

Tuesday Sep 23th

SIT IN YOUR GROUP AREA TODAY!

Wrap-Up of **Topic #5** on the Radiation Laws
to get ready for **Topic # 6**

Atmospheric & Structure & Composition

- **RQ-3** was cutoff 30 minutes before class today – if you missed it see FAQ #22
- **Clickers today – get ready!**

Your Clicker Participation Percentage (%) is now visible in D2L in your GRADEBOOK.

[If you've been clicking, but have 0% , your points are saved, but they are NOT yet linked to your name . . . so REGISTER and you will see them!]

HAPPY SEPTEMBER EQUINOX!

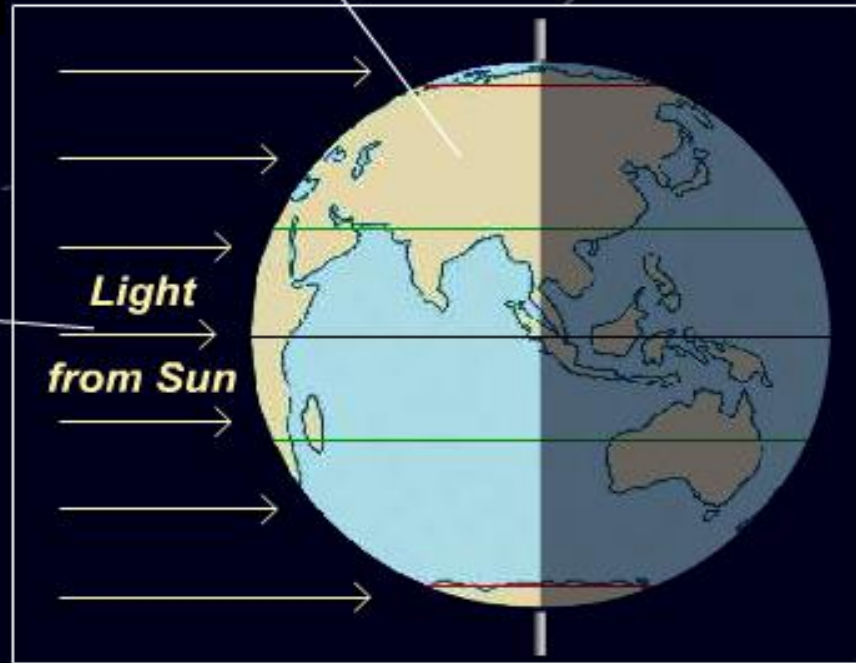
Yesterday 22 Sep 2014 @ 7:29 pm

**Equinox =
“equal night”**

All locations on
Earth experience
12 hours of daylight

Vertical rays of Sun
striking equator

*Light
from Sun*

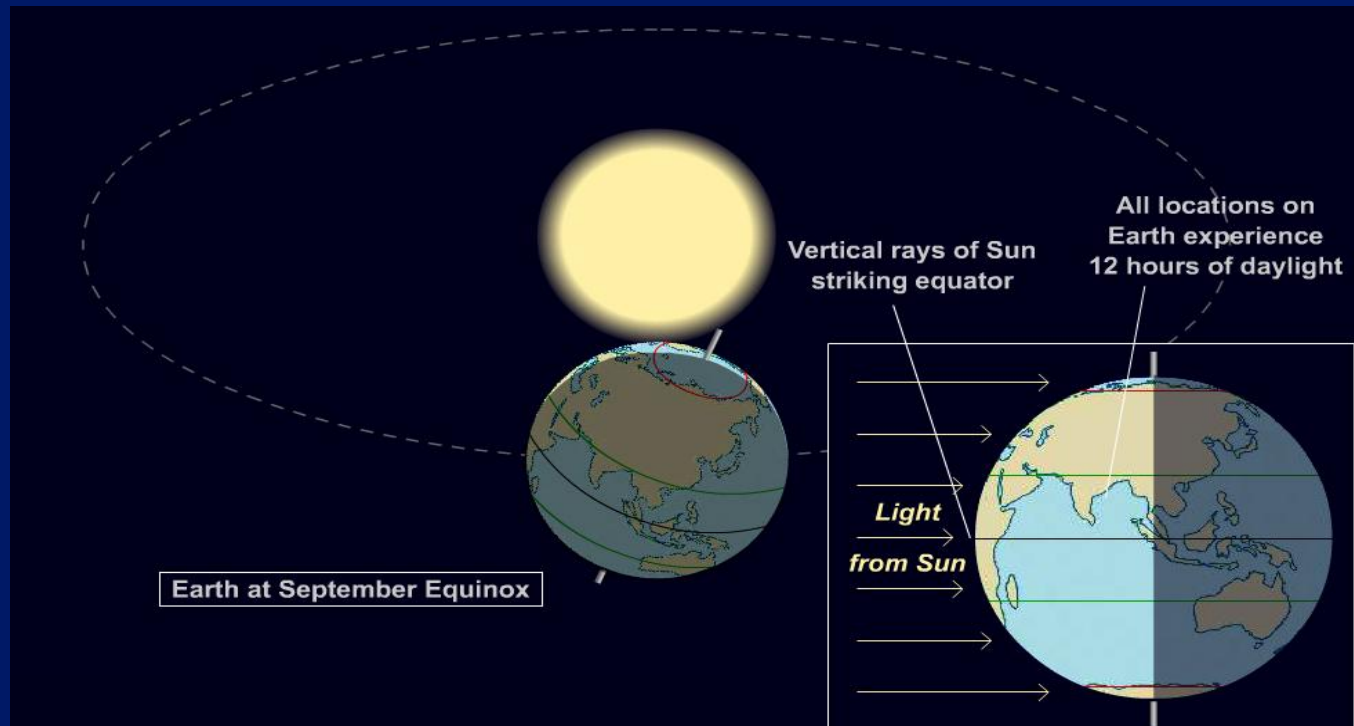


Preview of Topic #10: p 63

**Today is the
“First Day of Fall”
in the Northern Hemisphere!**



Google



You can view the animation yourself at:

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

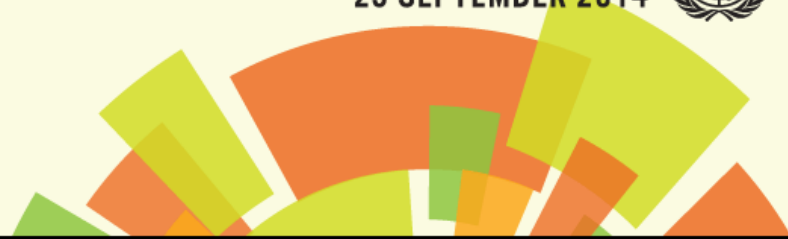
World leaders urged to change course at UN climate summit

Climate change takes front and center at United Nations summit

CLIMATE SUMMIT 2014

CATALYZING ACTION

UN HEADQUARTERS · NEW YORK
23 SEPTEMBER 2014



No "Plan B" for climate action as there is no "Planet B," says UN chief

Tucson's Event



Global Warming Concerns Grow

By MARJORIE CONNELLY SEPT. 22, 2014

CBS NEWS / September 22, 2014, 6:30 PM

Americans weigh in on global warming's impact

THE WALL STREET JOURNAL.

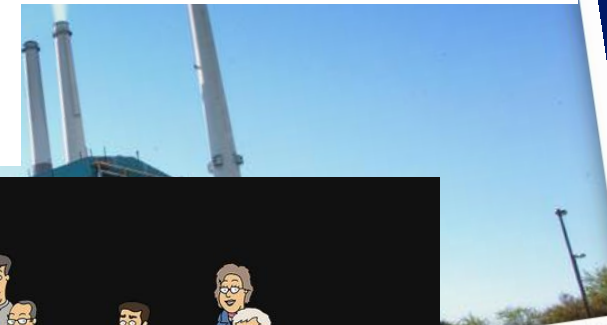
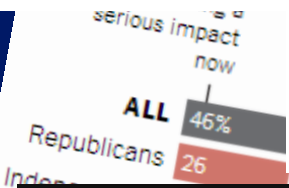
V:

THE SATURDAY ESSAY

Climate Science Is Not Settled

We are very far from the knowledge needed to make good climate policy, writes leading scientist Steven E. Koonin

“The impact today of human activity appears to be comparable to the intrinsic, natural variability of the climate system itself.”



urning power plant in
ge plan to reduce

97 HOURS OF CONSENSUS



Repu
Indepe
Dem
Based on
1,000 adu

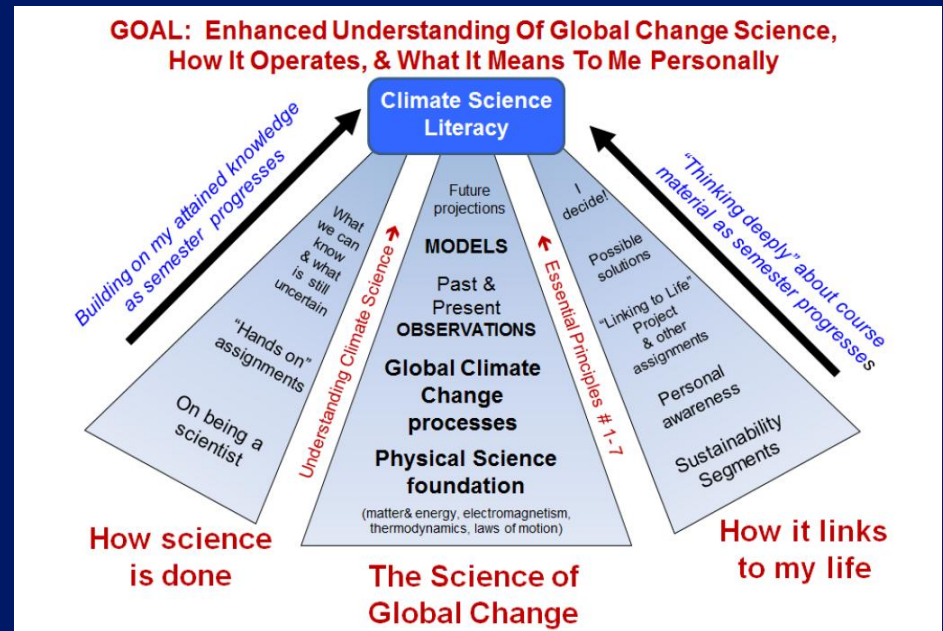
nds	7%
	27%
	22%

Our CLASS:

1. Learn & Understand the **SCIENCE** underlying all this!

2. Decide for yourself

3. Link this to **YOUR LIFE** in the way you want to live it

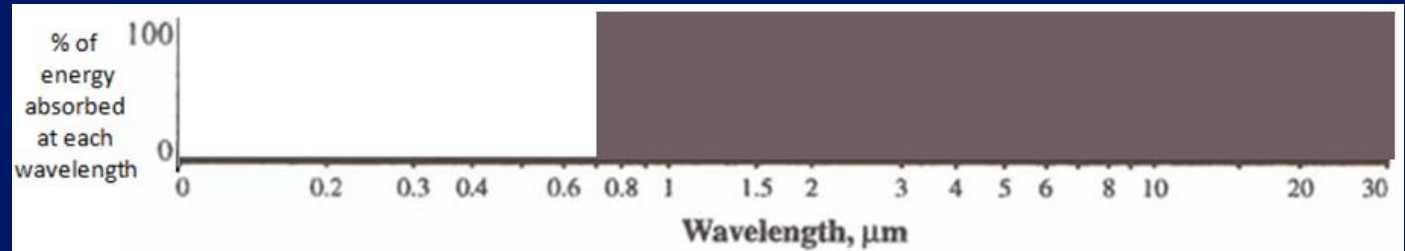


Sooooo. . . On with the SCIENCE!

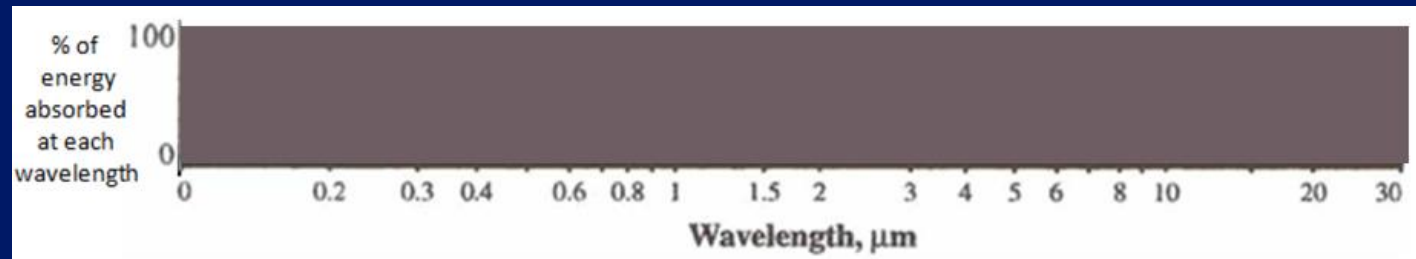
Fire up your CLICKERS for some questions to solidify the concepts from the last few classes

CLICKER Q1 Which of the following absorption curves represents a hypothetical atmosphere that has a “perfect” greenhouse effect ?

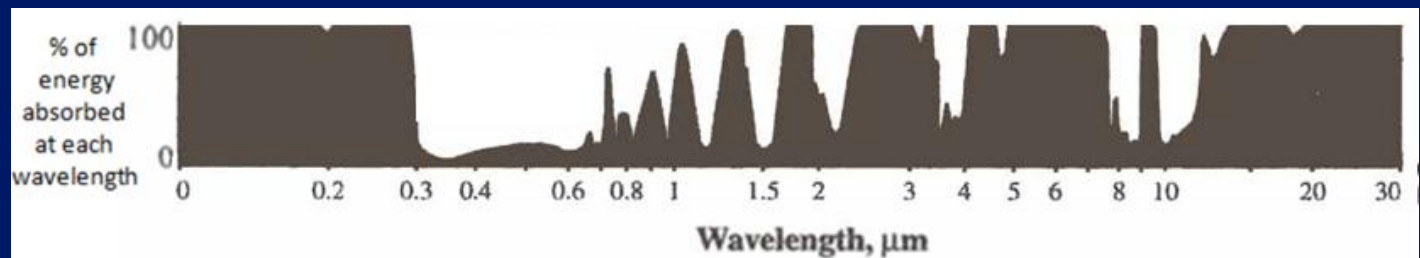
1.



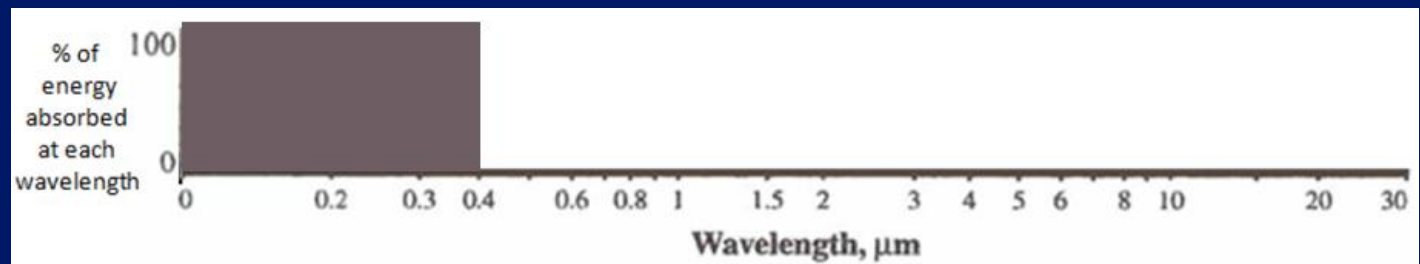
2.



3.

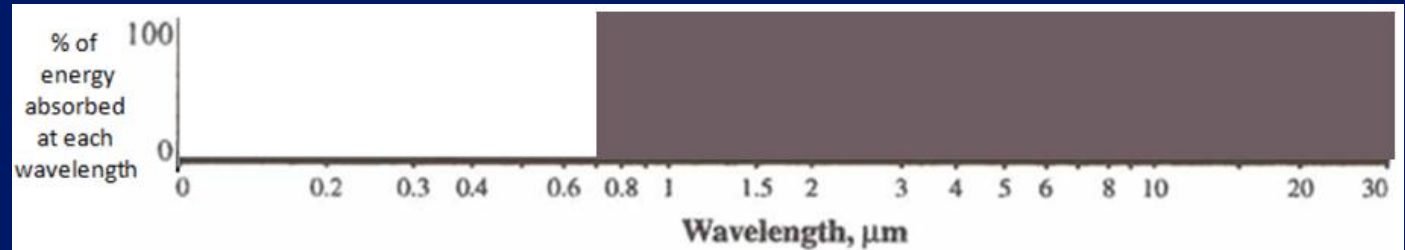


4.

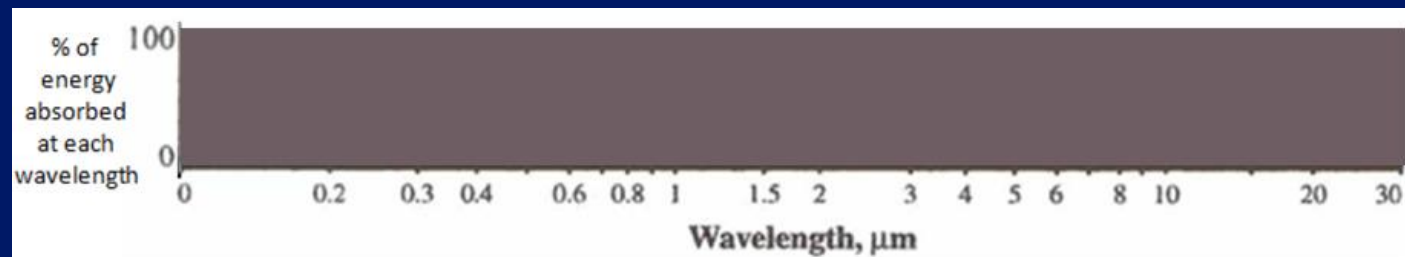


CLICKER Q1 Which of the following absorption curves represents a hypothetical atmosphere that has a “perfect” greenhouse effect ?

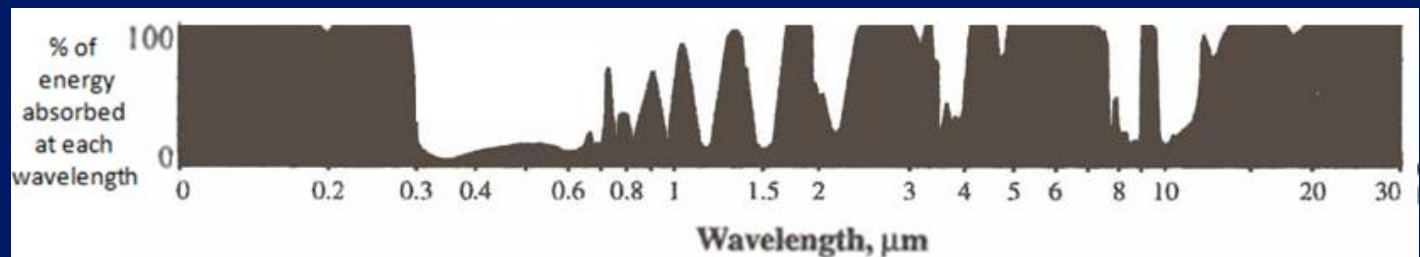
1.



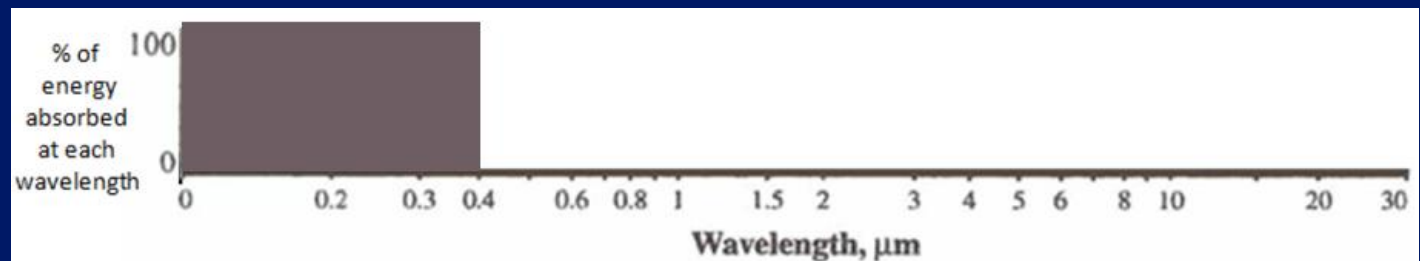
2.



3.

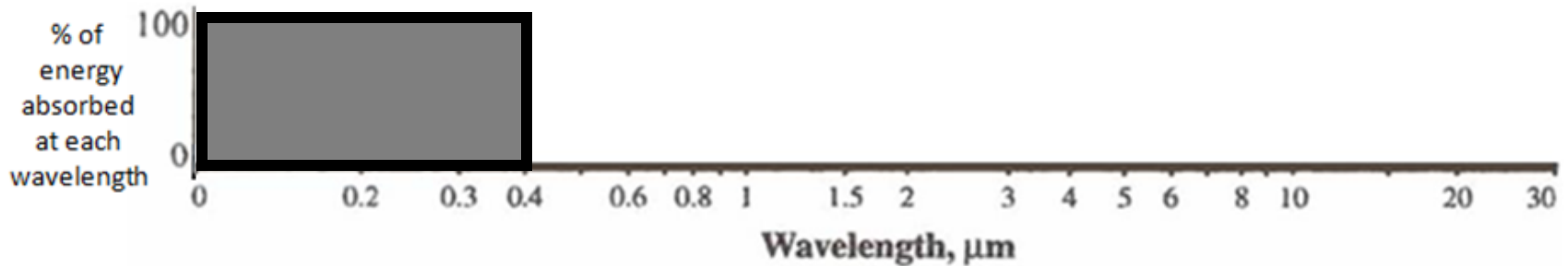


4.

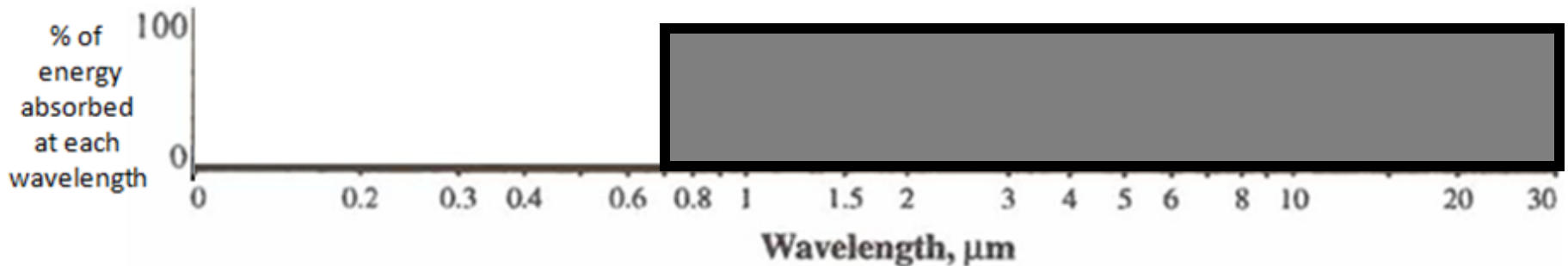


Next: The ANSWERS to the first part of G-1:

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.

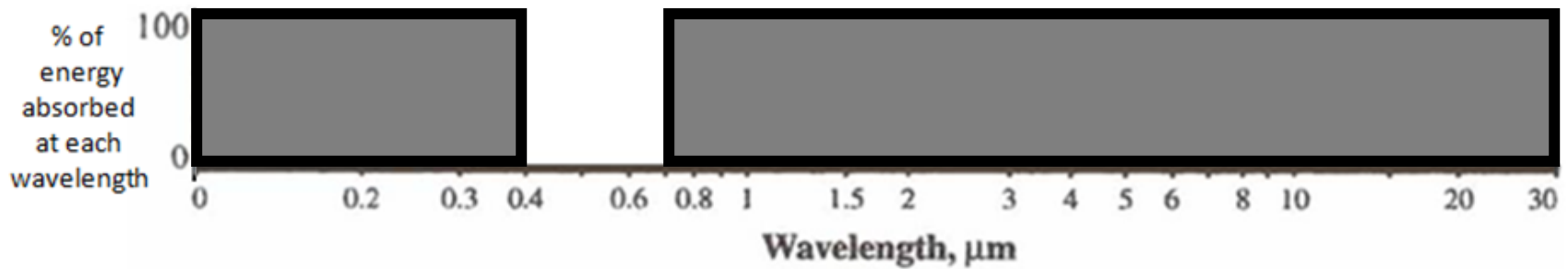


Q2. Draw an absorption curve for a "perfect" greenhouse gas that absorbs ALL IR radiation, but no visible or UV:

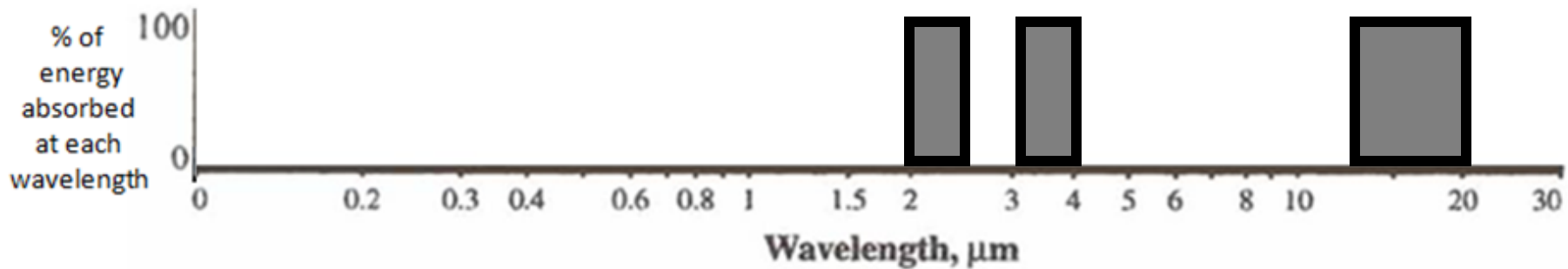


The ANSWERS to the first part of G-1:

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:

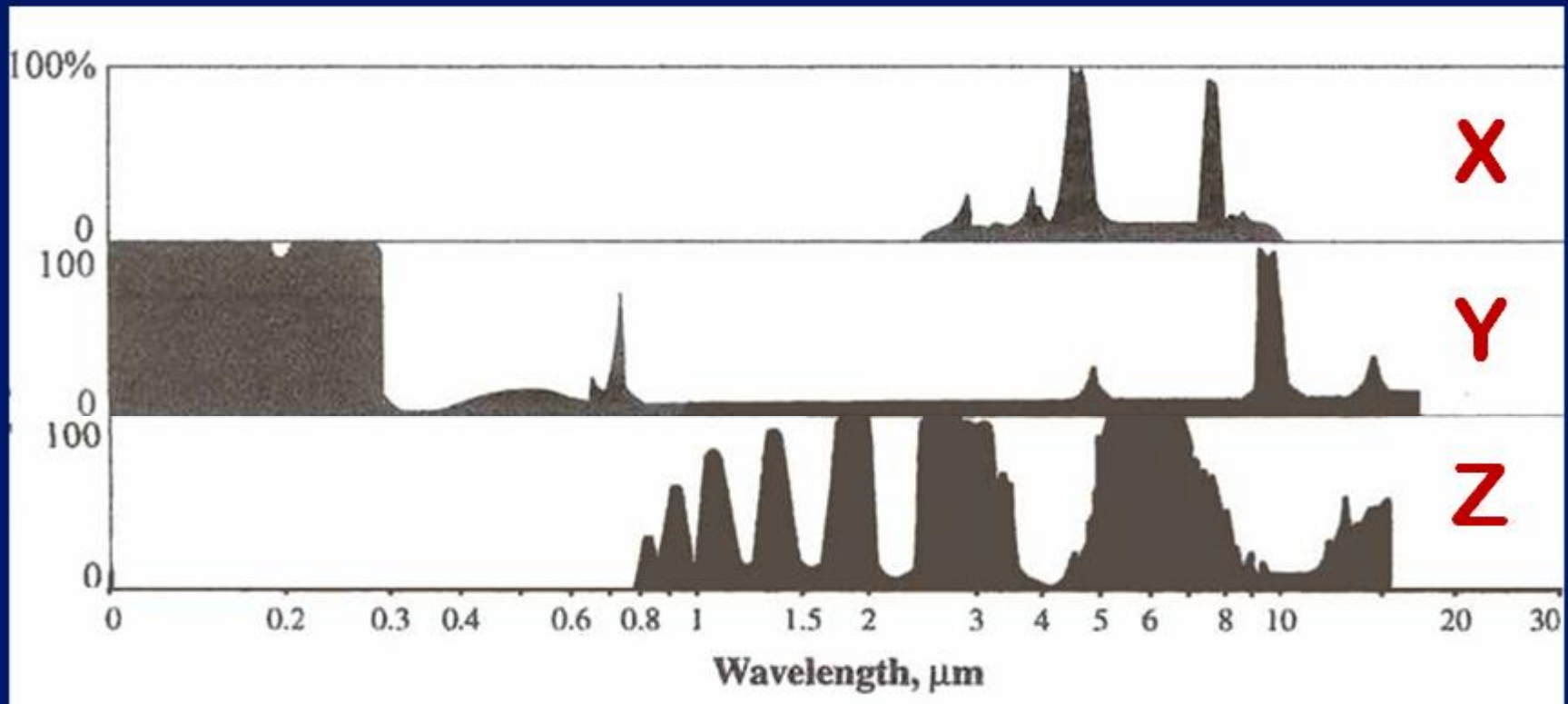


Q4. Draw an absorption curve for a hypothetical gas that can absorb 100% of the IR radiation in these three wavelength bands: band from 2 to 2.5 μm band from 3 to 4 μm band from 13 to 20 μm



CLICKER Q2 – Which of the following absorption curves is for a GAS that is NOT a greenhouse gas!

1: X **2: Y** **3: Z** **4: NONE of THEM**



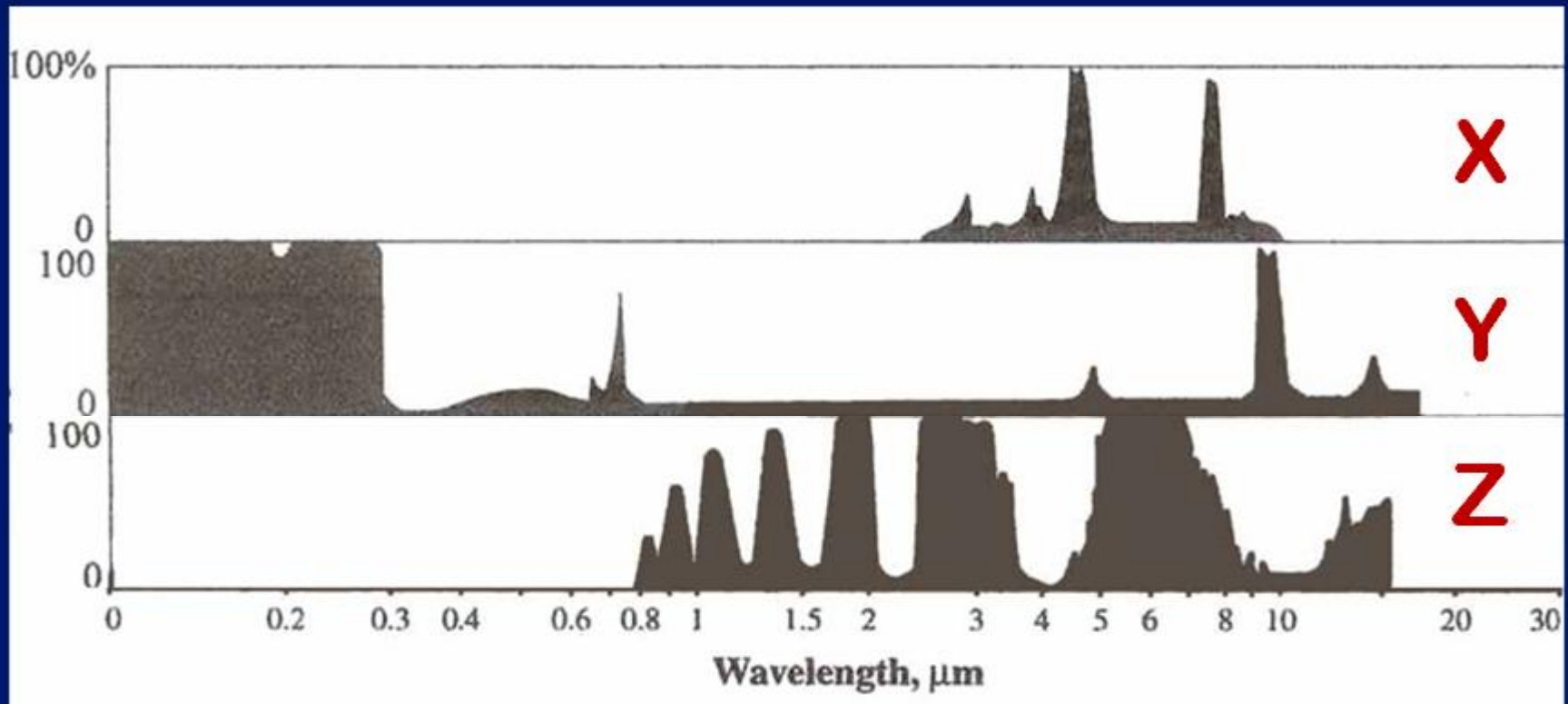
CLICKER Q2 – Which of the following absorption curves is for a GAS that is NOT a greenhouse gas!

1: X

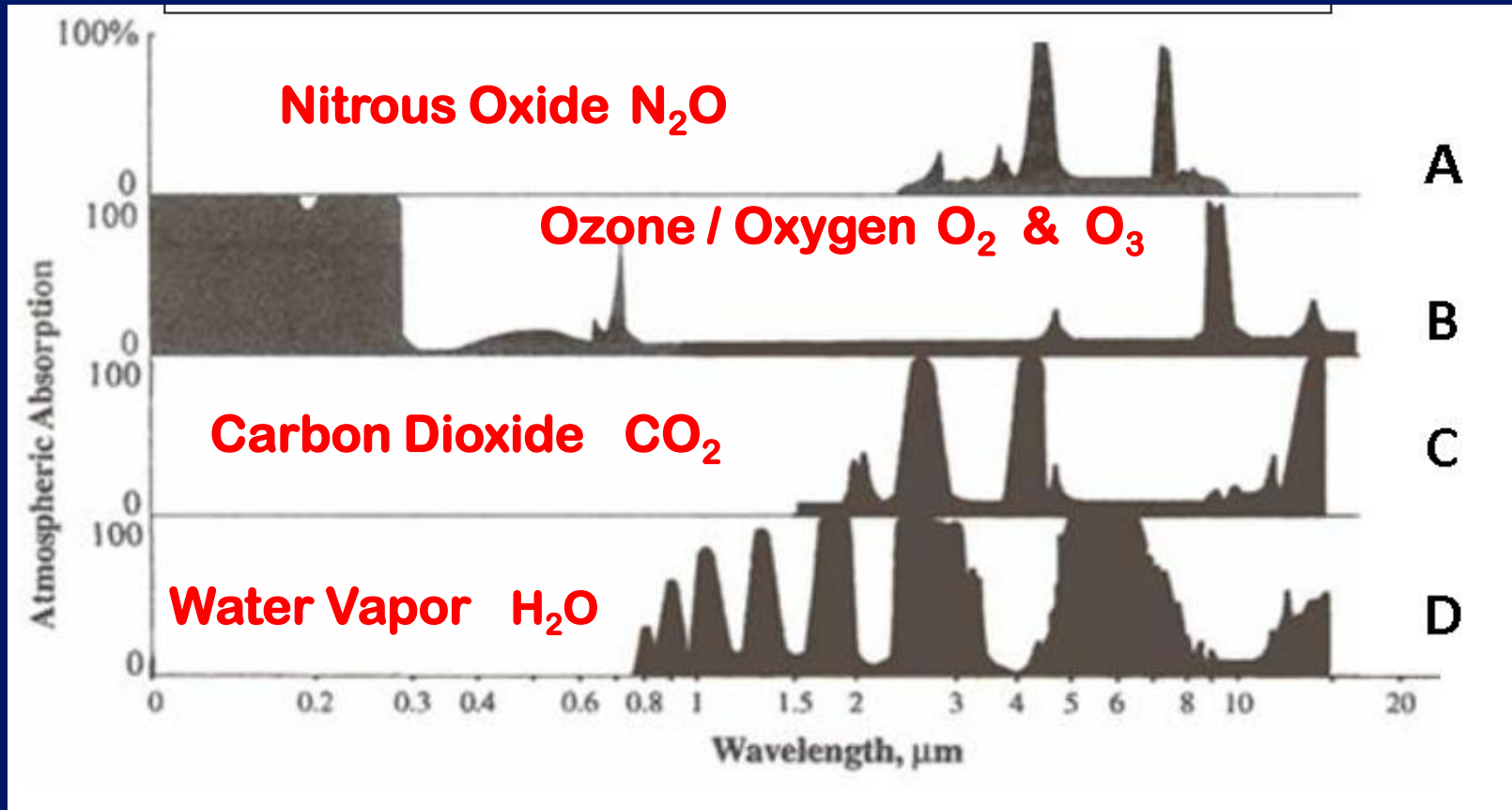
2: Y

3: Z

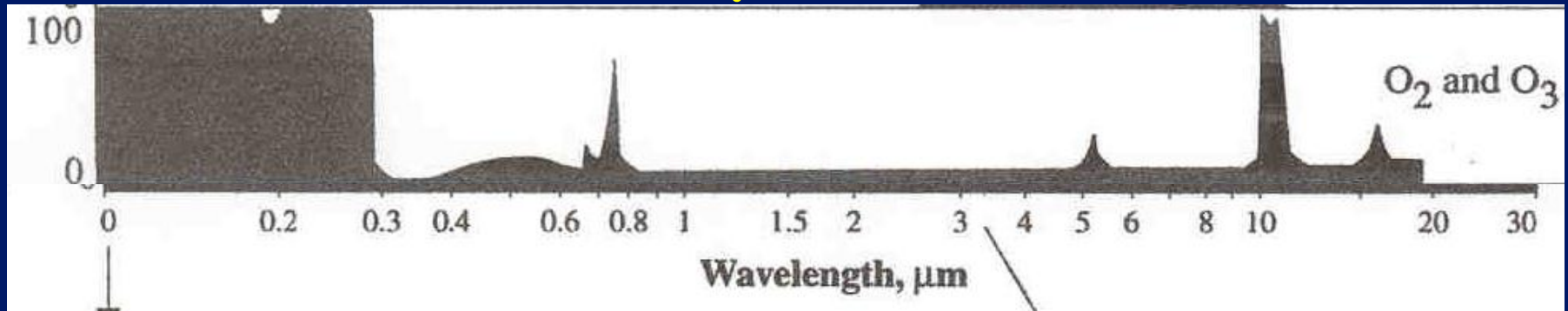
4: NONE of THEM



The ANSWERS to the first part of G-1:



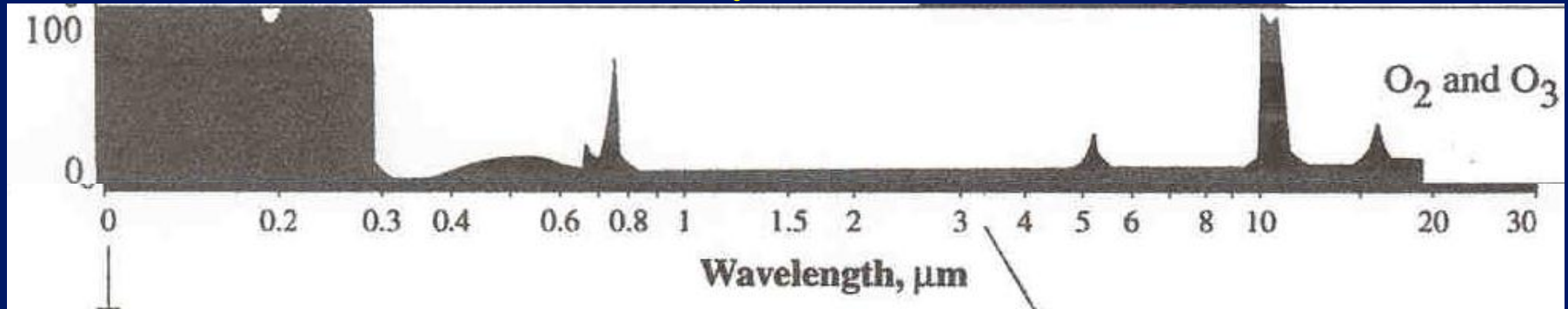
CLICKER Q3 HOW IS OZONE (actually O_3 & O_2) unique???



- 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



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

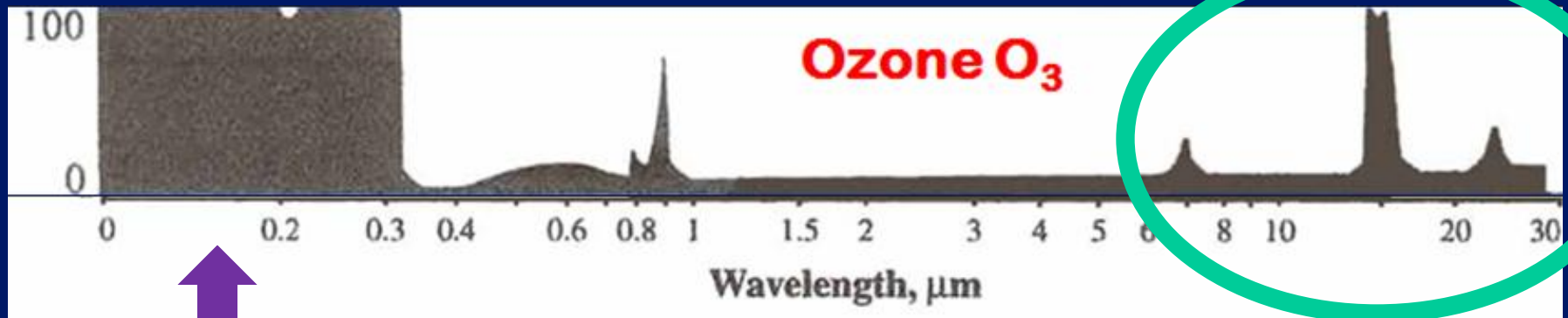


- 1) It absorbs **only UV** – hence it's **NOT** a GHG
- 2) It absorbs **almost ALL visible** wavelengths
- 3) It absorbs **BOTH UV** and **IR** so **IS** a GHG
- 4) It absorbs **BOTH UV** and **IR** so is **NOT** GHG

But **only** the IR absorption makes it a GHG!!

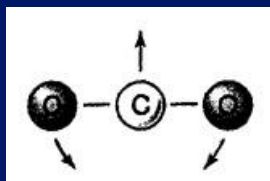
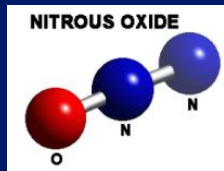
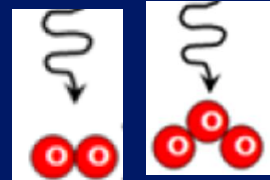
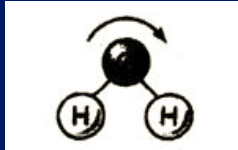


Absorption in this part of the absorption curve (IR wavelengths) indicates that OZONE is a greenhouse gas



. . . even though OZONE also absorbs radiation in the UV part of the spectrum!

Review



Gas	Primary absorption wavelengths (in micrometers)
-----	--

Water vapor
(H₂O)



0.8	4 to 7
1	9 to 10
1.5	11 to 20
2 to 3.5	

Molecular
oxygen (O₂) and
Ozone (O₃)

0.0001 to 0.280
8.5 to 10

Nitrous oxide
(N₂O)

4 to 5
7 to 7.5

Carbon dioxide
(CO₂)

2 to 2.5
3 to 4
13 to 20

In SGC E-Text
Chapt 3:

IR radiation!

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

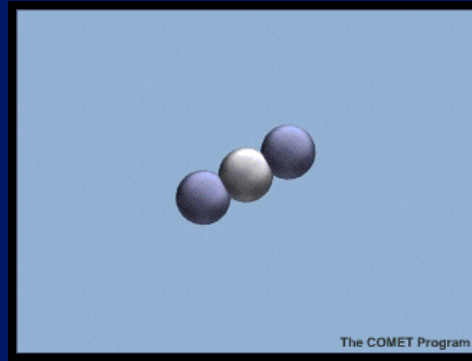
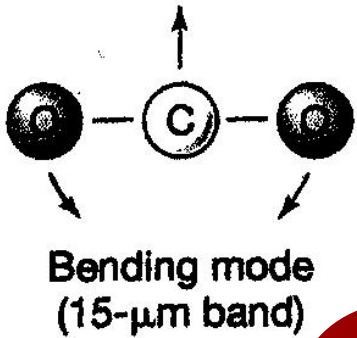
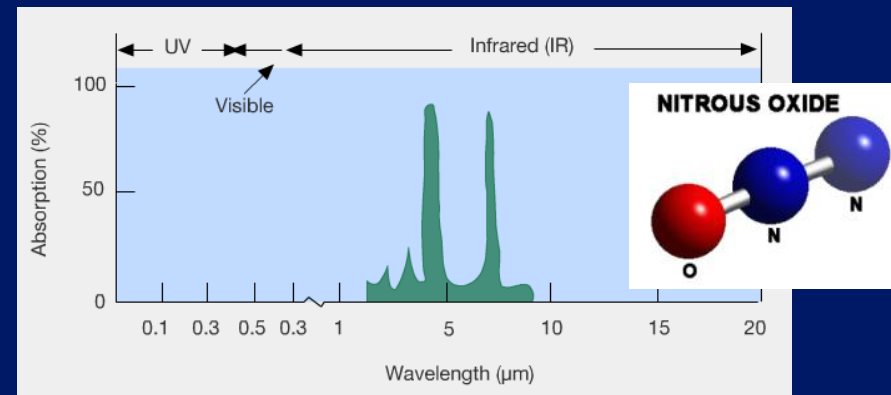
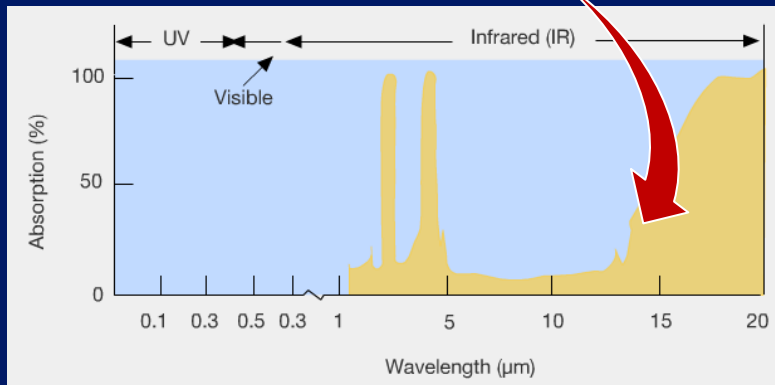


FIGURE 3-14

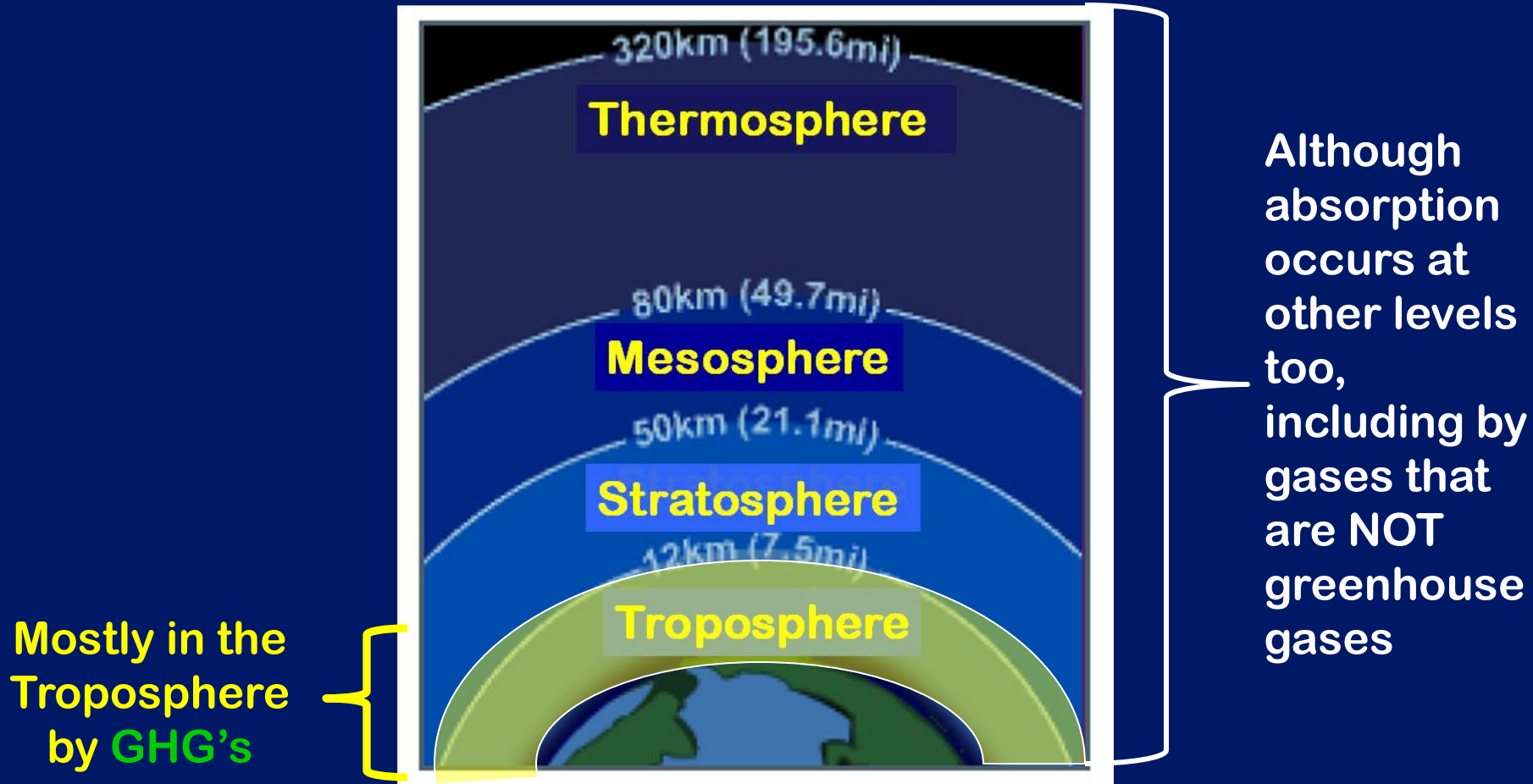


This vibration mode has a frequency that allows CO_2 to absorb IR radiation at a wavelength of about 15 micrometers



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

WHERE IS ALL THIS ABSORPTION HAPPENING?

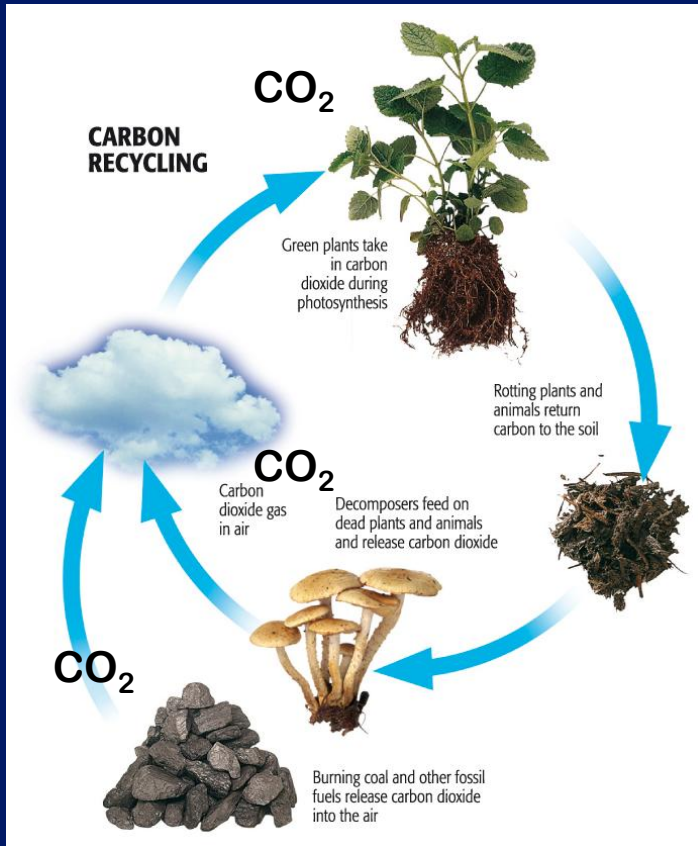
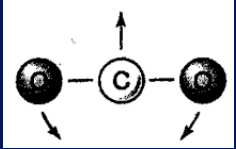


more in Topic #6 on Thursday

CARBON DIOXIDE

CO₂ moves in and out of the atmosphere

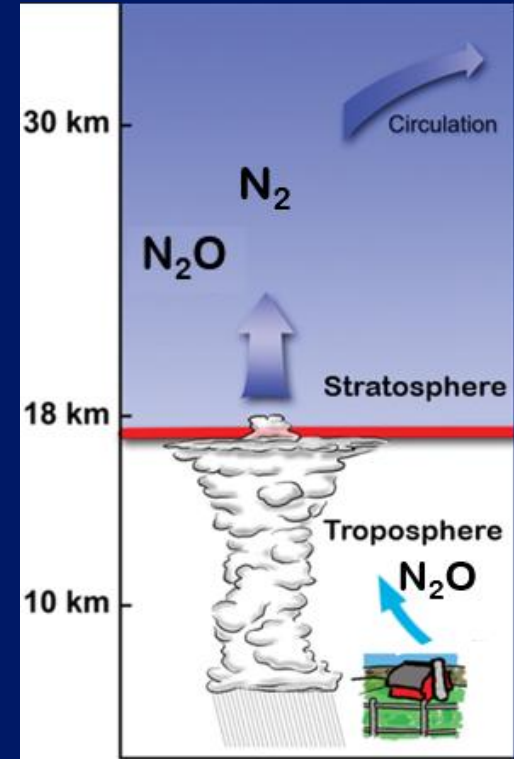
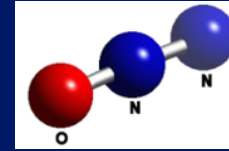
as part of the Carbon Cycle:



NITROUS OXIDE

N₂O moves in and out of the atmosphere

as part of the Nitrogen Cycle



N₂O is produced naturally in soil



also comes from fossil fuel combustion, burning forests, use of nitrogen fertilizers



NITROUS OXIDE
← **Another View**

**DANCE YOUR
PhD !!**



DANCE YOUR PhD:



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

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

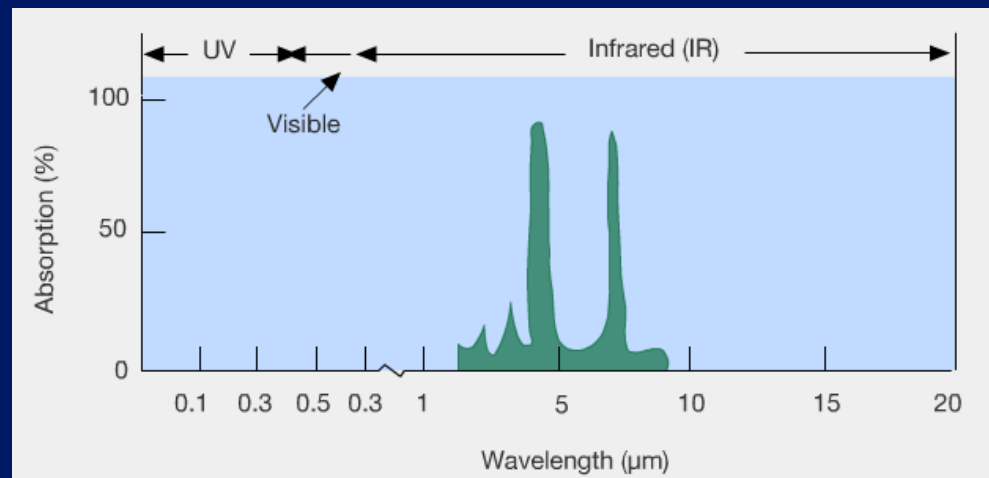
Now, 3 dancers will exhibit the **3 specific movements** of N_2O 's vibrational modes



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

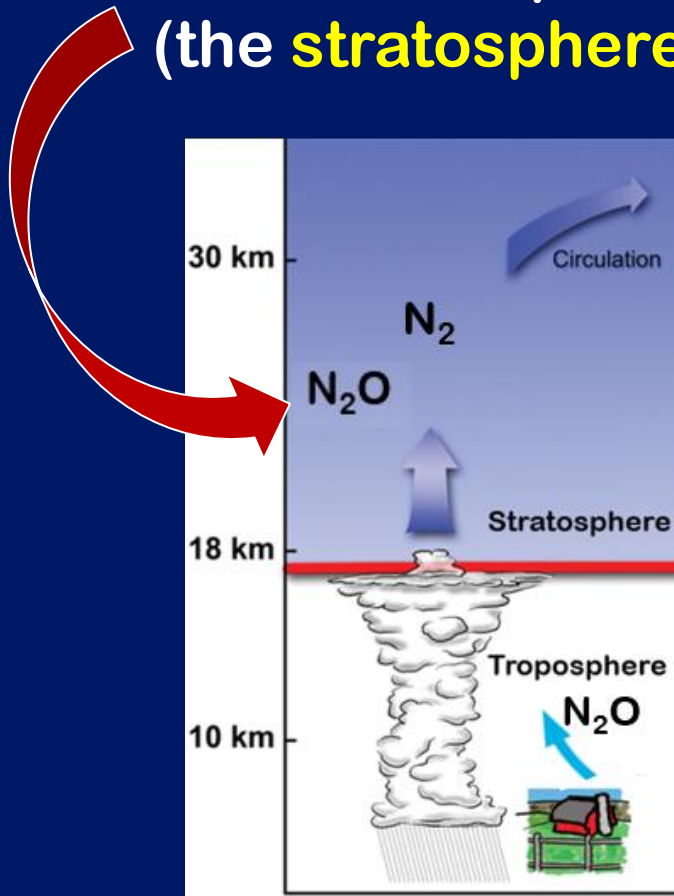


They grads will “dance” the 3 bending modes of N_2O that are due to **Infrared IR absorption at 3 different wavelengths**





Stepping onto chairs represents the circulation of the N_2O to higher levels in the atmosphere (the **stratosphere**)



... where it is then subject to intense **Ultraviolet (UV) radiation** from the sun.



With the **high energy** from the **UV radiation** bombarding the N_2O the dancers go crazy with high energy dancing.

Eventually the high intensity **UV radiation** leads to the **destruction of one of the N_2O molecules** (called “photolysis”) Shown by jumping from the chair at the end →



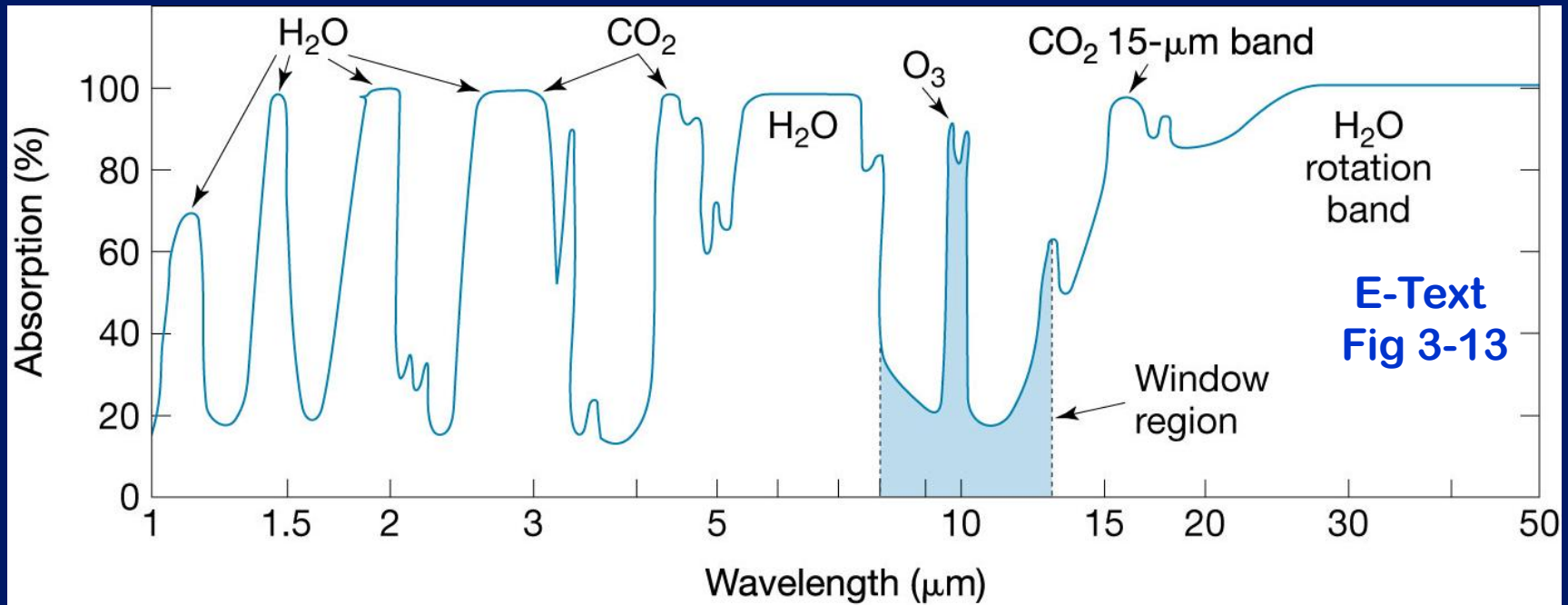
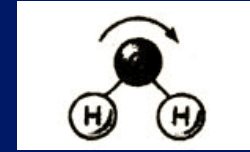
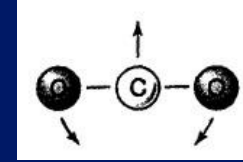
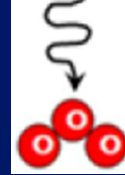
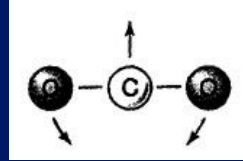
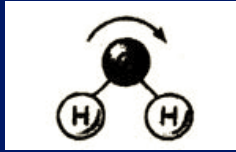


**DANCE YOUR
PhD !!**

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



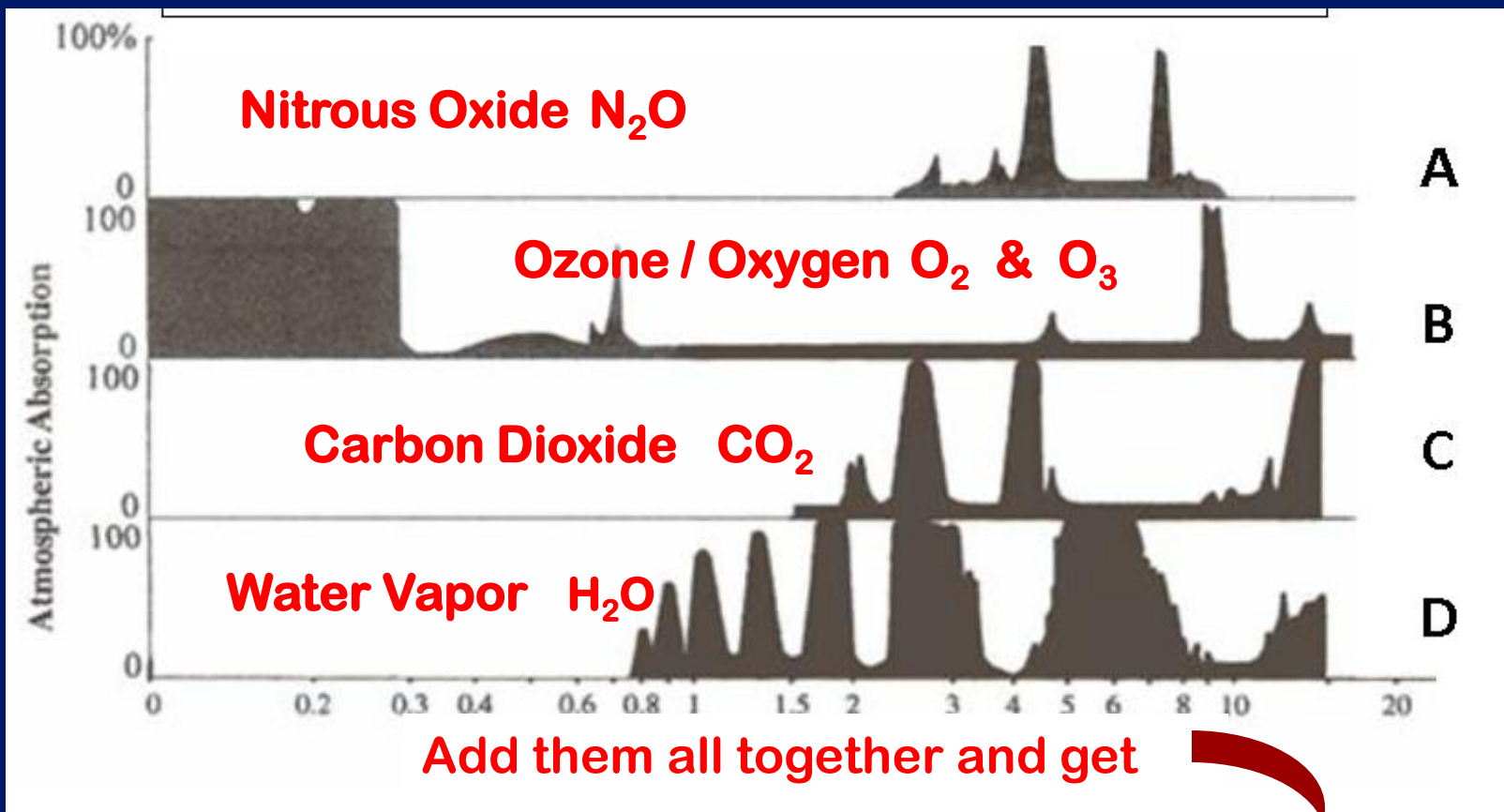
Close up view of combined absorption of IR wavelengths by GHG's: H_2O , CO_2 , O_3 :



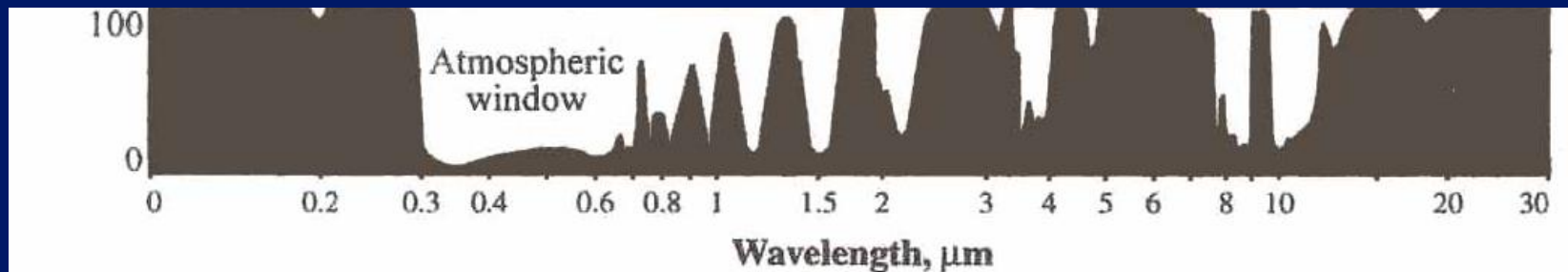
E-Text
Fig 3-13

Explore
Absorption
Curves
yourself:

http://apollo.lsc.vsc.edu/classes/met130/notes/chapter2/42_Selective_Absorption/42.html

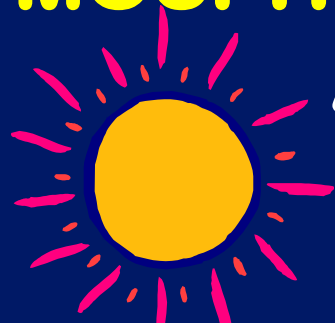


One graph showing absorption by ALL the atmospheric gases !



WHOLE ATMOSPHERE:

Absorption + Transmission

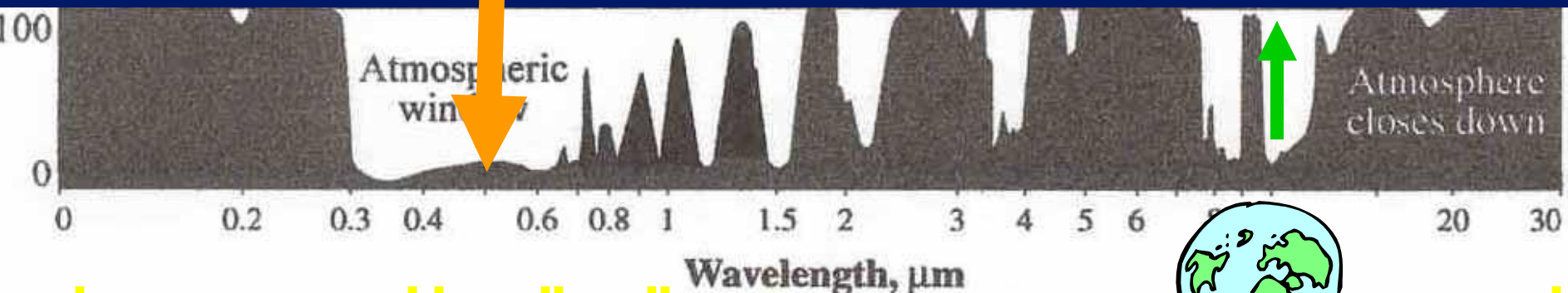


Window #1 with very little UV + Vis + NIR absorption!

Transmission of Incoming SW

Transmission of Outgoing LW

Window #2 with very little IR absorption!



UV

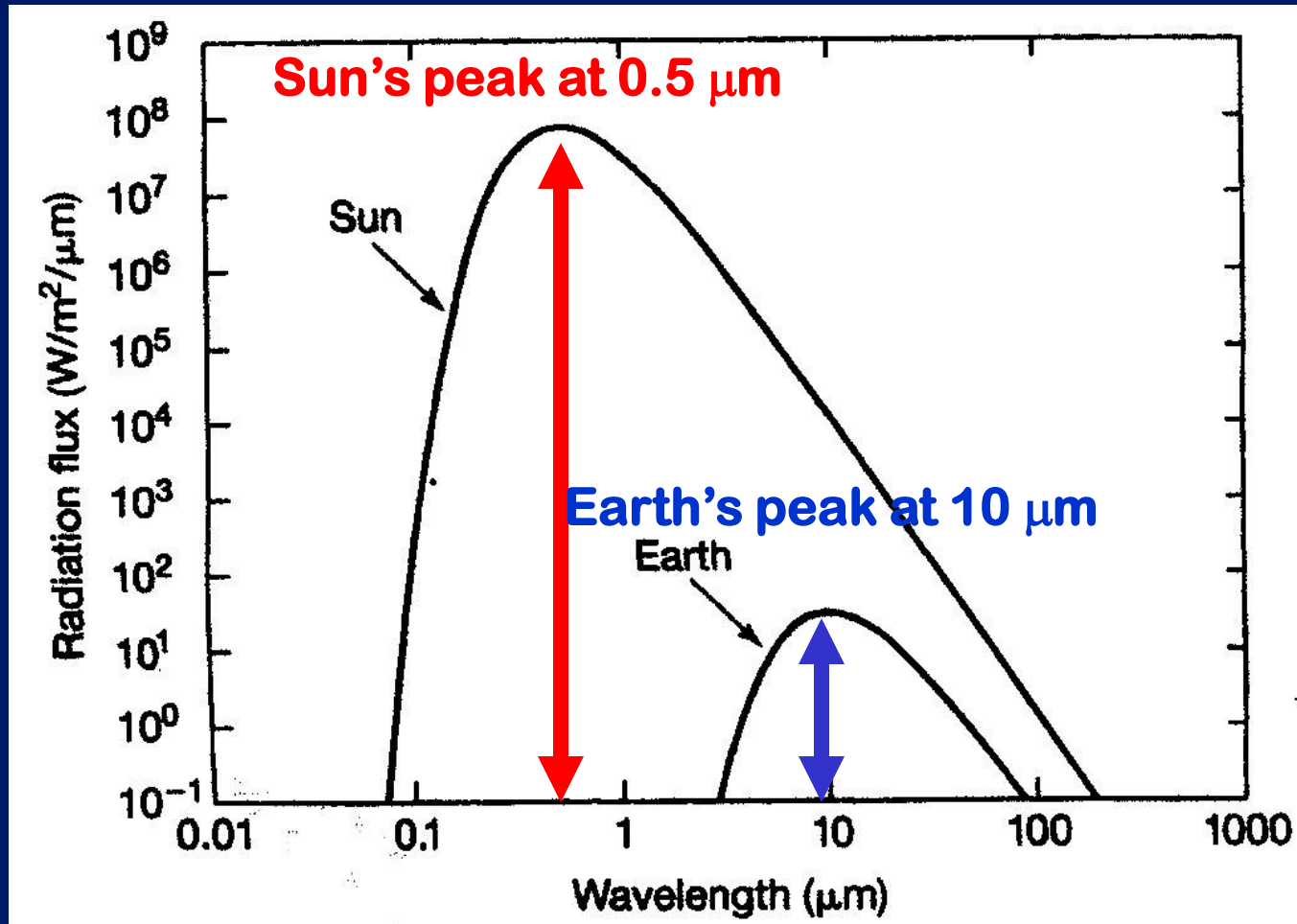
Visible

NIR

Far IR

**Incoming
SW SOLAR (UV + Vis)
window**

**Outgoing
LW TERRESTRIAL (IR)
window**



REMEMBER THIS???

Review p 28

CLICKER Q4 - Here's the absorption curve for ALL the gases in the atmosphere put together, i.e. curve for the **"Whole Atmosphere"**

We just talked about two **"windows"** in the curve that indicate at what wavelengths radiation easily comes **IN** to the surface of the Earth or escapes **OUT** to Space.

Q. Where are these two windows?

1: A + B

A
↓

2: B + E

B
↓

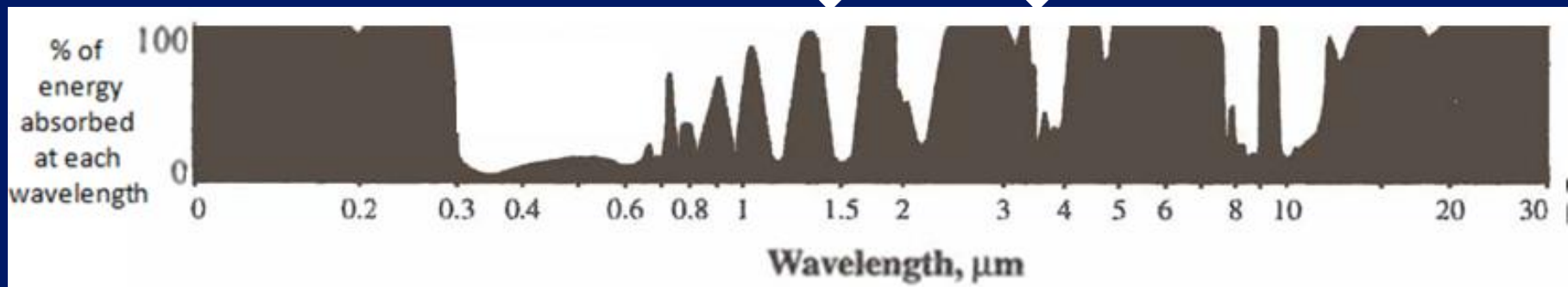
3: C & D

C
↓

D
↓

4: D + E

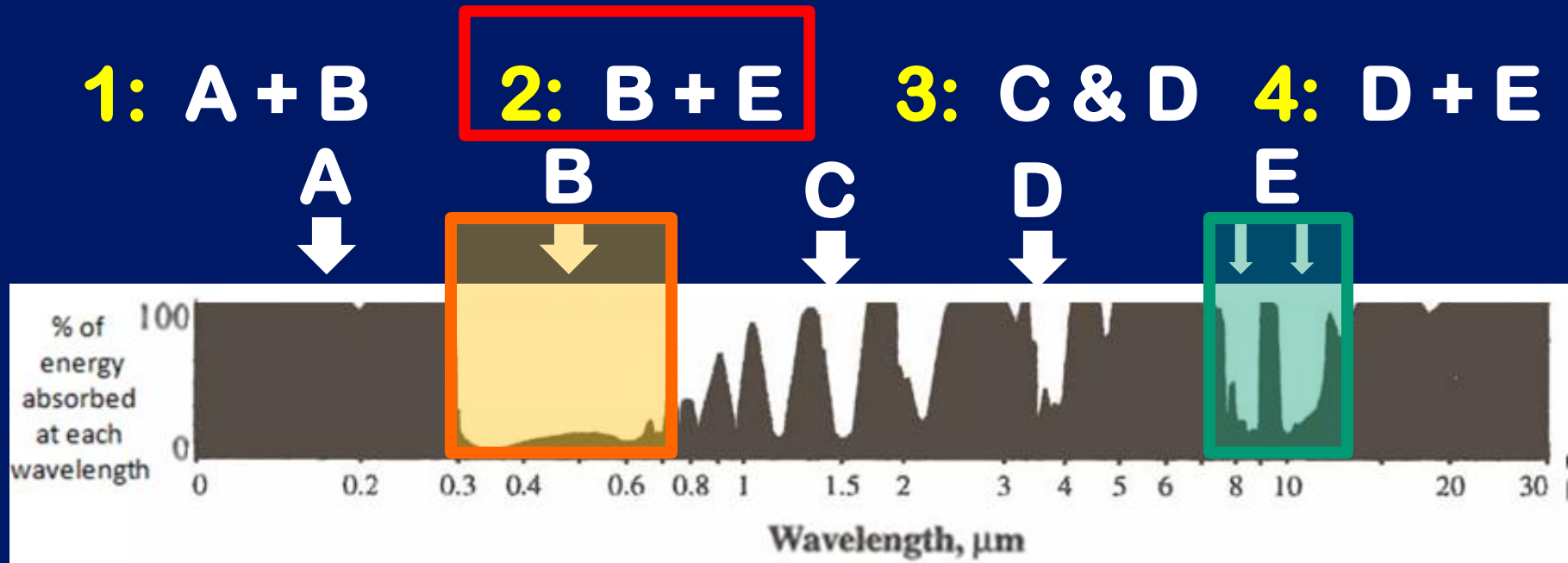
E
↓ ↓



CLICKER Q4 - Here's the absorption curve for ALL the gases in the atmosphere put together, i.e. curve for the "Whole Atmosphere"

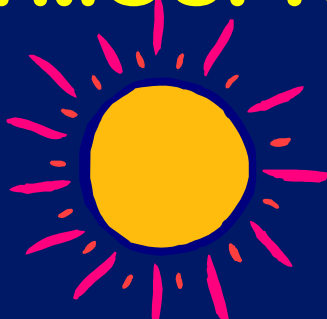
We just talked about two "windows" in the curve that indicate at what wavelengths radiation easily comes **IN** to the surface of the Earth or escapes **OUT** to Space.

Q. Where are these two windows?



WHOLE ATMOSPHERE:

Absorption + Transmission

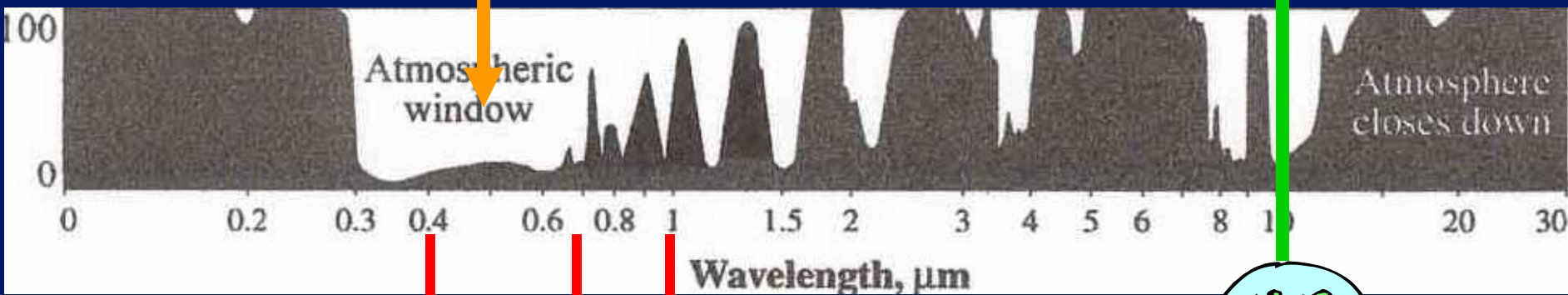


thru UV / Vis atmospheric window

TRANSMISSION OF Incoming SW
UV+Vis+NIR
is how the **SUN** **WARMS** the **EARTH**

thru IR atmospheric window

TRANSMISSION OF Outgoing LW / IR
is how the Earth **“COOLS ITSELF”**



UV

Visible

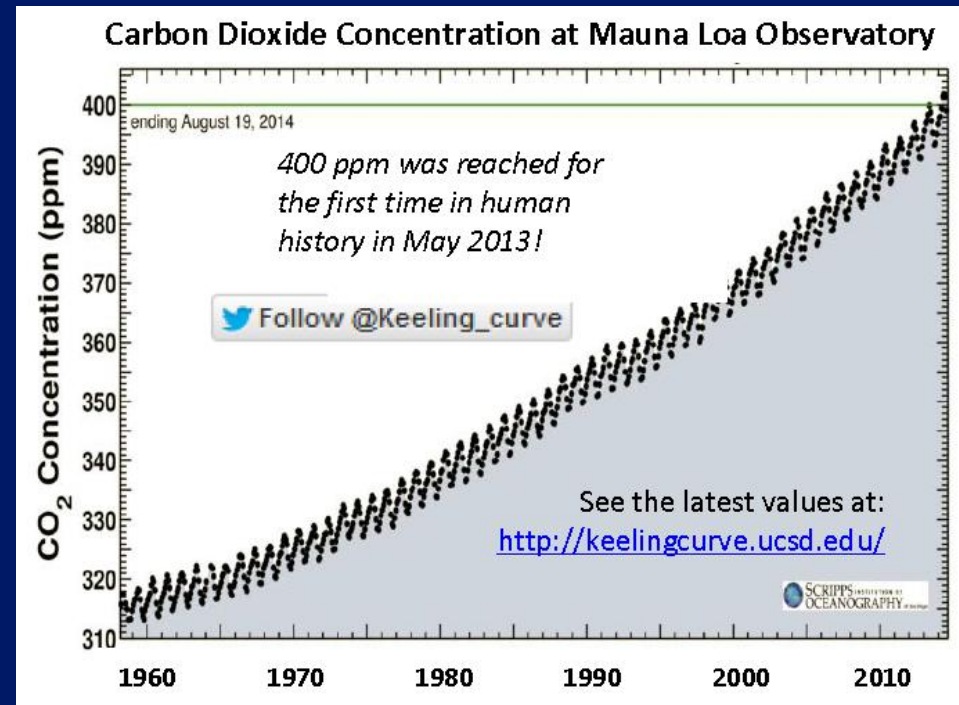
NIR

Far IR



If the Earth can “COOL itself” by transmitting IR through the IR Window, WHY SHOULD WE BE SO CONCERNED ABOUT INCREASING CO₂ ?

Even with the increases seen on the Keeling Curve, CO₂'s concentration in the atmosphere is **really low** compared to N₂ and O₂ isn't ?



← “Thinking more deeply” symbol

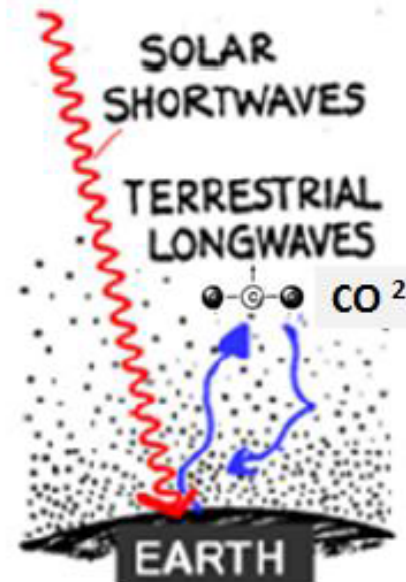
WHY BE CONCERNED ABOUT INCREASING CO₂ ?

EXPLORING
ANOTHER MYTH . . .



**CLIMATE
MYTH #30:**

*"Increasing CO₂
has little to
no effect"*



How do we know more CO₂ is causing warming?



The skeptic argument...

“Increasing CO₂ has little to no effect on enhancing the GREENHOUSE EFFECT because the amount is so small compared to the amount of other gases in the atmosphere.

Therefore the increase in human-produced CO₂ (as seen in the Keeling Curve) is NOT the cause of recent global warming!!

<http://www.skepticalscience.com/empirical-evidence-for-co2-enhanced-greenhouse-effect.htm>

How would you respond?

“Thinking more deeply” symbol →



A KEY POINT to respond with
is embedded in the box on
**“IMPLICATIONS OF LAW #6
FOR GLOBAL CLIMATE CHANGE”** on p 31

Read the box . . . then think a bit . . .
WHICH ITEMS (a - g) have relevant info for
responding to this skeptic’s argument?

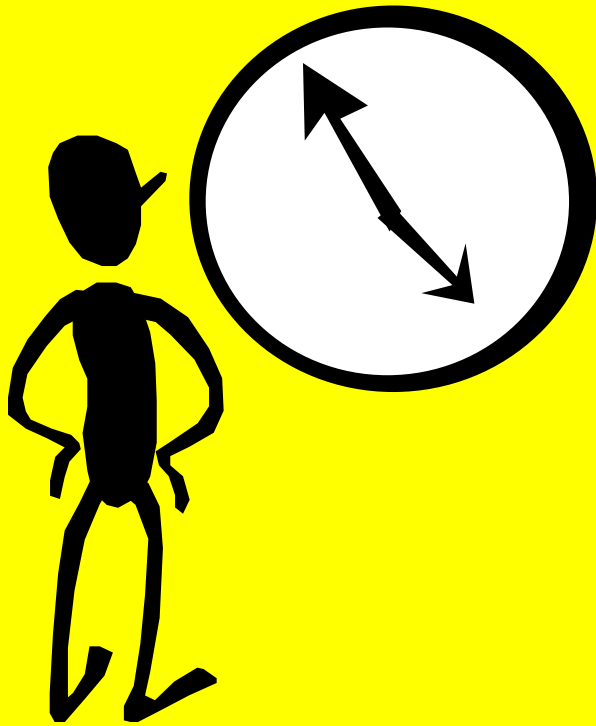
**NOW DISCUSS IN YOUR
GROUPS!!!**

& pick someone to respond back
for your group

**IT'S TIME TO
WRAP IT UP
AND QUIET DOWN**

&

REPORT BACK!!!

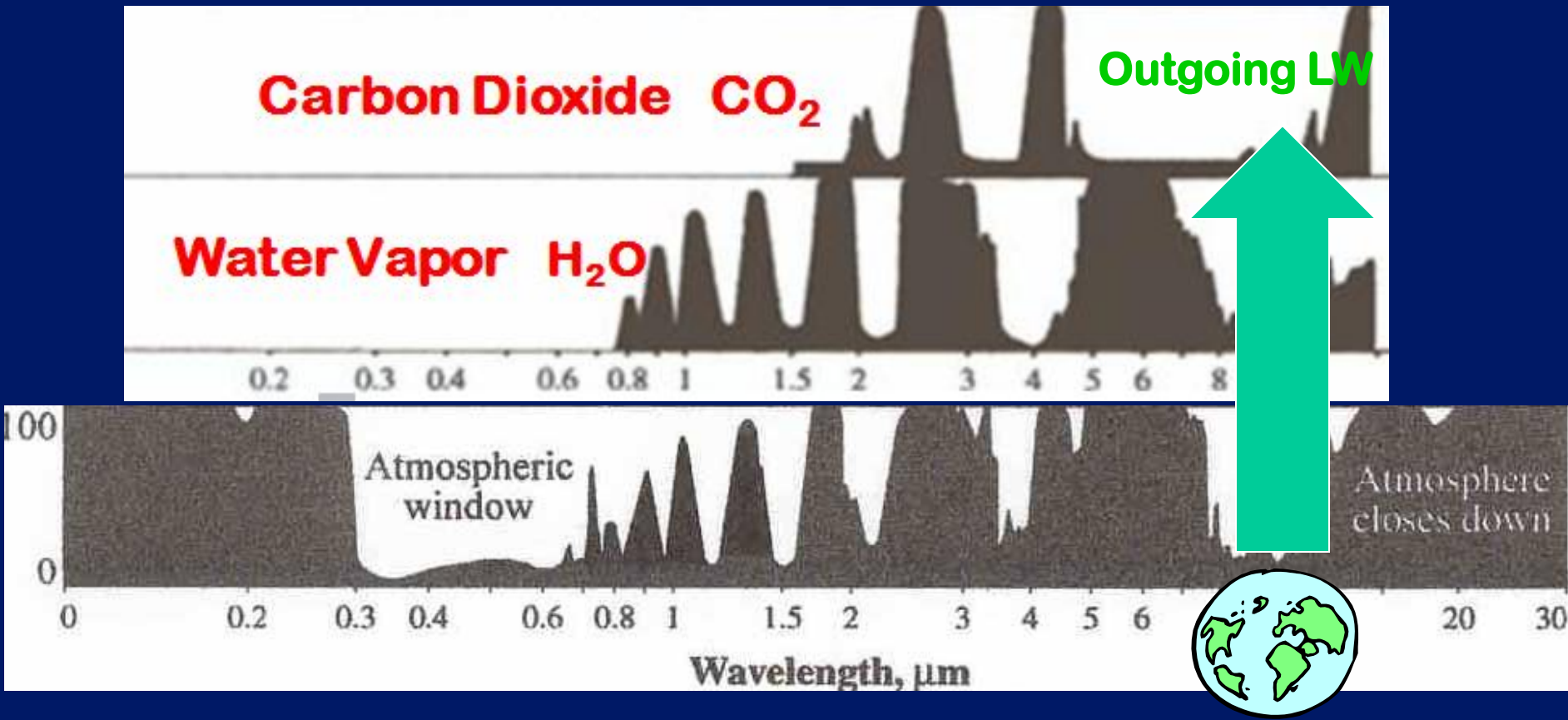


c) GREENHOUSE GASES both absorb and emit electromagnetic radiation in the infrared (IR) part of the spectrum – **once IR is absorbed by the greenhouse gases in the atmosphere, it can be emitted back to the Earth's surface to heat it all over again!!**

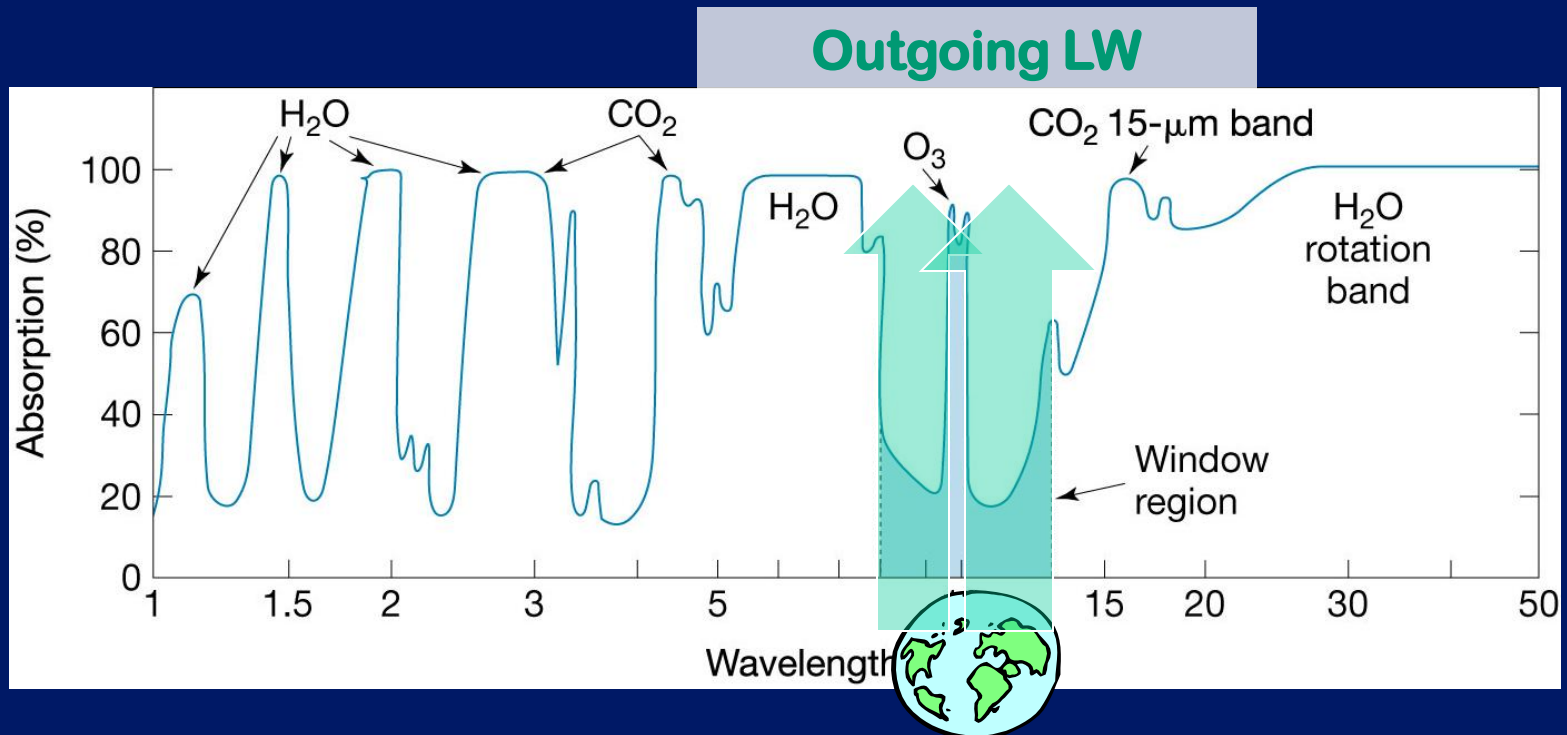
This is called the GREENHOUSE EFFECT!

f) Since **15 μm** is close to the peak of Earth's outgoing radiation, (**10 μm**), this absorption band **keeps a lot of Earth's longwave radiation from escaping to space.**

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



→ A gas has a **BIG effect** if it **absorbs** in a "window" of wavelengths where the atmosphere is fairly transparent (and the IR would otherwise escape to space!)



H₂O, O₃, and **CO₂**
are all **very close** to the outgoing IR window
Therefore they are effective in absorbing
outgoing IR wavelengths of energy!



g) If a gas absorbs radiation of any wavelength, **the amount absorbed will be proportional to**

(a) the **number of molecules** of gas and

(b) the **intensity of radiation** of that wavelength.

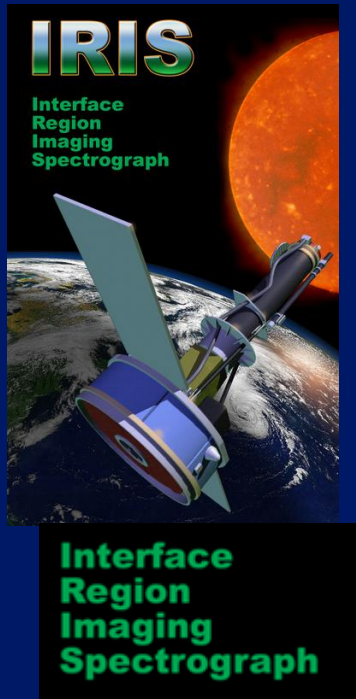


But . . . is there **enough volume** of these “trace gases”
to REALLY make a difference in the Greenhouse Effect
and therefore increase the temperature?

GIVE ME MORE EVIDENCE!

IS this GH Effect measurable??

Less IR
going to
space



Interface
Region
Imaging
Spectrograph



1970s

TODAY

FOURIER TRANSFORM
INFRARED SPECTROSCOPY
(FTIR) ANALYSIS



More IR
radiating
downward

How to RESPOND to a SKEPTIC:

- An enhanced greenhouse effect from CO₂ has been confirmed by multiple lines of empirical evidence:
- **Satellite measurements of infrared spectra** over the past 40 years **observe less energy escaping to space** at the wavelengths associated with CO₂.
- **Surface measurements** find more **downward infrared radiation** warming the planet's surface.
- This provides a direct, observed & measured **CAUSAL LINK** between CO₂ and global warming.



OK
TIME NOW FOR
GROUPS TO FINISH THE
LAST PART OF G-1

**SEE YOU
THURSDAY!!!**