

Human CO₂ Emissions Have Little Effect on Atmospheric CO₂

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Abstract: The United Nations *Intergovernmental Panel on Climate Change* (IPCC) agrees human CO₂ is only 5 percent and natural CO₂ is 95 percent of the CO₂ inflow into the atmosphere. The ratio of human to natural CO₂ in the atmosphere must equal the ratio of the inflows. Yet IPCC claims human CO₂ has caused all the rise in atmospheric CO₂ above 280 ppm, which is now 130 ppm or 32 percent of today's atmospheric CO₂. To cause the human 5 percent to become 32 percent in the atmosphere, the IPCC model treats human and natural CO₂ differently, which is impossible because the molecules are identical. IPCC's Bern model artificially traps human CO₂ in the atmosphere while it lets natural CO₂ flow freely out of the atmosphere. By contrast, a simple Physics Model treats all CO₂ molecules the same, as it should, and shows how CO₂ flows through the atmosphere and produces a balance level where outflow equals inflow. Thereafter, if inflow is constant, level remains constant. The Physics Model has only one hypothesis, that outflow is proportional to level. The Physics Model exactly replicates the 14C data from 1970 to 2014 with only two physical parameters: balance level and e-time. The 14C data trace how CO₂ flows out of the atmosphere. The Physics Model shows the 14 CO₂ e-time is a constant 16.5 years. Other data show e-time for 12CO₂ is about 4 to 5 years. IPCC claims human CO₂ reduces ocean buffer capacity. But that would increase e-time. The constant e-time proves IPCC's claim is false. IPCC argues that the human-caused reduction of 14C and 13C in the atmosphere prove human CO₂ causes all the increase in atmospheric CO₂. However, numbers show these isotope data support the Physics Model and reject the IPCC model. The Physics Model shows how inflows of human and natural CO₂ into the atmosphere set balance levels proportional to their inflows. Each balance level remains constant if its inflow remains constant. Continued constant CO₂ emissions do not add more CO₂ to the atmosphere. No CO₂ accumulates in the atmosphere. Present human CO₂ inflow produces a balance level of about 18 ppm. Present natural CO₂ inflow produces a balance level of about 392 ppm. Human CO₂ is insignificant to the increase of CO₂ in the atmosphere. Increased natural CO₂ inflow has increased the level of CO₂ in the atmosphere.

Keywords: Carbon Dioxide, CO₂, Climate Change, Anthropogenic

1. Introduction

The U.S. Global Change Research Program Climate Science Special Report (USGCRP) [1] claims,

This assessment concludes, based on extensive evidence, that it is extremely likely that human activities, especially emissions of greenhouse gases, are the dominant cause of the observed warming since the mid-20th century.

The United Nations Intergovernmental Panel on Climate Change (IPCC) [2] Executive Summary claims human emissions caused atmospheric CO₂ to increase from 280 ppm in 1750, to 410 ppm in 2018, for a total increase of 130 ppm.

IPCC and USGCRP claim there are “no convincing

alternative explanations” other than their theory to explain the “observational evidence.”

This paper presents a “convincing alternative explanation” that explains the data. A simple physics model explains the required first step of human-caused climate change: how human CO₂ changes atmospheric CO₂.

For simplicity, this paper uses levels in units of ppm (parts per million by volume in dry air) and flows in units of ppm per year. GtC (Gigatons of Carbon) units are converted into CO₂ units in ppm using:

$$1 \text{ ppm} = 2.12 \text{ GtC}$$

Authors who support the USGCRP [1] and IPCC [2, 3]

include Archer et al. [4], Cawley [5], Kern and Leuenberger [6], and Kohler [7].

Authors who conclude human CO₂ increases atmospheric CO₂ as a percentage of its inflow include Revelle and Suess [8], Starr [9], Segalstad [10], Jaworowski [11, 12], Beck [13], Rorsch, Courtney, and Thoenes [14], Courtney [15], Quirk [16], Essenhigh [17], Glassman [18], Salby [19-22], Humlum [23], Harde [24, 25], and Berry [26, 27].

2. The Science Problem

IPCC [2, 3] says nature emits about 120 GtC from land and 90 GtC from ocean for a total of 210 GtC per year. This is equivalent to about 98 ppm per year of natural CO₂ that flows into the atmosphere. IPCC admits its estimates of “gross fluxes generally have uncertainties of more than $\pm 20\%$.”

Boden [28] shows human CO₂ emissions in 2014 were 9.7 GtC per year, or 4.6 ppm per year. So, IPCC agrees that human inflow is less than 5% and nature is more than 95% of the total CO₂ inflow into the atmosphere. Yet IPCC assumes nature stayed constant since 1750 and human CO₂ causes 100 percent the increase in atmospheric CO₂ above 280 ppm, which today is 130 ppm or 32 percent of 410 ppm.

The Physics Model concludes the percent of human CO₂ in the atmosphere equals the percent of human CO₂ in the inflow.

Figure 1 shows how the predictions of the Physics Model and IPCC model differ regarding the composition of human CO₂ in the atmosphere.

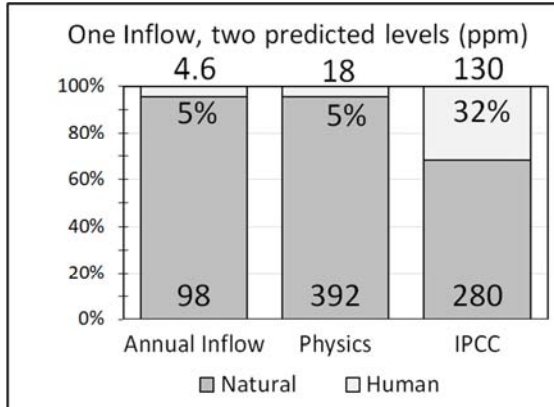


Figure 1. The IPCC agrees the inflow of human CO₂ is less than 5 percent. The Physics Model says the percent of human CO₂ in the atmosphere equals the percent of its inflow. IPCC claims human CO₂ adds all atmospheric CO₂ above 280 ppm, which is now 32 percent of the total.

If the IPCC model is correct, then the effect of human CO₂ emissions on atmospheric CO₂ is 100 percent. If the Physics Model is correct, then human CO₂ emissions do not cause climate change.

3. The Physics Model

3.1. How CO₂ Flows Through the Atmosphere

IPCC states, and much of the public believes, human emissions “add” CO₂ to the atmosphere. IPCC’s view is the

atmosphere is a garbage dump where human CO₂ is deposited and mostly stays forever.

However, nature must treat human and natural CO₂ the same because their molecules are identical. Nature has had millions of years to “add” to atmospheric CO₂. If nature’s CO₂ “adds” to atmospheric CO₂, the CO₂ in the atmosphere would be much higher than it is today.

Therefore, natural and human CO₂ do not “add” CO₂ to the atmosphere. Both natural and human CO₂ “flow through” the atmosphere. As CO₂ flows through the atmosphere, it raises the level of atmospheric CO₂ just enough so CO₂ outflow equals CO₂ inflow. Nature balances CO₂ in the atmosphere when outflow equals inflow.

You pump air into a tire or inner tube that has a leak. As you pump air into the tube, air leaks out of the tube. The faster you pump air in, the faster air leaks out. If you pump air into the tube at a constant rate, the air pressure in the tube will find a level where outflow equals inflow.

River water flows into a lake or a pond and flows out over a dam. If inflow increases, the water level increases until outflow over the dam equals inflow from the river. Then, the water level will remain constant so long as inflow remains constant. The river does not “add” water to the lake. Water “flows through” the lake and finds a balance level where outflow equals inflow.

Similarly, human and natural CO₂ flow through the atmosphere. The inflow creates a balance level that remains constant so long as inflow remains constant.

3.2. Physics Model System Description

Figure 2 shows a bucket of water as an analogy to CO₂ in the atmosphere. Water flows into the bucket at the top and flows out through a hole in the bottom. An outside source (faucet) controls the inflow.

The water level and the hole size control the outflow. No matter what the inflow, the level and the size of the hole control the outflow. Inflow only serves to set a balance level.

This paper uses e-time rather than “residence” time because there are many definitions of residence time. E-time has a precise definition: the time for the level to move $(1 - 1/e)$ of the distance from its present level to its balance level. The balance level is defined below.

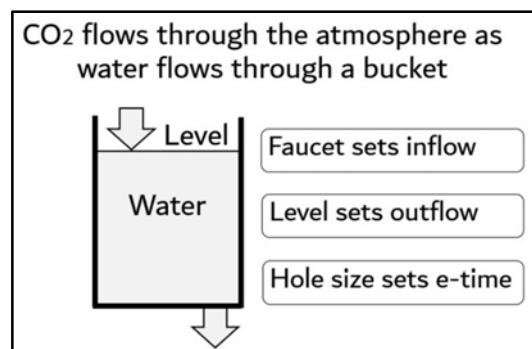


Figure 2. A bucket of water is an analogy to the Physics Model for atmospheric CO₂. Water flows through the bucket as CO₂ flows through the atmosphere.

The bucket analogy provides insight into e-time. If the hole in the bucket gets smaller, e-time increases. If the hole in the bucket gets larger, e-time decreases. The hole is an analogy to the ability of the oceans and land to absorb CO₂ from the atmosphere.

Figure 3 shows the Physics Model system for atmospheric CO₂. The system includes the level (concentration) of CO₂ in the atmosphere and the inflow and outflow of CO₂.

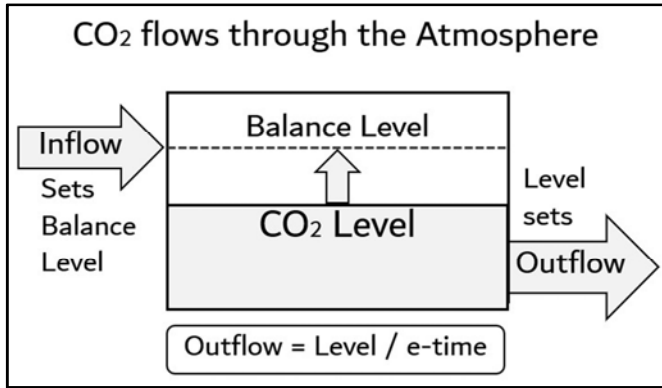


Figure 3. The Physics Model system for atmospheric CO₂. Inflow and Outflow determine the change in level. The only hypothesis is $Outflow = Level / e\text{-time}$.

The Physics Model applies independently and in total to all definitions of CO₂, e.g., to human CO₂, natural CO₂, and their sums, and to 12CO₂, 13CO₂, and 14CO₂, and their sums.

The Physics Model is complete. It is not necessary to add separate inflows for human and natural CO₂ to the Physics Model. Just use a copy of the Physics Model for each CO₂ definition desired.

The Physics Model does not need to describe the details of the external processes. Inflow, outflow, and e-time include all the effects of outside processes. If the Physics Model were connected to land and ocean reservoirs, it would behave exactly as derived in this paper.

Kohler [7] claims Harde's [24] model and therefore the Physics Model is "too simplistic" and "leads to flawed results for anthropogenic carbon in the atmosphere."

Kohler is wrong. There is no such thing as a system being "too simplistic." A system should be as simple as possible to solve a problem. The Physics Model shows how inflow, outflow, and e-time affect the level of CO₂ in the atmosphere. The IPCC model cannot do this.

3.3. Physics Model Derivation

A system describes a subset of nature. A system includes levels and flows between levels. Levels set flows and flows set new levels. The mathematics used in the Physics Model are analogous to the mathematics used to describe many engineering systems.

The Physics Model derivation begins with the continuity equation (1) which says the rate of change of level is the difference between inflow and outflow:

$$dL/dt = Inflow - Outflow \quad (1)$$

Where

L = CO₂ level (concentration in ppm)

t = time (years)

dL/dt = rate of change of L (ppm/year)

$Inflow$ = rate CO₂ moves into the system (ppm/year)

$Outflow$ = rate CO₂ moves out of the system (ppm/year)

Following the idea from the bucket of water, the Physics Model has only one hypothesis, that outflow is proportional to level:

$$Outflow = L / Te \quad (2)$$

where Te is the "e-folding time" or simply "e-time."

Substitute (2) into (1) to get,

$$dL/dt = Inflow - L / Te \quad (3)$$

One way to replace $Inflow$ in (3) is to set dL/dt to zero, which means the level is constant. Then $Inflow$ will equal a balance level, Lb , divided by e-time. However, a more elegant way to replace $Inflow$ is to simply define the balance level, Lb , as

$$Lb = Inflow * Te \quad (4)$$

Equation (4) shows how $Inflow$ and Te set the balance level. Substitute (4) for $Inflow$ into (3) to get,

$$dL/dt = - (L - Lb) / Te \quad (5)$$

Equation (5) shows the level always moves toward its balance level. At this point, both L and Lb are functions of time. Te can also be a function of time.

In the special case when Lb and Te are constant, there is an analytic solution to (5). Rearrange (5) to get

$$dL / (L - Lb) = - dt / Te \quad (6)$$

Then integrate (6) from Lo to L on the left side, and from 0 to t on the right side [29] to get

$$\ln [(L - Lb) / (Lo - Lb)] = - t / Te \quad (7)$$

where

Lo = Level at time zero ($t = 0$)

Lb = the balance level for a given inflow and Te

Te = time for L to move $(1 - 1/e)$ from L to Lb

$e = 2.7183$

The original integration of (6) contains two absolute values, but they cancel each other because both L and Lo are always either above or below Lb .

Raise e to the power of each side of (7), to get the level as a function of time:

$$L(t) = Lb + (Lo - Lb) \exp(- t/Te) \quad (8)$$

Equation (8) is the analytic solution of (5) when Lb and Te are constant.

The hypothesis (2) that outflow is proportional to level creates a "balance level." Equation (4) defines the balance level in terms of inflow and e-time.

Figure 4 shows how the level always moves toward its

balance level according to (5). While outflow is always proportional to level, inflow sets the balance level.

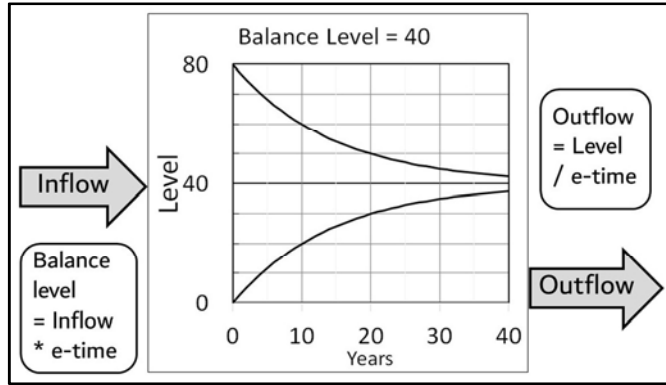


Figure 4. Inflow sets the balance level. The level at any time t determines the outflow. Level always moves toward the balance level, whether the level is above or below the balance level.

The Physics Model shows how CO₂ flows through the atmosphere. CO₂ does not “stick” in the atmosphere. A higher inflow merely raises the balance level. Then the level will rise until outflow equals inflow, which will be at the balance level.

3.4. Physics Model Consequences

All equations after (2) are deductions from hypothesis (2) and the continuity equation (1).

Equation (4) shows the balance level equals the product of inflow and e -time. Using IPCC numbers, and subscripts “p” to mean human (or people) and “n” to mean natural, the balance levels of human and natural CO₂ are 18.4 and 392 ppm:

$$Lbp = 4.6 \text{ (ppm/year)} * 4 \text{ (years)} = 18.4 \text{ ppm} \quad (9)$$

$$Lbn = 98 \text{ (ppm/year)} * 4 \text{ (years)} = 392 \text{ ppm} \quad (10)$$

The ratio of human to natural CO₂ is 4.6%. The percentage of human CO₂ to total CO₂ is 4.5%. Both are independent of e -time:

$$Lbp / Lbn = 4.6 / 98 = 4.6\% \quad (11)$$

$$Lbp / (Lbn + Lbp) = 4.6 / 102.6 = 4.5\% \quad (12)$$

Equation (9) shows present human emissions create a balance level of 18 ppm, independent of nature’s balance level. If nature’s balance level remained at 280 ppm after 1750, then present human emissions would have increased the CO₂ level 18 ppm from 280 ppm to 298 ppm.

Equation (10) shows present natural emissions create a balance level of 392 ppm. The human contribution of 18 ppm brings the total balance level to 410 ppm, which is close to the level in 2018.

Equation (11) shows the ratio of human to natural CO₂ in the atmosphere equals the ratio of their inflows, independent of e -time.

Equation (12) shows the percentage of human-produced CO₂ in the atmosphere equals its percentage of its inflow, independent of e -time.

Figure 5 illustrates these Physics Model conclusions when e -time is 4 years.

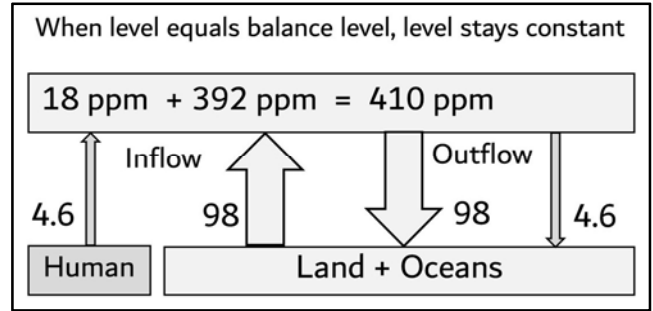


Figure 5. For an e -time of 4 years, the human inflow of 4.6 ppm per year sets a balance level of 18 ppm, and the natural inflow of 98 ppm per year sets a balance level of 392 ppm. When the level equals the total balance level of 410 ppm, outflow will equal inflow and level will be constant.

Equations (9) and (10) support the key conclusions of Harde [24, 25]:

Under present conditions, the natural emissions contribute 373 ppm and anthropogenic emissions 17 ppm to the total concentration of 390 ppm (2012).

4. The IPCC Bern Model

4.1. IPCC Bern Model Origin

In 1992, Siegenthaler and Joos [30] created the original Bern model. Their Figure 1 connects the atmosphere level to the upper ocean level, and the upper ocean level to the deep and interior ocean levels. They used ¹⁴C data to trace the flow of ¹²CO₂ from the atmosphere to the upper ocean and to the deep and interior oceans. Using some physics constraints, they attempted without success to fit three versions of their model to available data.

Earlier, in 1987, Maier-Reimer and Hasselmann [31] used an ocean circulation model connected to a one-layer atmosphere to reproduce the main features of the CO₂ distribution in the surface ocean. They applied a mathematical curve fit to represent their conclusions. Their curve fit used a sum of four exponentials with different amplitudes and time constants, as in today’s Bern model.

The use of four exponentials by [31] seems to result from their reconnection of both the deep and interior ocean levels directly to the atmosphere level. Such reconnection would be a serious modelling mistake. Other papers followed the model developed by [31].

Archer et al. [4] found the four-exponential models “agreed that 20–35% of the CO₂ remains in the atmosphere after equilibration with the ocean (2–20 centuries).”

Joos et al. [32] compared the response of such atmosphere-ocean models to a pulse emission of human CO₂. All the models predicted a “substantial fraction” of pulse would remain in the atmosphere and ocean for millennia.

The conclusions of [4, 30, 31, 32] must be questioned because:

1. Agreement among models does not prove they are

accurate.

2. All models treat human and natural CO₂ differently, which violates physics.
3. All models assume human CO₂ causes all the increase in atmospheric CO₂, which violates physics.
4. All models partition human CO₂ inflow into four artificial bins, which is unphysical.
5. All models lack a valid physics model for atmospheric CO₂.

Segalstad [10] notes that the models like [31] do not allow CO₂ to flow out of the atmosphere in linear proportion to the CO₂ level. Rather they use a non-linear constraint on the outflow that contradicts physics and chemistry.

Segalstad [10] concludes the alleged long residence time of 500 years for carbon to diffuse to the deep ocean is inaccurate because the 1000 GtC of suspended organic carbon in the upper 75 meters of the ocean can sink to the deep ocean in less than one year. That gives a residence time of 5 years rather than 500 years.

The IPCC Bern model that evolved from models like [31] artificially partitions human CO₂ into four separate bins. The separate bins prevent human CO₂ in one bin from moving to a bin with a faster e-time. This is like having three holes of different sizes in the bottom of a bucket and claiming the smallest hole restricts the flow through the largest hole.

The IPCC Bern model is unphysical. It begins with the assumption that human CO₂ causes all the increase in atmospheric CO₂. Then it creates a model that supports this assumption.

The Bern model fails Occam's Razor because it is unnecessarily complicated.

4.2. IPCC Bern Model Derivation

The Joos [33] Bern model is an integral equation rather than a level equation.

It is necessary to peer inside IPCC's Bern model. To deconstruct the integral version of the Bern model, let inflow occur only in the year when "t-prime" equals zero. Then the integral disappears, and the Bern model becomes a level equation.

The Bern level equation is,

$$L(t) = Lo [A_0 + A_1 \exp(-t/T_1) + A_2 \exp(-t/T_2) + A_3 \exp(-t/T_3)] \quad (13)$$

Where

t = time in years

Lo = level of atmospheric CO₂ in year $t = 0$

$L(t)$ = level of atmospheric CO₂ in year t

and the Bern TAR standard values, derived from curve-fitting the Bern model to the output of climate models, are,

$$A_0 = 0.150$$

$$A_1 = 0.252$$

$$A_2 = 0.279$$

$$A_3 = 0.319$$

$$T_1 = 173 \text{ years}$$

$$T_2 = 18.5 \text{ years}$$

$$T_3 = 1.19 \text{ years}$$

The A -values weight the four terms on the right-hand side of (13):

$$A_0 + A_1 + A_2 + A_3 = 1.000$$

In (13), set t equal to infinity to get,

$$L = A_0 Lo = 0.152 Lo \quad (14)$$

Equation (14) predicts a one-year inflow that sets Lo to 100 ppm, followed by zero inflow forever, will cause a permanent level of 15 ppm.

The four terms in (13) separate human (but not natural) CO₂ into 4 bins. Each bin has a different e-time. Only one bin allows human CO₂ to flow freely out of the atmosphere. Two bins trap human CO₂ for long times. One bin has no outflow and traps human CO₂ forever.

Figure 6 shows the size of the four Bern-model bins in percent and the amount of human CO₂ that remains in the atmosphere 8 years after an artificial pulse of human CO₂ enters the atmosphere.

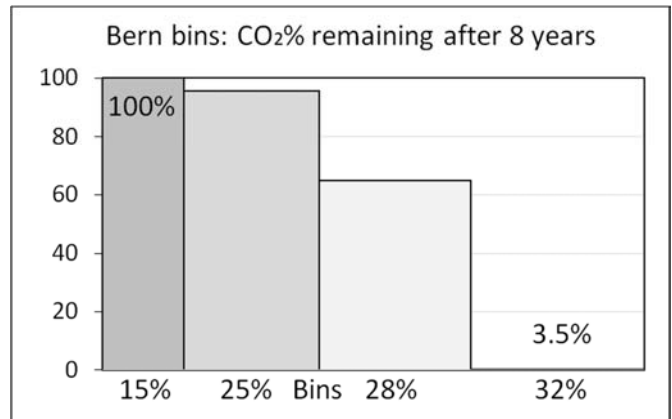


Figure 6. The percent of human CO₂ left in each Bern model bin after 8 years.

Bern (13) predicts 15 percent all human CO₂ entering the atmosphere stays in the atmosphere forever, 25 percent stays in the atmosphere almost forever, and only 32 percent flows freely out of the atmosphere.

4.3. How IPCC Gets 32 Percent

The burden of proof is upon the IPCC to explain how 5 percent human inflow becomes 32 percent in the atmosphere. IPCC cannot change the inflow. Therefore, IPCC must change the outflow. The IPCC Bern model restricts the outflow of human CO₂ while it lets natural CO₂ flow freely out of the atmosphere. The IPCC Bern model incorrectly treats human CO₂ differently than it treats natural CO₂. By doing so, it artificially increases human CO₂ in the atmosphere to 32 percent and beyond.

IPCC assumes its Bern model applies to human but not to natural CO₂. That assumption is unphysical because CO₂ molecules from human and natural sources are identical. All valid models must treat human and natural CO₂ the same.

If applied to natural CO₂, the Bern model predicts 15

percent of natural CO₂ sticks in the atmosphere. Then in 100 years, 1500 ppm of natural CO₂ sticks in the atmosphere. This clearly has not happened. Therefore, the Bern model is invalid.

For you mathematicians:

It is simple to prove the Bern model is unphysical. Take the derivative of (13) with respect to time. It is impossible to get rid of the exponential terms because the Bern model has more than one time constant in its exponentials. The Bern model dL/dt does not correspond to a physics formulation of a problem.

By contrast, it is straightforward to take the time derivative of the Physics Model (8) and reproduce its dL/dt form of (5).

The Physics Model began as a rate equation, as all physics models should. The Bern model began with a curve fit to an imaginary scenario for a level rather than as a rate equation for a level. The Bern model does not even include a continuity equation.

5. Theories Must Replicate Data

5.1. The 14C Data

The above-ground atomic bomb tests in the 1950s and 1960s almost doubled the concentration of 14C in the atmosphere. The 14C atoms were in the form of CO₂, called 14CO₂.

After the cessation of the bomb tests in 1963, the concentration of 14CO₂ decreased toward its natural balance level. The decrease occurred because the bomb-caused 14C inflow became zero while the natural 14C inflow continued.

The 14C data are in units of D14C per mil. The lower bound in D14C units is -1000. This value corresponds to zero 14C inflow into the atmosphere. In D14C units, the “natural” balance level, defined by the average measured level before 1950, is zero, 1000 up from -1000. [34].

Hua [34] processed 14C data for both hemispheres from 1954 to 2010. Turnbull [35] processed 14C data for Wellington, New Zealand, from 1954 to 2014. After 1970, 14CO₂ were well mixed between the hemispheres and 14CO₂ in the stratosphere were in the troposphere. The 14C data from both sources are virtually identical after 1970.

14C is an isotope of 12C. Levin et al. [36] conclude the C14 data provide “an invaluable tracer to gain insight into the carbon cycle dynamics.”

5.2. Physics Model Replicates the 14C Data

The Physics Model (8) accurately replicates the 14CO₂ data from 1970 to 2014 with e-time set to 16.5 years, balance level set to zero, and starting level set to the D14C level in 1970.

Figure 7 shows how the Physics Model replicates the 14C data.

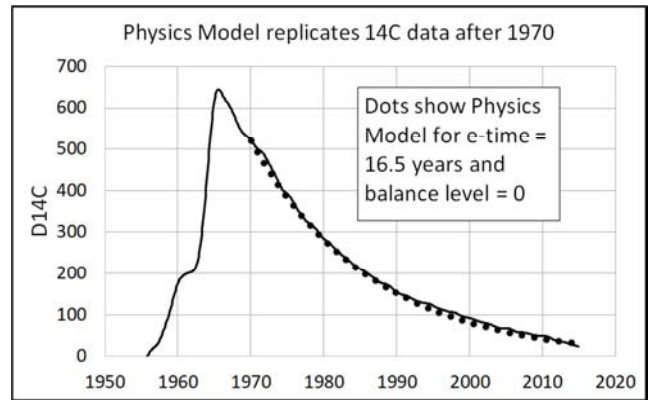


Figure 7. The 14C data from Turnbull [35] using 721 data points. The dotted line is the Physics Model replication of the data.

The Physics Model is not a curve fit with many parameters like the Bern model. The Physics model allows only 2 parameters to be adjusted: balance level and e-time, and they are both physical parameters. It is possible that the data would not allow replication by the Physics Model.

The replication of the 14C data begins by setting the Physics Model to the first data point in 1970. Then it is a matter of trying different balance levels and e-times until the model best fits the data. Although there is room for minor differences in the fit, the best fit seems to occur when the balance level is zero and e-time is 16.5 years.

The replication of the 14C data by the Physics Model has significant consequences. It shows the 14C natural balance level has remained close to zero and e-time has remained constant since 1970. If the e-time had changed since 1970, it would have required a variable e-time to make the Physics Model fit the data.

5.3. 12CO₂ Reacts Faster Than 14CO₂

Isotopes undergo the same chemical reactions but the rates that isotopes react can differ. Lighter isotopes form weaker chemical bonds and react faster than heavier isotopes [37].

Because 12CO₂ is a lighter molecule than 14CO₂, it reacts faster than 14CO₂. Therefore, its e-time will be shorter than for 14CO₂.

Equation (4) shows e-time equals *Level* divided by *Inflow*. Using IPCC numbers, e-time for 12CO₂ is about 400 ppm divided by 100 ppm per year, or 4 years. Also, IPCC [3] agrees 12CO₂ turnover time (e-time) is about 4 years. Segalstad [10] calculated 5 years for e-time.

Figure 8 shows the Physics Model (8) simulation of 12CO₂ using an e-time of 4 years. For comparison, Figure 8 shows the 14C data from Hua [34] and the Physics Model replication of 14CO₂ data with an e-time of 16.5.

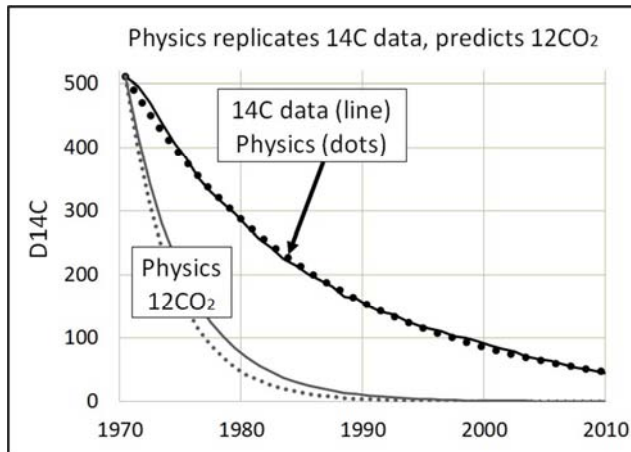


Figure 8. This plot uses the ^{14}C data from Hua [34] from 1970 to 2010. Hua data is in mid-years, so the fit begins in 1970.5. The Physics Model (dotted line) replicates the ^{14}C data with an e -time of 16.5 years. The Physics Model simulates $^{12}\text{CO}_2$ for an e -time of 4 years (dotted line) and 5 years (solid line).

5.4. IPCC Model Cannot Simulate $^{12}\text{CO}_2$

The Bern model claims to predict the outflow of $^{12}\text{CO}_2$. Therefore, the Bern model should come close to predicting the outflow of $^{12}\text{CO}_2$ as calculated by the Physics Model that replicates the ^{14}C data.

Figure 9 shows the Bern model (13) predictions. The IPCC Bern model begins with a short e -time, then increases its e -time. The increased e -time causes the Bern line to cross the ^{14}C line and thus conflicts with the ^{14}C data. The Bern model traps 15 percent of human CO_2 in the atmosphere forever.

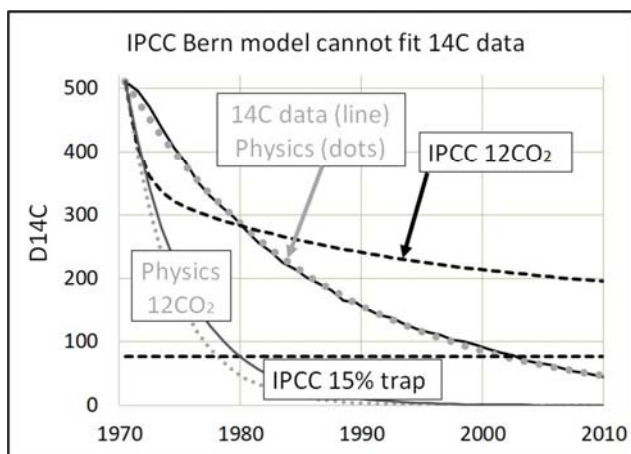


Figure 9. The IPCC Bern model (dashed lines) is not consistent with the $^{12}\text{CO}_2$ simulation or with $^{14}\text{CO}_2$ data. The Bern model includes a trap for 15 percent of human CO_2 .

The IPCC Bern model is not just a failure to simulate data. The Bern model is a functional failure. Its e -time increases significantly with time when ^{14}C data show e -time is constant. The only way the Bern model can increase with time is by using its history as a reference.

Figure 10 shows how the IPCC Bern model cannot even replicate itself when it is restarted at any point in its simulation.

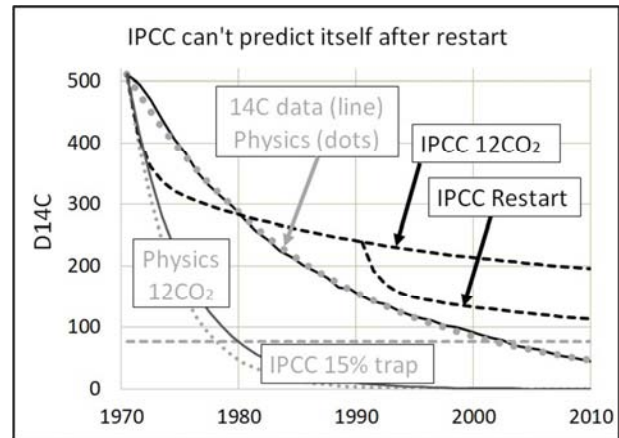


Figure 10. The Bern model (dashed lines) cannot even replicate itself after a restart.

The IPCC Bern model cannot continue its same prediction line if it is restarted at any point. The Bern model cannot properly restart because it depends upon its history, which makes it an invalid model.

A restart deletes the Bern model's history. This forces the Bern model to create a new history. In the real world, molecules do not remember their history. Molecules only know their present. Therefore, the IPCC Bern model fails the most basic test for a physical model.

Revelle and Suess [8] used ^{14}C data to calculate correctly that human CO_2 would increase atmospheric CO_2 by only 1.2 percent as of 1957, based for an e -time of 5 years.

5.5. IPCC's Buffer Theory is Invalid

IPCC [3] claims:

The fraction of anthropogenic CO_2 that is taken up by the ocean declines with increasing CO_2 concentration, due to reduced buffer capacity of the carbonate system.

Buffer capacity is the ability of the oceans to absorb CO_2 .

Kohler et al. [7] claim human (but not natural) CO_2 has reduced the "buffer capacity" of the carbonate system:

The rise in atmospheric and oceanic carbon content goes along with an increase in the Revelle factor, a phenomenon which is already measurable. This implies that the oceanic uptake of anthropogenic carbon will become slower if we continue to increase anthropogenic CO_2 emissions. This is already seen in all CHIMP5 model simulations.

Kohler's last sentence exhibits circular reasoning when it claims a model can prove what has been fed into the model.

All IPCC models use the buffer factor myth instead of Henry's Law to conclude human CO_2 causes all the rise in atmospheric CO_2 [10].

The problem for Kohler and IPCC is data. Where are the data that support their claim? They have only their models. Models are not data. Models must make predictions that replicate data. Their models cannot replicate data.

Ballantyne et al. [38] found "there is no empirical evidence" that the ability of the land and oceans to absorb atmospheric CO_2 "has started to diminish on the global scale."

The 14C data are the most accurate way to measure changes in the Revelle factor and “buffer capacity.” Reduced buffer capacity, if it existed, would increase e-time. The 14C data prove e-time has been constant since 1970. Therefore, IPCC’s buffer capacity has been constant.

IPCC’s buffer capacity claim is absurd because it assumes only human CO₂ reduces the buffer capacity while natural CO₂ outflow does not. IPCC treats human and natural CO₂ differently, which is impossible.

Kohler [7] claims lower buffer capacity affects only 12CO₂, not 14CO₂. That claim violates chemistry and physics. Segalstad [10] previously showed Kohler’s claim is impossible because “chemical and isotopic experiments show the equilibrium between CO₂ and water is obtained within a few hours.”

The IPCC Bern model is based upon the invalid assumption that human CO₂ decreases buffer capacity.

5.6. Isotope Data Support the Physics Model

IPCC [3] writes:

Third, the observed isotropic trends of 13C and 14C agree qualitatively with those expected due to the CO₂ emissions from fossil fuels and the biosphere, and they are quantitatively consistent with results from carbon cycle modeling.

Human fossil-fuel CO₂ is “14C-free” and the 14C balance level has decreased. IPCC [3] and Kohler [7] claim this proves human CO₂ caused all the rise in atmospheric CO₂.

But neither IPCC nor Kohler argue with numbers. Let’s do the calculations to compare the results from both models with the data. IPCC [2] says human CO₂ comprises 32 percent of atmospheric CO₂ while the Physics Model (12) says human CO₂ is less than 5%. The question is whether the available isotope data support or reject either of the models.

RealClimate [39] says the 13C/12C ratio for human CO₂ is about 98 percent of the ratio in natural CO₂, and the 13C ratio has declined about 0.15 percent since 1850. RealClimate says this proves human CO₂ caused all the increase in atmospheric CO₂ since 1850.

Human CO₂ causes the new balance level of D14C and 13C/12C to be:

$$Lb = Ln Rn + Lh Rh \quad (15)$$

Where

Lb = the new balance level (of D14C or 13C/12C)

Ln = the natural balance level (D14C = 0; 13C/12C = 100%)

Lh = the human balance level (D14C = -1000; 13C/12C = 98%)

Rn = the fraction of natural CO₂

Rh = the fraction of human CO₂

The Physics Model predicts for D14C:

$$Lb = (0) (0.955) + (-1000) (0.045) = -45 \quad (16)$$

The IPCC model predicts for D14C:

$$Lb = (0) (0.68) + (-1000) (0.32) = -320 \quad (17)$$

The Physics Model predicts for 13C/12C:

$$Lb = (100) (0.955) + (98) (0.045) = 99.91 \quad (18)$$

The IPCC model predicts for 13C/12C:

$$Lb = (100) (0.680) + (98) (0.320) = 99.36 \quad (19)$$

The 14C data

The Physics Model (16) predicts human CO₂ has lowered the balance level of 14C from zero to -45. The IPCC model (17) predicts human CO₂ has lowered the 14C balance level to -320.

Figure 11 compares the Physics and IPCC predicted levels for human CO₂ in the atmosphere.

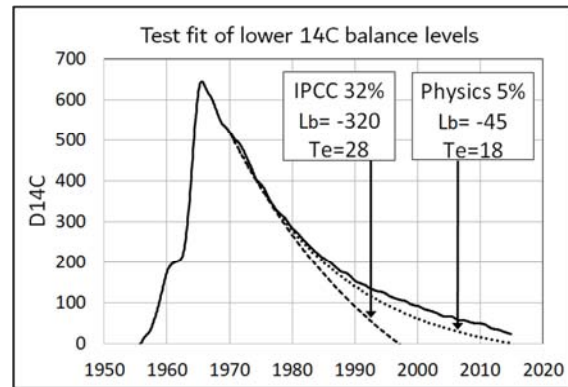


Figure 11. The dotted lines show the Physics Model calculation for a balance level of -45. The dashed line shows the Physics Model calculation for the IPCC predicted balance level of -320.

Figure 11 shows the Physics Model result of 5 percent human CO₂ in the atmosphere matches the 14C data much better than the IPCC model of 32 percent of human CO₂ in the atmosphere.

In summary, the 14C data support the Physics Model and reject the IPCC model.

The 13C data

The Physics Model (18) predicts human CO₂ has lowered the 13C ratio by 0.09. The IPCC model (19) predicts human CO₂ has lowered the 13C ratio by 0.64.

Figure 12 compares the Physics and IPCC predictions of the 13C/12C ratio to Real Climate’s numbers.

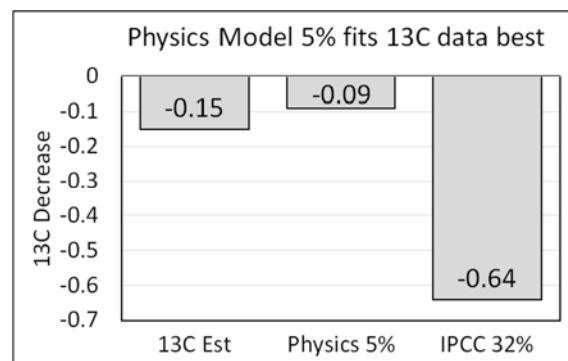


Figure 12. Real Climate [39] says the 13C ratio has decreased by 0.15 since 1750. Physics predicts a decrease of 0.09 and IPCC predicts a decrease of 0.64.

There seem to be no error bounds in the available ^{13}C data. Nevertheless, even without error bounds the ^{13}C data do not support the IPCC model over the Physics Model. So, the IPCC argument fails.

Segalstad [10] calculated similar results using permil units. He concluded the isotope data show human CO_2 cannot be more than 4 percent of atmospheric CO_2 .

5.7. Mauna Loa Data

Some scientists argue that a viable CO_2 model must replicate the Mauna Loa CO_2 data. The Physics Model can simulate the Mauna Loa data for atmospheric CO_2 as well as any other model.

Spencer [40] has a model that fits the Mauna Loa data. Spencer assumes like the IPCC that the natural level of CO_2 is fixed at 280 ppm and human CO_2 causes all the increase in atmospheric CO_2 . His model has many variables available to adjust so a fit to the Mauna Loa data is guaranteed.

The significance of the fit by the Physics Model is that it comes with physical constraints that the other models do not have. The Physics Model e-time must be 4 years and natural CO_2 must be 95 percent of atmospheric CO_2 .

Figure 13 shows how the Physics Model fits the Mauna Loa data.

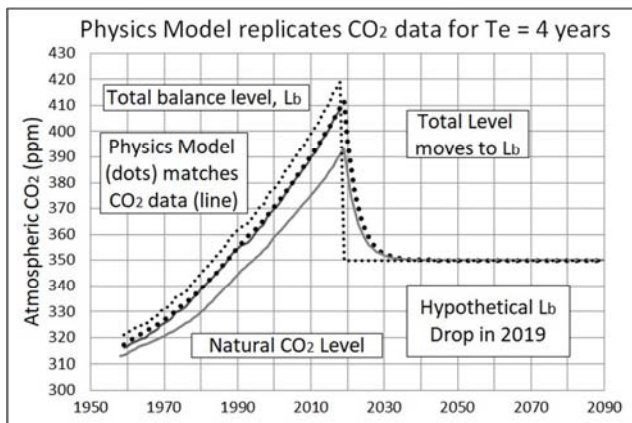


Figure 13. The Physics Model replicates the Mauna Loa data with an e-time of 4 years and the requirement that natural CO_2 is 95 percent of atmospheric CO_2 .

In Figure 14, the total balance level is the sum of natural and human balance levels. The balance level continues to rise. Level follows the balance level with a lag of about 4 years (the e-time), after the year 2000. This lag keeps the level about 10 ppm below the its balance level. Human CO_2 adds to the natural level to produce the total level, about 15 ppm above the natural level.

In 2019, the balance level in Figure 14 is artificially reset to 350 ppm to test how fast the CO_2 level moves to the new balance level. The total CO_2 level falls to its new balance level of 350 ppm in about 10 years. No CO_2 remains stuck in the atmosphere.

5.8. Ice-core Data

IPCC claims “the observational CO_2 records from ice cores ... show that the maximum range of natural variability

about the mean of 280 ppm during the past 1000 years was small.”

Using this invalid claim, IPCC assumes natural CO_2 emissions remained constant within about one percent. IPCC’s invalid claim about ice-core data is the basis of IPCC’s invalid claim that human CO_2 causes all the increase in atmospheric CO_2 above 280 ppm. This increase is presently 130 ppm or 32 percent.

Siegenthaler and Joos [30] observed that ice-core data show natural CO_2 increased by 17 ppm or 6 percent before 1900, when human CO_2 emissions totaled only 5 ppm. These ice-core data contradict IPCC’s claim that natural CO_2 emissions stayed constant after 1750.

Jaworowski [12] explains why ice-core data do not properly represent past atmospheric CO_2 . He concludes nature produces 97 percent of atmospheric CO_2 .

Proxy ice-core values for CO_2 remained low for the past 650,000 years [10, 12]. If these ice-core values represent atmospheric CO_2 , then atmospheric CO_2 did not cause any of the global warming in the last 650,000 years. And if CO_2 did not cause global warming in the past, then the IPCC has lost its claim that CO_2 causes present global warming [12].

Leaf stomata and chemical data prove the historical CO_2 level was much higher than derived from ice cores [12]. There is no evidence that the pre-industrial CO_2 level was 280 ppm as IPCC assumes.

Beck [13] reconstructed CO_2 from chemical data show the level reached 440 ppm in 1820 and again in 1945.

IPCC’s claim that human CO_2 produces all the increase in atmospheric CO_2 above 280 ppm is invalid. In science, when data contradict a theory, the theory false. The IPCC, however, ignores how its theories contradict data.

6. Theories Must Be Logical

6.1. IPCC’s Response Times Fail Physics

The Physics Model e-time has a precise definition: e-time is the time for the level to move $(1 - 1/e)$ of the distance to its balance level.

Segalstad [10] observes IPCC [3] uses many definitions of lifetime — like residence time, transit time, response time, e-folding time, and adjustment time — in its quest to prove human CO_2 remains in the atmosphere for hundreds of years. Many investigators, from 1957 to 1992, have calculated the e-time of atmospheric CO_2 is about 5 years [10].

IPCC [3] defines “adjustment time (T_a)” as:

The time-scale characterising the decay of an instantaneous pulse input into the reservoir.

Cawley [5] defines “adjustment time (T_a)” as:

The time taken for the atmospheric CO_2 concentration to substantially recover towards its original concentration following a perturbation.

The word “substantially” is imprecise.

Cawley follows IPCC to define “residence time (T_r)” as:

The average length of time a molecule of CO_2 remains in the atmosphere before being taken up by the oceans or terrestrial

biosphere.

Some authors use “residence time” to mean “e-time” but other authors, such as Cawley and IPCC, have a different meaning for residence time. This paper uses e-time because its definition is precise.

In summary, IPCC uses two different response times when it should use only e-time:

1. When the level is far from its balance level (which can be zero), IPCC thinks e-time is an *adjustment* time because the level is moving rapidly toward its balance level.
2. When the level is close to its balance level, IPCC thinks e-time is a *residence* time because “molecules” are flowing in and out with little change in level.

Figure 14 illustrates how e-time relates to IPCC’s adjustment and residence times.

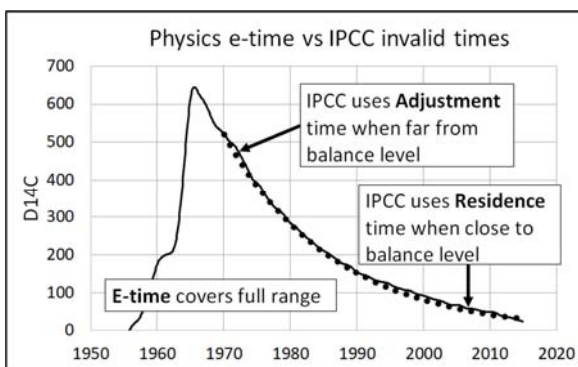


Figure 14. E-time covers the full range of movement of level to a balance level. IPCC [3] adjustment and residence times apply to only each end of the range.

IPCC defines “turnover time (T_t)” as:

The ratio of the mass M of a reservoir (e.g., a gaseous compound in the atmosphere) and the total rate of removal S from the reservoir: $T_t = M/S$.

IPCC’s turnover time seems to be the same as e-time except “removal” is not the same as outflow. Near the balance level, IPCC sometimes interprets “removal” to mean the difference between outflow and inflow.

IPCC says when outflow is proportional to level (the Physics Model hypothesis) then adjustment time equals turnover time. IPCC claims:

In simple cases, where the global removal of the compound is directly proportional to the total mass of the reservoir, the adjustment time equals the turnover time: $T_a = T_t$.

The Physics Model’s replication of the 14C data shows the 14CO₂ outflow is proportional to level. Therefore, by IPCC’s own definition, adjustment time equals e-time equals residence time.

IPCC says in further confusion:

In more complicated cases, where several reservoirs are involved or where the removal is not proportional to the total mass, the equality $T = T_a$ no longer holds.

Carbon dioxide is an extreme example. Its turnover time is only about 4 years because of the rapid exchange between atmosphere and the ocean and terrestrial biota.

Although an approximate value of 100 years may be given

for the adjustment time of CO₂ in the atmosphere, the actual adjustment is faster initially and slower later on.

IPCC agrees 12CO₂ turnover time (e-time) is about 4 years. IPCC claims adjustment time is “fast initially and slower later on” which is why its Bern model cannot replicate the 14C data in Figure 9.

The 14C data show the e-time for 14CO₂ is 16.5 years. This e-time is the upper bound for 12CO₂ e-time. The IPCC claim of hundreds of years is based on IPCC’s misunderstanding of e-time.

Unfortunately, there are many different definitions of residence time. Therefore, this paper uses e-time with its exact definition.

6.2. IPCC’s First Core Argument Is Illogical

The IPCC [2] first core argument notes that human emissions from 1750 to 2013 totaled 185 ppm while atmospheric CO₂ increased by only 117 ppm. These numbers are OK. But IPCC claims this proves human CO₂ caused all the increase in atmospheric CO₂ above 280 ppm. IPCC’s logic is faulty.

Figure 15 shows the IPCC first core argument.

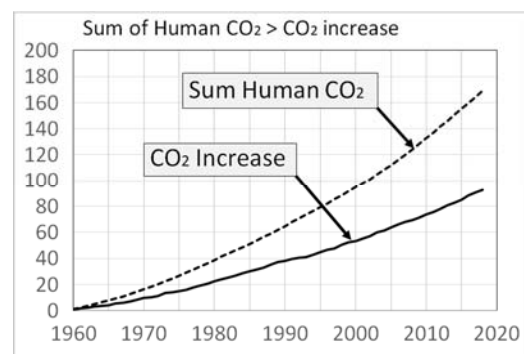


Figure 15. The sum of human CO₂ year-by-year is larger than the increase in atmospheric CO₂.

However, the fact that the sum of human emissions is greater than the increase does not prove human CO₂ caused the increase. The IPCC argument omits natural CO₂ which totaled about 6000 ppm during the same period, much larger than the sum of human CO₂.

Figure 16 shows the plot when the sum of natural CO₂ is included.

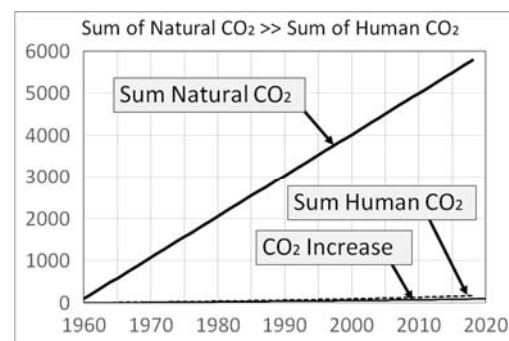


Figure 16. The sum of natural CO₂ compared to the sum of human CO₂ and the increase in CO₂.

The sum of natural CO₂ from 1959 to 2018 is 5700. The sum of human CO₂ over the same period is 170 ppm which is 3 percent of the natural CO₂ sum. IPCC's whole case depends upon its incorrect assumption that nature did not vary more than 3 percent since 1959 or since 1750. At the same time, IPCC admits it does not know nature's CO₂ emission within 50 percent.

The fundamental error in this IPCC argument is discussed in Section 3.1. The sums of inflows do not matter because inflows do not "add" to atmospheric CO₂. Inflows set balance levels. The human effect on the total balance level is less than 5 percent.

6.3. IPCC's Second Core Argument Is Illogical

IPCC [2] claims nature has been a "net carbon sink" since 1750, so nature could not have caused the observed rise in atmospheric carbon dioxide. Please refer to Figure 5 that shows the inflow and outflow of atmospheric CO₂.

Of course, nature is a "net carbon sink" because nature absorbs human CO₂ emissions. However, absorption of human CO₂ has no bearing whatsoever on how much natural CO₂ flows into the atmosphere. Nature can set its inflow as it pleases, no matter how much human inflow nature absorbs. The 98-ppm natural flow can double or reduce to one-half while nature continues to absorb the outflow of the human addition to atmospheric CO₂. So, the IPCC argument is absurd.

The Physics Model shows how CO₂ inflows set balance levels in atmospheric CO₂. At the balance level, outflow will equal inflow. No CO₂ gets trapped in the atmosphere.

6.4. Key IPCC Paper Makes Serious Errors

Kohler [7] uses Cawley [5] to "prove" the IPCC case. But Cawley fails physics and statistics.

Cawley [5] is a key paper for the IPCC theory. Cawley claims human CO₂ caused all the increase of atmospheric CO₂ above the 280 ppm in 1750. But Cawley's attempted proof fails physics.

Figure 17 shows three of Cawley's equations.

$F_e = k_e C + F_e^0 \quad (3)$	
$\frac{dC_A}{dt} = -\frac{C_A F_e}{C} \quad (7)$	
$\frac{dC_N}{dt} = F_i^0 - \frac{C_N F_e}{C} \quad (8)$	

Figure 17. Equations from Cawley [5].

Cawley's equation (3) attempts to do the same job as Physics Model (2), namely, to represent how level sets outflow. But Cawley adds to his equation (3) a second term that represents a steady-state outflow that is independent of level. Cawley's added term is fictitious because his first term on the right side of his equation (3) is the true source of all outflow. As a result, all Cawley's equations after his (3) are wrong, which makes his whole paper wrong.

Cawley's equation (7) should include his Fa for human inflow. His equations (7) and (8) should omit his arbitrary Fe for outflow and set outflow equal to level (his C) divided by his residence time. His residence time is also inaccurate as shown in Section 6.1.

6.5. Statistical Correlation

Cawley [5] argues,

Lastly, the rise in atmospheric carbon dioxide closely parallels the rise in anthropogenic emissions ... which would be somewhat of a coincidence if the rise were essentially natural in origin!

IPCC [3] writes:

Second, the observed rate of CO₂ increase closely parallels the accumulated emission trends from fossil fuel combustion and from land use changes.

IPCC incorrectly claims this proves human CO₂ causes the increase in atmospheric CO₂.

A standard scientific test for the non-existence of cause and effect is to show the correlation, of the assumed cause with the assumed effect, is zero.

For the IPCC to argue that human CO₂ causes climate change, the IPCC must show that the correlation of human emissions with the increase in atmospheric CO₂ is significantly greater than zero.

Proper statistics requires a detrended analysis of a time series to conclude cause and effect. Munshi [41] shows the "detrended correlation of annual emissions with annual changes in atmospheric CO₂" is zero. Chaamjamal [42] extended Munshi's calculations and found the correlations are zero for time intervals from one to five years.

Therefore, the standard statistical test for cause and effect proves human CO₂ is insignificant to the increase in atmospheric CO₂.

The ratio of annual change in atmospheric CO₂ to annual human CO₂ emissions that Munshi [41] tested is IPCC's "airborne fraction". Therefore, IPCC's airborne fraction has no useful meaning.

An estimate of the airborne fraction is about 2.5 ppm/year divided by 5 ppm/year, or 0.5. Since the increase in level is caused by an increase in natural CO₂ emissions, the airborne fraction has little physical meaning, and it would go to infinity if human emissions stopped.

7. Conclusions

The IPCC model and the Physics model compete to describe how human CO₂ emissions add to atmospheric CO₂. Both models agree that the CO₂ inflow into the atmosphere is less than 5 percent human CO₂ and more than 95 percent natural CO₂.

The IPCC model concludes that human CO₂ causes all the increase in atmospheric CO₂ above 280 ppm; that 15 percent of all human CO₂ emissions stays in the atmosphere forever; that 53 percent stays for hundreds of years; and only 32 percent flows freely out of the atmosphere like natural CO₂.

The Physics Model treats human CO₂ and natural CO₂ the

same because their CO₂ molecules are identical. The Physics model makes only one hypothesis: CO₂ outflow equals the level of CO₂ in the atmosphere divided by e-time.

The Physics Model concludes that inflow sets a balance level equal to inflow multiplied by e-time, and that continuing inflow does not continue to increase atmospheric CO₂. Rather inflow sets a balance level where outflow equals inflow and continuing inflow will not further increase the level of atmospheric CO₂ beyond the balance level.

The proper test of two theories is not to claim the IPCC theory explains “observational evidence.” The proper test is the scientific method: if a prediction is wrong, the theory is wrong.

The 14C data following the cessation of the atomic bomb tests show how the level of CO₂ in the atmosphere returns to its balance level after inflow decreases. All valid models of atmospheric CO₂ must be able to replicate the 14C data.

The Physics Model exactly replicates the 14C data after 1970. This replication shows the e-time for 14CO₂ is 16.5 years and that this e-time has been constant since 1970. The replication shows the Physics Model hypothesis — that outflow equals level divided by e-time — is correct.

The IPCC Bern model cannot replicate the 14C data. Its curve crosses the 14C data curve. The Bern model cannot even replicate itself if it is restarted at any point. This failure proves the IPCC Bern model does not have the mathematical structure for a valid model.

If natural CO₂ is inserted into the Bern model, as physics requires, the Bern model predicts that 15 percent of natural CO₂ inflow sticks in the atmosphere forever, which contradicts data and proves the Bern model is invalid.

The Physics Model concludes that the ratio of human to natural CO₂ in the atmosphere equals the ratio of their inflows, independent of e-time, and that the e-times for both human and natural CO₂ are the same. Using IPCC data, the e-time for 12CO₂ is about 4 years.

The ratio conclusion means human CO₂ adds only about 18 ppm and natural CO₂ adds about 392 ppm to today's CO₂ level of 410 ppm. If all human CO₂ emissions stopped and natural CO₂ emissions stayed constant, then the level of atmospheric CO₂ would fall only to 392 ppm in about 10 years. Nothing would be gained by stopping human CO₂ emissions. There are no long-term effects of human CO₂ emissions. Continued constant CO₂ emissions do not add more CO₂ to the atmosphere. Continued constant CO₂ emissions simply maintain the balance level.

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author.

Author's Contributions

The author declares he is the only contributor to the research in this paper.

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