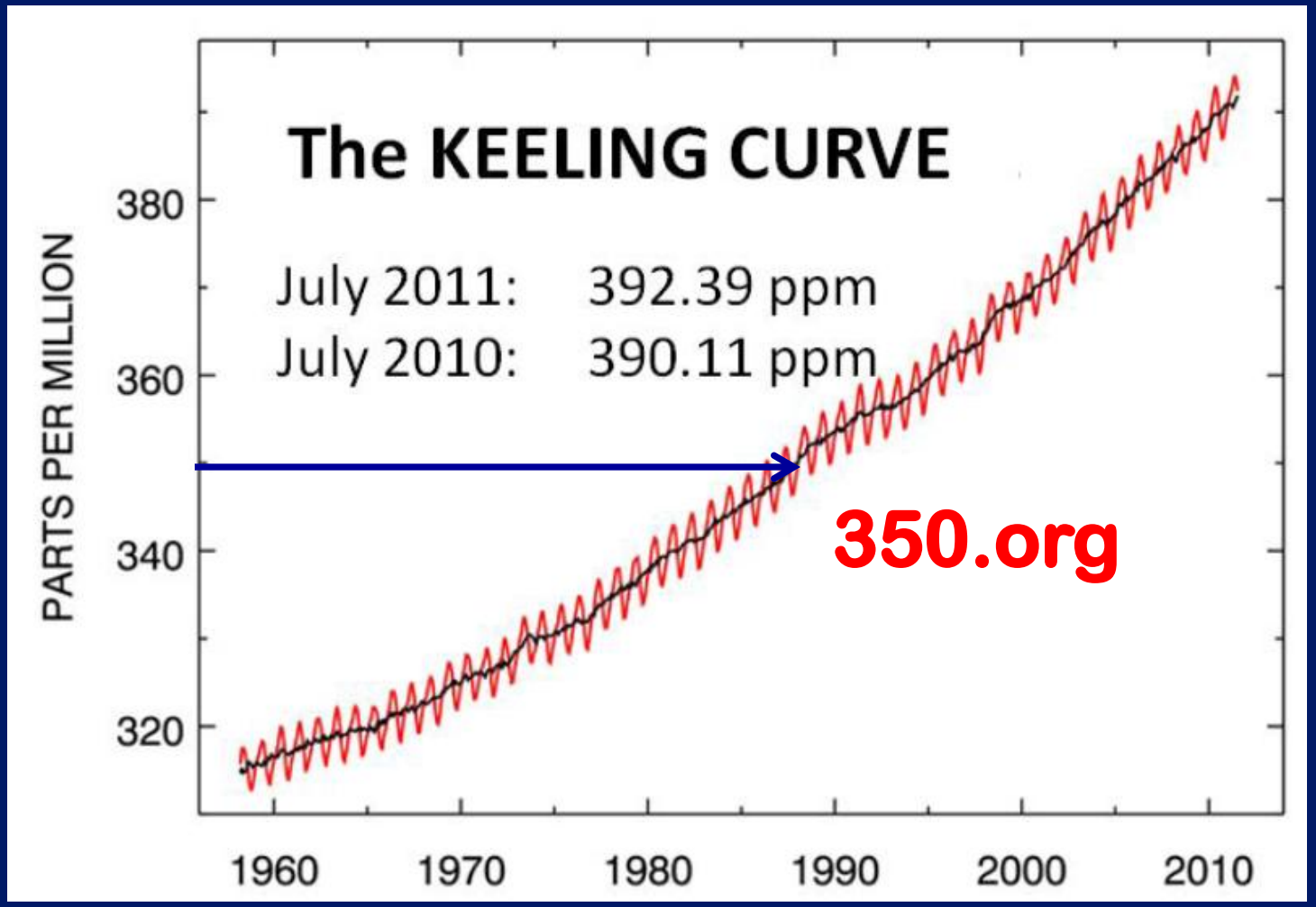
Class started out with an announcement about a local 350.org activity this weekend – for those interested ➔



Connect 2 Tucson bike ride will bring attention to global warming

Submitted by Teya Vitu, Downtown Tucson Partnership writer
Monday, September 19th, 2011, 12:00pm

Topics: Environment, Events, News, Sports & Recreation, Transportation

Get your bike ready and jot (or enter) Connect 2 Tucson on your calendar for Sept. 24.

This community bike ride passing through three Downtown neighborhoods is Tucson's contribution to worldwide events that day to draw attention to climate change and the need for humanity to move beyond fossil fuels.

Cities in 151 countries are taking part in Moving Planet, a one-day call to action by the 350.org international climate change campaign.

"Moving Planet will be a day to put our demands for climate action into motion – marching, biking, skating – calling for the world to go beyond fossil fuels," reads the proclamation under the About

Scientists in the past two decades have determined that 350 parts per million of carbon dioxide was the upper limit to keep the planet in a similar condition with have known throughout humanity. But the CO2 count has already reached 391 parts per million and the recent smoking guns have been shrinking polar ice caps and disappearing glaciers.

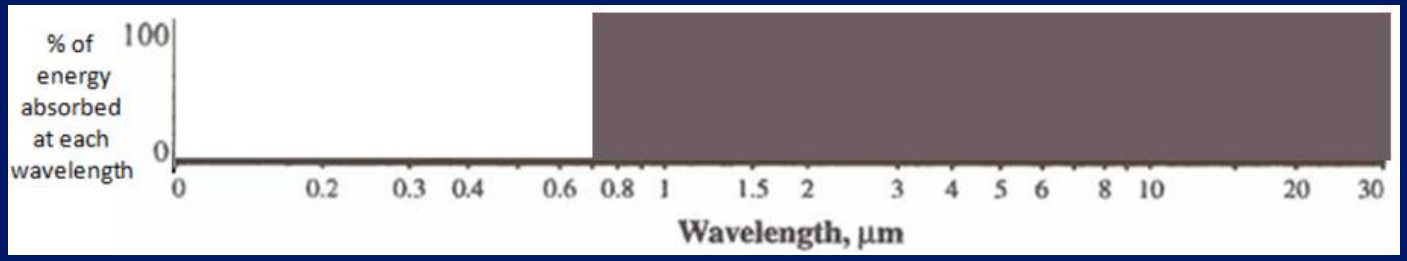
"We're doing this bike ride because 350 is the goal and we're at 391 now," Stewart said. "If we want to save the plant for future generations, we've really got to clean up our act. The ride itself is inspiring. It's a beautiful ride. You don't have to worry about cars and you can enjoy the spectacular views of the Santa Cruz and Rillito (parks)."

http://downtowntucson.kold.com/news/environment/60618-connect-2-tucson-bike-ride-will-bring-attention-global-warming

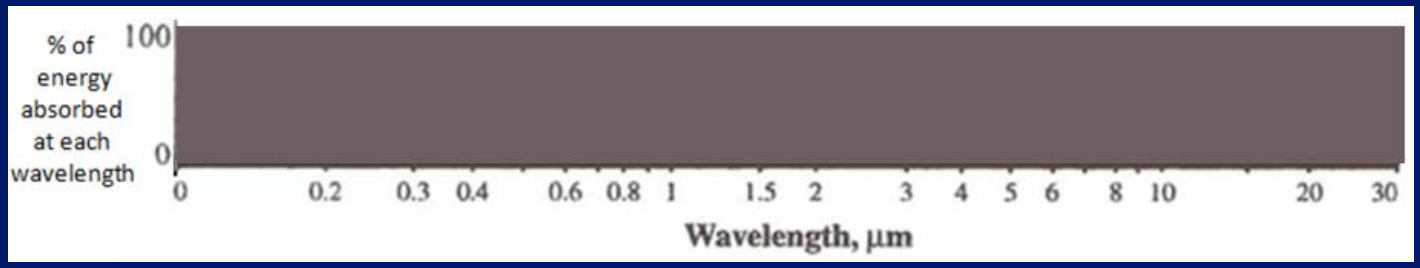
We than had some clicker questions to review key points from previous classes:

Q-A Which of the following absorption curves represents a hypothetical atmosphere that has a "perfect" greenhouse effect ?

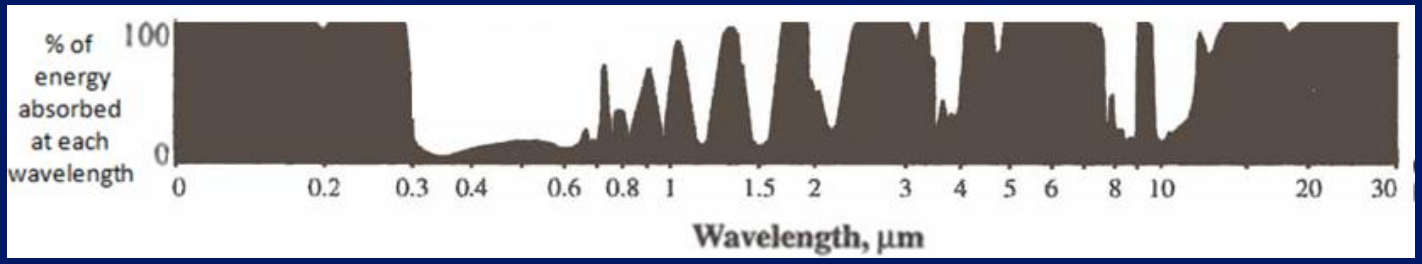
1.



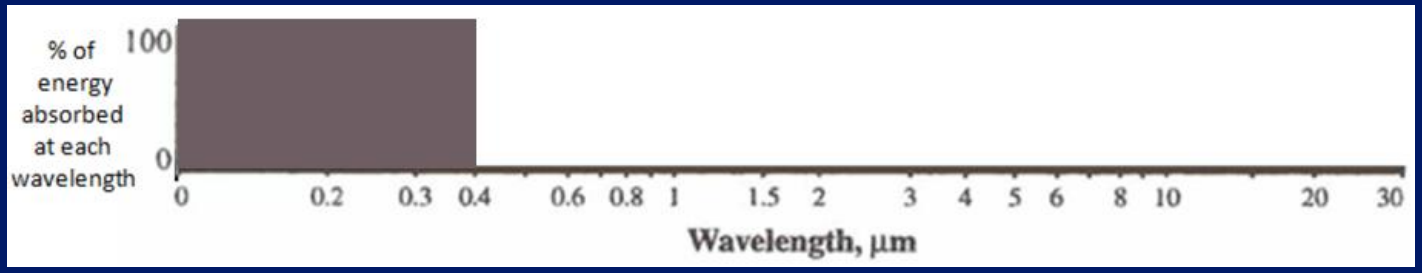
2.



3.

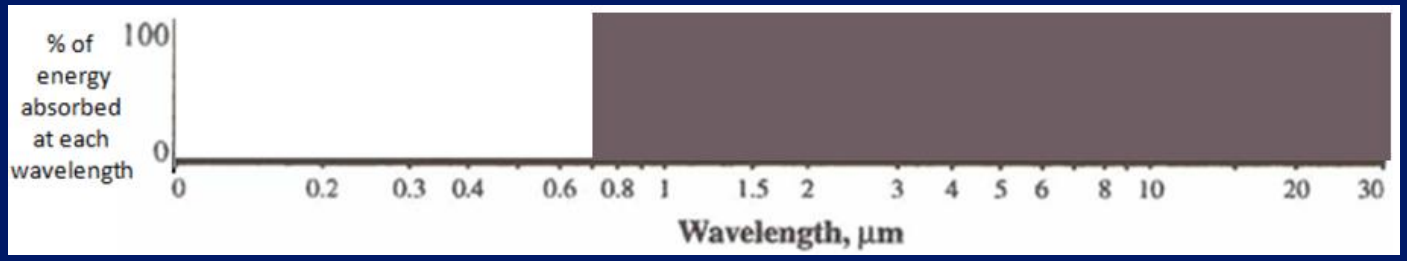


4.

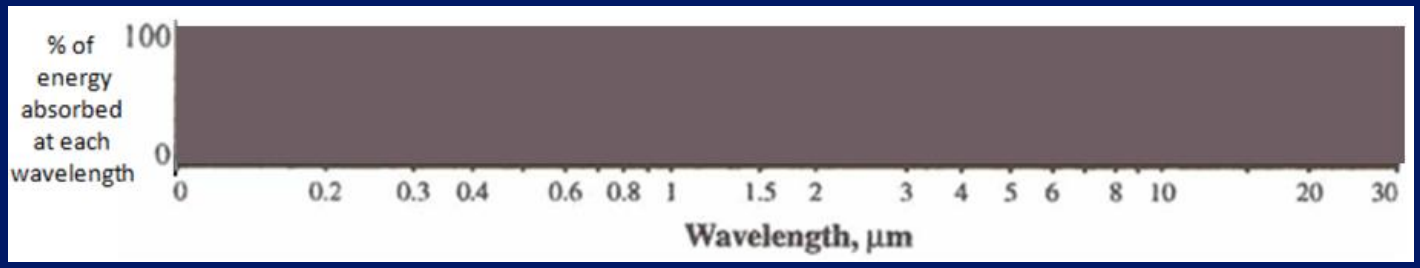


Q-A Which of the following absorption curves represents a <u>hypothetical</u> atmosphere that has a "perfect" greenhouse effect ?

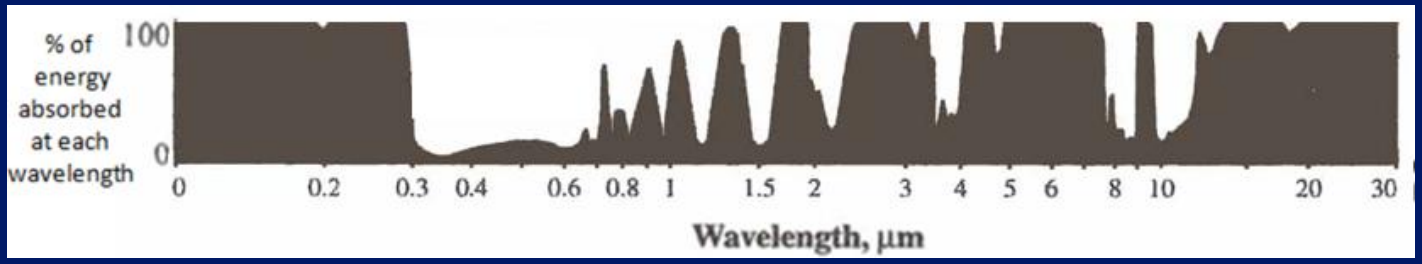
1.



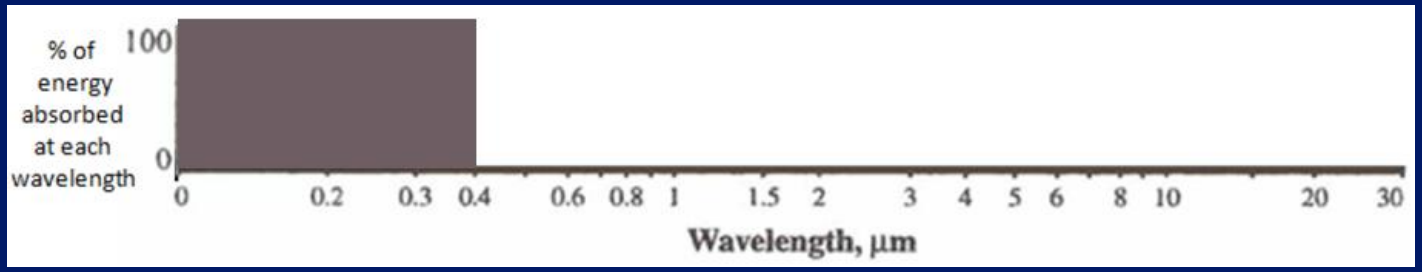
2.

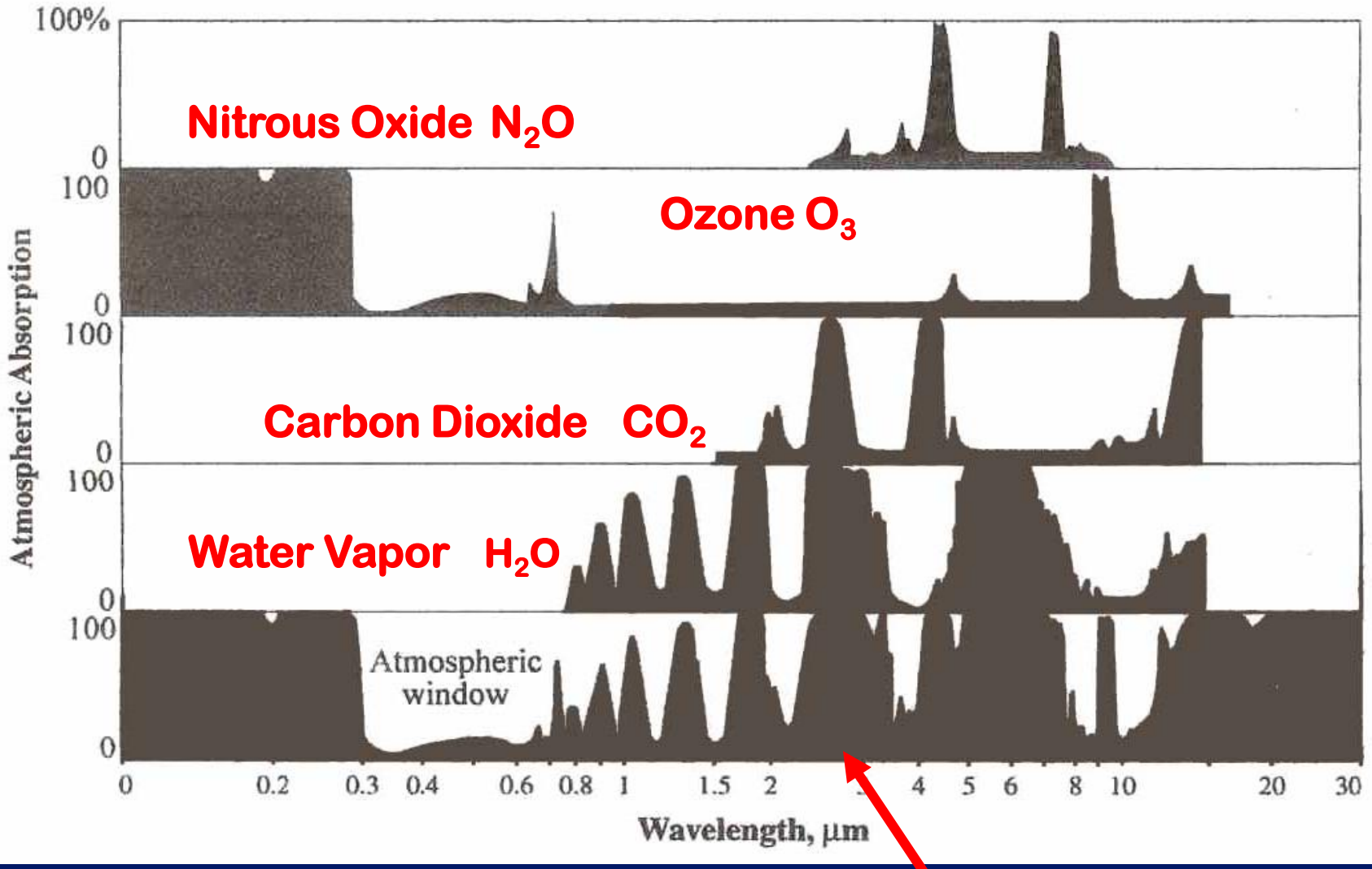


3.



4.

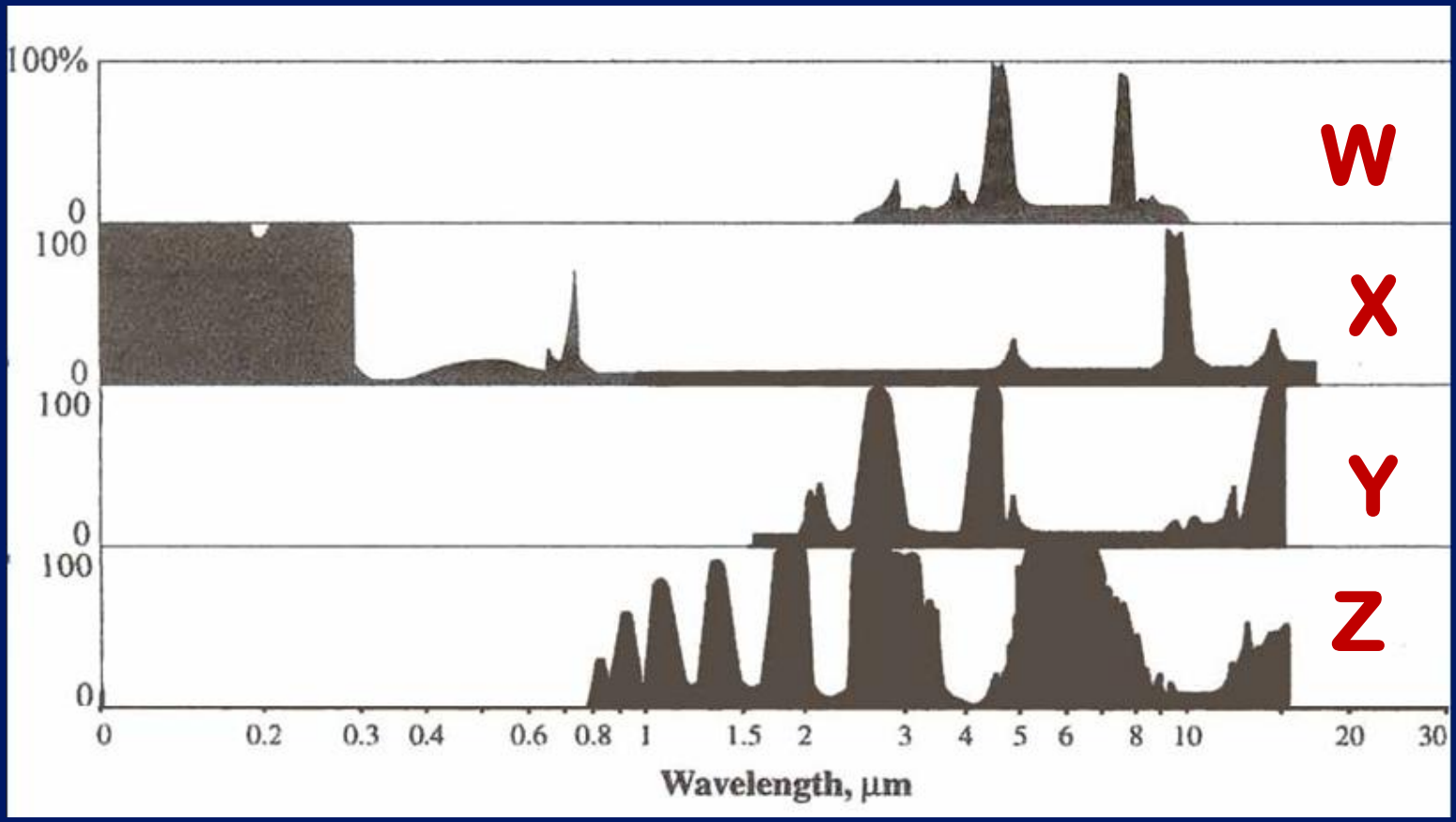




All gases in the atmosphere together!

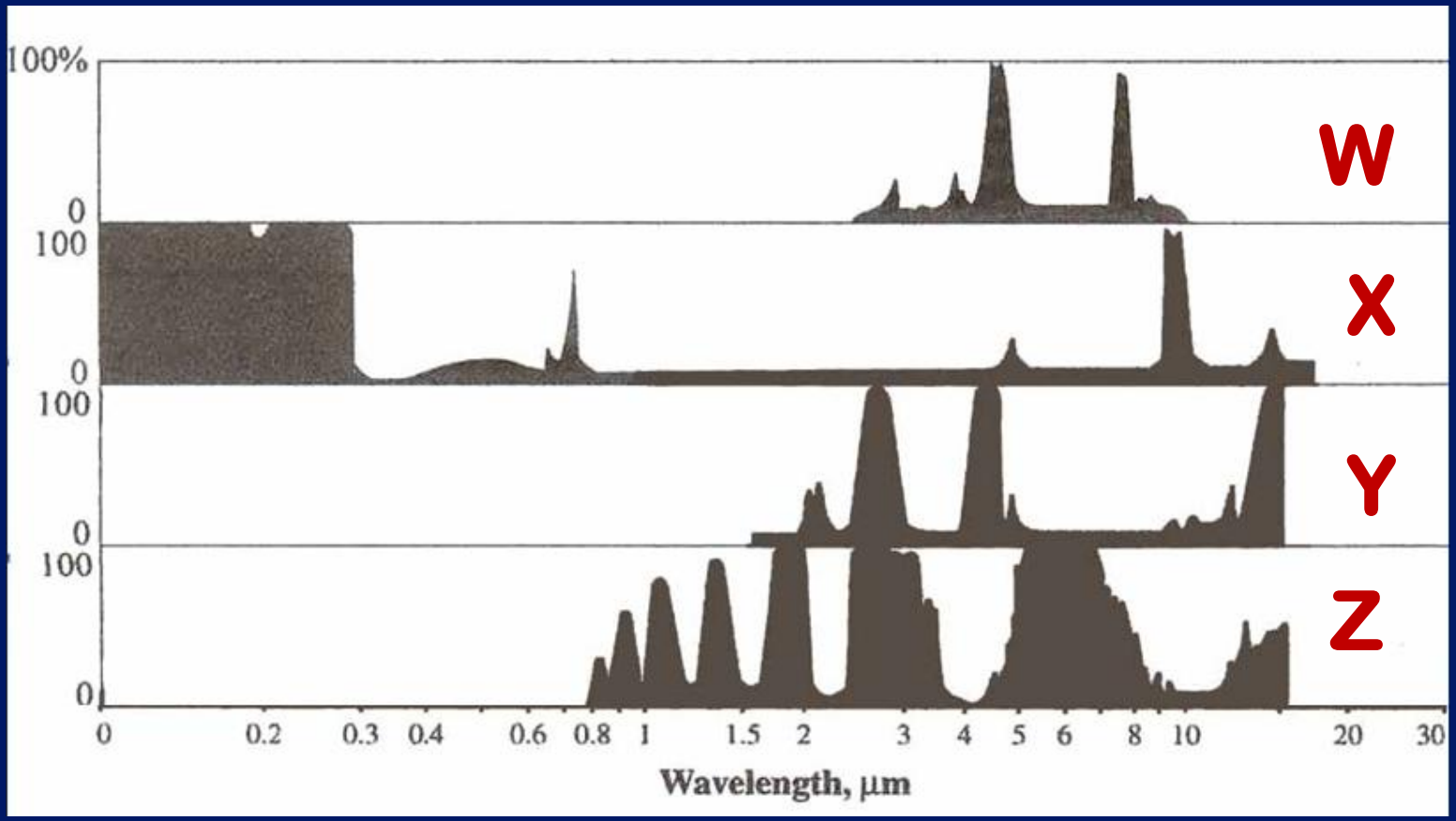
Q-B – Which of the following absorption curves is for a GAS that is NOT a greenhouse gas!

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

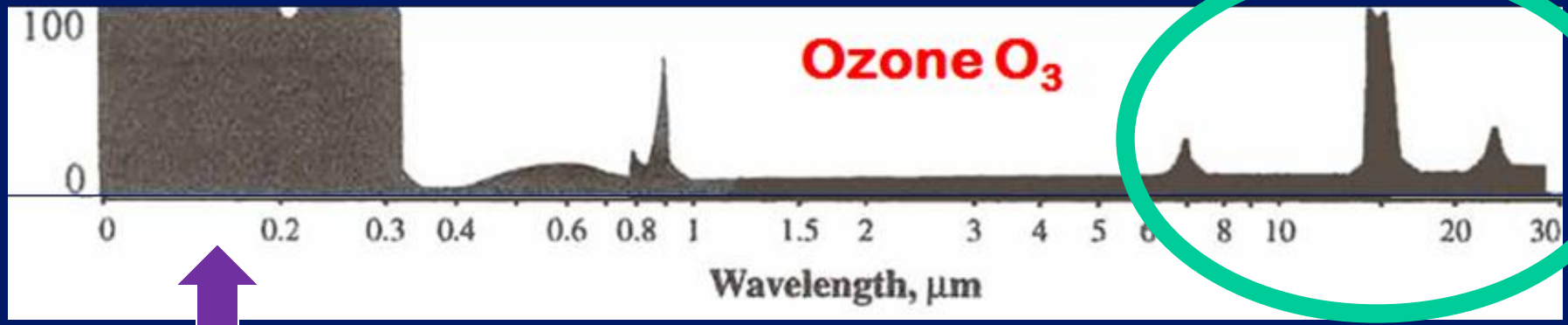


Q-B – Which of the following absorption curves is for a GAS that is NOT a greenhouse gas!

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



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



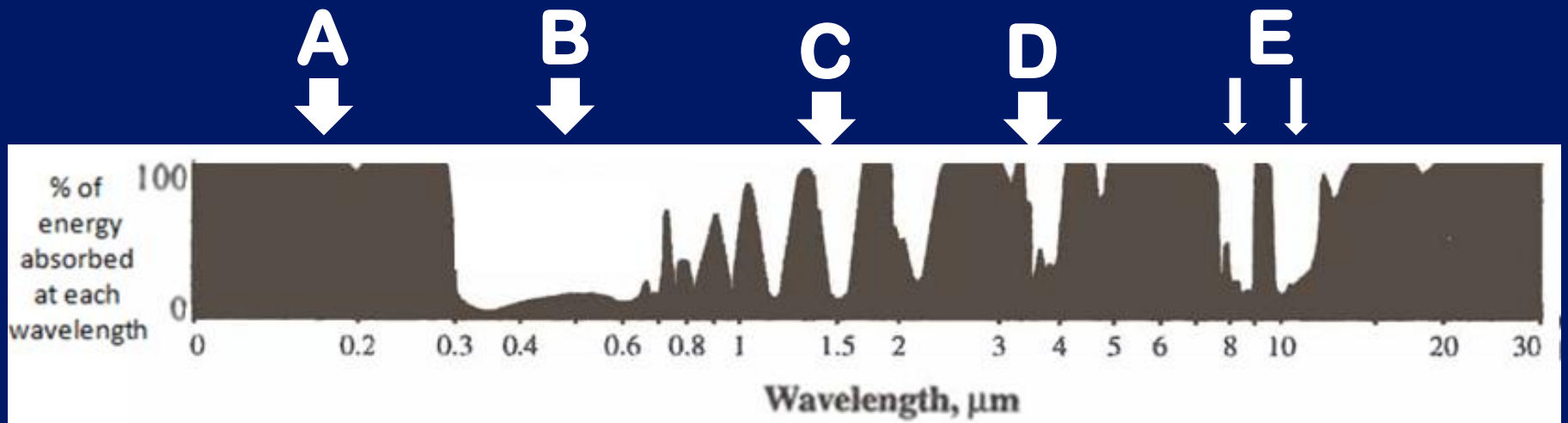
. . . even though OZONE also absorbs radiation in the UV part of the spectrum!

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

Last class we 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**

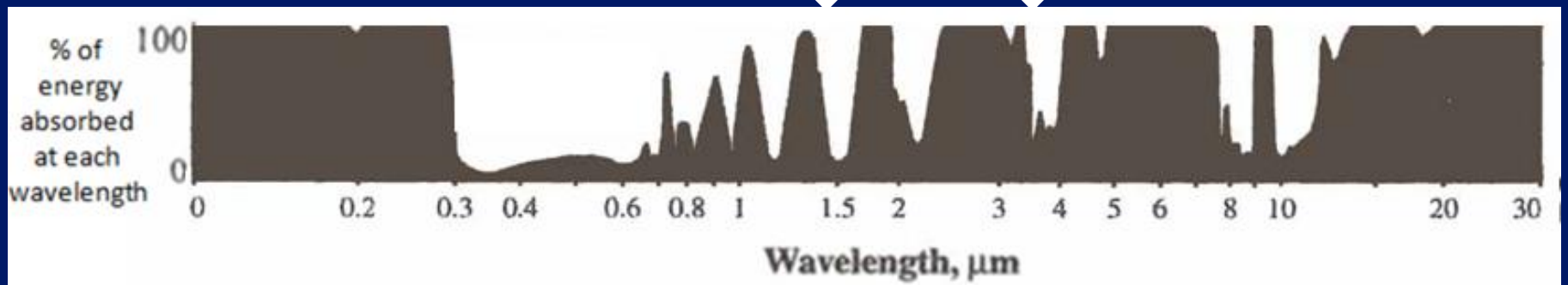


Q-C - Here's the absorption curve for ALL the gases in the atmosphere put together, i.e. curve for the **"Whole Atmosphere"**

Last week we 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.

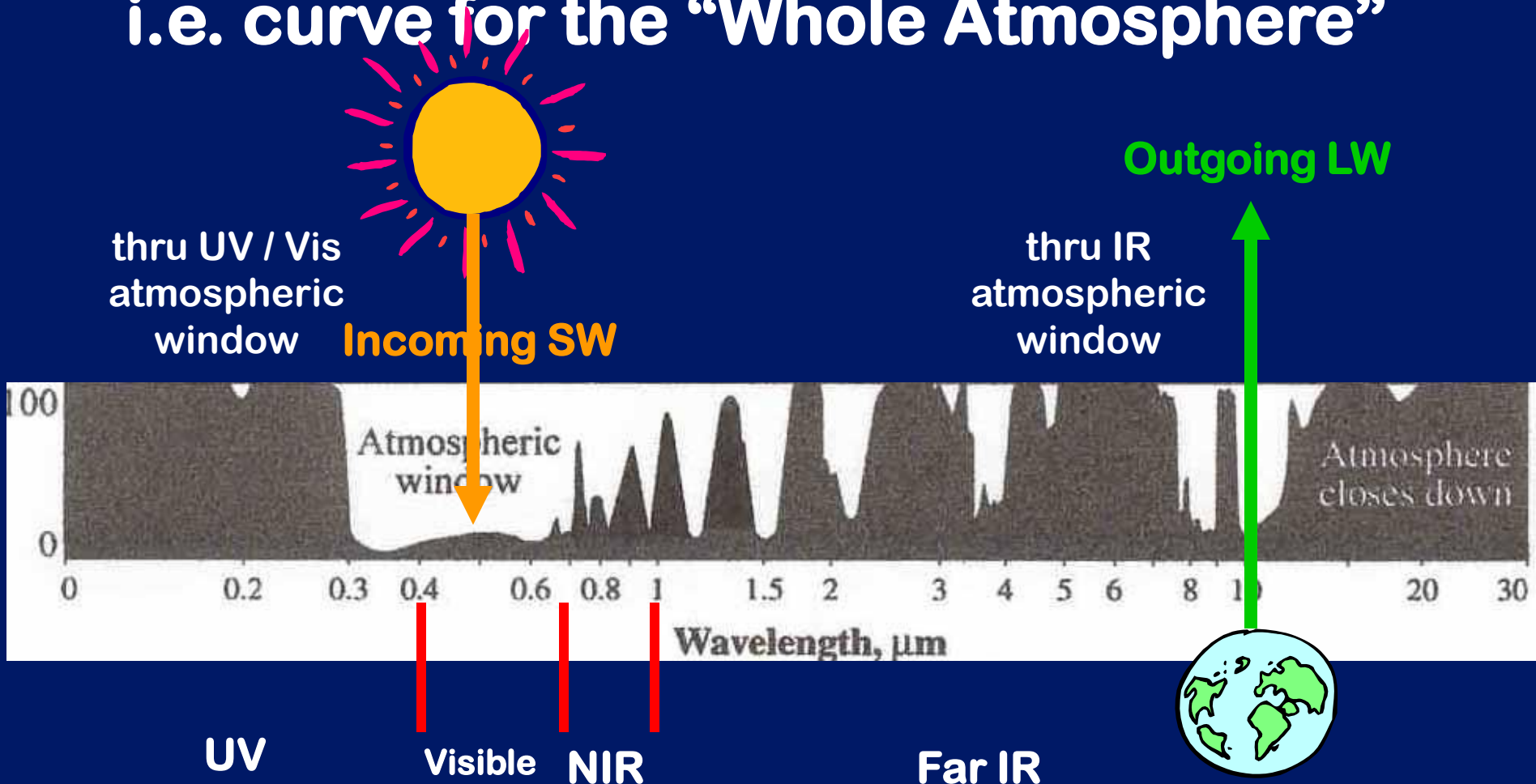
Where are these two windows?

1: A + B **2: B + E** **3: C & D** **4: D + E**



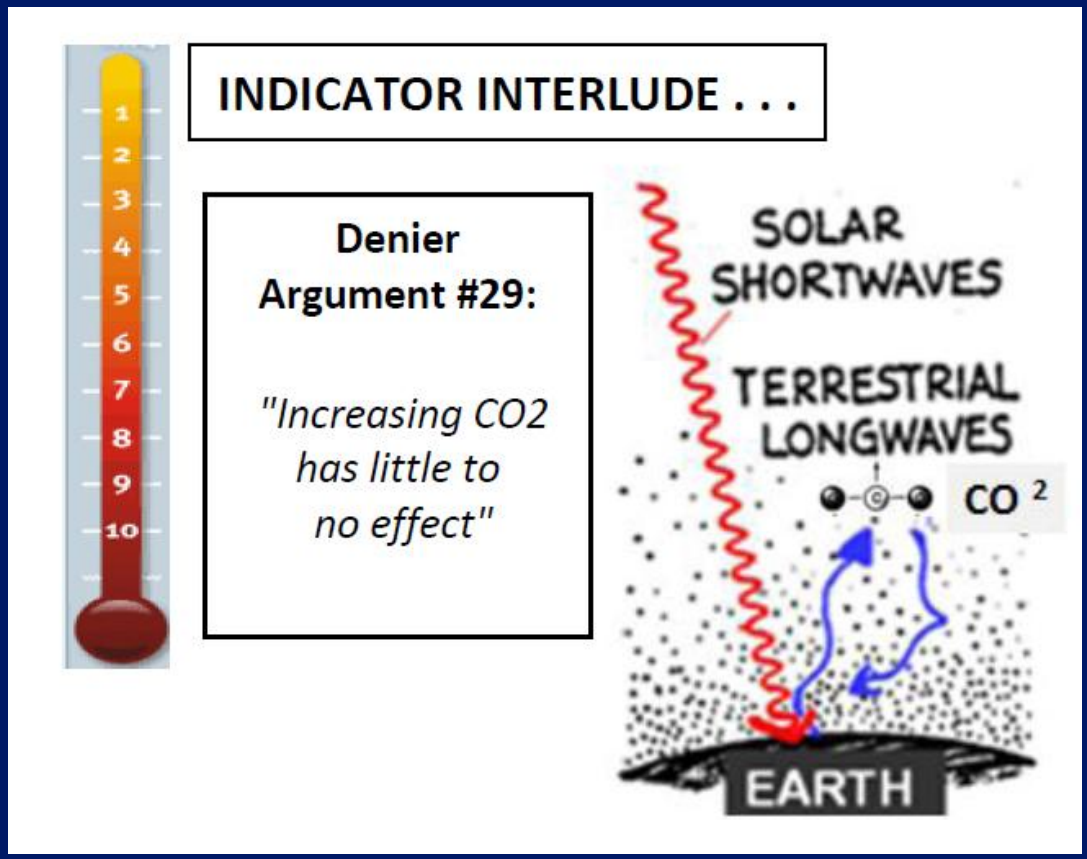
Absorption by ALL the gases in the atmosphere put together –

i.e. curve for the "Whole Atmosphere"



Bottom row p 38

Then Dr H asked students to respond to this argument. Two students did and got bonus points!



How would you respond?

Skeptical Science
Getting skeptical about global warming skepticism

www.skepticalscience.com

How do we know more CO2 is causing warming?

The skeptic argument...

Increasing CO2 has little to no effect
'While major green house gas H2O substantially warms the Earth, minor green house gases such as CO2 have little effect.... The 6-fold increase in hydrocarbon use since 1940 has had no noticeable effect on atmospheric temperature.' (Environmental Effects of Increased Atmospheric Carbon Dioxide)

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

How would you respond?

"Thinking more deeply" symbol ➔

SUMMARY OF KEY POINTS

a) The frequency & wavelength of a photon absorbed by a given electron, atom, molecule will be the same as the frequency/wavelength with which it is emitted.

b) O_3 (ozone) selectively absorbs ultraviolet (UV) radiation at wavelengths < ~ 0.3 μm
This is how the ozone layer in the stratosphere protects us from harmful, high energy radiation.

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!

d) The IR absorbed in the atmosphere by the GHG's can also be emitted upward to outer space, where it will be lost from the Earth-Atmosphere system altogether.

e) CO_2 is a triatomic molecule, and one way that CO_2 vibrates is in a "bending mode" that has a frequency that allows CO_2 to absorb IR radiation at wavelengths of 2.5 - 3.0 μm, at ~ 4 μm, and especially at a wavelength of about 15 μm. (the "15 μm CO_2 band")

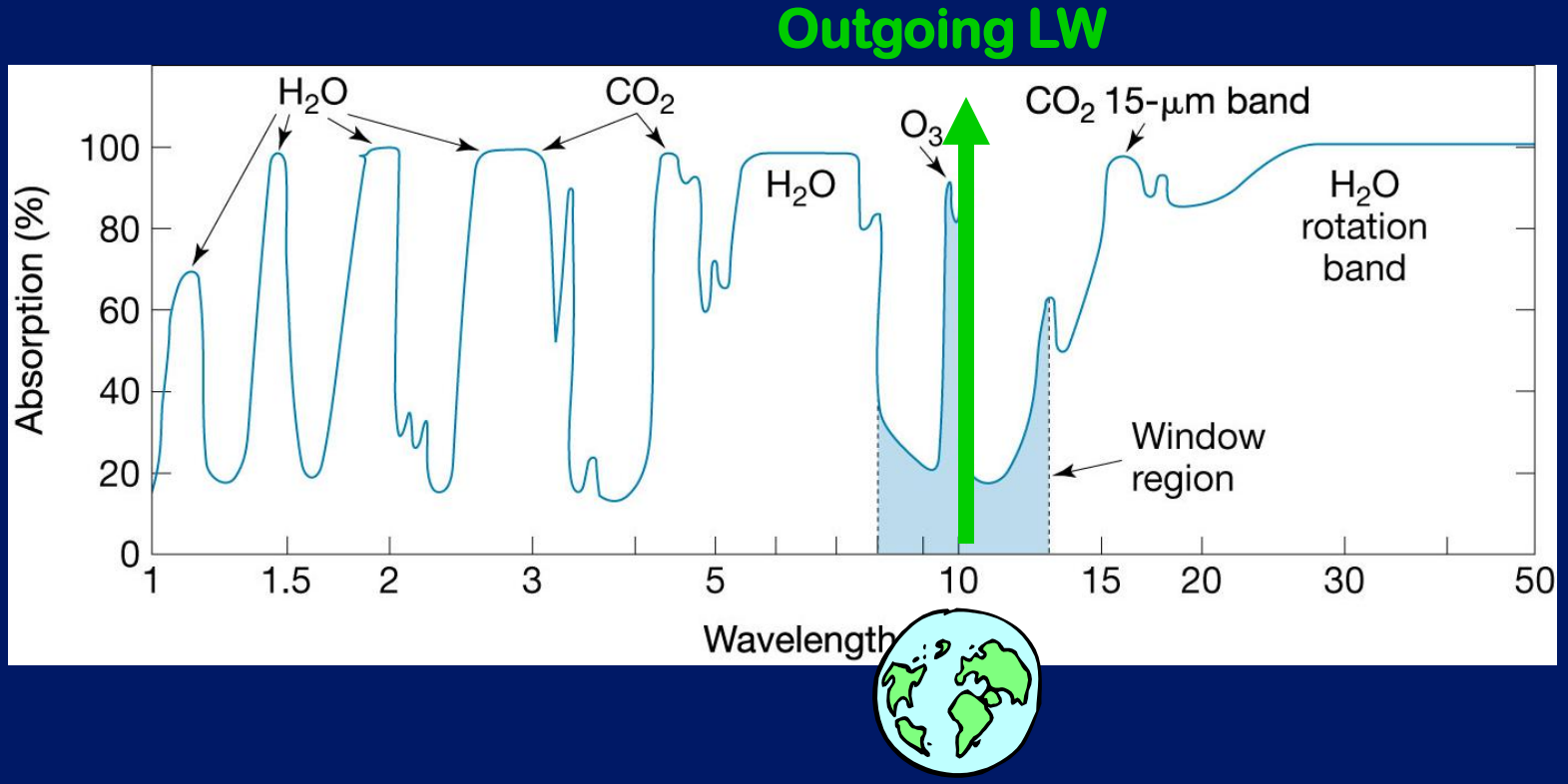
f) Since 15 μm is close to the peak of Earth's outgoing radiation, (10 μm), this absorption band keeps a lot of Earth's longwave radiation from escaping to space.

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

(a) the number of molecules of gas &

(b) the intensity of radiation of that wavelength.

➔ A gas has the most effect if it absorbs in a "window" of wavelengths where the atmosphere is fairly transparent:



H2O, CO2, and O3 are all close to the IR window – but is there enough volume of these "trace gases" to make a difference in temperature? Is the effect measurable??

Skeptical Science
Getting skeptical about global warming skepticism

RESPONSE:

- An enhanced greenhouse effect from CO2 has been confirmed by multiple lines of empirical evidence.

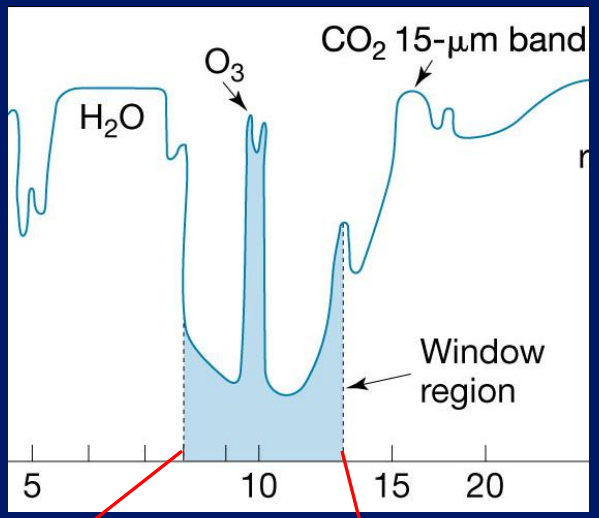
- Satellite measurements of infrared spectra over the past 40 years observe less energy escaping to space at the wavelengths associated with CO2.

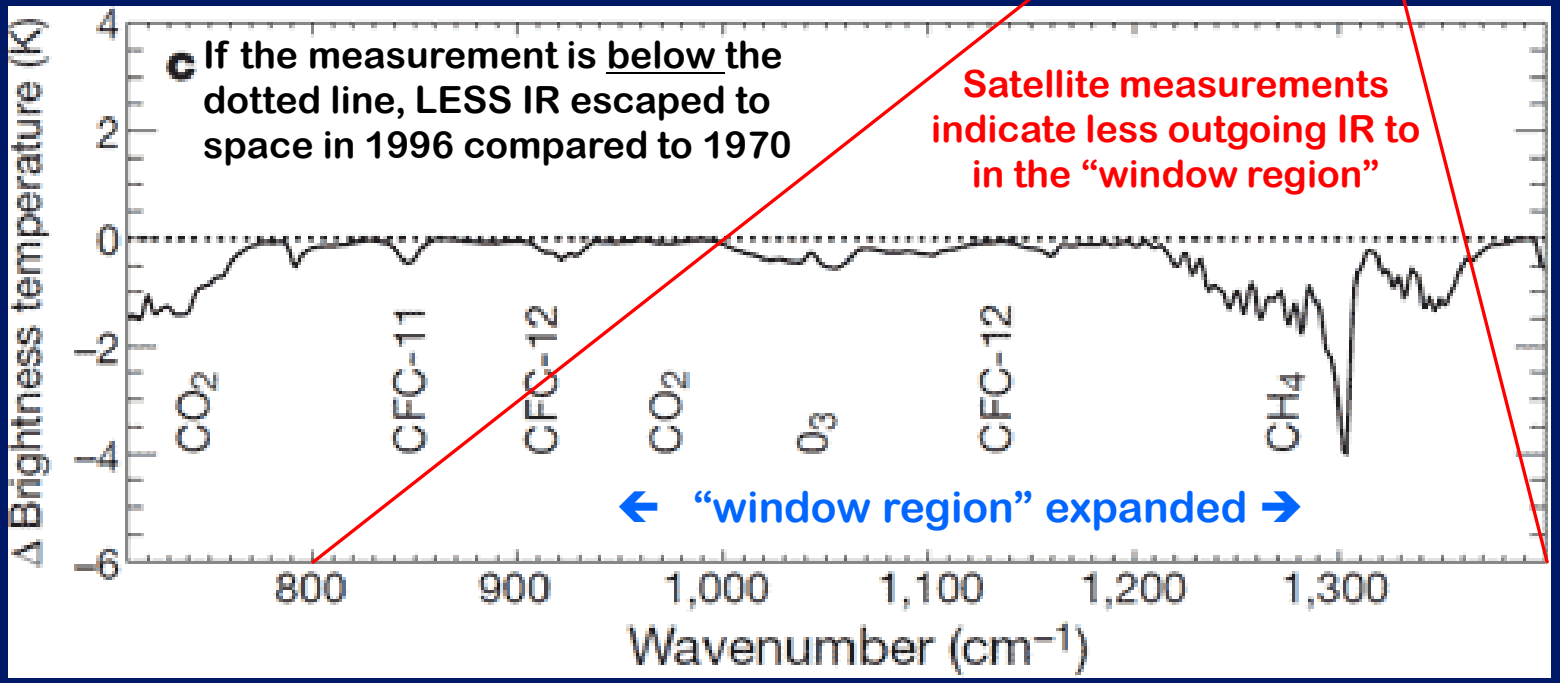
- Surface measurements find more downward infrared radiation warming the planet's surface.

- This provides a direct, empirical causal link between CO2 and global warming.

What they found was a drop in **OUTGOING RADIATION** at the wavelength bands that greenhouse gases such as carbon dioxide (CO_2) and methane (CH_4) absorb energy.

This change in outgoing radiation is consistent with theoretical expectations. Thus the paper found *"direct experimental evidence for a significant increase in the Earth's greenhouse effect"*.





Change in outgoing IR from 1970 to 1996 due to trace gases

Then we started a new topic:

Topic # 7
ATMOSPHERIC STRUCTURE
&
CHEMICAL COMPOSITION

All about the GASES IN THE ATMOSPHERE, esp. GREENHOUSE GASES!

Class Notes pp 39- 44

OBJECTIVES:

To understand:

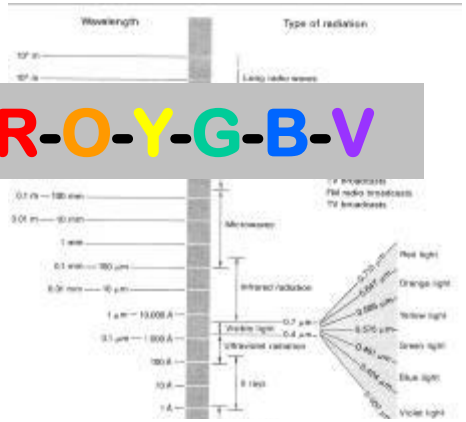
-- the VERTICALSTRUCTURE of the atmosphere & its relationship to temperature

-- which GASES are in the atmosphere

-- where they are concentrated, and

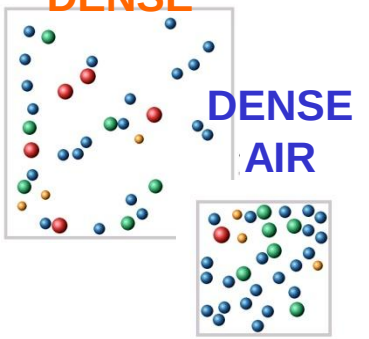
-- why gases at different levels are linked to the Greenhouse Effect & Ozone Depletion

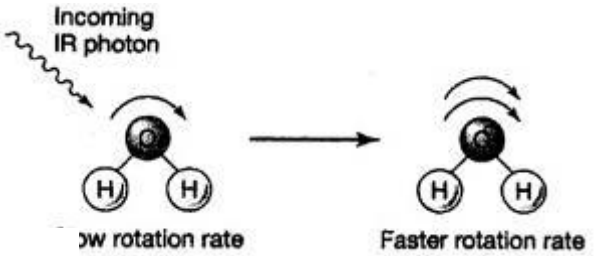
Things you've seen before that will all come together under this topic:

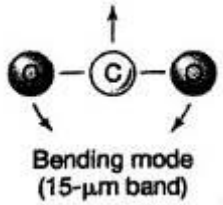


R-O-Y-G-B-V

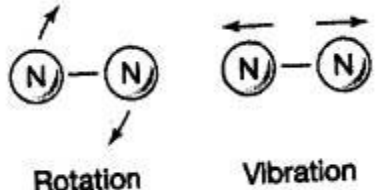
$$E = \sigma T^4$$

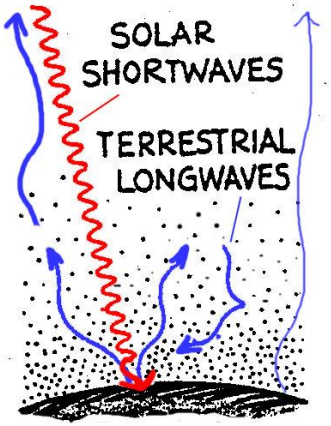


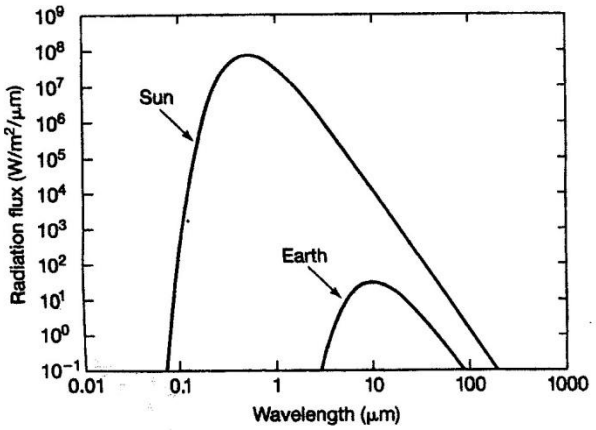


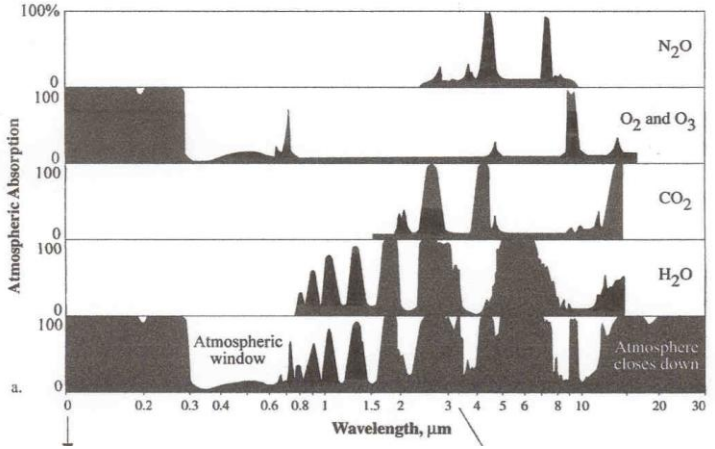


$$E = h c / \lambda$$









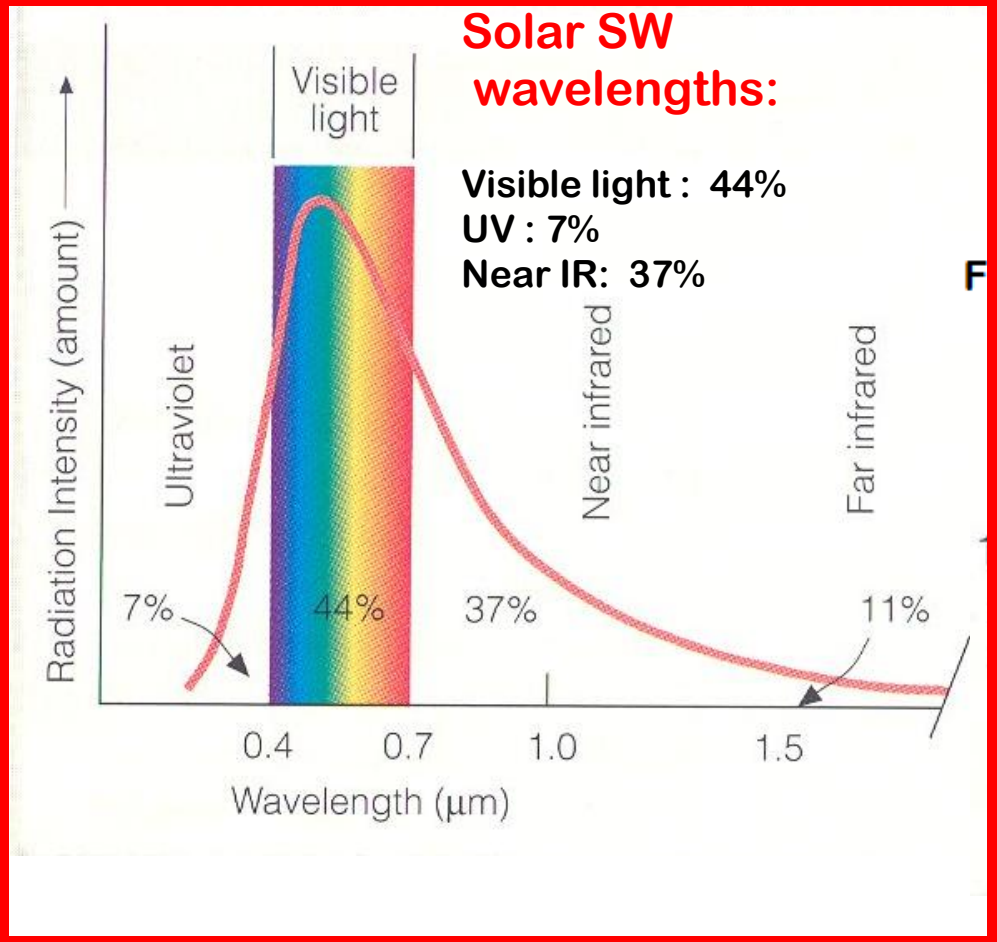
$$\lambda_m = a / T$$

We travel together, passengers in a little space-ship, dependent on its vulnerable supplies of air and soil.

~ Adlai Stevenson

Recall . . . .

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

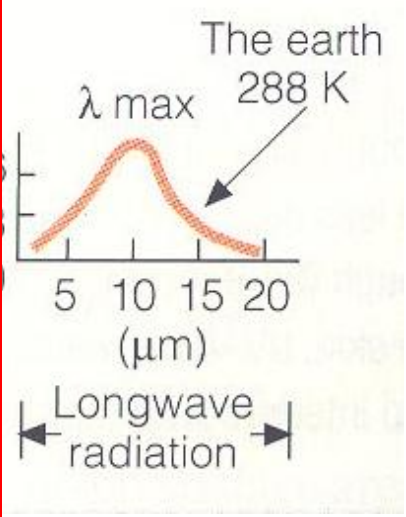


Solar SW wavelengths:

Visible light : 44%
UV : 7%
Near IR: 37%

Terrestrial (Earth) radiation wavelengths:

F r IR, with a maximum at ~ 10 μm

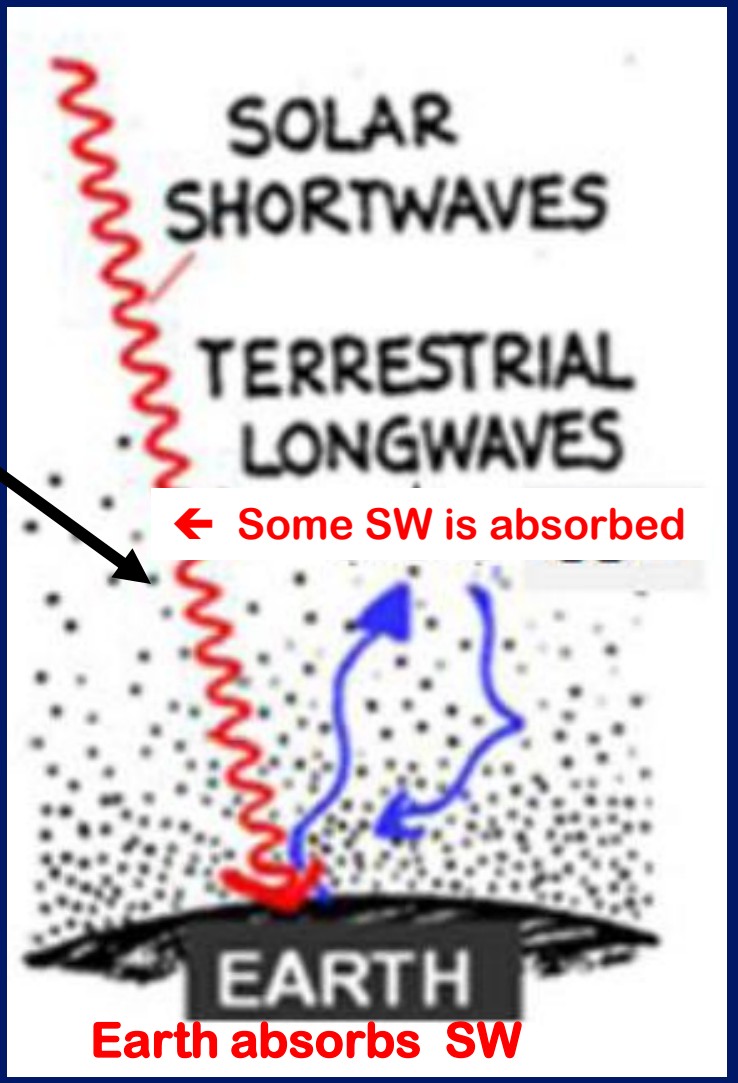


Review p 34

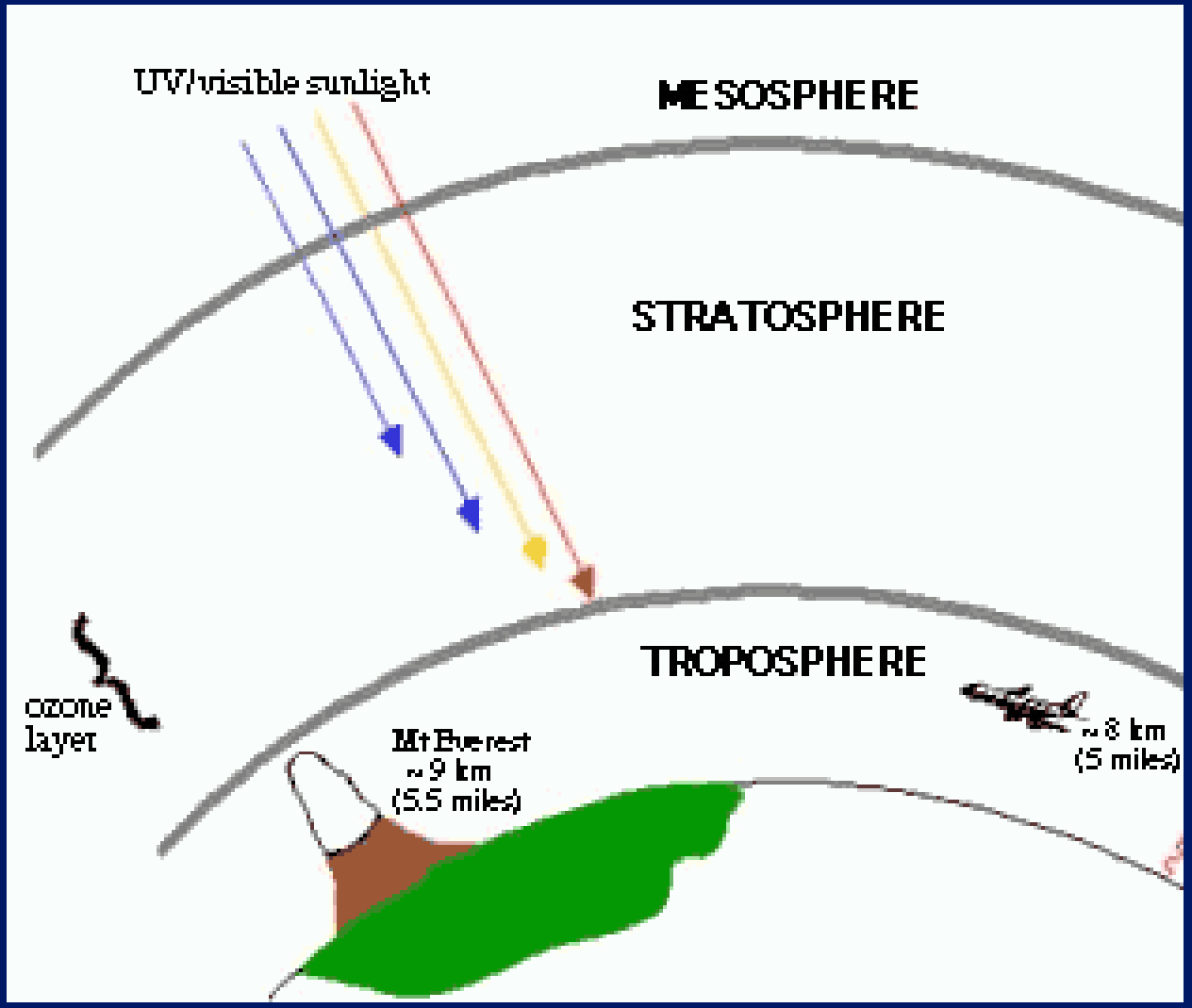
How do we correct the depiction of incoming SW?

Some SW gets absorbed on its way down to the surface!

(in addition to terrestrial LW (IR) radiation being absorbed in the GHE)

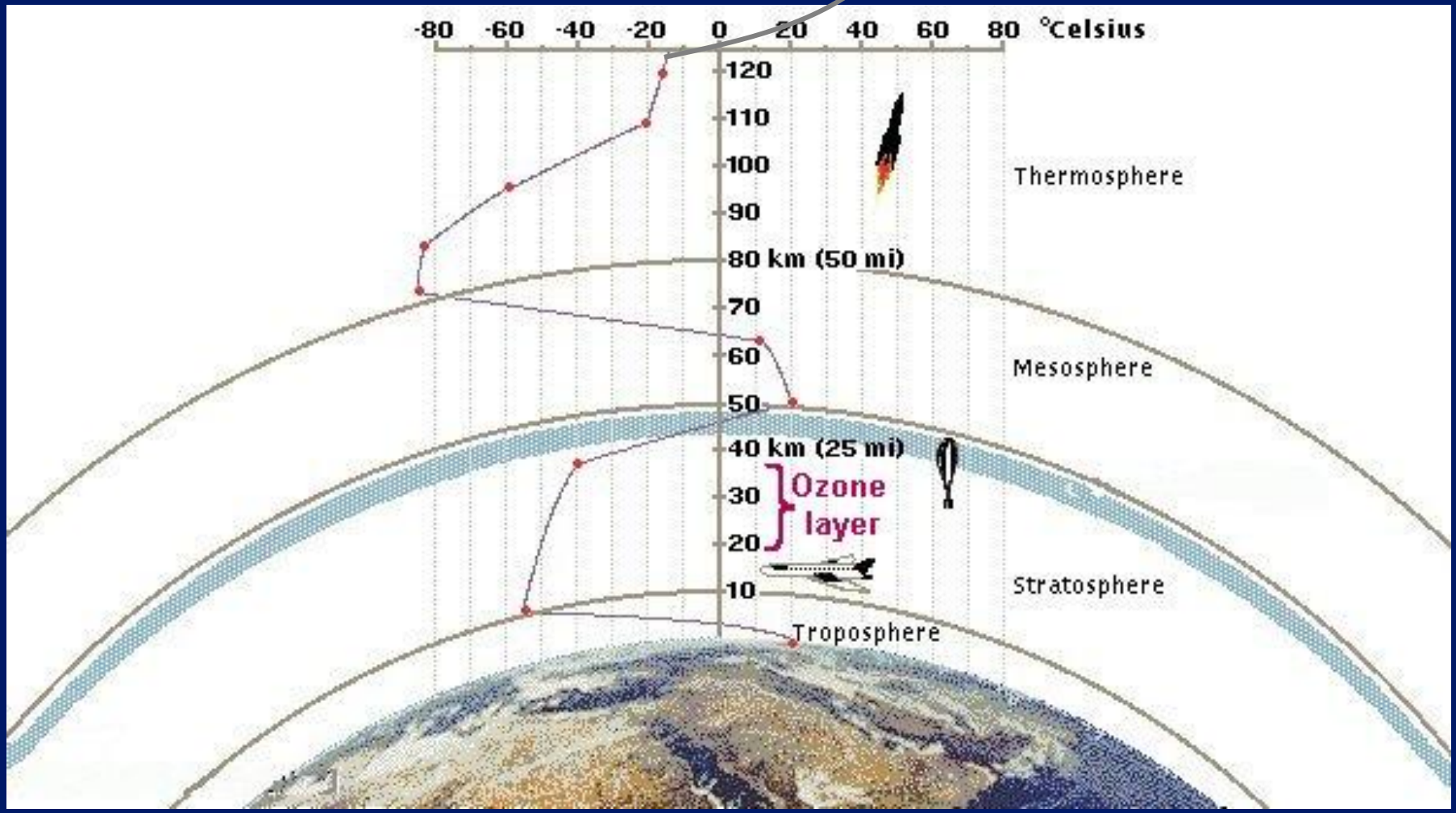


The atmosphere has a "structure" of different named layers . . . .



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

These layers have different thicknesses and temperatures. . . Most everything WE have experienced is in the lowest layer, the TROPOSPHERE



The Vertical Structure of the Atmosphere

KEY CONCEPT:

The atmosphere's vertical structure is defined by CHANGES in the trend of TEMPERATURE with height.

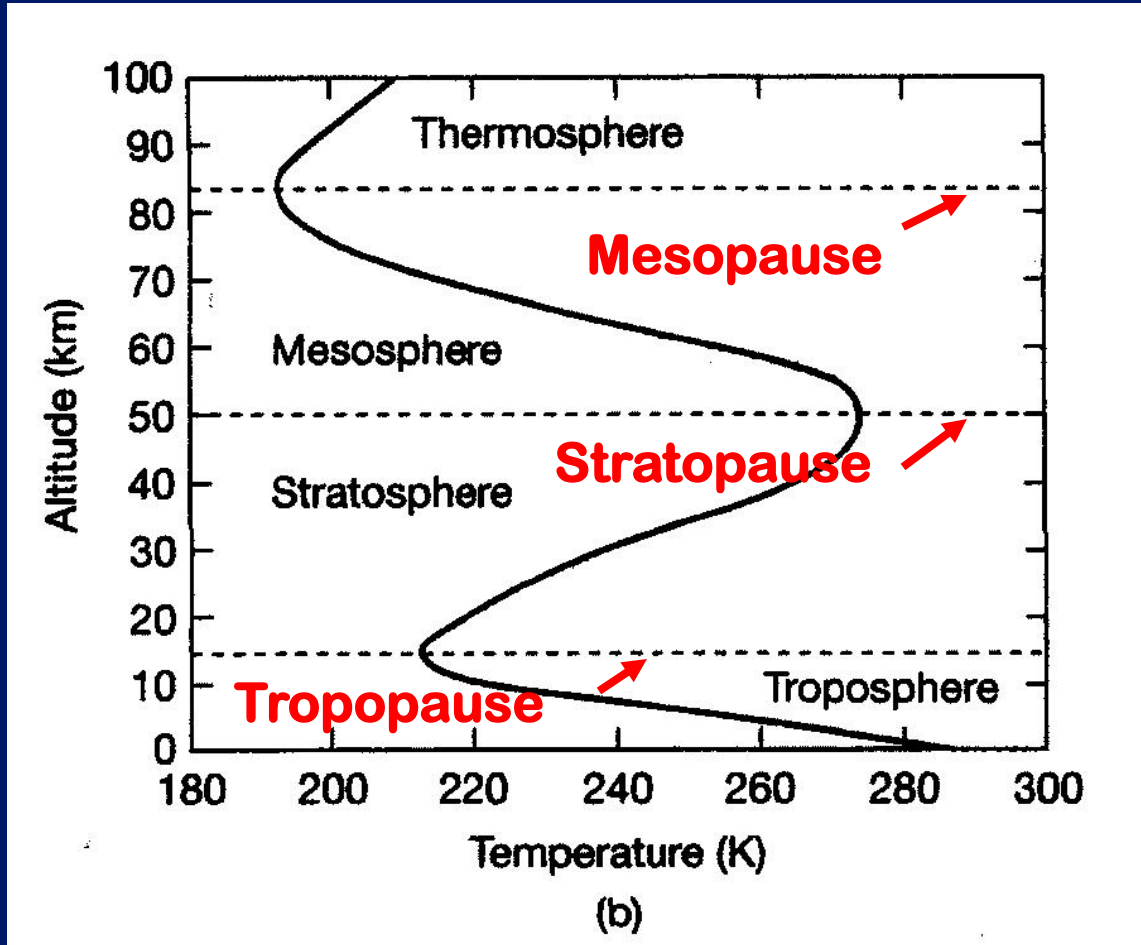


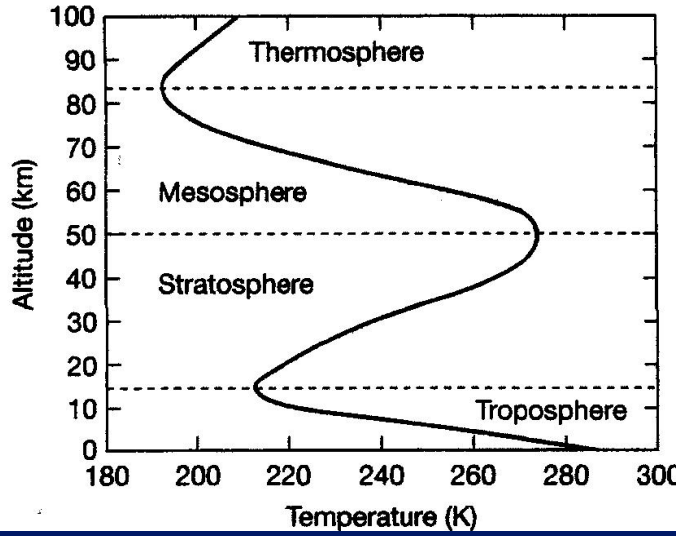
Figure 3-9b in SGC E-text

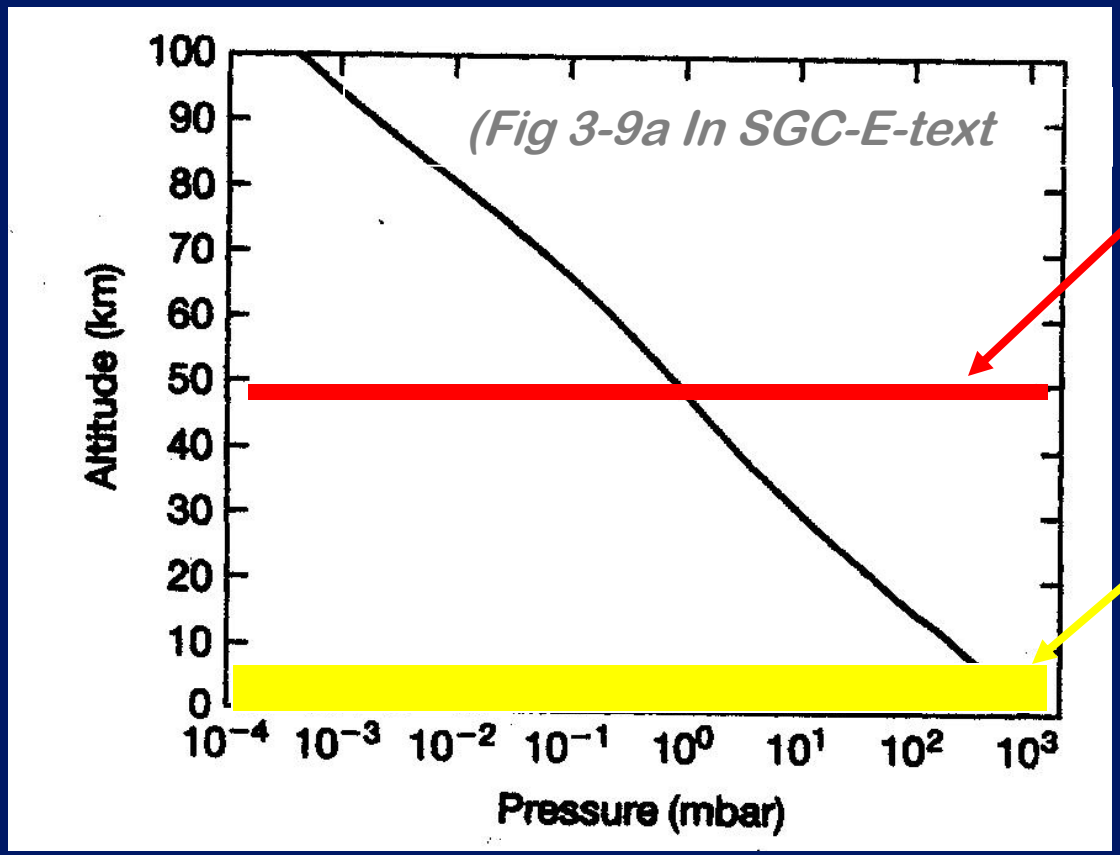
“TRy Sally’s Maroon THermals”

. . . or
think up
your own!

Atmospheric Pressure = weight of the air column above

Atmospheric Pressure & Mass Vary with Height





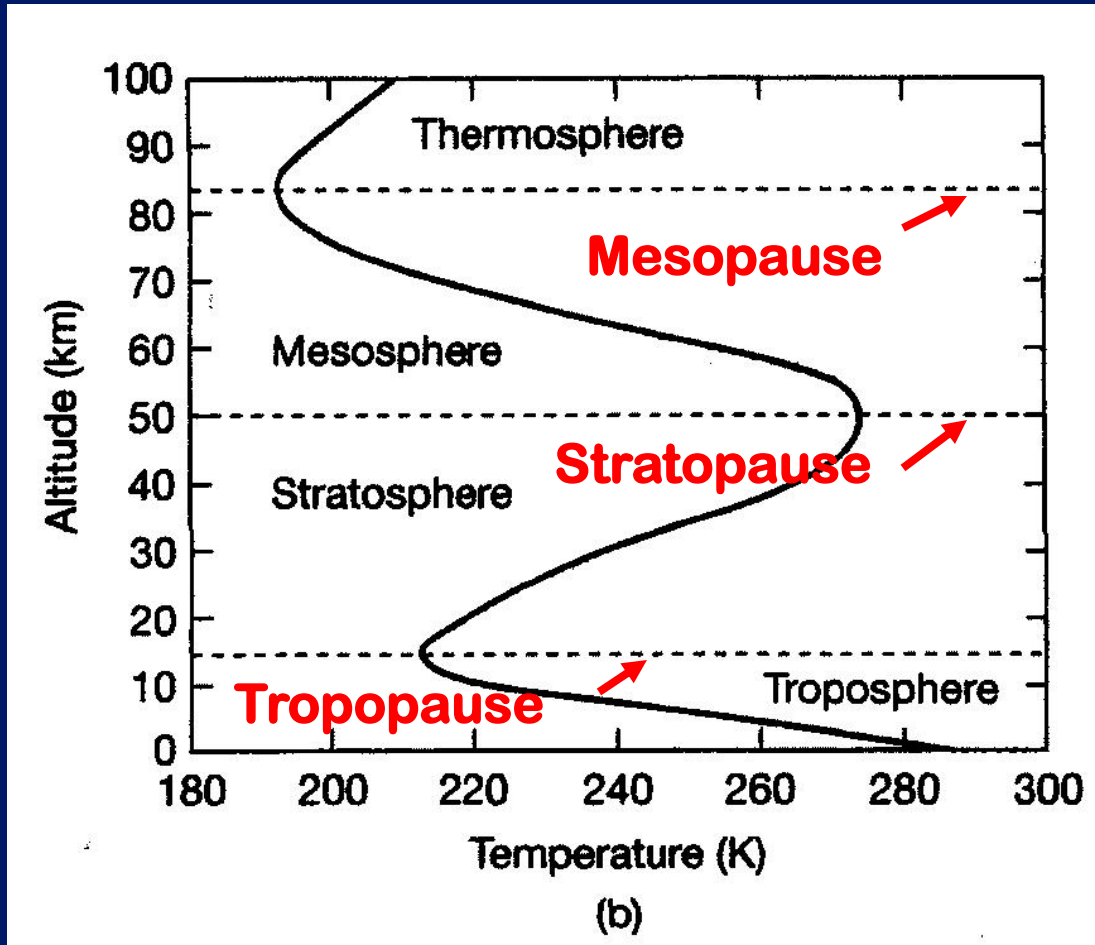
99% of mass lies below ~ 50 km (top of Stratosphere)

50% of mass lies below ~ 6 km (middle Troposphere)

The Vertical Structure of the Atmosphere

Why the zig-zags in the

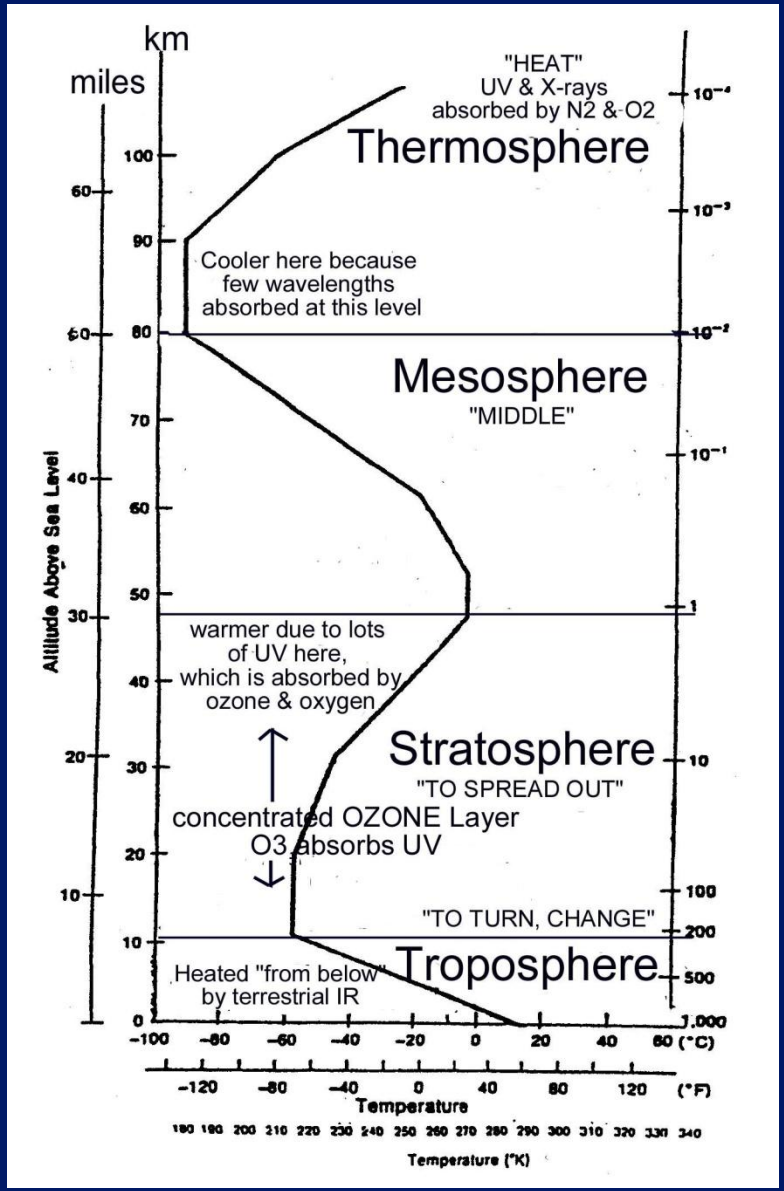
temperature / height graph?



The changes in temperature with height are the result of:

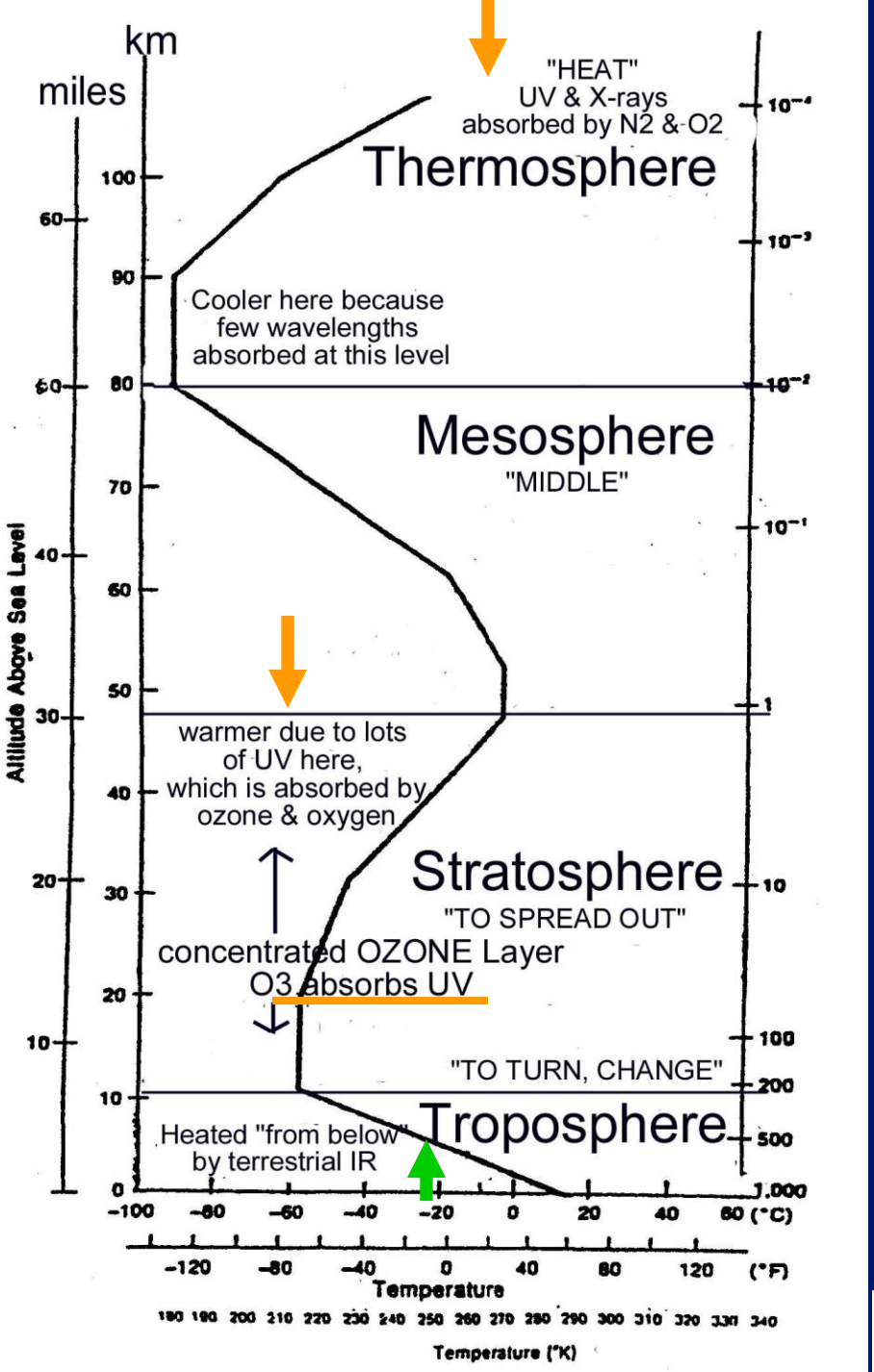
differential absorption of shortwave (SW) & longwave (LW) radiation

by atmospheric GASES concentrated at various altitudes.

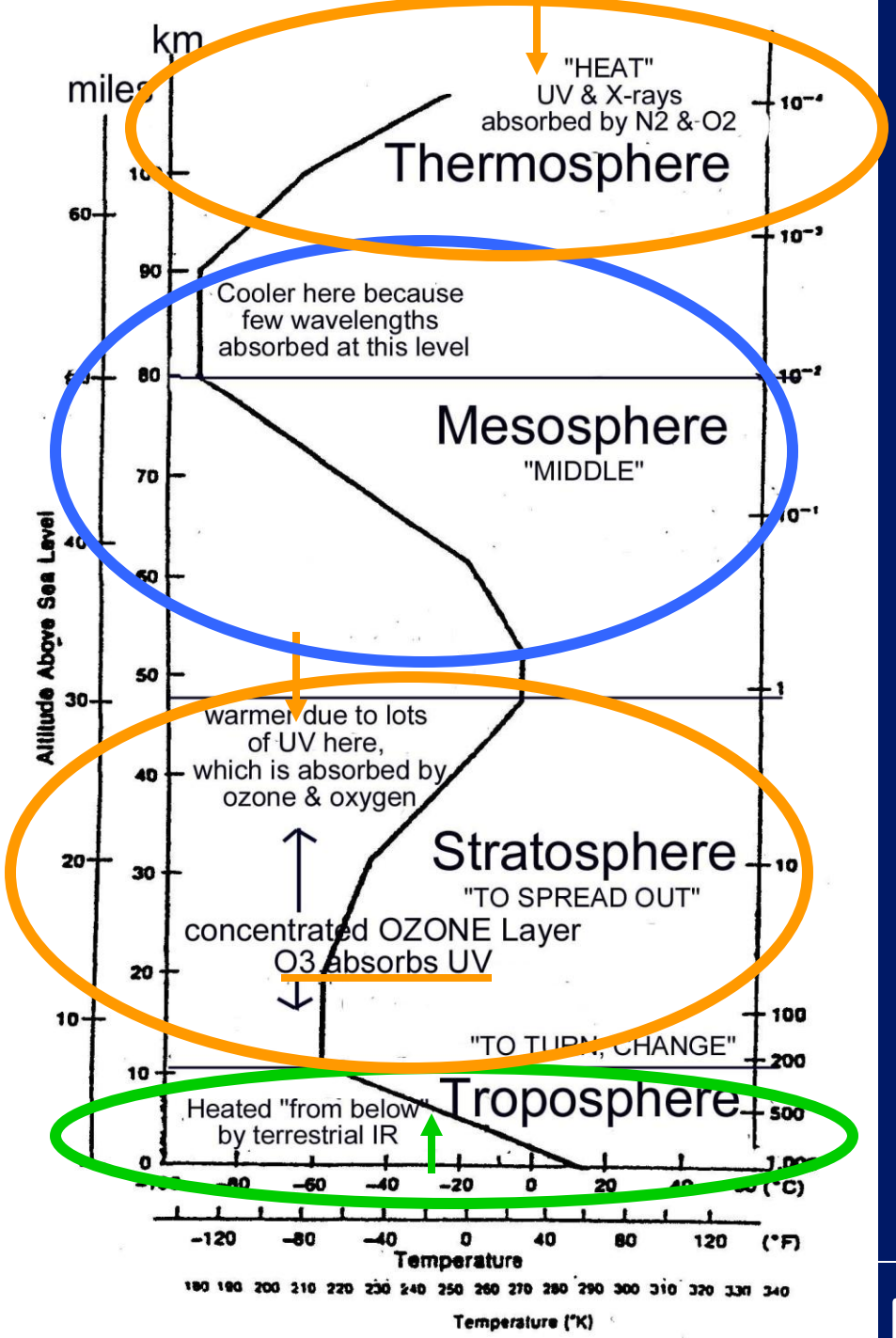


Incoming solar SW (mostly visible & near IR + UV)

Outgoing terrestrial LW (Far IR) radiated from Earth's surface

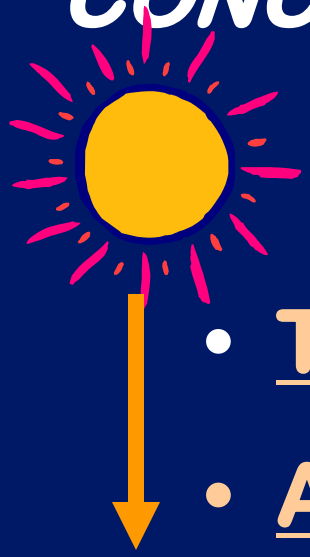


Here's why these changes in **temperature** occur ➔



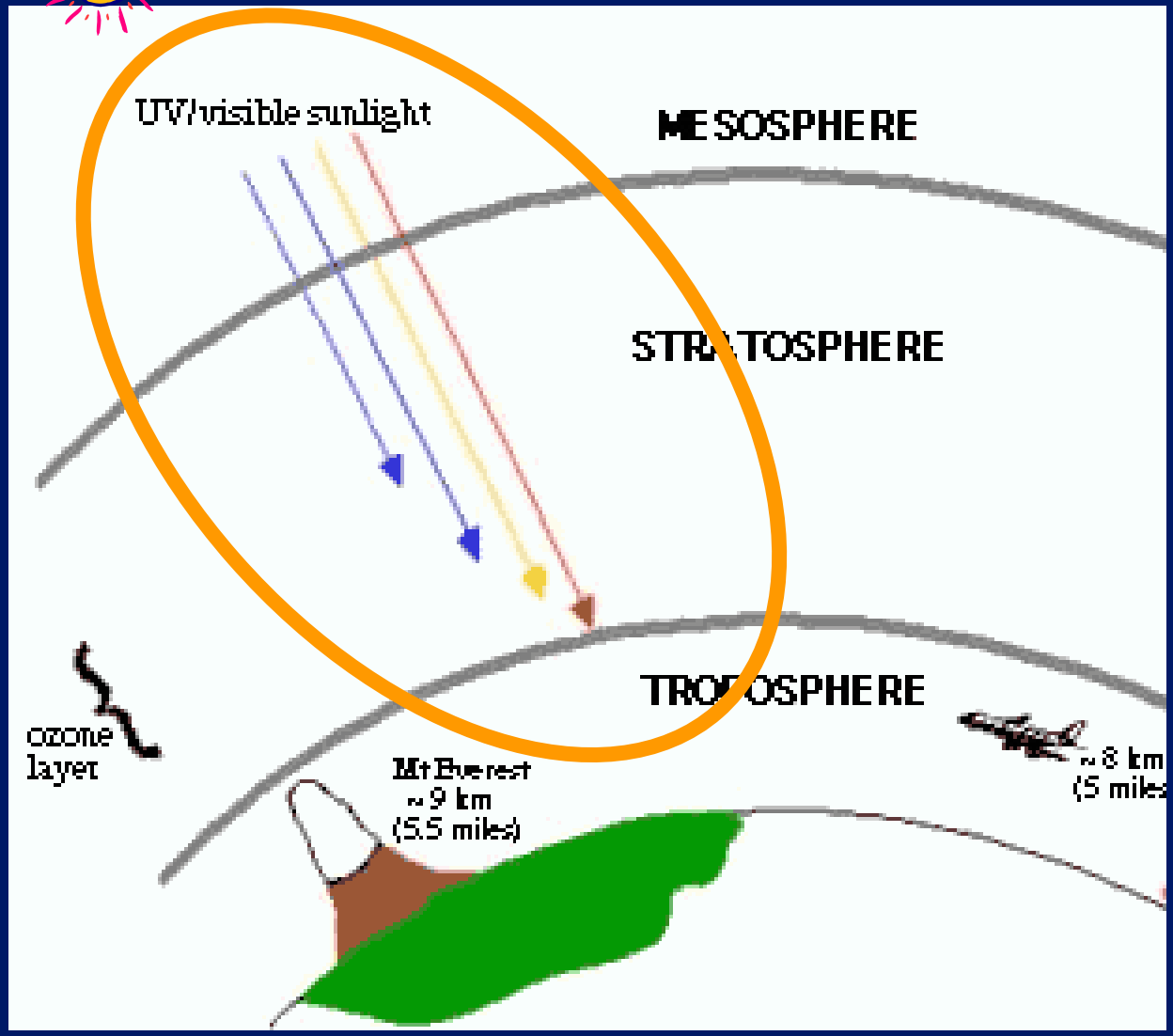
KEY CONCEPT:

On its way to the Earth's surface, several things can happen to incoming SOLAR RADIATION:



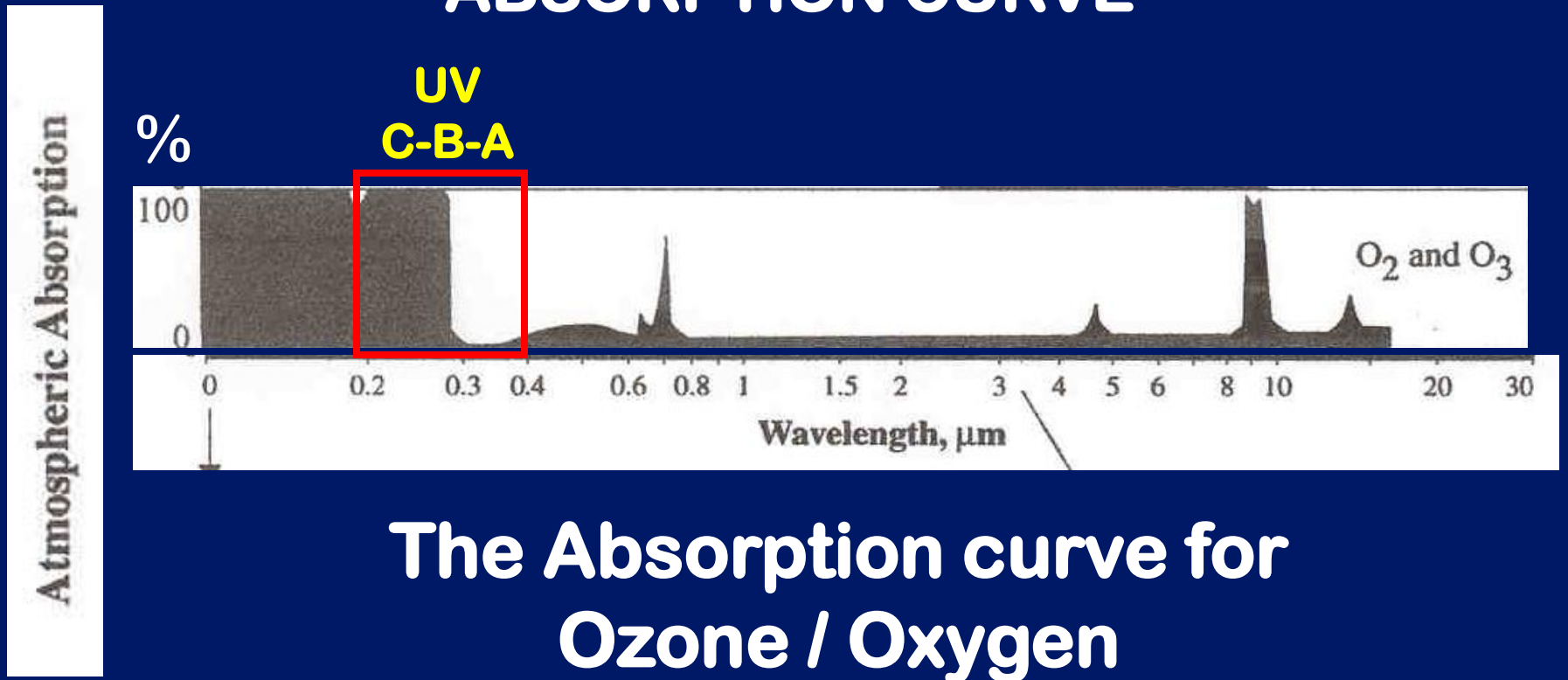
- **TRANSMITTED (to Earth's surface)**
- **ABSORBED (by gases, dust, clouds)**
- **SCATTERED / REFLECTED**
  - **Reflected back to space**
  - **Scattered (and indirectly transmitted to Earth's surface)**

Let's look closer at the incoming shortwave (SW) radiation (UV, Visible & "near IR")



REVIEW: The pattern of electromagnetic wavelengths that are **absorbed** & **emitted** by a particular atom (or combination of atoms)

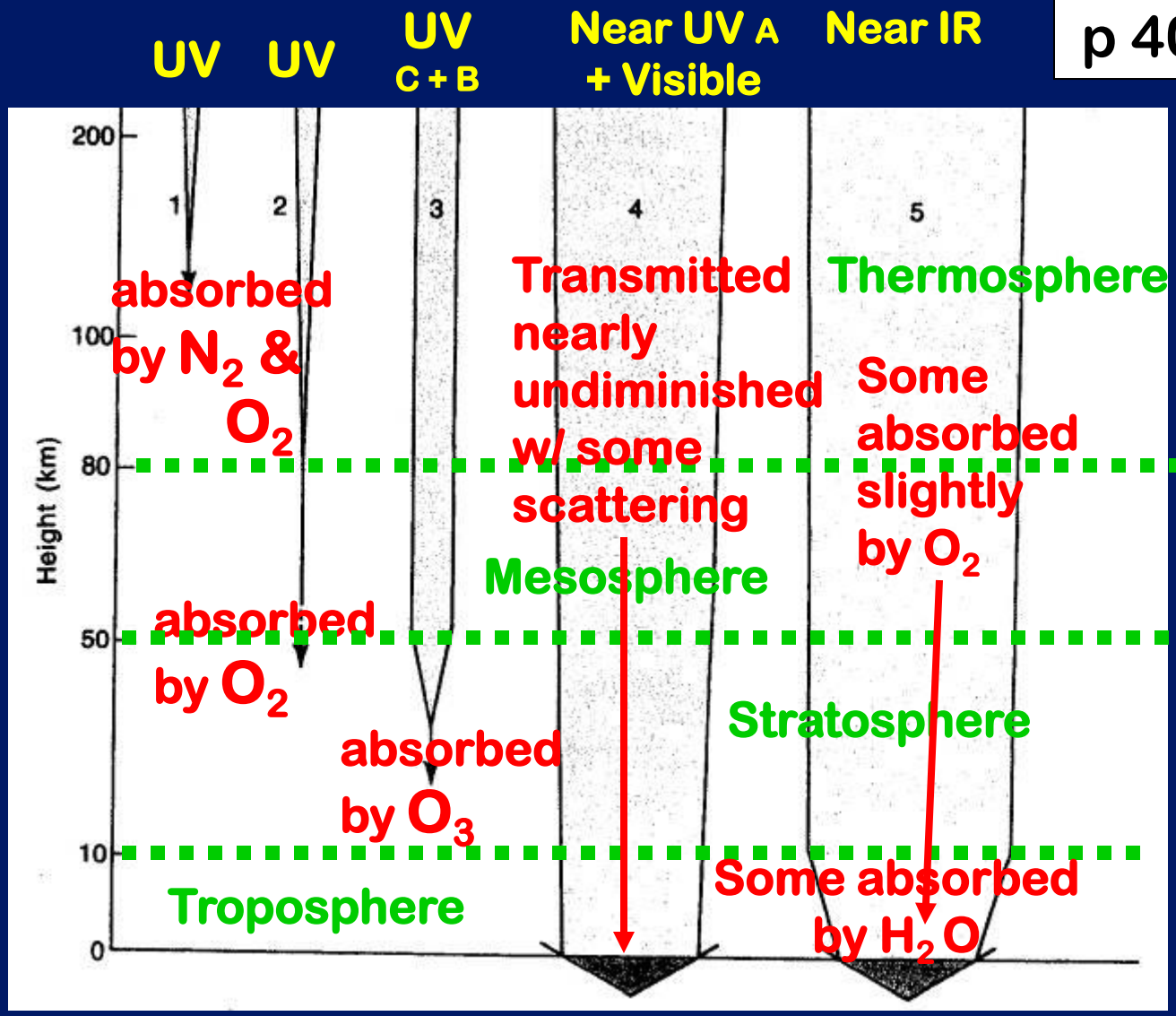
is called its ABSORPTION SPECTRUM or its ABSORPTION CURVE



The Absorption curve for Ozone / Oxygen

UV rays < .32 µm very harmful to life on Earth arrows 1, 2 + 3

How incoming SOLAR radiation of different wavelengths gets TRANSMITTED or ABSORBED by different gases on its way to the Earth's surface

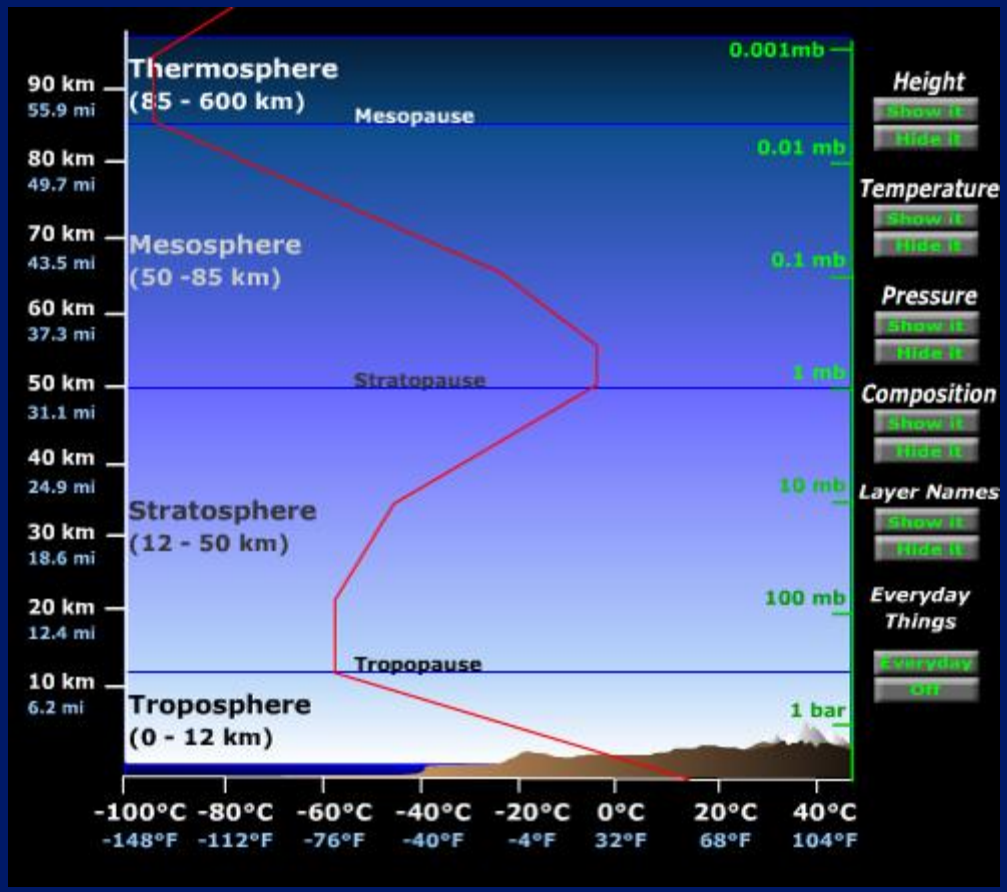


1. UV, $\lambda < 0.12$ µm, absorbed by N_2 and O_2 in upper atmosphere
2. UV, $0.12\ \mu m \leq \lambda < 0.18$ µm absorbed by O_2
3. UV, $0.18\ \mu m \leq \lambda < 0.34$, µm absorbed by O_3 in ozone layer
4. Near UV and visible, $0.34\ \mu m \leq \lambda < 0.7$ µm transmitted nearly undiminished except for scattering
5. Near IR, $0.7\ \mu m \leq \lambda < 3.0$ µm , absorbed slightly by O_2 and in troposphere by H_2O

Reminder: ***Ultraviolet radiation:*** *UVC = 0.20 - 0.29 UVB = 0.29 - 0.32 UVA = 0.32 - 0.40* µm

A nice online review . . .

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



The end of:

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

Thin-film solar panels powering new flexibility in home energy use

Susan Carpenter Los Angeles Times | Posted: Sunday, September 18, 2011 12:00 am

LOS ANGELES - Carl Harberger's 6,000-square-foot house in the Chats-worth neighborhood of Los Angeles is equipped with six refrigerators, five TVs, a smattering of computers and a pool, among other things - enough to draw the wagging finger of the eco-minded, were it not for what Harberger has on his roof.

By the end of the month, the Los Angeles Department of Water & Power is expected to flip the switch on the home's 24-kilowatt installation of thin-film solar panels, bringing to life what is believed to be the largest residential installation of its kind in the country.

The thin-film panels generate about 50 percent less electricity per square foot and cost about 10 percent more than traditional photovoltaic panels, but the flexible film can handle curved surfaces and integrate less obtrusively into a home's silhouette. It's also lighter - an advantage in earthquake country - and unlike bulky bracketed panels, thin film doesn't need to be drilled into the roof, reducing the risk of leaks.

Harberger's installation will power not only his lighting, electronics and air conditioning, but also systems that would traditionally be juiced with natural gas. The thin film will heat all the water for the home and run the forced-air heating system as well as the clothes dryer and oven.

Class ended just as the “Saved by the Sun” video ended!