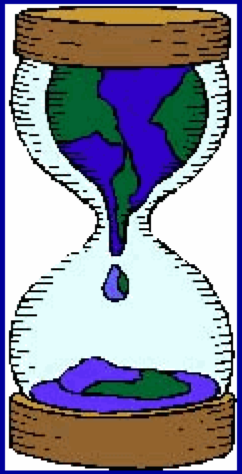
TODAY we'll START with :

THE SUSTAINABILITY SEGMENT



The next segment of:

"SAVED BY THE SUN"

More lecture & clicker points to follow the film . . .

An area set aside at the UA's Science and Technology Park hosts some of the latest solar-array technology.

UA Scientists, Utilities, Governments All Major Players in Solar Research

Arizona Daily Star | UA researchers, local governments, startup companies and the state's major utilities are experimenting with an array of solar solutions. The UA department of chemistry and biochemistry hosts the Center for Interface Science: Solar Electric Materials, which focuses on learning the sub-molecular process that occurs at the interface of materials in an attempt to create thin-film solar cells that are competitive with fossil fuels. more >

http://azstarnet.com/news/science/days-of-science-az-scientists-utilities-gov-ts-all-major/article_f563ebac-0605-5bc4-9350-6b2b478a5632.html

If Arizona scientists don't come up with the breakthroughs needed to put solar energy on par with burning fossil fuels, it won't be for lack of trying.

Local governments, university researchers, startup companies and the state's major utilities are experimenting with an array of solar solutions.

With partners in Colorado, New Jersey, Georgia and Washington, the center focuses on learning the sub-molecular process that occurs at the interface of materials in an attempt to create thin-film solar cells that are competitive with fossil fuels. The center's Georgia Tech-led group recently produced the world's first all-plastic solar cell.

The UA also tests the efficiency of an array of photovoltaic panels at the TEP test yard.

The UA's Science and Technology Park has a solar zone devoted to installations of the latest solar-energy arrays.

One coming attraction to that site is a focused photovoltaic array invented by Roger Angel of Steward Observatory, who is bringing the technology behind the world's most precise astronomical mirrors to the quest for affordable solar energy.

http://azstarnet.com/news/science/days-of-science-az-scientists-utilities-gov-ts-all-major/article_f563ebac-0605-5bc4-9350-6b2b478a5632.html

Now . . . To the film:

What's with SOLAR in GERMANY?

http://www.pbs.org/wgbh/nova/solar/

FIRE UP YOUR CLICKERS:
Channel 32

Test #1 was _______________

1 Too Easy	2 Too Hard	3 Just Right	4 Too picky	5 Too tricky

Topic #6
THE RADIATION LAWS(cont.):

APPLYING THE RADIATION LAWS

#1Emission of radiation

All substances emit radiation as long as their temperature is above absolute zero

Review pp 29-31

#2 Planck Function:

$$E = hc/\lambda$$

"SHORTER wavelengths have HIGHER intensity radiation than LONGER wavelengths"

3 Stefan-Boltzmann Law:

$$E = \sigma T^4$$

"The hotter the body, the (much) greater the amount of energy flux or radiation"

4 Wein's Law:

$$\lambda_m = a/T$$

"The <u>hotter</u> the body, the <u>shorter</u> the wavelength"
The <u>cooler</u> the body, the <u>longer</u> the wavelength"

review

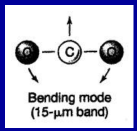
#5: Radiation & distance: inverse-square law

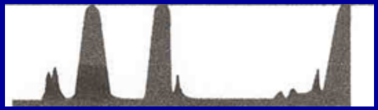
$$E_{flux} \approx (1/d^2)$$

"Energy flux decreases with increasing distance from source such that small changes in distance → large changes in energy received."

#6: Selective emission and absorption

"Some substances, especially gases, emit and absorb radiation at certain wavelengths only due to quantum behavior of electrons & molecules"





review

Electromagnetic energy does not NEED matter to be transferred, but when it DOES **react with matter,** it can be:

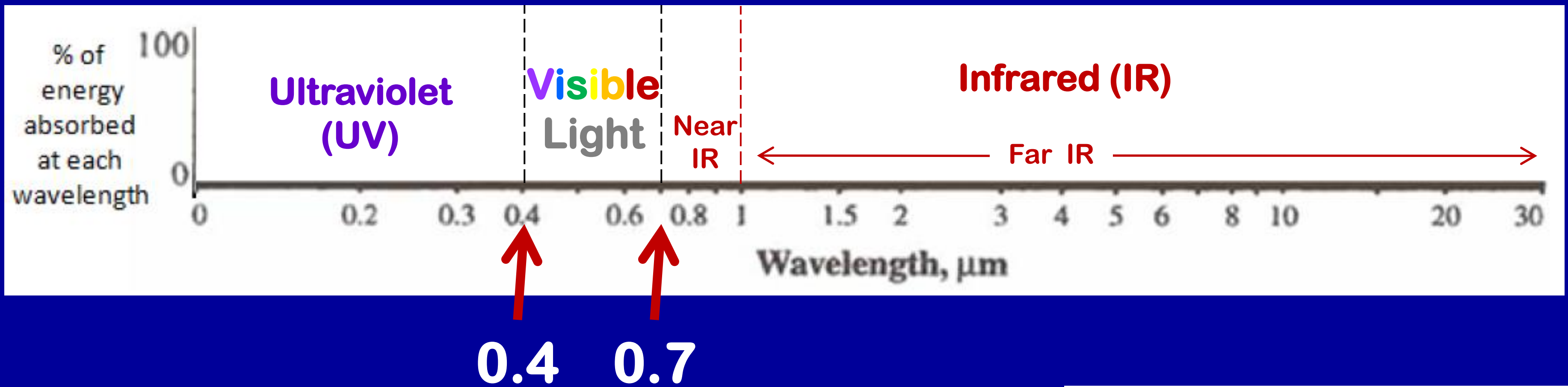
- **ABSORBED (and EMITTED)**
- **TRANSMITTED**
- **SCATTERED**, or
- **REFLECTED . . .**

. . . . through -- or by -- the matter

More about these 4 processes in upcoming lectures . . . .

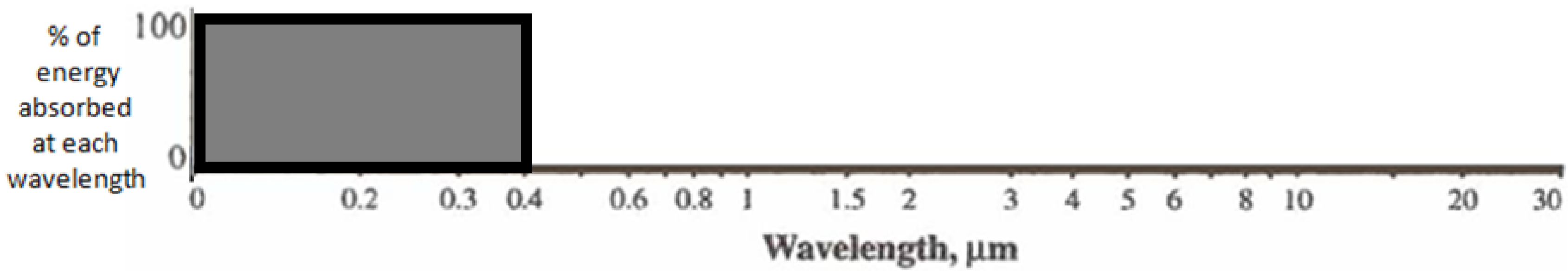
ABSORPTION CURVES

Graph the relationship between wavelength and % of energy absorbed (at a given wavelength)

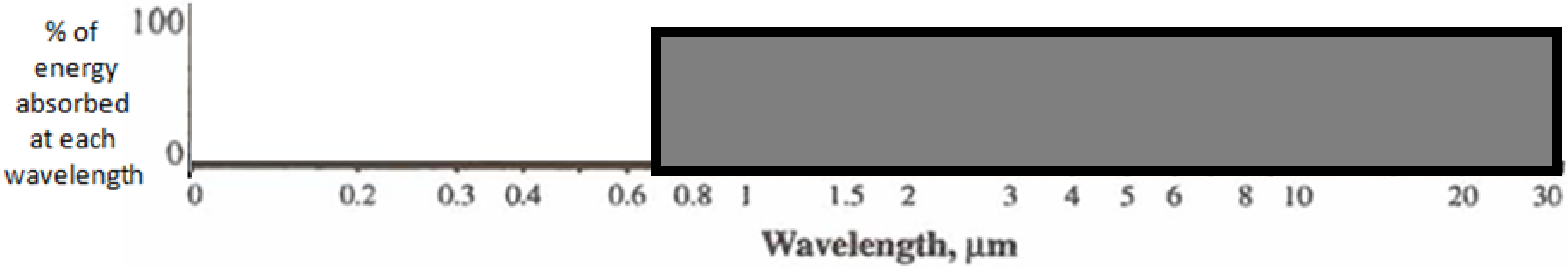


G-1 review p 32

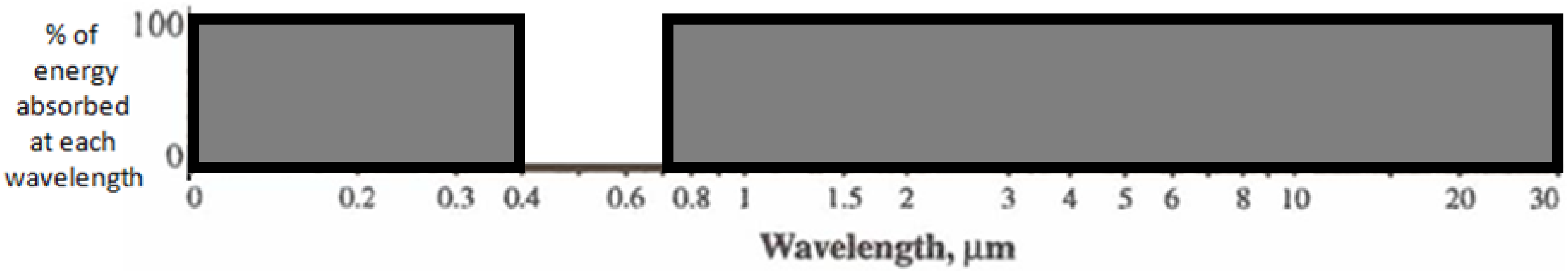
Q1. *Draw an absorption curve for a hypothetical gas that can absorb ALL UV radiation but zero visible light and IR radiation.* *Then* ***shade in the area under your curve*** *in this and subsequent questions.*



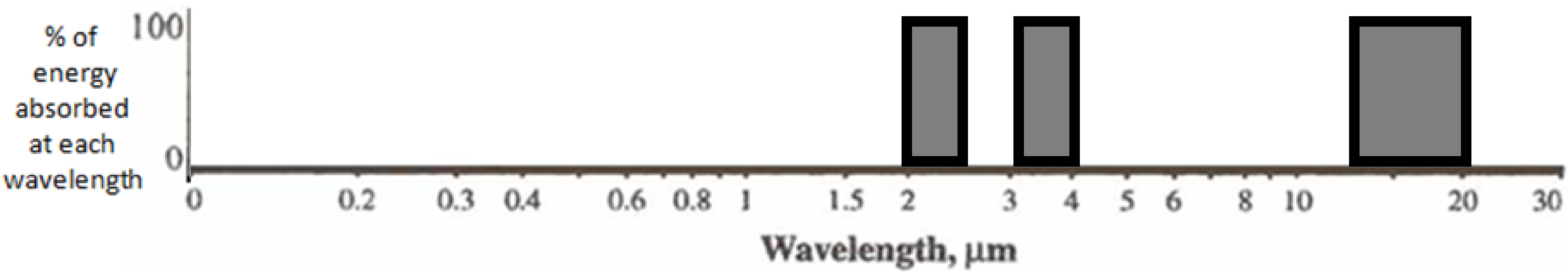
Q2. *Draw an absorption curve for a "perfect" greenhouse gas that absorbs ALL IR radiation, but no visible or UV:*



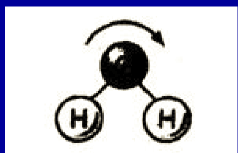
Q3. *Draw an absorption curve for a hypothetical gas that absorbs ALL UV radiation and ALL IR radiation, but leaves a "WINDOW" open for visible light, allowing the visible light wavelengths to pass through the gas unimpeded* ***without*** *being absorbed:*

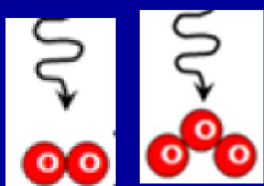


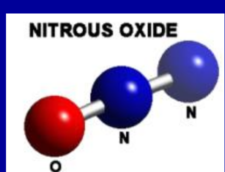
Q4. *Draw an absorption curve for a hypothetical gas that can absorb 100% of the IR radiation in these three wavelength bands*: band from 2 to 2.5 μm band from 3 to 4 μm band from 13 to 20 μm

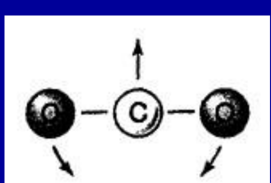


Skip to p 34:





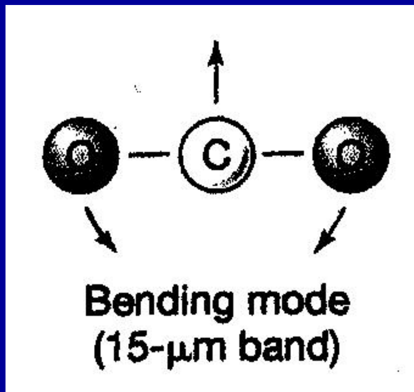




Gas	Primary absorption wavelengths *(in micrometers)*	
Water vapor (H_2O)	0.8 1 1.5 2 to 3.5	4 to 7 9 to 10 11 to 20
Molecular oxygen (O_2) and Ozone (O_3)	0.0001 to 0.280 8.5 to 10	
Nitrous oxide (N_2O)	4 to 5 7 to 7.5	
Carbon dioxide (CO_2)	2 to 2.5 3 to 4 13 to 20	

In SGC E-Text Chapt 3:

IR radiation!



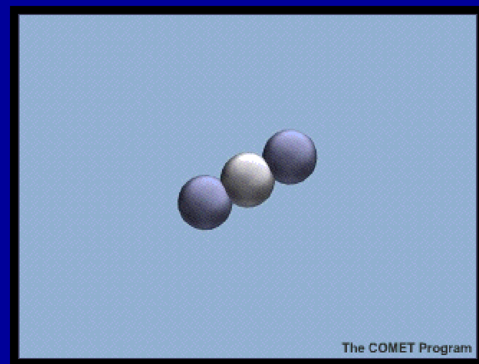


FIGURE 3-14

As a triatomic molecule, one way that CO_2 vibrates is in a "bending mode"

This vibration mode has a frequency that allows CO_2 to absorb IR radiation at a wavelength of about 15 micrometers

What about another triatomic molecule: N_2O (Nitrous oxide)?

DANCE YOUR PhD !!

Nitrous Oxide (N_2O) acts as a greenhouse gas through the absorption of radiation in 3 vibrational modes.

This graduate student is demonstrating the quantum behavior of a molecule of N_2O:

- one hand = a nitrogen atom
- torso = central nitrogen
- other hand = an oxygen atom

Now, 3 dancers will exhibit the 3 specific movements of N_2O's vibrational modes . . . . . .

☺

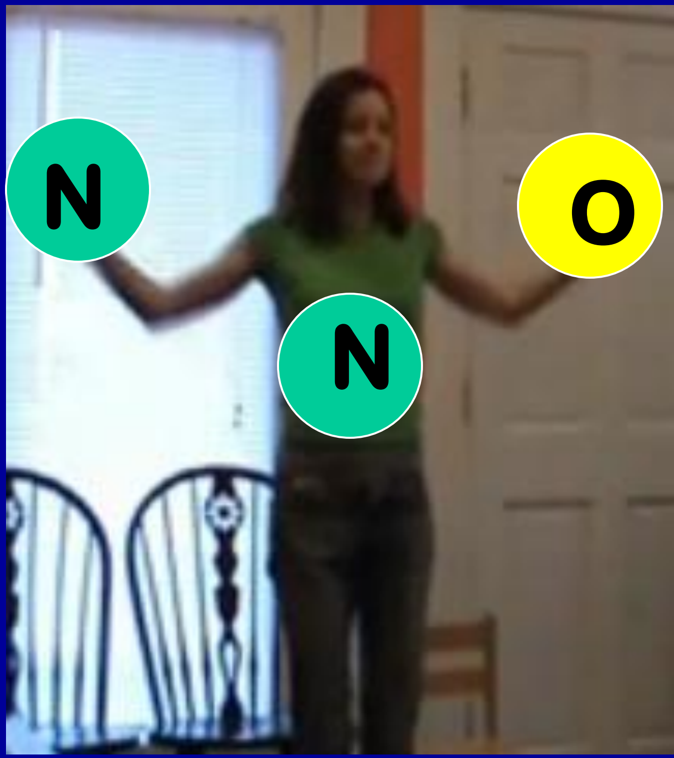
The N_2O starts in the soil where it is produced by microbial activity and "moves on up" into the atmosphere.

☺

Stepping onto the chairs represents the progression of N_2O to higher levels in the atmosphere (the stratosphere) where it is subject to intense Ultraviolet (UV) radiation from the sun.

This high energy from the bombarding UV radiation is shown in the dancers' high energy, more spastic dancing.

The high intensity UV radiation leads to the destruction of N_2O -- seen as jumping from the chair at the end ➔

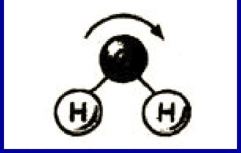


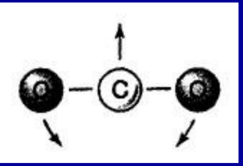
DANCE YOUR PhD !!

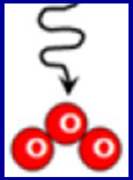
http://www.youtube.com/watch?v=L5j6BS3XoLc

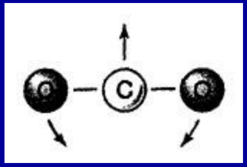
☺

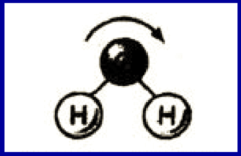
Close up view of absorption of IR wavelengths by different GHG's:

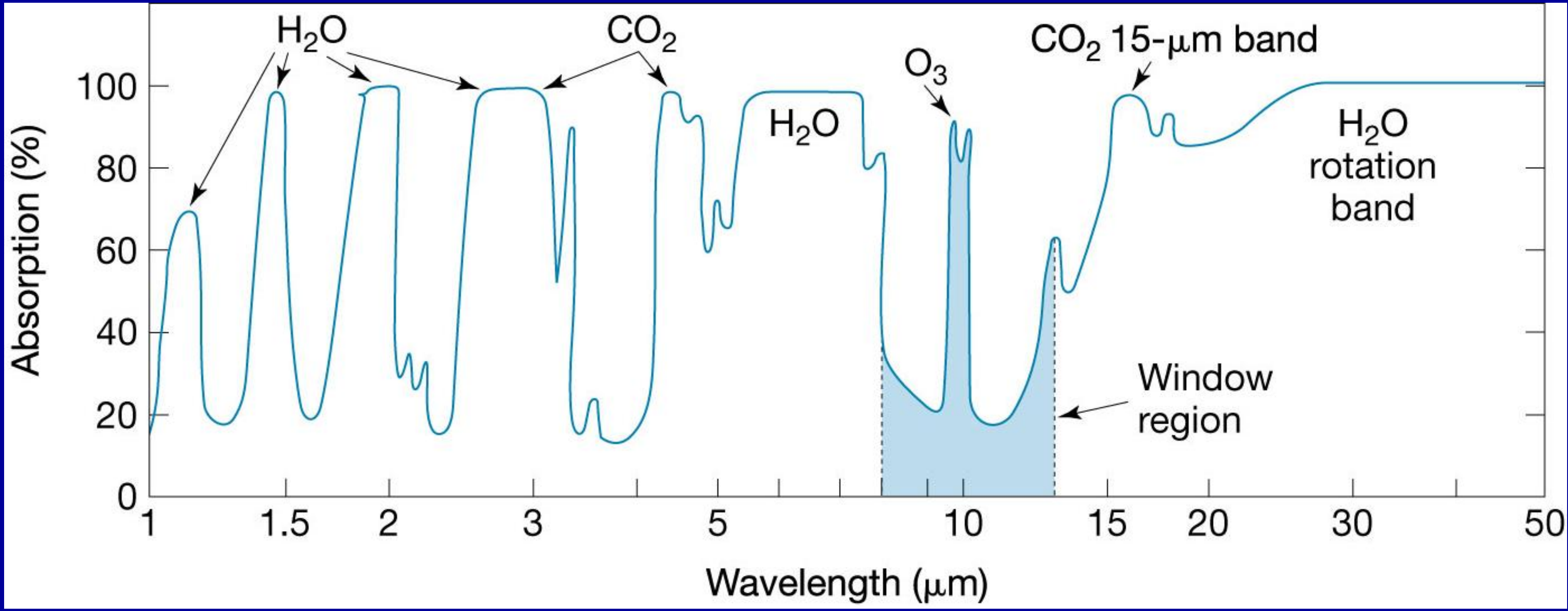








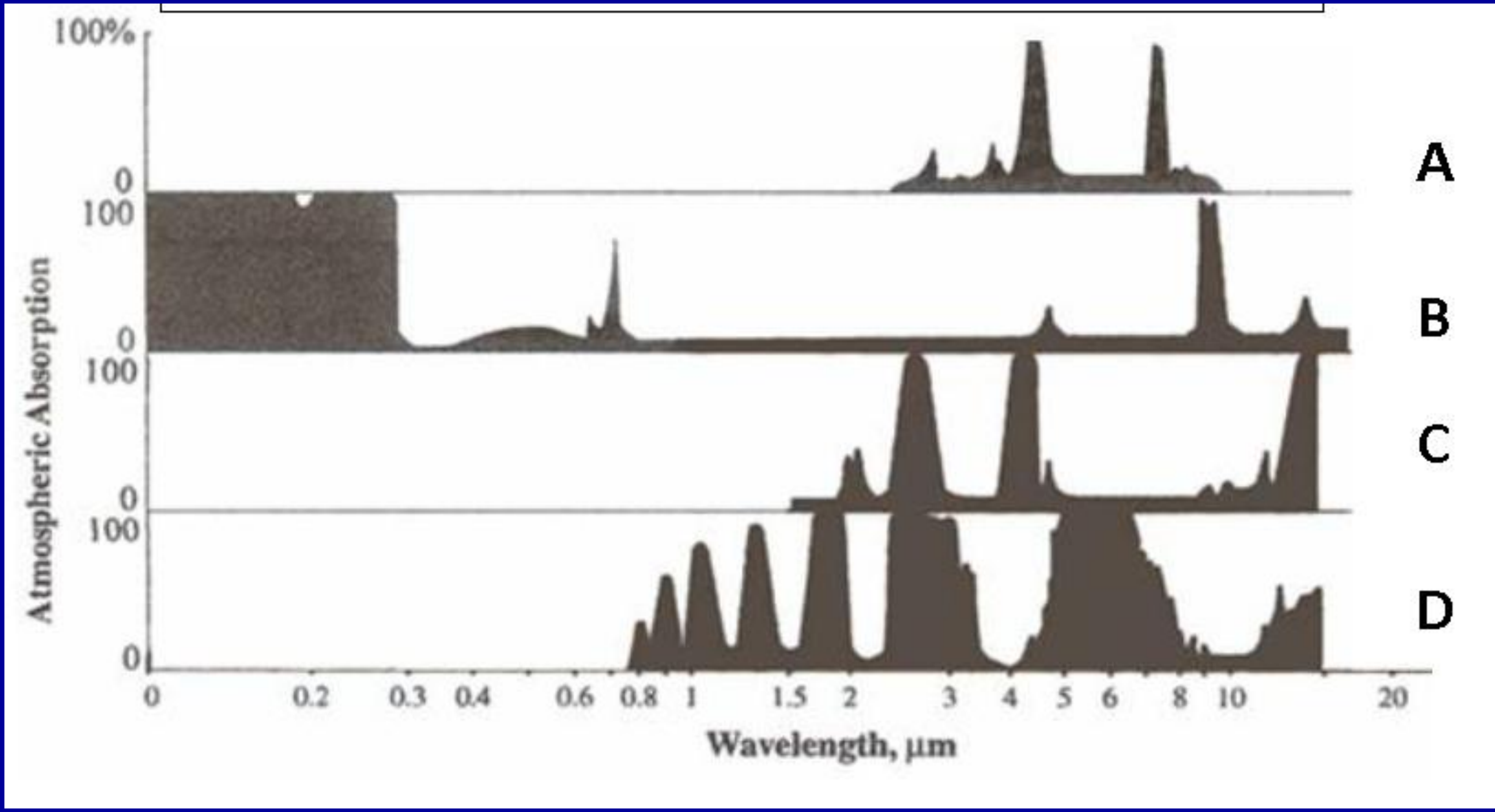




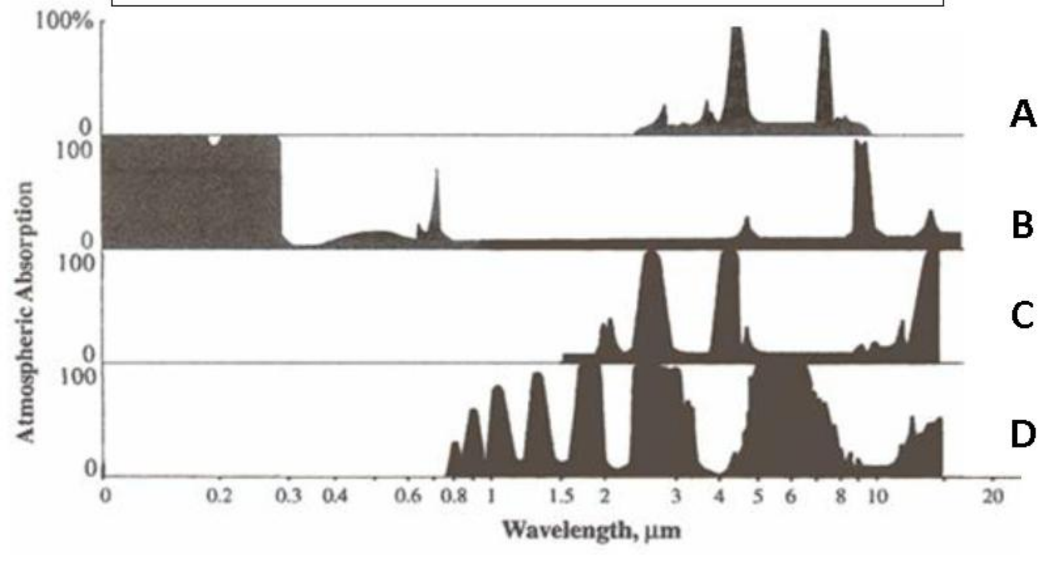
SGC E-Text Fig 3-13

Match the GAS with the Absorption Curve #:

CHOICES: CO_2 H_2O O_2/O_3 N_2O & ??



Then get your CLICKERS ready
Channel 32

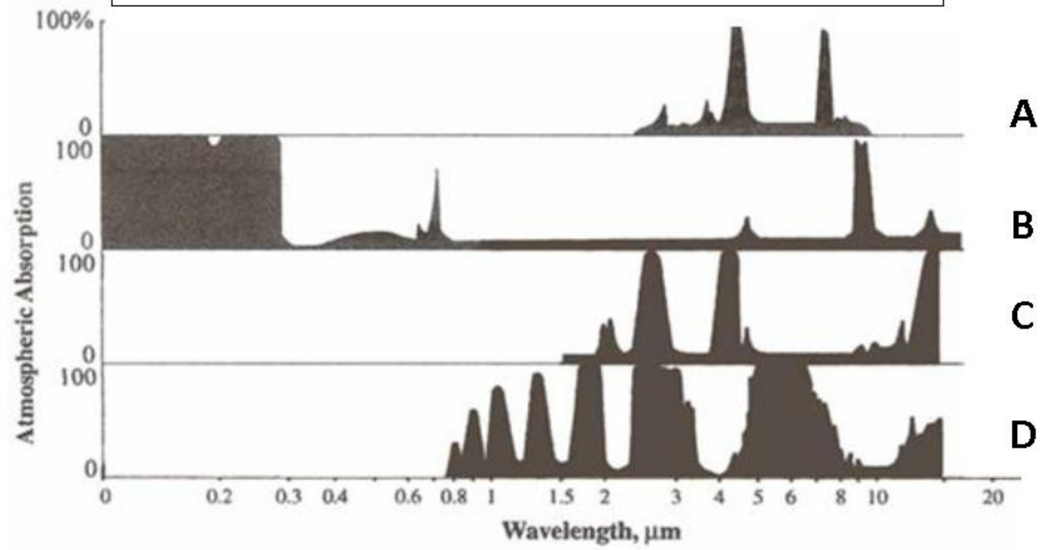


Q2- SELECT THE CORRECT COLUMN CHOICE:

Answer with Column Choice #:

1, 2, 3, or 4

	Choice 1	Choice 2	Choice 3	Choice 4
Curve A	CO_2	O_3	H_2O	N_2O
Curve B	N_2O	N_2O	O_3	O_3
Curve C	O_3	CO_2	N_2O	CO_2
Curve D	H_2O	O_3	CO_2	H_2O



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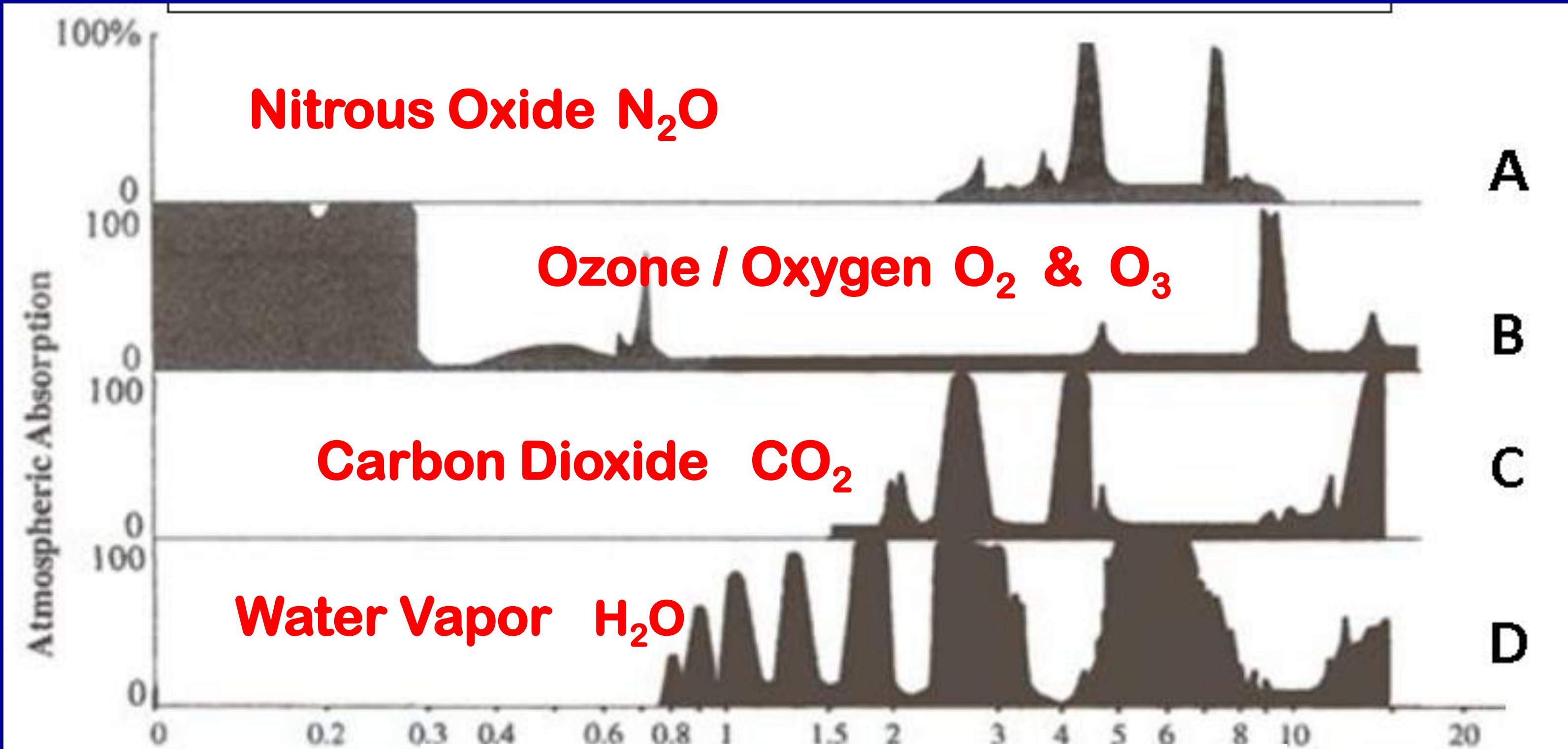
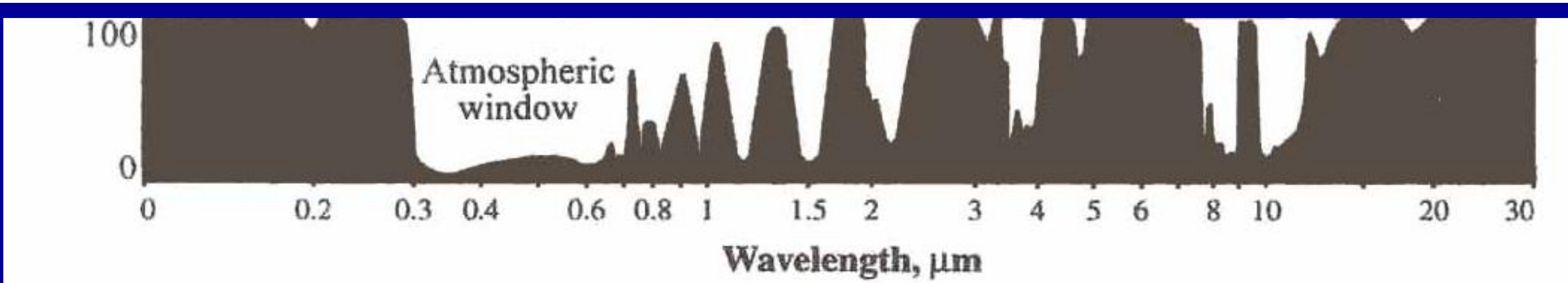
	Choice 1	Choice 2	Choice 3	Choice 4
Curve A	CO_2	O_3	H_2O	N_2O
Curve B	N_2O	N_2O	O_3	O_3
Curve C	O_3	CO_2	N_2O	CO_2
Curve D	H_2O	O_3	CO_2	H_2O



Add them all together and get

One graph showing absorption by ALL the atmospheric gases !

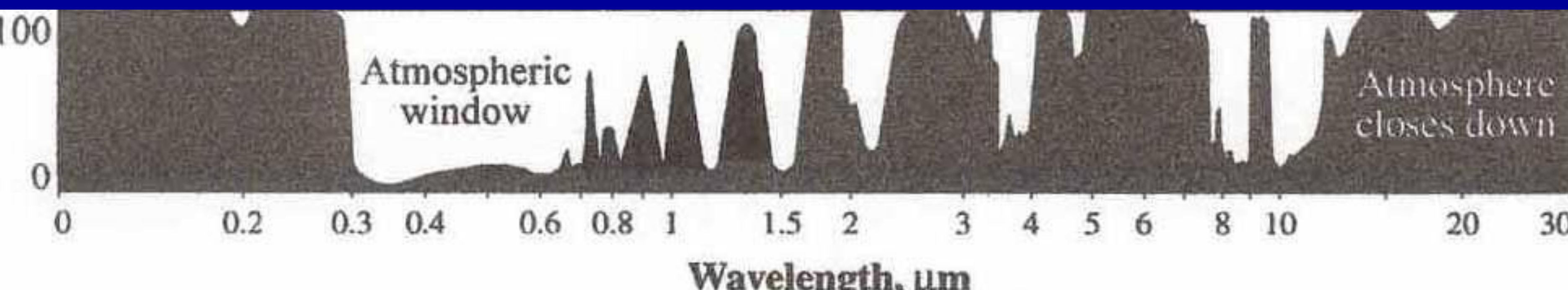


Absorption by ALL the gases in the atmosphere put together –

i.e. curve for the "Whole Atmosphere"

Window #1 with very little absorption!

Window #2 with very little absorption!



UV

Visible

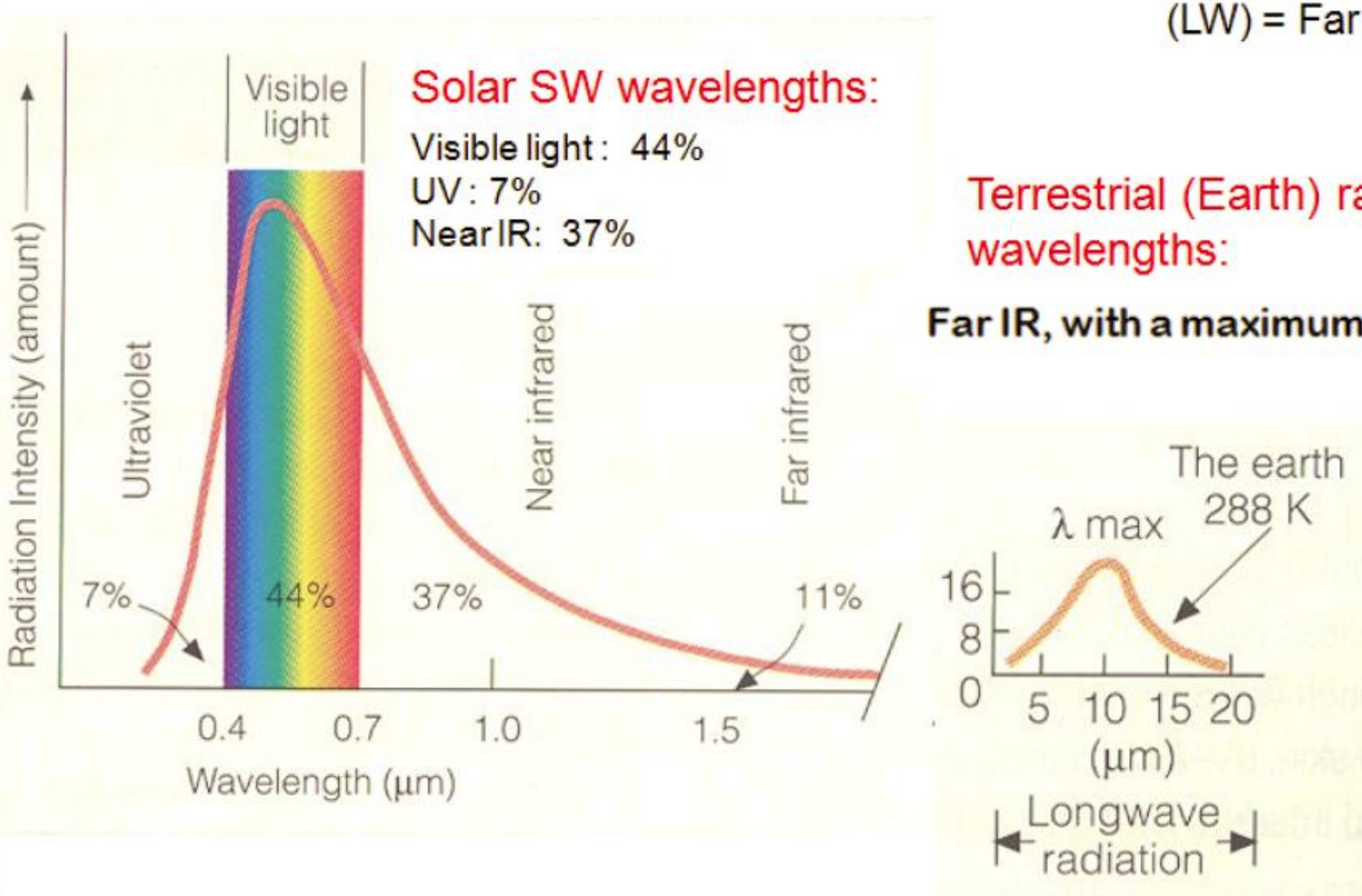
NIR

Far IR

Bottom row p 34

Shortwave SOLAR radiation
(SW) = UV + VIS + Near IR

TERRESTRIAL radiation
(LW) = Far IR

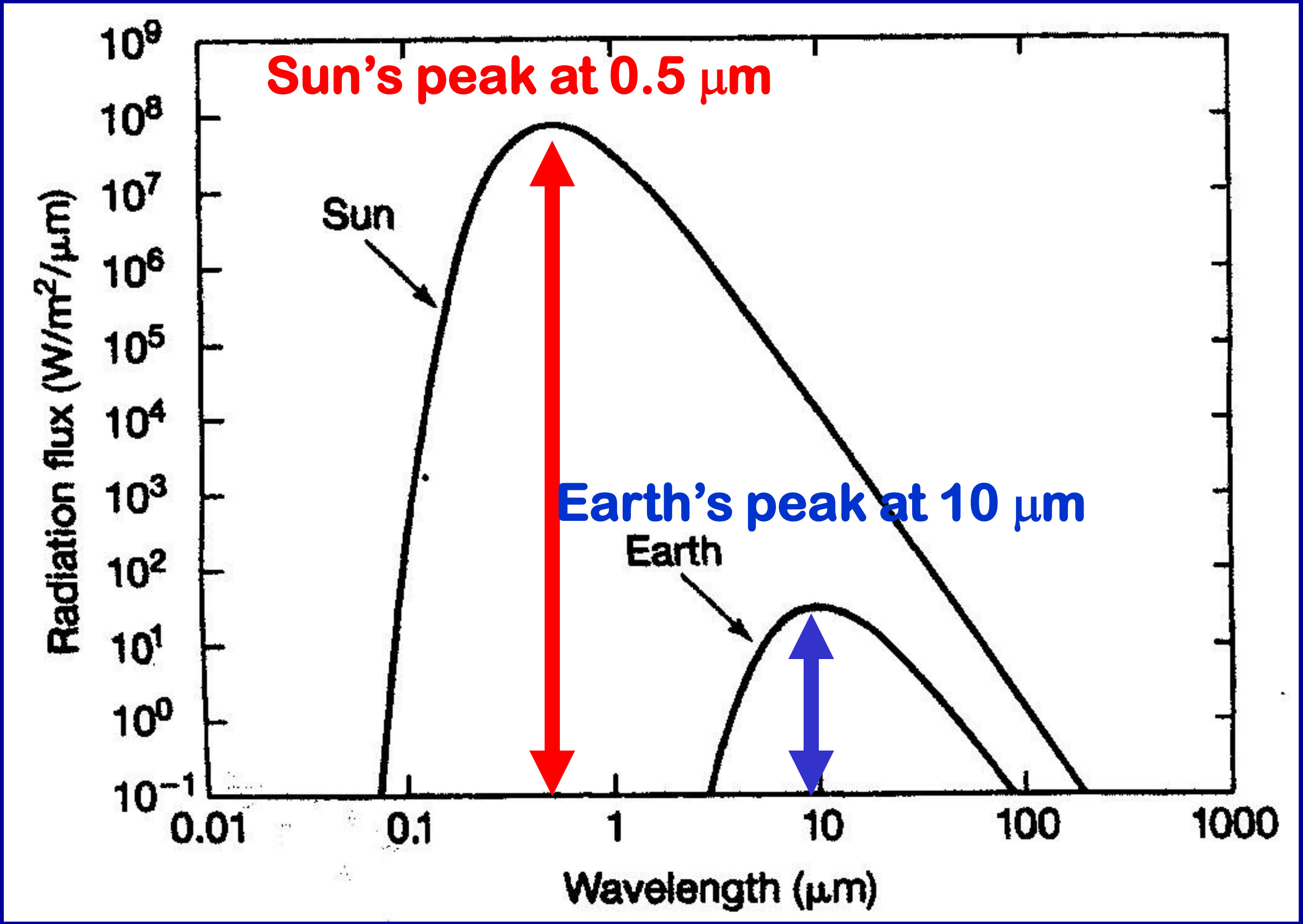


REMEMBER THIS???

Review p 30

Incoming
SW SOLAR (UV + Vis)
window

Outgoing
LW TERRESTRIAL (IR)
window

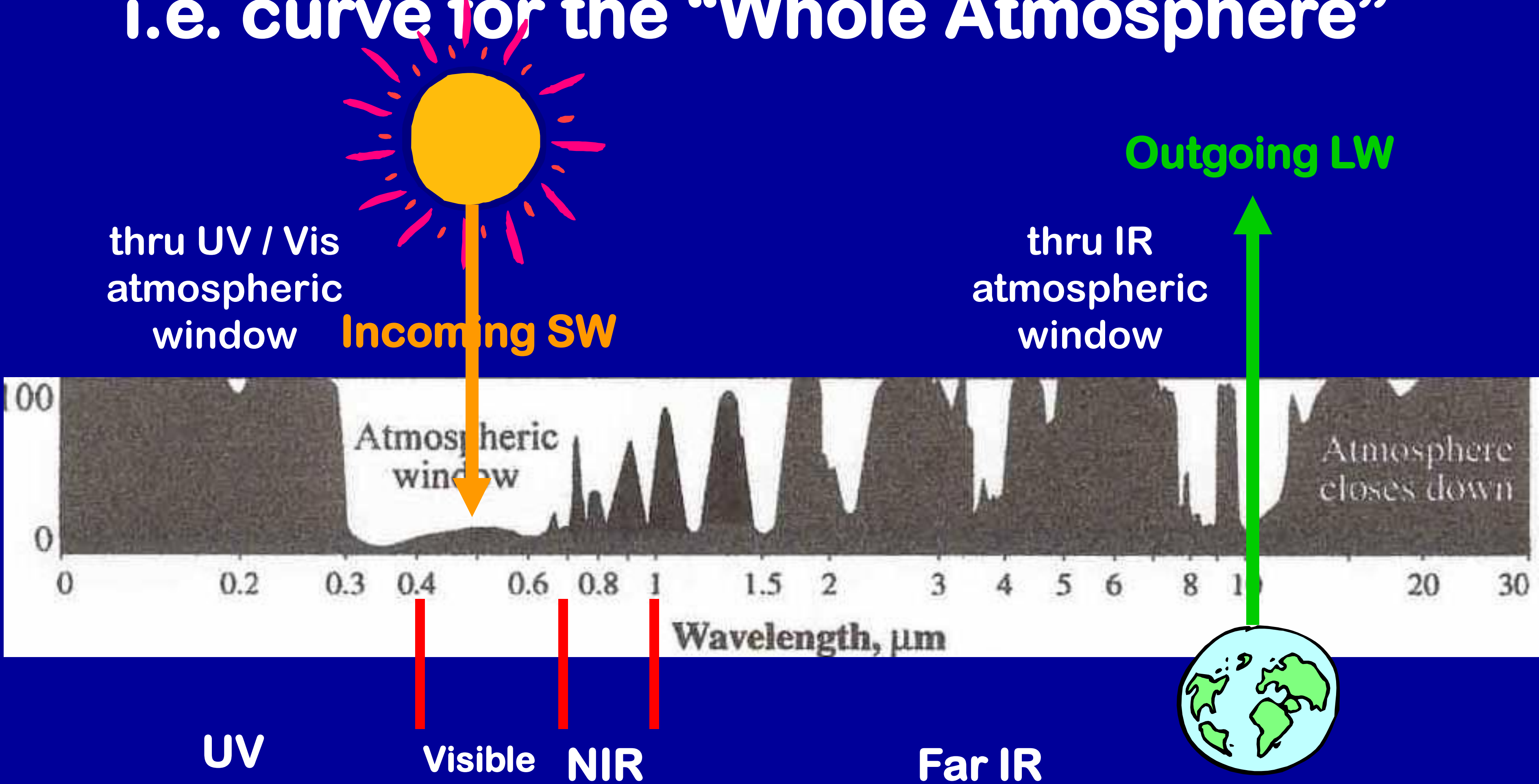


REMEMBER THIS???

Review p 30

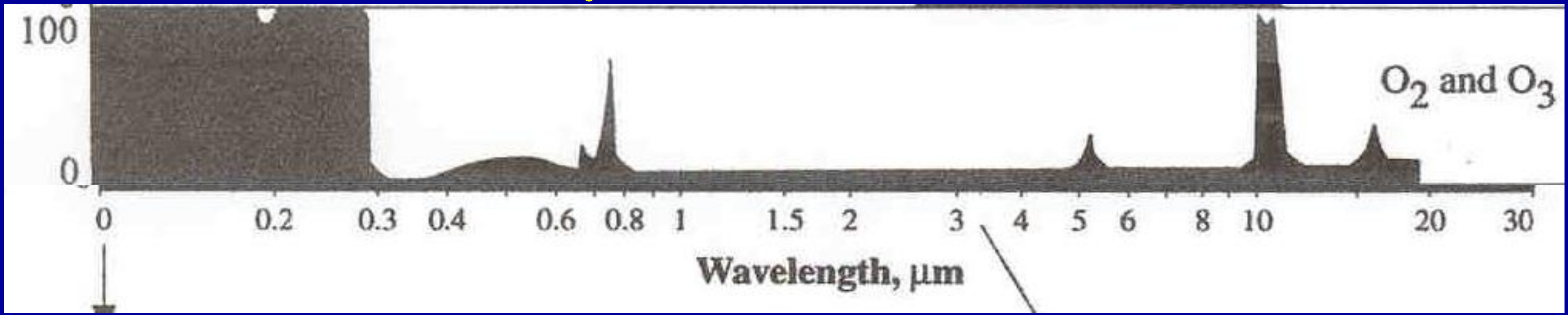
Absorption by ALL the gases in the atmosphere put together –

i.e. curve for the "Whole Atmosphere"



Bottom row p 34

Q3. HOW IS OZONE (actually O_3 & O_2) unique???



1) It absorbs only UV – hence it's NOT a GHG

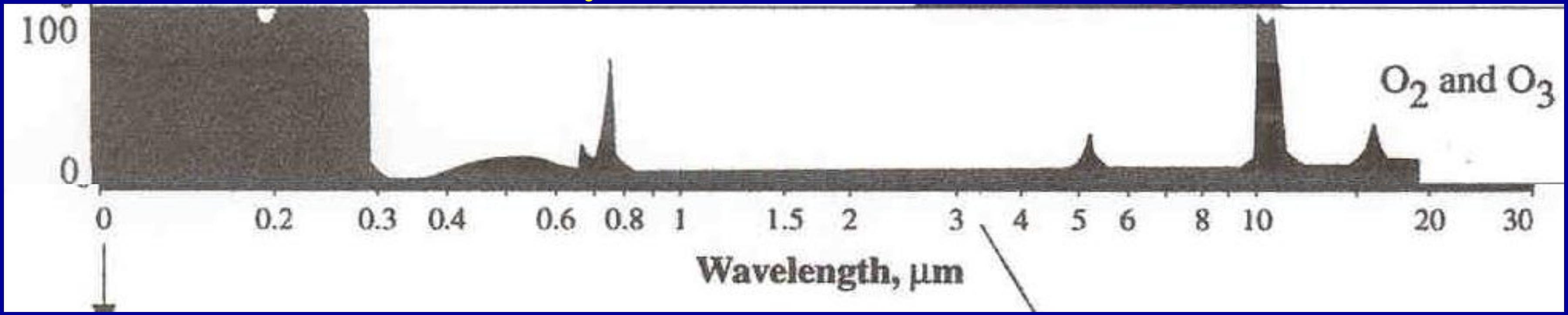
2) It absorbs almost ALL visible wavelengths

3) It absorbs BOTH UV and IR so IS a GHG

4) It absorbs BOTH UV and IR so is NOT GHG

☺

Q3. HOW IS OZONE (actually O_3 & O_2) unique???



1) It absorbs only UV – hence it's <u>NOT</u> a GHG

2) It absorbs almost ALL visible wavelengths

3) It absorbs <u>BOTH</u> UV and IR so <u>IS</u> a GHG

4) It absorbs BOTH UV and IR so is <u>NOT</u> GHG

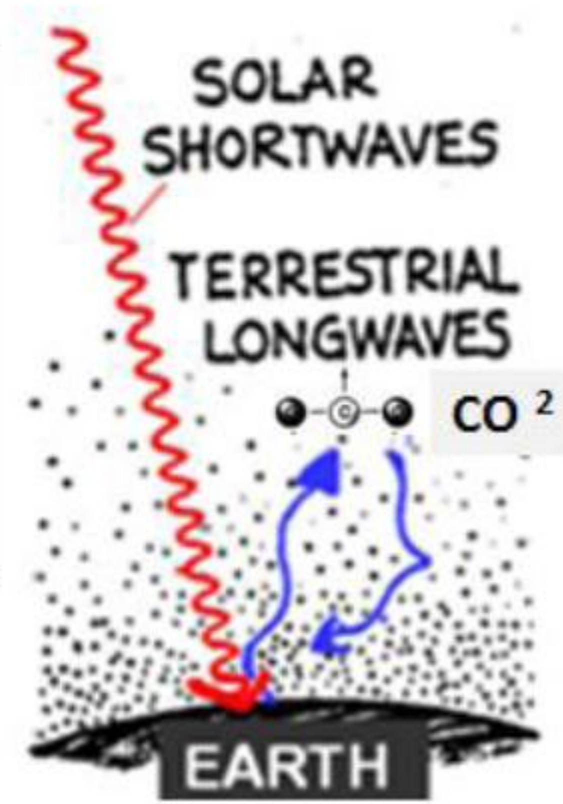
But <u>only</u> the IR absorption makes it a GHG!!

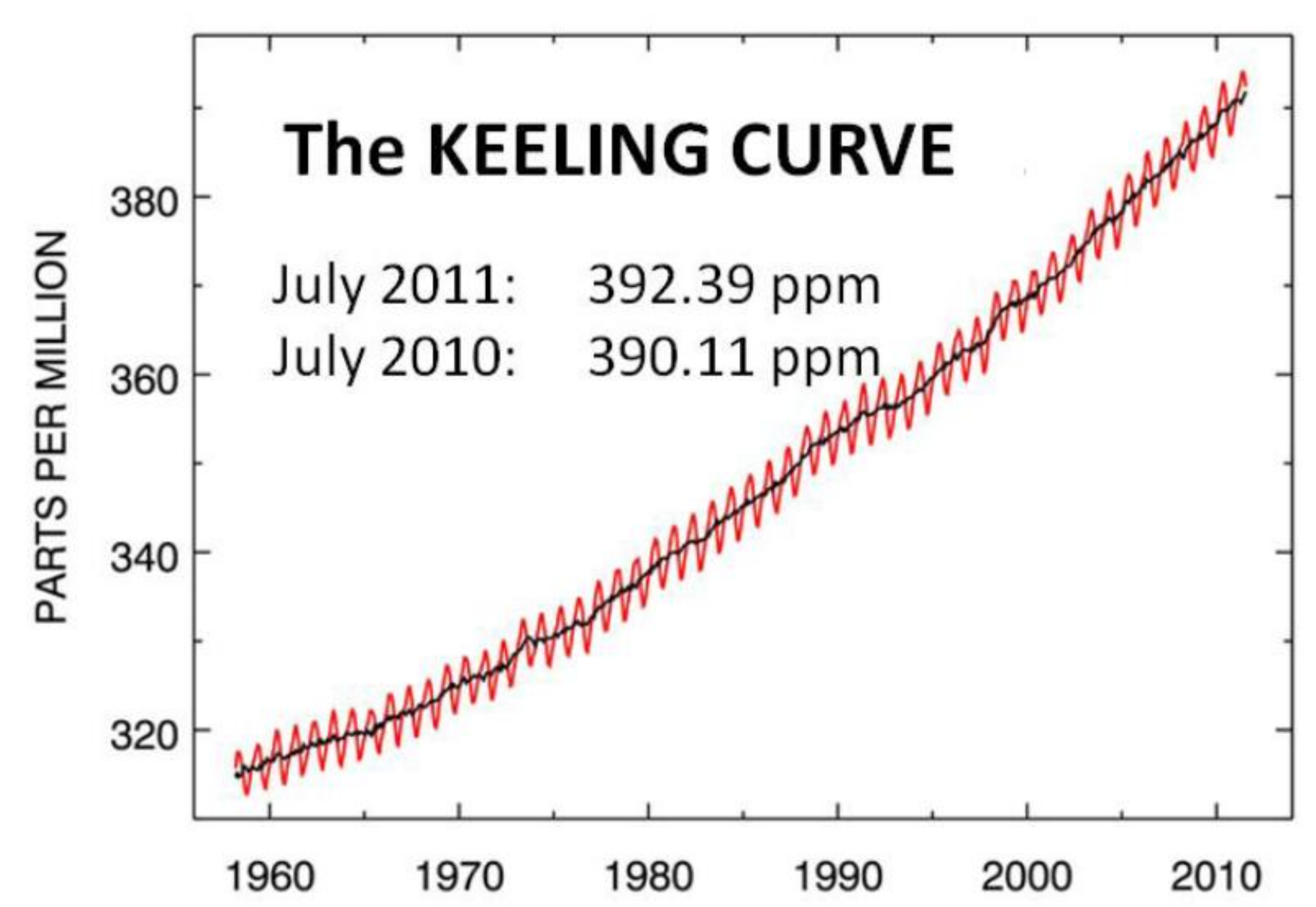
☺

INDICATOR INTERLUDE . . .

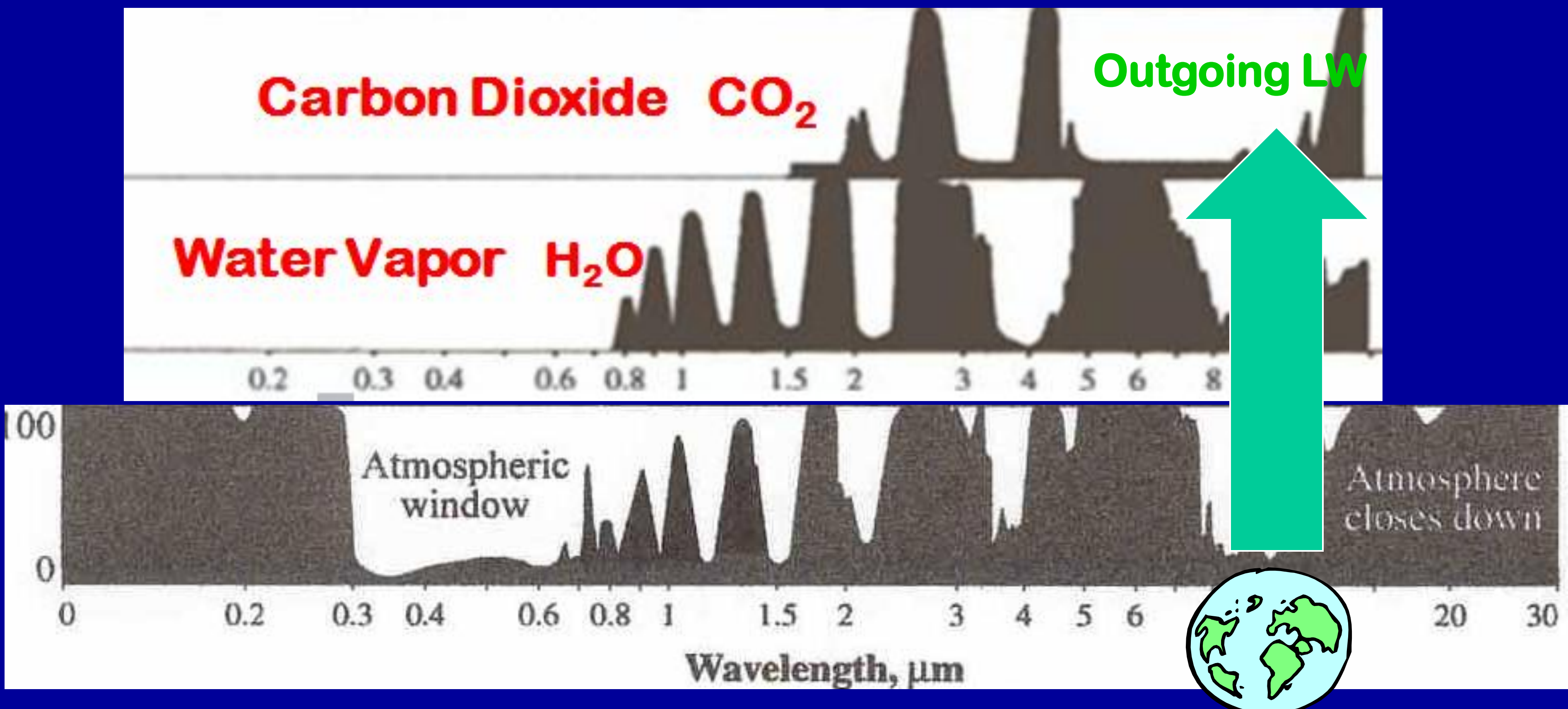
Denier Argument #29:

"Increasing CO2 has little to no effect"




The KEELING CURVE
July 2011: 392.39 ppm
July 2010: 390.11 ppm
PARTS PER MILLION
380
360
340
320
1960
1970
1980
1990
2000
2010

➔ A gas has a **BIG effect** if it **absorbs in or near a "window"** of wavelengths <u>where the atmosphere is fairly transparent.</u>



MORE ABOUT
GREENHOUSE GASES
ON WEDNESDAY!

Don't forget RQ-3