Partial Pressure and Total Emissivity of Carbon Dioxide at its Current Proportion in the Atmosphere

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Abstract

By means of accepted scientific algorithms derived from observation and experimentation, I calculated the total emissivity of carbon dioxide in the atmosphere at current physical conditions. The results of my calculations coincide accurately with the results of experimentation and observations by other authors. I have found that there is not a significant influence of carbon dioxide, at its current density in the atmosphere, on Earth's climate. Nevertheless, significant increases of the volumetric fraction of carbon dioxide in the mixture of gases of air would lead to important modifications of Earth's climate; in particular, higher temperatures of the atmosphere by emissions from the surface.

PARTIAL PRESSURE BY OPTICAL LENGTH OF CARBON DIOXIDE IN CURRENT ATMOSPHERE

1 atm is the total pressure of a column of air 4345.77 m height upon a surface area of 1 m^2. The volume of such column of air is 4345.77 m^3.

In average, the pressure of air per each one meter of altitude would be 0.2331 mb m. However, the pressure of the real atmosphere diminishes with altitude, so we must take 0.2331 mb m as an average of pressure through the optical path length of the atmosphere, not as a barometric measurement at increasing altitudes.

1 millibar (mb) of air is equal to 4.29 m. That is 0.2331 mb m, or 23.31 mb cm (0.02331 bar cm). This means that we need a column of air 429 cm height to exert a pressure of 1 millibar.

The total pressure of air is 1013 mb at sea level, which means that the pressure exerted upon the surface area of Earth is the pressure exerted by a column of air 4345.77 m height.

Partial Pressure of Carbon Dioxide ($(pCO_2L)_m$):

The partial pressure of carbon dioxide in a column of air 434500.77cm height is 0.00038 atm; therefore, its partial pressure exerted by one cm height of atmospheric carbon dioxide is:

$$\left(p_{CO_2}L\right)_m = \left(\frac{0.054}{t^2}\right) * \ 0.02331\ bar\ cm\ = \left(\frac{0.054}{0.0889}\right) * \ 0.02331\ bar\ cm\ = \ 0.014\ bar\ cm.$$

TOTAL EMISSIVITY OF CARBON DIOXIDE AT CURRENT ATMOSPHERIC PROPORTION:

From Michael F. Modest. *Radiative Heat Transfer*. 2003. Pp. 339-346,[1] The formula to obtain the total emissivity of any gas in a mixture of gases is as follows:

$$E_{CO_2} = \left(1 - \left(\left(\frac{(a-1)*(1-PE)}{(a+b)-(1+PE)}\right) * \left(e\left(-c\left(\left(Log_{10}\left(\frac{(P_aL)_m}{p_aL}\right)\right)^2\right)\right)\right)\right)\right) * \left(\left(E_{CO_2}\right)_0\right)$$

From Hottel's and Leckner's Charts[1, 2], according to experimentation and observation, at $\left(p_{CO_2}L\right)_0 = 1\ bar\ cm$ and temperature of 278 K, $\left(E_{CO_2}\right)_0$ is 0.002.

Introducing magnitudes:

$$E_{CO_2} = \left(1 - \left(\left(\frac{(2.97-1)*(1-0.98\ bar)}{(2.97+0.1)-(1+0.98\ bar)}\right) * \left(e\left(-1.47\left(\left(Log_{10}\left(\frac{0.014\ bar\ cm}{0.02331\ bar\ cm}\right)\right)^2\right)\right)\right)\right)\right) * (0.002) =$$

$$\Big(1 - \big((0.04) * (0.93)\big)\Big) * 0.002 = (0.963) * 0.002 = 0.0019$$

Therefore, the total emissivity of carbon dioxide in the atmosphere at its current concentration is 0.002.

Conclusion

As a matter of fact, if the density of any absorbent gas in the mixture of air were increased, the total emissivity of the air would also increase.

If the density of carbon dioxide were increased in the atmosphere, its total emissivity and absorptivity per unit mass would also increase because the mean free path length of photons between collisions with carbon dioxide molecules would be shortened and the amount of energy absorbed by the mass of carbon dioxide would also increase, i.e. more molecules of carbon dioxide would be excited by photons' energy emitted from a warmer surface.

Nevertheless, we would need a volumetric fraction of carbon dioxide in the atmosphere of 100000 ppmV exerting a partial pressure of 50 bar cm to elevate its total emissivity up to 0.157. 100000 ppmV of carbon dioxide represents a density of 0.18 kg/m^3.[1]

The current density of carbon dioxide in the atmosphere is 0.00071 kg/m^3. Obviously, we should not be worried about any significant change of climate due to increases of carbon dioxide in the atmosphere for many years ahead.

However, we should critically consider our unavoidable responsibility on preserving the environment in optimal conditions for guaranteeing the survival of upcoming human generations and of the remaining species of living beings inhabiting this planet.

Bibliography

1. Modest, Michael F. *Radiative Heat Transfer-Second Edition*. 2003. Elsevier Science, USA and Academic Press, UK.

2. Pitts, Donald and Sissom, Leighton. *Heat Transfer*. 1998. McGraw-Hill, NY