Capturing the Sun's energy in the atmosphere:

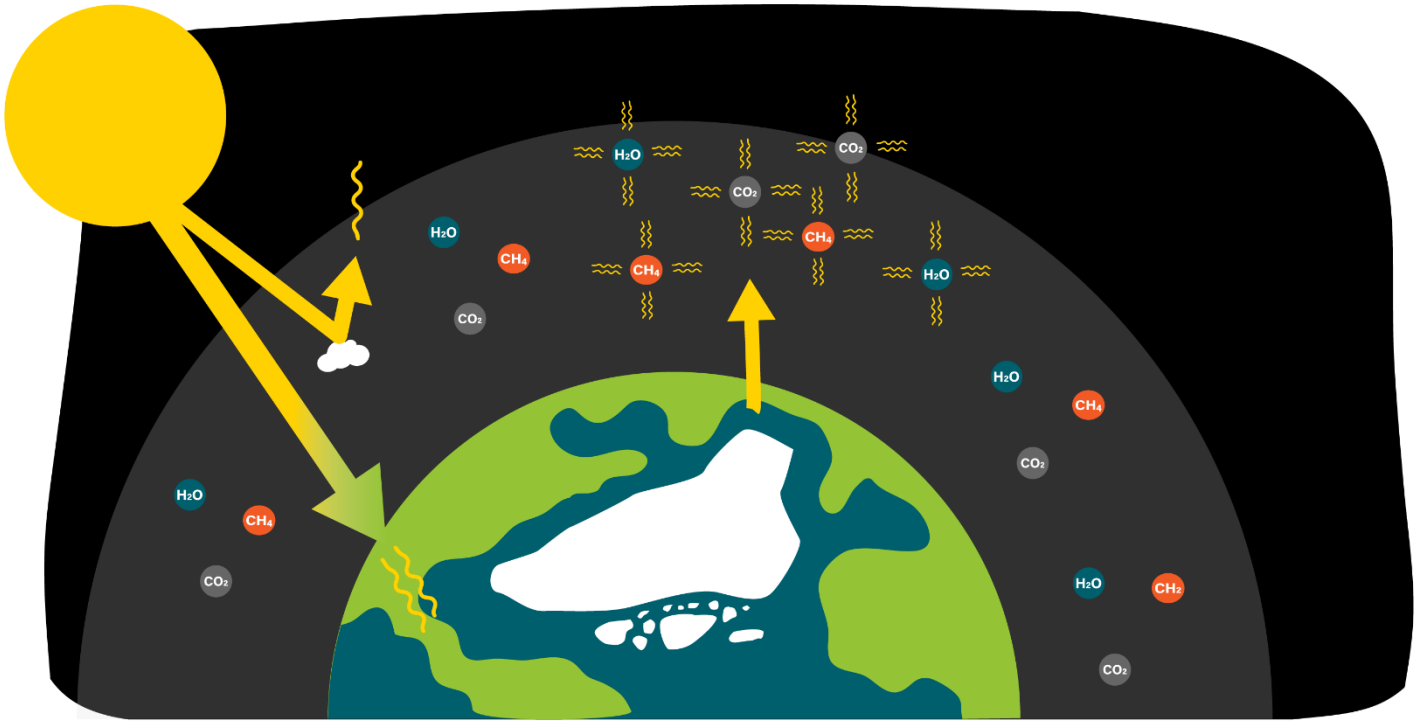
Earth's natural "greenhouse effect"

Earth's temperature begins with the Sun. Roughly a third of the sunlight that arrives on Earth is reflected back into space by bright surfaces like clouds and ice. Of the remaining two thirds, most is absorbed by the land and ocean, and the rest is absorbed by gases and dust in the atmosphere.

As rock, soil, lakes, and oceans are warmed by the Sun, they radiate heat energy back toward the sky and into space. From the surface, this energy travels into the atmosphere where most of it is absorbed by what we call "greenhouse gases" such as carbon dioxide (CO_2) and methane (CH_4), and also by water vapour (H_2O). Greenhouse gases get that name because they keep the Earth warm, similar to the way that glass traps heat in a greenhouse and warms the air inside.

When tiny molecules of greenhouse gases and water vapour absorb the energy radiating from Earth's surface, they turn into tiny heaters. Like the rocks around a fire pit, they radiate heat even after the fire goes out. They radiate in all directions. The energy that radiates back toward Earth heats both the atmosphere and the surface, adding to the heating we get from direct sunlight. We call this the "Greenhouse Effect".

This absorption and radiation of heat by the atmosphere—the natural greenhouse effect—is very important for life on Earth. Without the greenhouse effect, the Earth's average surface temperature would be much colder, about -18°C instead of the comfortable +15°C that it is today.

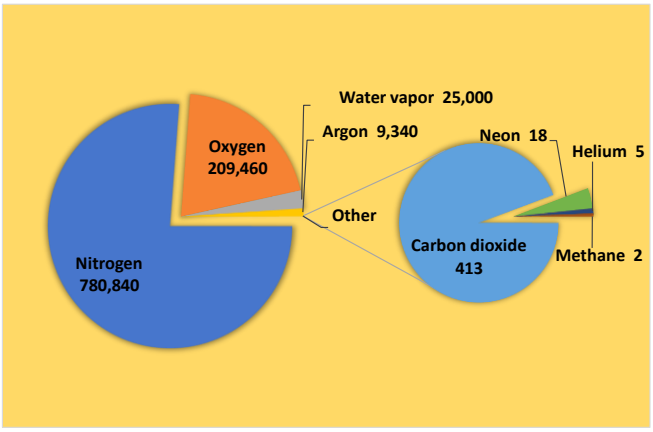


Why do greenhouse gases hold onto heat?

Although we can't see the atmosphere in front of us, we know that it contains gases. All gases and all materials around us are composed of atoms like oxygen (O), hydrogen (H) and carbon (C). Atoms combine to create complex arrangements called molecules, like water (H_2O) where 2 hydrogen atoms combine to 1 oxygen atom.

Earth's atmosphere contains gases like the oxygen (O_2) we breathe, and the carbon dioxide (CO_2) and nitrogen (N_2) that plants need.

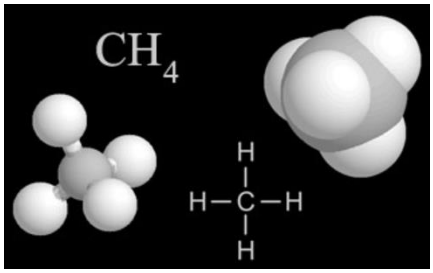
Some gases are considered greenhouse gases like carbon dioxide (CO_2), methane (CH_4) and water vapour (H_2O). Greenhouse gas molecules have more than 2 atoms bonded together. When infrared radiation (heat) from the ground hits them, the bonds begin to vibrate allowing them to hold on to the heat energy. Eventually the bonds stop vibrating and the molecule slowly releases the heat. The more bonds there are, the more a molecule can retain heat. A small molecule like oxygen (O_2) only has 1 bond so it does not retain much heat. Methane (CH_4) has 4 bonds and can retain 30 times more heat than carbon dioxide (CO_2) with only 2 bonds. Although CH_4 and CO_2 are both considered greenhouse gases for their ability to retain heat, there is more CO_2 in the atmosphere and so this molecule tends to be a bigger driver of the greenhouse effect. See animation of the vibrations here: https://www.chemtube3d.com/vibrationsco2/



Quantities of the most common gases in the atmosphere in parts per million. 1 part per million is like one wolf in a herd of one million caribou. Trace gases not shown. *Data from Haynes, H. M., ed. (2016–2017), CRC Handbook of Chemistry and Physics (97th ed.), CRC Press*

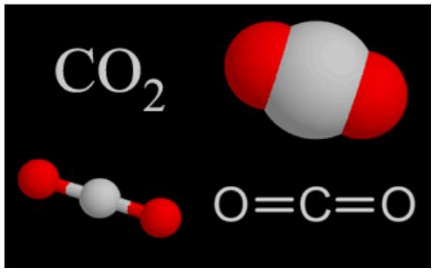
Know your greenhouse gases

Methane (CH_4), Carbon Dioxide (CO_2), Chlorofluorcarbons (CFCs), Hydrofluorocarbons (HCFCs), Water Vapour (H_2O), Nitrous Oxide (N_2O) and Ozone (O_3) are greenhouse gases. *https://scied.ucar.edu/carbon-dioxide*



Methane

- *Flammable and used as fuel known as natural gas*
- *Burning methane releases CO_2 and water*
- *Potent heat absorber (30X more than CO_2)*
- *Rise of 150% since 1750 because of human activity*
- *Natural sources: wetlands, oceans, termites*
- *Human sources: rice, landfills, cattle, energy*



Carbon dioxide

- *Non-flammable gas, the fizz in your drink*
- *Heat absorber and an important driver of Earth's temperature*
- *Rise of 40% since 1750 because of human activity*
- *Natural sources: volcanos, wildfire, respiration*
- *Human sources: food, energy, transportation*

UP NORTH ON CLIMATE
Climate Change Impact and Adaptation Study for the North of Ontario