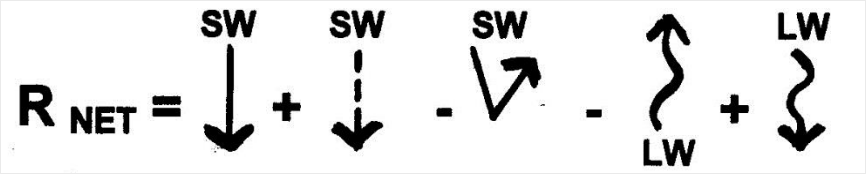
Today:

- ANSWERS to G3
- FEEDBACK LOOP ACTIVITY
  (based on "Too Hot Not to Handle")
- START NEW TOPIC:
  #10 on "How Climate Works
- Start connecting the General Circulation of the Atmosphere to your WORLD MAPS so you can construct a GLOBAL CLIMATE MAP!

THE G-3 ANSWERS

The LEFT side of the equation:

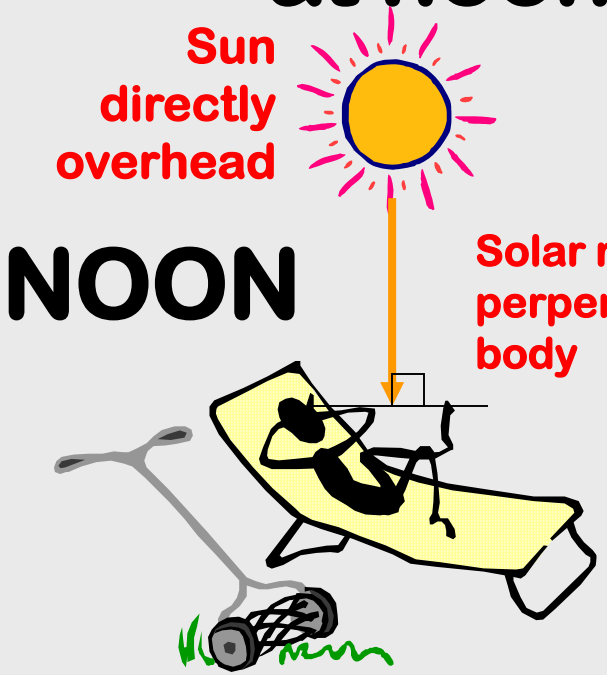


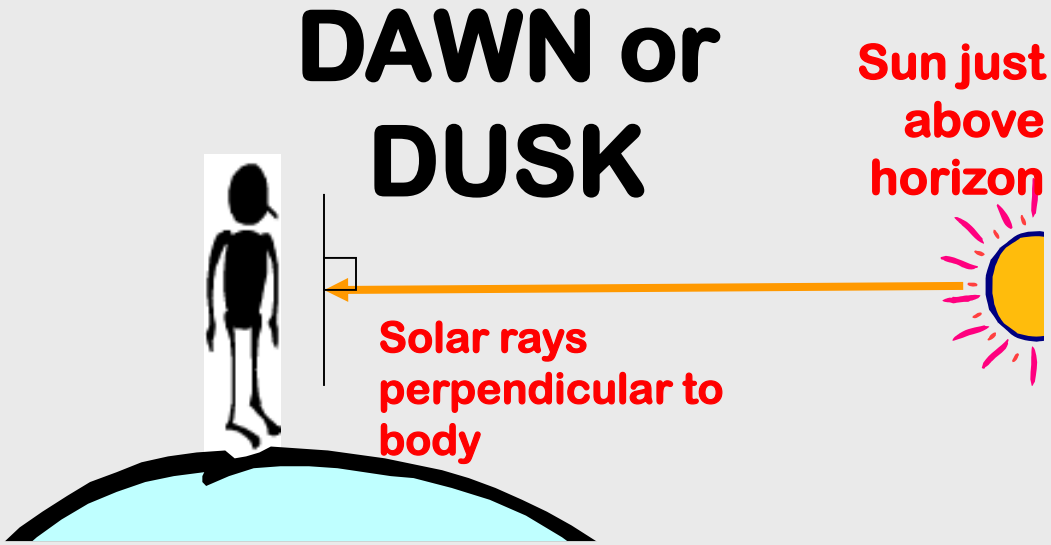
Practice:
blue skies

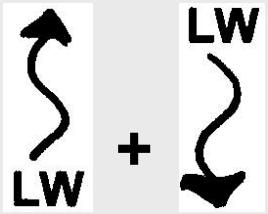
1. Sunglasses while skiing

2. Bright even though cloudy

3. More intense solar radiation (tan /skin damage, etc.) at noon vs. dawn or dusk



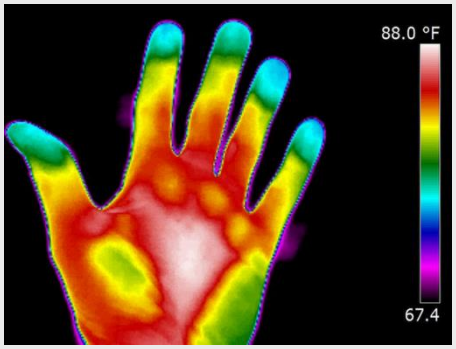


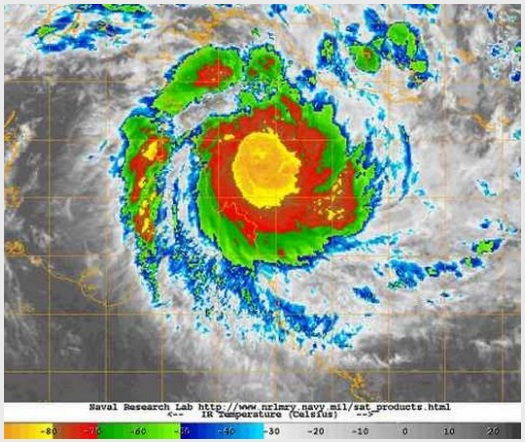
4. 

+ together = the Greenhouse Effect

5. Red sunsets

6. Infrared Imagery





7. Shadow on sunny day

8. Rainbow

9. Black streaks

10. Parking on blacktop on a sunny day

The RIGHT Side of the Equation:

= H + LE + G

11. Hot air balloon

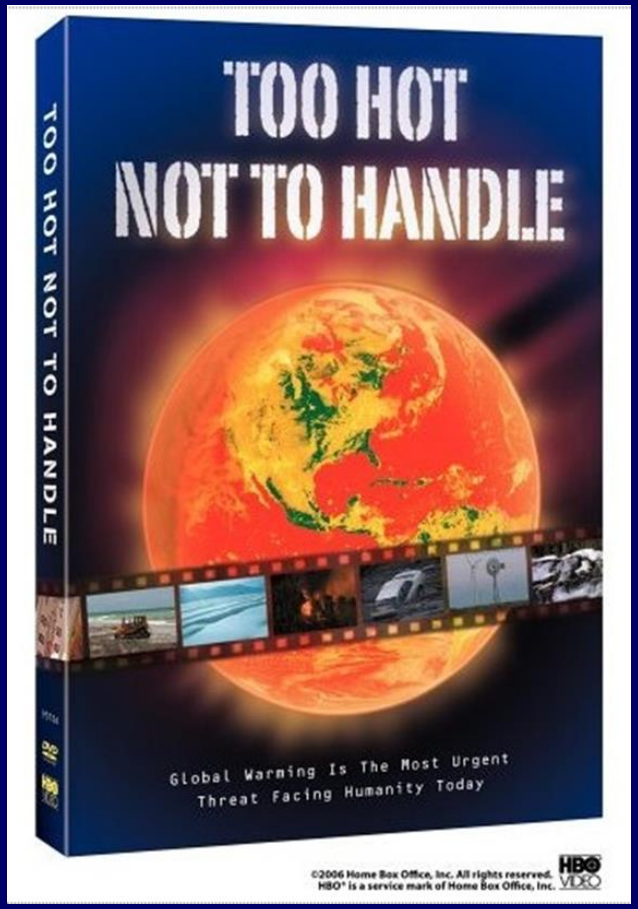
12. Pigs cooling off in the mud

13. Evaporative coolers work best in the desert

Hot DRY AIR goes IN & is forced thru WET pads

COOL AIR enters house & cools it !

Next short segment of our film:



“MELTING ALASKA”

Amount of melting

Amount of $\downarrow_{SW}$ Absorbed

Arctic Surface Temp

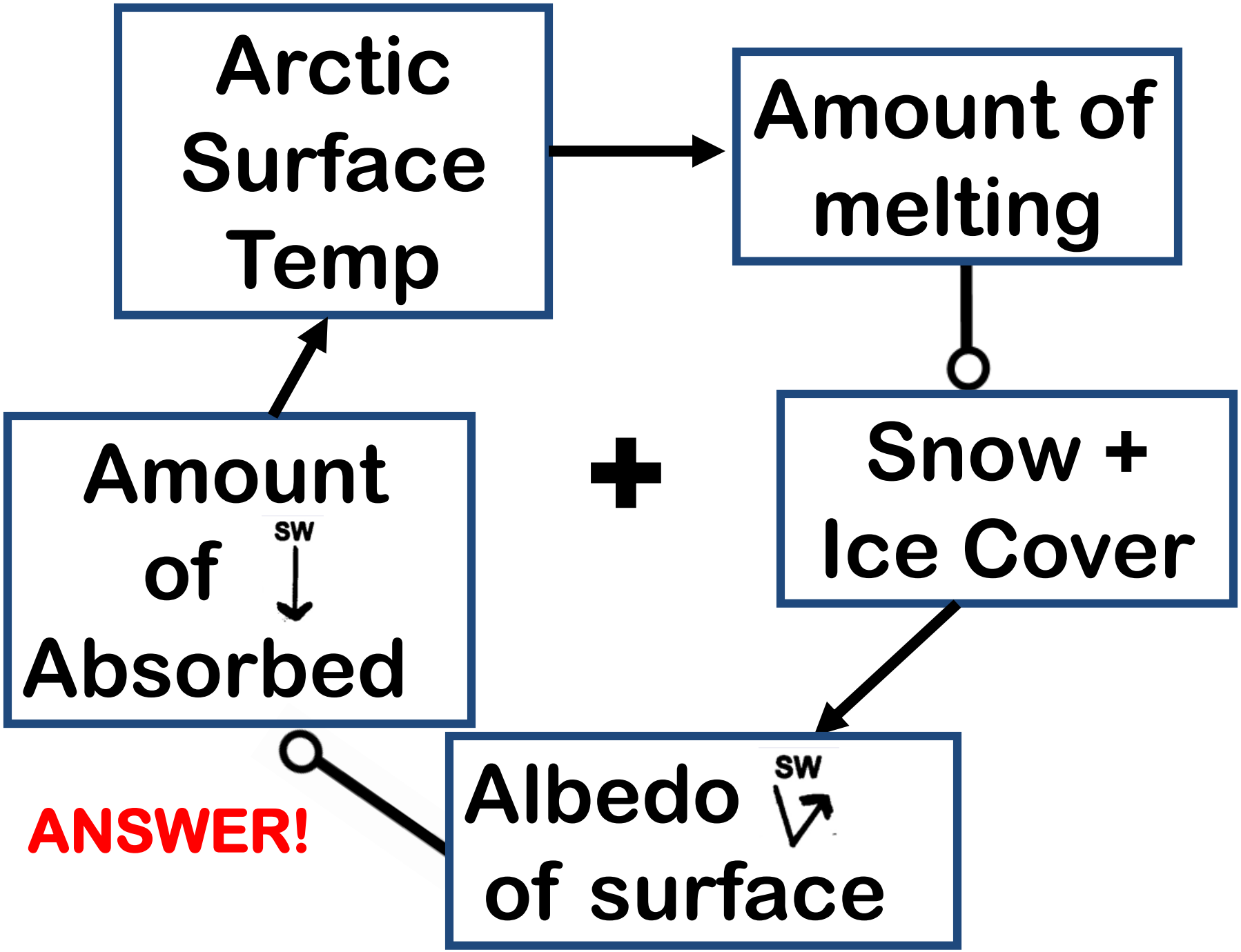
Snow + Ice Cover

Albedo of surface $\downarrow_{SW}$

Put the components in a logical loop + connect with the proper coupling arrows:

Then decide what kind of FEEDBACK LOOP IT IS.

When done & checked Give p 57 a try!


Arctic Surface Temp
Amount of melting
Amount of Absorbed SW ↓
+
Snow + Ice Cover
ANSWER!
Albedo of surface SW ↗

Topic # 10
HOW CLIMATE WORKS

A "Primer" on
How the Energy Balance Drives Atmospheric & Oceanic Circulation, Natural Climatic Processes

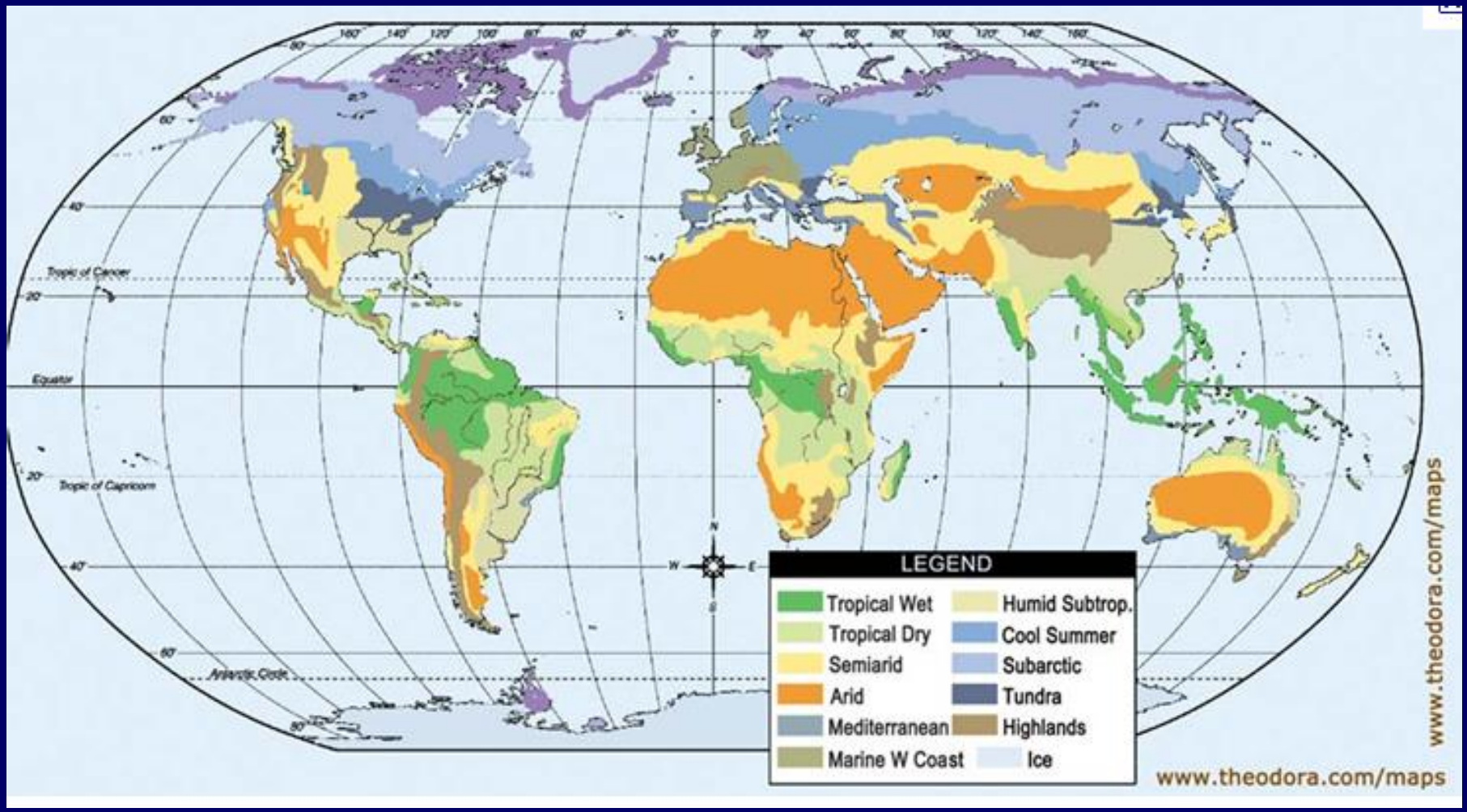
How do we get energy from this . . . .

. . . . to drive this ?

. . . . or this ?

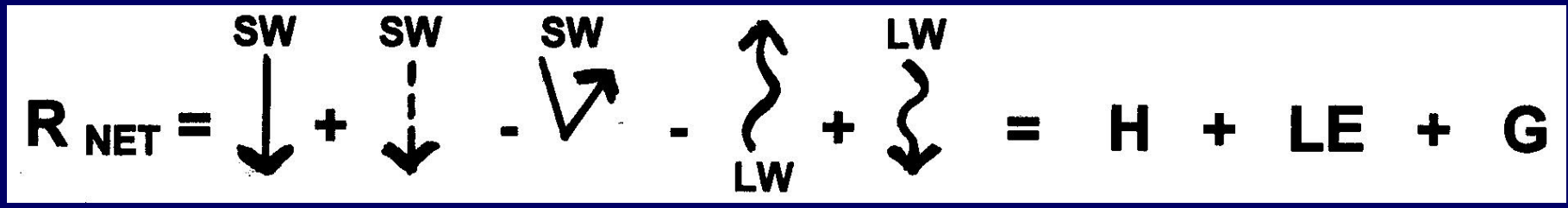
http://www.vets.ucar.edu/vg/T341/index.shtml

. . . .and end up with Global Climatic Regions:

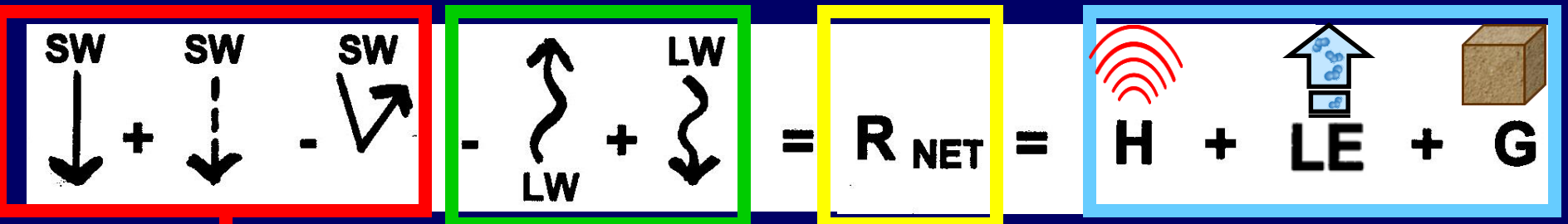


. . . .and CHANGES in these regions!

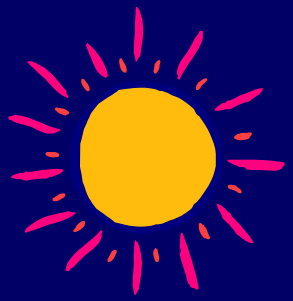
It all happens because of changes in the ENERGY BALANCE !



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 **WEATHER & CLIMATE !**

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.

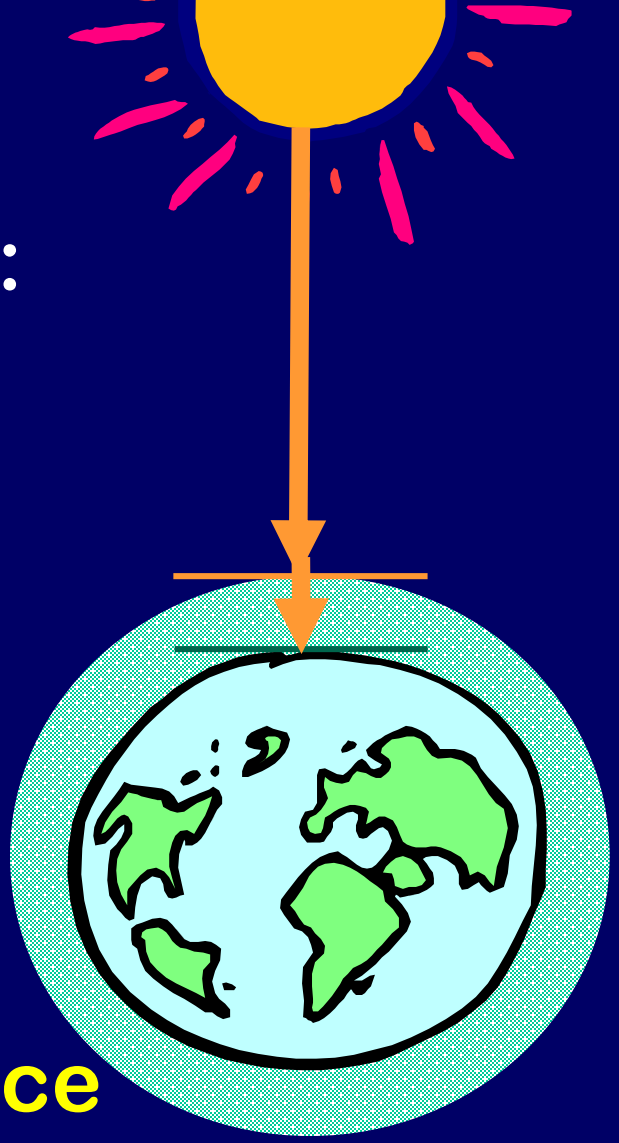
- Lewis Thomas

LINKING THE ENERGY BALANCE TO ATMOSPHERIC CIRCULATION:

We'll start with the SUN:

SOLAR INSOLATION

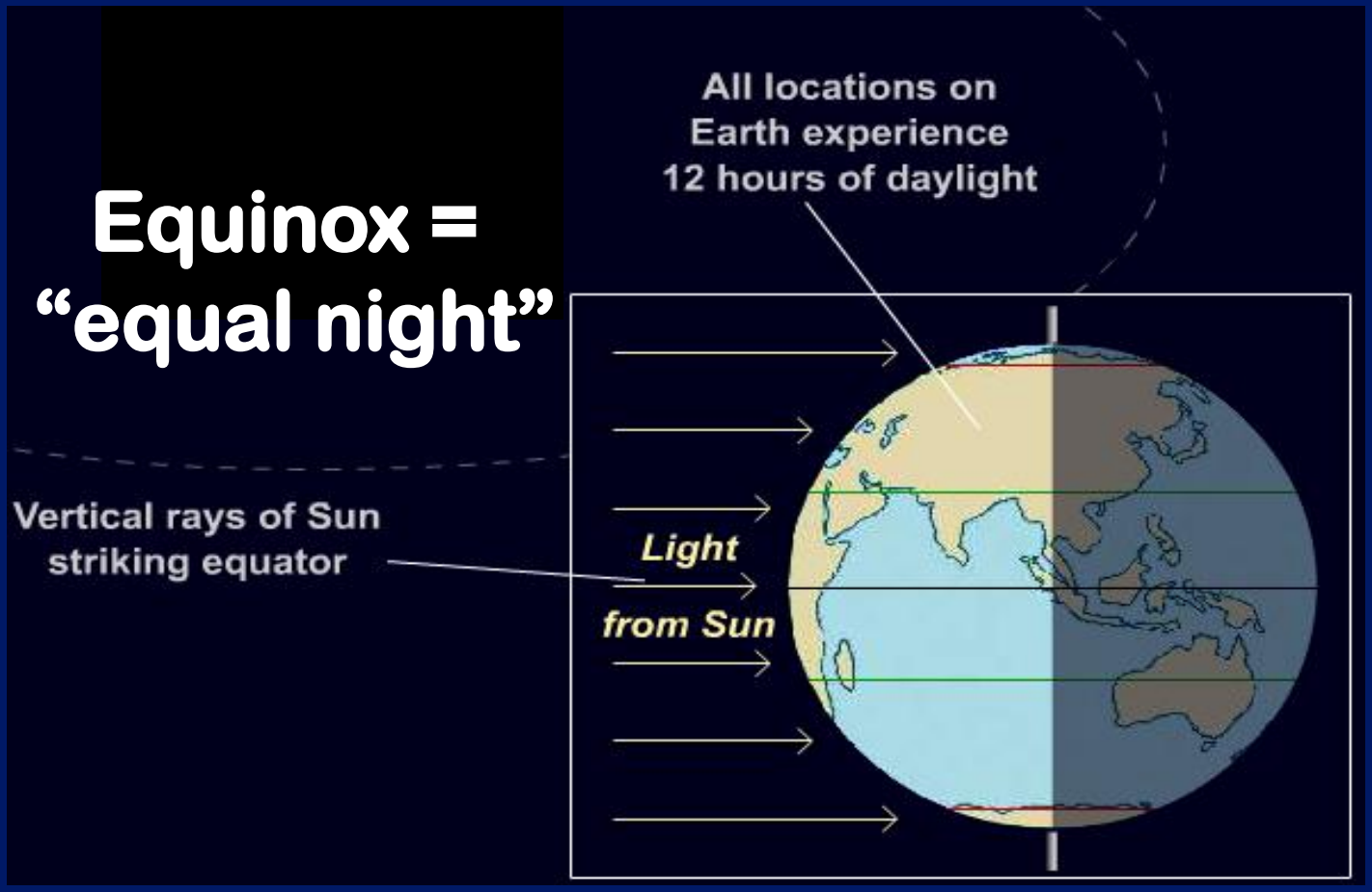
IN – SOL- ATION



= the amount of incoming solar radiation received by a horizontal surface
(e.g. at the top of the atmosphere, at the tropopause, at the Earth's surface, etc.)

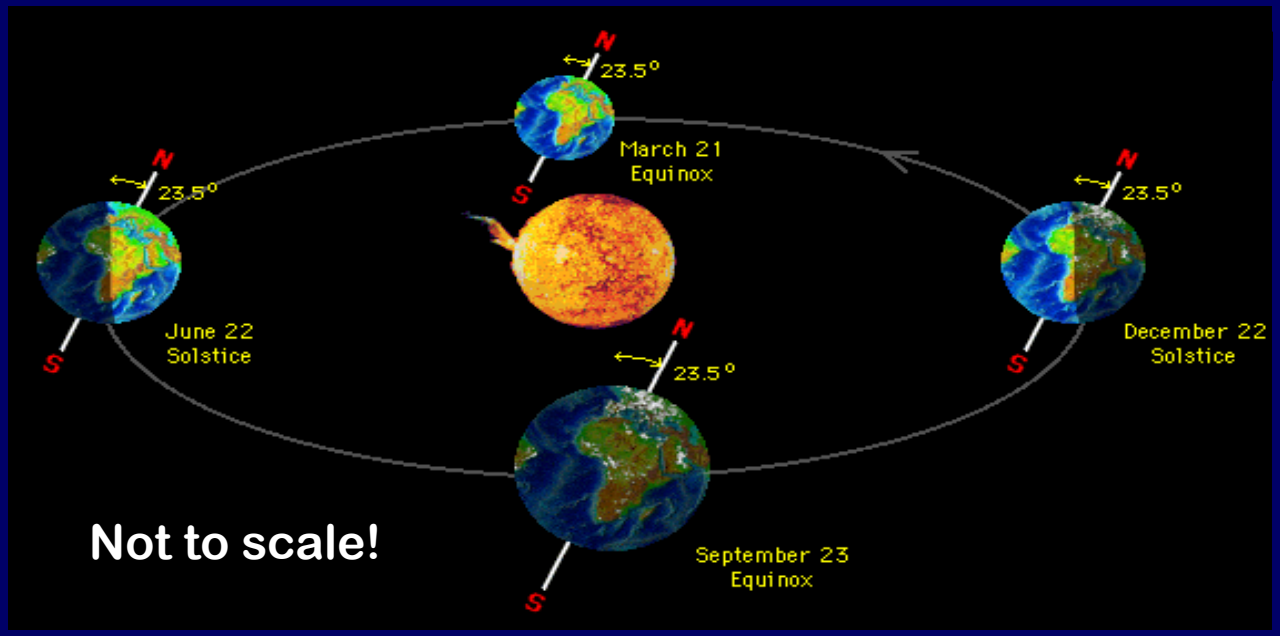
REMEMBER THIS??
HAPPY SEPTEMBER EQUINOX!

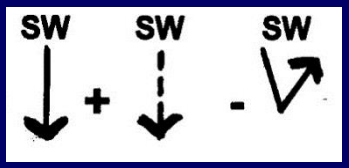
23 Sep 2015



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

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





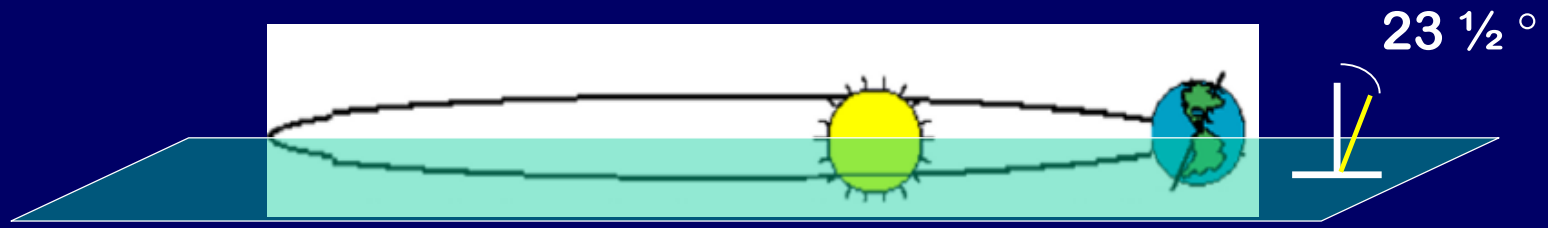
EARTH-SUN Relationships

4 Things to Know about Earth-Sun Relationships:

1) Earth orbits Sun
2) Orbit not a perfect circle
3) Orbit traces "a plane"
4) Earth's axis tilts

Review 59

The "4 Things to Know" about Earth-Sun Relationships:



1) Earth orbits Sun in one year

2) Orbit is not a perfect circle = an ellipse

3) Earth's orbit around Sun can be "traced" on a plane ("Plane of the Ecliptic" – plane passes thru the center of Sun & Earth)

4) Earth's axis tilts 23.5 ° from a ⊥ to the "Plane of The Ecliptic"

These 4 Earth-Sun "orbital" properties lead to 2 key factors that determine the AMOUNT OF SOLAR INSOLATION at any spot on Earth as the seasons progress:

(1) INTENSITY of sun's rays
Depends on AXIS TILT and how Earth's SURFACE RECEIVES Sun's rays
[Most intense = perpendicular rays ⊥]

(2) DURATION of insolation (day length)
Depends on LATITUDE & SEASON

➔ *Intensity & Duration vary with LATITUDE & TIME OF YEAR*

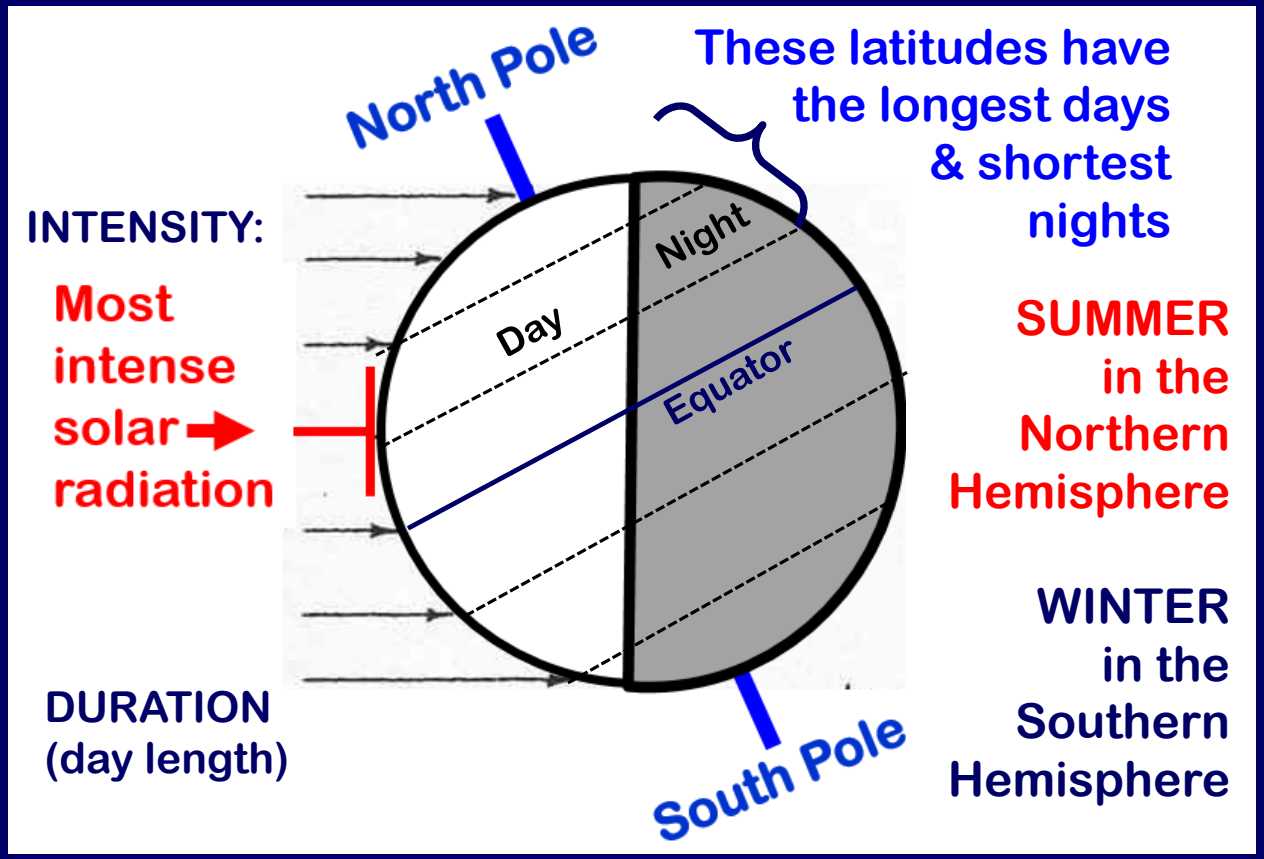
Box on p 59

INTENSITY + DURATION

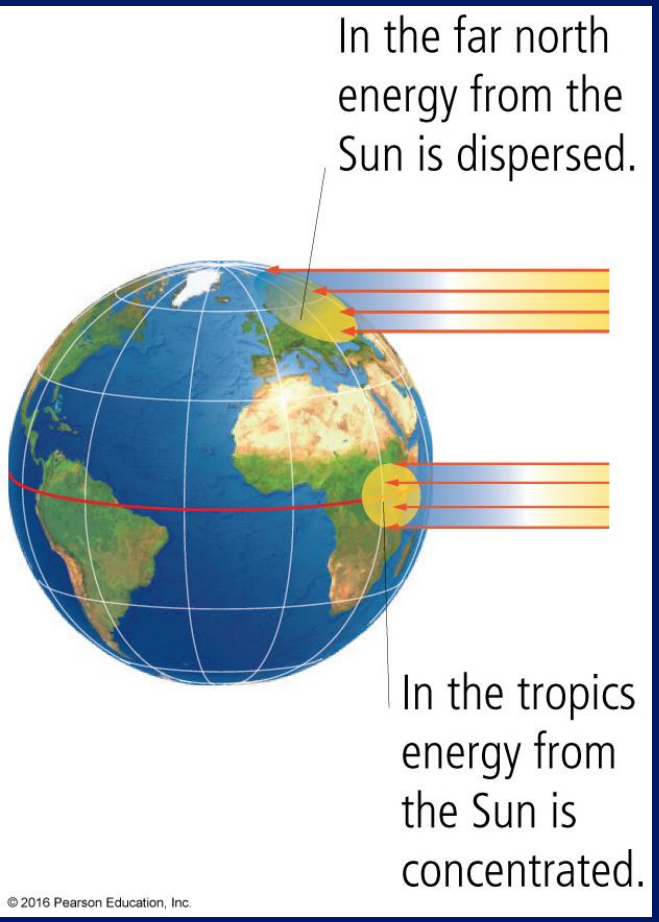
INTENSITY of sun's rays: depends on axis tilt and how earth intercepts sun's rays

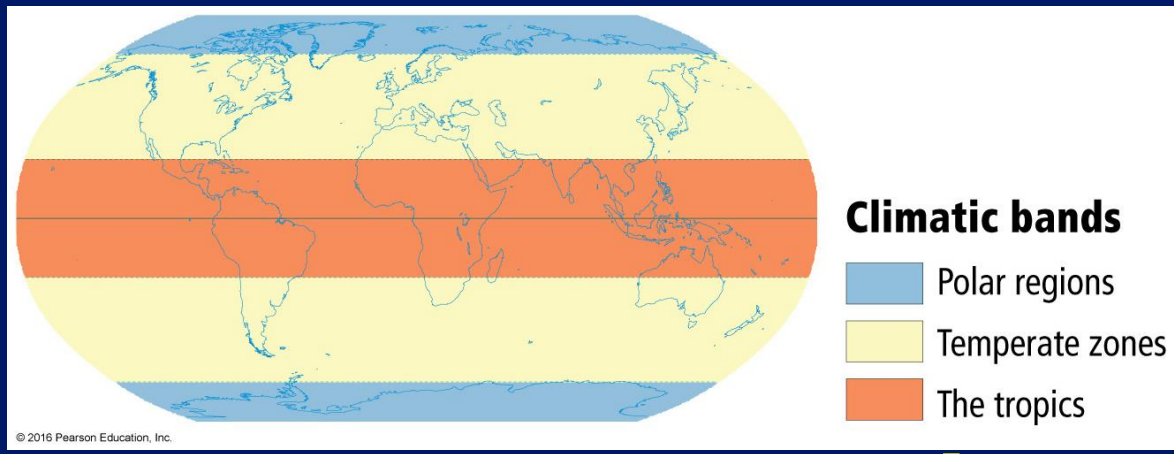
DURATION of daily insolation (day length): depends on where circle of illumination intersects latitude band

Sun's rays

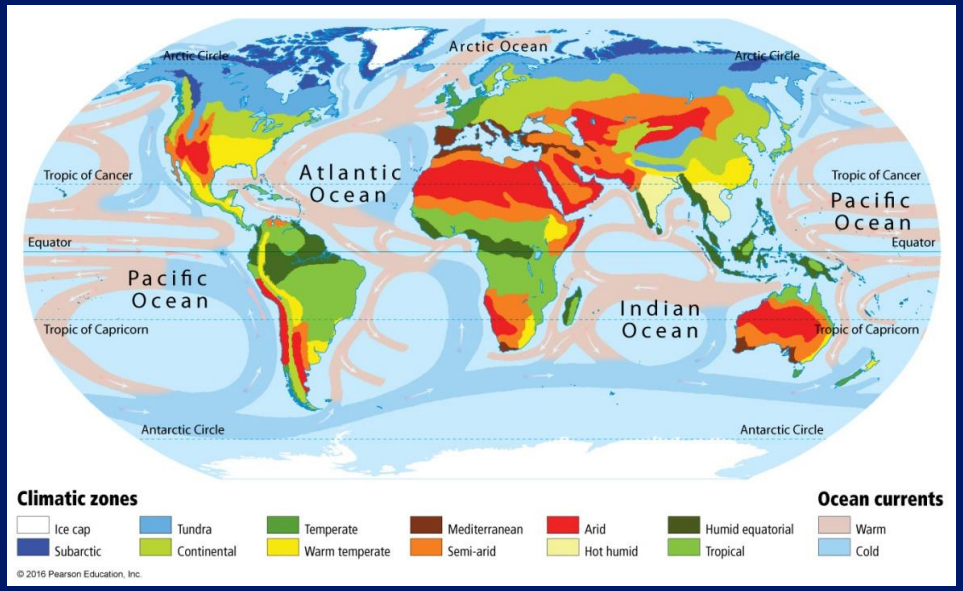


We'll learn how we get . . .



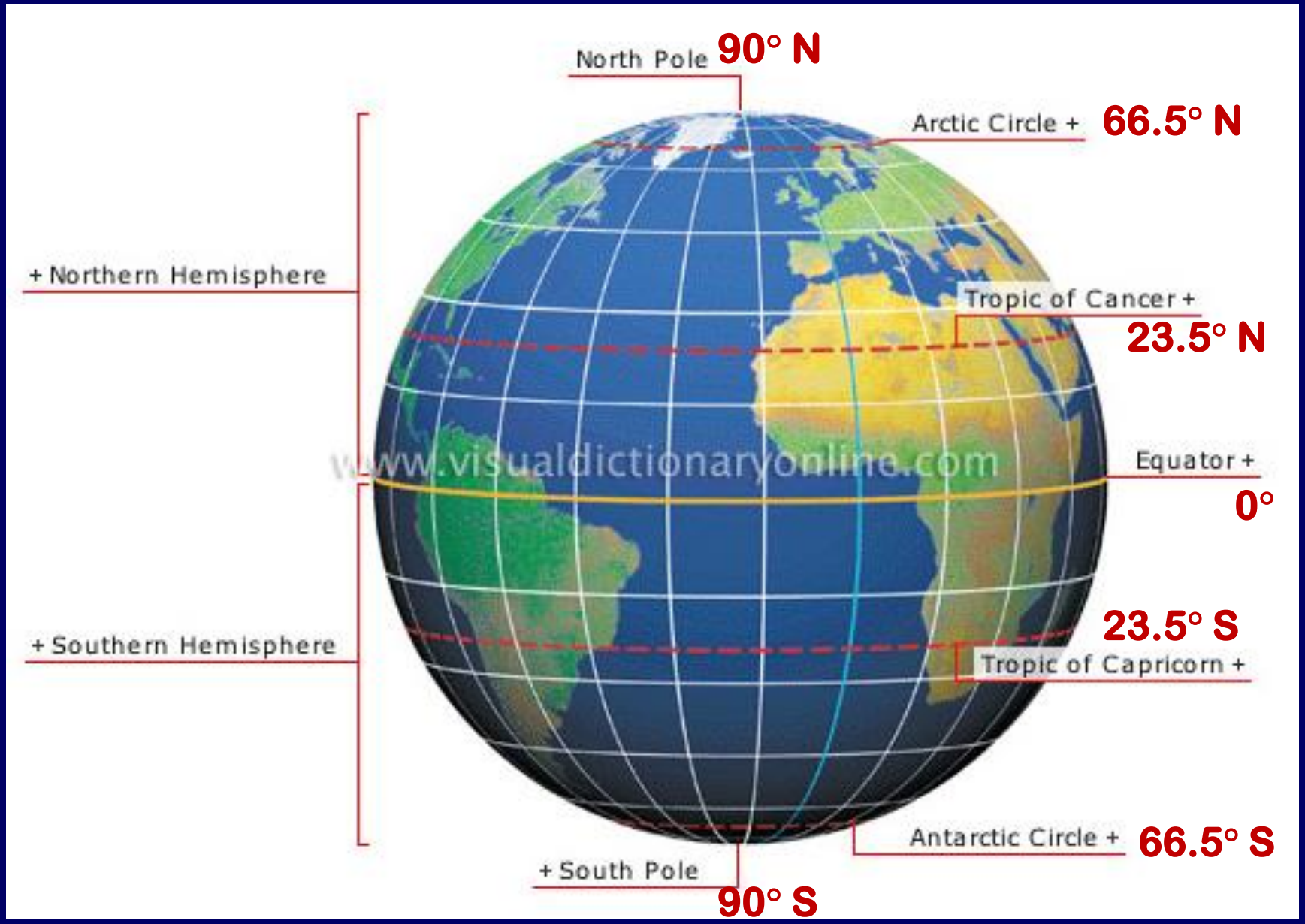


. . . from this ↑ . . .to this ↓



READ: Dire Predictions pp 10-15

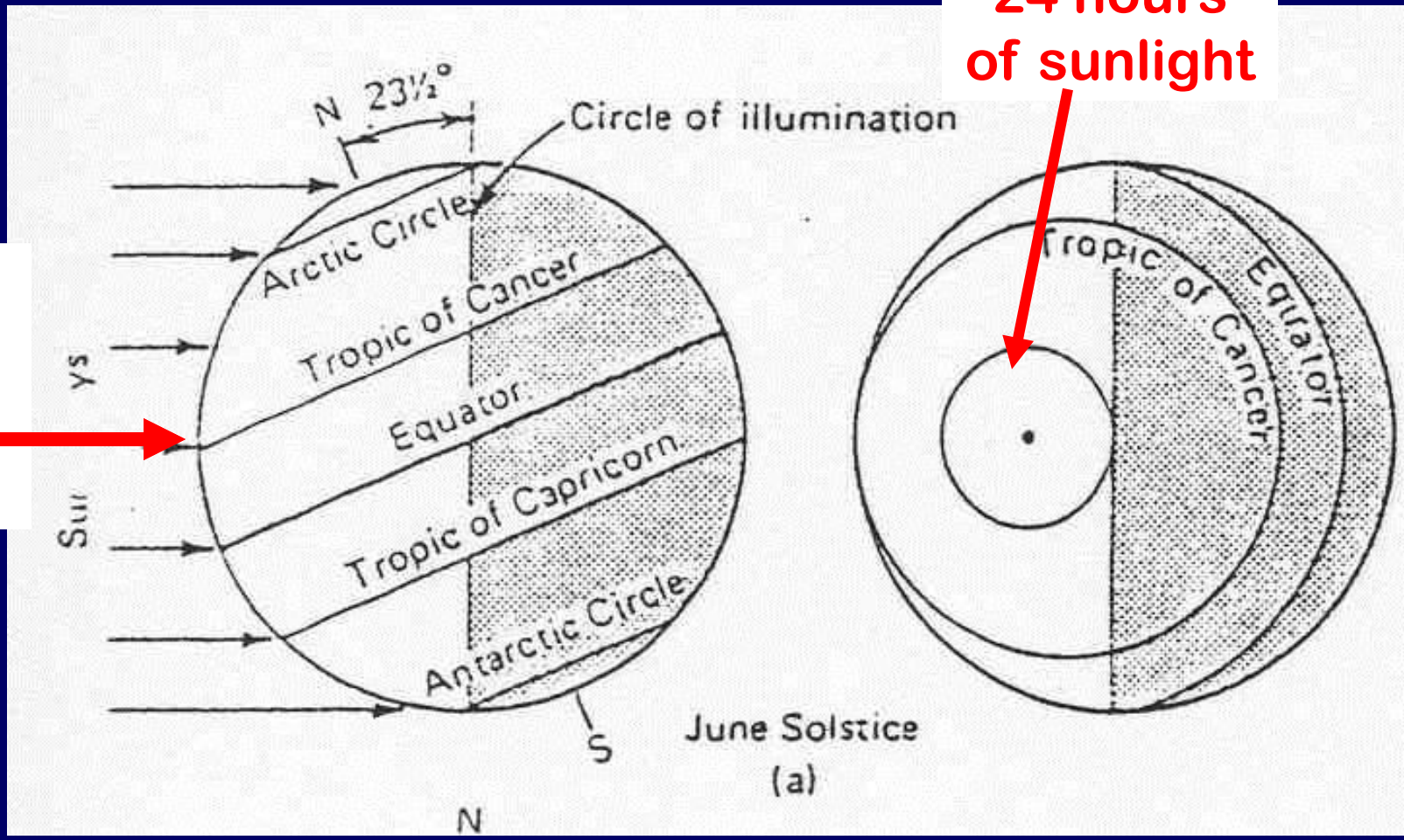
QUICKIE LATITUDE REVIEW:



JUNE SOLSTICE

24 hours of sunlight

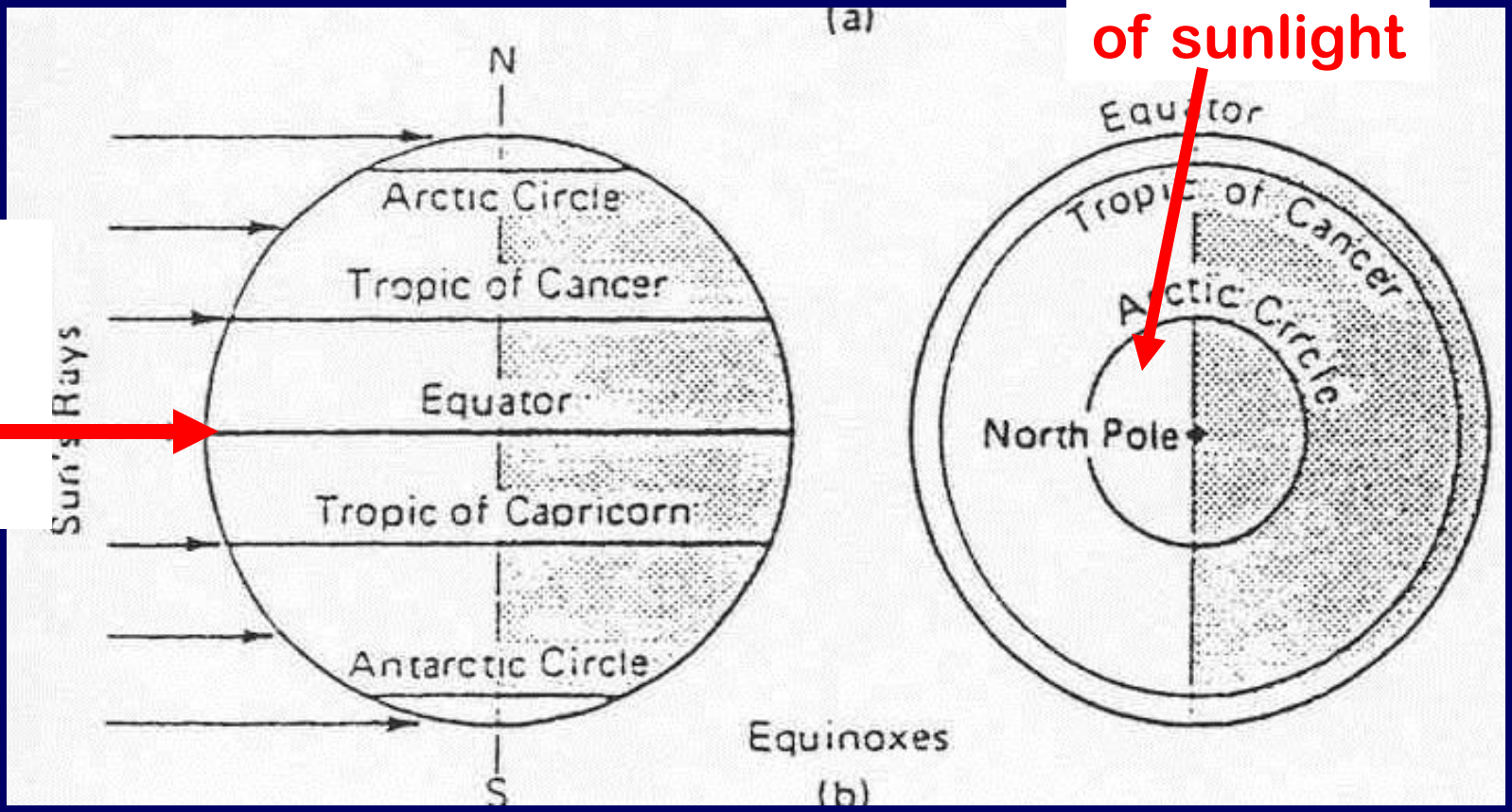
Most intense solar radiation



MARCH & SEPTEMBER EQUINOXES

12 hours of sunlight

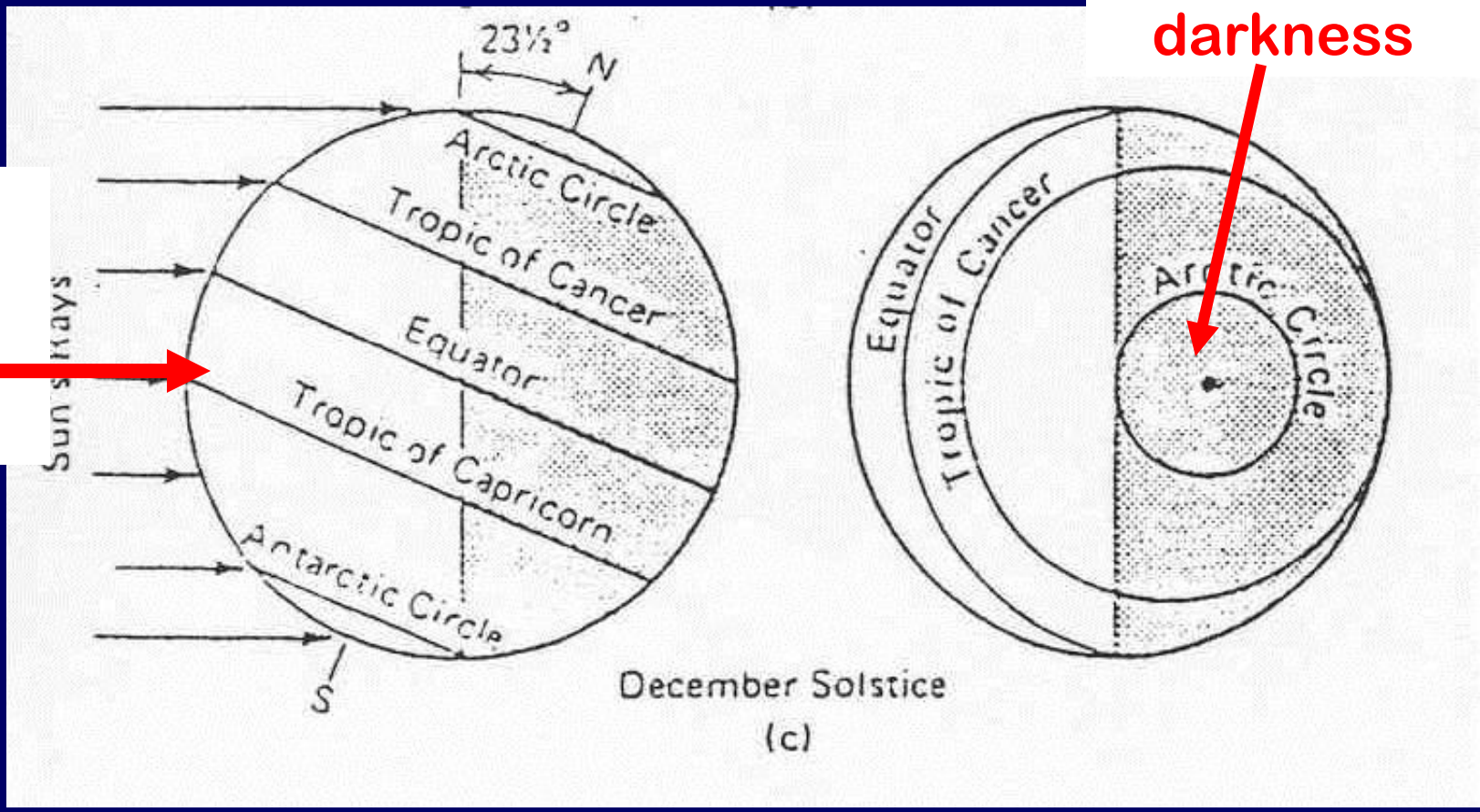
Most intense solar radiation



DECEMBER SOLSTICE

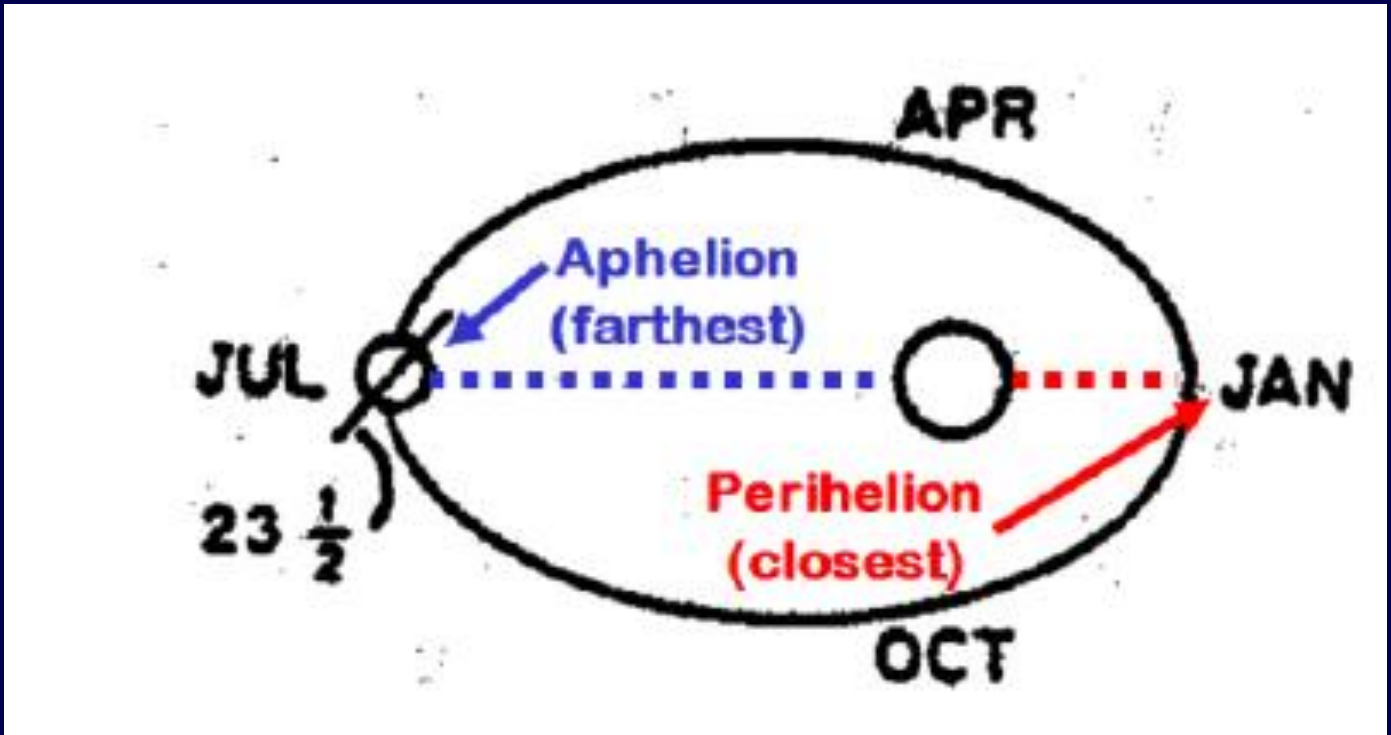
24 hours of darkness

Most intense solar radiation



Earth's Axis Tilt & Elliptical Orbit ➔

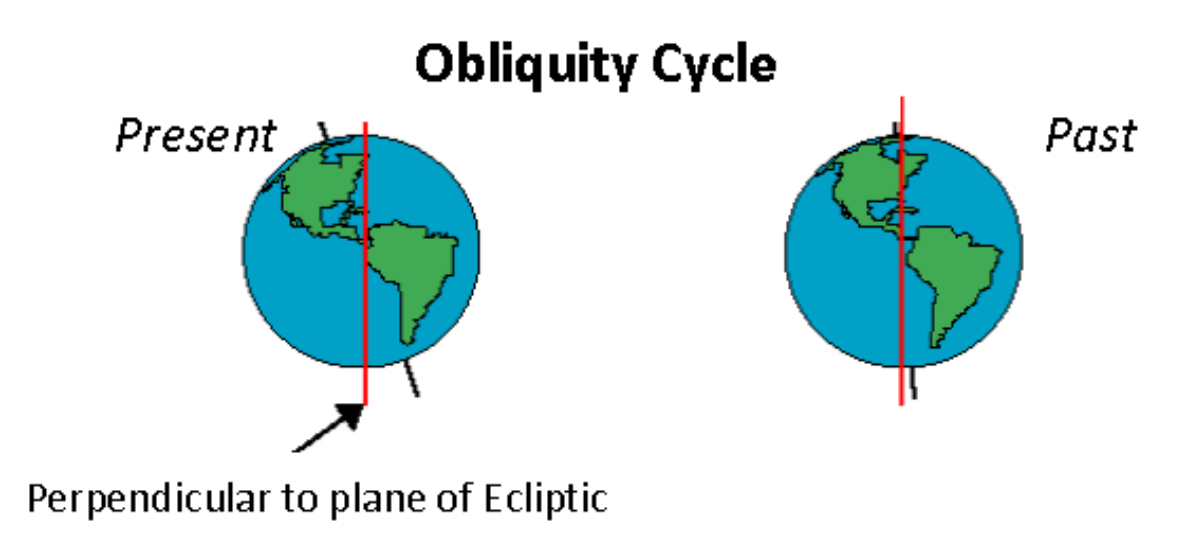
Contrast in Northern vs. Southern Hemisphere:



NATURAL CLIMATIC FORCING:
Milankovitch Cycles: (Lesson 2 tutorial)

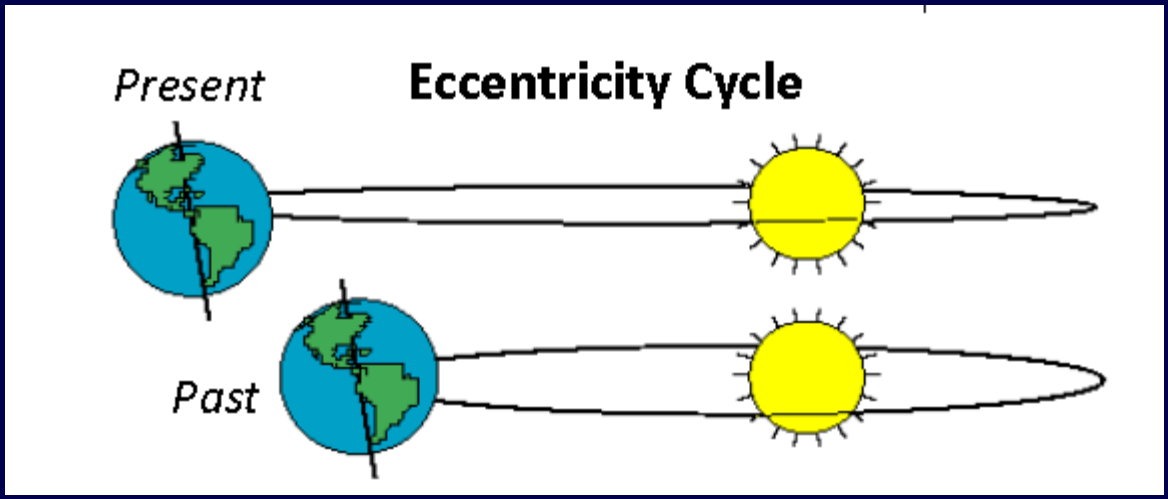
1. OBLIQUITY OF EARTH'S AXIS

Axis "tilts" 23.5 degrees from plane of ecliptic; causes the seasons; tilt angle varies over time

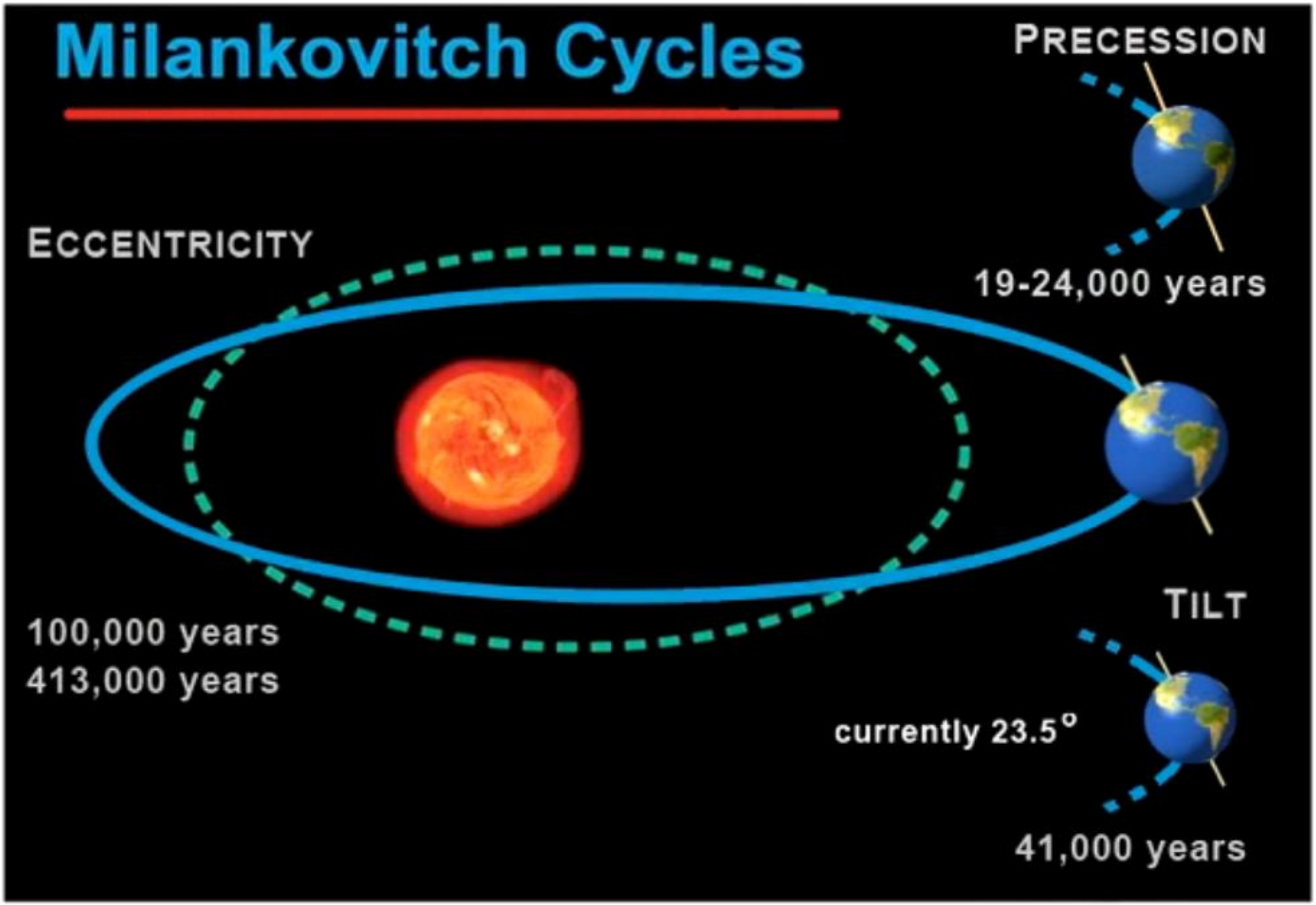


2. ECCENTRICITY OF ORBIT

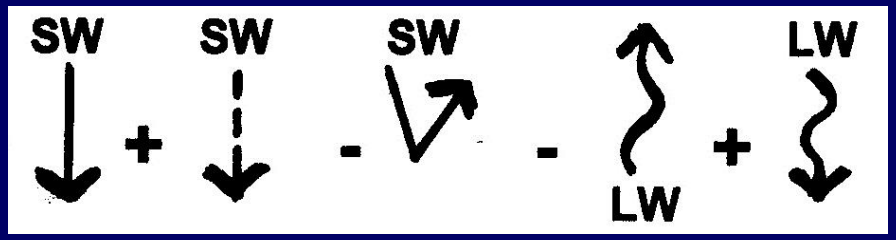
Earth's orbit around sun is not symmetrical;
varies from elliptical => circular shape over time



Assignment I-2 Tutorial : DUE SUNDAY NIGHT!

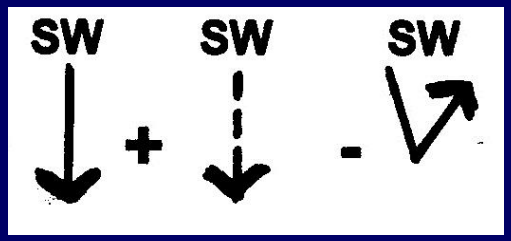


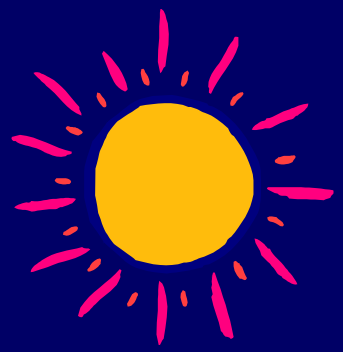
THE RADIATION BALANCE

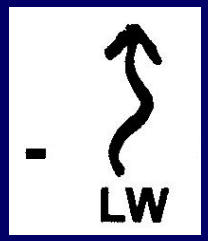


& THE GENERAL CIRCULATION OF THE ATMOSPHERE

HOW IT ALL FITS TOGETHER:







Over the course of a year . . .

The amount of **INCOMING SW** (Insolation) absorbed by EARTH **varies by LATITUDE**

(MORE comes in near the Equator, less near the Poles)

➔ **LOW LATITUDES** absorb <u>MORE</u> energy than **HIGH LATITUDES**

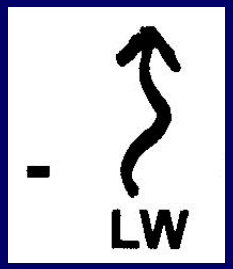
The amount of outgoing **TERRESTRIAL LW / IR** varies by latitude too --

<u>MORE</u> **LW / IR** is emitted at warmer **LOW LATITUDES**, <u>LESS</u> in cooler **HIGH LATITUDES**

HOWEVER . . .

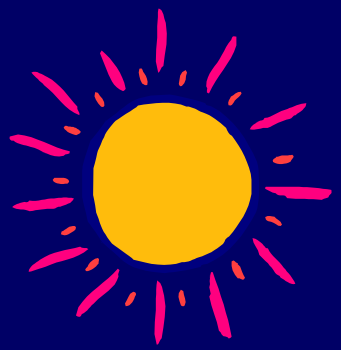
Box on p 61

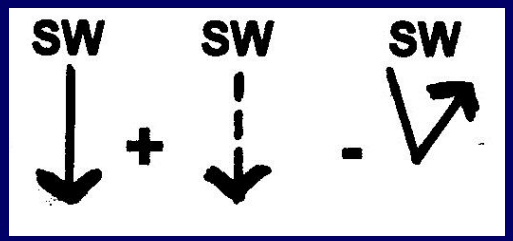
The EQUATOR-POLE DIFFERENCES of what goes OUT from the EARTH

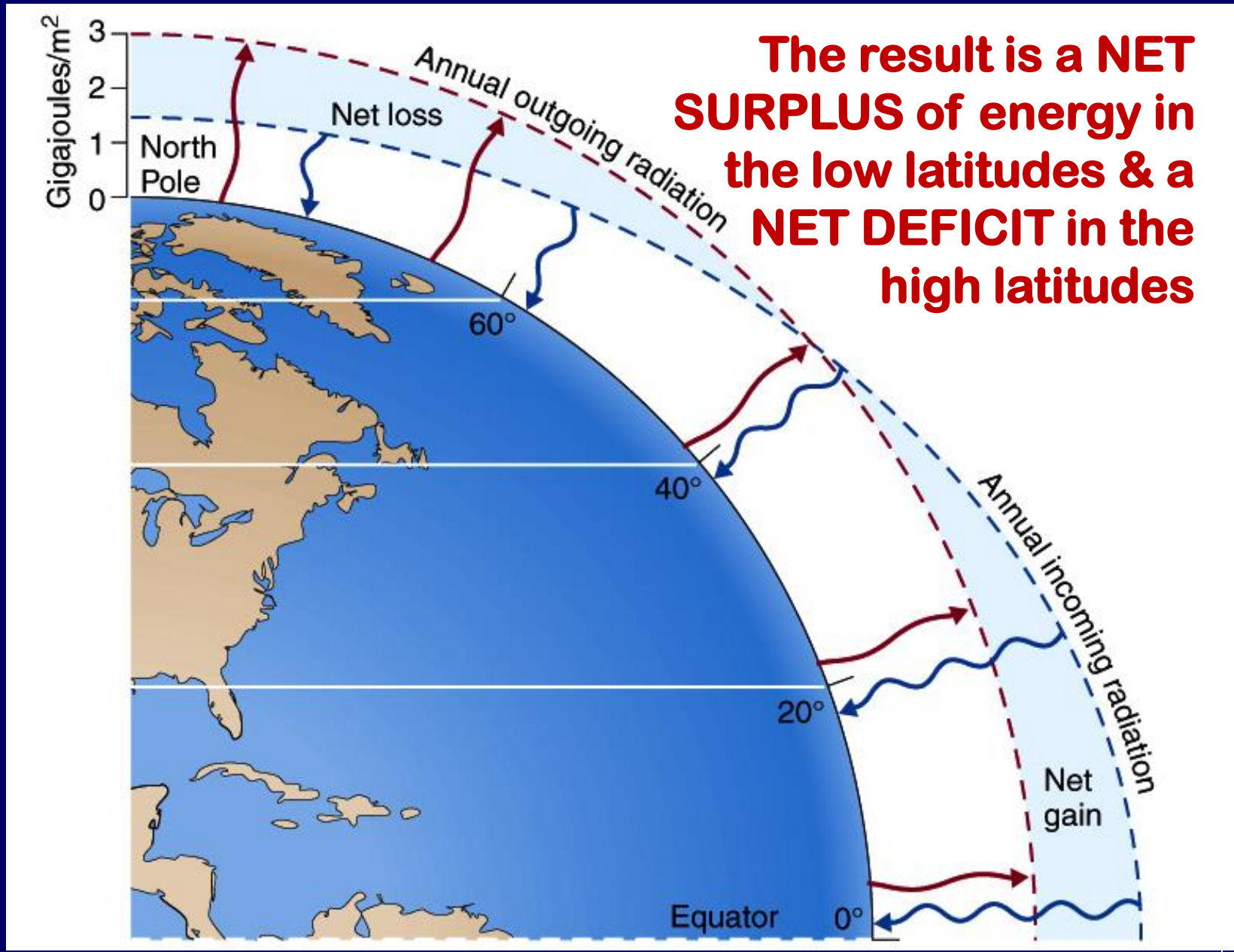


are less than the

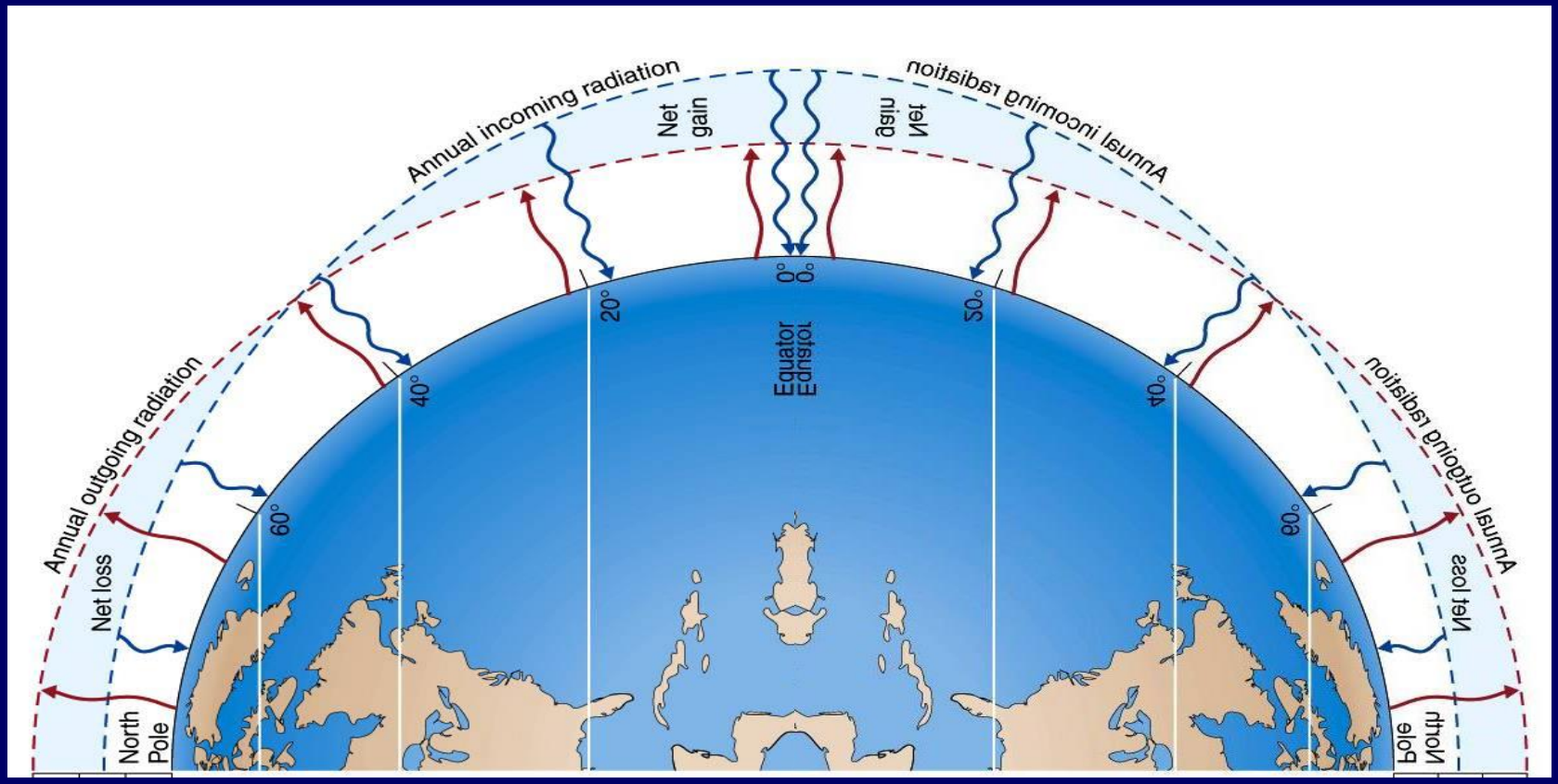
EQUATOR-POLE DIFFERENCES of what comes IN from the SUN





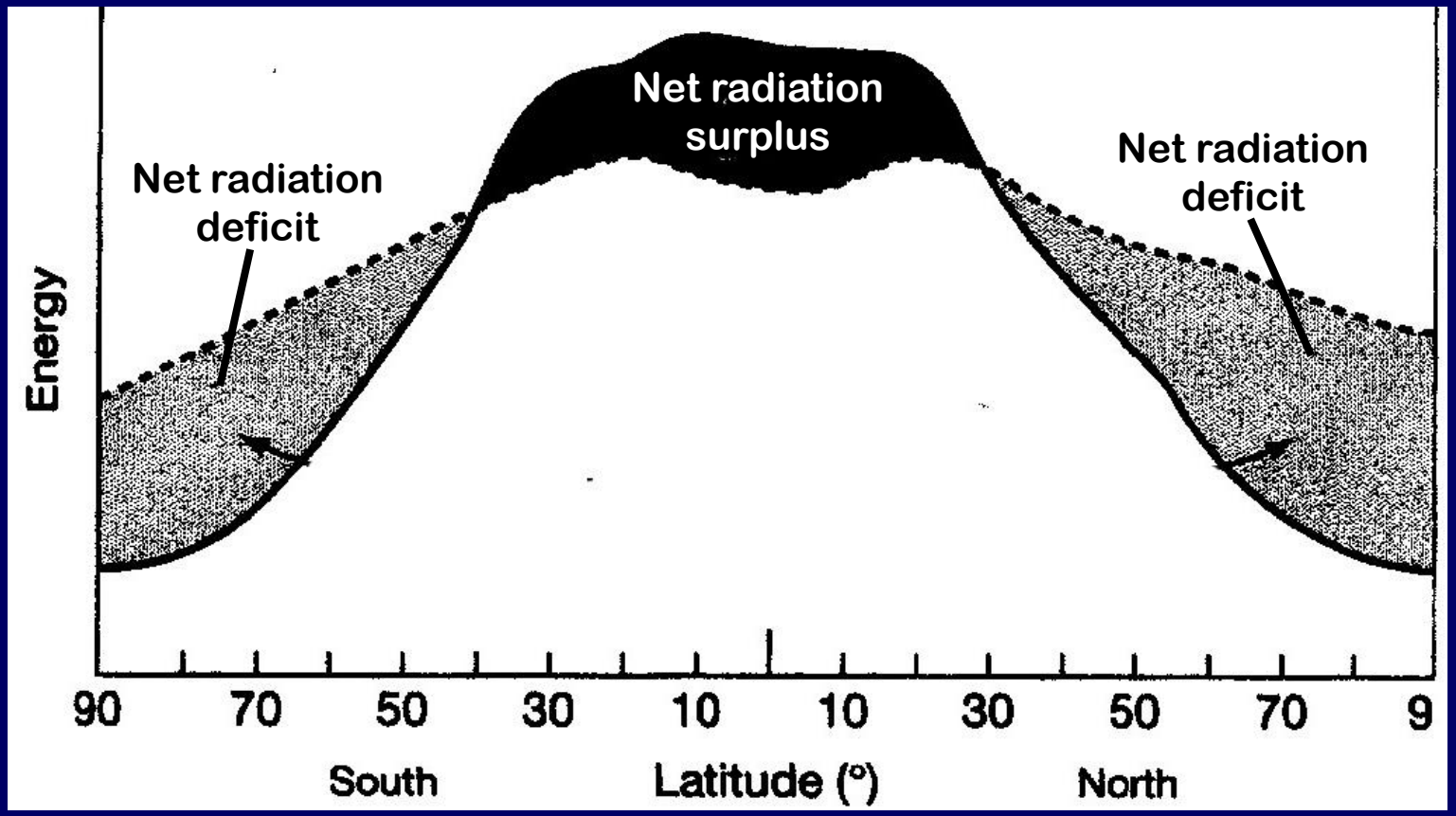


The result is a NET SURPLUS of energy in the low latitudes & a NET DEFICIT in the high latitudes

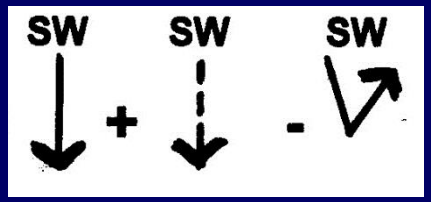


POLE **EQUATOR** **POLE**

Now lets look at a Pole to Pole Transect



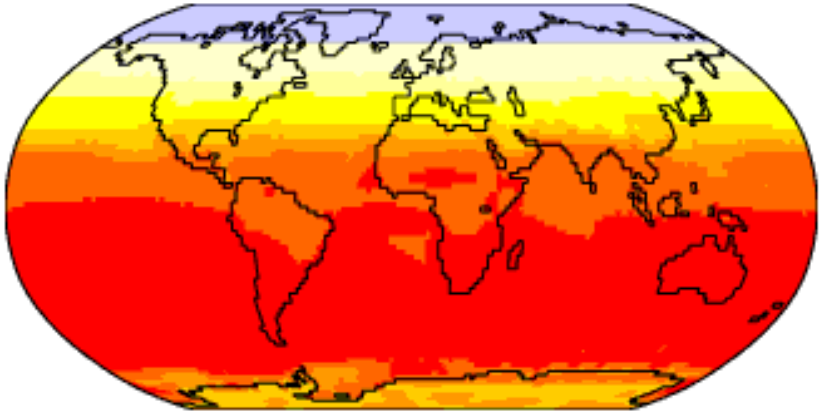
Absorbed solar energy



Emitted infrared energy

(at top of atmosphere)

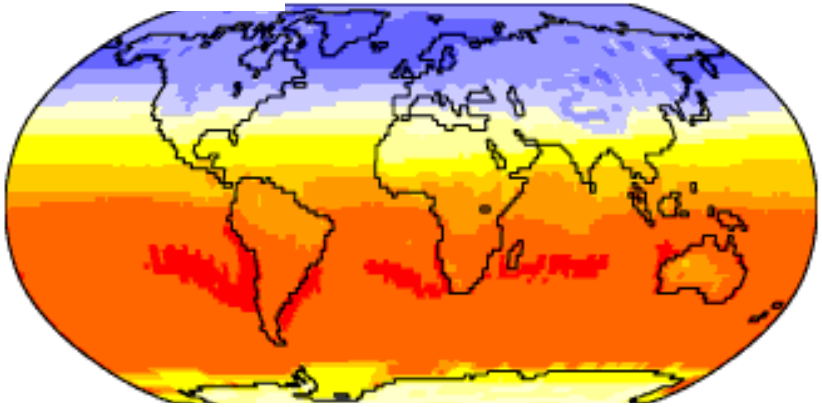
Short-Wave Radiation



Dec

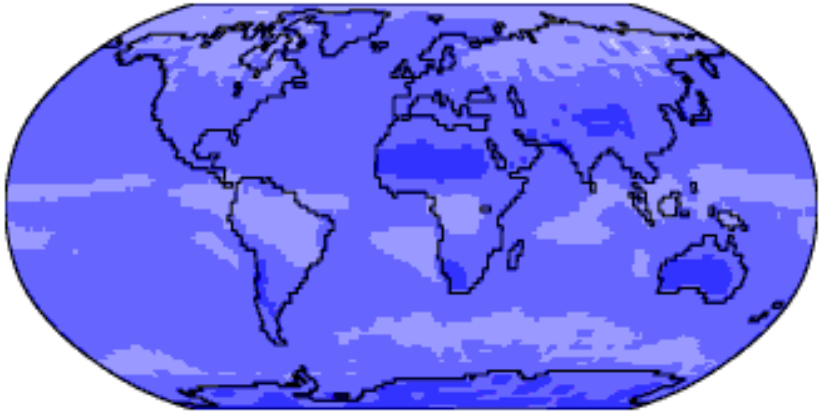
Absorbed solar energy

SW + SW - SW



Net Radiation R_{NET}

Long-Wave Radiation



- LW

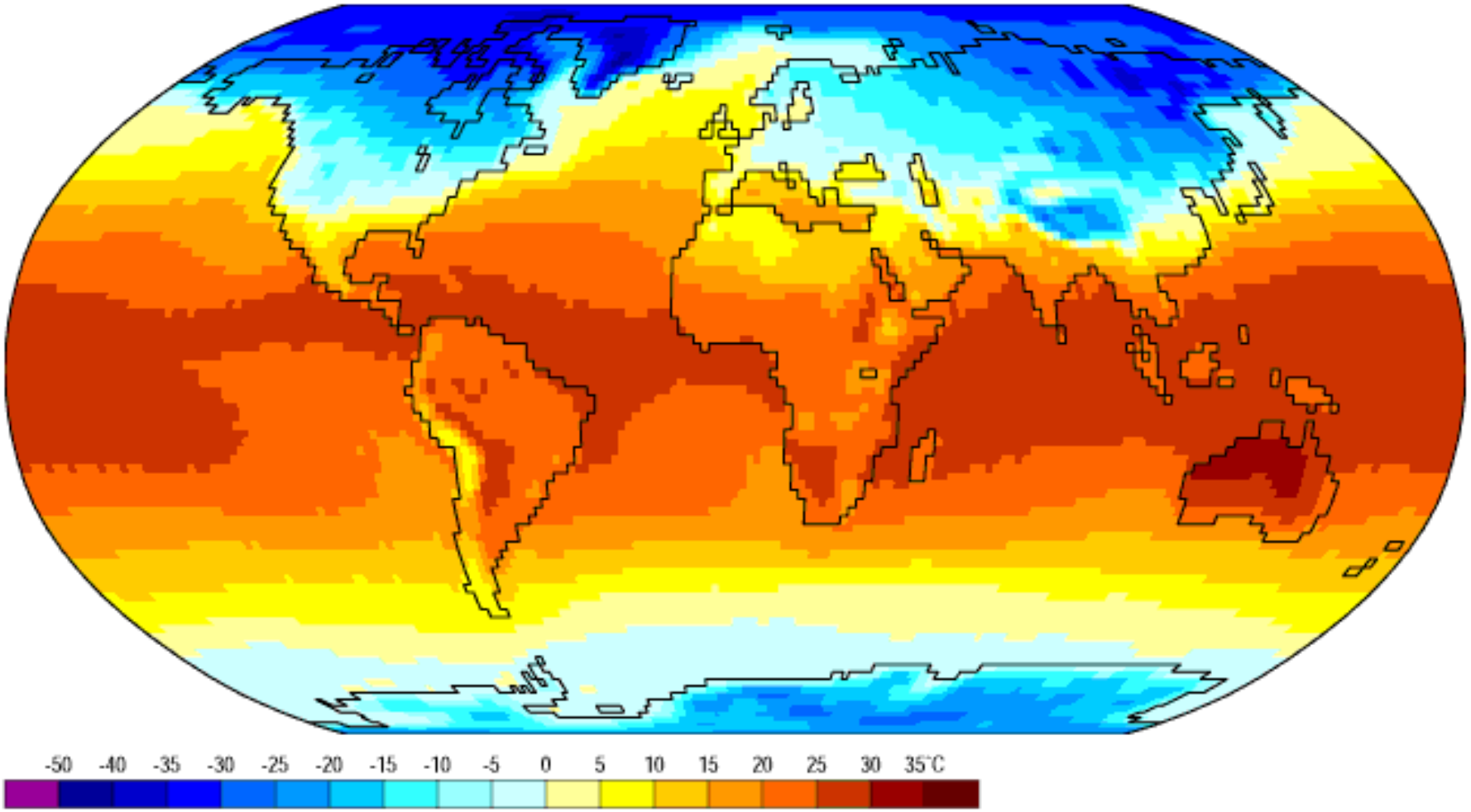
Emitted infrared energy

-100 -50 -25 0 25 50 100 125 150 200 W/m**2

Data: NCEP/NCAR Reanalysis Project, 1959-1997 Climatologies
Animation: Department of Geography, University of Oregon, March 2000

http://geography.uoregon.edu/envchange/clim_animations/

Surface Air Temperature



Data: NCEP/NCAR Reanalysis Project, 1959-1997 Climatologies
Animation: Department of Geography, University of Oregon, March 2000

The General Circulation of the Atmosphere
Let's draw it!

90 ° N

60 ° N

30 ° N

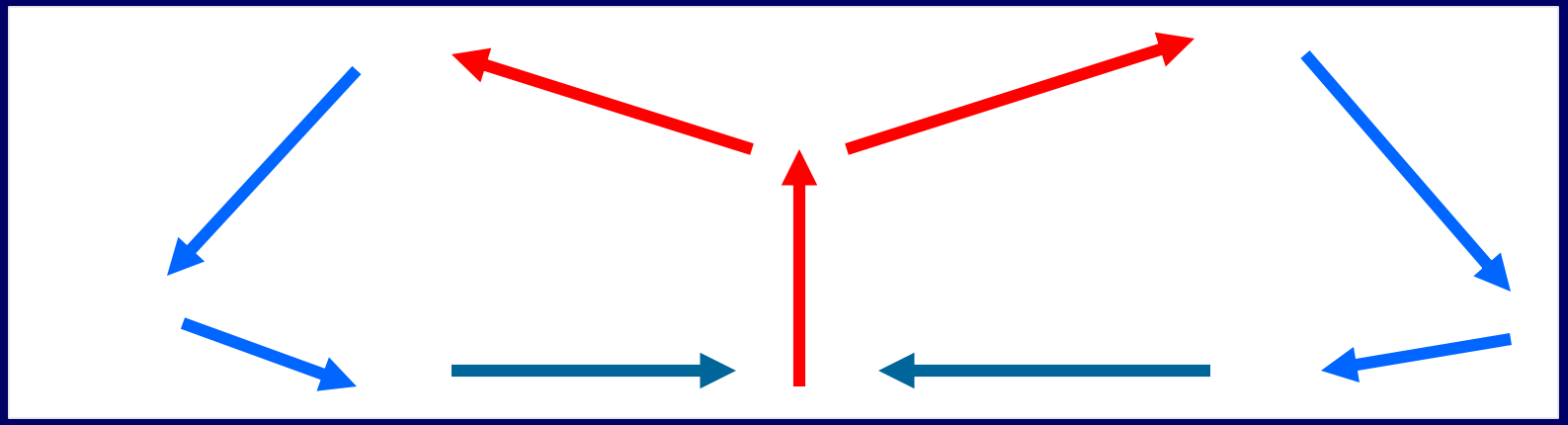
Equator

30 ° S

60 ° S

90° S

GIANT CONVECTION CELLS
driven by thermal differences:



90 60 30 0 30 60 90

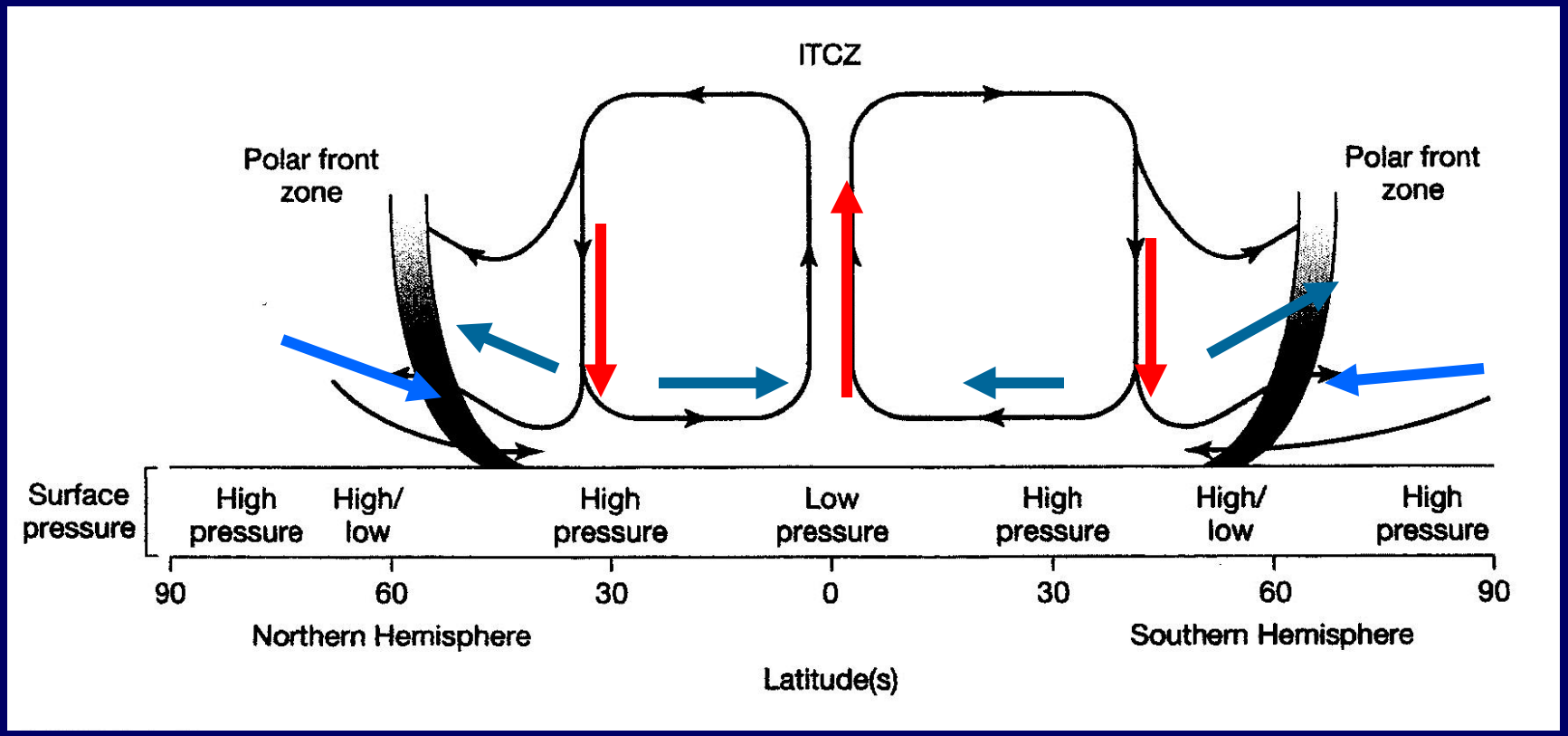
Northern Hemisphere EQUATOR Southern Hemisphere

COLD POLAR REGIONS

HOT TROPICS

COLD POLAR REGIONS

"HADLEY CELL"
← TRANSPORT →



COLD POLAR REGIONS

HOT TROPICS

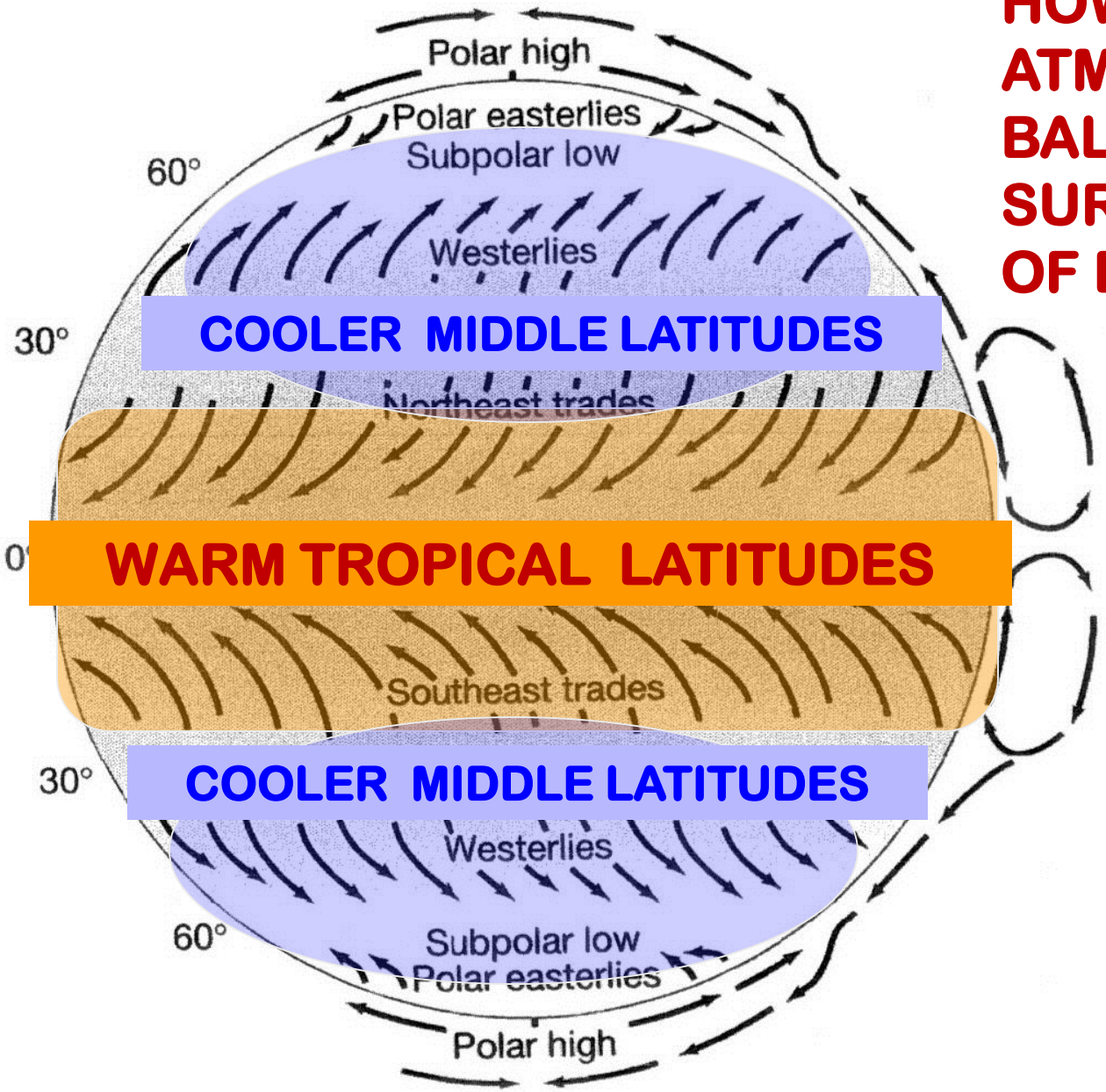
"HADLEY CELL"

← TRANSPORT →

COLD POLAR REGIONS

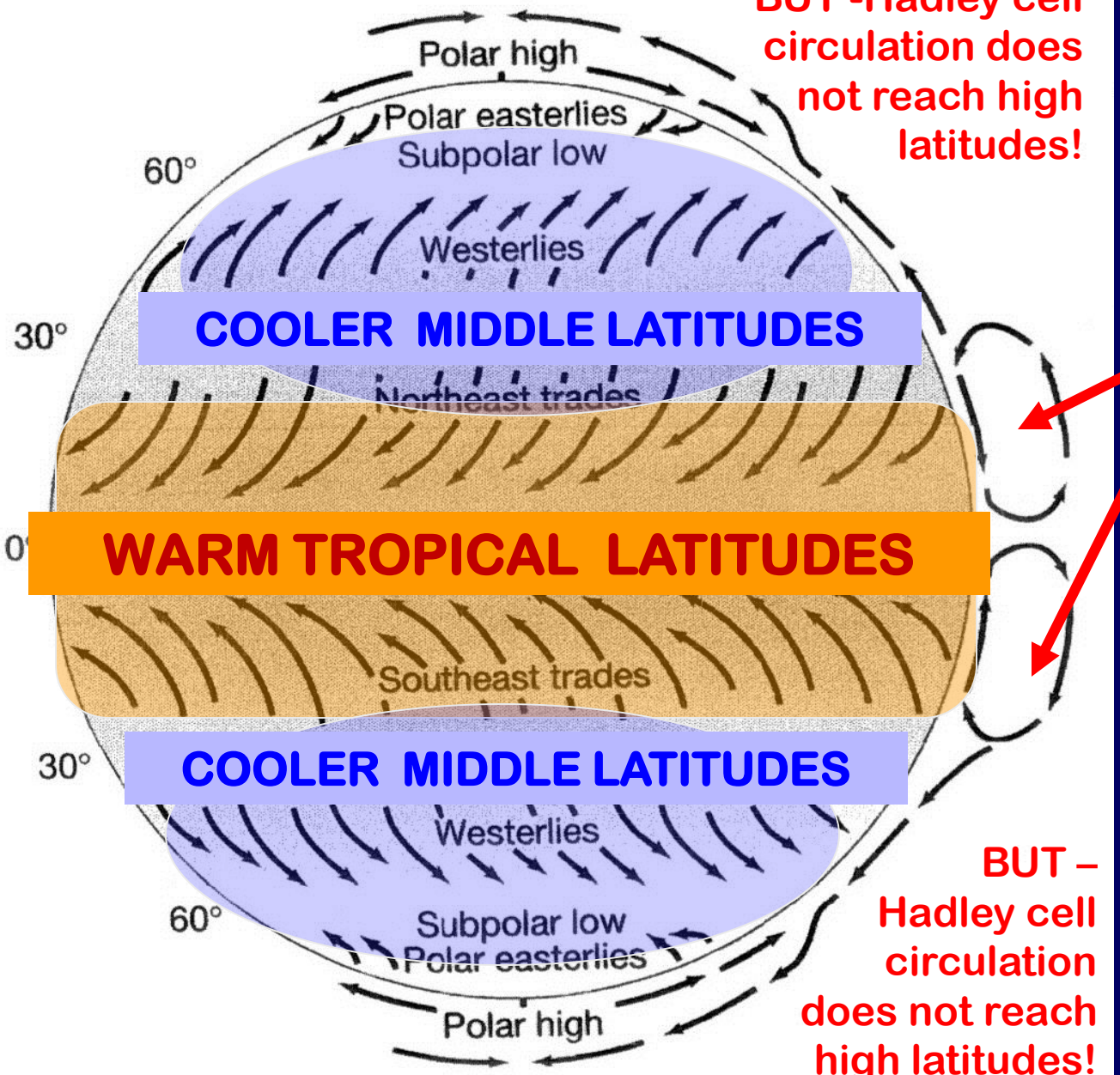
From SGC Chapter 4

HOW DOES THE ATMOSPHERE BALANCE OUT THE SURPLUS & DEFICIT OF ENERGY??



Energy Transfer via Convection Cells

Figure from SGC E-text Chapter 4



BUT -Hadley cell circulation does not reach high latitudes!

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Hadley Cells transport warm air poleward as SENSIBLE HEAT

HADLEY CELLS = key drivers!

Convection cell transfer of thermal energy from low latitude area of energy SURPLUS to higher latitude area of energy DEFICIT

ENERGY TRANSFER BY CONVECTION

To be continued . . .