

Why some gases are greenhouse gases, but most aren't, and some are stronger than others

About Gases

The layer model is what is called an **idealization** of the real world. It has the essential ingredient of the greenhouse effect, but it is missing numerous things that are important in the real atmosphere. Starting from the Layer Model, the next few chapters add things one at a time, assembling the rest of the ingredients that control the temperature of the real Earth. The first task is to understand how real gases interact with infrared (IR) light in the real atmosphere.

Let us begin by defining different ways of describing the amounts of gases in the atmosphere. The word **concentration** means the number of molecules within some volume. The difficulty this raises for gases in the atmosphere is that the concentration, defined in this way, changes as the gas expands or contracts. It is often more convenient to talk about proportions of gases; for example, oxygen is about 20% of the molecules of gas in the atmosphere, and nitrogen is almost 80%. The proportion of CO₂ is currently 0.039%. We can express that in a more mnemonic way by saying 390 parts per million, or **ppm**. This number is called a **mixing ratio**.

A gas exerts pressure, a pushing force, on itself or on the surface of anything in contact with it. The force comes from deflected momentum of gas molecules bouncing off the surface. The pressure of a mixture of gases can be taken apart into what are called **partial pressures** arising from each type of molecule in the gas, which add up to the total pressure. The partial pressure of CO₂, for example, is written as **pCO₂**.

One might expect heavier gases to contribute disproportionately to the pressure because they seem like they would hit the walls harder. It works out, however, that heavier gas molecules are moving more slowly than the light ones are, just enough so that the pushing force, proportional to the mass times the velocity, is the same on average with every type of molecule regardless of how heavy it is. It is as if a bunch of ping-pong balls and bowling balls rolled against the wall all pushed equally on the wall. They are equal because you have to roll the bowling balls more slowly. At a given temperature, each molecule has the same amount of energy on average invested in motion, what is called **kinetic energy**. A heavy molecule will move more slowly with its allotment of kinetic energy.

A gas pressure, in units of microatmospheres (μatm), is numerically nearly equal to its mixing ratio in parts per million (ppm).

The bottom line is that the partial pressure from a gas is more or less proportional to the mixing ratio, the numerical proportion of the gas. If you think in pressure units of atmospheres, the actual numbers are the same for the partial pressure and the mixing ratio. For CO₂, for example, the mixing ratio is currently about 390 ppm, and its pCO₂ is about 390 μatm .