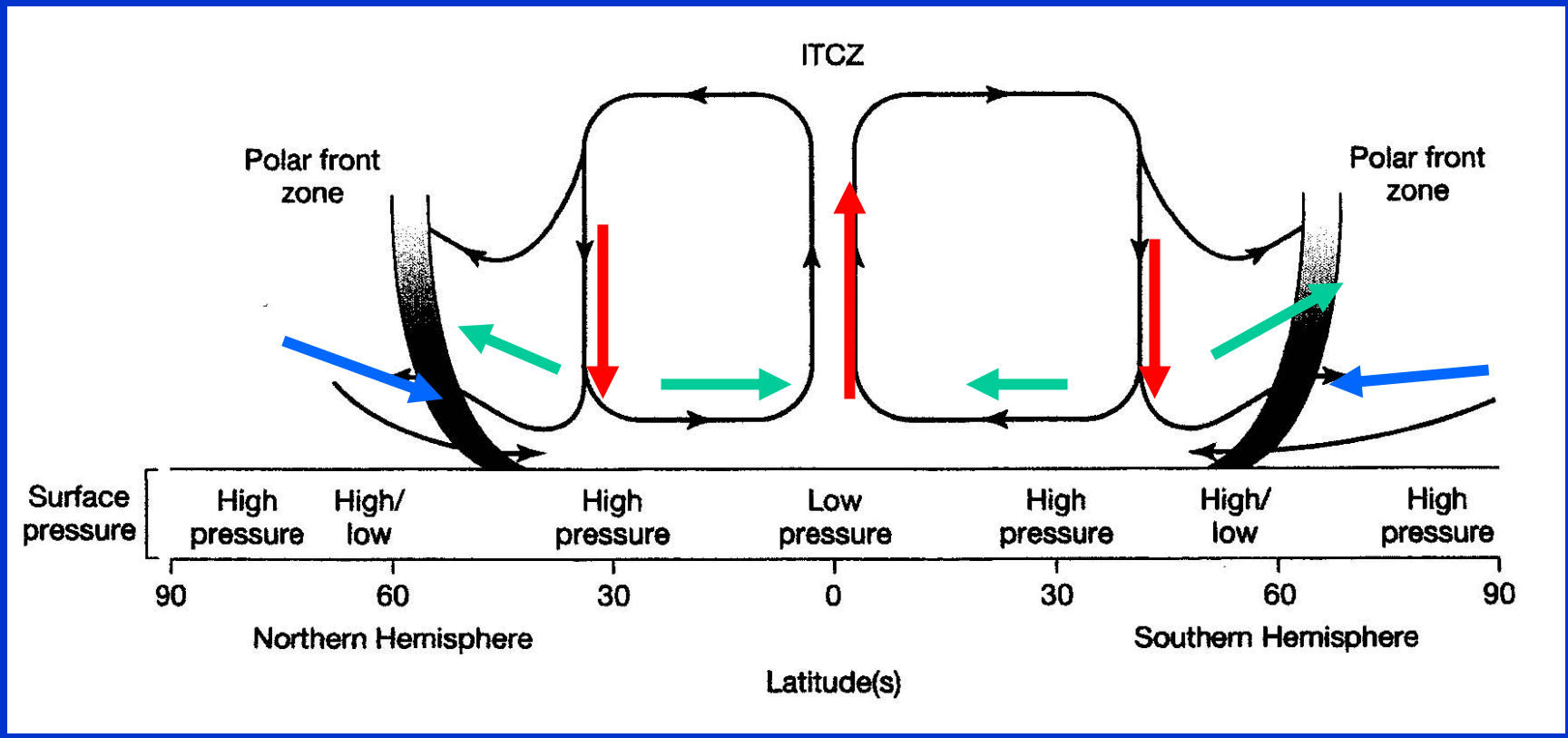
EQUATOR

Southern Hemisphere

COLD POLAR REGIONS

HOT TROPICS

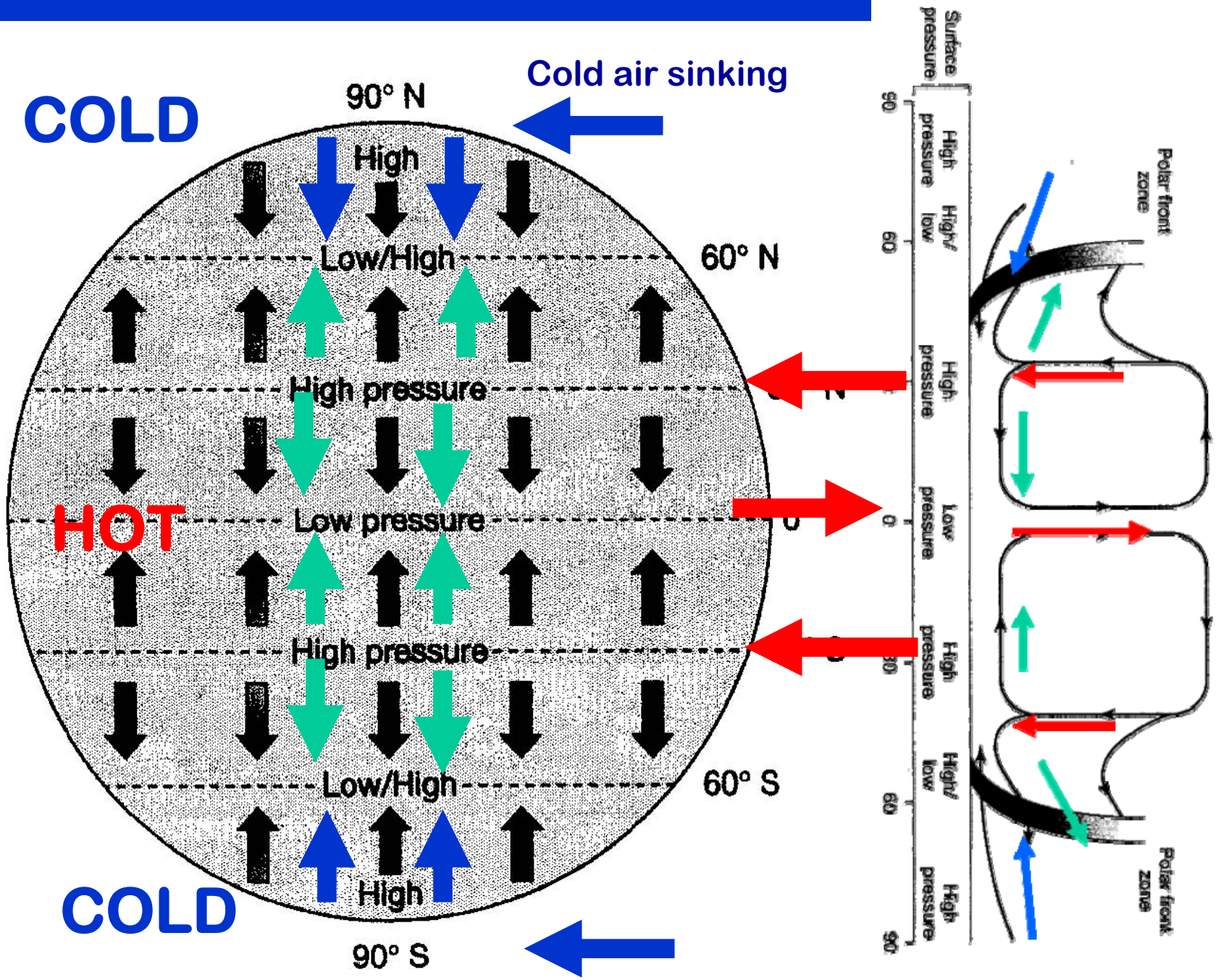
COLD POLAR REGIONS



COLD POLAR REGIONS

HOT TROPICS

COLD POLAR REGIONS


COLD
90° N
Cold air sinking
High
Low/High
60° N
High pressure
HOT
Low pressure
High pressure
Low/High
60° S
COLD
High
90° S
Surface pressure
High pressure
High/ low
High pressure
Low pressure
High pressure
High/ low
High pressure
90
60
0
60
90
Polar front zone
Polar front zone

Lecture ended here and the class then got in groups to finish up the
I-4 BCP Tree-Ring activity.