A new look at current climate science and carbon dioxide

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Highlights

Fossil fuels and CO_2 demonized by the idea of water vapor amplifying CO_2 warming

This idea does not take into account the gas laws or back radiation

Does not account for the response of CO_2 and water vapor to temperature changes

Compared to positive, dynamic back radiation, CO_2 is negative and insignificant

The sun has always controlled Earth's temperature and its climates

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Abstract

Energy from burning fossil fuels brings enormous benefits to the safety, health and general well-being of people and the environment. The resulting carbon dioxide enhances the growth rate of plants, is greening planet Earth and enhancing food security. Considering such vital benefits, why are fossil fuels being demonized? The problem began in the IPCC First Assessment Report (FAR) of 1990 with the statement that water vapor amplifies warming by carbon dioxide. The Fifth Assessment Report (AR5) in 2013 expanded this concept to include (a) water vapor typically amplifying warming by CO_2 by a factor of two to three times and (b) CO_2 controls water vapor concentration that goes up as CO_2 goes up and down as CO_2 goes down. This study proves these points are false by two independent methods that take into account the gas laws, response of CO_2 and water vapor to temperature changes and back radiation. Compared to the dynamic and positive warming by back radiation from the Poles to the Tropics, warming by CO_2 is passive, negative and appears insignificant. The evidence is clear; the sun has always controlled the temperature of the Earth's various climates.

Key words: AccuWeather, carbon dioxide, gas laws, ideal gas, scenario, smartphone, water vapor

1. Introduction

There are only four sources of energy available to the inhabitants of Earth: nuclear fusion in the sun, nuclear fission, tidal energy from the moon and hydropower from the Earth's gravity. Currently, the most important is nuclear fusion energy from the sun because it provides stored solar energy in the form of coal, oil and natural gas, the fossil fuels, and biomass [1]. It is stored solar energy that has made the world a better and safer place for humans and provides food security. Until plentiful coal, oil and natural gas became available, humans depended on trees for fuel. As the industrial age progressed, the demand for fuel increased dramatically. Trees were being burned faster than they could grow and forests were disappearing. Then came the switch to coal and the trees were saved. This occurred in Europe in the Early 1700s and in the U.S. about 1850 and the amount of forest area appears to have increased slightly since then.

Today, fossil fuels protect the forest environment directly and also indirectly by increasing the level of carbon dioxide (CO_2) in the atmosphere that increases the growth rate of plants. Over the past 35 years, images from satellites show the greening represents an increase in leaves on plants and trees equivalent to an area twice that of the continental United States [2]. The Earth is becoming measurably greener as plants proliferate.

It is becoming increasingly evident that policies demonizing fossil fuels and CO_2 in particular are causing harm to the environment and people. For example, extensive damage is being done to the environment of the southeastern U. S. by clear cutting large tracts of forest to provide wood pellet fuel to a former coal-fired power plant in England. See "Burned: Are trees the new coal?" available at https://burnedthemovie.com/.

The benefits of fossil fuels to mankind are so positive, the question arises: Why is there so much demonization of fossil fuels, and especially the carbon dioxide that is produced when they are burned to release energy? The answer lies in the Intergovernmental Panel on Climate Change (IPCC) First Assessment Report (FAR) issued in 1990 [3] as on page xxvii:

> “The simplest of these feedbacks arises because as the atmosphere warms, the amount of water vapor it holds increases. Water vapor is an important greenhouse gas and will therefore amplify the warming.”

This 1990 statement implies that water vapor amplifies warming by CO_2. This idea was repeated and expanded in IPCC Climate Change 2013: The Physical Science Basis (AR5) [4] in FAQ 8.1 on page 667:

> “Currently, water vapour has the largest greenhouse effect in the Earth’s atmosphere. However, other greenhouse gases, primarily CO_2, are necessary to sustain the presence of water vapour in the atmosphere. Indeed, if these other gases were removed from the atmosphere, its temperature would drop sufficiently to induce a decrease of water vapour, leading to a runaway drop of the greenhouse effect that would plunge the Earth into a frozen state. So greenhouse gases other than water vapour provide the temperature structure that sustains current levels of atmospheric water vapour. Therefore, although CO_2 is the main anthropogenic control knob on climate, water vapour is a strong and fast feedback that amplifies any initial forcing by a typical factor between two and three. Water vapour is not a significant initial forcing, but is nevertheless a fundamental agent of climate change.”

This statement expands the idea by quantifying the amplification as “a typical factor between two and three”. It further includes the concept that as CO_2 goes up, water vapor goes up and as CO_2 goes down, water vapor goes down.

The scientists who wrote both of these statements did not take into account all of the science that was available to them at the time. The 1990 statement did not take into account the gas laws of Boyle from 1662 and Charles/Gay-Lussac from 1787 or the psychrometric chart constructed by William Carrier in 1904. The 2013 statement did not take into account these two items or measurements of back radiation that became available after 1990.

These ideas in the IPCC reports can be summarized as follows: (1) CO_2 and water vapor are greenhouse gases and as such warm the atmosphere as their concentration increases, (2) warming by CO_2 causes more water vapor to form thereby causing a water vapor feedback loop that amplifies initial forcing by CO_2 a typical factor between two and three and (3) as CO_2 concentration goes up, water vapor concentration goes up, as do their respective warming effects, and vice versa. This scenario is widely accepted by the scientific community.

The purpose of this study is to provide scientific evidence that water vapor does not amplify warming by CO_2, CO_2 concentration does not affect water vapor concentration and the sun controls the Earth’s many climates from the Poles to the Tropics. The methodology is to take into account the gas laws, the response of CO_2 and water vapor to changes in atmospheric temperature, and measurements of back radiation. Back radiation is the radiation back to Earth from all of the greenhouse gases [5].

The study starts with a map of the World as in Figure 1. It shows 20 locations distributed relatively evenly through five latitude regions: the Arctic and Antarctic, the Equator, and the north and south mid-latitudes. It is evident that from the Poles to the Equator, the air becomes warmer, expands in accordance with the gas laws, and CO_2 concentration falls thereby reducing its warming effect. In contrast, the increased temperature allows the air to hold more water vapor and the concentration increases thereby increasing its warming effect; as one concentration goes up the other goes down. The evidence shows increased warming by water vapor does not increase warming by CO_2 as claimed in the current scenario.

Insert Figure 1 here.

The methodology provides a coherent set of data by using AccuWeather on a smartphone to record atmospheric temperature and relative humidity (RH) at all 20 locations at the same time, which for this study is 6:12 Montreal time on September 21, 2018, at the autumn equinox in the Northern Hemisphere. At each location, the set of readings is robust and provides the upper and lower values for temperature and RH experienced on Earth. The temperature and the gas laws provide the upper and lower values for CO_2 concentration. A psychrometric program, such as Humidair [19], used by engineers to design heating, ventilation and air conditioning systems, uses the temperature and RH to calculate the upper and lower values of water vapor concentration.

Plotting the quantitative results shows the relationship between concentrations of CO_2 and water vapor in response to changes in atmospheric temperature. A description of the methodology is given in sufficient detail to enable anyone to replicate the results and the figures.

The atmosphere consists of a mixture of gases that act as ideal gases and one non-ideal gas. Ideal gases are those gases that are always in the gaseous state under the conditions found on Earth, i.e., do not condense to a liquid. These are nitrogen, oxygen, the noble gases, such as argon, and the ideal greenhouse gases (GHG) such as CO_2, methane and nitrous oxide [6]. The one remaining component in the atmosphere is a GHG but not an ideal gas; it is water vapor.

All of the ideal gases are subject to the gas laws of Boyle and Charles/Gay-Lussac. The Intergovernmental Panel on Climate Change (IPCC) in its report Climate Change 2007: The Physical Science Basis (AR4) [7] identified 52 ideal GHG in the Earth's atmosphere. Consequently, whatever is confirmed for one of the ideal gases, such as CO_2, must apply to all of them.

The number of molecules of CO_2 per million molecules of dry air in the atmosphere is issued daily by the Mauna Loa Observatory [8]. This value was 405.65 ppm on September 21, 2018. It is the mole fraction, and does not change with temperature or elevation. It is useful for calculating the amount of dilution of CO_2 by water vapor. For example, when water vapor is 3%, or 30,000 parts per million molecules, ppm, in the atmosphere and CO_2 is 400 ppm the level of CO_2 is diluted by 12 ppm [6].

The warming effect, or radiative forcing (RF), of CO_2 is directly related to its concentration in the atmosphere through a mathematical function [9] [10] where concentration is defined as the amount of a substance in a defined space [11].

The baseline measurement issued daily by the Mauna Loa Observatory is used as the baseline for molecules per unit of volume [12] [13]. Because the concentration of CO_2 as molecules per unit volume varies with temperature and pressure, these must be specified. For this study Standard Temperature and Pressure are specified as 0^oC and 101.325 Pascals (Pa), or 1.01325 bar [14]. This allows calculation of CO_2 concentration at any location on Earth where the elevation, atmospheric temperature and RH are known.

A wide range of tools is used in this study. Some are new since the turn of the 21^{st} century. All are listed below in the order they became available:

1.1 AccuWeather provides measurements of atmospheric temperature (dry bulb) and RH in real time. These are readily accessed on a smartphone such that temperature and RH can be obtained at essentially the same time at all 20 locations. Smartphones capable of using AccuWeather became available around 2007 [15].

AccuWeather is a source of atmospheric temperature and RH from many locations worldwide and is available in real time. AccuWeather provides current weather conditions including current temperature, RH, local date and time, the current weather activity and a forecast from this base.

1.2 Google Earth is used to determine the elevation at each location from which to calculate the air pressure for use in the gas laws. Google Earth is readily accessed on a computer with access to the internet. The earliest versions of Google Earth appeared about 2004 [16].

1.3 The baseline concentration of CO_2 has been available since measurements began by Charles Keeling in 1959 at Mauna Loa in Hawaii, USA [17].

1.4 Psychrometric charts were developed by William Carrier and became available in 1904 [18]. Today's Humidair psychrometric program is much easier to use [19] than the charts. Psychrometric programs convert dry bulb temperature and RH into kilograms of water vapor per kilogram of dry air.

1.5 The gas laws were discovered by Boyle in 1662 and Charles/Gay-Lussac in 1787 [20] [21].

Boyle's Law states:

"The volume of a gas at constant temperature is inversely proportional to its pressure". For example, doubling the pressure reduces the volume to one-half and doubles the concentration of the gas.

Charles/Gay-Lussac's Law states:

"At constant pressure, the volume of a dry gas is proportional to the absolute temperature." For example, if the absolute temperature were to increase by 5%, the volume would increase by 5% and the concentration would decrease by 5%."

The mathematics to apply the gas laws is set up as equations (3) and (4).

2. Locations selected for study

The methodology is to select 20 locations, as in Figure 1 [22], around the Earth representative of the wide variety of climates and ranges of atmospheric temperatures, RH, CO_2 concentrations and water vapor concentrations. The 20 locations selected are distributed over five latitude zones in both east and west longitudes such that at any given time half are in sunlight and half are in darkness. Half are in one season such as starting into spring as the other half starts into autumn, the opposite season. The numbers of the locations in Figure 1 and Tables 1 and 2 correspond.

Insert Table 1 here.

Values for latitude, longitude and elevation for each of the 20 locations are from Google Earth and are Columns C, D and E of Table 1. From the elevation, the corresponding air pressure is calculated in Pa where one atmosphere of pressure is 101,325 Pa. The atmospheric pressure in Pa at any elevation is calculated using the Engineering Tool Box formula [23], Equation (1):

$$\text{Air pressure in Pa} = 101{,}325 \times (1 - 2.25577 \times 10^{-5} \times \text{meters})^{5.25588} \; . \; . \; . \; . \; . \; .(1)$$

For example, the air pressure at elevation of 32 metres at Pond Inlet is given by equation (2):

$$P = 101{,}325 \times (1 - 2.25577 \times 10^{-5} \times 32 \text{ meters})^{5.25588} = 101{,}325 \times (1 - 0.0012407)^{5.25588} = 100{,}941 \text{ Pa} \; . \; . \; . \; .(2)$$

The values in Table 2 for local date and time, Montreal time, atmospheric temperature and RH in columns E, F, G, H and I are conveniently available from AccuWeather on a smartphone. The time sequence starts at Montreal at 6:12 hours and ends 13 minutes later at Kirkenes at 6:25 Montreal time. The sequence was immediately repeated and there were no changes. The CO_2 concentration in Column J is calculated for each of the 20 locations using the local temperature and location pressure at essentially the same Montreal time, even though the local time zones are different.

Insert Table 2 here.

For reference, the Montreal time of 6:12 hours on September 21, 2018 is 40 hours and 42 minutes before the Autumn Equinox that occurred on September 22, 2018 at 22:54 Montreal time, and is close enough for our purposes and does not affect the results. Montreal time on September 21, 2018 was four hours after Coordinated Universal Time (UTC).

3. CO_2 concentration

The formula in equations (3) and (4) is the application of the gas laws to the baseline CO_2 concentration to calculate CO_2 concentration at each location:

$$CO_2 = 405.65 \times ((\text{Col. F})/101{,}325) \times (273/(\text{Col I} + 273)) \; . \; . \; . \; . \; . \; . \; .(3)$$

For Pond Inlet where air pressure is 100,941 Pa and temperature is -5°C:

$$CO_2 = 405.65 \times (100{,}941/101{,}325) \times (273/(-5 + 273)) = 411.7 \text{ ppm} \; . \; . \; . \; . \; . \; . \; .(4)$$

Figure 2 is a plot of the CO_2 concentration in Column L of Table 2 against atmospheric temperature of Column H. The higher concentrations of CO_2 are found at the lower temperatures and vice versa, which is consistent with the gas laws but is contrary to current climate science.

Insert Figure 2 here.

Table 3 was constructed to show the differences in CO_2 concentration, RF and temperature between five examples. The information from IPCC AR5 [24] is in Column A. The other four examples are the Northern Hemisphere autumn equinox and winter solstice in 2018 and the spring equinox and summer solstice of 2019. The difference in RF for Columns B, C, D and E is from Reference [**Error! Bookmark not defined.**] [**Error! Bookmark not defined.**].

The +0.85°C increase in atmospheric temperature implied by the IPCC to be the result of increased CO_2 concentration is not supported by the results of this study. Increased CO_2 concentration is associated with a significant decrease in temperature.

Equilibrium Climate Sensitivity (ECS) is the sensitivity of atmospheric temperature to changes in CO_2 concentration. The current expectation is that ECS is positive and determines the increase in atmospheric temperature for increases in CO_2 concentration. However, Table 3 and Figure 2 show that ECS for CO_2 is actually negative, i.e., inversely associated with increased temperature. For all 52 GHG that act as ideal gases the ECS is negative.

Insert Table 3 here.

The annual reduction in CO_2 concentration in the North American summer because of vegetation growth is accounted for in the daily baseline for CO_2 issued by the Mauna Loa Observatory.

With the increasing CO_2 concentration having no discernible warming effect on atmospheric temperature, it appears something other than the ideal GHG is controlling atmospheric temperature. That can only be water vapor because it is the only GHG remaining in the atmosphere not yet included in this study.

4. Water vapor

The amount of water vapor in the air is readily determined from the atmospheric temperature and the RH using a Humidair psychrometric program [19] or a psychrometric chart [25]. See Table 2.

The Humidair program is recommended as easy to use, accurate and precise. It requires the atmospheric temperature, RH and the pressure at the location converted to bar. One bar is, 100,000 Pa. The Humidair code to give the results in kilograms of water per kilogram of dry air is "W". The result in kilograms of water per kilogram of dry air can be multiplied by 1,000,000 to give parts per million and then by (28.9645/18.016) to give water vapor in the same units as CO_2. as in Column K of Table 2.

The water vapor concentration is added to Figure 2 as triangles to form Figure 3.

Insert Figure 3 here.

The results show increased levels of CO_2 in the atmosphere are associated with lower temperatures as would be expected from the gas laws. Figure 3 also shows that as atmospheric temperature falls, CO_2 concentration increases and water vapor concentration decreases. Thus, there can be no water vapor feedback caused by increased CO_2 concentration.

Observe in Figure 3 that when McMurdo in Antarctica is at -21^{o}C, Libreville on the Equator is at +28^{o}C. CO_2 concentration at Libreville is lower by 72.6 ppm from 438.9 to 366.3 ppm whereas water vapor is 29,863 ppm higher from 466 to 30,230 ppm. The reduction in CO_2 molecules is 0.24% of the increase in the number of water vapor molecules per unit of volume. Compared to the increase in water vapor molecules the reduction in the number of molecules of CO_2 appears to be negligible.

The increase in water vapor molecules is (30230/366.6) = 82.5 molecules for each molecule of CO_2. These values are for dry air. If the dilution of CO_2 by water vapor were included at Libreville, CO_2 concentration would be approximately (366.6 – 11.3) = 343.3 ppm and the ratio of water molecules to CO_2 molecules would be 85.1. As examples, the vertical lines at McMurdo, Dunedin and Libreville connect temperature and the concentrations of CO_2 and water vapor at three of the 20 points.

The concentrations of CO_2 and water vapor in Figure 3 are determined by atmospheric temperature. The temperature is controlled by the sun angle that varies from -23^{o} at the Poles to 90^{o} above the Equator. Atmospheric temperature follows the sun angle and water vapor concentration follows the temperature as in Figure 4 for Toronto, Canada.

Insert Figure 4 here.

5. Back radiation

Back radiation, the sum of radiation back to the Earth from all of the GHG is used to compare the warming effects of each GHG directly in Watts per square meter. Back radiation is also known as downward long wave radiation [26], is given by Equation (5):

Back radiation = Water vapor + CO_2 + remaining ideal GHG . . . .(5)

Figure 5 shows measured back radiation versus latitude as constructed from Table 1 and Figure 4 of Wild (2001) [27].Back radiation provides a means of quantifying the contribution of CO_2 to global warming using actual measurements of back radiation in terms of Watts per square metre (W m^{-2}).

From Figure SPM.5 of the Summary for Policymakers of AR5, the RF of CO_2 is approximately equal to the sum of the RF of all of the other ideal GHG. Equation (5) becomes Equation (6):

Back radiation = Water vapor + 2 CO_2 . . . . (6)

Rewriting Equation (6) gives Equation (7):

Water vapor = Back radiation + 2CO_2 . . . . (7)

Insert Figure 5 here.

Thus, back radiation is mostly from water vapor. Lines for the warming effect of CO_2 and that of the remaining GHG are added to Figure 5. The upper end of the CO_2 line is at the Poles at 9.4 W m^{-2}, and the lower end is in the Tropics at 8.5 W m^{-2}. The drop in warming is 0.9 W m^{-2}, as determined from Figure 6. Over the same range, warming by back radiation increased by ≈320 W m^{-2} and increased atmospheric temperature by ≈50^{o}C. If warming of ≈320 W m^{-2} by back radiation causes a change in atmospheric temperature of ≈50^{o}C, then the possible temperature change for a drop in CO_2 is ≈(50 x (0.9/320) ≈14^{o}C.

This value is negative compared to that of back radiation that is mostly water vapor and is small enough it is unlikely to have a significant effect on atmospheric temperature.

Both Figures 3 and 5 show that as warming by CO_2 increases, warming by water vapor decreases: and vice versa; one goes up and the other goes down. In Figure 3, the difference over the Poles to the Tropics is in the number of molecules of water vapor per molecule of CO_2. This is only an indication that warming by water vapor is substantially higher than that of CO_2 because the comparative warming per molecule is not known. Figure 5 relates the concentration of each gas to its warming effect in Watts per square meter, a reliable comparison.

The slope of the line representing warming by the remaining ideal GHG is similar to that of CO_2; it is small and negative compared to that of water vapor.

Insert Figure 6 here.

The relationship between RF and concentration of CO_2 is given in Figure 6 [**Error! Bookmark not defined.**]. For purposes of this study, RF is ≈9 W m^{-2} at current levels of CO_2, and the maximum warming by CO_2 is ≈10.5 W m^{-2}.

It is important to note that although the CO_2 baseline is increasing over time, the relative positions of the CO_2 points in Figure 3 do not change. From Figure 6, at concentration over 655 ppm, CO_2 can have no further warming effect on the atmosphere.

6. The role of the sun

The question often arises as to whether or not atmospheric temperature is causing the water vapor concentration or is water vapor concentration causing atmospheric temperature. Observations over the course of a year at any place on Earth show the sun leads temperature and water vapor concentration follows the temperature. The average annual records for Toronto, Canada, in Figure 4 are typical and show the sun angle leads atmospheric temperature and water vapor concentration by approximately six weeks [28].

Figure 3 shows water vapor is the only GHG that increases in concentration as atmosphere temperature increases. This is consistent with IPCC report Climate Change 2013: The Physical Science Basis (AR5) [20] where Figure TS.1 on page 38 shows the change in specific humidity over the mid-1970s to 2011 correlates well with the increase in atmospheric temperature. Box TFE.1 on page 42 indicates the increase in specific humidity was 3.5% and caused a temperature increase of 0.5^oC over the period mid-1970s to 2011. Only the sun has enough energy to raise the concentration of water vapor in the atmosphere. For example, on average, one quarter of the sun's energy radiated to Earth goes to evaporate water to water vapor [29] [30].

The sun is firmly in control of the Earth's temperature, both annually and over decades. The ideal GHG, such as CO_2 and methane, have negligible effect on the Earth's temperature because their warming effect is so small as to be negligible compared to that of water vapor.

7. Estimates of possible errors

To help the reader, estimates of the magnitude of possible errors on the results and conclusions are presented in this section.

7.1. Estimates of possible errors related to CO_2 concentration and atmospheric temperature:

7.1.1. Measurement of daily CO_2 concentration. The concentration reported is to two decimal places. If the number were out by one unit in the second decimal place, the error would be 0.01, and the percent error would be (0.01/405.65) = 0.0025%.

7.1.2. Conversion from parts per million molecules of dry air to parts per million by volume = (0.3/400) = 0.075%.

7.1.3, Measurement of atmospheric temperature: If the temperature was rounded off by 1^{o}C, the maximum error would be (1/273K) = 0.37%.

7.1.4 Measurement of elevation by Google Earth has an error of -18 to + 23 metres [31]. This calculates to a pressure range from 101,049 Pa to 101,541 Pa, a difference of 492 Pa, or (492/101,325) = 0.49% of atmospheric pressure.

7.1.5. The sum of these errors is 0.92%

Estimate of the possible errors related to calculation of the concentration of water vapor:

7.2. The smallest RH is 10% at Karamay, China and if it was off by one percentage point, the error would be 10%. The largest is 99% at Pond Inlet where being off by one percentage point would represent an error of 1%. The average RH for the 20 locations at 6:12 hours was 68.7%. If this were out by one percentage point, the maximum average error would be (1/68.7) = 1.46%.

Adding the possible errors related to concentration of water vapor brings the total to (0.37 + 1.46) = 1.83%

Thus, the combined total possible errors in the numbers used to calculate the CO_2 concentration are less than 1.0% and the average possible error in calculating water vapor concentration is less than 2%.

The magnitude of these errors has no significant effect on Figures 2 and 3 or on the conclusions of this study.

7.3. The 20 locations are well placed to give representative results for different dates and times. The "snapshot" for Line 1 of Table 6 is Figure 2 at 6:12 on September 21, 2018. The error range for the eleven examples in Table 6 taken over nine months is from -1.9% to +4.2% around the average. This small error range is a clear indication of the validity of the representative nature of the 20 locations.

Insert Table 4 here.

8. Summary and conclusions:

Fossil fuels have raised most of the world's people out of poverty and given them meaningful and healthful lives. Fossil fuels are directly protecting the environment by saving trees from their historical role as fuel to provide heat for human society. Fossil fuels also provide indirect support to human society by increasing the level of CO_2 in the atmosphere. This increases the growth rate of plants, which are at the bottom of the food chain, and leads to better food security.

With fossils fuels having so many benefits, why are they demonized? The answer lies in the IPCC First Assessment Report in 1990. It implies that as temperature rises, water vapor increases and through feedback amplifies the initial warming by CO_2. This is repeated and expanded in Climate Change2013:

The Physical Science basis (AR5) where the feedback claims to increase warming by CO_2 by two to three times and CO_2 concentration controls water vapor concentration. To summarize, current climate science claims CO_2 is a warming gas and as its concentration increases it warms the air. The air can then hold more water vapor and that amplifies the warming by CO_2 in a water feedback loop, i.e., as the concentration of CO_2 increases, the concentration of water vapor increases. This scenario does not take into account the gas laws, the response of CO_2 and water vapor to changes in air temperature and back radiation. When these factors are taken into account, a new scenario emerges. It identifies and provides support for the fact that in response to an increase in atmospheric temperature, the concentration of CO_2 decreases and the concentration of water vapor increases. This is opposite to current climate science.

This fact is confirmed by back radiation, the sum of radiation back to the Earth from all of the GHG. The warming effect of each GHG is compared directly in Watts per square meter ($W\ m^{-2}$) so the effects of atmospheric temperature on each can be accurately evaluated.

8.1 In response to an increase in atmospheric temperature CO_2 concentration goes down, water vapor concentration goes up and vice versa, as do their respective warming effects. Thus, increasing CO_2 cannot create a water vapor feedback loop. CO_2 does not warm the atmosphere and cause climate change; it does not cause temperature, it responds to temperature.

8.2 In the example of this study, from the Poles to the Tropics, warming by back radiation increases by ≈320 $W\ m^{-2}$ and increases atmospheric temperature by ≈50^{o}C. Over the same range warming by CO_2 falls by 0.9 $W\ m^{-2}$; a drop equivalent to ≈(50 x (0.9/320)) ≈0.14^{o}C.

8.3 Compared to the positive and dynamic warming by back radiation, warming by CO_2 is passive, slightly negative and causes insignificant warming of the atmosphere.

8.4. Considering the warming effect of CO_2 outside of the Gas Laws and the atmosphere in which they operate leads to the incorrect claim that increased CO_2 concentration warms the atmosphere and causes climate change.

8.5. When all of the relevant science is taken into account, it is clear CO_2 does not warm the atmosphere and cause climate change. CO_2 does not cause temperature change, it responds to temperature changes. Water vapor is the only GHG where increased concentration is associated with increased atmospheric temperature.

8.6. The sun angle through water vapor is the primary control of Earth's temperature and its climates. Atmospheric temperature follows the sun angle by approximately six weeks. Water vapor concentration and its large warming effect follow the temperature. Atmospheric temperature and water vapor correlate well over decades as indicated in IPCC report AR5.

8.7. All 52 ideal gases identified as GHG by the IPCC in AR4 act opposite to water vapor. Included are methane, nitrous oxide and all of the trace gases. All have negligible warming effect on atmospheric temperature. All have negative Equilibrium Climate Sensitivity (ECS).

8.8. Estimates of possible errors show the error for CO_2 concentration versus atmospheric temperature is less than 1% and for water vapor versus atmospheric temperature it is less than 2%. Errors in the slope of the linear trend lines for CO_2 are -1.9% to +4.2%. These errors have no significant effect on the results or conclusions of this paper.

8.9. Earth's environment and people are hurting because of current policies based on the widely held belief that CO_2 can dangerously warm the atmosphere and cause climate change. Fossil fuels provide 80% of the World's fuel supply and reducing access to energy hurts the environment and people.

Tables and Figures

Table 1. Latitudes, longitudes, elevation in metres and atmospheric pressure in Pascals for 20 locations in representative areas around the Earth.

	A Latitude zone	B Location and country	C Latitude	D Longitude	E Elev’n, metres	F Pressure, Pascals
1		Pond Inlet, Canada	72° 42’ N	77° 58’ W	31	100941
2	**Above**	Tiksi, Russia	71° 38’ N	128° 51’ E	41	100833
3	**Arctic Circle**	Kirkenes, Norway	69° 40' N	30° 03’ E	15	101145
4		Inuvik, Canada	68° 22’ N	133° 43’ W	26	101013
5		Karamay, China	45° 35’ N	84° 53’ E	356	97121
6		Portland, Oregon, USA	45.31° N	122° 40’ W	2	101301
7	**Mid-latitudes**	Milan, Italy	45° 28’ N	9° 11’ E	126	99820
8	**North**	Harbin, China	45° 48' N	126° 32’ E	120	99619
9		Montreal, Canada	45° 30’ N	73° 34’ W	29	100582
10		Minneapolis, USA	45° 59’ N	93° 16’ W	255	98299
11		Libreville, Gabon	0° 25' N	9° 28’ E	30	100965
12	**Equator**	Kampala, Uganda	0° 21' N	32° 35’ E	1190	87823
13		Quito, Ecuador	0° 11' S	78° 28’ W	2922	70807
14		Samarinda, Borneo	0° 30' S	117° 08’ E	3	101289
15		Santiago, Chile	33° 27’ S	70° 40’ W	533	95084
16	**Mid-latitudes**	Port Elizabeth, South Africa	33° 58’ S	25°36’ E	61	100594
17	**South**	Hobart, Australia	42° 53’ S	147° 20’ E	9	101217
18		Dunedin, New Zealand	45° 53' S	170° 30’ E	6	101253
19		Rio Grande, Tierra del Fuego	53° 47’ S	67° 42’ W	15	101145
20	**Below Antarctic Circle**	McMurdo Station, Antarctica	77° 50' S	166° 41’ E	10	101205

Table 2. Date and time of atmospheric temperature, relative humidity, CO_2 concentration in dry air and water vapor concentration for 20 locations at 6:12 hours on September 21, 2018

	B	E	F	G	H	I	J	K
	Location	2018 Local Date	Local time	Montreal time	Temp., ^oC	RH, %	$CO_{2,}$ ppm dry air	Water vapor, ppm
1	Pond Inlet	Sep 21	6:15	6:15	-5	99	411.7	3971
2	Tiksi	Sep 21	19:20	6:20	2	79	400.7	5583
3	Kirkenes	Sep 21	12:25	6:25	12	57	387.9	7999
4	Inuvik	Sep 21	4:13	6:13	0	59	404.4	3596
5	Karamay	Sep 21	18:25	6:25	24	10	357.4	3096
6	Portland	Sep 21	3:24	6:24	12	86	388.5	12099
7	Milan	Sep 21	12:18	6:18	25	66	366.1	21493
8	Harbin	Sep 21	18:19	6:19	15	92	378.0	16021
9	Montreal	Sep 21	6:12	6:12	15	81	381.7	13926
10	Minneapolis	Sep 21	5:23	6:23	14	90	374.3	14912
11	Libreville	Sep 21	11:21	6:21	28	78	366.6	30230
12	Kampala	Sep 21	13:17	6:17	25	70	322.1	26016
13	Quito	Sep 21	5:16	6:16	10	54	273.5	9482
14	Samarinda	Sep 21	18:17	6:17	30	66	365.4	28581
15	Santiago	Sep 21	7:22	6:22	9	52	368.5	6342
16	Port Elizabeth	Sep 21	12:22	6:22	19	48	376.5	10641
17	Hobart	Sep 21	20:24	6:24	16	48	382.8	8733
18	Dunedin	Sep 21	22:14	6:14	7	97	395.2	9730
19	Rio Grande	Sep 21	7:21	6:21	-2	92	407.9	4750
20	McMurdo Station	Sep 21	20:19	6:19	-21	50	438.9	466

Table 3. The IPCC concept that increased CO_2 is related to increased temperature [24] in Column A is compared with the results of applying the gas laws at 20 locations.

	A	B	C	D	E
		McMurdo (Antarctica) toLibreville (Equator)			
		6:12	17:06	17:58	11:54
	IPCC	Sep.21	Dec. 21	Mar. 20	June 21
	AR5	2018	2018	2019	2019
Increase in CO_2, ppm (dry air)	116	72.3	42.0	74.6	104.2
Δ Radiative forcing, Wm^{-2}	+1.68	+1.05	+0.54	+0.88	1.16
Change in temperature, ^oC	+0.85	+49	+30	+49	+65
		Pond Inlet (Arctic) to Libreville (Equator))			
Increase in CO_2, ppm (dry air)		45.1	92.0	88.3	33.8
Δ Radiative forcing, Wm^{-2}		+0.59	+1.07	+1.02	0.44
Change in temperature, ^oC		+33	+60	+56	+25
Equilibrium Climate Sensitivity (ECS)	Positive	Negative	Negative	Negative	Negative

Table 4. This table shows the variability of the linear trend lines of Figure 2 for eleven replications of this study. The error ranges are for a change in CO_2 concentration for 60°C difference in temperature, as in Column F, around the average. The dates are from September 21, 2018 to June 21, 2019.

	A	B	C	D	E	F
			CO_2 vs temp.	CO_2 increase	Difference. from the	
			Equation of trend	for x=60°C,	average of 291.41	Error range,
	Date	Time	line, y =	ppm	ppm	%
1	Sep 21	6:12	-1.6336x+396.77	298.57	+7.2	+2.5
2	Dec 21	17:06	-1.8624x+400.28	288.54	-2.9	-1.0
3	Mar 20	17:58	-1.9216x+404.54	289.24	-2.2	-0.7
4	April 3	12:00	-1.973x+404.47	286.60	-4.8	-1.7
5	April 3	18:00	-1.9883x+404.71	285.94	-5.5	-1.9
6	April 3	24:00	-1.8689x+404.04	292.44	+1.0	+0.4
7	April 4	6:00	-1.8155x+403.49	295.58	+4.2	+1.4
8	April 4	21:00	-1.8897x+403.41	290.55	-0.5	+0.3
9	April 10	13:00	-1.9939x+406.03	286.40	-5.0	+1.7
10	April 10	20:00	-1.9669x+405.96	287.95	-3.5	+1.2
11	June 21	10:56	-1.7076x +406.17	303.71	+2.3	+4.2

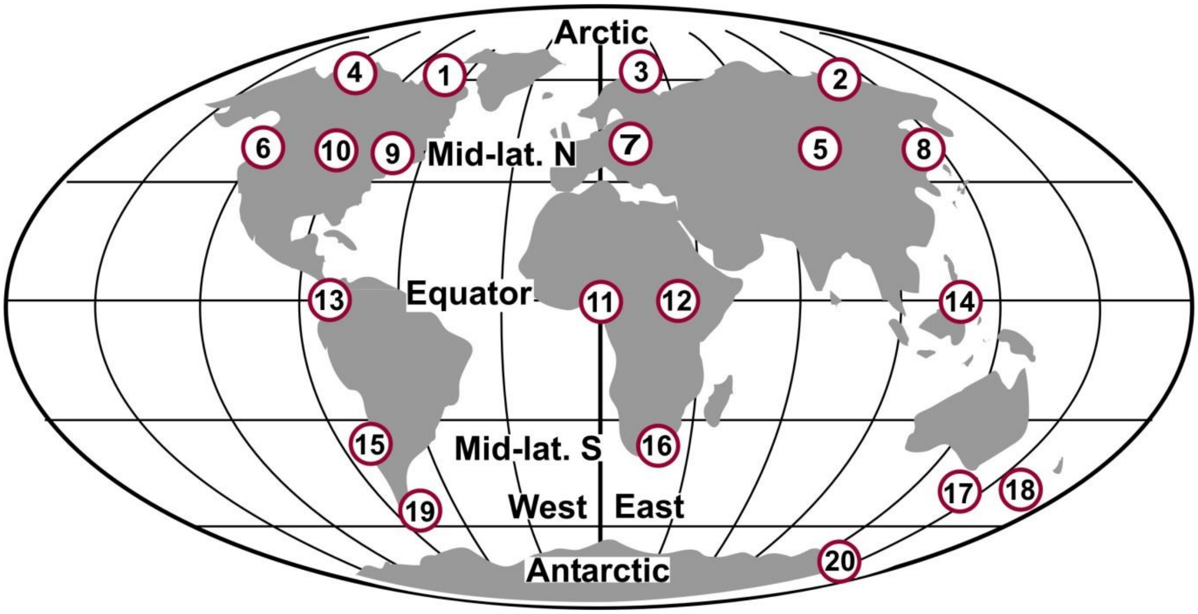

Figure 1. World map adapted from Reference [22] showing the location of 20 representative locations in five latitude zones as well as east and west longitude. The numbers correspond to Table 1.

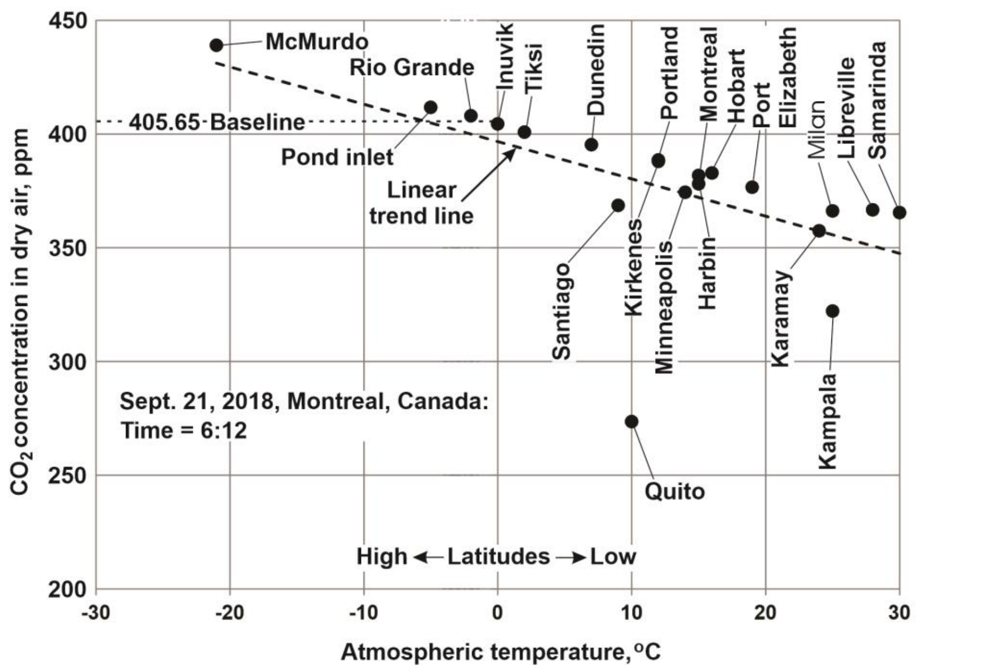

Figure 2. Plot of CO_2 concentration versus atmospheric temperature for 20 locations at 6:12 Montreal time on September 21, 2018. Higher concentrations of CO_2 are associated with lower temperatures as expected from the gas laws.

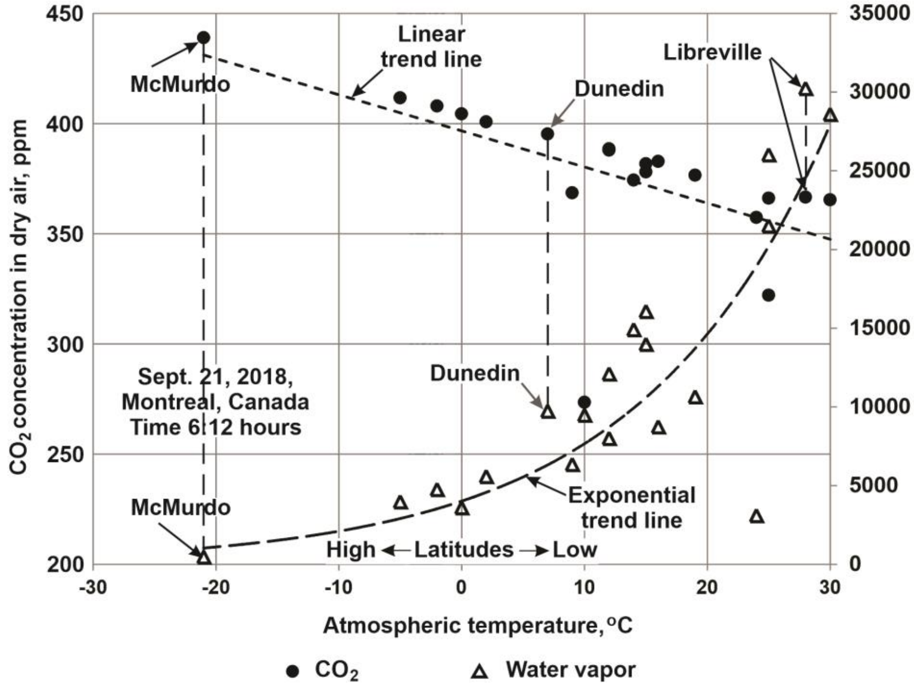

Figure 3. Plot of CO_2 and water vapor concentration versus atmospheric temperature for 20 locations at 6:12 Montreal time on September 21, 2018. Water vapor and CO_2 act opposite to each other, i.e., as temperature increases water vapor concentration rises and CO_2 concentration falls, and vice versa.

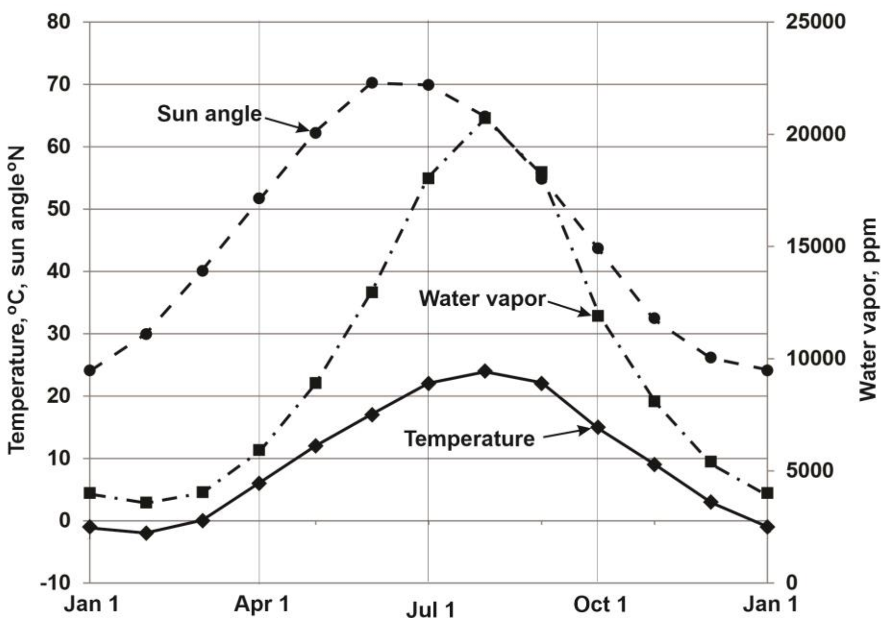

Figure 4. Typically, the sun angle leads temperature and water vapor concentration by approximately six weeks over the course of a year. Water vapor follows atmospheric temperature. This figure is constructed for Toronto, Canada based on the high temperature for the day and the corresponding RH.

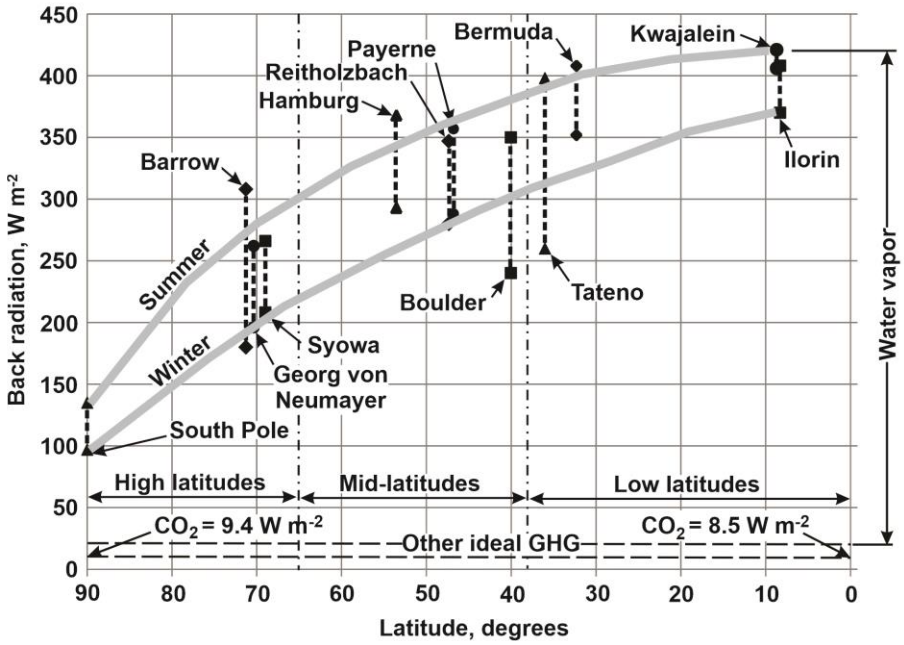

Figure 5. Back radiation versus latitude adapted from Table 1 and Figure 4 of Wild (2001) with the levels of CO_2 and the ideal GHG added.

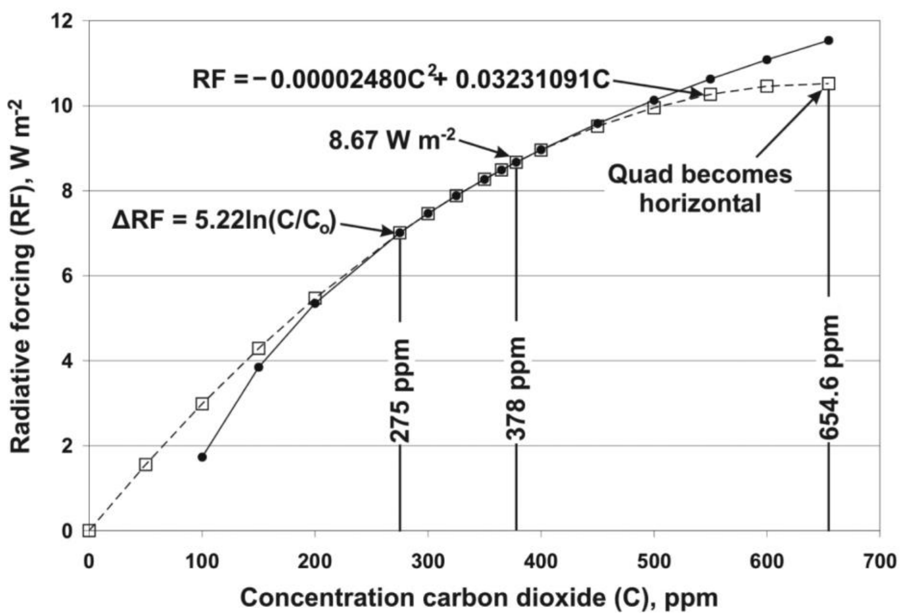

Figure 6. Table 4 from Reference [**Error! Bookmark not defined.**]. The quadratic model starts at zero because RF = zero at zero CO_2 concentration and provides a link to the RF scale. This allows calculation of the actual RF rather than ΔRF between two concentrations.

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