Thursday Oct 9

Sit anywhere today

Topic #8 The Global Energy Balance & Answers to G-2 Assignment

ANNOUNCEMENTS

- The Midterm Exam is next Thursday, Oct 16th
- The Study Guide will be posted by Friday night
- STUDY SESSION(s) will be held next week - TBA

Clicker Q1:

When is the BEST time for a Midterm Exam Study Session next week?

A. Monday 4:00 – 5:30 pm
B. Tuesday 4:00 – 5:30 pm
C. Wednesday 4:00 – 6:00 pm
D. Wednesday 7:00 – 9:00 pm
E. Wednesday 11 pm – 1 am in D2L chat room
F. OTHER

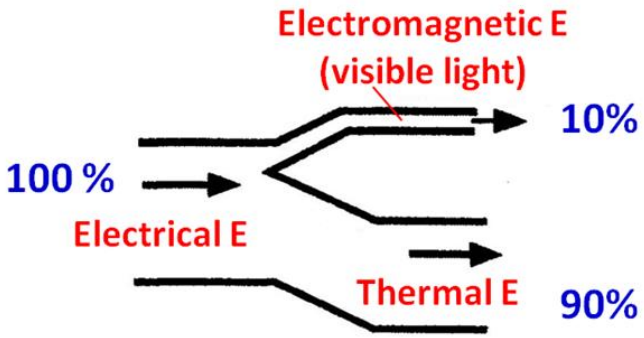
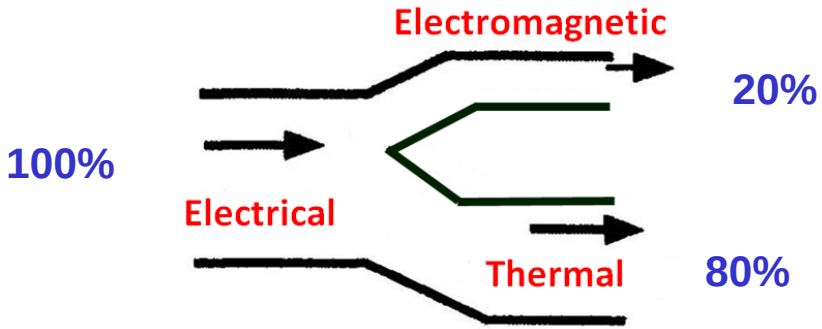
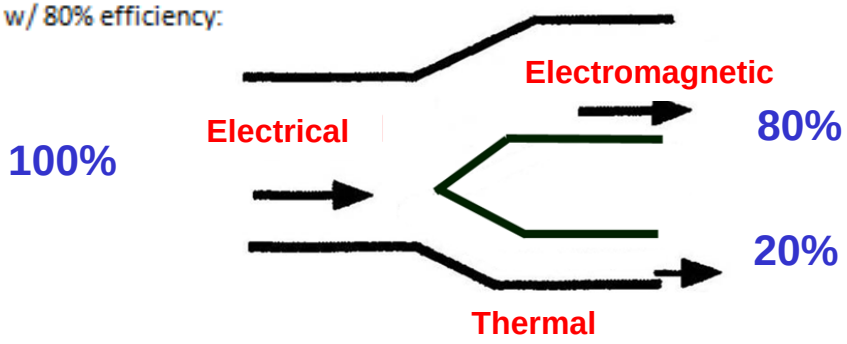
Clicker Q2:

When is the SECOND BEST time for a Midterm Exam Study Session next week?

A. Monday 4:00 – 5:30 pm
B. Tuesday 4:00 – 5:30 pm
C. Wednesday 4:00 – 6:00 pm
D. Wednesday 7:00 – 9:00 pm
E. Wednesday 11 pm – 1 am in D2L chat room
F. OTHER

WRAPPING UP TOPIC #7

G-2 ENERGY EFFICIENCY
THE ANSWERS

		RANK
	Diagram for Incandescent bulb 	3
	Diagram for CFL bulb: 	2
	Diagram for LED w/ 80% efficiency: 	1

Common 60W Incandescent Bulb

uses 60W per bulb for 800 lumens

1 bulb lasts 1,200 hrs

20 years = 21 bulbs

An **INCANDESCENT BULB** uses heat caused by an electrical current. When electrical current passes through a wire, it causes the wire to heat. The wire, or filament, gets so hot that it glows and gives off VISIBLE LIGHT.

Common 14W CFL Bulb

uses 14W per bulb for 800 lumens

1 bulb lasts 10,000 hrs

20 years = 3 CFL bulbs

In a **CFL**, an electric current is driven through a tube containing argon gas and a small amount of **mercury** vapor. This generates UV radiation that excites a fluorescent coating (called phosphor) on the inside of the tube, which then emits VISIBLE LIGHT.

ENERGY STAR

Source: http://www.energystar.gov/

SCIENCE

108 COMMENTS

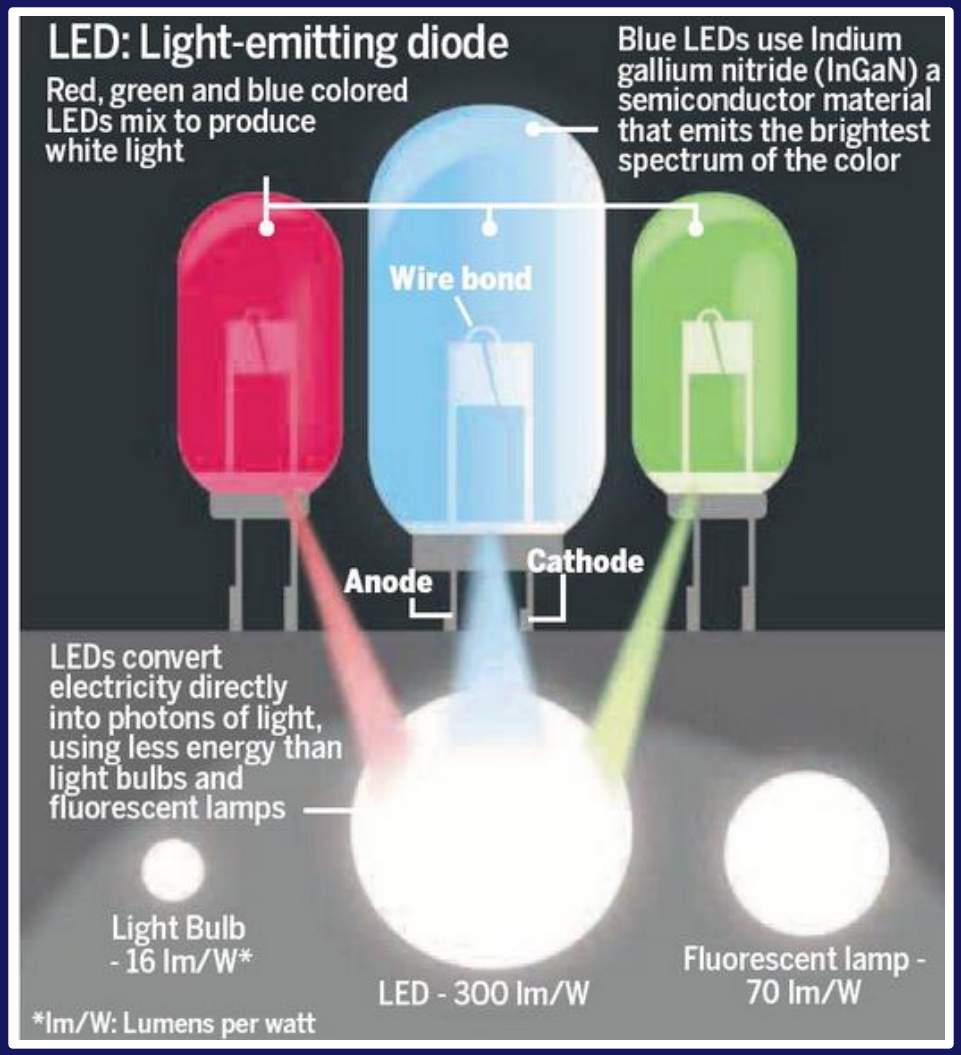
2 Japanese and 1 American Share Nobel in Physics for Work on LED Lights

From left, the researchers Isamu Akasaki, Hiroshi Amano and Shuji Nakamura were awarded the Nobel Prize in Physics for "the invention of efficient blue light-emitting diodes, which has enabled bright and energy-saving white light sources." Randall Lamb/Agence France-Presse — Getty Images

"They succeeded where everyone else had failed," the academy said.

Their work has spurred the creation of a whole new industry. The committee that chose the winners said light-emitting diodes, or LEDs, would be the lighting source of the 21st century, just as the incandescent bulb illuminated the 20th.

LED Light Bulbs



Sources: The Royal Swedish Academy of Sciences, NoblePrize.org, OSRAM Opto Semiconductors, BBC, Reuters
Graphic: Erik Rodriguez

10/8/14

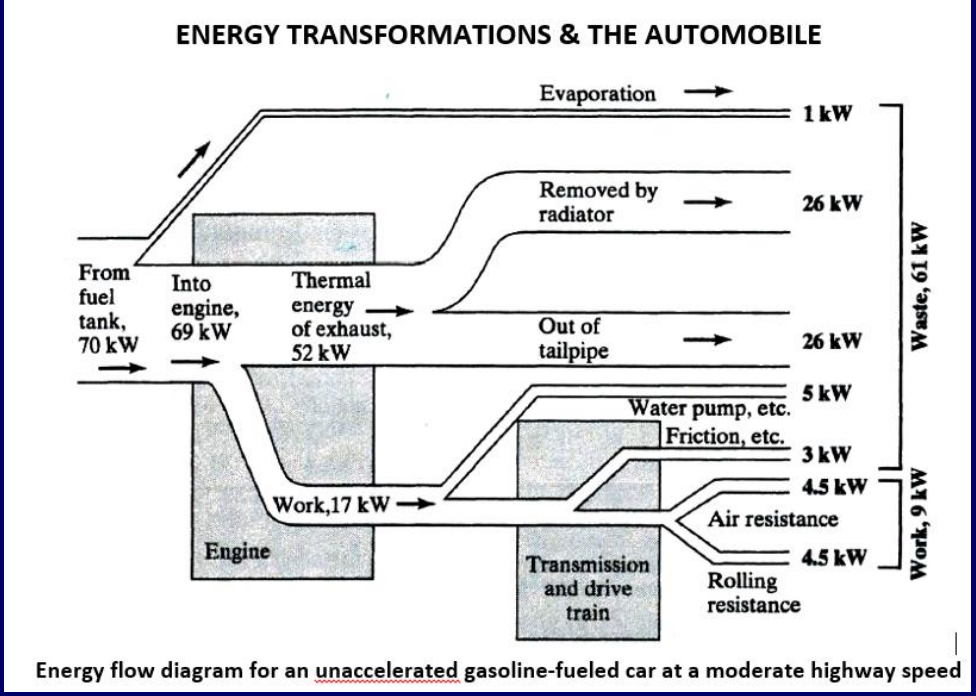
uses 12.5W per bulb for 800 lumens

1 bulb lasts 25,000 hrs

20 years = 1 LED bulb

Philips 12.5W AmbientLED Bulb

"LEDs convert electricity directly into photons of light. . ."



Q1. What % of the energy in the fuel does work running the engine?

Answer = **24%** = Engine's Energy Efficiency

(17 ÷ 70)

Q2. What % of the energy in the fuel eventually does "work" that moves the car (by overcoming air resistance and rolling resistance)?

Answer = **13%** = Overall Energy Efficiency of the Automobile

(9 ÷ 70)

Q5. Why are FREIGHT TRAINS more efficient?

Q6. Why is AIR FREIGHT the LEAST efficient mode?

Q7. Why is BICYCLING so much more efficient than walking?

Rank the Efficiency of Each Type of Electricity-Producing Power Source:

#1 = Most Efficient

- burning fossil fuel (coal) for electricity

Coal-fired electric power plant

- sunlight to electricity in a solar panel

Photovoltaic (PV) panel

- hydro power turbines

Hydroelectric plant

- wind turbines

Wind farm

ANSWER: Rank the Efficiency of Each Type of Electricity-Producing Power Source:

#1 = Most Efficient

#3 burning fossil fuel (coal) for electricity ~ 33-38%

Coal-fired electric power plant

#4 sunlight to electricity in a solar panel ~15-20%

Photovoltaic (PV) panel

#1 hydro power ~85-90% turbines

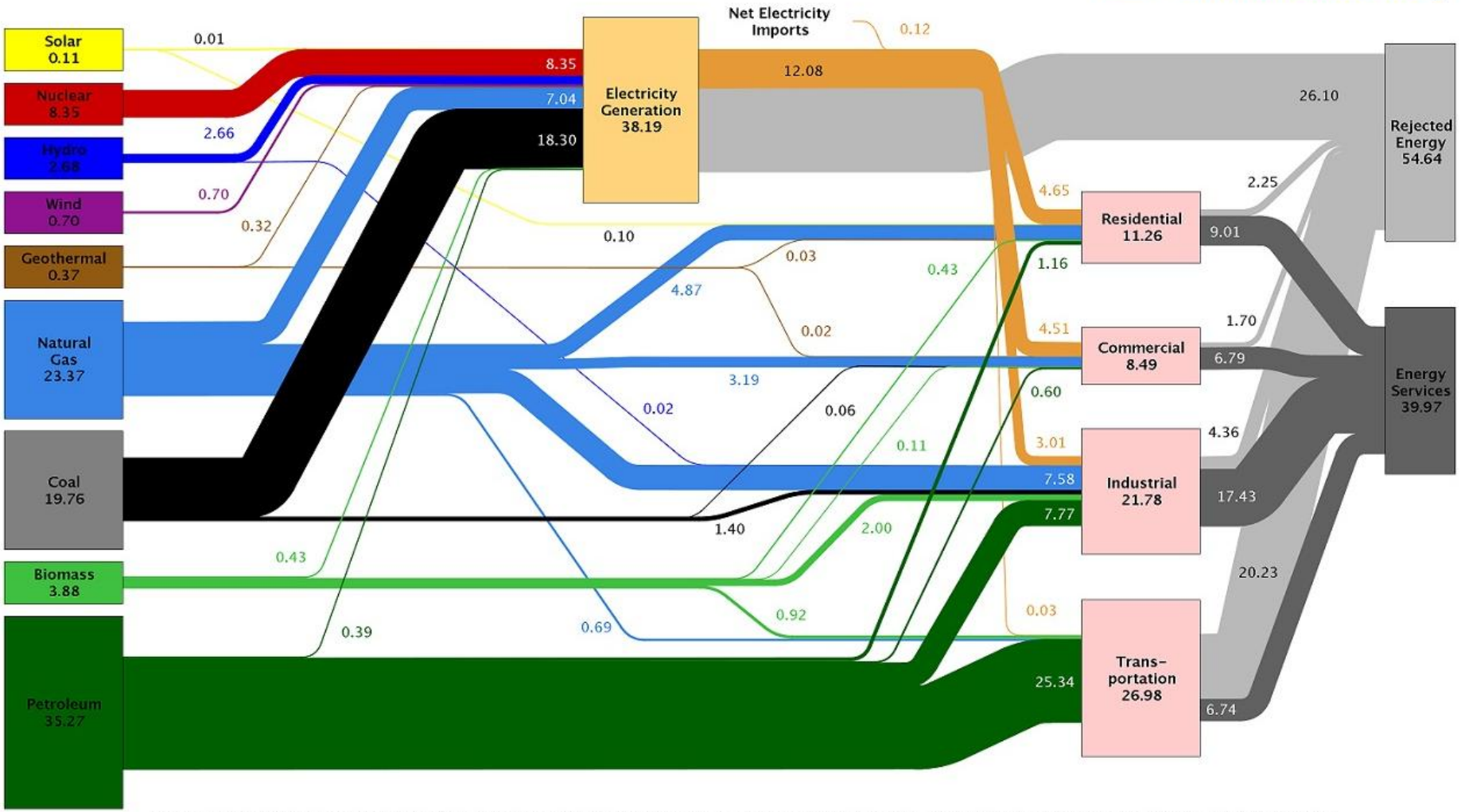
Hydroelectric plant

#2 wind turbines ~30-45%

Wind farm

Estimated U.S. Energy Use in 2009: ~94.6 Quads

Lawrence Livermore National Laboratory

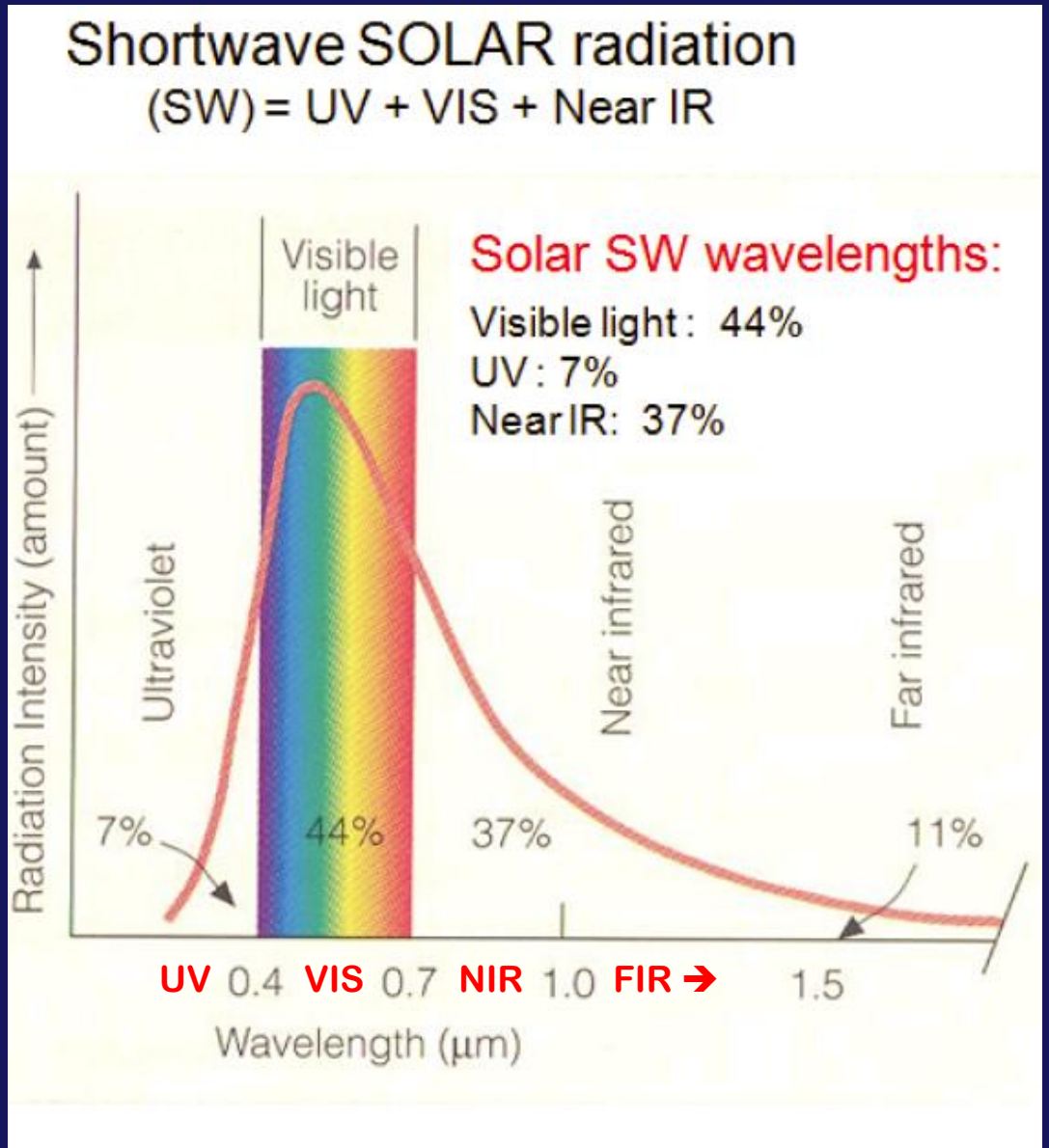


Source: LLNL 2010. Data is based on DOE/EIA-0384(2009), August 2010. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports flows for non-thermal resources (i.e., hydro, wind and solar) in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 80% for the residential, commercial and industrial sectors, and as 25% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

Topic # 8
THE EARTH'S GLOBAL ENERGY BALANCE

Applying the laws, etc. to understand how processes all work together to create global weather & climate!!

FOR THE ENERGY BALANCE TOPIC



we'll use SW & LW abbreviations:

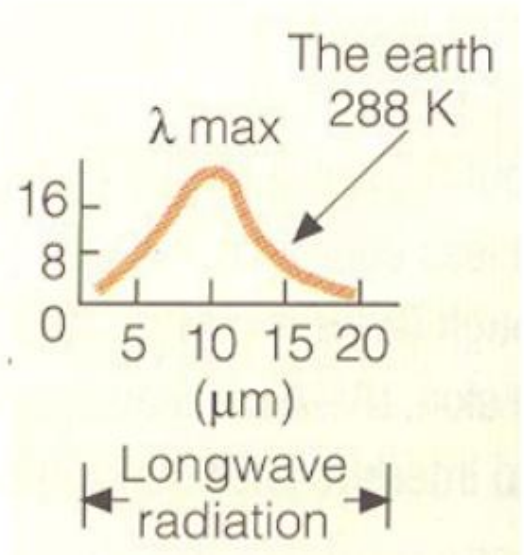
SW = UV + VIS primarily

+ NIR (Near IR that "reflects" like VIS)

TERRESTRIAL radiation
(LW) = Far IR

Terrestrial (Earth) radiation wavelengths:

Far IR, with a maximum at ~ 10 μm



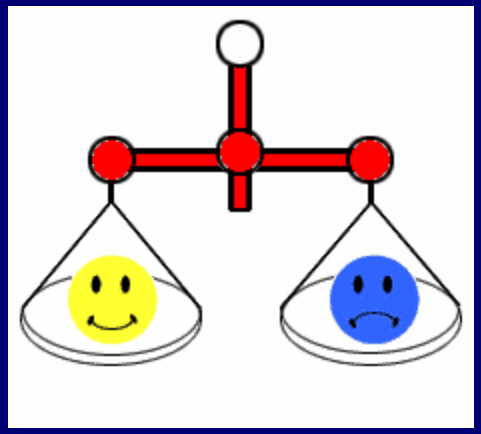
LW = all infrared (Far IR)

Topic # 8
THE EARTH'S GLOBAL ENERGY BALANCE

Applying the laws, etc. to understand how processes all work together to create global weather & climate!!

Go to p 49 &
"bookmark" p 121 in Appendix
in Class Notes
We'll be referring to both sections in class today

Today's Quote:
A Different Sort of "ENERGY BALANCE":



Look at life as an energy economy game. Each day, ask yourself,

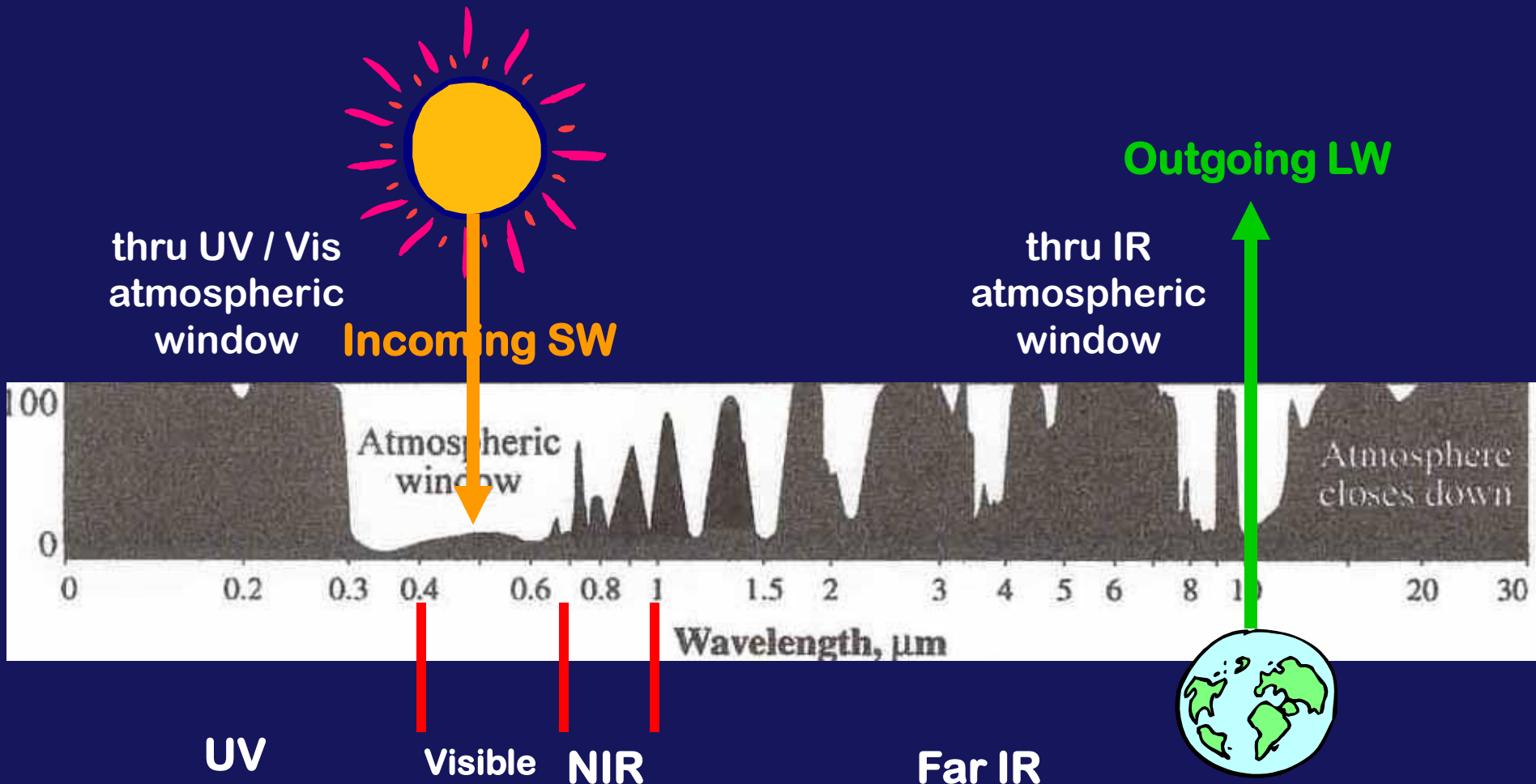
Are my energy expenditures (actions, reactions, thoughts, and feelings) productive or nonproductive?

During the course of my day, have I accumulated more stress or more peace?

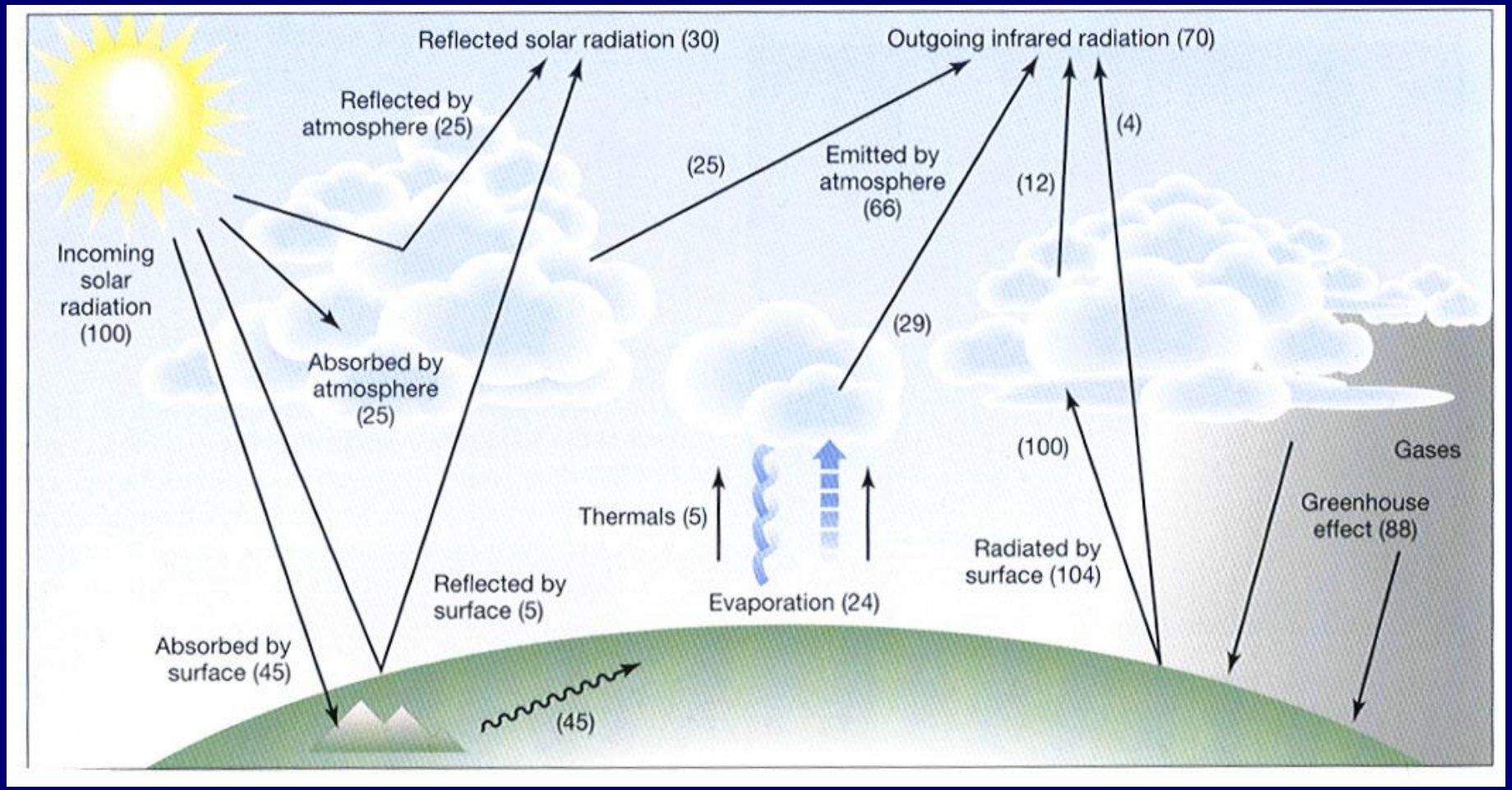
~ Doc Childre and Howard Martin

Review: Absorption curve for the "Whole Atmosphere"

OVERALL BALANCE: Incoming = Outgoing

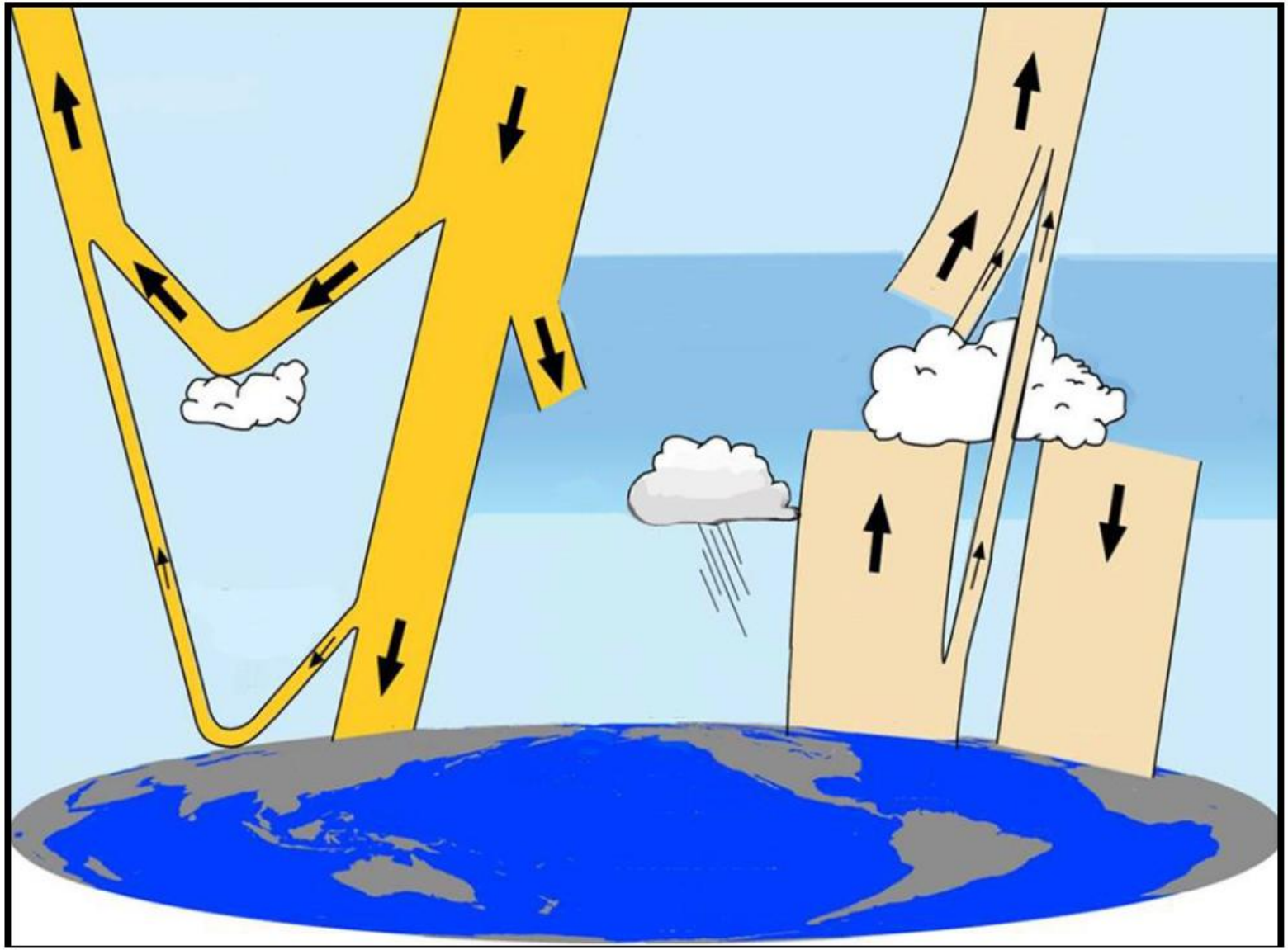


Typical Energy Balance Diagram



From SGC-E-Text Chapter Fig 3-19

You've got a similar one (without labels) on p 49:



Energy Balance Equation:

$$R_{net} = (Q + q) - a - Lu + Ld = H + LE + G$$

(one of several ways this equation can be written)

Up till now we've been emphasizing Absorption, Emission & Transmission ➔

BUT Electromagnetic Radiation can also be:

Electromagnetic Radiation can be:

- **ABSORBED (and EMITTED)**
- **TRANSMITTED**
- **SCATTERED, or**
- **REFLECTED**

Let's see how it all fits together in the various components of the **Earth's Energy Balance**

➔**We'll use "cartoon symbols" . . .**

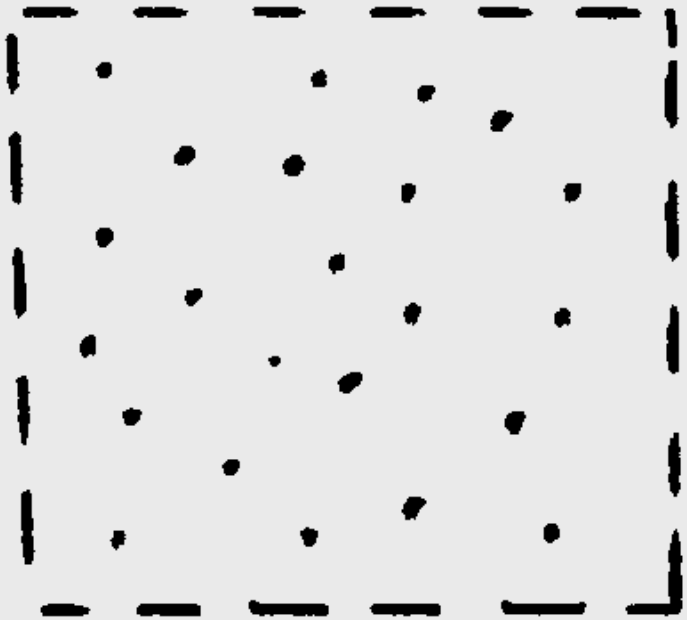
“CARTOON” SYMBOLS:

To represent the Earth’s surface:

Note -taking suggested:

on blank page 50

“CARTOON” SYMBOLS:

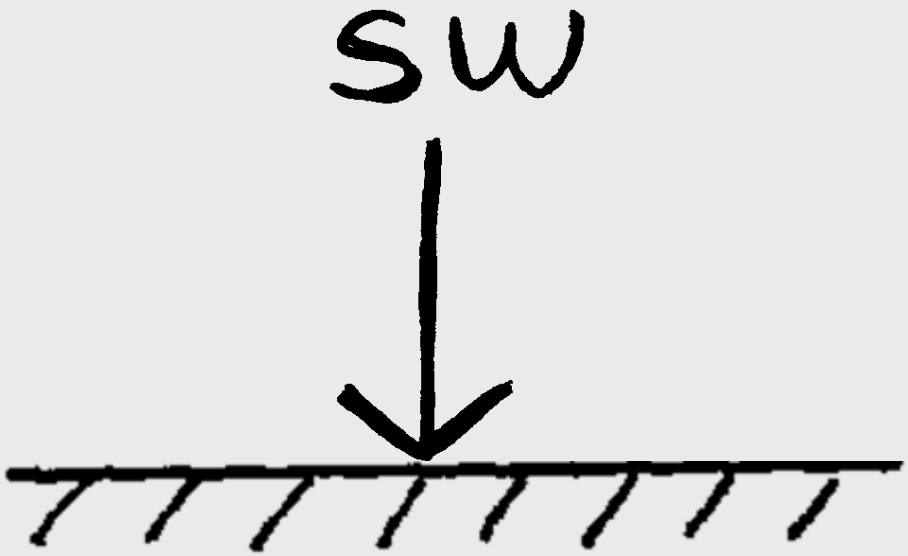


To represent the atmosphere – composed of both invisible gases, aerosols, dust and other particulate matter:

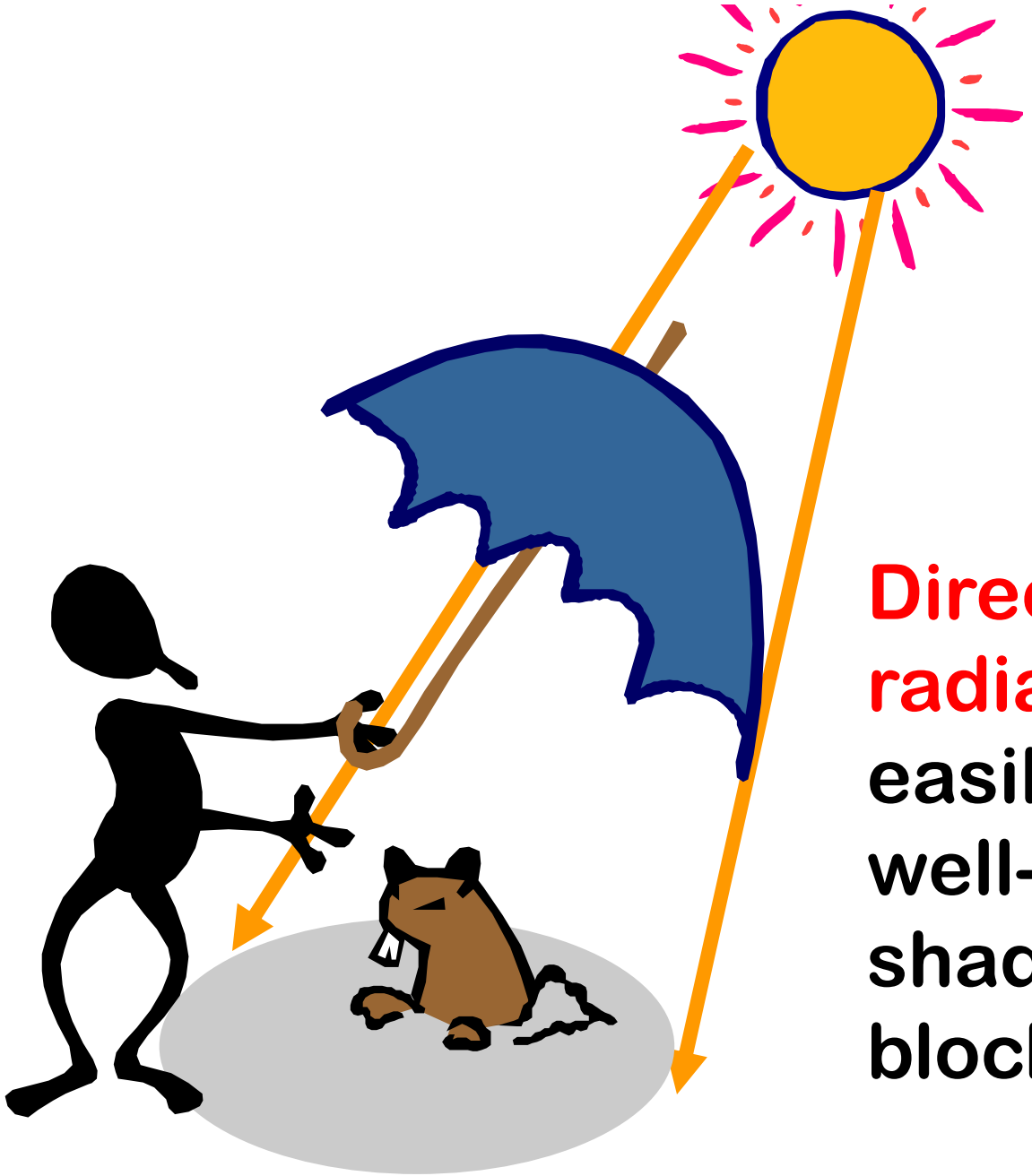
“CARTOON” SYMBOLS:

To represent CLOUDS

"CARTOON" SYMBOLS:

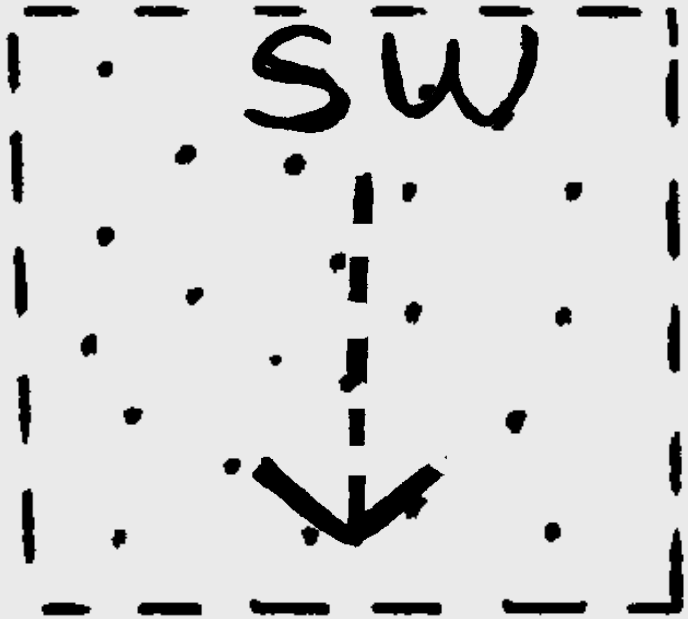


To represent SOLAR (shortwave) radiation coming in DIRECTLY. (aka Direct shortwave radiation)



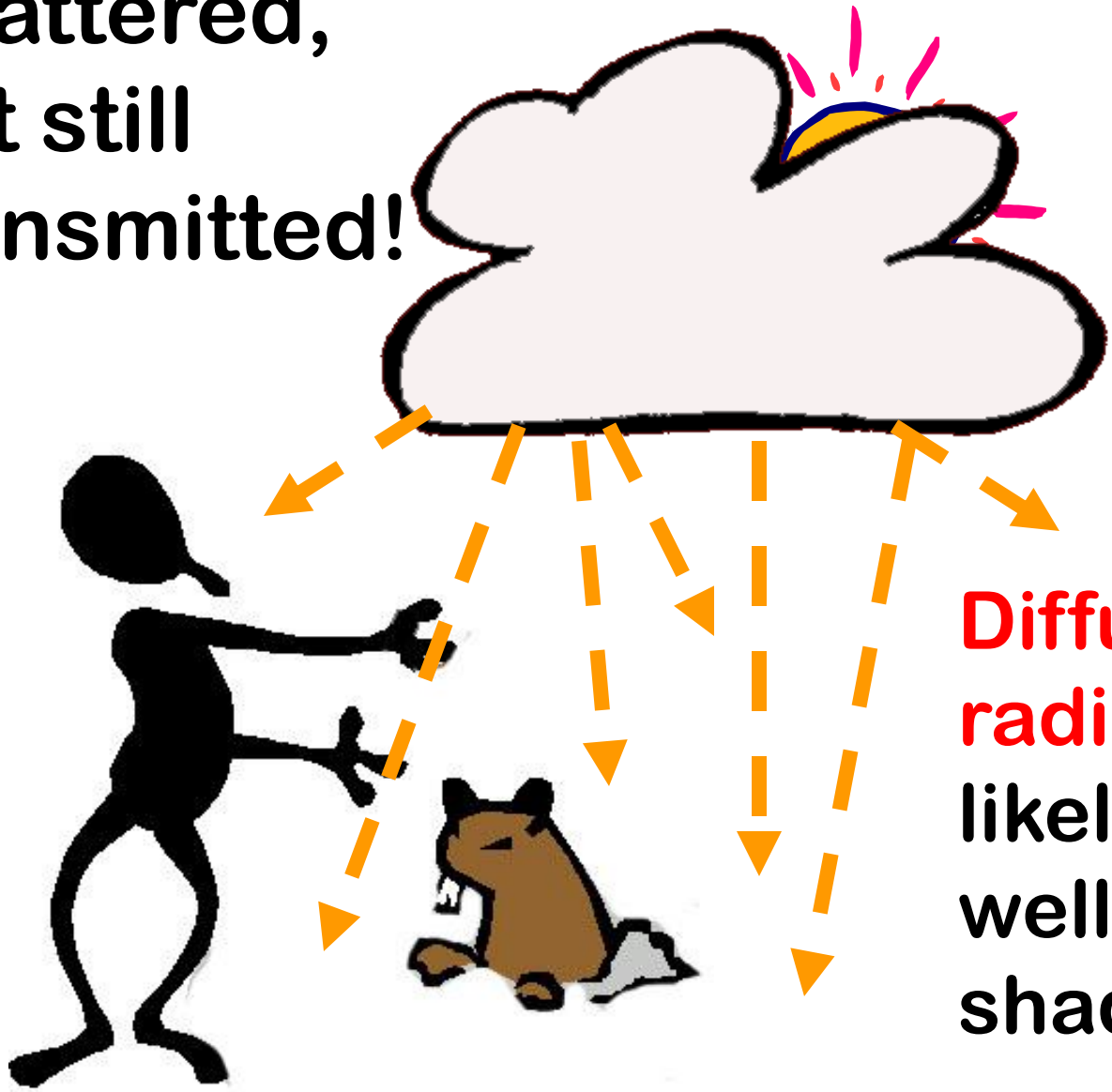
Direct SW radiation easily casts well-defined shadows when blocked

"CARTOON" SYMBOLS:



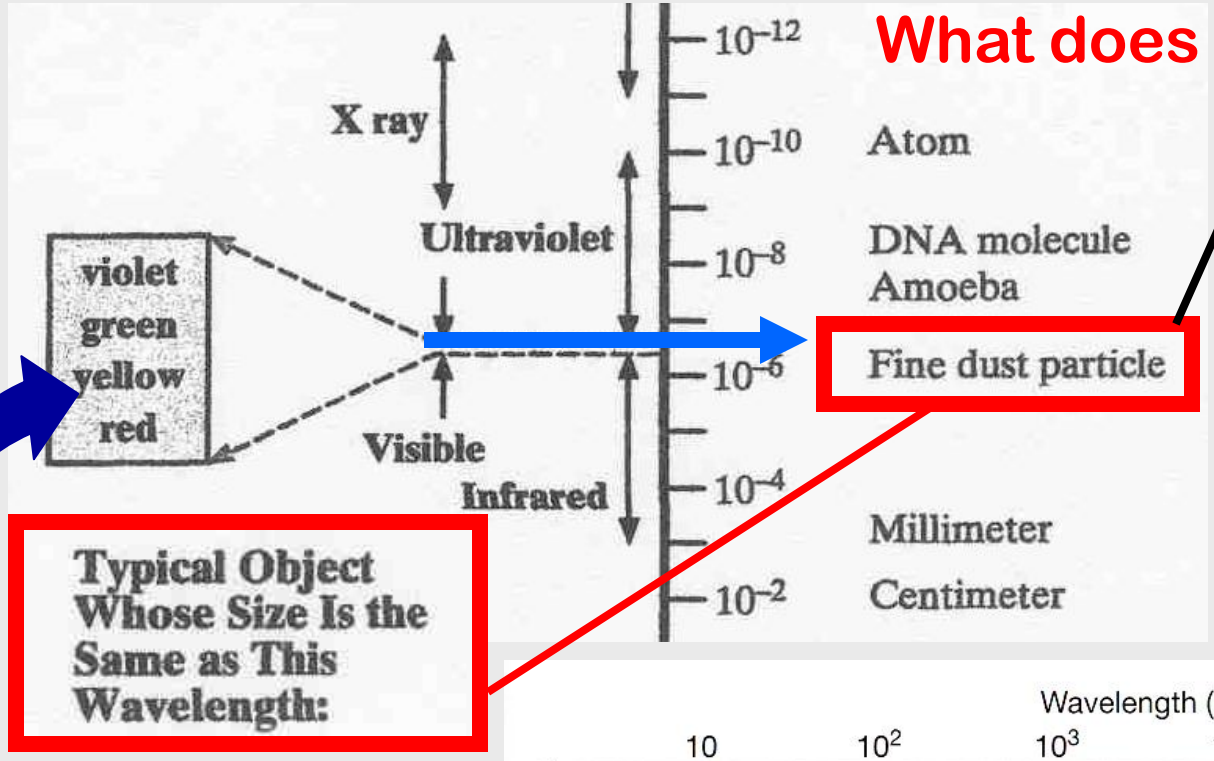
To represent SOLAR (shortwave) radiation coming in as **DIFFUSE shortwave radiation**, i.e. scattered by gases, clouds, and particles in the atmosphere.

Scattered, but still transmitted!

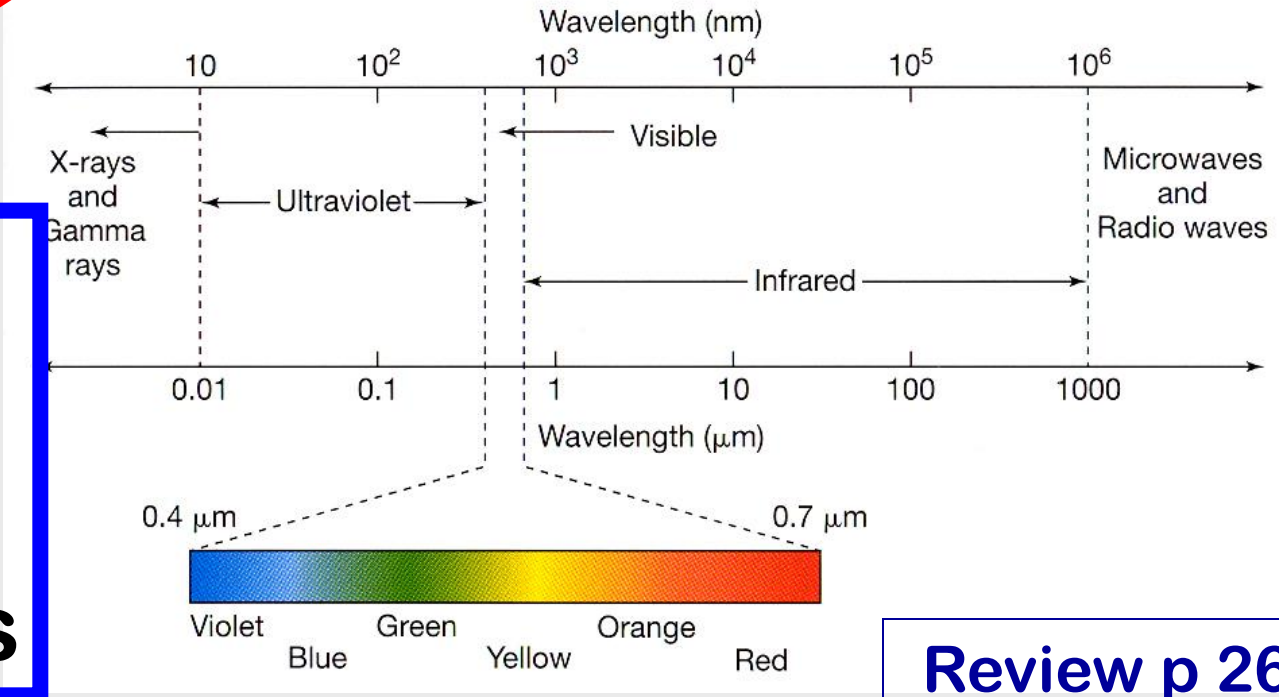


Diffuse SW radiation is less likely to cast a well-defined shadow!

What does the scattering?

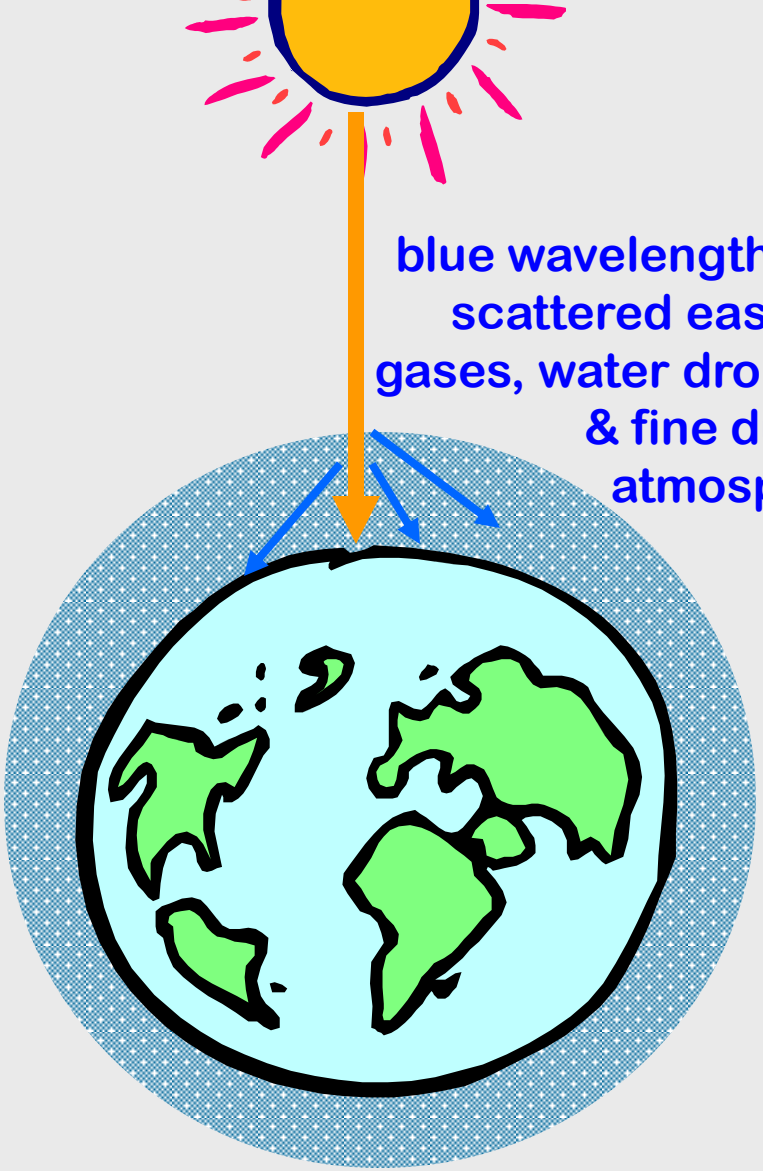


Different sized dust particles, water droplets, aerosols,
(even GAS MOLECULES themselves!)



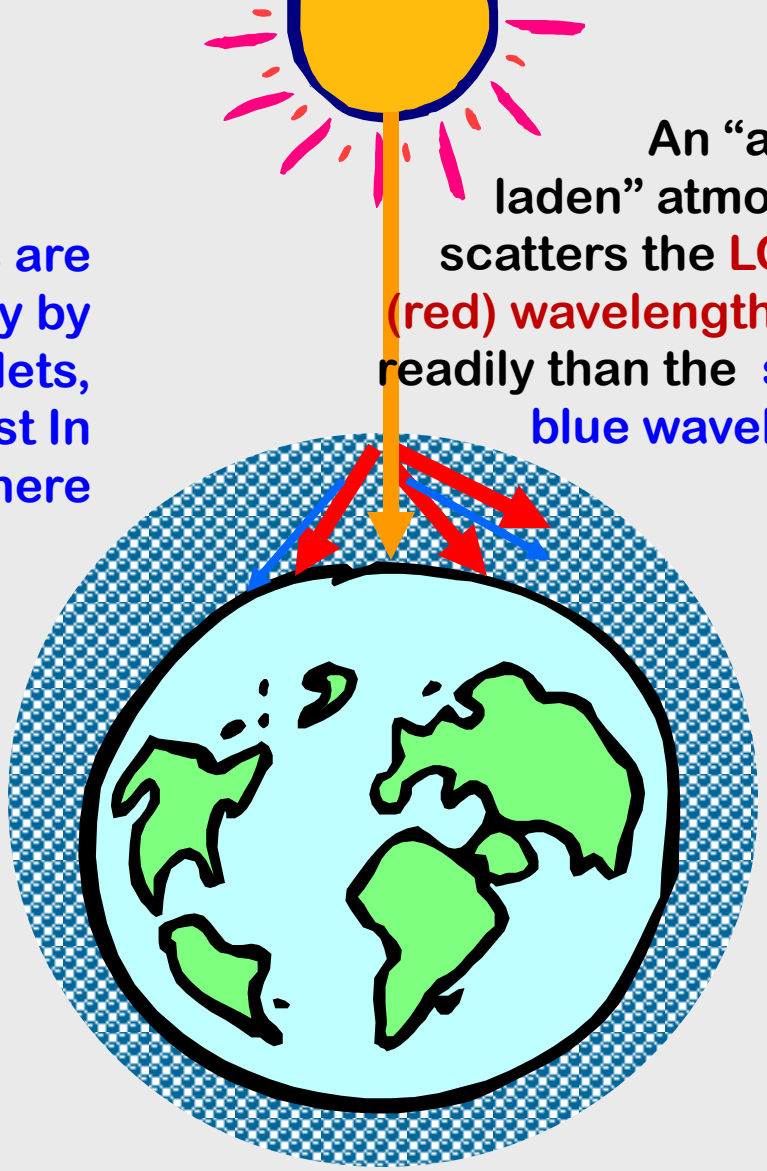
Scattering of visible light wavelengths

Review p 26



blue wavelengths are scattered easily by gases, water droplets, & fine dust In atmosphere

“Clear” atmosphere composed primarily of fine particles, water droplets, gas molecules



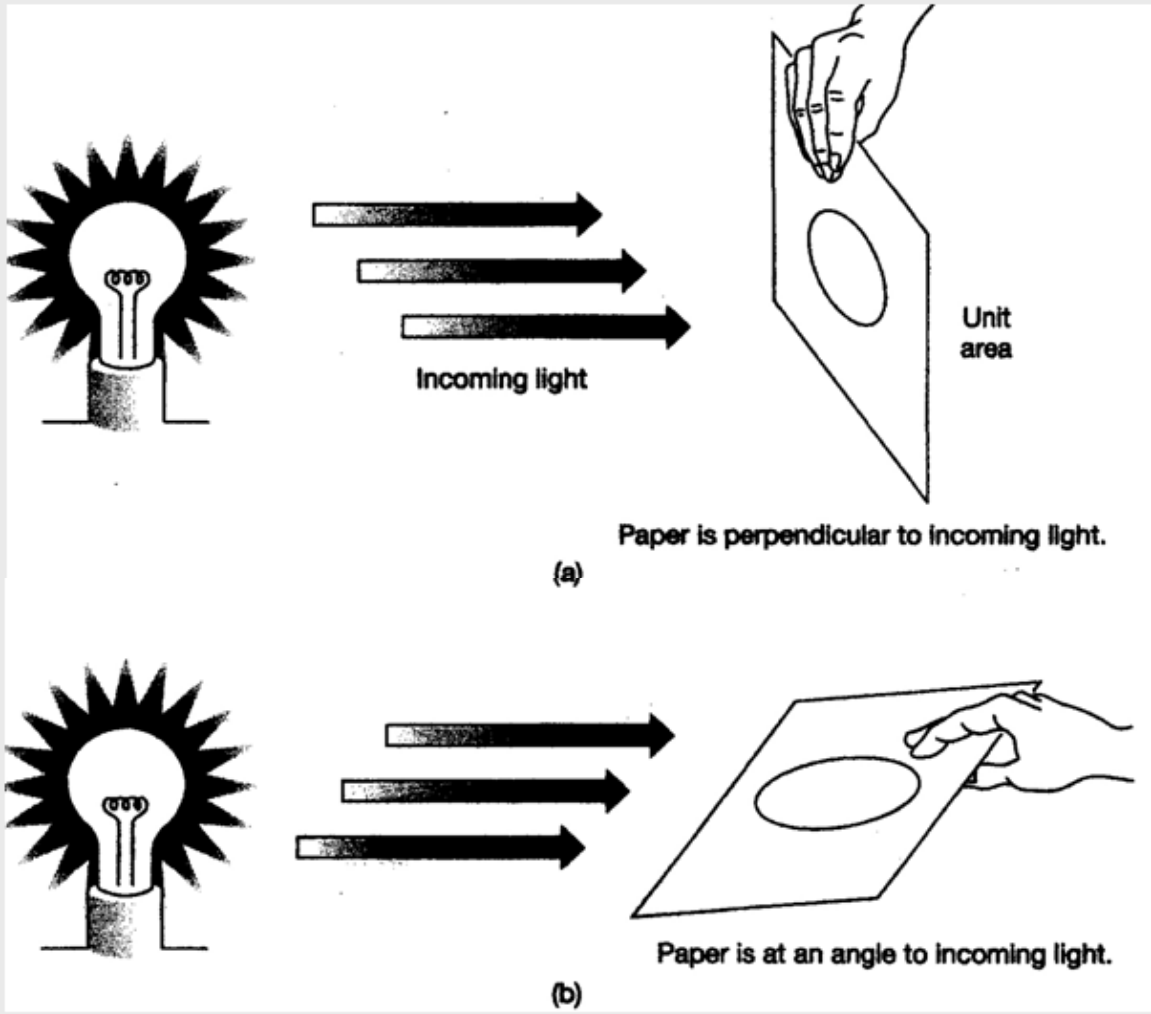
An “aerosol-laden” atmosphere scatters the LONGER (red) wavelengths more readily than the shorter blue wavelengths

“Dirty” (aerosol-laden) atmosphere composed of fine particles, gases, & H_2O -- PLUS larger dust particles, aerosols, pollution, etc.

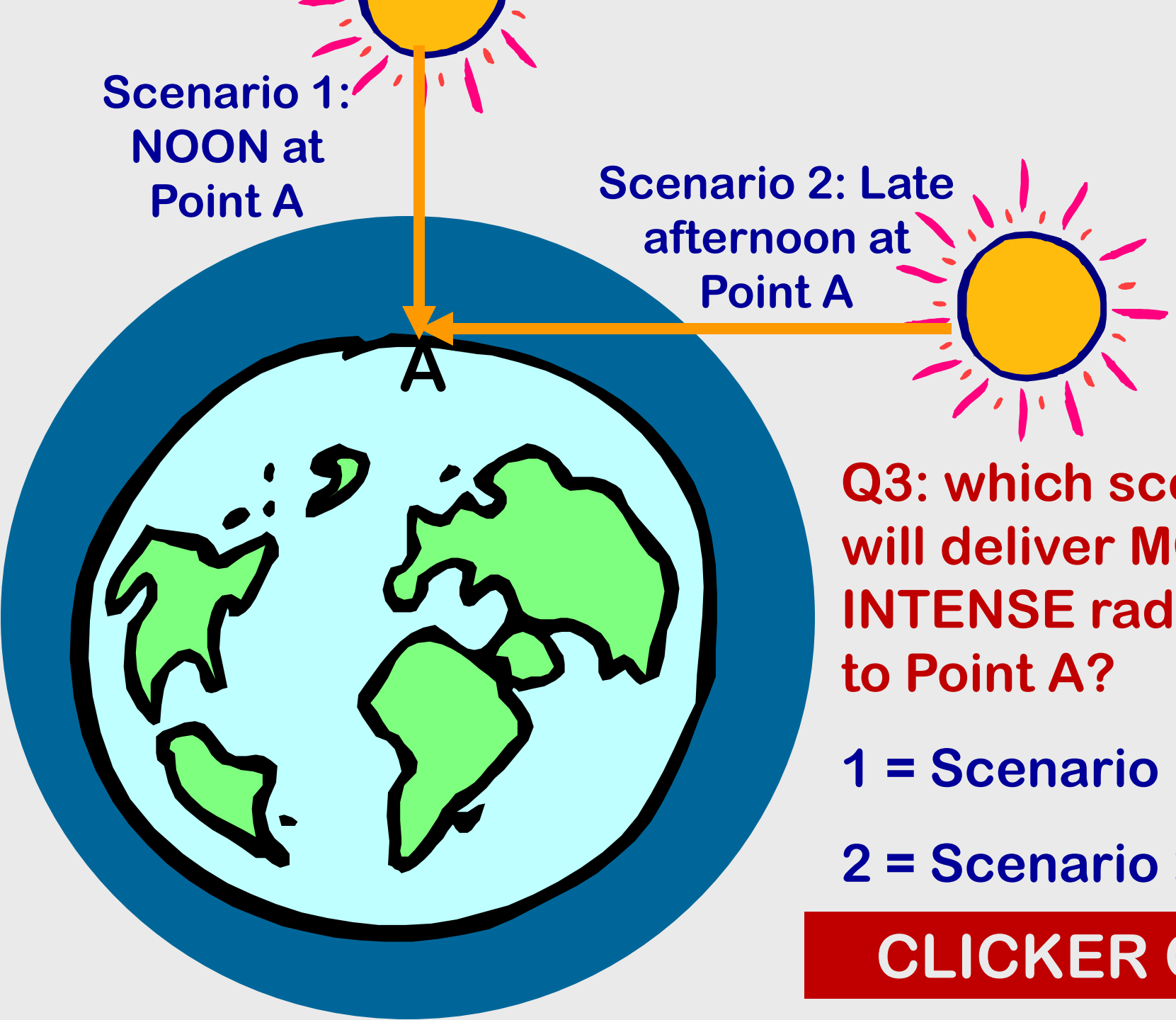
ALSO: The angle at which direct SW radiation is intercepted by a surface makes a difference!!

Radiation is concentrated over a small area & hence is more intense when it comes in perpendicular to the surface

Radiation is spread out over a larger area & hence is less intense per unit area when it comes in at an angle.



From Figure 3-4 in SGC-E-text, Ch 3

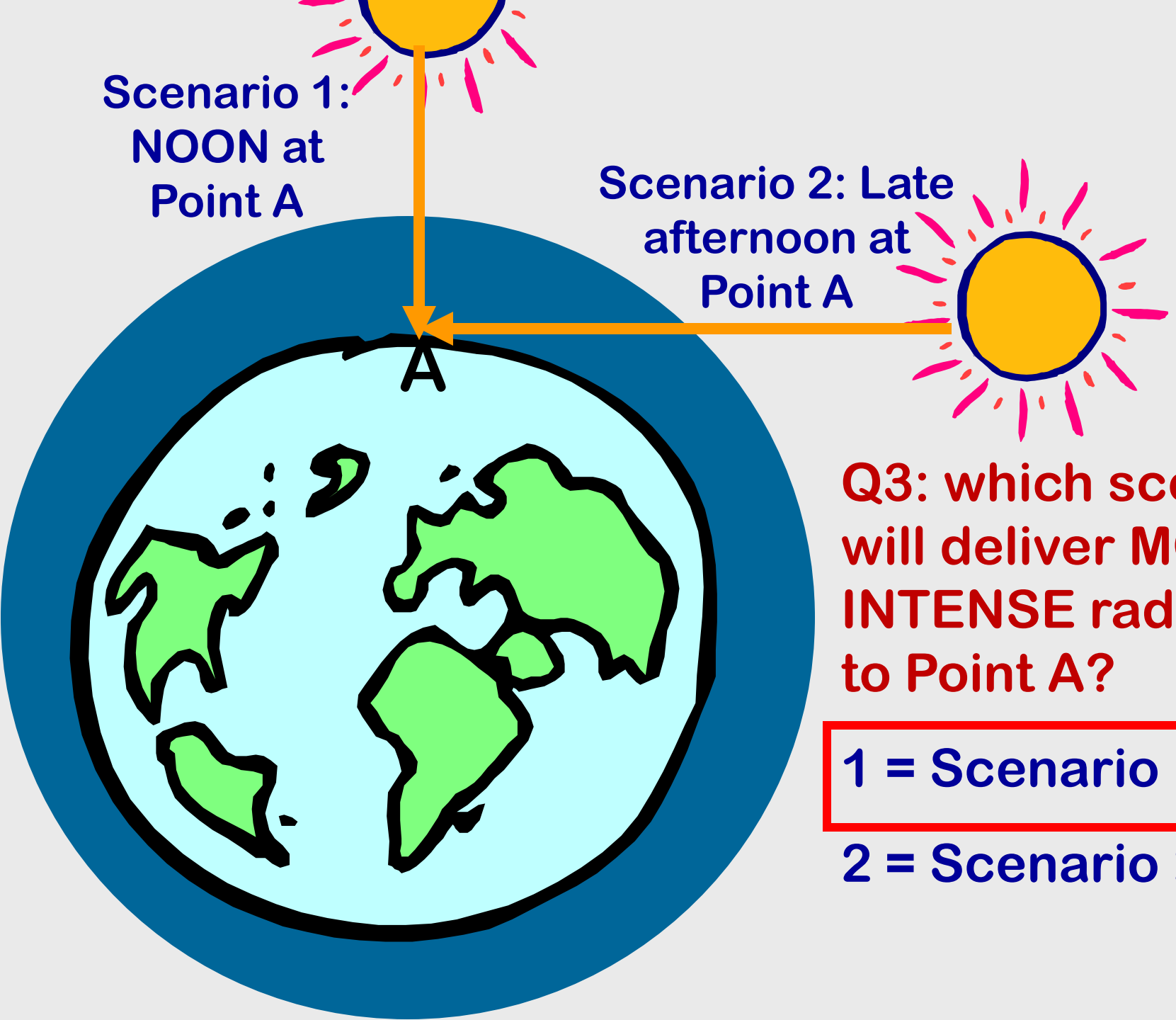


Q3: which scenario will deliver MORE INTENSE radiation to Point A?

1 = Scenario 1

2 = Scenario 2

CLICKER Q!



Q3: which scenario will deliver MORE INTENSE radiation to Point A?

1 = Scenario 1

2 = Scenario 2

Q4- WHY is the intensity of the SW radiation at Point A not as strong in the late afternoon as it is at noon?

CLICKER Q!

1 = because as the Sun goes down close to sunset time, it gives off less radiation

2 = because the SW radiation is coming in at an angle in the late afternoon, and is not directly overhead (perpendicular) like it is at noon.

3 = because the SW radiation is being transmitted through a thicker atmosphere & hence scattered more

4 – BOTH #2 and #3 are applicable!

Q4- WHY is the intensity of the SW radiation at Point A not as strong in the late afternoon as it is at noon?

1 = because as the Sun goes down close to sunset time, it gives off less radiation

2 = because the SW radiation is coming in at an angle in the late afternoon, and is not directly overhead (perpendicular) like it is at noon.

3 = because the SW radiation is being transmitted through a thicker atmosphere & hence scattered more

4 – BOTH #2 and #3 are applicable!

"CARTOON" SYMBOLS:

To represent SOLAR (shortwave) radiation that is REFLECTED (or scattered) BACK TO SPACE by: atmosphere, clouds, Earth's surface, etc.

Key term:

ALBEDO = reflectivity of a surface

"*symbol*" = a

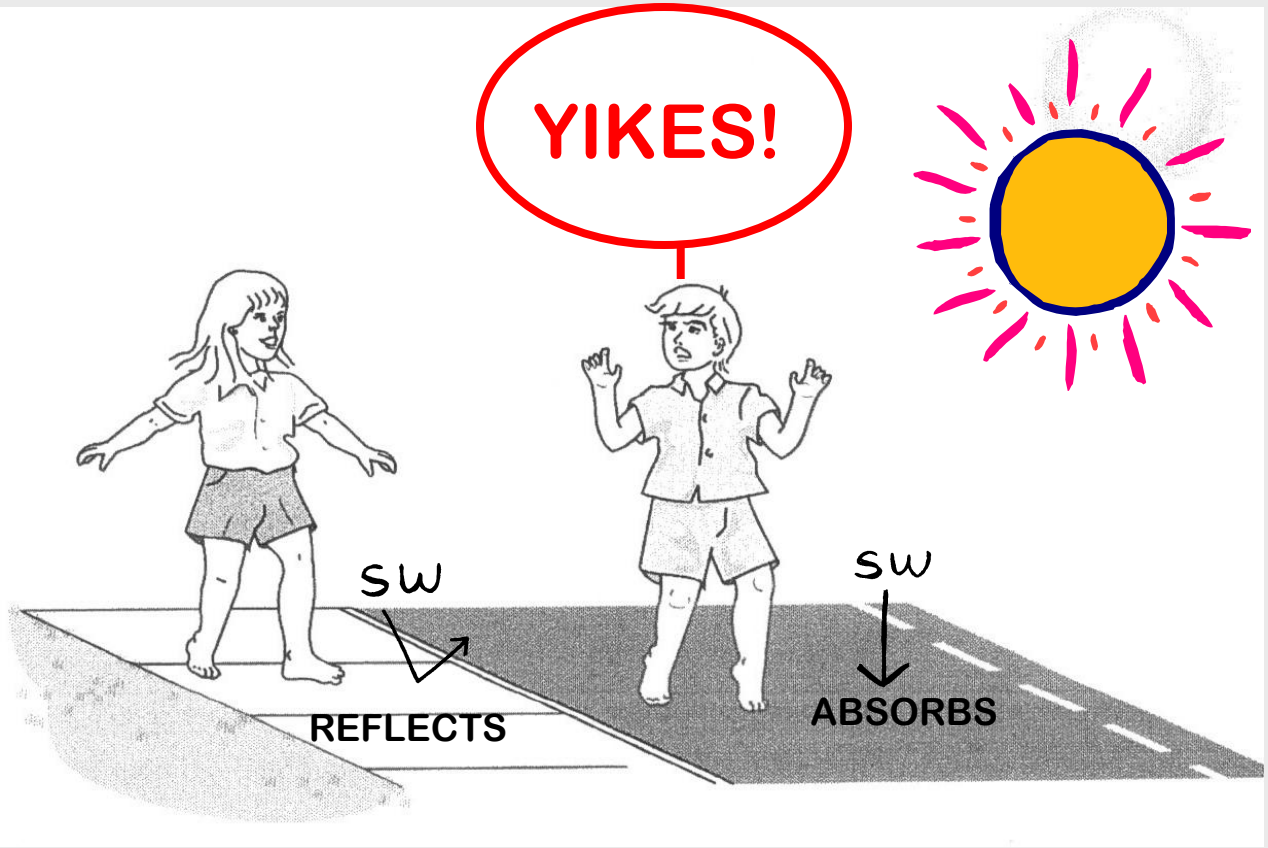
Represented as:

a decimal from 0 to 1.0 *or*

% from 0 – 100 % (perfect reflectivity)

Hence, amount ABSORBED = (1 – albedo)

Bottom of p 49



If a surface's albedo is HIGH, absorption by the surface is LOW ➔ COOLER surface

If a surface's albedo is LOW absorption by the surface is HIGH => HOTTER surface!

Albedos of Some Common Surfaces

Type of Surface	*Albedo*
Sand	0.20–0.30
Grass	0.20–0.25
Forest	0.05–0.10
Water (overhead Sun)	0.03–0.05
Water (Sun near horizon)	0.50–0.80
Fresh snow	0.80–0.85
Thick cloud	0.70–0.80

Low albedo

High albedo

➔ CLOUDS: 0.44 (high, thin clouds) - 0.90 (low, thick clouds)

AVERAGE PLANET EARTH = ~ 0.30

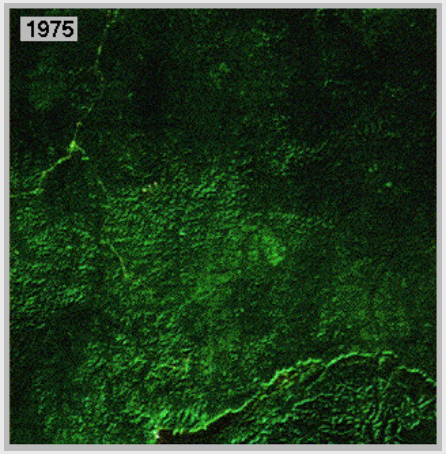
CLICKER Q!

Q5: What will happen to incoming SW over the Amazon Rain Forest if parts of it are deforested?

1 = more SW will be absorbed

2 = less SW will be absorbed

Before



After

Q5: What will happen to incoming SW over the Amazon Rain Forest if parts of it are deforested?

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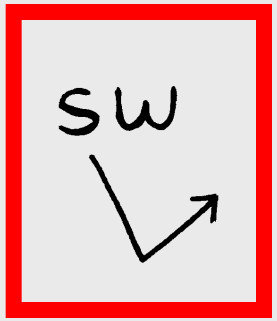
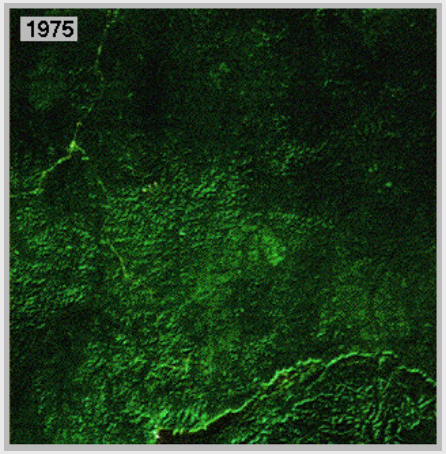


Before



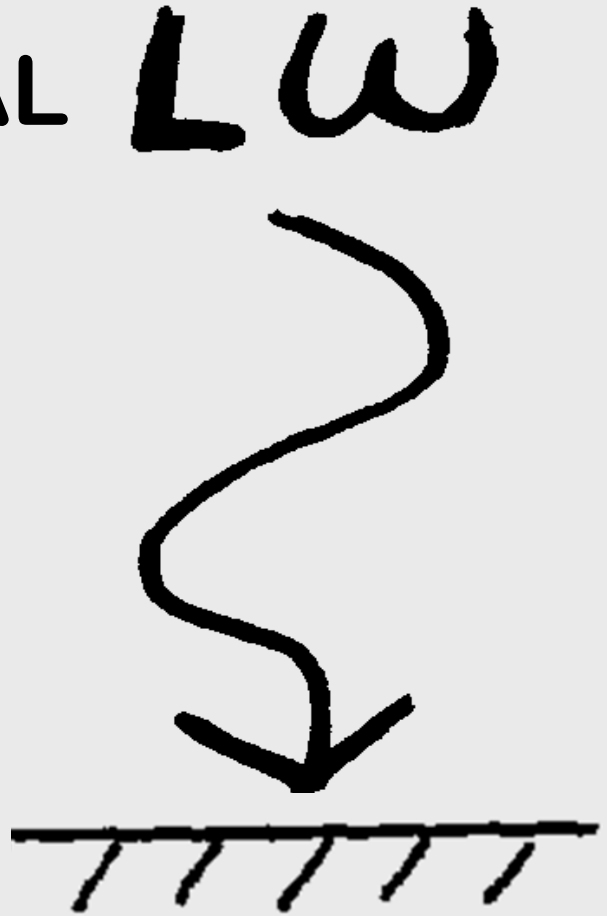
After

"CARTOON" SYMBOLS:

To represent TERRESTRIAL (longwave IR) radiation emitted upward by the Earth's surface or the atmosphere

"CARTOON" SYMBOLS:

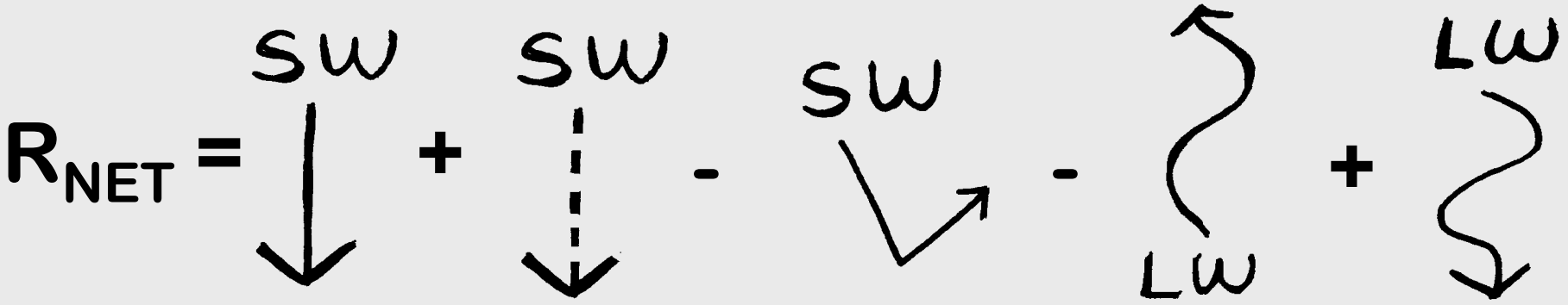
To represent TERRESTRIAL (longwave IR) re-radiation emitted downward by the Earth's ATMOSPHERE



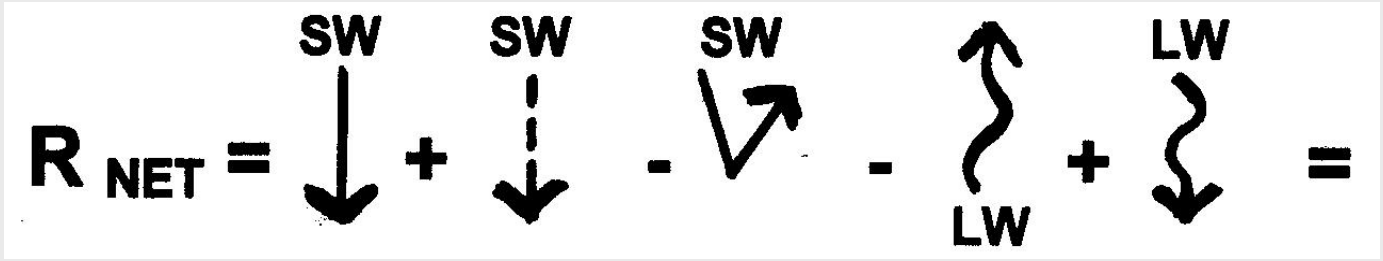
Now flip to p 121 in Appendix ➔

PUTTING IT TOGETHER:

Can you place + and – signs where they ought to go in the equation?



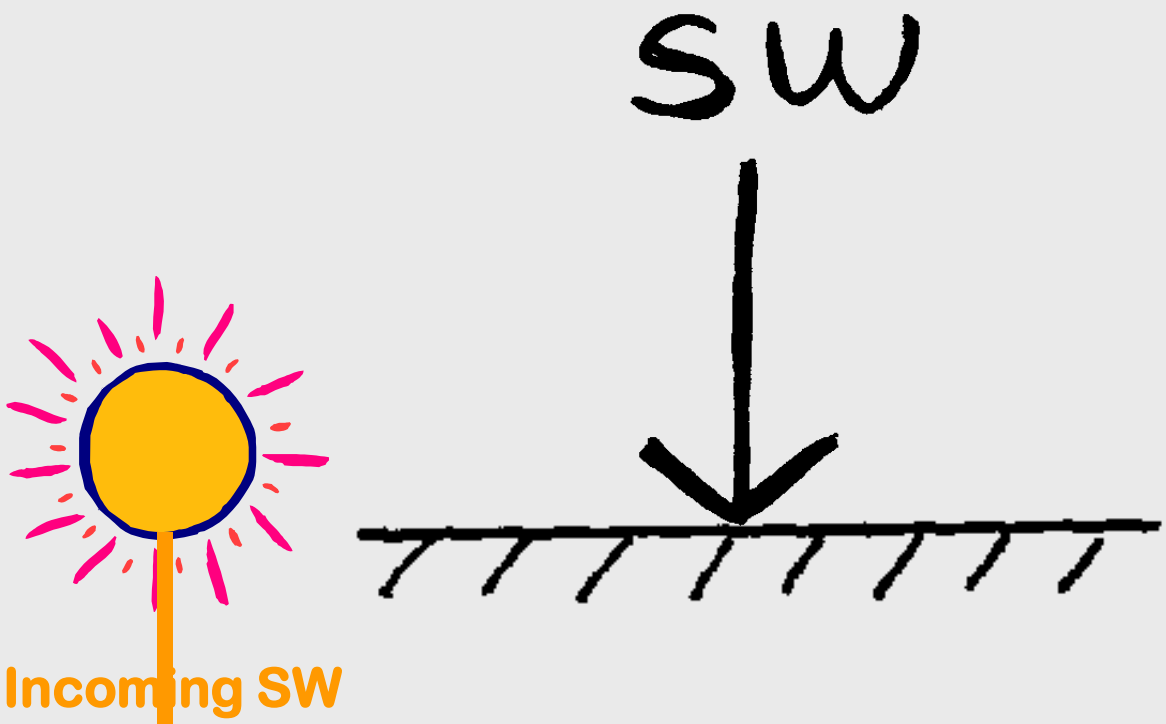
$$R_{NET} = (Q + q) - a - Lu + Ld$$

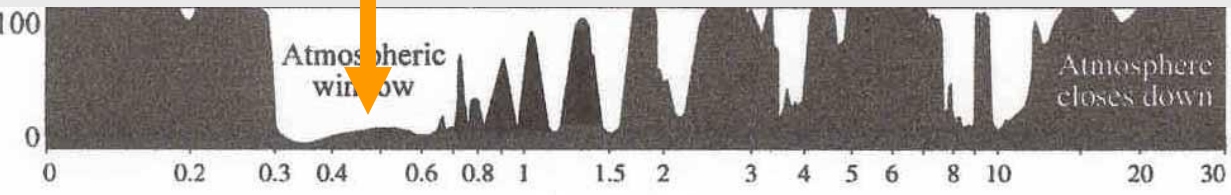


Now we'll look at the energy pathways in a bit more detail by combining the cartoon symbols in various ways . . .

To describe the real Earth-Atmosphere system, more detail is needed in our simple representation . . . . .
We'll use our symbols to build an energy balance "model"

SW BEAMED DIRECTLY TO EARTH'S SURFACE WHERE IT IS ABSORBED:

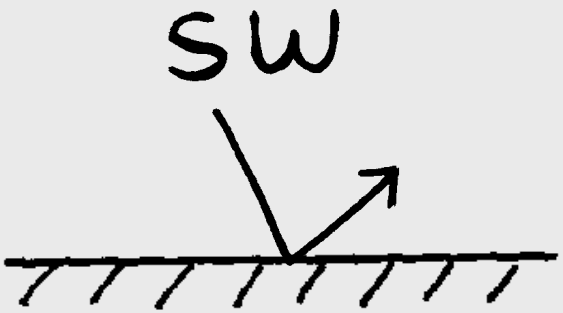




SW REFLECTED BACK TO SPACE:

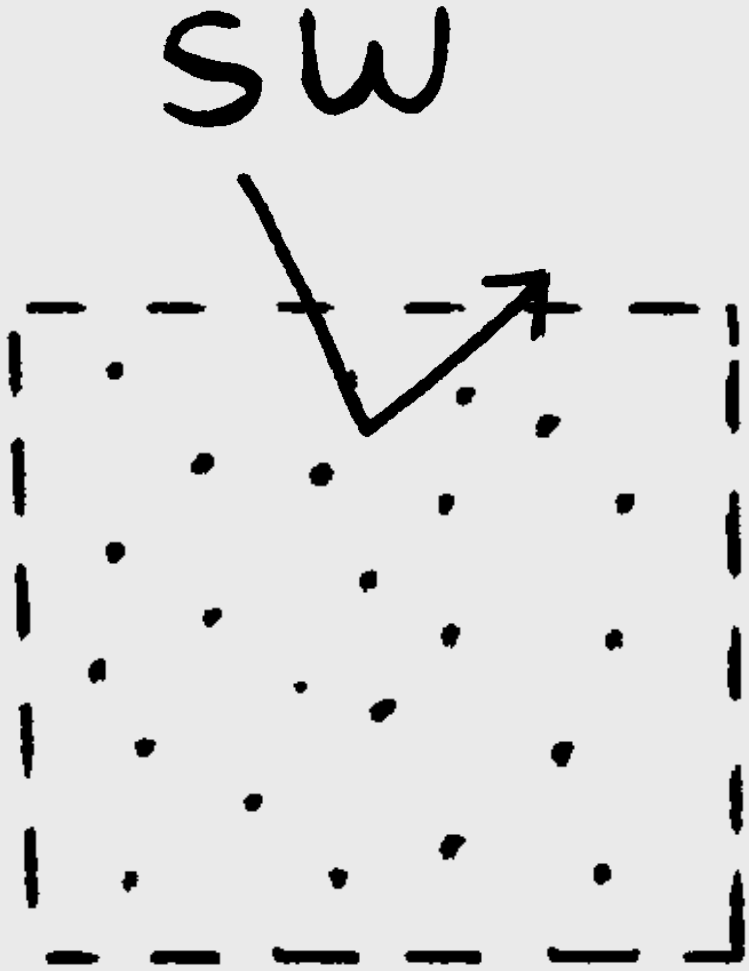
By
clouds

By
Earth's
surface

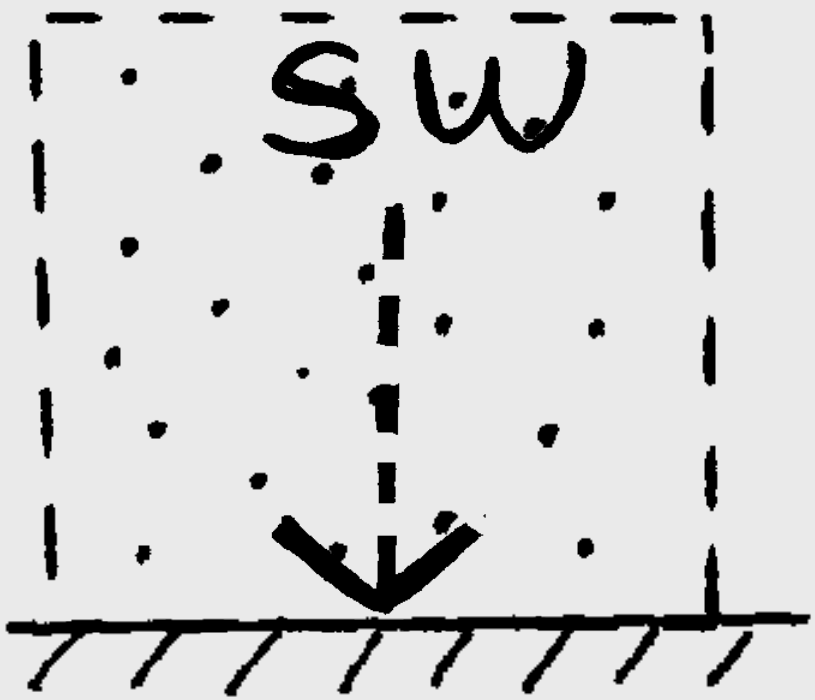


This is determined by the ALBEDO of the clouds or surface

SW SCATTERED BACK TO SPACE BY ATMOSPHERE:

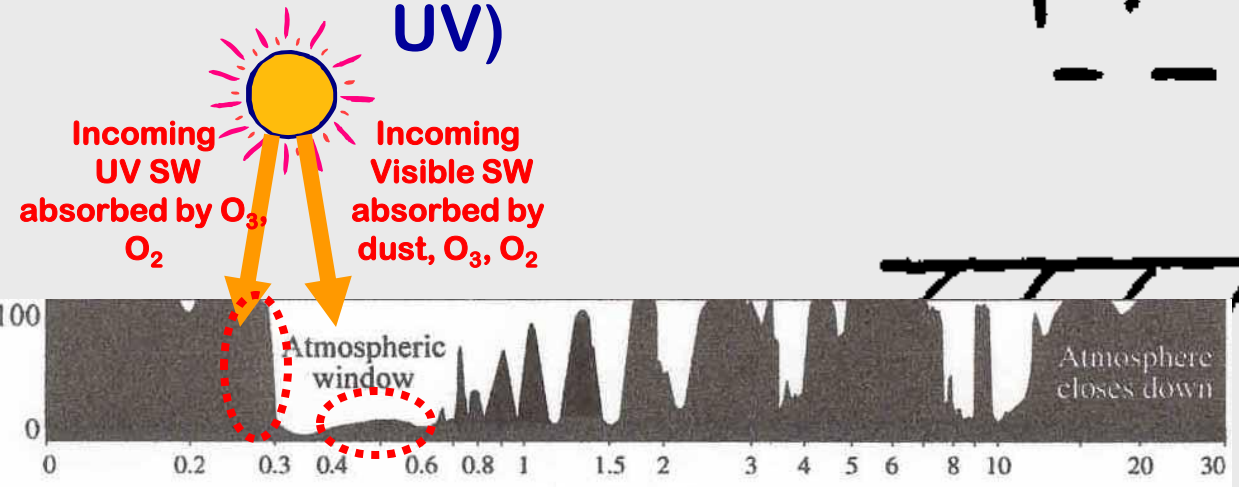


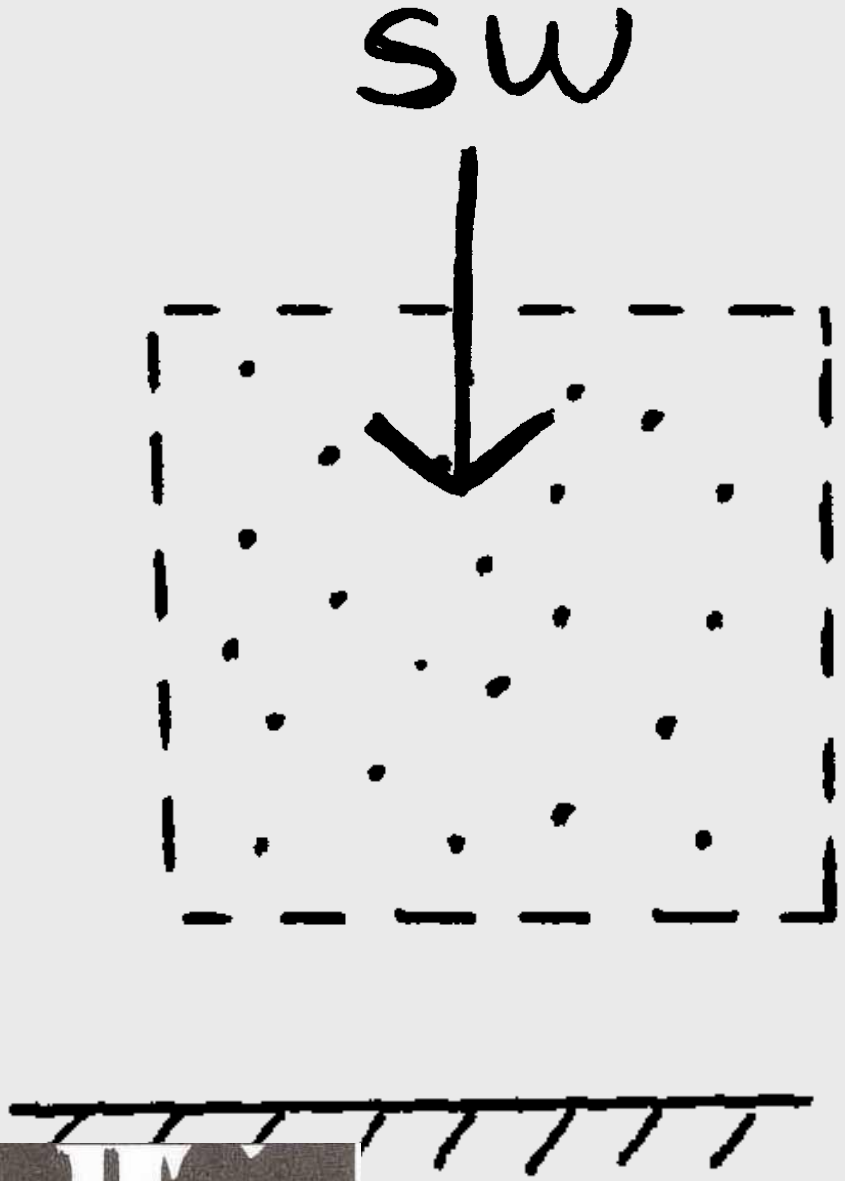
SW SCATTERED DOWN TO EARTH's SURFACE where it is absorbed



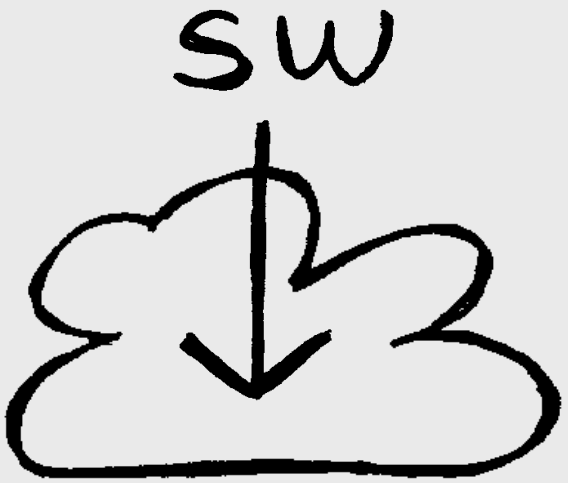
SW ABSORBED IN ATMOSPHERE BY GASES, DUST, etc.

(including Ozone absorbing shortwave UV)

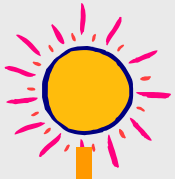




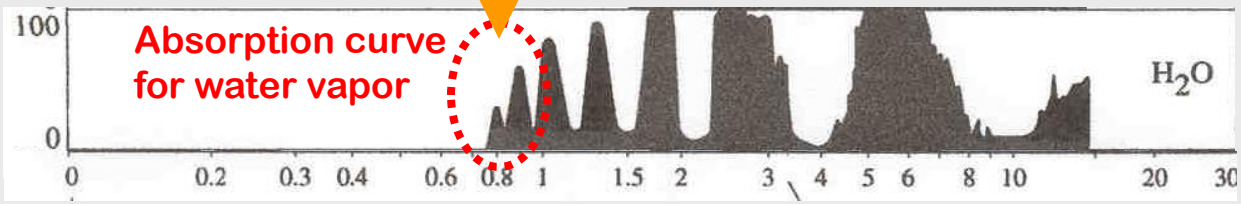
SW ABSORBED In ATMOSPHERE BY CLOUDS & H2O vapor:



(NOTE: clouds are made up of tiny droplets of water surrounded by lots of water vapor)

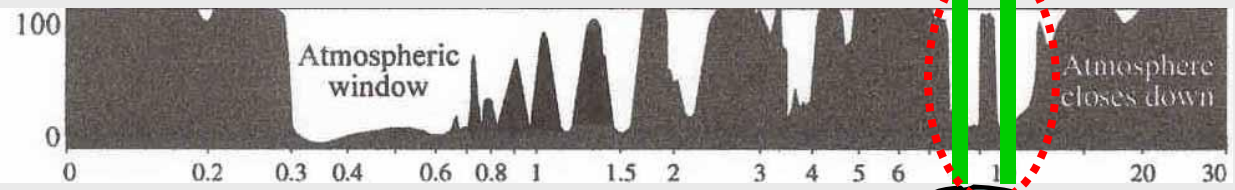


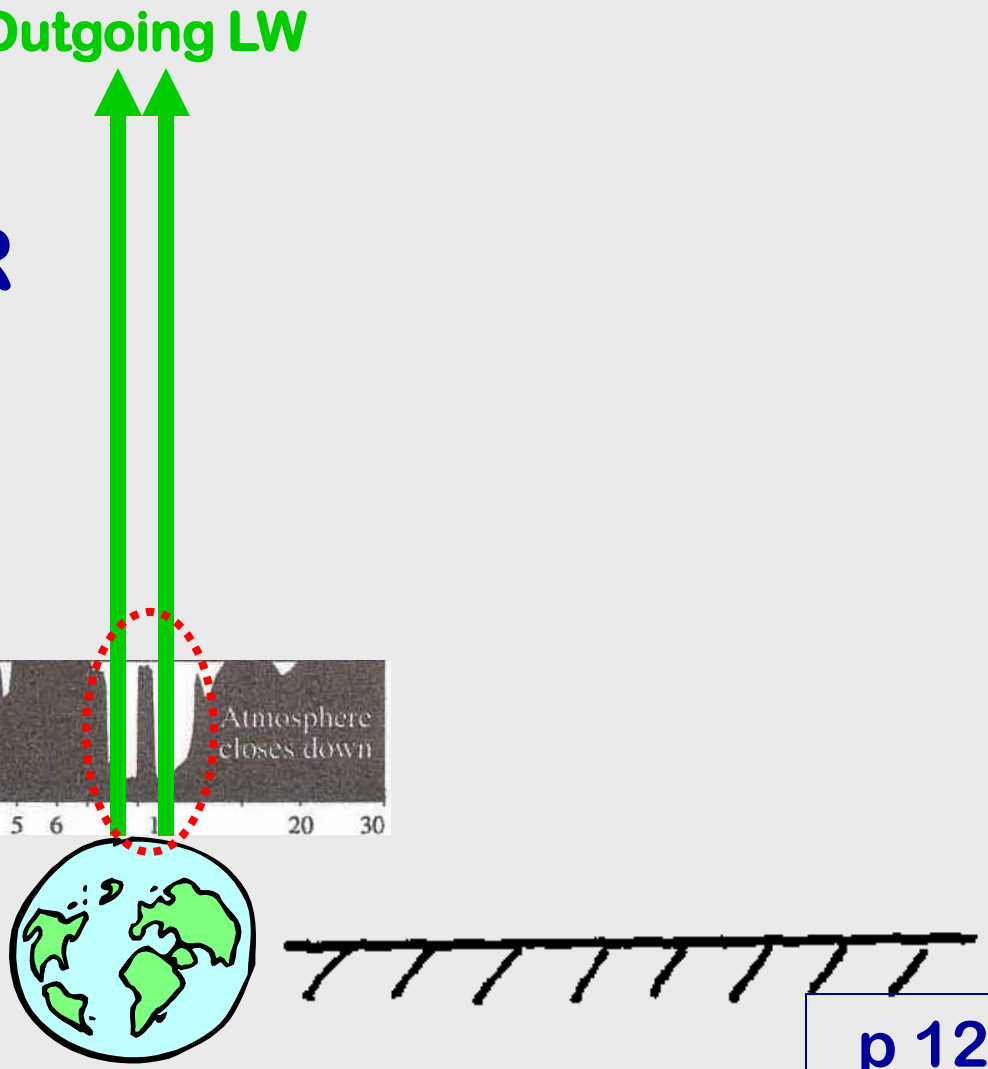
Incoming Visible & Near IR SW absorbed by water vapor & clouds



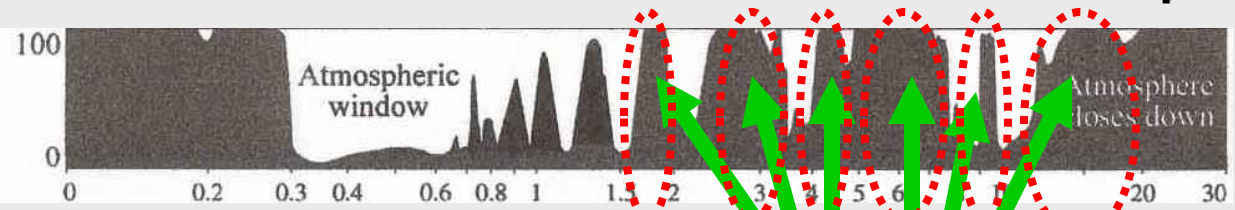
LW (IR) EMITTED FROM EARTH'S SURFACE ESCAPING TO SPACE THROUGH THE "OUTGOING IR ATMOSPHERIC WINDOW"

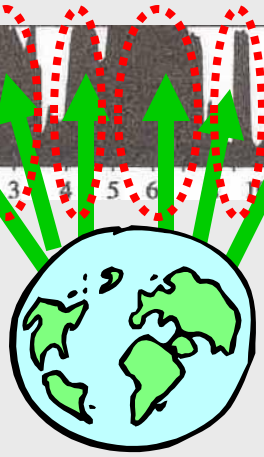
LW

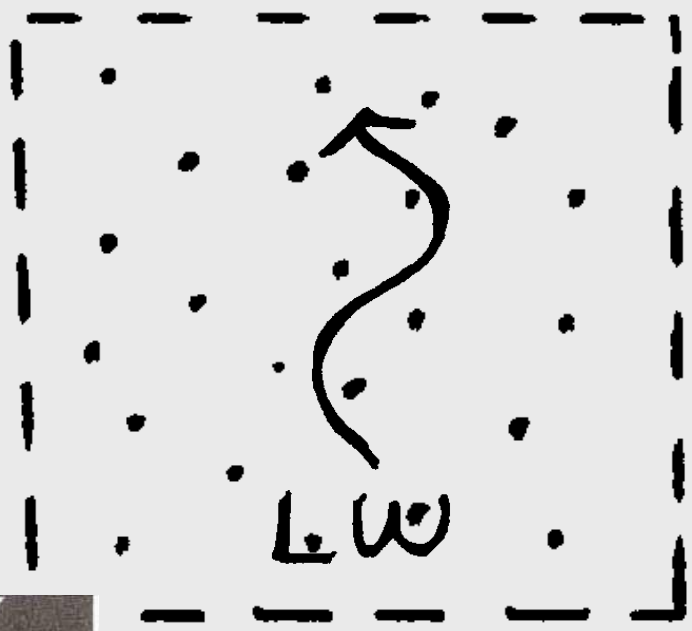


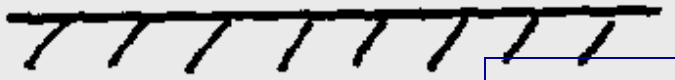


IR EMITTED FROM EARTH'S SURFACE BUT ABSORBED IN THE ATMOSPHERE BY GREENHOUSE GASES (H_2O,CO_2, CH_4, ETC.)

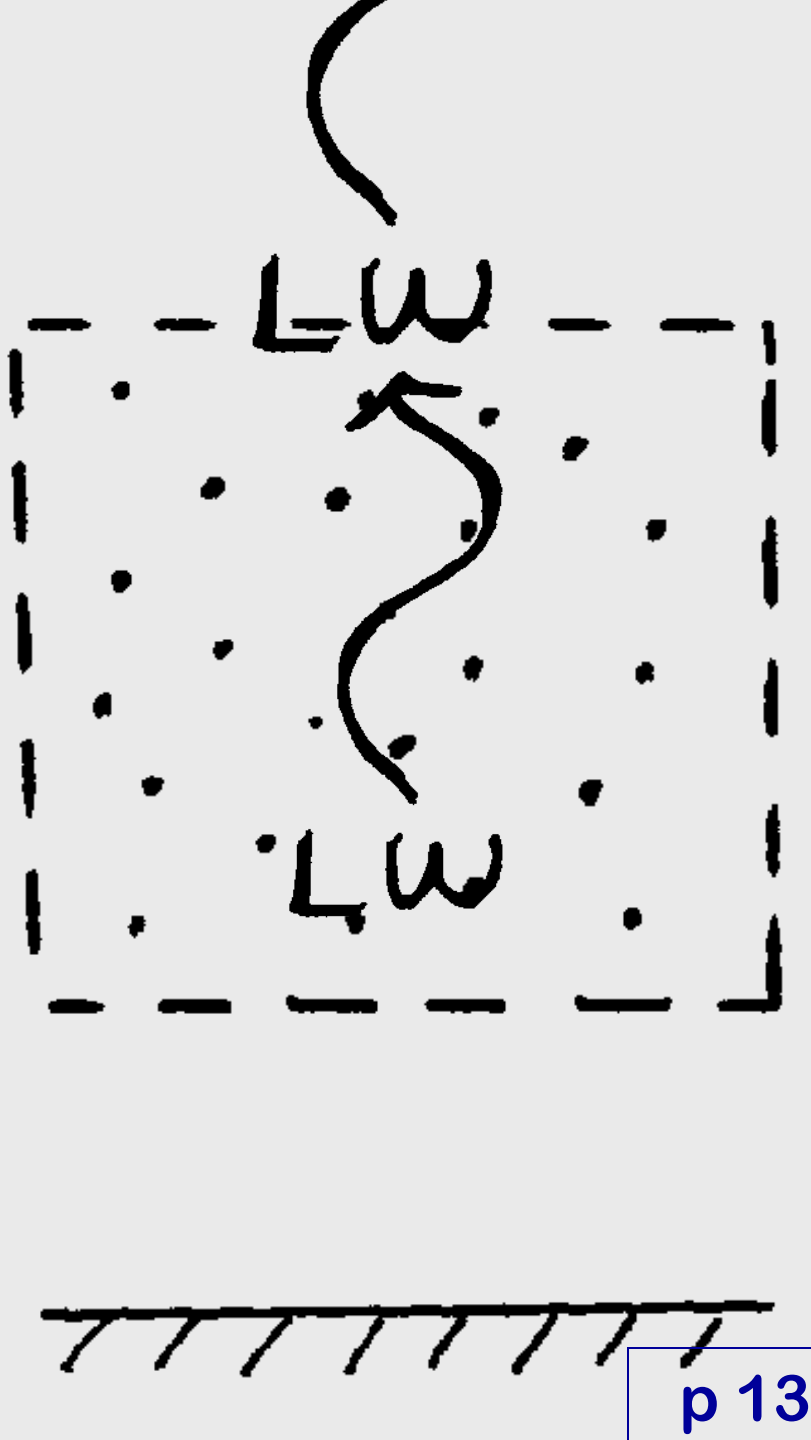




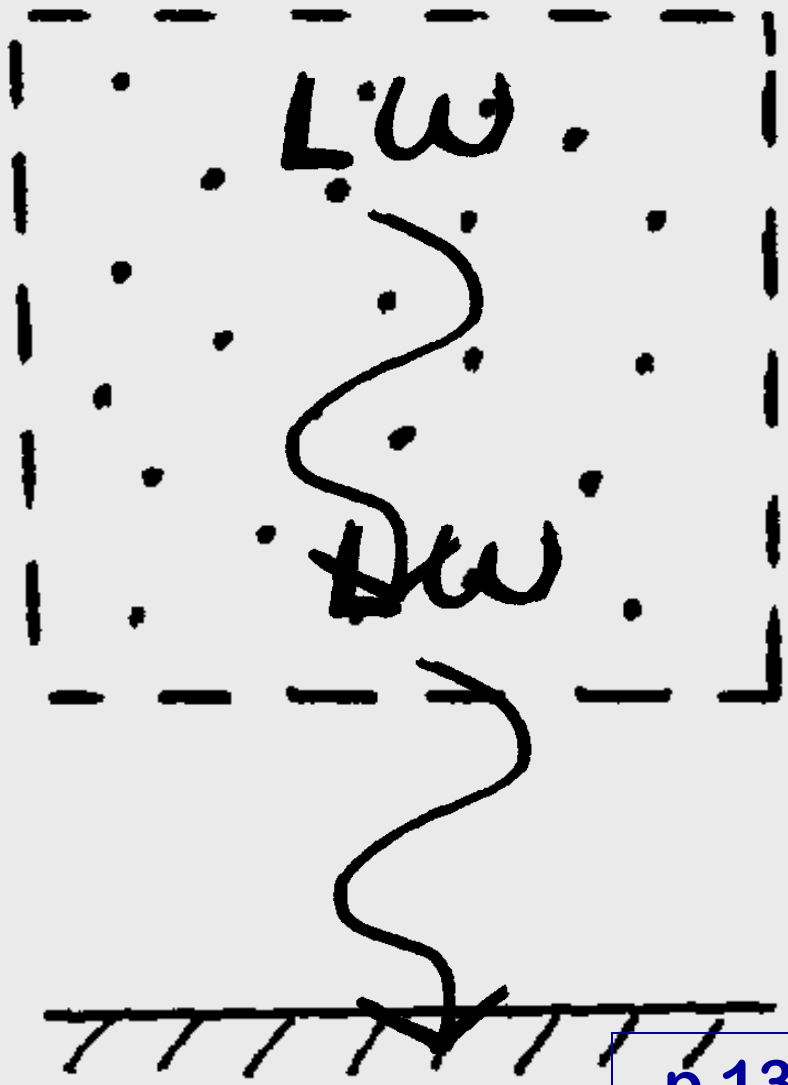




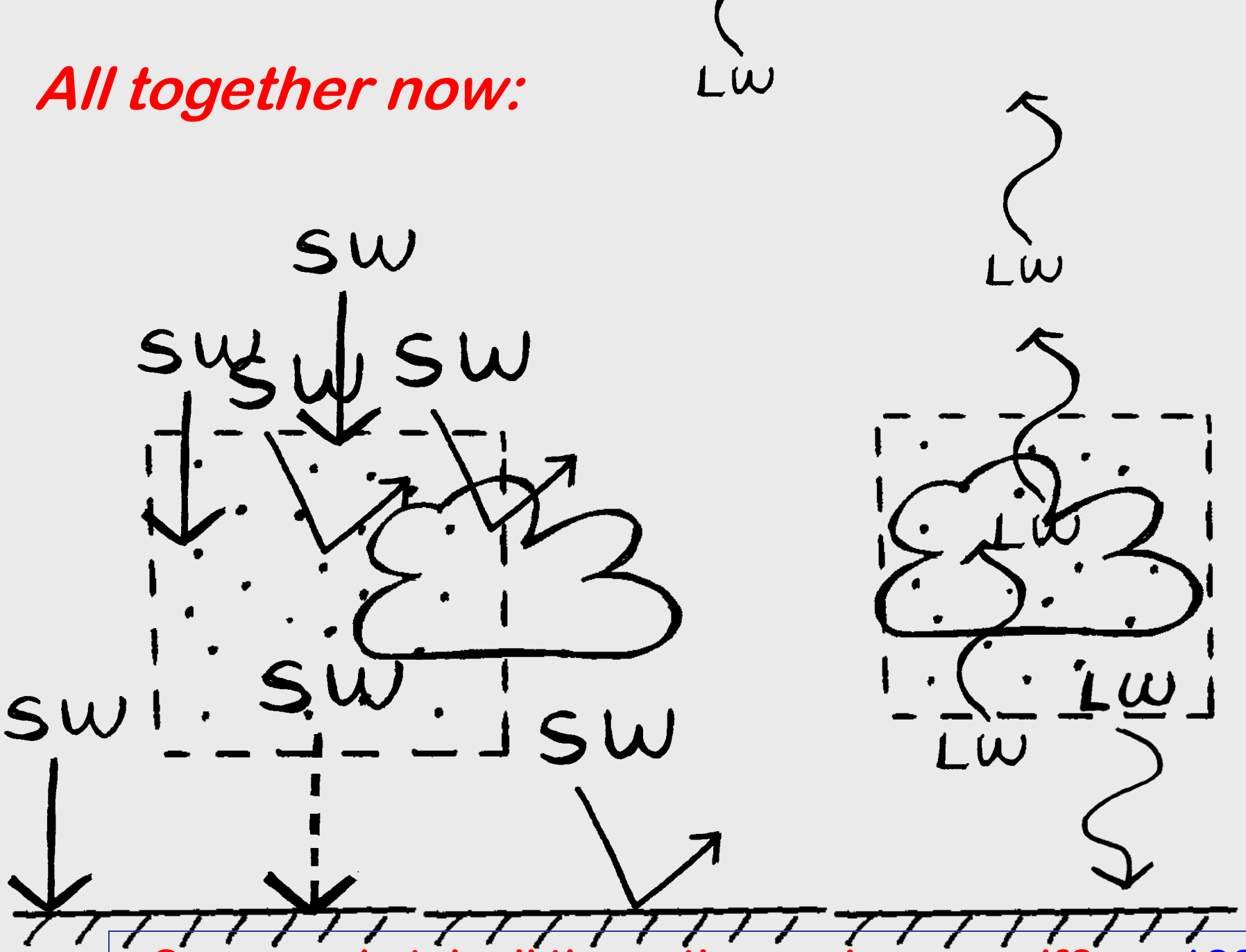
IR EMITTED FROM ATMOSPHERE ESCAPING TO SPACE



IR EMITTED FROM ATMOSPHERE AND RADIATED BACK TO SURFACE WHERE IT IS ABSORBED



All together now:



Can you sketch all the pathways in yourself? p 122

What if . . .

. . . The Earth didn't have an atmosphere, and therefore didn't have a greenhouse effect??

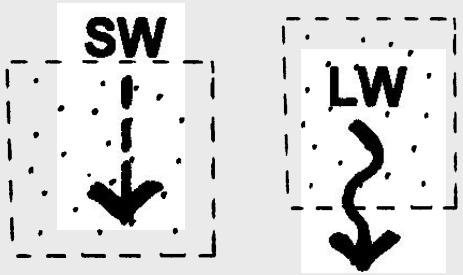
What would the energy pathways in the Earth-Sun system look like?

top of p 123

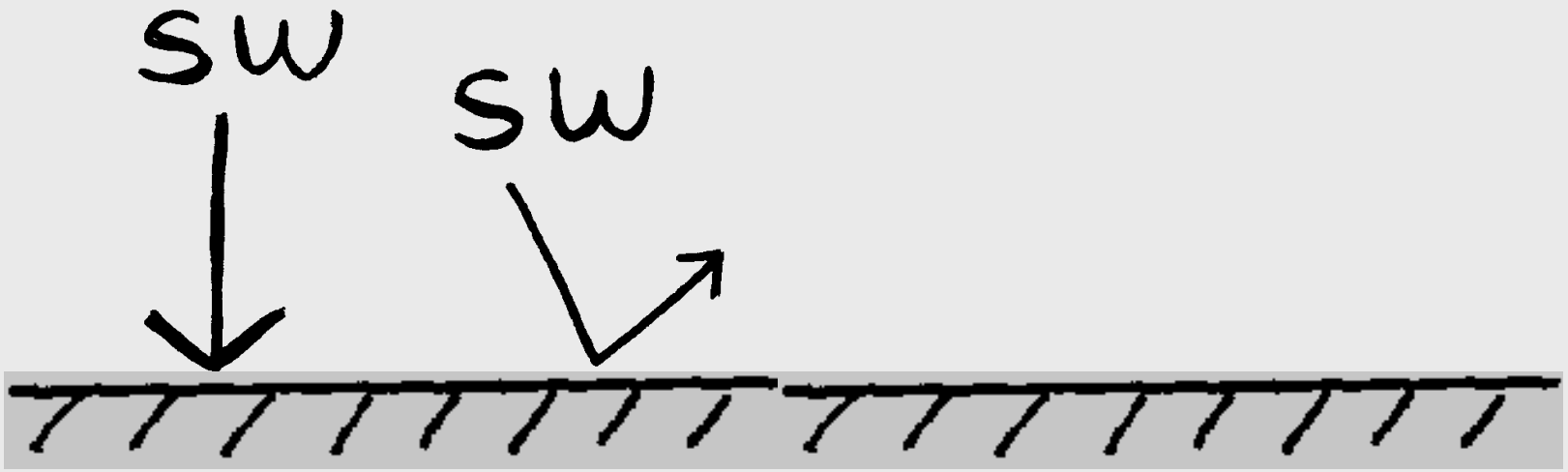
LW

Which terms are not involved?

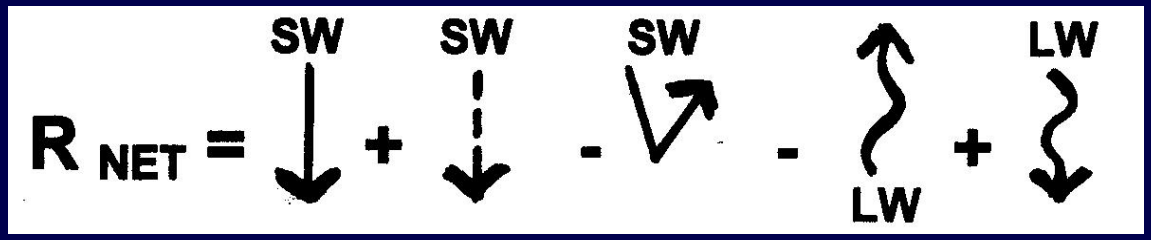
No scattering of SW by <u>atmosphere</u>



No downward re-radiation of LW / IR from the <u>atmosphere</u> because there would be NO GHG's

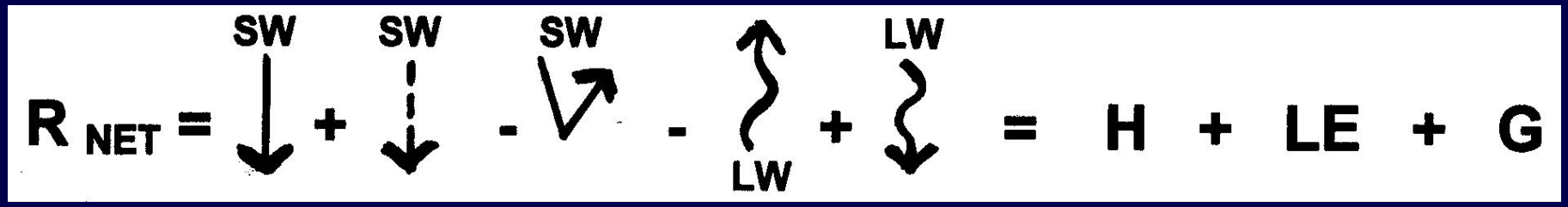


top of p 123

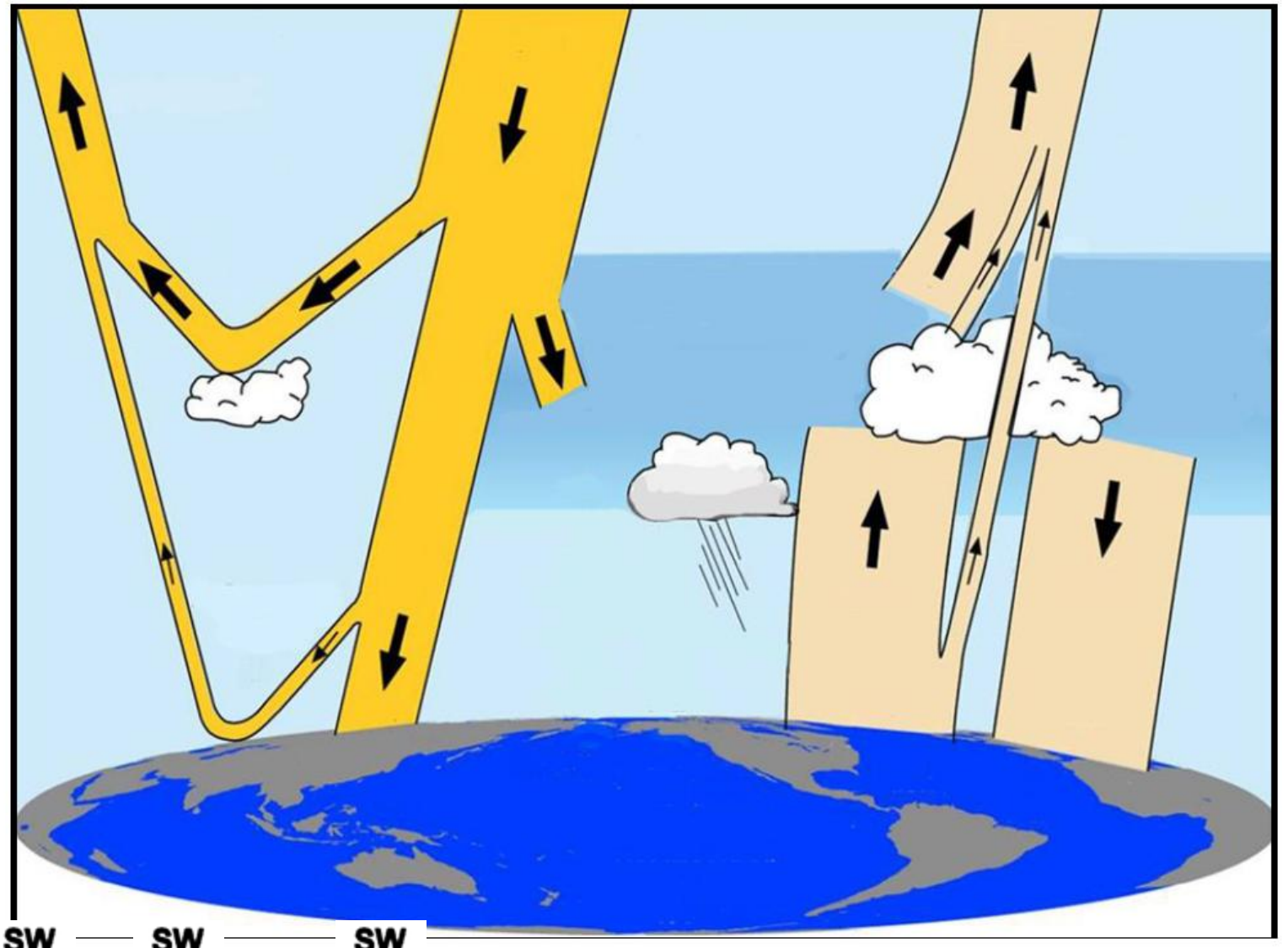


R_{NET} : NET RADIATION

In – Out = R_{NET}



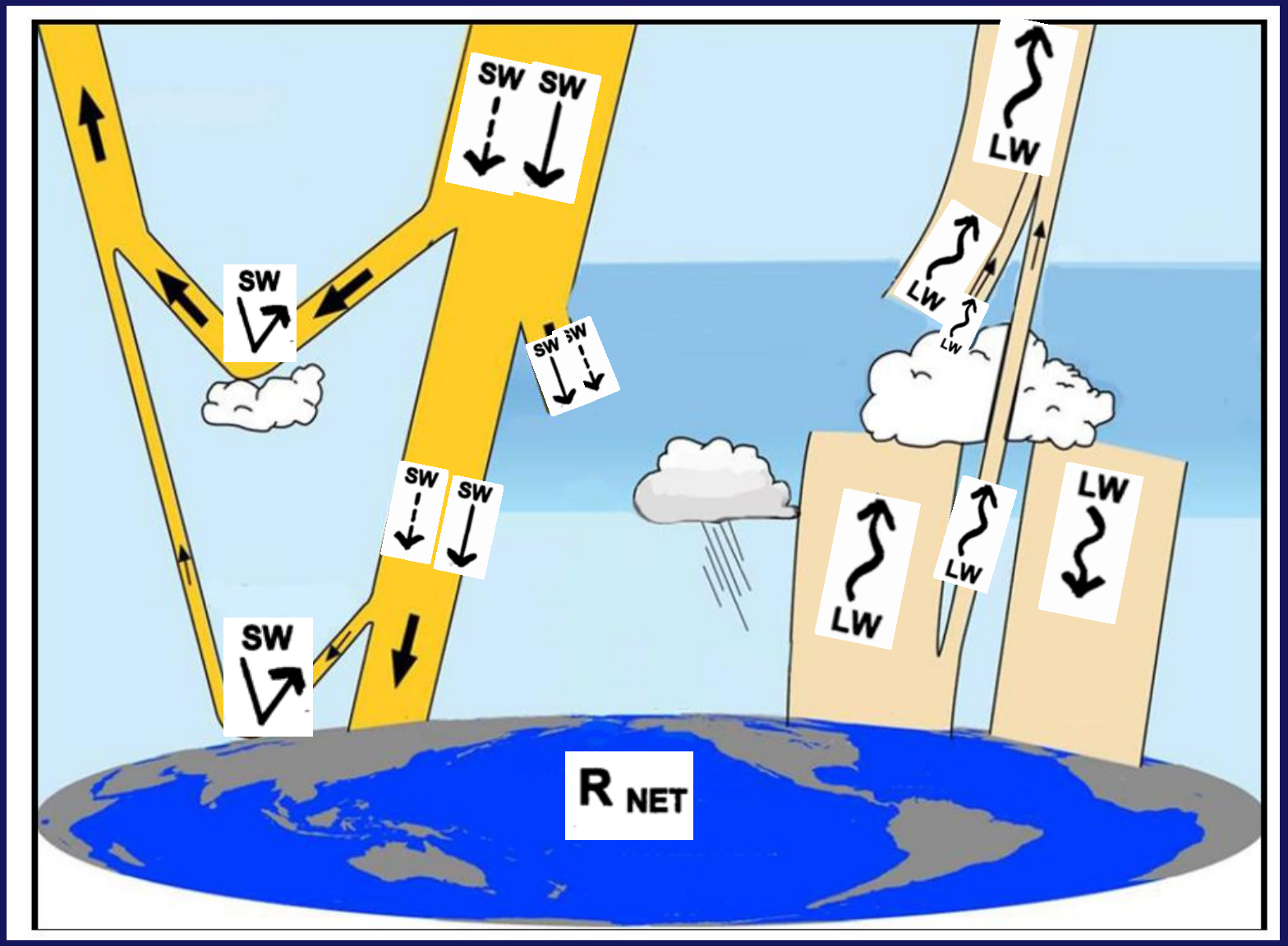
Place the symbols in the proper places on the diagram (you won't use them all!)



SW SW SW SW SW SW SW SW SW SW SW SW

LW LW LW LW LW LW LW

SW SW SW R NET


R NET = SW + SW - SW - LW + LW
SW
SW
SW
SW
SW
SW
SW
SW
LW
LW
LW
LW
LW
LW
LW
R NET

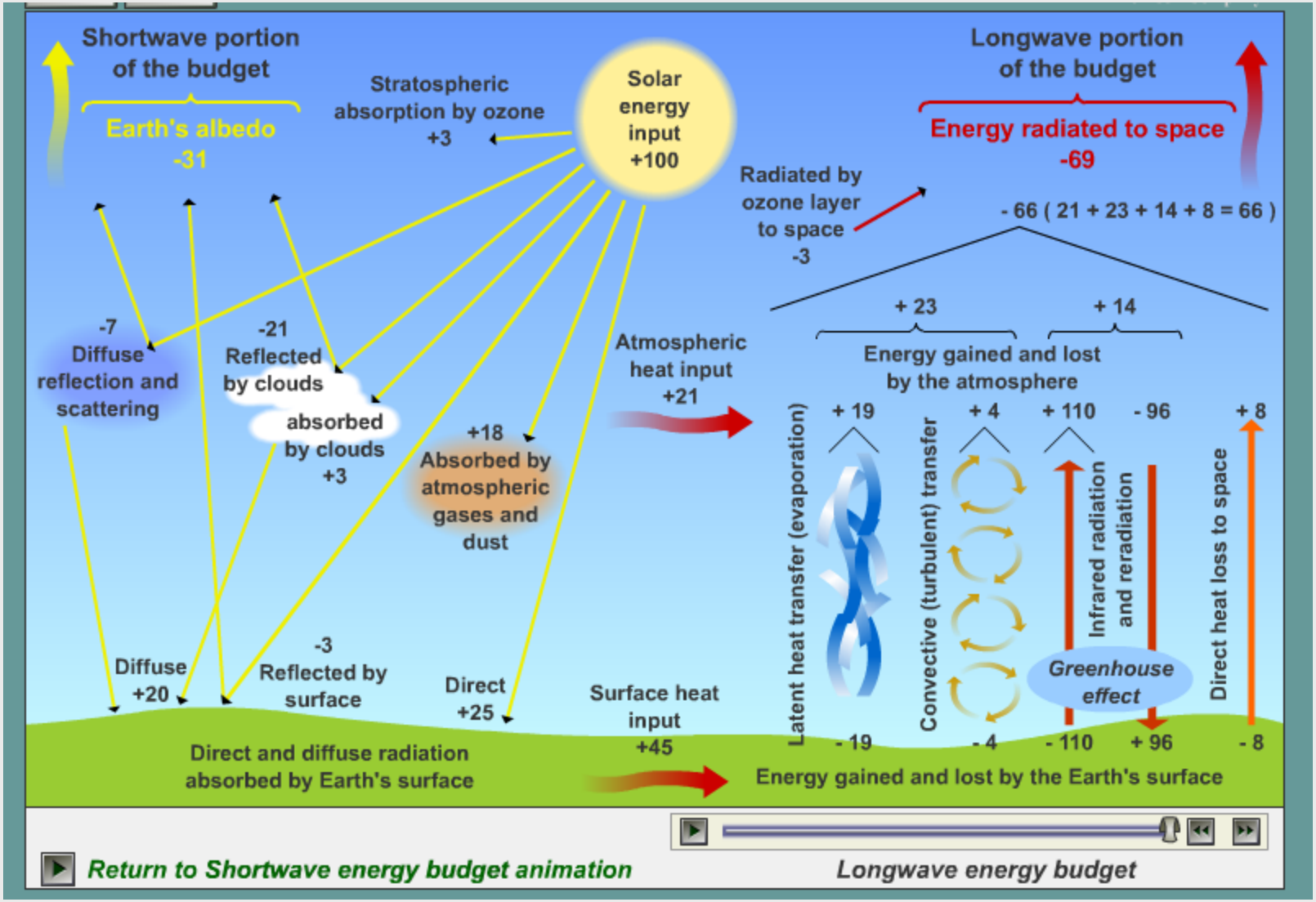
Two Energy Balance Animations

showing energy flow pathways & "units" of energy that eventually balance out:

GLOBAL ENERGY BALANCE & PATHWAYS:

http://earthguide.ucsd.edu/earthguide/diagrams/energybalance/index.html

SHORTWAVE & LONGWAVE ENERGY FLOW & BUDGET:
http://mesoscale.agron.iastate.edu/agron206/animations/10_AtmoEbal.html



GLOBAL ENERGY BALANCE & PATHWAYS:
SHORTWAVE & LONGWAVE ENERGY FLOW & BUDGET

http://mesoscale.agron.iastate.edu/agron206/animations/10_AtmoEbal.html

GO TOP 10 CATS!
Beat USC!!!!