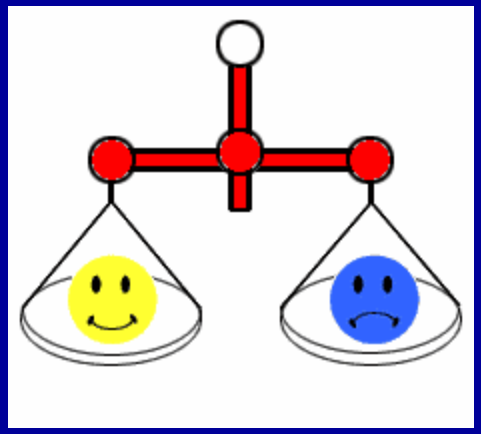
Topic # 10
THE EARTH'S GLOBAL ENERGY BALANCE

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

"BOOKMARK" p 53 & p 122 (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

Remember this concept . . . . ?

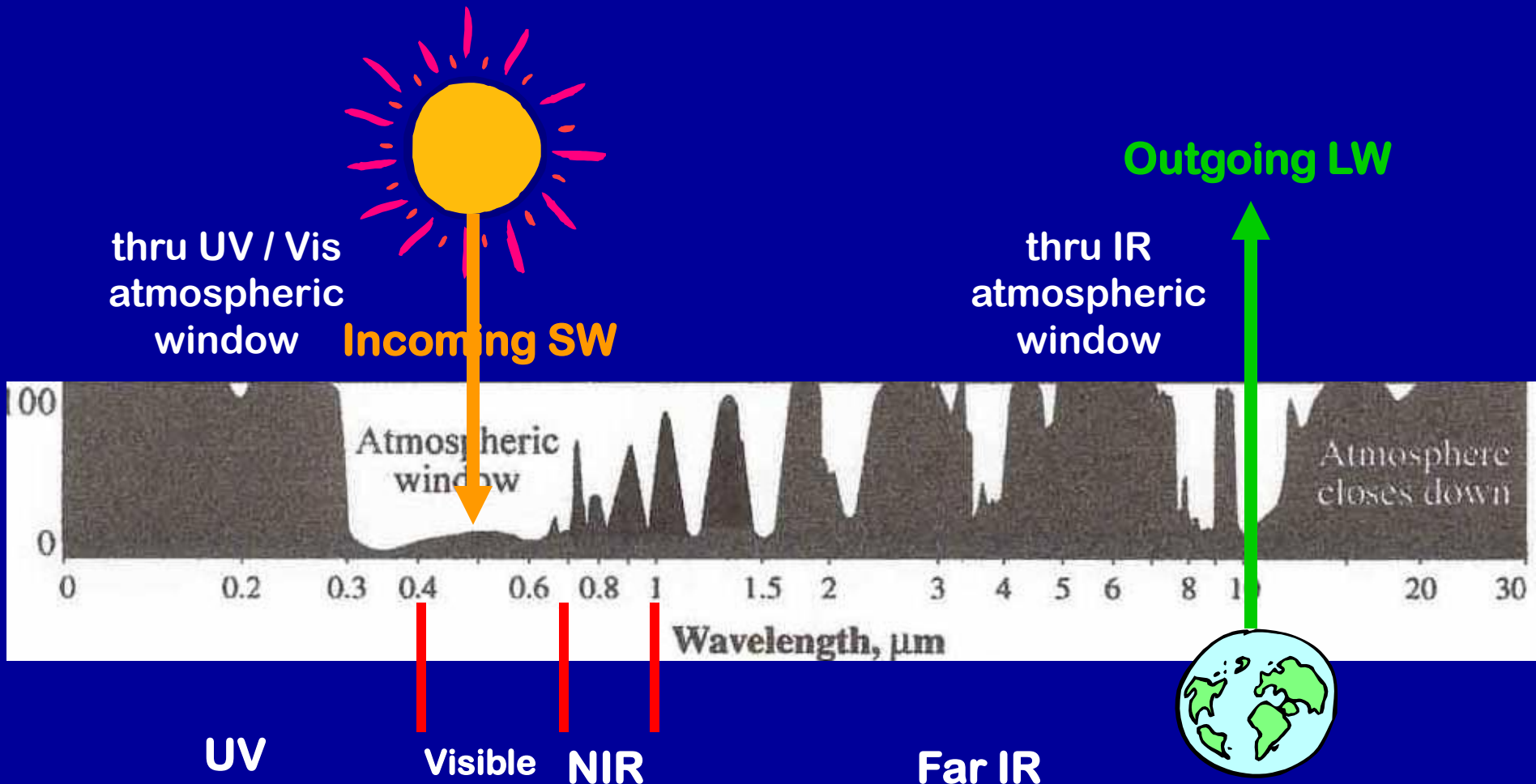
RADIATIVE FORCING (RF)

Radiative Forcing (RF) = Change in INCOMING minus OUTGOING radiation **at the tropopause** due to some factor.

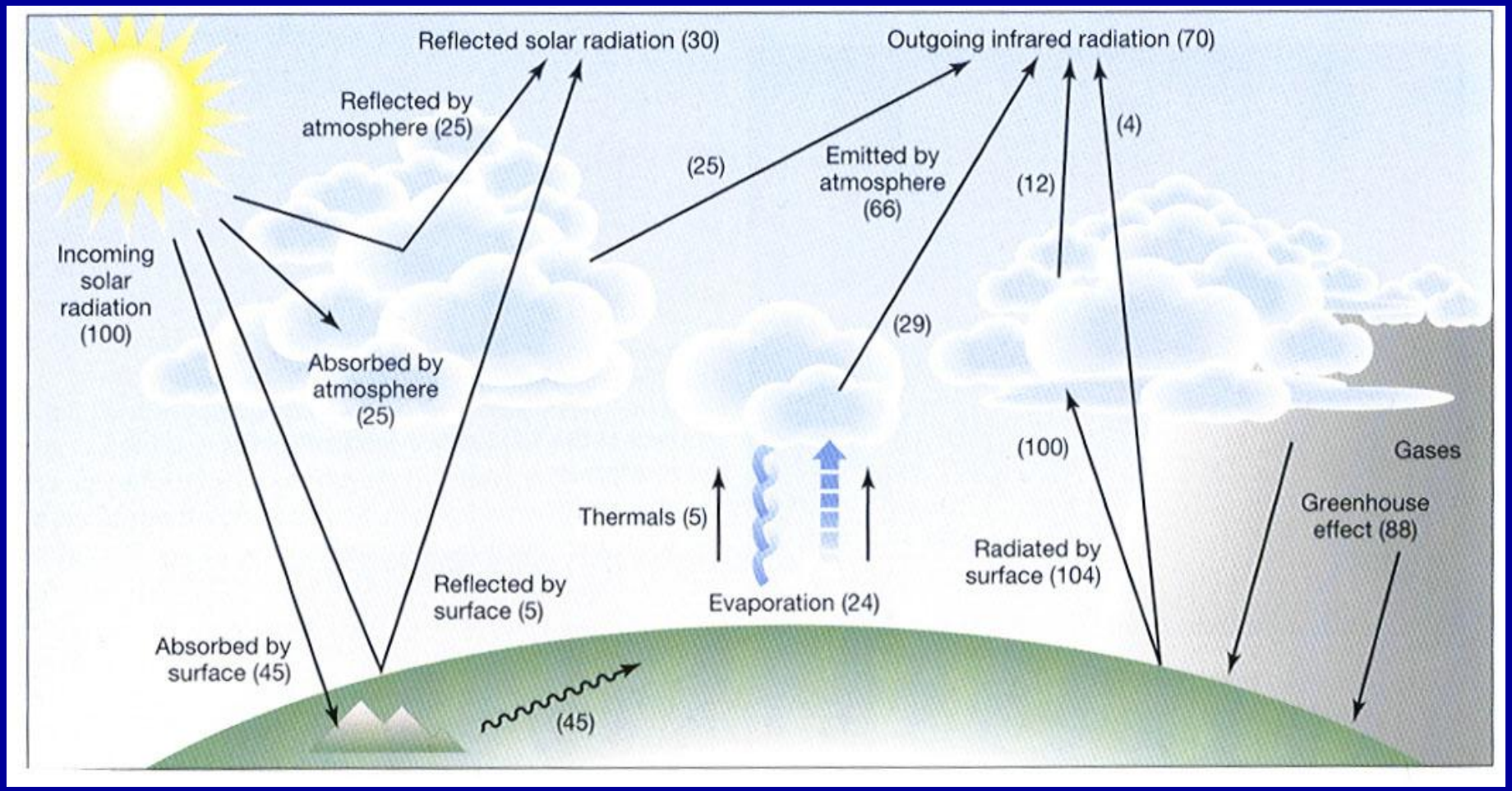
Introduced earlier – see small box on p 39

Review: Absorption curve for the "Whole Atmosphere"

OVERALL BALANCE: Incoming = Outgoing



Typical Energy Balance Diagram



From SGC-E-Text Chapter Fig 3-19

Similar to p 53 in Class Notes
but with different "units"

Energy Balance Equation:

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

(one of several ways this equation can be written)

Introduced briefly earlier:

Electromagnetic Radiation can be:

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

Let's try to find an easy way to understand and remember all the components of the Earth's Energy Balance

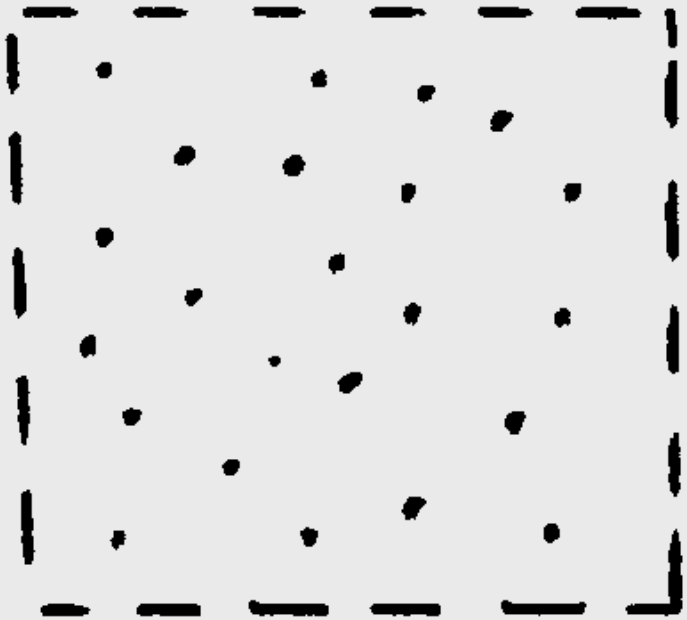
We'll use "cartoon symbols" . . .

“CARTOON” SYMBOLS:

To represent the Earth’s surface:

Note -taking suggested:

“CARTOON” SYMBOLS:

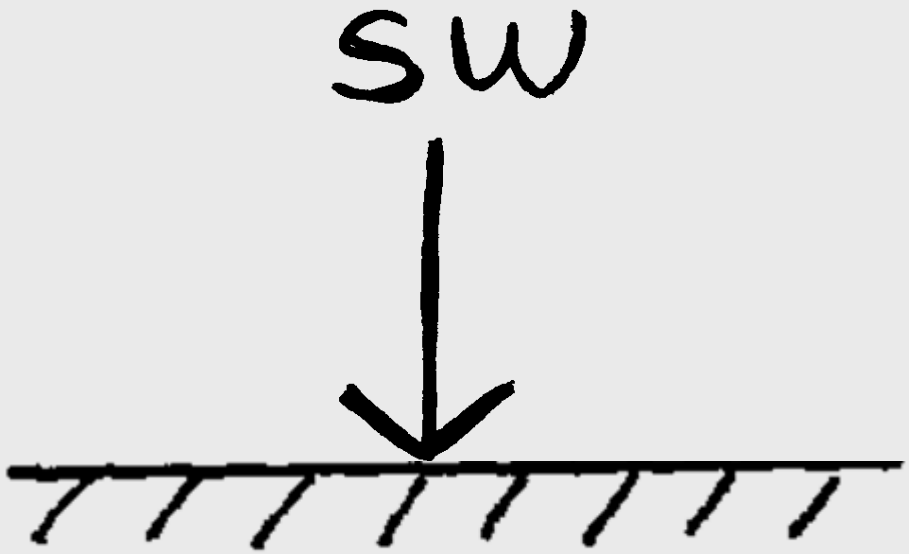


To represent the atmosphere – composed of both invisible gases, aerosols, dust and other particulate matter:

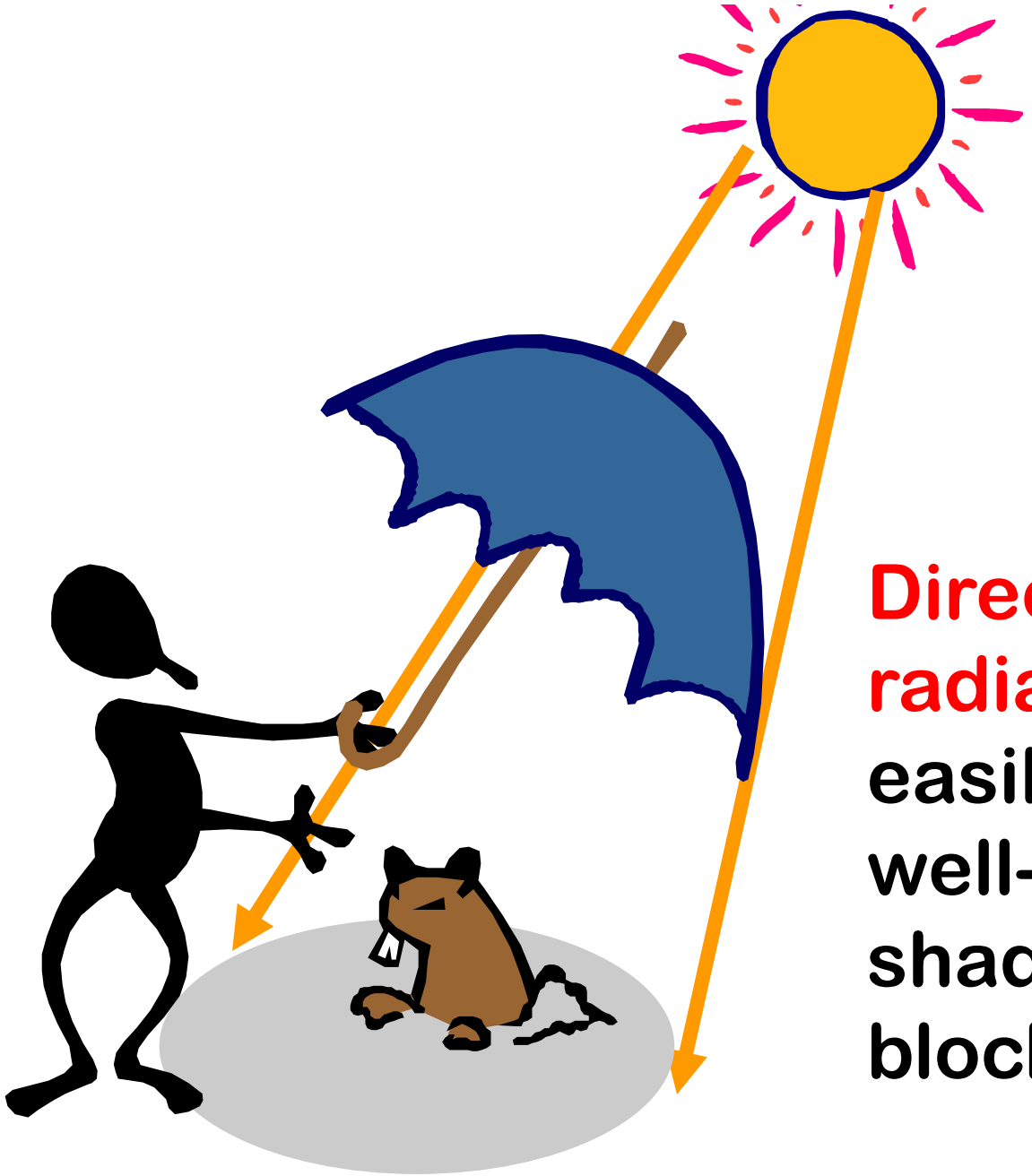
“CARTOON” SYMBOLS:

To represent CLOUDS

"CARTOON" SYMBOLS:

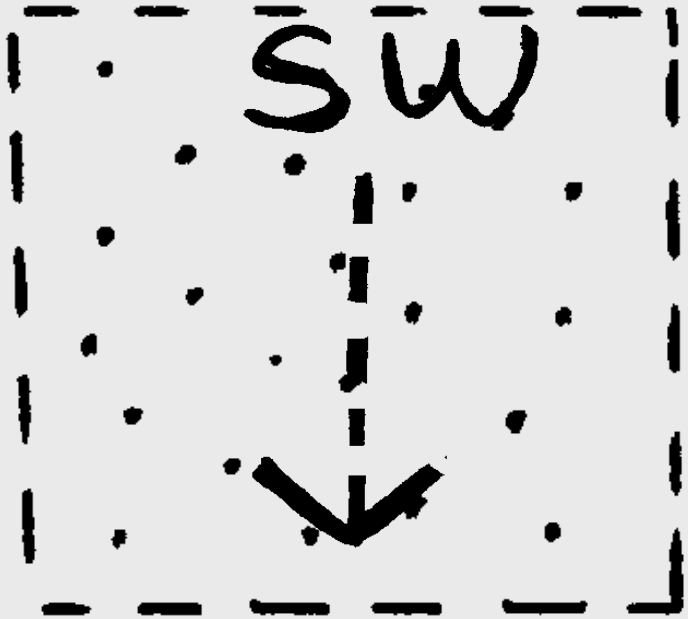


To represent SOLAR (shortwave) radiation coming in DIRECTLY. (aka Direct shortwave radiation)



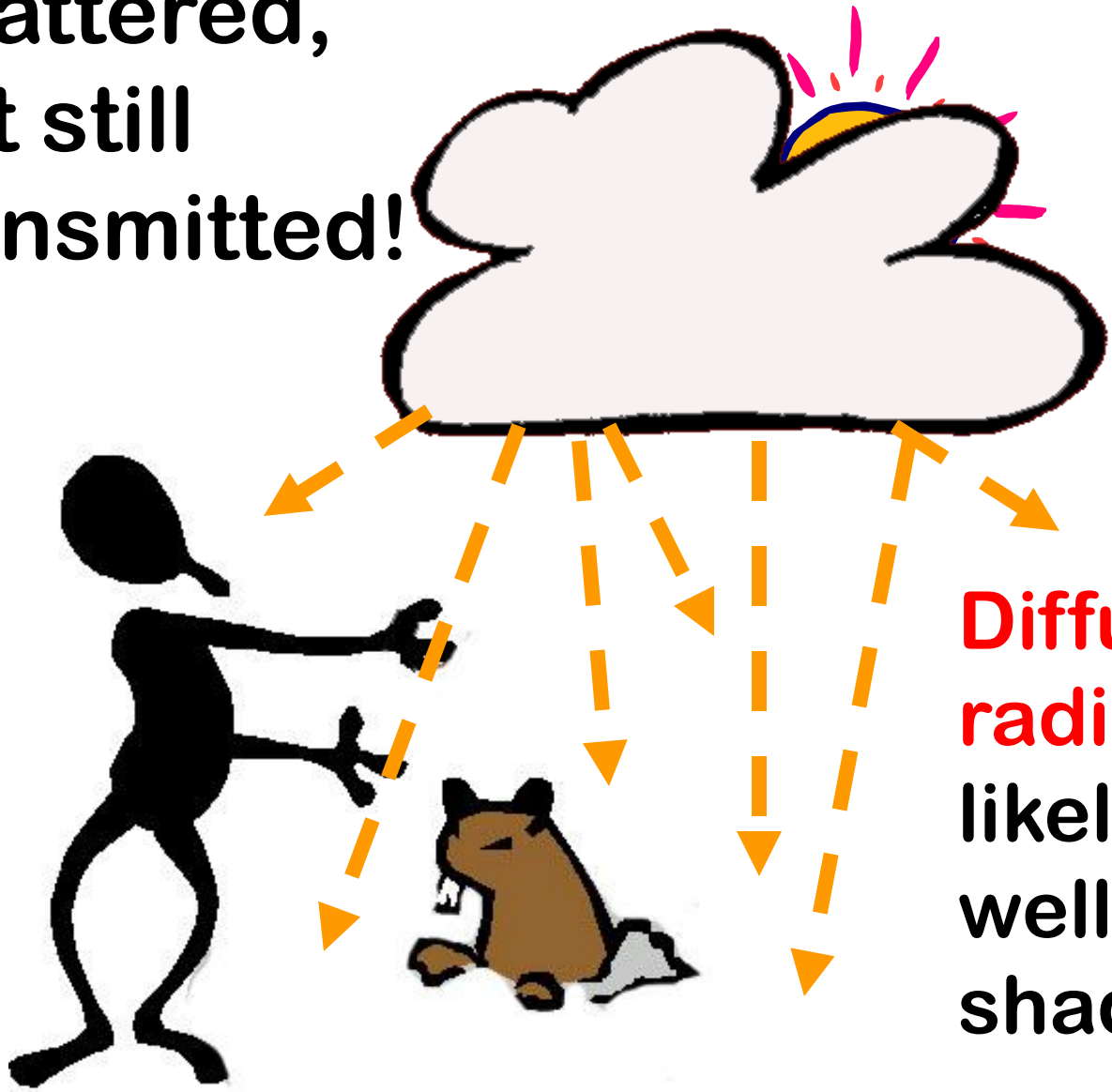
Direct SW radiation easily casts well-defined shadows when blocked

"CARTOON" SYMBOLS:

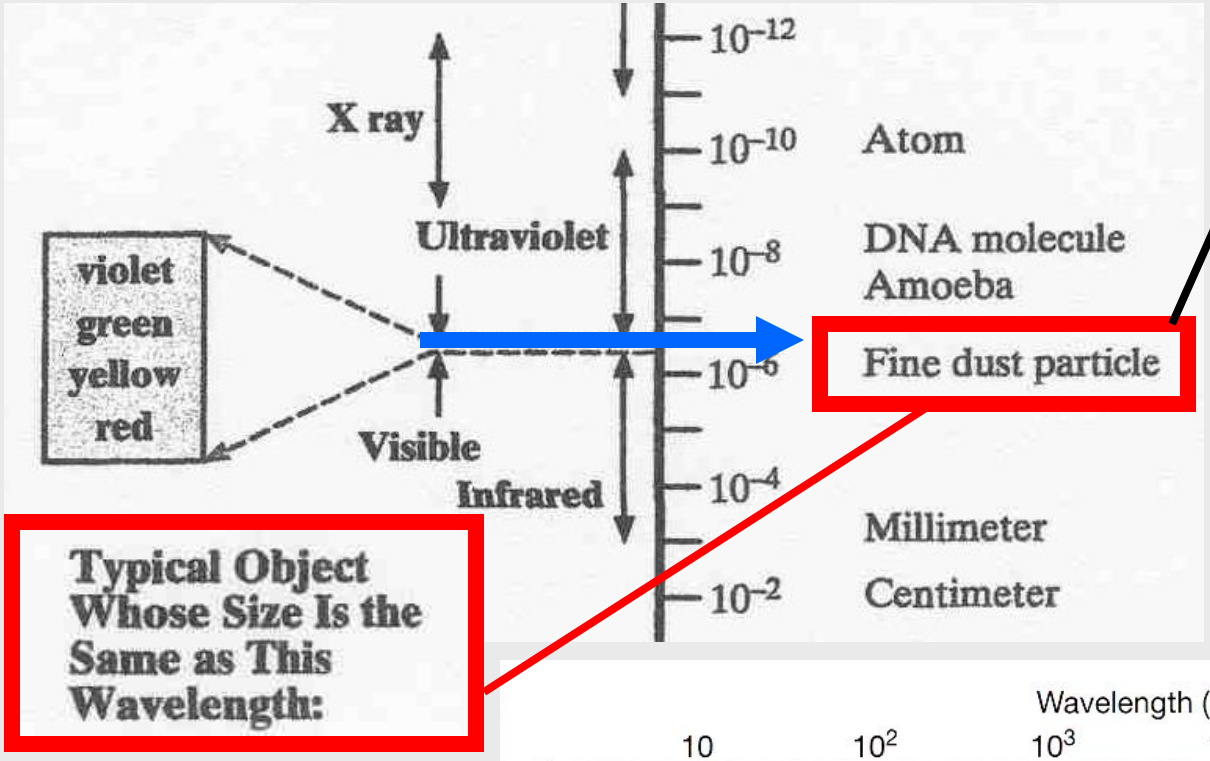


To represent SOLAR (shortwave) radiation coming in as **DIFFUSE shortwave radiation**, i.e. scattered by gases, clouds, and particles in the atmosphere.

Scattered, but still transmitted!



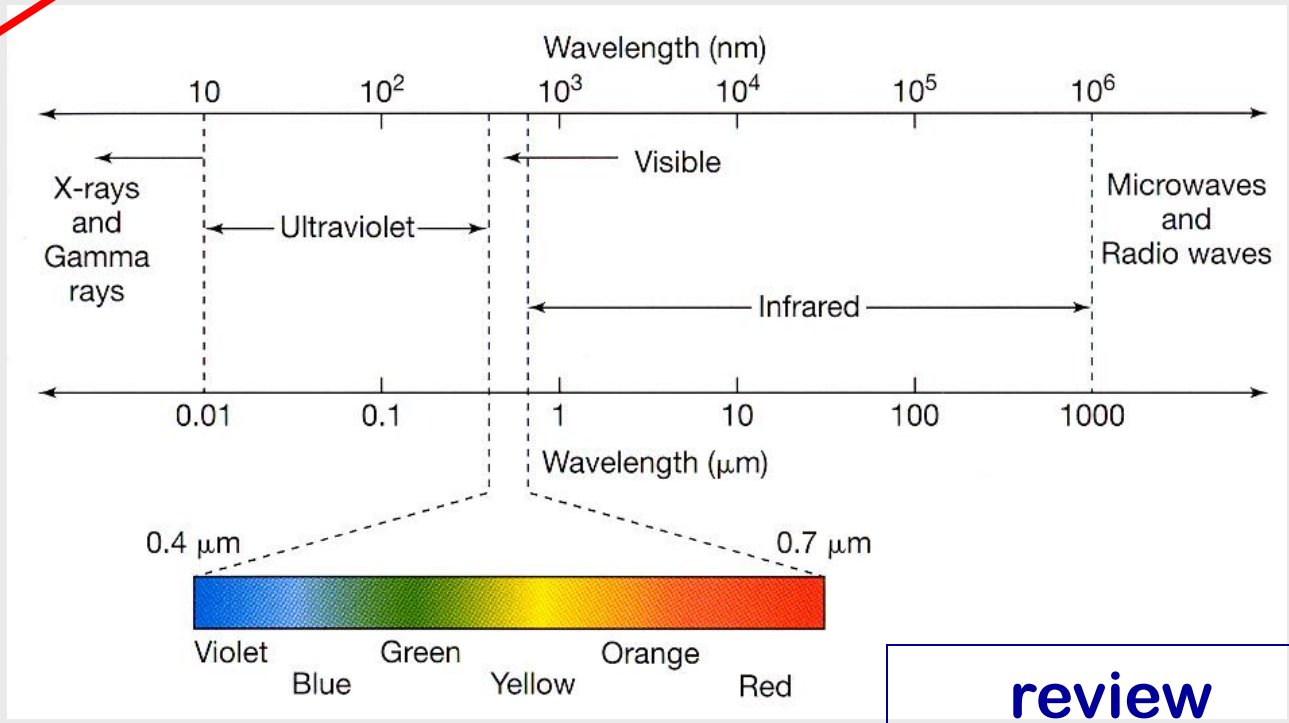
Diffuse SW radiation is less likely to cast a well-defined shadow!



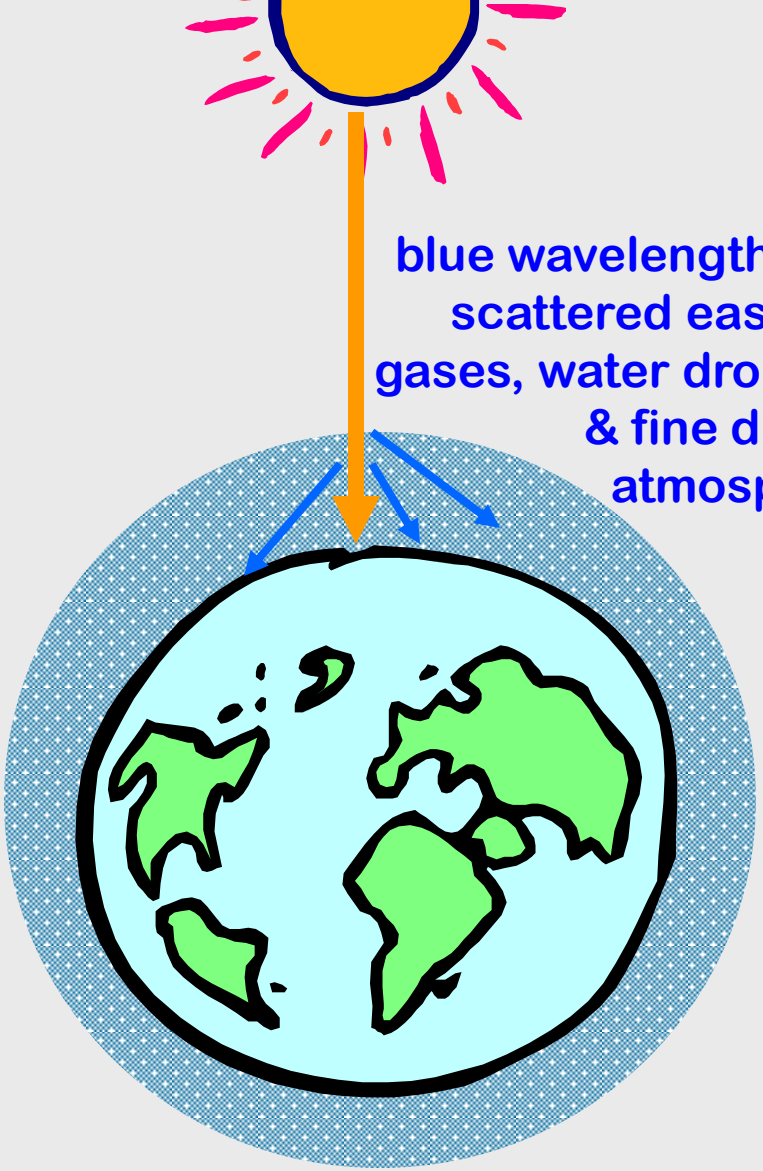
Different sized dust particles, water droplets, aerosols,

(even gas molecules themselves)

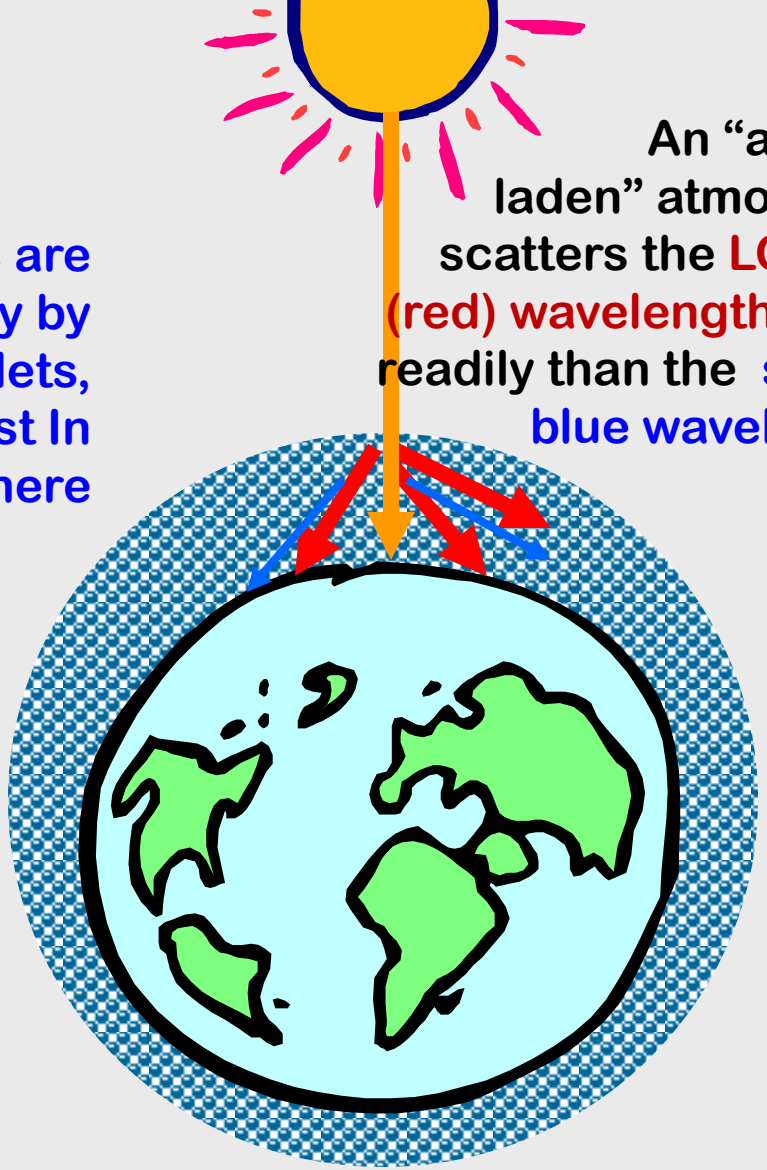
Scattering of visible light



review



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

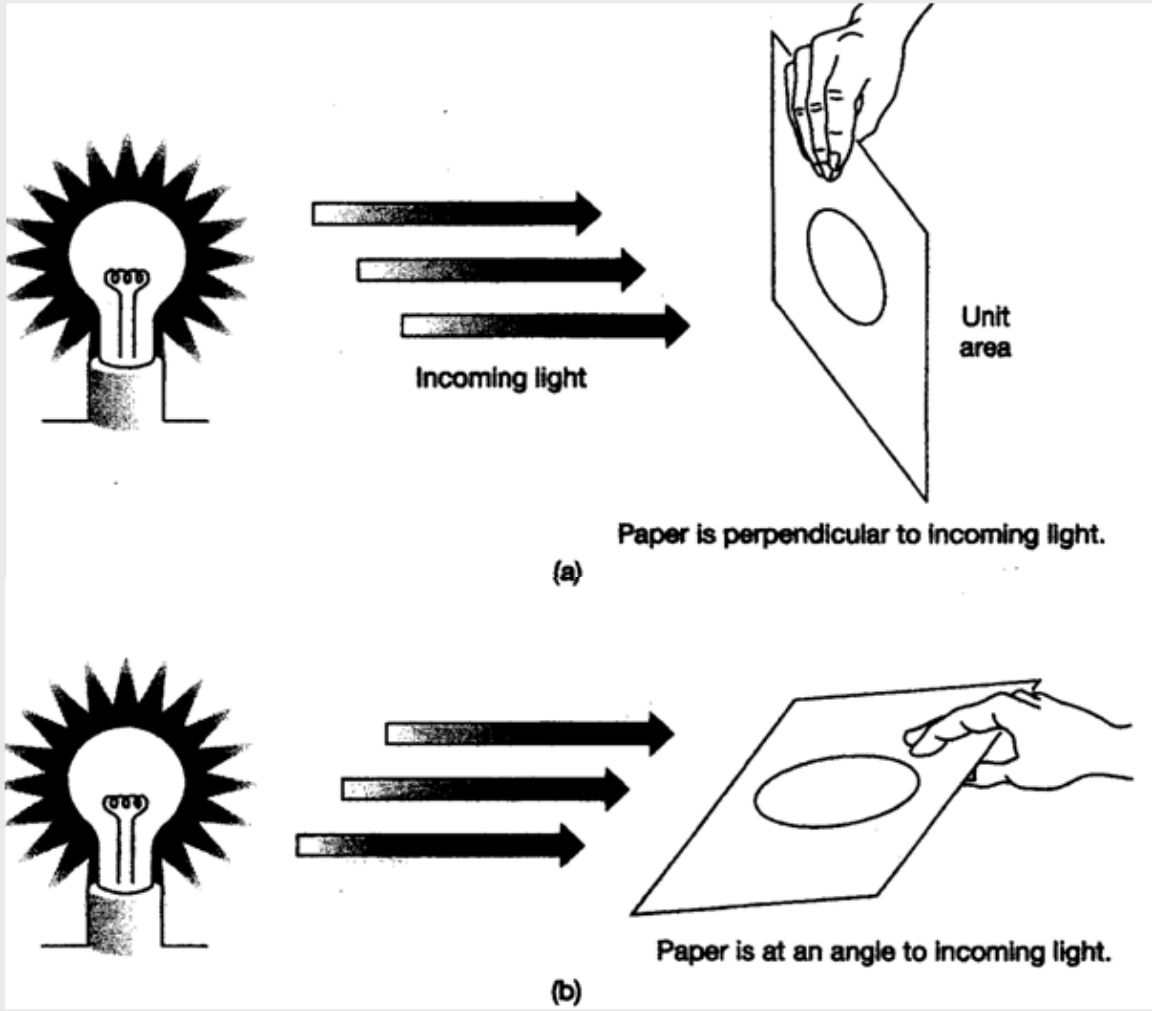


"Dirty" (aerosol-laden) atmosphere composed of fine particles, gases, & H_2O -- PLUS larger dust particles, aerosols, pollution, etc.

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

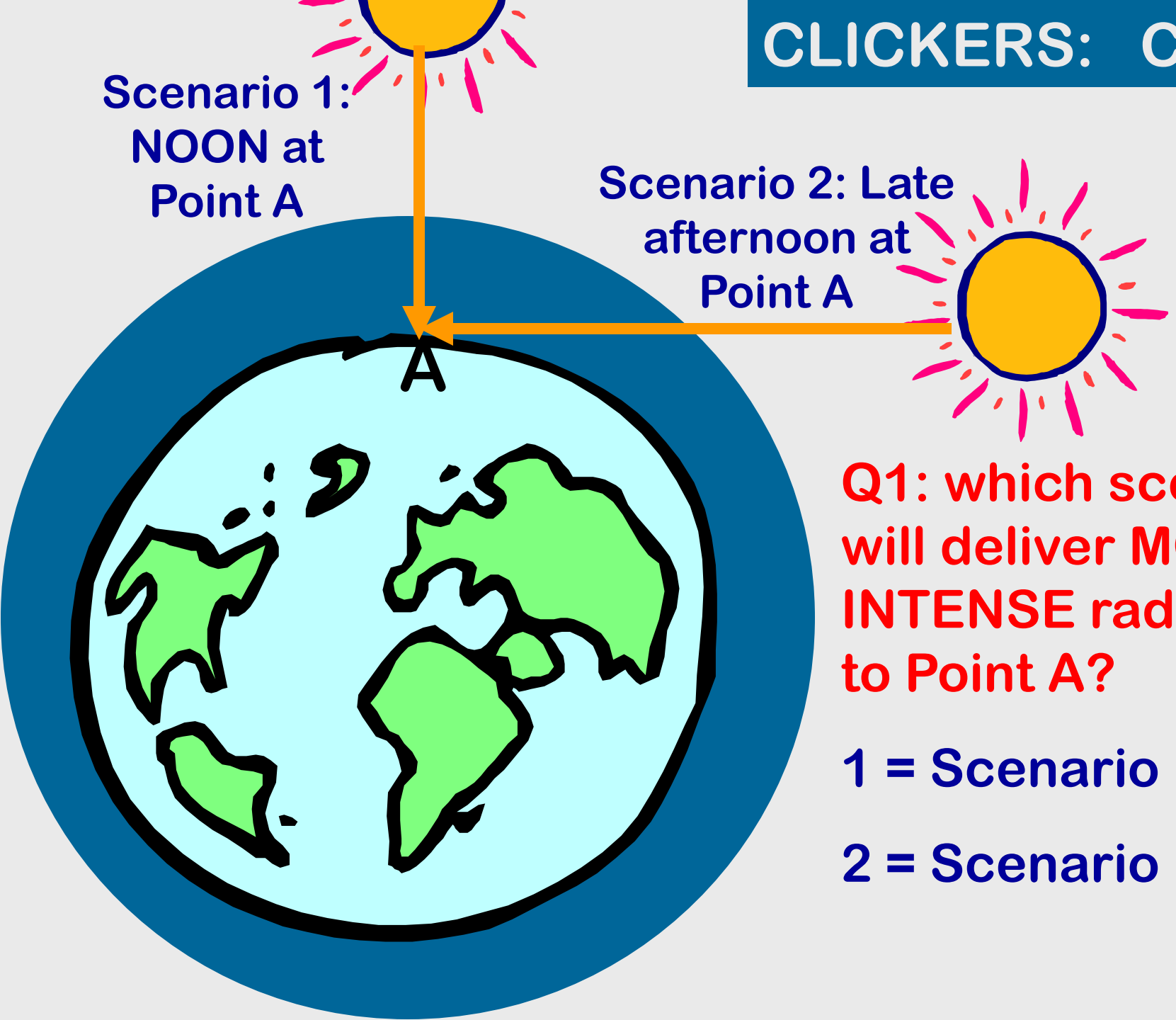
Radiation is concentrated over a small area & hence is more intense when it comes in perpendicular to the surface

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

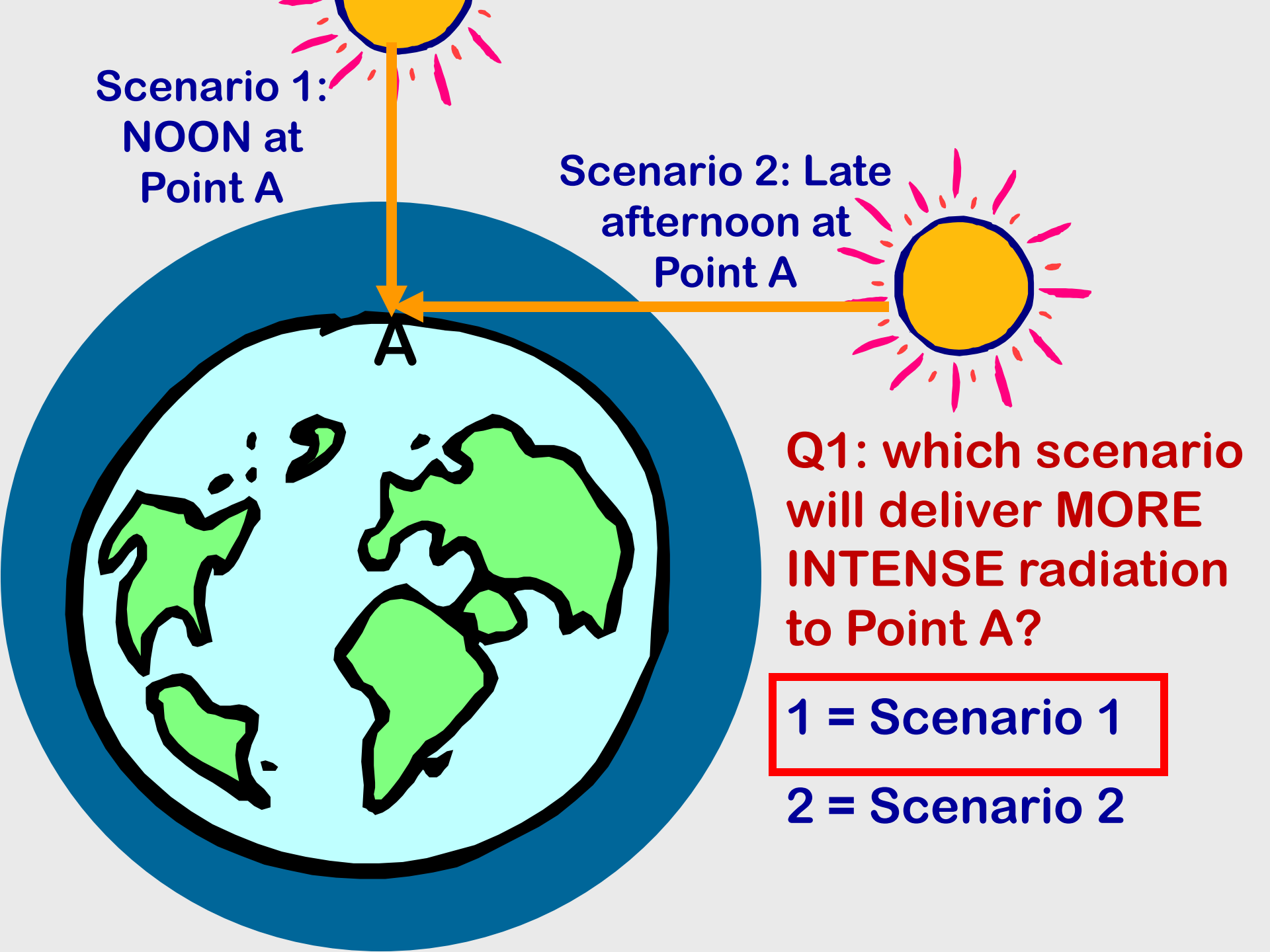
CLICKERS: Ch 32



Q1: which scenario will deliver MORE INTENSE radiation to Point A?

1 = Scenario 1

2 = Scenario 2



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Q2- 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!

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"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

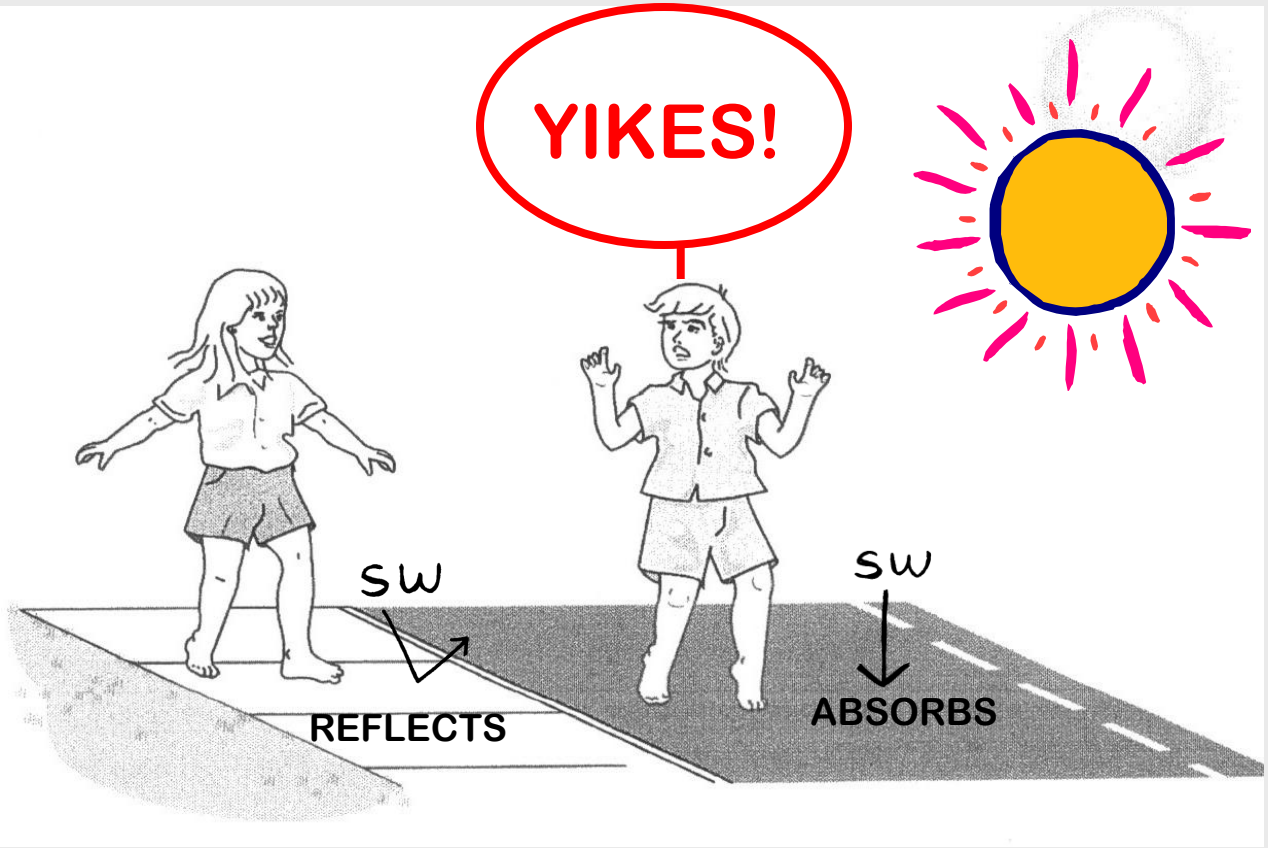
Represented as:

a decimal from 0 to 1.0 *or*

% from 0 – 100 % (perfect reflectivity)

Hence, amount ABSORBED = (1 – albedo)

← Flip back to p 53



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

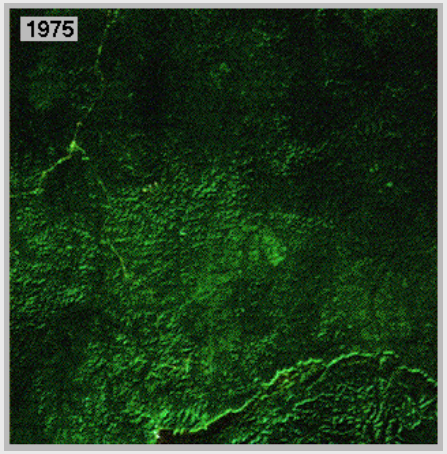
CLICKERS again!

Q3: 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

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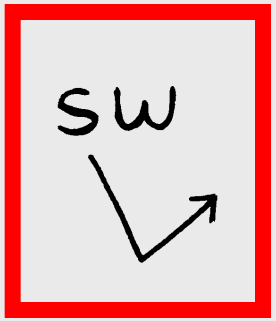
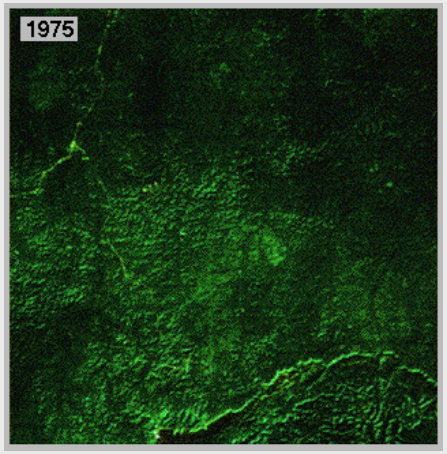


Before



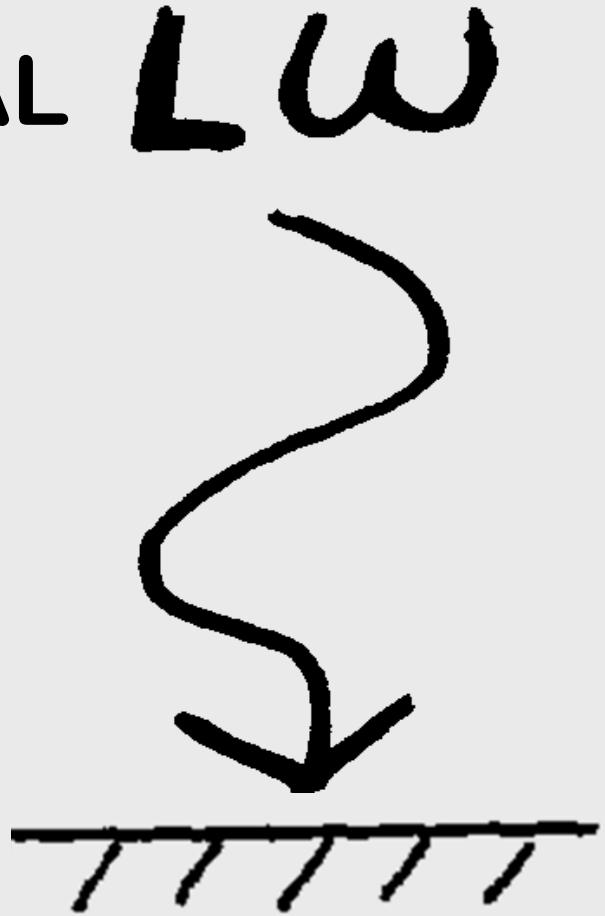
After

"CARTOON" SYMBOLS:

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

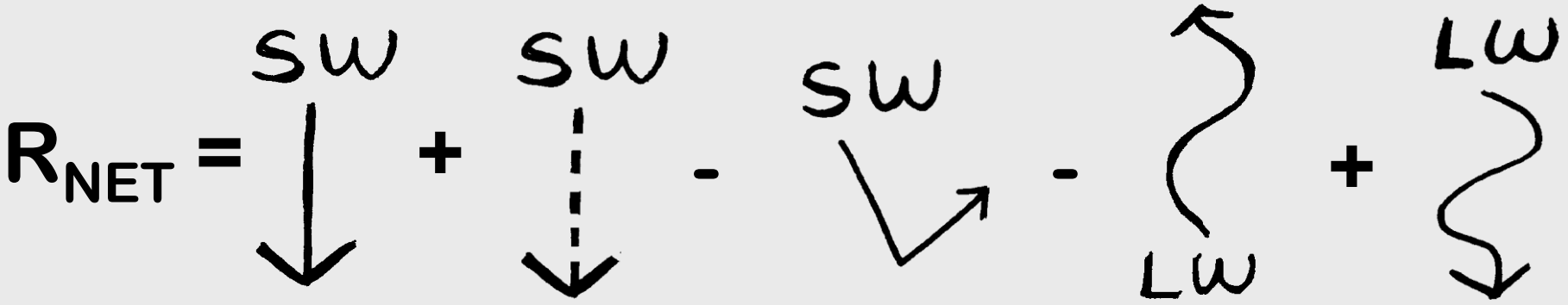
"CARTOON" SYMBOLS:

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



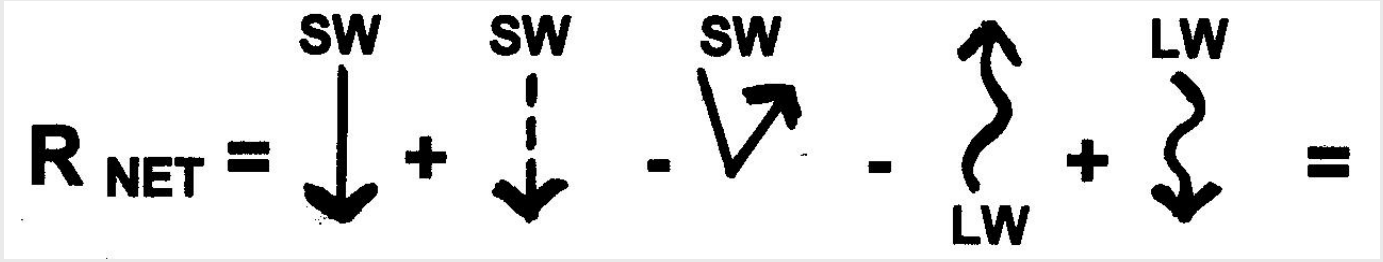
PUTTING IT TOGETHER:

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



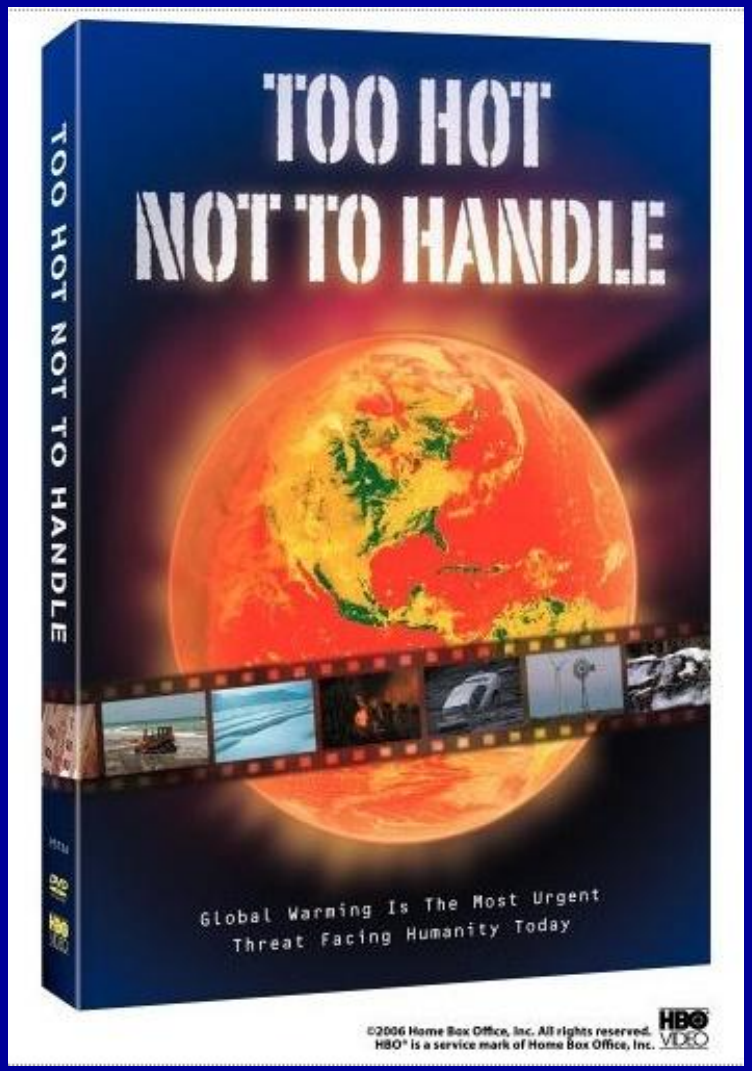
$$R_{NET} = (Q + q) - a - Lu + Ld$$

Top of p 122



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

A new film for our "SUSTAINABILITY SEGMENT"



HBO Documentary FIlm (2006)

Remember to always review the WEEKLY D2L CHECKLIST for what you should be doing . . . .

NOTE: We'll be reading more in the Dire Predictions text in upcoming weeks – see Checklist for the specific pages.