Making Sense of "Greenhouse Gases"

The Greenhouse Effect: Part 1 - What makes a Greenhouse Gas?

Back in **CSSG-2.1** we discussed that today's global warming is the result of Earth's Energy Imbalance (that is, Energy IN is currently greater than Energy OUT, so the Earth is warming at this time).

"Energy IN"

is the <u>absorbed energy.</u>

29 M

Some of the **"Energy IN"** is **<u>absorbed by the atmosphere</u>**, as shown in a white circle above.

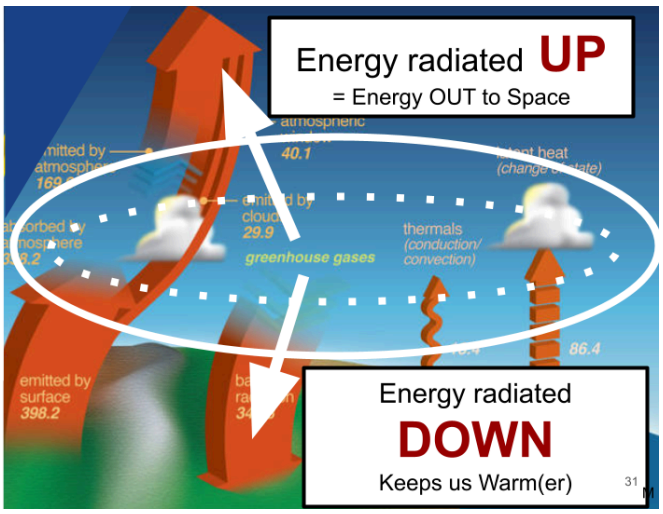
Likewise, **<u>as the Earth tries to get rid</u>** of all the energy **in the graphic below**, the atmosphere plays a much bigger role.

The Atmosphere plays a role!

Greenhouse Gases (GHGs) absorb energy,

then

radiate it back out



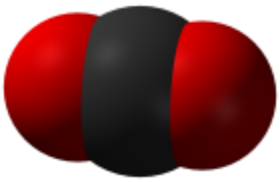
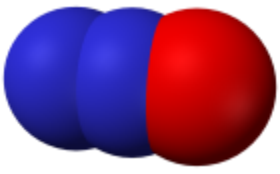
So, what's going on?? What in the atmosphere <u>absorbs a little of the incoming</u> sunlight <u>and</u> <u>a whole lot of the outgoing</u>, invisible "Earthlight" = "heat" ??

Making Sense of "Greenhouse Gases"

The Greenhouse Effect: Part 1 - What makes a Greenhouse Gas?

The answer is, as you certainly have guessed from all the things you have heard and read, the atmosphere is able to absorb and hold a great deal of energy because of **"Greenhouse Gases".**

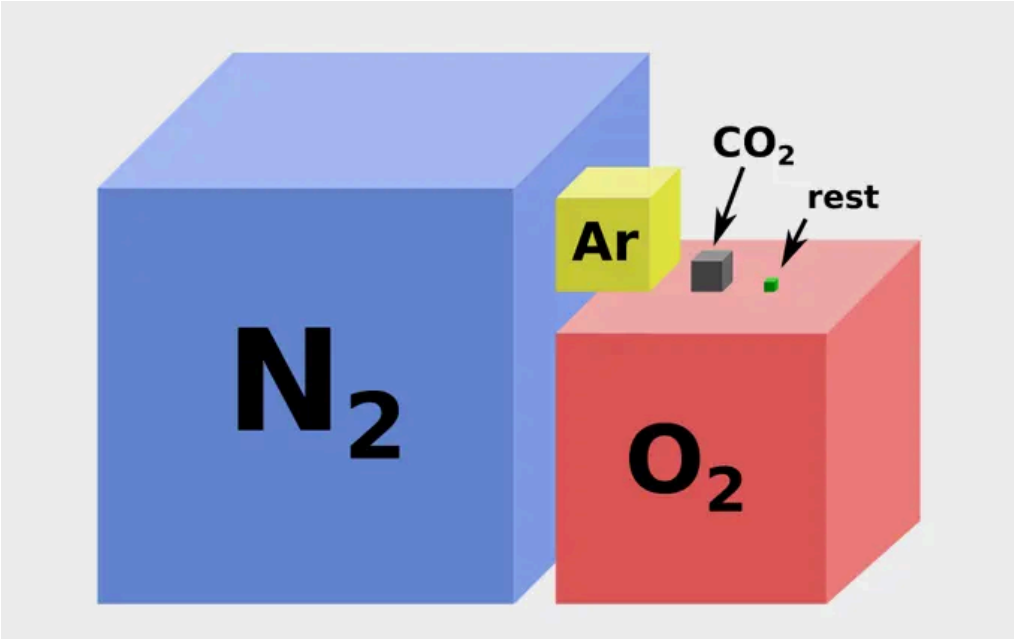
Today's materials mainly concern **WHY a gas** tends to absorb and hold a great deal of energy, **rather than WHICH gases** are relevant in our atmosphere. But, that being said, here are the main greenhouse gases for easy reference (there are others, but it is not necessary to focus on them for now). At this point, though, **LOOK AT THE STRUCTURE OF THESE MOLECULES - the text is less important today**:

Influential Greenhouse Gases (see https://gml.noaa.gov/outreach/carbon_toolkit/	
	Carbon Dioxide (CO_2) is a colorless, odorless gas consisting of molecules made up of two oxygen atoms and one carbon atom. Carbon dioxide is produced when an organic carbon compound (such as wood) or fossilized organic matter, (such as coal, oil, or natural gas) is burned in the presence of oxygen. Carbon dioxide is removed from the atmosphere by carbon dioxide "sinks", such as absorption by seawater and photosynthesis by ocean-dwelling plankton and land plants, including forests and grasslands. However, seawater is also a source, of CO_2 to the atmosphere, along with land plants, animals, and soils, when CO_2 is released during respiration.
	Methane (CH_4) is a colorless, odorless non-toxic gas consisting of molecules made up of four hydrogen atoms and one carbon atom. Methane is combustible, and it is the main constituent of natural gas-a fossil fuel. Methane is released when organic matter decomposes in low oxygen environments. Natural sources include wetlands, swamps and marshes, termites, and oceans. Human sources include the mining of fossil fuels and transportation of natural gas, digestive processes in ruminant animals such as cattle, rice paddies and the buried waste in landfills. Most methane is broken down in the atmosphere by reacting with small very reactive molecules called hydroxyl (OH) radicals.
	Nitrous oxide (N_2O) is a colorless, non-flammable gas with a sweetish odor, commonly known as "laughing gas", and sometimes used as an anesthetic. Nitrous oxide is naturally produced in the oceans and in rainforests. Man-made sources of nitrous oxide include the use of fertilizers in agriculture, nylon and nitric acid production, cars with catalytic converters and the burning of organic matter. Nitrous oxide is broken down in the atmosphere by chemical reactions driven by sunlight.

Making Sense of "Greenhouse Gases"

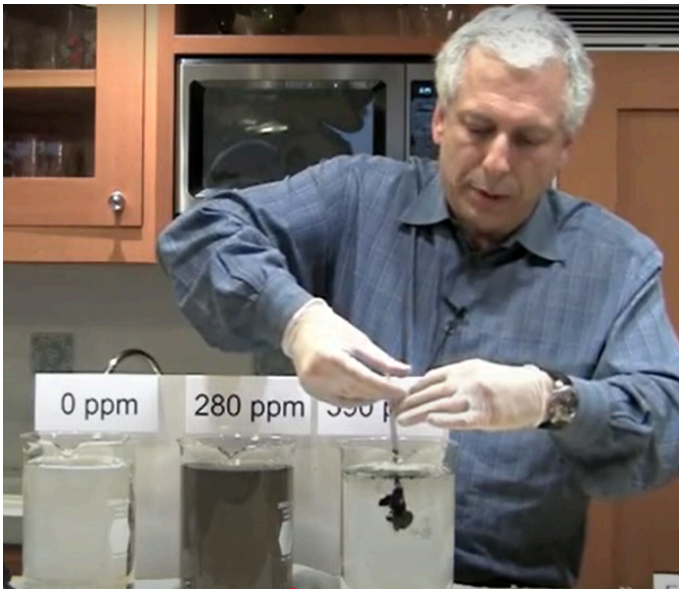
The Greenhouse Effect: Part 1 - What makes a Greenhouse Gas?

The above gases make up **less than 0.1% of the whole atmosphere!** CO_2, the most often discussed, is **only 0.04% of air**. Take a look:



https://earthhow.com/earth-atmosphere-composition/

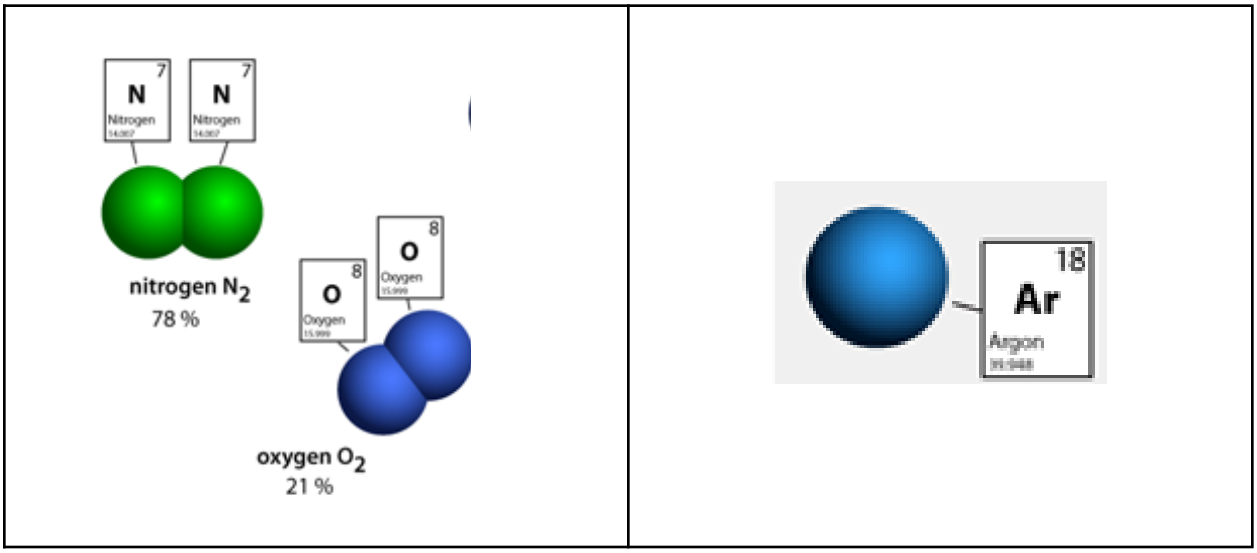
Look at the amount of CO_2 compared to the major components of the atmosphere. It is just over 0.04 % (420 parts per million) of the air we breathe. To internalize that such a small component can have a huge effect, look at this video —-->>https://www.youtube.com/watch?v=hwtO6nAXrGk



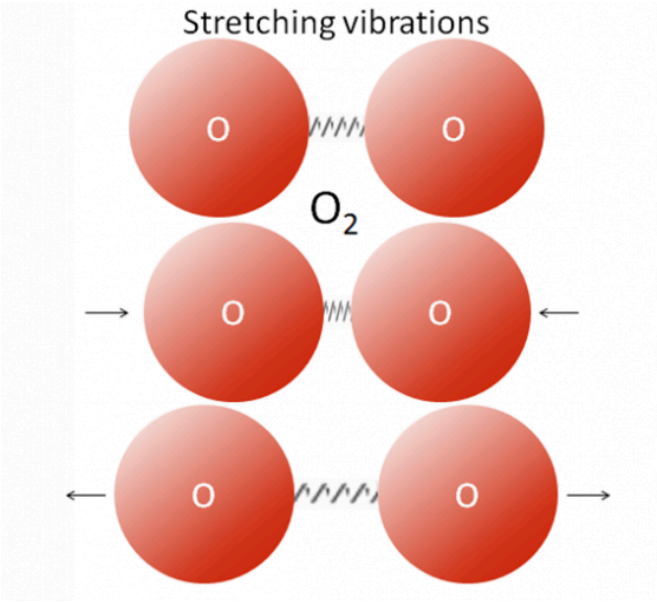
Making Sense of "Greenhouse Gases"

The Greenhouse Effect: Part 1 - What makes a Greenhouse Gas?

Now, take a look at the **structures** of the molecules which make up almost all of the atmosphere. **Nitrogen** (N_2: 78.1%), **Oxygen** (O_2 : 20.9%), and **Argon** (Ar: 0.9%) in this graphic below:



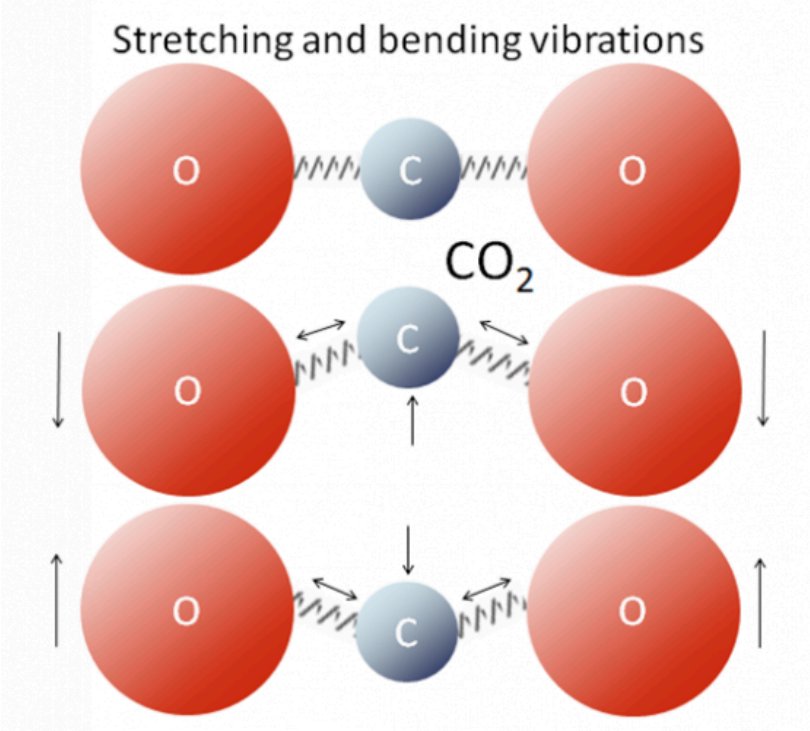
The takeaway is this: The **simple structures** (in this case, Nitrogen, Oxygen, and Argon) pretty much **bounce around as a unit or stretch a bit**. Very little internal vibrations - which could absorb energy - are possible.



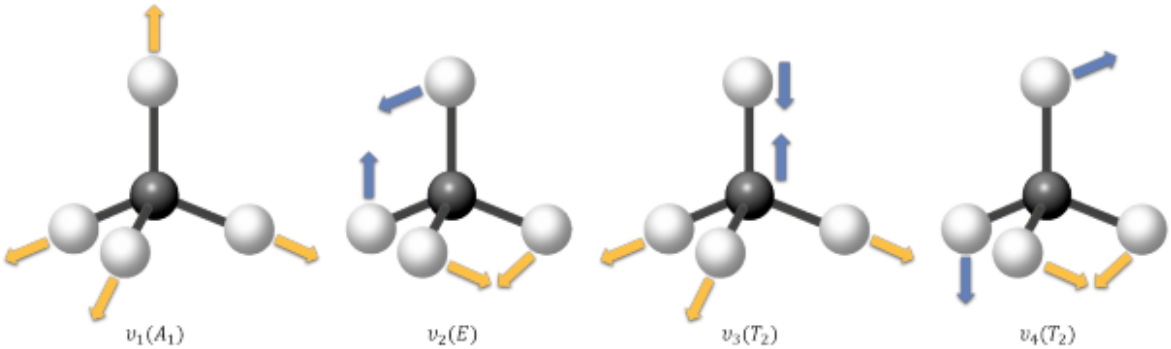
Making Sense of "Greenhouse Gases"

The Greenhouse Effect: Part 1 - What makes a Greenhouse Gas?

The **more complex structures, like CO_2**, can flex and stretch in all kinds of directions like these:



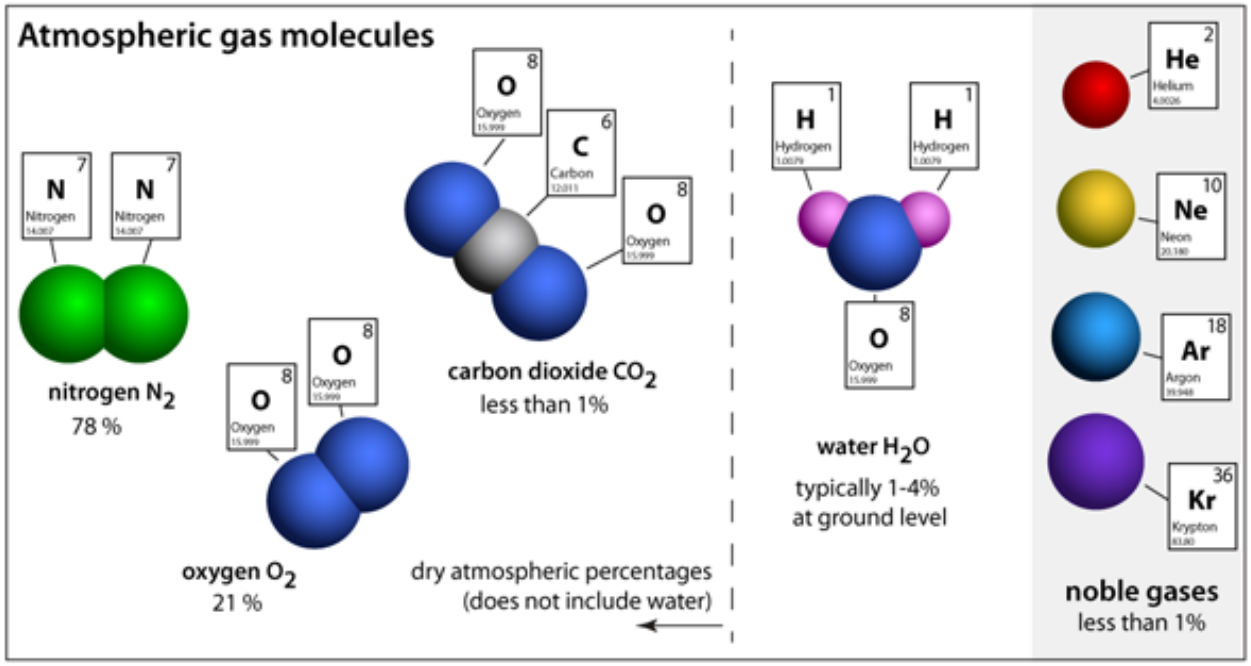
And **Methane** can do even more:



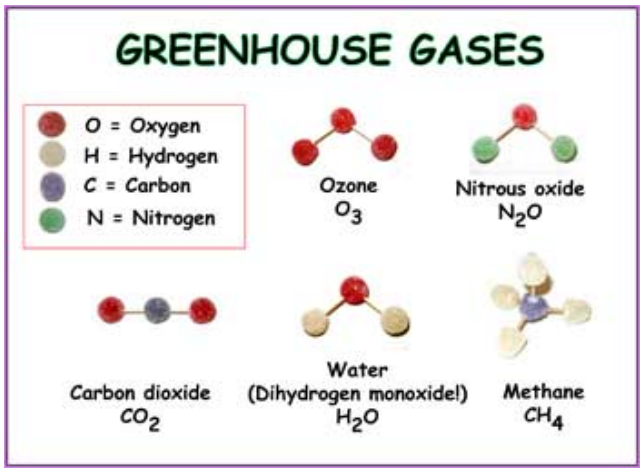
Making Sense of "Greenhouse Gases"

The Greenhouse Effect: Part 1 - What makes a Greenhouse Gas?

So, using the insights from above, we can add one more complex molecule - **WATER! We will learn another time how water ADDS to the greenhouse effect - as the planet gets warmer, the air can hold more moisture (humidity) and this increases the greenhouse effect.**



Focus on the STRUCTURES - simple and rigid vs. more complex and flexible. And a useful summary graphic of these more complex gases could be:

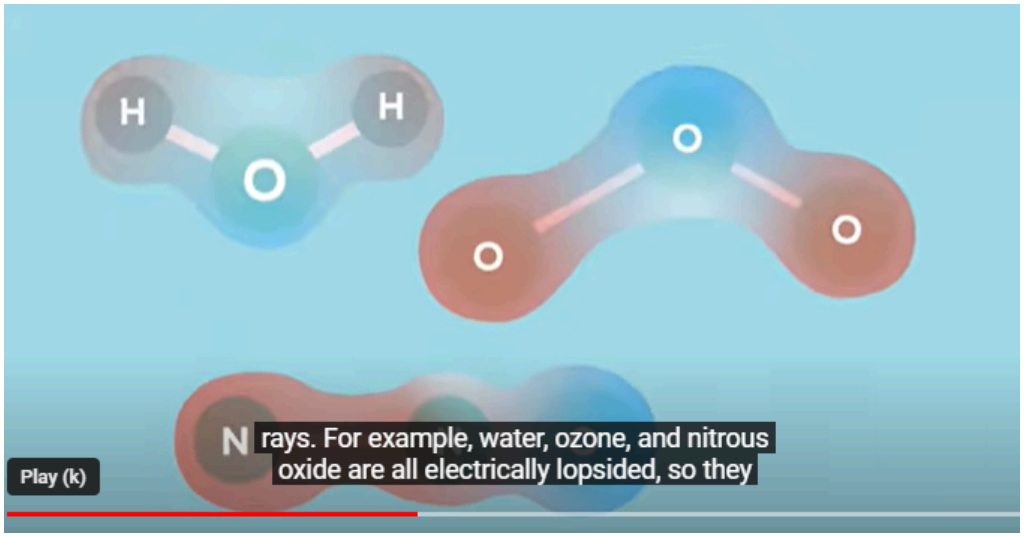


https://spaceplace.nasa.gov/gumdrops/en/

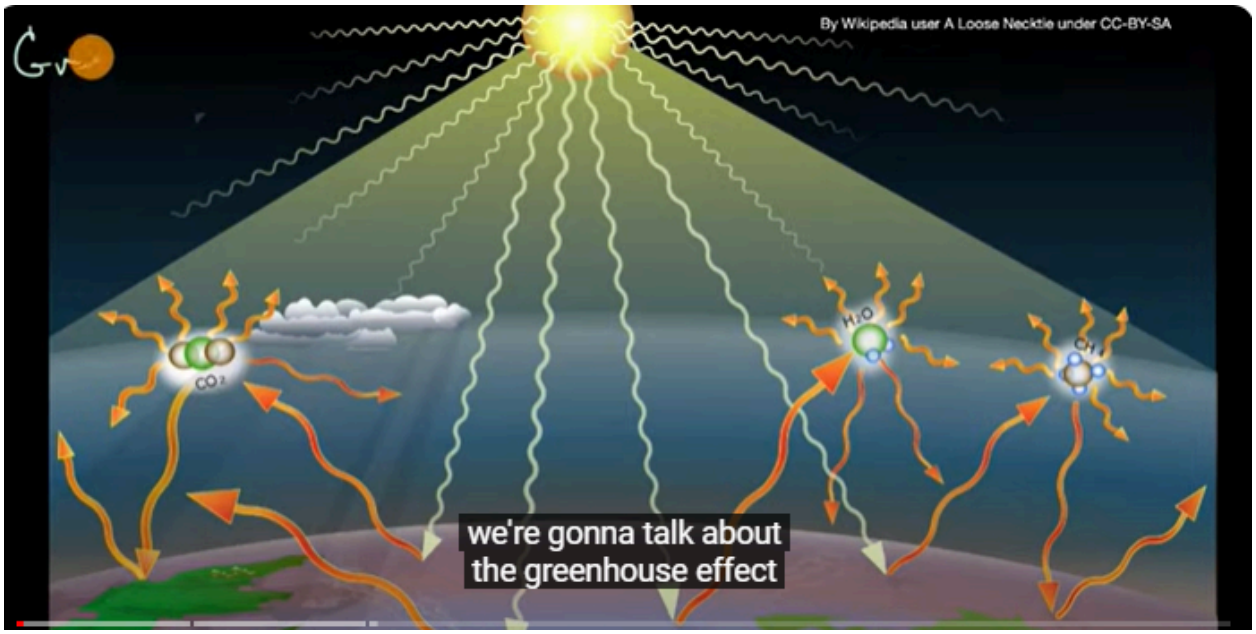
Making Sense of "Greenhouse Gases"

The Greenhouse Effect: Part 1 - What makes a Greenhouse Gas?

If possible, please watch the following two videos. They both have more material than we are covering at this point, but they do a good job of imaging what we've addressed here. The first is 3 minutes long. Use this link—> https://www.youtube.com/watch?v=sTvqIijqvTg



And, finally, here is another video which can help to bring these ideas into focus Use this link —> https://www.youtube.com/watch?v=YpfxiDktSoI. It's a bit longer, and again covers additional material, but is worth the time for our purposes today.



Making Sense of "Greenhouse Gases"

The Greenhouse Effect: Part 1 - What makes a Greenhouse Gas?

Next time, now that we've looked at **STRUCTURES,** we will look at **HOW those simple structures ignore passing energy and how the more complex structures ensure that energy is absorbed**. And, if energy is absorbed, **HOW** it is re-emitted back to earth or out to space.

This has a lot to do with the **type of light we get directly from the Sun** (notice from the very first graphic today the small amount of incoming sunlight which is absorbed by the atmosphere)

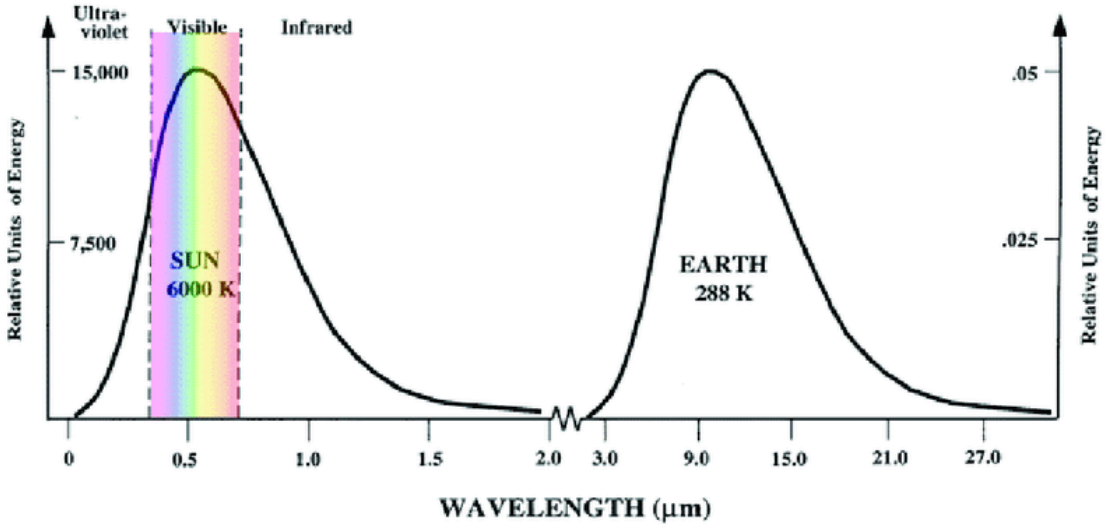
Vs

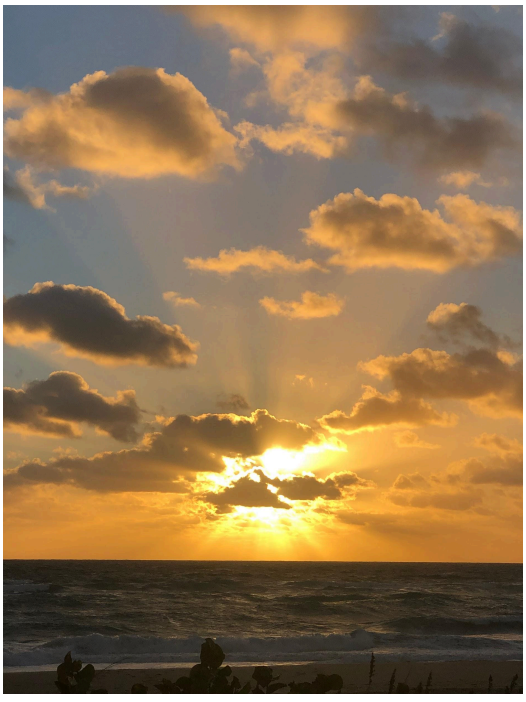
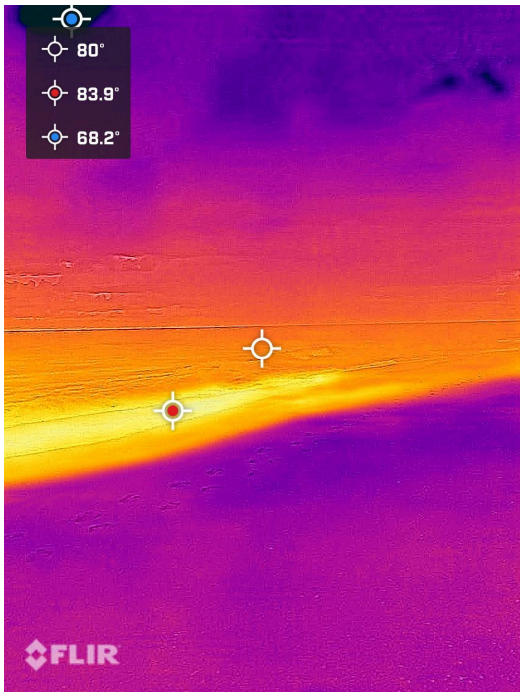
the **type of light the cooler bodies like the earth's surface** and ourselves emit (which is highly absorbed as it goes from the surface up into the atmosphere).

Making Sense of "Greenhouse Gases"

The Greenhouse Effect: Part 1 - What makes a Greenhouse Gas?

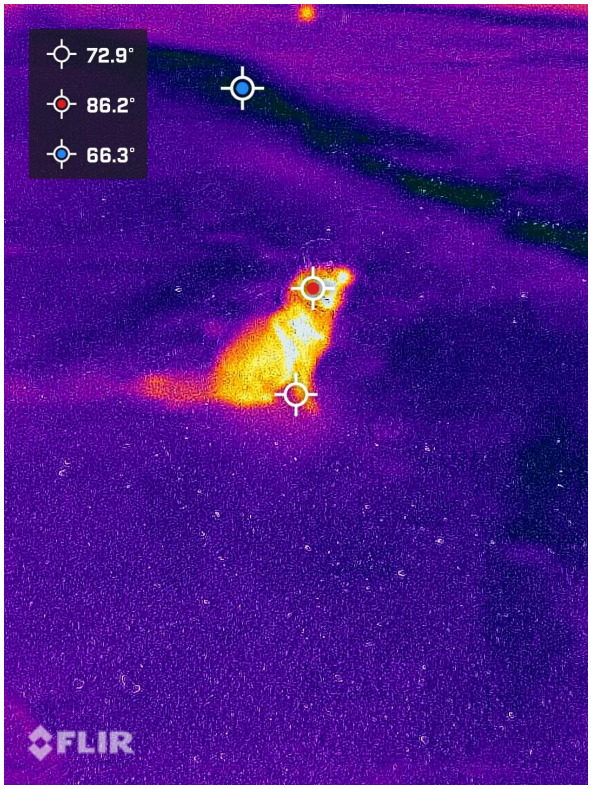
As a teaser, we will often comment that the (mostly visible) **light coming in from the sun** is different from the (invisible, infrared) **light going out from the earth**. We will see charts like this one over time and you'll grow to love them, I'm totally sure (!).



DIRECT and REFLECTED (mostly visible) **light coming in from the sun**	**EMITTED** (Heat = invisible "infrared" because it is beyond the red we can see) **light going out from the earth** - and us!
	

Making Sense of "Greenhouse Gases"

The Greenhouse Effect: Part 1 - What makes a Greenhouse Gas?

REFLECTED Sunlight (Visible - high energy)	EMITTED heatlight from Pumpkin and the ground (Invisible - low energy)
	

Making Sense of
“Greenhouse Gases”

The Greenhouse Effect: Part 1 - What makes a Greenhouse Gas?