Meteorology – Lecture 4

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Important notes

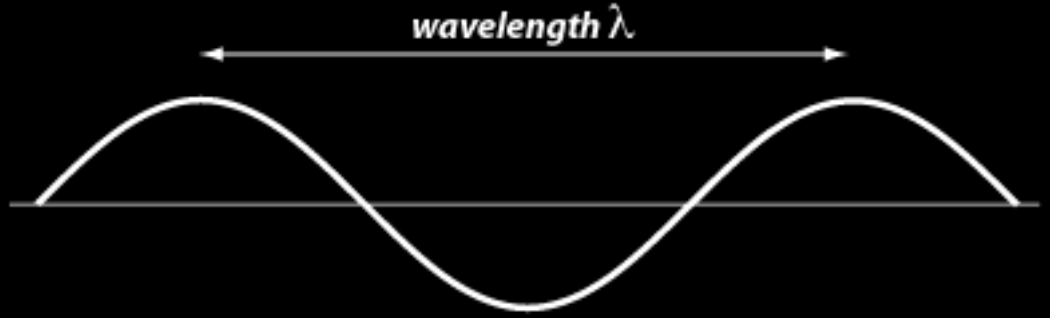
- These slides show some figures and videos prepared by Robert G. Fovell (RGF) for his “Meteorology” course, published by The Great Courses (TGC). Unless otherwise identified, they were created by RGF.
- In some cases, the figures employed in the course video are different from what I present here, but these were the figures I provided to TGC at the time the course was taped.
- These figures are intended to supplement the videos, in order to facilitate understanding of the concepts discussed in the course. *These slide shows cannot, and are not intended to, replace the course itself and are not expected to be understandable in isolation.*
- Accordingly, these presentations do not represent a summary of each lecture, and neither do they contain each lecture’s full content.

Animations linked in the PowerPoint version of these slides may also be found here:

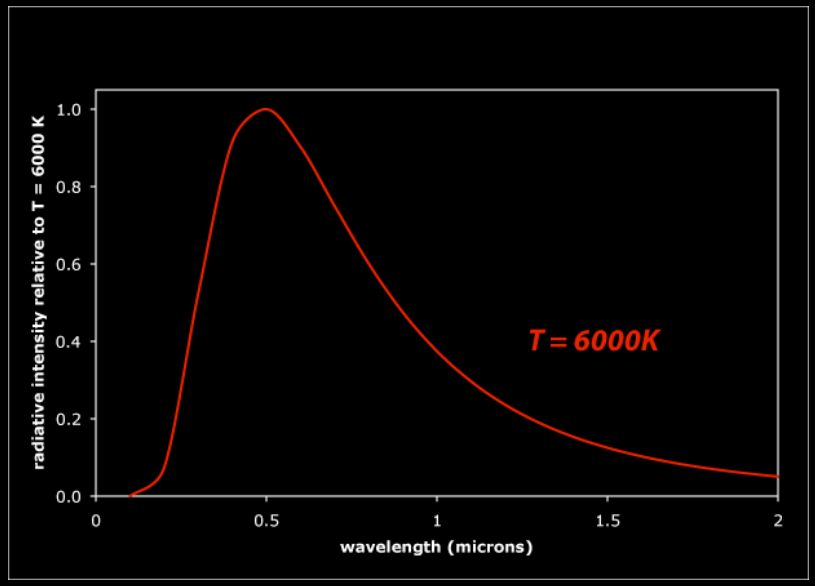
http://people.atmos.ucla.edu/fovell/meteo/

Wavelength

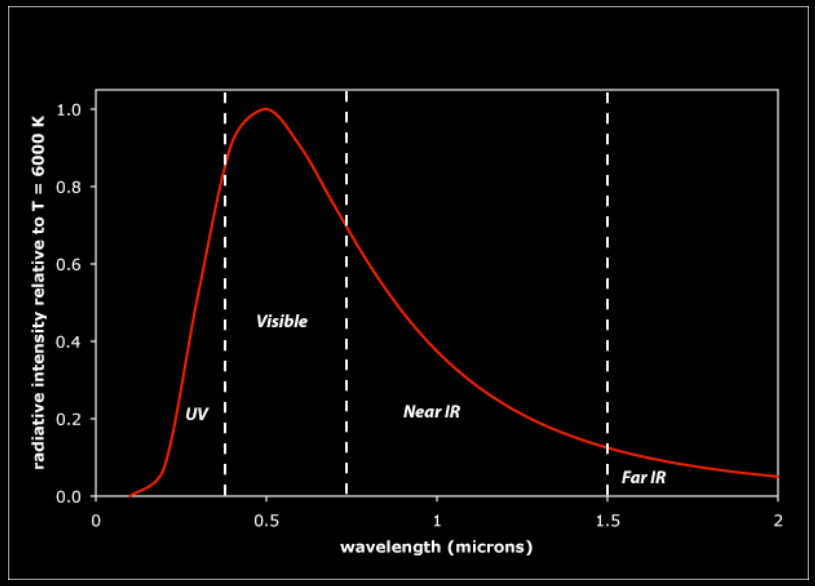
Radiation travels as waves - waves are characterized by wavelength



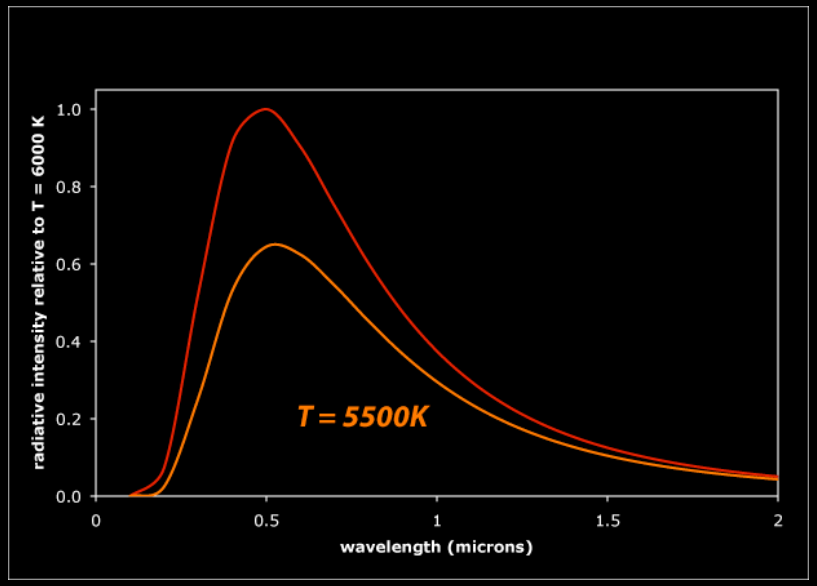
Planck curves



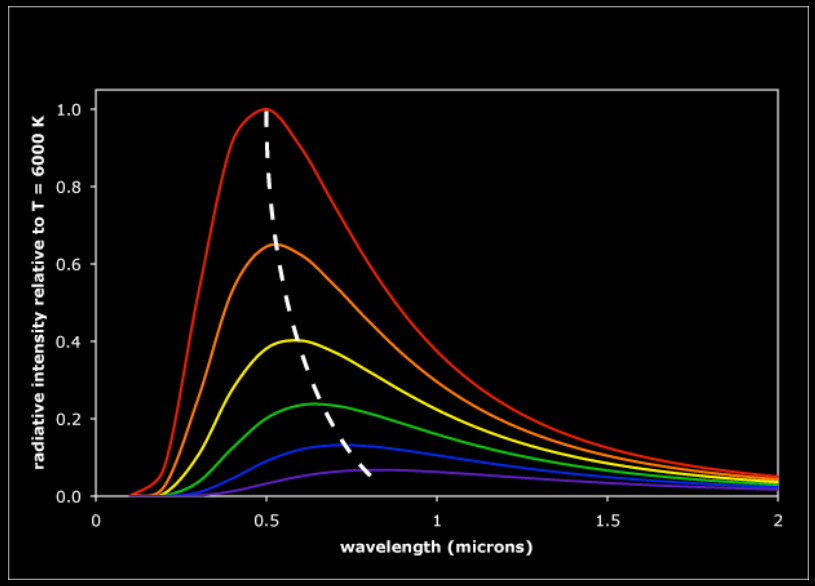
- Planck curve for a 6000K object… approximately Sun's outer surface
- Total radiative energy emitted is AREA under the curve



- Subdivide into our four principal types
- Peak in visible near green/yellow
- Our sun is a yellowish star… reflecting its temperature

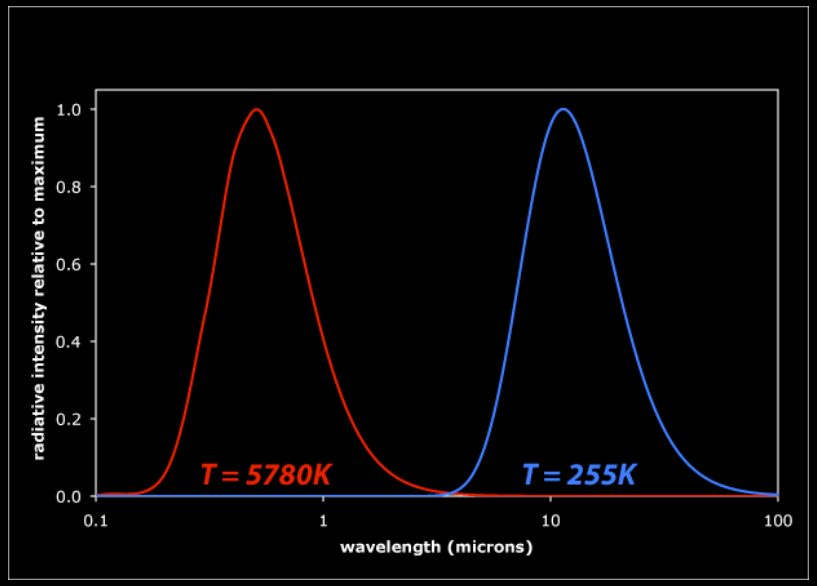


- Planck curve for 500 K cooler object (still hot!)
- Area under curve a lot smaller, illustrating Stefan-Boltzmann law
- Less radiation at EVERY wavelength
- Hard to see, but peak has shifted to right, still in visible but towards red

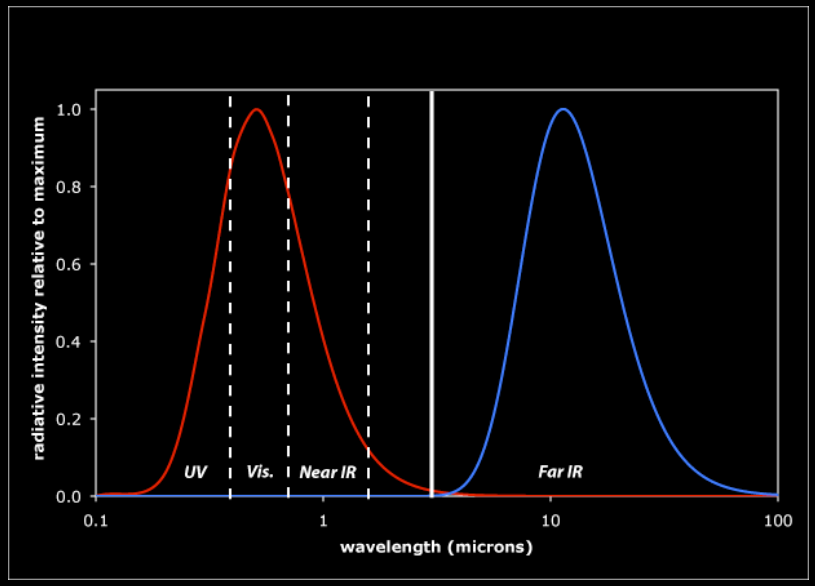


- For progressively colder objects, peak shift to longer wavelength now obvious
- Wien's law: *wavelength of max emission inversely proportional to temperature*

Emission of radiation

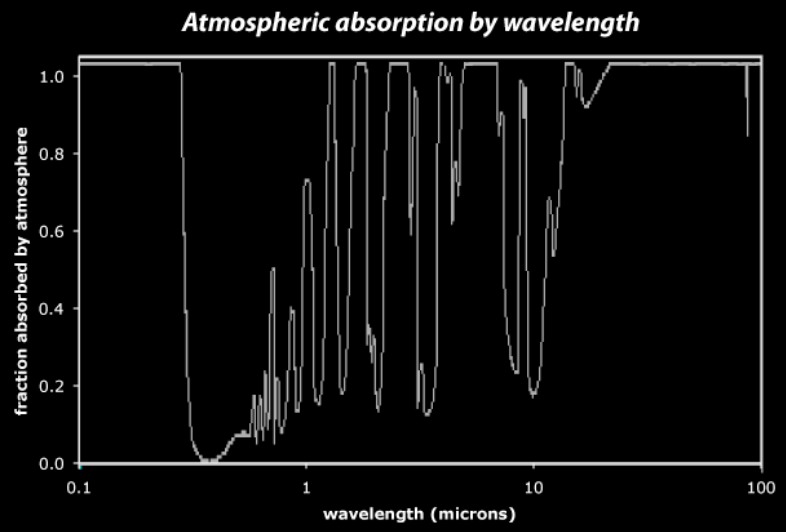


- Here are Planck curves for Sun and Earth, plotted on the same scale
- Sun's much hotter -- why do the curves have equal height?
- TWO reasons:
- (1) Solar radiation spread through space
- (2) For thermal equillibrium, we need IN = OUT
- ALMOST NO OVERLAP!
- Leads to interesting & powerful consequence - the **greenhouse effect**

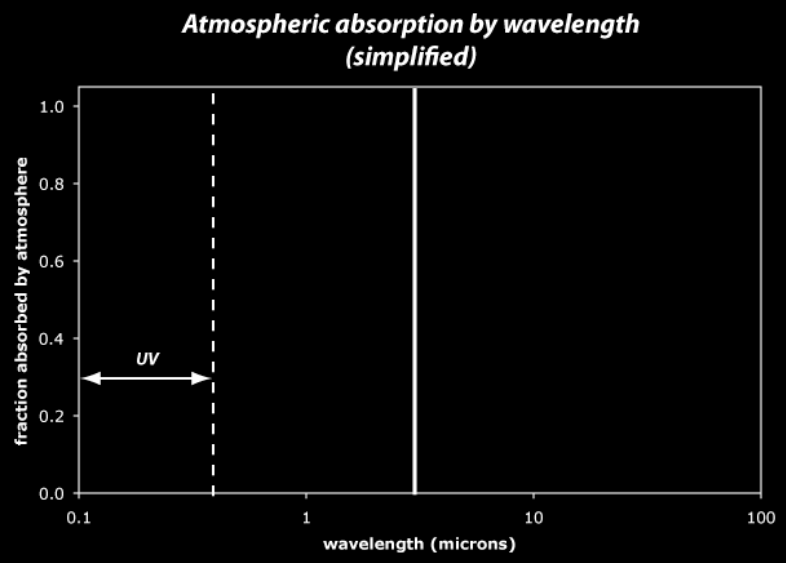


- Solar radiation = shortwave = DOWN
- Earth radiation = longwave = UP
- Division… about 3 microns
- Little radiation there… so demarcation need not be precise

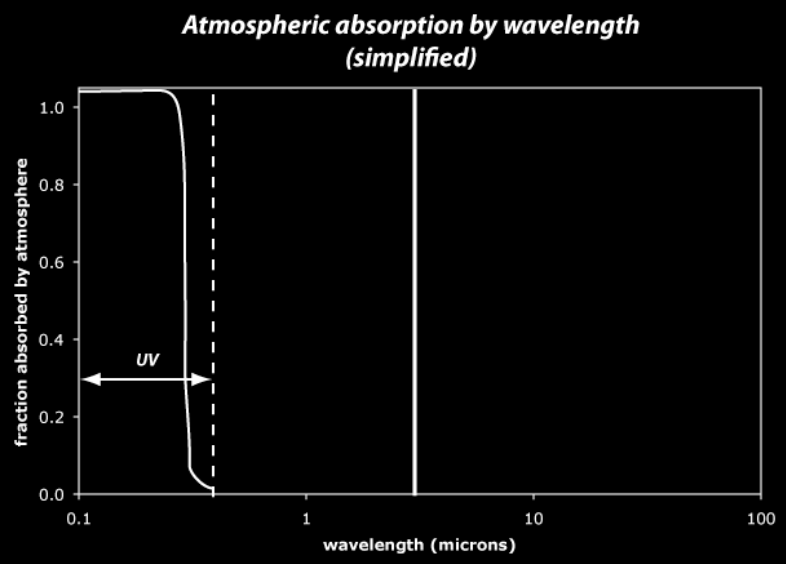
Absorption of radiation by Earth's atmosphere



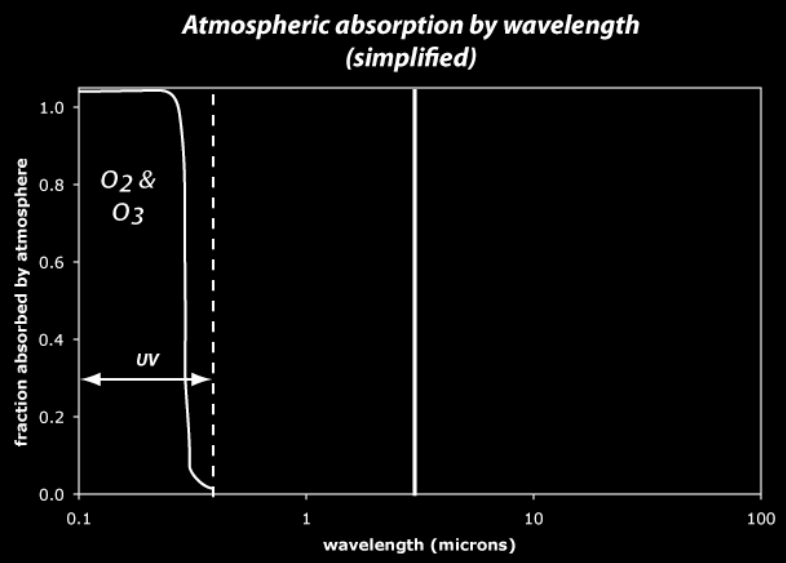
- Vertical axis = fraction of radiation ABSORBED by atmosphere (*absorption affinity*)
- Complex… reflects internal dynamics of atoms/molecules
- Recreate a *simpler* version of diagram, step by step



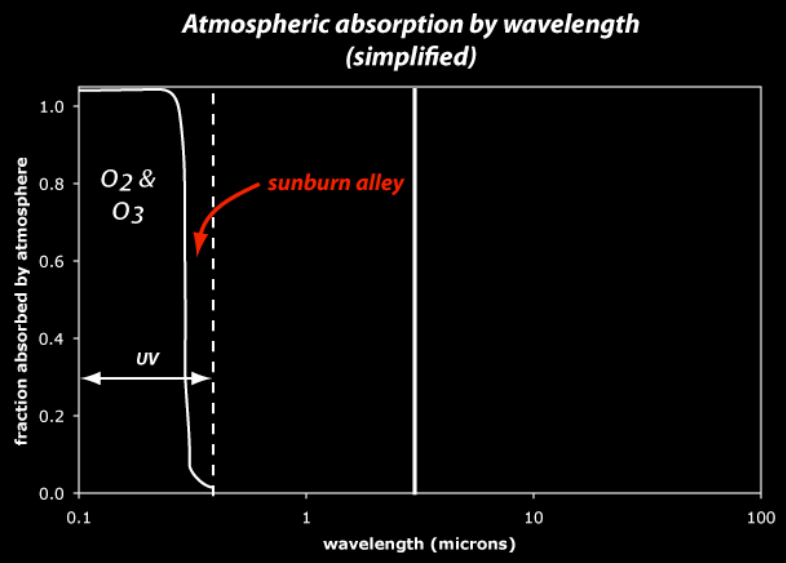
- First part
- Shortest wavelengths of sunlight
- UV
- Less than 0.4 micron



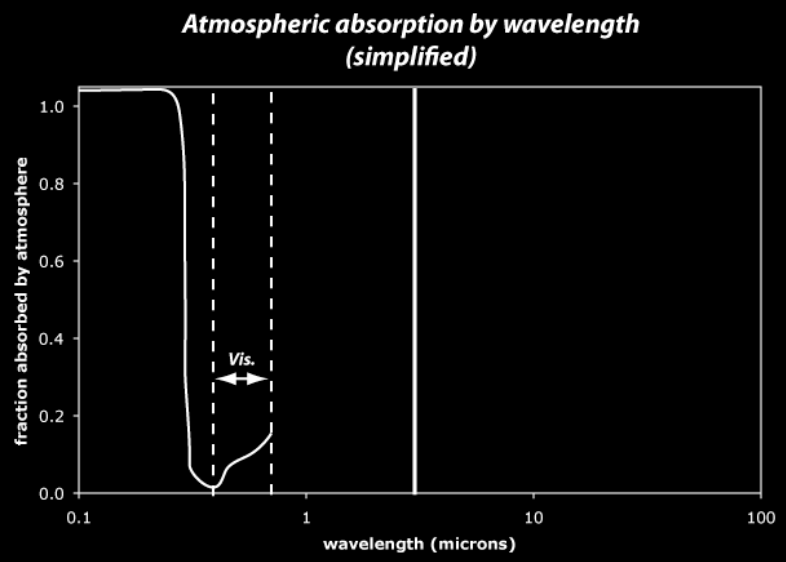
- Simplified absorption for UV
- Absorption is generally very high.. Almost 100%



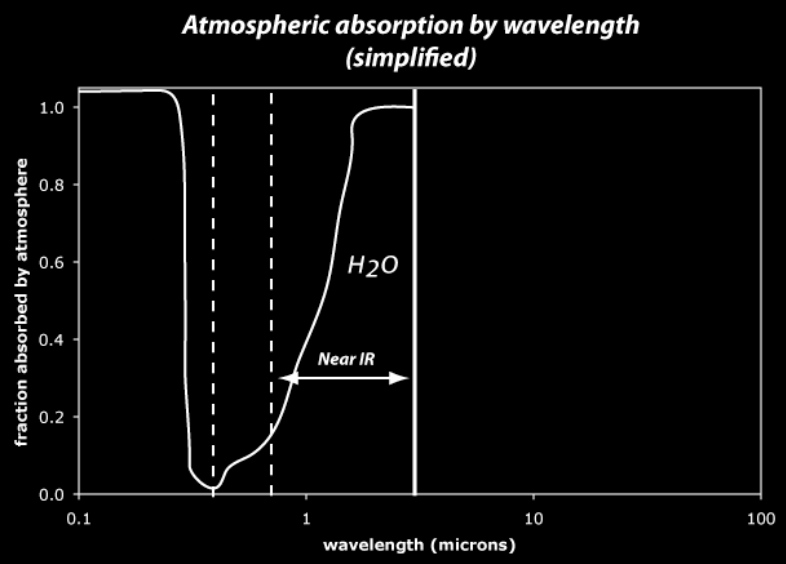
- Absorption accomplished by O_2 and O_3 in **stratosphere**
- It's why stratosphere exists and is "relatively" warm
- Ozone hole lets these wavelengths pass



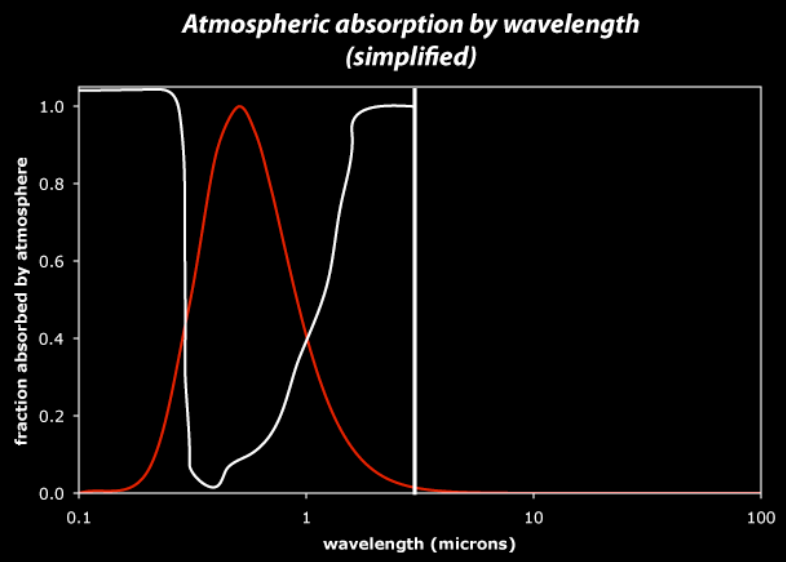
- Longest wavelengths of UV pass through… "**sunburn alley**" (my term)



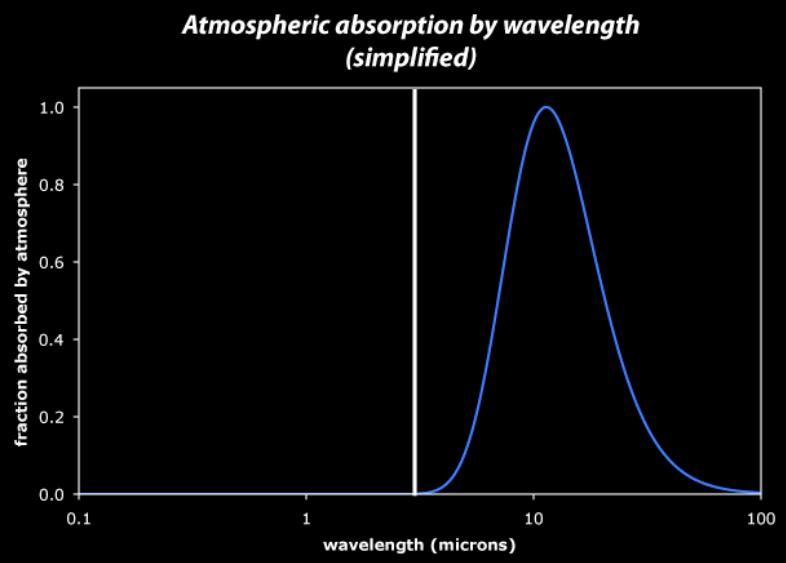
- Very little absorption of visible light
- Look closely.. There is a little bit… *orange and red*
- We'll see if this absorption means anything later in course



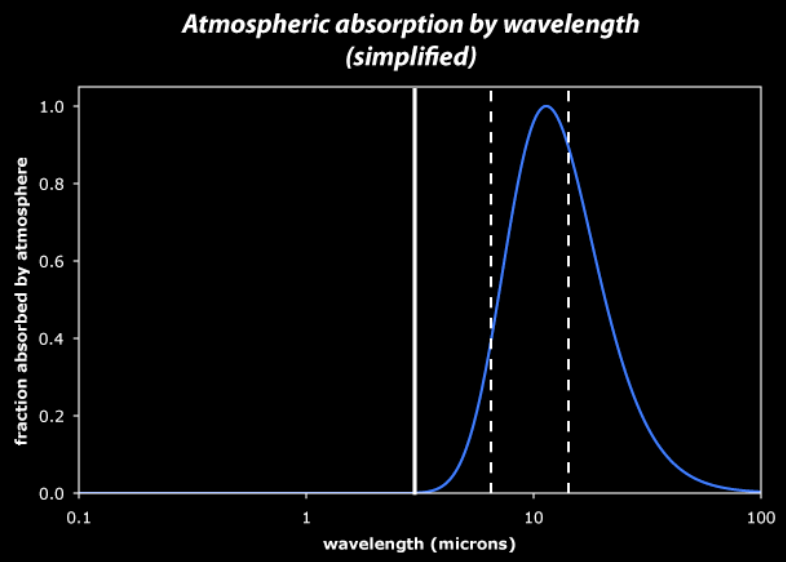
- What's left mainly Near IR. Some Far IR too
- Back to some significant absorption… mainly by **water vapor**



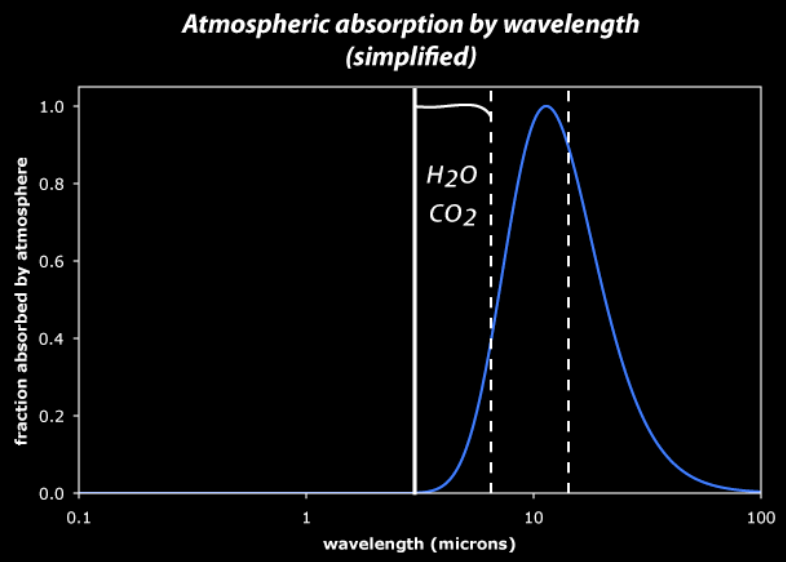
- The sun's emission and atmosphere's absorption curves resemble each other… except they're ***flipped***
- **Atmosphere absorbs BEST what the sun makes LEAST of**
- Half of the sun's radiation is almost totally ignored!
- Much of *that* can reach the ground. To warm the Earth…



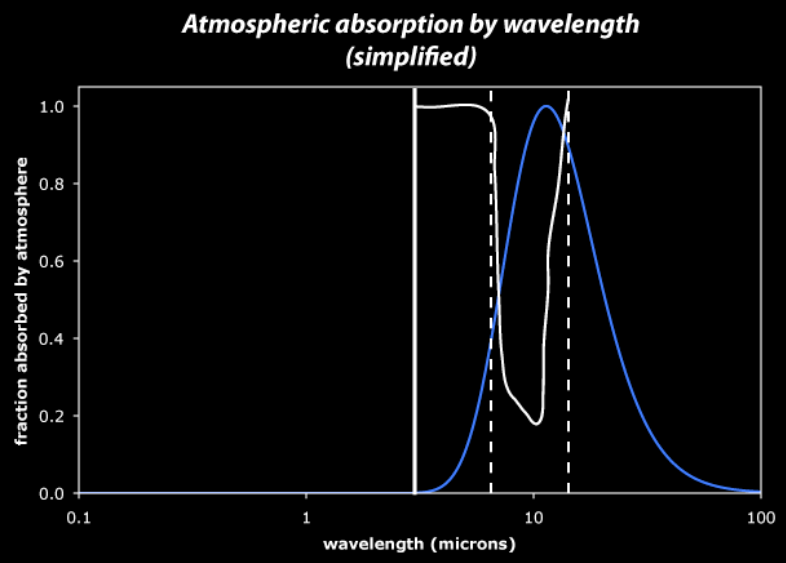
- We’re halfway done…
- Now we’re dealing with radiation emitted by the cool Earth… as a result of absorbing all that nice visible light
- Longer wavelengths. Far IR
- Another bell curve



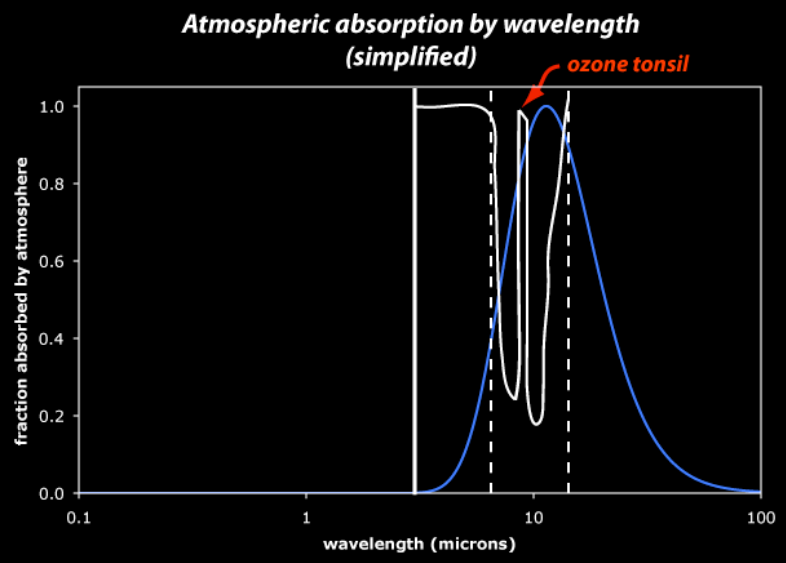
- Let's divide Earth's upward longwave radiation into three sections as well
- But it's ALL FAR IR



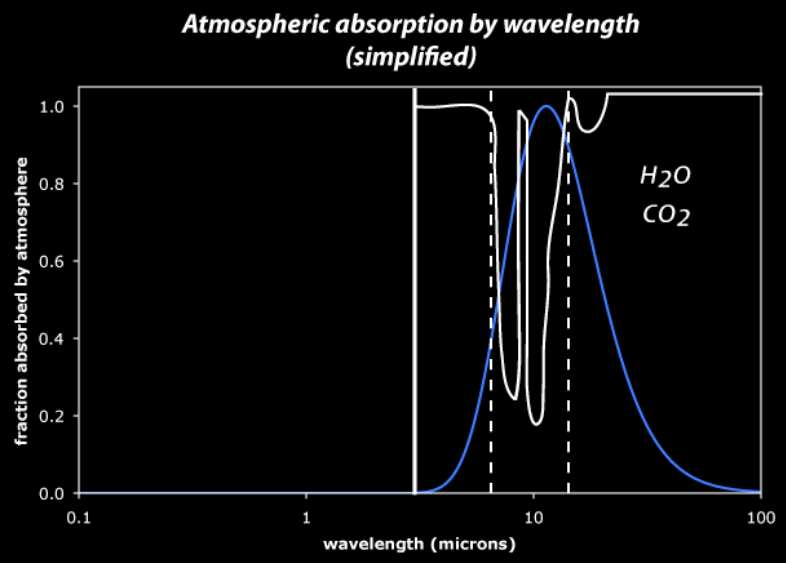
- In the first section, almost 100% absorption - by H_2O and CO_2
- This is outgoing radiation being absorbed and reemitted, some sent back down
- This is part of the greenhouse effect



- In the middle section, emission is large but absorption is smaller (7-11 microns)
- This is called the ***atmospheric window***
- Much of the radiation emitted here escapes to space and isn't recycled into the greenhouse effect



- That was a little too simple…
- There's a "smudge" on the atmospheric window, where **ozone** does some absorption
- I call it the "ozone tonsil" (Not a real term)
- It's why O_3 is a greenhouse gas

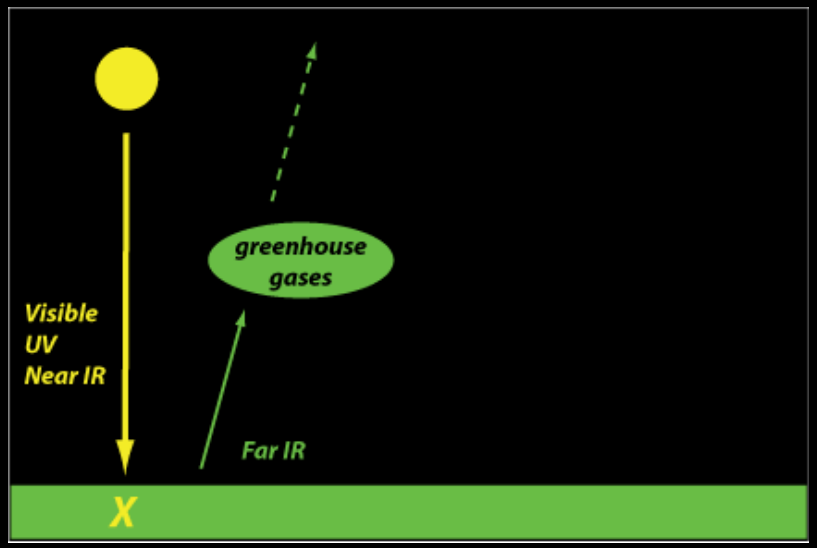


- FINALLY our last section…
- Less emission but lots of absorption
- H_20 and CO_2 again

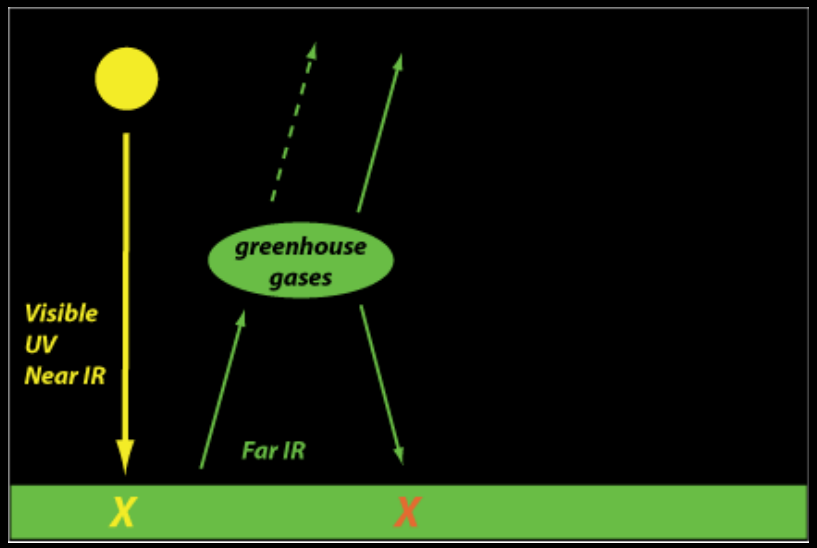
Another view of the greenhouse effect

- Sunlight is streaming through the atmosphere…
- Visible/UV/Near IR
- Largely ignored by the finicky atmosphere
- Absorbed by the ground and warms it up
- The ground's a blackbody… "It'll eat anything"

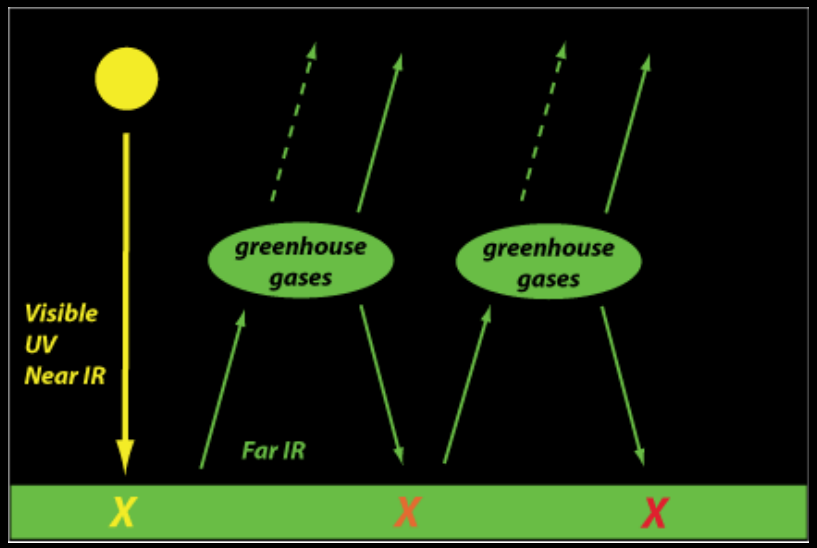
- Earth also radiates
- At *longer* wavelengths reflecting its cooler temperature
- This is NOT the greenhouse effect… ***yet***



- Some of the outgoing radiation escapes to space…
- But some is *absorbed* by greenhouse gases
- ***Selective absorbers***
- They wouldn't touch the short wavelength radiation raining down but they like the long wavelength stuff going up…



- The greenhouse gases themselves radiate… in all directions.. Including ***down***…
- …to be absorbed by our old blackbody friend, the ground, which will "eat" anything…
- So, it warms up MORE



- ***If you absorb you must emit***
- The ground emits radiation *again*…
- Some of this escapes to space…
- Some is absorbed by our greenhouse gases…
- What is absorbed is again emitted
- Some of that towards the ground, which warms up even more

[end]