Emission of Re-radiated Thermal Radiation, Various Gases Including CO2

(Excerpt from "Climate Change: The Facts—2020," Chapter 11 [Dr. Geoffrey Duffy], pages 172-5. Scroll down for graph.)

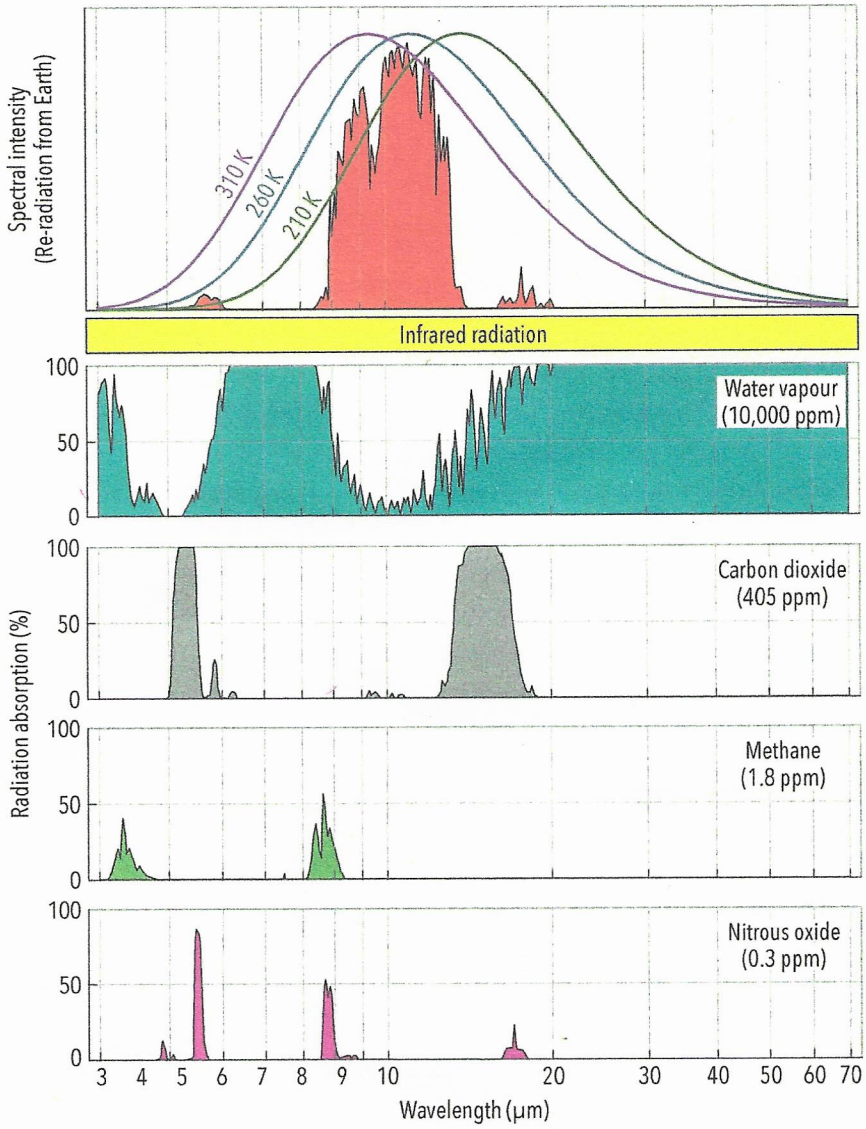
Less than 60% of all solar radiation ever reaches the planet's surface. When it does, the solar radiation 'impacts' the Earth's surface by 'exciting' surface molecules (land and sea) to various extents. These molecules vibrate, rotate, twist, or oscillate more and emit long-wavelength radiation. It is this re-radiation that greenhouse gas molecules can more readily interact with. The energised atmospheric molecules themselves can now also move faster and collide more frequently with all other atmospheric molecules.

Greenhouse gases within the first few hundred metres elevation absorb some of this radiant energy in various ways depending on the structure of the molecule. None absorb over the total span of wavelengths, now 3 to 70 micrometres. Each gas is sensitive to a specific frequency band as shown in Figure 11.4. As mentioned, the height of each peak indicates the magnitude of energy absorbed at each specific wavelength. The peak width indicates the sensitivity span of each greenhouse gas and thus the potential portion available to absorb the emitted longwave re-radiation from the planet's surface.

The low-concentration gas CH_4 (1.8 ppm) has two narrow bands, each absorbing less than 50% of radiant energy. They compete with water vapour anyway (water vapour is more than 5500 times higher in concentration). N_2O (0.3 ppm) has three very narrow bands, with only one peaking at about 90% at just one wavelength point (water vapour concentration >33,000 higher). CO_2 (405 ppm) only has a further two bands that are slightly wider than CH_4 and N_2O, but operate over a very small proportion of the total re-radiation span from Earth (<8% of the total wavelength span).

In stark contrast, water vapour is fully active across 85% of the total span (note log scale). Water vapour is at a far higher concentration (10,000 ppm at 20 °C and 75 RH%). If radiation is regarded as the key issue in changes of weather, then the focus must simply be on water vapour in the atmosphere and the absorption of longwave radiation. CO_2 makes a very small contribution, and CH_4 and N_2O and ozone (O_3) are really almost inconsequential. In fact, by determining the total energy absorbed (area under the curve), water vapour is twelve times more effective than CO_2 in longwave radiation absorption.

Figure 11.4 Emission of re-radiated thermal radiation



Electromagnetic radiation re-emitted from Earth in the 3 to 70 micrometre wavelength range. The top panel shows longwave infrared emissions not absorbed by greenhouse gases. The bottom four panels show absorption spectra for each respective greenhouse gas, as labelled.

Source: Google File: Atmospheric Transmission.png Radiation Transmitted by the Atmosphere https://commons.wikimedia.org/wiki/File:Atmospheric_Transmission.png.