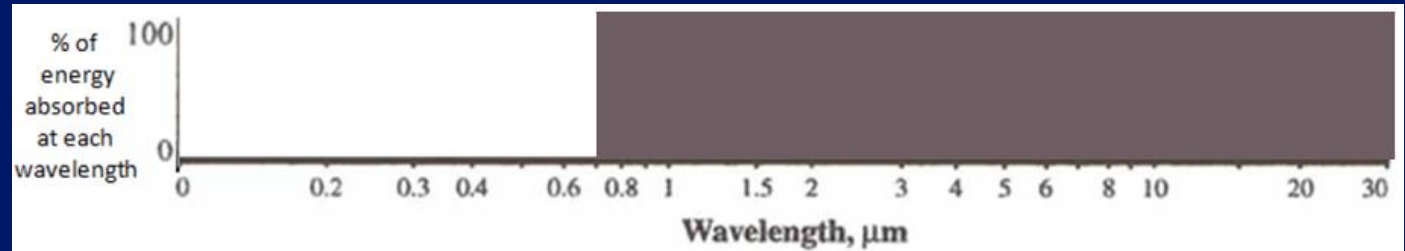


WRAP UP OF TOPIC #6

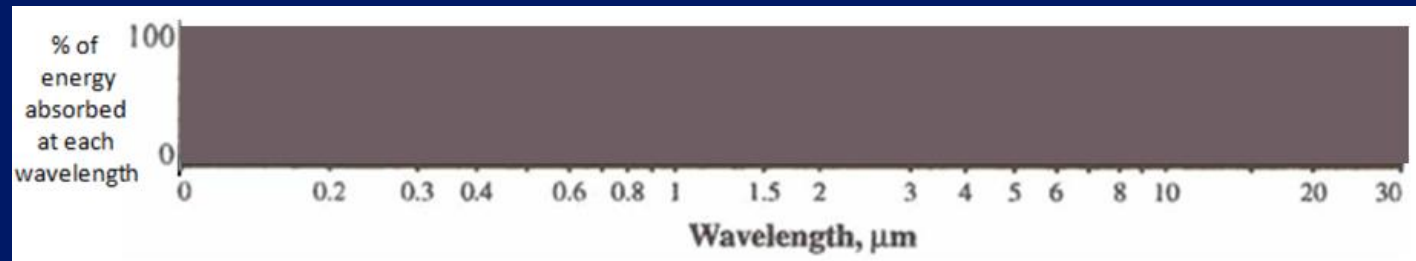
Fire up your CLICKERS for some questions to solidify the concepts from the last few classes:

Q-1 Which of the following absorption curves represents a hypothetical atmosphere that has a “perfect” greenhouse effect ?

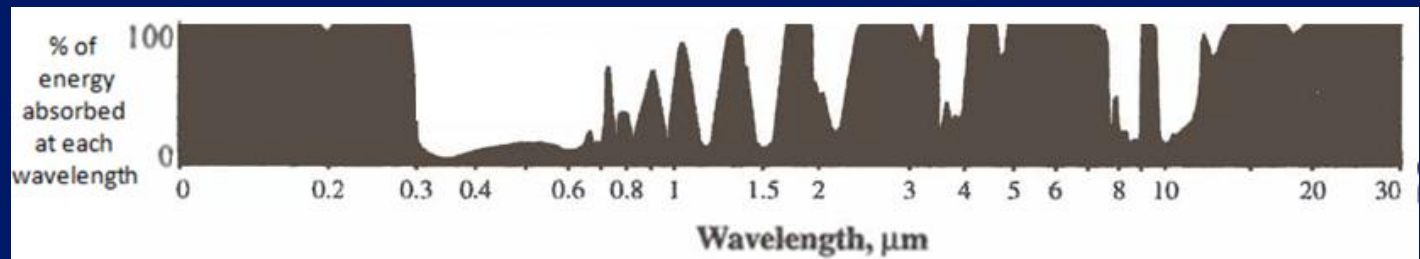
1.



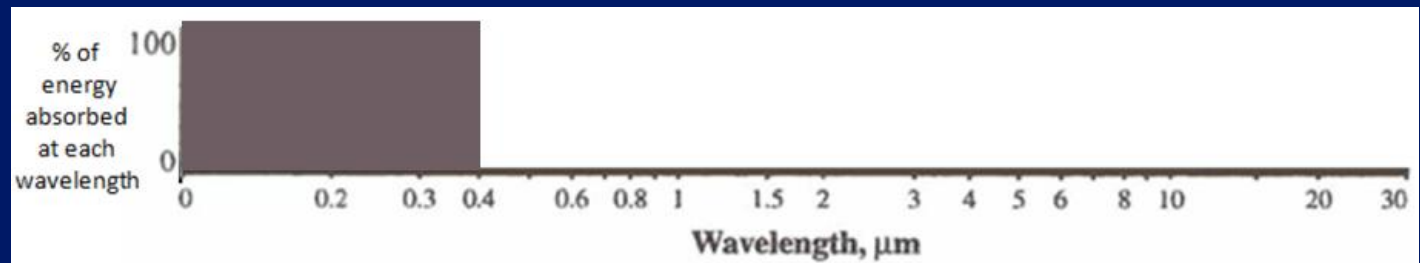
2.



3.

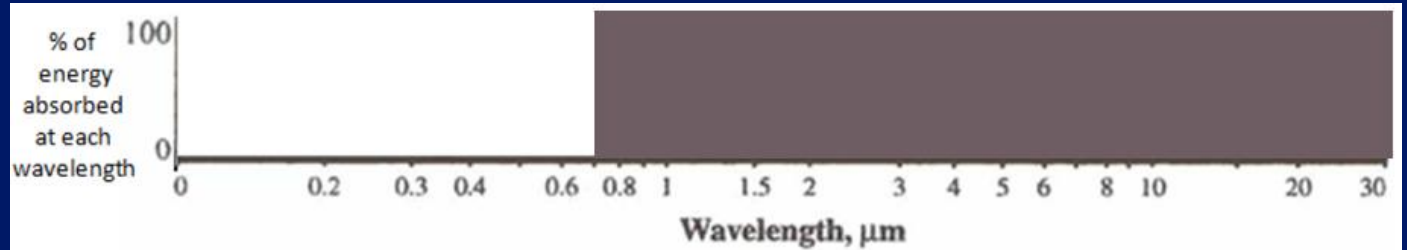


4.

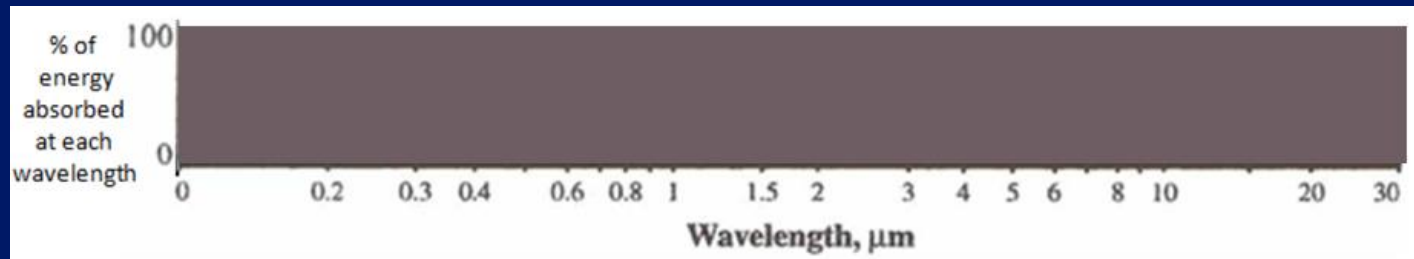


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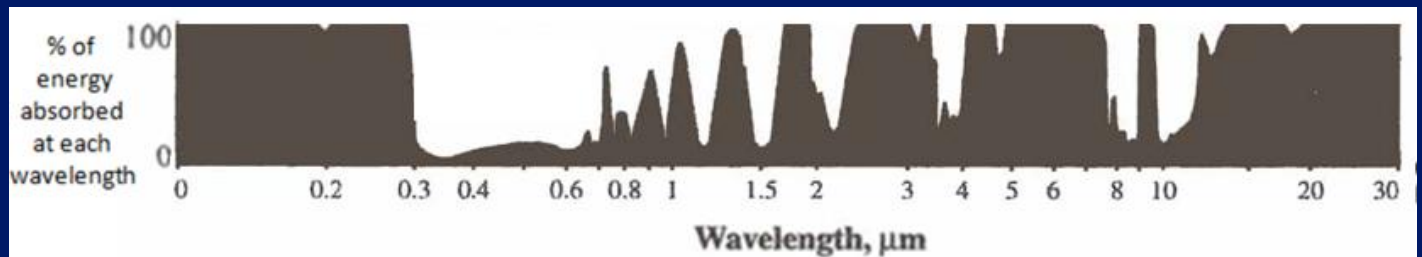
1.



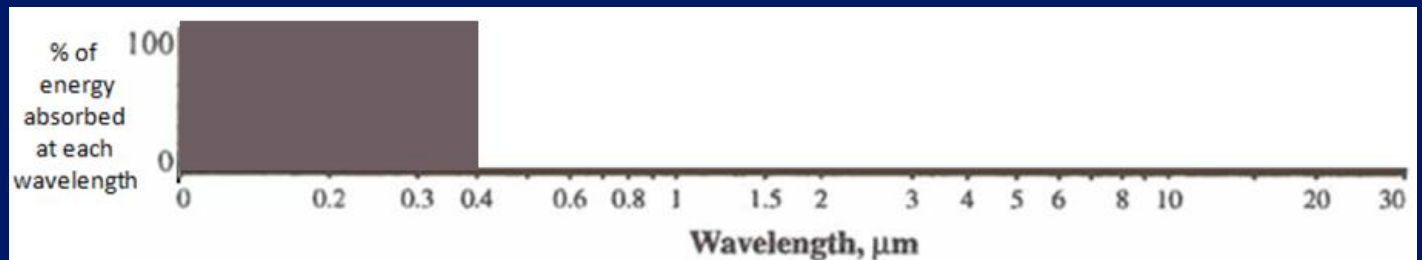
2.



3.

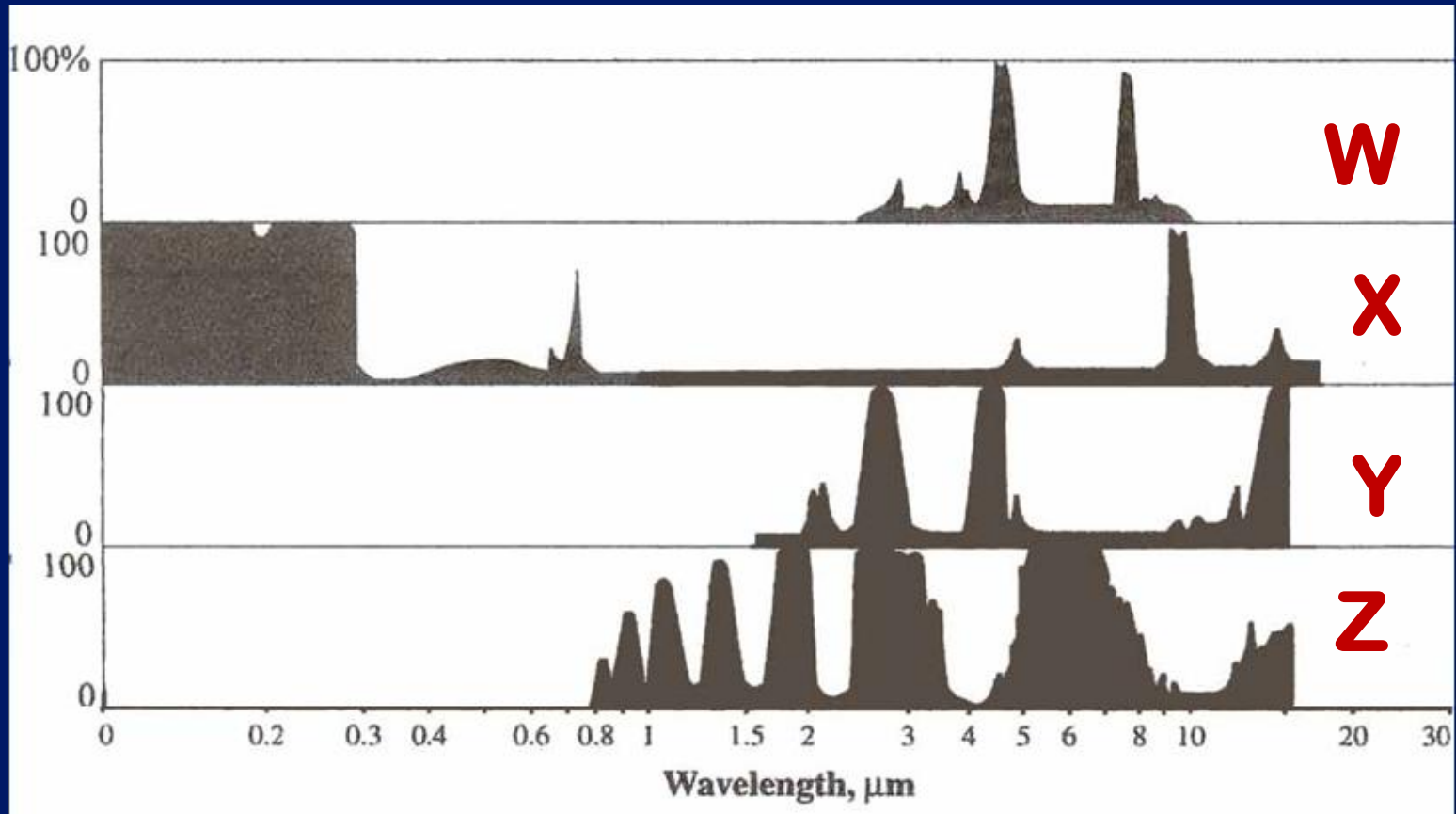


4.



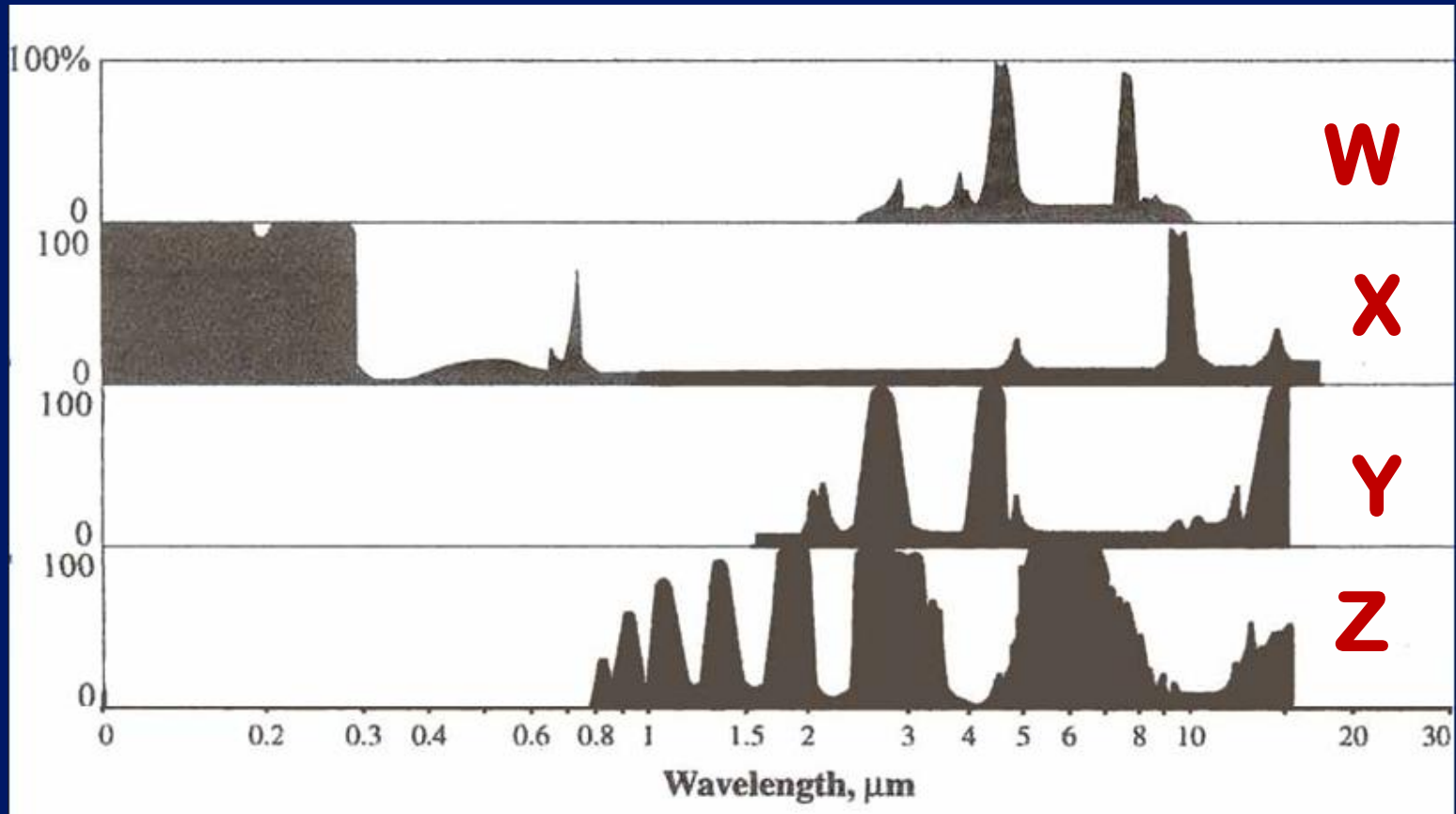
Q-2 – Which of the following absorption curves is for a GAS that is NOT a greenhouse gas!

1: W 2: X 3: Y 4: Z 5: NONE of THEM

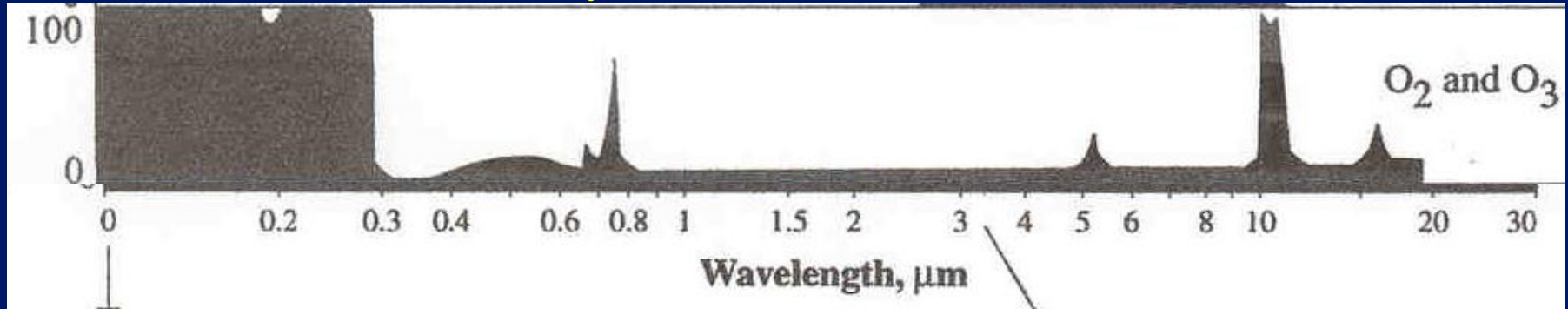


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- 1: W 2: X 3: Y 4: Z 5: NONE of THEM



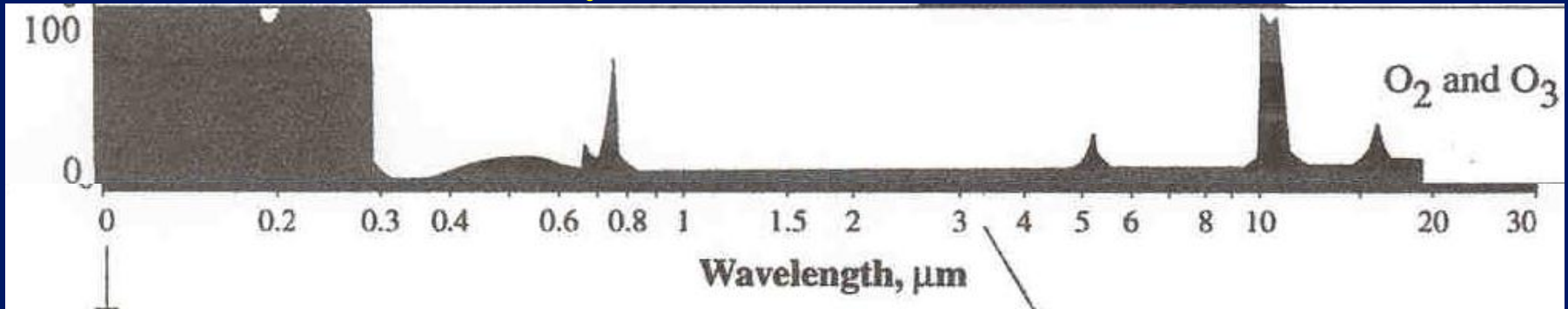
Q3. HOW IS OZONE (actually O_3 & O_2) unique???



- 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???

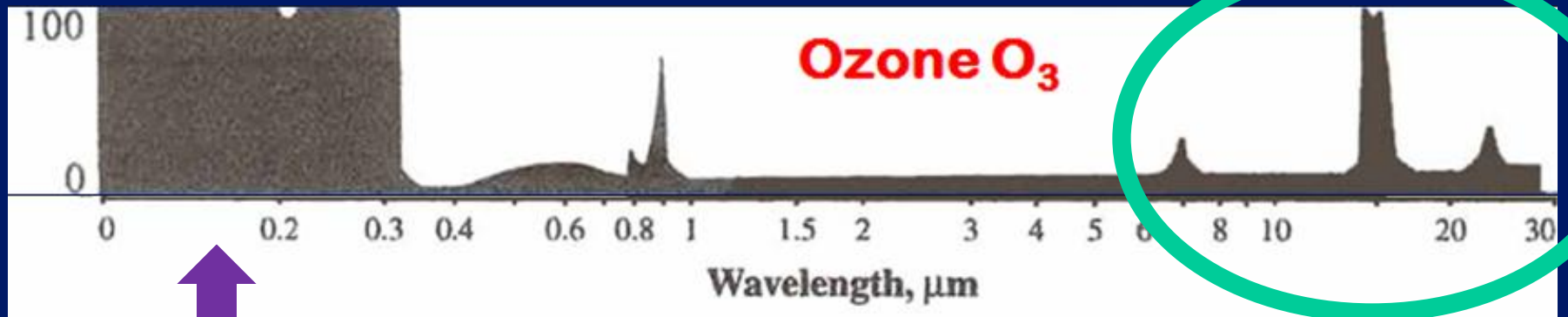


- 1) It absorbs **only UV** – hence it's **NOT** a GHG
- 2) It absorbs **almost ALL visible** wavelengths
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- 4) It absorbs **BOTH UV** and **IR** so is **NOT** GHG

But only the IR absorption makes it a GHG!!

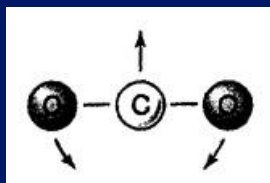
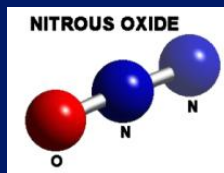
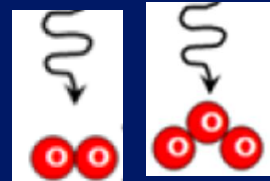
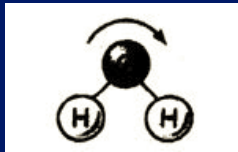


Absorption in this part of the absorption curve (IR wavelengths) indicates that OZONE is a greenhouse gas



. . . 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)

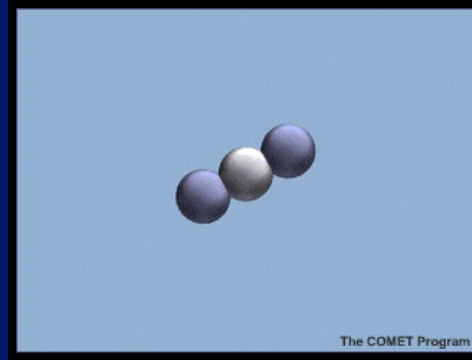
4 to 5
7 to 7.5

Carbon dioxide
(CO₂)

2 to 2.5
3 to 4
13 to 20

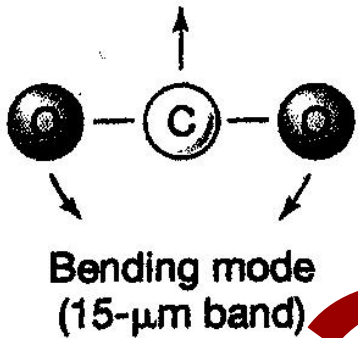
In SGC E-Text
Chapt 3:

IR radiation!

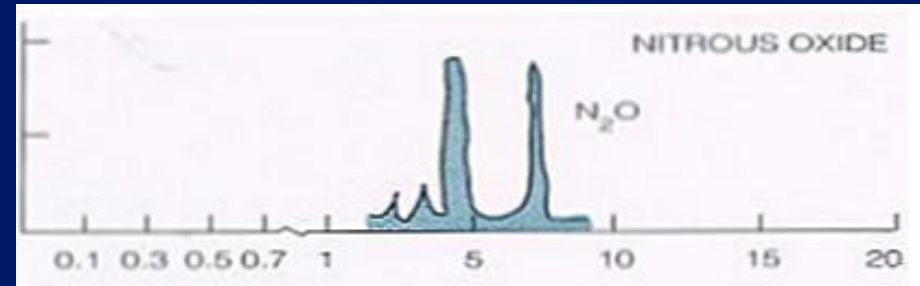
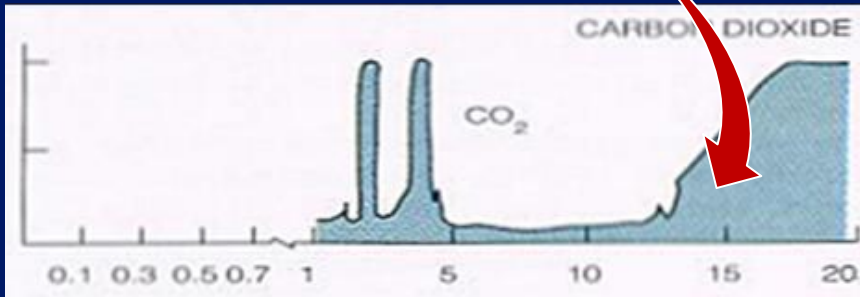


As a triatomic molecule, one way that CO₂ vibrates is in a “bending mode”

FIGURE 3-14



This vibration mode has a frequency that allows CO₂ to absorb IR radiation at a wavelength of about 15 micrometers



What about another triatomic molecule:
N₂O (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. The bending modes are due to **Infrared IR absorption at 3 different wavelengths**



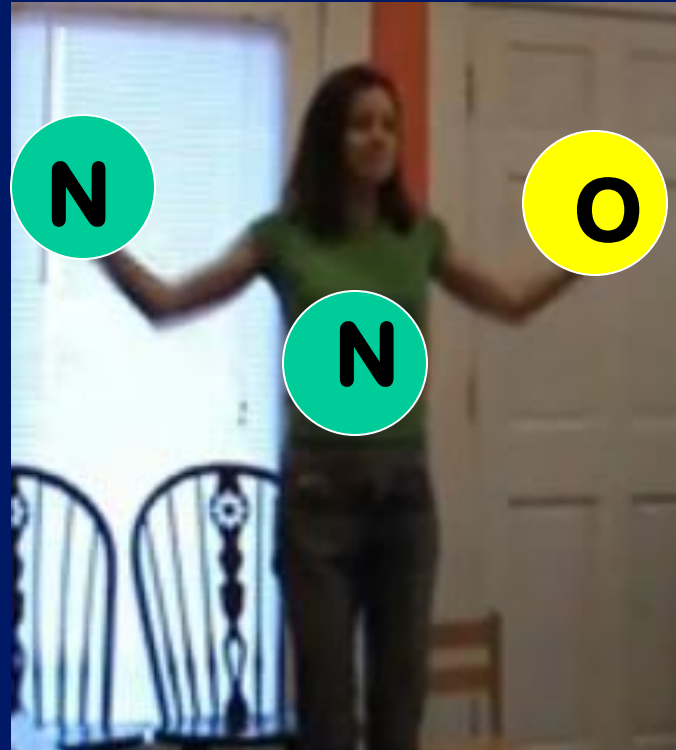
Stepping onto the chairs represents the circulation of N_2O to higher levels in the atmosphere (the stratosphere) where it is then subject to intense **Ultraviolet (UV) radiation** from the sun.



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 one of the N_2O molecules-- seen as jumping from the chair at the end →



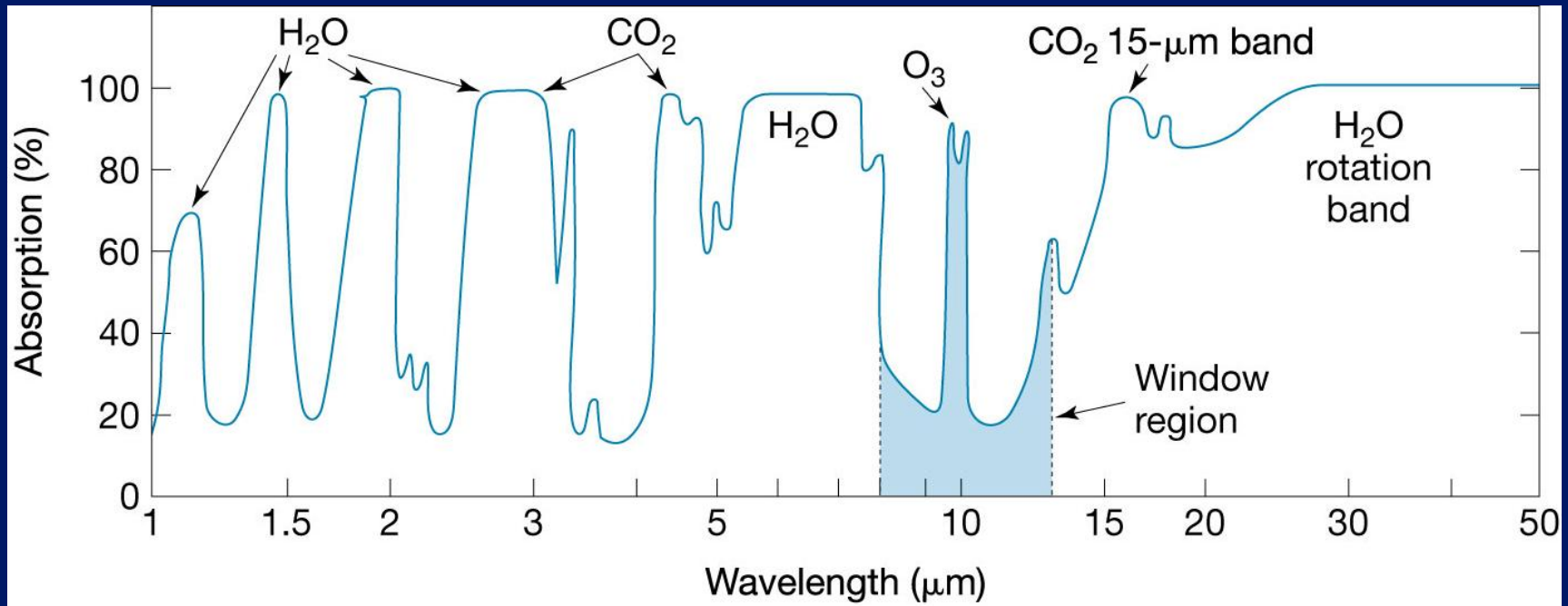
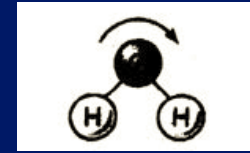
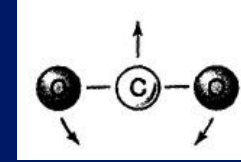
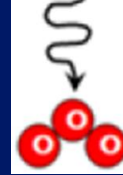
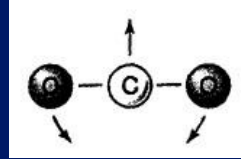
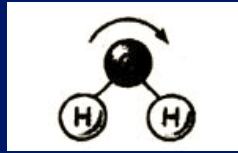


**DANCE YOUR
PhD !!**

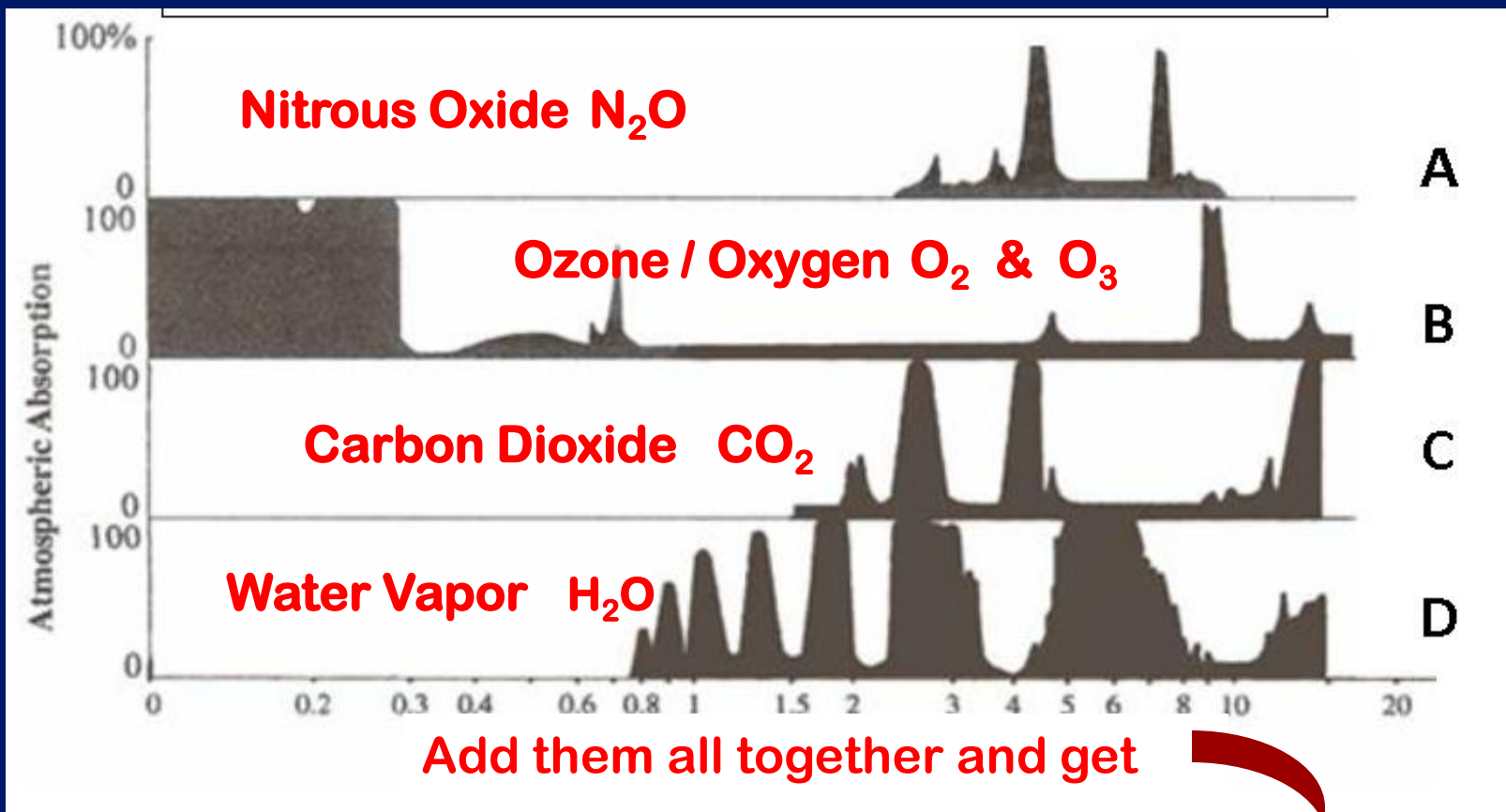
<http://www.youtube.com/watch?v=L5j6BS3XoLc>



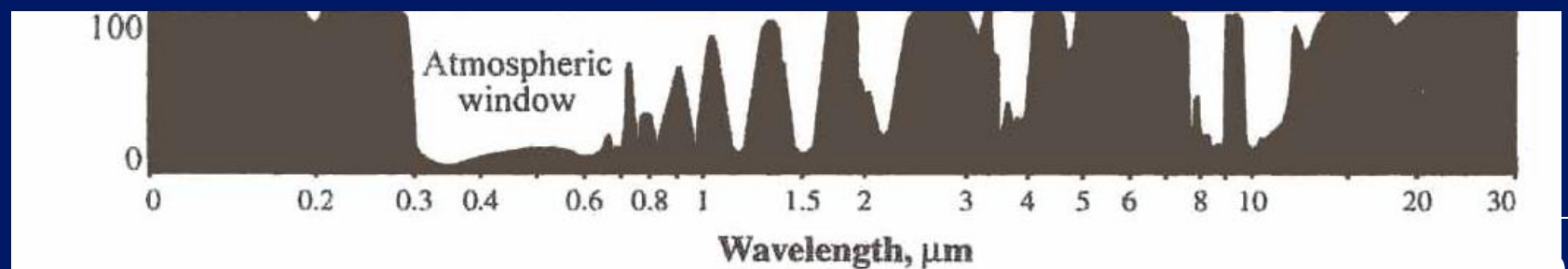
Close up view of absorption of IR wavelengths by different GHG's:



SGC E-Text Fig 3-13

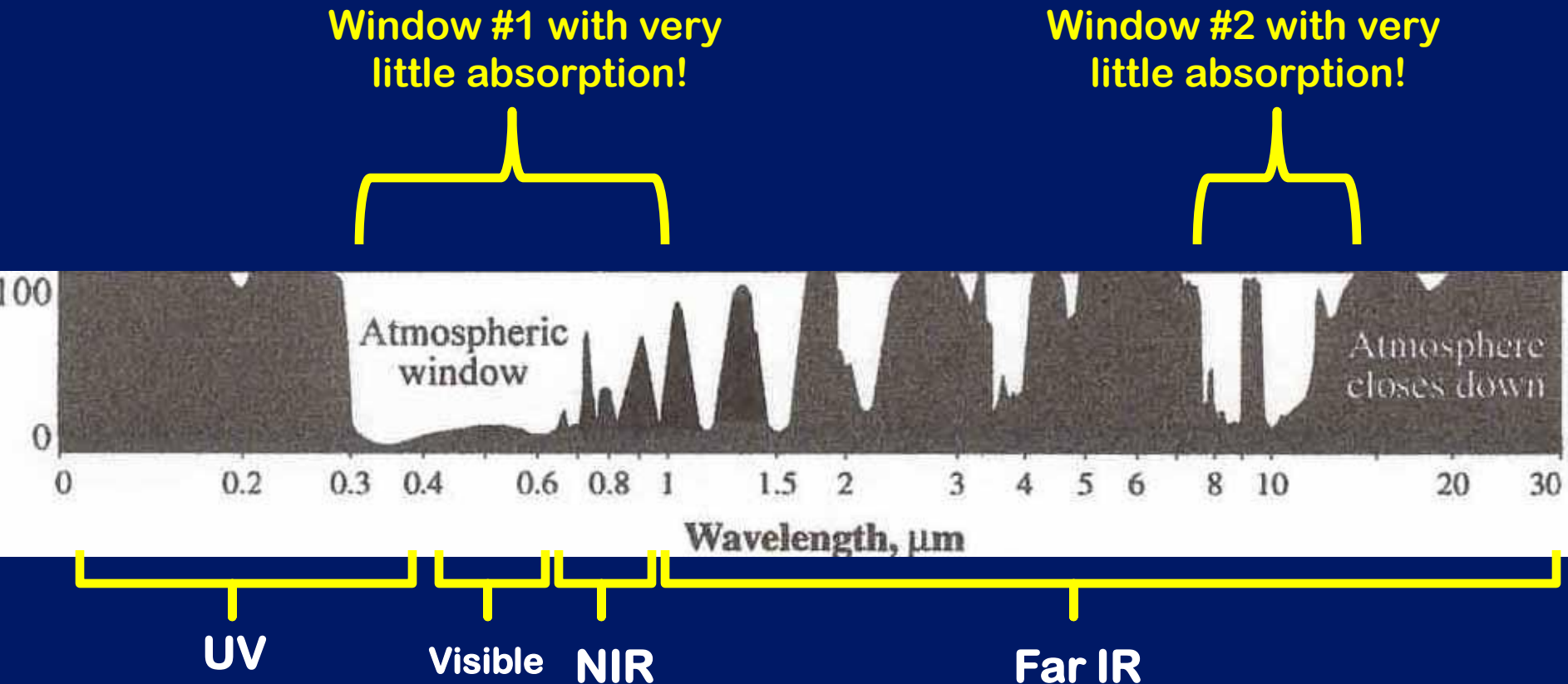


One graph showing absorption by ALL the atmospheric gases !



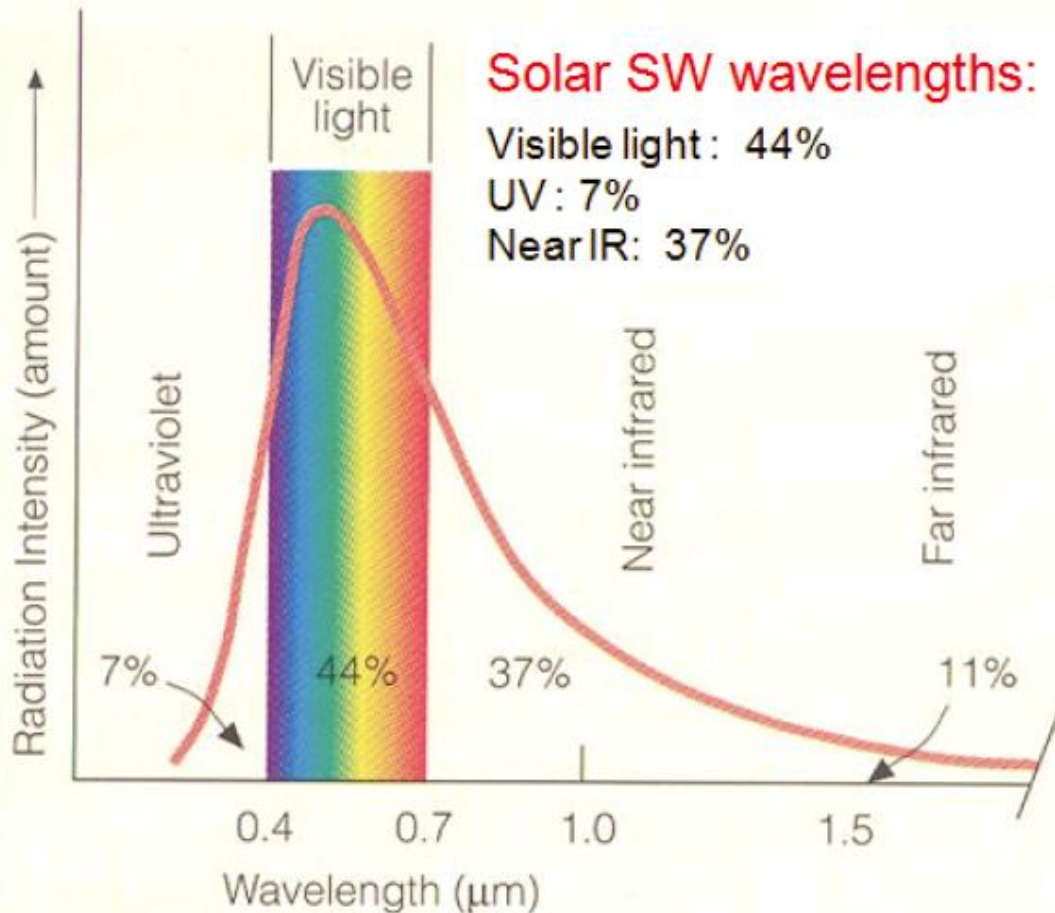
Absorption by ALL the gases in the atmosphere put together –

i.e. curve for the “Whole Atmosphere”



Shortwave SOLAR radiation

(SW) = UV + VIS + Near IR

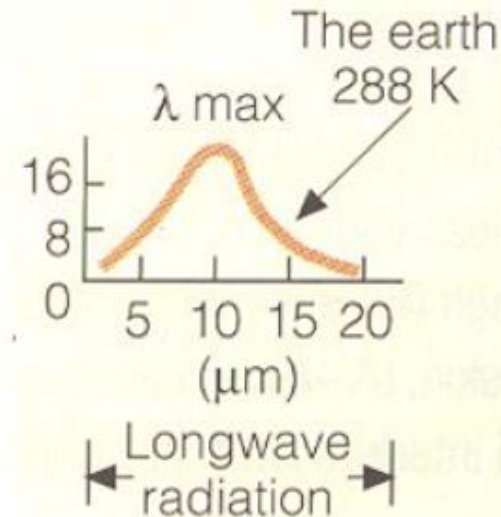


TERRESTRIAL radiation

(LW) = Far IR

Terrestrial (Earth) radiation wavelengths:

Far IR, with a maximum at ~ 10 μm

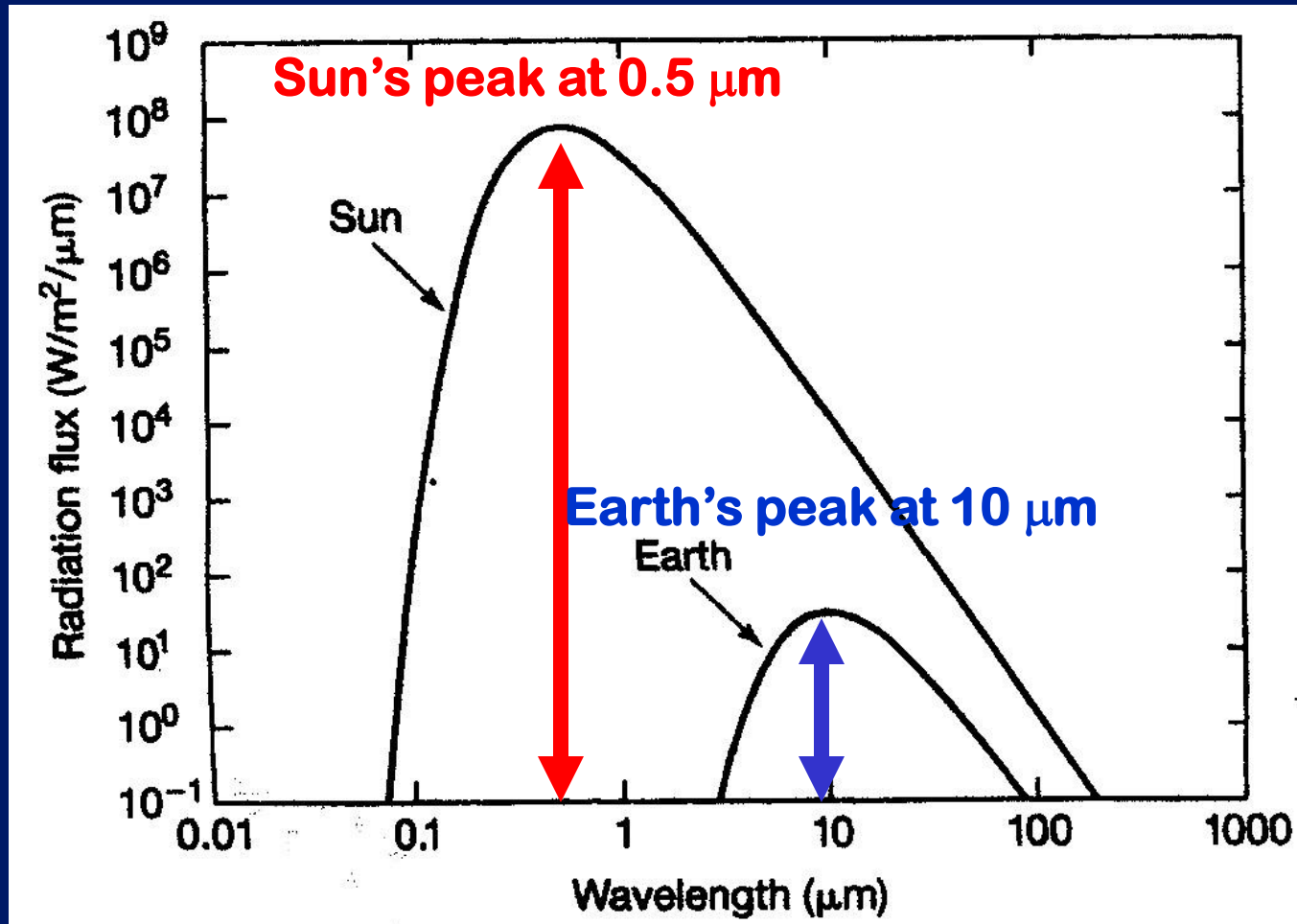


REMEMBER THIS???

Review p 30

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

**Outgoing
LW TERRESTRIAL (IR)
window**

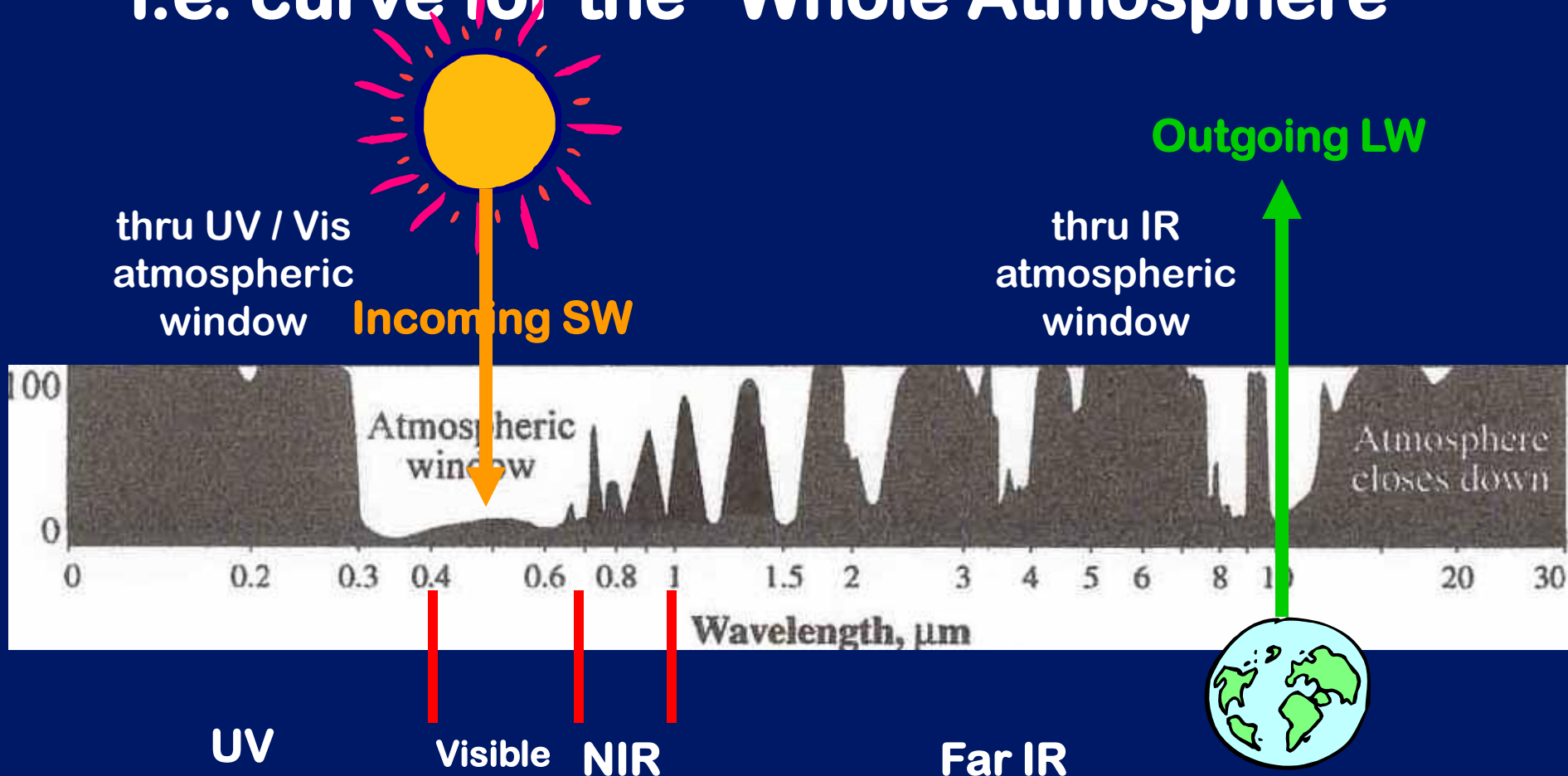


REMEMBER THIS???

Review p 30

Absorption by ALL the gases in the atmosphere put together –

i.e. curve for the “Whole Atmosphere”

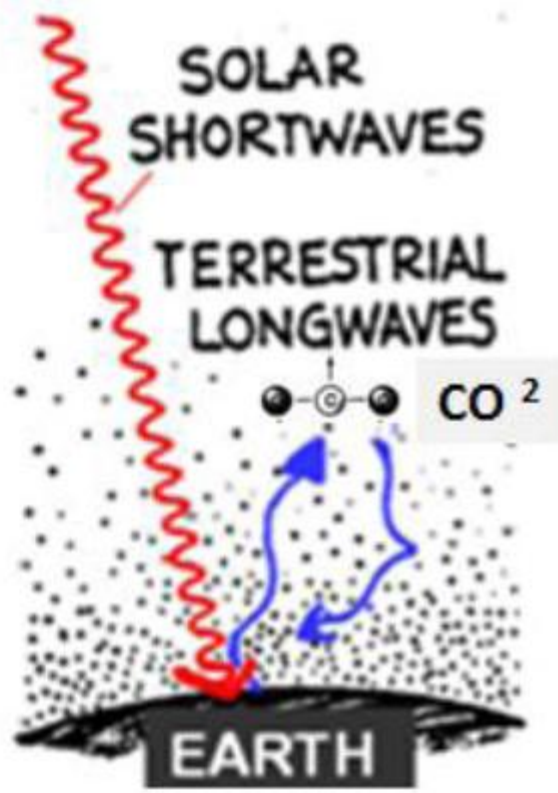




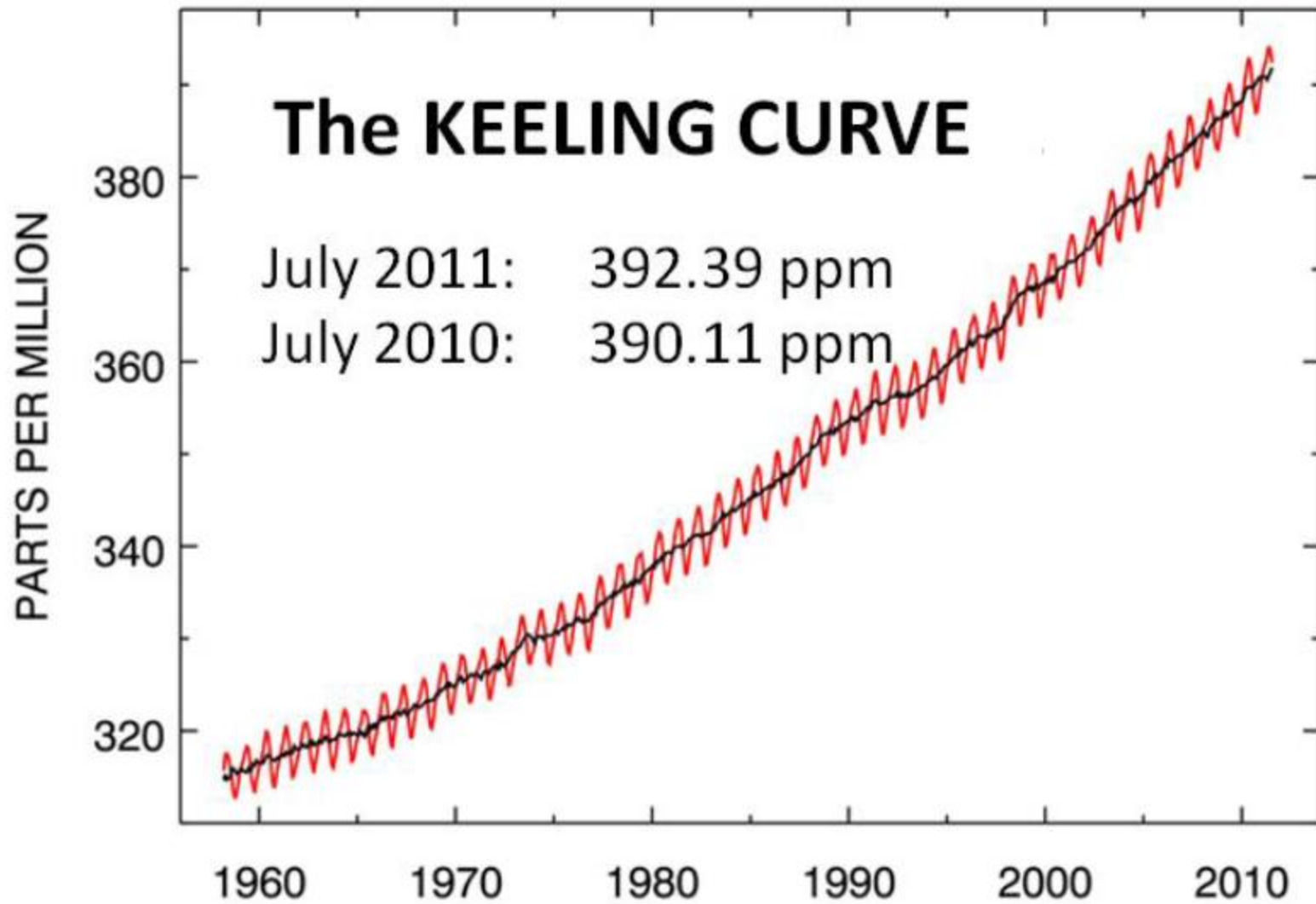
INDICATOR INTERLUDE . . .

**Denier
Argument #29:**

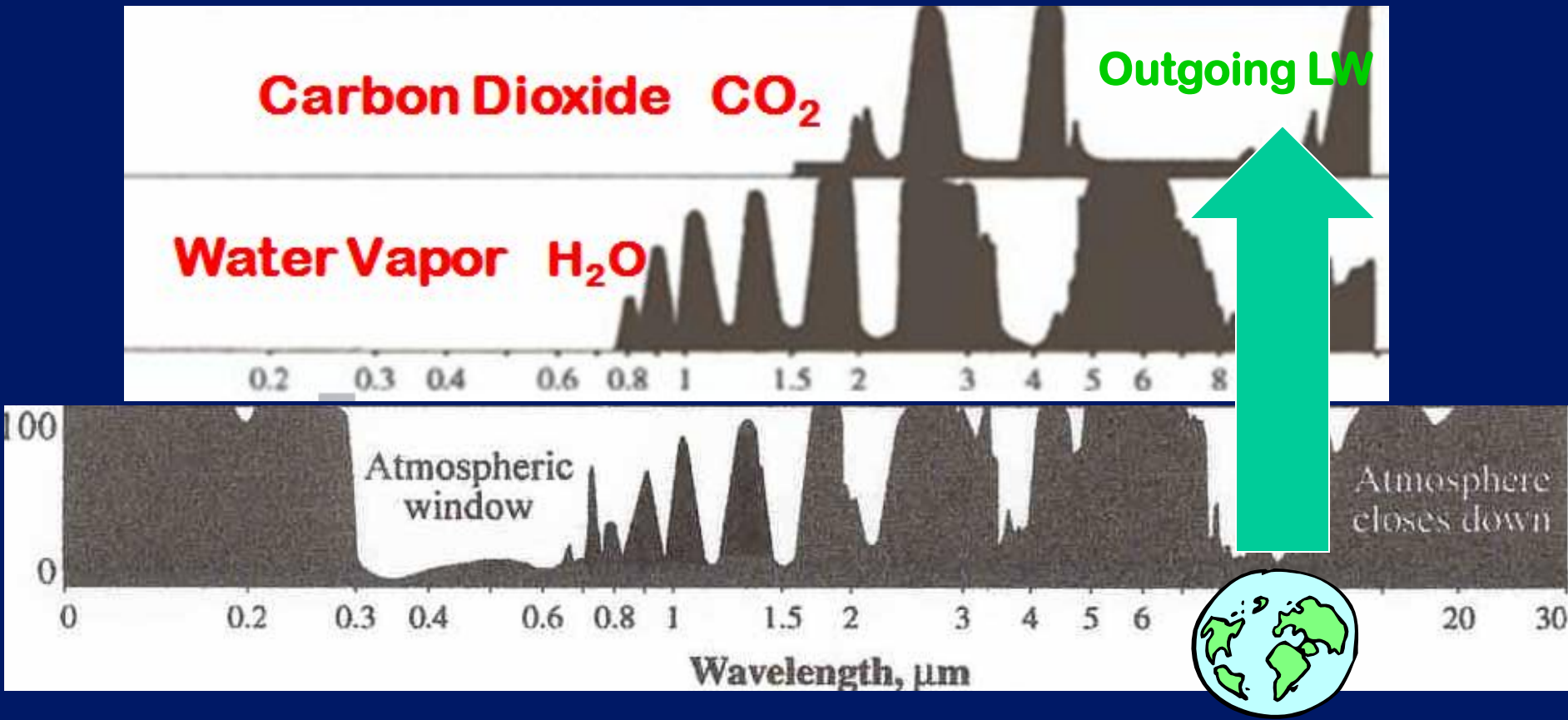
*"Increasing CO₂
has little to
no effect"*



The KEELING CURVE



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



Q-3 - 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.

Where are these two windows?

1: A + B

2: B + E

3: C & D

4: D + E

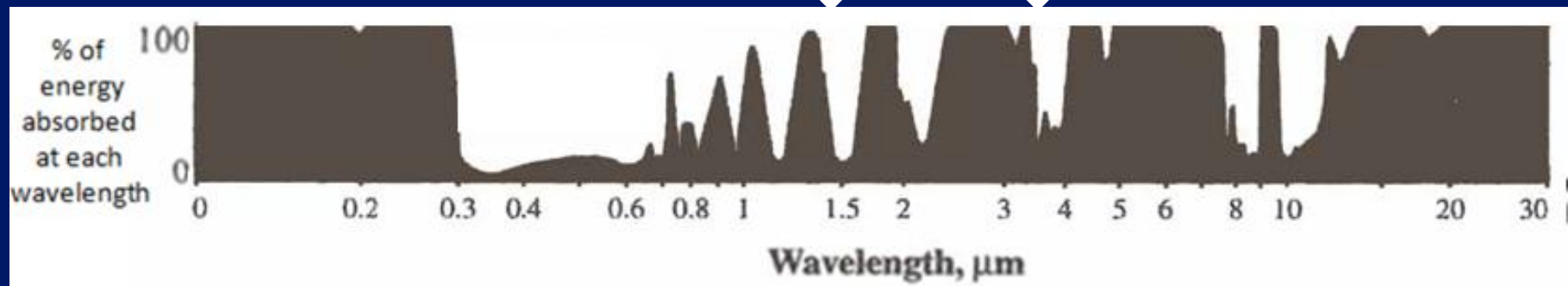
A
↓

B
↓

C
↓

D
↓

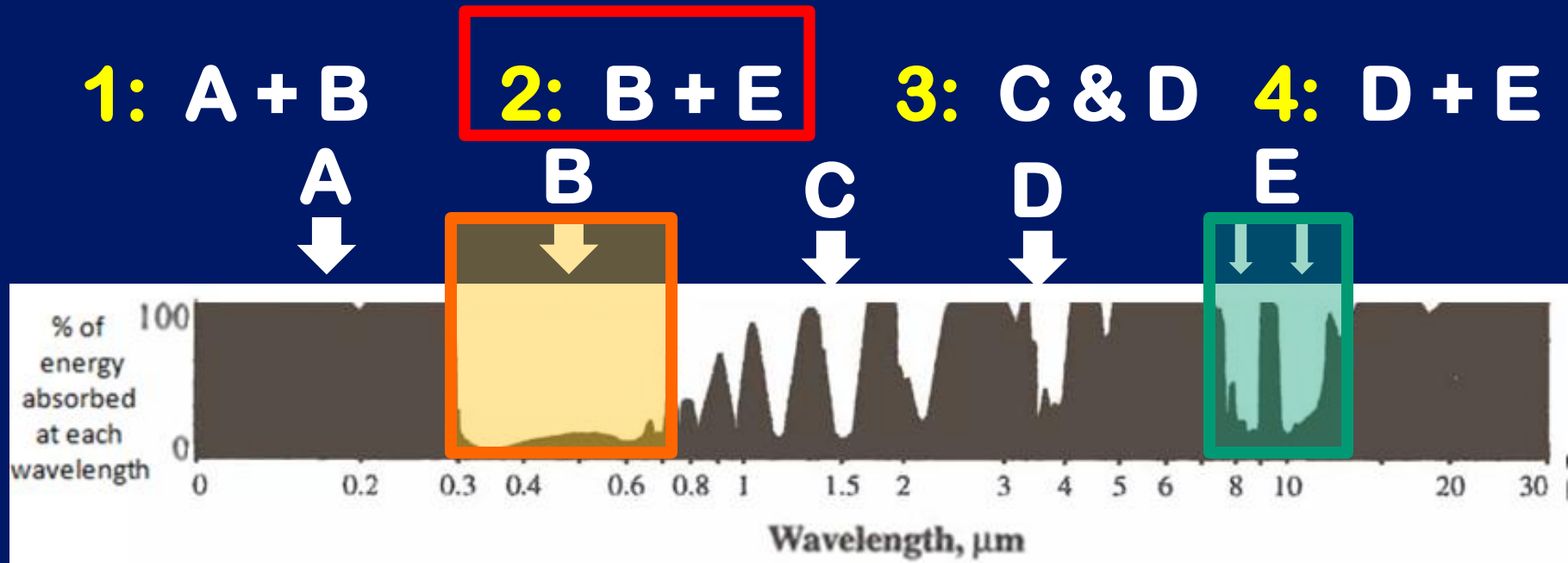
E
↓ ↓



Q-3 - Here's the absorption curve for ALL the gases in the atmosphere put together, i.e. curve for the **"Whole Atmosphere"**

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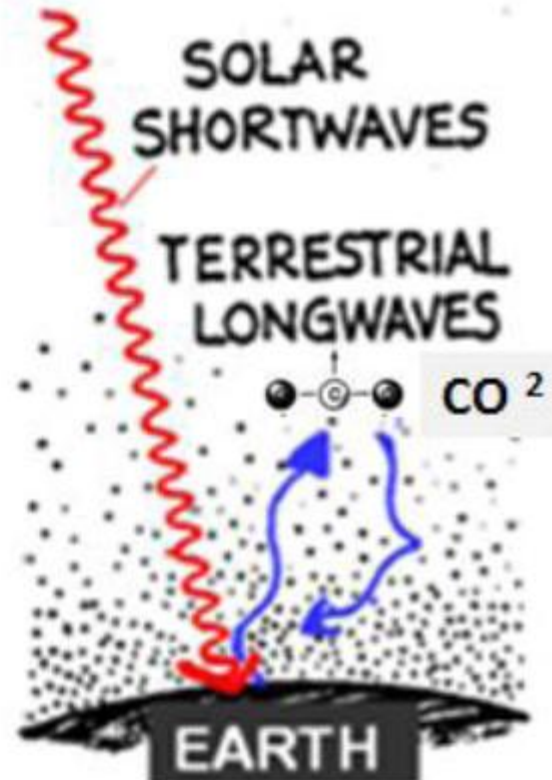




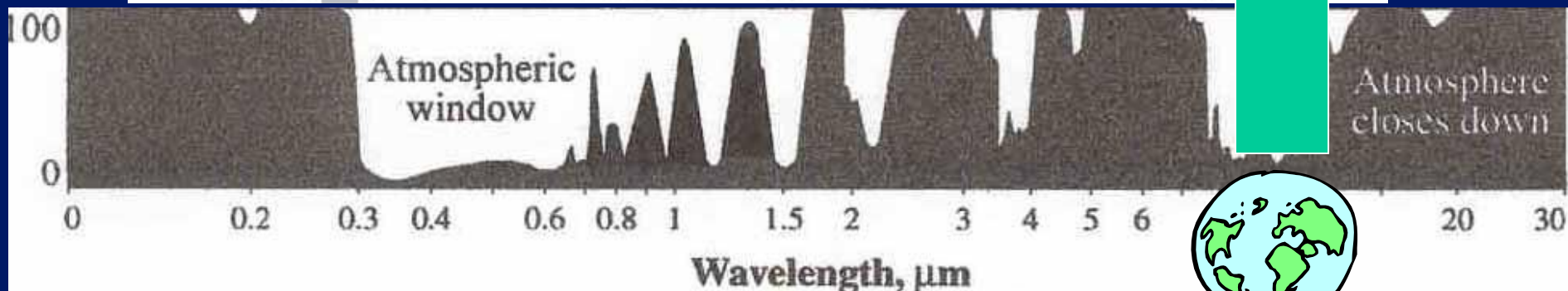
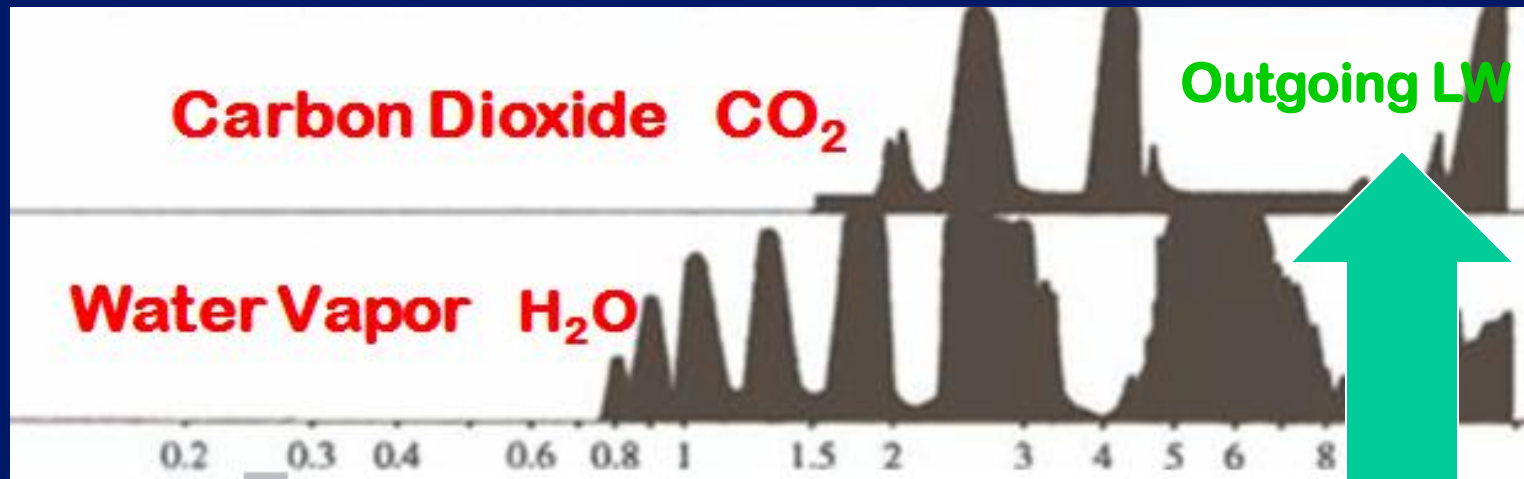
INDICATOR INTERLUDE . . .

**Denier
Argument #29:**

*"Increasing CO₂
has little to
no effect"*



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

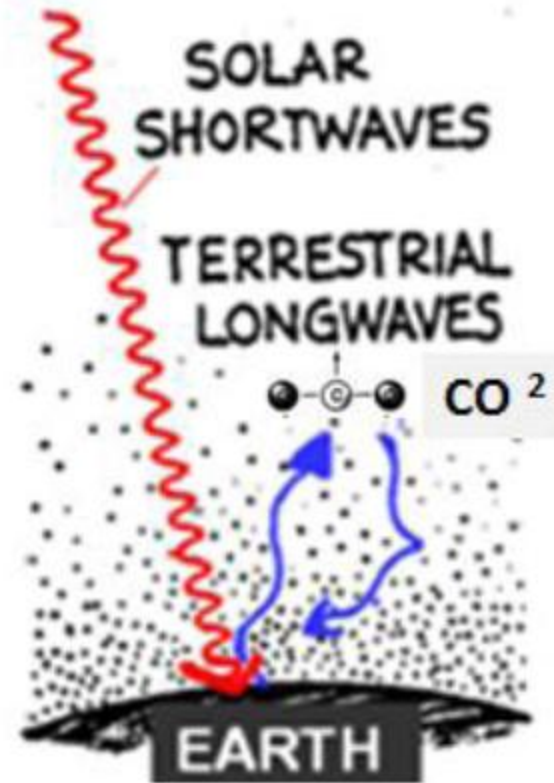


INDICATOR INTERLUDE . . .



**Denier
Argument #29:**

*"Increasing CO₂
has little to
no effect"*



How would you respond?

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 33

Read the box . . .
then think a bit . . .

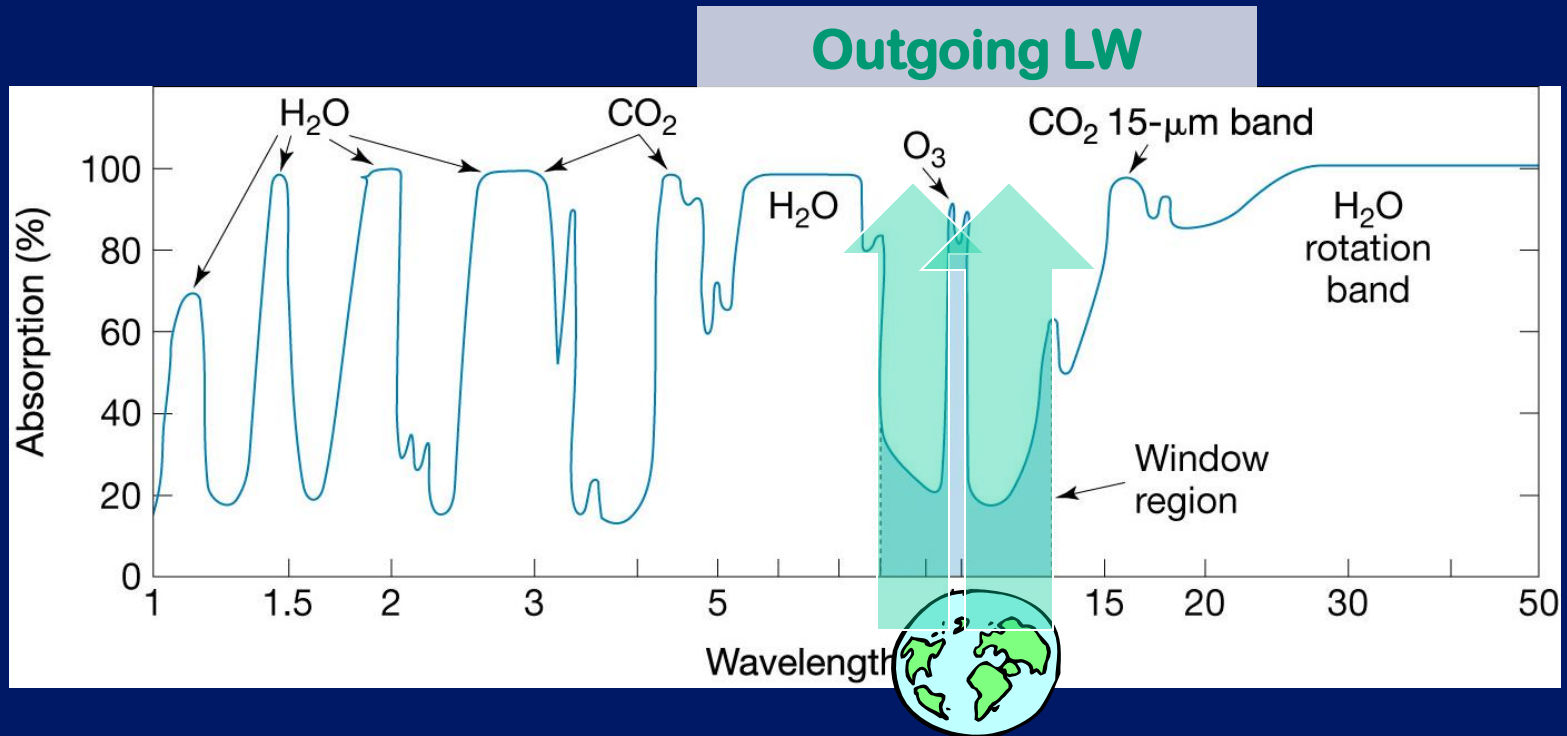
Which items (a - f) have relevant info
for responding to this skeptic's
argument?

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 the **most 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!



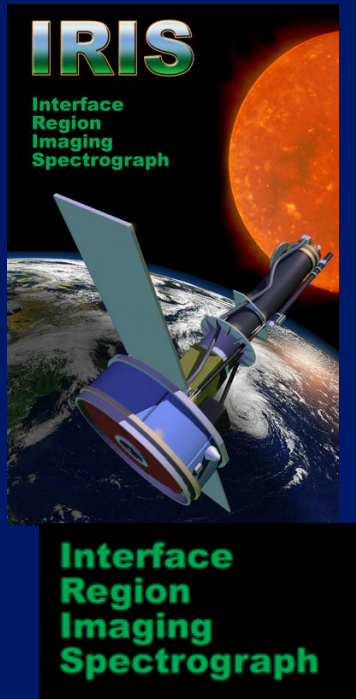


But . . . is there **enough volume** of these “trace gases”
to REALLY make a difference in the Greenhouse Effect
and therefore increase the temperature?

GIVE ME MORE EVIDENCE!

IS this GH Effect measurable??

Less IR
going to
space



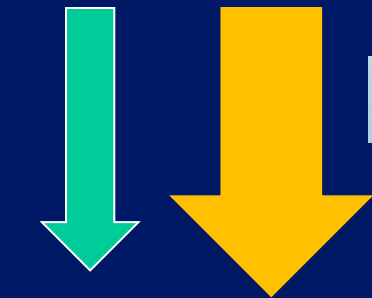
Interface
Region
Imaging
Spectrograph



1970s

TODAY

FOURIER TRANSFORM
INFRARED SPECTROSCOPY
(FTIR) ANALYSIS



More IR
radiating
downward

RESPONSE TO 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, empirical **causal link** between CO₂ and global warming.













HOMEWORK ASSIGNMENTS!!

ASSIGNMENTS




Fall 2013 Semester

NOTE: If you have questions about a grade, see D2L to find out who graded the assignment and talk to or email that GTA *directly* about your grade.

GROUP ASSIGNMENTS <i>(In-Class Activities)</i>	INDIVIDUAL ASSIGNMENTS <i>(Short Writing Assignments)</i>
 G-1 Absorption Curves <i>in class on Sep 17th</i>	 <u>I-1 Climate Science Basics</u> Lesson 1 CO ₂ & the GH Effect
 G-2 Assignment <i>(to be posted)</i>	 <u>I-2 Climate Science Basics</u> Lesson 2 Mother Nature's Influence
 G-3 Assignment <i>(to be posted)</i>	 <u>I-3 Climate Science Basics</u> Lesson 3 Observable Changes
 G-4 Assignment <i>(to be posted)</i>	 <u>I-4 Climate Science Basics</u> Lesson 4 Intro to Climate Modeling
 G-5 Assignment <i>(to be posted)</i>	 I-5 Assignment <i>(to be posted)</i>

LINKING-TO-LIFE PROJECT
(Individual Term Project)

OVERVIEW OF THE TERM PROJECT

	<u>PART A: YOUR ECOLOGICAL FOOTPRINT</u>
	<u>PART B: FILM REVIEWS & TOPIC SELECTION</u> <i>to be posted Wed Sep 25th</i>
	PART C: FINAL REPORT

ASSIGNMENTS PAGE

(Short writing assignments after viewing a Tutorial Lesson

Linking-to-Life Part B directions will be posted tomorrow

Read through the DIRECTIONS & bring your questions to Thursday's class.

PROJECT TOPICS

PROJECT CATEGORIES

See category choices below or devise your own.

PROJECT CATEGORY	Earth's Global Environment	Energy Conservation	Transportation Options	Water Sustainability	Food & the Environment	Artistic Expression / Advocacy	GC-Savvy Consumerism, Sustainability & Business
							
POSSIBLE QUESTIONS	How do human's impact the environment in different parts of the world?	Where does <u>my</u> energy come from?	Can I find a "dream car" that balances performance, fuel economy, cost, and "crashworthiness"?	Where does <u>my</u> water come from?	How does food production impact global change?	Can science and art be linked?	How can I make "global change savvy" consumer choices?
<i>You are encouraged to come up with your OWN question to investigate!</i>	Are there global examples of sustainable practices?	How can I lower my carbon footprint – why should I?	What's the most sustainable form of transportation for my needs?	What are Tucson & Phoenix water managers doing to address sustainability?	How far does my food travel to get to me?	How can my art, writing, or poetry express my views on the environment?	Can a business be run sustainably?
<i>But if you like, you may use one of these suggestions.</i>	What is my response to the "Home" film: "Listen . . .to this extraordinary story and decide what you want to do with it."	Is solar energy viable for me?	What's the most promising type of alternative fuel vehicle?	How is climate change exacerbating the future of water in the arid West -- and the world?	Why <u>does</u> meat add so much CO2?	What does the SGC textbook cover "say" to me about Global Change?	Can Energy Star labels help me find "green" electronics and appliances?
		Will energy policies work?	What are + and - of travel by plane vs., train, vs. auto?	What's the connection between energy & water supplies?	How are food production and deforestation linked?	Is there an advocacy group that resonates with me?	How can I detect and avoid "greenwashing"?
		Does our local utility have a "green power" program?			Which Tucson supermarkets provide the most food choices?		

Water: Where Science and Art Meet

TODAY!

**Artistic
Expression /
Advocacy**



A Panel Discussion with Javier Duran, Ellen McMahon, Rebecca Senf, and Gregg Garfin

Tuesday, September 24, 2013

5:30 PM

Center for Creative Photography
Auditorium

The Center for Creative Photography and the Confluentcenter for Creative Inquiry will explore the issues surrounding water and sustainability in the desert with a panel discussion titled *Water: Where Science and Art Meet* on Tuesday, Sept. 24 at 5:30 p.m. in the Center's Auditorium. The focal point of the discussion will be the Confluentcenter's highly acclaimed book *Ground/Water: The Art, Design and Science of a Dry River* and photographs from CCP's *Water in the West* archive collection. Confluentcenter director, Dr. Javier Duran, will moderate the panel which will include Ellen McMahon, one of the editors of the *Ground/Water* book and a professor of art at the UA; Dr. Rebecca Senf, Norton Family Curator of Photography at CCP and the Phoenix Art Museum; Dr. Gregg Garfin, deputy director for Science Translation and Outreach at the Institute of the Environment; and Edgar Cardenas, doctoral candidate at the ASU School of Sustainability.

Talk

Environmental Themes: Culture and Creative Arts

Link: <http://www.creativephotography.org/exhibitions-events/events>

Notes: See a review of *Ground/Water* in *Proximities*.

FRIDAY!

@ 10:30 am

in the

Student Union

KIVA Room

The Physical Science Basis

WORKING GROUP 1: FIFTH ASSESSMENT REPORT

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE



Earth's Global
Environment



<http://www.climas.arizona.edu/events/IPCC-Release>

The first report to be released by the Intergovernmental Panel on Climate Change 5th Assessment will be released on Sept. 27, 2013.

The Working Group 1 report, entitled "The Physical Science Basis," covers what we know about how the Earth's climate is changing and why, as well as what climate change is likely in the future, depending on the levels of greenhouse gases emitted by humans over the next century and beyond.

A panel of UA climate science experts has been assembled to comment on the report and to field questions.

PART OF THE THIRD ANNUAL NATIONAL PLUG IN DAY CELEBRATION

TUCSON PLUGS IN 2013

ELECTRIC VEHICLES & CLEAN ENERGY TECHNOLOGY
ON DISPLAY / FREE & OPEN TO THE PUBLIC

SUNDAY, SEPT. 29, 9AM - 1PM

BOOKMAN'S SPORTS EXCHANGE,
3330 E. SPEEDWAY BLVD.

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Transportation
Options



SUNDAY!

TUCSON PLUGS IN 2013 is an opportunity for the general public - free of charge - to come out and see the latest in EV technology.

Both private vehicle owners and local auto dealerships will have plug-in vehicles on display. Additionally there will be exhibits showing a variety of sustainable and environmentally-responsible energy technologies.

<http://tucsonplugsin.blogspot.com/>

The next segment of:



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

**SEE YOU
THURSDAY!!!**