An Unsettling Look at the Settled Science of Global Warming
Part 1: Scientific Discussion

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Executive Summary

This paper puts forward the hypothesis that:

Atmospheric Carbon Dioxide (CO2) levels are at a point where increasing them further will have no impact on climate. CO2 contributes to the greenhouse effect. This contribution reaches a maximum at a specific level of CO2 at which point there is no further impact. In simplistic terms, you cannot get blacker than black. Controlling CO2 emissions will have no impact on climate.

The basis for this hypothesis is the use of engineering methods for the calculation of radiant heat transfer in the atmosphere. This paper summarizes a technique for the use of standard curves and tables for determining atmospheric emissivity and hence absorbance of heat.

Introduction

This paper examines one aspect of the underlying science of climate change: The absorption of radiant heat in the atmosphere by Carbon Dioxide.

It ignores the impact of water vapour and other gases that impact on the heat balance of the atmosphere (note that these impacts strengthen the underlying hypothesis). The technique summarized in this paper confirms that, at current and historic levels of CO2, the atmospheric temperature and hence, climate is NOT affected by changes in CO2. The basis of this is that the current (385 ppm) and historic (278 ppm) levels of CO2 are too high and the atmosphere is already at a state of maximum CO2 caused emissivity. If the hypothesis put forward by this paper is correct, then there will be no change in climate from decreasing or increasing CO2 levels.

The Engineering of Radiant Heat Transfer

This section looks at engineering rather than pure science because the science of radiant heat transfer has matured to the point where engineering solutions have been developed and widely implemented. The critical parameter in determining how much radiant energy will be absorbed by a gas is the emissivity of the gas.

The calculation of atmospheric emissivity due to carbon dioxide is very complex. A simplified method was needed to provide accurate calculations for radiant heat loss in the atmosphere. One of these approximations is known as the path length method. This method uses empirically derived curves that relate path length to emissivity.

The values for these curves were derived by Hottel[i] and others in the 1940's and refined extensively by Leckner[ii] in the 1970's. Hottell produced a set of curves from which emissivity is graphically determined. Leckner performed extensive experimentation to refine the curves. Though there is some variation with temperature and pressure in the absolute values of the emissivity, the shapes and distribution of the curves is fairly consistent. Note that in terms of the ranges of temperature used in developing the curves, the variation in emissivity due to variation in atmospheric temperature with elevation (the lapse rate) is very small. Before describing the curves in detail, the terms used need to be explained;

Black Body Radiator is a concept in heat transfer. All things radiate heat energy. The amount of heat energy is a function of the temperature. A black body radiates heat according to an ideal. All real things are not quite ideal. As such, they do not radiate as a black body. This means that a factor must be applied to the equation to assure that reality meets the ideal. This factor is emissivity.

Emissivity is a measure of how close to a black body radiator a material is. A perfect black body will absorb 100% of the radiant energy that hits it and have an emissivity of 1. It will also emit radiant energy at wavelengths directly related to the temperature of the body. A grey body will absorb some percentage of the radiant energy that hits it and have an emissivity of less than 1. The percentage that the grey body absorbs is directly proportional to the emissivity. For a gas, this emissivity will vary with "Path Length".

Path Length is the product of the partial pressure of the gas multiplied by the thickness of the layer of gas. This means that a thin layer of a very high concentration of gas will have a path length similar to a thick layer of a low concentration of gas. For the atmosphere, this is complicated by the fact that the absolute pressure varies with elevation.

Partial Pressure of a gas is the proportion of the total pressure in the atmosphere due to any particular gas. For CO_2, the concentration throughout the atmosphere has been shown to be consistent when measured in parts per million. The partial pressure of CO_2 is thus the parts per million multiplied by the atmospheric pressure.

Heat Absorption is the amount of heat energy absorbed by a gas, $q=\varepsilon\sigma(T^4)$ where ε is emissivity and σ is the stefan boltzmann constant. Heat emission is also modeled by this equation.

Forcing seems to be the difference obtained by subtracting Heat Absorption at 278°C from Heat Absorption at any particular temperature. The IPCC AR4 shows 3 different estimations of forcing. The IPCC report asserts that the equation $\Delta F = \alpha \ln(C/C_o)$ is most accurate, where ΔF is forcing, α is a constant, value 5.35, C is the concentration of CO_2 and Co is some arbitrary initial value, in the case of climate models, 278 ppm. This definition may not be accurate. The reader is encouraged to consult the IPCC summary reports to try to decipher the meaning of forcing.

Figure 1 Emissivity at 0°C, After Leckner

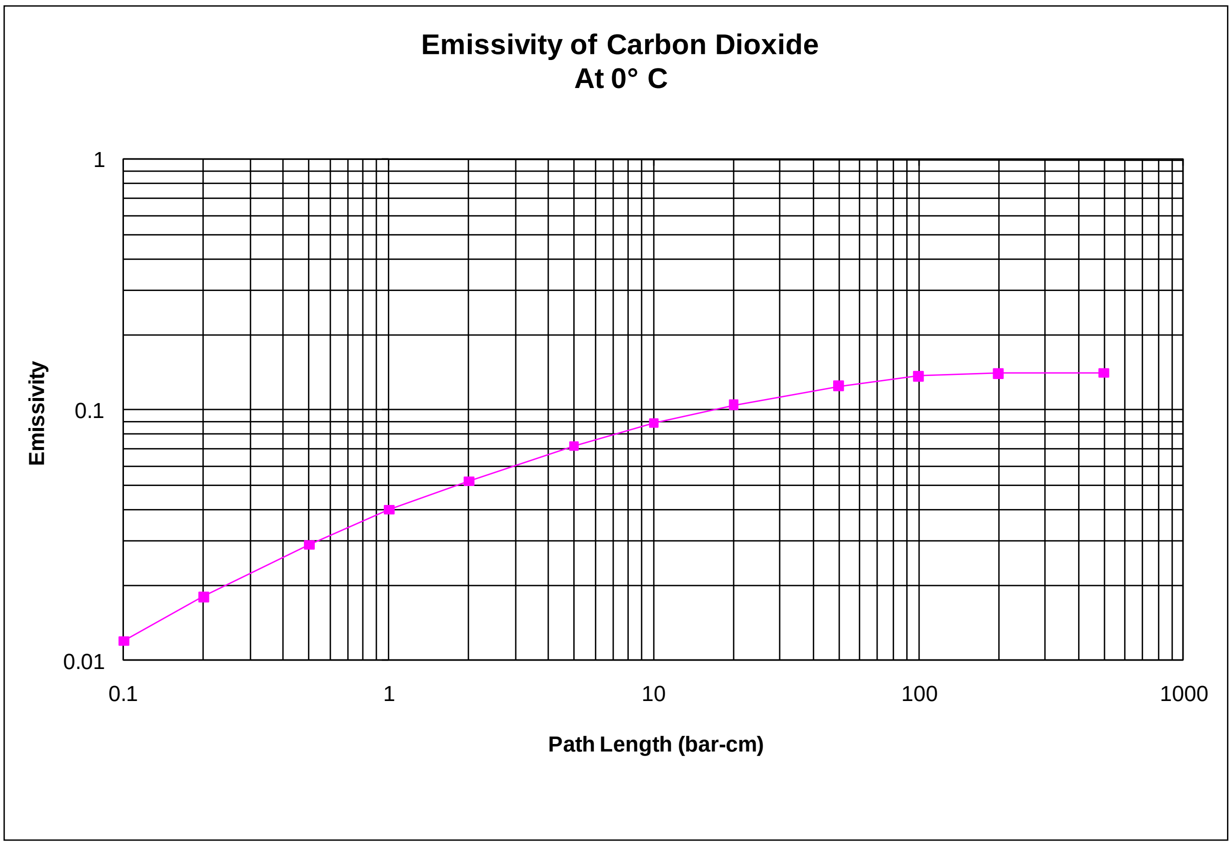


Figure 1 is an illustration of one curve from the family of CO2 emissivity curves. This was obtained by plotting the emissivity at the temperature stated for various path lengths. Other curves in the family can be generated for any particular temperature. A review of Leckner's curves shows that in the range of temperatures of the atmosphere (293K to 216K) a single temperature will suffice for estimating emissivity. The temperature chosen was 273K. Note that the area below 273K is a projection beyond Leckner's curves and may be in error.

The curve shows NO change in emissivity at path lengths greater than 500 Bar – cm and minimal change after a path length of 100 Bar – cm

These types of curves are used by engineers in design. The success of the designs is an indication of the validity of the curves. Any alternate explanation for radiant heat loss through the atmosphere must provide results with at least the same degree of success in predicting reality. The question is how to apply them to the atmosphere.

Atmospheric Path Length

The determination of path length usually assumes constant pressure as the following calculation illustrates:

Given a concentration of 100 parts per million CO2 and an atmospheric pressure of 1 Bar, what is the path length over 10 meters?

The path length of CO2 is:

$$100\ ppm\ CO_2 \times \frac{1}{10^6} \times 1.0\ Bar \times 10\ m \times 100 \frac{cm}{m} = 0.1 Bar \bullet cm$$

The units "Bar-cm" are used as these are the units used for the curve. (The Hottel work used "ft-Atm").

This paper calculates total path based on a sum of short paths. Thus for 20 meters, one would add the 0.1 Bar-cm to 0.1 Bar-cm to obtain 0.2 Bar-cm.

The variation of pressure with altitude is approximated by the following equation:

$$P = P_0 \left(\frac{T_b}{T_b + hL} \right)^{\frac{gM}{RL}}$$ iii

Using this equation, atmospheric pressure at 10 meter intervals was calculated. The partial pressure for each 10 meter interval was calculated using the pressure at the top of the slice. The 1,000 individual path lengths are then added to obtain the total path length for the troposphere (10,000 meters). From 10,000 meters to 42,000 meters, the slice was increased from 10 meters to 100 meters to reduce the total number of calculations. (Integration of the equations and solving from 0 to h=42 km will result in a more accurate path length, but would have required an extensive mathematical derivation within this paper. Such a derivation would itself be subject to error and hence has been skipped at this time.)

The set of calculations was performed for 100 ppm. Path lengths for other concentrations of CO2 can be obtained as follows:

$$pL_{new} = \frac{ppmCO_{2\ new}}{100} \times pL_{at\,100\,ppm}$$

For 100 ppm, the calculated path length was 67 $Bar \bullet cm$. Referring to Figure 1, it can be seen that the Leckner[iv] curve gives an emissivity of 0.13. Table 1 summarizes atmosphere emissivities for 100 to 800 ppm of CO2.

Table 1

CO2 Concentration (ppm)	Emissivity
100	0.13
200	0.1395
400	0.140
800	0.141 (maximum)

Comments on the Data

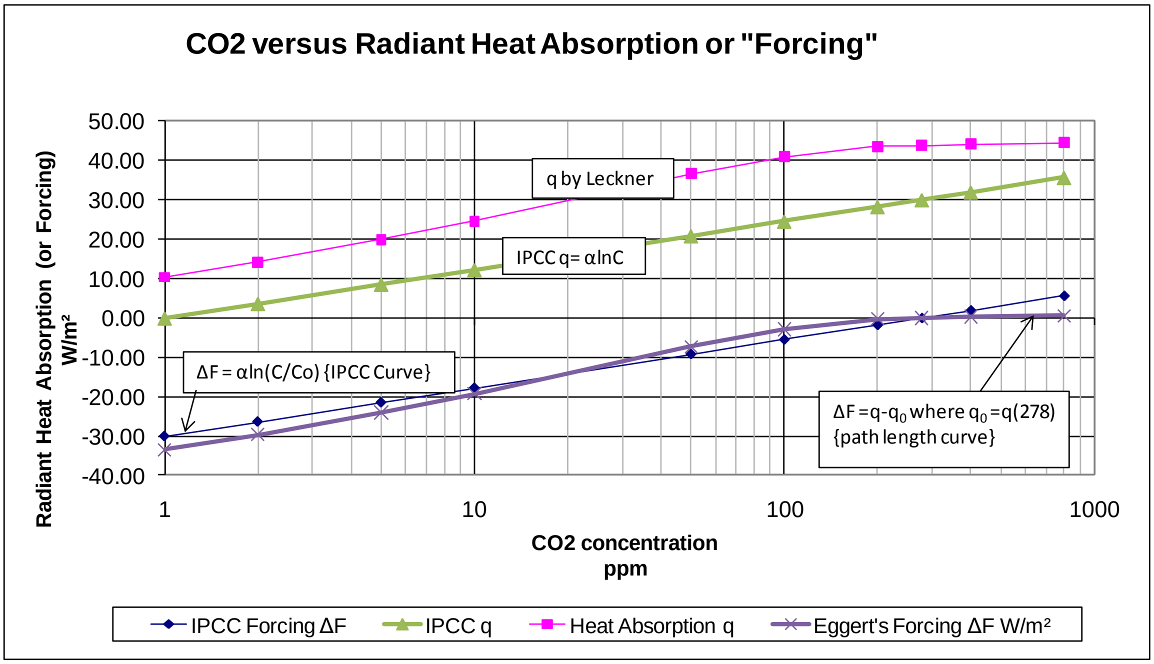
There are some simplifications to the data in this analysis. First, the impact of temperature variation within the atmosphere has been ignored. Both the Leckner and the historically earlier Hottel curves show variation with temperature, but the shape of the curves and more importantly, the differences in emissivity between path lengths is consistent. This implies that the curves will tend to move parallel to the y axis (emissivity), rather than the x axis (path length) with changing temperature. This in turn means that though there may be movement in the final emissivity, the path length at which maximum emissivity is attained will be relatively constant. Indeed, the total variation in atmospheric temperature is relatively small compared to the range of temperatures considered in Hottell's methods.

This then means that the concentration of CO2 at which there is no further change in emissivity is relatively constant. Second, there is some variation of emissivity with change in absolute pressure. This too will have an impact on relative magnitude of emissivity. The actual emissivity will move parallel to the y axis in this case, hence not changing the underlying hypothesis.

Utilizing the derived emissivities from this exercise to calculate atmospheric heat absorption generates a curve that is nearly identical to the IPCC model of

$\Delta F = \alpha \ln (C/Co)$ where α=5.35 and Co= 278ppm (1 of three such equations in the Fourth Assessment Report of the IPCC or AR4) which all generate curves of similar shape and magnitude)[v]

Figure 2 Emissivity at 0°C, After Leckner



The data and derivation of Figure 2 is shown at the end of this paper.

Figure 2 shows 4 curves. One is a direct plot of $\Delta F = \alpha \ln (C/Co)$. This is called “forcing” by IPCC scientists and represents an approximation of the impact of a change in CO2 concentration from the impact at some arbitrary point. The math symbol “ln” means natural logarithm. Taking the logarithm of a quotient is the same as subtraction. Another way of writing the IPCC curve equation is: $\Delta F = (\alpha \ln C) - (\alpha \ln Co)$. This equation implies that the absolute radiant heat loss from the atmosphere (the correct symbol for this is q) is $q= \alpha \ln C$. This is the second curve. The third and fourth curves are obtained using the emissivity as determined from Leckner’s curves. This is then used in the equation $q=\varepsilon\sigma(T^4)$. In this equation, ε is emissivity of the intervening gas, σ is the Stephan Boltzman constant at T is temperature of the radiating surface in Kelvin. This equation is not a simplification, if one assumes that the absorbing surface is space and further that the temperature of space is 0k (it is actually closer to 4K).

Figure 2 shows the two curves relative to each other. They are nearly identical in shape. The IPCC curve artificially offsets the 0 at 278 ppm atmospheric CO2. The IPCC curve does not reach a maximum. Rather it continues to grow up to 100% CO2. The IPCC curve closely models the curve generated using standard engineering methods, though offset by the artificial requirement to have a 0 at 278 ppm. The deviation of the IPCC curve from the Eggert curve after about 200 ppm, is not supported by the well documented and tested methods of calculating radiant heat transfer through an atmosphere.

Conclusion

Beyond 200 ppm, the Leckner curves indicate that there is a negligible change in emissivity and hence a negligible change in forcing. That is: **Above 200 ppm atmospheric concentration of CO2 there is no increase in the greenhouse affect due to CO2, and changes to human emissions of CO2 will have no affect on climate.**

References

Bejan, Adrian; Kraus, Allan D. Heat Transfer Handbook. John Wiley & Sons., 2003 Page 618 (Leckner’s curves, available in electronic form from www.knovel.com)

Schumann, Reinhardt, Metallurgical Engineering, Volume 1, Addison-Wesley, 1952 (Hottel’s curves -->> note the year.)

US Standard Atmosphere (personal copy of PDF printed from internet, for barometric equation).

http://www.esrl.noaa.gov/gmd/aggi/ IPCC equation for “forcing”. Also quoted in AR4 by the IPCC.

Data and Calculations

Partial Data for Calculation of Total Path Length

Altitude meters	Atmospheric Pressure	Unit Path Length at 100 ppm CO2 (bar-cm)	Cumulative Path Length at 100 ppm CO2 ppm CO1
0	1.00000000000	0	0
10	0.99874992129	0.0999	0.0999
20	0.99750110826	0.0998	0.1996
30	0.99625355992	0.0996	0.2993
40	0.99500727530	0.0995	0.3988
50	0.99376225341	0.0994	0.4981
60	0.99251849327	0.0993	0.5974
70	0.99127599391	0.0991	0.6965
80	0.99003475435	0.0990	0.7955
90	0.98879477361	0.0989	0.8944
100	0.98755605071	0.0988	0.9931
Column A Given	Column B Equation 1	Column C Equation 2	Column D Equation 3

Equation 1:

=((O6/(O6+(O7*A7)))^((O8*O9)/(O10*O7)))

Where:

273.15	Tb	O6
-0.0065	L	O7
9.80665	g	O8
28.9644	M	O9
8.31E+03	R	O10
101325	P	O11

Refer to the US Standard Atmosphere for a description of these constants. Also note that the excessive number of significant figures are a relic of the spreadsheet calculation. No rounding was used in the method. This does not greatly change the final results.

Equation 2:

=C$4*10^-6*$B7*(100*$A7-100*$A6)

Where:

C$4 = 100 ppm CO2, $B7 is Column B (pressure), $A7 is elevation in meters.

Equation 3:

=$D6+$C7

Where $D6 is the previous cumulative total path length

$C7 is the unit path length.

Data for Figure 2

http://www.esrl.noaa.gov/gmd/aggi/
see also AR4

$\Delta F = \alpha \ln(C/Co)$		W/m^2
Co=	278	ppm CO_2
α=	5.35	W/m^2
$q=\varepsilon\sigma(T^4)$		W/m^2
σ=	5.67E-08	SB constant
T=	273.15	Kelvin

Note that in both cases, ΔF is equal to $q-q_0$ where q_0 is at CO2=278

Atmospheric CO2 ppm	IPCC Forcing ΔF W/m^2	IPCC q W/m^2	Path Length Bar-cm	Leckner ε	Heat Absorption q W/m^2	Forcing ΔF W/m^2
1	**-30.11**	**0.00**	0.67	0.033	**10.42**	**-33.46**
2	**-26.40**	**3.71**	1.3	0.045	**14.20**	**-29.67**
5	**-21.50**	**8.61**	3.4	0.063	**19.89**	**-23.99**
10	**-17.79**	**12.32**	6.7	0.078	**24.62**	**-19.25**
50	**-9.18**	**20.93**	33.5	0.116	**36.62**	**-7.26**
100	**-5.47**	**24.64**	67.0	0.130	**41.03**	**-2.84**
200	**-1.76**	**28.35**	134.0	0.138	**43.56**	**-0.32**
278	**0.00**	**30.11**	186.3	0.139	**43.88**	**0.00**
400	**1.95**	**32.05**	268.1	0.140	**44.19**	**0.32**
800	**5.65**	**35.76**	536.1	0.141	**44.51**	**0.63**

The values for emissivity from Leckner are from the source cited in the references. The author has not yet obtained permission to include these graphs, but they are available from the internet or most university libraries.

Data from Leckner's curves used in this report

After Leckner at 0 C

pL bar - cm	ε Leckner
0.1	0.012
0.2	0.018
0.5	0.029
1	0.04
2	0.052
5	0.072
10	0.089
20	0.105
50	0.125
100	0.137
200	0.14
500	0.141

These are graphically determined values. Bejan and Kraus[ii] provides a calculation method for exact values.

References

[i] Schumann, Reinhardt, Metallurgical Engineering, Volume 1, Addison-Wesley, 1952 (Hottel's curves -->> note the year.)

[ii] Bejan, Adrian; Kraus, Allan D. Heat Transfer Handbook. John Wiley & Sons., 2003 Page 618 (Leckner's curves, available in electronic form from www.knovel.com)

[iii] US Standard Atmosphere (personal copy of PDF printed from internet, for barometric equation).

[iv] Bejan, Adrian; Kraus, Allan D. Heat Transfer Handbook. John Wiley & Sons., 2003 Page 618 (Leckner's curves, available in electronic form from www.knovel.com)

[v] http://www.esrl.noaa.gov/gmd/aggi/ IPCC equation for "forcing". This equation is also quoted in the fourth assessment report along with two other curves of similar shape and magnitude.